RV PROFESSOR LOGACHEV
Research Cruise 09

SEDIMENT DISTRIBUTION ON THE REYKJANES RIDGE NEAR 59°N

Kiel - Reykjanes Ridge - Kiel

August 30 - September 17, 1993

Edited by
H.-J. WALLRABE-ADAMS & K.S. LACKSCHEWITZ
with contributions of the cruise participants

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Content

1. Introduction

Since October 1, 1991, the Geomar Research Center for Marine Geosciences, the Institute of Baltic Sea Research and the Geological Department of the University of Greifswald have performed a joint project dealing with sedimentation processes on mid-ocean ridges. The project is supported by the Federal Ministry for Research and Technology (part project of Geomar no. 03R619A). The scientific program is closely connected to international ridge research programs like "Ridge" (USA), "Bridge" (UK), "Interridge" and the German national initiative "DeRidge". This project follows similar investigations in the area of the Kolbeinsey Ridge from 1988 to 1990. The project's scientific objective is to develop a model concerning the genetic evolution of the depositional environment "mid-oceanic ridge". Depositional processes being active at mid-oceanic ridges, the spatial and temporal variability of these processes and consequently, the various sedimentary facies are principal objectives of investigation. Main thematic topics attempt to characterize different types of sedimentary facies and their genetic development and particle associations. Moreover, we focus on distribution patterns of distinct sedimentary facies, on the chronological order of facies types, including their genetic processes, and the demarcation of "MOR sediments" from adjacent basin sediments. Area of investigation is the Reykjanes Ridge between 57° N and 62° N.

Study area of RV "Logachev" Cruise 09 was part of the central Reykjanes Ridge near 59°N. First geological and geophysical investigations were done during a research cruise with RV "Sonne" (SO82) in October 1992. During this cruise a bathymetric map was produced and seven cores were taken. On the basis of these results the following described Cruise LO09 was planned. LO09 has to be focused first on sediment sampling within the mapped SO82-area and second to extend the study area by additional caustic profiling (SEL90) and sampling.
The results show a very complex sedimentation environment in the study area. Further investigations will lead to a model of sedimentation processes in mid-ocean ridges.

2. Research program and cruise track

The research program is focused on the investigation of the sedimentation processes in the active mid-ocean ridge and its spatial and temporal variability. The methods used include acoustic profiling, sediment sampling and complex investigations of the recovered material (sedimentology, geochemistry, physical properties, palaeontology).
Research area (Fig. 1) is between **58°30'N/60°N** and **28°W/33°W**, maximum water depth is ca. 2000m.

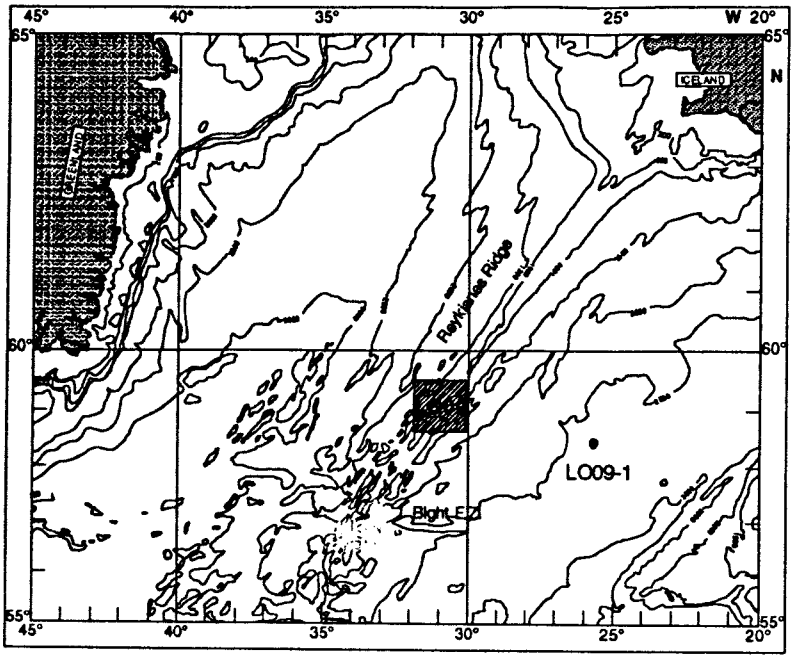

Fig. 1: LO09 study area in the North Atlantic.

2.1 Cruise plan

During the Cruise SO82 with RV "Sonne" in Oct. 92, a segment of the ridge (Fig. 1) was mapped with the *Hydrosweep* multibeam echo sounder and the subbottom profiler systems *Parasound* and *SEL90*. Seven sites were cored with box corer, large box corer and gravity corer. It was planned to take further samples in this area. Furthermore, it was planned to map an adjacent area with a towed version of a SEL90-subbottom-profiler and also to sample in this areas.

The first part of Cruise LO09 was planned on the results of the SO82b cruise. Promising site positions were selected with the help of the bathymetric map and acoustic profiles of the Parasound and SEL90 systems. On this basis sixteen stations were selected (Tab 1, Fig. 2). During the second part an additional area was mapped by thirteen SEL90 acoustic tracks (Fig. 2). On the basis of these tracks seven sites were selected and cored (Tab 1, Fig. 2).

2.2 The ship

Because it is not very common until today to use Russian research vessels here are some short notes on the RV "Prof. Logachev". The ship was built in 1990 in Nickolaev (Black Sea), the owner is the "Russian Polar Marine Geological Research Expedition" in St. Petersburg. RV Logachev is designed for offshore geological and geophysical exploration, often used for research

on mid-ocean ridges, especially the investigation of the basaltic basement, hydrothermal activities and ore deposits. Some technical information is given below:

Dimensions:	length 104.4m, width 10.02m, height 10.2m
Displacement:	5 700 tn
Loaded/ballasted speed:	12.5/13.2 kn
Construction draught:	5.88 m
Cruising capacity & range:	60 days, 30 000 miles
Complement:	51
Scientists:	max. 42

The ship is navigated by a GPS system and possibly with an automatic positioning system. The scientific equipment includes the MARS-ABYSSAL system, designed to collect and record seismic, seismoacoustic, magnetometric and gravimetric data, and devices for TV and photo observations. An unmanned underwater equipment for hydroacoustic and photographic surveys of the sea floor (JANTAR) and a sea floor transponder navigation system are available . For sampling hard rocks a TV guided hydraulic grab is on board.

2.3. Participants

Ship's crew

A. Arutyunov	(master)	Y. Sokol	(chief mate)
F. Kalimullin	(2nd mate)	O. Simanovich	(3rd mate)
V. Kalashnikov	(4th mate)	N. Tyulaev	(doctor)
V. Taran	(chief radio)	A. Il'chuk	(radioman)
A. Litvinov	(radioman)	G. Shoniy	(Ch. engineer)
I. Dolgopolov	(2nd engin.)	V. Vasich	(3rd engin.)
V. Selenis	(3rd engin.)	S. Plakhotnik	(4th engin.)
V. Serebrennikov	(4th engin.)	A. Solotkin	(ch. electr.)
S. Balyakov	(2nd electr.)	P. Nikiforov	(3rd electr.)
V. Bereznikov	(boatswain)	G. Dianov	(sailor)
I. Semenov	(sailor)	V. Sergeev	(sailor)
L. Lapsakov	(sailor)	A. Pozhidaev	(sailor)
A. Maslov	(sailor)	E. Matveev	(chief cook)
I. Osipov	(2nd cook)	A. Antonov	(3rd cook)
V. Sud'eva	(stewardess)	N. Perova	(stewardess)
A. Burmak	(stewardess)	M. Maliy	(steward)
S. Vetrova	(stewardess)	E. Zhitkova	(stewardess)
A. Belogubkin	(motorman)	A. Terent'ev	(motorman)
V. Kruglykov	(motorman)	A. Krivonozhenkov	(motorman)
Y. Repin	(motorman)	M. Steyman	(motorman)
Y. Maslov	(welder)	G. Kapranov	(electrician)
A. Pischikov	(electrician)		

Ship's scientists (NPO Sevmorgeologia)

M. Malsov	(chief engineer)	P. Borisov	(engineer)
V. Sheremet	(engineer)	I. Goncharov	(engineer)
V. Telepaev	(engineer)	Y. Solov'ev	(translator)

Scientific crew

1.	J. Dehn	petrologist	GEOM
2.	T. Förster	electronic eng.	IOW
3.	A. Frahm	technician	IOW
4.	M. Frenz	student	FRG
5.	B. Gehrke	sedimentologist	GEOM
6.	L. Horstmann	student	GEOM
7.	U. Haupt	student	FRG
8.	K. S. Lackschewitz	co-chief scientist	GEOM
9.	T. Merkel	electronic eng.	URE
10.	S. Müller	electronic eng.	URE
11.	G. Nickel	technican	IOW
12.	V. Schmidt	sedimentologist	FRG
13.	J. Sumner	petrologist	GEOM
14.	R. Urgeles Esclasans	student	GPI/UB
15.	H.-J. Wallrabe-Adams	chief scientist	GEOM

Participating institutions

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IOW - Institute of Baltic Research
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FRG - Department of Geosciences
Ernst-Moritz-Arndt-University
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URE - Institute of Communications Technology and
Information Electronics
University of Rostock
R.-Wagner-Str. 31
D-18119 Warnemünde

UB - Department of Geosciences
University of Barcelona

3. Cruise narrative

RV "Prof. Logachev" left the pier of the Sea Fish Market (GEOMAR) on August 30, 1993 at 12:00h. With northern direction the ship passed Denmark, the Kattegat, Skagerrak and the North Sea during the next days. On September 1, 18:00h we passed the Orkney- and Shetland Islands, entered the Atlantic Ocean and headed to the first site at 58°20'N/25°40'W. During this time we prepared the scientific equipment for operation. Some difficulties occured with the large box corer and the lifting trolley and also with the electrical installation of our laboratory-container. On September 3, the SEL90-sub bottom profiler was tested. The test was negative, caused by strong interferences from the ship.

On September 4, 10:00h, we reached station no. 1 and started our sampling program with LBC and GC. We tried to use the pinger system to control the depth of the device, but it failed. Also the LBC failed and some repairs were necessary. A second test of SEL90 was negative, too.

The next morning we reached the work area of SO82b. Based on the Hydrosweep map and the Parasound/SEL90 results of SO82b several sites were suggested by Dr. R. Endler (IOW). The station program for the next days (Tab. 1) was extracted from these suggestions.

On September 5, stations no.2 to no.4 were cored. During the next night a new test program for SEL90 system was planned.

The SEL90 worked well and we could start our profiling program. The weather conditions were still good and the next time we sampled by day and measured SEL90 profiles by night (Tab. 1).

The further sampling program ran very good. Some difficulties occured on sites in the central ridge area, were three GKGs failed indicating that a sediment cover was absent.

No indications of recent hydrothermal activities in the study area were identified during the cruise, except site no.9 where some hydrothermally cemented breccias were sampled.

Extraordinary sediments occured west of a seamount at 58°53'N-30°19'W (sites 14 - 16, Chap. 5.3.1.). This seamount was named "Catalonia-Seamount" by us.

At 12:00h on September 12, we finished our work with the last SEL profile and set course for Kiel.

On September 17 at 14:00h, RV "Prof. Logachev" arrived at Kiel Sea Fish Market (GEOMAR).

Tab. 1: Site locations and SEL90 acoustic tracks (time in UTC).

DATE	ARRIVAL Bottom	DEPART.	STATION	LATITUDE	LONGITUDE	DEVICE	PENETR. (m)	RECOV. (m)	DEPTH mbsl
04.09.93	10:00	15:30	1						2775
04.09.93	11:56		1	58°19.421'N	25°39.899'W	LBC		0,00	2769
04.09.93	14:20		1	58°20.081'N	25°39.752'W	GC	3,80	5,16	2761
05.09.93	8:25	11:30	2						1720
05.09.93	8:57		2	59°1.040'N	30°20.002'W	GC	5,10	5,22	1717
05.09.93	10:40		2	59°1.019'N	30°20.158'W	LBC		0,25	1719
05.09.93	12:50	16:35	3						1242
05.09.93	13:17		3	59°7.179'N	30°32.266'W	GGC	6,30	5,70	1257
05.09.93	14:47		3	59°7.221'N	30°32.367'W	GC	5,80	5,38	1258
05.09.93	16:02		3	59°7.291'N	30°32.165'W	LBC		0,33	1254
05.09.93	17:20	18:40	4						
05.09.93	18:00		4	59°8.746'N	30°36.575'W	LBC		0,25	1335
05.09.93	19:27	20:30	5						
05.09.93	20:10		5	59°8.426'N	30°39.463'W	LBC		0,00	1020
06.09.93	9:10	10:05	5 (2nd)						1102
06.09.93	9:36		5 (2nd)	59°8.426'N	30°39.525'W	LBC		0,00	1017
06.09.93	10:55	12:15	6						1305
06.09.93	11:34		6	59°9.357'N	30°41.808'W	LBC		0,25	1375
06.09.93	13:10	17:10	7						1450
06.09.93	14:28		7	59°11.950'N	30°48.321'W	LBC		0,40	1449
06.09.93	15:49		7	59°11.886'N	30°48.359'W	GGC	3,15	2,75	1451
06.09.93	16:45		7	59°11.928'N	30°48.386'W	GC	5,80	5,00	1451
06.09.93	18:15	20:30	8						1338
06.09.93	18:49		8	59°15.557'N	30°53.907'W	LBC		0,30	1332
06.09.93	19:57		8	59°15.565'N	30°53.940'W	GC	5,80	5,60	1335
07.09.93	10:50	12:50	9						1430
07.09.93	10:50	14:20	9						1430
07.09.93	11:21		9	59°12.421'N	31°06.431'W	GC		0,01	1445
07.09.93	12:22		9	59°12.397'N	31°06.451'W	LBC		0,00	1405
07.09.93	13:47		9	59°12.305'N	31°05.945'W	LBC		0,36	1493
07.09.93	15:21	18:30	10						1390
07.09.93	15:55		10	59°07.581'N	30°53.960'W	LBC		0,28	1380
07.09.93	17:05		10	59°07.592'N	30°53.903'W	GGC	3,40	2,75	1380
07.09.93	18:00		10	59°07.578'N	30°53.928'W	GC	5,80	5,50	1378

Tab. 1: Continuation

DATE	ARRIVAL Bottom	DEPART.	STATION	LATITUDE	LONGITUDE	DEVICE	PENETR. (m)	RECOV. (m)	DEPTH mbsl
08.09.93	09:25	10:42	11						1030
08.09.93	10:11		11	59°03.553'N	30°47.758'W	LBC		0,00	1177
08.09.93	11:20	12:30	12						1350
08.09.93	11:55		12	59°04.126'N	30°44.860'W	LBC		0,00	1324
08.09.93			13	canceled					
08.09.93	14:22	18:45	14						1730
08.09.93	15:11		14	58°56.329'N	30°24.531'W	LBC		0,55	1719
08.09.93	16:45		14	58°56.280'N	30°24.522'W	GGC		2,77	1722
08.09.93	18:01		14	58°56.315'N	30°24.546'W	GC	7,30	5,57	1720
09.09.93	07:10	10:20	15						1160
09.09.93	07:43		15	58°54.734'N	30°20.444'W	LBC		0,15	1201
09.09.93	08:50		15	58°54.692'N	30°20.458'W	GGC	2,80	2,76	1203
09.09.93	09:50		15	58°54.750'N	30°20.292'W	GC	3,60	3,10	1201
09.09.93	10:53	15:00	16						1620
09.09.93	11:38		16	58°54.122'N	30°22.374'W	LBC		0,00	1621
09.09.93	12:54		16	58°54.099'N	30°22.440'W	LBC		0,28	1622
09.09.93	14:22		16	58°54.055'N	30°22.423'W	GC	5,90	5,35	1621
09.09.93	16:00	19:10	17						1380
09.09.93	16:35		17	58°54.852'N	30°32.834'W	GGC	4,80	2,75	1399
09.09.93	17:37		17	58°54.897'N	30°32.844'W	GC	5,90	5,60	1397
09.09.93	18:39		17	58°54.892'N	30°32.837'W	LBC		0,42	1396
10.09.93	08:00	10:10	18						1490
10.09.93	08:32		18	58°58.053'N	30°40.793'W	LBC		0,34	1472
10.09.93	09:46		18	58°58.043'N	30°40.989'W	GC		5,50	1471
10.09.93	11:05	15:20	19						1250
10.09.93	11:52		19	59°00,589'N	30°48,011'W	LBC		0,00	1295
10.09.93	13:39		19	59°00,678'N	30°47,840'W	LBC		0,00	1275
10.09.93	14:51		19	59°00.610'N	30°47.909'W	LBC		0,33	1240
10.09.93	16:40	18:50	20						
10.09.93	17:17		20	59°04.912'N	30°58.637'W	LBC		0,34	1396
10.09.93	18:22		20	59°04.935'N	30°58.619'W	GC	5,80	5,55	1394
11.09.93	17:00		21						1450
11.09.93	17:45		21	58°56.506'N	30°45.188'W	LBC		0,35	1437
11.09.93	18:44		21	58°56.516'N	30°45.189'W	GC	5,80	5,68	1437

Tab. 1: Continuation

DATE	ARRIVAL Bottom	DEPART.	STATION	LATITUDE	LONGITUDE	DEVICE	PENETR. (m)	RECOV. (m)	DEPTH mbsl
11.09.93	13:14	16:07	22						1130
11.09.93	14:07		22	58°56.262'N	30°52.437'W	LBC		0,00	1129
11.09.93	15:42		22	58°56.193'N	30°52.577'W	LBC		0,28	1139
11.09.93	08:39	11:35	23						1370
11.09.93	09:02		23	59°01.827'N	31°06.876'W	GC	5,80	5,45	1417
11.09.93	09:53		23	59°01.799'N	31°06.866'W	GGC	6,00	5,80	1422
11.09.93	11:06		23	59°01.819'N	31°06.886'W	LBC		0,38	1422
SEL90 profiles									
05.09.93	22:04		L1 Start	59°10,628'N	30°32,398'W	SEL90			
06.09.93		02:42	L1 End	59°00,019'N	30°04,208'W	SEL90			
06.09.93	03:19		L2 Start	58°59,331'N	30°05,819'W	SEL90			
06.09.93		08:15	L2 End	59°10,864'N	30°36,340'W	SEL90			
06.09.93	22:14		L3 Start	59°08,493'N	31°03,984'W	SEL90			
07.09.93		03:40	L3 End	58°54,935'N	30°29,086'W	SEL90			
07.09.93	04:06		L4 Start	58°53,928'N	30°30,481'W	SEL90			
07.09.93		09:46	L4 End	59°07,037'N	31°04,227'W	SEL90			
07.09.93	19:53		L5 Start	59°05,991'N	31°05,591'W	SEL90			
08.09.93		00:57	L5 End	58°52,909'N	30°32,034'W	SEL90			
08.09.93	02:07		L6 Start	58°51,909'N	30°33,434'W	SEL90			
08.09.93		07:45	L6 End	59°05,905'N	31°09,439'W	SEL90			
08.09.93	20:00		L8 Start	58°50,224'N	30°37,251'W	SEL90			
09.09.93		01:50	L8 End	59°03,505'N	31°11,382'W	SEL90			
			L9	canceled, bad weather cond.					
09.09.93			L10 Start	58°50,490'N	30°35,860'W	SEL90			
10.09.93		01:31	L10 End	59°04,069'N	31°10,540'W	SEL90			
10.09.93	01:52		L7 Start	59°04,530'N	31°10,039'W	SEL90			
10.09.93		06:22	L7 End	58°51,320'N	30°36,070'W	SEL90			
10.09.93	20:01		L12 Start	59°06,446'N	31°09,078'W	SEL90			
11.09.93		01:31	L12 End	58°52,451'N	30°32,709'W	SEL90			
11.09.93	01:59		L11 Start	58°51,391'N	30°34,184'W	SEL90			
11.09.93		07:46	L11 End	59°05,215'N	31°09,912'W	SEL90			
11.09.93	20:29		L13 Start	58°52,974'N	30°30,564'W	SEL90			
12.09.93		02:31	L13 End	59°06,997'N	31°06,274'W	SEL90			
12.09.93	02:51		L14 Start	59°08,023'N	31°04,510'W	SEL90			
12.09.93		11:28	L14 End	58°45,613'N	30°06,350'W	SEL90			

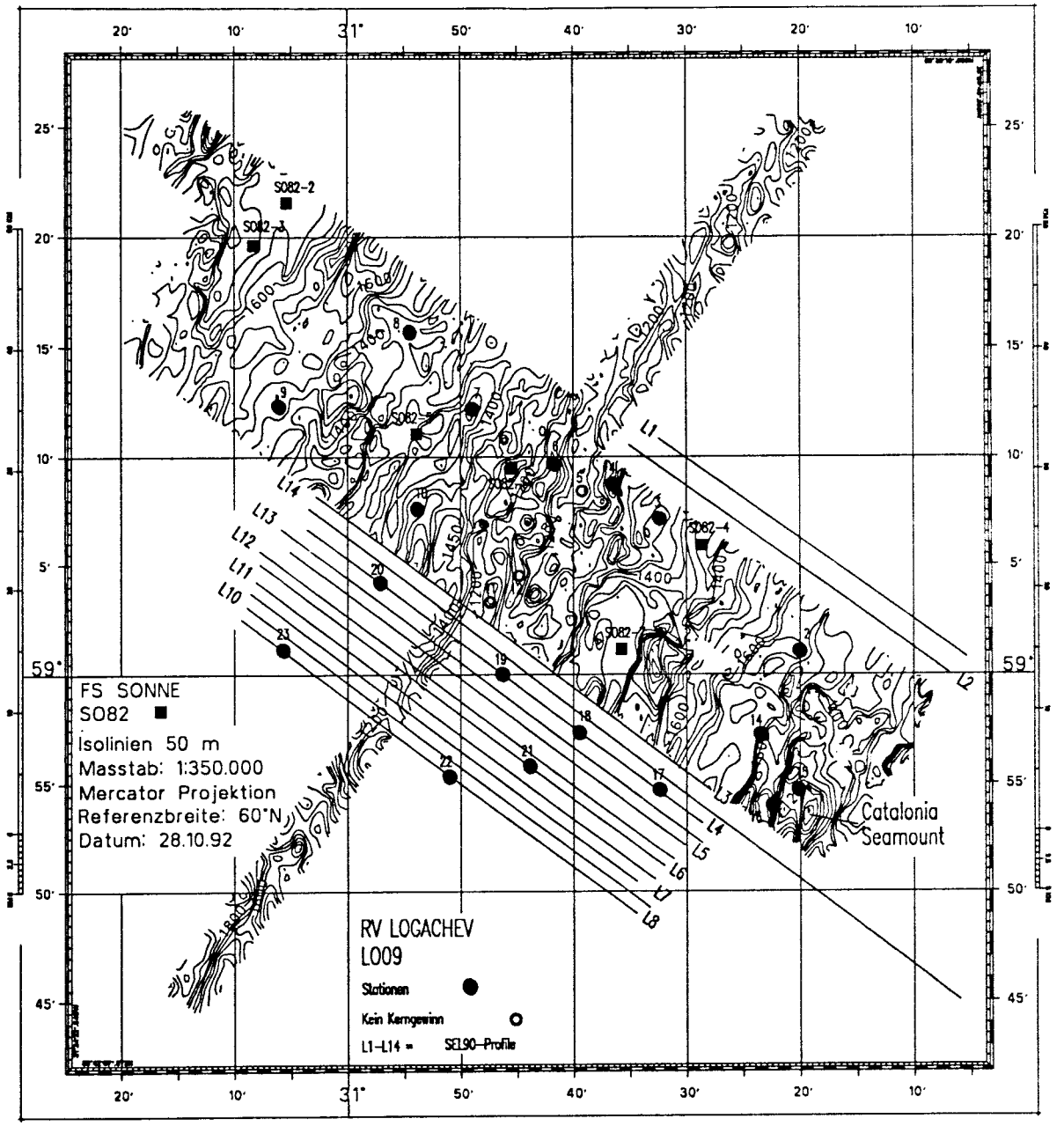


Fig. 2: Studied area of LO09 with site positions and SEL90 acoustic tracks (open symbols = no recovery); including SO82 stations.

4. Methods

4.1. Sediment sampling devices

A. Frahm, G. Nickel

Large box corer (LBC)

Dimensions: 0.5m * 0.5m * 0.6m samples, net weight 1000kg

No. of times used: 28 total core recovery: 5.75m

Giant gravity corer (GGC)
Dimensions: 0.15m * 0.15m * 3m / 6m, net weight 1000-1500kg
No. of times used: 7 total core recovery: 23.03m
(5 times 3m, 2 times 6m)

Gravity corer (GC)
Dimensions: 0.14m in diameter, 6m long, net weight 900-1200kg
No. of times used: 15 total core recovery: 73.66m

All sediment sampling devices worked very reliably. The box grabber worked well after some repairs during the first stations and needed some further repairs during the cruise.

4.2. Core description and sampling scheme

The studies on the large box cores and giant gravity cores opened on board were conducted accordingly to the following standard:

A) Photographs of the core's surfaces and their profiles (see ENDLER & LACKSCHEWITZ 1993) and description of the core's surfaces and their profiles (after Ocean Drilling Program standard)
B) Core sub-sampling

- benthological sampling (macrofauna) at the sediment surface
- a surface sample of 0.5cm by 100cm^2, for sedimentological studies
- a surface sample of 0.5cm by 100cm^2, for nannofossil studies
- a surface sample of 0.5cm by 300cm^2, for benthic foraminiferal studies
- a surface sample of 0.5cm by 100cm^2, for geochemical studies
- sediment sampling in 3 * 0.5 m plexiglass boxes (large box core) for the archive (GEOMAR, Kiel), for sedimentology and geochemistry (University of Greifswald, GEOMAR)
- sampling of radiography samples (large box core), for sediment texture studies
- sampling of a plexiglass tube (64cm * 54mm) (large box core) for soil mechanics (IOW)
- sediment sampling in 1m plexiglass boxes (giant gravity core), for archives (GEOMAR, Kiel)
- sediment sampling in 1m plexiglass boxes (giant gravity core), for sedimentology and geochemistry
- sampling of centimeter-size rock fragments of the surface and of the profile (large box core, giant gravity core)

- production and description of smear slides (after ODP standard) of various lithological units (large box core, giant gravity core); Tab. A1 in the appendix.

The gravity cores were not opened on board.

4.3. Acoustic equipment

The *seismoacoustic subbottom profiling system SEL90* applied on SO82b was used during this cruise in a new version (Chap. 5.1.). Due to the impossibility of installing the system in the ship's body, a towed fish contained the transducers. The system itself works properly during the entire cruise but some difficulties occured due to disturbances coming from the ship.

5. First results

5.1. Technical report on the application of the sediment echo sounder SEL-90 with a dragged transducer system

S. Müller, T. Merkel, T. Förster

The goals of this expedition for our research group were to add to the SO82 morphological coverage of a middle ocean ridge further profiles and to find areas with sediment coverage. Since a sounding shaft for the transducers was not present on the ship, the SEL90 had to be placed in a system which could be dragged behind the ship. Clearly, the application of this method is greatly limited by the length of the cable and the orientation of the device in high seas.
During the operation of the SEL90, significant problems were encountered in the form of electromagnetic interference from ship board systems. The interference was present over a wide band, and, therefore, could not be sufficiently reduced through electronic filters or improvised cable shielding. The interference was so large at 5kHz and 10kHz that the signal noise ratio was too large to recover the deep sea signal. As a result the profiles were performed with a 20kHz signal frequency throughout the cruise. This frequency provided a good measurement of the bottom topography, but has a very small penetration depth. Therefore, it was not possible to locate areas with thicker sediment deposits. The resolution of the surface sediments was approximately 1 meter, the penetration depth was ca. 15 meters. The noise and signal loss in the echo gram increased with higher seas. This was the result of increased air bubble formation directly under the transducer array. In order to reduce this effect the array was dragged as deep as possible (ca. 2m). This application, with compensation for the high seas which effects the constant measurement of the water depth, is not reliable for a complex bottom morphology. This type of morphology is present at mid-ocean ridges, where canyons and steep slopes make determination of the water depth difficult. The echo response of the SEL90 was also monitored during the

profiles. This permitted better tracking of the bottom profile, particularly on slopes. This adjustment will be used in the future with a sensor to monitor ship movements in an effort to correct the signal fluctuation produced by high seas.
Since there was no compatible ship computer, or data-retrieval system, the on board GPS receiver was coupled to a PC. The data was stored on disk and taken for later data processing.

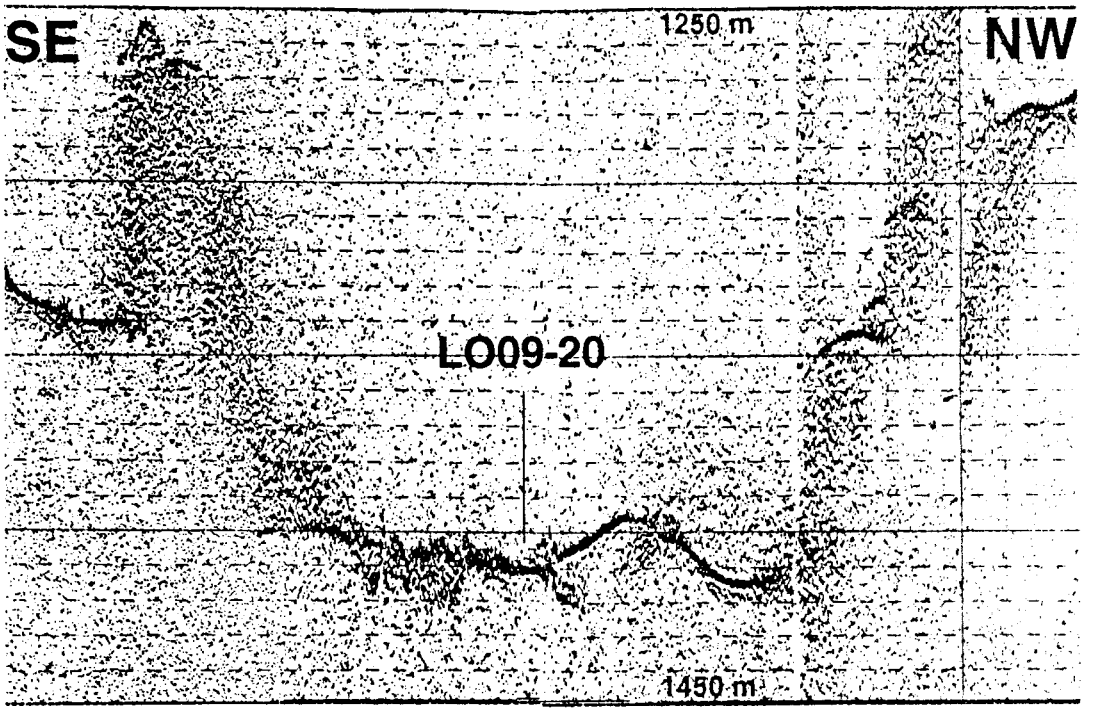
In conclusion, the usage of the SEL90 produced the best possible results in consideration of the ship board possibilities. Shielded cabling and improved transducer electronics should be prepared for future applications on similar vessels. In addition, an efficient method to compensate for the swell should be developed to further improve the application of the outboard system.

5.2. Morphology

H.-J. Wallrabe-Adams, T. Förster, K.S. Lackschewitz

Seismoacoustic measurements by means of the SEL90 system were planned for two reasons. Firstly, like on cruise SO82, sedimentary coverage and sediment structures of the research area should be mapped. Secondly, the bathymetry of the region was to be determined with the help of these data. The first task could be carried out just very incompletely. Due to disturbances from the ship (compare Chap. 5.1.) the device could not be run at a frequency for the sufficient penetration to record sediments. Just the soil echo was mostly clear and could, thus, be used as a pure depth information to describe the morphology. All the profiles were gained parallel to the measurements carried out on SO82 (NW-SE), i.e. at right angles to the ridge's trend (Fig. 2).

First, two profiles (L1, L2) north-eastern to the SO82 region were measured. These profiles partly served to test SEL90, too. They cover the area from the south-eastern flank of the ridge to the central graben shoulder. In the profile L2 a broad basin with a relatively plane relief with a medium depth of about 1550m is morphologically striking. To the north-east in the profile L1 this basin is then only visible with a fifth or sixth in width. The profiles from L3 to L14 expand the mapped area from SO82 to the south-west. Besides, they were the basis of fixing the stations in this area.



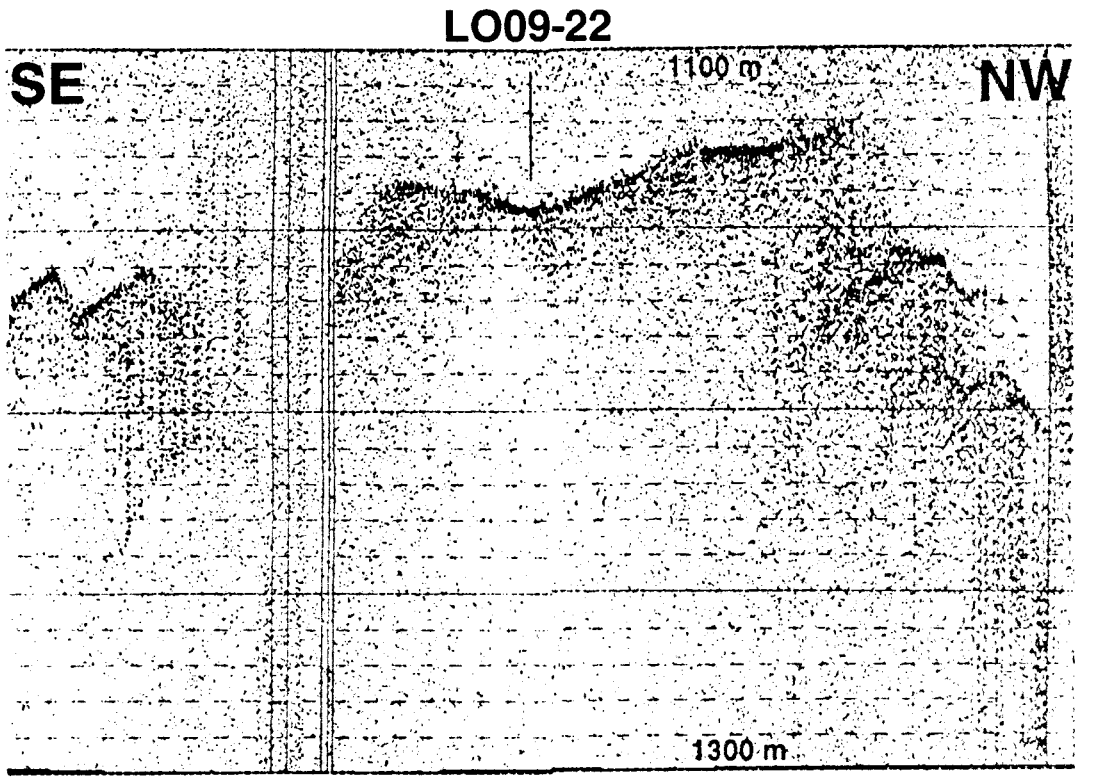


Fig. 3: SEL90 records from the Reykjanes Ridge and site positons of LO09-20 and LO09-22.
a) NW ridge flank on profile L4, b) SE shoulder of the central graben on profile L8

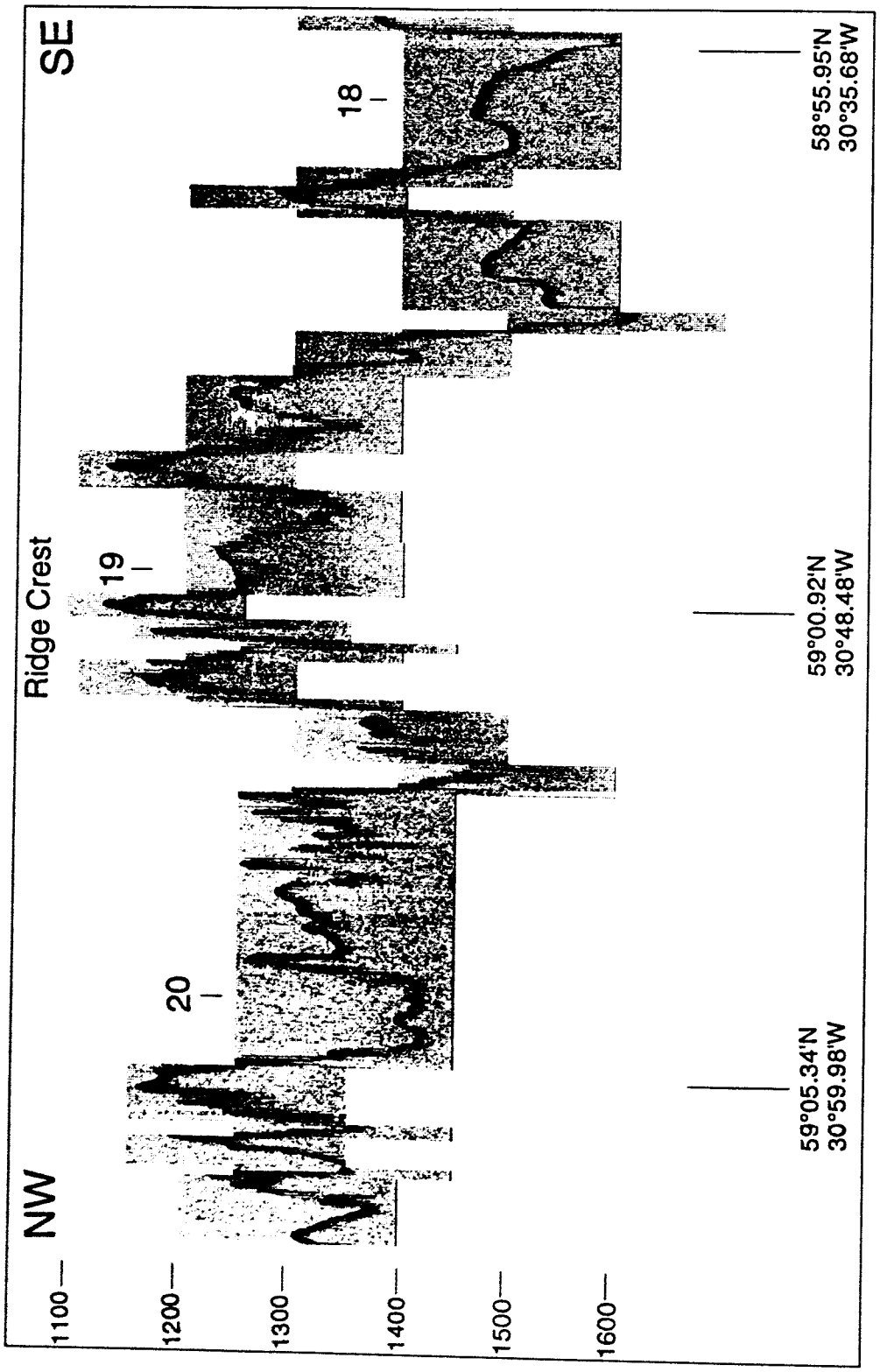


Fig. 4: Morphology of the Reykjanes Ridge near 59°N (LO09 SEL-profile 4) with stations 18 to 20.

On the basis of the profiles L1 to L14 the ridge's morphology is visible well (Fig. 4). The active spreading center is marked by a rift valley (graben structure), which surface is about 200 to 250m deeper than the graben shoulders. The width of the central graben varies from 1500 to max 4000m. The ridge's flanks are strongly structured morphologically. The structures of the south-eastern flank seem to be arranged over a larger area and also seem to be less cragged as on the north-western flank. Obviously, the sedimentary cover in the southeastern area is also more completely developed and has a greater thickness as it is visible on the north-west flank.

5.3. Sedimentology

J. Dehn, M. Frenz, B. Gehrke, K.S. Lackschewitz, J. Sumner

In the area of the Reykjanes Ridge (59N, 30W) sediment sampling was carried out using a large box corer, a giant gravity corer (3 to 6m), and a gravity corer (6m, Chap. 4.1.). Of the 23 coring stations, 14 were defined using Hydrosweep maps and seismoacoustic profiles of RV "Sonne" cruise 82 (ENDLER & LACKSCHEWITZ 1993) and 9 stations by means of the Rostock sediment penetrating echo sounder SEL90.
The geographical positions of the coring localities are shown in Figure 2. Detailed smear slide and core descriptions are included in the appendix (Tab. A1, Fig B1-B28).

5.3.1. Description of surface sediments

The surface sediments recovered are classified into the following five categories and described below.

1.) Nannofossil-Foraminferal Ooze, Stations 1, 2, 3, 4, 5, 9, 10, 16,17, 19, 20, 21
2.) Sponge Spicules, Stations 7, 8, 14, 22
    - Special: Microsponge Spicules with abundant diatoms, 14
3.) Clayey Sediments, Stations 17, 18, 19, 20
4.) Volcanic Glass, Stations 6 (brown), 23 (transparent), 9
5.) Foraminiferal Sand, Station 15

Nannofossil-Foraminiferal Ooze:
Stations 1, 2, 3, 4, 5, 9, 10, 16, 17, 19, 20, 21
Water depth 1200 to 1700 mbsl, Station 1, 2700 mbsl

This sediment is primarily composed of yellow brown to olive brown (2.5Y 5/3 to 2.5Y4/3) clayey silty sand. Surface fauna was noticeably scarce, the most abundant forms being pteropods. Sponges were only observed in these sediments at Station 19. The sediment is moderately bioturbated displaying little or no lamination but common mottling. The sand sized fraction comprises foraminifers with minor diatoms. The most common (>70%) planktic foraminifers are *Globigerina bulloides* and *Neogloboquadrina pachyderma*. Benthic foraminifers are only present in trace amounts at stations 9, 10, and 21. The nannofossils (ca. 25%) are dominated by coccoliths. The next most common components are diatoms (ca. 10%) and sponge spicules (ca. 20%).

Sponge Spicule Ooze:

Stations 7, 8, 14, 22

Water depth 1100-1400 mbsl, Station 14, 1700 mbsl

These sediments are sandy clayey silt composed of maximum 80% sponge spicules (Station 14) forming interwoven mats up to 6 cm in thickness. Individual sponge spicules reach up to several decimeters in length. The sediments are olive brown (2.5Y 4/3) to dark greyish yellow brown (2.5Y5/2). Sponges comprise the most common surface fauna, bryozoans and pteropods are also present in lesser amounts. The sediments are non-bioturbated to slightly bioturbated, with the sponge mats forming discrete layers. The next most common components are foraminifers (dominantly planktic forms), nannofossils (coccoliths) and diatoms. Terrigenous and volcanic components were present only in trace amounts.

The sponge spicules recovered at Station 14 were derived from a different species of sponge than the other Stations. Here the spicules were silt or smaller in grain sized and formed aggregate clumps (Plate 1/1). These micro sponge spicule clumps formed discrete layers in the profile of Station 14. These layers were greyish olive (7.5Y 5/2) in color, often with darker layers of grey (7.5Y 5/1). These darker layers, originally thought to contain volcanic material, are enriched in diatoms (up to 30%).

The occurrence of the sponges could not be correlated to water depth or bottom morphology, nor to the results of the "Sonne" Cruise 82 (ENDLER & LACKSCHEWITZ 1993).

Clayey Sediments:

Stations 17, 18, 19, 20

Water depth 1300-1470 mbsl

These sediments are silty sandy clays containing as much as 30% clay (Station 18). They are dull yellowish brown (10YR 5/4) to olive brown (2.5YR 4/3) in color. Sponges were recovered on the surface at Stations 17 and 19. Station 17 also contained molluscs and gastropods on a sponge spicule mat. The other Stations displayed few benthic fauna. The sediments are slightly to

moderately bioturbated. Mottling is rare, though irregular layers of sponge spicules can be seen in profile. With the exception of Station 18, the sediments are primarily biogenic. Foraminifers are dominant, with no preference for either benthic or planktic forms. Nannofossils, sponge spicules and diatoms compose the other major components. The diatoms display more diversity at Station 17 than at any other Station. Rough evaluation of the grain size in smear slide analysis shows a weakly bimodal distribution, depleted in silt size particles. All of the Stations with clay rich surface sediments lie along a NW to SE trending profile (Fig. 2). Station 18, with the highest clay content lies in the same basin as Station SO82-7 with 65% clay. Similarly, both Station 18 and SO82-7 are devoid of other terrigenous or volcanic components.

Volcanic Glass Rich Sediments and Volcanic Rocks:
Stations 6, 23 and 9

Station 6, 1375 mbsl
Volcanic Glass Foraminiferal Ooze with Nannofossils
The surface sediments comprise clayey sandy silt, yellowish brown (2.5Y5/3) in color. The surface is speckled with fine sand sized volcaniclastic material, primarily angular glass shards with occasional (less than 10%) vesicles. The recovered macrofauna is discussed in chapter 5.4. In smear slide, brown volcanic glass composes ca. 30% of the sediment. The shards are angular blocky shards devoid of vesicles. Plagioclase feldspar, quartz, and transparent volcanic glass are present in trace amounts. The dominant biogenic components are planktic foraminifers, nannofossils, sponge spicules, diatoms and benthic foraminifers.
This station is the only one situated on the crest of the Reykjanes Ridge with sediment recovery. Though the large box corer functioned perfectly, no sediment was recovered at stations 11 and 12, also located on the ridge crest. These two stations are most likely devoid of sediment. The SEL90 profiles from "Sonne" Cruise 82 suggested that these sites had little or no sediment cover.

Station 23, 1420 mbsl
Volcanic Glass Foraminiferal Ooze with Nannofossils and Sponge Spicules
The surface sediments are clayey silty sand, olive brown (2.5Y 4/3) in color. Macrofauna were observed including sponges and pteropods. Volcanic glass composes 25% of the sediment, 20% being transparent glass, therefore with SiO2 contents of ca. 65% or higher (SCHMINCKE 1981). The remaining glass is brown and of basaltic composition. The sediment also contains 10% quartz. The remaining components are biogenic, dominated by planktic foraminifers. Nannofossils, sponge spicules and diatoms are also present.

Station 9, 1500 mbsl

The large box corer from this station recovered nannofossil foraminiferal ooze and has been described above. A gravity core was also performed at Station 9, without sediment recovery. Only a handful of igneous and volcanic rocks were found in the core catcher, presumably from the surface sediments. Approximately 30 pieces were recovered, from 0.2 to 7.5 cm in diameter. All of the pebbles were angular to subangular in shape. Each piece is at least partially covered with a black (ferrous?) oxide, probably of hydrothermal origin. This coating is greyish black (N2) to brownish black (5YR 2/1) in color. Two representative pieces were described in greater detail.

Piece 1

The broken surface of this clastic rock shows several scoriaceous glass fragments (0.3 to 2 cm in diameter) which have undergone extensive alteration. The largest piece (2 cm) retains some fresh black glass at its core (Fig 5). Several layers of alteration minerals can be seen. They are rusty red platy clays mixed with yellow clays or zeolites. The center of some vesicles and cavities are filled with calcite. The breccia is cemented by the clay minerals. Many, but not all scoria pieces appear to have had the oxide armoring on them before they were incorporated into the breccia, indicating that they were on the bottom for some time before the breccia was formed. The vesicle size in the glass ranges from 0.25 to 2 mm. The glass surfaces are weathered in circular shapes which resemble vesicles but are too uniform have formed from a volcanic process. At least three generations of these depressions are seen at approximately one factor 5 difference in size. An occasional terrigenous clast is also present. One such appears to be a sandstone, ca. 2mm in diameter, composed of smaller particles (< 0.5 mm). Some calcareous cement is present as shown by hydrochloric acid.

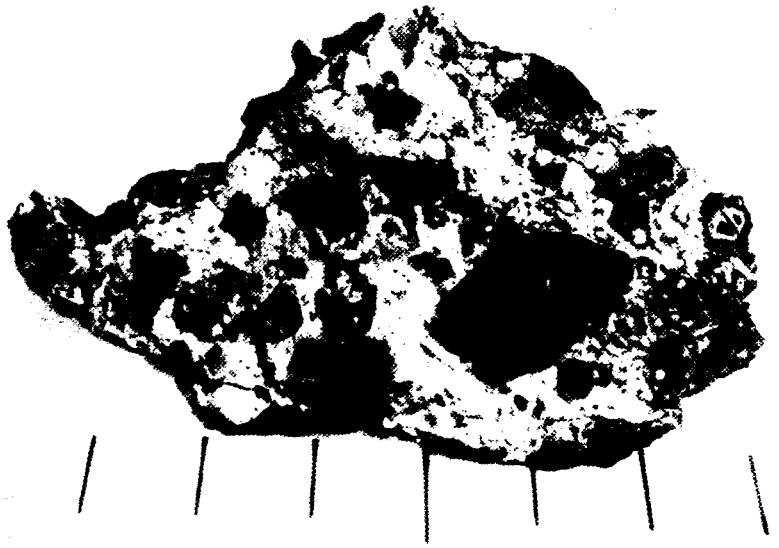


Fig. 5: Photograph of a piece of cemented breccia (Photo V. Schmidt, scale in cm).

Piece 2

This piece is a subangular lithic ca. 4cm in diameter. It has a dark grey (N3) to greyish black (N2) oxide armoring. This stone was broken in order to determine its composition. It is of igneous origin and contains quartz, biotite, and feldspar. The quartz crystals are ca. 1mm in size and make up approximately 50% of the rocks volume. Plagioclase crystals are of similar size and compose ca. 30% volume. The biotite crystals are partially altered to phlogopite (red gold tinge) and make up ca. 20% of the rock. A weak lineation is observed on the fresh surface. This fabric may suggest metamorphic processes. This rock is tentatively identified as a granite, and is most likely a dropstone.

Foraminifera Sand:

Station 15

Water depth 1200 mbsl

This station lies on the slopes of the Catalonia Seamount. This sediment is brown (10YR 4/4) in color with black specks of volcanic material. The volcanic particles appear to be glass, subangular to subrounded up to 2 cm in diameter. White shell fragments were also observed. A starfish, several small sponges (ca. 2cm) were present on the surface. The sediment is very well sorted (sand sized). The sand comprises mostly foraminifers (70% planktic and 15% benthic forms) with nannofossils, quartz and small lithic (volcanic) clasts.

5.3.2. Description of subsurface sediments

These recovered sediments are predominately nannofossil foraminiferal oozes with varying amount of sponge spicules and diatoms. Clayey sediments are also present in large amounts. Because of the variation, each Station will be described separately.

Station 3

Water depth 1250 mbsl

The surface sediments are nannofossil foraminiferal oozes with diatoms and sponge spicules. Few or no fauna was recovered on the surface. There is no correlation of the surface sediments to the large gravity core, probably due to its over-penetration.

The subsurface sediments have been divided into 4 units.

Unit 1, 0-0.95 m

This unit is dull yellowish brown (10YR 4/3) to dark brown (10YR 3/3) in color. Abundant coral and shell fragments were observed (see section 5.4.). One scoria fragment was also noted. No

significant sedimentary structures are seen, and the core is only slightly disturbed by drilling. A smear slide sample is used to classify this sediment as a diatom-foraminiferal ooze with sponge spicules and volcanic glass. The glass makes up 15% of the sediment and is dominated by transparent glass. The texture of the sediment is a sandy silty clay.

Unit 2, 0.95 - 1.52 m

This a homogeneous, moderately bioturbated dark olive grey (2.5 GY 4/1) ooze. A sample at 1.25 m has a sandy silty clay texture, and is a clayey foraminiferal ooze with nannofossils and sponge spicules. The terrigenous and/or volcanic input is relatively high at 15% with 5% plagioclase crystals, 5% quartz and 5% transparent volcanic glass.

Unit 3, 1.52 - 3.66 m

This is an olive grey (2.5GY 5/1) unit with dark olive grey (2.5GY 3/1) mottles. It is slightly to moderately bioturbated. There are 4 layers and lenses of sponge spicules up to 3 cm in thickness. Two layers of shell fragments ca. 2 cm in thickness were also noted. The shell fragments are greater than 3mm in size. The color of the unit grades to greyish olive (5Y 5/2) at ca. 2.45 m, and then to dark greyish yellow (2.5Y 4/2) at 2.70 m with dark olive grey mottles (2.5GY 4/1).
Four smear slide samples were analyzed to characterize this unit. The first ca. 1.90 m is a clayey foraminiferal ooze with nannofossils and sponge spicules. Its texture is sandy clayey silt. The clay content is relatively high (30%). This sample also contains 5% quartz grains.
The sponge spicule layers were also sampled at 2.30 m. This sediment is slightly coarser grained (clayey sandy silt). It is classified as a clayey sponge spicule ooze with 30% clay and 55% sponge spicules.
The last sample was taken at 2.85 m. It retains the finer grain size of the first sample, representative of the host sediment, sandy clayey silt. Its composition has changed slightly to nannofossil-foraminiferal ooze with sponge spicules and diatoms. The decrease in clay and the increase in diatoms is probably responsible for the color change to darker tones (see Station 14).
A darker layer with tiny black specks at 3.50 m was also sampled. This minor lithology is much coarser grained, silty clayey sand. It is a foraminiferal ooze with nannofossils and abundant basalt fragments. The basalt fragments (30%) are up to 3 mm in size. Quartz is also present as subrounded crystals (8%). This layer is used to mark the base of Unit 3.

Unit 4, 3.66 - 5.70 m (EOC)

This unit is olive grey with lenses and laminations of dark olive grey (5GY 4/1) and olive brown (2.5Y 4/4), respectively. It grades often to different shades (greyish yellow (2.5Y 6/2) at 4.32 m, yellowish brown (2.5Y 5/3) at 4.63 m, greyish olive (5Y 5/3) 4.70 m, greyish yellow (2.5Y 7/2) 5.05 m, yellowish brown (2.5Y 5/4) 5.28 m). The unit is slightly to moderately bioturbated. A chert fragment was found at 4.35 m. It had ca. 2cm diameter, vesicles of non-volcanic origin ca. 1.5 mm in size. They are uniform in shape, with a small rill at center. The entire unit has abundant

sponge spicules, and had a hairy appearance. A darker layer is seen at 5.58 m and is normally graded, fining upwards. This is probably the result of the bioturbation (RUDDIMAN & GLOVER 1972)
Samples were taken at 4.95 m to characterize the unit and at 5.60 m to study the darker layer. The first sample is a foraminiferal clay with sponge spicules. It is fine grained, silty sandy clay due to its large clay content (60%). The minor lithology is a very diffuse ash layer. It is slightly coarser grained, sandy clayey silt. It is classified as a foraminiferal clay with nannofossils and volcanic glass. Here the clay content has decreased to 30%. The volcanic glass composes only 10% of the sediment and is very fine grained (ca. 10μm). The shards are all transparent suggesting high silica contents.

Station 7
Water depth 1375 mbsl
The surface sediments here are foraminiferal sponge spicule oozes with nannofossils and diatoms. There is no correlation to the large gravity corer due to over-penetration.

The subsurface sediments are divided into 2 units.

Unit 1, 0 - 1.23 m
This is a dull yellowish brown (10YR 5/3) sediment grading to brown (10YR 4/4) at 0.35 m with regular lamination of olive brown (2.5Y 4/3) ca. 5 cm in thickness every 10 to 25 cm. The unit appears only slightly bioturbated. Dark armored dropstones, ca. 0.5-2 cm in diameter observed throughout the unit.
A smear slide was taken at 0.75 m in a slightly darker lamination. It is a nannofossil-foraminiferal ooze with sponge spicules. It is a sandy clayey silt with 8% brown (i.e. mafic) volcanic glass. Benthic foraminifers are rare or absent in this sample.

Unit 2, 1.23 - 2.75 m (EOC)
This unit changes color very often, but is dominantly brown (10YR 4/4) with mottles of olive brown (2.5Y 4/3). The color changes are irregular, but are all shades of brown (yellowish brown (2.5Y 5/3)) at 1.60 m with mottles dull yellowish brown (10YR 5/4), 1.90 m to dull yellow brown (10YR 5/4), band of dull yellow (2.5Y 6/3) 2.15 - 2.23 m, then yellowish brown (2.5Y 5/3) to 2.40 m, dull yellowish brown with mottles of brown (10YR 4/4)). There is a sponge spicule layer, yellowish brown (2.5Y 7/3) at 2.57 - 2.64 m. There are three basalt dropstones 1.5 - 6 cm diameter at 1.25, 1.50, 2.30 m. One of the samples is clearly vesicular. The stones exhibit scratches which could indicate glacial transport. A small calcite bleb was seen at 1.85 m.

Station 10

Water depth 1380 mbsl

The surface sediments at this station are nannofossil-foraminiferal oozes with sponge spicules and diatoms. Their texture is sandy clayey silt. There is no correlation to the subsurface sediments of the large gravity corer. It is estimated that ca. 10 cm are missing between the large box corer and the top to the large gravity corer. The surface was probably recovered in the large gravity corer, but beyond the sampled area in the weight array.

The subsurface sediments are divided into two units.

Unit 1, 0 - 2.53 m

This unit is mostly olive brown (2.5Y 4/3) with mottles of yellowish grey (2.5Y 4/1), laminations of brownish black (2.5Y 3/2) and dull yellowish brown (10YR 4/3) between 0.50-0.70 m depth. The unit is slightly to moderately bioturbated. There is a lense of shell fragments (< 3 mm) at ca. 0.80 m. A dropstone was discovered at 0.12 m. It is 1cm in diameter, subrounded, and armored with a dark oxide (see surface sediments, Station 9). A dark diffuse layer is seen at 1.40-1.47 m. This is interpreted as an ash layer (Plate 1/3), and roughly correlates to a similar occurence in the core at the "Sonne" station SO82-5.

Four samples were taken to characterize the host sediment and the ash layer. The host sediment, at 0.25 m is a nannofossil-foraminiferal clay with sponge spicules and diatoms. It is fine grained, sandy silty clay, due to the large clay content (50%). At 0.60 m, below the yellowish brown top of the core, the sediment is classified as a clay. It is also fine grained, being 85% clay. A dark lense of dark greyish yellow (2.5Y 4/2) at 0.76 m is also sandy silty clay. It is, however, classified as a quartz clay. It comprises 70% clay and 15% quartz crystals.

The ash layer was sampled at 1.43 m. It is a clayey volcanic ash. Its grain size is much coarser than that of the host sediment, silty clayey sand. Brown vesicle free, angular blocky glass shard compose 55% of the sample. These shards are probably of hyaloclastic origin, having spalled off of quenched pillow basalts and submarine lava flows.

Unit 2, 2.53 - 2.75 m (EOC)

These sediments are dark greyish yellow (2.5Y 5/2) and change to dark greyish yellow (2.5Y 4/2) at ca. 2.67 m. Sponge spicules are abundant, giving the core a hairy appearance. The spicules form one large clump (ca. 2.5 cm in size) at 2.62 m.

A sample was taken at 2.60 m, and is classified as a clay with sponge spicules. It has a correspondingly fine grain size of sandy silty clay.

Station 14

Water depth 1722 mbsl

The surface sediments here are diatom-sponge spicule oozes with nannofossils and foraminifers. They are sandy clayey silts. A rough correlation with sub-surface sediments of the large gravity corer can be made at ca. 0.26 m with the micro-sponge spicule mats (see following description).

The subsurface sediments are divided into two units.

Unit 1, 0-1.25 m

The host sediments here are olive grey (5GY 6/1) with sponge spicule mats of olive grey (10Y 5/2). The top of the core, broken off in a sponge spicule mat, is greyish olive (7.5Y 5/3). The unit is slightly to non-bioturbated. The sponge spicule mats are regularly darker in color (olive black, 10Y 3/2) at their base. The mats range from 3 cm to 36 cm in thickness. Rough estimation of the grain size is a sandy clayey silt.

Smear slides taken in the large box corer at this station show that the mats are composed of very fine sponge spicules (Plate 1/1), and that the darker basal layer is very diatom rich (see surface sediment description).

Unit 2, 1.25-2.77 m (EOC)

This unit is dark olive grey (2.5GY 4/1) to ca. 1.30 m with sponge spicule mats of olive grey (10Y 5/2). From 1.56 m it is grey (10Y 4/1) in color to ca. 2.00 m. This unit is comparatively foraminifers rich Unit 1 up to ca. 1.80 m. The micro sponge spicule mats are < 2 cm in thickness and occur at ca. 1.90 and 2.08 m. From ca. 2.30 to 2.50 and at 2.75 m clayey lenses occur. They are olive grey (5GY 5/1) in color.

Samples were taken at 1.53 m in a sponge spicule mat, and at 2.50 m in the host sediment. The host sediment is a sponge spicule clay with nannofossils and volcanic glass. It is fine grained, clayey sandy silt. Clear (i.e. silicic) volcanic glass composes 10% of the sample. The sponge spicule mat is a sponge spicule ooze of coarser grain size, clayey sandy silt. It is composed of over 90% sponge needles.

Station 15

Water depth 1203 mbsl

The surface sediment here is a foraminiferal sand (Plate 1/2). It is a clayey sand silt comprised of mostly planktic foraminifers. This sediment correlates to the upper surface recovered in the large gravity corer.

The subsurface sediments comprise one unit.

Unit 1, 0-2.76 cm (EOC)

This is a light grey (10YR 7/1) to brown (10YR 4/4) sediment with intermittent layers of foraminiferal sand. The sandy layers commonly have darker coarse grained (ca. 1 mm) lithics at their base. These layers range from 2-10 cm in thickness. Irregular sponge spicule layers are also seen as a weak lineation of clumps or mats. After 1.90 m these layers sometimes contain fossils (corals and shell fragments). The sediments are slightly to non-bioturbated.

The major lithology is a nannofossil-foraminiferal ooze with quartz. It is coarse grained, clayey silty sand and contains 15% subrounded ca. 1.5mm quartz grains.

The sandy layers are foraminiferal sands with abundand quartz. They are also coarse grained, clayey silty sand, containing 30% quartz crystals. The foraminifers are dominated by planktic forms (45% to 15% benthic forms).

At the base of the core the lithology changes to a foraminiferal clay with nannofossils. It is a silty sandy clay, with 55 % clay. This may represent a second unit, but has not been separated from the main unit since it is only present in the core catcher, and cannot be characterized.

Station 17

Water depth 1399 mbsl

The surface sediment is a nannofossil-foraminiferal ooze. It is coarse grained, silty clayey sand. The surface is covered with a mat of sponge spicules which are not represented in the smear slide analysis. They are not present due to their large grain size (lengths of several centimeters). The surface sediments cannot be correlated to the subsurface sediments of the large gravity corer due to over-penetration.

The subsurface sediments comprise one unit.

Unit 1, 0-2.77 m (EOC)

This is a brown (10YR 4/4) sediment up to 0.90 m where the color changes to greyish olive (5Y 5/3). At 0.56 -78 m and in mottles at 1.25 m the color returns brown (10YR 4/4). There is a sandy layer, composed mostly of foraminiferas at the top of the core. A lense comprising quartz crystals coated in black oxide is present at 0.60 m. The entire unit is very weakly mottled from 0.80 m to 2.00 m.

Two smear slides were taken to characterize the major lithology at 0.50 and 1.70 m. They are both foraminiferal clays. They are fine grained sandy silty clays. The top of the core is a clayey foraminifera ooze with volcanic glass. It is coarse grained (silty clayey sand). Transparent volcanic glass makes up 8% of the sediment, with 4% brown glass. The quartz oxide sand at 0.64 m comprises 70% black oxide or oxide covered grains.

Station 23

Water depth 1422 mbsl

The surface sediments recovered at this Station are volcanic glass-foraminiferal oozes with nannofossils and sponge spicules. They are coarse grained (clayey silty sand) and contain 25% volcanic glass (20% silicic shards). Precise correlation of these sediments to the subsurface sediments is possible only after detailed sedimentological and isotope studies.

The subsurface sediments have been divided into 6 units.

Unit 1, 0-0.50 m

This unit is slightly mottled and finely layered. It is yellowish brown (2.5Y 5/4) in color. It was sampled at 0.50 m and classified as a nannofossil-volcanic glass ooze with sponge spicules and foraminifers. It is a clayey sandy silt. The volcanic glass is transparent, only a trace of mafic glass was found. There is a large quartz component in the sediment (17%).

Unit 2, 0.50-1.10 m

This layer is greyish olive (7.5Y 5/2 to 4/2) in color. The sediment is mottled. The mottles are yellowish brown with darker olive brown centers (2.5Y 5/4, center 4/3). A granite dropstone (14 cm diameter) was found at 0.92 m.

This unit is characterized as a diatom-foraminiferal ooze with quartz and sponge spicules. It is relatively coarse grained (clayey silty sand) and contains 15% quartz.

Unit 3, 1.10-1.90 m

This unit grades in color from greyish olive (5Y 4/2) to grey (5Y 4/1). It also contains abundant small black glassy fragments (1-2 mm), probably basaltic scoria.

Unit 4, 1.90-5.10 m

This unit is greyish olive (7.5Y 4/2) in color, and is separated from Unit 3 by the absence of volcanic material. The entire unit is faintly mottled. A sample taken at 2.25 m was used to characterize this unit as a clay with quartz. It is fine grained (sandy silty clay) and contains only traces of foraminifers. A mottle sampled at 3.30 m was a foraminiferal-quartz ooze. Diatoms, sponge spicules and nannofossils are also present at 10%. The mottle is slightly coarser grained (clayey sandy silt) than the host sediment.

Unit 5, 5.10-5.12 m

This is a thin ash layer correlating roughly to a layer recovered by the "Sonne" at station SO82-5. It is dark greenish grey (7.5GY 3/1) in color. A sample of the layer permitted the classification of

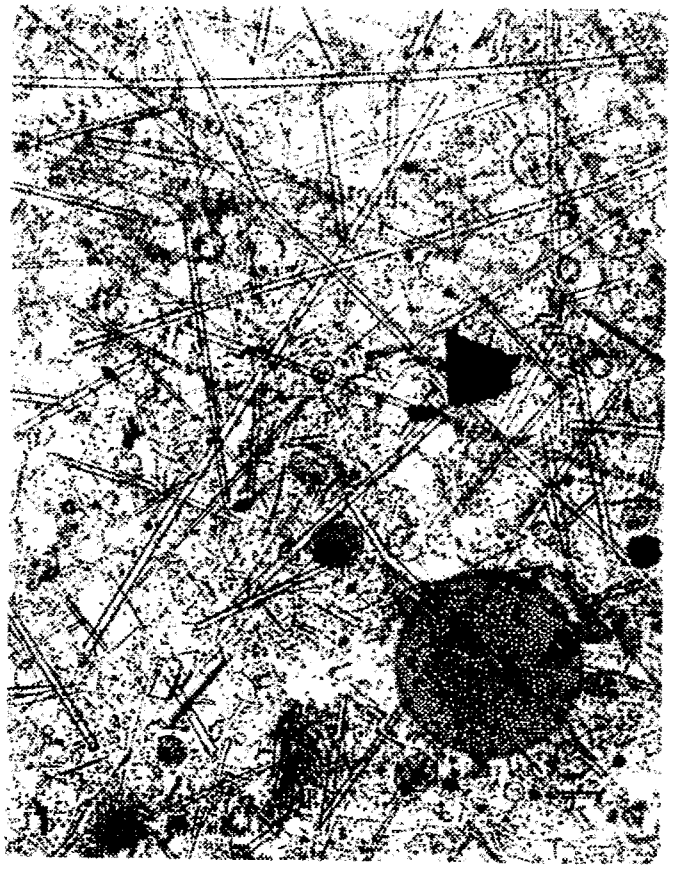
a clayey volcanic ash with quartz and foraminifera. It is a sandy clayey silt, and composed of 40% transparent (silicic) glass shards (Plate 1/4).

Unit 6, 5.13 - 5.80 m (EOC)
This unit is dark olive grey (2.5 GY 3/1 and 4/1) in color. It is a clay with foraminifers of fine grain size (sandy silty clay). The clay component in this sample is 65%.

Plate 1: Smear slides of four different sediment types (photographs J. Dehn, Length of bars 100 µm).

1. Smear slide shows a mate of micro sponge spicules with diatoms (14-LBC--44).
2. Foraminiferal sand with well preserved planktic foraminifera tests (15-LBC--0)
3. Ash layer with brown vesicle free, angular blocky glass shards (10-GGC-1-143)
4. Clayey volcanic ash with quartz. The ash layer is composed of 40% silicic glass shards (23-GGC-2-511).

PLATE 1



5.3.3. Discussion of preliminary results

The differences in composition of the surface sediments suggest recent changes in the sedimentation processes in the study area. The majority of the surface sediments are marked by the influx of carbonate pelagic particles (planktic foraminifers, coccoliths). The planktic foraminifers are dominated by the form *Globigerina bulliodes* (D'ORBNIGNY) which in large occurrences indicates the influence of a temperate water mass.

Autochthonous spicules were observed at four stations. They often formed dense mats of several centimeter thickness. Similar occurrences have been reported in the areas of the mid-ocean ridge and seamounts at the Kolbeinsey Ridge in the Iceland Sea (LACKSCHEWITZ 1991) as well as on the Jan Mayen Spur and the Vesterisbanken Seamount in the Greenland Sea (HENRICH et al. 1992). These spicule mats are formed through the *in situ* decay of dead porifera and the subsequent deposition of the remaining spicules. This process also forms the substrate for the growth of further individual sponges. The resultant spicule mats provide tiny hollows and niches in which fine material and microfossils are collected, e.g. the diatoms seen in the darker sponge mats of Station 14.

The occurrences of microsponge needles (in the sediments of a steep slope east of the central graben, Station 14) suggest a differing oceanographic environment. The exact relationship between autochthonous spicules and marine environment is not yet clear and should be the topic of further study. The occurrence of differing bottom current relationships, as observed by DIETRICH & KONTAR (1990) on the Reykjanes Ridge, help to explain the wide bathymetric distribution of the spicules.

In contrary to the spicule rich localities, the clay rich stations (LO09-17, -18, -19, and -20) are indicators of depositional areas protected from strong currents. Three of these stations lie in the basin within the ridge (Fig. 2). Station 18 lies north of the Station SO82-7 ("Sonne" Cruise 82) in the same basin. Sedimentary studies of this Station also demonstrated a high clay component. Grain-size and settling velocity analyses characterize this region as an accumulation area for eroded and weathered material (GEHRKE et al., submitt.). Further studies are necessary to determine if this is also the case for stations 17, 19 and 20.

The foraminiferal sand facies on the slope of the Catalonia Seamount are interpreted as the result from winnowing and reworking by bottom currents. This is similar to results obtained by GEHRKE et al. (submitt.) from surface sediments of the outer western Reykjanes Ridge and of the plateau area in the central ridge. The well-sorted and coarse-sandy sediment is formed by winnowing and removal of fines in a coarse-grained sediment by powerful bottom currents. Numerous measurements in the western North Atlantic have shown persistent westerly and southwesterly currents of 5-20 cm/s (SHOR et al., 1984).

An increase in the amount of brown (basaltic) volcanic glass in the central graben (Station 6) provides evidence for submarine volcanic activity along the ridge axis. The blocky vesicle free form of the glasses suggests a hyaloclastic origin. Other stations in the central graben were devoid of volcanogenic sediments. The clear silicic glasses of Station 23 document large, inter-regional subaerial eruptions. There is no clear indicator as to their origin, they could have easily traveled many thousand kilometers.

The brown and olive colored sediments found in the cores of Stations 3, 7, and 10 show a marked similarity to the sediments recovered by "Sonne" Cruise 82. Spicule rich layers occur repeatedly in both sets of cores. However, marked differences can be seen in both sets of cores when examined in detail, for example the coral branches of the species *Lophelia* in the upper section of the giant gravity core at Station 3. Such azooxanthellate corals have been recently described in high latitudes on the Icelandic Shelf as well as the Norwegian Shelf. Until now, this form has not been described in a mid-ocean ridge environment.

A basaltic ash layer, present in Station 10 (1.40-1.47 m) seems to correlate to a similar layer in Core SO82-5 (see ENDLER & LACKSCHEWITZ 1993). This ash layer is the only indicator in the cores for volcanic activity in the late Quaternary. The ash layer in the sediments of Station 23 matches the widespread Ash Zone II in the North Atlantic in its form and position in the core. This zone is dated at 57,500 y BP by RUDDIMAN et al. (1984).

Disperse coarse-grained (> 100 µm) terrigenous material was observed spread throughout most of the cores recovered. Previous studies of marine sediments from the North Atlantic have shown that coarse terrigenous particles (> 63 µm) can be interpreted as ice-rafted material (RUDDIMAN 1977, BOND et al. 1992). This indicates occasional melting of the icebergs in the region.

The common change from foraminifera-rich sand layers and fine-grained sponge needle-rich sections in Core LO-09-15 GGC on the Catalonia Seamount indicates changes in the energy niveau of the sea-floor water mass with time. This is probably related to the complex physiographic conditions and the effect of latitude dependent climatic changes on the properties of the sea-floor water mass.

Simplified lithological profiles are shown in Figure 6.

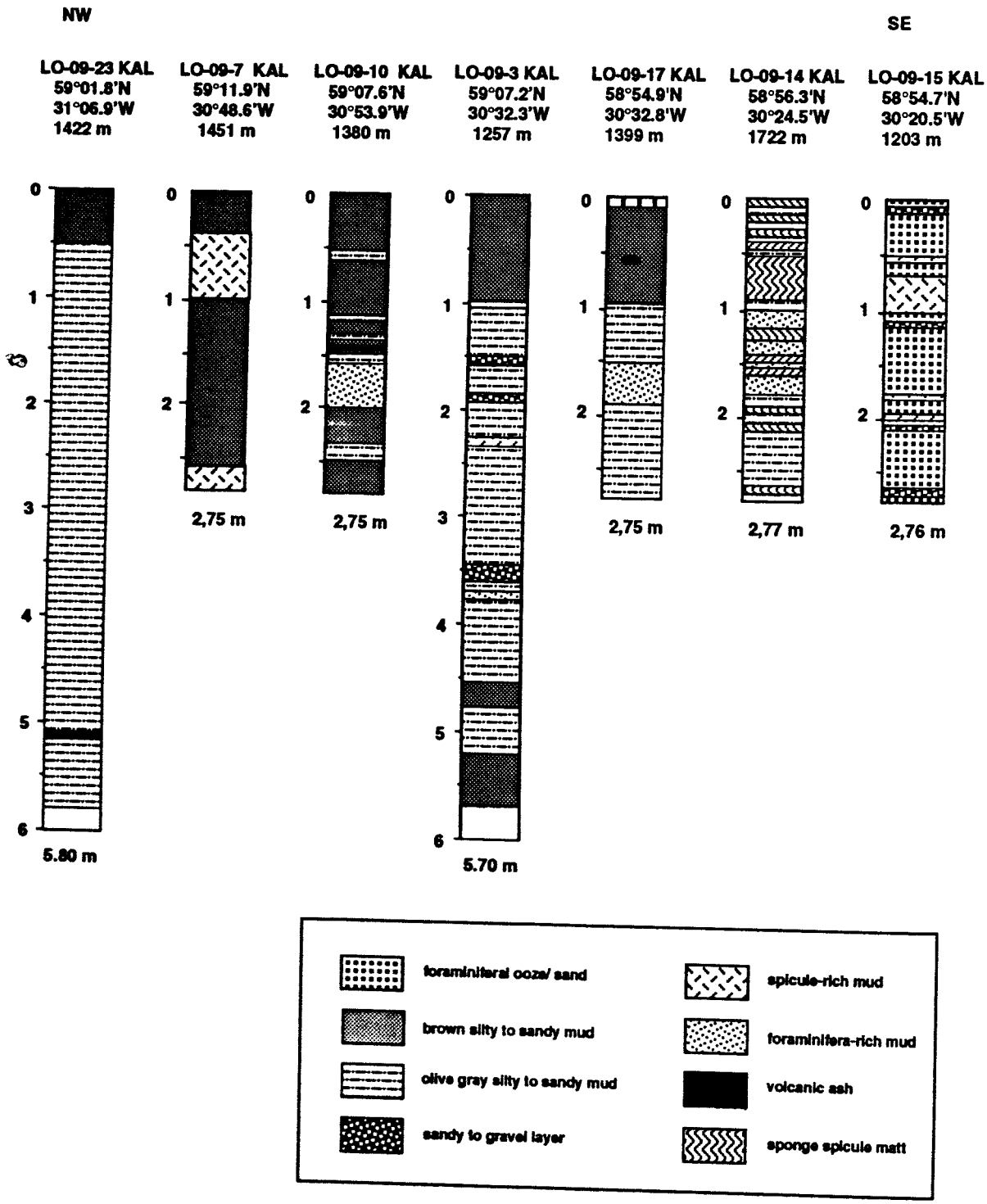


Fig. 6: Lithology of GGC cores of LO09.

5.4. Benthic studies

L. Horstmann, K.S. Lackschewitz

The benthic fauna of the deeper, oceanic regions of the Reykjanes Ridge is still poorly known in terms of physical and biological patterns that determine the composition of the fauna. The area is quite complex in its topography and presumably also in its physical characteristics (currents, sedimentation, etc.), although the watermasses may be homogeneous. This complexity of the topography may be reflected in hetergeneous habitats within this ridge environment, resulting in patchiness of the benthic fauna.

First results show that some of the surface samples seem to have a rich benthic fauna. Most of the samples were taken from bottoms with fine, soft mud. Especially, the surface sediments from the stations LO-09-7, -8 and -17 have a rich epifauna and are characterized by an abundance of sponges. The spicule meshwork provide here an ideal substratum for fixosessile benthic organisms like bryozoans. Branched bryozoans are often connected with the sediment surface. Behind that also concentrations of brachiopods and pteropods could be observed in the spicule meshwork. Besides the sponges there are gastropods (e.g. *Conus sp.*, *Turitella sp.*) and molluscs (e.g. pecten sp.) on the sediments of these stations. Other stations such as LO-09-15, -19, -22 and -23 exhibited also some sponges.
On the surface sediment of the station LO-09-9 fragments of basalt form the substratum for smaller types of sponges. The surface sediments of the stations LO-09-3 und -4 reveal some brittle stars of the species *Ophiura textura*. Abundant coral fragments were observed in the subsurface sediments of station 3 (see core description). The red corals are several centimeters in length and of Lophelia type including *L. pertusa* (LINNE) (pers. comm. A. FREIWALD).

Unlike the above-described sediments the surfaces of the stations LO-09-2, -16, -20 and -21 are distinguished by a small colonization of benthic organisms.

6. Summary

During cruise 09 with RV "Logachev" to the Reykjanes Ridge (North Atlantic) at 59°N, sediment distribution and composition has been investigated. A detailed bathymetric map (Hydrosweep and several SEL90 and Parasound profiles from the cruise with RV "Sonne" in 1992) served as basis of the recent work. Thirteen SEL90 profiles have been measured additionally during LO09. These information supported the sampling program. Twenty sites have been sampled successfully with a large box corer, giant box corer and a gravity corer.

The sedimentation environment in the study area is highly variable. Morphologically, three different sediment covered features are important: The active spreading center, the rift valley, contains only thin and patchy sedimentary deposits. On the flanks of the ridge, basins are filled with thick sequences and also some elevated plateaus show a sediment coverage. Some special conditions have been observed near a seamount ("Catalonia Seamount"). Generally, the thickness of sediments increases with increasing distance from the ridge crest.
The lithology of the sediments varies between nannofossil-foraminferal oozes, foraminiferal sands, sponge spicules rich sediments, clayey sediments, and volcanic ashes. Some deposits, especially in the vicinity of the Catalonia Seamount are strongly influenced by bottom currents. The pelagic input is dominated by planktic foraminifers (e.g. *Globigerina bulloides* and *Neogloboquadrina pachyderma*) and calcareous nannoplankton. As an important biogenic component, sponges and sponge spicules are observed. They occur as living organisms and autochthonous mats on the sediment surface and as allochthonous particles in spicule rich layers of some cores. Volcanic material occurs in the sediments from the ridge crest, indicating volcanic activity and in distinct layers of subaerially transported ashes coming from terrestrial sources (Iceland).

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Appendix

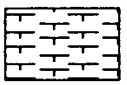
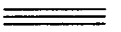
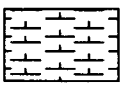
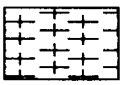
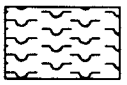
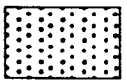
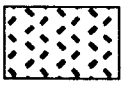
Tab. A1: Semi-quantitative smear slide description

Sample (Core-Dev.-No-Depth	Planktic Forams	Benthic Forams	Nannos	Diatoms	Sponge Spicules	Rads	Brown Glass	Transp. Glass	Plag	Qtz	Lithics	Clay	Diverse	SAND	SILT	CLAY	Total
1-GC-6-0	40	*	25	15	15		3	2	*	*			Ol, Px	40	30	30	100
1-GC-1-516	30	5	15	15	15		*	5	*	15			Plag, Calcite	10	45	45	100
2-GC-1-522	20	15	40	*	15	*	*	5		*				10	40	50	95
2-LBC- -0	30		30	8	15	*		8					Px, Amph	15	55	30	91
2-LBC- -4	15	21	25	10	25		*	2		*			Px,Amph	20	30	50	98
2-LBC- -11	42	21	7		28			*		*			Px	60	20	20	98
2-LBC- -16	18	35	26	*	18		*	1		*			Px	33	25	42	98
3-GGC-1-30	10	10	10	20	20		5	10		2			Px	20	40	40	87
3-GGC-1-125	20	10	20		10		*	5	5	5		20		10	30	60	95
3-GGC-1-190	30	6	15		10		*	*	*	5		30	Px	10	50	40	96
3-GGC-1-230	3	3	5	3	55		*	*				30		30	50	20	99
3-GGC-2-15	35	12	25	10	10		2	*	*	*			K-Spar	10	60	30	94
3-GGC-2-80	35	8	15		8			*	*	8	25			40	30	30	99
3-GGC-2-225	20	1	5		10		2	2	*	*		60		20	20	60	100
3-GGC-2-290	20	20	10					10	2	5		30	Calcite	10	60	30	97
3-LBC- -0	30	5	30	15	15	*	3	3						20	60	20	101
4-LBC- -0	30	3	20	30	15		*	*	*	*				15	30	55	98
6-LBC- -0	30	3	10	10	10		30	*	*	*				30	50	20	93
6-LBC- -18	25	3	12	8	12		25	15	*	*				30	50	20	100
7-LBC- -0	20	5	10	10	45		*	*	*					30	30	40	90
7-GGC-1-75	40	*	40		10		*	8		2			Px	20	50	30	100
7-GGC-1-185	10	*	10		5		*	5		*		70		10	40	50	100
8-LBC- -0	20	10	20	10	30		*	*		*				30	40	30	90
9-LBC- -0	35	*	35	15	15		*	*	*	*				20	40	40	100
10-LBC- -0	30	*	30	15	15		*	*		*				15	45	40	90
10-GGC-1-25	10	10	10		10		*	*		*		50		5	35	40	90
10-GGC-1-60	3		5		*		*	5				85		5	10	85	98
10-GGC-1-76	5		5		*		*	5		15		70	Biotite	5	25	70	100
10-GGC-1-143	5	2	5	2	5		55	*		*		25		60	15	25	99
10-GGC-1-260	5	3	5		10		*	5				45		5	20	70	73
14-LBC- -0	10	*	20	25	45		*	*		*				15	55	30	100
14-LBC- -0	3		20	30	45		*	*						10	70	20	98
14-LBC- -14	2	2	5	10	80		*	*		*				5	80	15	99
14-LBC- -36	10	10	10	15	45		*	3						30	50	20	93
14-LBC- -44	*	*	7	35	55			*						5	75	20	97
14-GGC-1-153			4	4	92		*	*						10	85	5	100
14-GGC-1-250	*	*	10	5	25	*	*	10	*	*		50		5	35	60	100
15-LBC- -0	70	15	5	*	*	*				5	5		Px	70	25	5	100
15-GGC-1-85	40	20	20		7		*	*		15			Px	50	30	20	102
15-GGC-1-216	45	15	5	*	5				*	30			Calcite	80	15	5	100
15-GGC-1-276	25	5	15				*	*				55		30	10	60	100
16-LBC- -0	40	20	20	8	8		*	*						50	45	5	96
17-LBC- -0	15	30	20	7	7	*	*	*		*		15		50	15	35	94
17-GGC-1-1	40	8	8	4	8	*	4	8		*		20		40	30	30	100
17-GGC-1-50	10	2	4		2		*	3		4		75		5	15	80	100
17-GGC-1-64	5		*		*		*	*		25			Black Ox.: 70	90	5	5	30
17-GGC-1-170	20	4	8	8	4		*	*		8		40		20	30	50	92

Tab. 1A: Continuation

Sample (Core-Dev.-No-Depth	Planktic Forams	Benthic Forams	Nannos	Diatoms	Sponge Spicules	Rads	Brown Glass	Transp. Glass	Plag	Qtz	Lithics	Clay	Diverse	SAND	SILT	CLAY	Total
18-LBC- -0	20	6	15	10	15	*						30		30	25	45	90
19-LBC- -0	27	8	27	8	14	*	*	*		*		14		35	25	40	98
20-LBC- -0	25	12	25	12	8	*	3	*		*		12		30	30	40	97
21-LBC- -0	20	*	20	10	10	*	*	15		15				45	35	20	90
22-LBC- -0	13	5	25	5	50	*	*	*		*				30	40	30	98
23-LBC- -0	25	*	15	8	15	*	5	20		10				50	40	10	98
23-GGC-1-50	10	*	20	5	15		*	23		17		10		35	40	25	100
23-GGC-1-100	23	5	7	23	11		2	*		15		11		50	30	20	97
23-GGC-1-225	3	*	6		6		*	*		15		65		5	25	70	95
23-GGC-2-330	17	5	10	10	10		*	*		30		10		30	40	30	92
23-GGC-2-511	8	4	8	4	4		*	40	*	20		20		10	50	40	108
23-GGC-2-527	6	6	6	3	3		*	6		6		63		10	20	70	99

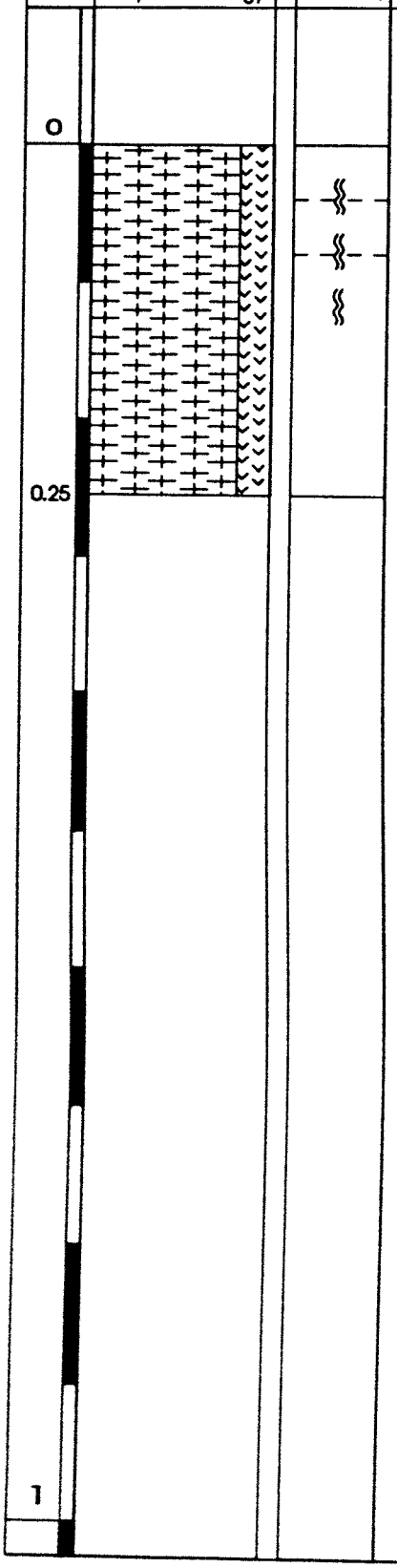
LEGEND

Lithologies	Structures
 *Foraminiferal ooze*	 *Laminations*
 *Nannofossil ooze*	 *Normal Grading*
 *Nannofossil-foraminiferal ooze*	*Sharp contact*
 *Clay*	*Gradational contact*
 *Diatom ooze*	 *Fining upwards*
 *Spiculite*	 *Fining downwards*
 *Sand*	 *Dropstone / Lithic*
 *Volcanic ash*	 *Megafossil (coral, bryozoa)*
	Slight bioturbation
	 *Moderate bioturbation*
	 *Strong bioturbation*
	 *Whole shell*
	 *Shell fragment*
	 *Sponge spicule mat*
	 *Chert*
	 *Lense*

PROFESSOR LOGACHEV CRUISE 9

Station: 2
Core: LBC
Page 1 of 1

Recovery: 0.25 m Water Depth: 1719 m

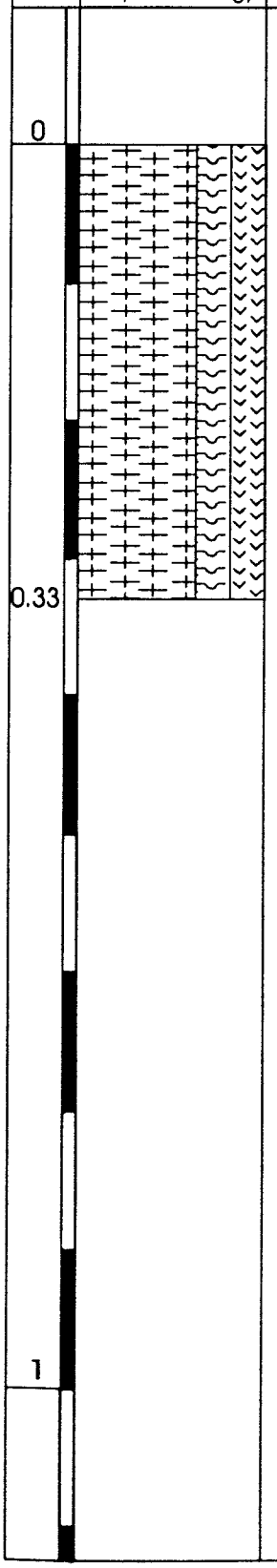


Structure	Color	Lithologic Description	Smear Slide
		Nannofossil-foraminiferal ooze with sponge spicules	
	2.5Y 4/4	surface: clayey-sandy silt, olive brown colours (2.5Y 4/4), worms on surface;	
	5Y 4/3	Unit I: 0-4 cm: sandy silty clay, dark olive (5Y 4/3), high water content, olive brown (2.5Y 4/3) and dark brown (10YR 3/4) intercalations;	0 4
	2.5Y 4/3	Unit II: 4-8 cm: clayey sandy silt, olive brown (2.5Y 4/3), mottled areas of dark brown (10YR 3/4) and olive (5Y 5/4) colour, boundary of the layer disturbed by bioturbation;	11
	5Y 5/2	Unit III: 8-16 cm: clayey silty sand, olive gray (5Y 5/2), intercalations of gray (10Y 5/1) and olive gray (10Y 4/1) patches with high water content,	16
		16-25,5 cm: silty sandy clay, bottom portion of core 5Y 4/3 become darker: dark olive (5Y 4/3), mottled;	

PROFESSOR LOGACHEV CRUISE 9

Station: 3
Core: LBC
Page 1 of 1

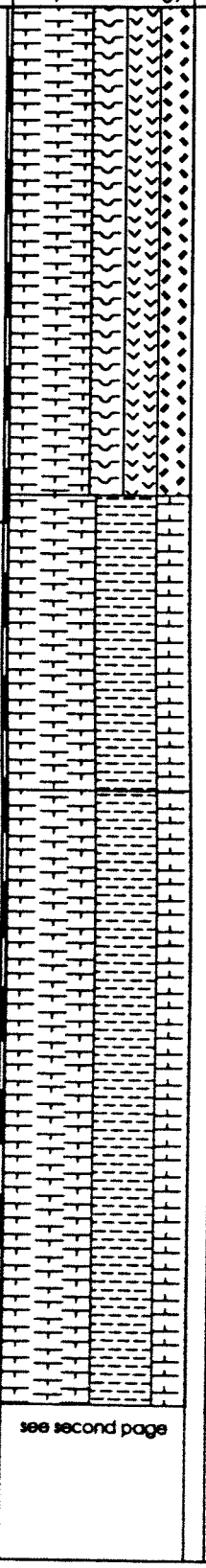
Recovery: 0.33 m Water Depth: 1254 m



PROFESSOR LOGACHEV CRUISE 9

Station: 3
Core: GGC

Recovery: 5.7m Water Depth: 1257m

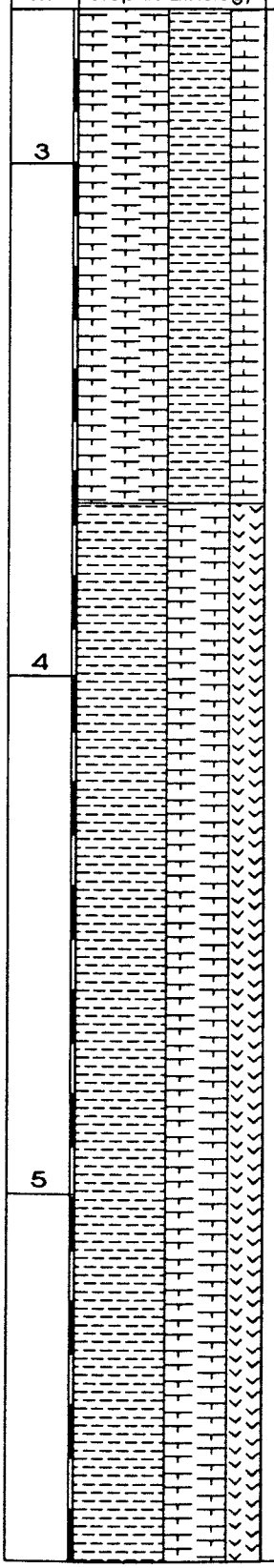


m	Structure	Color	Lithologic Description	Smear Slide
			Diatom-foraminiferal ooze with sponge spicules and volcanic glass	
		10YR 4/3	Unit I: 0-0.95 m: sandy silty clay,	
			0-0.20 m: dull yellowish brown,	
		10YR 3/3	0.20-0.95 m: dark brown,	30
			0.25-0.75 m: abundant corals (Lophelia type) and shell fragments,	
1			**Clayey foraminiferal ooze with nannofossils**	
		2.5GY 4/1	Unit II: 0.95-1.52 m: sandy silty clay, dark olive gray, homogeneous sediment, moderately bioturbated,	125
			Clayey foraminiferal ooze with nannofossils	
		2.5GY 5/1	Unit III: 1.52-3.66 m: sandy clayey silt,	
			1.52-2.3 m: olive gray,	
			1.52 m: coarse grained (< 3 mm), shelly layer with sponge spicules, bryozoans and foraminifers, sandy clayey silt,	
			1.65-1.82 m: mottled with dark olive gray (2.5GY 3/1),	190
2			1.95 m: coarse grained (< 4 mm), shelly layer with bryozoans, corals, foraminifers, less sponge spicules, sandy clayey silt,	
			2.1-2.5 m: sediment strongly mottled with dark olive gray (2.5GY 3/1),	230
		5Y 5/2	2.3-2.7 m: grayish olive, mottled with dark olive gray (2.5GY 4/1),	
			2.3 m: sponge spicule rich layer, irregular thickness 1-3 cm, clayey sandy silt	
3				

PROFESSOR LOGACHEV CRUISE 9

Station: 3
Core: GGC

Recovery: 5.7m Water Depth: 1257m

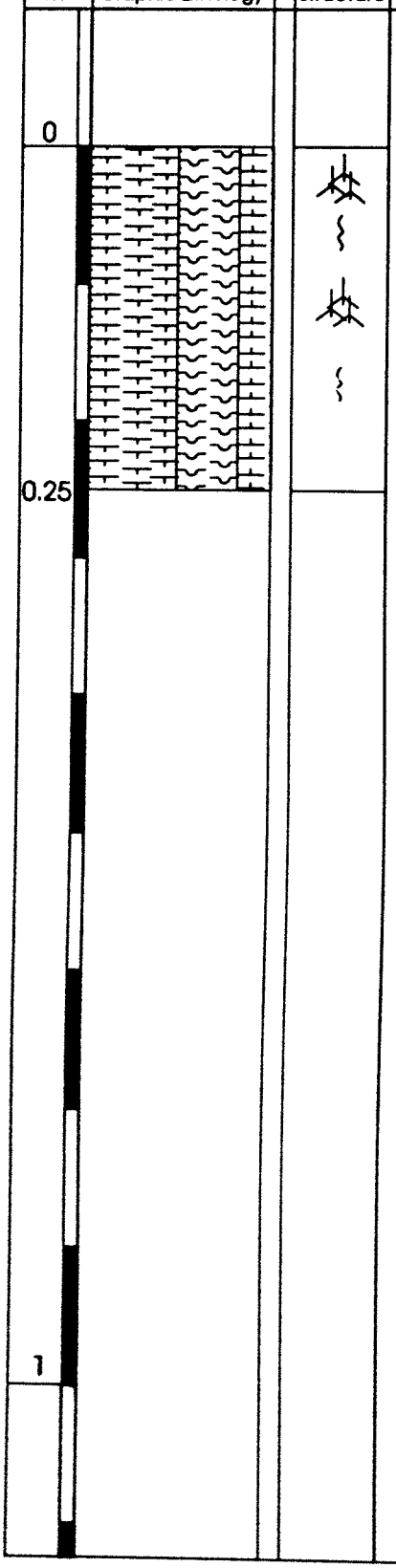


Color	Lithologic Description	Smear Slide
	Clayey foraminiferal ooze with nannofossils	
	Unit III: 1.52-3.66 m: sandy clayey silt,	
	2.85 m: brachiopoda,	285
2.5Y 4/2	2.7-3.1 m: dark grayish yellow, blebs of sandy silty clay, dark olive gray (2.5GY 4/1),	
2.5GY 3/1	3.1-3.45 m: dark olive gray, abundant sponge spicules in small lenses, weakly forming layers, slightly mottled,	
	3.25 m: coral fragments,	
2.5GY 4/1	3.45-3.66 m: dark olive gray, layer with tiny black specks, silty clayey sand, basalt fragments,	350
	Foraminiferal clay with sponge spicules	
	Unit IV: 3.66-5.7 m: sandy silty clay,	
	3.7-3.72 m: sandy layer, rich in foraminifers and shell fragments,	
2.5GY 6/1	3.66-4.32 m: olive gray,	
	3.95 m: brown with reddish laminations, olive brown (2.5Y 4/4), sponge spiucles, distributed in sediment,	
	4.35 m: chert fragment, 1.5 mm in diameter,	
2.5Y 6/2	4.32-4.55 m: grayish yellow sediment,	
2.5Y 5/3	4.55- 4.7 m: yellowish brown colours, increasing in grain size, visible foraminifers up to 3 mm in size,	
5Y 5/3	4.7-4.97 m: grayish olive, abundant sponge spicules mottled, slightly to moderately bioturbated,	
	4.87 m: shell fragment,	495
2.5Y 7/2	4.97-5.27 m: grayish yellow,	
2.5Y 5/4	5.27-5.7 m: yellowish brown,	560
2.5Y 3/3	5.7 m: dark olive brown, coarser grained, thin layer on base, sandy clayey silt,	

PROFESSOR LOGACHEV CRUISE 9

Station: 4
Core: LBC
Page 1 of 1

Recovery: 0.25 m Water Depth: 1335 m



PROFESSOR LOGACHEV CRUISE 9

Station: 6
Core: LBC
Page 1 of 1

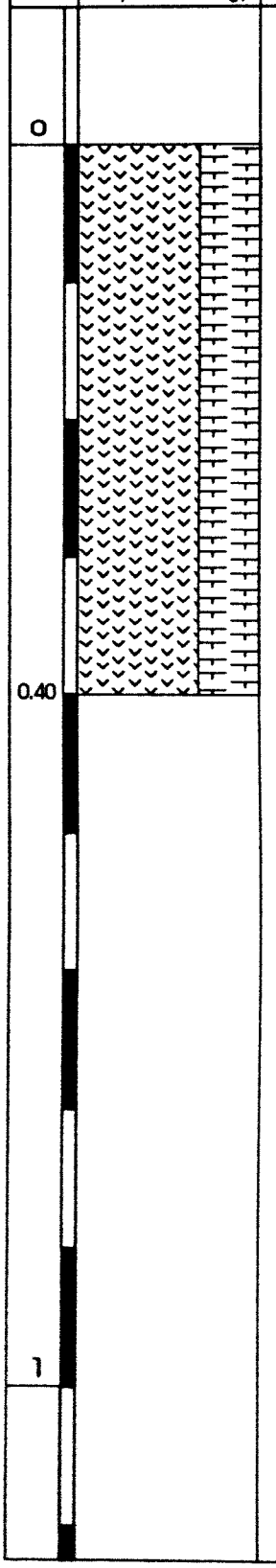
Recovery: 0.25 m Water Depth: 1375 m

m	Graphic Lithology	Structure	Color	Lithologic Description	Smear Slide
0				**Volcanic ash-bearing foraminiferal ooze with nannofossils and sponge spicules**	
			2.5Y 5/3	surface: clayey sandy silt, yellowish brown (2.5Y 5/3), sediment was build up mainly by planktic foraminifers and brown volcanic glass;	0
			2.5Y 5/3	Unit I: 0-25 cm: sediment according to surface, volcanic ash is scattered over the core and is locally enriched in discrete lenses with yellowish gray colours (2.5Y 5/1);	18
0.25					
1					

PROFESSOR LOGACHEV CRUISE 9

Station: 7
Core: LBC
Page 1 of 1

Recovery: 0.40 m Water Depth: 1449 m

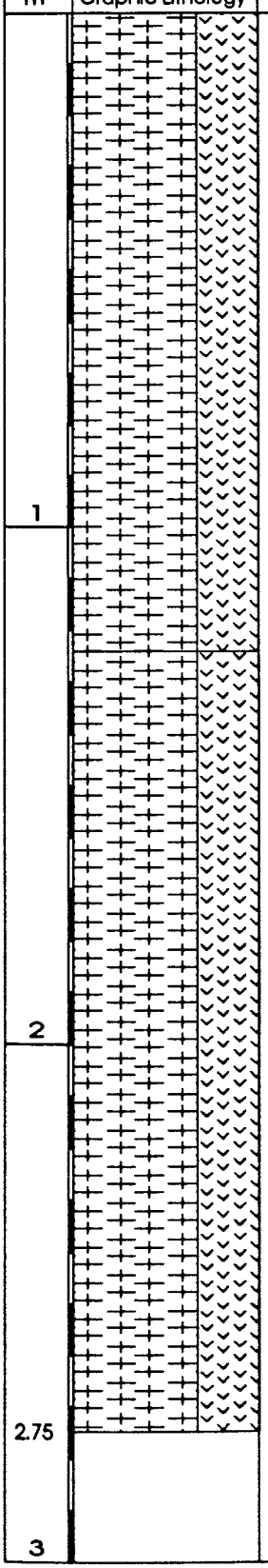


Color	Lithologic Description	Smear Slide
	Foraminiferal sponge spicule ooze	
2.5Y 5/2	surface: sandy-silty clay, dark grayish yellow (2.5Y 5/2), sponge spicules are abundant, the upper 4 cm of the core were constructed by a network of spicules, the sediment surface were inhabited by plenty of living sponges;	0
2.5Y 5/4	Unit I: 0-40 cm: sandy-silty clay, colour changes to yellowish brown (2.5Y 5/4), furthermore abundant sponge spicules, as well as intercalated in the core as spicule-'felts' and disseminated over the sediment column;	

PROFESSOR LOGACHEV CRUISE 9

Station: 7
Core: GGC
Page 1 of 1

Recovery: 2.75m Water Depth: 1451m



Color	Lithologic Description	Smear Slide
	Nannofossil-foraminiferal ooze with sponge spicules	
10YR 5/3	Unit I: 0-1.23 m: sandy silty clay,	
	0-0.35 m: dull yellowish brown (10YR 5/3),	
	0.25 m: dropstone, 0.75 cm in diameter, subangular, basalt,	
10YR 4/4	0.35-1.62 m: brown (10YR 4/4),	
	0.35-1.0 m: abundant sponge spicules, sediment mottled,	
	0.4 m: subrounded basalt, 2 cm in diameter,	
	0.82 m: basalt, subrounded, 0.5 cm in diameter,	
	0.5-0.53 m; 0.62-0.65 m; 0.75-0.79 m; 1.0-1.02 m; 1.18-1.2 m: olive brown layers (2.5Y 4/3), sandy clayey silt,	75
	Nannofossil-foraminiferal ooze with sponge spicules	
10YR 4/4	Unit II: 1.23-2.75 m: sandy silty clay, sediment strongly mottled,	
	1.25 m: basalt, subrounded, 1.5 cm in diameter,	
	1.23-1.6 m: brown (10YR 4/4), mottled with olive brown (2.5Y 4/3), shell fragments (Mytlus?),	
2.5Y 5/3	1.6-1.9 m: yellowish brown (2.5Y 5/3),	
	1.7-1.8 m: irregular lenses of dull yellowish brown (10YR 5/4),	
	1.85 m: white stuff,	185
10YR 5/4	1.9-2.15 m: dull yellowish brown (10YR 5/4),	
2.5Y 6/3	2.15-2.25 m: dull yellow layer (2.5Y 6/3),	
2.5Y 5/3	2.25-2.45 m: yellowish brown (2.5Y 5/3), subangular basalts, oxidised, 6 cm in diameter - vesicular, 4 cm in diameter - on-vesicular,	
10YR 5/4	2.45-2.75 m: dull yellowish brown (10YR 5/4), mottled,	
	2.6-2.65 m: sponge spicule rich layer, light yellow (2.5Y 7/3),	
	2.65-2.75 m: sediment sponge spicule rich	

PROFESSOR LOGACHEV CRUISE 9

Station: 8
Core: LBC

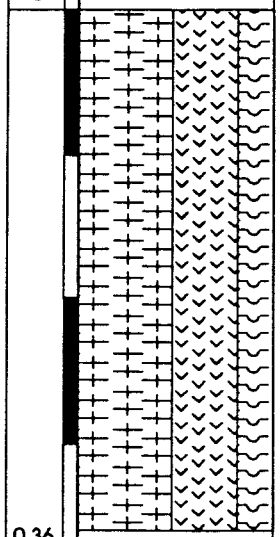
Recovery: 0.30 m Water Depth: 1332 m

m	Graphic Lithology	Structure	Color	Lithologic Description	Smear Slide
0				**Foraminiferal-sponge spicule ooze with nannofossils**	
			2.5Y 4/3	surface: sandy-clayey silt, poorly sorted, olive brown (2.5Y 4/3), settlement abundant (sponges, worms, pteropods), the ppermost 2 cm of the core were buildup by spicule-'felts';	0
			2.5Y 5/4	Unit I: 2-19 cm: sandy-clayey silt, colour changes to yellowish brown (2.5Y 5/4), 13-14 cm: spicule-'felt' interbedded;	
0.30			2.5Y 5/3	Unit II: 19-31 cm: sandy clayey silt, yellowish brown (2.5Y 5/3), grayish yellow (2.5Y 6/2) lenses are present, 30-31 cm: base of core is composed of a spicule-'felt';	
1					

PROFESSOR LOGACHEV CRUISE 9

Station: 9
Core: LBC
Page 1 of 1

Recovery: 0.36 m Water Depth: 1493 m



m	Structure	Color	Lithologic Description	Smear Slide
0			**Nannofossil-foraminiferal ooze with diatoms and sponge spicules**	
		2.5Y 5/4	surface: sandy silty clay, (smear slide: silt, clay 40 %), yellowish brown coloured (2.5Y 5/4), foraminifers abundant, less spicules and fauna;	0
		2.5Y 5/4	Unit I: 0-5 cm: sandy silty clay, sediment according to surface, yellowish brown (2.5Y 5/4);	
		2.5Y 5/3	Unit II: 5-30 cm: sandy clayey silt, yellowish brown (2.5Y 5/3), 14-17 cm: some finer grained dark olive brown (2.5Y 3/3) lenses appear;	
0.36		2.5Y 4/3	Unit III: 30-36 cm: clayey sandy silt, olive brown (2.5Y 4/3), 30 cm: dark grayish yellow (2.5Y 5/2) zone, coarser grained (fine sand) by calcareous fragments;	
1				

PROFESSOR LOGACHEV CRUISE 9

Station: 10
Core: LBC
Page 1 of 1

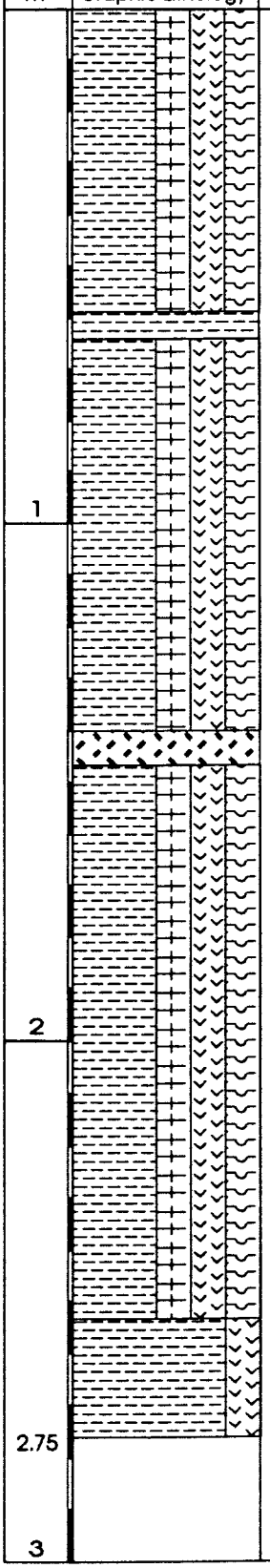
Recovery: 0.28 m Water Depth: 1380 m

m	Graphic Lithology	Structure	Color	Lithologic Description	Smear Slide
0				**Nannofossil-foraminiferal ooze with sponge spicules and diatoms**	
			2.5Y 5/3	surface: sandy clayey silt, predominantly fine-grained, minor sand, colour yellowish brown (2.5Y 5/3);	
			2.5Y 5/3	Unit I: 0-28 cm: sandy clayey silt, sediment corresponding to surface, yellowish brown colours (2.5Y 5/3), no colour changes downcore, homogeneous sediment,	
				10 cm: lenses filled with coarser grains, yellowish brown (2.5Y 5/4),	
				26 cm: intercalations of dark grayish yellow sediment (2.5Y 5/2),	
0.28					
1					

PROFESSOR LOGACHEV CRUISE 9

Station: 10
Core: GGC
Page 1 of 1

Recovery: 2.75m Water Depth: 1380m



Graphic Lithology | Structure | Color | Lithologic Description | Smear Slide

Nannofossil-foraminiferal clay with sponge spicules and diatoms

2.5Y 4/3

Unit I: 0-2.53 m: sandy silty clay and silty clay, olive brown (2.5Y 4/3), sediment is slightly to moderately bioturbated,

25

0.12 m: dropstone, 1 cm in diameter, subrounded, armored with dark oxide,

0.5-0.7 m: brownish black (2.5Y 3/2) and yellowish brown (10YR 4/3) laminations,

60

0.8 m: lense of shell fragments (< 3 mm), dark olive brown (2.5Y 3/3),

76

1.0-1.2 m: yellowish gray (2.5Y 4/1) irregular lenses of silty clay,

1.3-1.5 m: yellowish gray (2.5Y 4/1) laminations, silty clay,

1.4-1.47 m: diffuse ash layer with black specks, clayey, host sediment silty clayey sand,

143

1.55 m

1.62 m

1.6-2.0 m: many foraminifers, yellowish gray (2.5Y 4/1) laminations of silty clay,

1.8-1.9 m

2.05-2.35 m: yellowish gray (2.5Y 4/1) strongly mottled, irregular layers,

2.5Y 4/1

2.4-2.53 m: yellowish gray (2.5Y 4/2) layer, mottled with olive brown (2.5Y 4/3),

Clay with sponge spicules

260

2.5Y 5/2

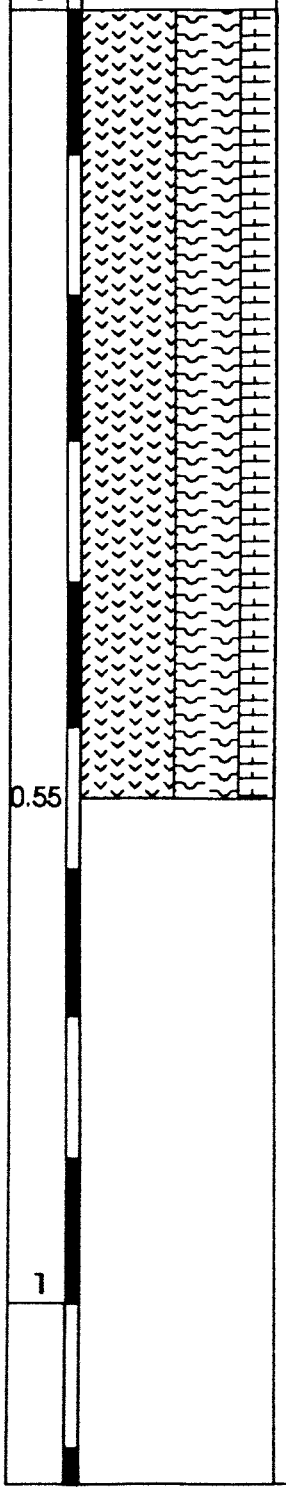
Unit II: 2.53-2.75 m: dark grayish yellow (2.5Y 5/2), irregular lenses and sponge spicule dump,

2.6-2.75 m: dark grayish yellow (2.5Y 4/2) sandy silty clay with sponge spicules,

PROFESSOR LOGACHEV CRUISE 9

Station: 14
Core: LBC
Page 1 of 1

Recovery: 0.55 m Water Depth: 1719 m

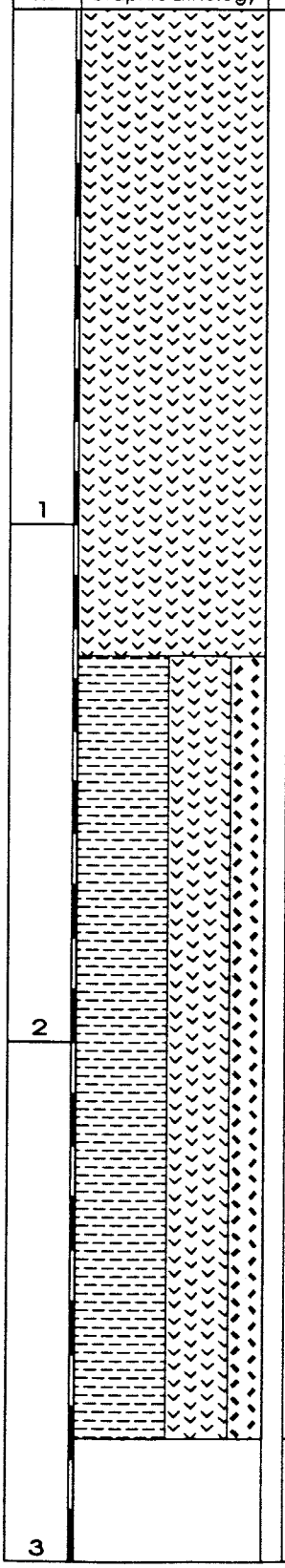


m	Color	Lithologic Description	Smear Slide
		Diatom-sponge spicule ooze with nannofossils	
0	5Y 4/3	surface: surface disturbed ca. 10 cm above top of BG removed?, no water, top 1 cm: dark olive (5Y 4/3);	0
	7.5Y 4/2	Unit I: 0-10 cm: grayish olive (7.5Y 4/2), sediment mottled,	
		7 cm: lense of diatoms, olive black (7.5Y 3/1);	
	2.5GY 5/1	Unit II: 10-35 cm: olive gray (2.5GY 5/1), minor foraminifers,	
		13 cm: irregular lenses of diatoms gray (5Y 4/1)	
		14 cm: (smear slide): sponge spicule ooze with diatoms,	14
		15-17cm: irregular lenses of diatoms, gray (5Y 4/1), 20-35 cm: faintly mottled silty clay,	
		20-21.5 cm: olive gray (5GY 5/1), irregular layer,	
		34 cm: irregular lense of diatoms, greenish gray (7.5GY 5/1),	
	7.5Y 5/2	Unit III: 35-38 cm: organic-rich layer, grayish olive (7.5Y 5/2),	
		38-41 cm: diatom-rich layer, gray (7.5Y 4/1),	36
		41-44 cm: olive gray (2.5GY 5/1),	
		42-45 cm: irregular organic-rich layer, grayish olive (7.5Y 5/2),	
		45-46 cm: irregular layer with 'microsponge' spicule matts, dark coloured because of intermingled diatoms, dark olive gray (5GY 3/1),	44
	7.5GY 5/1	Unit IV 46-55 cm: greenish gray (7.5GY 5/1),	
		48-49 cm: olive gray (10Y 4/2), diatom-rich lense, dark olive gray (2.5GY 4/1),	
		49-55 cm: faintly mottled sandy silty clay	

PROFESSOR LOGACHEV CRUISE 9

Station: 14
Core: GGC
Page 1 of 1

Recovery: 2.77m Water Depth: 1722m



Color	Lithologic Description	Smear Slide
	Sponge spicule ooze	
7.5Y 5/3	Unit I: 0-1.25 m: sandy clayey silt, micro sponge spicule matt rich, 0-0.05 m: micro sponge spicule matt layer, grayish olive coloured, the base of the matt darker coloured, 10Y 3/2 - olive black, diatom rich, 0.1-0.15 m: micro sponge spicule matt layer, 0.19-0.22 m: micro sponge spicule matt layer, 0.25-0.42 m: micro sponge spicule matt layer,	
10Y 5/2	0.05-0.42 m: olive gray sandy clayey silt,	
5GY 6/1	0.42-0.52 m: olive gray sediment, moderate foraminifers, fish remains on base,	
	0.55 m: larger matts,	53
	0.52-0.87 m: micro sponge spicule matt layer, diatom rich, with rare (< 3 cm) small foraminifer lenses,	
	0.65-0.7 m: darker micro sponge spicule matt, olive gray (10Y 4/2), diatom rich,	
10Y 5/2	0.52-1.22 m: olive gray,	
10Y 5/1	0.98-1.0 m: gray irregular micro sponge spicule matts,	
	1.0-1.75 m: foraminifer rich,	
	1.05 m: large matt lense,	
10Y 3/2	1.05-1.15 m: dark lenses, olive black,	
	1.10-1.25 m: layer of micro sponge spicule matts,	
10Y 3/1	1.25 m: irregular dark lenses, olive black,	
	Sponge spicule clay with volcanic glass	
	Unit II: 1.25-2.77 m: clayey sandy silt,	
2.5GY 4/1	1.25-1.5 m: dark olive gray, foraminifer rich,	
10Y 5/2	1.4-1.48 m: sponge spicule matts, weakly internally layered, olive gray,	
10Y 5/2	1.5-1.55 m: sponge spicule matts, weakly internally layered,	
10Y 4/1	1.5-2.0 m: gray sediment, mottled, foraminifer rich,	
	1.75 m: lenses of sponge spicule matts,	
	1.9 m 1.92 m thin layers of micro sponge spicule matts,	
10Y 4/2	2.15 m: thin layers of sponge spicule matts, olive gray,	
	2.3 m: clay lense, mottled and weakly laminated, olive gray (5GY 5/1),	
	1.92-2.77 m: moderate foraminifers,	
5GY 4/1	2.0-2.77 m: dark olive gray,	250
	2.72 m: thin layer of sponge spicule matts,	
	2.75 m: clay lense, olive gray (5GY 5/1),	

PROFESSOR LOGACHEV CRUISE 9

Station: 15
Core: LBC
Page 1 of 1

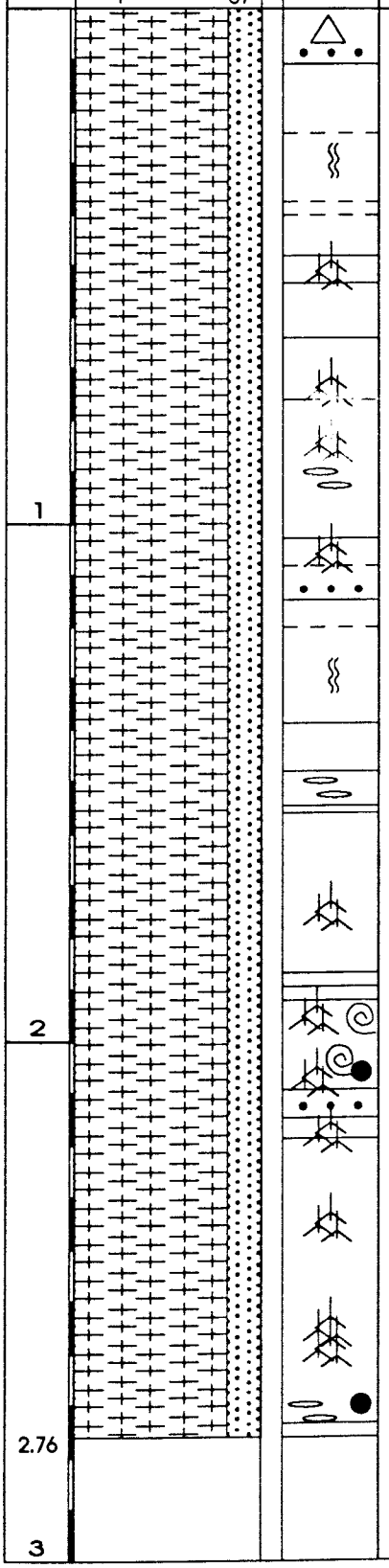
Recovery: 0.15 m Water Depth: 1201 m

m	Graphic Lithology	Structure	Color	Lithologic Description	Smear Slide
				Foraminiferal sand	
0			10YR 4/4	surface: silty sand, weakly clayey, brown (10YR 4/4), volcanic glass fragments (max. size ca 2 cm), with irregular coarse grained patches of shell fragments, whole shells (limpet type), starfish, small sea-urchins,	0
			10YR 4/4	Unit I: 0-5 cm: sand, brown (10YR 4/4), coarse grained, becoming finer grained downcore throughout Unit I, sponge spicules, gravel (volcanic glass), subangular to subrounded, shell fragments;	
			10YR 4/3	Unit II: 5-11 cm: sandy silty clay, dull yellowish brown (10 YR 4/3)	
0.15			10YR 4/6	Unit III: 11-15 cm: sandy silty clay, very minor sand, brown (10YR 4/6)	
1					

PROFESSOR LOGACHEV CRUISE 9

Station: 15
Core: GGC
Page 1 of 1

Recovery: 2.76m Water Depth: 1203m

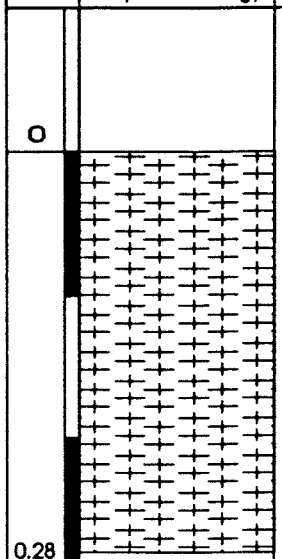


m	Color	Lithologic Description	Smear Slide
		Nannofossil-foraminiferal ooze with quartz	
	10YR 5/4	Unit I: 0-2.76 m: clayey silty sand,	
		0-0.13 m: sand, dull yellowish brown, fining upwards, foraminifers,	
		0.13 m: thin irregular gravelly layer (< 1 cm), black, subangular volcanic glass,	
	10YR 5/3	0.13-0.35 m: dull yellowish brown,	
		0.35 m: darker layer, dull yellowish brown (10YR 4/3),	
	10YR 4/4	0.36-0.55 m: brown sediment,	
		0.5-0.55 m: irregular sponge spicule rich layer,	
	10YR 5/4	0.55-0.66 m: dull yellowish brown	
	10YR 4/4	0.66-1.03 m: brown layer, sponge spicule rich,	
		0.66-0.75 m: scattered sponge spicule blebs (dumps),	
		0.85-0.9 m: scattered sponge spicule blebs, irregular layer,	85
1		0.95 m: irregular sandy lense,	
	10YR 5/4	1.03-1.1 m: dull yellowish brown, irregular layer with sponge spicule blebs,	
	10YR 4/4	1.1-1.42 m: brown sediment,	
		1.1-1.17 m: sandy layer with black lithics (concentrated at base), irregular based,	
		1.2-1.4 m: sediment mottled,	
	10YR 5/4	1.42-1.47 m: dull yellowish brown, sand layer (foraminifers),	
	10YR 4/4	1.47-1.55 m: brown, irregular sand lense interbedded,	
	10YR 5/4	1.55-1.6 m: dull yell. brown, sandy layer (foraminifers),	
	10YR 4/4	1.6-1.87 m: brown sediment, slight increasing of grainsize because of more foraminifers,	
		1.75-1.87 m: increasing sponge spicules,	
		1.8 m: sponge spicule blebs,	
	10YR 5/3	1.87-1.9 m: darker irregular layer, dull yellowish brown,	
	10YR 7/3	1.9-1.92 m: dull yellow orange,	
2	10YR 6/3	1.92-2.1 m: dull yellow orange,	
		1.92-2 m: sponge spicules, rugose corals and shell fragments,	
		2.1 m: sandstone pebble , 1.5 cm in diameter, coated in manganese (10YR 2/3 - brownish black) on base of the layer,	
	10YR 4/4	2.1-2.2 m: brown sediment,	216
		2.1-2.15 m: sponge spicule rich layer with shell fragments and coral fragments,	
		2.15-2.2 m: sandy layer with shell fragments and black rock fragments (< 0.5 cm),	
		2.35 m: irregular lense/layer of sponge spicule blebs,	
	10YR 5/3	2.2-2.75 m: dull yellowish brown sediment, sponge spicule rich,	
		2.52-2.55 m: irregular layer of sponge spicule blebs,	
		2.57-2.6 m: irregular sponge spicule layer,	
		2.7 m: sandy lense and black subangular rock fragment, 0.75 cm in diameter, coated in manganese (10YR 1.7/1 - black), increasing sand content,	276
2.76	10YR 7/3	2.75-2.76 m: dull yellow orange sediment, more clayey	
3			

PROFESSOR LOGACHEV CRUISE 9

Station: 16
Core: LBC
Page 1 of 1

Recovery: 0.28 m Water Depth: 1622 m



m	Graphic Lithology	Structure	Color	Lithologic Description	Smear Slide
				Nannofossil-foraminiferal ooze	
			5Y 4/3	surface: silty sand, weakly clayey, dark olive (5Y 4/3), foraminiferal-rich;	
0					0
			2.5Y 4/3	Unit I: 0-4,5 cm: clayey silty sand, olive brown (2.5Y 4/3);	
			2.5Y 4/6	Unit II: 4,5-6,5 cm: clayey silty sand, olive brown (2.5Y 4/6), dark grayish yellow lense (2.5Y 4/2);	
			2.5Y 5/4	Unit III: 6,5-11 cm: clayey silty sand, yellowish brown (2.5Y 5/4), base disturbed by bioturbation;	
			2.5Y 6/2	Unit IV: 11-19 cm: clayey silty sand, grayish yellow (2.5Y 6/2), layer mottled, dull yellow lenses (2.5Y 6/4), base disturbed;	
			5Y 6/2	Unit V: 16-28 cm: clayey silty sand, grayish olive (5Y 6/2), mottled with dull yellow (2.5Y 6/4),	
0.28				24 cm: dark lense, brownish black (2.5Y 3/2);	
1					

PROFESSOR LOGACHEV CRUISE 9

Station: 17
Core: LBC

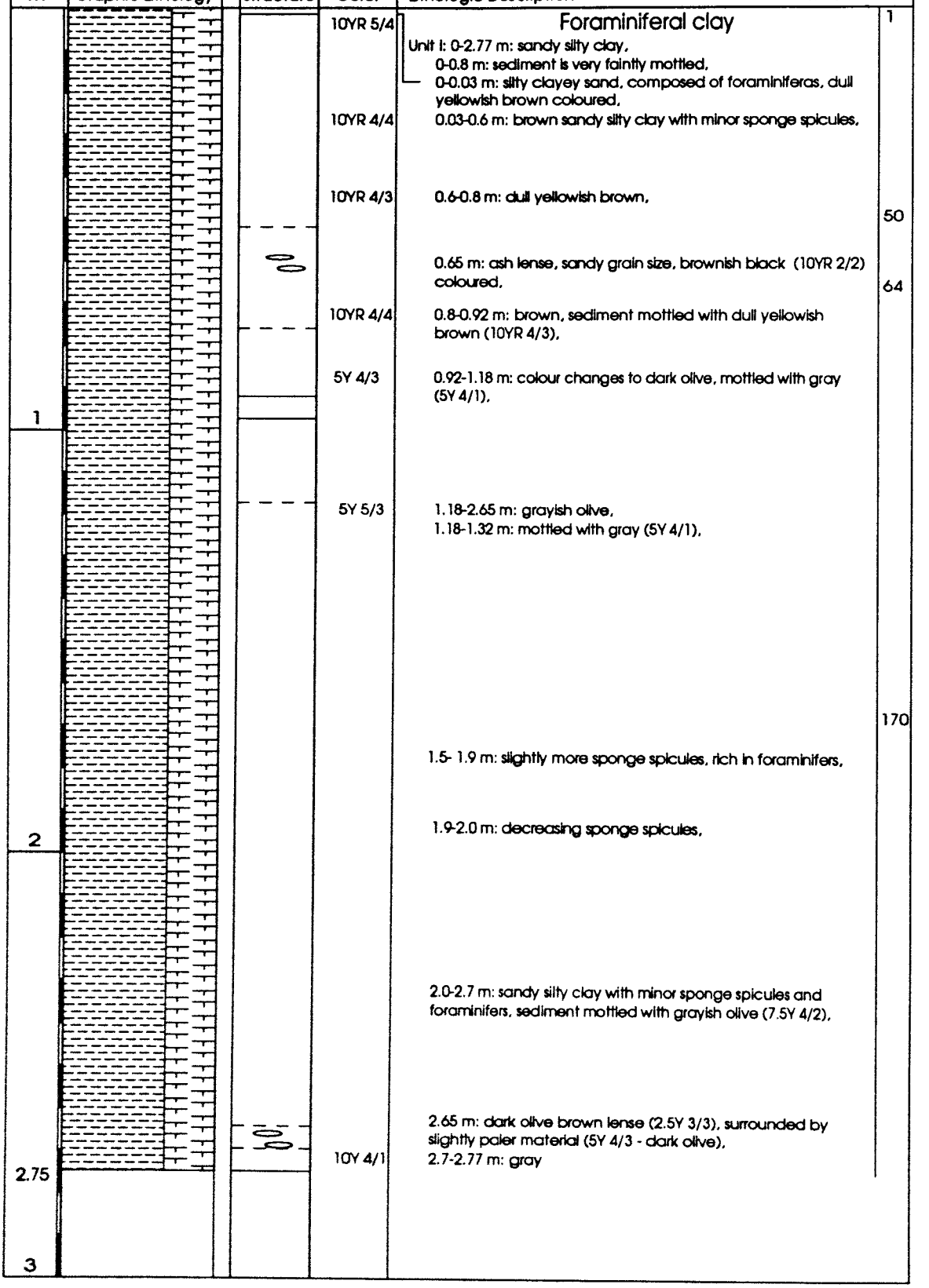
Recovery: 0.42 m Water Depth: 1396 m

m	Graphic Lithology	Structure	Color	Lithologic Description	Smear Slide
0				**Nannofossil-foraminiferal ooze**	
			2.5Y 4/4	surface: silty clayey sand, olive brown (2.5Y 4/4), thick carpet of sponge needles with sea-urchins, brown and yellow sponges, small bivalves (<1cm), semi transparent, small gastropods (<0,4 cm), rare coral, bryozoan branches, shell fragments;	0
			10YR 5/4	Unit I: 0-42 cm: sandy silty clay with irregular sponge needle layers, dull yellowish brown (10YR 5/4), homogeneous sediment;	
0.42					
1					

PROFESSOR LOGACHEV CRUISE 9

Station: 17
Core: GGC
Page 1 of 1

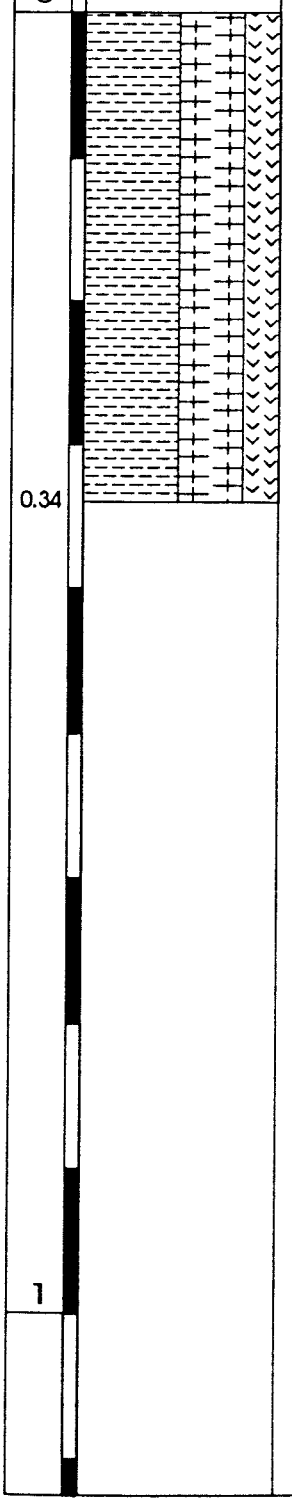
Recovery: 2.75m Water Depth: 1399m



PROFESSOR LOGACHEV CRUISE 9

Station: 18
Core: LBC
Page 1 of 1

Recovery: 0.34 m Water Depth: 1472 m



Structure	Color	Lithologic Description	Smear Slide
		Foraminiferal clay with nannofossils and sponge spicules	
	2.5Y 4/3	surface: silty sandy clay, olive brown (2.5Y 4/3), high water content, foraminifers, some gastropods, some sponge spicules, rare benthos;	0
	2.5Y 4/3	Unit I: 0-4 cm: silty sandy clay, according to surface;	
	2.5Y 4/4	Unit II: 4-10 cm: clayey silt, olive brown (2.5Y 4/4), sponge spicules;	
	2.5Y 3/3	Unit III: 10-13 cm: silty clay, dark olive brown (2.5Y 3/3), strongly mottled, brown lense on top (10YR 4/6), dark lense on base (2.5YR 3/2 - brownish black) of Unit;	
	5Y 5/3	Unit IV: 13-22 cm: clayey silt, grayish olive (5Y 5/3), strongly mottled;	
	10Y 5/1	Unit V: 22-34 cm: clayey silt, gray (10Y 5/1), foraminifers abundant, sponge spicules;	

PROFESSOR LOGACHEV CRUISE 9

Station: 19
Core: LBC
Page 1 of 1

Recovery: 0.33 m Water Depth: 1240 m

m	Graphic Lithology	Structure	Color	Lithologic Description	Smear Slide
				Nannofossil-foraminiferal ooze with clay and sponge spicules	
0			2.5Y 4/3	surface: silty sandy clay , olive brown (2.5Y 4/3), sponge spicules and foraminifers abundant, less benthic organisms;	0
			2.5Y 4/4	Unit I 0-33 cm: sandy silty clay, 0-4 cm: sediment according to surface, sponge spicules abundant, 4-14 cm: less spicules, 14-16 cm: irregular layer, disturbed by bioturbation, olive brown (2.5Y 4/4) 16-32 cm: sediment strongly mottled, lenses resp. 2.5Y 4/4 irregular layers olive brown (2.5Y 4/4) coloured,	
0.33			2.5Y 5/2	32-33 cm: dark grayish yellow (2.5Y 5/2), foraminifers abundant, top of the layer 2 mm thick zone of reddish colours (2.5Y 5/6 - yellowish brown)	
1					

PROFESSOR LOGACHEV CRUISE 9

Station: 20
Core: LBC
Page 1 of 1

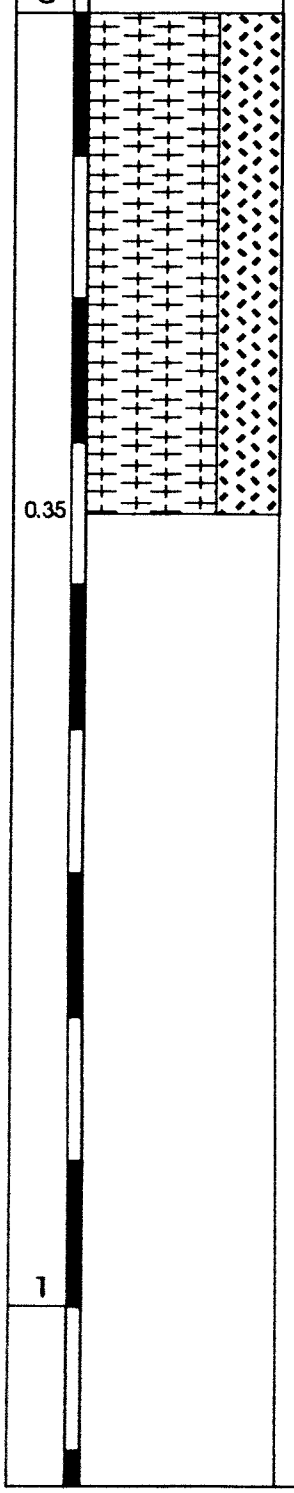
Recovery: 0.34 m Water Depth: 1396 m

m	Graphic Lithology	Structure	Color	Lithologic Description	Smear Slide
0				Nannofossil-foraminiferal ooze	
			2.5Y 4/3	surface: sandy silty clay, olive brown (2.5Y 4/3), very high water content, shell fragments;	0
			2.5Y 4/3	Unit I: 0-6 cm: sediment according to surface,	
			2.5Y 5/4	Unit II: 6-34 cm: sandy silty clay, yellowish brown (2.5Y 5/4), sponge spicules, stains of oxidized organic material on top of the layer, 2.5Y 4/2	
				13-15 cm: darker coloured irregular layer, disturbed, dark yellowish gray (2.5Y 4/2);	
0.34					
1					

PROFESSOR LOGACHEV CRUISE 9

Station: 21
Core: LBC
Page 1 of 1

Recovery: 0.35 m Water Depth: 1437 m



Structure	Color	Lithologic Description	Smear Slide
		Nannofossil-foraminiferal ooze with volcanic glass	
	2.5Y 4/3	surface: clayey silty sand, high water content, olive brown (2.5Y 4/3), foraminifers, gastropods, less sponge spicules, clear volcanic glass;	0
	2.5Y 4/3	Unit I: 0-6 cm: clayey silty sand, sediment according to surface;	
	2.5Y 4/3	Unit II: 6-35 cm: sandy clayey silt, 6-23 cm: olive brown (2.5Y 4/3) sediment, intercalated with lighter and darker coloured layers: 6-7 cm: yellowish brown (2.5Y 5/3) layer, mottled, 7-13 cm: olive brown (2.5Y 4/3), 13-17 cm: dark grayish yellow (2.5Y 4/2), 17-19 cm: olive brown (2.5Y 4/3), 19-20 cm: yellowish gray (2.5Y 4/1), 20-23 cm: olive brown (2.5Y 4/3),	
	2.5Y 5/6	23 cm: yellowish brown (2.5Y 5/6),	
	2.5Y 5/2	23-27 cm: dark grayish yellow (2.5Y 5/2),	
	7.5Y 5/2	27-35 cm: grayish olive (7.5Y 5/2);	

PROFESSOR LOGACHEV CRUISE 9

Station: 22
Core: LBC
Page 1 of 1

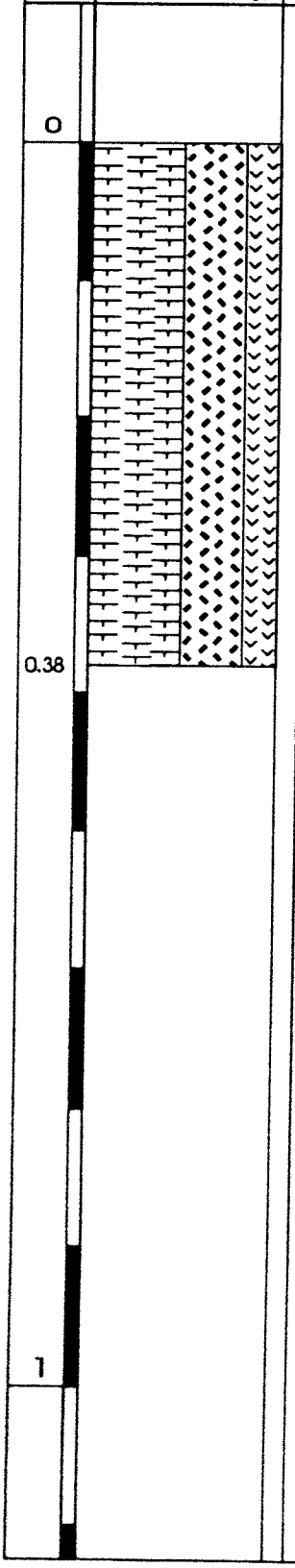
Recovery: 0.28 m Water Depth: 1139 m

m	Graphic Lithology	Structure	Color	Lithologic Description	Smear Slide
				Nannofossil-sponge spicule ooze with foraminifers	
0			2.5Y 4/3	surface: clayey-sandy silt, olive brown (2.5Y 4/3), bryozoa, sponges, spicule-'felts';	0
			2.5Y 4/3	Unit I: 0-6 cm: sediment according to surface, spicule-'felts';	
			2.5Y 5/3	Unit II: 6-28 cm: clayey sandy silt, yellowish brown (2.5Y 5/3), sponge spicules disseminated, foraminifers abundant,	
				13 cm layer buildup by sponge spicules,	
0.28				21 cm layer buildup by sponge spicules;	
1					

PROFESSOR LOGACHEV CRUISE 9

Station: 23
Core: LBC
Page 1 of 1

Recovery: 0.38 m Water Depth: 1422 m

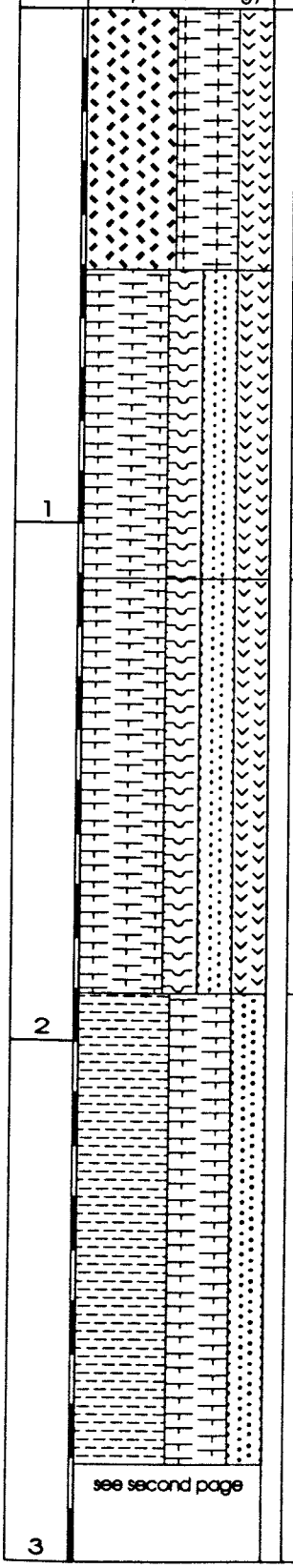


Structure	Color	Lithologic Description	Smear Slide
		Volcanic glass-foraminiferal ooze with nannofossils and sponge spicules	
	2.5Y 4/3	surface: silty sand, slightly clayey, olive brown (2.5Y 4/3), foraminifers, pteropods, less sponges, volcanic glass;	0
	2.5Y 4/3	Unit I: 0-6 cm: sediment according to surface	
	2.5Y 5/4	Unit II: 6-38 cm: clayey silty sand, yellowish brown (2.5Y 5/4),	
		17 cm: dull yellowish lense (2.5Y 6/3),	
		20 cm: irregular layer, yellowish brown (10YR 5/6),	
		26 cm: irregular lenses, yellowish brown (10YR 5/6),	
		34 cm: irregular lenses, yellowish brown (10YR 5/6);	

PROFESSOR LOGACHEV CRUISE 9

Station: 23
Core: GGC
Page 1 of 2

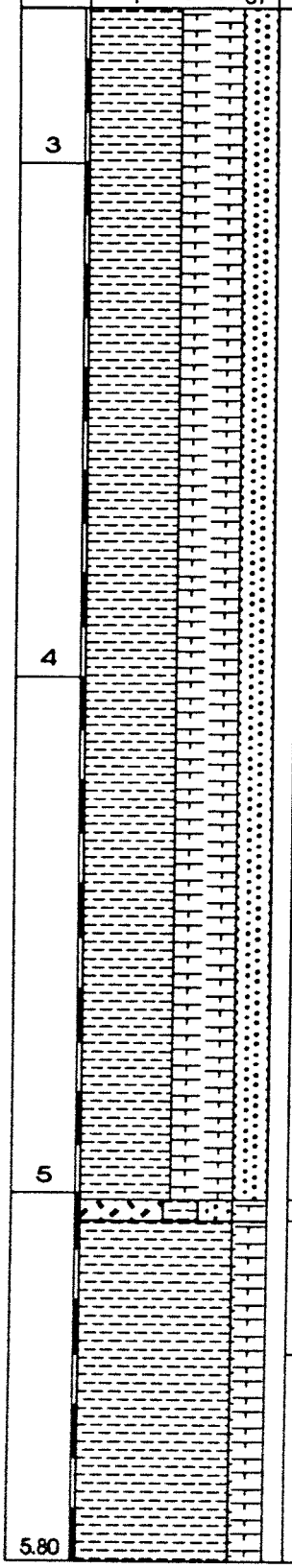
Recovery: 5.8m Water Depth: 1422m



PROFESSOR LOGACHEV CRUISE 9

Station: 23
Core: GGC
Page 2 of 2

Recovery: 5.8m Water Depth: 1422m



m	Structure	Color	Lithologic Description	Smear Slide
			Foraminiferal clay with quartz	
			Unit IV:	
			1.9-5.1 m: sandy silty clay,	
3			2.8-3.8m: clayey sandy silt	
			3.3 m: foraminferal quartz ooze, clayey sandy silt	330
			3.8-3.9 m: dark olive gray (2.5GY 3/1) silty sandy clay	
4			3.9-5.1 m: clayey sandy silt	
			Clayey volcanic ash with quartz and foraminifers	
5		7.5GY 3/1	Unit V: 5.1-6.12 m: ash layer, sandy clayey silt, dark greenish gray (7.5GY 3/1),	511
			Clay with foraminifers	
		2.5GY 3/1	Unit VI: 5.12-5.8 m: silty sandy clay to 4/1 dark olive gray (2.5GY 3/1. 4/1), mottled with grayish olive (7.5Y 4/2)	527
5.80				