METEOR-BERICHTE
98-1

Canary Islands 1996/97
Cruise No. 37
4 December 1996 - 22 January 1997

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1998

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Abstract

With two legs the German Research Vessel METEOR performed its 37th cruise from 4 December, 1996 to 22 January, 1997 in the Canary Island Region. The cruise started at Lisbon, Portugal and ended at Las Palmas, Canary Islands, Spain. Between the legs the harbor of Las Palmas was visited. Both legs were performed within two major projects of basic marine research. CANIGO (Canary Islands Azores Gibraltar Observations) is a multinational project funded by the European Union to investigate by field experiments and modeling the circulation and watermasses in the subtropical eastern North Atlantic and to determine the distribution and the fluxes of a diversity of parameters in this region. ESTOC is a European time series station that has been set up since 1994 in a joint effort of four institutes from Spain and Germany 60 nm north of Gran Canaria and Tenerife, and that serves as a background station for CANIGO. Main objectives were the recovery of sample material from the water column and the sea floor for micropaleontological, geochemical, chemical, and isotope analyses, the exchange and set of moorings with current meters and sediment traps at selected positions, and the study of sedimentary structures using geoacustic methods. This cruise report includes a summary of the research objectives, cruise narratives and first preliminary results together with extended tables on all stations occupied during the two legs of the expeditions. The cruise was funded by the Deutsche Forschungsgemeinschaft (German Science Foundation).

Zusammenfassung

Die 37. Reise des deutschen Forschungsschiffes METEOR fand in zwei Fahrtabschnitten vom 04. Dezember 1996 bis 22. Januar 1997 in die Kanarenregion statt. Die Expedition begann in Lissabon, Portugal und endete in Las Palmas, Kanarische Inseln, Spanien. Zwischen den Fahrtabschnitten wurde der Hafen von Las Palmas angelaufen. Beide Fahrtabschnitte waren in zwei Projekte der marinen Grundlagenforschung eingebunden. Hauptziele des von der Europäischen Union geförderten multinationalen CANIGO-Projektes (Canary Islands Azores Gibraltar Observations) sind die Bestimmung der Zirkulation und der Wassermassentransporte im subtropischen östlichen Nordatlantik und die damit zusammenhängenden Flüsse mehrerer biogeochemischer Parameter mit Hilfe von direkten Beobachtungen und Modellen sowie die Rekonstruktion der Einflüsse des küstennahen Auftriebes und des Eintrages von Saharastaub auf die Partikelflüsse im Ozean. Die Untersuchungen waren ferner in dem spanisch-deutschen Zeitserienprojekt ESTOC (European Station for Time Series in the Ocean, Canary Islands) eingebunden, welches etwa 100 Km nördlich von Gran Canaria und Teneriffa seit 1994 betrieben wird. Schwerpunkte der Arbeiten während der METEOR-Fahrt waren Probenahmen aus der Wassersäule und vom Meeresboden, die Erfassung der Sedimentstrukturen mit geoakustischen Methoden sowie die Aussetzung und der Austausch von Strömungsmesser und Partikelfallen. Dieser Expeditionsbericht enthält eine Zusammenfassung der Forschungsziele, Berichte zum Fahrtverlauf und erste, vorläufige Forschungsergebnisse zusammen mit umfangreichen Tabellen zu den Arbeiten auf den einzelnen Stationen der zwei Fahrtabschnitte. Die Reise wurde durch die Deutsche Forschungsgemeinschaft gefördert.

1. Research objectives

The work during the two legs of METEOR cruise no. 37 was embedded mainly in two major interdisciplinary and multinational projects: the European funded CANIGO (Canary Islands Azores Gibraltar Observations) and the Spanish German ocean time series station ESTOC (European Station for Time Series Observations, Canary Islands). 100 km north of Gran Canaria. The CANIGO programme is financially supported by the MAST III programme (Contract MAS3-CT96-0060). The ocean domain covered by CANIGO is a special region in European waters as it includes the eastern subtropical North Atlantic gyre, a coastal upwelling zone, the Mediterranean Atlantic exchange, and the deposition of aeolic particle from the Sahara. This combination of large-scale phenomena makes it a key region for global-scale processes. The understanding of the physical fluxes and the related biological and geochemical proceses thus contributes to the scientific knowledge in the much wider context of climate change. The main objective of CANIGO is to understand the functioning of the marine system in the Canary-Azores-Gibraltar region of the Northeast Atlantic Ocean and its links with the Alboran Sea through comprehensive interdisciplinary basin scale studies. Therefore, the METEOR cruise 37 has two general scientific objectives. On leg M 37/1 it is planned to quantify the influence of the coastal upwelling and the Saharan dust on particle fluxes in the Canary region and to investigate its change through the last glacial and interglacial periods. On leg M 37/2 it is scheduled to obtain an improved knowledge of the physical processes controlling the subtrobical gyre and the related mesoscale circulation through observations and circulation models.

The main goal of the first leg (Fig.1) was to sample sedimentary deposits along a series of transects from the shelf off Morocco to the open ocean. In addition, a 29° transect was planned from the eutrophic shelf via the ESTOC station to the oligotrophic open ocean north of La Palma. On all transects gravity corer, large box corer and multicorer were employed. Detailed analyses of this sample material with geochemical, sedimentological, micropaleontological and isotopic methods will determine the regional sedimentation patterns and their mostly climatically controlled late Quaternary variations. Another main topic was the investigation of the particle flux through the water column. North of La Palma a sediment trap mooring was deployed and at the ESTOC station north of Gran Canaria the sediment trap mooring was recovered and redeployed. During this leg continuous geoacoustic recording was performed using the ship's systems PARASOUND and HYDROSWEEP.

The area north of the Canary Islands and until the latitude of Madeira is characterised in the upper layers by recirculating branches of the North Atlantic's subtropical gyre that feed the Canary Current and that are influenced by upwelling events off the African coast. Therefore the second leg of METEOR cruise 37 was aimed at studying the circulation and transports of water masses, the associated fluxes of bio-geochemical parameters in the water column and through the air sea surface in this area and their variability in space and time.

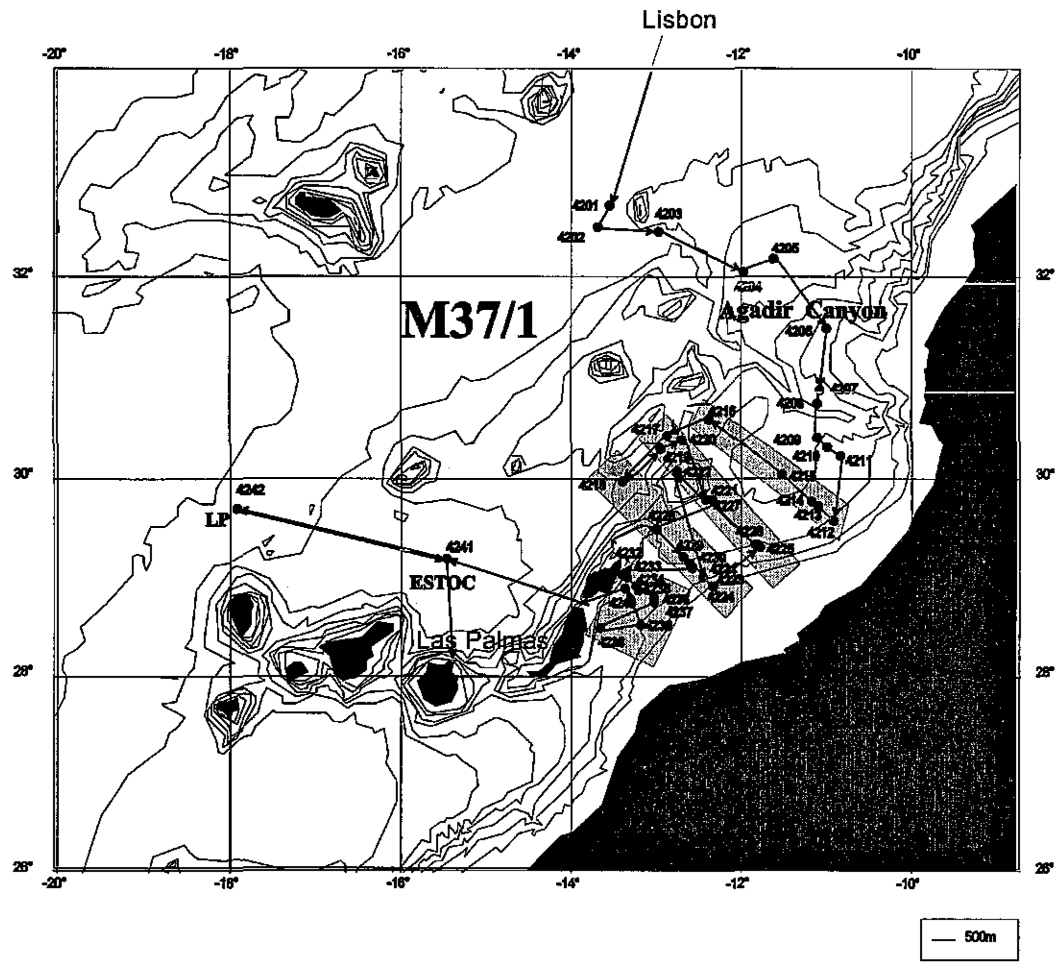
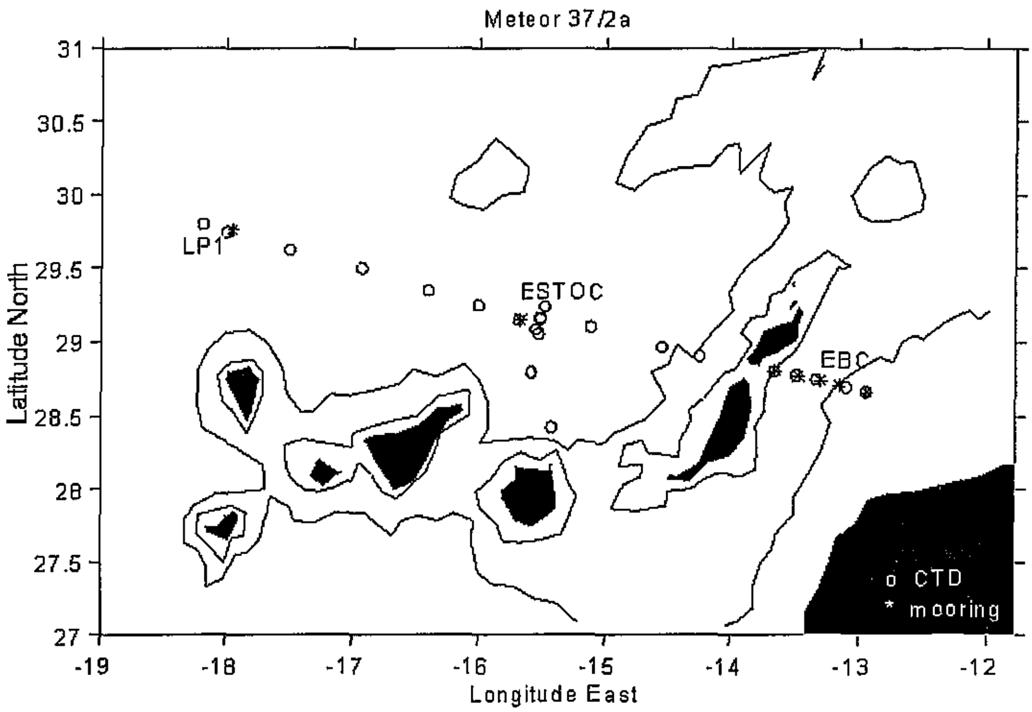


Fig. 1 Cruise track and sampling positions during M 37/1

Methods included to use moored current meters and sediment traps to study the vertical structure of the eastern boundary current and sedimentation rates of a diversity of bio-chemical parameters at three key sites (Fig. 2, upper panel): (i) in an array of 5 moorings (EBC) east of Fuerteventura / Lanzarote, an area that is strongly influenced by upwelling, (ii) at the open ocean time series station ESTOC which serves also as a background station for CANIGO, and (iii) at the more oligotrophic station LP1 north of La Palma.

To estimate the spatial structure and variability of fluxes in the recirculation regime, a hydrographic box of 45 stations was obtained north of the Canary Islands (Fig. 2, lower panel) to estimate transports of waters masses and bio-chemical parameters. Classic hydrography along with direct current measurements from lowered and ship mounted ADCP was used. Samling included also CO_2 parameters, DOC, Al and other trace metals, coccolithophores, diatoms, zooplankton, and fish larvae.



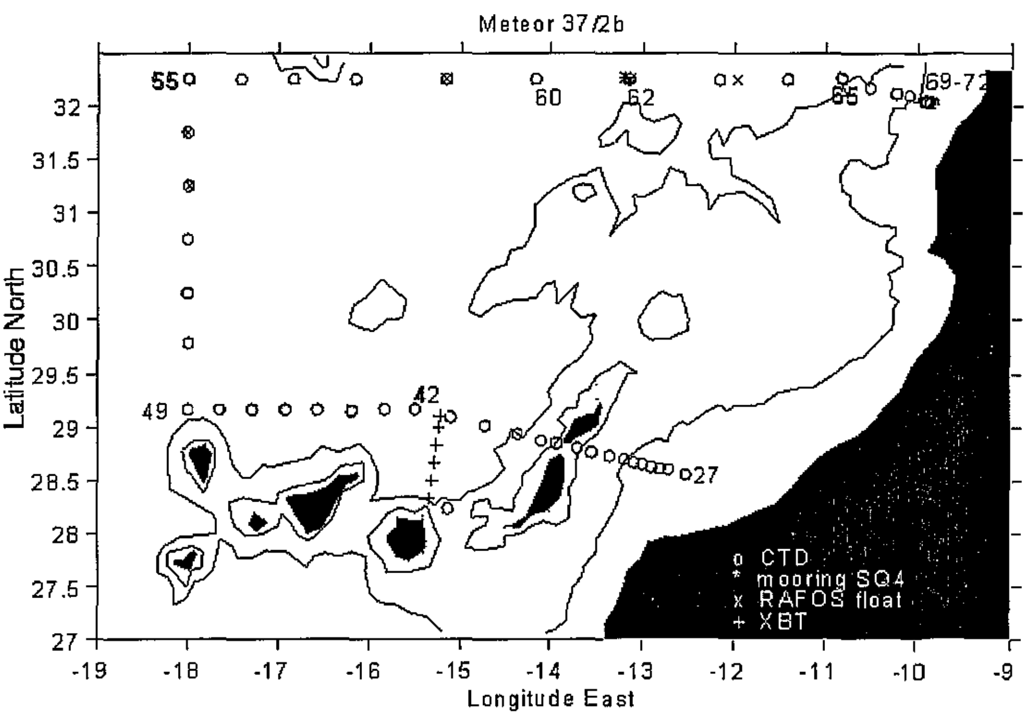


Fig 2: Station Map M 37/2a (upper panel) and M 37/2b (lower panel) with positions of CTD casts (o), moorings (*), and launched floats (x) and XBTs (+)

Tab. 1 Legs and chief scientists of METEOR cruise no. 37

Leg M 37/1

04 December 1996 - 23 December 1996

Lisbon/Portugal - Las Palmas/Canary Islands/Spain

Chief Scientist: Prof. Dr. G. Wefer

Leg M 37/2

28 December 1996 - 22 January 1997

Las Palmas - Las Palmas

Chief Scientist: Dr. T. J. Müller

Coordination:

Prof. Dr. G. Wefer

Masters (F.S. METEOR):

Leg M 37/1

Captain D. Kalthoff

Leg M 37/2

Captain M. Kull

2. Participants

Tab. 2 Participants of METEOR cruise no. 37

Leg M 37/1

Name	Subject	Institution
Wefer, Gerold, Prof. Dr. (Chief Scientist)	Marine Geology	GeoB
Abrantes, Fátima, Dr.	Micropalaeontology	IGM
Bassek, Dieter, Technician	Meteorology	DWD
Bollmann, Jörg, Dr.	Micropalaeontology	ETH
Bozzano, Graziella, M.Sc.	Sedimentology	UB
Diekamp, Volker, Technician	Marine Geology	GeoB
Dittert, Lars, Dipl.-Geol.	Geochemistry	GeoB
Eberwein, Astrid, Student	Marine Geology	GeoB
Klump, Jens, M.Sc.	Marine Geology	GeoB
Kuhlmann, Holger, Student	Marine Geology	GeoB
Lindblom, Sten, Dr.,	Organic Geochemistry	US
Meggers, Helge, Dr.	Marine Geology	GeoB
Meinecke, Gerrit, Dr.	Marine Geology	GeoB
Metzler, Wolfgang, Dipl. Ing.	Marine Geology	GeoB
Moustafa, Yaser, Dipl. Geol.	Marine Geology	GeoB
Peters, Manno, Dr.	Meteorology	DWD
Ratmeyer, Volker, Dipl. Geol.	Marine Geology	GeoB
Rieß, Wolfgang, Dipl. Biol.	Biogeochemistry	MPI
Rosiak, Uwe, Technician	Marine Geology	GeoB
Segl, Monika, Dr.	Marine Geology	GeoB
Skoglund, Sverker, Dipl. Ing.	Marine Geology	GeoB
Targarona, Jordi, M.Sc.	Sedimentology	UB
Vaqueiro, Sandra, Student	Micropalaeontology	IGM
Waldmann, Christoph, Dr.	Marine Geology	GeoB
Wenzhöfer, Frank	Biogeochemistry	MPI/GeoB
Zabel, Matthias	Geochemistry	GeoB

Leg M 37/2

For logistic reasons, the leg M 37/2 had two parts:

Part 37/2a: Las Palmas-Las Palmas, 28.12.1996 - 05.01.1997

Part 37/2b: Las Palmas-Las Palmas, 06.01.1997 - 22.01.1997

			Leg M 37/2	
			a	b
Name	**Subject**	**Institution**		
Müller, Thomas J., Dr.	Physical Oceanography	IFMK	--------------	--------------
Chief Scientist				
Beining, Peter, Dr.	Physical Oceanography	IFMK		------
Busse, Markus, Student	Physical Oceanography	IFMK	--------------	--------------
Cisneros-A., Jesus, M. Sc.	Physical Oceanography	ULPGC	------	
Garcia-R., Carlos, M. Sc.	Physical Oceanography	IEO	------	
Hernandez-G., Alonso, Dr.	Physical Oceanography	ULPGC	------	
Kipping, Antonius, Techn.	Moorings	IFMK	------	
Koy, Uwe, Techn.	CTD, floats	IFMK	--------------	--------------
Lopez.-L., Federico, M. Sc.	Physical Oceanography	IEO	------	
Meyer, Peter, Dipl-Ing.	Moorings, CTD	IFMK	--------------	--------------
Rose, Henning, Dipl-Phys.	Tracer Oceanography	UBT	------	
Schuster, Connie, Techn.	Physical Oceanography	IFMK	------	
Torre, Silvia, M. Sc.	Physical Oceanography	IEO	------	
Neuer, Susanne, Dr.	Particle Flux	GeoB	------	
Kemle-v. Mücke, S., Dr.	Foraminifera	GeoB	------	
Darling, Kate, Dr.	Foraminifera	UoE	------	
Stewart, Ian, Student	Foraminifera	UoE	------	
Otto, Sabine, Dr.	Trace metals	UBMCh	------	
Deeken, Aloys, Dipl. Chem.	Trace metals	UBMCh	------	
Kukolka, Florian, Student	Trace metals	UBMCh	------	
Correira, Antonio, Techn.	Diatoms	UL		------
Bollmann, Jörg, Dr.	Coccolithophorides	ETH		------

Leg M 37/2 - continued

Name	Subject	Institution	Leg M 37/2 a	Leg M 37/2 b
Barth, Hans, Dr.	Marine optics	UO	------	
Zielinski, Oliver, Dipl-Phys.	Marine optics	UO	------	
Loquay, Klaus, Techn.	Marine optics	UO	------	
Hernandez-B., Joaquin Dr.	Trace metals	ULPGC	------	
Gelado C., Maria, M. Sc.	Trace metals	ULPGC	------	
Munoz, Francisco, Student	Trace metals	ULPGC	------	
Mintrop, Ludger, Dr.	CO_2	GeoB	------	
Gonzalez-D, Melchior, Dr.	pH, Alkalin.	ULPGC	------	
Perez, Fiz, Dr.	CO_2	CIMV	------	
Friis, Karsten, Student	CO_2	IFMK	------	
Cianca-A, Andres, M. Sc.	Marine chemistry	ICCM	------	
Godoy, Juana, M. Sc.	Marine chemistry	ICCM	------	
Perez-M., Francisco, M. Sc	Marine chemistry	ICCM	------	
Villagarcia, Maria, Dr.	Marine chemistry	ICCM	------	
Fengler, Günther, Dr.	DOC	IBGM	------	
John, Hans-Christian, Dr.	Zooplankton	BAH	------	
Zelck, Clementine, Dipl.-Biol.	Zooplankton	BAH	------	

Tab. 3: Participating Institutions

BAH	Biologische Anstalt Helgoland Zentrale Hamburg Notke Straße 31 D-22607 Hamburg Germany
CIMV	Consejo Superior de Investigaciones Instituto Investigacions Mariñas Eduardo Cabello 6 E-36208 Vigo Spain
DWD	Deutscher Wetterdienst Geschäftsfeld Seeschiffahrt Bernhard-Nocht-Straße 76 D-20359 Hamburg Germany
ETH	Geologisches Institut ETH Zentrum Sonneggstr. 5 CH-8092 Zürich Switzerland
GeoB	Fachbereich 5 - Geowissenschaften Universität Bremen Klagenfurterstr. D-28359 Bremen Germany
IBGM	Institut für Biogeochemie und Meereschemie Universität Hamburg Edmund-Siemers-Allee 1 D-20146 Hamburg Germany
IGM	Instituto Geológico e Mineiro Rua das Academia das Ciências 19-2° POR-1200 Lisbon Portugal
IFMK	Institut für Meereskunde Universität Kiel Düsternbrooker Weg 20 D-24105 Kiel Germany

ICCM	Instituto Canario de Ciencias Marinas Dirección General de Universidades e Investigación Consejeria de Educacion E-35200 Telde Canary Islands, Spain
IEO	Instituto Español de Oceanografia Centro Oceanografico de Canarias Avda. San Andres km 7 E-38170 Santa Cruz de Tenerife Canary-Islands, Spain
MPI	Max-Planck-Institut für Marine Mikrobiologie Celsius Straße 1 D-28359 Bremen Germany
UB	Universidad de Barcelona Instituto de Ciencias del Mar CSIC Paseo Joan de Borbo s/n E-08039 Barcelona Spain
UBMCh	Fachbereich 2 - Biologie/Chemie Meereschemie Universität Bremen Leobener Straße D-28359 Bremen Germany
UBT	Fachbereich 1 - Physik Tracerozeanographie Universität Bremen Kufsteiner Str. 1 D-28359 Bremen Germany
UoE	University of Edinburgh Grant Institute Dept. of Geology and Geophysics West Mains Road GB-Edinburgh, EH9 3JW United Kingdom

UO	Carl von Ossietzky Universität Oldenburg Fachbereich Physik Carl von Ossietzky Str. 9-11 D-26111 Oldenburg Germany
UL	Instituto de Oceanografia Faculdade de Ciencias Univ. de Lisboa Campo Grande POR-1700 Lisboa Portugal
ULPGC	Universidad de Las Palmas de G. Canaria Edificio de Ciencias Básicas Campus Universitario Tafira E-35017 Las Palmas de Gran Canaria Canary-Islands, Spain
US	University of Stockholm Dept. of Geology and Geochemistry S-10691 Stockholm Sweden

3. Research Programme

Leg M 37/1

Purpose of this cruise was the investigation of biogeochemical processes and fluxes on different spatial and temporal scales in relation to water mass circulation. Research during this cruise was linked to the long time observation at the Spanish-German time-series station ESTOC. Also field work for the European MAST-III-Programme CANIGO was started with this METEOR cruise. Particle flux observations in the water column and sediment sampling were undertaken. In addition lander-systems were deployed and equipment for recording particle fluxes to the deep-sea were tested.

Special aim of the METEOR-cruise 37/1 was the determination of the variability of biogeochemistry parameters and their relation to the spatial extension of the water masses in the region north of the Canary Islands. Sediment sampling will give an indication about variability of particle flux and deposition of atmospheric dust during the last glacial- and interglacial periods. Also the reaction rates of the organic material and its decomposition at the sediment/bottom-water-boundary along the productivity gradient north of the Canary Islands from the shelf via the ESTOC-station to a position north of La Palma will be measured. The timing of this METEOR-cruise overlaps with the highest plankton-productivity observed in this region, the winter bloom.

After intensive PARASOUND- and HYDROSWEEP- measurements in the Agadir Canyon, on 4 profiles between the Moroccan coast and the Canary Islands, and on a zonal transect along 29°N, suitable locations were sampled with conventional wireline coring techniques and will be subsequently analysed on shore using physical, isotopic, micropaleontological and sedimentological methods. In addition to the sediment sampling, the sediment trap mooring at the ESTOC-station was retrieved and redeployed. Furthermore, a JoJo-CTD (Conductivity Temperature Depth) was tested.

Most of the research during METEOR-Leg 37/1 is related to a subproject within the EU-project CANIGO. CANIGO is a multidisciplinary programme within MAST III ("Marine Science and Technology"), consisting of 4 subprojects. The overall aim of Subproject 3 within CANIGO ("Particle Flux and Paleoceanography in the Eastern Boundary Current System“) is to quantitatively determine the influence of coastal upwelling and Saharan dust on the magnitude and composition of particle flux in the Canary region, and to investigate how this influence changed through the last glacial and interglacial period.

Particle flux

Seasonal particle sedimentation has been monitored over several years in the Eastern Boundary Current. Particle flux is investigated by deploying a sediment trap mooring at the ESTOC station. These mooring contain three sediment traps (20 cup collector), the upper one at least 500 m above the sea-floor, the lower one at least 500 m below surface. The particulate material collected will be analysed to determine total flux, particulate flux, particulate organic carbon, particulate nitrogen, biogenic opal, carbonate and carbon isotopes of organic matter, and lithogenic material. The trapped material will further be investigated for species composition of the planktonic organisms (pteropods, foraminifera, radiolaria, coccolithophorids, and diatoms), together with the chemical and isotopic compositions of these organisms and the composition of the organic and terrigenous material. The objective of these studies is to identify signals of seasonal variations in those components, which play an important role in the sediment formation process. The results of these investigations will form a basis for the reconstruction of paleo-current systems and paleoproduction from the sediments.

Particle Camera

A particle camera was used in profiling mode from shipboard to investigate concentration, nature and sinking speed of particulate matter. The main goal is to quantify particle flux and determine its composition on seasonal and interannual time scales to be able to discern autochthonous export production from the eolian input and deep and shallow sources of advected particulate matter.

Geochemistry

Detailed measurements of concentration gradients in the pore water were undertaken. Extensive analyses of the sediment are planned at shore to quantify processes of early diagenesis in marine sediments from different productivity regions. The results are used to supplement already existing geochemical model programmes on early diagenesis. Another research topic was the comparison between in situ and laboratory measurements to quantify geochemical changes affected by pressure relief and warming during sampling. For this purpose incubation experiments on core material were carried out.

Biogeochemistry

The goal of the projects conducted by the MPI is to understand the quantitative importance of the dominant mineralization processes in the upwelling region along the African coast as a function of organic sedimentation rates due to different surface productivities or to different water depths. The microbial transformation rates of the elements C, O, Mn, Fe and S were studied with in-situ techniques or on board the ship. The role of the main electron acceptors, O_2, NO_3^-, Mn (IV), Fe (III) und SO_4^{2-} for the oxidation of organic material was analysed by direct process measurements. The data will be compared with the results from geochemical modelling of the same processes.

Marine Geology/ Sedimentology

The structures of the near-surface sediments, which reflect the effects of paleoceanographic and paleoclimatic variability in the sedimentation processes, were continuously recorded at high resolution during the entire METEOR Cruise 37/1 with the PARASOUND echosounder.

In addition, a survey of the general morphologic setting was achieved by the swath bathymetry system HYDROSWEEP. Both acoustic board systems are normally used on site to find suitable locations of sediment sampling. Analyses of surface samples recovered with boxcorers and multicorers together with sediment sequences from gravity- and piston cores should result in a detailed picture of both the recent sedimentary environment and former glacial/interglacial fluctuations.

Micropalaeontology/Biology

The abundance and composition of planktonic foraminifera and pteropods will be determined on samples from the water column (in 5 depth intervals) which have been taken by using multiple opening-closing net hauls. In addition samples were taken to determine the species composition of dead and living benthic foraminifera (greater 63 µm) along the Moroccan coast and across a productivity gradient from the coast seaward using a multicorer and rose bengal staining of live protoplasm.

Leg M 37/2

Along the CANIGO and ESTOC scientific goals, METEOR cruise M37/2 was aimed at providing a data base for studying the circulation and water mass transports in the subtropical eastern North Atlantic north and east of the Canary Islands. The region encompasses the eastern boundary current system. Determining the variability of the circulation and associated bio-geochemical fluxes on time scales from days to annual and longer, and on spatial scales that include the mesoscale (30 km) up to basin scale is included. The flow field, the water mass transports and the associated bio-geochemical fluxes in the region are strongly influenced by both, the recirculation of the subtropical gyre that feeds the Canary Current and the seasonally varying trade wind field with its impact on the upwelling system and the eastern boundary current system off Morocco.

To attack the problem, basically two methods are used. First, at selected positions the vertical structure of currents and the vertical transport of particles are measured for a period of ca 18 months from January 1997 on to cover more than one season. The sites chosen (see Fig. 2) are the ESTOC position, an array of five moorings in the eastern boundary current system (EBC) east of Lanzarote and Fuerteventura that will be influenced strongly by upwelling events, and a more oligotrophic open ocean position north of La Palma (LP1). Current meters and sediment traps will be moored, with a service of instruments scheduled for autumn 1997 from the German reserach vessel POSEIDON. During the first part of M37/2, it was planned to

- exchange the ESTOC current meter mooring (IFMK)
- to set the five moorings array EBC (IFMK, IEO, ULPGC, GeoB)
- to set a mooring at site LP1 (GeoB, IFMK)
- to measure the vertical particle flux in the upper 200 m near ESTOC and at the same time to perform incubation experiments (GeoB)
- to measure the concentraions and vertical fluxes of certain trace metals at the ESTOC, EBC and LP1 sites (UBMCh)
- to take samples for CFCs as reference for the time varying input function at ESTOC (UBT)
- to determine the near surface distribution of foraminifera (GeoB, UoE)

Second, a closed box north and east of the Canary Islands is designed with 45 hydrographic stations spaced between 7 nm on and close to the shelf, and 40 nm in the deep basin. On each station, bottom deep CTD and lowered ADCP measurements and water sampling for dissolved oxygen, nutrients and chlorophyll analysis build the basic hydrographic measurements to determine the flow field and the water mass distribution. Enroute, the upper ocean current profiles down to 200 m and the sea surface temperature and salinity are measured using a vessel mounted ADCP and a thermosalinograph in combination with GPS positioning. These basic measurements on the box will be repeated in autumn 1997 and spring 1998 with POSEIDON, and in summer 1998 with METEOR. During the second part of M 37/2 these and additional samples were taken and measurements were made to

- to determine the absolute flow field and with a CTD/rosette/ADCP system and with shipborne ADCP (IFMK)
- to provide water mass information from oxygen, nutrient and chlorophyll (ICCM)
- to use optical sensors attached to a CTD for biological interpretations (UO)
- to measure parameters of the CO_2 system in the water column and at the air sea interface (IFMK, CIMV, ULPCG)
- to take samples for dissolved organic carbon DOC (IBGM)
- to take samples for coccolithophores and diatoms (ETH, UL)
- to measure aluminium and other metals in the water column (ULPGC)

- to detect fish larvae as tracers for intermediate water masses (BAH)

4. Narrative of the Cruise

4.1 Leg M37/1 (G. Wefer)

METEOR departed Lisbon on Wednesday, 4 December, 1996 at 17:00, beginning the first leg of the 37th Cruise. Departure was delayed for several hours due to late arrival of freight and bunker oil caused by the OSZE conference which took place at Lisbon from December 1 to 3, 1996. On board were 16 colleagues from the Geoscience Department of Bremen University, one from ETHZ Zürich, two from Instituto Geologico e Minero Lisbon, two from Instituto de Ciencias del Mar Barcelona, one from Department of Geology and Geochemistry Stockholm, two from Max-Planck-Institute for Marine Microbiology in Bremen and two from the Sea Weather Office in Hamburg. On the way to the first station in the Agadir Canyon, PARASOUND and HYDROSWEEP systems were used.

The first working area in the Agadir Canyon was reached about 1.5 days later (Fig. 1). After surveys with PARASOUND and HYDROSWEEP sediments were sampled at 11 stations with multicorer, boxcorer and gravity corer in water depths between 1700 and 4300 meters. After finishing the program in the Agadir Canyon, four profiles perpendicular to the coast of Morocco were sampled with multicorer and gravity corer. At two stations a piston corer was used. The objective of sampling transects perpendicular to the coast is to obtain sediment material to reconstruct the history of coastal upwelling and Saharan dust supply during the last glacial/interglacial cycles. Initial results indicate that the 6 to 12 m long cores in water depths between 400 and 2500 m were collected with very little disturbance of the recovered material. Core descriptions and initial stratigraphic analyses show continuous sedimentation in most cores and normal sedimentation rates for this area. At two profiles the lander systems PROFILUR and ELINOR were deployed and recovered about two days later. Furthermore the JoJo-CTD-system TRAMP was tested on a cable. After 12 days the sampling program on the continental slope of Morocco was completed and the ESTOC station north of Gran Canaria was reached.

On December 18, 1996 the CI-6 sediment trap mooring (deployed with POLARSTERN last year) was recovered and mooring CI-7 was deployed. Both moorings were equipped with three sediment traps, several current meters and pumping systems to collect particulate material. A first inspection of the sampling bottles of mooring CI-6 shows distinct seasonal flux patterns. In addition, sediment cores were recovered with box and gravity corers and plankton was sampled with a multiple closing net from different water depths. After deployment of both lander systems at the ESTOC station, METEOR took course west to the next mooring station.

After arriving at the mooring station north of the Island of La Palma, the TRAMP system was deployed for a 12 hours in free-drifting mode, followed by sampling sediment with multicorer, boxcorer and gravity corer. In the morning of December 20 the TRAMP system was recovered. Due to strong winds and high waves a mooring equipped with sediment traps and current meters could not be deployed. It was planned to deploy this mooring during Leg 37/2 at the beginning of January.

On the way to Las Palmas the two lander systems were recovered at the ESTOC station. After completion of the work, METEOR continued to Las Palmas harbour, arriving on December 22, at 17:00, ending the first leg of cruise 37.

4.2 Leg M37/2 (T. J. Müller)

For logistic reasons, this leg was divided into two parts. After loading of scientific equipment and embarking of the scientific party, METEOR sailed from Las Palmas on the 28 December 1996 in the afternoon. This first part, leg M 37/2a, was aimed at mooring and station work near the centre of the CANIGO array in the eastern boundary current system (EBC), at the ESTOC station and at the more oligotrophic CANIGO position LP1 north of the island of La Palma (Fig.2). Here, special water sampling was performed for trace metal analysis. Near ESTOC, an experiment was designed to determine the vertical flux of particles in the surface layer. On station, plankton was caught from near the surface using pumps and handhold nets. Additional CTD stations between the mooring positions completed the hydrographic work. En route, meteorological data, sea surface temperature and salinity were measured almost continuously from the ship-borne thermosalinograph. Unfortunately, we could not measure the vertical current profiles due to a failure of the ADCP mounted on the ship's hull. A spare was available only later for leg M 37/2b.

About 4 hours after sailing for leg M 37/2a, we successfully performed a test station with a CTD/rosette system. Attached to the CTD/rosette were two acoustic releases of IFMK to test for later use in moorings.

Early in the morning next day, we arrived at the ESTOC station position at nominally 29°10'N, 15°30'W and 3610 m water depth. Here, after a CTD/rosette cast, the first two of five casts with special bottles and pumps for trace metal sampling were obtained to achieve a densely sampled profile throughout the water column. Between these casts, at a position some 10 nm north-east of ESTOC a drifting sediment trap was deployed to measure for a few days the particle flux in the upper 200 m layer.

We then steamed to the position of the first of five CANIGO moorings that we deployed in the eastern boundary current array EBC on the 30 Dec and 31 Dec 1996 during day time. The five moorings all reach up to 150 m below the surface and carry a total of 23 current meters and 2 sediment traps. During the night and between the mooring work, five CTD stations near the mooring positions and three hydrocasts for a trace metal profile near mooring EBC3 were obtained. The CTD stations form a section across the channel between Lanzarote/Fuerteventura and the Morroccian shelf.

While steaming again to the ESTOC station, we celebrated New Year's Eve with a mixture of German and Spanish traditions. On New Year's Day morning, the third of five trace metal casts and a shallow CTD/rosette profile for water sampling at the ESTOC position was obtained. We then searched successfully for the drifting sediment trap for recovery. After almost immediate redeployement of the trap, another shallow CTD/rosette was taken to supply water for the incubation experiment that runs while the trap is drifting. In the afternoon, the ESTOC current meter mooring was successfully recovered after 15 months. All meters have worked. The fourth and fifth trace metal cast and a CTD/rosette cast close to the bottom with CFC sampling were obtained during the night.

We then steamed towards the position LP1 north of the island of La Palma at nominally 29°45'N, 18°00'W. We reached that position on 02 Jan 1997, performed another test with an acoustic release attached to the CTD/rosette, took the first two of three trace metal casts and a deep CTD/rosette cast. On 03 Jan 1997 we deployed CANIGO mooring LP1 with two sediment traps and three current meters. The final trace metal cast completed the work at this position.

Heading again for the ESTOC position, we took four CTD stations down to 2000 m below the Mediterranean outflow water to achieve additional information on the thermocline circulation north of the Canary Islands. The ESTOC current meter mooring was set and the drifting sediment trap successfully recovered on 04 Jan 1997. Five CTD stations towards Lanzarote/Fuerteventura completed a section that starts at the African shelf, passes the current meter array EBC and the ESTOC position and reaches to the mooring position LP1.

METEOR called port of Las Palmas on 05 Jan 1997 for personnel exchange. The groups from the IEO, ULPGC, GeoB, UBMCh, UBT and UoE involved in mooring work, trace metals, CFC and foraminifera disembarked. Embarking were groups from eight institutes from four nations.

METEOR sailed from Las Palmas for Leg M37/2b on 06 Jan 1997 in the evening (Fig.2). In port, a spare ADCP had been mounted in the ship's moon pool for enroute upper ocean direct current measurements. Leg M37/2b was aimed to measure and sample important hydrographic, chemical and bilogical parameters on a closed box north of the Canary Islands for balance and flux calculations. In addition to the upper ocean enroute current profile and sea surface temperature and salinity, pCO2 was measured by pumping water from the pool.

After a test station late in the evening on the same day, station work started on 07 Jan 1997 east of Lanzarote and Fuerteventura on the shelf at 100 m water depth with a station spacing of 7 nm that was increased to 20 nm towards the ESTOC position. Each station consisted of a bottom deep CTD/rosette cast with sampling for dissolved oxygen, nutrients and chlorophyll. Attached to the CTD/rosette was an ADCP to measure the absolute current profile in the whole water column. Also on each station, another CTD with optical sensors attached took casts down to 2000 m. Samples for the CO_2 system, dissolved organic carbon, aluminium, coccolithophores and plankton were taken from the rosette bottles on roughly every other station. Deep plankton net hauls down to 1000 m and on some stations down to 2000 m were restricted to the continental shelf break and the adjacent deep basin.

The box basically consists of three CTD/rosette sections: the first runs almost zonally along mooring array EBC towards ESTOC and then to a position north of La Palma at 29°10'N, 18°00'W, the second meridionally towards Madeira until 32°15' N, the third then zonally onto the shelf until the 100 m bottom contour. A total of 45 stations were obtained on these three sections. The box was then completed with enroute ADCP measurements that ran south-westward and almost parallel to and on the shelf break towards the EBC array.

The routine station work was interrupted by several events. First, on the westbound section a helicopter from the regional Canary Islands rescue basis supplied with a chemical that was essential for the oxygen standardisation. The chemical that had been brought onboard in port had turned out not to fulfil its specifications. Next, on the south-west corner of the box, we had to interrupt the station work for several hours due to gale winds. On the northbound section, two RAFOS floats were launched to 1000 m nominal depth within the EU funded EUROFLOAT programme. Three further floats were launched on the northern eastbound section, the third one of these (No. 214) was positioned as to be caught by Meddy 'Jani' that was detected by CTD measurements on station 63 at 32°15'N, 12°10.1'W. Also, a sound source (SQ4/V379) was moored on this section at 32°16' N, 13°12' W to improve tracking of RAFOS floats that drift towards the Canary islands within the CANIGO and EUROFLOAT projects.

After having completed a final ADCP section that closed the box along the 200 m depth contour off Morocco, METEOR again headed towards the ESTOC position to obtain an XBT section with six launches from here towards Gran Canaria. This section is part of the regular monthly ESTOC station work performed by the ICCM. Leg M 37/2b was completed in Las Palmas on 22 Jan 1997 early in the morning.

5. Preliminary Results

5.1 Marine Geoscience M 37/1

5.1.1 CTD-O_2-Chlorophyll Probe

(V. Ratmeyer, G. Meinecke)

The CTD-profiler SEABIRD SBE 19 equipped with an oxygen sensor and a SEATECH fluorometer was attached 30 m above the multicorer. Additionally, the CTD was mounted above the ParCa camera system. The raw data were recovered on board and downcast standard plots were immediately produced. Problems arouse with the fluorometer cell which recorded constantly spiking values at depths below 500 m. A total of 7 profiles were taken between the Agadir Canyon (GeoB 4201) and the La Palma station (GeoB 4242).

Figs. 3-4 show CTD profiles, from the Agadir Canyon, and the Canary Island region north of La Palma Island. In the Agadir Canyon (GeoB 4201, Fig. 3) a rapid decrease in the oxygen content was found below the main thermocline situated in 120 m. Low oxygen contents (around 6 mg/l) were measured between 600 and 1200 m water depth, where the Mediterranean Outflow Water could be identified concurrently with high salinity values around 36 psu. Oxygen values increased rather continuously down to 2200 m water depth where they reached about 8 mg/l in the NADW. A subsurface chlorophyll concentration maximum at 100 m was observed a this site, just above the thermocline.

At the LP station (GeoB 4242, Fig. 4) a similar stratification of the water column was found, but with slightly higher temperatures at surface and higher chlorophyll values.

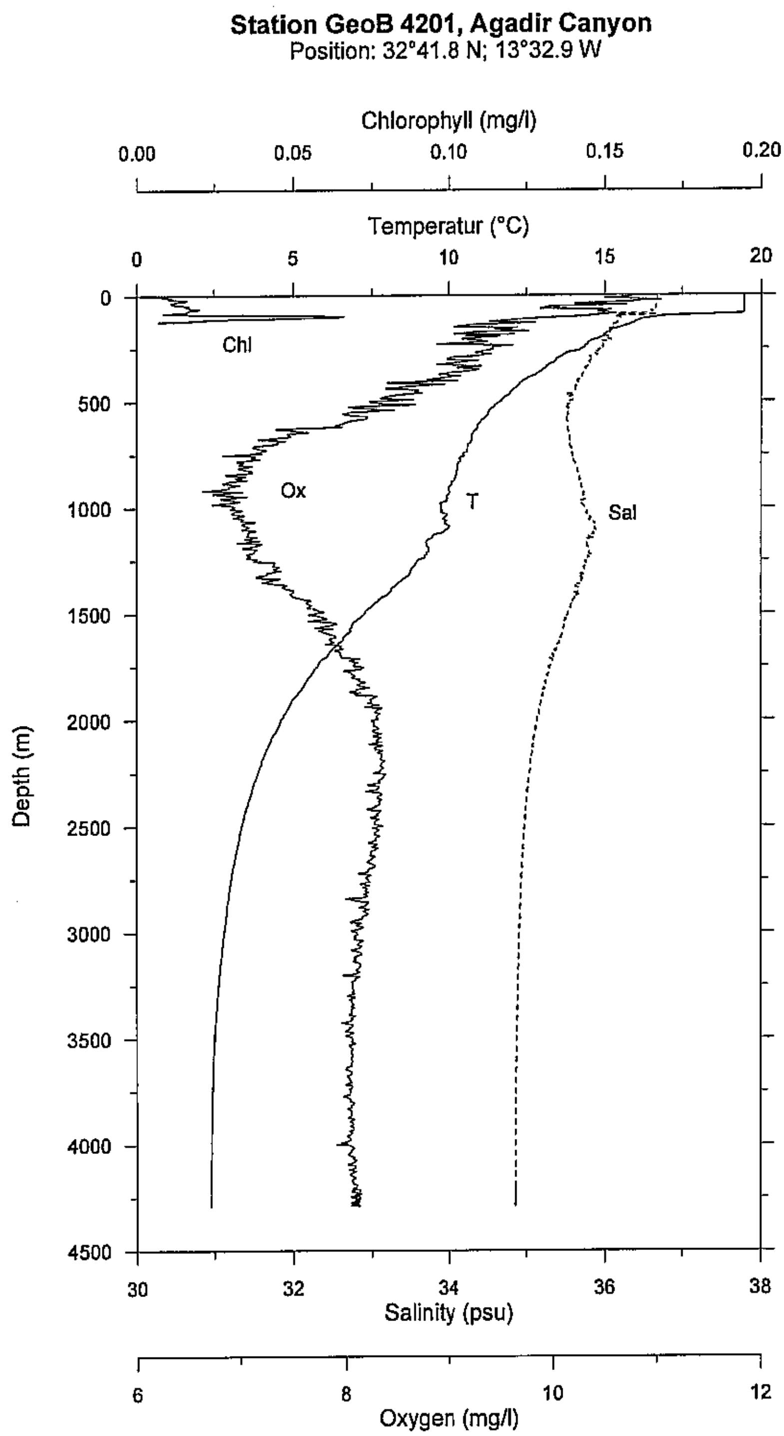


Fig. 3: CTD-, Oxygen and chlorophyll values at site GeoB 4201

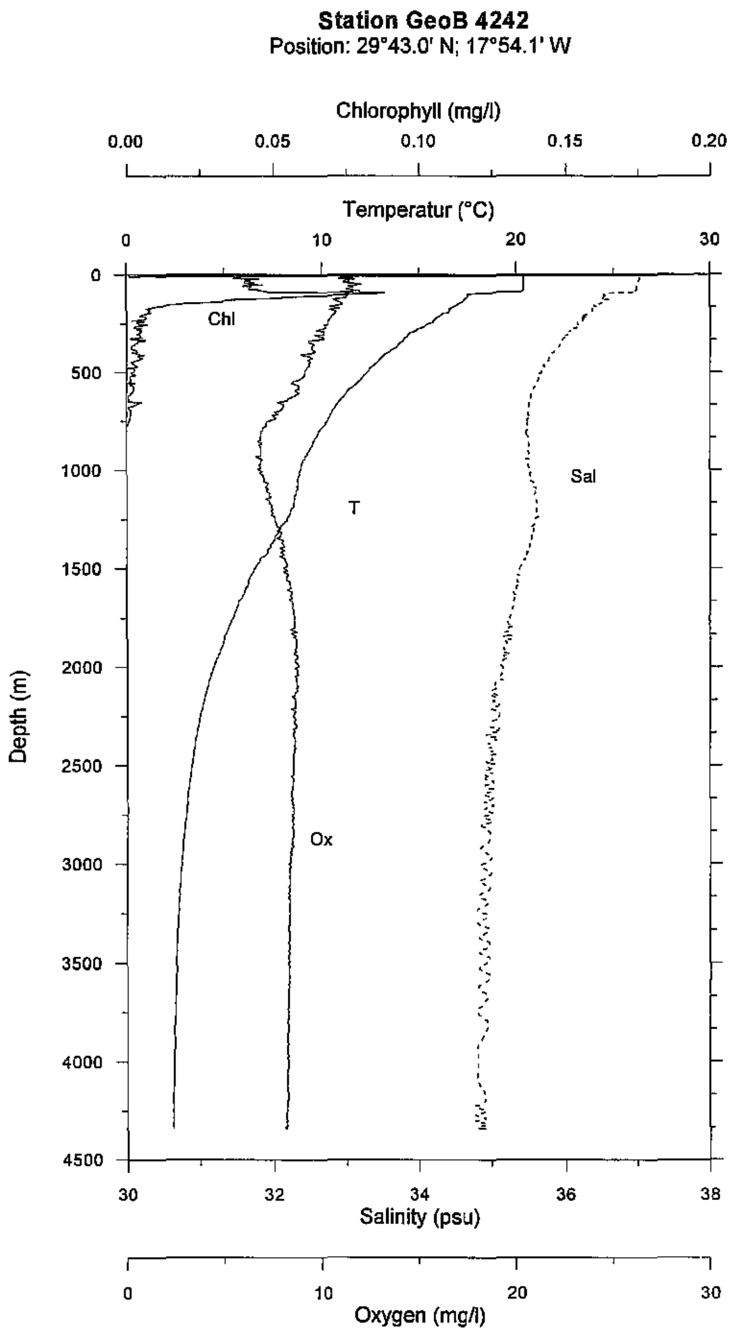


Fig. 4: CTD-, Oxygen and chlorophyll values at site GeoB 4242

5.1.2 YoYo-CTD-TRAMP-System

(S. Skoglund, C. Waldmann, G. Meinecke)

5.1.2.1 Methods

TRAMP is an autonomous, multi cycling, data collecting profiler designed for marine research and monitoring. The instrument is built in light weight, non corroding titanium and plastic and it profiles along a guiding rope through the water column while taking measurements on its way up. Brake mode operation is also possible. At present stage, up to 1000 profiles down to a maximum depth of 600 m can be achieved. Data is stored on RAM (2 Mbytes) and hard disk (up to 810 Mbytes) and TRAMP interfaces almost any commercially available sensor - up to 30 analogue and an unlimited number (theoretically) of logical (RS232 and RS485) sensor channels can be connected simultaneously. Maximum sampling frequency is 20 Hz.

A powerful PC-program handles all data recording, data processing and graphic presentation as well as instrument operation set-up which helps making TRAMP a flexible platform. Further development of the system is possible (remote communication, free drifting operation, etc.).

TRAMP was equipped with an internal 2-channel tilt sensor and pressure sensor and an external FSI micro CTD during the whole project.

Purpose

The purpose of the cruise was to test TRAMP performance under real field conditions, and to perform at least one shorter drift experiment.

Major activity on board

3 single mode test profiles down to 50 m/300 m, 4 cycle mode test profiles from the ship side down to 50/300 m and one 11 h drifting experiment down to 350 m depth were carried out. After repair and small changes of the hydraulic system, we achieved an improvement in global pumping efficiency of about 7 % at max. pressure and about 20-25 % at low pressure. In other words : 7 - 25 % more profiles for the same amount of batteries. Methods for simplifying system bleeding were discussed.

5.1.2.2 First Shipboard Results

Drift experiment

The drifter experiment started at location (29°42'95 N, 17°54'04 W) at 23.00 on December. 19 and ended around 10.00 following day. Sea state was up to 7-8 Beaufort with quite high swells. We set the instrument to collect 10000 records per profile at a sampling rate of 5 Hz and chose profiling speed level +6. TRAMP performed 11 yo-yo profiles. The first 5 profiles were carried out according to the plan and here TRAMP collected data all the way from the anchor (about 350 m) right up to the subsurface buoy (about 20 m). Overall cycle time was about 1 h 20 minutes. Average profiling speed was 38-39 cm/s for all profiles and didn't change very much with depth. No significant high frequency signal in the profiling speed could be seen. Instrument tilt (sideways and lengthways) was always in the range -5 to +5 degrees centered around 0 and 1 degrees for all profiles. A high frequency signal with a period of about 10-12 s dominates the tilt signals, reflecting the impact from surface waves.

The CTD values has not yet been compared with the parallel CTD cast taken with a SeaBird instrument but seem reasonable. The upper mixed layer is very stable and all 5 profiles give the same temperature and conductivity values.

Profile 6 to profile 11 shows that the instrument has got stuck in the top position around 20 m. It is however clear from the data files that pumping has been carried out as intended during all these profiles. When recovering the system we noticed one distinct mark in each upper rotator and the top stop was floating around in the surface.

We present some graphs (Fig. 5-8) showing the yo-yo performance as well as profile performance.

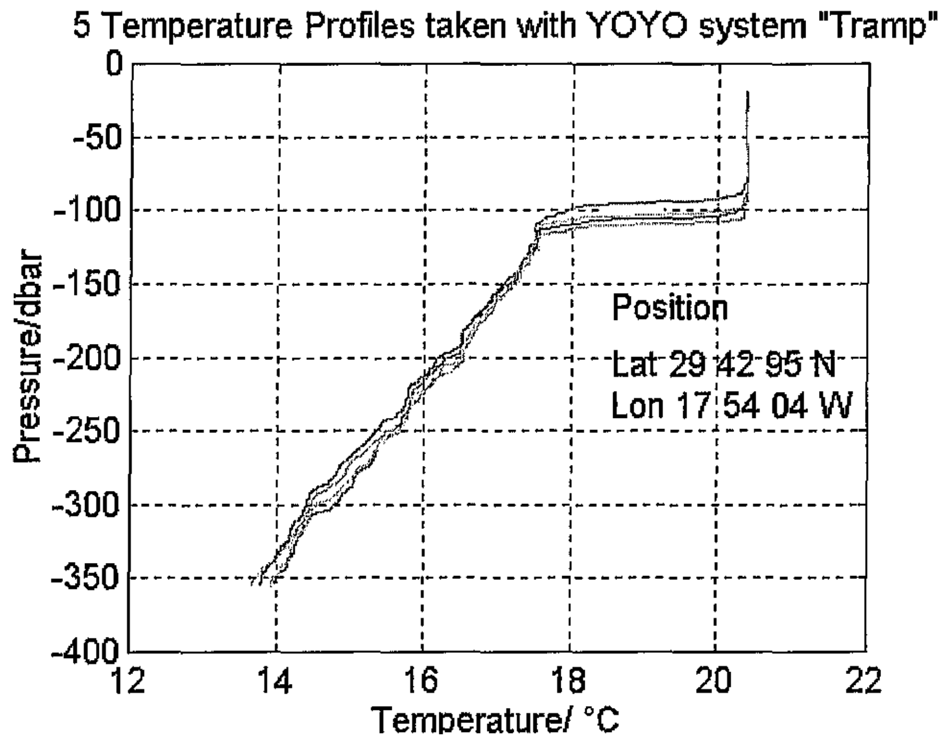


Fig. 5: The measured 5 temperature profiles taken approximately every hour

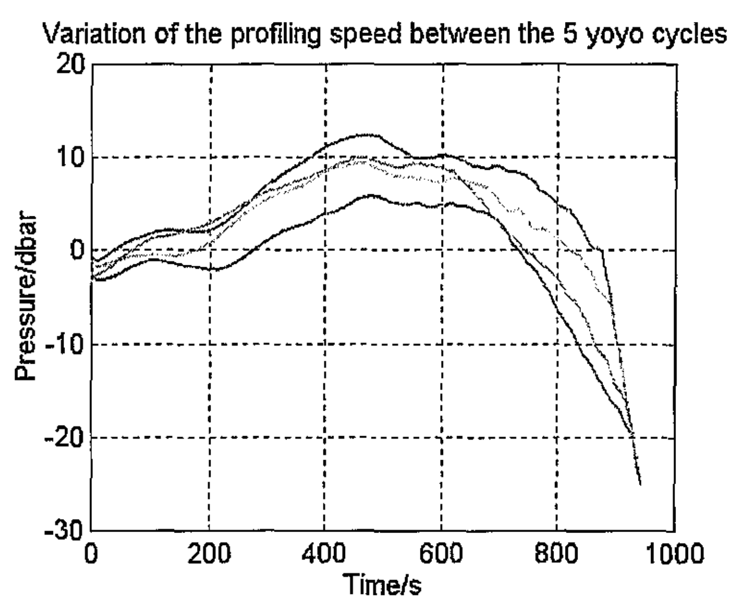


Fig. 6: The variation of the profiling speed is shown as difference of the individual pressure records to a least squared fitted line. The variation in speed is about 2 cm/s at a mean speed of 40 cm/s. The strong gradient in the last 200 seconds is related to the thermocline.

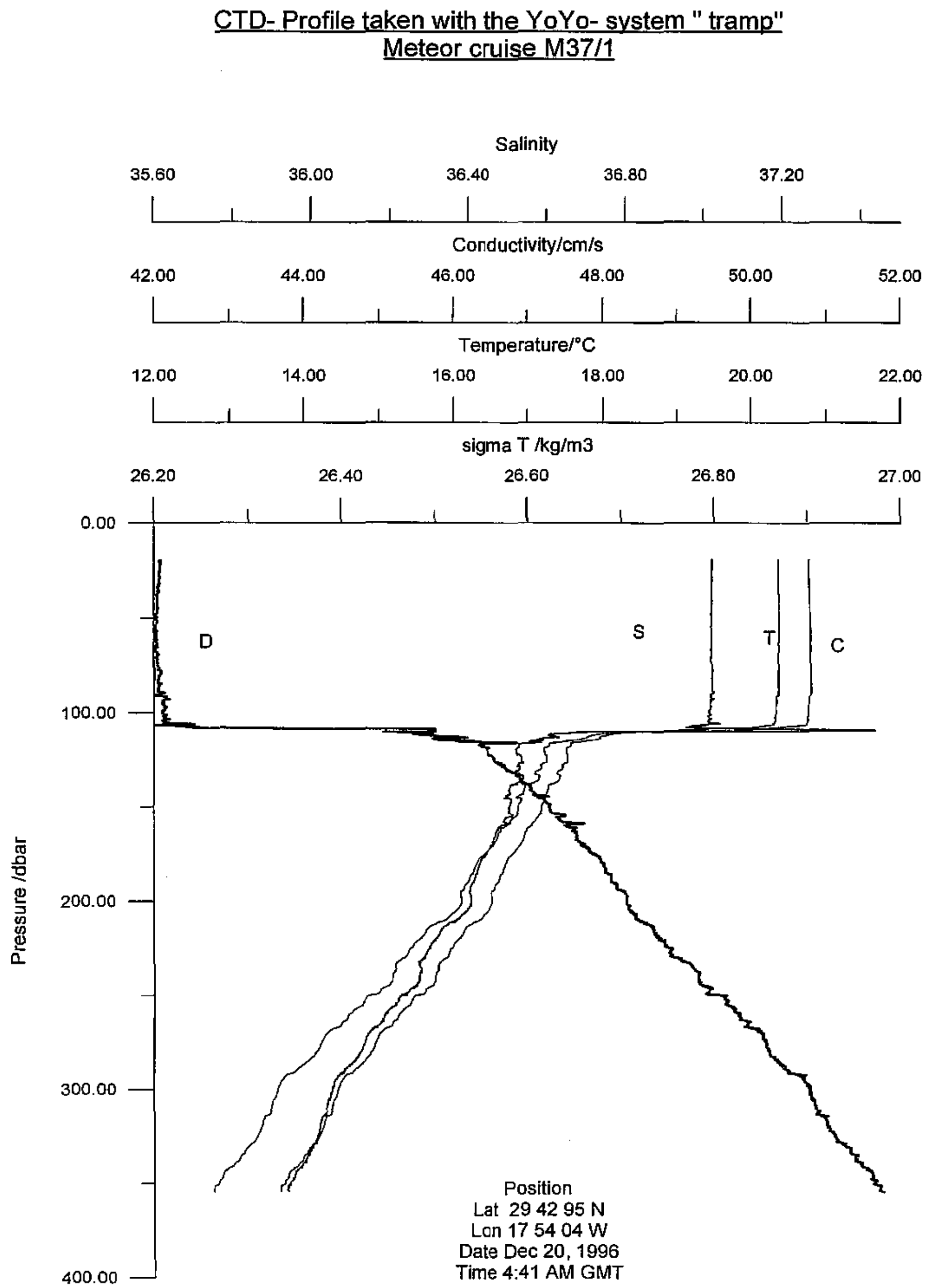


Fig. 7 : One of the 5 complete CTD- profiles taken with the YoYo- system "tramp" while deployed on a free drifting mooring.

Sample rate: 5Hz
Profiling speed: 40 cm/s
Conductivity slowdown: 1 s

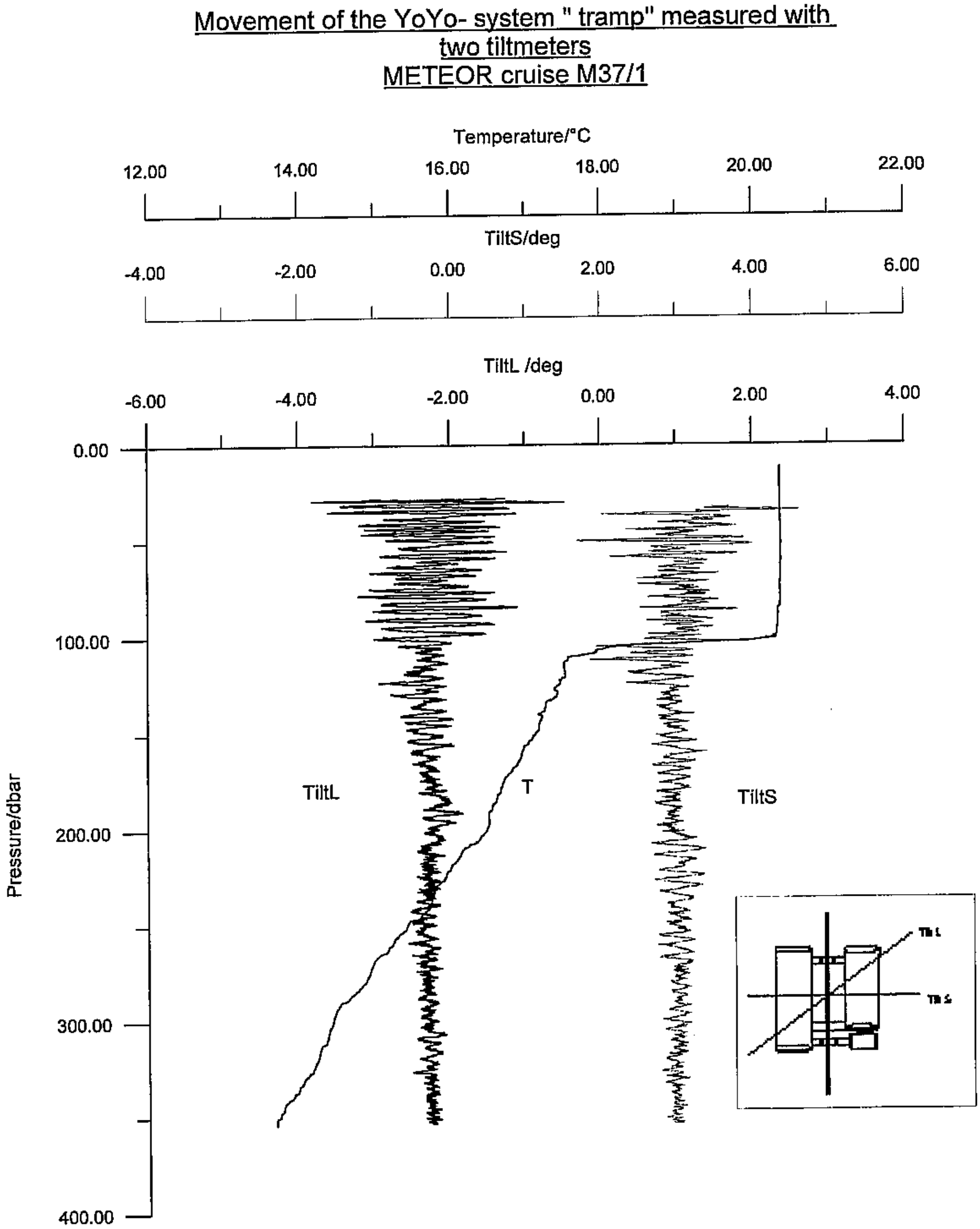


Fig. 8: The tilt of the instrument measured with two accelerometers while rising up the rope. The inset shows the axis of rotation

5.1.2.3 Conclusions

- The drift experiment shows that TRAMP can take repeated unattended profiles in an attractive way. We couldn't detect any problem in instrument performance during the whole experiment. The reason why it got stuck in the top position was due to poor design of the top stop. Profiling and tilt characteristics as well as CTD measurements all seem to be quit satisfactory. We see the experiment as a firm and promising stand into more modern and efficient experimental marine research. The way forward is now to follow up with more experiments under longer duration and thorough analyses. Parallel to this - a remote communication system should be implemented. We judge that TRAMP has the potential.

- All Teflon sealing in contact with hydraulic oil should be exchanged to suitable sealing since we can't exclude that long term exposing to hydraulic oil might be destructive to Teflon sealing (unless the opposite can be proven).

- We found that small mechanical changes in the magnetic coupling transferring DC-motor power to the pump improved global pumping efficiency with 7 - 25 %.

- Another and better design of the top stop should be used. We suggest to use some kind of elasticity (for example mechanical spring) that could reduce the impact of mechanical shock.

- Ways to simplify the bleeding of the hydraulic system should be investigated more thoroughly.

5.1.3 Water Sampling for Chlorophyll Measurements

(V. Diekamp)

For the determination of chlorophyll-a concentrations in the surface waters, 0.5l of seawater was collected 3 times a day from the ships seawater pump (inlet in about 3.5 m water depth).

Tab. 4: Sample locations for chlorophyll-a measurements

Nr.	Datum (1996)	Zeit	Länge (°W)	Breite (°N)	Wassertiefe (m)	Temperatur (°C)	Volumen (l)
1\2	06. Dez	12:28	13°32,6	32°42,2	4211	19,3	2*0,5
3\4	06. Dez	18:45	13°40,1	32°28,8	4263	19,5	2*0,5
5\6	07. Dez	08:50	11°55,1	32°02,1	3207	19,0	2*0,5
7\8	07. Dez	12:11	11°38,9	32°10,8	3273	19,4	2*0,5
9\10	07. Dez	18:40	11°06,5	31°35,9	3562	17,7	2*0,5
11\12	08. Dez	08:40	11°05,1	30°21,4	2749	18,5	2*0,5
13\14	08. Dez	12:25	10°58,2	30°17,4	1959	17,7	2*0,5
15\16	08. Dez	18:52	10°49,3	30°11,6	1773	17,7	2*0,5
17\18	09. Dez	08:51	10°57,0	29°36,1	1256	19,2	2*0,5
19\20	09. Dez	12:14	11°04,7	29°41,9	1549	19,3	2*0,5
21\22	09. Dez	18:56	11°11,8	29°46,9	1790	19,3	2*0,5
23\24	10. Dez	08:44	11°54,0	30°16,7	2179	18,7	2*0,5
25\26	10. Dez	12:15	12°23,8	30°37,7	2322	18,9	2*0,5
27\28	10. Dez	18:44	12°52,4	30°26,6	2502	19,4	2*0,5
29\30	11. Dez	08:46	13°22,7	29°57,6	2731	19,1	2*0,5
31\32	11. Dez	12:14	13°22,5	29°57,2	2724	19,1	2*0,5
33\34	11. Dez	18:50	13°22,0	29°57,0	2716	19,3	2*0,5
35\36	12. Dez	08:46	12°51,4	30°13,5	1897	19,1	2*0,5
37\38	12. Dez	12:27	12°53,2	30°26,2	2501	19,3	2*0,5
39\40	12. Dez	18:47	12°53,5	30°26,7	2504	19,2	2*0,5
41\42	13. Dez	08:53	12°20,1	29°45,9	1827	19,0	2*0,5
43\44	13. Dez	12:16	12°27,5	30°02,3	879	19,1	2*0,5
45\46	13. Dez	18:55	12°49,6	30°11,6	869	19,2	2*0,5
47\48	14. Dez	09:00	12°21,2	28°54,8	309	19,2	2*0,5
49\50	14. Dez	12:22	11°36,2	29°05,6	138	19,0	2*0,5
51\52	14. Dez	20:17	11°49,9	29°19,1	1398	19,3	2*0,5
53\54	15. Dez	08:45	12°59,5	29°28,2	1632	19,7	2*0,5
55\56	15. Dez	12:30	12°59,2	29°29,2	1645	19,9	2*0,5
57\58	15. Dez	18:49	12°35,9	29°07,8	1314	19,5	2*0,5
59\60	16. Dez	08:46	13°23,3	29°01,3	1161	19,8	2*0,5
61\62	16. Dez	12:24	13°19,7	28°58,9	1303	19,8	2*0,5
63\64	16. Dez	19:00	13°10,9	28°51,4	1246	19,5	2*0,5
65\66	17. Dez	18:48	13°13,1	28°53,3	1356	19,4	2*0,5
67\68	18. Dez	08:50	15°27,6	29°09,0	3613	20,6	2*0,5
69\70	18. Dez	12:26	15°27,9	29°07,4	3611	20,6	2*0,5
71\72	18. Dez	18:48	15°27,2	29°18,1	3609	20,6	2*0,5
73\74	19. Dez	08:56	15°34,4	29°11,6	3619	20,5	2*0,5
75\76	19. Dez	12:19	16°13,3	29°20,2	3671	20,5	2*0,5
77\78	19. Dez	18:48	17°23,1	29°36,0	4136	20,5	2*0,5
79\80	20. Dez	08:43	17°53,4	29°40,6	4289	20,3	2*0,5

The water was filtered onto glass fibre filters and frozen to -20°C. Chorophyll-a measurements by means of fluorometry will be carried out back in the laboratory in Bremen. The chlorophyll-a data should give information on seasonal and regional variability in biomass distribution; satellite derived chlorophyll-a concentrations may also calibrated against these measurements. For sampling locations see Tab 4.

5.1.4 Plankton Sampling Using a Multiple Closing Net

(M. Segl, J. Klump)

Plankton was sampled with a multiple closing net (Fa. HYDROBIOS) with 0.25 m^2 opening and 64 micrometer mesh size. It was used for vertical hawls at 1 site (GeoB 4241, ESTOC). The multinet station comprised three hawls:

1. The depth intervals from 500-300, 300-200, 200-100, 100-50 and 50-0 m.

2. The depth intervals from 400-200, 200-100, 100-0, 40-20 and 20-0 m.

3. The depth intervals from 250-00, 100-75, 75-50, 50-25 and 25-0 m.

Hawl 1 will be used for studies of planktonic foraminifers, hawl 2 for radiolarians and diatoms, and hawl 3 for geochemical and isotopic analyses. The samples containing mostly zooplankton and some phytoplankton and only small amounts of phytoplankton were carefully rinsed with seawater into KAUTEX bottles, fixed with mercury chloride for the reduction of bacterial degradation, and stored at 4°C. At station, 2 l Niskin bottles were used during the first and the third hawl to obtain water samples from the different water depths for analyses of carbon and oxygen stable isotopes.

5.1.5 In-situ Particle Camera System

(V. Ratmeyer, W. Metzler)

For measuring the vertical particle concentration, size distribution and aggregate composition in the water column, a high-resolution photographic camera system was used (Ratmeyer and Wefer, 1996). It was designed and improved in consideration of similar systems used by Honjo et al. (1984), Asper (1987) and Lampitt (1985). This method provides *in situ* information on the origin and abundance of particles and aggregates (marine snow). In addition to the use of sediment traps particle flux can be measured even in areas or depths with high lateral transport.

The aim of deployment to different depths between 1000 and 3000 m during M37-1 was to observe the deep-sea particle population and possible lateral advection of particle clouds from the continental shelf towards the open ocean. Due to bad weather conditions at the mooring sites, only one abundance profile was made at station GeoB 4214 down to 1600 m water depth.

The camera was triggered by a computer on deck of the ship. Communication with the ship is performed by two micro-computers inside the in-situ particle camera (ParCa) system, allowing different exposure programs to be run during profiling and moored deployment. Pictures were exposed while lowering the system with a speed of 0.3 m/sec. The flash duration of < 1/2.000 second was short enough to get sharp pictures of particles down to a size of 80 µm using Kodak Tri X Pan Film. Quantitative analysis of concentration, shape and size of particles will be performed using a PC-based image analysis system. This was not possible during the cruise and will therefore be done in Bremen.

In addition to the profiling deployment of the system, instrument improvement and testing was done during the cruise. For measuring particle size and sinking speed, a Sony VX1000E video camera was electronically modified and fitted to the controller of the ParCa system. Instrument testing was successfully performed aboard RV METEOR. Further development and in-situ testing will be performed during METEOR cruise M 38-1.

5.1.5 Particle Collection with Sediment Traps

(V. Ratmeyer, M. Segl, G. Meinecke)

Deployment and recovery data of the CI-6 mooring as well as the sampling data of the traps are listed in Tab. 5. During cruise M37/1 one mooring (CI-6) was recovered and deployed again (CI-7) at the same position. The mooring array was equipped with 3 multisample sediment traps, 3 currentmeters (2 INFLUX-currentmeters) and 2 multi-pump-systems (for particles and trace-elements). The CI-7 was deployed 60 sm north off Gran Canaria at the ESTOC station located in the mid productive area in the Canary Island region.

On December 17, the mooring CI-6 was recovered successfully. This mooring array was equipped with 3 multisample traps at 731 m, 976 m and 3062 m water depth and 2 INFLUX currentmeters at 1000 m and 3087 m. Additionally, a multi-pump-system was installed at 877 m depth. All instruments worked successfully. Sediment traps had been programmed for a 20 day sampling interval starting at November, 18, 1995. After recovery, the traps provided three complete sample series. A preliminary flux estimation shows a seasonal changing flux pattern with highest total particle fluxes between February and March 1996 (Fig. 9). Highest fluxes were recorded with the upper trap, lowest fluxes occurred in middle the trap at 976 m. Both upper traps show a higher variability of fluxes during deployment time compared to the lower trap at 3087 m. The estimated results roughly confirm previous findings from earlier measurements at this position. Trap-samples and results from the pump-system and the currentmeters will be analyzed at the University of Bremen.

On December 18, the CI-7 mooring array was successfully deployed at the same position (Fig. 10). The traps were scheduled for a 20 x 14 day sampling interval starting at December 23, 1996.

On the December 20 of the LP-1 mooring array was to be deployed in the oligotrophic oceanic region near La Palma, Canary Island. Due to bad weather conditions this mooring was not deployed. Instead, the deployment was delayed until the M 37-2 cruise.

Tab. 5: Positions and deployment data of sediment trap moorings

Mooring	Position	Water depth (m)	Sampling-interval	Instrument	Depth (m)	Intervals
Mooring recovery during M 37-1:						
ESTOC-Station / 60 sm north off Gran Canaria, Canary Island						
CI 6	29°09,1'N	3618	18.11.1995	S/MT 243-02	731	20x20 days
	15°28,1'W		20.12.1996	S/MT 234	976	20x20 days
				S/MT 234	3062	20x20 days
				INFLUX	1001	
				INFLUX	3087	
				Multi-Pump System	877	12 samples
Mooring deployment during M 37-1:						
ESTOC-Station / 60 sm north off Gran Canaria, Canary Island						
CI 7	29°11,0'N	3610	23.12.1996	S/MT 230	750	20x14 days
	15°27,0'W		29.09.1997	S/MT 234	1010	20x14 days
				S/MT 234	3050	20x14 days
				INFLUX	770	
				INFLUX	1030	
				RCM 8	3070	
				Multi-Pump System -142	885	12 samples
				Multi-Pump System -47	905	12 samples

Instruments used:

S/MT 243-02	= Sediment trap S/MT 243-02 Aquatec Meerestechnik, Kiel
S/MT 234	= Sediment trap S/MT 234 Aquatec Meerestechnik, Kiel
S/MT 230	= Sediment trap S/MT 230 Salzgitter Elektronik, Kiel
INFLUX	= INFLUX currentmeter with fluorometer, backscatter- and 0x.-sensor
RCM 8	= current meter Aanderaa, RCM 8
Multi-Pump-System	= Multi-Pump-System for particulate matter and trace metals

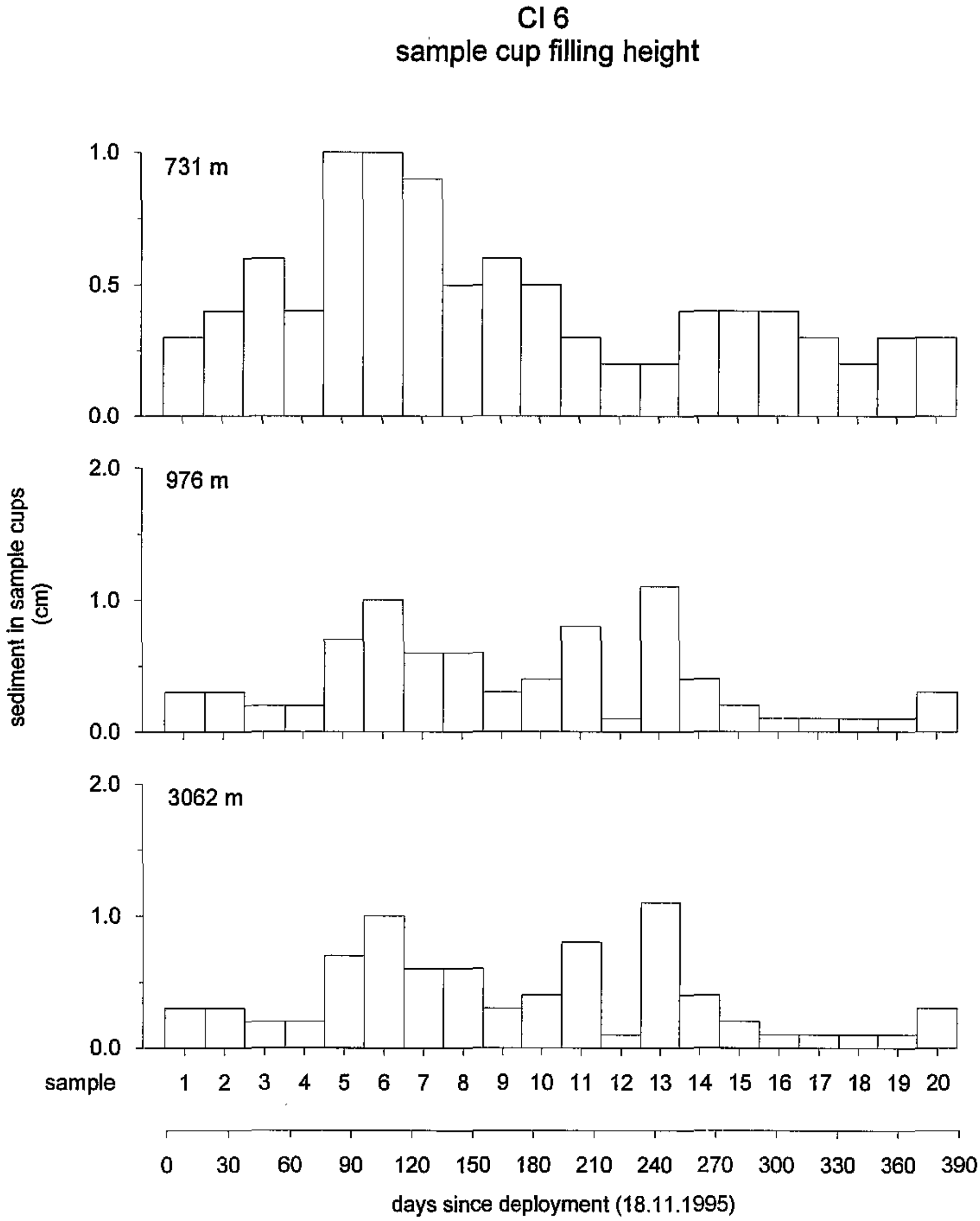


Fig. 9: Particle flux estimation from CI 6

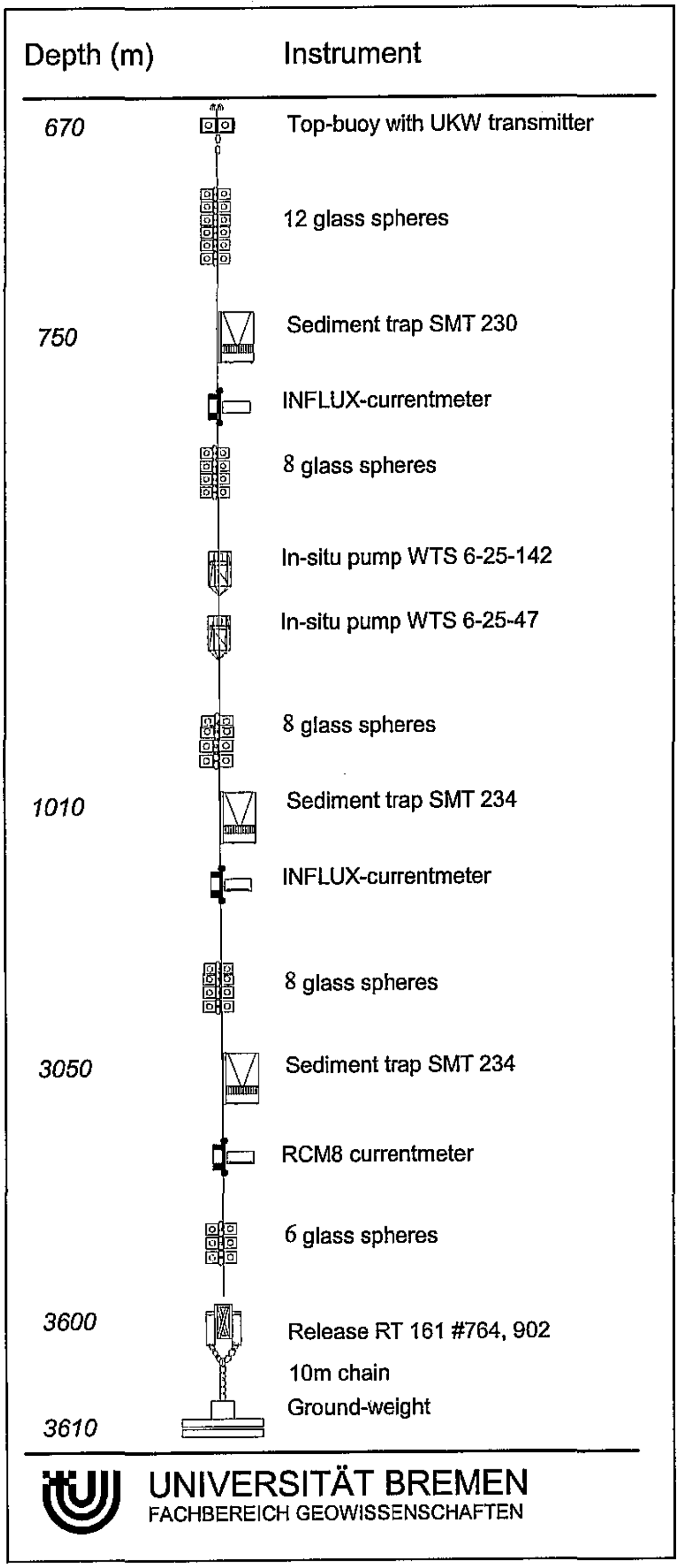


Fig. 10: Schematic plan of mooring CI-7

5.1.7 Lander Systems

(W. Riess, F. Wenzhöfer)

During the cruise, the lander systems ELINOR and PROFILUR were deployed for in situ measurements of oxygen, pH, CO_2, Mn and nutrients three times each. In addition laboratory incubations were made with sediment cores taken from a multicorer (Tab. 6).

Tab.6: Station list for lander system measurements

Station	Elinor	Profilur	Laborarory
GeoB4217	x	x	x
GeoB4234	x	x	x
GeoB4241 (ESTOC)	x	x	x (Boxcorer)

5.1.7.1 Methods

Lander system ELINOR

Elinor is a free-falling lander system for the in situ incubation of a sediment surface of about 900 qcm and an overlying waterbody of 6 to 15 liters. Therefor, Elinor is equipped with a PTFE-coated titanium chamber that is forced into the sediment and then closed with a lid to which a stirrer and two clarktype oxygen-electrodes are mounted. The stirrer creates a diffusive boundary layer (DBL) of approximately 0.7 millimeters.

Oxygen uptake together with temperature and pressure is measured continuously for up to 72 hours. For analysis of nutrients, Mn, CO_2 and additionally Winkler titration a water sampling system takes to 10 water samples of 50 ml each out of the incubated waterbody at pre-programmed time intervals.

Also N^{15}-nitrate can be injected for determination and quantification of denitrification.

The purpose is to study the total flux of oxygen into the sediment and the flux of mineralization products into the water phase and with that to calculate mineralization rates. The importance of different electron acceptors can also be calculated.

After finishing the measurements Elinor brings the incubated sediment up to the surface where samples for biomass, water content and fauna distribution are taken.

Lander system PROFILUR

Profilur is a free falling lander system designed to measure oxygen, pH and carbondioxide profiles *in situ* with a depth resolution of 100 µm (25 - 200 µm). The lander is equipped with six oxygen electrodes, three pH electrodes and one carbondioxide electrode. The pre-programmed lander penetrates the surface sediment up to 10 to 15 cm depth with the electrodes. Through this system the oxygen peneration and the diffusive flux of oxygen can be determined. With the pH and carbondioxide profiles the calcit dissolution in the sediment can be determined. For calibration of the electrodes and chemical analysis a watersample of five liters 50 cm above the sediment surface is taken. A camera system is mounted for documentation and analysis of the sediment surface.

Laboratory incubations

In addition to the in situ measurements sediment cores were taken and measured as a back up. These cores were incubated in the lab at nearly in situ conditions. The difference between the in situ and the lab incubation data show the effect of disturbance by bringing the sediment cores to the surface.

5.1.7.2 First Shipboard Results

In Fig. 11 it is shown, that after falling through the water column and landing on the bottom, no oxygen is taken up during incubation.

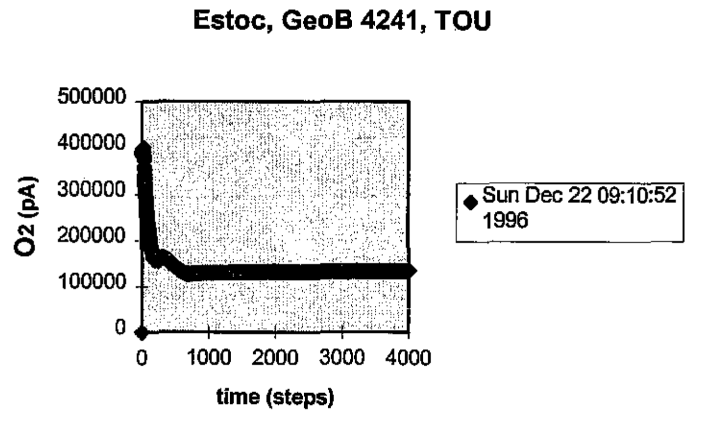


Fig. 11: Elinor-measurements in situ at Estoc

Fig. 12 shows the decrease in the oxygen signal after closure of the lid (at step 500). In this case four large shrimps were incubated accidentally with the sediment.

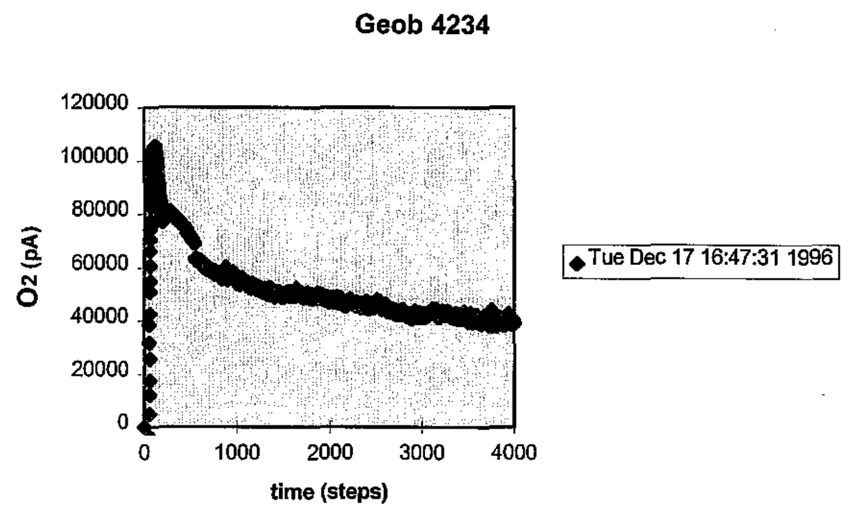


Fig. 12: Elinor-measurement in situ with macrofauna inhabiting sediment

A typical oxygen profile in the sediment from station GeoB 4234, measured *in situ* by Profilur, is presented in Fig. 13.

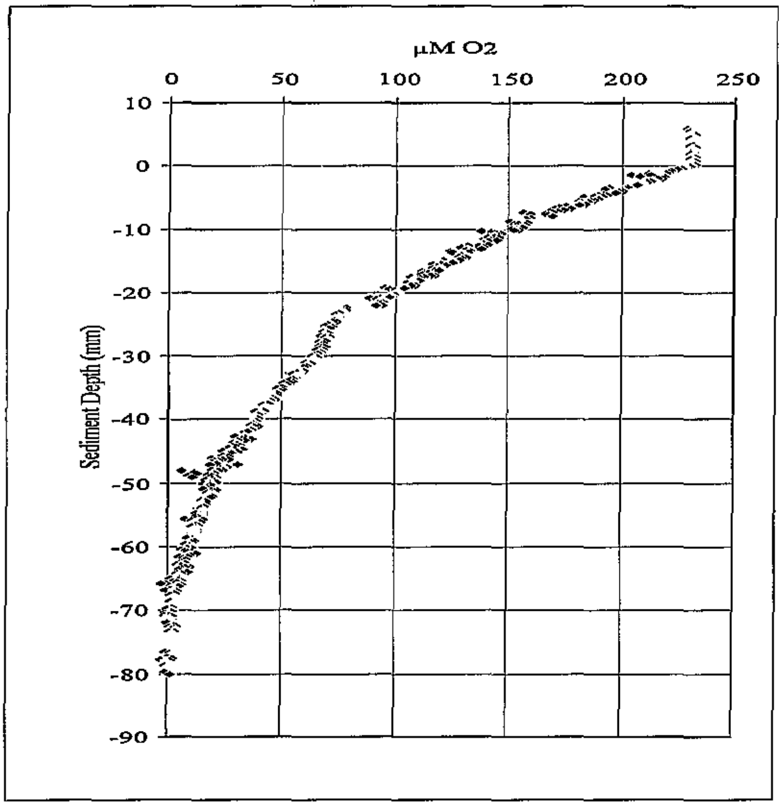


Fig. 13: Oxygen profile at station GeoB 4234 (Profilur)

5.1.8 Sediment Sampling

(F. Abrantes, J. Bollmann, G. Bozzano, V. Diekamp, A. Eberwein, J. Klump, S. Lindblom, H. Meggers, G. Meinecke, Y. Moustafa, V. Ratmeyer, M. Segl, J. Targarona, S. Vaqueiro)

Sediments were recovered at 40 stations in the Agadir Canyon, along 4 profiles perpendicular to the NW African margin between 28° and 30°N, and at the ESTOC and La Palma mooring stations. Surface sediments were generally recovered with a multicorer, however, a box corer was used as an alternative when the multicorer recovery was poor, i.e., in the Agadir Canyon area and at the ESTOC and La Palma mooring stations (Tabs. 7 and 8). To recover deeper sediment sequences a gravity corer with different pipe lengths and a weight of 1.5 tons on top was used at 35 stations (Tab. 9 and Fig. 1). Piston coring was also successfully done at two stations (GeoB4228-3 and GeoB 4229-1). Both coring systems were utilized at station GeoB4228. A core of 698 cm was recovered by the gravity corer and a 1188 cm core was recovered by the piston corer. The apparently higher sediment core recovery from the piston corer still has to be confirmed in a comparative study of the piston core and the shorter gravity core. Such a study will allow the identification of possible sediment disturbances by the respective coring techniques.

5.1.8.1 Sediment Surface Sampling with Multicorer and Boxcorer

Multicorer

The main tool for the recovery of undisturbed sediment surfaces and the overlying bottom water was the multicorer equipped with 8 tubes of 10 cm and 4 smaller tubes of 5 cm in diameter. The multicorer was used at 30 stations. In some cases the system failed, but mostly the core recovery was good, typically 10 to 12 tubes were filled, and cores of very good quality reaching 35 cm of sediment were recovered from station GeoB4210 to station 4240.

At each multicorer station, the overlying bottom water of one of the large tubes was sampled for stable isotope measurements at Bremen. The surface of a small tube was sampled $CaCO_3$ analysis. Four of the large tubes and 1 of the smaller tubes were usually sampled in 1 cm slices for analysis of C_{org}, foraminifera and diatoms. The C_{org} samples were frozen immediately after collection at -27°C. Foraminifera samples were stained with a solution of 1g of rose bengal in 1 l ethanol. A second set of non-stained samples was also collected for foraminiferal analysis. All the foraminiferal and diatom samples were kept at 4°C. In some stations one of the smaller cores was sampled in 2 cm slices for organic geochemistry (see chapter 5.1.8.3). One large core was frozen for later AMS C-14 dating on planktic foraminifera and fine fraction (<38μm). On selected stations large cores were used for geochemical and biogeochemical studies. Mostly one large and one small core were frozen as archive material. When available, a smaller core was also sampled for sedimentological studies by the representatives of the Barcelona group on board. Tab. 7 presents a summary of the multicorer sampling.

Tab. 7. Multicorer sampling, METEOR cruise 37-1

A. Large tubes

GeoB No.	Depth (m)	Recovery (cm)	Geochem.	Archives	MPI	Corg.	Diatoms	Forams (BR)	C14	Sedim.
4210-2	1959	16	-	2	1	1	1	2	-	1
4211-1	1773	35	1	1	-	1	1	2	-	1
4212-3	1256	30	-	1	-	1	1	2	1	1
4213-1	1547	20	-	1	-	1	-	2	1	-
4214-3	1788	35	-	-	-	1	1	1	1	-
4215-1	2106	33	1	1	-	1	1	2	1	1
4216-2	2325	27	-	-	-	1	1	1	1	-
4217-1	2504	7	-	-	-	-	-	-	-	-
4217-4	2507	32	1	1	3	1	-	1	1	-
4223-1	777	35	-	1	-	1	1	2	1	-
4225-3	1281	30	1	1	-	1	-	1	1	-
4226-1	1400	35	1	1	-	1	1	2	1	-
4227-1	1826	10	-	-	-	-	-	1	1	-
4228-1	1633	35	1	1	-	1	1	1	1	-
4229-2	1422	31	-	1	-	-	-	1	1	-
4230-1	1316	30	-	1	-	1	1	2	1	-
4231-2	1207	31	1	1	-	1	1	1	1	-
4232-1	1161	13	1	1	-	1	1	2	1	-
4233-2	1303	34	-	-	-	1	-	1	1	-
4234-1	1360	31	1	1	3	1	-	2	-	-
4235-1	1244	31	-	1	-	1	1	2	1	-
4236-2	1030	14	-	1	-	1	-	2	1	-
4237-1	800	13	-	1	-	-	1	2	1	-
4238-2	1185	26	-	2	-	1	1	2	1	-
4239-1	881	12	-	1	-	1	-	2	1	-

Tab. 7 continued - Multicorer sampling, METEOR cruise 37-1

B. Small tubes

GeoB No.	Org.Geoch.	Foram	Sedim.	C14	MPI	Archives	Diatoms	Fora (BR)	Geochem.	Corg.
4210-2	1	-	-	1	-	-	-	-	-	-
4211-1	-	-	-	-	1	1	-	-	-	-
4212-3	1	-	-	-	-	-	-	-	-	-
4213-1	1	1	1	-	-	-	1	-	-	-
4214-3	-	1	1	-	-	1	-	1	-	-
4215-1	1	1	-	-	-	1	-	-	1	-
4216-2	-	1	1	-	-	2	-	-	-	-
4217-1	-	1	-	1	-	-	1			1
4217-4	-	1	-	-	-	1	1	-	1	-
4223-1	1	1	1	-	-	1	-	-	-	-
4225-3	-	1	-	-	-	1	1	-	1	-
4226-1	-	1	-	-	-	1	-	-	1	-
4227-1	-	1	-	-	-	1	1	-	-	1
4228-1	-	1	-	-	-	1	-	1	1	-
4229-2	-	1	-	-	-	1	1	-	-	1
4230-1	1	1	1	-	-	1	-	-	-	-
4231-2	-	1	-	-	-	1	-	1	1	-
4232-1	1	1	-	-	-	1	-	-	1	-
4233-2	-	1	-	-	-	2	1	-	-	-
4234-1	1	1	-	-	-	1	1	-	-	-
4235-1	-	1	-	-	-	1	-	-	-	-
4236-2	-	1	1	-	-	1	1	-	-	-
4237-1	-	1	1	-	-	1	-	-	-	-
4238-2	-	1	1	-	-	2	-	-	-	-
4239-1	1	1	1	-	-	-	1	-	-	-

Boxcorer

The boxcorer was used as an alternative at 13 stations, when the multicorer recovery was poor or none, i.e. in the Agadir Canyon working area and the mooring stations. The boxcorer used permits the recovery of 50 x 50 x 50 cm of surface sediments. When on board, the overlying waters was removed from the box, sediment temperature was taken from 6 cm depth and the surface sediments described and photographed. The surface sediments were then normally sampled as follows.

2 cores (d=12 cm) as archive
1 core (d=12 cm) for organic carbon analyses
1 core (d=12 cm) for analysis of diatoms
1 core (d=12 cm) for sedimentological studies/Barcelona (in the Agadir Canyon)
200 cm^2 for foraminiferal analysis (stained with rose bengal)
200 cm^2 for organic carbon analysis (frozen at -27°C)
200 cm^2 for radiolaria analysis
25 cm^2 for diatom analysis
25 cm^2 for magnetic bacteria analysis

1g for $CaCO_3$ analysis
1 mg for Coccoliths analysis

The front cover of the boxcorer was then removed, the sediment cleaned, described and photographed. Three series of syringe samples were then taken at 3 cm intervals, for analyses of foraminifera, coccoliths and stable isotopes, organic geochemistry and physical properties. From several stations a series of syringes was also taken for diatom studies.

Tab. 8 Boxcorer sampling, METEOR cruise 37-1

A. Cores (12 cm)

GeoB No.	Water depth (m)	Recovery (cm)	Geochem. (Bremen)	Sedimentol. (Barcelona)	Archives (Bremen)	Biogeoch. (MPI)	Corg. (Bremen)	Diatoms (Lisbon)
4202-1	4289	39	-	1	2	-	1	-
4204-1	3213	14	-	1	2	-	1	-
4205-1	3272	23	-	1	2	-	1	-
4206-2	1855	35	-	1	2	-	1	1
4207-1	2123	25	-	1	2	-	1	1
4208-1	2724	23	-	1	2	-	1	1
4209-1	2150	33	-	1	2	-	1	-
4220-2	406	15	-	-	2	-	1	1
4241-5	3610	30	1	-	2	1	1	-
4242-4	4292	33	-	-	3	-	1	-

B. Syringes (10 ml)

GeoB No.	Micropal.	Corg.	Diatoms
4202-1	12	12	-
4204-1	4	4	-
4205-1	8	8	-
4206-2	12	12	12
4207-1	7	7	-
4208-1	6	6	-
4209-1	10	11	-
4220-2	5	5	5
4241-5	9	9	9
4242-4	10	10	10

Tab. 8 continued - C. Surface sediment samples (25-200 ccm)

GeoB No.	Radiolaria	Magnetic bacteria	Diatoms	Organics	Foraminif. (with BR)	Sedimentol.
4202-1	200	25	25	200	200	100
4204-1	200	25	25	200	200	100
4205-1	200	25	25	200	200	100
4206-2	200	25	25	200	200	100
4207-1	200	25	25	200	200	100
4208-1	200	25	25	200	200	100
4209-1	200	25	25	200	200	100
4220-2	200	25	25	200	200	-
4241-5	200	25	25	200	200	-
4242-4	200	25	25	200	200	-

5.1.8.2 Sediment Sampling with Gravity Cores and Piston Cores

36 gravity- and piston cores, in a total of 254,05 m of sediments were recovered from 34 stations with recoveries which vary between 0,77 m and 11,17 m. Gravity coring was unsuccessful at stations (GeoB4201-2; GeoB4212-1; GeoB4220-3, and GeoB4224-1).

9 cores (GeoB4201-1, GeoB4205-2, GeoB4206-1, GeoB4212-2, GeoB4214-2, GeoB4215-1, GeoB4216-2, GeoB4217-6 and GeoB4223-2) were opened, described and sampled on board (Tab. 9). After splitting, the archive section was described following the ODP nomenclature and sediment color was determined by comparison with the MUNSEL soil color charts. A color scanner was used to record the color of the fresh sediments at the 5 cm sampling interval (see spectrophotometry section). All core sections were photographed together with a color reference card.

Tab. 9 Gravity core sampling, *METEOR* cruise 37-1

GeoB No.	Water depth (m)	Recovery (cm)	A-serie Corg	B-Serie Isotopes/ Forams	C-Serie Coccoliths	D-Serie Diatoms	Sedi-mentology	Smearslides	Carbonate Content
4201-2	4210	77	15	15	-	-	15	-	-
4205-2	3296	501	100	100	-	-	100	8	-
4206-1	1849	571	114	114	-	-	114	20	-
4212-2	1258	857	171	171	171	171	-	28	86
4214-1	1791	952	190	190	190	190	-	25	-
4215-2	2105	777	155	155	155	155	-	27	91
4216-1	2324	1119	223	223	223	223	-	47	-
4217-6	2506	716	143	143	143	143	-	32	47
4223-2	775	782	156	156	156	156	-	19	-
4241-10	438	3610	-	-	-	-	-	-	-

Tab. 9 continued: Gravity core sampling, *METEOR* cruise 37-1

GeoB No.	Water depth (m)	Recovery (cm)	Org. Geochem.	Geo-chemistry
4201-2	4210	77	-	-
4205-2	3296	501	1	-
4206-1	1849	571	1	-
4212-2	1258	857	4	-
4214-1	1791	952	3	-
4215-2	2105	777	6	-
4216-1	2324	1119	6	-
4217-6	2506	716	2	-
4223-2	775	782	8	-
4241-10	438	3610	-	total

On the working half of the split cores, three series of known volume samples, A, B and C were taken with 10 cm^3 syringes every 5 cm, starting at 3 cm below the top of the core. Series A will be analyzed for organic geochemistry and physical properties. Series B will be used for foraminiferal and stable isotope analyses, and Series C will be used for coccoliths analysis. A fourth Series (D) of known volume samples, for diatom analysis, was taken with 5 cm^3 syringes. Samples for $CaCO_3$ analysis to be done on board, using the „Müller-bomb" were taken on three cores every 10 cm or when changes in lithology were noticeable. 20 cm^3 samples for organic geochemistry analysis were taken at an average of 1 every two meters. Tab. 9 summarizes the gravity core sampling.

5.1.8.2.1 Methods

Spectrophotometry

The light reflectance of all gravity cores was measured at 31 wavelength channels in the range of visible light (400 - 700 nm). This method is used to quantify the color of the sediment.

A Minolta CM-2002™ hand-held spectrophotometer was used. The readings were taken immediately after splitting the core. The archive halves of the cores were scraped with a knife to expose a fresh, unsmeared surface for the measurements. The core was then covered with a transparent plastic film to protect the camera. Measurements were taken every 5 cm, at the sampling positions on the work half, to resolve small scale color changes. Before measurements were taken, a white calibration of the spectrophotometer was performed using a white calibration standard and a white reference measurement was included in the data file. The calibration surface was covered with the same plastic film as the core to avoid any bias in the readings. The data were stored in the instrument and later transferred to a personal computer using the program "COCOS" (V. 0.95, by G. Ruhland, Univ. of Bremen) and then imported into a spreadsheet program.

The reflectance profiles at the three wavelengths (450 nm, 550 nm, 700 nm) are shown next to the core diagrams (Figs. 15-23; see Fig. 14 for legend). These three wavelengths give a good overview of sediment color spectrum, since they cover most of the spectrum measured. In addition they represent the colors blue, green and red, respectively.

The color of the sediment is strongly influenced by its carbonate content and terrigenous material. In cores with a carbonate content below approx. 50 wt.% the lightness (L*) of the sediment correlates well with the carbonate content. This correlation can be used as a basis for a preliminary stratigraphy by correlating the lightness of the sediment color to the carbonate data of other cores from the region, which has been published in the literature (Diester-Haass, 1983). The hue (H) of the sediment color seems to be strongly influenced by the input of terrigenous material and seems to follow a precessional cycle (23 ka).

Carbonate Measurements

Carbonate contents were measured on board using a "Karbonat-Bombe". The $CaCO_3$ content of a sample was ascertained by the measurement of the CO_2 pressure after the treatment with HCl. The absolute error of a single determination is given as about 1% calcium carbonate (Müller & Gastner, 1971).

In total, three cores (GeoB 4212-2, GeoB 4215-2, GeoB 4217-6) were measured for their carbonate content (Tab. 6, Figs. 18, 20, 22), usually at 5-20 cm intervals.

All cores which were taken in this area show a similar pattern of alternating high and relatively low carbonate contents, indicating glacial to interglacial variations in productivity. Maximum values exceeding 50-60 wt.-% reveal interglacial conditions, whereas peak glacials probably are characterized by carbonate values generally below 30 wt.-%.

Smear Slide Analysis

An initial analysis of the sedimentary components present in the sediments retrieved from the opened and described cores was investigated by means of smear slide analyses. A total of 310 slides were prepared and analyzed. The number of samples taken from each core varied depending on the homogeneity of the sediment and the occurrence of features of specific interest. However, and given the lithologic homogeneity observed in most of the open cores, the position of many samples was determined by changes in colour. Smear slides were prepared with "Norland Optical Adhesive" as a mounting medium, dried with UV light for a minimum of 10 minutes. Slides were studied at 400 xs magnification on a "Olympus BH-2" petrological microscope along two perpendicular profiles through the central area of the cover slip. Percent estimations were done using Rothwell's reproduction of Folk's series of comparative percentage diagrams as a guide (Rothwell, 1989). Even with the use of the percentage diagrams some of the observed variability may be due to operator variation. Sediment classification followed the ODP terminology (Dean et al., 1985). Downcore distribution of the more abundant and/or consistently present terrigenous and biogenic components is presented in Figs. 16 to 23.

5.1.8.2.2 First Shipboard Results

<u>Agadir Canyon Area</u>

9 Boxcores (GeoB4201-2, GeoB4202-1, GeoB4204-1, GeoB4205-1, GeoB4206-2, GeoB4207-1; GeoB4208-1, GeoB4209-1) and 3 gravity cores (GeoB4201-1, GeoB4205-2 and GeoB4206-1) were recovered in this working area at 4210 m, 3296 m, and 1849 m water depth respectively. The length of the gravity cores varied between 77 cm (GeoB4201-1) and 571 cm (GeoB4206-1) and consist mainly of nannofossil ooze with intercalations of sandy calcareous ooze. The sediment color varies between brown and light olive gray and bioturbation was clearly visible throughout the cores.

<u>NW Africa - Profile 2</u>

Four cores of Profile 2 (GeoB4212-2, GeoB4214-1, GeoB4215-2, GeoB4216-1) and 2 cores of Profile 3 (GeoB4223-2 and GeoB4217-6) were opened and described. Bioturbation was high to moderate in all cores. The sediment was mostly a nannofossil ooze with some layers richer in terrigenous mud "muddy nanno ooze" and the occurrence of sporadic sandy layers rich in glauconite. "Volcanic ash layers" were found in the two deepest cores opened (GeoB4216-1 and GeoB4217-6).

The biogenic components of these sediments was mainly calcareous with the dominance of nannofossils as indicated by the sediment name. Other calcareous organisms such as foraminifera are always present but generally in percentages lower than 15%; calcareous bioclasts are also nearly always present. Calcareous dinoflagellate cyts, thoracospheres, and calcareous calpeonellids were also present reaching abundances of 5% in some levels of cores GeoB4212-2 and GeoB4215-2. The siliceous biogenic component is represented by sponge spicules, radiolaria, silicoflagellates and diatoms. Sponge spicules are the most consistently present, and silicoflagellates the most rare of the siliceous biogenic component. Diatoms are present in all cores being more abundant in cores GeoB4214-1, GeoB4215-2 and GeoB4216-1 (5-20%) at a depth between 50 to 70 cm below the surface. Fresh water diatoms and phytoliths were also detected in several levels of cores GeoB4214-1, GeoB4215-2, GeoB4216-1 and GeoB4217-6. The terrigenous component consisted mainly of silt sized quartz and colored minerals, such as pyroxene, amphiboles and opaque minerals considered respectively as accessory and Fe-rich minerals, and clay. A somewhat important authigenic component is represented by the persistent presence of black spots identified as pyrite and silt sized dolomite crystals all along the 6 cores as well as by glauconite rich layers detected in the two cores collected between 1258 and 1791 m water depth (GeoB4212-2 at 825cm and GeoB4214-1 at 747 and 807 cm). Figs. 15 to 23 present the core description, results of the smear-slide analysis, color data, and $CaCO_3$ data when available (see Fig. 14 for legend).

The generally low abundance of diatoms as well the presence of thoracopheres in these sediments seem to reflect low productivity conditions in this specific area, while the presence of fresh-water diatoms and phytoliths indicate the influence of wind blown materials from the NW African arid regions. The downcore distribution and abundance of these wind blown components together with the study of dinoflagellate cysts and pollen will allow a land-sea correlation of events.

Terrigeous contribution is mainly reflected by the sediment composition of cores GeoB4206-1 and GeoB4223-2. Indication of reworked sediments in cores GeoB4214-1, GeoB4215-2, GeoB4216-1 and GeoB4217-6 is given by the presence of *Discoasters*.

The establishment of a preliminary stratigraphy for these cores was attempted on board, using a correlation of the lightness (L*) record of all cores and the $CaCO_3$ record of cores GeoB4212-2, GeoB4215-2 and GeoB4217-6 to published records for the area (Diester-Haass, 1983). Further information was gained from the *Gephyrocapsa* dominance of the coccolith assemblage indicating the presence of sediments older than stage 6 at 789 cm in core GeoB4214-1, 669 cm in core GeoB4216-1 and 654 cm in core GeoB4217-6. Sedimentation rates (SR) are estimated to be between 4 and 6 cm/kyr for cores GeoB4212-2, GeoB4214-1, GeoB4215-2, and GeoB4216-1. Core GeoB4217-6 appears to have a SR half of the estimated for the other cores, while core GeoB4223-2 looks very homogeneous and may have a much higher sedimentation rate.

5.1.8.3 Organic Geochemistry

The North-African costal area off Morocco has a continental slope environment where upwelling conditions favor marine primary productivity in the ocean. This results in the accumulation of organic matter on the sea floor. In addition, a terrestrial input is provided from the African continent either as windblown dust or by river input. The accumulation of organic matter in the long-term sedimentary column can only occur if conditions for preservation are favorable on the sea-floor. This is the case where there is a lack of oxygen to consume and alter all the accumulated organic matter. This is usually found as an oxygen minimum layer at certain water depths which may vary with varying oceanographic conditions.

By sampling sedimentary cores, gravity cores, box cores and multicores, preserved organic matter may be collected and analyzed for organic geochemical components (Tab. 10). Ideally, sampling of sediments with the highest organic matter content should provide the optimum results of organic matter production and preservation in the ocean. The aim of sampling for organic geochemistry analysis on Meteor cruise 37/1 has been to find suitable material in the core material collected. The analyses will be conducted on shore focusing on solvent-extractable lipids, hydrocarbons, alcohols and fatty acids. This will be supplemented with analyses of Ba, Al, Ti, Zr, Ni, Cu and silica which may indicate changes in biological productivity and input from volcanic sources. This may provide data for quantitative calculations of marine versus terrestrial input of organic matter over an extended time period, here mainly going back to the last glacial-interglacial stage.

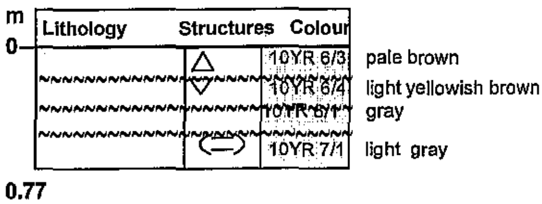
Tab. 10: Samples taken onboard METEOR 37/1 for organic geochemistry analyses on shore

Sample no.	Core-type	Station	Interval cm	Core length cm	Water depth m	Note
1	GKG	GeoB 4202-2	20-35?	39	4 284	15 cm slice
2	GKG	GeoB 4209-1	0-2	33	2 169	surfacesample
3	GKG	GeoB 4209-1	10-13	33	2 169	20 cc
4	GKG	GeoB 4209-1	18-21	33	2 169	20 cc
5	SL	GeoB 4206-1	54-58	571	1 849	20 cc
6	MUC	GeoB 4210-2	0-14	14	1 959	7 samples., 2 cm
7	MUC	GeoB 4212-3	0-33	33	1 256	15 samples, 2 cm
8	MUC	GeoB 4213-1	0-20	20	1 549	10 samples, 2 cm
9	SL	GeoB 4205-2	303-306	501	3 272	20 cc
10	MUC	GeoB 4215-1	0-30	30	4 284	15 samples
11	SL	GeoB 4215-2	48-52	777	2 105	20 cc
12	SL	GeoB 4215-2	123-126	777	2 105	20 cc
13	SL	GeoB 4215-2	252-256	777	2 105	20 cc
14	SL	GeoB 4215-2	298-301	777	2 105	20 cc
15	SL	GeoB 4215-2	549-552	777	2 105	20 cc
16	SL	GeoB 4215-2	614-617	777	2 105	20 cc
17	SL	GeoB 4217-6	88-92	706	2 506	20 cc
18	SL	GeoB 4217-6	372-376	706	2 506	20 cc
19	SL	GeoB 4216-1	58-62	1 117	2 324	20 cc
20	SL	GeoB 4216-1	195-198	1 117	2 324	20 cc
21	SL	GeoB 4216-1	308-312	1 117	2 324	20 cc
22	SL	GeoB 4216-1	403-407	1 117	2 324	20 cc
23	SL	GeoB 4216-1	563-567	1 117	2 324	20 cc
24	SL	GeoB 4216-1	958-962	1 117	2 324	20 cc
25	SL	GeoB 4212-2	48-52	857	1 256	20 cc
26	SL	GeoB 4212-2	219-223	857	1 256	20 cc
27	SL	GeoB 4212-2	434-435	857	1 256	20 cc
28	SL	GeoB 4212-2	683-687	857	1 256	20 cc
29	MUC	GeoB 4231-1	0-30	31	1207	15 samples, 2 cm
30	SL	GeoB 4214-1	59-64	952	1 791	20 cc
31	SL	Geob 4214-1	309-313	952	1 791	20 cc
32	SL	GeoB 4214-1	639-643	952	1 791	20 cc
33	MUC	GeoB 4232-1	0-19	19	1 160	9 samples, 2 cm
34	SL	GeoB 4223-2	69-73	779	775	20 cc
35	SL	GeoB 4223-2	164-168	779	775	20 cc
36	SL	GeoB 4223-2	253-257	779	775	20 cc
37	MUC	GeoB 4239-1	0-16	16	884	8 samples, 2 cm
38	SL	GeoB 4223-2	333-337	779	775	20 cc
39	SL	GeoB 4223-2	380-384	779	775	20 cc
40	SL	GeoB 4223-2	453-457	779	775	20 cc
41	SL	GeoB 4223-2	513-517	779	775	20 cc
42	SL	GeoB 4223-2	632-636	779	775	20 cc

GeoB 4201-2

Date: 06.12.96 Pos: 32°41,8' N 13°32,9' W
Water Depth: 4208 m Core Length: 77 cm

Lithology



No smear-slide analysis

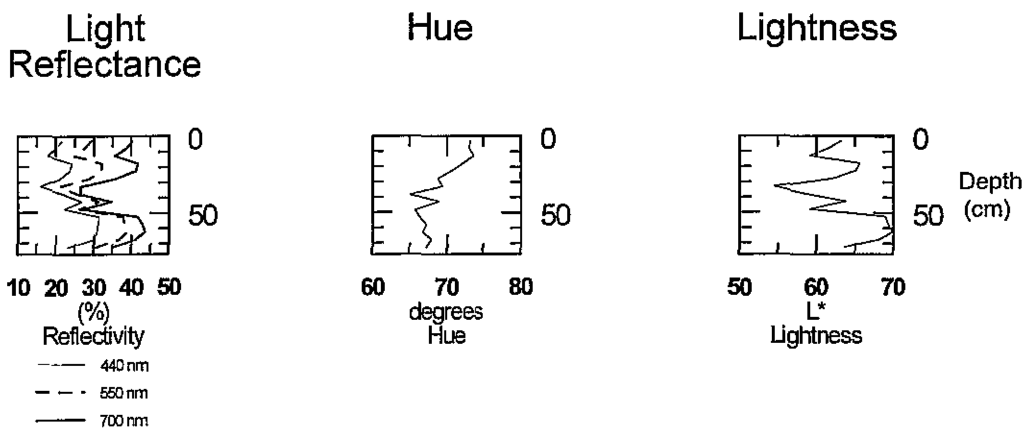


Fig. 14: Sediment descriptions, colour reflectance, hue, and lightness for the gravity core GeoB 4201-2

GeoB 4205-2	Date: 7.12.96 Pos: 32°10,8' N 11°38,9' W Water Depth: 3272 m Core Length: 501 cm

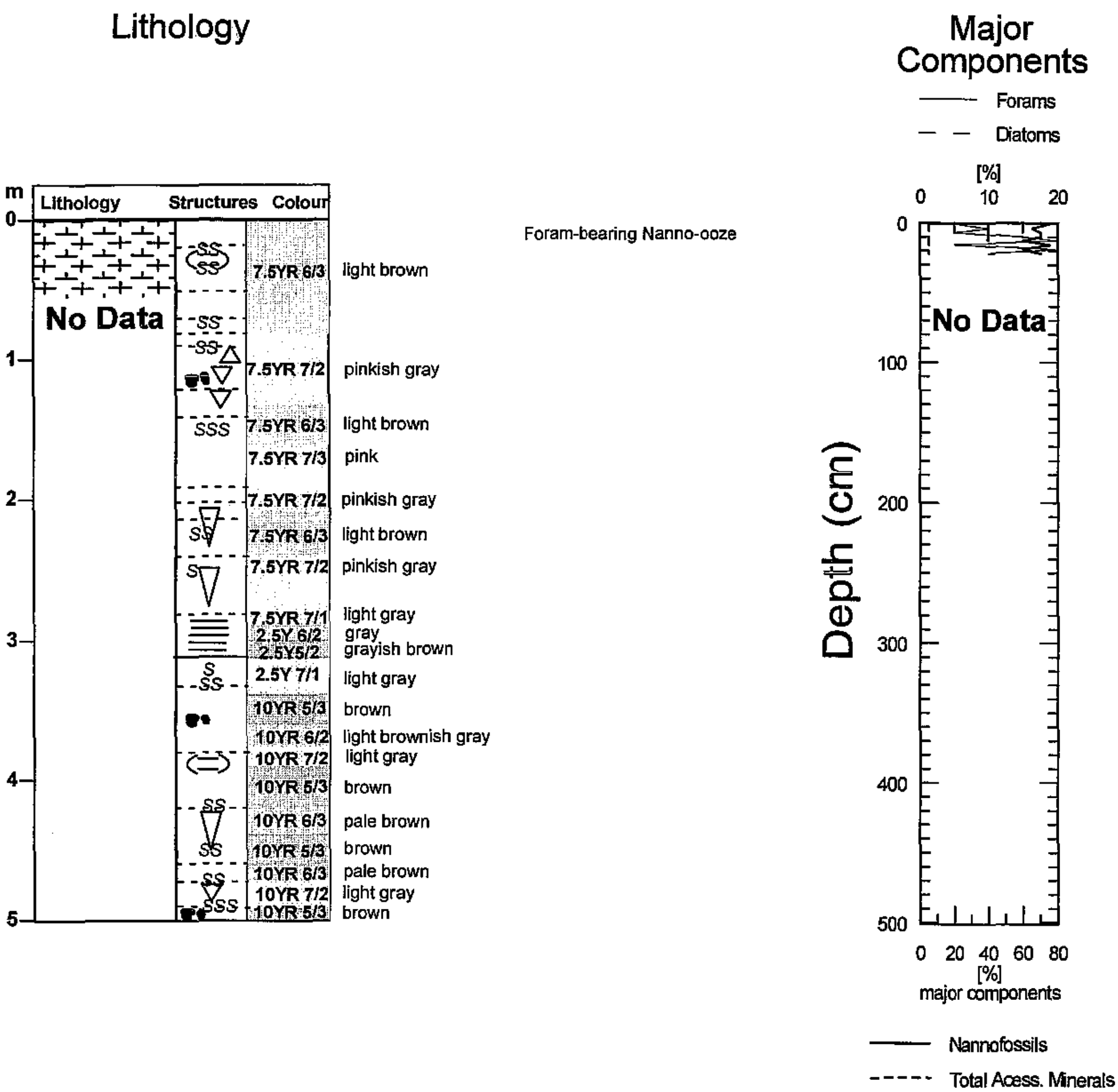
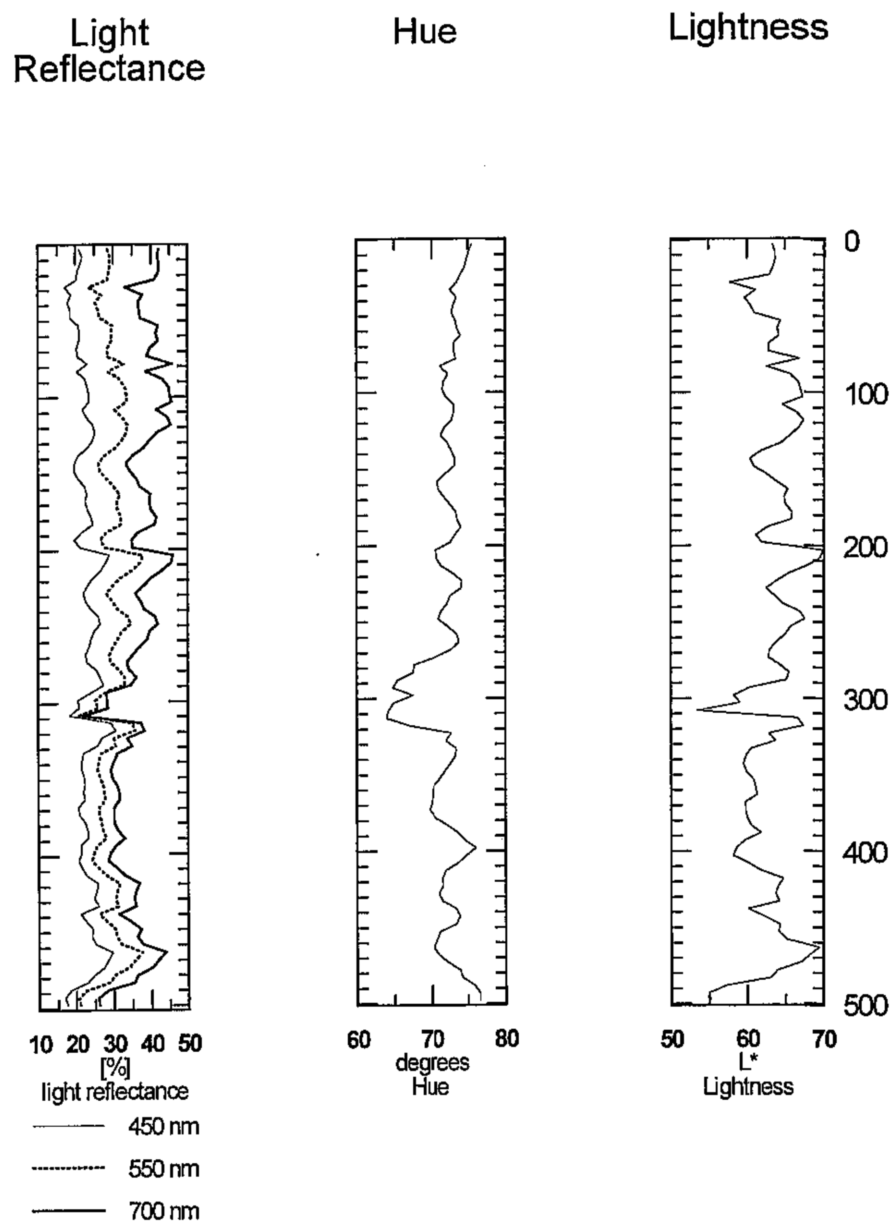


Fig. 15: Sediment descriptions, colour reflectance, hue, lightness, and smear slide analysis for the gravity core GeoB 4205-2

GeoB 4205-2



Light Reflectance
Hue
Lightness
0
100
200
300
400
500
10 20 30 40 50
[%]
light reflectance
450 nm
550 nm
700 nm
60 70 80
degrees
Hue
50 60 70
L*
Lightness

GeoB 4206-1 Date: 7.12.96 Pos: 31°29,9' N 11°00,8' W
Water Depth: 1848 m Core Length: 571 cm

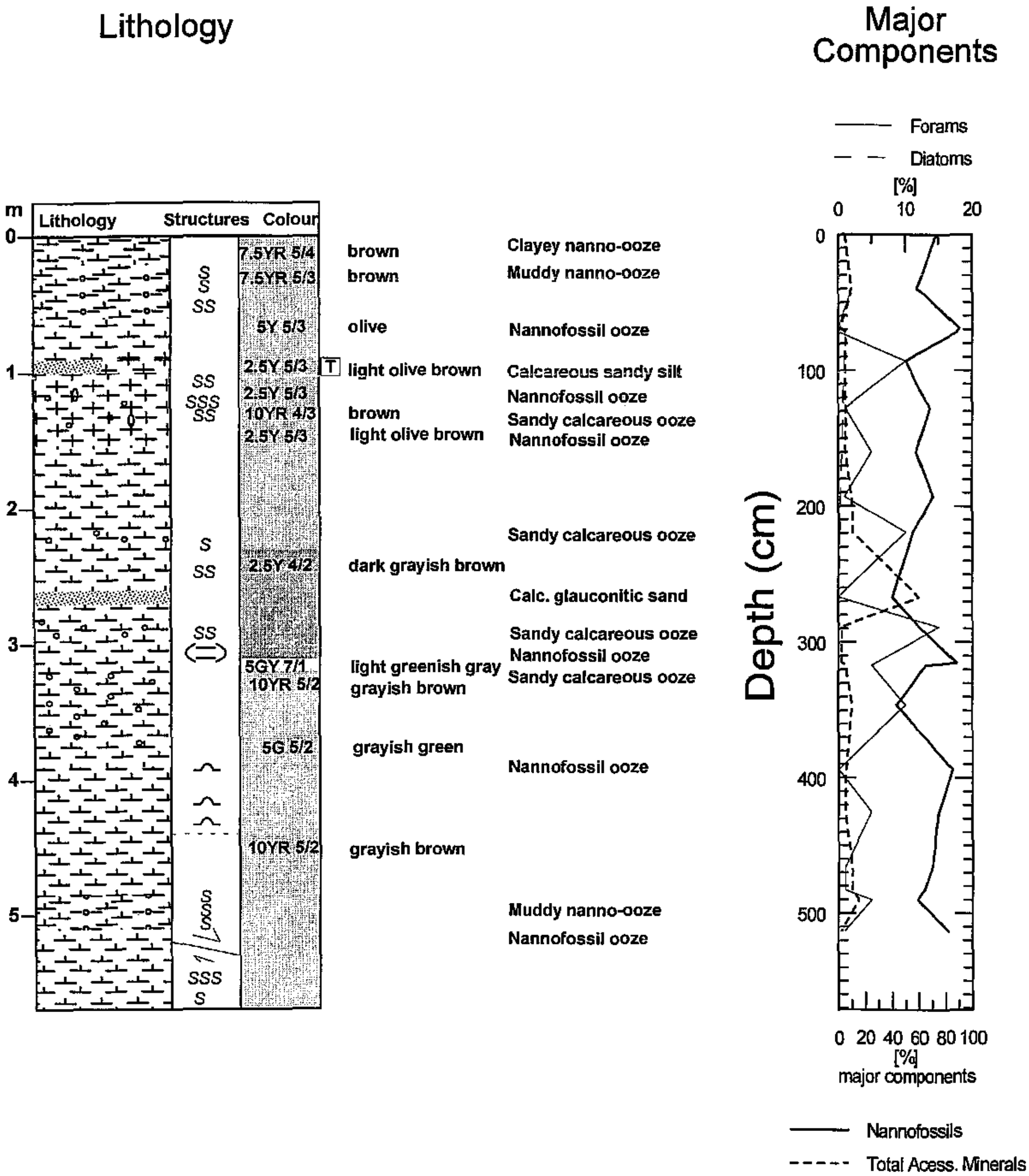
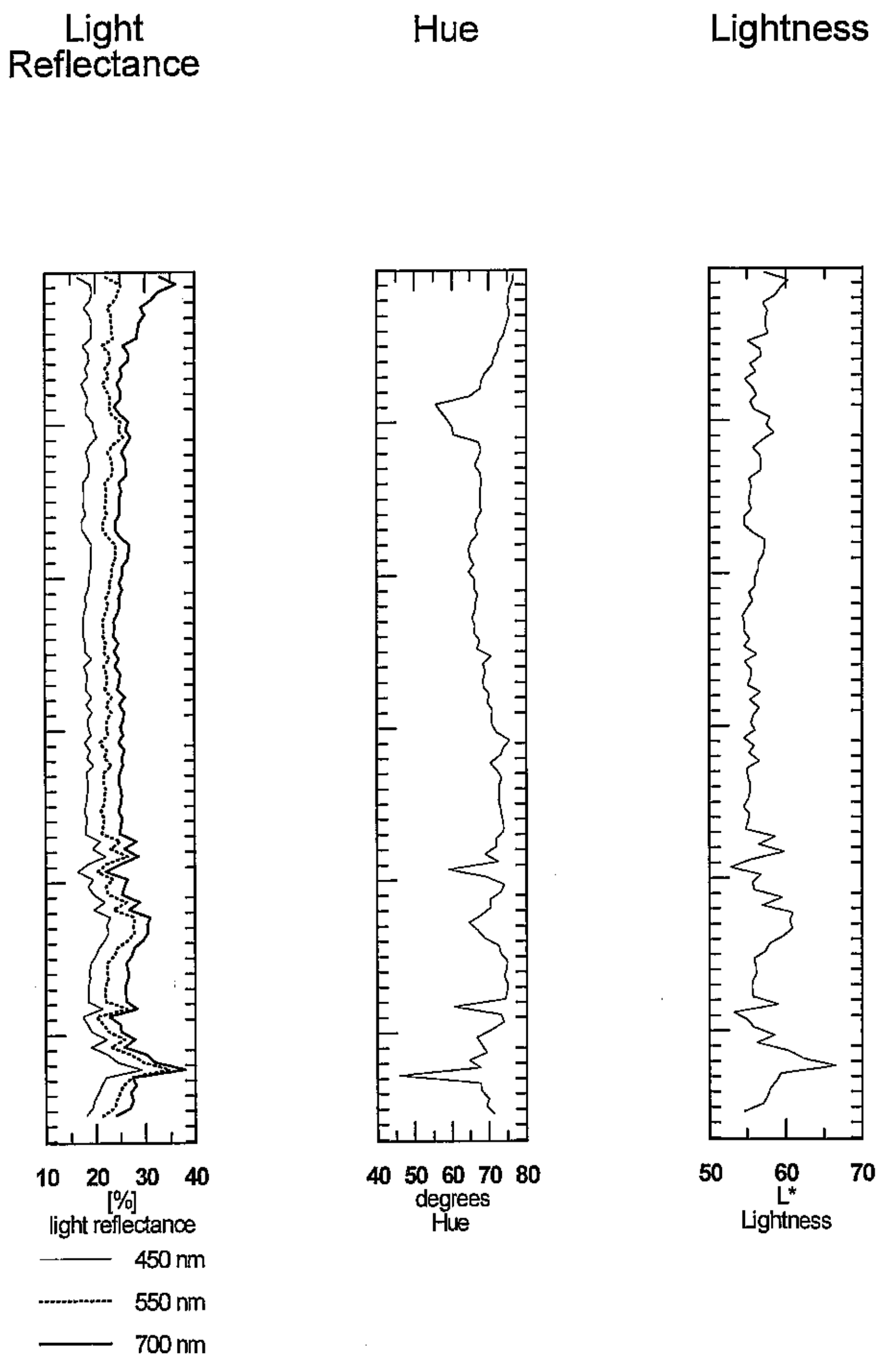


Fig. 16: Sediment descriptions, colour reflectance, hue, lightness, and smear slide analysis for the gravity core GeoB 4206-1

GeoB 4206-1


Light
Reflectance
Hue
Lightness
10 20 30 40
[%]
light reflectance
450 nm
550 nm
700 nm
40 50 60 70 80
degrees
Hue
50 60 70
L*
Lightness

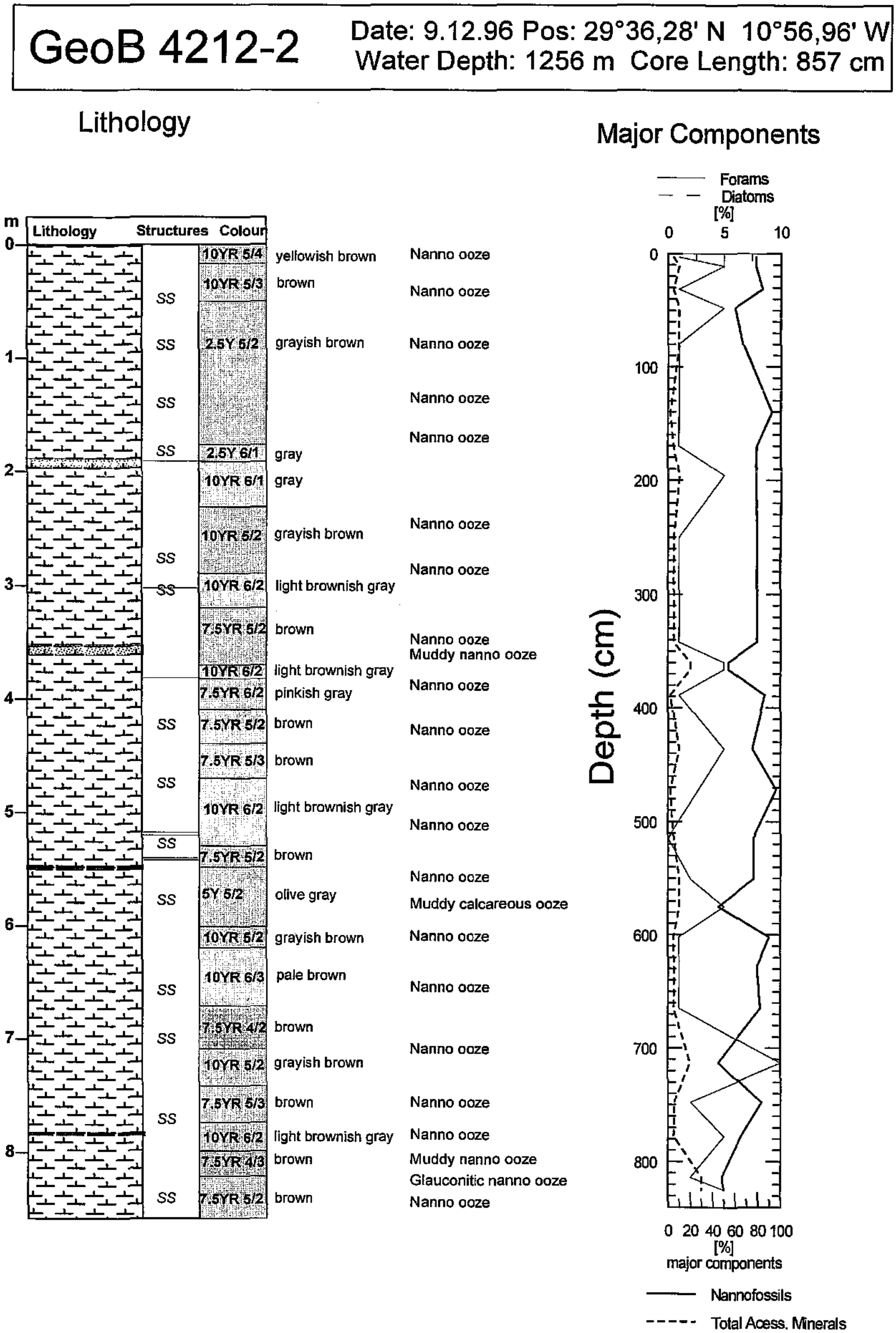
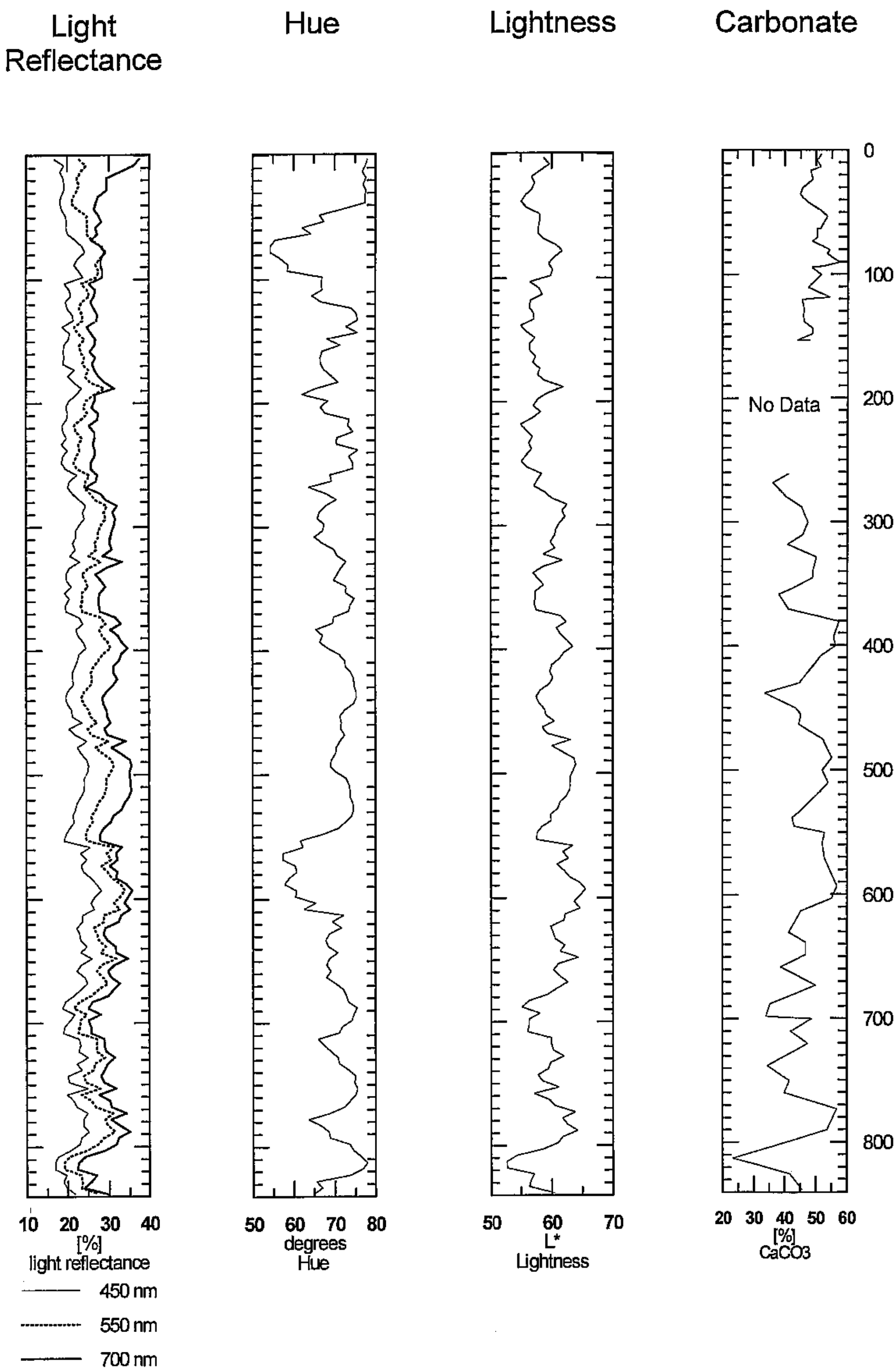


Fig. 17: Sediment descriptions, colour reflectance, hue, lightness, carbonate content, and smear slide analysis for the gravity core GeoB 4212-2

GeoB 4212-2


Light Reflectance
Hue
Lightness
Carbonate
0
100
200
300
400
500
600
700
800
No Data
10 20 30 40
[%]
light reflectance
450 nm
550 nm
700 nm
50 60 70 80
degrees
Hue
50 60 70
L*
Lightness
20 30 40 50 60
[%]
CaCO3

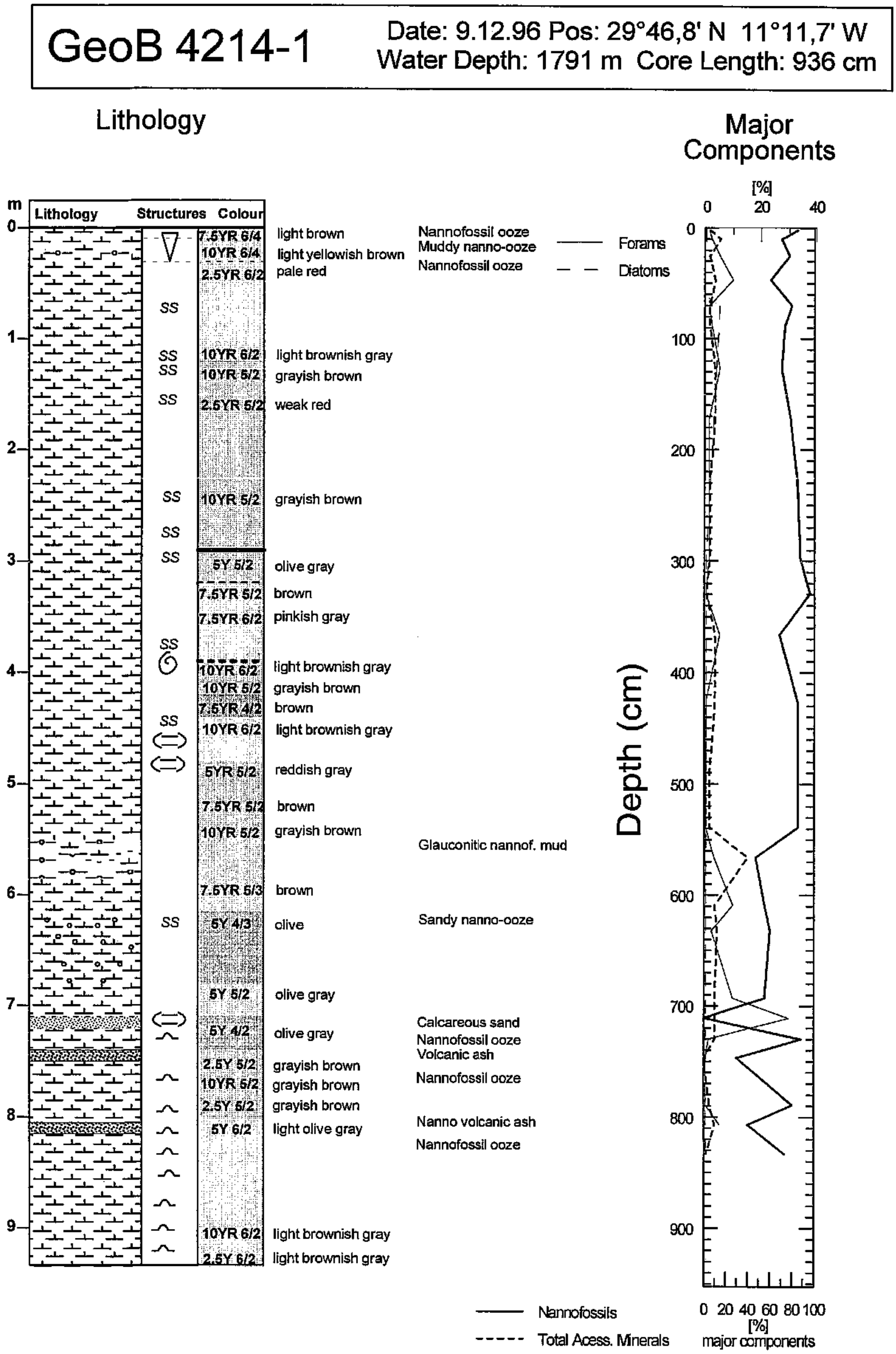
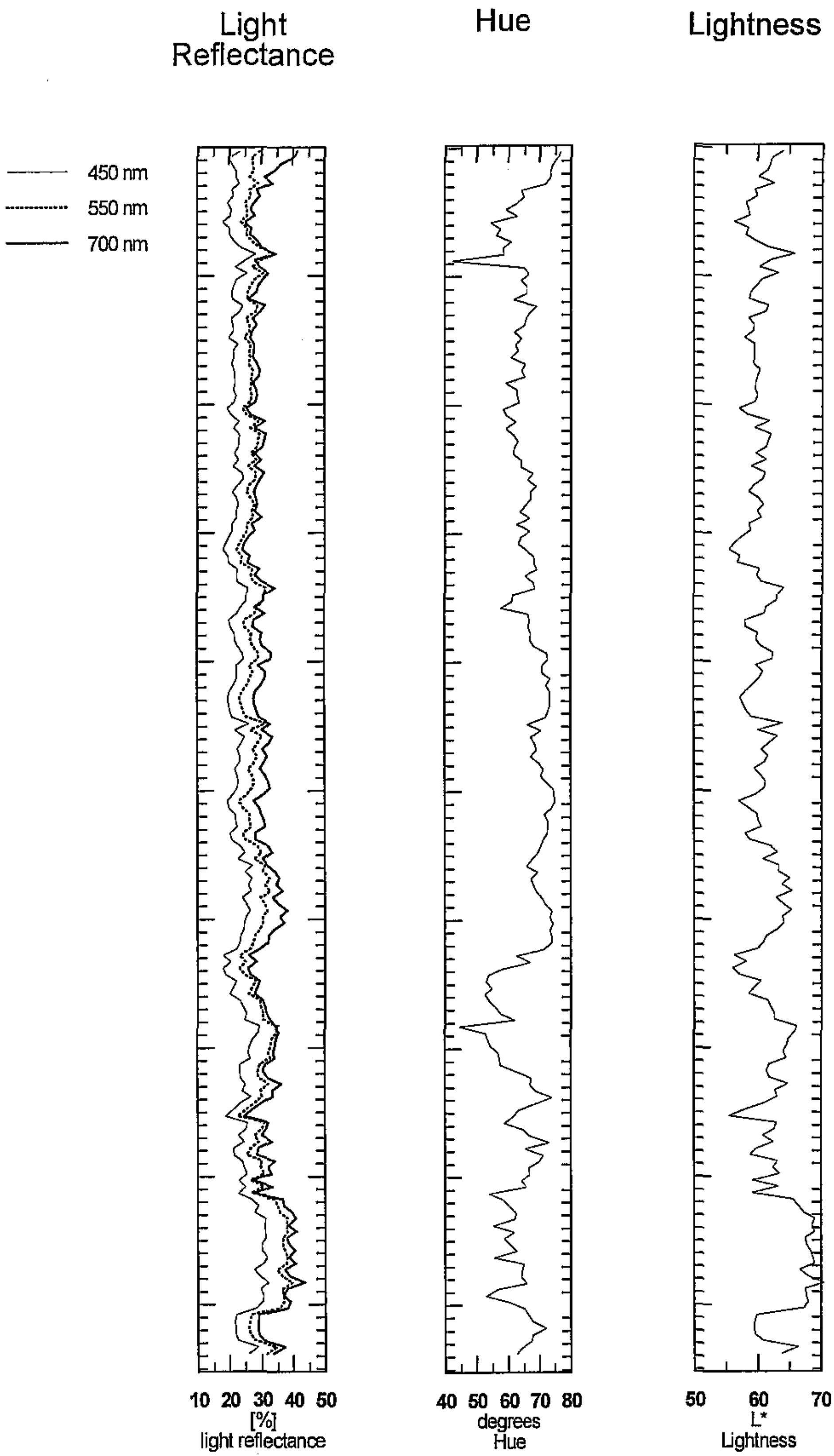


Fig. 18: Sediment descriptions, colour reflectance, hue, lightness, and smear slide analysis for the gravity core 4214-1

GeoB 4214-1


Light Reflectance
Hue
Lightness
450 nm
550 nm
700 nm
10 20 30 40 50
[%]
light reflectance
40 50 60 70 80
degrees
Hue
50 60 70
L*
Lightness

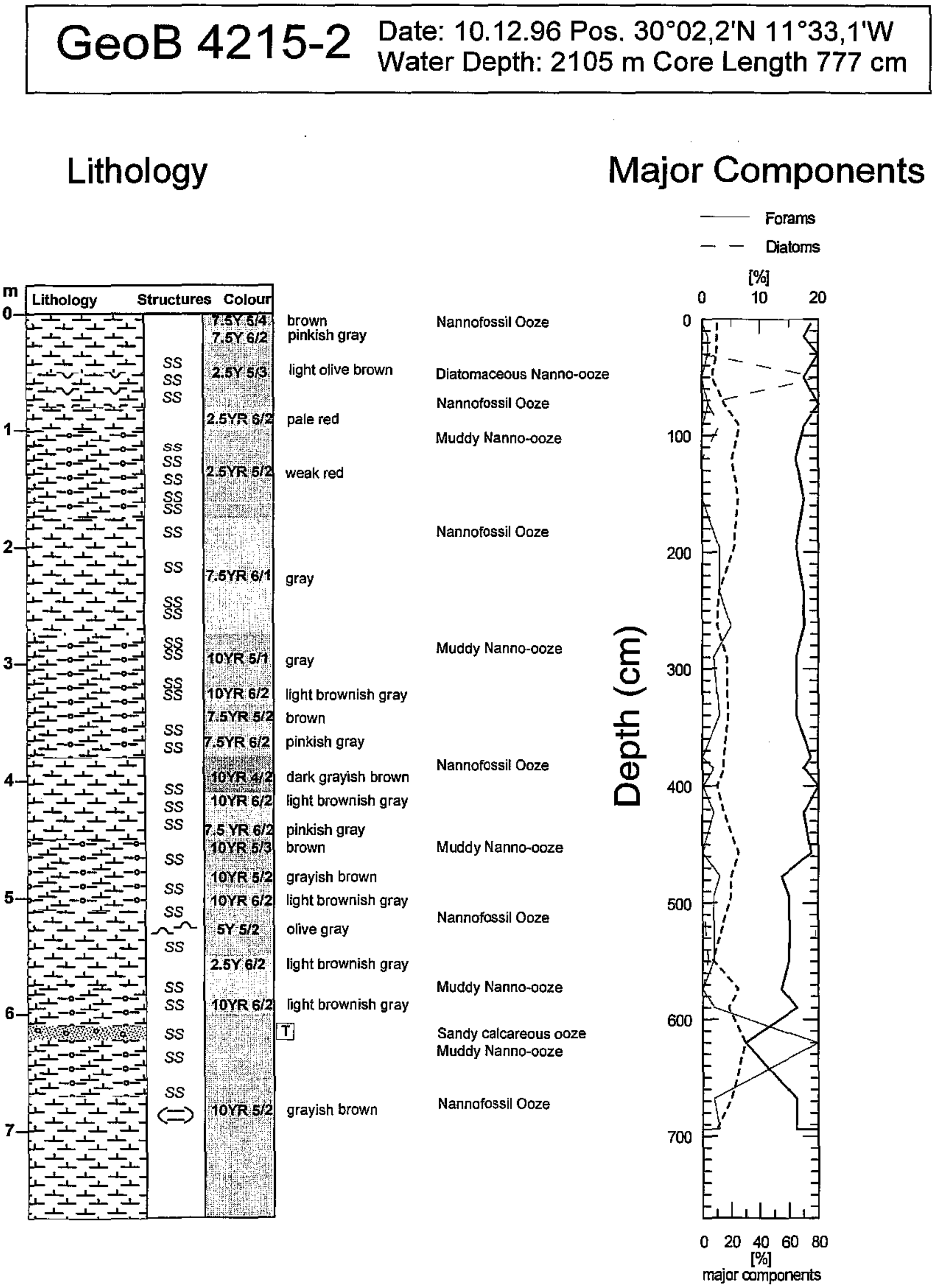
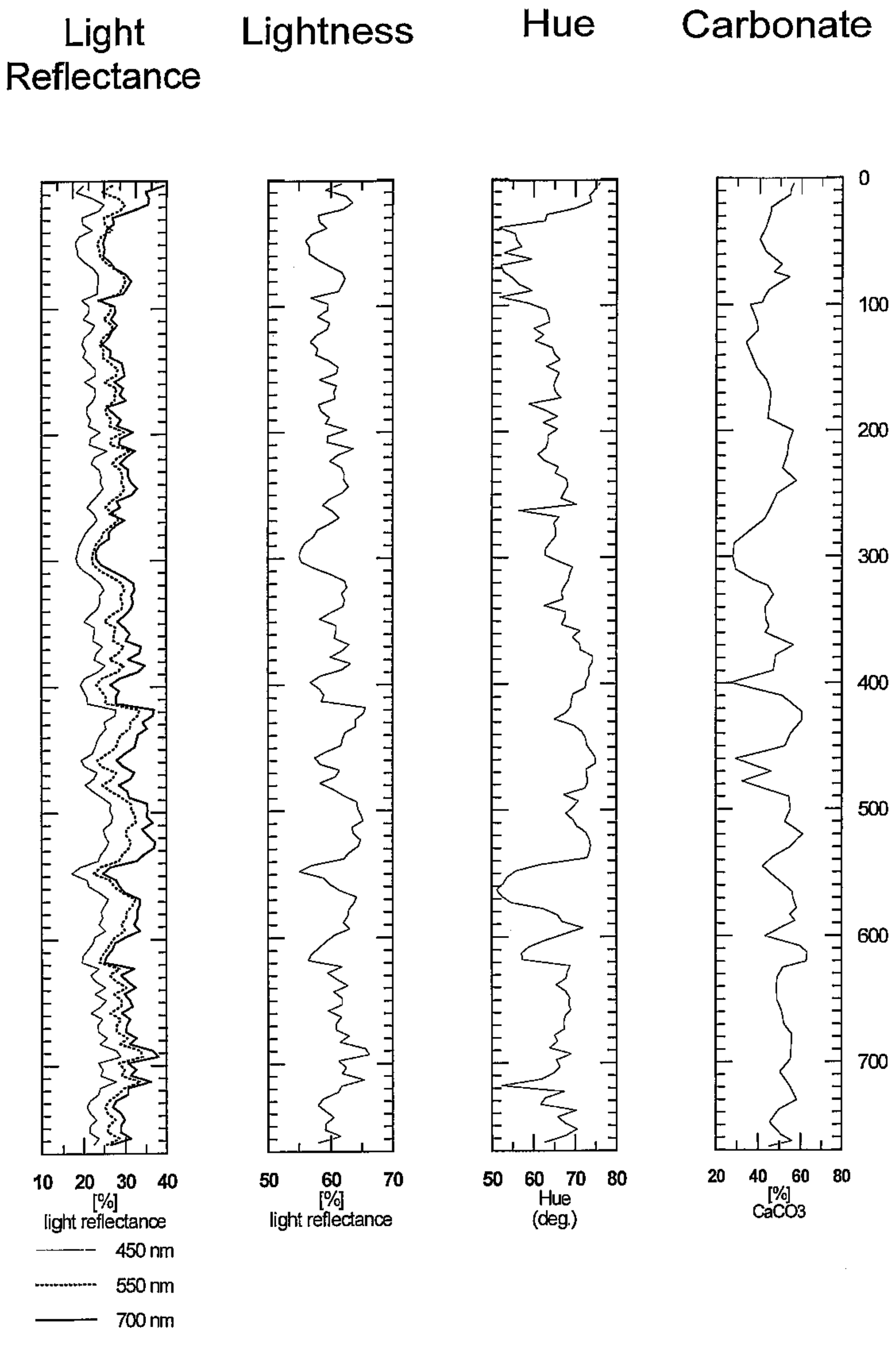


Fig. 19: Sediment descriptions, colour reflectance, hue, lightness, carbonate content, and smear slide analysis for the gravity core 4215-2

GeoB 4215-2


Light Reflectance
Lightness
Hue
Carbonate
0
100
200
300
400
500
600
700
10 20 30 40
[%]
light reflectance
450 nm
550 nm
700 nm
50 60 70
[%]
light reflectance
50 60 70 80
Hue
(deg.)
20 40 60 80
[%]
CaCO3

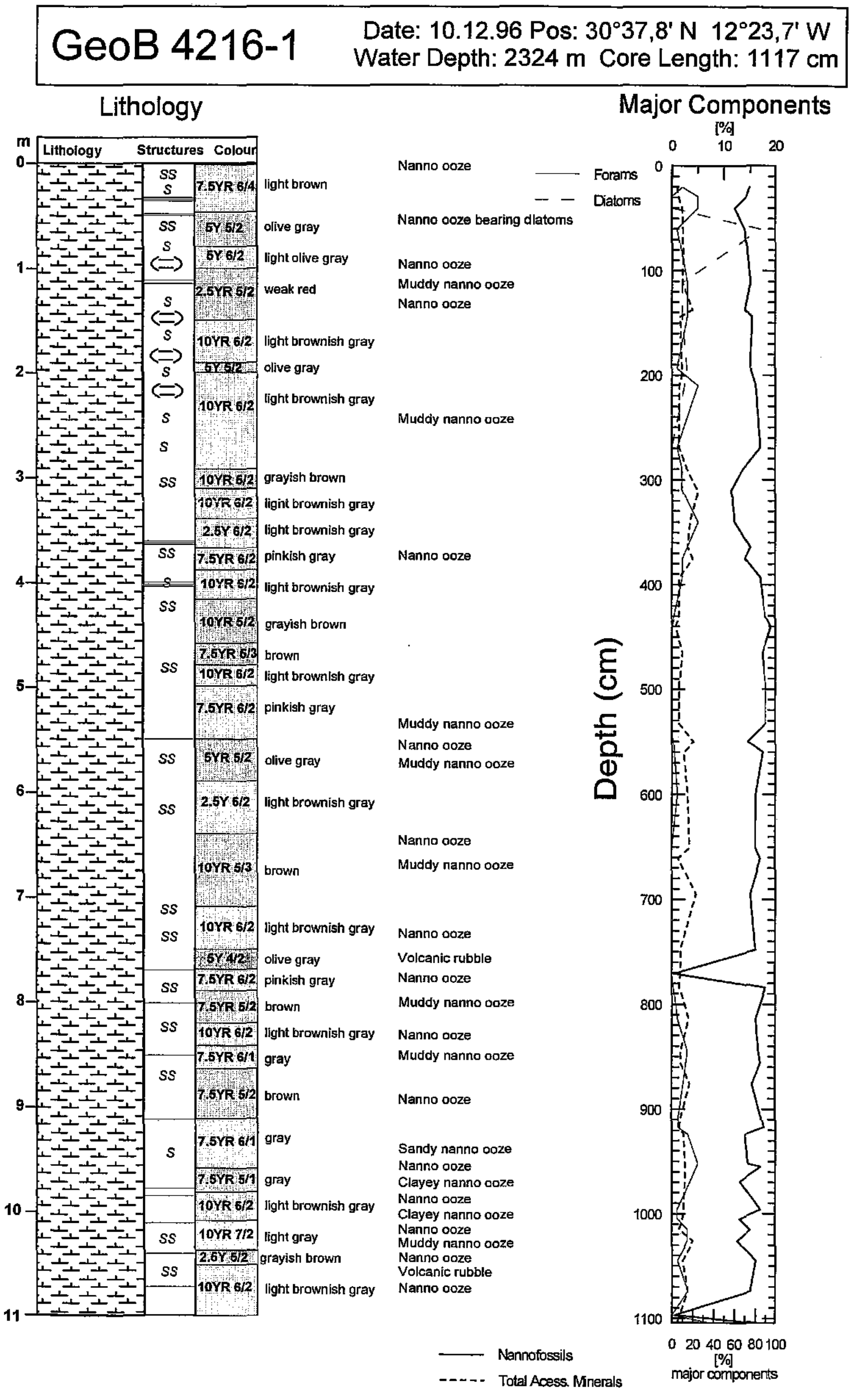
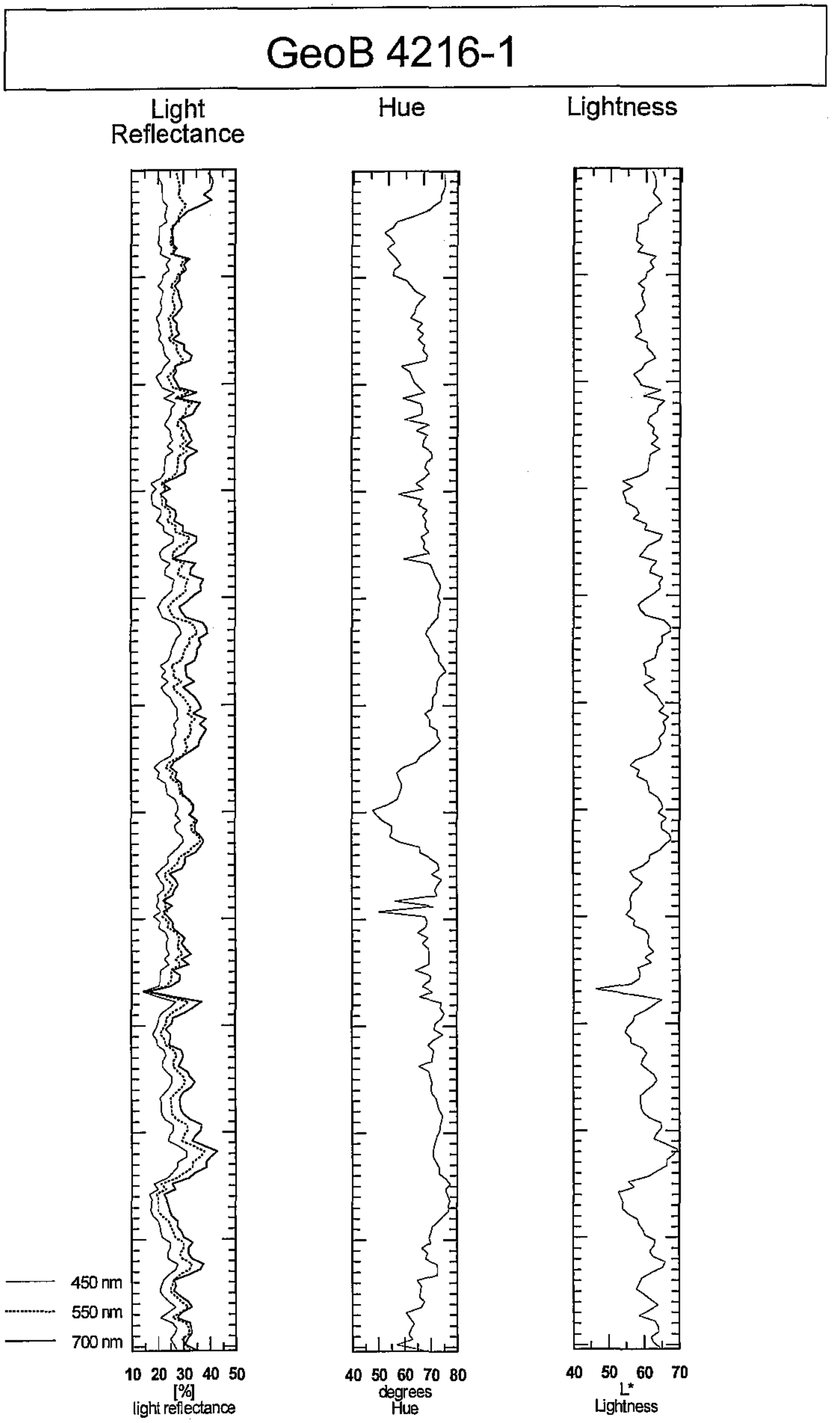
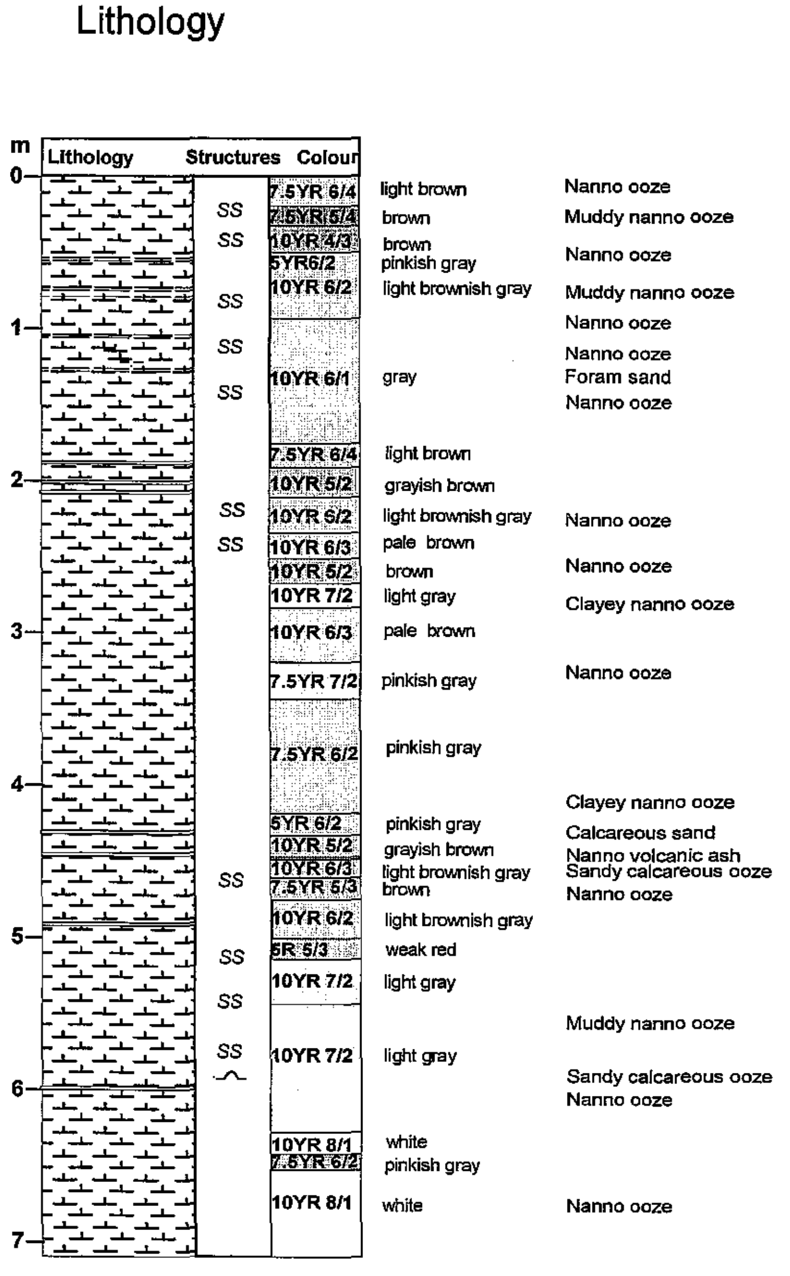


Fig. 20: Sediment descriptions, colour reflectance, hue, lightness, and smear slide analysis for the gravity core GeoB 4216-1


GeoB 4216-1
Light Reflectance
Hue
Lightness
450 nm
550 nm
700 nm
10 20 30 40 50
[%]
light reflectance
40 50 60 70 80
degrees
Hue
40 50 60 70
L*
Lightness

GeoB 4217-6	Date: 10.12.96 Pos: 30°26,1' N 12°53,7' W Water Depth: 2506 m Core Length:716 cm



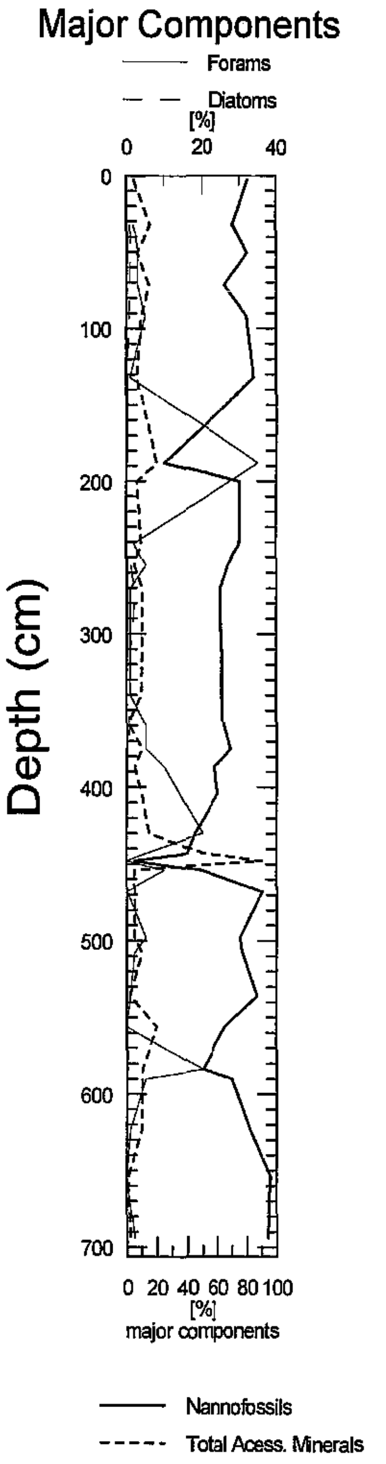
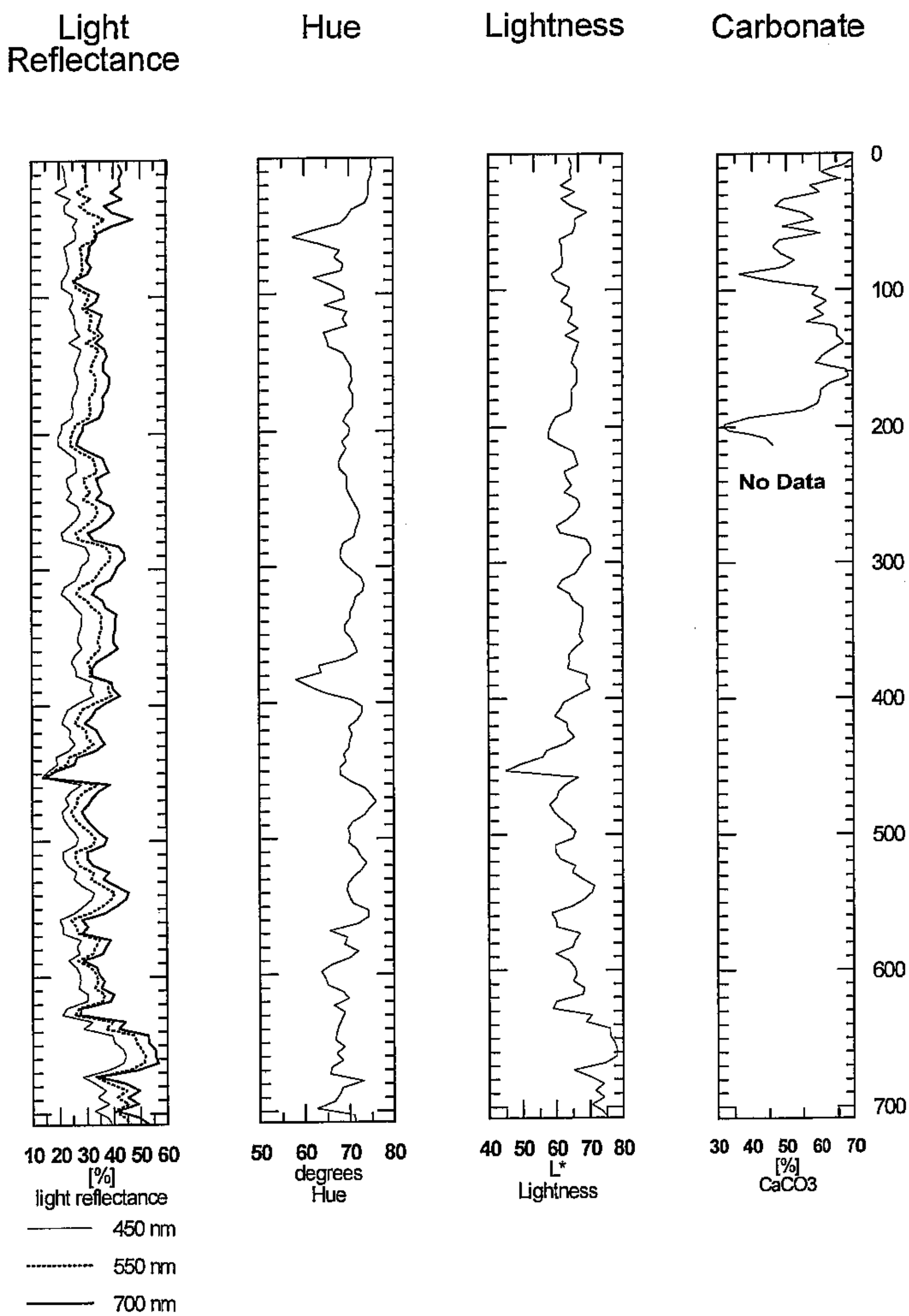


Fig. 21: Sediment descriptions, colour reflectance, hue, lightness, carbonate content, and smear slide analysis for the gravity core GeoB 4217-6

GeoB 4217-6



Light Reflectance
Hue
Lightness
Carbonate
No Data
0
100
200
300
400
500
600
700
10 20 30 40 50 60
[%]
light reflectance
450 nm
550 nm
700 nm
50 60 70 80
degrees
Hue
40 50 60 70 80
L*
Lightness
30 40 50 60 70
[%]
CaCO3

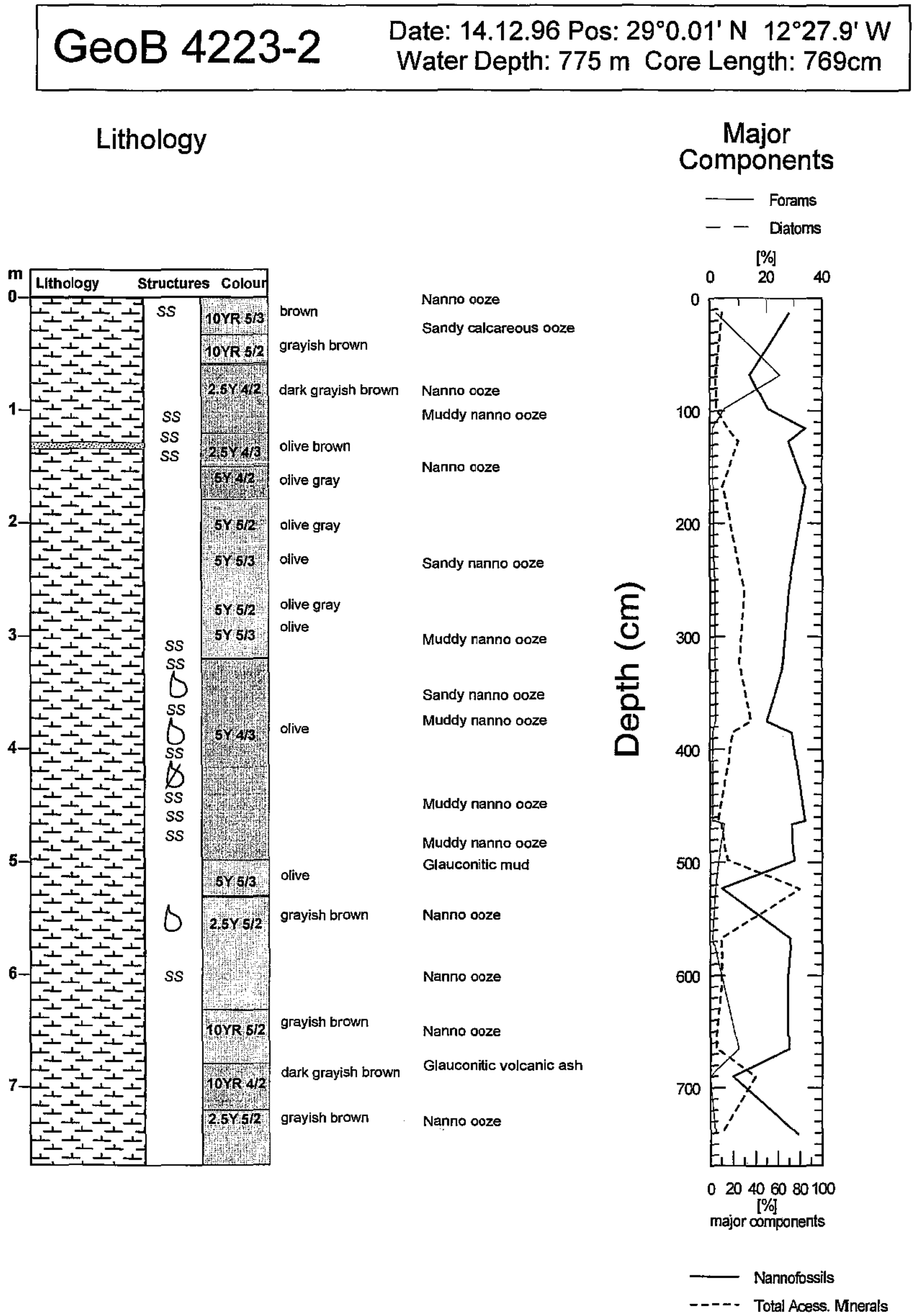
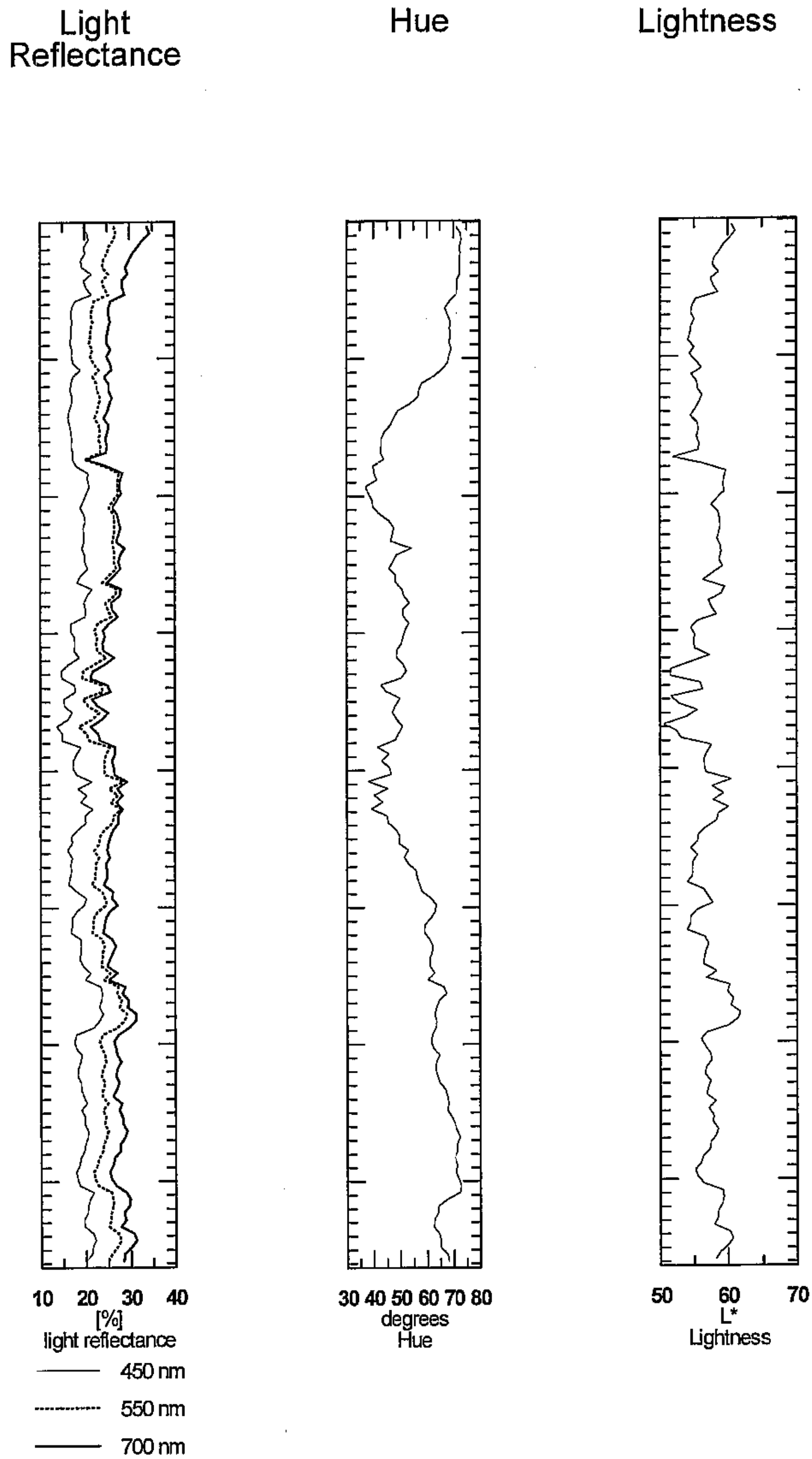


Fig. 22: Sediment descriptions, colour reflectance, hue, lightness, and smear slide analysis for the gravity core GeoB 4223-2

GeoB 4223-2


Light Reflectance
Hue
Lightness
10 20 30 40
[%]
light reflectance
450 nm
550 nm
700 nm
30 40 50 60 70 80
degrees
Hue
50 60 70
L*
Lightness

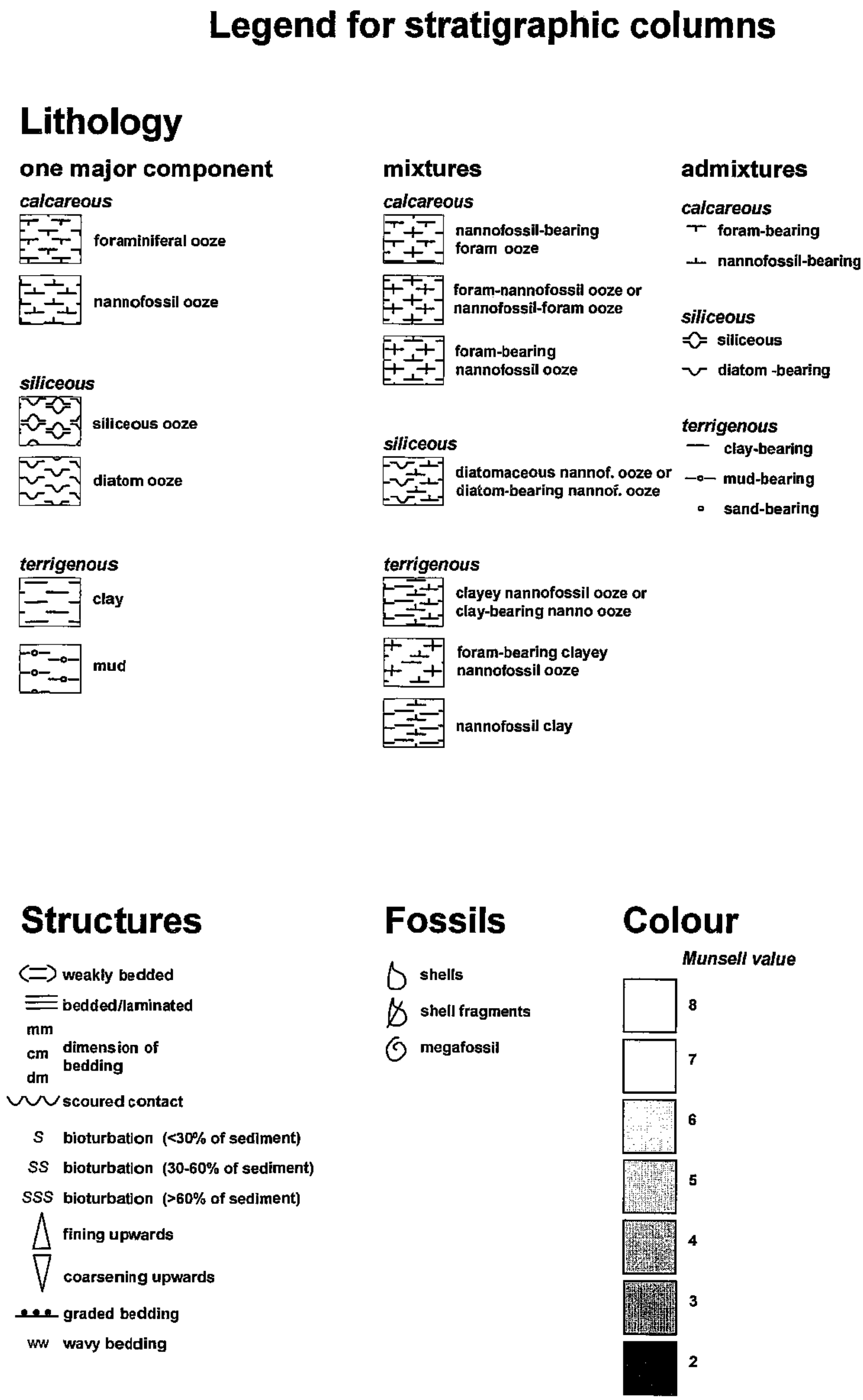


Fig. 23: Legend for stratigraphic columns of Figs. 15-22

5.1.9 Pore Water Chemistry

(L. Dittert, M. Zabel)

The main objective of geochemical investigations focused on the ESTOC-station. To characterize the area in regard to pathways of particle input to the Canary Basin surface sediments were additionally taken at several locations down the northwest African continental slope. By the description of the pore water chemistry analyzing different components, especially nutrient concentrations, it is possible to estimate the regional distribution of the organic matter input to the sea floor. Coupled with those microbial cathalysed early diagenetic processes causing the geochemical conditions of the benthic environment, multitude of abiotic reactions took place. Because of significantly different reactions in dependence of the redox conditions a lot of abiotic processes are also mainly influenced by the mineralization of organic matter. To investigate the sediment composition and especially the concentrations of trace elements within the complex solid phase / pore water system and therefore the effects of interannual and glazial to interglazial variations are the goal of a project (BIGSET - *"Biogeochemical substance and energy fluxes in the deep sea"*) these study is embedded. The long term time series of sediment trap experiments at the ESTOC-station and the international and interdisciplinary cooperations make this location very appropriate to detailed investigations within the context described above. Further on a special topic will be concerned with dust input from the Sahara desert.

5.1.9.1 Methods

To prevent a warming of the sediments on board all cores were transferred into a cooling room immediately after recovery and maintained at a temperature of 4°C.

The multicorer cores and the box corer core were processed within a few hours. Two samples of the associated bottom water were taken for nutrient analysis. The remaining bottom water was carefully removed from the multicorer tube by means of a siphon in order to avoid destruction of the sediment surface. During subsequent cutting of the cores into slices for pressure filtration in a glovebox with argon atmosphere, pH and Eh measurements were performed with a minimum resolution depth of 0.5 cm. Conductivity and temperature were measured on a second, parallel core to calculate sediment density and porosity.

The gravity core was cut into 1 m segments on deck. Within two days after recovery, gravity core was cut lengthwise into two halves and processed. On the working halves pH and Eh were determined and sediment samples were taken every 20 cm for pressure filtration. Additionally solid phase samples were taken at 5 cm intervals and kept in gas-tight glass bottles under argon atmosphere. Conductivity and temperature were measured on the archive halves. The storage temperature for all sediments was -20°C to avoid dissimilatory oxidation. All work done on opened cores was carried out in a glove box under argon atmosphere. For pressure filration Teflon-squeezers were used. The squeezers were operated with argon at a pressure gradually increasing up to 5 bar. The pore water was retrieved through 0.2 μm cellulose acetate membrane filters. Depending on the porosity and compressibility of the sediments, the amount of pore water recovered ranged between 5 and 20 ml. After squeezing the remaining sediment was stored in PE-foil for further analysis.

The following parameters were determined on this cruise:
Eh, pH, conductivity (porosity), NO_3^-, NH_4^+, PO_4^{3-}, alkalinity and Fe^{2+}.

Eh, pH, conductivity and temperature values were determined by means of electrodes before the sediment structure was disturbed by sampling for pressure filtration. Nitrate and phosphate were measured photometrically with an autoanalyzer using standard methods. The ammonium concentrations were determined by using a NH_3/HCl reactor and measuring the conductivity change within the acid (rapid flow-through injection analysis technique). Alkalinity was calculated from a volumetric analysis by titration of 1 ml sample with 0.01 HCl, respectively. For the analysis of iron subsamples of 1 ml were taken within the glove box and immediately complexed with 50 μl of Ferrospectral and determined photometrically afterwards.

The remaining pore water samples were acidified with HNO_3^-(suprapure) down to a pH value of 2 and stored at 4°C until further treatment in Bremen. Before subsamples of 1 ml were diluted 1:20 for ion chromatography analysis (HPLC) of SO_4^{2-} and Cl^- on the Meteor cruise M38/2.

5.1.9.2 First Shipboard Results

During the cruise, one gravity core, one box corer core and nine multicorer cores were geochemically examined. The gravity core and pertinent sediment surface samples were recovered at the ESTOC-station (GeoB 4241). The nine multicorer cores were recovered at stations GeoB 4211, GeoB 4215, GeoB 4217, GeoB 4225, GeoB 4226, GeoB 4228, GeoB 4231, GeoB 4232 and GeoB 4234.

All of the sampling sites are characterized by low rates of early diagenetic processes. Thus, the pore water concentration profiles indicated relatively reduced mineralization of organic matter. Especially the very slight release rates of nutrients like phosphate or ammonium support this first conclusion in general. Sediment analysis of the organic carbon content will be conducted back on shore in the home lab, but from the preliminary geochemical results values should be rather low.

The surface sediments of the first three investigated sites (GeoB 4211, GeoB 4215 and GeoB 4217 show the usual sequence. Possibly caused by the decreasing particle input offshore, all parameters indicated decreasing consumption or release rates, respectively, with increasing water depth. As an example, Fig. 24 shows the respective pore water profiles of nitrate.

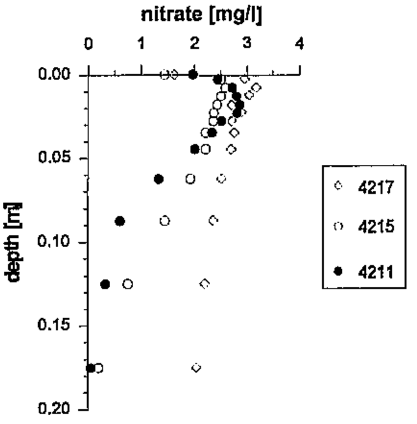


Fig. 24 Nitrate pore water profiles from multicorer sediments sampled of sites GeoB 4211, GeoB 4215 and GeoB 4217

More to the south this relationship changed. Focusing here on nitrate reduction rates, the organic matter flux to the sediments should be relatively reduced but organic matter seemed enriched in the deeper areas between the Canary Islands and the African continent. From higher benthic bio-geochemical intensities we suppose a lateral input pathway, probably by current induced redeposition of particles from the more productive shallower but relatively steep coastal areas to the deeper parts. Fig. 25 gives a first hypothetical idea of the regional distribution of the early diagenetic process rates. Given values are calculations of nitrate reduction rates in mmol/m²a and based on the assumption of an only diffusive transport.

Assuming steady state conditions, Fick's first law was used for determination. The diffusive coefficient (0,845 cm^2/d) was recalculated for in situ temperatures (CTD-data).

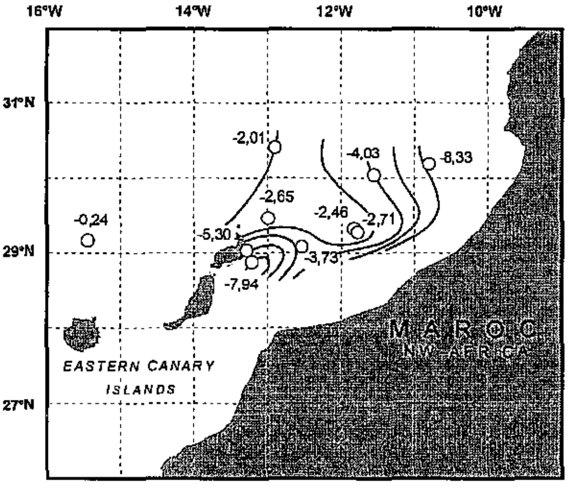


Fig. 25 Regional distribution of nitrate reduction rates within the study area. Values are given in $mmol/m^2a$. This first hypothetical result refers to lateral particle transport processes from steep shore areas to the deepest regions between the Canary Islands and the African continent

As was explained in the introduction, our main interest concentrated on the ESTOC-mooring-station. But the sediment structure with many coarse grained turbidites on this site first admit the effective employment of the multicorer and also in the deeper parts sandy layers influence the geochemistry environment of the sediment column. Gravity core GeoB 4241-10 has a length of about 4,4 m and contains at least 5 turbidites with an thickness from several centimeters up to 0,3 meters. Fig. 26 depicts the distribution of the pH-values, nitrate and ammonium concentrations with core depth. Within the pH-values two of those disturbances of the continuous sedimentation are characterized by close to bottom water conditions. Possibly this is caused by advective flow. The other two concentration profiles indicated very low mineralization processes in the deeper parts of the sediment. In comparison to results from the other sites, the nitrate reduction rate was only 0,62 $mmol/m^2a$ and has a penetration of about 2,3 m.

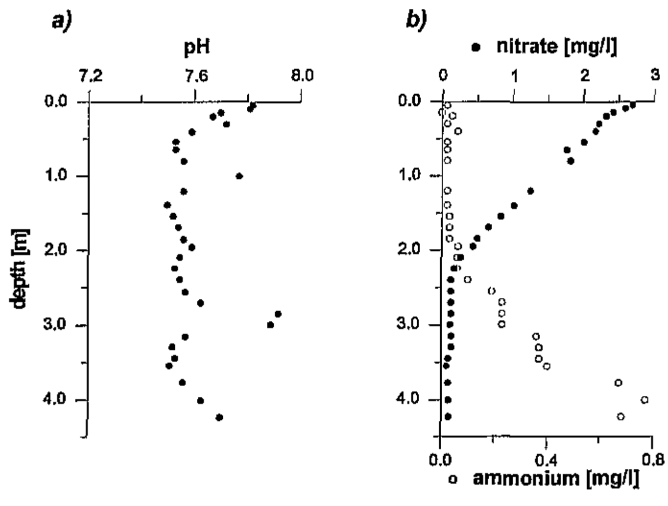


Fig. 26 pH-value, nitrate and ammonium pore water profiles from the ESTOC-station GeoB 4241 (a) the continuous sediment sequence is disturbed by a lot of turbidites (pH-values), b) early diagenetic processes take place with very low rates (NO_3^{2-} and NH_4^+)

Further detailed investigations of the solid phase element composition should give more information, especially to the aeolian dust input and its variation over the youngest geological time scale.

5.1.10 Underway Geophysics

(G. Bozzano, H. Meggers, M. Segl, J. Targarona and Shipboard PARASOUND Watchers)

During the entire METEOR Cruise M37/1, the shipboard acoustical systems PARASOUND and HYDROSWEEP were used on a 24 hour schedule one day after leaving the 200 sm zone of Portugal to record continuous high resolution bathymetric and sediment echosounding profiles.

5.1.10.1 Methods

PARASOUND: The PARASOUND system surveys the uppermost sedimentary layers of the seafloor. Due to the high signal frequency of 4 kHz, the short signal length of two sinoid pulses, and the narrow beam angle of 4.5°, a very high vertical resolution is achieved. Sedimentary layers along the ship track on a scale of less than one meter can be resolved. The PARASOUND data provided information about the physical state of the sea bottom as well as about sediment structures up to a depth of 50m below sea floor. The penetration of the PARASOUND signal depends on the density of the uppermost sediment layers and the impedance contrasts between these layers and at the sea floor. Thus, the penetration was used as a first hint for the quality of a potential coring location. The digitization and storage of the echosounding seismograms were conducted by usage of the software package ParaDigMa (Spieß, 1993). This system converts the analog to digital data and stores them on 9-track tapes in a SEG-Y like format, making data available for further post-processing. The pre-processed data are plotted online with a HP color printer and some plots of the cruise are presented here. These plots provided a first impression of variations in sea floor morphology, sediment coverage and sediment patterns along the ships track. In addition, navigation data are printed and stored to disk simultaneously. Beside the usage of the PARASOUND as a tool for localization of promising core sites, it is possible to image and describe the dominating sedimentation processes and to interpret the structural context of the longer sediment cores.

HYDROSWEEP: The general purpose of the HYDROSWEEP is to survey topographic features of the seafloor. A sector of 90° is covered by a fan of 59 pre-formed beams. Thus, a stripe with the width of twice the waterdepth is mapped perpendicular to the ship track. Data are stored on magnetic tapes in a sensor independent format. Since a workstation is directly installed beside the ParaDigMa PC, the PARASOUND operator is able to check the topographic map and cross- and ahead profiles on the HYDROSWEEP screen. This optimized the PARASOUND control, because in combination with the sediment echosounder HYDROSWEEP is proved to be a very efficient aid for the selection of suitable coring stations. The precise knowledge of the local bathymetry is essential to select suitable sites, to select the coring device, and to evaluate the impact of morphology, slope angles and sediment instabilities on the continuity of sedimentation. Also, the detailed 3D information of the seafloor topography represents an important contribution to the interpretation of the 2D PARASOUND cross-sections. Since rough sea bottom topography and bad weather conditions caused problems with the system, the data processing of the multibeam sounder often resulted in gaps.

5.1.10.2 First Shipboard Results

During cruise METEOR M37/1 different profiles of sediment cores were taken in the research field of Subproject 3 within CANIGO. These coring locations were all found by the aid of PARASOUND and HYDROSWEEP systems. The cruise M37/1 led the ship to extremely different sedimentary environments including ridges, seamounts and channels. The following examples are intended to give a short overview of the sediment structures which were found nearby the Agadir Canyon and between the Canary Islands and the African continent.

The quality of PARASOUND data for sediment sampling will be illustrated with examples from a track up the continental slope off Morocco, where the sampling locations GeoB 4228 to 4231 are situated (Fig. 28 and 29). The profile strikes perpendicular to the coast and is located between 29°30.6N, 13°02.1W and 29°04.7N, 12°32.4W. The waterdepths were between 1600 m and 1000 m. The signal penetration was 20 m on the flat sites, where the sediment sampling sites were and was about 2 m where the slope was very steep. Even on the steep parts of the profile, there was a mostly regular layering with distinct reflectors to be observed. Therefore it is assumed that undisturbed deposited sediments were present there.

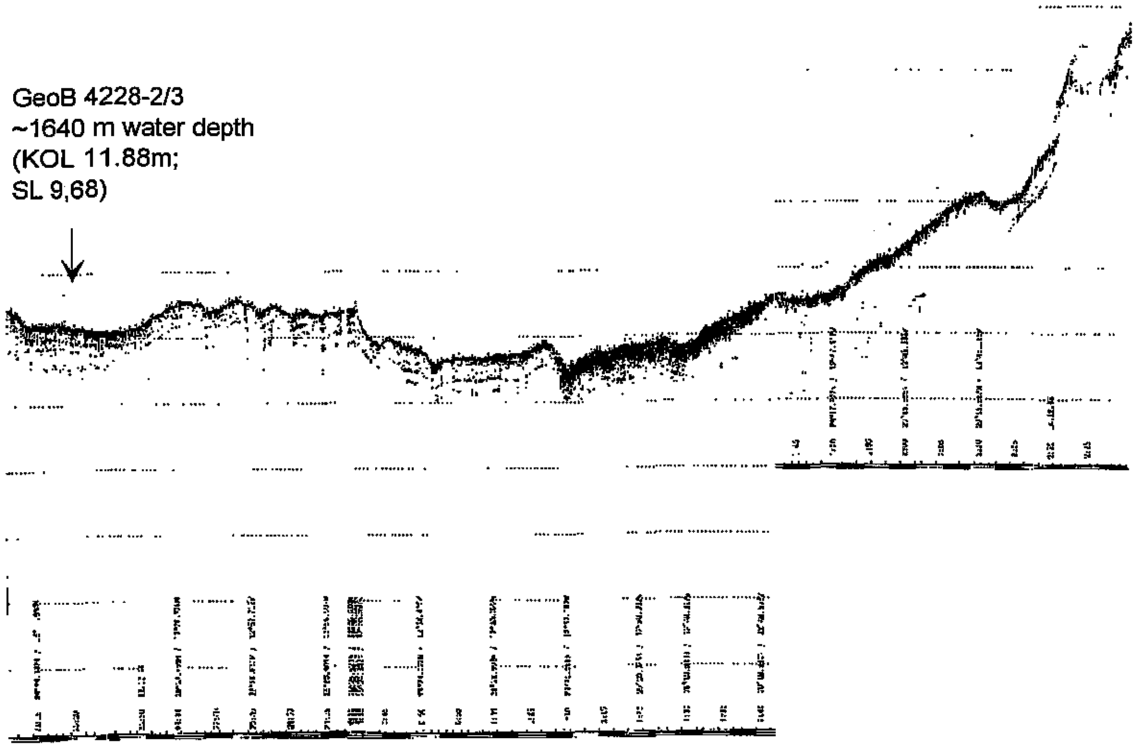


Fig. 27 Digital PARASOUND seismogram section recorded on a profil between 29°30,6N, 13°02,1W and 29°04,7N, 12°32,4W (continued in Fig. 28)

The investigation of the relationship between sediment profiles and bathymetry in the Agadir canyon and adjacent area (between 33°-29°N and 11°-13°W), during the M37/1 cruise, was also conducted with the acoustical systems PARASOUND and HYDROSWEEP. Here we present a selected set of PARASOUND and HYDROSWEEP data and profiles that characterized the main sedimentary structures recognized in the different depositional environments nearby the canyon (Figs. 29 to 34).

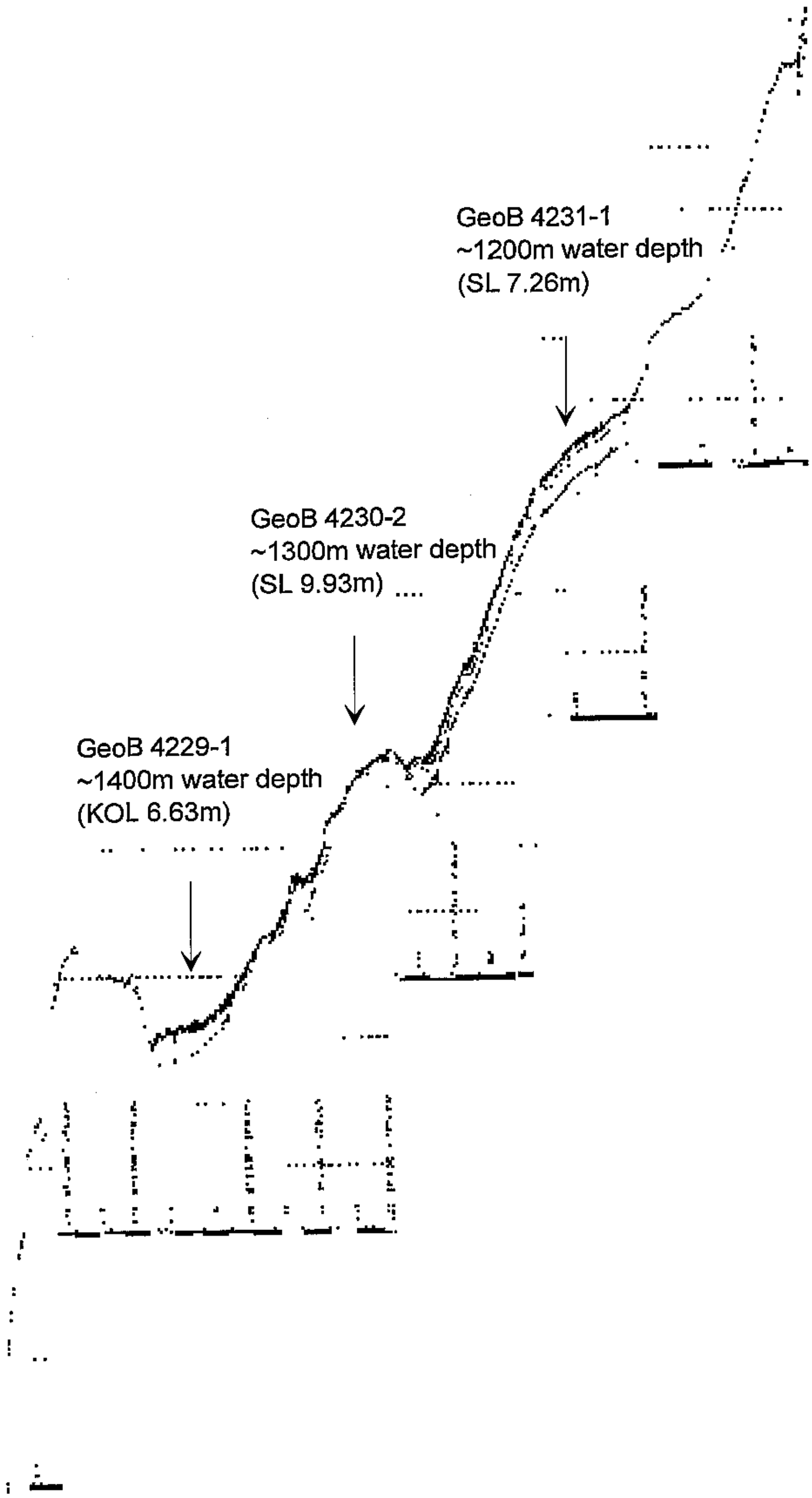


Fig. 28 Digital PARASOUND seismogram section recorded on a profil between 29°30,6N, 13°02,1W and 29°04,7N, 12°32,4W (continued from Fig. 27)

Abyssal plain

PARASOUND and HYDROSWEEP systems were switched on before arrival to the Agadir area, within the domain of the abyssal plain. The profiles of the abyssal plain north of the Agadir Canyon region show a flat sea floor, parallel reflectors and good penetration of the echosound into the sediment (40 m). Interesting was that the parallel stratification is interrupted by several dome shaped structures (Fig. 29). Large structures raising about 100 m above the sea-floor and smaller ones with about 1-2 m high cut through the surrounding reflectors. In the deep-sea environments, mud diapirism can occur when buried sediments bearing high water content experience the weight from overlying sediments. Under these conditions, sediments with high water content behave plastically and begin to move towards the surface cutting through the surrounding sediments. Therefore, a tentative interpretation of the structures in the abyssal plain is that they could be mud diapirs.

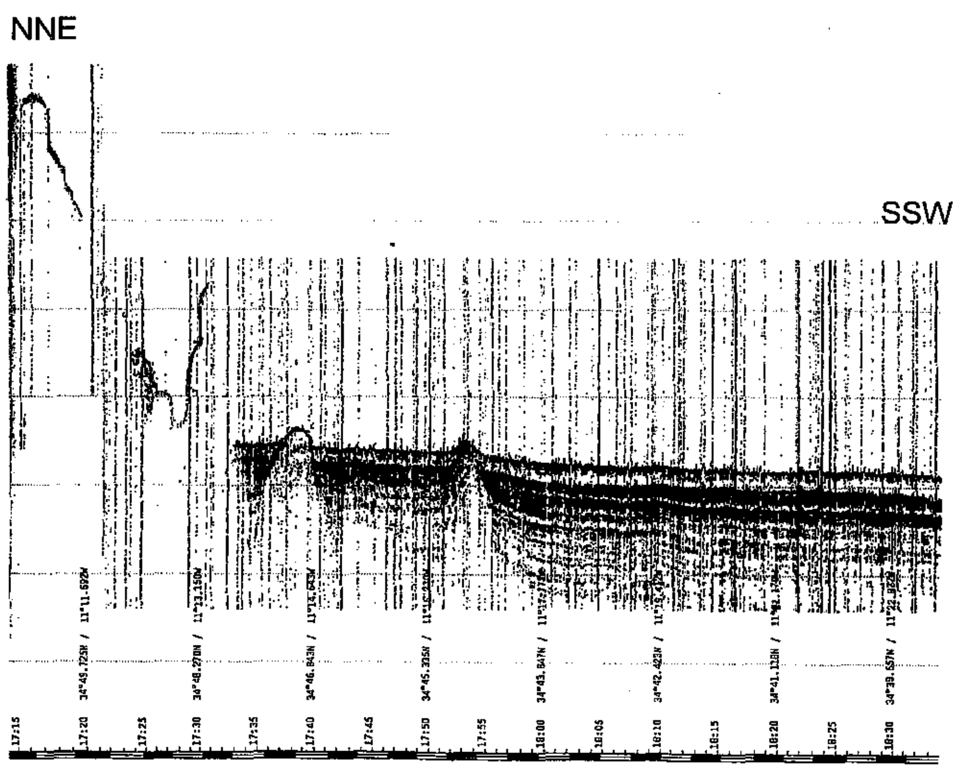


Fig. 29 Digital PARASOUND seismogram section recorded north of the Agadir region between 34°50'N/11°11'W and 34°39'N/11°23'W. Figure shows dome-shaped structures cutting the stratification and a transparent layer from the center to the SSW

In addition to these features, transparent layers within the echosounder plots indicated that echosound was absorbed, which revealed the presence of soft and fine grained sediments with properties close to the sea water. Transparent layers in this areas have been interpreted as turbidites, slumps and debris flows, since sediments from these bodies have a high water content. Because of its thickness (3-6 m) and large lateral continuity, the transparent layer in Fig. 29 can be interpreted as a turbidite. The slope in this area is very gentle (20 m drop on 20 km) with parallel stratification and sedimentation rates increasing down-slope. Deep-sea fans usually have low angle slopes and display alternating well-stratified and transparent layers. Since we were in the sedimentation context of the abyssal plain, the sedimentation pattern described may correspond to the distal part of a deep-sea fan environment.

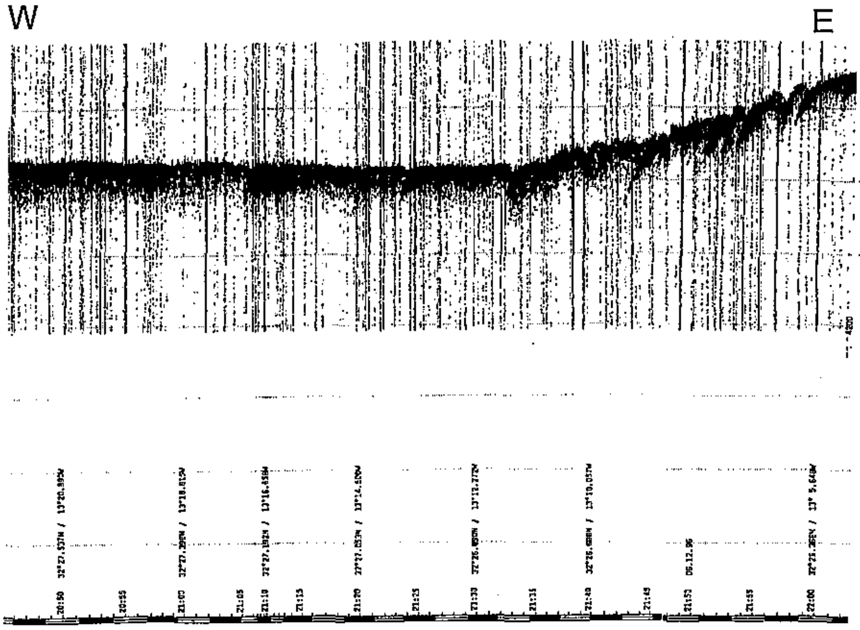


Fig. 30 Digital PARASOUND seismogram section from the region between 32°27'N/13° 21'W and 32°26'N/13°5'W. The high reflection signal indicates the presence of a coarse grained material on the sea-floor

Lower continental slope (Agadir canyon)

The area of the Agadir canyon has been the main focus of attention. The aim was to survey the canyon domain from distal to proximal environments. First, the distal area was surveyed along the canyon floor on a W-E direction. The sea-floor was located at an average water depth of 4150 m. A very strong reflector and low echosounding penetration (4 m) were characteristic of the area (Fig. 30). In addition, no layering was be observed. Surface sediments were obtained with box coring (GeoB4201-3). The sediments are silty clays with lenses of coarse grained material and bioturbation is high. The HYDROSWEEP shows an undulating bottom topography, a gentle slope and that the canyon is not confined between walls. These topographical features together with the profiles and sediments suggest that the canyon lost competence which induced sedimentation of the coarsest material.

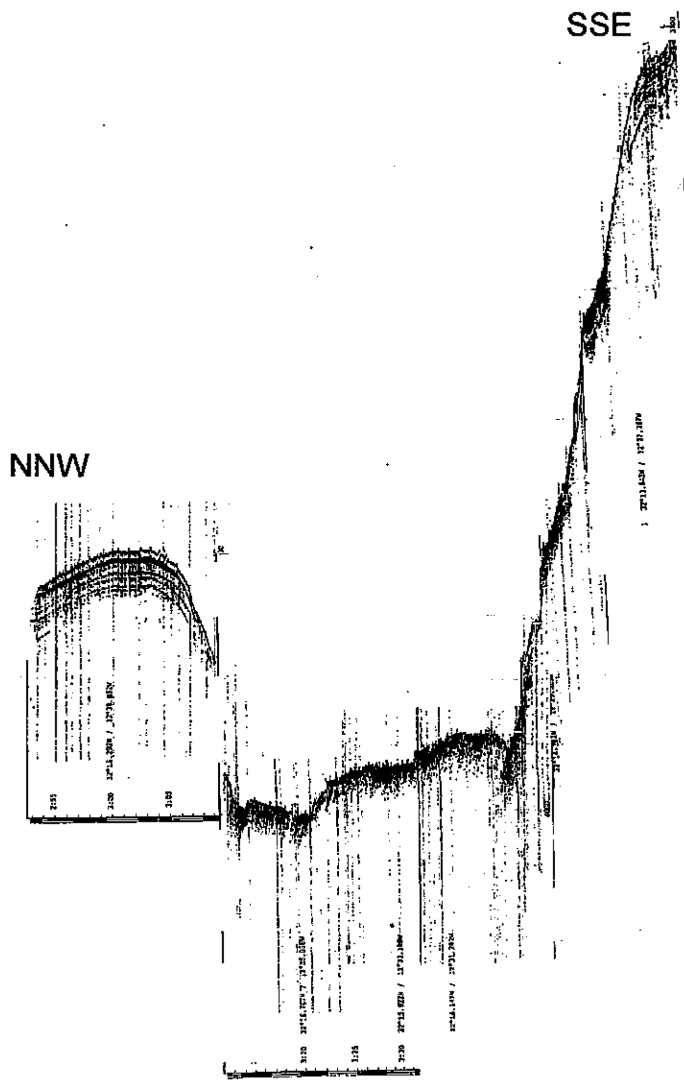


Fig. 31 Digital PARASOUND seismogram section from the region between 32°18'N/12°39'W and 32°13'N/12°27'W. Profile across the Agadir Canyon. Levee deposits can be recognized in the northern part . The strong reflector indicates the canyon floor.

Following the W-E survey, the ship's track crossed later a meander in the Agadir canyon. The NW margin showed well stratified layers that became thinner and join towards the canyon wall. This sedimentation pattern reveals the presence of a levee. A strong reflector at about 4200 m depth indicated a canyon floor with coarse grained material (Fig. 31). The HYDROSWEEP showed that the NW wall of the canyon was steeper than the SE. Depth and width of the canyon according to this map were about 300 m and 10 km, respectively. The relief given by the levee was probably too small (10 m) to be resolved by the HYDROSWEEP data.

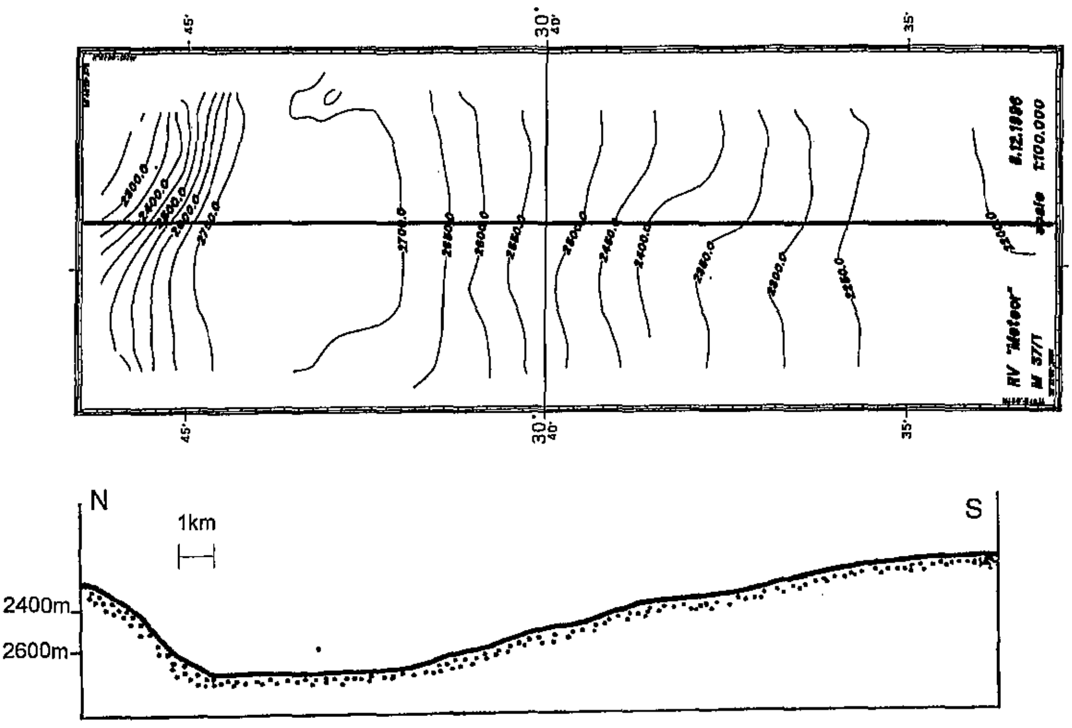


Fig. 32 HYDROSWEEP map (between 30°46'N/11°1'W and 30°32'N/11°7'W) showing the asymetrical shape of the canyon with a steep northern wall and a relatively flat and wide canyon floor

Continental slope between 3000-1500 m water depth (Agadir canyon)

A more proximal area within the canyon domain was surveyed perpendicularly to the axis of the canyon. The north wall of the canyon was steep and showed a transparent layer. This layer had a short lateral continuity, it began with a scar and ended with a rugged relief; therefore it is interpreted as a slump. A strong reflector at 2720 m average depth indicated the canyon floor. Sediments from the canyon were recovered with a boxcorer (GeoB4208-1). The lithology was silty clay. This profile, compared with the previous ones, showed smaller echosound penetration into the canyon floor. In addition, the floor showed little relief. This may indicate that deposition of coarse material occurs further downstream, while in this area erosive and mass transport processes dominated. After HYDROSWEEP data two cross sections were obtained. The first section (Fig. 32) showed that the canyon was about 300 m deep and 4.5 km wide and that margins were asymmetric. The second section (Fig. 33) showed a small channel with narrow and steep margins. Since its course was parallel to the canyon, it was probably a secondary channel of the Agadir canyon.

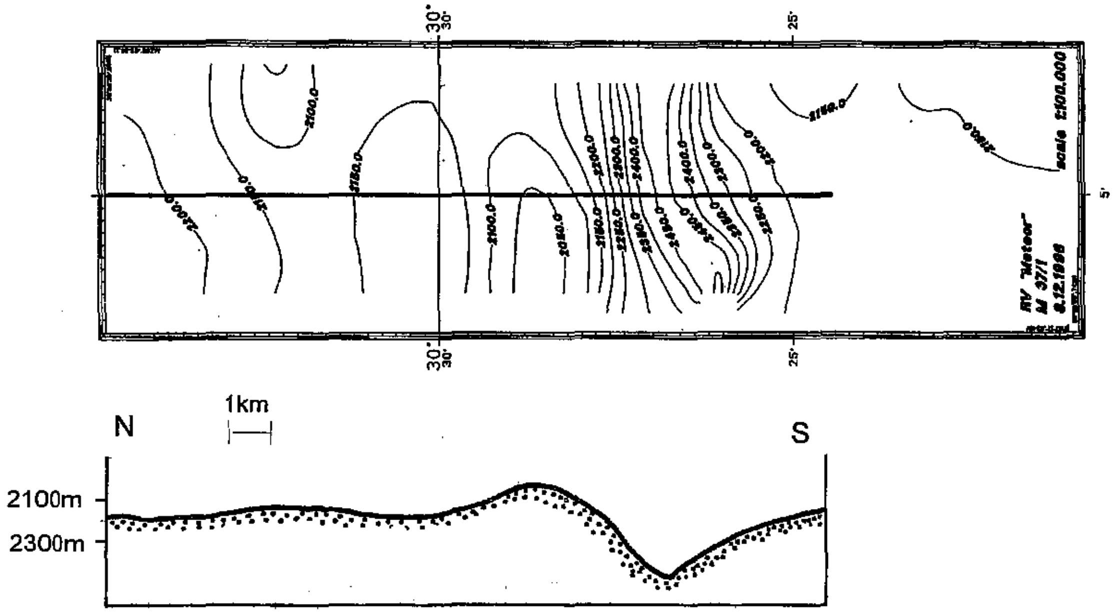


Fig. 33 HYDROSWEEP map (30°34'N/11°2' and 30°21'N/11°7'W) showing a narrow channel with steep margins, probably a secondary channel of the Agadir canyon

Continental slope between 3000-1500 m water depth (area adjacent to Agadir canyon)

The Fuerteventura and Lanzarote Islands are part of a small ridge roughly parallel to the African coast of which the islands are the highest peaks. North of Lanzarote, the ridge continued underwater until the Agadir canyon. Three parallel PARASOUND transects NW-SE (Fig. 34) were used to study the morphological features of the area between the ridge and the continental slope. The evidence gathered from these transects indicated that the valley between the Fuerteventura-Lanzarote ridge and the mainland probably contained a canyon which influence the sedimentation rates by transport of coarse grained material through bottom water currents. Although a more extensive survey is needed to map its course.

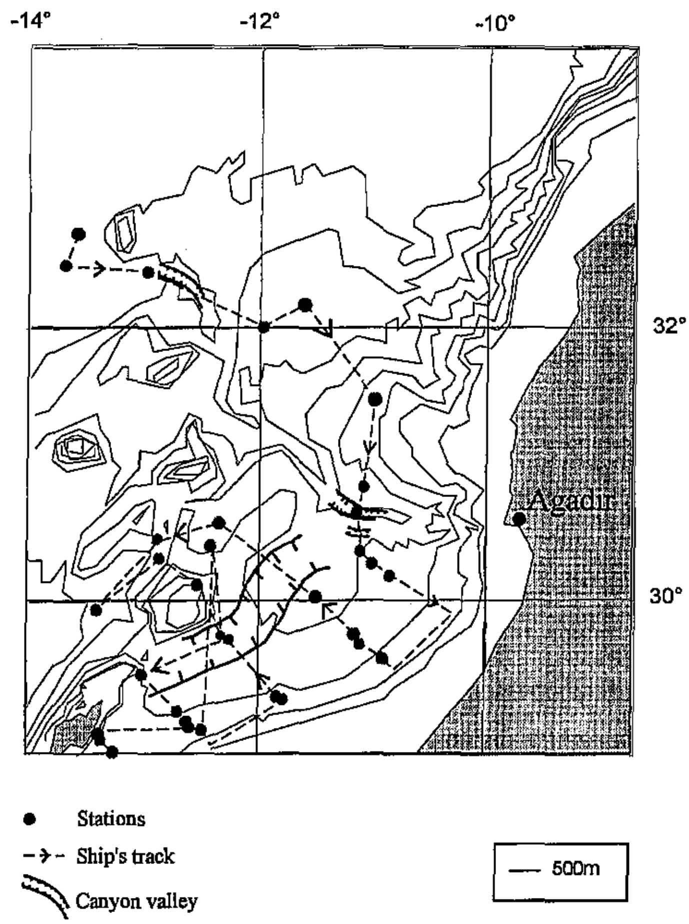


Fig. 34 Bathymetry chart showing the position of the canyons recognized from the PARASOUND and HYDROSWEEP records

5.2 Marine Geoscience M 37/2

5.2.1 Physical Oceanography

(T.J. Müller, P. Beining, M. Busse, A. Cianca, J. Godoy, J. Perez, J. Reppin, M. Villagarcia)

Moorings

All moorings but the ESTOC current meter mooring V367200 were set for the first time period. Therefore, data from these will be available only after instrument service in autumn 1997. Mooring V367200 was the second recovery of IFMK's current meter mooring at the ESTOC position. The data return was good. Calibration of Aanderaa current meters RCM8 and that of the ADCP follow the manufacturer's instructions (RDI, 1989; Aanderaa, 1995). The pressure record in the uppermost instrument shows that mooring motion was low (less 20 dbar). Salinity was derived from measured temperature and conductivity, and nominal pressure (instrument depth). All temperature measurements and the derived salinities were checked against CTD temperature profiles taken before laying and after recovery. Linear corrections were applied where necessary. After calibration, the time series were low pass filtered with a cut off period of 36 h and then averaged to daily values.

Displayed in Fig. 35 are the combined series of currents from the two settings which start in autumn 1994. No clear signal of a steady southward flowing Canary Current can be detected in the upper layers. Instead, the signals. in the whole water column are dominated by mesoscale activity, some with a strong baratropic component. Note, that during the 27 month period, at least two meddies passed the ESTOC position.

Hydrography

A Neil Brown MKIIIB CTD (IFMK internal code NB2) was used to obtain continuous profiles of temperature and salinity. Attached to the CTD was also an oxygen sensor. This sensor did not have an internal temperature which makes absolute calibration of this sensor difficult. On some stations, also a fluorometer was attached (see 7.2). Also attached on most of the stations was a (lowered) lADCP.

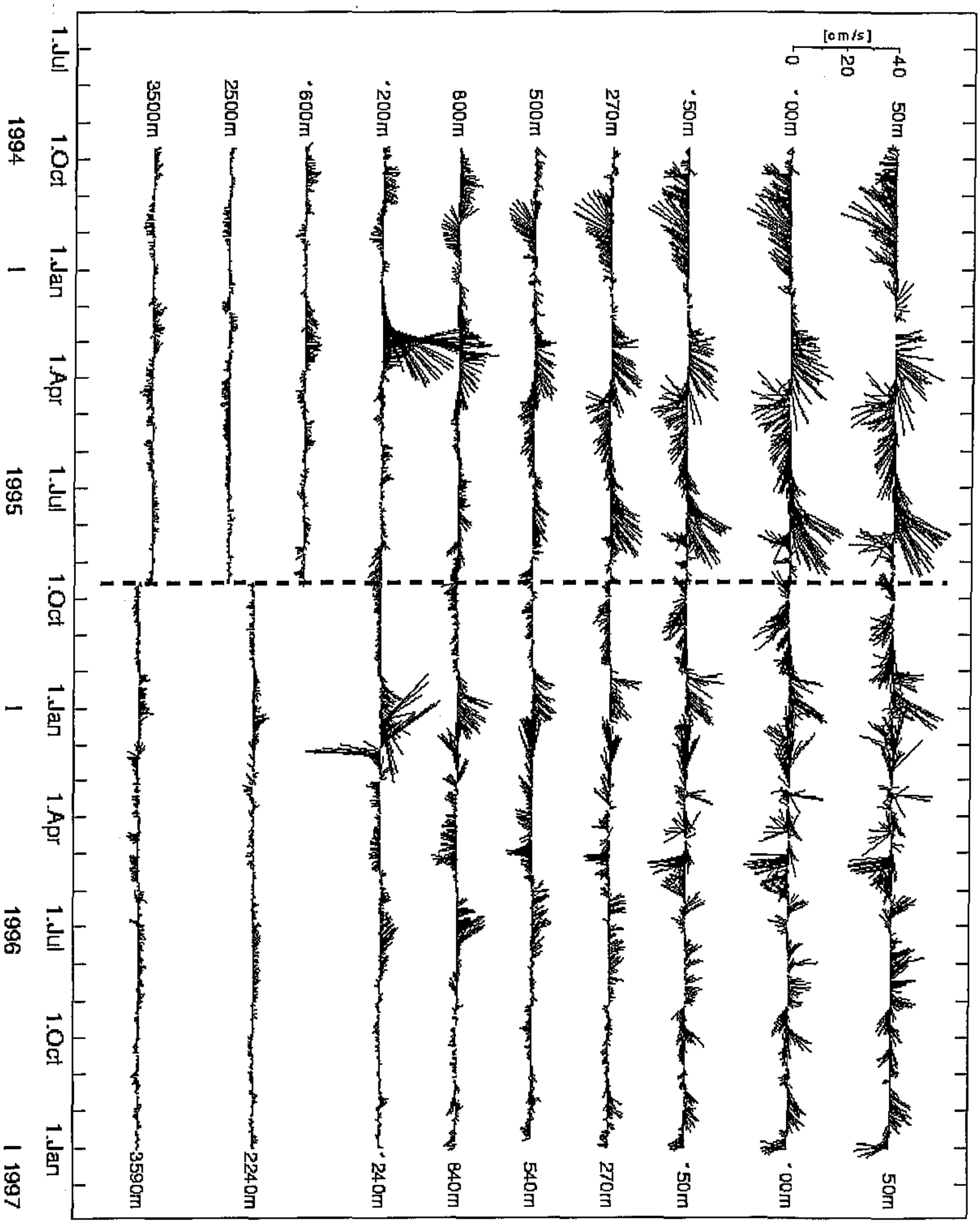


Fig. 35: Currents at the ESTOC position, starting in September 1994; moorings V367100 and V367200. Upward is north.

The CTD's pressure and temperature sensors were calibrated in the laboratory to WOCE standards (better 2 mK, 3 dbar at 6000 dbar). The conductivity sensor was calibrated by comparison with the in-situ conductivity of bottle samples taken during the up profile with the rosette. CTD data processing and removal of typical nonlinear effects in sensor responses followed Müller et al. (1995). The samples were analyzed with a Guildline AUTOSAL salinometer to better 0.002 psu for single samples, with a few outliers being ignored. The resulting deviations of calibrated CTD salinity from bottle salinity in up profiles is shown in Fig 36. The expected error of salinity in CTD profiles is expected to be less 0.002 psu.

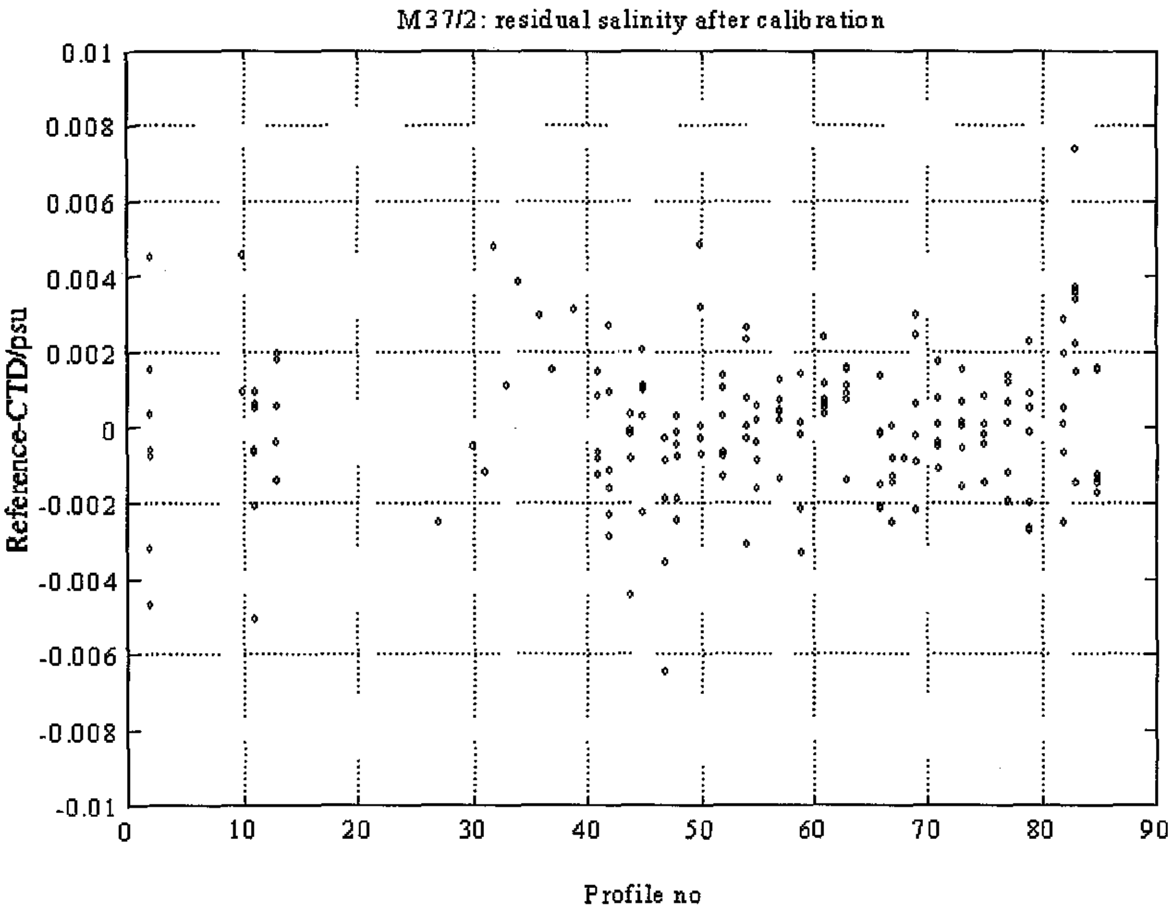


Fig. 36: Residuals of the salinity calibration of the MKIIIB CTD (IFMK internal code NB2)

On the CANIGO box, nearly all bottle samples were analyzed for oxygen and nutrients. Analysis for dissolved oxygen used the Winkler method with improvements to WOCE standards (WOCE Operations Manual, 1994). Samples for nutrient analysis were frozen at -20°C and then analyzed at the ICCM following the WOCE standards (WOCE, 1994). For details see the first ESTOC time series report (Llinas et al., 1997).

As a first result, we display the distribution of potential temperature and salinity along the three sides of the CANIGO box (Fig. 37). Between Lanzarote and the African shelf and centered at about 800 m depth below the North Atlantic Central Water, we identify the Antarctic Intermediate Water with its salinity minimum and silicate maximum (not shown here). It probably is transported northwards with a poleward undercurrent and cannot be identified in salinity further north at 32°N. The Mediterranean Water with the salinity maximum at 1100 dbar to 1200 dbar is most pronounced in Meddy 'Jani' observed on the

32°N section. Outside this Meddy, the salinity maximum generally decreases to the south and west.

Direct shipborne current measurements

Attached to the CTD/rosette system was a 150 kHz ADCP. Lowered during CTD casts (lADCP), it measures currents relative to the vessel from which together with GPS positioning absolute currents in the water column can be derived (Fischer and Visbeck, 1993).

Another 150 kHz ADCP was mounted in the ship's moonpool (vADCP) to continuously measure current profiles in the upper 300 m. In Fig. 38, we display the current distribution in the upper levels. Again, no clear Canary Current can be detected, probably because the tides have not yet been removed from the signal.

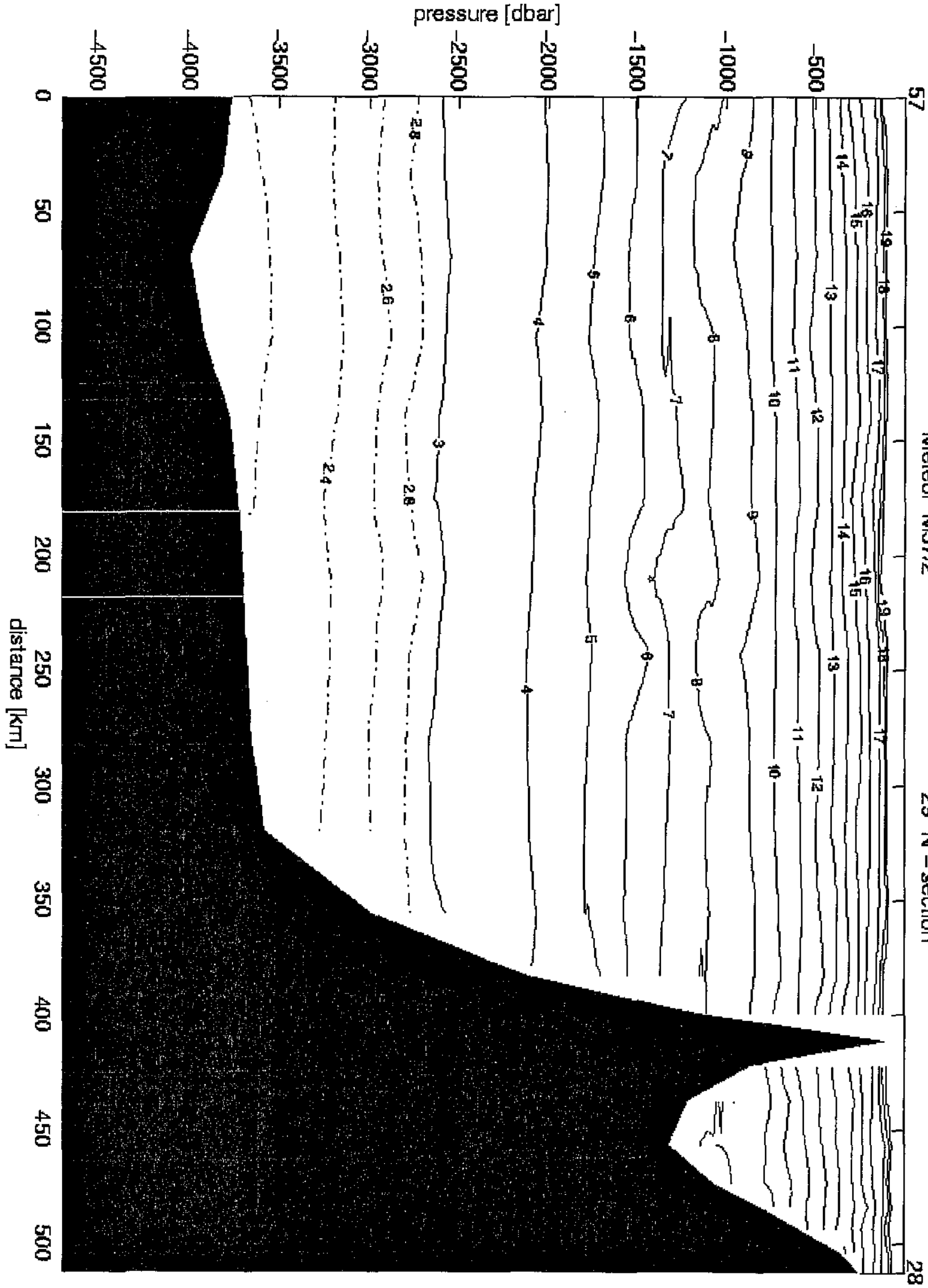


Fig. 37a: Distribution of potential temperature along 29°N

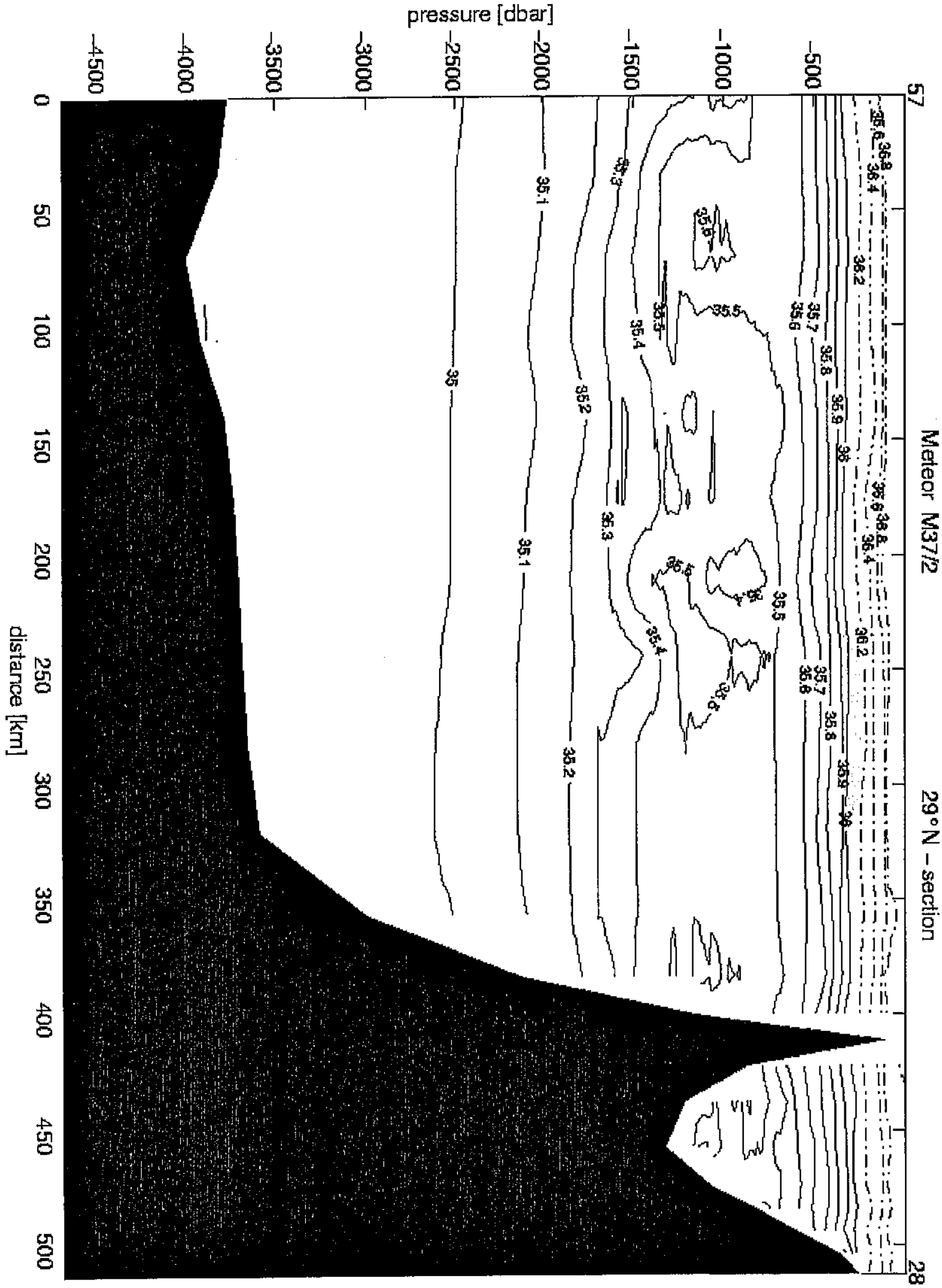


Fig. 37b: Distribution of salinity along 29°N

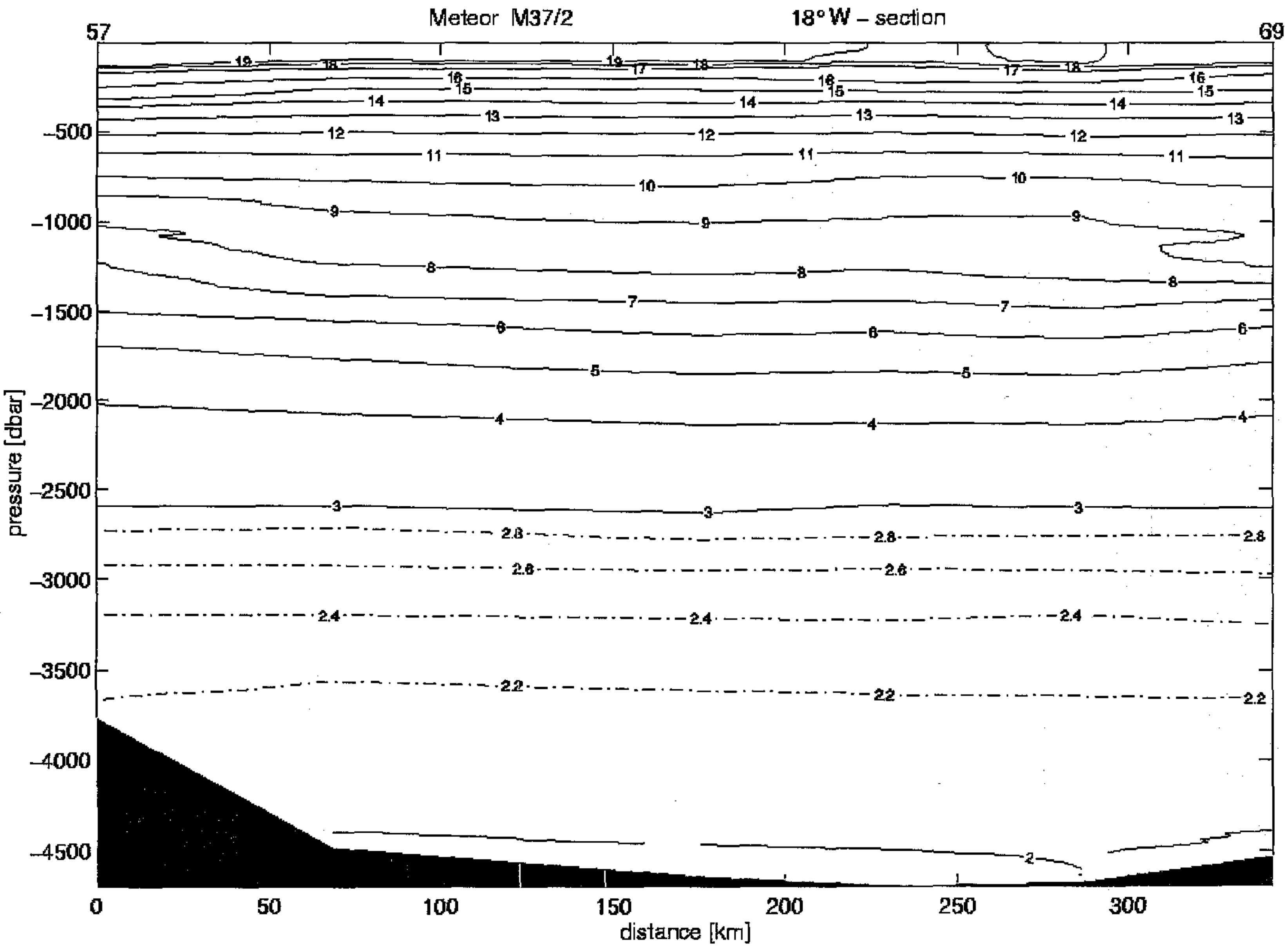


Fig. 37c: Distribution of potential temperature along 18°W

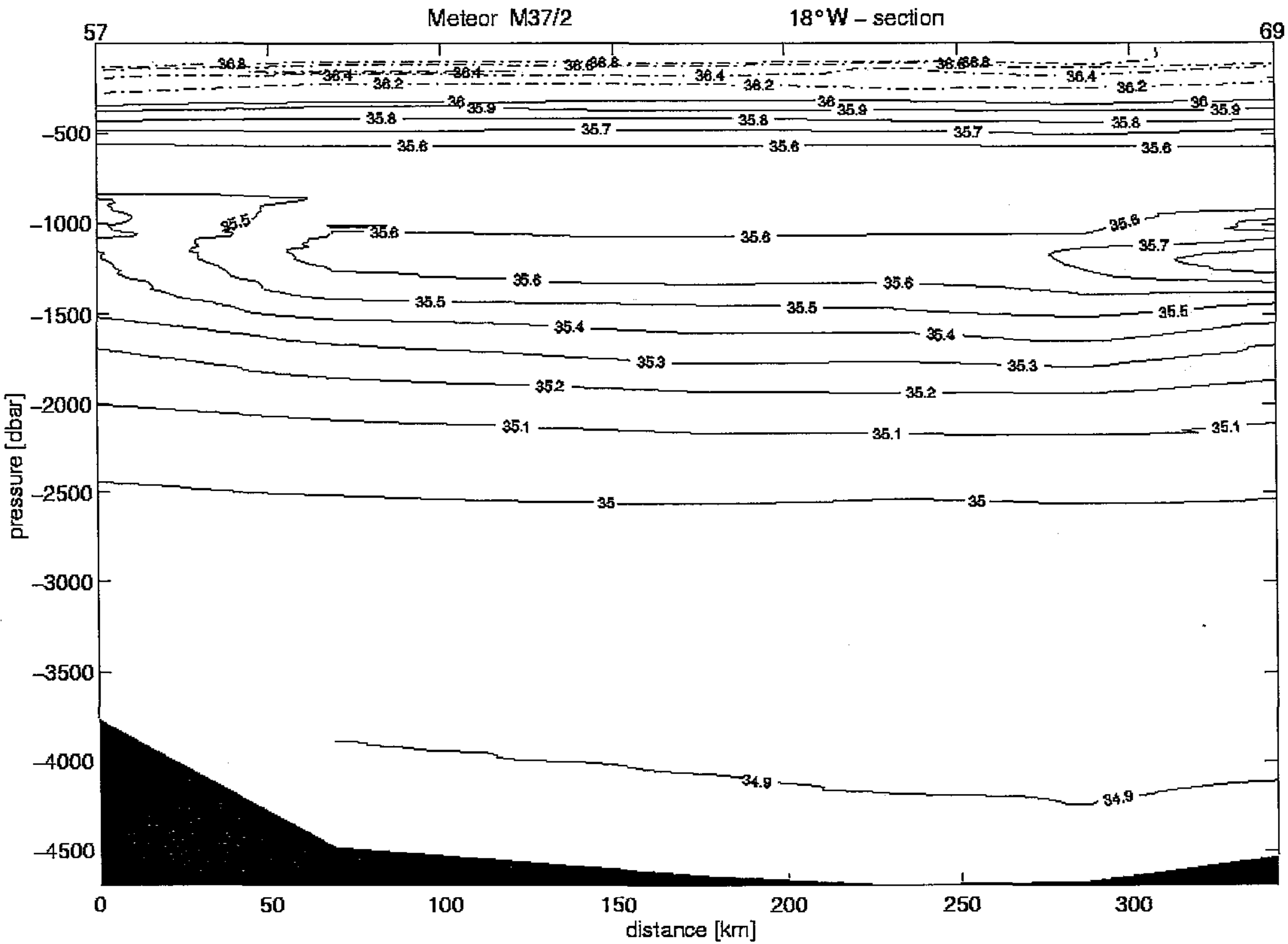


Fig. 37d: Distribution of salinity along 18°W

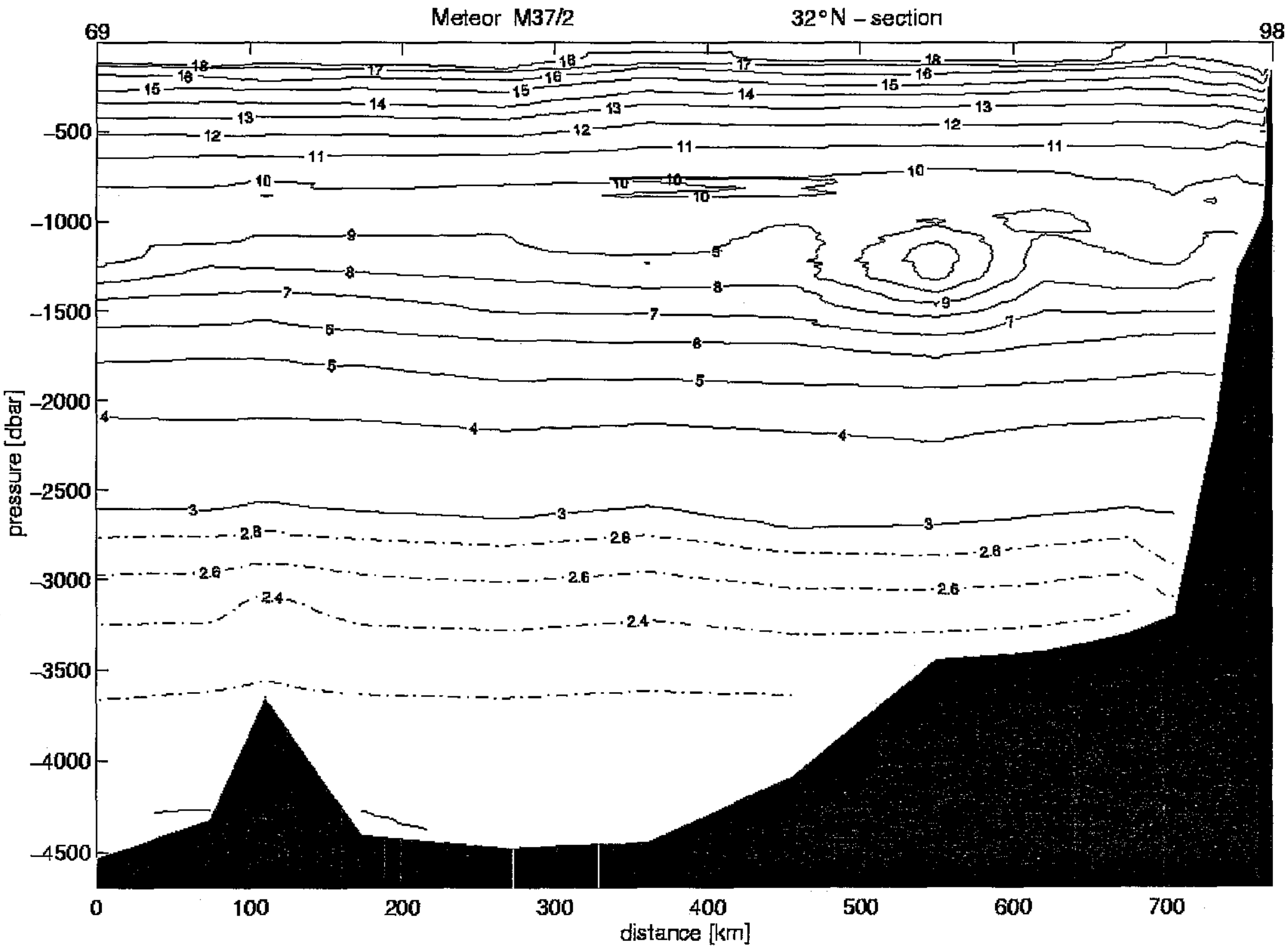


Fig. 37e: Distribution of potential temperature along 32°N

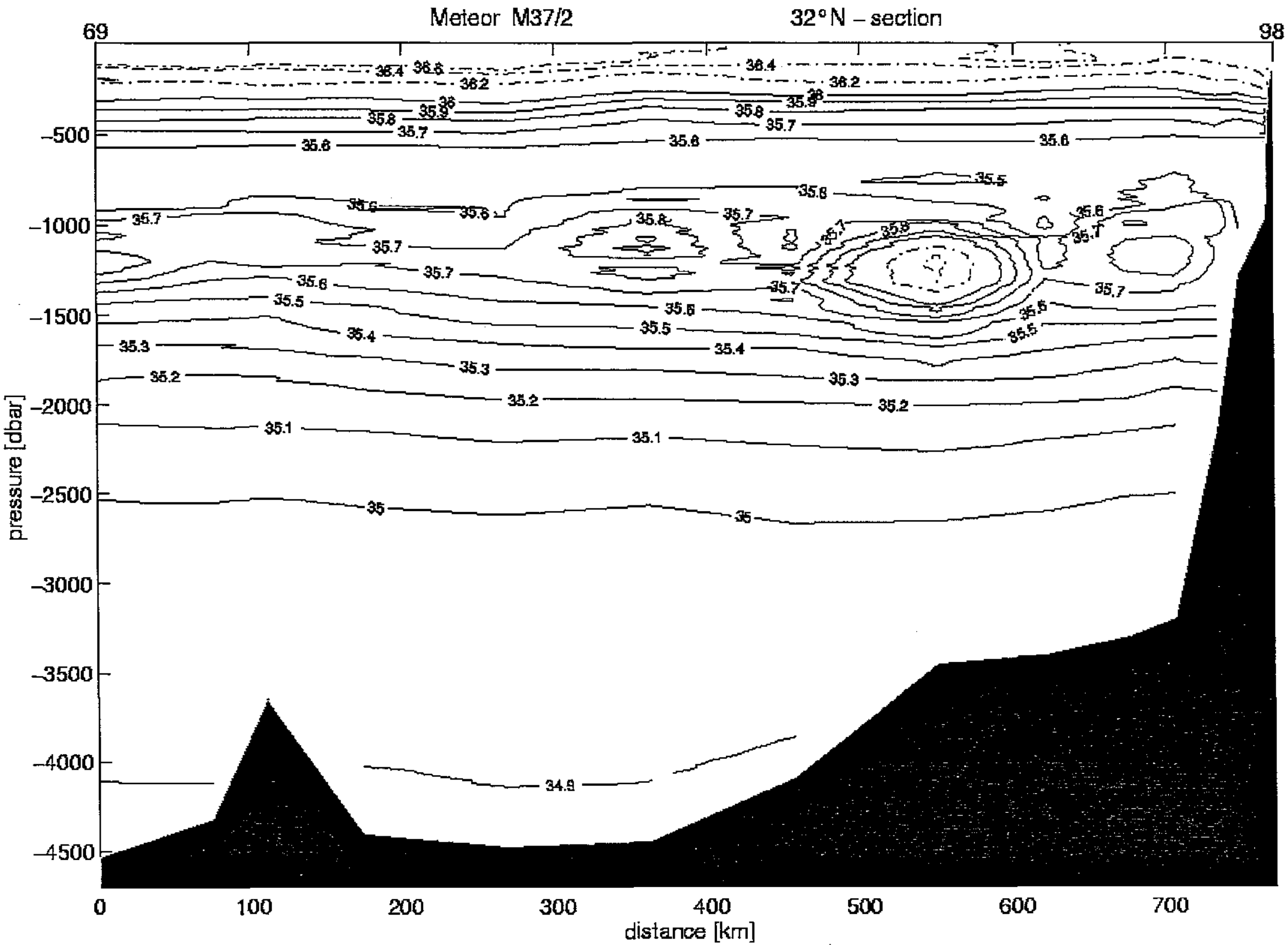


Fig. 37f: Distribution of salinity along 32°N

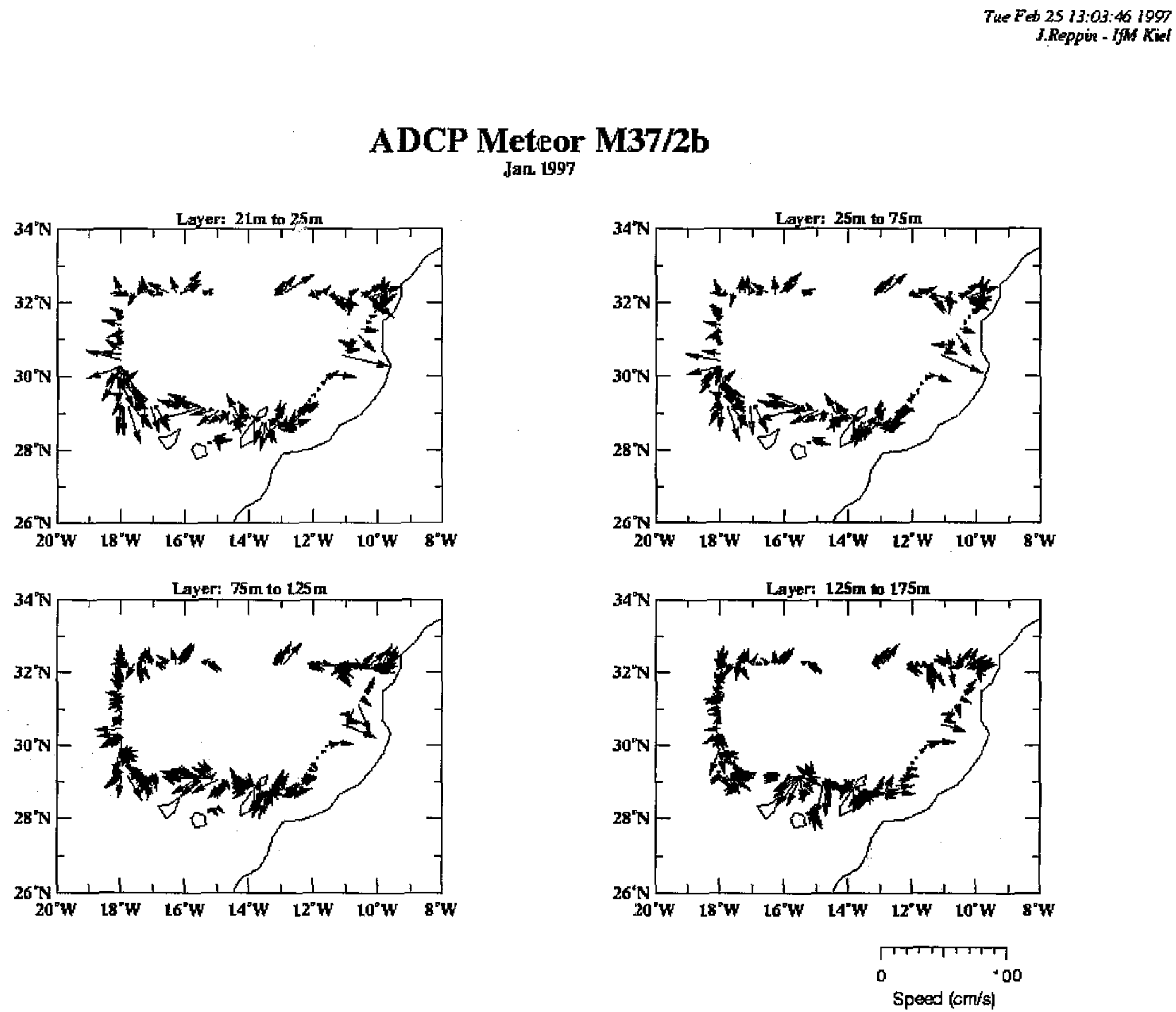


Fig. 38a: Currents between 21 m and 175 m as measured with the vessel mounted ADCP

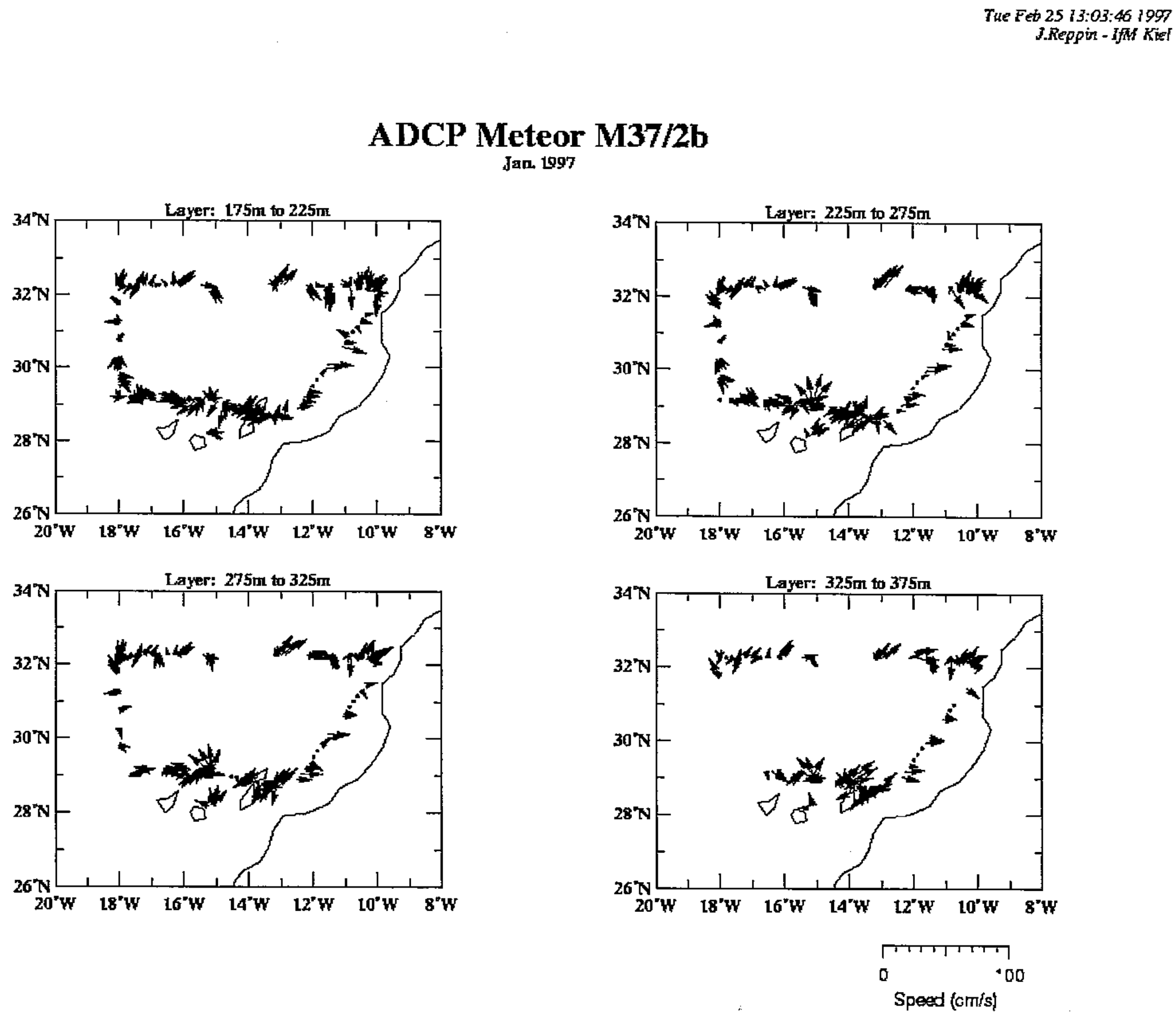


Fig. 38b: Currents between 175 m and 375 m as measured with the vessel mounted ADCP

5.2.2 Particle Fluxes

(S. Neuer)

Process studies near ESTOC with drifting near surface traps

Particle flux in the ESTOC (European Station for Time-series in the Ocean, Canary Islands) region is subject to seasonal and short-term variability due to varying productivity and hydrographic conditions. Experiments with moored particle traps at the ESTOC station show that a large portion of deep particle flux originates laterally. Thus it is important to determine particulate carbon flux directly below the euphotic zone. Ideally, these sinking flux determinations need to be coupled with measurements of the standing stock and production rates of the plankton community in the euphotic zone.

To study particle flux below the euphotic zone, two types of surface-tethered particle interceptor traps (PIT) were deployed in 200 and 220 m (Fig. 39) during two mooring periods, one beginning on 29.Dec. 1996 and ending 1. Jan. 1997 and the second one starting on 1. Jan. 1997 and ending on 4. Jan. 1997. The first array was deployed north-east of the ESTOC station and drifted 26.7 km south-west at 20.7 cm/s, the second one was deployed at the recovery position and continued 32.8 km on the south-west course at 22.2 cm/s (see Tab. 11). The traps were attached to a surface spar buoy with an ARGOS transmitter, flash and a Radar reflector. The main buoyancy was located at about 30 m depth to minimize the influence of the wind-driven EKMAN layer. Several positions per day were obtained for the traps using the CLS ARGOS location service in Toulouse/France.

To quantify the plankton community in the euphotic zone during the trap deployments, samples were taken for chlorophyll, taxonomically characteristic pigments (analyzed with High Pressure Liquid Chromatography, HPLC) and POC (Particulate organic carbon). All of the water samples were filtered on GF/F filters. While chlorophyll a was analyzed onboard ship as an acetone extract using a Turner AU 10 fluorometer (supplied by the group of O. Llinas, ICCM Telde), POC and HPLC samples were kept frozen until analysis onshore.

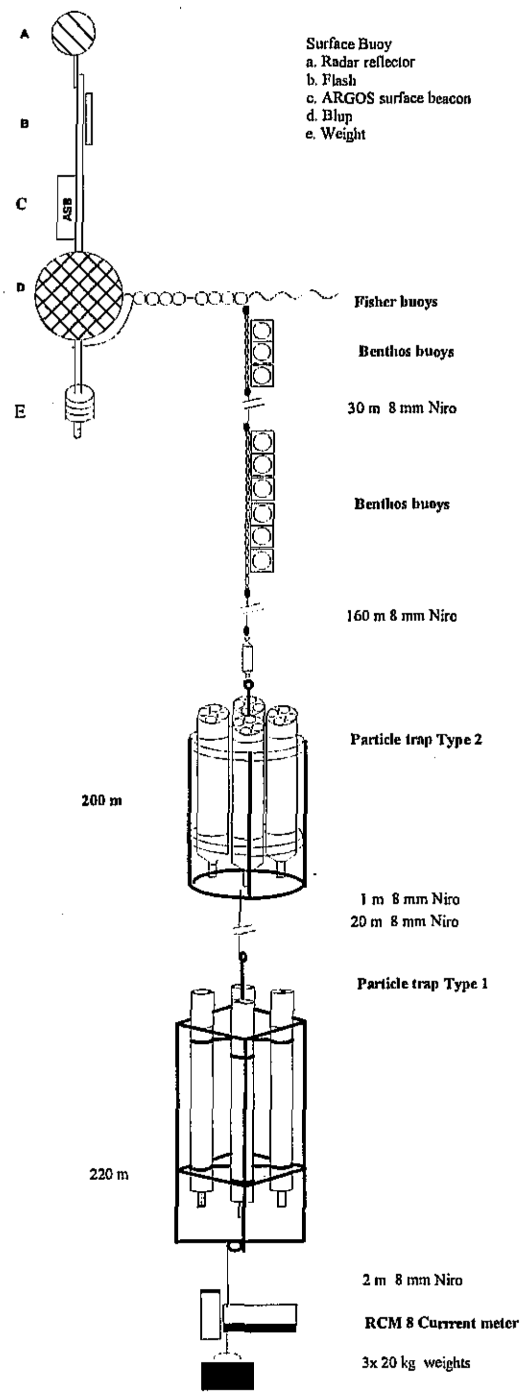


Fig. 39: Design of the GeoB drifting trap mooring

During the deployment of the particle trap, I conducted 3 dilution experiments to determine phytoplankton growth and microzooplankton grazing rates onboard close to in-situ conditions. Dilution experiments were carried out mostly with water from 25 m and 50 m depth collected at the beginning of the deployment period of the particle trap. The incubations were carried out in an on-deck incubator with neutral density screens to simulate in-situ light conditions.

Tab. 11: Inventory of GeoB activities during M37/2a, 28 Dec 1996 - 05 Jan 1997, Canary Islands

Date	Stat	GeoB	Lat N Long W	Depth m	Start time UTC	Chl (depth/m)	HPLC (depth/m)	POC (depth/m)	Dil-Exp (depth/m)	Mooring	Drifting Trap
29.12	457	4245	29°10 15°30	3613	02:10	10,25,50, 75,100,15 0,200	10,25, 50, 75,100	10,25,50, 75,100, 150,200, 400,600, 800,1000, 2000,300 0	25,50		water for trap
29.12	459	4246	29°19.8 15°28.3	3603	12:35						into water 200, 220m
30.12	463	4247	28°44.5 13°18.0	1197	12:48					EBC 3	
31.12	470	4248	28°40.0 12°57.0	498	4:45				25		
31.12	471	4249	28°42.5 13°09.3	996	9:11					EBC 2	
01.01 .	2	4250	29°05.7 15°31.5	3608	12:57						Recover y
01.01 .	3	4251	29°05.6 15°31.7	3608	13:03						into water 200, 220m
01.01 .	4	4252	29°05.2 15°32.3	3612	13:42	10,25,50, 75,100,15 0,200	10,25, 50, 75,100,2 00	10,25,50, 75,100, 150,200			
02.01	7	4253	29°03.6 15°31.0	3608	14:08				25,50		
03.01	14	4254	28°48.2 17°57.3	4327	9:33					LP 1	
04.01	22	4255	28°48.2 15°35.4	3586	18:10						Recover
04.01	23	4256	28°47.9 15°34.7	3585	18:51	10,50, 75,100,15 0	10,50, 75,100,1 50				

Particle collection with moored particle traps

During M 37/2a, one particle trap was attached to each of the Kiel current meter moorings EBC 2 and EBC 3 in the Eastern Boundary Current at 700 m depth. In addition, EBC 3 had one INFLUX current meter (group of G. Krause, AWI) attached 20 m below the particle trap. INFLUX current meters carry a fluorometer and a transmissometer in addition to CTD sensors and can thus record episodic particle sedimentation events at depth. All traps were programmed for 20 x 14 days sampling intervals starting January 6, 1997.

On January 3, mooring LP 1 was deployed as the westernmost particle trap mooring in the CANIGO mooring line which covers the horizontal productivity gradient from the coastal upwelling zone to the open ocean. In this mooring line, the ESTOC mooring CI which was exchanged on M37/1 is located on about the midpoint and the particle traps in the EBC2 and EBC3 arrays are located on the eastern end of the gradient.

Mooring LP 1 is equipped with two particle traps in 1028 m and 3780 m and one INFLUX current meter in 1048 m depth (Tab. 12). All traps were programmed for 20 x 14 days sampling intervals starting January 6, 1997.

Tab. 12: Instruments used and deployment depths on mooring LP 1

Mooring	Position	Water depth	Sampling interval	Instrument	Depth (m)	Intervals
LP1	29°45,73	4327	6.01.1997-	RCM 5	850	
			13.10.1997	SMT 234	1028	20x14 days
				INFLUX	1048	
				RCM 5	1570	
				SMT 230	3780	20x14 days

Instruments:

S/MT 234,	Particle trap, Aquatec Meerestechnik , Kiel
S/MT 230	Particle trap, Sazgitter Electronik , Kiel
INFLUX	INFLUX current meter (group G. Krause, AWI) with CTD, fluorometer, transmissometer
RCM 5	Aanderaa current meter

5.2.3 Trace Metal Measurements at ESTOC, EBC and LP1

(A. Deeken, F. Kukolka, S. Otto)

The interaction of particles and water is a key process for the biogeochemical cycling of chemical elements in the ocean. Uptake onto particulate matter and subsequent sinking mechanisms (scavenging) is the major control on the chemical composition of seawater and maintains the concentrations of many elements in seawater rather low. The particulate matter itself consists of (i) suspended particulate matter (SPM) which is supposed to consist of almost non-sinkable biogenic and terrestrial detritus with a large surface area and (ii) the relative fast sinking particles found in sediment traps, responsible for the vertical transport to the sediments. The comparison of the trace element composition and distribution in these three different phases (dissolved, SPM and particulate trap material) are excepted to provide important clues on transport and sorption mechanisms as well as on the general geochemical behavior of these elements in the ocean.

Our task during this cruise was to examine the vertical distribution of trace metals in dissolved and suspended form in the water column. For this purpose, we investigated three different mooring locations, reaching from the eutrophic coast-near region off Africa towards the more oligotrophic open ocean. Samples of dissolved trace metals and suspended particulate matter were collected from the entire water column by means of GoFlo bottles and *in situ* filtration using special *in situ* pumps. Bottle casts combined with *in situ* SPM collections were performed at station EBC 3 (east of the islands Lanzarote and Fuerteventura), at the ESTOC station and at station LP (north of La Palma). The positions occupied were sampled with a high vertical resolution (sixteen to twenty-nine sampling depths). All samples were collected rigorously applying clean sampling techniques to avoid contamination as far as possible. GoFlo bottles and *in situ* pumps were attached to a non-metallic wire and sample processing was done inside a clean bench. Dissolved trace element samples were pressure-filtered with nitrogen gas through pre-cleaned 0.4 µm polycarbonate membranes directly from the sampling bottles, whereas SPM was sampled onto filters of identical material.

Due to technical problems with the new generation of *in situ* pumps used, sampling of SPM was reduced at all positions. At the ESTOC station, SPM samples from nine depths, at EBC 3 six samples and at LP two SPM samples were obtained.

Besides trace metal sampling, water samples were analyzed for nutrients as well as for oxygen. The nutrients nitrate, phosphate and silicate were determined according to standard photometric procedures. Oxygen was analyzed through titration using the Winkler method. The only trace metal to be determined onboard was total dissolvable Aluminum by a fluorescence method. All other dissolved trace metals will be analyzed onshore, as well as the filters from the *in situ* pumps.

5.2.4 Measurements of Foraminifera During M37/2

Net Sampling for Planktic Foraminifera

(S. Kemle-von Mücke)

Plankton samples were collected from about 5 m water depth using the shipboard fire pump system. The sea water was filtered through a plankton net with a mesh size of 70 microns each day. The aim was to collect planktic foraminifera to investigate the species assemblage and abundance for later comparison with temperature, salinity, chlorophyll *a* content and nutrient concentration in the surface water. Apart from the first two samples, the planktic foraminifera were picked out from the plankton sample and oxidized with 3,8 % NaOCl buffered with NadiBorat to obtain clean foraminifera shells. The foraminifera were rinsed with distilled water and 96 % ethanol and stored in fema cells. Site locations of the sampling are listed in Tab.13. The temperature and salinity data given in the table originate from the ship thermosalinometer.

Only very few foraminifera were found in all the samples and these foraminifera were so small that it was often difficult to accurately identify the species. The dominant species was *Turborotalita humilis* followed by *Globigerinella siphonifera*, (*Globigerinella calida*), *Globigerinita glutinata*, *Globigerinoides ruber*. Other species found were *Globorotalia crassaformis*, *Globorotalia inflata*, *Globigerina bulloides,(may be Globigerina falconensis or Orbulina universa)*, *Turborotalita quinqueloba*. By far the most common zooplankton were the copepods. In addition, various zooplankton were present: euphausides, pteropods, some ostracodes, radiolarian, dinoflagellates and diatoms.

Tab. 13: Planktic foraminifera net sampling data

Sample No.	Date 1996/97	Start Pump Local Time	Position	Salinity (‰)	Temperature (°C)	Stop Pump Local Time	Position	Salinity (‰)	Temperature (°C)	Liters Pumped	Remarks
1	29.Dez.	10:00	29°14N/15°27W	36,82	19,95	12:45	29°19N/15°28W	36,83	20	ca.1980	few small forams
2	"	15:30	29°19N/15°27W	36,84	20	18:25	29°18N/15°27W	36,83	20	ca.2180	"
3	30.Dez.	09:00	28°48N/13°36W	36,8	19,6	11:30	28°45N/13.22W	36,74	19,53	ca. 1880	"
4	31.Dez.	08:45	28°41N/13°8W	36,74	19,3	10:45	28°43N/13°12W	36,77	19,6	ca. 2400	"
5	01.Jan.	08:15	29°9N/15°30W	36,84	19,82	11:15	29°8N/15°30W	36,76	19,84	ca. 3600	"
6	02.Jan.	07:55	29°18N/16°5W	36,84	20	10:55	29°26N/16°39W	36,8	20,12	ca. 3600	"
7	03. Jan	06:45	29°45N/18°11W	36,82	19,98	10:45	29°45N/17°57W	36,84	20,05	ca. 4800	"
8	04. Jan	08:15	29°15/15°59W	36,8	20,2	11:15	29°8N/15°40W	36,75	20,07	ca. 3600	"

Collection of Planktic Foraminifera for DNA Analysis

(K. Darling, I. Stewart)

The foraminifera were collected by pumping sea water through a 70 micron mesh net as described in the preceding paragraph. The plankton net was also deployed approximately four meters below the water surface for two periods of ten minutes. Little difference was found between the two collection methods. As the collection was made for DNA analysis, it was not necessary to quantitatively estimate the foraminiferal assemblage per volume of water. Pumping was therefore continuous, with serial samples being taken at short time intervals to maximize the viability of the living cells and to allow time for species identification. The sampling details are outlined in Tab. 14. Following selection of individual specimens, they were crushed into 30µl of buffer to protect the DNA from enzymatic activity. The samples were then individually labeled and stored at -20°C.

Foraminifers were scarce in the surface waters and positive identification of individual species proved difficult, as the foraminifers throughout the whole of the collection period were immature. It is therefore not possible to provide an accurate species list at this stage. We found *Turborotalita humilis*, *Globigerinella siphonifera* (which possibly includes Type I and Type II forms of *G. siphonifera* and *G. calida*), *Globigerinita glutinata*, *Globigerinoides ruber* (pink and white forms). In addition we found five specimens of *Neogloboquadrina* (intergrade) and single specimens of *Globigerinoides sacculifer* and *Globorotalia* *truncatulinoides.* Other species found were possibly *Globigerina bulloides / Globigerina falconensis* and *Orbulina universa.* DNA analysis will provide a more accurate species list when sequence alignment can be made against known species within the DNA database. A total of 123 individual specimens were taken for analysis.

Tab. 14: Sampling data for the collection of planktic foraminifers for DNA analysis

Sample day	Date	Pump start time	Position	Salinity °/oo	Temp. °C	Pump stop time	Position	Salinity °/oo	Temp. °C	Liters pumped
1	29.12.96	13.00	29°20N/ 15°28W	36.83	19.9	15.00	29°20N/ 15°28W	36.84	20.0	1400
2	30.12.96	11.30	28°45N/ 13°22W	36.74	19.5	15.30	28°45N/ 13°19W	36.74	19.4	2800
3	31.12.96	11.00	28°41N/ 13°09W	36.77	19.2	12.30	28°41N/ 13°09W	36.76	19.2	1050
4	1.1.97	12.00	29°05N/ 15°32W	36.76	19.7	16.00	29°05N/ 15°32W	36.84	19.7	4800
5	2.1.97	11.00	29°31N/ 17°02W	36.80	19.8	16.00	29°37N/ 17°27W	36.87	19.8	7000
6	3.1.97	10.45	29°45N/ 17°57W	36.84	19.7	18.30	29°44N/ 17°58W	36.80	19.7	9300
7	4.1.97	11.15	29°09N/ 15°40W	36.75	19.7	18.00	28°47N/ 15°34W	36.75	19.5	8100

5.2.5 Bio-optical Measurements on the CANIGO box

(Hans Barth, Klaus Loquay, Oliver Zielinski)

Introduction

The main element in the flow of dissolved and particulate organic matter and of living organisms is carbon. Calculations which include only chemical and physical properties of the ocean for the exchange of carbon lead to wrong predictions. Only the inclusion of biological activities can fill this gap in understanding the carbon cycle. In January and February the hydrographic conditions of the Canary Island region are characterized by coastal upwelling of intermediate water to the surface and by an increase in phytoplankton growth. One of the main objectives is to study the carbon assimilation and transport mechanisms by biological activities to understand and quantify the amount of carbon which is transported to deep waters by mixing and sinking.

Dissolved and particulate substances in seawater can be sensitively characterized by optical methods. The method is very fast since it doesn't need any preparation of samples. *Gelbstoff* as a major compound of marine DOM, chlorophyll *a* and other phytoplankton pigments like phycoerythrin, fucoxanthin and fucocyanin, and the aromatic amino acid tryptophan can be measured with fluorescence methods. The attenuation coefficient is an optical parameter which depends sensitively on suspended and dissolved substances. Its measurement is of interest not only for the understanding of optical conditions in water, but it also allows for a fast determination of absorbing and scattering matter in the form of depth profiles, which can hardly be obtained with other methods in realtime.

Optical parameters have met the interest of oceanographers and limnologists for a long time. Devices which measure optical data are utilized to classify water masses on the basis of optical properties and to obtain information on particulate matter or dissolved organic substances. The most prominent instruments of that kind used in the present study are the following:

Laboratory Instruments:	In situ Instruments:
Spectrofluorometer	Multi Channel Fluorometer
Spectrophotometer	Polychromatic Transmissometer
	Radiometer

For hydrographic parameters a CTD is added to the in situ probes. All of these instruments are connected by a central underwater unit to obtain simultaneous data sets from the water column (down to 3000m).

Methods

The following instruments were used throughout the campaign (Figs. 40, 41):

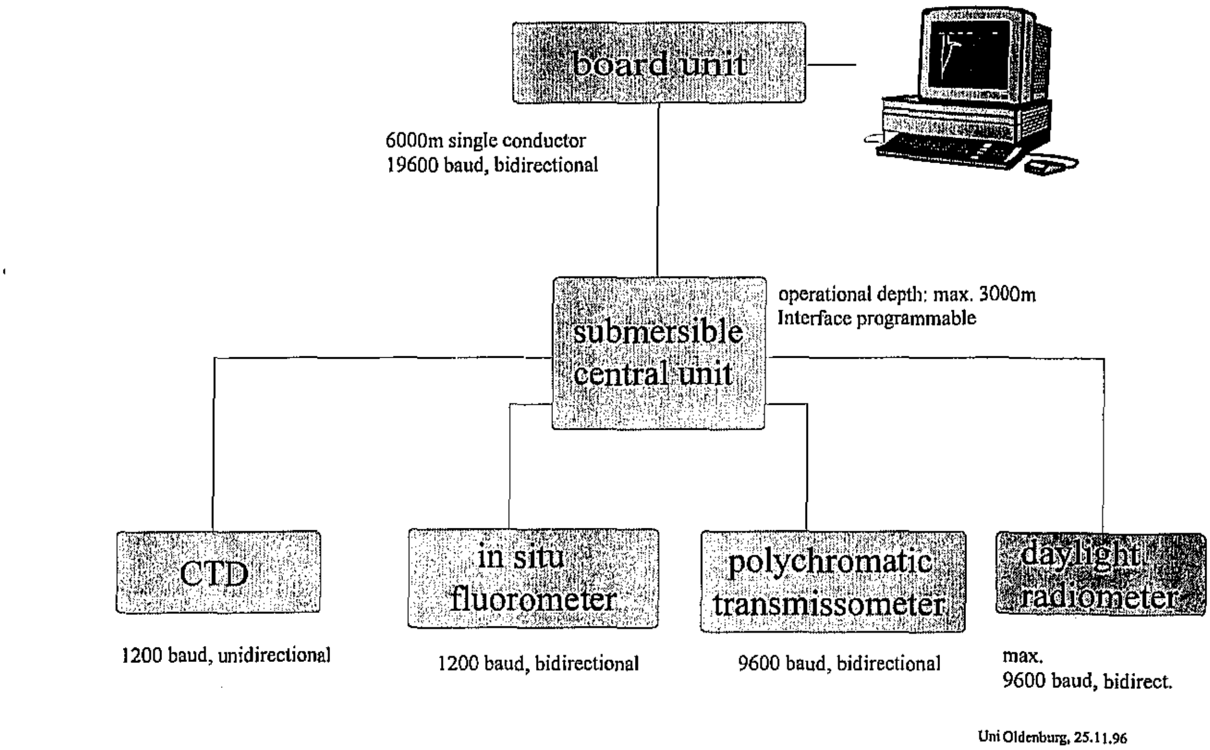


Fig. 40: Coupling of the optical sensors

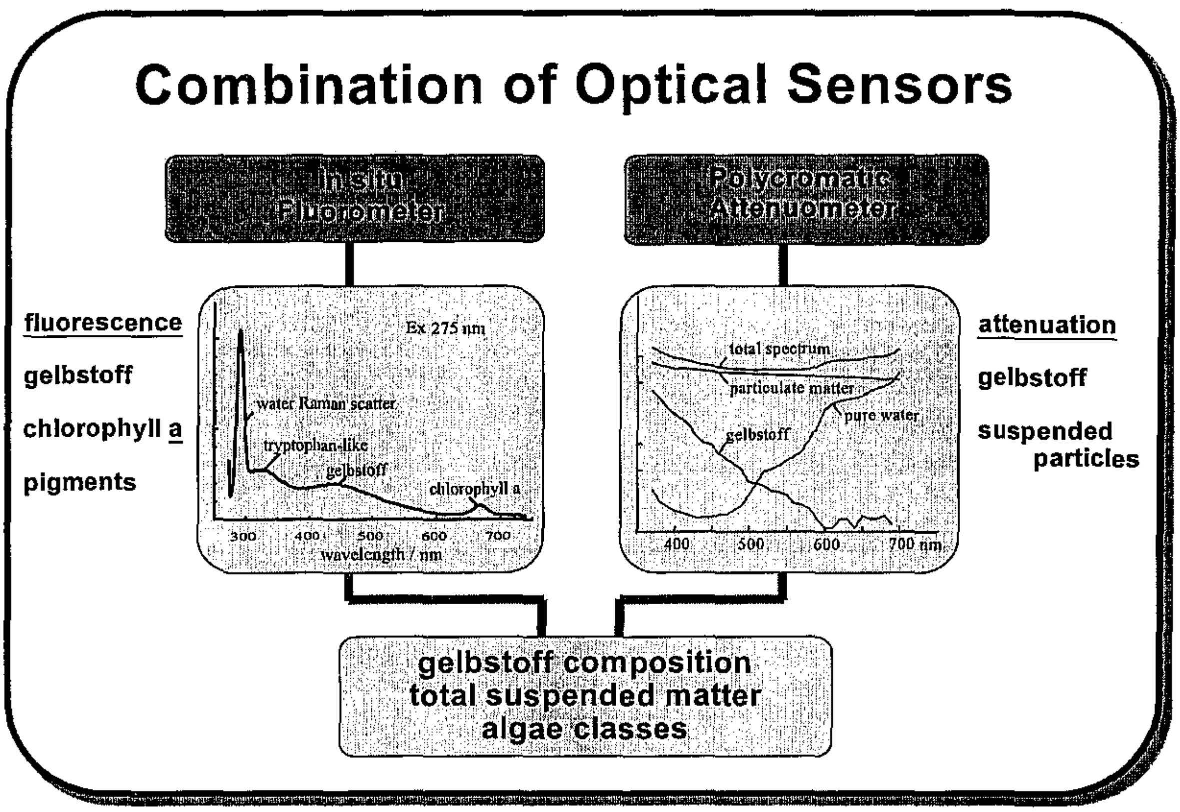


Fig. 41: Information which can be obtained by measuring optical parameters

Spectrophotometer:

Type: Perkin Elmer, Lambda-18

Measurements: Absorption of filtrated (Whatman GF/F) and unfiltrated samples in the range from 189.6 to 700 nm. Yellow substance concentration can be derived by interpretation of the spectra.

Spectrofluorometer:

Type: Perkin Elmer, LS-50

Measurements: Five different excitation scans were used

Scan	Excitation wavelength [nm]	Ramanpeak [nm]	detected substance with relevant wavelength [nm]
A	530	646.5	Chlorophyll *a* at 680 nm
B	420	490.0	Chlorophyll *a* at 680 nm
H	308	344.0	Tryptophan at 340 nm Gelbstoff at 420 nm
J	270	397.3	Tryptophan at 340 nm Gelbstoff at 440 nm
N	230	249.5	Tyrosine at 300 nm Tryptophan at 340 nm Gelbstoff at 420 nm

Multi Channel Fluorometer:

Type: Prototype

Measurements: Using two excitation wavelengths (270 nm and 420 nm) from a Xe-flashlamp spectrum via optical filters, the following substances are detected:

Raman at 397.3 nm and 490.0 nm, Chlorophyll, yellow substance, Tryptophan, Phycoerythrin and Fucoxanthin.

Polychromatic Transmissometer:

Type: Prototype

Measurements: Attenuation coefficient in the range of 370 nm to 730 nm at 134 wavelengths. The optical pathlength is adjustable to different turbidity situations.

Radiometer:

Type: Prototype

Measurements: Underwater light field (vectorial irradiance), upwelling and downwelling in the range of 370 nm to 730 nm at 67 wavelengths.

CTD:

Type: Meerestechnik Elektronik, OTS 1500

Measurements: Pressure, conductivity and temperature. Calculated components include salinity and sound speed.

Data sampling

Water samples from the Niskin Sampler were taken (if available) at every station from the CTD/rosette following this scheme: 10 m, 25 m, 50 m, 75 m, 100 m, 125 m, 300 m, 1000 m, 1250 m, 1500 m depth and 20 m above seafloor. The optical sensors were used at every station down to a depth of 1500 m. Station 38 was probed down to 2070 m, station 63 where the Meddy 'Jani' was observed (Fig. 42) down to 1800 m. Underwater light field measurements were carried out only at daytime starting with station 56.

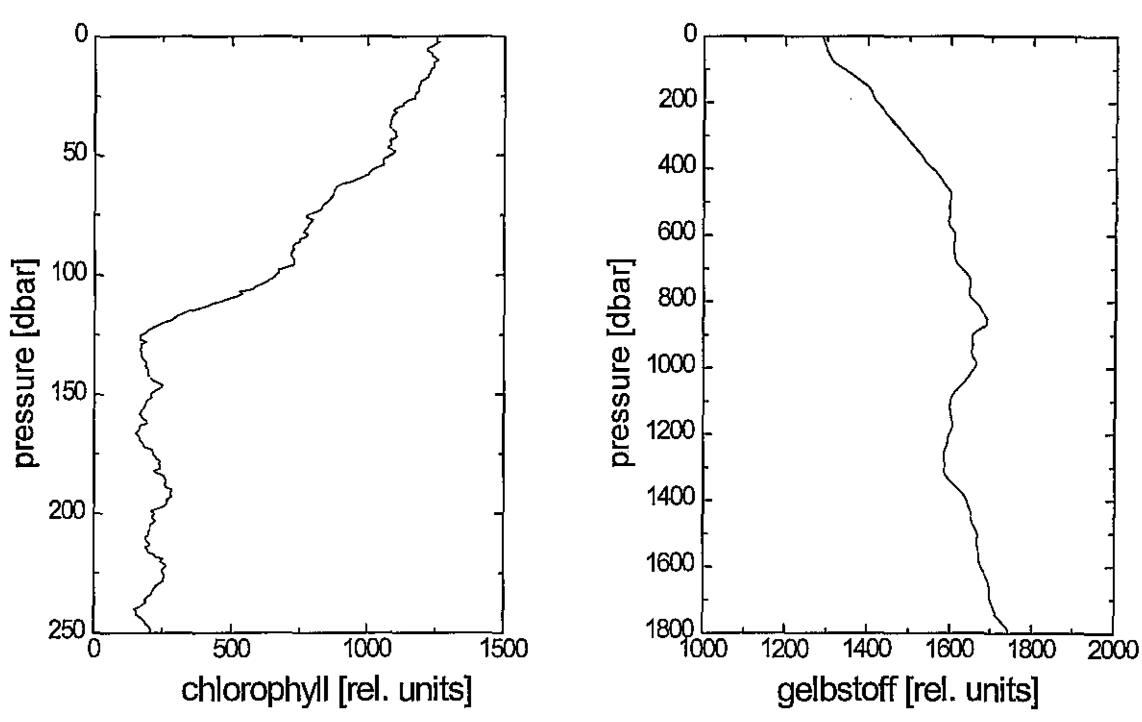


Fig. 42: Distribution of temperature, salinity, chlorphyll and gelbstoff at the Meddy 'Jani' station 63

5.2.6 Measurements of Al and other Trace Metals on the CANIGO box

(M.D. Gelado-Caballero, F.J. Martin- Muñoz and J.J.Hernández-Brito)

Introduction

Aluminum distributions in Canary Islands (Central East Atlantic Waters) show a great variability [Gelado-Caballero et al. , 1996]. The area possesses major features that could affect the aluminium biogeochemical behaviour, such as elevated aeolian (dust) inputs from the Sahara desert, proximity to areas of upwelling (150-200 Km) and mesoscale features induced by the effect islands on the course of the Canary Current. The aluminum distributions show a marked latitudinal gradient from East to West. The study of the Al variations along these gradients and at a fixed station could give a better knowledge of the physical and biogeochemical processes controlling mesoscale distribution of aluminum in the area.

Al determinations

The HPACSV (High Performance Adsorptive Cathodic Stripping Voltametry) method (Hernández-Brito et al., 1994a) was used to measure on board dissolved aluminum in seawater. Samples are prepared in Teflon cups of polarographic cell, containing 10 ml of water, 2·10-6 M DASA and 0.01 M BES. The solution is purged using nitrogen (3 minutes) to remove dissolved oxygen. The adsorption potential (-0.9 V) is applied to the working electrode, while the solution is stirred. After 40 s accumulation time, the stirring is stopped and 5 s is allowed for the solution to became quiescent. The scanning is started at -0.9 V and terminated at -1.4 V. The scan is made using staircase modulation with a scan rate of 30 V/s and a pulse height of 5 mV. The DASA-Al peak appears at ca. -1.25 V. A standard addition procedure is used to quantify the aluminum concentration of the sample. Determinations were carried out in a flow bench class-100 to avoid contamination of the sample by dust particles.
The electrochemical system used has been designed to measure the instantaneous currents at short times with a low noise level (Hernandez-Brito et al., 1994b). Thus, the analytical time required for each sample is substantially reduced, allowing an increase of measurements on board. A PAR- 303A electrochemical cell with hanging mercury drop electrode (HMDE) was connected to a specially made computer-controlled potentiostat.

The reproducibility of the method was less than 4% for a 21 nM Al concentration based on seven replicates sampled at 2000 m (28°25.40′ N 15° 24.70′W). A detection limit of 2.5 nM was calculated using these results.

The water sampling was carried out using Niskin bottles provided with silicone rubber and stain steel springs. Replicated samples taken at the same depth showed no significant contamination from the springs (less than 4%). The possible contamination by the rosette frame was tested by comparison with seawater sampled using a rubber boat. Aluminum values using both devices showed differences within the experimental error (4%). Samples were taken and manipulated wearing plastic gloves to avoid contamination. Additional samples were frozen at polyethylene bottles to carry out analysis at the land-based laboratory. Every container has been previously cleaned using conventional procedures in the trace metal assay.

Preliminary results

More than 500 samples were analyzed on board. Preliminary results shows that aluminum distribution in the water columns appears to be related to the physical and biogeochemical processes in the area sampled. Aluminum distribution in the surface waters shows a winter mixed surface layer without the maximum concentrations found during previous cruises at summer and fall at the area. Mid-depth aluminum distributions seem to be related to the water masses. Low Al values have been found (800 m) in the channel between Lanzarote and the African continental slope. Low salinity waters have been measured at the same depth. Stations located west of Lanzarote show higher aluminum concentrations and no salinity minimum at this deepness. An aluminum maximum appears at intermediate waters (1000-1300 m) and it seems to be related with the intrusion of Mediterranean waters. A minimum in the aluminum distributions occurs below the Mediterranean waters. The aluminum concentrations increase again below 2500 m. Stations close to the continental slope show higher aluminum near the bottom layer. It could be an indication of sediment dissolution or lateral transport of sediment at the deep layers. The profiles in the western most stations show no significant alterations near the bottom.

5.2.7 Measurements of CO_2 on the CANIGO box

(L. Mintrop, M. Gonzalez-Davila, F.F. Perez)

A total of 351 samples were drawn and immediately analyzed for total dissolved inorganic carbon (C_T). 18 further samples were drawn from 6 sample bottles (3 each), which had been closed at 3 different depths (10, 3799, 1100m) at stations 59, 62, 64, and 65. These samples served for an alkalinity intercalibration between the 3 different CO_2 - workgroups and were measured after the cruise. The analytical methods involved are a coulometric titration technique for C_T (SOMMA-system, Johnson et al., 1994; DOE, 1994) and potentiometric titration for A_T, basically according to Millero et al. (1993), but carried out in an open vessel (VINDTA-system, Mintrop, 1996, unpubl.). Alkalinity was calculated from the titration curve by a curve fitting procedure (Millero and Campbell, 1994). The coulometric system was calibrated with pure CO_2 (gas calibration) and tested by running different batches of certified reference material (CRM, provided by A. Dickson, SIO, La Jolla, CA, U.S.A.). The same CRMs were also used to monitor alkalinity titrations. For the VINDTA system, the pipette volume was determined by filling with distilled water and weighting, the acid used was prepared in a batch, and the acid factor of the batch was determined coulometrically (A. Dickson, pers. comm.). The precision (between-bottle reproducibility) as judged from regular measurements of duplicate samples was 0.5 $\mu mol \cdot kg^{-1}$ for C_T and 0.5 $\mu mol \cdot kg^{-1}$ for A_T. Accuracy of the data has been estimated to be about 1.5 $\mu mol \cdot kg^{-1}$ for C_T and 2.0 $\mu mol \cdot kg^{-1}$ for A_T.

The alkalinity intercomparison gave a very close agreement of the results for the three groups involved within the precision of the method (within $\pm$ 1 $\mu mol \cdot kg^{-1}$) thus allowing perfect data exchange within the groups for the future. The determination of dissolved inorganic carbon gave distinct differences in the depth distribution for the northern and southern zonal transects. We hope to be able to calculate carbon transport with the help of hydrogaphical data and estimates for water transport rates resulting from the investigations of the physical oceanography work groups. Fig. 43 shows an isoplot along the southern transect towards east, the meridional transect northbound and the zonal continuation along the northern transect back to the African coast. Outstanding feature is the maximum at 1000-1500m depth, indicating the Mediterranean outflow; higher values at depth in the southern transect in comparison to the northern transect indicate the prevalence of southern component water here.

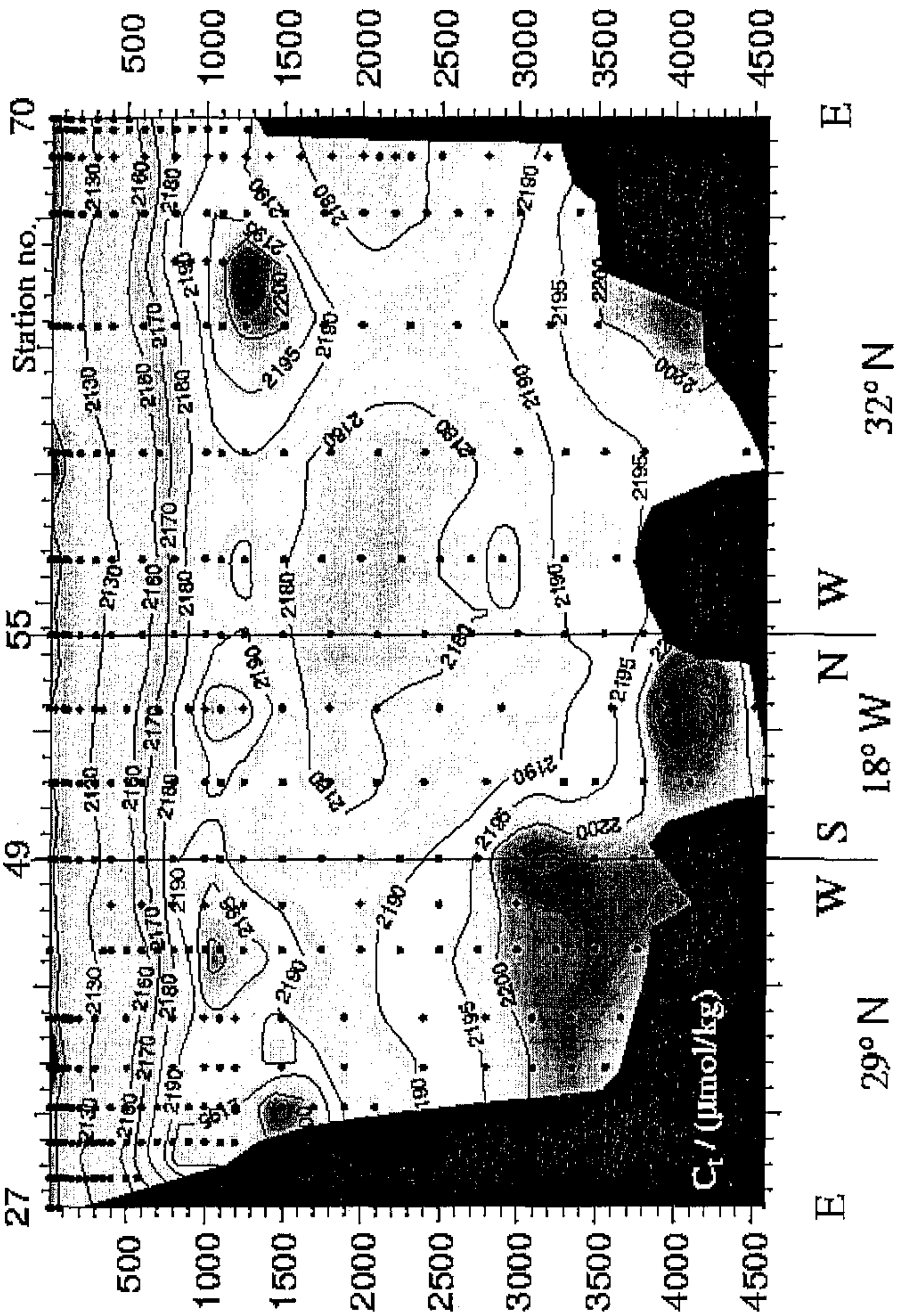


Fig. 42: Distribution of total Carbon along the 29°N, 18°W and the 32°N sections. The view onto the sections is from the east

5.2.8 Measurements of DOC on the CANIGO box

(G. Fengler)

Introduction

Dissolved organic carbon (DOC) in the ocean contain a total mass of carbon comparable to that in the atmosphere (Hedges, 1992). Consequently small changes in the cycling of DOC have a potentially large impact on the global carbon cycle. Despite this importance, DOC still continues to be the least understood pool of carbon. Many recent studies have addressed the question of the nature of DOC and the problems involved in its measurements (e.g. Sugimura & Suzuki, 1988; Suzuki 1993; Hedges & Lee, 1993; Sharp, 1993; Cauwet, 1994).

The objective of this study is, to determine the spatial distribution of DOC within the research area.

Methods

Ultra-clean sampling and filtration techniques were employed on samples recovered from CTD-Hydro-casts (see 7.2). DOC is operationally defined here as all organic carbon passing a glass fibre filter (GF/F, Whatman precombusted at 450°C for 5h). Quantitative analyses of DOC will be performed within the laboratories of the Institute of Biogeochemistry and Marine Chemistry at the University of Hamburg by using the high-temperature oxidation (HTCO) method in which a home-made DOC-analyzer will be used. After carbonate removal by acidification to a pH of 2 with 50% H_3PO_4 and subsequent purging (10 min with CO_2 free oxygen), 100 µl samples will be injected directly onto the pure platinum catalyst (Ionics, Inc.) and oxidize at 800°C. The effluent from the furnace passes through a water separator, a mossy tintrap to remove HCl gas, through a cold trap at 1° C, a $MgClO_4$ trap, a particle filter (Balston Type 9900-05-BK DFU) and finally into an IR analyzer (Licor 6252). Oxygen will be used as the carrier gas at 130 ml/min. Peak areas will be determined with an Hewlett Packard 3396A integrator. The calibration of the DOC-analyzer will be done with a series of potassium hydrogenophtalate standard solutions.

5.2.9 Measurements of Cocolithophores and Diatoms on the CANIGO box

Coccolithophores

(J. Bollmann)

Coccolithophore sampling during cruise M37/2B is part of CANIGO Subproject 3. The scientific goals are (a) to obtain a better understanding of the seasonal and interannual interaction between coccolithophores and the physical environment and (b) to compare this interaction with the long-term variability of coccolith composition and flux into the sedimentary archives.

During cruise M37/2b, water casts of 10 liters were taken at 23 stations and the following water depth levels were sampled: 0, 10, 25, 50, 75, 100, 125, 150, 200, 250, 300 meters. 13 stations were sampled along a zonal transect from the African coast to La Palma, 2 stations were sampled during the meridional transect from La Palma to Madeira and 8 stations during the zonal transect from Madeira towards the African coast (Fig. 2, see also 7.2).

Carboys were rinsed twice (about 0.5 liters) with tap water and up to 8 liters of water were transferred from the Niskin bottles for each depth level into carboys. Within one hour the water was filtered onboard through Nucleopore PC filters (0.8µm, 47 mm diameter) using a low-vacuum filtration device. Filtration was terminated if the filter became clogged up and the amount of remaining water was measured and noted. After filtration the filters were rinsed with 50ml of distilled water to eliminate all traces of sea salt, to which 1-2 drops of NH_4OH per liter were added to obtain a pH of about 8.5 to prevent carbonate dissolution. Rinsed filters were transferred to labeled petri-dishes, dried immediately in an oven at 55° and stored in a refrigerator.

In subsequent analyses using a Scanning Electron Microscope cell density (#/l) and taxonomic composition of the coccolithophore populations will be determined. In addition morphological features of *Gephyrocapsa* sp. and *Calcidiscus leptoporus* will be analyzed.

Diatoms

(J. Bollmann, Antonio Correira)

Diatom sampling during cruise M37/2b is part of the CANIGO Subproject 3. The scientific goals are (a) to determine diatom standing stock and assemblage composition at distinct water depth levels and (b) to construct transfer functions between diatom abundances and assemblages and environmental parameters and (c) to compare the results of these analyses with long-term variability of diatom compositions in sediments and diatom flux into the sedimentary archives.

During cruise M37/2b water casts of 10 liters were taken at 11 stations along a zonal transect from the African coast to La Palma and the following water depth levels were sampled: 0, 10, 25, 50, 75, 100, 125, 150, 200, 250, 300 meters. 200 ml water were transferred from Niskin bottles into plastic bottles and Formol and Hexamethyl-Tetramine was added.

At 25 stations a plankton net with 63 µm mesh size was used to sample diatoms within the upper 100 m water column (intergrated sampling). The net was released to 100m water depth and was pulled with 0.3 m/s back to the surface. Subsequently the net was rinsed with sea water and the catch was transferred into a plastic bottle and Glutardialdehyde was added.

In subsequent analyses using a light microscope and if necessary a Scanning Electron Microscope, diatom standing stock and assemblage composition will be determined.

5.2.10 Zooplankton as Tracers in Intermediate Waters off Morocco at 29°N and 32°N

(H.-Ch. John, C. Zelck)

Purpose

It is intended to analyze the intermediate meridional plankton transports along the Moroccan continental slope. It is presumed that some tropical planktonic species reach Morocco by means of a narrow poleward undercurrent located at about 400 to 800 m depth, whilst other, more northern species drift southwards in a zonally broader band influenced by the Mediterranean Outflow Water (MOW), located at broadly 1000 m depth. The bottom topography of the Canary Archipelago is likely to disturb both flows at least locally.

Sampling

Mesozooplankton of the 300 μm size fraction was sampled by vertical tows with a multiple-opening-closing net (MUV). The MUV had an integrated CTD-system with real-time data transfer to the lab. Sampling was generally done between 1000 m and the surface, separated into 5 strata 200 m wide each, unless shallower bottom depths interfered. In these cases narrower strata were sampled. Six additional deep stepwise tows down to 2000 m were also made on identical positions. Details on the tows and vertical resolution are listed in Table 5, haul positions are listed in Section 7.2.

All stations yielded successful tows, except that three malfunctions of the sampler resulted in integrations of two depth strata each (Table 5). One stratum was completely lost due to a torn net. Some of the CTD-files show spikes, for which the reasons are still unknown, but the data can be recovered.

The stations ran broadly zonal and cross-slope along the transects at approximately 29°N and 32°N, except for test station no. 1. The station spacing was from the shelf edge across the continental slope approximately 5-6 nautical miles (n.m.), but increased from 10 to 60 n.m. in the open ocean.

Tab. 15: MUV-tows obtained during leg 2 of „Meteor" cruise 37. Listed are ship station versus haul numbers, the depth strata sampled and the abundance of fish larvae (as far as analyzed during the cruise)

Sta #	Haul #	Net 1 (m)	Net 2 (m)	Net 3 (m)	Net 4 (m)	Net 5 (m)	N Fish /1m²
26	1	1000-800	800-600	600-400	400-200	200-0	92
29	2	240-200	200-150	150-100	100-50	50-0	64
30	3	350-300	300-200	200-100	100-50	50-0	88
31	4	575-400	400-300	300-200	200-100	100-0	32
32	5	795-600	600-400	400-200	200-100	100-0	48
33	6	1000-800	800-600	600-400	-	400-0	56
34	7	1000-800	800-600	600-400	400-200	200-0	28
35	8	1000-800	800-600	600-400	400-200	200-0	60
36	9	800-600	600-400	400-200	200-100	100-0	124
37	10	985-800	800-600	600-400	400-200	200-0	60
38	11	2000-1600	1600-1400	1400-1200	1200-1000	1000-0	28
38	12	1000-800	800-600	600-400	400-200	200-0	0
39	13	1000-800	800-600	600-400	400-200	200-0	52
39	14	2000-1600	1600-1400	1400-1200	1200-1000	1000-0	
40	15	1000-800	800-600	600-400	400-200	200-0	
42	16	1000-600	600-400	400-200	200-100	100-0	
44	17	1000-800	800-600	600-400	400-200	200-0	
46	18	1000-800	800-600	600-400	400-200	200-0	
49	19	1000-800	800-600	600-400	-	400-0	
62	20	1000-800	800-600	600-400	400-200	200-0	
62	21	2000-1600	1600-1400	1400-1200	1200-1000	1000-0	
63	22	1000-800	800-600	600-400	400-200	200-0	
64	23	1000-800	800-600	600-400	400-200	200-0	
65	24	1000-800	800-600	600-400	400-200	200-0	
65	25	2000-1600	1600-1400	1400-1200	1200-1000	1000-0	
66	26	1000-800	800-600	600-400	400-200	200-0	
66	27	2000-1600	1600-1400	1400-1200	1200-1000	1000-0	
67	28	1000-800	800-600	600-400	400-200	200-0	
67	29	2000-1600	1600-1400	1400-1200	1200-1000	1000-0	
68	30	1000-800	800-600	600-400	400-200	200-0	
69	31	1000-800	800-600	600-400	400-200	200-0	
70	32	500-400	400-300	300-200	200-100	100-0	

Results

On board, only the first 12 hauls could be coarsely analyzed. The fish larvae abundances (included in Tab. 15) are perhaps slight underestimates due to both, the quick check and the vertical tows. The material is generally in excellent conditions.

Ichthyology

We obtained a developmental series from early larvae to transforming specimens of lanternfish Lobianchia dofleini. Such series are known to science and are adequately described, but larvae of this species have previously not been caught by us and were missing from the collections of „Zoologisches Museum Hamburg".

We identified a transforming specimen of deep-sea smelt Bathylagus greyae. The larval development of B. greyae was previously unknown, contrary to most other Atlantic bathylagids. We caught also two early bathylagid larvae. These lacked meristic features for identification, but they showed a similar basic pigment pattern as the transforming B. greyae, and they definitely not belonged to any of the known species.

We caught in one of the deep hauls a transforming larva of the bathypelagic family Searsiidae. The specimen is by meristic characters and postopercular pores with a high degree of certainty referable to Normichthys operosus. The ontogeny of Searsiidae seems to be completely unknown in spite of being a large family with 31 species.

The remaining fish species are well known to us. The ichthyocoenosis appears to have by diversity and some indicator species (Vinciguerria nimbaria, Engraulis encrasicolus, no Clupeidae) a warm-water character both near-shore and offshore. Within the archipelago neritic and oceanic species co-occurred. The highest abundances were found at the slopes (Tab. 2).

Invertebrates

We caught in two hauls two bathypelagic Nemertini which have to be handed to experts. They appear to us laymen remarkable in that one seems to deviate from normal organization by a dorsal insertion of the lateral nerves. The other, less transparent one is an egg-bearing female folding its sides ventrally to form a „marsupium" and shoowing „leg-like" appendages in front and behind the marsupium.

The upwelling-systems copepod Calanoides carinatus was almost absent from the samples. Only two specimens were so far found within the Canary Archipelago.

Meridional plankton drift

Potential indicators for the poleward intermediate undercurrent were found only within the archipelago itself, but not at the Moroccan slope. The flow there may have been weak or non-existent during the warm conditions. The tropical mesopelagic fish Cyclothone livida seems to be frequent and to coincide in depth with a poleward flow passing through the archipelago. It needs further analysis to establish its offshore boundaries. No species indicating the MOW (Cyclothone pygmaea, Ceratoscopelus maderensis) have so far been found, but the majority of deep tows has yet to be analyzed.

6. Ship's Meteorological Station

(M. Peters, D. Bassek)

Activities of the ship's weather watch

Two written weather reports were generated daily for the scientific and nautical crew. These reports were explained verbally in greater detail. Except for some observations from the ship's weather station, the basis for the forecasts were synoptic weather charts which were produced twice a day using the 6:00 and 12:00 UTC meteorological observations from ships of the northern Atlantic and land stations of western Europe and north-western Africa. Additionally, forecast charts of the DWD (Deutscher Wetterdienst), the ECMF (European Centre of Middle Range Weather Forecasts) and the English weather service in Bracknell were used.

Eight weather observations per day were generated, six of them with cloud and sea observations. These were transferred into the international observation network via the DCP (Data Collecting Platform). Daily at noon a radio-probe weather balloon was released to altitudes up to 25 km for the determination of vertical temperature, moisture and wind profiles using the ASAP system (Automated Shipboard Aerological Program). The measured values also were entered into the GTS data network via the DCP. At last, many meteorological parameters (wind direction and speed, moisture, precipitation rates, radiation, temperature of air and water) were continually measured and recorded.

6.1 Weather and Meteorological Conditions During M 37/1

At 18:00 UTC of December 4, 1996 METEOR left Lisbon. On the transit to the research area in the Agadir Canyon we were situated between a high pressure cell over the Azores and a low over Spain. The resulting northerly winds blew at Bft 6 to 7 and there were many showers. On December 8 a ridge of the high moved over METEOR leading to a decrease of the wind speed and more sunny conditions between the Canary Islands and the Moroccan coast. But on December 10, a large low approached from the western Atlantic affecting METEOR with south-westerly winds Bft 7 to 8 and again there were several showers. The storm low only moved slowly eastwards to Spain, thus we had Southwest Bft 5 to 6 for several days and swell up to 4 m.

After a short period under the influence of a high pressure ridge, a new storm low moved over the Atlantic in an easterly direction. From December 15th to 17th, we were at the southern edge of the low. There, we only had moderate winds partly due to the shelter from Lanzerote and Fuerteventura. But when we cruised towards the ESTOC-station on December 18th wind speed and swell increased on the western side of the islands. There, we experienced westerly winds about Bft 6. Being north of La Palma on December 20th and 21st a secondary low was responsible for westerly winds Bft 7, temporary Bft 8 and gusts up to Bft 10. Those winds were accompanied by wave heights of 8 m and many showers, even some thunderstorms were observed. On our way to Las Palmas via the ESTOC-station the wind speed decreased again on December 22nd.

6.2 Weather and Meteorological Conditions During M 37/2

At 16:00 UTC of December 28th, 1996 METEOR cruised out of Las Palmas. Being north of the Canary Islands we were situated at the edge of a low west of Portugal. There we mostly had moderate westerly winds, only when we were passed by cold fronts we experienced Bft 6 to 7 with showersqualls, even a few thunderstorms were observed.

After the interruption of the cruise at Las Palmas at January 5th and 6th, 1997 a low moved eastwards far north of the Canary Islands. Thus, there were some showers but only south-westerly winds Bft 4 to 5. Lateron we were influenced by a high pressure cell with only light to moderate winds. From January 12th to 14th an intense low was situated in the area of Madeira. Being north of La Palma we had some spells with Bft 8 and heavy showers and thunderstorms. While cruising the hydrographic box the low was filling on our way to Madeira and the windspeed decreased. From January 15th to 18th we were steaming eastwards at roughly 32°N. At those days we were situated north of a high with south-westerly winds Bft 4 to 5. At the last days of the cruise near the Moroccan coast we were influenced by a low moving from the Biscay towards the Canary Islands. Thus, we experienced some periods with Bft 6 and heavy showers. In the morning hours of January 22nd METEOR reached Las Palmas again.

7. Lists

7.1 Leg M 37/1

List of abbreviations used in the station list of M 37/1:

CI6,CI7	Sediment trap and current-meter moorings (Canary Islands)
CTD:	Conductivity, Temperature Density Probe
GKG:	Giant Box Corer
MUC:	Multiple Corer, 8 tubes with 10cm diameter, 4 tubes with 6cm diameter
MN:	Multiple closing plankton net
SL:	Gravity Core (6, 12 or 18m)
KOL:	Piston Core (18m)
LAND	Elinor, Profilur (Lander systems)
TRAMP:	Profiling CTD-System
KAM:	Particle-Camera System

Station List Meteor 37/ 1

GeoB #	Date 1996	Coring device	Time seafloor (UTC)	Latitude (° N)	Longitude (° W)	Water depth (m)	Core-length (cm)	Remarks
Agadir Canyon								
4201-1	06.12	MUC/CTD	09:56	32°41,9	13°32,9	4240	-	no core recovery
4201-2		SL6	12:38	32°42,1	13°32,7	4210	77	tube bended, lower part of core recovered
4202-1	06.12.	GKG/ CTD	17:40	32°28,6	13°39,8	4289	39	
4203-1	06.12	GKG	23:41	32°25,9	12°57,5	4208	-	no core recovery
4204-1	07.12	GKG	07:33	32°01,0	11°56,7	3213	14	
4205-1	07.12	GKG	11:22	32°10,9	11°38,9	3272	23	
4205-2	07.12.	SL6	13:42	32°10,8	11°38,9	3296	501	
4206-1	07.12	SL6	20:10	31°29,9	11°00,9	1849	571	
4206-2	07.12	GKG	21:52	31°30,0	11°01,3	1855	35	
4207-1	08.12	GKG	02:36	30°51,8	11°04,3	2123	25	
4208-1	08.12	GKG	05:03	30°42,8	11°04,7	2724	23	
4209-1	08.12	GKG	08:45	30°21,4	11°05,0	2150	33	problems with Hydrosweep
4209-2	08.12	SL12	10:36	30°22,2	11°05,1	2170	970	
4210-1	08.12	SL12	13:08	30°18,0	10°58,8	1963	424	
4210-2	08.12	MUC/ CTD	14:41	30°18,0	10°58,8	1959	16	
4211-1	08.12	MUC	17:56	30°11,6	10°49,3	1773	35	
4211-2	08.12	SL12	19:23	30°11,6	10°49,3	1775	650	
Profil 1								
4212-1	09.12	SL12	06:01	29°36,3	10°57,0	1258	-	problems with winch-recorder, no core recovery
4212-2	09.12	SL12	07:11	29°36,3	10°57,0	1258	857	
4212-3	09.12	MUC	08:15	29°36,2	10°57,0	1256	30	
4213-1	09.12	MUC	11:18	29°41,8	11°04,7	1547	20	
4213-2	09.12	SL12	12:44	29°41,8	11°04,7	1549	754	
4214-1	09.12	SL12	16:14	29°46,9	11°11,9	1791	952	
4214-2	09.12	TRAMP -Test	18:46	29°47,0	11°11,9	1791		19:05 TRAMP system failed
4214-3	09.12	MUC	19:48	29°46,9	11°11,8	1788	35	4 big and 4 small tubes filled
4214-4	09.12.	KAM/ CTD	22:31	27°47,0	11°11,6	1788		max. depth 1600m
4215-1	10.12	MUC	03:22	30°02,2	11°33,2	2106	33	
4215-2	10.12	SL12	05:05	30°02,2	11°33,1	2105	766	
4216-1	10.12	SL12	13:22	30°37,8	12°23,8	2324	1117	
4216-2	10.12	MUC	15:09	30°37,9	12°23,8	2325	27	4 big tubes, 4 small tubes filled
Profil 2								
4217-1	10.12	MUC	20:03	30°26,1	12°53,7	2504	7	all big tubes empty or washed out
4217-2	10.12	Profilur	21:19	30°26,1	12°53,7			program for 21 hours, expected end-time 11.12 18:10

List (continued)

GeoB #	Date 1996	Coring device	Time seafloor (UTC)	Latitude (° N)	Longitude (° W)	Water depth (m)	Core-length (cm)	Remarks
4217-2	10.12	Elinor	21:41	30°25,9	12°53,7			program for 36 hours, expected end-time 12.12 09:30
4217-3	10.12	TRAMP -Test	22:15	30°25,3	12°54,8	2507		max. depth 54m, system worked
4217-4	10.12	MUC	23:35	30°25,0	12°54,5	2507	32	
4217-5	10.12	SL18	01:42	30°25,2	12°54,7	2506	716	
4218-1	11.12	SL18	09:34	29°57,3	12°54,7	2723	619	
4218-2	11.12	MUC	15:58	29°57,8	13°22,7	2734		no recovery
4218-3	11.12	MUC	17:40	29°57,2	13°22,6	2722		no recovery
4219-1	12.12	Elinor Profilur	10:43	30°26,0	12°53,7	2508		Elinor retrieved; Profilur not retrieved
4220-1	13.12	MUC	01:40	30°06,9	12°43,4	404	-	all tubes empty
4220-2	13.12	GKG	02:22	30°07,0	12°43,5	406	15	
4220-3	13.12	SL6	03:48	30°07,0	12°43,5	407	-	coral fragments in CC
4221-1	13.12	SL12	08:38	29°46,5	12°20,1	1826	843	
4221-2	13.12	MUC	10:10	29°46,5	12°20,3	1826	-	all tubes empty
4222-1	13.12	Profilur	15:21	30°33,7	12°40,1	2439		Profilur retrieved
4222-2	13.12	TRAMP Test	16:05	30°33,8	12°40,0	2439		o.k., max SL 280m
4223-1	14.12	MUC	05:40	29°01,1	12°28,0	777	35	
4223-2	14.12	SL12	06:35	29°01,0	12°28,0	775	779	
4224-1	14.12	SL6	08:40	28°54,9	12°20,9	295	-	no recovery
4225-1	14.12	SL12	14:56	29°16,6	11°46,9	1281	725	
4225-2	14.12	TRAMP Test	16:00	29°16,6	11°46,7	1286		JoJo-function failed, max. SL 298m
4225-3	14.12	MUC	17:40	29°16,5	11°46,9	1281	30	3 big tubes empty
4226-1	14.12	MUC	19:27	29°19,2	11°50,0	1400	35	
4226-2	14.12	TRAMP Test	20:40	29°19,2	11°50,0	1398		max. SL 50 m
4226-3	14.12	SL12	22:03	29°19,1	11°50,0	1397	907	upper 7cm in a plastic bag
4227-1	15.12	MUC	02:31	29°46,1	12°20,2	1826		2 big tubes filled
Profil 3								
4228-1	15.12	MUC+ CTD	07:16	29°28,2	12°59,4	1633	35	
4228-2	15.12.	SL12	08:31	29°28,2	12°59,6	1632	968	
4228-3	15.12.	KOL18	11:57	29°28,7	12°59,3	1638	1188	
4229-1	15.12	KOL18	16:05	29°11,1	12°39,0	1426	663	
4229-2	15.12	MUC	17:34	29°10,9	12°38,3	1422	31	
4230-1	15.12	MUC	19:09	29°07,7	12°35,8	1316	30	
4230-2	15.12	SL12	20:11	29°07,8	12°35,8	1316	993	
4231-1	15.12	SL12	21:47	29°05,2	12°33,1	1197	726	
4231-2	15.12	MUC	22:47	29°05,3	12°33,3	1207	31	3 big tubes empty

List (continued)

GeoB #	Date 1996	Coring device	Time seafloor (UTC)	Latitude (° N)	Longitude (° W)	Water depth (m)	Core-length (cm)	Remarks
Profil 3								
4232-1	16.12	MUC	08:19	29°01,3	13°23,2	1161	13	
4232-2	16.12	SL12	09:36	29°01,3	13°23,2	1160	991	
4233-1	16.12	SL12	12:56	28°58,6	13°19,8	1302	1076	
4233-2	16.12	MUC	14:06	28°58,5	13°19,8	1303	34	
4234-1	16:12	MUC+ CTD	16:02	28°53,4	13°13,6	1360	31	
4234-2	16.12	Elinor Profilur	17:16	28°53,5	13°13,5	1362		both deployed
4235-1	16.12	MUC	18:31	28°51,4	13°10,8	1244	31	
4235-2	16.12	SL12	19:29	28°51,4	13°11,4	1247	777	
4236-1	16.12	SL12	21:04	28°47,0	13°05,5	1031	1084	
4236-2	16.12	MUC	22:00	28°47,0	13°05,7	1030	14	
4237-1	16.12	MUC	23:44	28°43,7	13°01,0	800	13	
4237-2	17.12	SL12	00:30	28°43,7	13°01,0	805	966	
4238-1	17.12	SL12	07:00	28°27,1	13°38,1	1185	771	
4238-2	17.12	MUC	08:13	28°27,1	13°38,1	1185	26	
4239-1	17.12	MUC	11:12	28°29,6	13°10,8	881	12	
4239-2	17.12	SL12	12:07	28°29,7	13°10,8	880	986	
4240-1	17.12	Elinor	15:15	28°53,5	13°13,4	1360		Elinor retrieved
4240-2	17.12	SL12	16:43	28°53,3	13°13,5	1358	688	H_2S
4240-3	17.12	Profilur	17:35	28°53,4	13°13,1	1358		Profilur retrieved
4240-4	17.12	Tramp-Test	18:09	28°53,4	13°13,1	1358		max SL 300m
ESTOC								
4241-1	18.12	CI6	09:10	29°09,1	15°27,7	3612		11:20 retrieved
4241-2	18.12	MUC	12:35	29°07,4	15°28,0	3610	-	all tubes empty
4241-3	18.12	CI7	14:18	29°11,0	15°27,0	3610		16:44 deployed, 17:10 top buoy sinks
4241-4	18.12	MUC	18.33	29°10,1	15°27,2	3610		all tubes empty
4241-5	18.12	GKG	20:38	29°10,0	15°27,2	3610	30	
4241-6	18.12	GKG	22:45	29°09,9	15°27,2	3609	-	no surface-sediment
4241-7	19.12	MN	00:56	29°09,9	15°27,6	3610		800, 300, 200, 100, 50m
4241-8	19.12	MN	02:10	29°10,0	15°27,3	3609		400, 200, 100, 40, 20m
4241-9	19.12	MN	02:35	29°09,9	15°27,1	3609		250, 100, 75, 50, 25m
4241-10	19.12	SL6	04:04	29°10,0	15°27,1	3610	438	Geochemistry
4241-11	19.12	SL6	06.16	29°10,0	15°27,1	3609	374	
4241-12	19.12	LAND	07:54	29°10,0	15°27,2	2611		7:54 Profilur deployed, 8:13 Elinor deployed
La Palma								
4242-1	19.12	TRAMP Test	22:22	29°43,0	17°53,9	4313		free floating tramp sytem
4242-2	20.12	MUC	00:35	29°42,4	17°53,7	4307		all tubes empty
4242-3	20.12	GKG+ CTD	03:12	29°41,6	17°53,7	4297	-	GKG did not close

List (continued)

GeoB #	Date 1996	Coring device	Time seafloor (UTC)	Latitude (° N)	Longitude (° W)	Water depth (m)	Core-length (cm)	Remarks
4242-4	20.12	GKG	05:23	29°40,9	17°53,4	4292	33	surface disturbed
4242-5	20.12	SL6	08:00	29°40,5	17°53,3	4286	488	
4242-6	20.12	TRAMP	10:45	29°41,0	17°53,3	4295		TRAMP recovered
4242-7	20.12	LP-1	12:38	29°42,9	17°54,7			deployment cancelled due to bad weather
ESTOC								
4243-1	22.12	LAND	02:52	28°55,1	15°07,7			03:48 Profilur recovered
4244-1	22.12	LAND	08:40	29°09,8	15°26,8			08:50 Elinor recovered

7.2 Leg M 37/2

Last changes:
Station 68, profile 93, positon to 32 04.850, 010 05.868
CFCs sampled at station 7, profile 11

List of abbreviations used in the station list of M 37/2:

St : Station no.
Pr : CTD profile no., monotonically increasing during the cruise
Wd : Waterdepth
Instr : Type of instrumentation or mooring or equipment
NBX : Neil Brown CTD probe no X with 21x10 l bottle rosette
RXXX: RAFOS float no. XXX
VXXX: Mooring no XXX
DTRAP: Drifting sediment traps
TRACE: Cast for trace elements with GoFlo bottles and in-situ pumps on Kevlaer rope
XBTJJ : XBT type T7, profile no JJ

Parameter list for CTD/rosette:
1 Ctd with optic sensors ahead or after CTD/rosette
2 lowered ADCP (LADCP) on CTD/rosette
3 rosette
4 oxygen
5 carbon dioxide system components
6 dissolved organic carbon (DOC)
7 aluminium
8 nutrients
9 chlorophyll
10 salt
11 optics
12 coccolitho...
13 plankton samples from rosette
14 plankton net after or ahead of CTD/rosette
15 multiple closing net after or ahead of CTD/rosette

From stations 456 to 473, 1 to 4 and 66 to 72, a fluorometer was attached to the CTD.

```
                                                     Parameter no
                                                     --------------------------
-
Date Time St Pr  Latitude Longitude  Wd Inst   1 2 3 4 5 6 7 8 9 10 11 12
13 14 15
UTC  UTC          North   West                        0 not sampled
MMDD hhmm        GG MM.MM GG MM.MM  [m]               1 sampled
1996/97
---------------------------------------------------------------------------
------
1228 1624                                      Sail from Las Palmas, begin
of M37/2
1228 2025 456  1  28 25.40 15 24.70 3350 NB2   Test acoustic release
1229 0215 457  2  29 10.00 15 30.00 3600 NB2
1229 1045 458  3  29 14.50 15 27.90 3600 TRACE
1229 1236 469 -9  29 19.8  15 28.3  3603 DTRAP Drifting sediment trap
deployed
1229 1406 460 -9  29 19.3  15 27.3  3605 TRACE
1230 0744 461 -9  28 48.39 13 38.83 1044 VEBC5 CANIGO mooring EBC5 deployed
1230 0755 462  4  28 48.30 13 39.30 1030 NB2
1230 1049 463 -9  28 46.39 13 28.02 1281 VEBC4 CANIGO mooring EBC4 deployed
1230 1406 464 -9  28 44.49 13 17.96 1180 V3771 CANIGO mooring EBC3/377100
deployed
1230 1523 465 -9  28 45.0  13 19.8  1276 TRACE
1230 1925 466  5  28 46.50 13 29.10 1280 NB2
1230 2129 467 -9  28 46.3  13 29.0  1279 TRACE
1231 0015 468  6  28 44.90 13 19.80 1240 NB2
1231 0230 469  7  28 41.90 13 06.00  850 NB2
1231 0455 470  8  28 40.00 12 57.00  500 NB2
1231 0735 471 -9  28 39.89 12 56.83  490 VEBC1 CANIGO mooring EBC1 deployed
1231 1045 472 -9  28 42.49 13 09.34  996 V3781 CANIGO mooring EBC2/378100
deployed
1231 1134 473 -9  28 44.4  13 15.6  1138 TRACE
0101 0800   1 -9  29 09.7  15 30.1  3609 TRACE
0101 1000   1  9  29 09.40 15 30.17 3608 NB2
0101 1230   2 -9  29 06.4  15 31.5  3608 DTRAP Drifting sediment trap
recovered
0101 1323   3 -9  29 05.57 15 31.67 3609 DTRAP Drifting sediment trap
deployed
0101 1345   4 10  29 05.20 15 32.30 3610 NB2
0101 1606   5 -9  29 09.75 15 40.15 3624 V3672 ESTOC mooring V367200
recovered
0101 2015   6 -9  29 10.0  15 30.1  3608 TRACE
0101 2257   7 11  29 03.50 15 31.00 3600 NB2   ESTOC: CFCs sampled from
rosette
0102 0325   8 -9  29 10.00 15 30.00 3600 TRACE
0102 1910   9 12  29 45.00 17 59.90 4350 NB2   Test acoustic release
0102 2059  10 -9  29 45.9  18 02.9  4366 TRACE
0102 2319  11 13  29 45.00 17 59.90 4355 NB2
0103 0306  12 -9  29 46.0  18 03.0  4366 TRACE
0103 0635  13 14  29 48.00 18 11.50 4403 NB2
0103 1202  14 -9  29 45.73 17 57.26 4327 VLP1  CANIGO mooring LP1 deployed
0103 1247  15 -9  29 45.9  18 03.0  4365 TRACE
0103 2100  16 15  29 37.56 17 29.81 4201 NB2
0104 0110  17 16  29 29.99 16 55.97 3800 NB2
0104 0553  18 17  29 20.96 16 23.93 3704 NB2
0104 0803  19 18  29 15.05 15 59.95 3633 NB2
0104 1435  20 -9  29  9.0  15 40.0  3616 V3673 ESTOC mooring V376300
deployed
```

0104 1455 21 19 29 9.08 15 40.95 3617 NB2
0104 1810 22 -9 28 48.2 15 35.4 3586 DTRAP Drifting sediment trap
recovered
0104 1850 22 20 28 47.91 15 34.72 3586 NB2
0104 1927 22 21 28 47.76 15 34.76 3500 NB2
0104 2250 23 22 29 06.09 15 6.51 3576 NB2
0105 0235 24 23 28 58.00 14 33.00 3300 NB2
0105 0500 25 24 28 54.40 14 15.20 2962 NB2
0105 1412 Call port of Las Palmas, end
of M37/2a

0106 1900 Sail from Las Palmas, begin
of M37/2b
0106 2300 26 25 28 14.22 15 08.38 2716 NB2 Test Station
0107 1435 27 26 28 33.49 12 31.97 100 NB2 1 0 1 1 1 1 1 1 1 0 1 1
1 0 0
0107 1708 28 27 28 36.39 12 43.38 171 NB2 1 0 1 0 1 1 1 1 0 0 1 0
0 0 0
0107 1917 29 28 28 37.03 12 48.88 248 NB2 1 1 1 1 1 0 1 1 1 0 0 1
1 1 0
0107 2058 29 29 28 37.12 12 48.62 247 NB2 1 1 1 1 1 1 1 1 1 0 1 1
1 0 1
0107 2253 30 30 28 37.81 12 54.35 357 NB2 1 0 1 0 1 1 1 1 0 1 1 0
0 0 1
0108 0145 31 31 28 39.49 13 00.23 587 NB2 1 1 1 1 1 0 1 1 1 1 1 1
1 1 1
0108 0515 32 32 28 40.44 13 06.00 799 NB2 1 1 1 0 1 0 1 1 0 1 1 0
0 0 1
0108 0859 33 33 28 42.28 13 12.22 1059 NB2 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1
0108 1315 34 34 28 44.14 13 22.05 1300 NB2 1 1 1 0 1 1 1 1 0 1 1 0
0 0 1
0108 1905 35 35 28 45.96 13 33.64 1197 NB2 1 1 1 1 1 1 1 1 1 0 1 1
1 0 1
0108 2323 36 36 28 48.31 13 42.65 848 NB2 1 1 1 1 1 1 1 1 1 1 1 0
0 0 1
0109 0330 37 37 28 51.21 13 56.34 1130 NB2 1 1 1 1 1 0 1 1 1 1 1 0
0 0 1
0109 0557 37 38 28 50.97 13 56.06 1030 NB2 1 0 1 0 0 0 0 0 0 0 0 1
0 1 1
0109 0935 38 39 28 52.50 14 06.39 2100 NB2 1 1 1 1 1 1 1 1 1 1 1 0
1 0 1
0109 1325 38 40 28 52.50 14 06.22 2100 NB2 1 0 1 0 0 0 0 0 0 0 0 1
0 1 0
0109 1747 39 41 28 56.37 14 22.42 2945 NB2 1 1 1 1 0 1 1 1 1 1 1 0
0 0 1

Parameter no

Date UTC MMDD 1996/97	Time UTC hhmm	St	Pr	Latitude North GG	MM.MM	Longitude West GG	MM.MM	Wd [m]	Inst	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0110	0155	40	42	29	01.03	14	43.93	3517	NB2	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0
0110	0548	40	43	29	00.98	14	44.02	3515	NB2	1	0	1	1	1	0	1	1	1	0	0	1	0	0	1
0110	0913	41	44	29	05.71	15	06.69	3581	NB2	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
0110	1518	42	45	29	09.97	15	29.98	3615	NB2	1	1	1	1	1	1	1	0	0	1	1	0	0	0	0
0110	1945	42	46	29	10.09	15	30.08	3615	NB2	1	0	1	0	0	0	0	0	0	0	0	1	1	0	1
0110	2300	43	47	29	10.23	15	50.07	3629	NB2	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0
0111	0505	44	48	29	09.91	16	11.84	3660	NB2	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0
0111	0852	44	49	29	09.10	16	12.02	3707	NB2	1	0	1	0	0	0	0	0	0	0	0	1	0	1	1
0111	1124	45	50	29	09.90	16	33.99	3707	NB2	1	1	1	1	1	0	0	1	0	1	1	0	0	0	0
0111	1531	45	51	29	09.94	16	34.00	3708	NB2	1	0	1	1	1	0	1	1	1	0	1	0	0	0	0
0111	1755	46	52	29	09.96	16	54.91	3839	NB2	1	1	1	1	0	1	1	1	0	1	1	0	0	0	0
0111	2305	46	53	29	09.88	16	54.67	3837	NB2	1	0	1	1	0	1	1	1	1	0	1	1	1	1	1
0112	0137	47	54	29	10.00	17	17.04	3916	NB2	1	1	1	1	1	0	1	1	0	1	1	0	0	0	0
0112	1026	48	55	29	09.89	17	39.13	3741	NB2	1	1	1	1	0	1	1	1	0	1	1	0	0	0	0
0112	1500	48	56	29	09.87	17	38.71	3736	NB2	1	0	1	1	0	1	1	1	1	0	1	1	0	0	0
0112	1753	49	57	29	09.94	17	59.99	3694	NB2	1	1	1	1	1	1	1	1	0	1	1	0	0	0	1
0112	2304	49	58	29	09.76	18	00.11	3693	NB2	1	0	1	1	1	1	1	1	1	0	1	1	0	1	0
0113	0318	50	59	29	47.02	17	59.90	4373	NB2	1	1	1	1	0	0	1	1	0	1	1	0	0	0	0
0113	0800	50	60	29	46.94	18	00.09	4370	NB2	1	0	1	1	0	0	1	1	1	0	1	1	1	0	0
0113	1616	51	61	30	14.91	18	00.17	4492	NB2	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0
0113	2050	51	62	30	14.82	18	00.57	4492	NB2	1	0	1	1	1	1	1	1	1	0	1	0	0	0	0
0114	0024	52	63	30	44.99	17	59.98	4542	NB2	1	1	1	1	0	0	1	1	0	1	1	0	0	0	0
0114	0510	52	64	30	44.99	18	00.10	4543	NB2	1	1	1	1	0	0	1	1	1	0	1	0	0	0	0
0114	1055	53	65	31	14.95	18	00.01	4576	NB2	1	0	1	1	1	1	1	1	1	0	1	0	0	0	0

0 not sampled
1 sampled

0114 1208 53 66 31 14.98 18 00.00 4574 NB2 1 1 1 1 0 1 1 1 0 1 1 0
0 0 0
0114 1529 53 -9 31 14.98 17 59.99 4573 R209 RAFOS float 209
0114 1855 54 67 31 44.98 17 59.97 4553 NB2 1 1 1 1 0 1 1 1 0 1 1 0
0 0 0
0114 2318 54 68 31 45.05 18 00.34 4553 NB2 1 0 1 1 0 1 1 1 1 1 1 0
0 0 0
0114 2347 54 -9 31 44.99 18 00.35 4553 R211 RAFOS float 211
0115 0303 55 69 32 14.96 17 59.89 4427 NB2 1 1 1 1 0 1 1 1 0 1 1 0
0 0 0
0115 0740 55 70 32 15.18 18 00.24 4426 NB2 1 1 1 1 1 1 1 1 1 0 1 1
0 1 0
0115 1124 56 71 32 15.07 17 24.89 4222 NB2 1 1 1 1 1 1 1 1 0 1 1 0
0 0 0
0115 1603 56 72 32 14.98 17 25.01 4221 NB2 1 0 1 1 1 1 1 1 1 0 1 0
0 1 0
0115 1932 57 73 32 14.98 16 49.92 3582 NB2 1 1 1 1 1 1 1 1 0 1 1 0
0 0 0
0115 2340 57 74 32 14.99 16 50.12 3570 NB2 1 0 1 1 0 1 1 1 1 0 0 0
0 1 0
0116 0309 58 75 32 14.94 16 09.95 4300 NB2 1 1 1 1 0 0 1 1 0 1 1 0
0 0 0
0116 0751 58 76 32 15.08 16 09.95 4303 NB2 1 0 1 1 0 0 1 1 1 0 1 1
0 1 0
0116 1246 59 77 32 14.92 15 09.98 4367 NB2 1 1 1 1 0 1 1 1 0 1 1 0
0 0 0
0116 1715 59 78 32 14.93 15 09.98 4368 NB2 1 0 1 1 1 1 1 1 1 0 1 0
0 0 0
0116 1752 59 78 32 14.86 15 09.97 4368 R212 RAFOS float 212
0116 2245 60 79 32 14.98 14 10.06 4336 NB2 1 1 1 1 1 0 1 1 0 1 1 0
0 0 0
0117 0309 60 80 32 14.98 14 10.15 4335 NB2 1 0 1 1 1 0 1 1 1 0 1 1
0 0 0
0117 0830 61 -9 32 16.00 13 12.40 4020 V3791 CANIGO sound source mooring
SQ4/V379100 deployed
0117 1045 62 81 32 14.88 13 09.82 3995 NB2 1 0 1 1 1 1 1 1 1 0 1 0
0 0 0
0117 1408 62 82 32 15.00 13 09.96 3998 NB2 1 1 1 1 1 1 1 0 0 1 1 0
0 1 1
0117 1848 62 -9 32 15.06 13 09.88 4000 R213 RAFOS float 213
0118 0420 63 83 32 14.94 12 09.92 3379 NB2 1 1 1 1 0 0 1 1 0 1 1 0
0 0 0
0118 0935 63 84 32 14.95 12 09.72 3378 NB2 1 0 1 1 1 0 1 1 1 0 1 1
0 1 1
0118 1104 -9 -9 32 14.87 11 58.24 -9 R214 RAFOS float 214
0118 1335 64 85 32 15.02 11 24.91 3337 NB2 1 1 1 1 1 1 1 1 0 1 1 0
0 0 0
0118 1850 64 86 32 14.94 11 24.90 3334 NB2 1 0 1 1 0 1 1 1 1 0 1 0
0 1 1
0118 2203 65 87 32 15.95 10 50.06 3240 NB2 1 1 1 1 0 1 1 1 0 1 1 0
0 0 1
0119 0430 65 88 32 15.06 10 50.00 3233 NB2 1 0 1 1 0 1 1 1 1 0 1 1
0 1 1
0119 0648 66 89 32 10.07 10 31.88 3001 NB2 1 1 1 1 1 0 1 1 0 0 1 0
0 0 1
0119 1305 66 90 32 09.98 10 31.88 2986 NB2 1 0 1 1 1 0 1 1 1 0 0 0
0 1 1
0119 1452 67 91 32 07.19 10 14.83 2074 NB2 1 1 1 1 0 1 1 1 0 0 1 0
0 0 1

```
0119 2037  67 92  32 06.76 10 14.90 2011 NB2   1 0 1 1 0 1 0 1 1  0  1  1
0  1  1
0119 2203  68 93  32 04.85 10 05.87 1219 NB2   1 1 1 1 1 1 1 1 0  0  1  0
0  0  1
0120 0220  69 94  32 02.71 09 55.42  908 NB2   1 0 1 1 0 0 1 1 1  0  1  0
0  0  0
0120 0555  69 95  32 02.55 09 55.45 1026 NB2   1 0 1 0 0 0 0 0 0  0  0  1
0  1  1
0120 0705  70 96  32 02.72 09 54.60  501 NB2   1 1 1 1 1 1 1 1 1  0  1  0
0  0  1
0120 0922  71 97  32 02.21 09 53.90  265 NB2   1 0 1 1 1 1 1 1 1  0  1  1
0  1  0
0120 1137  72 98  32 01.94 09 51.87  107 NB2   1 0 1 1 1 1 0 1 1  0  0  1
0  1  0
0121 2356  -9 -9  29 06.4  15 13.6  3592 XBT01
0122 0037  -9 -9  29 00.0  15 14.6  3598 XBT02
0122 0136  -9 -9  28 50.0  15 16.2  3594 XBT03
```

```
Parameter no
                                                       ----------------------------
-
Date Time St Pr  Latitude Longitude  Wd Inst   1 2 3 4 5 6 7 8 9 10 11 12
13 14 15
UTC  UTC           North   West                        0 not sampled
MMDD hhmm        GG MM.MM GG MM.MM  [m]                1 sampled
1996/97
--------------------------------------------------------------------------
------
0122 0246  -9 -9  28 40.0  15 17.7  3584 XBT04
0122 0400  -9 -9  28 30.0  15 19.2  3472 XBT05
0122 0510  -9 -9  28 20.0  15 29.9  3148 XBT06
0122 0630                                          Call port of Las Palmas,
end of M37/2
```

8. Concluding Remarks

The goals of the research program of leg M37 were achieved. With few exceptions, all measuring systems functioned flawlessly. The success of the cruise was made possible by the exemplary performance of the crew. During work on deck and in maneuvering of the ship, the highest competence was displayed. Throughout the cruise there was outstanding teamwork and friendly comradeship between the crew and the scientists. For this we very sincerely thank Captain Kalthoff (M 37/1) and Captain Kull (M 37/2) and the entire crew.

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