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S. Drachenberg, O. Esper, S. Gerhardt, M. Segl, N. Zatloukal (M 41/2)

REPORT AND PRELIMINARY RESULTS OF METEOR CRUISE M 41/1 MALAGA - LIBREVILLE, 13.2. - 15.3.1998

with Partial Results of METEOR CRUISE 41/2 Libreville - Vitória, 18.03.1998-15.04.1998

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Universität Bremen

Postfach 330 440

D 28334 BREMEN

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Schulz, H.D. and cruise participants

Report and preliminary results of METEOR-Cruise M 41/1, Málaga - Libreville, 13.2.-15.3.1998

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1 Participants M 41/1

Name	Discipline	Institution
Adegbie, Adesina, M.Sc.	Marine Geology	GeoB
Boehme, Susan, Dr.	Biogeochemistry	MPI
Brune, Anja, cand. geol.	Paleobiology	GeoB
Däumler, Katharina, Dipl. Geophys.	Geophysics	GeoB
Dehning, Klaus, techn. assistant	Marine Geology	GeoB
de Vries, Uwe, cand. geol.	Geochemistry	GeoB
Diekamp, Volker, techn. assistant	Marine Geology	GeoB
Enneking, Karsten, techn. assistant	Marine Geology	GeoB
Ferdelman, Tim, Dr.	Biogeochemistry	MPI
Funk, Jens, Dipl. Geol.	Geophysics	GeoB
Hell, Joseph Victor, Dr. (obs. Cameroon)	Sedimentary Geology	IRGM
Hilgenfeldt, Christian, techn. assistant	Geophysics	GeoB
Hinrichs, Sigrid, techn. assistant	Geochemistry	GeoB
Joppich, Christoph, Dr.	Meteorology	DWD
Kasten, Sabine, Dr.	Geochemistry	GeoB
Klump, Jens, B.Sc. Honours	Marine Geology	GeoB
Lavik, Gaute, Dipl. Geol.	Marine Geology	GeoB
Meyer, Anne, techn. assistant	Paleobiology	GeoB
Meyer, Stephan, techn. assistant	Biogeochemistry	MPI
Ochsenhirt, Wolf-Thilo, technician	Meteorology	DWD
Schewe, Felix, techn. assistant	Marine Geology	GeoB
Schneider, Ralph, Dr.	Marine Geology	GeoB
Schulz, Horst D., Prof. Dr. (chief scientist)	Geochemistry	GeoB
Siemer, Susanne, techn. assistant	Geochemistry	GeoB
Strotmann, Bettina, Dipl. Geol.	Biogeochemistry	MPI
Stuut, Jan-Berend, M.Sc.	Sedimentology	NIOZ
von Lom-Keil, Hanno, Dipl. Geophys.	Geophysics	GeoB
Wagner, Thomas, Dr.	Sedimentology	GeoB
Wenzhöfer, Frank, Dipl. Ing.	Biogeochemistry	MPI/GeoB
Zabel, Matthias, Dr.	Geochemistry	GeoB

DWD	Deutscher Wetterdienst - Seewetteramt - Bernhard-Nocht-Straße 76, D 20359 Hamburg
GeoB	Fachbereich Geowissenschaften, Universität Bremen Klagenfurter Straße, D 28359 Bremen
IRGM	Institut de Recherches Géologiques et Minières BP. 4110, Nlongkak, Yaounde, Cameroon
MPI	Max-Planck-Institut für Marine Mikrobiologie Celsiusstraße 1, D 28359 Bremen
NIOZ	Nederlands Instituut voor Onderzoek der Zee Postbus 59, 1790 AB Den Burg, Nederland

Note

This cruise report also includes results of different working groups of Geoscience Bremen (GeoB) from cruise M 41/2. These results concern the chapters 4.2, 4.3, 4.6, and 4.7.

Participants M 41/2 (GeoB)

Name	Discipline	Institution
Drachenberg, Sebastian, Stud. Geol.	Marine Geology	GeoB
Esper, Oliver, Dipl. Geol.	Paleobiology	GeoB
Gerhardt, Sabine, Dipl. Geol.	Sedimentology	GeoB
Segl, Monika, Dr.	Marine Geology	GeoB
Zatloukal, Nicole, techn. assistant	Paleobiology	GeoB

2 Research Program

2.1 Locations of Measurements and Sampling

The cruise M 41/1 was planned to gain missing information on the area of the Niger fan and the Bight of Bonny by continuing the program of the Special Research Project 261 (SFB 261). During the cruise M 34/2 in 1997 mainly a biogeochemical and geochemical program was carried out at locations covering the upwelling area off Namibia and Southern Angola. The present expedition, therefore, was a spatial and thematic continuation of the former cruise. Underway, the sampling location GeoB 1401 at a water depth of 4000 m off the deep-sea fan of the river Congo (Meteor cruise M 16/1) was re-sampled with new scientific questions and measuring techniques (e.g. concentrations and gradients of methane or deep sulphate reduction rates measured by addition of radioactive-labeled sulfur). The ship's track and all sampling locations of M 41/1 are depicted in Fig. 1.

2.2 Scientific Programs of the Different Groups

The scientific co-operations of the different groups on board of the ship were part of the long-term research project SFB 261 and aimed at reconstructing the mass budget and current systems of the South Atlantic during the Late Quaternary. The scientific questions of the different groups are described in detail below.

Marine Geology / Sedimentology

The choice of suitable sites for sampling of near-surface sediments was based upon seismoacoustic measurements. These activities are fully integrated into the schedule of the echographic and seismic profiling program. Following the successful experience of many previous cruises, the combination of HYDROSWEEP and PARASOUND records provides an excellent basis for the choice and positioning of sampling sites. Sediments were recovered with gravity cores and multicorers for undisturbed surface samples. Both were described, sub-sampled, and prepared for conservation. Of special interest was the sampling of near-surface sediments from the Niger and Congo river areas. Climate-induced changes in paleoproductivity and supply of terrigenous matter are documented by variations in relative proportions of marine and terrigenous organic matter preserved in marine sediments. Quantitative assessment of these autochthonous and allochthonous organic fractions is planned using organic petrologic and pyrolytic analyses. Overall, sample analyses should result in a reconstruction of the sedimentary environment and a better understanding of changes during glacial/interglacial cycles.

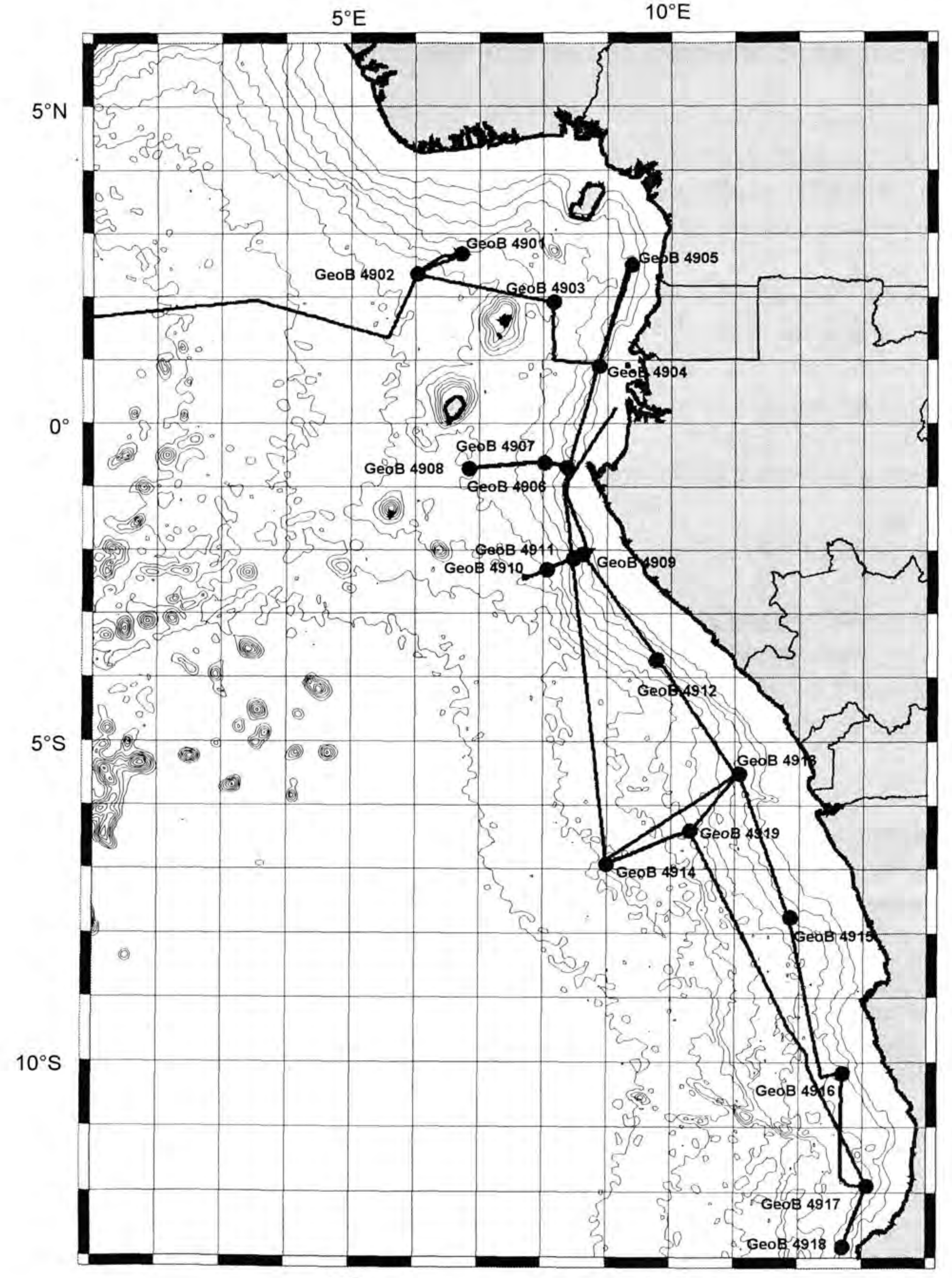

Figure 1: Cruise track and sampling stations of M 41/1.

Micropaleontology

For the determination of the distribution patterns of dinoflagellate associations, samples from the surface water were collected several times a day by means of the ship's membrane pump from February, 22 (1° N, 7° W) until the end of the cruise. From these samples, living individuals were isolated on board for culturing experiments; for further investigations, the samples were fixed and stored at 4°C. At sampling stations, plankton samples from max. 100 m depth were collected with a rosette sampler. For investigations on the associations of calcareous and organic walled dinoflagellate cysts in sediments, which can be used as a proxy for glacial and interglacial climate fluctuations, one core from the multicorer and selected samples from gravity cores was taken at each station.

Geophysics

During the cruise the shipboard echosounder systems HYDROSWEEP and PARASOUND were continuously operated where permissions were available to record the bathymetry of the ocean floor and shallow sediment structures. As with previous successful experience, the geological sampling sites could efficiently be selected based on these surveys. Due to the complex sedimentation environment in the Congo and Niger deep sea fans, a thorough acoustic pre-site survey with both systems was conducted. Multiple frequency tests at all coring stations are a prerequisite for the detailed correlation of PARASOUND records with onboard physical property logs. A special field of interest is the investigation of vertical fluid migration zones in the Congo deep sea fan region. Here, the core material is expected to provide useful rock magnetic data regarding diagenetic alteration of the deposits. For an understanding of the Quaternary sediment records it is necessary to quantitatively discriminate early diagenetic effects from climatically controlled sedimentary processes.

Biogeochemistry

Two benthic lander systems (chamber lander and profiling lander) were deployed to quantify the mineralization processes across the sediment water interface, the penetration depth of oxygen in deep-sea sediments and the dissolution of calcite.

The profiling lander was equipped with two different measurement modules: one system for electrochemical measurements and one for opto-chemical measurements. In conjunction with O_2- and pH-electrodes new CO_2- and Ca-optodes were tested. In-situ pH- and carbonate-profiles are of importance to understand and quantify the processes of calcite dissolution driven by benthic activity in the sediment. At stations where deep oxygen penetration was assumed the system was also used for deep oxygen profile measurements. The penetration of oxygen essentially depends on the amount of degradable organic carbon available in the sediments and can, therefore, be used as an indicator of productivity and activity in a specific area. Oxygen penetration also controls the depth distribution of many redox-reactions in sediments. The Chamber lander was deployed in conjunction with the profiling lander for quantification of total fluxes from the seabed. Shipboard incubations were also conducted in conjunction with in-situ measurements to try to understand and quantify the differences between shipboard and in-situ measurements. The distribution of sulfate reduction rates in the surface sediments was made using the ^{35}S method on all stations sampled with a multicorer. Rates of sulfate reduction were also measured on two gravity cores with special focus on the methane-sulfate transition zone. Samples for the isotopic analysis of stable sulfur isotopes, stable oxygen isotopes in dissolved sulfate, and the isotopic signature of methane were obtained as well as samples for the study of bacterial distributions using DNA probes.

Geochemistry

The geochemical investigation of surface sediments on an isobath parallel transect along the West African continental margin at approximately 1300 m water depth was a consequent continuation of the research program of M 34/2. By determination of indicative pore water constituents regional variations of benthic mineralization processes were described. On M 34/2 significant regional inhomogeneities of benthic activity could be detected along the 1300 m isobath transect off Namibia. With the northward extension of these investigations it was now possible to characterize the whole West African continental margin. At five stations high resolution pore water analyses and solid phase sampling of gravity cores were carried out. The main focus of these investigations was on anaerobic mineralization processes in the methane oxidation zone and the sulfide-reoxidation zone. Generally, the processes in the sulfide-reoxidation zone are badly understood. Therefore, it is the aim to better understand what the control mechanisms of these processes might be. Subsequent computer simulations of the data are planned to examine how non-steady state sedimentary conditions could be responsible for the observed distribution of pore water species.

Working permissions and the final schedule of the cruise

The final research program and especially the locations for sampling were somewhat affected by the working permissions of the different African states. We had applied for the working permission in the 200 miles economic zones of Nigeria, Cameroon, Equatorial Guinea, Gabon, São Tomé & Principe, Congo (Brazzaville) and Angola. In Congo (Brazzaville) it was not possible for the German authorities to deliver the application because, simply, no real government of Congo (Brazzaville) does exist at the moment. Equatorial Guinea refused the application. Two days before the beginning of the cruise we received an offer from Nigeria for a working permission in the 200 miles economic zone with the condition, that two military observers should stay on board only during the operation in the Nigerian zone. This was not acceptable for us, especially because the time schedule would not have allowed twice the way into a harbor of Nigeria. We got eventually the working permissions from Cameroon, São Tomé / Principe, Gabon and Angola. Cameroon sent a scientific observer (Dr. Joseph Victor Hell), who stayed on board during the entire cruise from Málaga to Libreville and was very committed helping in the laboratories of different groups.

So all our sampling locations on the Niger Fan are located somewhat closer to Principe than to Nigeria. All locations in the Bight of Bonny are either just within the zones of Cameroon or of Gabon or are a little bit closer to Principe or São Tomé than to Equatorial Guinea. The more southern locations could easily be chosen within the 200 miles economic zones of Gabon and Angola. Overall, the scientific program was fullfilled as far as the sampling locations and the core material is concerned. Only the continuous measurements of the PARASOUND-System and HYDROSWEEP-System and the sampling and salinity measurements in the surface water suffered from the frequent switching on and switching off of the specific devices.

3 Summarized Cruise Report

After the arrival of the complete advance group of cruise members on February 11, 1998, and of all six containers in the morning of the next day all material was embarked as planned. After the arrival of all remaining cruise members in the evening of February 12, 1998, the RV METEOR departed from Málaga right on schedule at 10am on February 13, 1998. Since the observer of São Tomé / Principe did not arrive, Anja Brune was able to stay on board. Hence, all potential cabin space was occupied.

During transit to the Niger-Delta in fine weather and a calm sea, the Canary Islands were passed in the afternoon of February 15, 1998 . During the ongoing cruise along the coast of West Africa, temperatures increased day by day, reaching up to 30°C as we approached the equator and the working area of the Niger-Delta and the islands of São Tomé and Principe. In the meantime, the different working groups had nothing left to prepare for. All labs were equipped and all the devices had been tested and everybody was eager to work with real samples. The only one on board who was able to collect samples during transit was Jan-Berend Stuut with his dust sampler, collecting huge amounts of dust derived from the Sahara Desert. Temporarily, visibility was reduced to 4-5 km and the deck had to be cleaned each day. Also, the big African grasshoppers were to be found on deck.

With the arrival in the economic zone of São Tomé / Principe on February 25, 1998, the work began with a station on the Niger-Fan at a water depth of about 2000 m. The whole equipment, including the rosette-sampler, multicorer, gravity corer, and the lander systems was employed at this station. Unfortunately, the 18 m gravity corer was too short for the poorly conditioned sediment so that the corer had to be rearranged to a length of 24 m resulting in two cores with about 20 m in length. Both lander systems, ELINOR and PROFILUR, returned to the sea surface after triggering of the acoustic release systems. Due to the experienced crew, both landers were retrieved very quickly. All systems had worked perfectly, resulting in a complete set of microelectrode measurements for oxygen, pH, carbon dioxide and calcium in the interstitial water. This allows for the first time a complete description of all parameters by *in situ* measurements, determining the carbon dioxide system in deep-sea sediments.

At the second station on the Niger-Fan at a water depth of 3200 m the 18 m gravity corer - which was used for safety reasons - was again too short for sampling of the very soft sediment. The second attempt with 24 m of corer length resulted in a core of 22.64 m with only 36 cm remaining in the core since a 24 m corer allows a maximum core length of 23 m.

Then, a number of stations followed in close succession. Overall, there were two stations on the Niger-Fan, three stations in the Bight of Bonny, three stations along a transect off Port Gentil, three stations along another transect at 2°20´S, one station at 1300 m in front of the mouth of the Congo, and, at the end the re-sampling of station GeoB 1401 – now with a bunch of new questions and the opportunity to measure methane concentrations in the pore water of the deeper sediment layers. In all cases, the gravity corer obtained long cores. At station GeoB 1401 (now GeoB 4914) the same procedure as on the Niger-Fan stations had to be carried out. Again, the 18 m corer was too short. The 24 m gravity corer retrieved a core of 20.7 m, extending deeply into the methanogenic zone.

In spite of all long cores obtained before station GeoB 4914, the geochemists were not too happy with the pore water results since the methanogenic zone was not reached in any of these cores. Obviously, the total input of organic matter and therefore the reaction rates between methane and sulfate are drastically reduced compared to the upwelling area off Namibia. This situation was now changed. Overall, station GeoB 4914 revealed a core which is 5 m longer than GeoB 1401. It was possible to determine a high resolution methane profile with a steep gradient into the methane-oxidation zone and, furthermore, a big number of ikaites in size of a fist were obtained.

On the southern prolongation of the cruise four more stations were taken on the isobath parallel transect of 1300 m with the southernmost station at about 13°S, gaining a connection to the northernmost station (GeoB 3713) of cruise M34/2. During the final part of the cruise, the length of the gravity cores returned to a usual length of about ten meters. From March 11, 1998, the transit to Libreville was interrupted by a few tasks that were left out on the way because of the narrow time scale during lander deployments. RV METEOR arrived savely the harbor of Libreville in the morning of March 15, 1998.

The final result of the expedition was very impressive. Overall, 19 stations were taken with 25 successful deployments of the gravity corer (5 x GC12, 15 x GC18, 5 x GC24), partly with lengths of more than 20 m. The multicorer was successfully deployed 35 times combined with one deployment of the CTD on each station. The rosette sampler was employed for the Paleobiology group 16 times (down to water depths of 200 m) and additionally for the Marine Geology group on four stations (down to water depths of 2500, 2700, 2800, and 3000 m, respectively). The lander systems were each deployed 6 times and always returned as scheduled without major malfunction.

Summing up the results, the most optimistic expectations of the marine geologists, the paleobiologists, the biogeochemists, and the geochemists were exceeded. Meanwhile, the cores from the Niger-Fan and the Bight of Bonny (which are up to 20-22 m in length) have been described and a preliminary Menardii-Stratigraphy was established. The cores reveal an almost continuous sedimentation without intercalations of turbidites or erosion events, and a sedimentation rate of about 10 cm / 1000 yr was estimated. Concerning the early diagenetic processes in sediments this cruise continued a transect parallel to the West African coastline at a water depth of about 1300 m beginning at M34/2. This transect which is supported by some profiles across the continental slope reaches now a whole distance of about 4000 m from south of the Benguela-Upwelling area to the Niger-Fan and allows the analysis of regional variations of the intensity of early diagenetic processes.

During the whole cruise some problems occurred with the PARASOUND-System. Only the paper record worked like usual, whereas the screen display and the data record on the PARADIGMA-System was often interrupted. Generally, this did not cause any problems for the station search, but for the data management and recording. Since March 13, 1998 – two days before the end of the cruise - the electronic engineers obviously succeeded to clear the trouble. The HYDROSWEEP-System worked perfectly like usual and also provided decisive support on the choice of the stations.

4 Preliminary Results

4.1 Underway Geophysics

(K. Däumler, J. Funk, C. Hilgenfeldt, H. v. Lom-Keil and Shipboard Scientific Party)

4.1.1 Introduction

During METEOR Cruise M 41/1 the shipboard acoustical systems HYDROSWEEP and PARASOUND were used on a 24-hour schedule to record continuous high resolution bathymetric and sediment echosounding profiles. The PARASOUND seismograms were digitized and stored with the digital acquisition system PARADIGMA (SPIEß, 1993).

The underway geophysical program along several profiles on the Niger and Congo sedimentary fan area and southward on the Angola continental margin serves the long term research objectives of the DFG Sonderforschungsbereich 261. The recorded digital data provide valuable information for surveying suitable coring stations in different sedimentation environments and for studies of sedimentary structures and processes.

4.1.2 Recording Parameters and Preliminary Data Processing.

The shipboard sediment echosounder PARASOUND and the multibeam echosounder HYDROSWEEP were operated by the scientific crew on a 24-hour watch except on transit sections across the territorial waters of Nigeria, Equatorial Guinea and Republic of Congo. Both systems worked without technical problems. Due to the calm weather conditions the data coverage of the HYDROSWEEP system was quite good on all tracks.

The multibeam sounder HYDROSWEEP provides an image of the sea floor topography with a swath width of twice the water depth and, in combination with the sediment echosounder PARASOUND, serves as a very efficient tool to select appropriate coring sites based on the precise knowledge of the local topography and morphology, slope angles, and sediment instabilities.

The sediment echosounder data were routinely registered as paper recordings with the DESO 25 device and simultaneously recorded digitally by means of the PARADIGMA 4.01 system (SPIEß, 1993). The data were directly stored on 6250 bpi, 1/2" magnetic tapes using a modified 16-bit version of the standard, industry-compatible SEGY-format.

The seismograms were sampled at 40 kHz with a typical recording length of 266 ms for a depth window of ~200 m. The source signal was a non-bandlimited sinusoidal wavelet of 4 kHz dominant frequency with a duration of 2 periods.

A pre-processed colored seismic section was produced online with an HP DeskJet printer, using a vertical depth scale of several hundred meters to eliminate most of the jumps in the reception window depth. To suppress low frequency acoustic and high frequency electronic noise the seismograms were filtered with a wide bandpass filter from 2.0 to 6.0 kHz. In addition, the data were normalized to a constant value much smaller than the maximum amplitude which amplifies in particular deeper and weaker reflections. These online plots give a first impression of variations in sea floor morphology, depositional patterns and sedimentary structures along the ship track.

Due to minor technical problems with an electronic filter module on the first part of the cruise the quality of the digitally recorded data was not as good as usual, but may be enhanced by further data processing.

To study the influence of frequency and length of source signal, the signal parameters were varied systematically at core sampling stations ('Source signal test'). The signal frequency was repeatedly increased from 2.5-5.5 kHz in 0.5 kHz steps, while the pulse length was set to 1, 2 and 4. Each combination was recorded for 2 minutes to enable seismogram stacking. To analyze interference phenomena and to enhance resolution for direct comparison with core measurements of sediment physical properties (p-wave velocity and wet bulk density), seismograms with different frequencies will later be studied more in detail.

4.1.3 Shipboard Results

During cruise M 41/1 mainly a narrow north to south oriented corridor in the eastern equatorial Atlantic was studied by core sampling and echosounder survey. The area extends from 3° N, 6° E to 13° S 13° E and follows approximately the 1300 m isobath, hence continuing the survey performed on cruise M 34/2 to the north. Three short profiles from east to west were recorded at 0° 40' S, 3° S and 6° S, ranging in water depth from 1300 m down to 3000-4000 m. Additionally, a short HYDROSWEEP survey in the vicinity of site 4901 was carried out. The distances between these survey profiles were adjusted to water depth and HYDROSWEEP swath width to receive optimum coverage of the sea floor.

The following figures show typical examples of digital PARASOUND sections for different sedimentary environments visited during the cruise. In order to image adequately the observed features, the digital seismogram sections were prepared for printing by translating the amplitudes of individual traces into gray scales on a 600 dpi laser printer. The depth axis is given in meters, based on a constant water sound velocity of 1500 m/s. The distance scale is given in kilometers.

Figure 2 shows a map of the ship's track of Meteor cruise M 41/1. The locations of the figures discussed are emphasized by gray shaded ellipses and annotated accordingly.

The first example (Figure 3) was recorded in the Guinea Basin on transit to the first coring site of the cruise. It extends from 1°16' N 3°28' W to 1°16' N 3°24' W at a water depth of 5100 m. A signal penetration of up to 50 m is achieved. The basin is characterized by parallel, well stratified sedimentation. Approximately 10 mbsf lateral amplitude variations can be observed, indicating locale changes in sediment properties.

While approaching the first coring site on the distal Niger sedimentation fan, the sedimentation patterns become more complicated. The example shown in Figure 4 was recorded from 1°56' N 3°27' E to 1°41' N 4°25' E at 4200 m water depth.

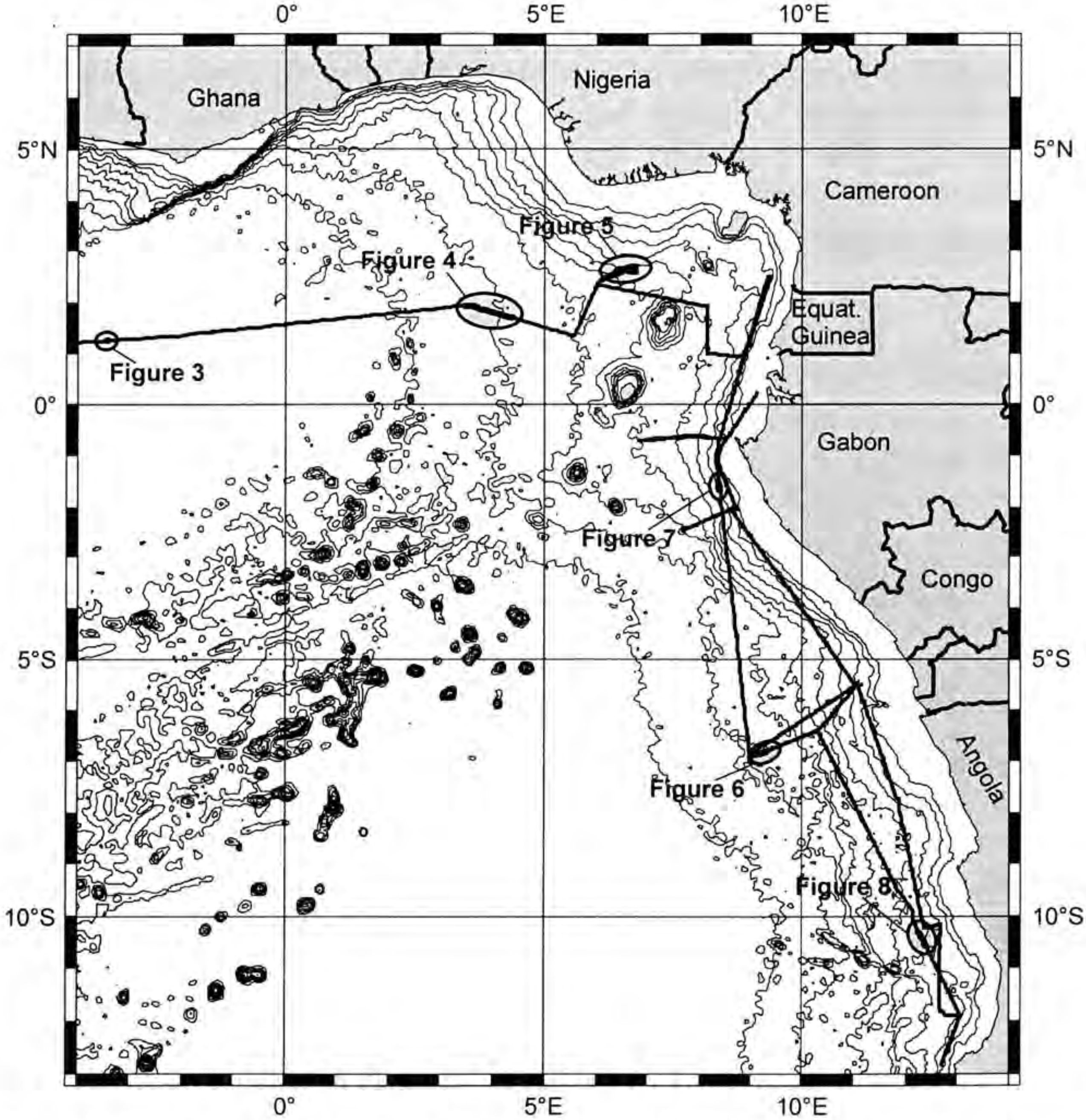

Figure 2: Cruise track of RV METEOR on the journey M41/1. The presented examples (Figures 3-8) are denoted by gray ellipses and named accordingly.

Several small channels of up to 50 m depth cut the sea floor. The bottom of the channels is characterized by high amplitudes and very low signal penetration, whereas the signal penetration in between the channels reaches 60 to 70 m. Small mudwave structures can be recognized on the flanks of the channels, as is typical for many channel-levee systems.

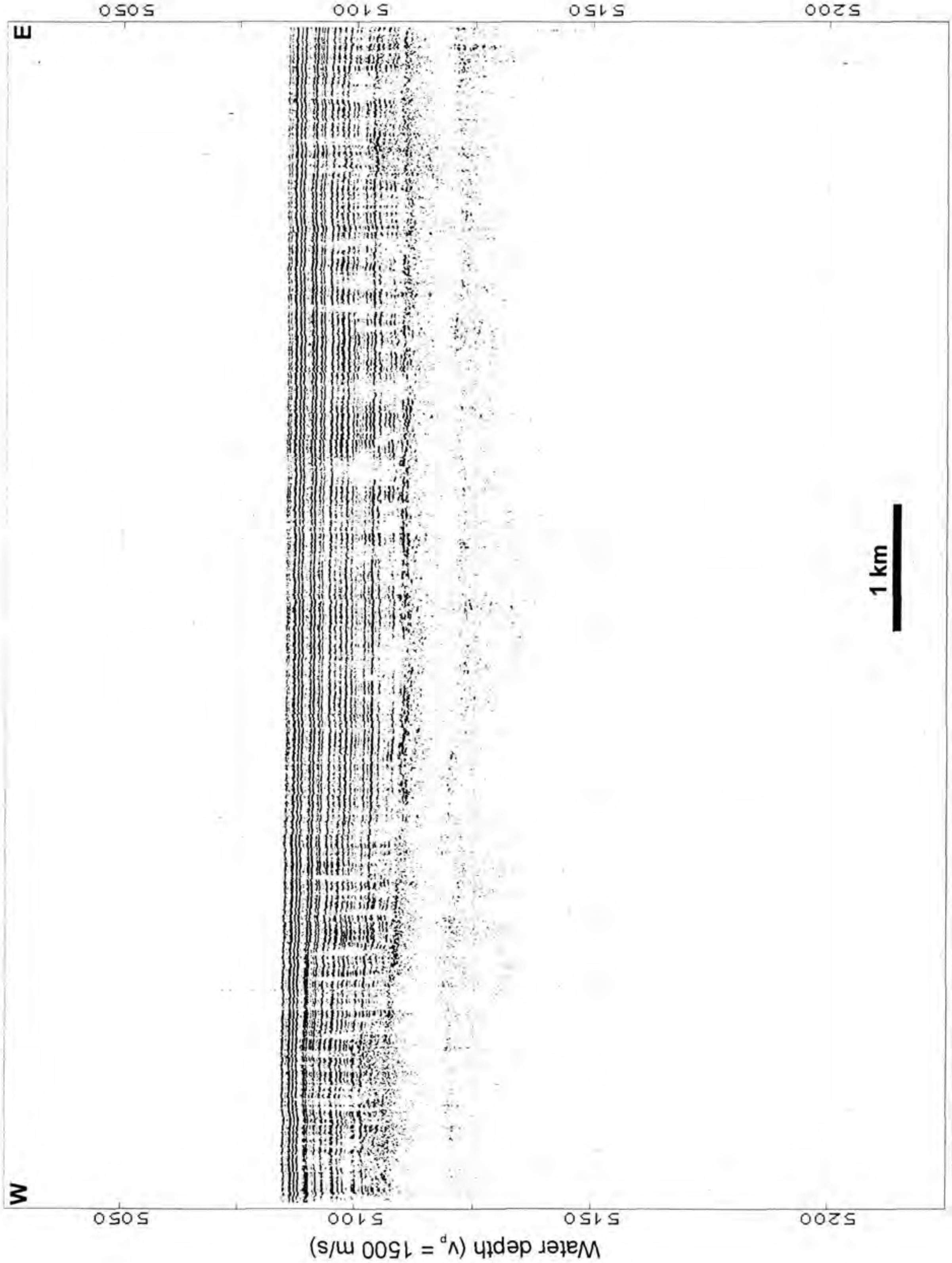

Figure 3: PARASOUND-Section in the Guinea Basin at a water depth of 5100 m

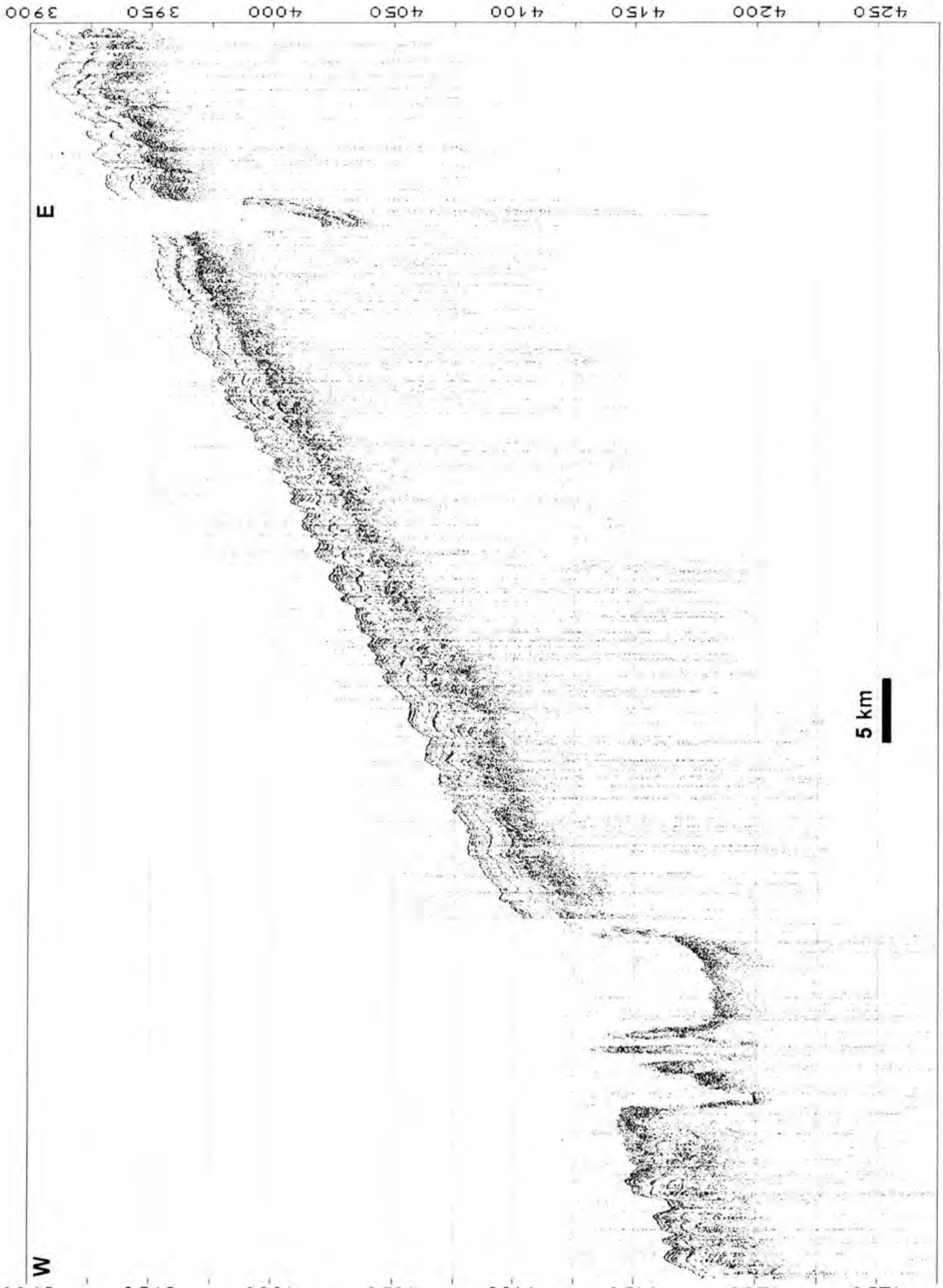

Figure 4: PARASOUND-Section on the distal Niger sedimentation fan, showing channel-levee structures

Figure 5 shows a map of the sea floor topography in the vicinity of site 4901, as it could be obtained by a detailed bathymetric survey with the HYDROSWEEP swath sounder. The map covers an area starting at 2°45' N 6°38' E in the north west to 2°33' N 6°52' E in the south east. The coring site is located on a small terrace at 2150 m water depth.

The profile presented in Figure 6 was recorded on the distal Congo fan at a water depth of 3800 m. It extends from 6°47' S 9°21' E to 6°52' S 9°10' E in an east west direction perpendicular to the slope. The wavelike structures visible on the eastern part of the profile have been observed on several profiles on the Congo fan on Cruise Sonne SO 86 as well and may be formed by slight downslope movement of highly fluidized sediment blocks. The well stratified layers at the central part of the profile are interrupted in 10 mbsf by a high amplitude structure that cuts through several of the overlaying sediment layers. On top of this structure, lateral amplitude variations can be recognized. The type and origin of the structure is not yet clear.

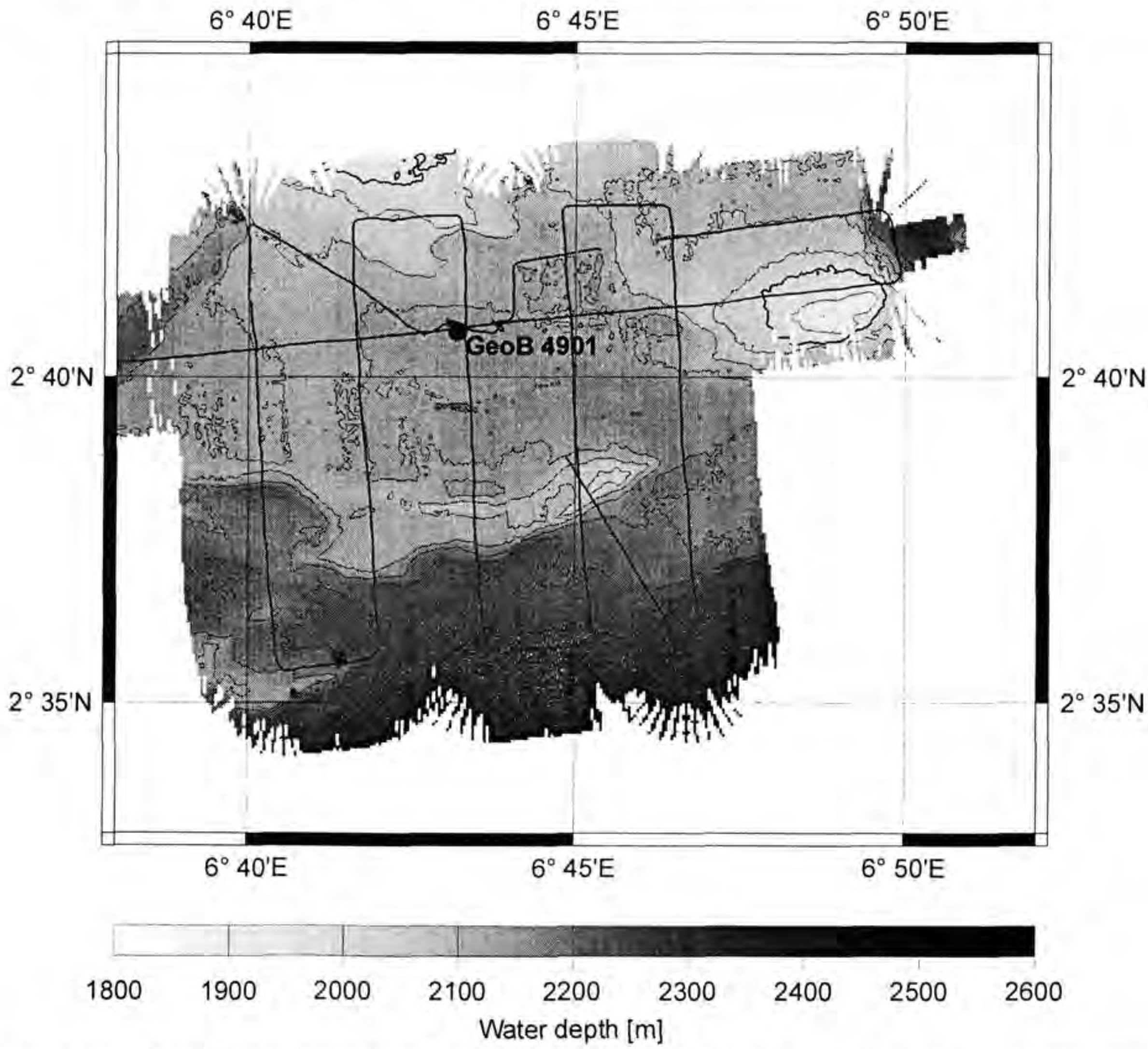

Figure 5: Sea floor topography at site GeoB 4901 as acquired from HYDROSWEEP survey.

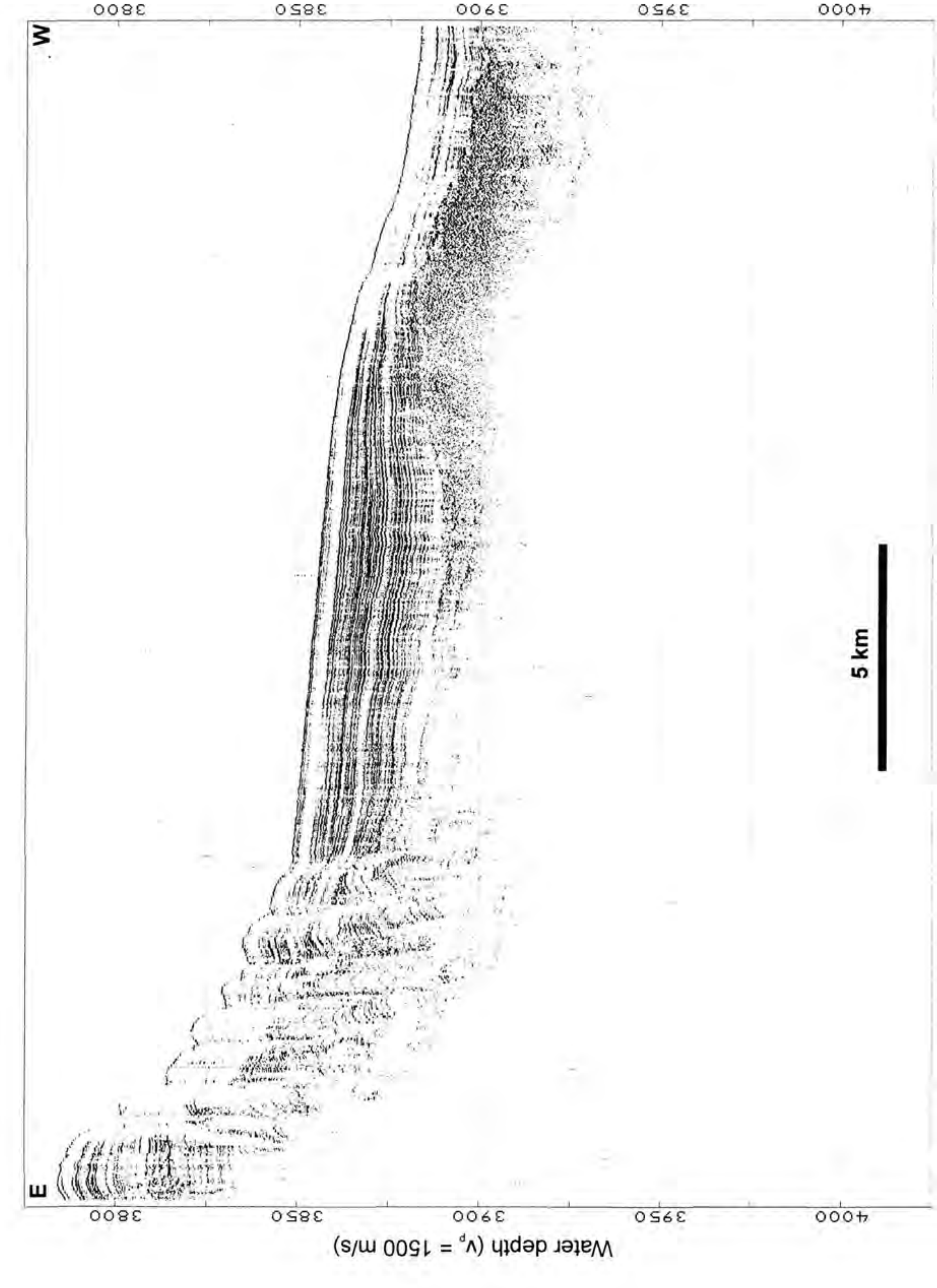

Figure 6: PARASOUND-section on the distal Congo fan

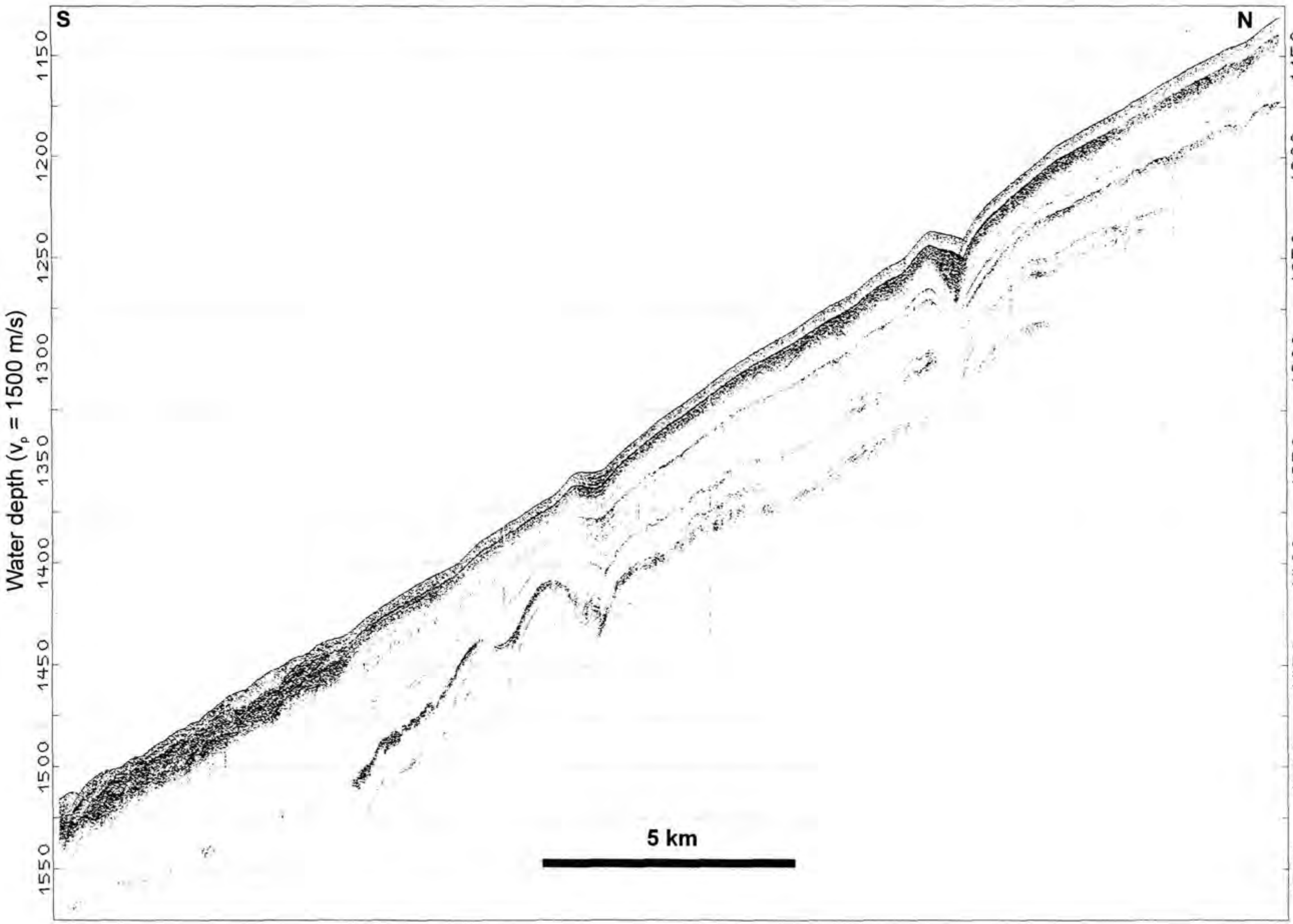

Figure 7: PARASOUND-Section on the Gabon continental slope showing several high amplitude reflectors

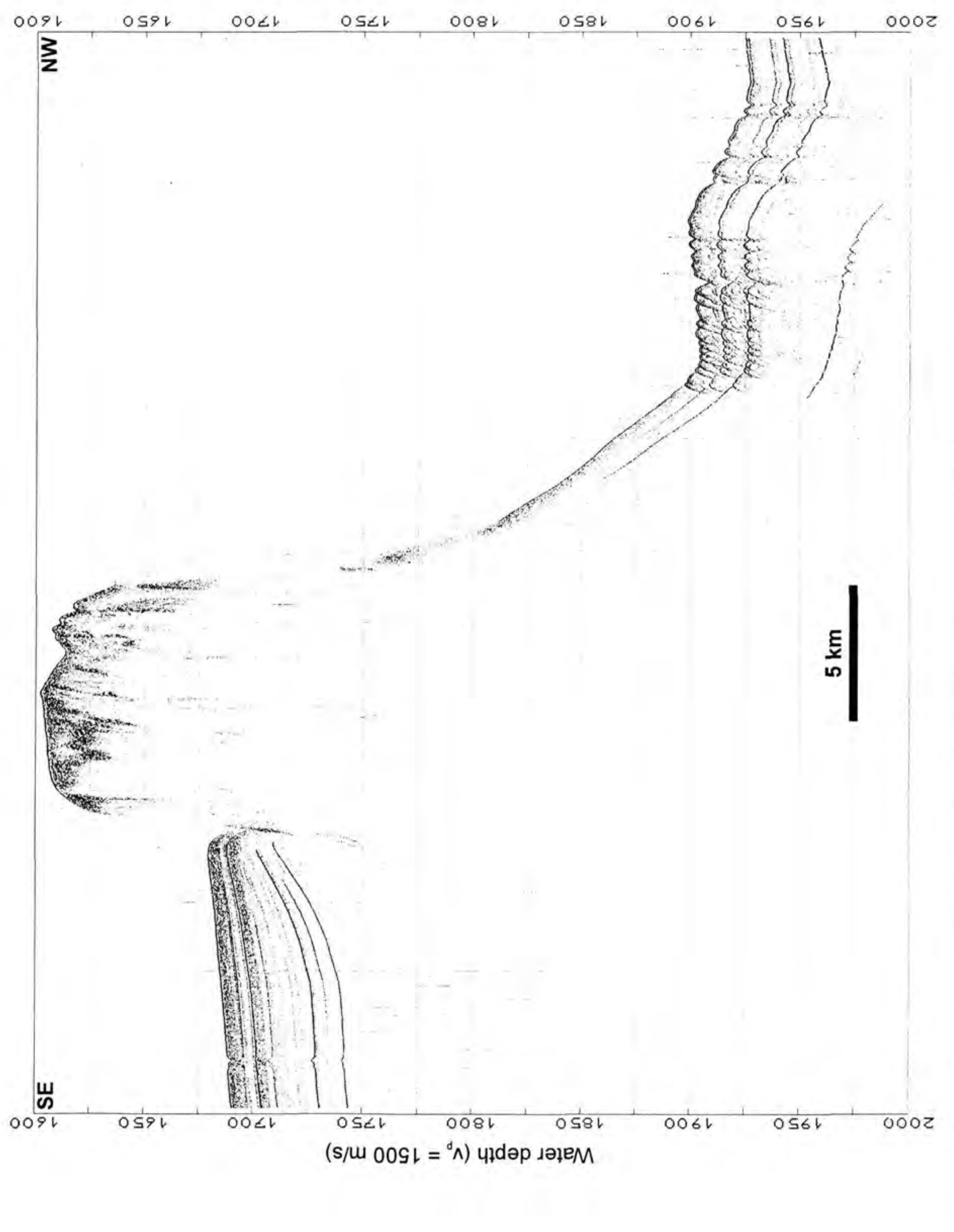

Figure 8: PARASOUND-section on the continental slope off Angola

Figure 7 shows a section recorded on the 1300 m isobath at 1°43' S 8°25' E on the Gabon continental slope. The sediments are stratified with several high amplitude reflectors intermitted by nearly transparent layers. The signal penetration reaches up to 70 m. In the southern part of the profile a layer of 20 m thickness with high amplitudes is embedded. Two small and partly buried incisions can be observed.

The sedimentation environment in the southern part of the surveyed corridor off Angola is influenced by salt tectonic induced topography. Figure 8 shows a profile recorded in south north direction parallel to the continental margin from 10°35' S 12°24' E to 10°17' S 12°15' E. The water depth is ranging from 1600 m to 1900 m. An 80 m high obstacle with steep flanks disturbs the otherwise well stratified sedimentation. The sediment layers are thinning in the vicinity of the obstacle and northward some ripple structures can be noticed. These ripples may be formed by local current effects or as a result of sediment movement

4.2 Sediment Sampling

(M 41/1: A. Adegbie, K. Dehning, V. Diekamp, J. Klump, G. Lavik, F. Schewe, R. Schneider, J.-B. Stuut, T. Wagner)
(M 41/2: S. Drachenberg, O. Esper, S. Gerhardt, M. Segl and N. Zatloukal)

Sediments were recovered at 19 stations during cruise M 41/1, and at 6 stations during cruise M 41/2, using a multicorer and by gravity coring. The multicorer was used to obtain undisturbed sediment surfaces and the overlying bottom water. To recover deeper sediment sequences a gravity corer with different pipe lengths and a weight of 1.5 tons on top was used at 18 stations. Core recovery was mostly very good, the longest gravity core measuring 22.66 m in length.

4.2.1. Sediment Surface Sampling with Multicorer

The main tool for the recovery of undisturbed sediment surfaces and the overlying bottom water was the multicorer equipped with eight tubes of 10 cm and four smaller tubes with 5 cm diameter. The multicorer was used at 5 stations. The core recovery was generally very good, and usually all tubes were filled.

At each multicorer station, the overlying bottom water was sampled for stable isotope measurements at the stable isotope lab in Bremen. From each multicorer tubes were usually sampled as follows:

- **one large tube** is cut in 1 cm slices for analysis of C_{org}. The slices are frozen immediately after cutting at -20°C.. On these samples the content of C_{org} will be determined. On some of the samples stable carbon and nitrogen isotopes, alkenones and the isotopic composition of the alkenones will be measured.

- **two large tubes** are cut into 1cm slices and stained with a solution of 1g of rose bengal in 1 l ethanol before storing away at 4°C. On these samples the planktonic foraminiferal assemblage will be investigated. Benthic foraminifera, which still contain organic material are colored red by the rose bengal and will be used to determine the bioturbation depth.
- **one large tube** is cut in slices of 1 cm which are immediately stored at -20°C in the deep-freeze room. At Bremen University further investigations, e.g. organic microscopy, will be carried out.
- **one large tube** is cut into 1 cm slices and deep frozen at -20°C. At University of Bremen these samples will be wet-sieved (split into sand-, silt- and clay-sized particles), dried and de-carbonated with hydrochloric acid. Afterwards, the settling velocity of each non-biogenic sample will be measured with a silt-settling-tube and a sedigraph (particle-size-analyzer), in order to evaluate the grain size distribution and the mean particle sizes. These sediment parameters, in combination with the hydrosphere values (salinity, pressure, temperature etc.) will provide a better understanding of regional circulation patterns and local marine current systems.
- **one large tube** is cut into 1cm slices and stored at 4°C. On these samples the assemblage of calcareous and organic dinoflagellates will be studied.
- **one large tube** is frozen completely as archive.
- **one large tube** is frozen as archive after removing of the surface for the analysis of radiolarian- and diatom- assemblages.
- **three small tubes** are frozen as archive.
- **one small tube** is frozen for later investigation of physical properties.

4.2.2. Sediment Sampling with Gravity Cores

Twenty-three gravity cores with a total length of 296 m of sediments were recovered from 19 stations during cruise M 41/1. The core recovery varied between 0.69 m and 22.66 m representing more than 200,000 years based on results obtained from preliminary stratigraphy.

Six cores (GeoB 4901-8, 4902-3, 4905-4, 4909-5, 4909-6, and 4911-3) were opened, described and sampled on board. After splitting, the archive section was described following the ODP nomenclature and sediment color was determined by comparison with the MUNSELL® soil color charts. A hand-held photo-spectrometer was used to record the color of the fresh sediments at 5 cm sampling intervals (see Section 4.3.1). All cores were photographed together with a color reference card.

Table 1: Multicorer Sampling (M 41/1)

GeoB No.	Length (cm)	Foraminifera	Dinoflagellates	Coccolithophorids	Organic Carbon	Geology	Organ. Petrography	Geochemistry Porewaters	Sulfate	O_2-Consumption	Benthic Forams	Magnetic Properties	Surface Samples: Pollen	Clays	Diatoms	Radiolaria
4901-5	36		1 lg(S)	1 lg(S)	1 lg(S,I)		1 lg(S)	1 lg, 1 sm	2 lg, 2 sm	1 lg		1 sm(S)				
4901-6	31	2 lg(S)			1 lg(A)	1 lg(A,I)	1 lg(A)		1 sm		2 lg(S)		1 lg	1 sm	1 sm	1sm
4902-4	35	2 lg(S)	1 lg(S)	1 lg(S)	2 lg(S,A,I)	1 lg(A)	1 lg(S), 1 sm(A)					1 sm(S)	1 sm		←- 1 sm -→	
4903-2	36		1 lg(S)	1 lg(S)	2 lg(S,A)	1 lg(A,I)	1 lg(S)	1 lg, 1 sm	2 sm	1 lg		1 sm(S)				
4903-3	37	2 lg(S)				1 sm(A)	1 lg(A), 1 sm(A)		2 lg, 1 sm				1 lg	1 sm	1 lg	1 lg
4904-6	53	2 lg(S)	1 lg(S)		1 lg(A,I)	1 lg(A)	1 lg (S)	1 lg,1sm	2 sm			1 sm(S)	1 lg			
4904-7	54			1 lg(S)	1 lg(S)		1 sm(A)		2 lg, 1 sm	1 lg	2 lg(S)			1 sm	1 sm	1 lg
4905-2	60		1 lg	1 lg(S)	1 lg (S,A))		1 lg(S)		2 sm			1 sm(S)	1 lg	1 sm		
4905-3	56	2 lg(S, only $\delta^{18}O$)				1 lg(A)	1 sm(A)	1 lg, 1 sm	2 lg, 1 sm	1 lg					←- 1 sm -→	
4906-4	37				2 lg(S,A,,I)		2 lg (S,A)	1 lg, 1 sm	2 lg, 2 sm	1 lg		1 sm(S)				
4906-5	35	2 lg(S)	1 lg(S)	1 lg(S)		1 lg(A)			1 sm		2 lg(S)		1 lg	1 sm	1 sm	1 sm
4907-2	38	2 lg(S)	1 lg(S)	1 lg(S)	2 lg(S,A,I)	1 sm(A)	1 lg(S)	1 lg, 1 sm				1 sm(S)		1 sm		
4908-3	28	2 lg(S)	1 lg(S)		2 lg(S,A,I)			1 lg, 1 sm	2 lg, 2 sm			1 sm(S)				
4908-4	20			1 lg(S)	1 sm(A)	1 lg(A)	2 lg(S,A)		1 sm	2 lg			1 lg	1 sm	1 sm	1 lg
4909-3	30		1 lg(S)		2 lg(S,A)		1 lg (S,I)	1 lg, 1 sm	2 lg, 2 sm	1 lg		1 sm(S)				
4909-4	30	2 lg(S)		1 lg(S)		1 lg(A)	1 sm(A)		1 sm		2 lg(S)		1 lg	1 sm	1 sm	1 lg
4910-4	37	2 lg(S)	1 lg(S)	1 lg(S)	2 lg(S,A)	1 sm(A)	1 lg(S)					1 sm(S)	1 lg	1 sm	←- 1 sm -→	
4911-1	39		1 lg(S,I)	1 lg(S)			1 lg(S), 2 sm(A)						1 lg	1 sm	←- 1 sm -→	
4911-2	39	2 lg(S)			2 lg(S,A)	3 sm(A)						1 sm(S)				
4912-3	32		1 lg(S)	1 lg(S)	2 lg(S,A)		1 lg(S,I)	1 lg, 1 sm	2 sm	1 lg		1 sm(S)	1 lg			
4912-4	34	2 lg(S)			1 sm(A)	1 lg, 1 sm(A)	1 lg(A)		2 lg, 1 sm					1 sm	1 lg	1 lg
4913-3	45		1 lg(S)	1 lg(S)	2 lg(S,A, I)			1 lg, 1sm	2 lg, 2 sm	1 lg		1 sm(S)				
4913-4	45	2 lg(S)				1 lg(A)	2 lg(S,A)		1 sm		2 lg(S)		1 lg	1 sm	1 sm	1 sm
4914-4	45		1 lg(S)			1 lg(A)	2 lg(S,A,I)	1 lg, 1 sm	2 lg, 2 sm			1 sm(S)				
4914-5	44	2 lg(S)		1 lg(S)	2 lg(S,A)		1 lg(A)		1 sm	1 lg			1 lg	1 sm	1 sm	1sm
4915-2	42		1 lg(S)	1 lg(S)	2 lg(S,A,I)			1 lg, 1 sm	2 lg, 2 sm	1 lg		1 sm(S)				
4915-3	42	2 lg(S)				3 lg(A)	2 lg(S,A)		1 sm				1 lg	1 sm	1 sm	1 sm
4916-3	37		1 lg(S)	1 lg(S,I)	2 lg(S,A)			1 lg, 1 sm	2 lg, 2 sm	1 lg		1 sm(S)				
4916-4	37	2 lg(S)				1 lg, 1 sm(A)	2 lg(S,A)		1 sm				1 lg	1 sm	1 sm	1 lg
4917-4	37		1 lg(S)	1 lg(S)	2 lg(S,A,I)			1 lg, 1 sm	2 lg, 2 sm	1 lg		1 sm(S)				
4917-5	33	2 lg(S)				1 lg(A)	2 lg(S,A)		1 sm		2 lg(S)		1 lg	1 sm	1 sm	1 sm
4918-3	39		1 lg(S)	1 lg(S)	2 lg(S,A)	1 lg(A), (no H_2O isotope samples)			2 lg, 2 sm	1 lg		1 sm			1 sm	
4918-4	35	2 lg(S)			1 lg(A)	1 lg, 1 sm(A)	2 lg(S,A)	1 lg	1 sm				1 lg	1 sm		1 sm
4919-1	45	1 lg(S)	1 lg(S)		1 lg(S)	O_2 tube(A)	1 lg(S)	1 lg	2 lg, 3 sm	1 lg		1 sm				

Codes: lg - large tube, sm - small tube, (A) - Archives frozen, (I) - Isotope samples of superimposed water, (S) - 1 cm slices,

Table 2: Station list M 41/1

GeoB No.	Date 1998	Equipment	Time Seafloor (UTC)	Location Latitude	Location Longitude	Water Depth (m)	Core Length (cm)	Remarks
EASTERN NIGER FAN								
4901-1	25.02.	Elinor	20:01	02°40.8´N	06°43.8´E	2186		Launched.
	26.02.		16:53	02°40.8´N	06°43.9´E			Recovered.
4901-2	25.02.	Profilur	20:08	02°40.8´N	06°43.9´E	2184		Launched.
	26.02.		17:45	02°40.8´N	06°44.0´E			Recovered.
4901-3		ROS18	20:32	02°40.9´N	06°43.8´E	2185		To 200m WD, 18x10L.
4901-4		MUC/CTD	21:43	02°40.8´N	06°43.2´E	2186		Not properly released.
4901-5		MUC	23:28	02°40.9´N	06°43.2´E	2177	36	8 big + 4 small tubes, olive to dark gray hemipelagic mud.
4901-6	26.02.	MUC	01:05	02°40.7´N	06°43.2´E	2188	36	8 big + 4 small tubes.
4901-7		SL18	02:34	02°40.7´N	06°43.3´E	2188	---	Overpenetration, uppermost sediments lost, not archived.
4901-8		SL24	05:58	02°40.7´N	06°43.2´E	2184	2028	CC: dark gray hemipelagic mud.
4901-9		SL24	07:57	02°40.8´N	06°43.1´E	2181	1816	-- " --, Geochemistry.
08:30 - 16:00 HYDROSWEEP Survey until beginning of ELINOR and PROFILUR recovery at 17:00.								
4902-1	27.02.	ROS18	00:05	02°21.2´N	06°01.8´E	3222		To 2500m WD, 18x10L, for water $\delta^{18}O$ and $\delta^{13}C$, and coccolithophorids only.
4902-2		SL18	02:11	02°21.3´N	06°01.8´E	3221	----	Overpenetration, uppermost sediment lost, not archived
4902-3		SL24	04:27	02°21.3´N	06°01.8´E	3223	2264	CC: dark gray hemipelagic mud.
4902-4		MUC/CTD	07:17	02°21.2´N	06°01.8´E	3221	35	8 big + 4 small tubes; CTD: no fluorescence and oxygen data.
NE OFF SAN THOME								
4903-1	27.02.	ROS18	19:50	01°55.0´N	08°10.1´E	2384		To 200m WD, 18x10L.
4903-2		MUC/CTD	20:55	01°55.0´N	08°10.2´E	2385	36	8 big + 4 small tubes.
4903-3		MUC	22:33	01°55.0´N	08°10.2´E	2384	36	8 big + 4 small tubes.
4903-4	28.02.	SL24	00:20	01°54.9´N	08°10.1´E	2385	230	Corer broken (Banana), no CC, 2. segment disturbed.
OFF NORTHERN GABON (Bight of Biafra)								
4904-1	28.02.	ELINOR	11:04	00°57.0´N	08°48.0´E	1208		1. Time launched.
			16:15	00°56.6´N	08°52.0´E			1. Time recovered for program reset.
			17:52	00°56.6´N	08°52.8´E			2. Time launched
	01.03.		16:35	00°56.6´N	08°52.8´E			2. Time recovered.
4904-2	28.02.	PROFILUR	11:20	00°56.6´N	08°52.8´E	1209		Launched.
	01.03.		17:14	00°56.7´N	08°52.8´E			Recovered.
4904-3	28.02.	ROS18	11:36	00°57.7´N	08°52.8´E	1344		To 200m WD, 18x10L.
4904-4		SL12	12:13	00°57.6´N	08°52.8´E	1339	1148	CC: dark gray, hemipelagic mud.
4904-5		SL18	13:40	00°57.6´N	08°52.8´E	1337	1030	-- " ---, Geochemistry.
4904-6		MUC/CTD	15:17	00°57.7´N	08°52.8´E	1349	48-52	8 big and 4 small tubes.
4904-7		MUC	16:52	00°57.6´N	08°52.8´E	1341	48-52	8 big and 4 small tubes.
OFF CAMEROON								
4905-1	01.03.	ROS18	03:16	02°30.1´N	09°23.5´E	1325		To 200m WD, 18x10L.
4905-2		MUC/CTD	04:04	02°30.0´N	09°23.4´E	1329	55-60	6 big and 4 small tubes, 2 big tubes with sediment over the top.
4905-3		MUC	05:30	02°30.1´N	09°23.4´E	1326	54-56	7 big and 4 small tubes, 1 empty.
4905-4		SL18	06:48	02°30.0´N	09°23.4´E	1328	1218	CC: dark olive hemipelagic mud.

Table 2: continued

GeoB No.	Date 1998	Equipment	Time Seafloor (UTC)	Location Latitude	Location Longitude	Water Depth (m)	Core Length (cm)	Remarks
OFF GABON (Profile 1)								
4906-1	02.03.	ELINOR	02:45	00°41.2´S	08°22.9´E	1249		Launched.
	03.03.		16:00	00°41.1´S	08°22.7´E			Recovered.
4906-2	02.03.	ROS18	03:10	00°41.4´S	08°22.5´E	1278		To 200m WD, 18x10L.
4906-3		SL18	03:48	00°41.4´S	08°22.6´E	1274	1236	CC: Olive, hemipelagic mud.
4906-4		MUC/CTD	05:35	00°41.4´S	08°22.7´E	1272	35-37	8 big and 4 small tubes.
4906-5		MUC	06:34	00°41.4´S	08°22.6´E	1277	34-35	8 big and 4 small tubes.
4906-6	02.03.	PROFILUR	07:15	00°41.2´S	08°22.9´E	1252		Launched.
	03.03		14:49	00°41.2´S	08°22.9´E			Recovered.
4907-1	02.03.	ROS18	09:55	00°37.5´S	08°01.8´E	2057		To 200m WD, 17x10L, one 10ml bottle empty.
4907-2		MUC/CTD	10:58	00°37.5´S	08°01.6´E	2066	38-40	8 big and 4 small tubes.
4907-3		SL18	12:28	00°37.5´S	08°01.6´E	2066	1685	CC: olive hemipelagic mud.
4908-1	02.03.	ROS18	19:36	00°42.6´S	06°50.3´E	3029	18x10L	To 200m WD, 18x10L.
4908-2		SL18	20:36	00°42.7´S	06°50.2´E	3029	1765	Upper 40 cm of surface sediment in the weight set, CC: olive hemipelagic mud.
4908-3		MUC/CTD	23:21	00°42.8´S	06°50.3´E	3028	26-28	8 big and 4 small tubes.
4908-4	03.03.	MUC	01:23	00°42.7´S	06°50.3´E	3028	18-20	8 big and 4 small tubes.
4908-5		ROS18	03:40	00°43.8´S	06°50.0´E	3029		To 2700 m WD, 18x10L.
OFF GABON (Profile 2)								
4909-1	04.03.	ELINOR	00:38	02°04.4´S	08°37.6´E	1308		Launched.
	05.03.		11:35	02°04.4´S	08°37.7´E			Recovered.
4909-2	04.03.	ROS18	00:50	02°03.2´S	08°37.5´E	1303		To 200m WD, 18x10L.
4909-3		MUC/CTD	01:46	02°04.1´S	08°37.5´E	1305	28-30	8 big and 4 small tubes.
4909-4		MUC	02:51	02°04.2´S	08°37.5´E	1313	28-30	8 big and 4 small tubes.
4909-5		SL18	03:57	02°04.1´S	08°37.5´E	1308	819	CC: Carbonate ooze, olive-gray
4909-6		SL18	05:11	02°04.1´S	08°37.6´E	1308	1068?	-- " --, Geochemistry.
4909-7		PROFILUR	05:47	02°04.4´S	08°37.5´E	1317		Launched.
	05.03.		10:38	02°04.3´S	08°37.8´E			Recovered.
4910-1	04.03.	ROS18	14:40	02°18.9´S	08°04.1´E	3000		To 200m WD, 18x10L.
4910-2		SL18	15:34	02°19.0´S	08°04.1´E	3002	985	CC: olive hemipelagic mud.
4910-3		MUC/CTD	17:50	02°19.0´S	08°04.0´E	3004	----	Not released, tubes empty.
4910-4		MUC	19:47	02°19.0´S	08°04.1´E	3003	36-37	8 big and 4 small tubes.
4910-5		ROS	22:06	02°19.9´S	08°04.1´E	3005		To 2800m WD, 18x10L.
4911-1	05.03.	MUC	02:45	02°08.2´S	08°28.7´E	1950	39	4 big and 4 small tubes, 4 big tubes not released.
4911-2		MUC	04:15	02°08.3´S	08°28.7´E	1950	39	4 big and 4 small tubes, 4 big tubes not released.
4911-3		SL18	05:38	02°08.2´S	08°28.6´E	1950	970	CC: olive hemipelagic mud.
OFF SOUTHERN GABON								
4912-1	05.03.	ROS18	22:21	03°43.9´S	09°47.1´E	1306		To 200m WD, 18x10L.
4912-2		SL18	22:58	03°43.9´S	09°47.0´E	1312	1153	CC: olive hemipelagic mud.
4912-3	06.03.	MUC/CTD	00:30	03°43.8´S	09°47.1´E	1298	31-32	8 big and 4 small tubes.
4912-4		MUC	01:31	03°43.8´S	09°47.1´E	1298	31-32	8 big and 4 small tubes
NORTHERN CONGO FAN								
4913-1	06.03.	ELINOR	14:50	05°30.0´S	11°04.4´E	1297		Launched.
	08.03.		10:48	05°30.0´S	11°04.3´E			Recovered.
4913-2	06.03.	ROS18	15:03	05°29.9´S	11°04.4´E	1299		To 200m WD, 18x10L.
4913-3		MUC/CTD	15:51	05°30.2´S	11°04.3´E	1296	43-45	8 big and 4 small tubes.
4913-4		MUC	17:50	05°30.2´S	11°04.3´E	1300	43-45	8 big and 4 small tubes.
4913-5		SL18	17:58	05°30.2´S	11°04.3´E	1309	902	Geochemistry.
4913-6		SL18	19:07	05°30.1´S	11°04.4´E	1304	1090	CC: olive hemipelagic mud.
4913-7		PROFILUR	19:57	05°29.9´S	11°04.5´E	1303		Launched.
	08.03.		10:45	05°30.1´S	11°04.2´E			Recovered.

Table 2: continued

GeoB No.	Date 1998	Equipment	Time Seafloor (UTC)	Location Latitude	Location Longitude	Water Depth (m)	Core Length (cm)	Remarks
SOUTHERN CONGO FAN (GeoB 1009, 1401)								
4914-1	07.03.	ROS18	09:40	06°56.0´S	08°59.9´E	3979		To 200 m WD, 18x10L.
4914-2		SL18	10:47	06°56.0´S	09°00.0´E	3972	>1800	Overpenetration, surface sediment in the weight set, archived for ikaites.
4914-3		SL24	13:33	06°56.0´S	09°00.0´E	3977	2175	Geochemistry, ikaites, CC: olive hemipelagic mud, plant debris, mica.
4914-4		MUC/CTD	16:32	06°56.0´S	09°00.0´E	3971	43-45	7 big and 4 small tubes, 1 without surface sediment.
4914-5		MUC	18:56	06°56.0´S	09°00.0´E	3973	42-44	8 big and 4 small tubes.
OFF ANGOLA								
4915-1	08.03.	ROS18	23:45	07°45.0´S	11°52.4´E	1306		To 200m WD, 18x10L.
4915-2	09.03.	MUC/CTD	00:29	07°45.0´S	11°52.4´E	1306	41-42	8 big and 4 small tubes.
4915-3		MUC	01:31	07°45.0´S	11°52.4´E	1305	40-42	8 big and 4 small tubes.
4915-4		SL18	02:33	07°45.0´S	11°52.4´E	1302	846	CC: olive hemipelagic mud.
4916-1	09.03.	ROS18	20:04	10°10.1´S	12°41.1´E	1300		To 200m WD, 18x10L.
4916-2		SL18	20:38	10°10.3´S	12°41.2´E	1298	69	No penetration, Corer broken, no CC sample, mollusk remains in the CC, olive hemipelagic mud.
4916-3		MUC/CTD	23:12	10°10.4´S	12°41.2´E	1294	37-38	8 big and 4 small tubes.
4916-4	10.03.	MUC	00:16	10°10.2´S	12°41.2´E	1300	36-37	8 big and 4 small tubes, surface sediment lost in 1 big tube.
4917-1	10.03.	ELINOR	12:06	11°54.4´S	13°04.3´E	1301		Launched.
	11.03.		10:48	11°54.3´S	13°04.3´E			Recovered.
4917-2	10.03.	PROFILUR	12:14	11°54.4´S	13°04.4´E	1299		Launched.
	11.03.		10:07	11°54.2´S	13°04.3´E			Recovered.
4917-3	10.03.	ROS18	12:21	11°54.4´S	13°04.4´E	1298		To 200m WD, 18x10L.
4917-4		MUC/CTD	13:09	11°54.2´S	13°04.4´E	1300	36-37	8 big and 4 small tubes.
4917-5		MUC	14:12	11°54.2´S	13°04.4´E	1299	30-31	8 big and 4 small tubes.
4917-6		SL12	15:13	11°54.2´S	13°04.4´E	1299	1050	CC: olive carbonate mud. Geochemistry.
4917-7		SL12	16:20	11°54.1´S	13°04.4´E	1297	---	No sediment in the corer. Core catcher turned inside out.
4917-8	11.03.	SL12	09:04	11°54.2´S	13°04.4´E	1299	927	CC: Olive hemipelagic mud, sandy.
4918-1	10.03.	ROS18	22:40	12°50.4´S	12°41.7´E	1347		To 200m WD, 18x10L.
4918-2		SL12	23:22	12°50.4´S	12°41.8´E	1341	469	CC: Olive hemipelagic mud, sandy, mica, mollusks.
4918-3	11.03.	MUC/CTD	00:40	12°50.4´S	12°41.9´E	1337	35-35	8 big and 4 small tubes.
4918-4		MUC	01:49	12°50.4´S	12°41.8´E	1338	34-35	8 big and 4 small tubes.
4918-5		SL12	02:46	12°50.4´S	12°41.8´E	1339	869	CC: Olive hemipelagic mud, sandy.
4919-1	12.3.	MUC	20:52	6°23,9´S	10°18,2´E	3050	45	8 big and 4 small tubes.

Table 3: Station list M 41/2

GeoB No.	Date 1998	Equipment	Time bottom contact (UTC)	Location Latitude	Location Longitude	Water Depth (m)		Remarks
Guinea Basin								
5001-1	20.03.	CTD		02°02.3'S	01°09.1'E	4593		CTD data for calibration of HYDROSWEEP
5001-2		ROS		02°02.2'S	01°09.2 'E	4600		Samples at water depth 200m, 150,50,20,10
NW Ascencion Island								
5002-1	27.03.	MUC/CTD	10:15	08°08.6'S	14°32.5'W	2851		8 big, 4 small tubes filled, 27cm
5002-2		SL12	10:57	08°08.6'S	14°32.5'W	2851	—	Tube bent, no core recovery
5002-3		SL6	13:52	08°08.6'S	14°32.5'W	2849		5.60m core recovery
5002-4		ROS		08°08.8'S	14°32.0'W	2846		water samples from 200, 150, 90, 50, 20, 10m depth
NE Ascencion Island								
5003-1	27.03.	SL6	19:37	07°48.1'S	14°11.8'W	2884		no core recovery
Mid-Atlantic Ridge								
5004-1	01.04.	MUC/CTD	23:23	09°10.0'S	13°20.5'W	2791		no core recovery
5004-2	02.04.	MUC/CTD	01:23	09°10.0'S	13°20.4'W	2790		6 big, 4 small tubes filled, 10cm
5004-3		SL6	03:05	09°10.0'S	13°20.4'W	2789		Tube bent, core recovery 67cm
5005-1	03.04.	TD		09°43.7'S	12°49.7'W			Corals
5006-1	04.04.	MUC/CTD	18:27	09°45.6'S	12°22.1'W	3244		7 big, 4 small tubes filled 30cm, 1 big tube 10cm
5006-2		SL6	20:20	09°45.6'S	12°22.1'W	3244		core recovery 5.71m
5007-1	08.04.	MUC/CTD	20:42	12°23.6'S	13°56.3'W	3668		5 big, 3 small tubes filled to 8 - 10cm
5007-2		SL12	22:54	12°23.6'S	13°56.3'W	3668		core recovery 9.34m
5008-1	09.04.	ROS		12°55.8'S	15°41.1'W	3405		water samples from 200, 150, 100, 50, 20m
5008-2		SL12	12:18	12°55.8'S	15°41.1'W	3405		Tube bent, core recovery 3.73m
5008-3		MUC/CTD	14:40	12°55.8'S	15°41.1'W	3407		8 big and 4 small tubes, 20-24cm

ROS - Rosette water samples, 18 water bottles, 10 l
MUC/CTD - Multicorer with CTD attached 50 m above
SL6/12 - gravity corer with 6 and 12 m pipe length, respectively.
TD - Dredge

Five gravity cores were recovered from 6 stations during cruise M 41/2. The core recovery varied between 0,67 m and 9.30 m representing more than 125,000 years based on results obtained from preliminary stratigraphy.

Three cores (GeoB 5002-3, 5004-3, and 5006-2) were opened, described and sampled on board. together with cores GeoB 4904-4, 4906-3, 4907-3, 4908-2, and 4912-2. The remaining cores were opened on leg M 41/3.

On the working half of the split cores, the electric resistivity R was determined using a handheld sensor with miniaturized four-electrodes-in-line (`Wenner`) configuration (electrode spacing: 4mm). A rectangular alternating current signal is fed to the sediment about 1cm below the surface by the two outer electrodes. Assuming a homogeneously conducting medium, the potential difference at the inner two electrodes is directly proportional to the sediment resistivity R. A fast resistance thermometer provides data for a temperature correction. According to the empirical ARCHIE`s equation the porosity of the sediment can be calculated, which can be converted to the wet bulk density following a recommendation by BOYCE (1968).

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 the analysis of particulate organic matter (macerals). Smaller samples were taken systematically for the preparation of a preliminary stratigraphy based upon the abundance of the foraminifer *Globorotalia menardii*.

4.3. Visual Core Description and Stratigraphy

(M 41/1: A. Adegbie, J. Klump, R. Schneider, T. Wagner)
(M 41/2: S. Drachenberg, M. Segl)

4.3.1. Methods

The most important observations from the core descriptions were obtained by shipboard analysis during METEOR-Cruise M 41/1+2 and are summarised in core description forms following ODP convention (Figures. 9-28). Stratigraphic analysis and estimates of sand content were performed onboard ship using counts of the relative abundance of the foraminifer *G. menardii* (ERICSON AND WOLLIN, 1968, Figure 29a) and variations in the amount of residual sand size material after wet sieving (Figure 29b).

Smear slides were taken from all representative lithological units in all cores and from layers of special interest. The slides were then mounted with "Norland optical adhesive". A total of 70 smear slides were examined on board ship using a transmitted light microscope at 100 to 400x magnification under plane-polarized and cross-polarized light. The results of the smear-slide analysis are summarized in Table 4 and are illustrated in Figures 30-34.

The sediment classification is based on ODP nomenclature following the terminology defined by DEAN et al. (1985). The structure column shows features such as intensity of bioturbation, layering, nature of lithological contacts and presence of mega-fossils. The hue and chroma attributes of the sediment color were determined by comparison with the MUNSELL® soil color charts as soon as the cores were split. Colors are named and coded according to the MUNSELL® color notation.

To quantify the color of the sediment a Minolta CM-2002™ hand-held spectrophotometer was used to measure the light reflectance of all gravity cores at 31 wavelength channels in the range of visible light (400 - 700 nm). 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 same positions as the samples taken from 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 PCPlus™, then converted to an ASCII table using a conversion utility written by G. Ruhland (Univ. 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. 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 might be published in the literature. The hue (H) of the sediment color seems to be strongly influenced by the input of terrigenous material.

4.3.2. Shipboard Results

Core **GeoB 4901-8** (position: 02°40.7'N 06°43.2'W, water depth: 2184 m, length: 2028 cm)

Down to a depth of 1090 cm core GeoB 4901-8 consists of clay-bearing diatom nanno-ooze. It is highly bioturbated and dark greenish gray in appearance showing variations in supply of terrigenous plant matter. Terrigenous plant matter frequently shows a fibrous shape with indications for plant burning ("charcoal"-type organic matter). Evidence for turbidites or contourites were not found. Below four meters depth fractured pteropod shells are abundant, above unidentified calcareous shell debris can be found. Throughout this section of the core open worm burrows, partly filled with fecal pellets, are found. Below 1090 cm to about 1250 cm the sediment is composed of clay-bearing siliceous nanno-ooze. From 1250 to 1360 cm clay-bearing foram-nanno-ooze is found. A pronounced increase in foraminifera, observed by smear slide analysis at about 13 m depth, correlates with highest abundance of *G. menardii* and sand size fraction, probably indicating peak interglacial conditions during marine isotopic substage 5.5. At about 1360 cm the color of the sediment changes to greenish black and a faint H_2S odor can be noticed. The H_2S odor becomes more pronounced further downcore. The composition of the sediment changes to clay-bearing diatom nanno-ooze. Below 1350 cm (biozones X through U) estimated sand contents reveal a highly variable pattern, suggesting relatively short-termed climate controlled changes in marine sedimentation. At 1930 cm the composition of the sediment changes to clay-bearing nanno-ooze and the color changes to a dark greenish gray.

Core **GeoB 4902-3** (position: 02°21.3'N 06°01.8'W, water depth: 3223 m, length: 2264 cm)

Core GeoB 4902-3 consists entirely of dark greenish gray clayey siliceous nanno-ooze. Based on preliminary stratigraphy, its sedimentary record extends back to marine isotopic stage 7. No indications for turbidites or contourites were observed, suggesting a continuous hemipelagic sedimentation over the past 200,000 years. The core is moderately to strongly bioturbated. Based on smear slide analysis calcareous, siliceous, and terrigenous components are present in equal proportions showing minor variations. Comparable to core 4901-8 terrigenous organic matter is present in most parts of the core also showing some evidence for plant burning. A pronounced peak in foraminifera was observed at about 13.5 m and 16 m within biozone U. In contrast to core GeoB 4901-8 calcareous components remain low during marine isotopic stage 5 (biozone X). Sand contents are in the same range as estimated for core 4901-8 but show less distinct variations. Fragments of pteropod shells were observed in the core and an intact mollusc shell was found at a depth of 1850 cm. H_2S becomes noticeable below a depth of six meters. Open worm burrows can be found in the upper eleven meters of the core.

Core **GeoB 4903-4** (position: 01°54.9'N 08°10.1'E, water depth: 2385 m, length: 230 cm)

The hole core consists of nannofossil ooze with varying contents of clay and diatoms. Most sections of the core are moderate bioturbated. The entire core is mostly homogeneously greenish very dark gray, and color changes are gradual. At a depth of 30 and 120 cm are some pteropod shells.

Core **GeoB 4904-4** (position: 00°57.6'N 08°52.8'E, water depth: 1339 m, length: 1148 cm)

Down to a depth of 570 cm core GeoB 4904-4 consists of nannofossil ooze with varying contents of clay and diatoms. From 570 to 750 cm and from 930 to the end of the core the sediment is mainly made up by nannofossil diatom ooze. From 750 to 930 it consists of diatom-bearing nannofossil ooze. The entire core is mostly homogeneously greenish very dark gray, and color changes are gradual. Bioturbation must have been high, but appears moderate. A vertical worm burrow can be observed between 865 and 882 cm. Open burrows can be found at 395, 410, and 440 cm.

Core **GeoB 4905-4** (position: 02°30.0'N 09°23.4'W, water depth: 1328 m, length: 1218 cm)

The upper part of this core consists of dark bluish gray silica-bearing nannofossil clay with some fragments of pteropod shells. Evidence for turbidites or contourites were not observed. The base of the core extends into biozone Y considering preliminary stratigraphic data. Below 680 cm the composition of the sediment changes to a clay-bearing diatom nanno-ooze with fractured pteropod shells. Results from smear slide analysis indicate a decrease in the bulk terrigenous fraction below 4m depth which is paralleled by an increase of the siliceous, calcareous, and plant matter fraction. The sand profile shows two pronounced maxima in the lower part of the core (biozone Y). At 680 cm an unidentified megafossil was found. Open worm burrows were found in the upper half of the core.

Core **GeoB 4906-3** (position: 00°41.4'S 08°22.6'E, water depth: 1274, length: 1236 cm)

Down to a depth of 1110 cm core GeoB 4906-3 consists of diatom ooze with varying contents of clay and nannofossils. At 1110 cm diatoms are gradually replaced by nannofossils as main sediment constituents. There is little color change to be observed since variation is gradual and ranges only between dark gray to black with a varying olive-component. The core appears moderately bioturbated. At core depths 60, 75, 80, 87, 105, and 125 cm open worm burrows can be found, a part of them being filled with fecal pellets. At a depth of 732 cm there are abundant mesoscopic gastropod shells. At a depth of 895 cm a complete bivalve test can be observed.

Core **GeoB 4907-3** (position: 00°37.5'S 08°01.6'E, water depth: 2066 m, length: 1685 cm)

The uppermost 80 cm of core GeoB 4907-3 consist of nannofossil ooze. Within the depth interval 80 to 450 cm the core contains nannofossil siliceous ooze. Between 450 and 1210 cm there is quartz and silica-bearing nannofossil ooze. At 1210 cm the composition of the sediment gradually changes to nannofossil ooze down to a depth of 1450 cm, where clay becomes more pronounced down to 1560 cm. The last meter of core GeoB 4907-3 consists of silica-bearing nannofossil ooze. Down to a depth of approximately 1000 cm pteropod shells and fragments can abundantly be found. At a depth of ca. 450 cm a faint odor of hydrogen sulfide can be noticed. The odor becomes more pronounced downcore. Core GeoB 4907-3 bears abundant megafossils. More extraordinary among these are a complete bivalve test at a depth of 32 cm and a benthic foraminifer at 214 cm. Bioturbation is usually moderate to strong but there is also an interval of highly bioturbated sediment between 1430 and 1450 cm. There is little evidence for mass flows but a tiny sandy layer can be observed at a depth of 890 cm. Color data provides only little changes from dark gray to black.

Core **GeoB 4908-2** (position: 00°42.7'S 06°50.2'E, water depth: 3029 m, length: 1765 cm)

Core GeoB 4908-2 is dominated by nannofossil ooze, within the depth intervals 0-20 cm, 125 -150 cm, and 890-1220 cm, also classified as the above. Between 20 and 307 cm the core consists of Diatom bearing nannofossil ooze. In the depth interval between 307 and 385 cm the core consists of siliceous nannofossil ooze. The interval between 385 and 587 cm is made up by diatomaceous nannofossil ooze. Between 587 and 890 and between 1510 and 1748 cm diatoms are less abundant. For these intervals the sediment is classified as silica-bearing nannofossil ooze. Core GeoB 4908-2 consists of siliceous nannofossil in the depth interval 1220 to 1510 cm. Sandy foraminiferal layers can be observed at 280, 307, and 1445 cm. At 1080 a 15 cm thick up to gravel-sized layer of terrigenous components like quartz and feldspar and calcareous shell fragments is apparently a turbidite.

Core **GeoB 4909-5** (position: 02°04.1'N 08°37.5'W, water depth: 1308 m, length: 819 cm) and Core **GeoB 4909-6** (position: 02°04.1'N 08°37.6'W, water depth: 1308 m, length: 1068 cm)

The top 450 cm of core GeoB 4909-5 consists of clayey foram-bearing nanno-ooze. At about one meter depth fish otoliths were found, and a small gastropod shell at about 160 cm. Fractured pteropod shells can be found down to a depth of about 530 cm. Below 450 cm the composition of the sediment changes to foram-bearing nannofossil clay. The entire core is dark greenish gray in appearance. Based on preliminary stratigraphy, its sedimentary record extends back to marine isotopic stage 5. Estimated sand contents reveal two maxima during past glacial biozone Y, comparable to those observed in core 4905-4. The shallower position of these peaks in core 4909-5 and biostratigraphic evidence suggest considerably lower sedimentation rates compared to core 4905-4. Smear slide analysis reveal a continuous downcore decrease of the calcareous fraction which is paralleled by an increase of quartz. Quartz and other minerals frequently occur as coarse and well rounded grains, suggesting supply by eolian transport from arid continental areas.

To extend the sediment record, the bottom part of core GeoB 4909-6 from 610 to 1061 cm was added. It too consists of dark greenish gray foram-bearing nannofossil clay, as does the lower part of core GeoB 4909-5. Both cores can be depth correlated to each other by their physical properties, e.g. reflectance.

Core **GeoB 4910-2** (position: 02°19.0'N 08°04.1'W, water depth: 3002 m, length: 985 cm)

Core GeoB 4910-2 is dominated by nannofossil ooze, within the depth intervals 0-110 cm, 155-300 cm, 390-415 cm, 425-605 cm, and 770-943 cm. Between 110-155 cm and 605-770 cm the core consists of Diatom bearing nannofossil ooze. In the depth interval between 300 and 390 cm the core consists of siliceous nannofossil ooze. At 425 a 10 cm thick up to gravel-sized layer of terrigenous components like quartz and feldspar and calcareous shell fragments is apparently a turbidite. At a depth interval of 355 to 390 cm a sandy layer fining upwards can be observed.. There are only little variations in bioturbation, being mostly moderate. At some depths worm burrows of a few centimeters in diameter can be observed. There is little variation in color from greenish gray to very dark greenish gray or olive gray.

Core **GeoB 4911-3** (position: 02°08.2'N 08°28.6'W, water depth: 1950 m, length: 970 cm)

Down to a depth of 540 cm, this core consists of clay-bearing siliceous nanno-ooze with abundant pteropod shells. A small sandy turbidite is intercalated at 438 cm. Below 540 cm the core shows a succession of sandy turbidites. The entire core is dark greenish gray in appearance. No biostratigraphic and sand content data were produced on board Meteor Cruise 41-1. Smear slide analysis performed on hemipelagic sections above 5m reveal equal amounts of the calcareous, siliceous and terrigenous fraction. Turbitites almost entirely consist of well rounded, coarse grained quartz and other mineral grains. Few carbonaceous fragments were encountered in a turbiditic sequence at the base of the core.

Core **GeoB 4912-2** (position: 03°43.9'S 09°47.0'E; water depth: 1312 m, length: 1153 cm)

Core GeoB 4912-2 consists mainly of nannofossil ooze. From the top down to a depth of 610 cm the sediment is clay bearing nannofossil ooze. Within the depth interval 610 to 670 cm core GeoB 4912-2 consists of clayey nannofossil ooze. Between 670 and 795 cm the sediment is made up by clay bearing nannofossil ooze. From 795 cm down the bottom the core consists of nannofossil ooze. There is little variation in bioturbation, being mostly moderate. Between 220 and 250 cm a worm burrow of a few centimeters in diameter can be observed. There is little variation in color from dark gray to very dark gray.

Core **GeoB 4913-6** (position: 05°30.1'S 11°04.4'E; water depth: 1304 m, length: 1090 cm)

The core is mainly dominated by a silty clay, which is nannofossil- and partly diatom-bearing. In the first 140 cm nannofossils are rare. At 105 cm a big bivalve shell occurs. Between 155 to 130 cm the sediment coarsening upwards, as between 170 to 155 cm the sediment fining upwards. At 270 cm abundant pteropod shells can be observed. A small sandy layer is intercalated at 492 to 503 cm and at 978 to 980 cm. Between 580 to 553 cm the sediment again coarsening upwards, as between 598 to 580 cm the sediment again fining upwards. There is only small variation in bioturbation, being mostly moderate. Color changes are minor, varying from dark olive gray and very dark gray to black.

Core **GeoB 4915-4** (position: 07°45.0'S 11°52.4'E; water depth: 1302 m, length: 846 cm)

Core GeoB 4915-4 consists mainly of nannofossil clay. Between 110 and 475 cm the sediment is clayey nannofossil ooze. From 770 cm down the bottom the core consists of Clay. The core is little to moderate bioturbated. Color changes between dark greenish gray and very dark gray.

Core **GeoB 4916-2** (position: 10°10.3'S 12°41.2'E; water depth: 1298 m, length: 69 cm)

The core consists of nannofossil bearing clay or nannofossil clay. Moderate bioturbation and worm burrows are observed throughout the core. The dark greenish gray color does not change.

Legend for stratigraphic columns

Lithology

one major component

calcareous

foraminiferal ooze

nannofossil ooze

siliceous

siliceous ooze

diatom ooze

terrigenous

clay

mud

mixtures

calcareous

nannofossil-bearing foram ooze

foram-nannofossil ooze or nannofossil-foram ooze

foram-bearing nannofossil ooze

siliceous

diatomaceous nannof. ooze or diatom-bearing nannof. ooze

terrigenous

clayey nannofossil ooze or clay-bearing nanno ooze

foram-bearing clayey nannofossil ooze

nannofossil clay

admixtures

calcareous

foram-bearing

nannofossil-bearing

siliceous

siliceous

diatom -bearing

terrigenous

clay-bearing

mud-bearing

sand-bearing

Structures

weakly bedded

bedded/laminated

mm / cm / dm dimension of bedding

scoured contact

S bioturbation (<30% of sediment)

SS bioturbation (30-60% of sediment)

SSS bioturbation (>60% of sediment)

fining upwards

coarsening upwards

graded bedding

ww wavy bedding

Fossils

shells

shell fragments

megafossil

Lightreflectance

400 nm

550 nm

700 nm

Colour

Munsell value

8

7

6

5

4

3

2

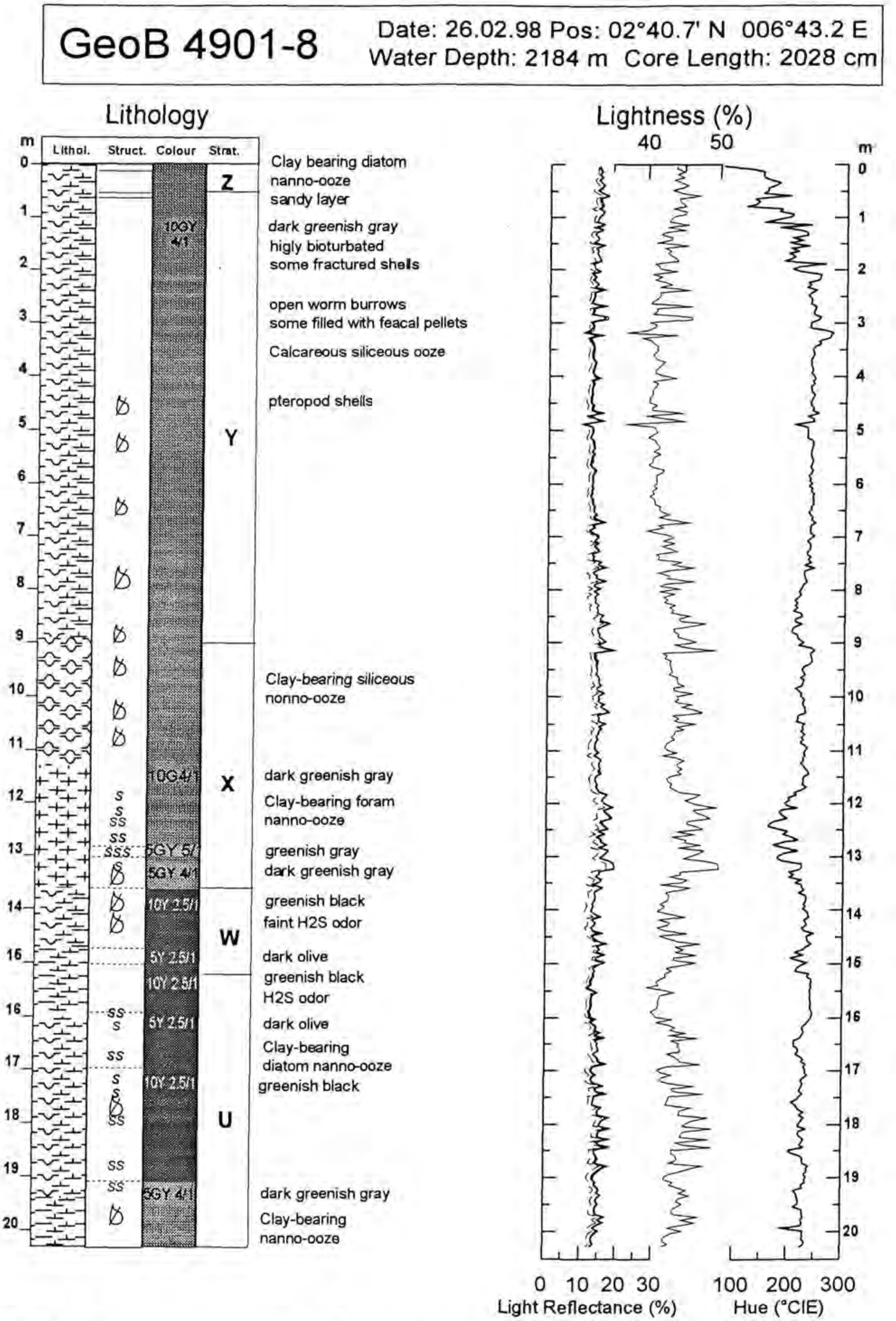

Figure 9a: Core description of GeoB 4901-8.

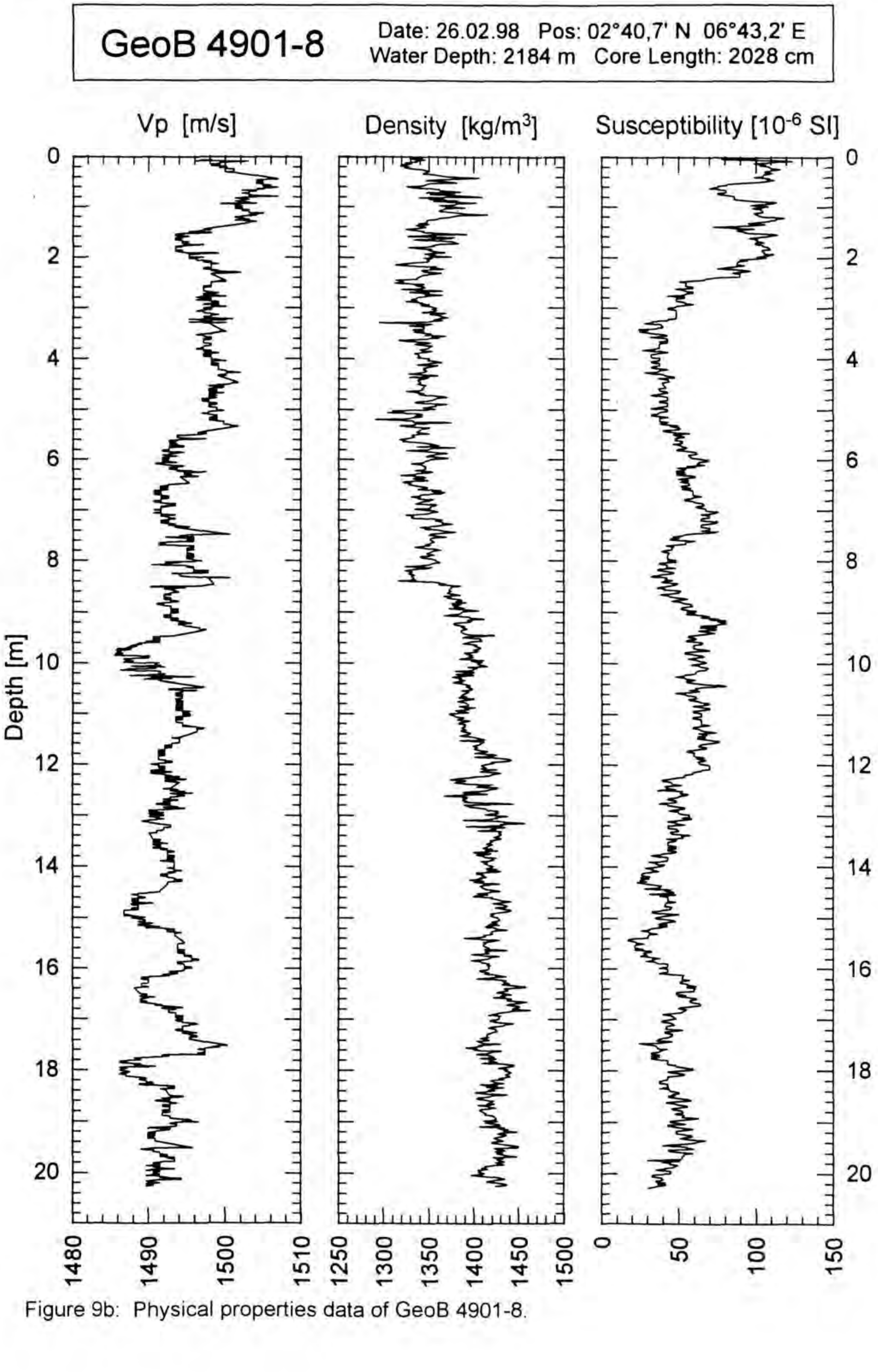

Figure 9b: Physical properties data of GeoB 4901-8.

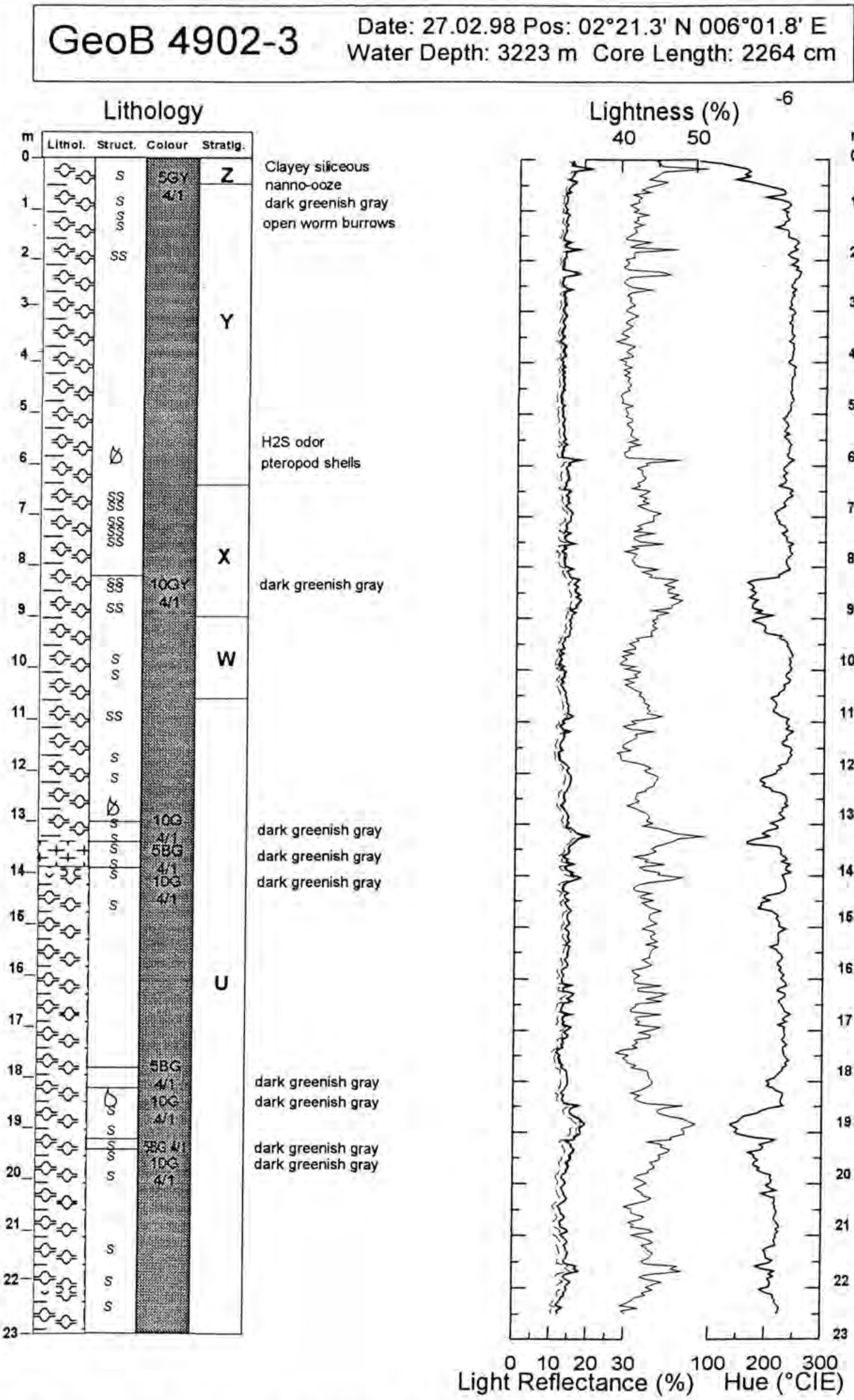

Figure 10a: Core description of GeoB 4902-3.

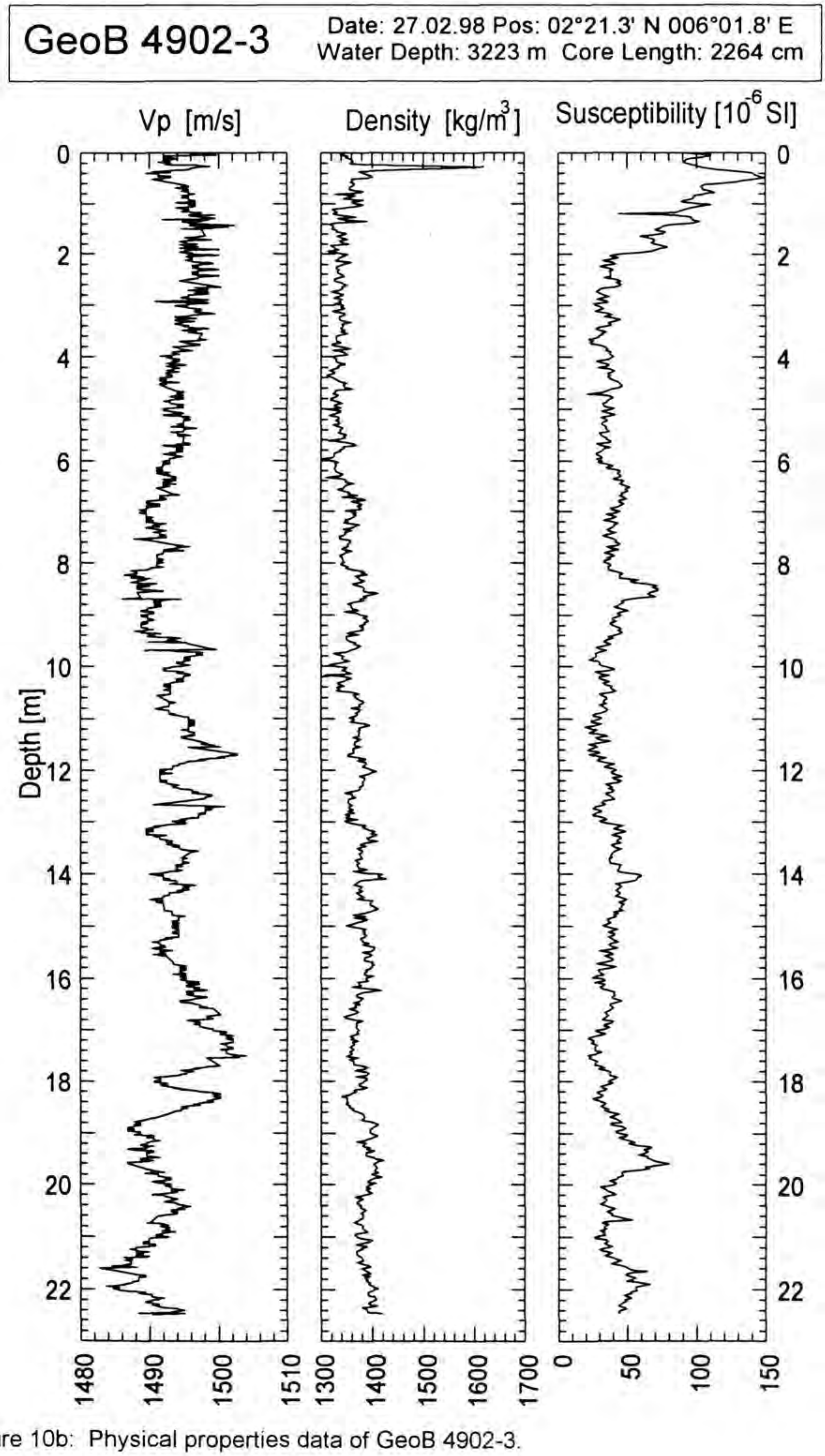

Figure 10b: Physical properties data of GeoB 4902-3.

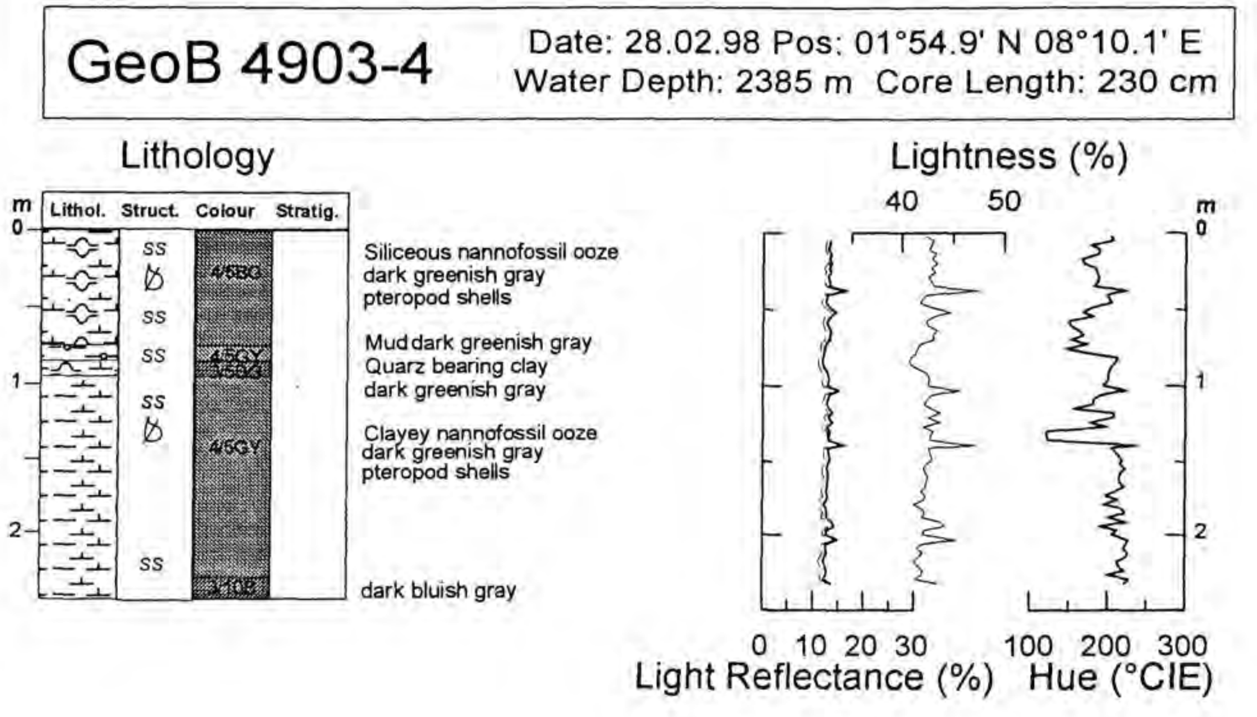

Figure 11a: Core description of GeoB 4903-4

no data available

Figure 11b: Physical properties data of GeoB 4903-4.

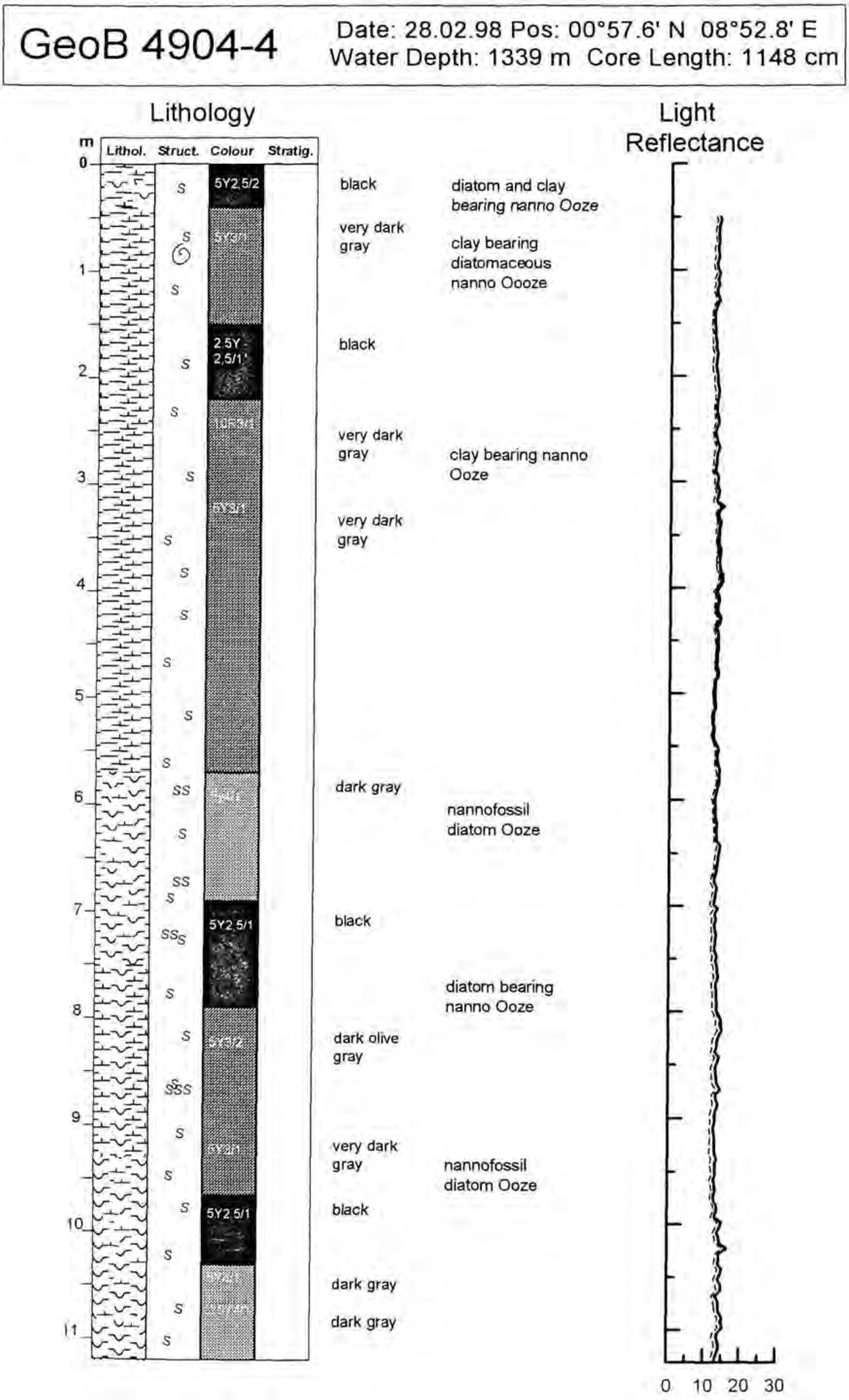

Figure 12a: Core description of GeoB 4904-4.

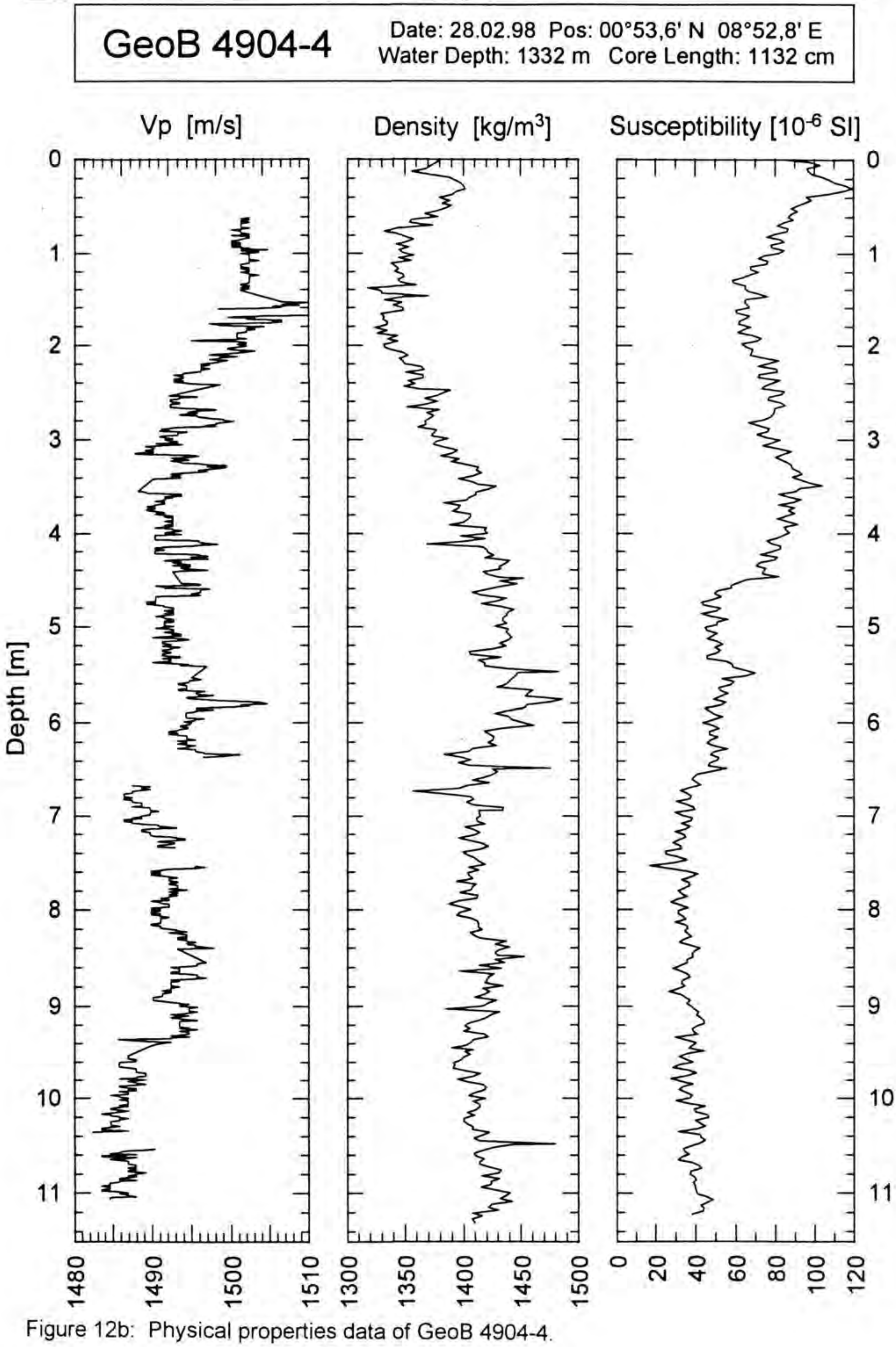

Figure 12b: Physical properties data of GeoB 4904-4.

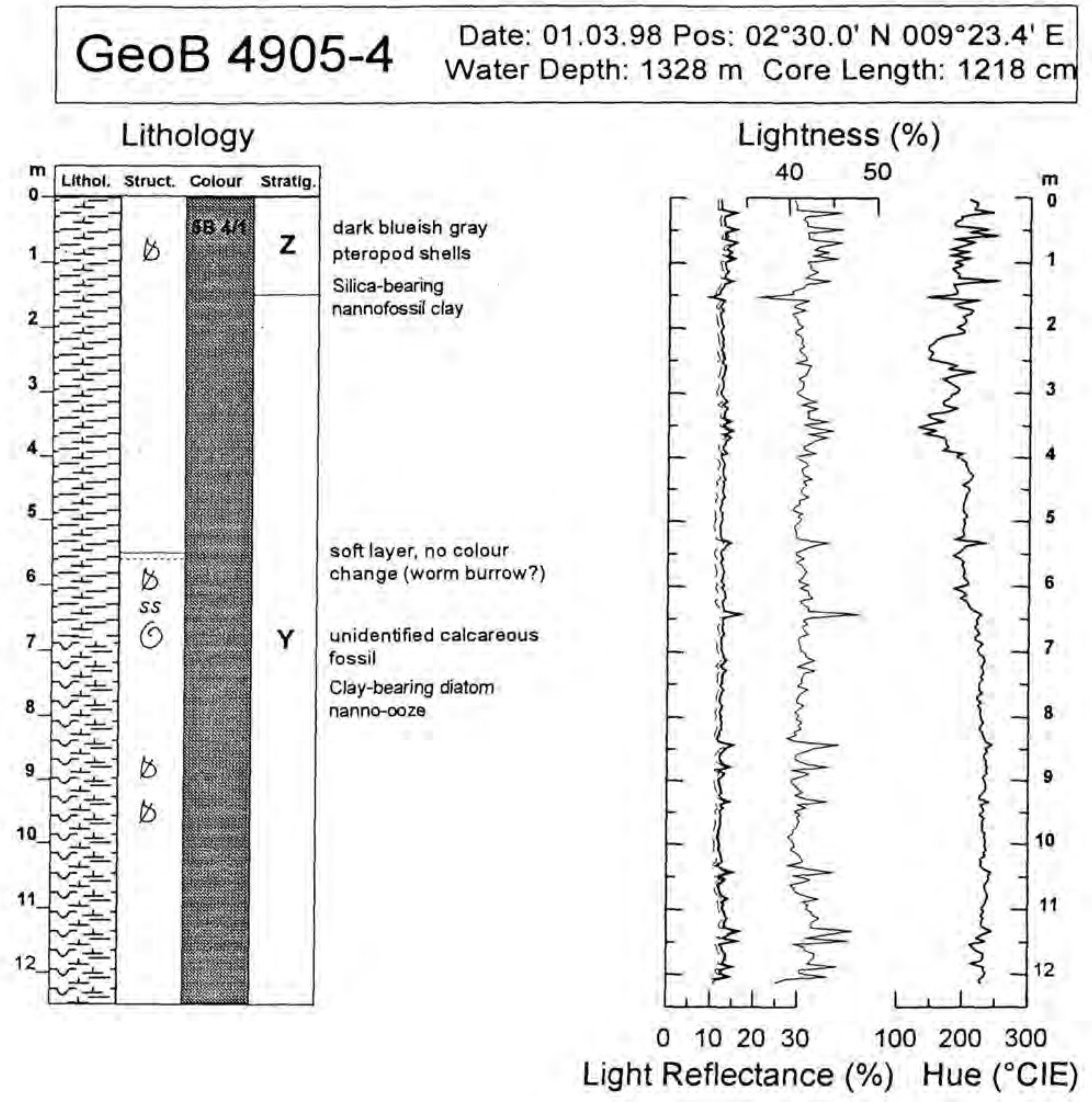

Figure 13a: Core description of GeoB 4905-4.

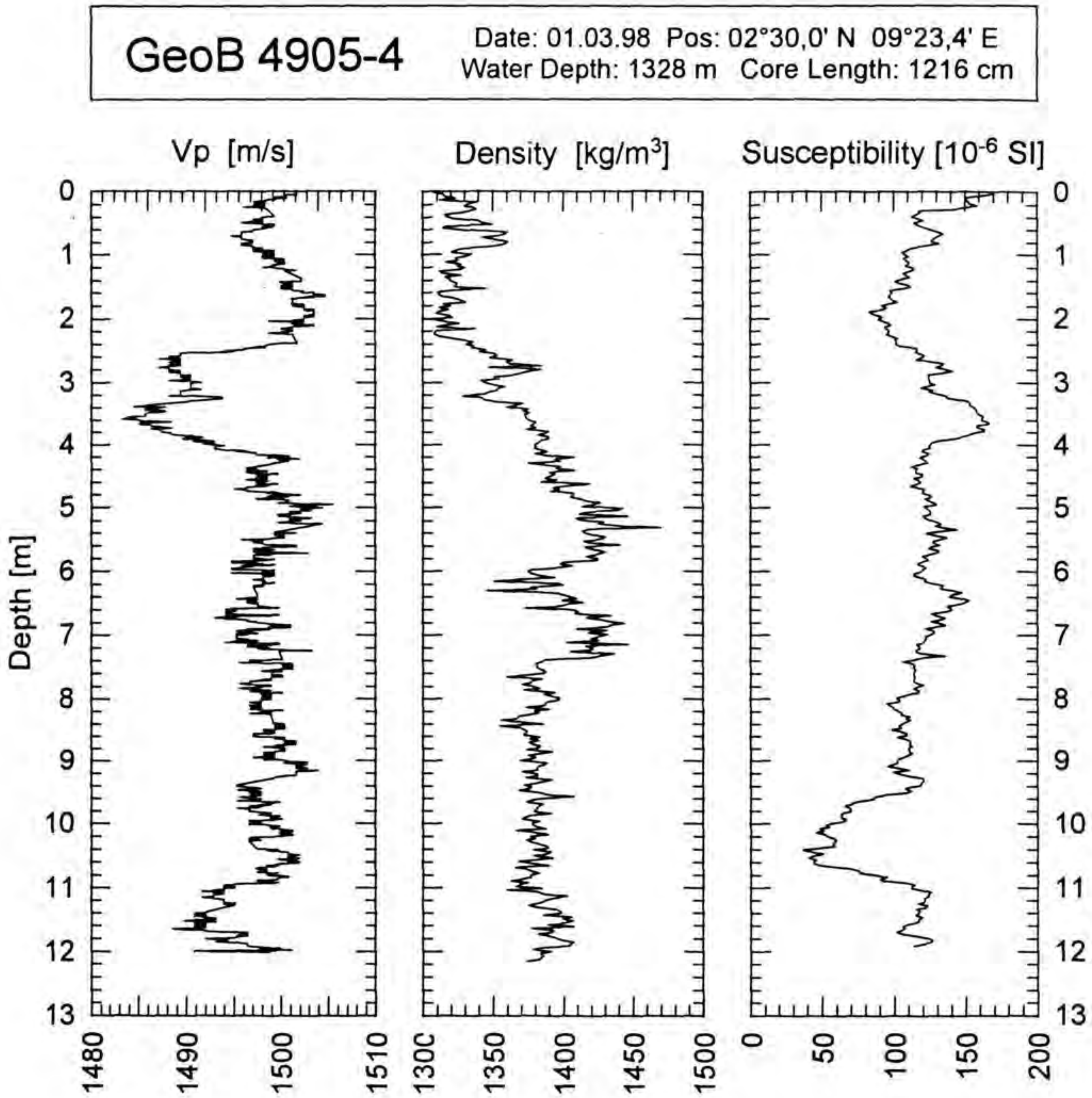

Figure 13b: Physical properties data of GeoB 4905-4.

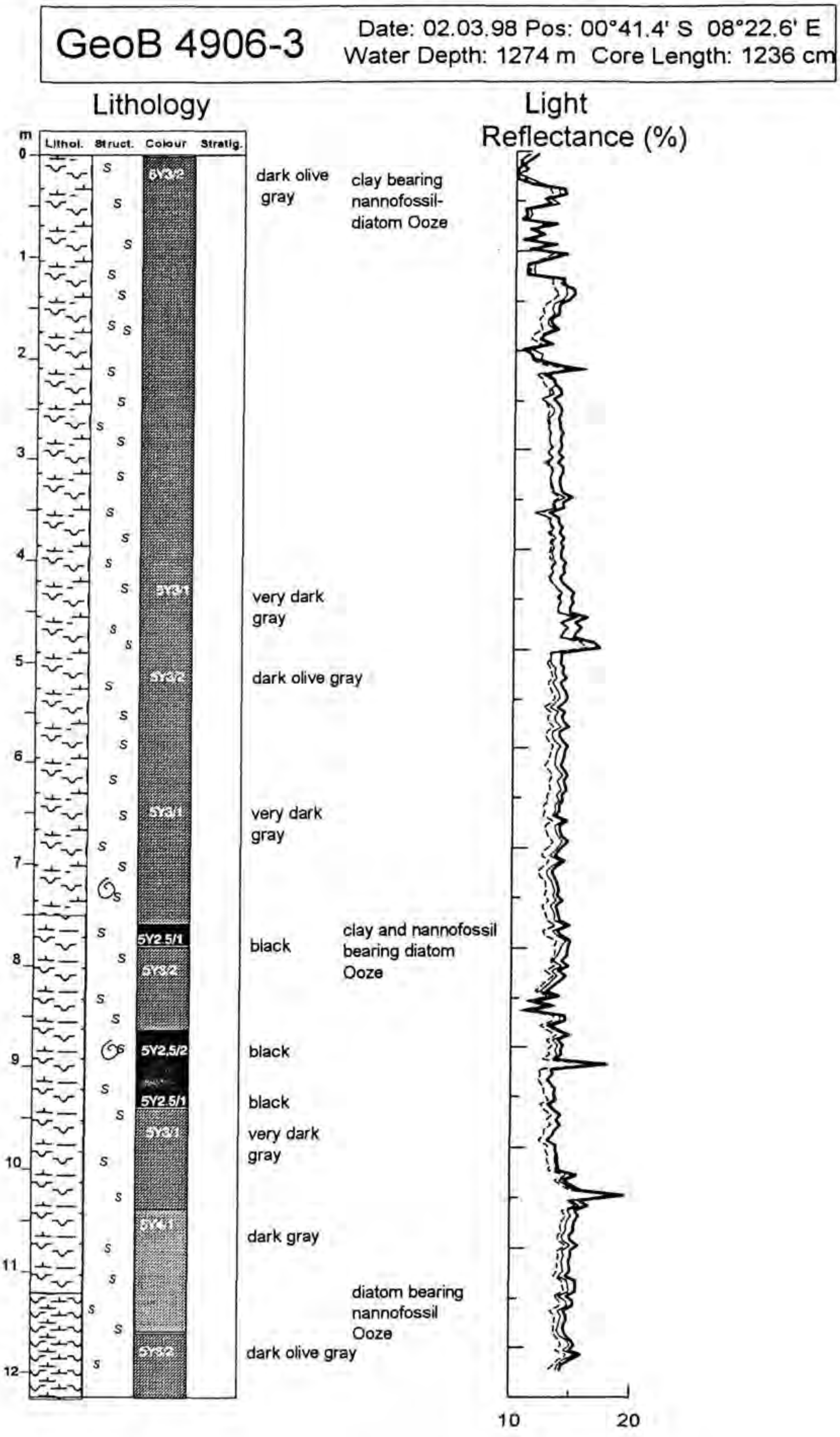

Figure 14a: Core description of GeoB 4906-3.

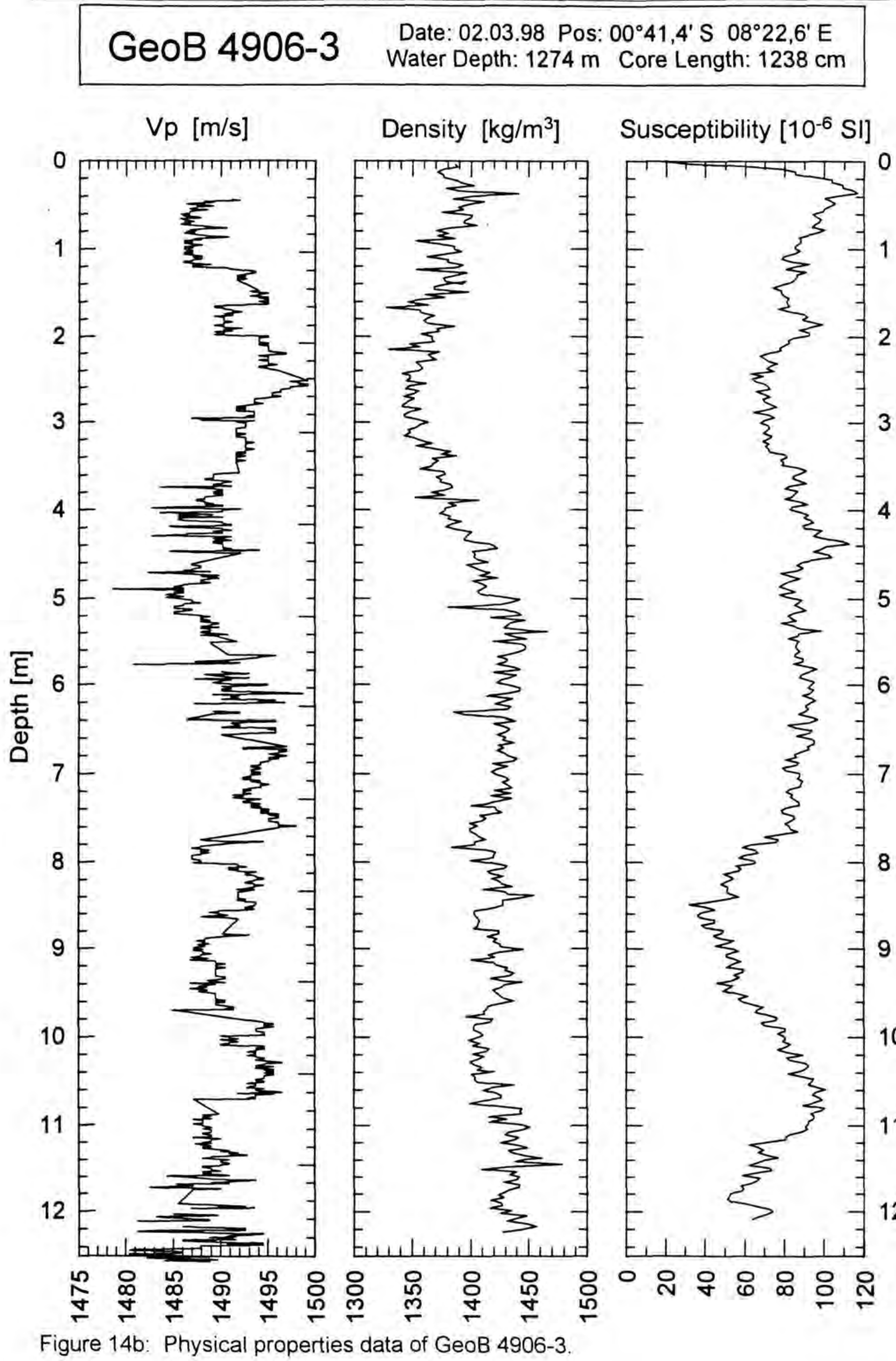

Figure 14b: Physical properties data of GeoB 4906-3.

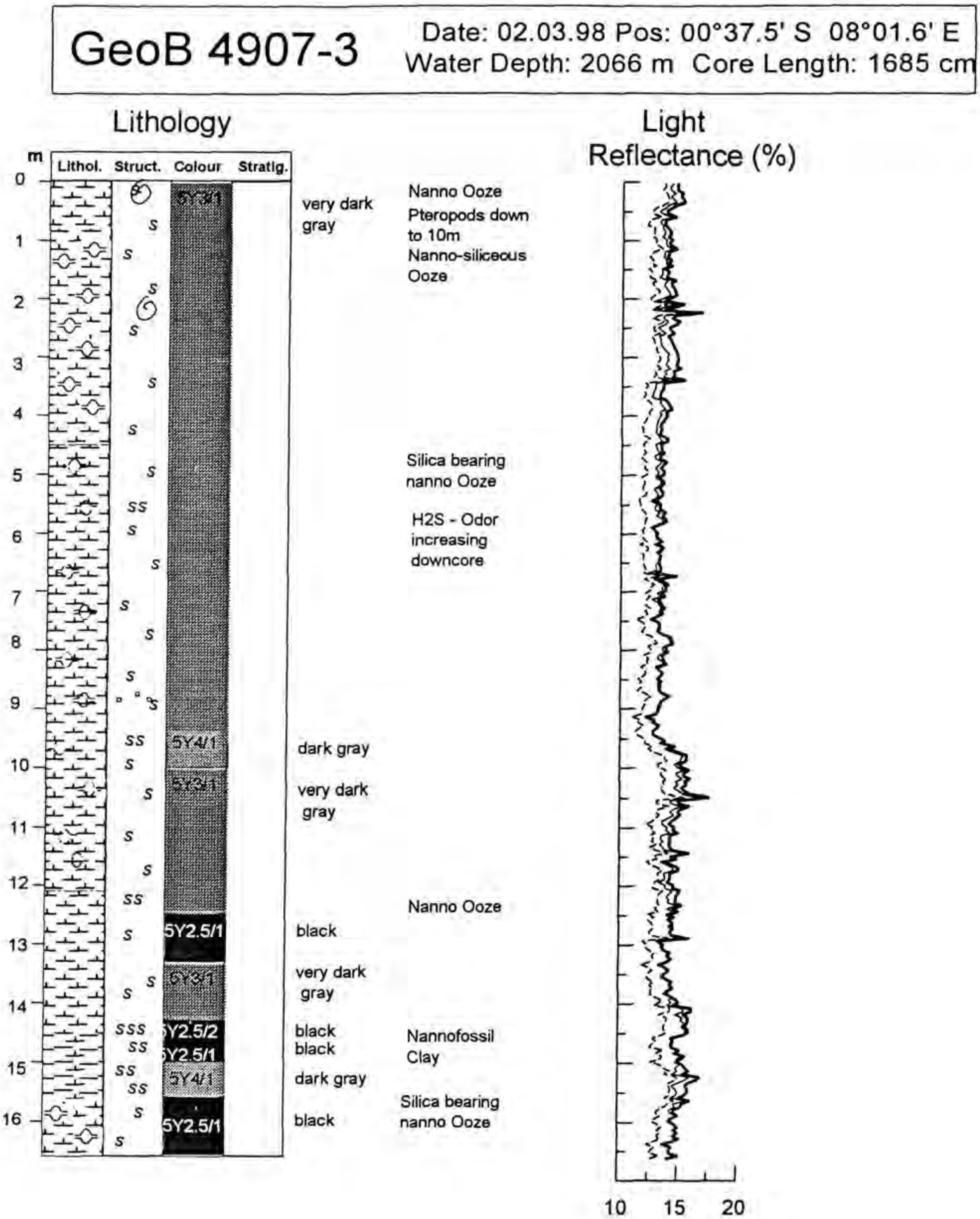

Figure 15a: Core description of GeoB 4907-3.

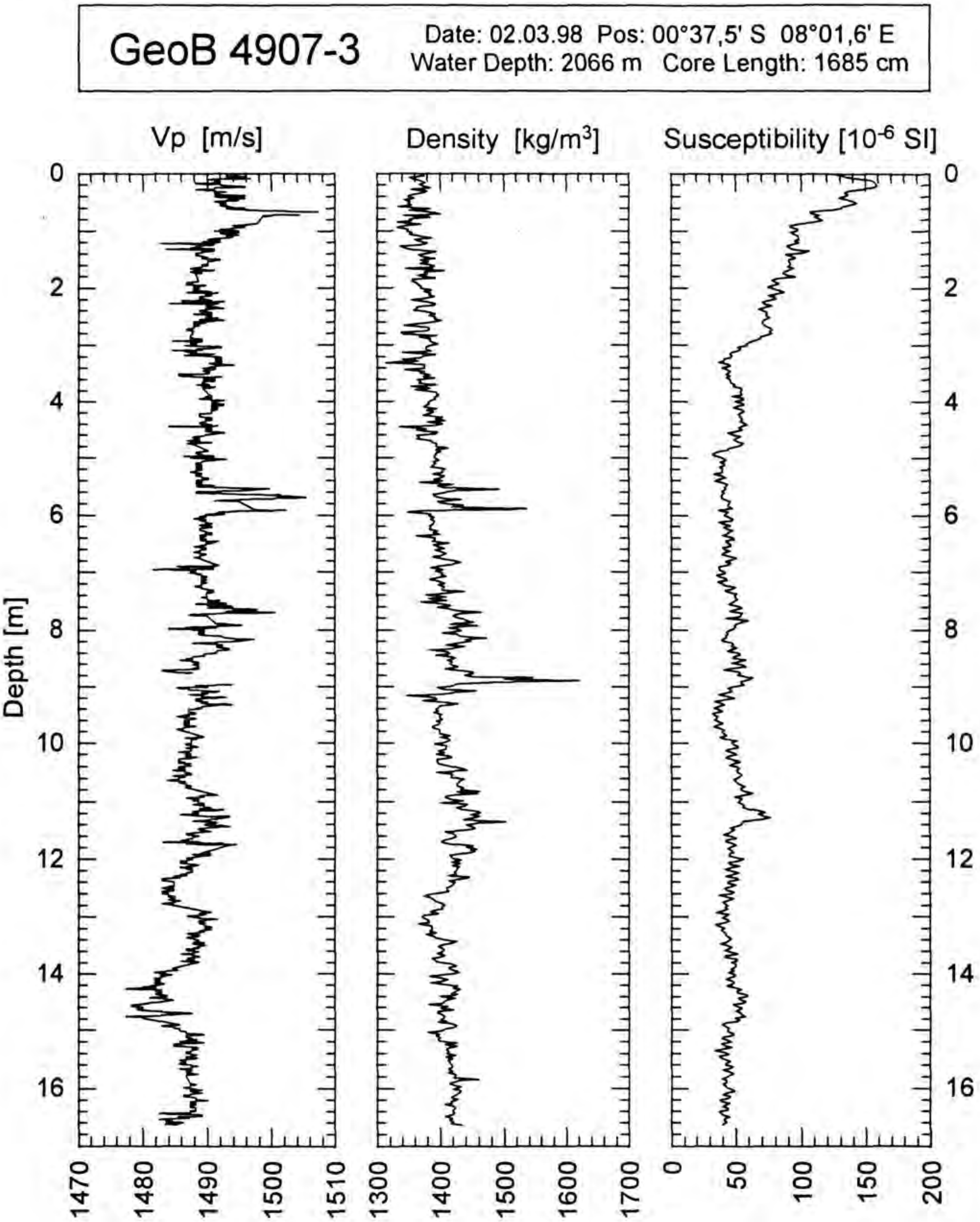

Figure 15b: Physical properties data of GeoB 4907-3.

GeoB 4908-2

Date: 02.03.98 Pos: 00°42.7°' S 06°50.2' E
Water Depth: 3029 m Core Length: 1765 cm

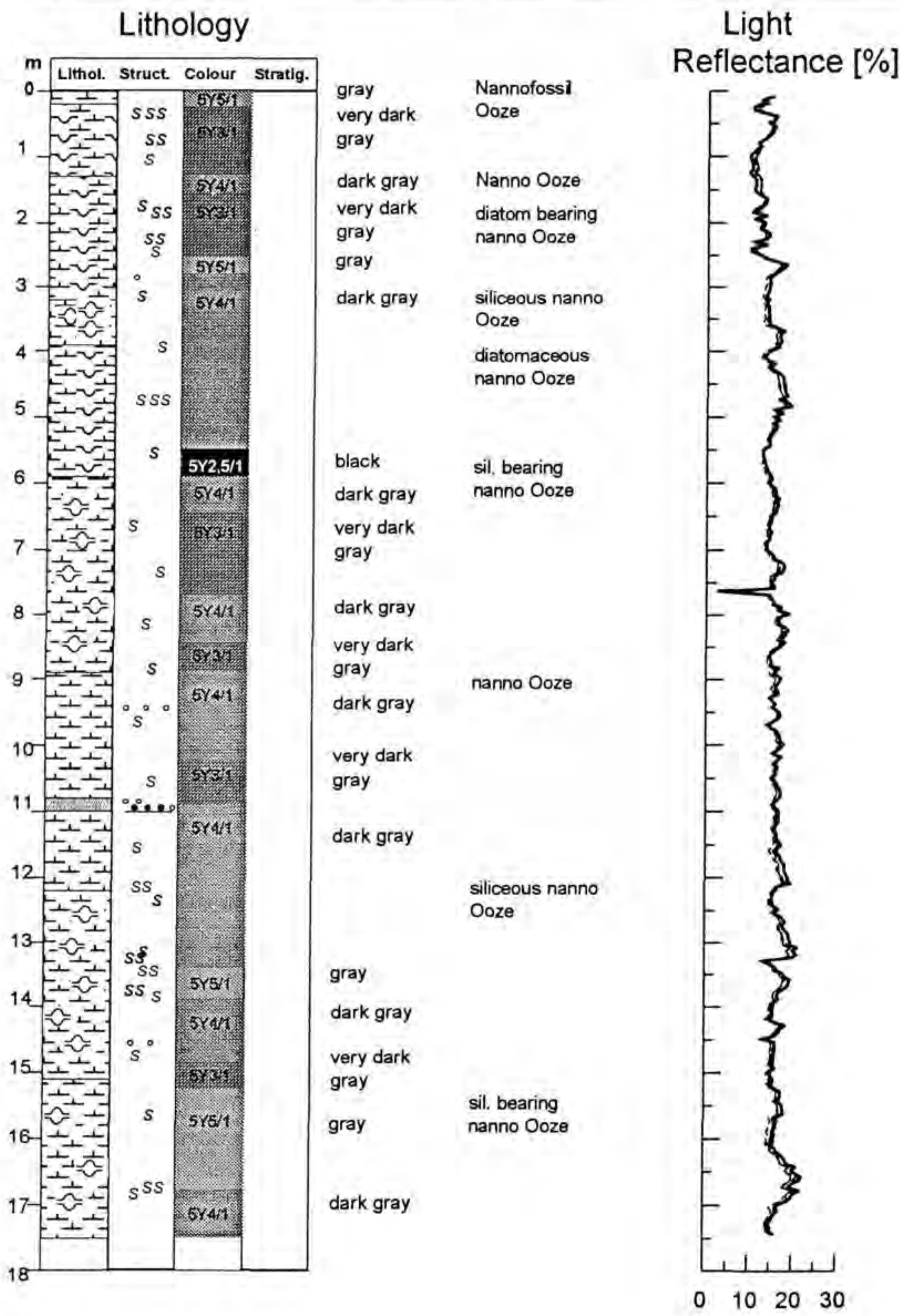

Figure 16a: Core description of GeoB 4908-2.

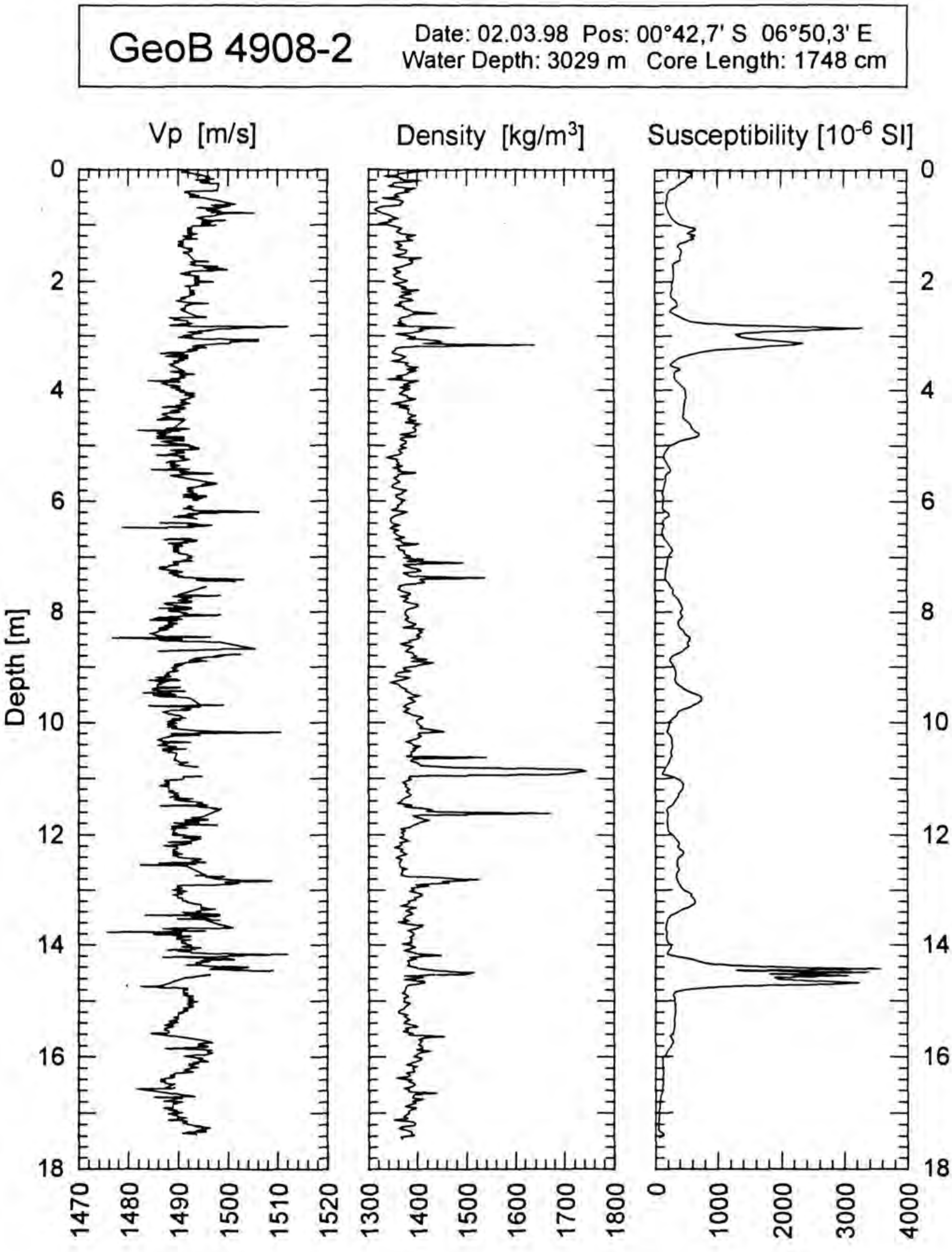

Figure 16b: Physical properties data of GeoB 4908-2.

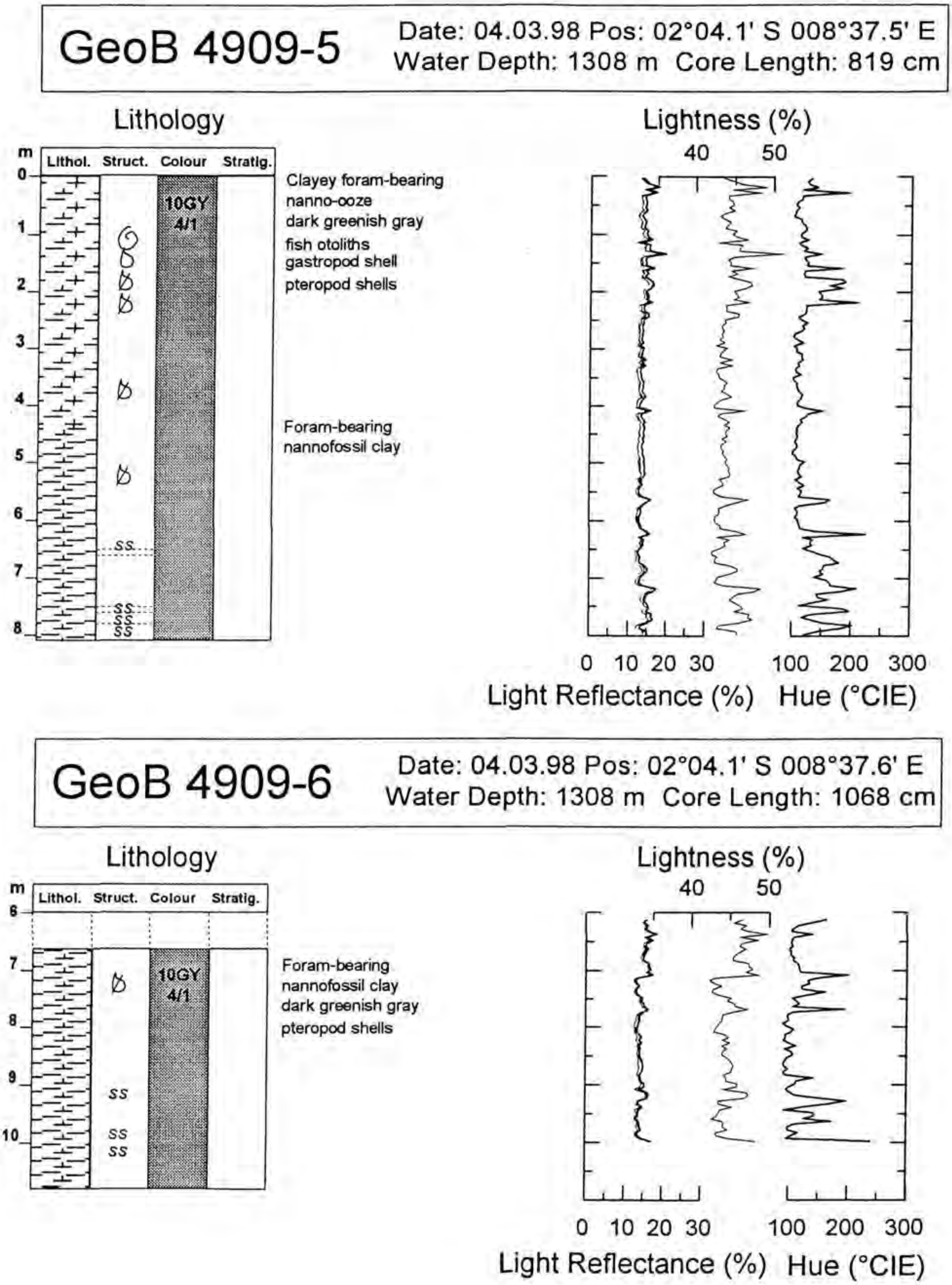

Figure 17a: Core description of GeoB 4909-5 and 4909-6.

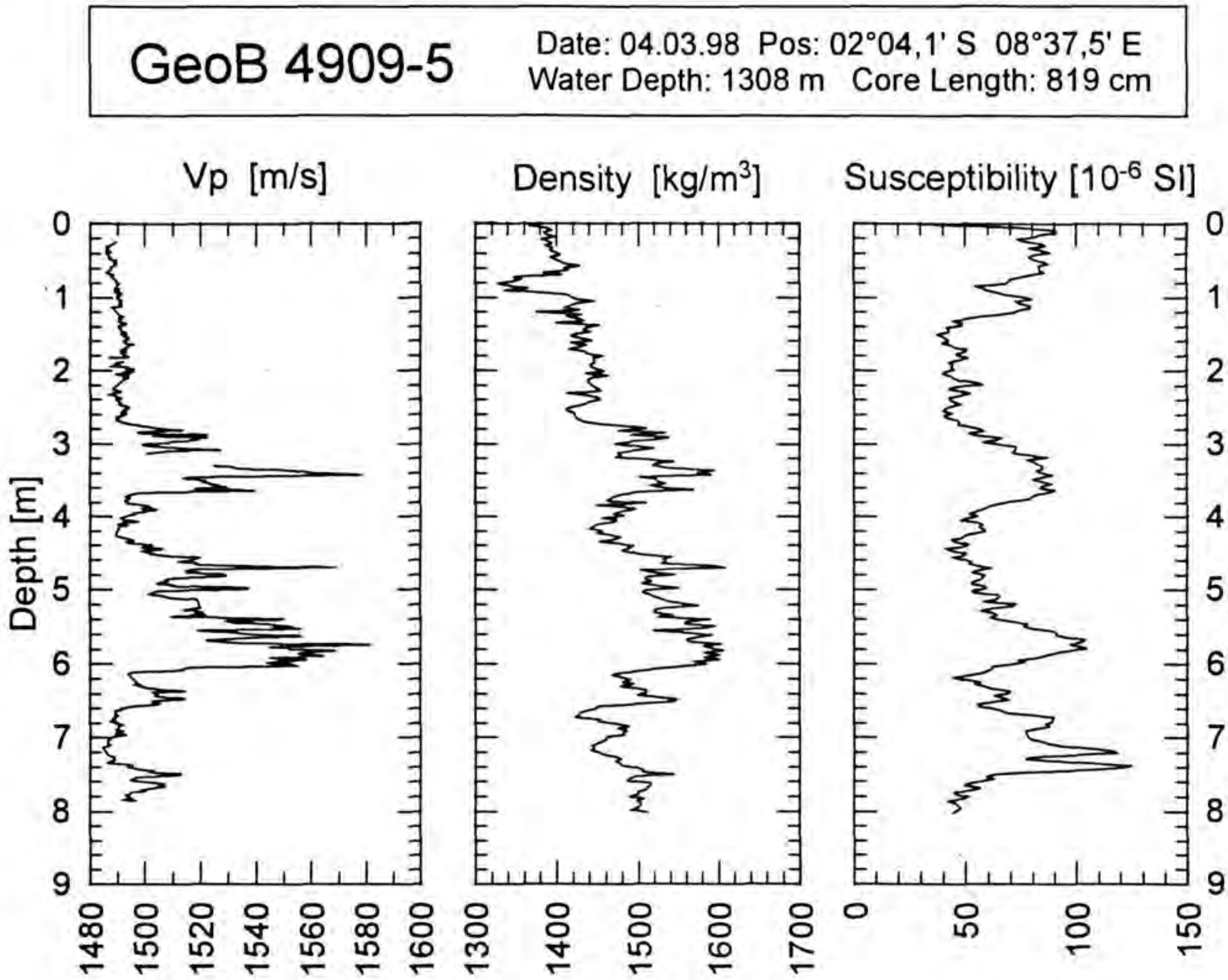

Figure 17b: Physical properties data of GeoB 4909-5.

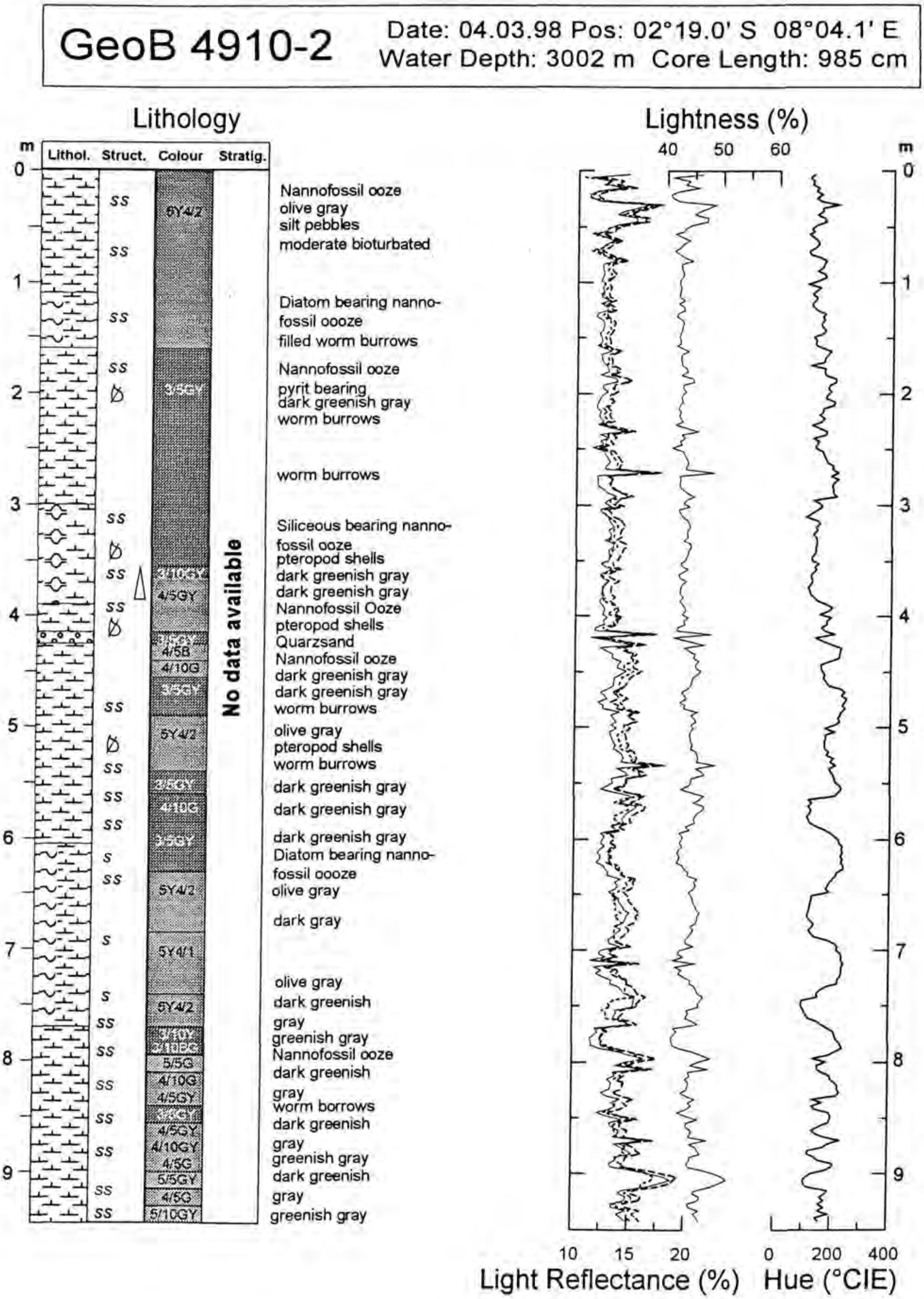

Figure 18a: Core description of GeoB 4910-2.

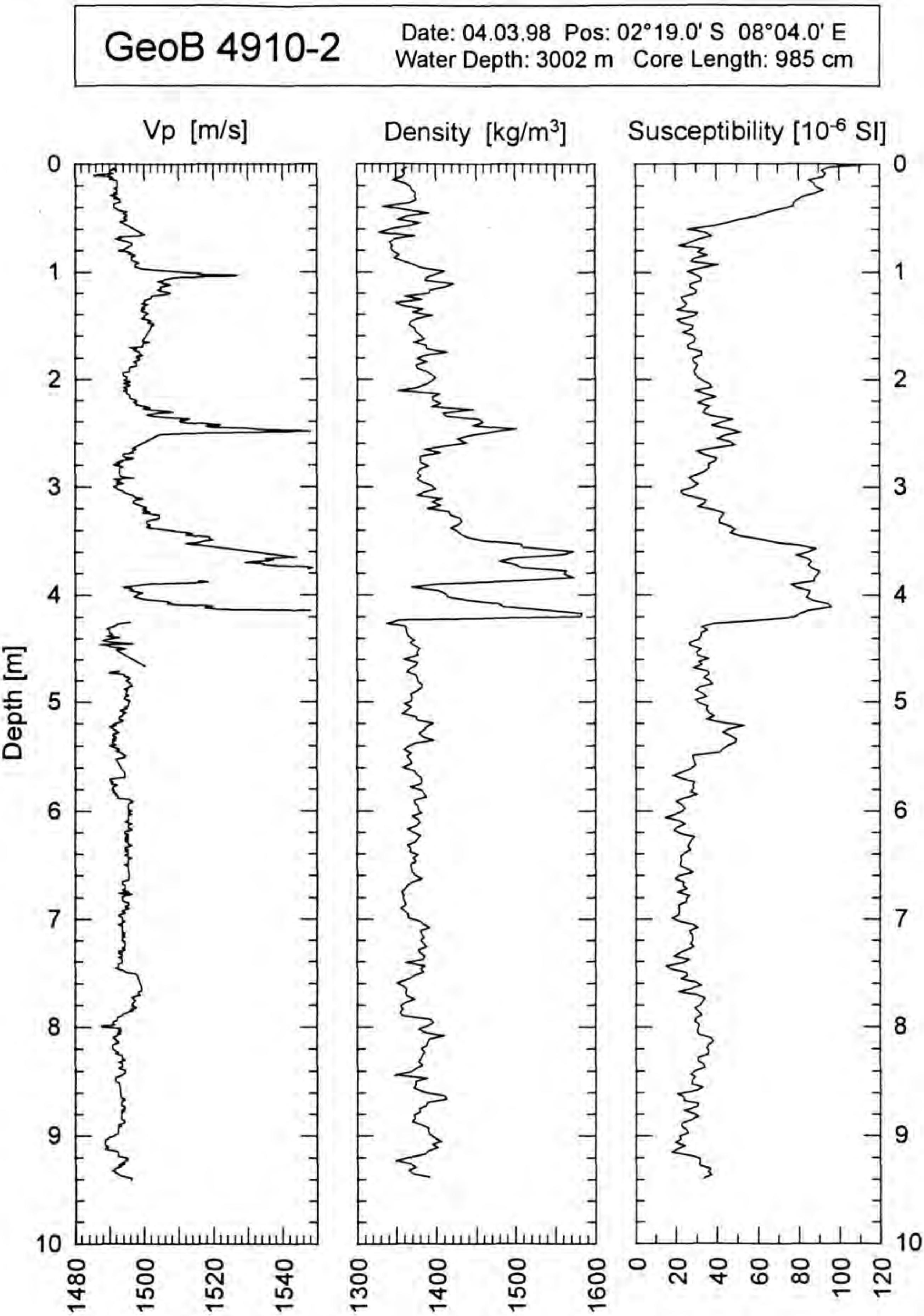

Figure 18b: Physical properties data of GeoB 4910-2.

GeoB 4911-3	Date: 05.03.98 Pos: 02°08.2' S 008°28.6' E Water Depth: 1950 m Core Length: 970 cm

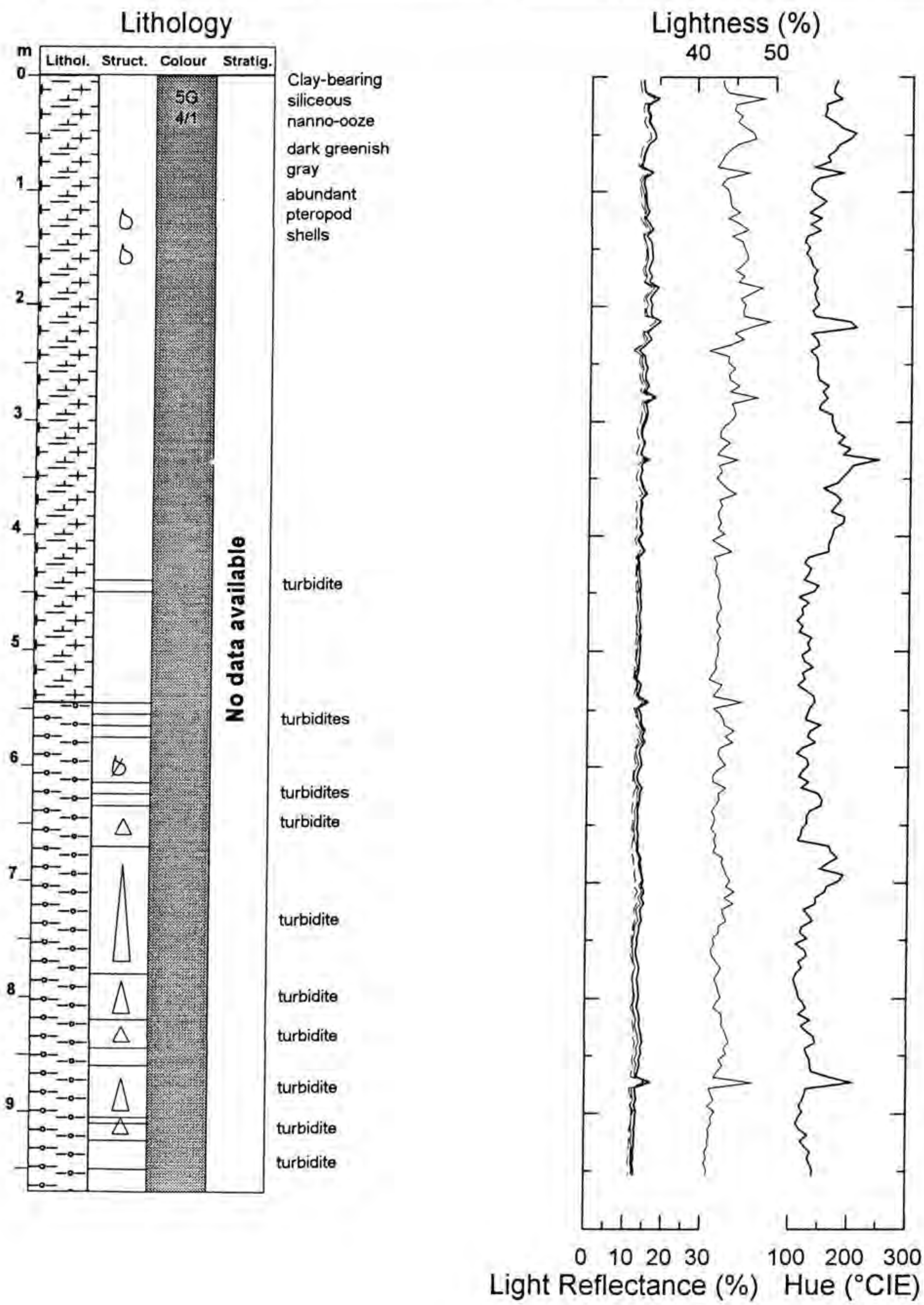

Figure 19a: Core description of GeoB 4911-3.

GeoB 4911-3

Date: 05.03.98 Pos: 02°08.2' S 08°28.6' E
Water Depth: 1950 m Core Length: 970 cm

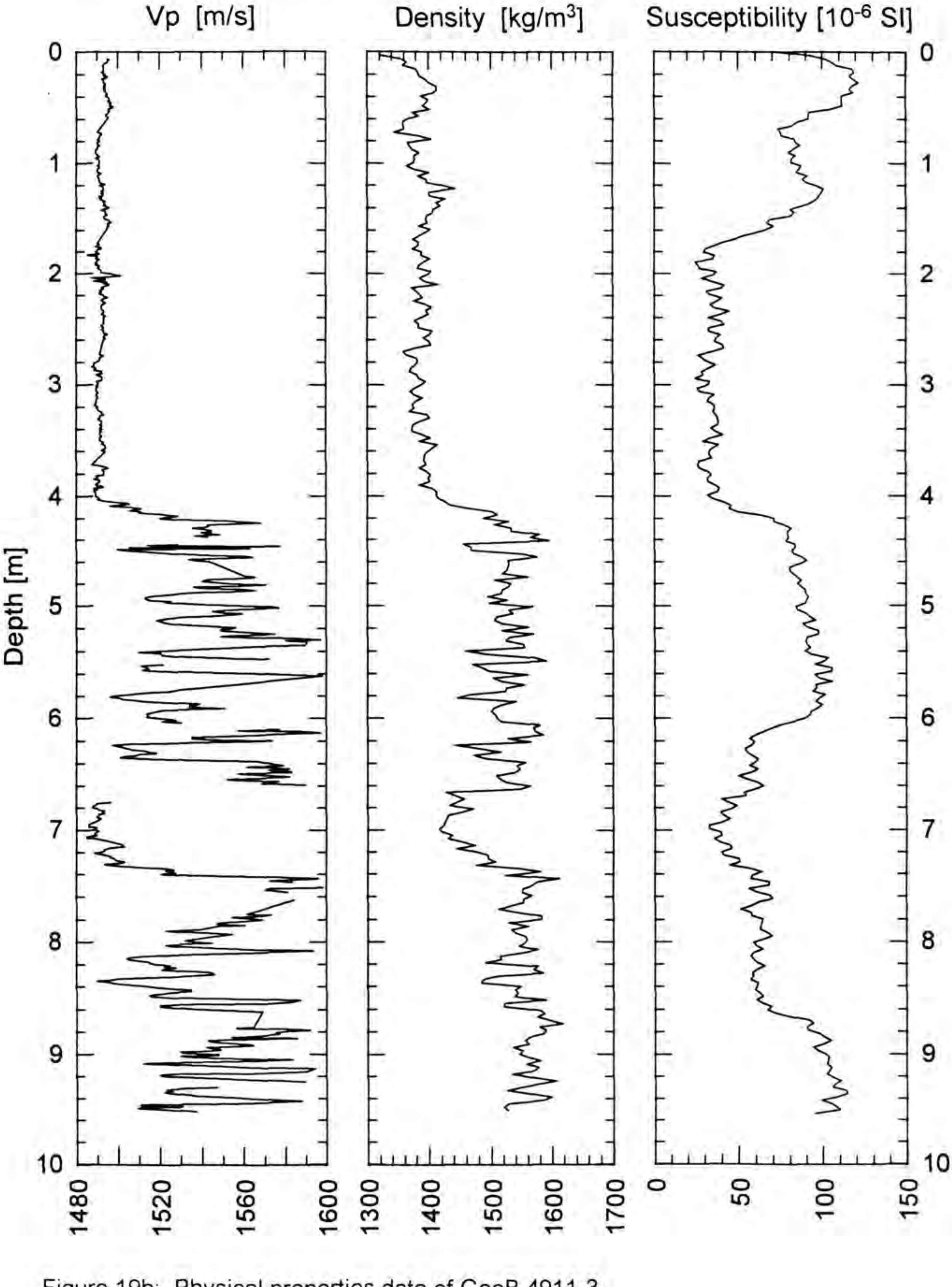

Figure 19b: Physical properties data of GeoB 4911-3.

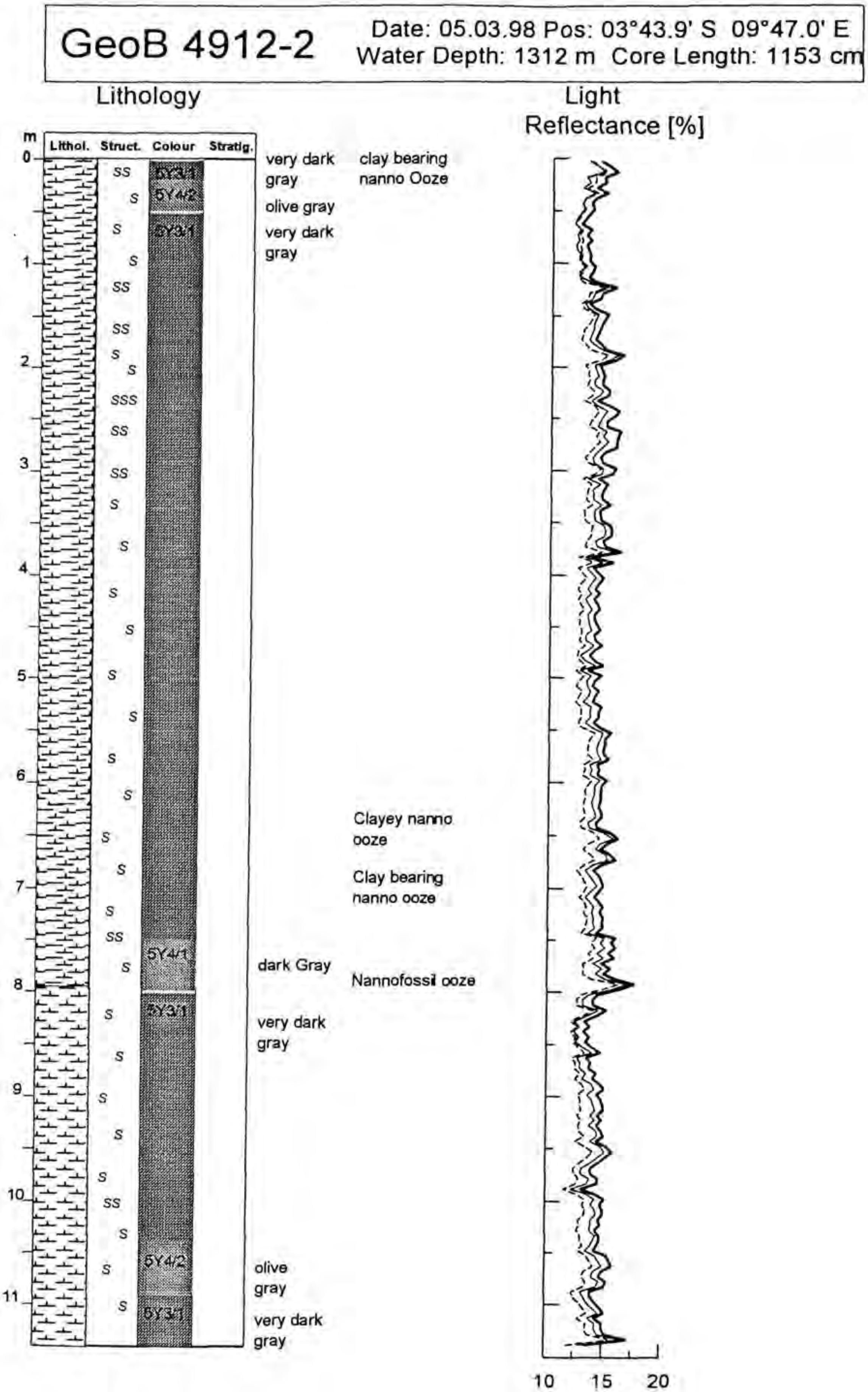

Figure 20a: Core description of GeoB 4912-2.

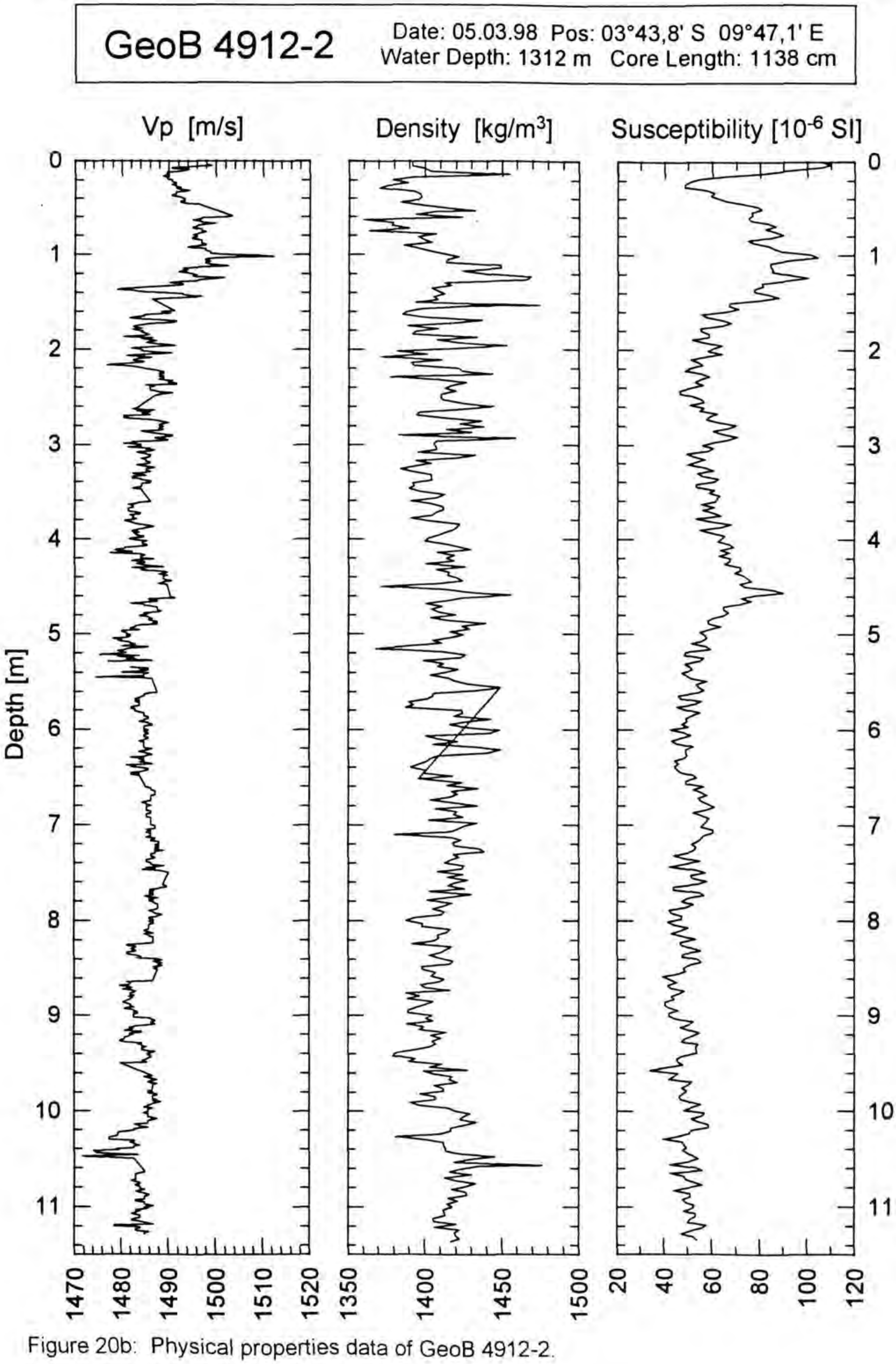

Figure 20b: Physical properties data of GeoB 4912-2.

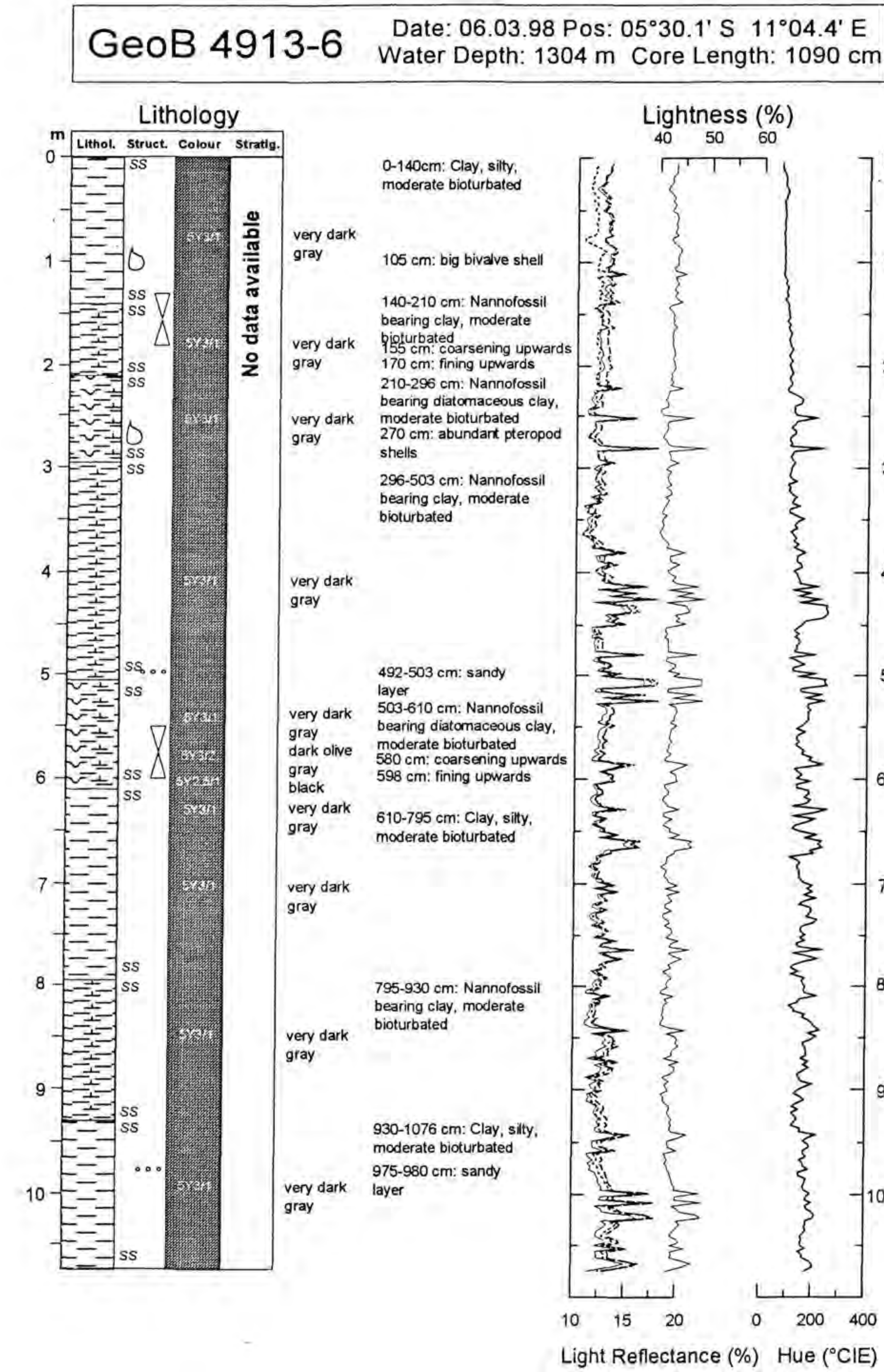

Figure 21a: Core description of GeoB 4913-6.

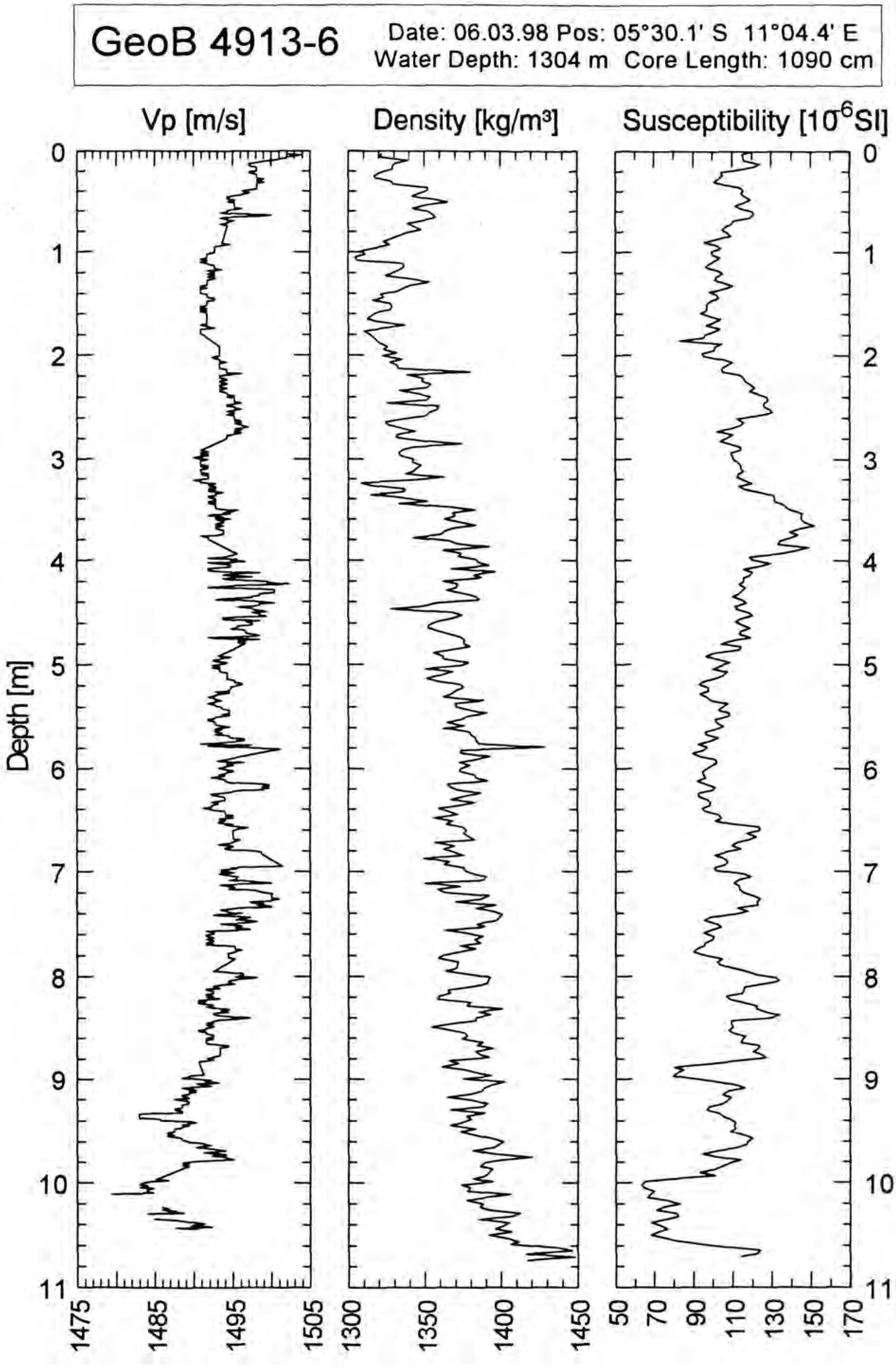

Figure 21b: Physical properties data of GeoB 4913-6.

GeoB 4915-4

Date: 09.03.98 Pos: 07°45.0°' S 11°52.4' E
Water Depth: 1302 m Core Length: 846 cm

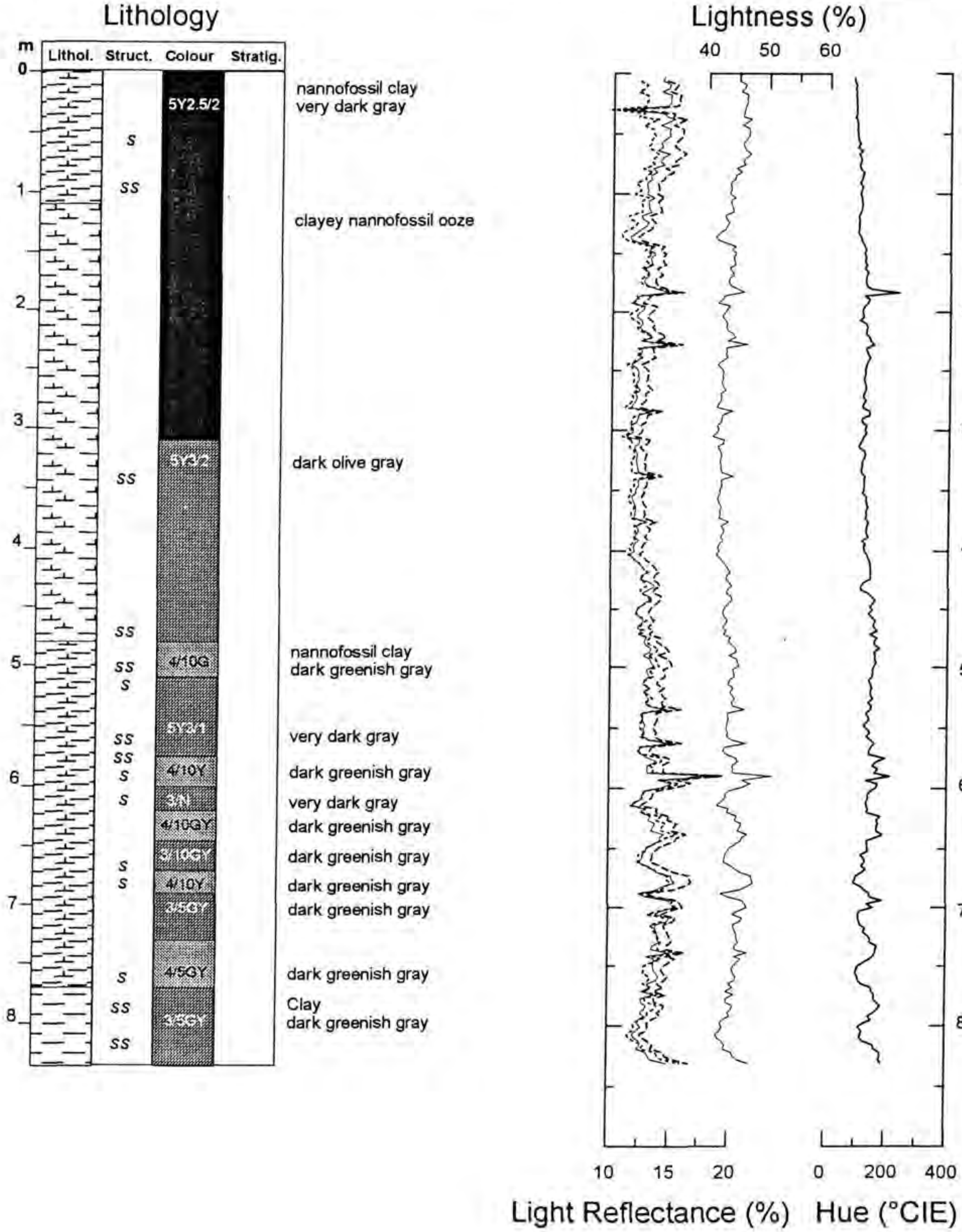

Figure 22a: Core description of GeoB 4915-4.

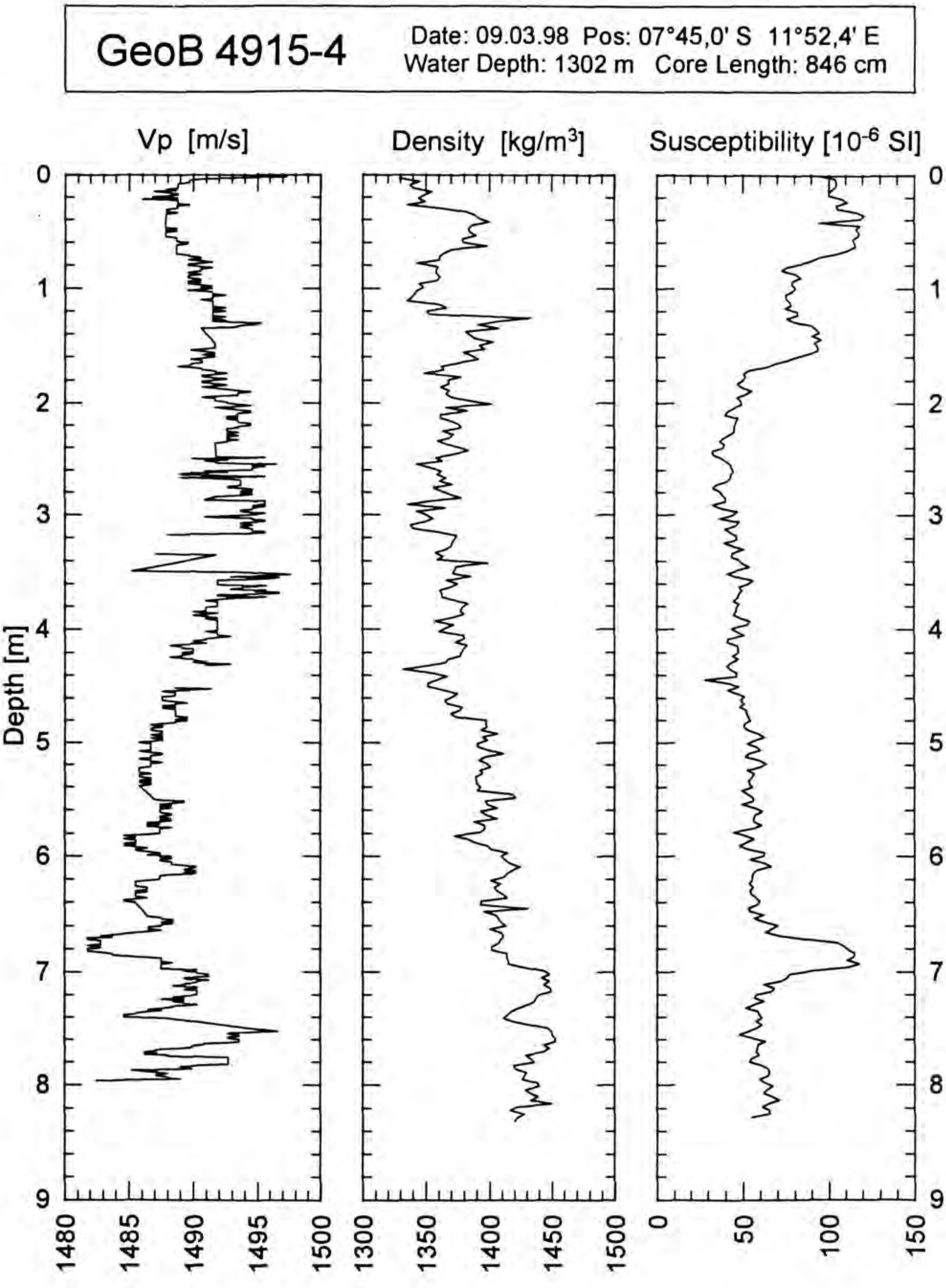

Figure 22b: Physical properties data of GeoB 4915-4.

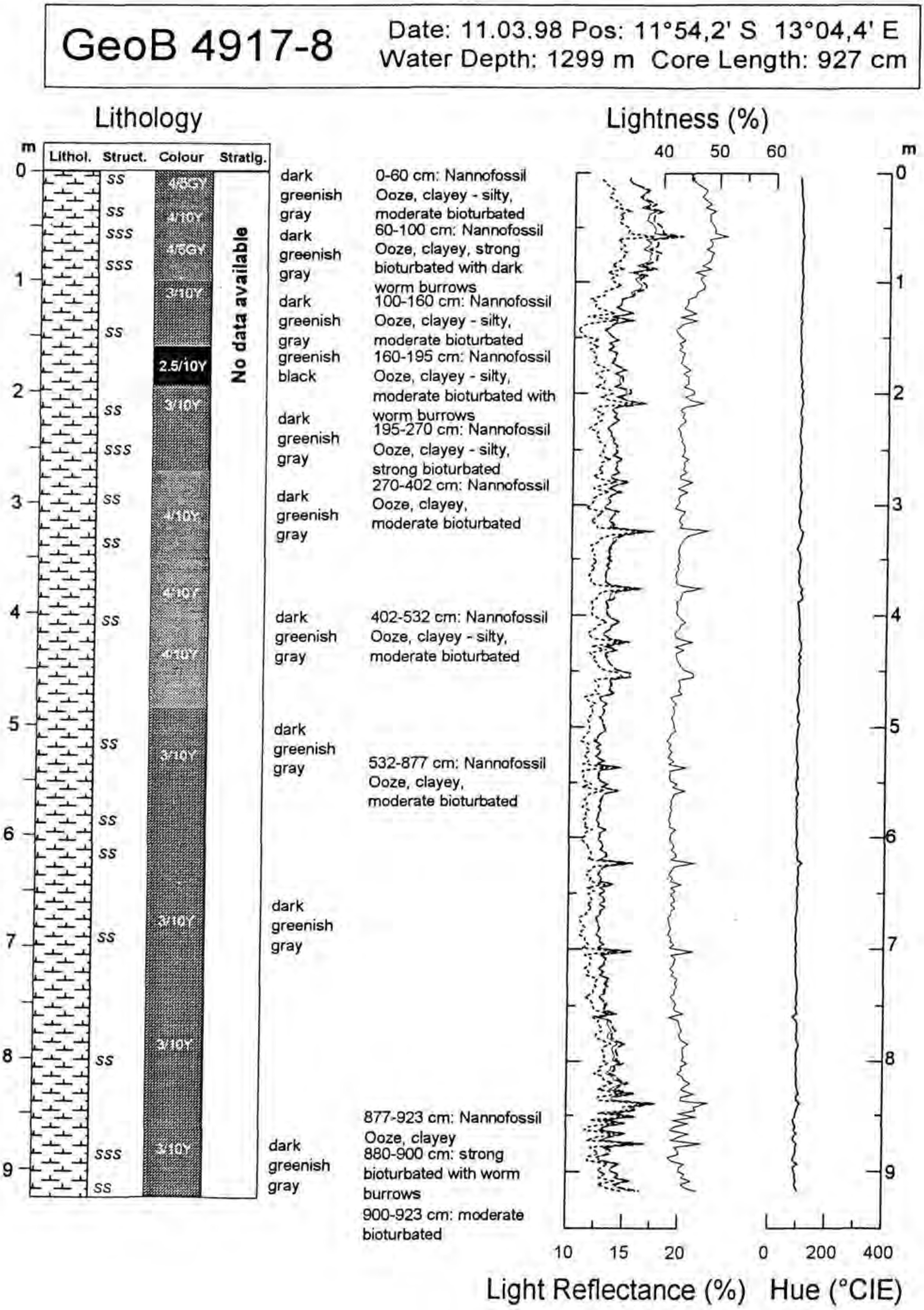

Figure 23a: Core description of GeoB 4917-8.

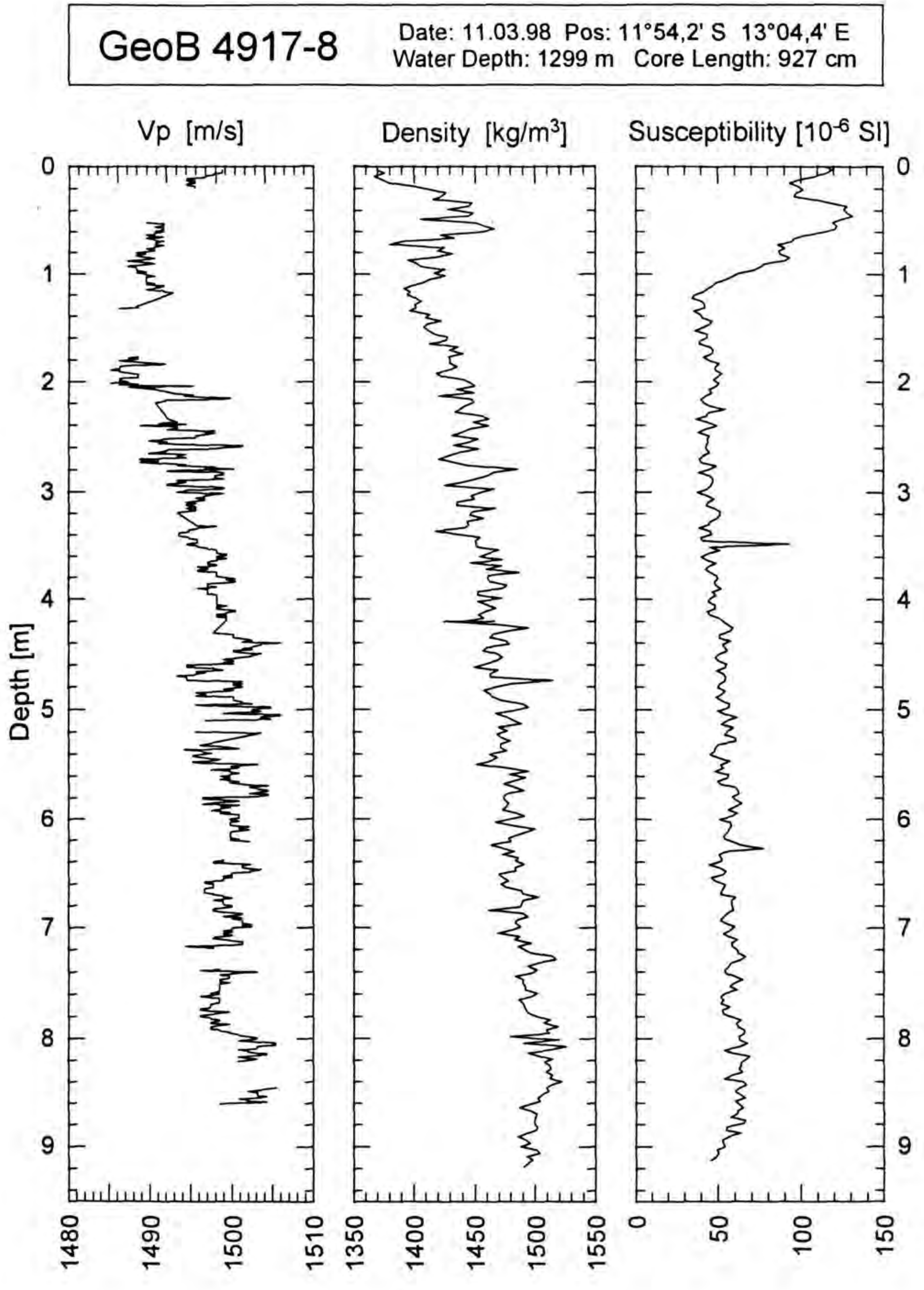

Figure 23b: Physical properties data of GeoB 4917-8.

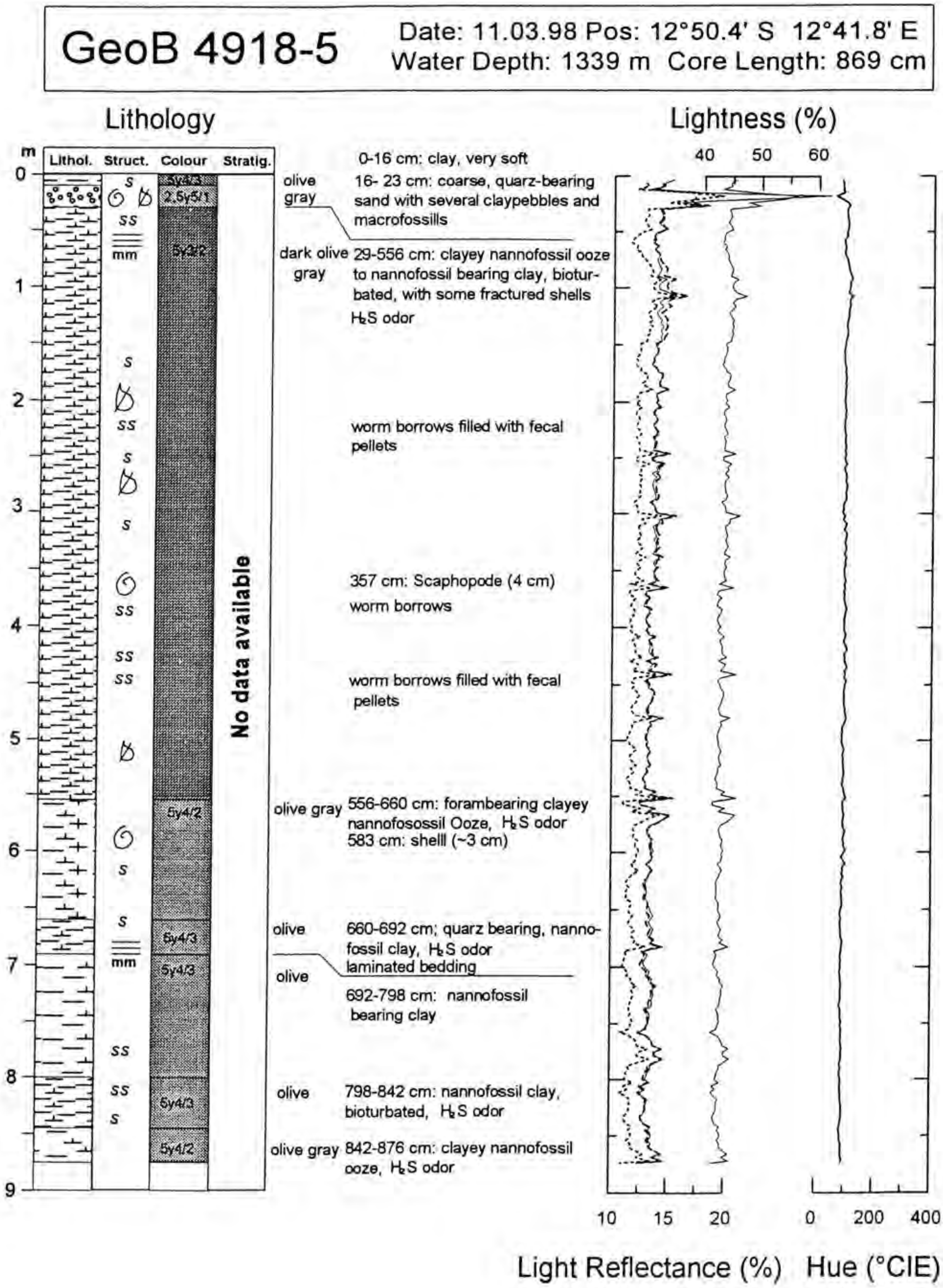

Figure 24a: Core description of GeoB 4918-5.

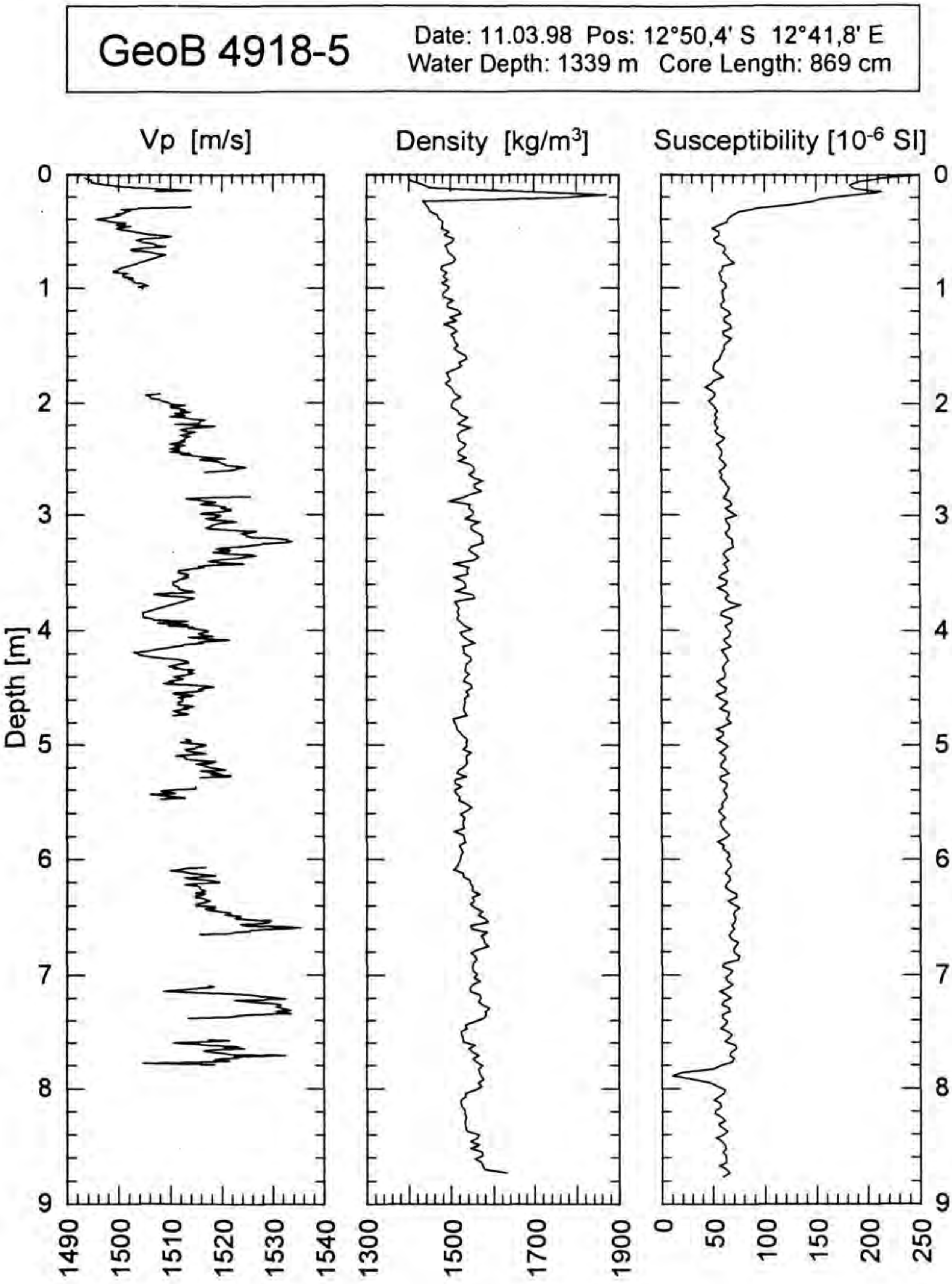

Figure 24b: Physical properties data of GeoB 4918-5.

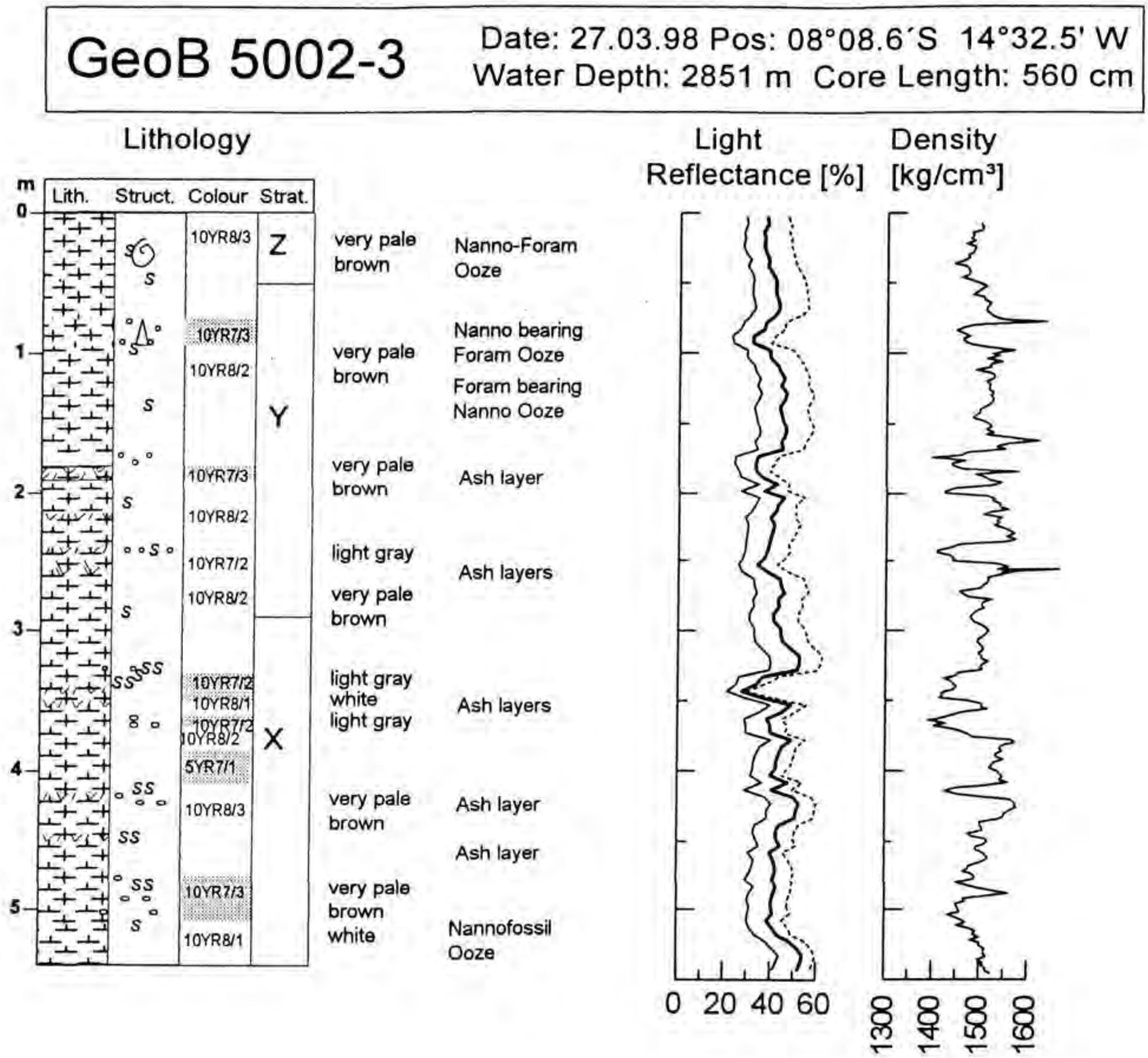

Figure 25: Core description of GeoB 5002-3.

GeoB 5006-2 Date: 04.04.98 Pos: 09°45,6' S 12°22,1' W
Water Depth: 3244 m Core Length: 571 cm

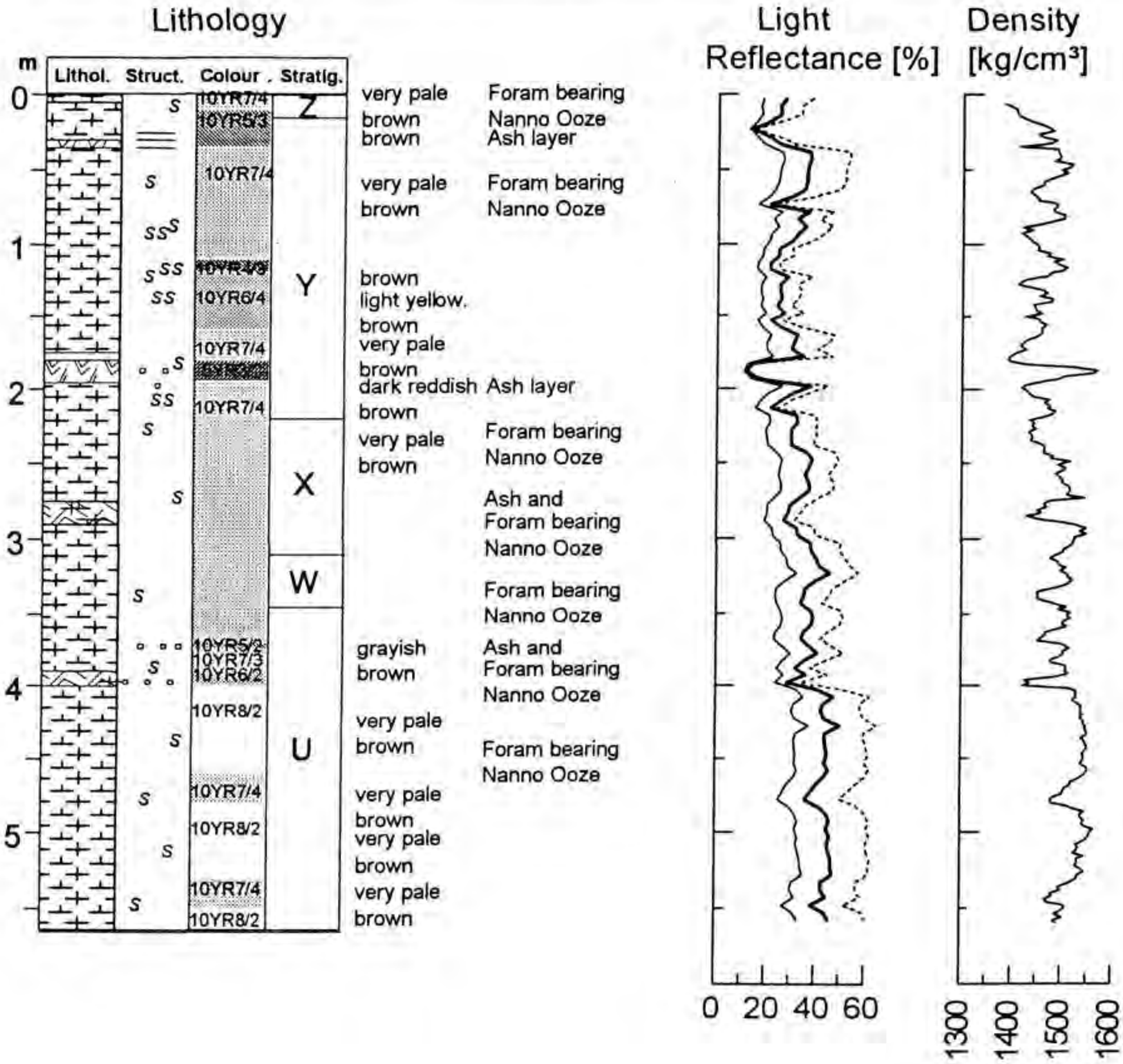

Figure 26: Core description of GeoB 5006-2.

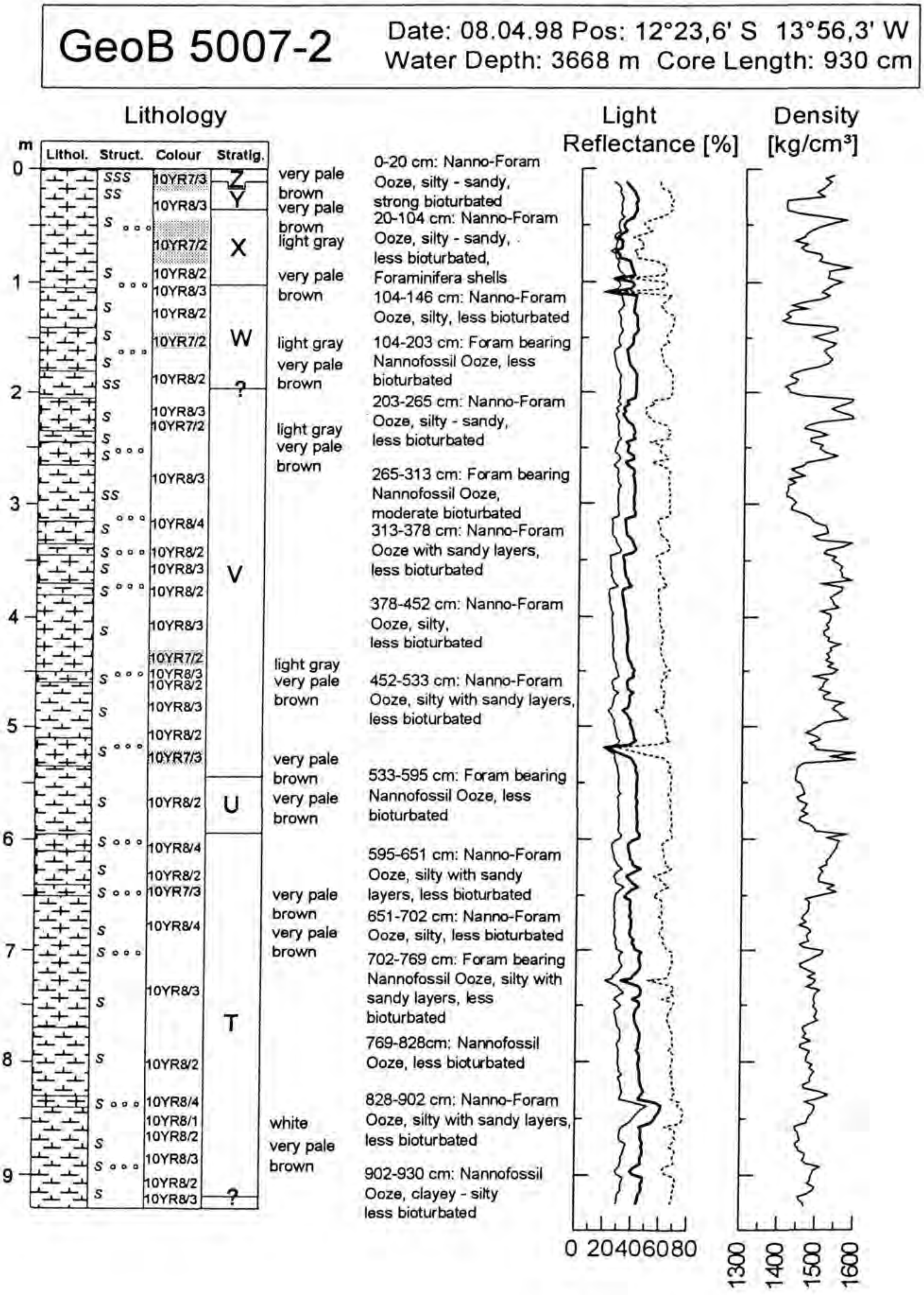

Figure 27: Core description of GeoB 5007-2.

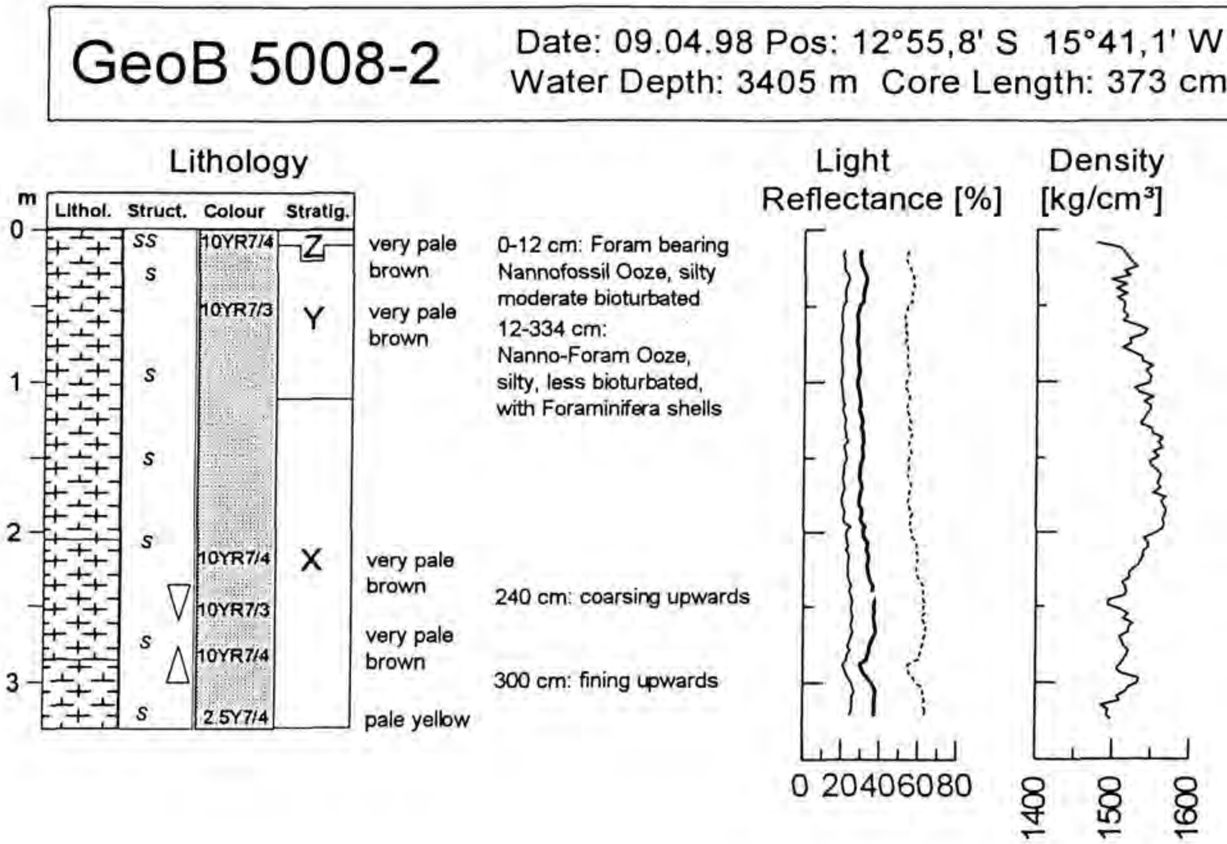

Figure 28: Core description of GeoB 5008-2.

Table 4: List of smear slide analysis.

GeoB 4901-8

Depth (cm)	Silt (%)	Clay (%)	Quartz (%)	Clay (%)	Acces. Min. (%)	Pyrite (%)	Fora-Minifers (%)	Nanno-fossils (%)	Diatms (%)	Radio-larians (%)	Spoge Spicules (%)	Silico-flagellates (%)	Plant Debris (%)	Name
1	10	90	0	30	1	2,5	2,5	40	15	2,5	5	1,5	0	Cb-DNO
20	10	90	1	25	2	1	3	40	10	10	7	1	0	Cb-DNO
115	10	90	0	25	1	0,5	2	46	15	1,5	6	2	1	Cb-DNO
190	10	90	0	25	2	0,5	3	41	15	1	10	1	1,5	Cb-DNO
280	10	90	0	30	1	1	3	40	11	1	10	2	1	Cb-DNO
400	15	85	0	25	1,5	0,5	2,5	42	13	1,5	11	1,5	1,5	Cb-DNO
500	15	85	0	25	2	1	3	40	10	1	15	2	1	Cb-DNO
590	20	80	0	20	3	1	3	44	10	1	15	1	2	Cb-DNO
690	30	70	0	15	2	1	2	44	10	2	20	1	3	Cb-DNO
790	30	70	0	15	1	0	3	35	15	2	25	3	1	Cb-DNO
890	20	80	0	25	2	1	2	40	10	5	10	3	2	Cb-DNO
990	20	80	2	30	2	1	3	40	10	1	8	1	2	Cb-DNO
1090	20	80	0	35	3	1	2	35	8	3	10	2	1	Cb-SiNO
1190	30	70	5	30	2	1	5	40	5	2	8	1	1	Cb-NO
1280	35	65	10	25	1	0	10	46	0	1	5	2	0	Cb-FNO
1340	35	65	10	25	1	1	10	38	2	5	5	2	1	Cb-FNO
1390	30	70	5	30	2	1	5	35	8	2	8	2	2	Cb-SiNO
1490	35	65	3	25	2	1	10	40	10	2	4	2	1	Cb-DNO
1560	35	65	3	25	2	1	5	38	12	2	8	2	2	Cb-NO
1660	30	70	5	30	3	1	5	40	8	1	3	3	1	Cb-DNO
1760	35	65	2	25	2	2	3	40	10	2	10	2	2	Cb-DNO
1930	30	70	1	30	3	1	3	38	10	2	8	2	2	Cb-DNO
2020	35	65	5	25	2	1	4	40	8	2	10	2	1	Cb-NO

GeoB 4902-3

Depth (cm)	Silt (%)	Clay (%)	Quartz (%)	Clay (%)	Acces. Min. (%)	Pyrite (%)	Fora-Minifers (%)	Nanno-fossils (%)	Diatms (%)	Radio-larians (%)	Spoge Spicules (%)	Silico-flagellates (%)	Plant Debris (%)	Name
1	30	70	2	23	3	2	5	30	10	2	15	3	5	clb-SiNO
40	20	80	2	25	2	0	6	35	10	3	15	2	0	cl-SiNO
140	25	75	1	25	2	0	2	35	10	1	20	4	0	clb-SiNO
240	30	70	0	26	3	0	2	30	10	1	25	1	2	cl-SiNO
340	30	70	1	25	2	0	2	28	15	2	20	2	3	cl-SiNO
440	25	75	1	30	2	0	0	26	15	2	20	2	2	cl-SiNO
540	20	80	3	30	2	0	2	27	15	3	15	1	2	cl-SiNO
640	20	80	2	25	3	0	2	30	15	2	18	3	0	cl-SiNO
865	15	85	4	20	2	0	3	35	10	5	20	1	0	clb-SiNO
960	15	85	3	23	3	0	5	35	8	3	15	3	2	clb-SiNO
1060	20	80	1	28	3	0	5	35	8	3	12	3	2	cl-SiNO
1160	25	75	1	25	5	1	5	30	8	2	15	3	5	cl-SiNO
1260	20	80	2	30	4	0	3	25	10	2	20	3	1	cl-SiNO
1330	25	75	1	30	2	0	10	40	3	5	5	2	2	cl-FNO
1379	25	75	1	30	3	0	5	30	10	2	15	2	2	cl-SiNO
1425	30	70	1	30	3	0	4	28	7	3	20	2	2	cl-SiNO
1463	30	70	1	28	3	0	5	35	8	2	15	2	1	cl-SiNO
1560	30	70	1	30	1	1	8	33	9	3	10	3	1	cl-SiNO
1660	20	80	1	30	2	0	4	32	8	3	15	1	4	cl-SiNO
1760	30	70	0	25	3	0	1	30	10	5	22	1	3	cl-SiNO
1860	20	80	0	25	1	0	2	30	7	5	27	3	0	cl-SiNO
1960	25	75	2	26	2	0	1	32	8	3	22	3	1	cl-SiNO
2060	30	70	1	30	2	0	1	30	10	3	20	2	1	cl-SiNO
2160	25	75	1	30	2	0	1	30	10	2	20	2	2	cl-SiNO
2240	25	75	2	30	3	0	1	28	12	2	18	2	2	cl-SiNO

GeoB 4905-4

Depth (cm)	Silt (%)	Clay (%)	Quartz (%)	Clay (%)	Acces. Min. (%)	Pyrite (%)	Fora-Minifers (%)	Nanno-fossils (%)	Diatms (%)	Radio-larians (%)	Spoge Spicules (%)	Silico-flagellates (%)	Plant Debris (%)	Name
80	15	85	5	50	2	1	5	20	5	2	8	2	0	sib-NCl
180	15	85	5	40	3	0	3	22	8	2	15	2	0	sib-NCl
280	5	95	5	60	3	1	2	15	2	2	10	0	0	sib-NCl
380	10	90	5	60	3	2	2	15	5	2	5	0	1	NCl
551	25	75	5	50	5	2	5	10	8	3	8	2	2	sib-NCl
580	25	75	5	40	3	1	5	30	5	0	10	0	1	sib-NCl
680	20	80	8	45	3	0	5	22	5	0	10	1	1	sib-NCl
780	30	70	5	30	4	0	3	25	10	5	15	2	1	cb-DNO
980	25	75	5	30	3	0	3	23	15	2	15	2	2	cb-DNO
1180	30	70	5	30	3	0	5	30	10	2	13	1	1	cb-siNO

Table 4: continued

GeoB 4909-4

Depth (cm)	Silt (%)	Clay (%)	Quartz (%)	Clay (%)	Acces. Min. (%)	Pyrite (%)	Fora-Minifers (%)	Nanno-fossils (%)	Diatms (%)	Radio-larians (%)	Spoge Spicules (%)	Silico-flagellates (%)	Plant Debris (%)	Name
80	30	70	10	30	4	0	20	35	0	0	1	0	0	cl-FNO
180	40	60	15	28	5	0	15	30	1	0	5	1	0	cl-FNO
380	40	60	20	25	5	0	15	30	0	0	5	0	0	cl-FNO
580	50	50	30	23	10	0	10	25	0	0	2	0	0	f-NCl
660	40	60	20	30	5	0	15	24	1	0	5	0	0	f-NCl

Core **GeoB 4917-8** (position: 11°54.2'S 13°04.4'E; water depth: 1299 m, length; 927 cm)

Core GeoB 4917-8 is dominated by generally moderate bioturbated nannofossil ooze. The more uniform lithology changes between silty to clayey and clayey grain sizes. In the depths between 60 to 100 cm, 160 to 195 cm and 880 to 900 cm the sediment is somewhat stronger bioturbated by worm burrow. Color changes from dark greenish gray to greenish black. A H2S odor were perceived at some depths. Core

Core **GeoB 4918-5** (position: 12°50.4'S 12°41.8'E; water depth: 1339 m, length: 869 cm)

Core GeoB 4918-5 consists mainly of nannofossil clay or clayey nannofossil ooze. From the top down to a depth of 23 cm the sediment is quartz-bearing sand with several clay pebbles. Within the depth interval 660-692 cm, core consists of quartz bearing nannofossil clay. The entire core is moderately bioturbated. Worm burrow of filled with fecal pellets can be observed at several depth. At 357 cm a scaphopode shell of 4 cm is observed. The core is little to moderate bioturbated. Color changes between olive and dark olive gray. At several depth a strong H2S odor was perceptible.

Core **GeoB 5002-3** (position: 08°08.6'S 14°32.5'W, water depth: 2849 m, length 560 cm)

The uppermost 76 cm of the core consist of a very pale brown nanno-foram ooze. From a depth of 96 to 525 cm it consists of very pale brown to light gray foram-bearing nannofossil ooze. Below 525 cm the sediment is made up by white nannofossil ooze. At a depth interval of 76 to 96 cm a sandy layer fining upwards can be observed. At several positions in the core ash layers, usually few millimeters thick, made up by volcanic glass were found. There are additional sandy layers at different depths often associated with basal ash layers. The entire core is moderately to strongly bioturbated.

Core **GeoB 5004-3** (position 09°10.0'S 13°20.4'W, water depth: 2789 m, length: 67 cm): Core GeoB 5004-3 consists entirely of very pale brown foraminiferal nannofossil ooze, with foraminifer-bearing nannofossil ooze intercalated in the depth intervals 35 to 40 cm and 45 to 50 cm. The entire core is moderately bioturbated.

Core **GeoB 5006-2** (position: 09°45.6'S 12°22.1'W, water depth: 3244 m, length: 571 cm)

The entire core GeoB 5006-2 consists of foram-bearing nanno-ooze. At distinct layers the sediment is enriched in volcanic glass, resulting in ash layers at depths of 30 and 185 cm. Minor glass content was observed at 275 and 390 cm. Lamination can be observed between 30 and 33 cm. Sandy layers are found at 185, 275, and 390 cm. Bioturbation is strong in the upper two meters and moderate from 2 meters down to the end of core GeoB 5006-2. In general, the sediment color is very pale brown. Major changes in color are associated with ash and sandy layers.

Core **GeoB 5007-2** (position: 12°23.6'S 13°56.3'W, water depth: 3668 m, length: 934 cm)

This core consists of white to light gray and very pale brown nanno-foram ooze or foram bearing nannofossil ooze. The lithology changes between silty to sandy grain sizes. At the top, the core is strong bioturbated. Beneath the top the core is mainly less bioturbated, only between 265 to 313 a moderate bioturbation is observed. Throughout the whole core sandy layers (up to 5 cm thick) can be observed. The base of the core extends into biozone T considering preliminary stratigraphic data. The mean sedimentation rate of core GeoB 5007-2 was hereafter about 1.1 cm / ka. Generally, the estimated sand content is variable, suggesting climate controlled changes in marine bio-production.

Core **GeoB 5008-2** (position: 12°55.8'S 15°41.1'W, water depth: 3405 m, length: 373 cm)

The dominant lithology of this core is silty foram bearing nannofossil ooze (0 - 12 cm) and silty nanno-foram ooze (12 - 234 cm). The whole core is generally less bioturbated, only at the top the bioturbation increase. Between 270 to 240 cm the sediment coarsening upwards, as between 300 to 270 cm the sediment fining upwards. The colors range from pale yellow to very pale brown. Considering preliminary stratigraphic data the base of the core extends into biozone X and the mean sedimentation rate was about 1.3 cm / ka.

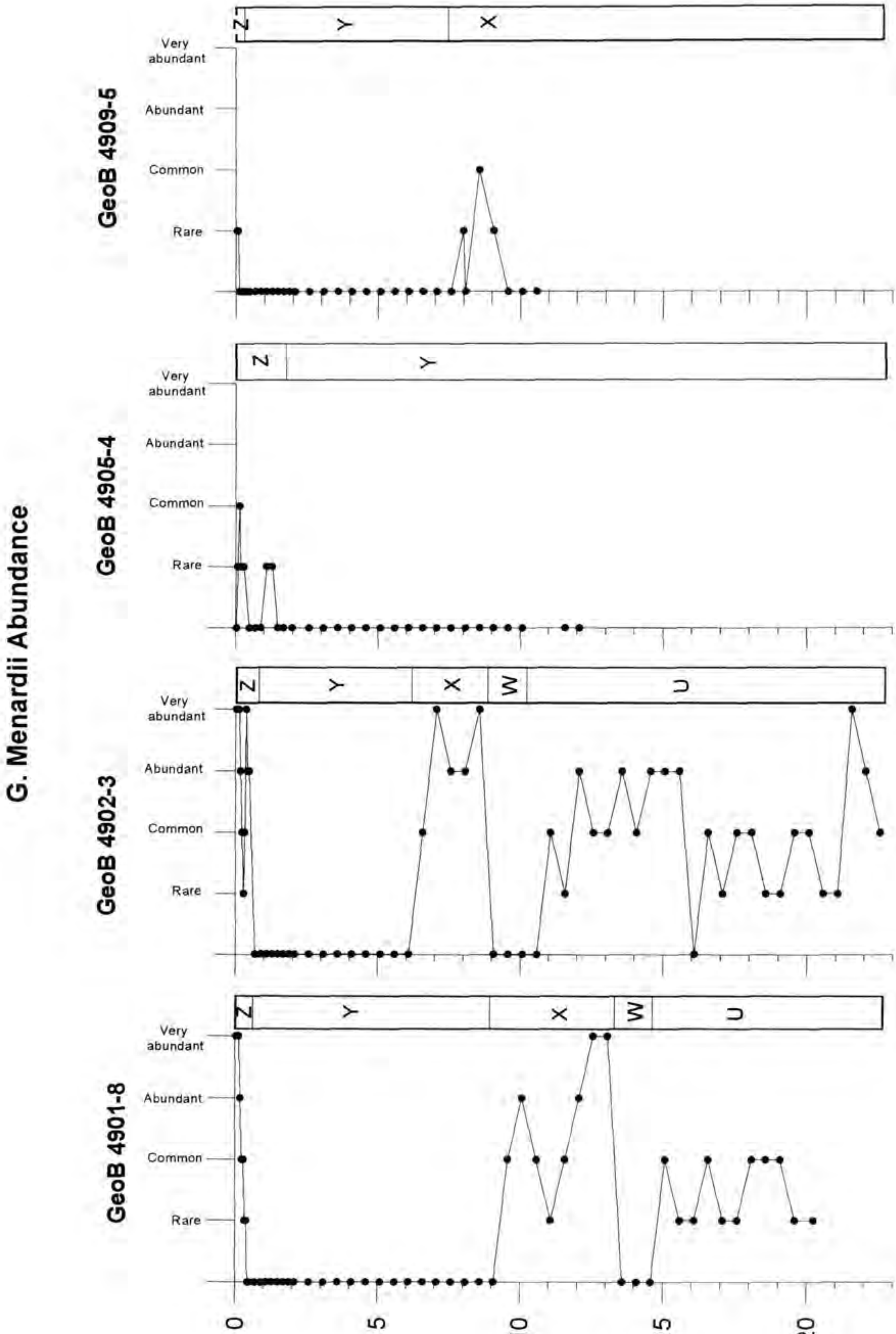

Figure 29a: Biostratigraphic analysis of GeoB 4901-8, 4902-3, 4905-4, and 4909-5.

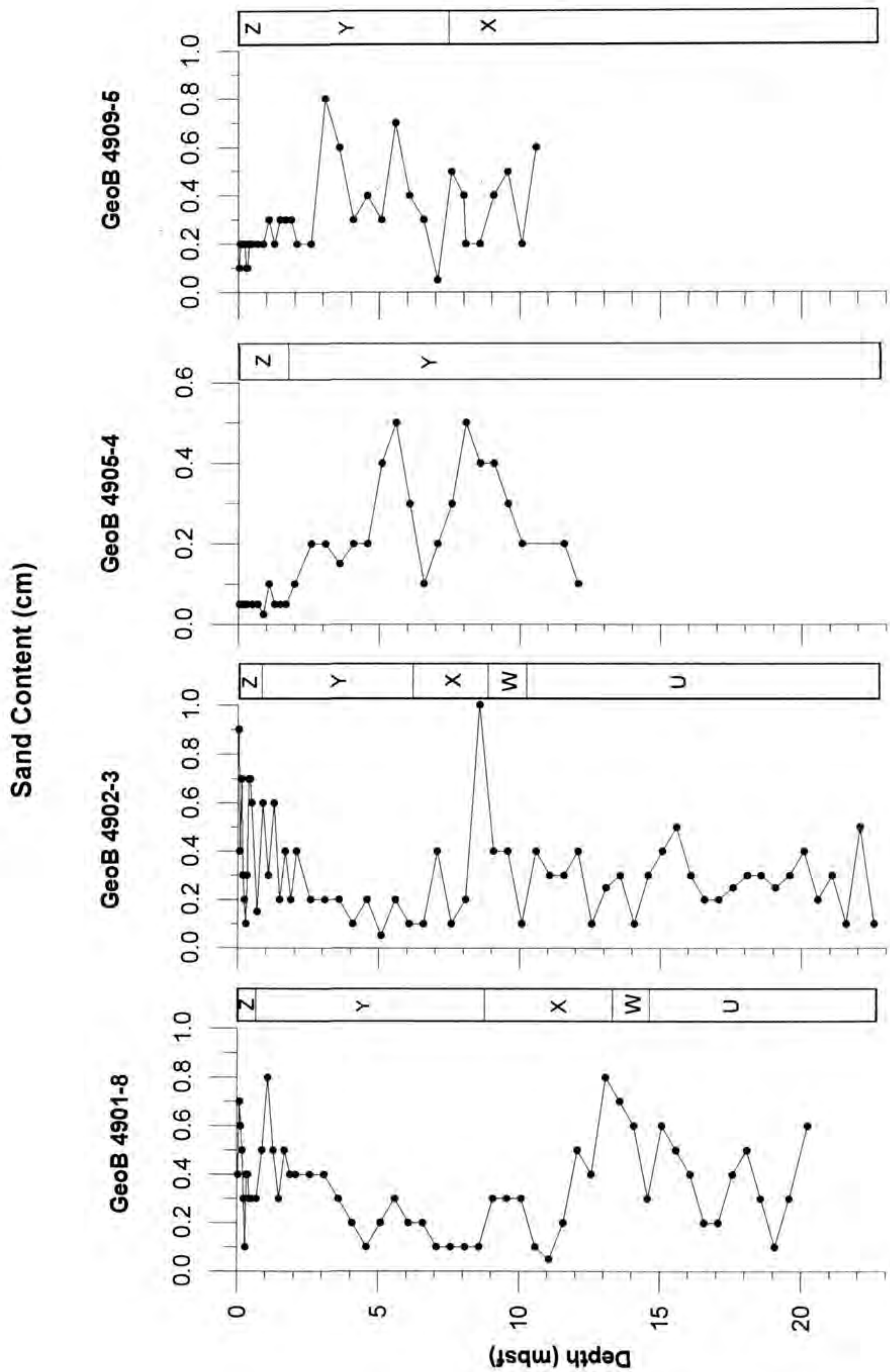

Figure 29b: Stratigraphic analysis of GeoB 4901-8, 4902-3, 4905-4, and 4909-5.

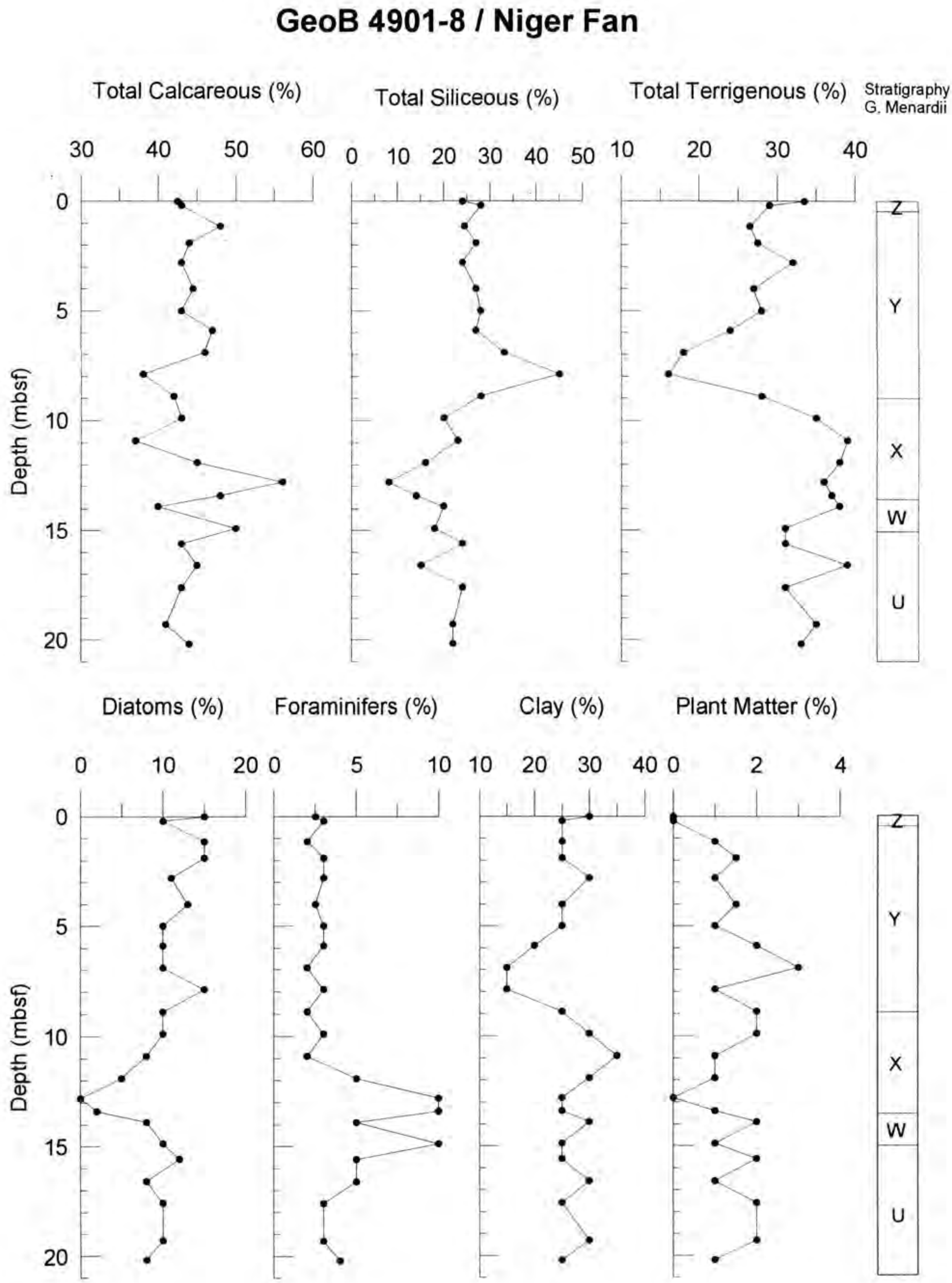

Figure 30: Results of smear slide analysis (GeoB 4901-8).

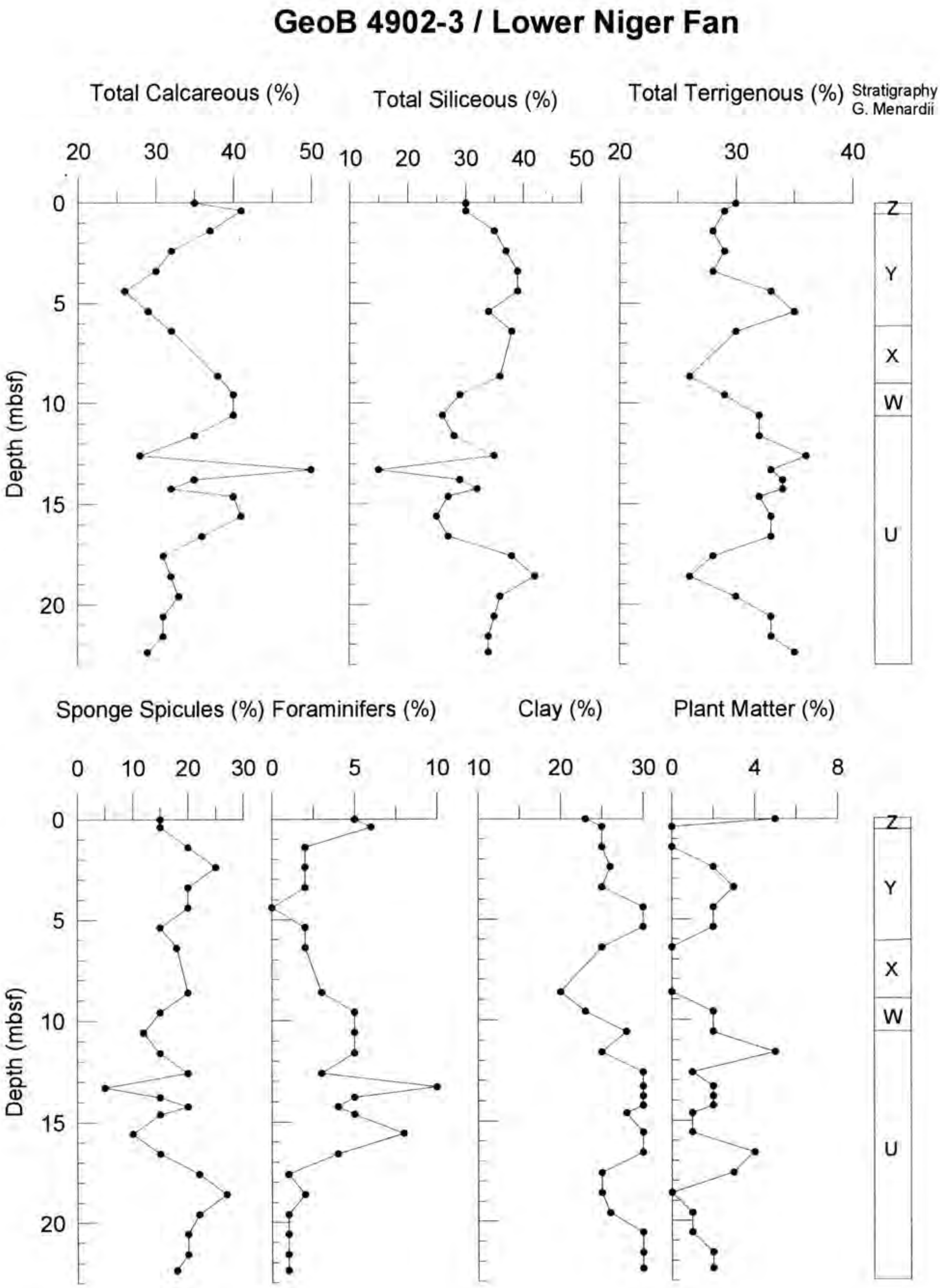

Figure 31: Results of smear slide analysis (GeoB 4902-3).

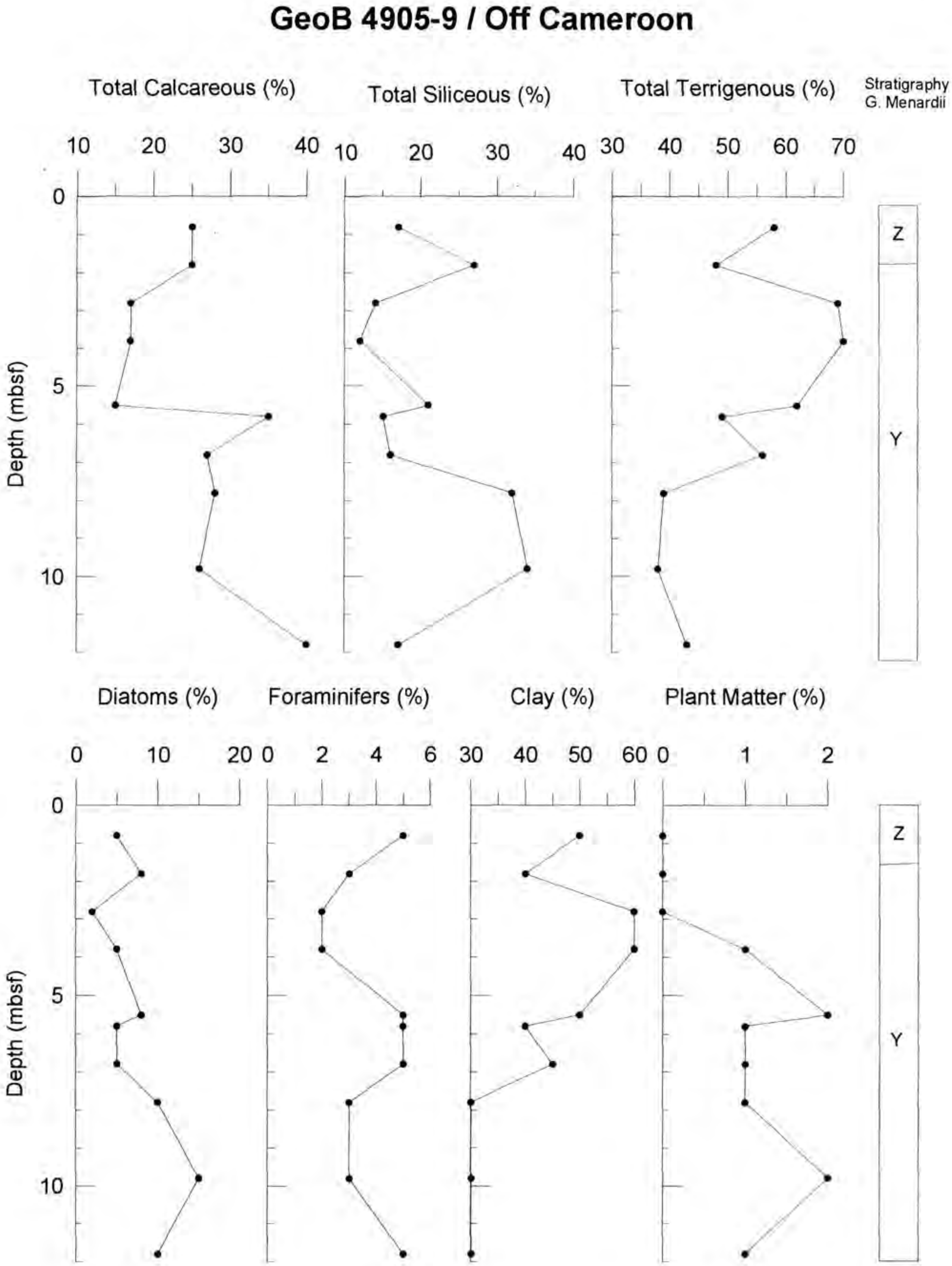

Figure 32: Results of smear slide analysis (GeoB 4905-9).

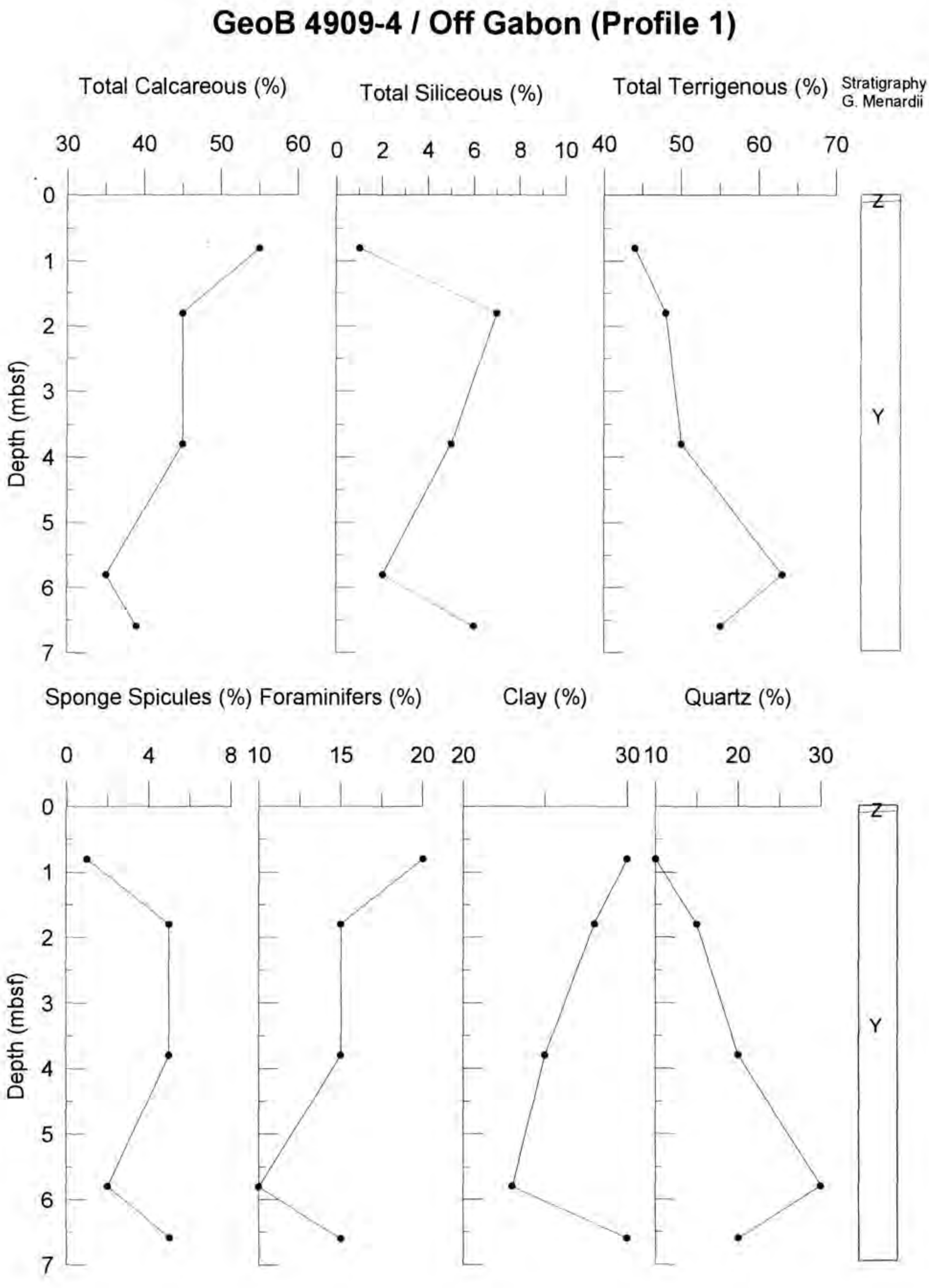

Figure 33: Results of smear slide analysis (GeoB 4909-4).

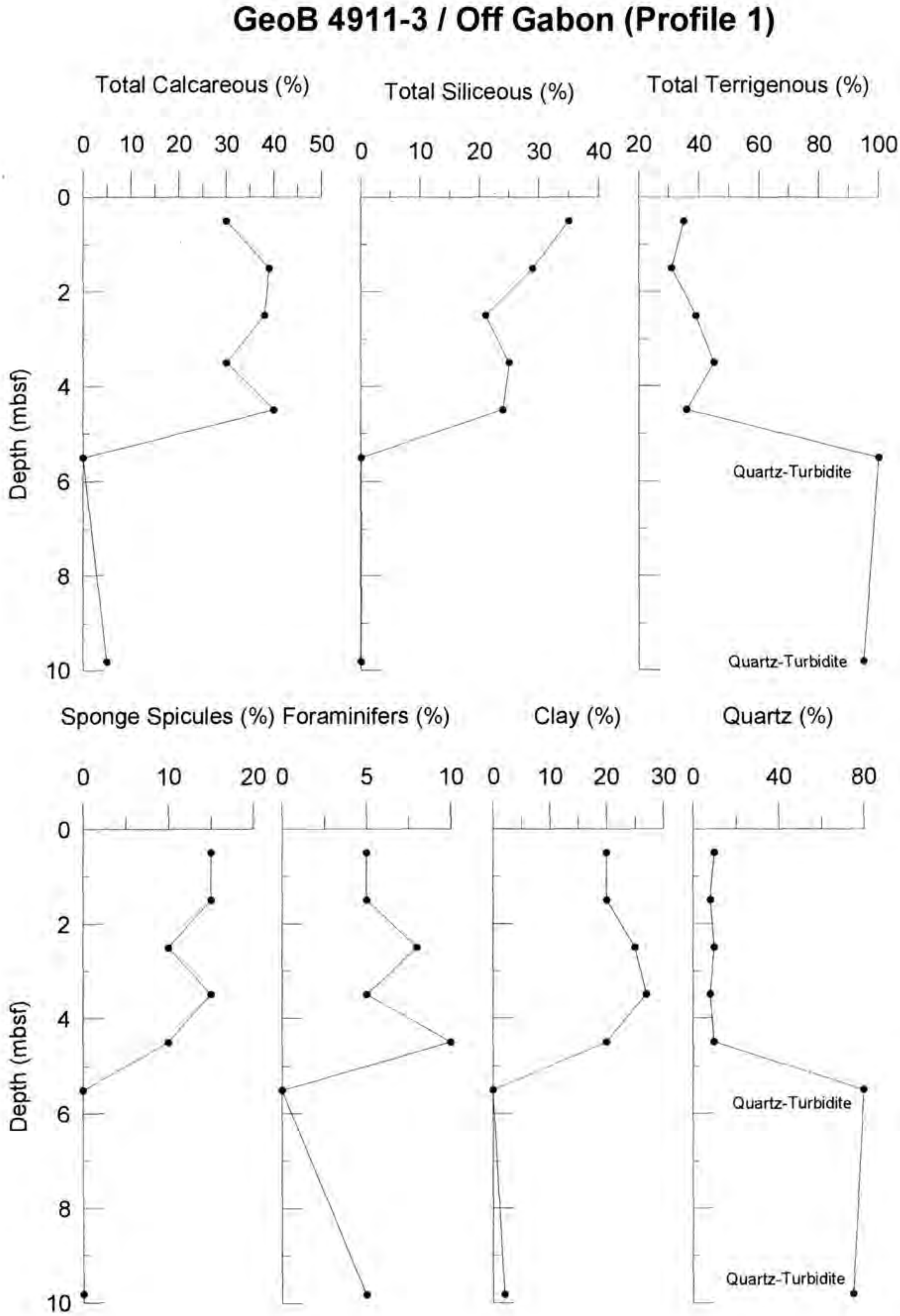

Figure 34: Results of smear slide analysis (GeoB 4911-3).

4.4 Physical Properties Studies

(K. Däumler, J. Funk, C. Hilgenfeldt, H. von Lom-Keil)

The complete sediment series recovered with the gravity corer during METEOR cruise M 41/1 were subjected to laboratory geophysical studies. Shipboard measurements on the segmented cores routinely comprised three basic physical parameters:

- compressional (p-) wave velocity v_p,
- electric resistivity R_S (as a measure of density and porosity)
- magnetic volume susceptibility κ.

These properties are closely related to lithology and grain-size of the sediments and provide high-resolution core logs (spacing 1 cm for p-wave velocity, 3 cm for electric resistivity and magnetic volume susceptibility) available prior to all other detailed investigations. In addition, oriented samples for subsequent shore based rock and paleomagnetic studies were taken at typically 10 cm intervals.

4.4.1 Physical Background and Experimental Techniques

The experimental set ups for the shipboard measurements were basically identical to those of previous cruises. Their descriptions are therefore kept brief here. A more detailed treatment of the experimental procedures are given in WEFER et al. (1991) for R_S and SCHULZ et al. (1991) for v_p.

P-Wave Velocity

The p-wave velocity v_p is derived from digitally processed ultrasonic transmission seismograms recorded perpendicular to the core axis with a fully automated logging system. First arrivals are picked using a cross-correlation algorithm based on the 'zero-offset' signal of the piezoelectric wheel probes. Combined with the core diameter d, the travel time of the first arrivals t yields a p-wave velocity profile with an accuracy of 1 to 2 m/s

$$v_p = (d - d_L) / (t - t_0 - t_L)$$

where d_L is the thickness of the liner walls, t_L the travel time through the liner walls and t_0 the 'zero-offset' travel time.

Following SCHULTHEISS and MCPHAIL (1989), a temperature calibration of v_p is effected using the equation

$$V_{20} = v_T + 3 \cdot (20 - T)$$

where v_{20} is the p-wave velocity at 20° C and T the temperature (in °C) of the core segment when logged. Simultaneously, the maximum peak-to-peak amplitudes of the transmission seismograms are evaluated to estimate attenuation variations along the sediment core. P-wave profiles can be used for locating strong as well as fine-scale lithological changes, e.g., turbidite layers or gradual changes in the sand, silt or clay content.

Electrical Resistivity, Porosity and Density

The electrical sediment resistivity R_S was determined using a handhold sensor with a miniaturized four-electrodes-in-line ('Wenner') configuration (electrode spacing: 4 mm). A rectangular alternating current signal is fed to the sediment about 1 cm below the split core surface by the two outer electrodes. Assuming a homogeneously conducting medium, the potential difference at the inner two electrodes will be directly proportional to the sediment resistivity R_S. An integrated fast resistance thermometer simultaneously provides data for a temperature correction.

According to the empirical ARCHIE's equation, the ratio of sediment resistivity R_S and pore water resistivity R_W can be approximated by a power function of porosity ϕ

$$R_S / R_W = k \cdot \phi^{-m}$$

Following a recommendation by BOYCE (1968), suitable for sea water saturated clay-rich sediments, values of 1.30 and 1.45 were used for the constants k and m, respectively. The calculated porosity ϕ is subsequently converted to wet bulk density ρ_{wet} using the equation (BOYCE, 1976)

$$\rho_{wet} = \phi \cdot \rho_f + (1 - \phi) \cdot \rho_m$$

with a pore water density ρ_f of 1030 kg/m^3 and a matrix density ρ_m of 2670 kg/m^3. For the sake of an unbiased uniform treatment of all cores, these empirical coefficients were not adapted to individual sediment lithologies at this stage. Nevertheless, at least relative density changes should be well documented.

Magnetic Volume Susceptibility

The magnetic volume susceptibility κ is defined by the equations

$$B = \mu_0 \cdot \mu_r \cdot H = \mu_0 \cdot (1 + \kappa) \cdot H = \mu_0 \cdot H + \mu_0 \cdot \kappa \cdot H = B_0 + M$$

with the magnetic induction B, the absolute and relative permeabilities μ_0 and μ_r, the magnetizing field H, the magnetic induction of free space B_0 and the volume magnetization M. As can be seen from the third term, κ is a dimensionless physical quantity. It records the amount to which a material is magnetized by an external magnetic field.

For marine sediments the magnetic susceptibility may vary from an absolute minimum value of around $-15 \cdot 10^{-6}$ (diamagnetic minerals such as pure carbonate or silicate) to a maximum of some $10.000 \cdot 10^{-6}$ for basaltic debris rich in (titano-) magnetite. In most cases κ is primarily determined by the concentration of ferrimagnetic minerals, while paramagnetic matrix components such as clays are of minor importance. High magnetic susceptibilities indicate high concentrations of lithogenic compounds / high iron (bio-)mineralization or low carbonate / opal productivity and vice versa. This relation may serve for the mutual correlation of sedimentary sequences which were deposited under similar global or regional conditions.

The measuring equipment consists of a commercial BARTINGTON M.S.2 susceptibility meter with a 125 mm loop sensor and a non-magnetic core conveyor system. Due to the sensor size, its sensitivity extents over a core interval of about 8 cm. Consequently, sharp susceptibility changes in the sediment column will appear smoothed in the κ core log.

4.4.2 Shipboard Results

Sampling Sites and Recovery

The gravity coring program of cruise M 41/1 concentrated primarily on the complex sedimentation environment of the Niger and Congo deep sea fans covering an area of about 3°N to 10°S and 6° to 13°E.

Sediments were retrieved from the eastern Niger Fan (GeoB 4901, GeoB 4902), northeast of San Thomé island (GeoB 4903), off Cameroon (GeoB 4905) and off northern Gabon (GeoB 4904). Coring stations GeoB 4906 - 4908 as well as GeoB 4909 - 4911 make up two bathymetric transects over the continental slope off Gabon from 3029 to 1308 m water depth. Further coring activities were the Congo Fan off Angola (GeoB 4914 - 4918). With coring station GeoB 4914 former locations GeoB 1009 and GeoB 1401 of METEOR cruises 6/6 (1988) and 16/6 (1991) were re-sampled.

Due to the generally very soft, clay-rich sediments the recovery was exceptional good with core lengths of 22 m. Physical properties measurements were performed on a total of 15 sediment cores with a cumulative length of 188 m (upper part of Figure 35).

Preliminary Results

Physical properties data are demonstrated in the lower part of Figure 35. Dots mark the median values of compressional wave velocity, density and magnetic susceptibility for each core, vertical bars denote their standard deviations. Each diagram is divided into four parts corresponding to the different working areas described above.

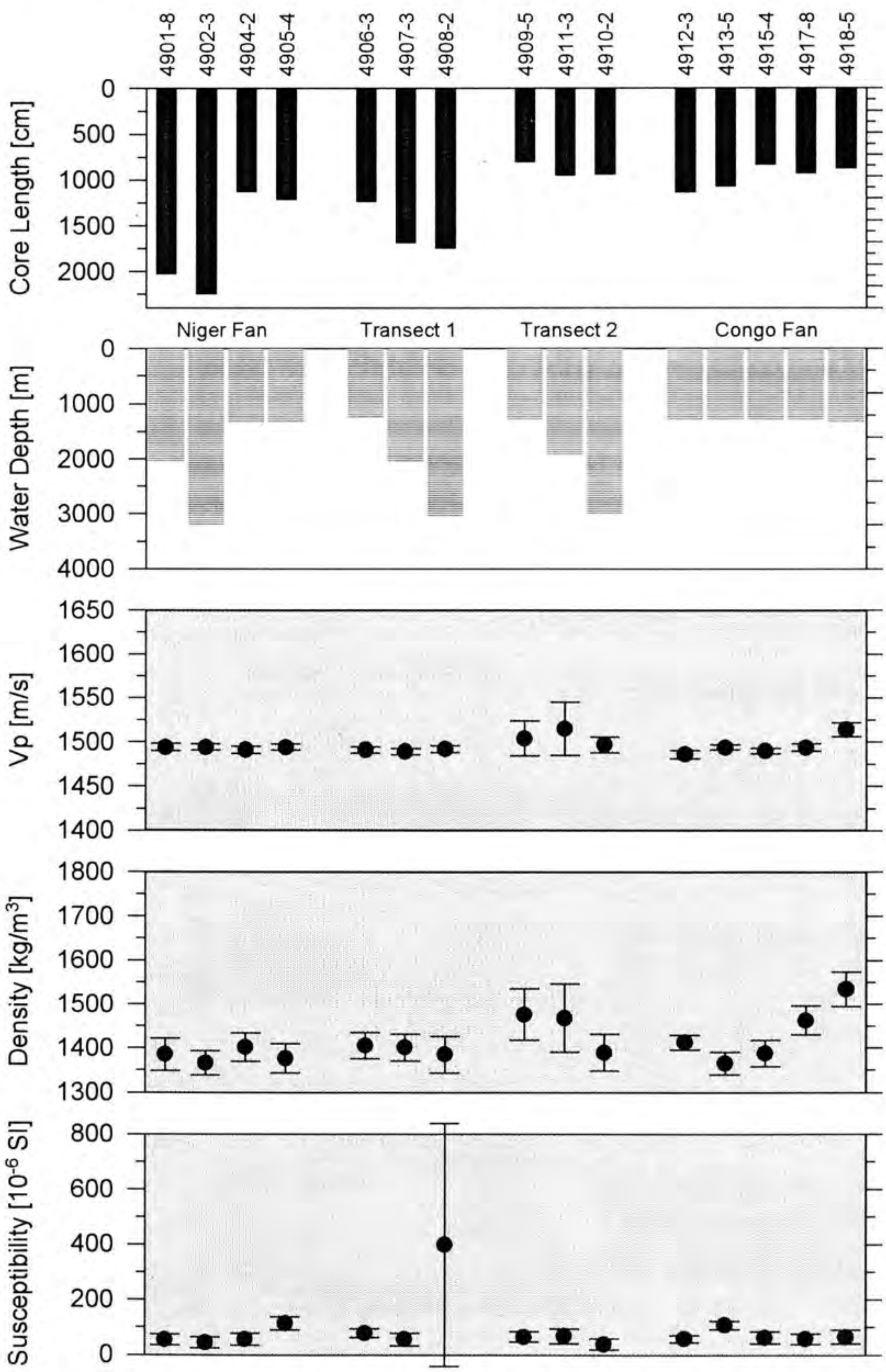

Figure 35: Mean compressional wave velocities, densities and magnetic susceptibilities of gravity cores GeoB 4901-8 through 4918-5 as compared to variations in water depth at the sampling sites and core recovery. The vertical bars denote standard deviations.

Detailed core logs are shown together with core descriptions (Figures 9 to 24).

The average p-wave velocities range between 1486 and 1515 m/s with low values reflecting high porosity (up to 80 %) and high clay contents. The v_p data display no obvious trends in relation to water depth or specific regional distinctions.

Measurements were frequently inhibited in lower core sections by H_2S and CH_4 degassing due to pressure release. Gas accumulations between core and liner and gas bubbles in the sediment matrix greatly attenuate the unltrasonic transmission and led to many data gaps also in the shallower core segments.

Mean densities, calculated on basis of porosity data, range from 1365 to 1534 kg/m^3. Compared to the Niger Fan sediments higher density values are found on Congo Fan sediments and on Transect 2 at the continental slope off Gabon.

Mean susceptibilities range between 38 and $399 \cdot 10^{-6}$ SI for the entire core collection. Core GeoB 4908-2 displays two significant susceptibility peaks (up to $3561 \cdot 10^{-6}$ SI), probably indicating thick volcanic ash layers. In none of the working areas an unequivocal relationship between susceptibility and water depth is observed.

4.5 Biogeochemical Studies

4.5.1 *In situ* Measurements of Organic Matter Decomposition

(S. Boehme, S. Meyer, F. Wenzhöfer)

On the leg M 41/1, we have deployed and recovered two free falling landers at the six stations GeoB 4901, 4904, 4906, 4909, 4913, 4917. Elinor is a free falling *in situ* chamber lander and Profilur is a free falling *in situ* profiling lander. All six stations were located along the 1300 m isobath. In addition to the lander data, lab profiles of oxygen were measured on multicorers at each of the geochemical stations.

Elinor

The pre-programmed free falling chamber lander is designed to incubate *in situ,* a sediment surface of 900 m^2 with overlying water column 10-15 cm high. The chamber is programmed to close after reaching the seafloor and a stirring mechanism is activated to create a diffusive boundary layer of approximately 0.7mm. At timed intervals, a 60 ml sample of chamber water is removed and stored until the incubation is complete. The lander is capable of collecting 8 samples and injecting a tracer if desired (At Stations 4913 and 4917, bromide was injected to study mixing by organisms). The lander is also equipped with two electrodes (in this case, one Clark type oxygen electrode and one pH electrode) inside the chamber and two oxygen optodes. One optode is located inside the chamber and the second is used to monitor oxygen outside the chamber. In order to quantify the remineralization rates in the surface sediments, the water samples collected during the incubations are analyzed for nutrients, alkalinity, manganese, iron, dissolved inorganic carbon, and calcium. Nutrients and alkalinity were measured on board. The rest of the analyses are done in Bremen.

At the end of the incubation, a shovel system closes and the incubated sediment and overlying water is transported to the surface intact. These sediments were sub cored for benthic foraminifera analyses, porosity, TOC, biomass, and pore water extraction. These samples will be used to compare the diffusive and total fluxes within the sediments and assess biomass.

Profilur

The pre-programmed free falling lander Profilur is designed to measure *in situ* profiles of various species with a depth resolution of 25 to 200µm. The electronic cylinder has microelectrode ports for 10 sensors (oxygen, pH, Ca^{2+} and H_2S sensors). These sensors are typically able to penetrate the sediment to a depth of 10 to 15 cm. The data are used to determine the depth of oxygen penetration as an indicator of remineralization rates and diffusive fluxes of the various measured parameters. In addition to the electrode measurements, Profilur also has a second electronic cylinder for micro-optode sensors (oxygen and CO_2). During this cruise, both CO_2 and Ca^{2+} sensors were utilized for the first time. The lander also carries a camera and flash for documentation of the sediment type and a Niskin bottle that is closed prior to resurfacing of the lander to collect samples for calibration and bottom water chemical analysis.

Laboratory

The in situ measurements were supported by shipboard incubations and subsequent measurement of oxygen profiles from sediment cores collected by multicorer. Incubations were performed at all of the stations where the pore water chemistry (See 4.5.3) is being analyzed for geochemical studies of remineralization.

Preliminary Results

An example of the data collected with an oxygen electrode from inside the Elinor chamber is shown in Figure 36 for Station 4901. The electrode is allowed to stabilize after reaching the seafloor and measurements are made for approximately one hour before closing the lid. After the lid closes, oxygen uptake results in a signal decrease that can be used to determine an oxygen uptake rate of the incubated sediment. Figure 37 shows typical profiles of oxygen, pH, Ca^{2+} and CO_2 measured with Profilur at station GeoB 4909 (Ca^{2+} and CO_2 profiles are not yet calibrated). During this cruise we

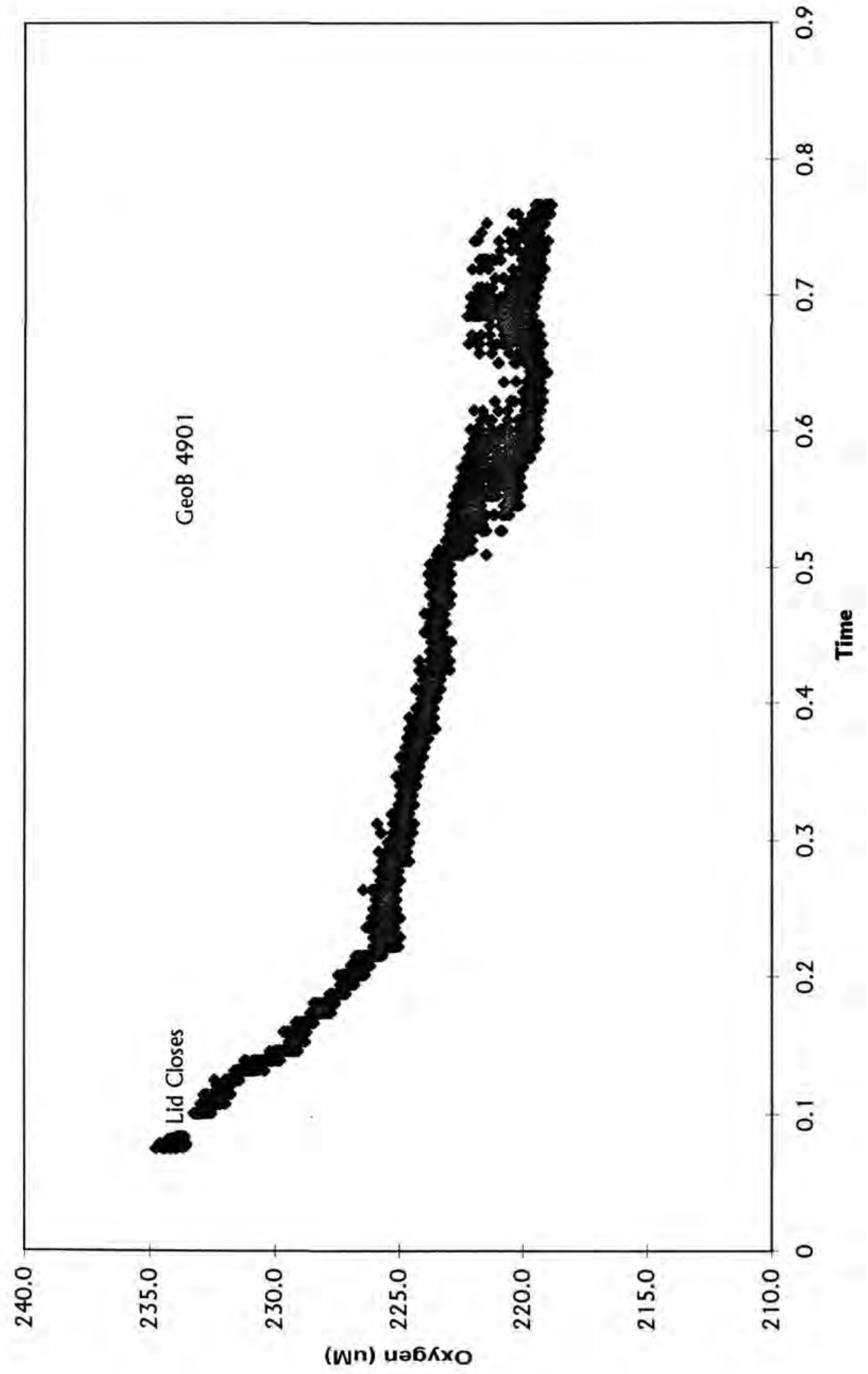

Figure 36: Oxygen decrease in the chamber of ELINOR at station GeoB 4901.

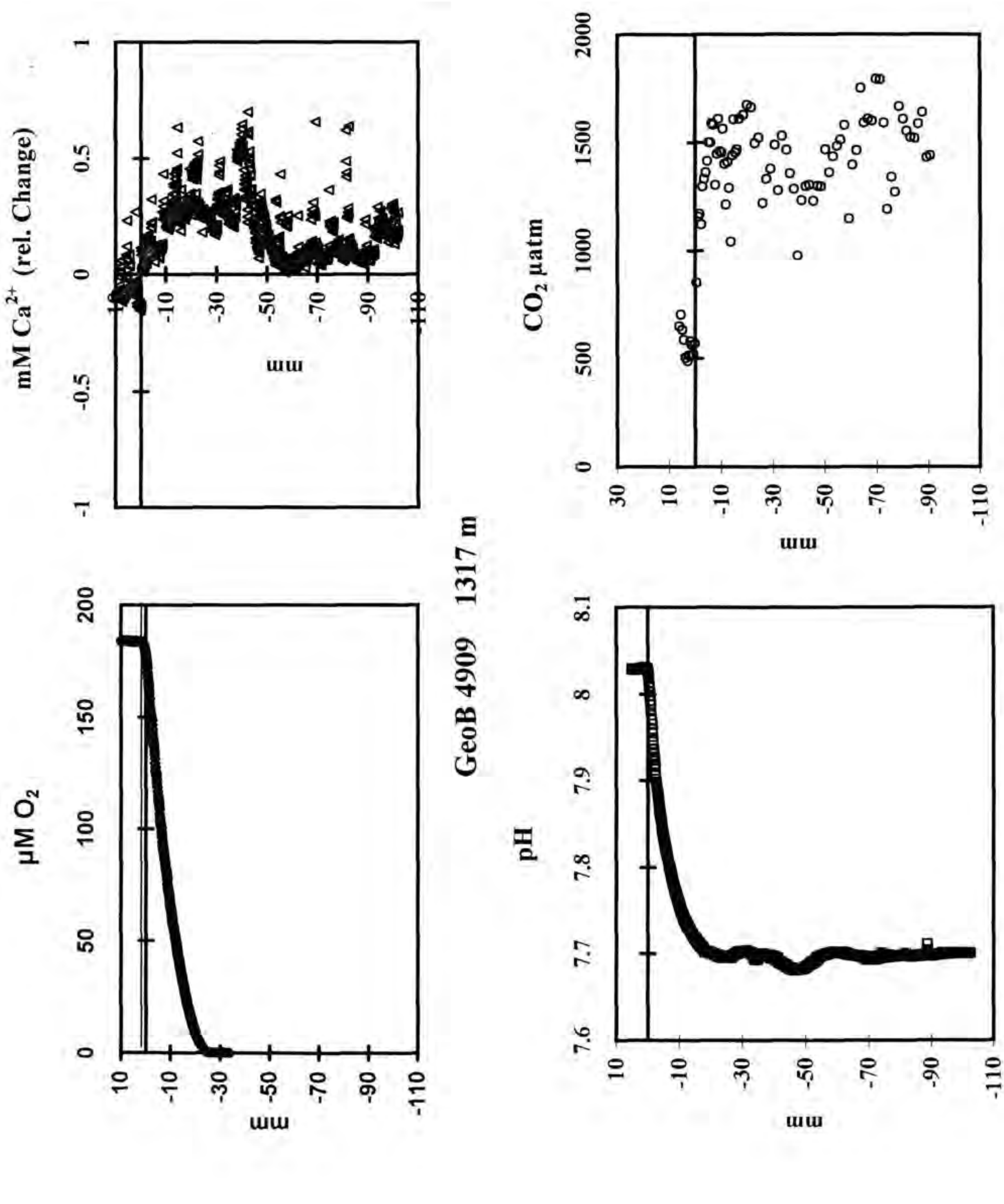

Figure 37: Oxygen, pH, Ca^{2+} and CO_2 profiles measured with PROFILUR at station GeoB 4909.

were able to measure for the first time CO_2 and Ca^{2+} *in situ*. pH, Ca^{2+} and CO_2 measurements now make it possible to calculate the metabolic driven dissolution of calcite *in situ*.

4.5.2 Pore Water Chemistry

(U. de Vries, K. Enneking, S. Hinrichs, S. Kasten, S. Siemer, M. Zabel)

The main objective of geochemical investigations carried out during this cruise is the systematic determination of regional variations in benthic mineralization processes on an isobath parallel transect along the West African continental margin at a water depth of approximately 1300 m. This means a consequent northward continuation of the research program of METEOR cruise M 34/2 on which significant regional inhomogeneities of benthic activity could be detected along the 1300 m isobath transect off Namibia. The northward extension of these investigations seems to be very interesting with respect to a characterization of the whole West African continental margin.

For this purpose relevant pore water constituents for gravity and multicorer cores recovered on the 1300 m transect are analyzed on board-ship. These parameters allow the identification and quantification of the particular mineralization processes involved in the degradation of organic matter within the sediments. In addition, the solid phase of gravity cores is sampled under argon atmosphere for later bulk sediment and mineralogical examinations on shore. The main focus of the investigations is on anaerobic early diagenetic processes in the zone of methane oxidation and in the zone of sulfide reoxidation. While these reaction zones are well documented geochemically the exact biogeochemical processes and mechanisms involved are not yet fully understood.

Besides the systematic sampling and examination of the sediments along the 1300 m isobath transect it is also planned to resample the former station GeoB 1401 on the Congo Fan. At this site the sedimentary sequence of the upper 16 m is characterized by an undisturbed sediment segment of about 10 m reaching into oxygen isotope stage 6 which overlies turbidites of much younger age. As a possible explanation for this stratigraphy a submarine landslide has been proposed. It is the aim to study and better understand the influence of such nonsteady-state sedimentary conditions on the distribution of pore water constituents as well as on the composition of the sedimentary solid phase.

All investigations are carried out in close co-operation with the biogeochemistry group (see chapters 4.5.1, and 4.5.3).

Methods

In order 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 2°-4°C.

The multicorer cores were processed within a few hours. Samples of the associated bottom water were taken for pH and Eh measurements within the glove box and 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 core into slices for pressure filtration, pH and Eh measurements were performed with a minimum depth resolution of 0.5 cm. Conductivity and temperature were measured on a second, parallel core to calculate sediment density and porosity.

The gravity cores were cut into 1-m segments on deck. At sampling locations where methane was expected to be present, syringe samples were taken on deck from every cut segment surface. Higher resolution sampling for methane analysis was carried out in the cooling laboratory immediately after storing by sawing 2-4 cm rectangles into the PVC liner. In this way, syringe samples of 5 ml sediment were taken every 10-25 cm and injected into 50 ml septum vials containing 20 ml of seawater. After closing and subsequent shaking methane becomes enriched in the headspace of the vial. Parallel to the sampling for methane analysis, hydrogen sulfide was determined by means of a needle electrode and a reference electrode in sediments in which relatively low concentrations of H_2S were expected. In case of higher hydrogen sulfide contents, 2.5 ml syringe samples of sediment were taken from the rectangular openings in the core liners and injected into 5 ml of SAOB buffer (sulfur anti-oxidizing buffer). The contents of hydrogen sulfide fixed within this buffer solution were later determined with a H_2S electrode.

Within a few days after recovery, gravity cores were cut lengthwise into two halves and processed. On the working halves pH and Eh were determined using punch-in electrodes and sediment samples were taken every 10 to 35 cm for pressure filtration. Conductivity and temperature were measured on the archive halves. Solid phase samples were taken at the same intervals and kept in gas-tight glass bottles under argon atmosphere. The storage temperature for all sediments was -20°C to avoid dissimilatory oxidation.

All work done on opened multicorer and gravity cores was carried out in a glove box under argon atmosphere. For pressure filtration Teflon- and PE-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 10 and 30 ml. From the retrieved pore water sub-samples of 10 ml were used by the biogeochemistry group for further analysis (see chapter 4.5.4).

The following parameters were determined on this cruise:

Eh, pH, conductivity (porosity), NO_3^-, PO_4^{3-}, NH_4^+, alkalinity, Fe^{2+}, SO_4^{2-}, Cl^-, F^-, H_2S, dissolved inorganic carbon (DIC), non-purchable organic carbon (NPOC) and CH_4.

Redox potential (Eh), pH values, conductivity and temperature 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 autoanalyser using standard methods. Ammonium was determined through conductivity measurements after extruding NH_3 by sodium hydroxide and introducing it into HCl. Alkalinity was calculated from a volumetric analysis by tritration of 1.5 ml pore water sample with 0.01 or 0.05 M HCl, respectively. For the analysis of dissolved iron sub-samples of 1 ml were taken within the glove box and immediately complexed with 50 µl of Ferrospectral and determined photometrically afterwards. Sulfate (SO_4^{2-}) and chloride (Cl^-) were analyzed by ion chromatography from pore water diluted 1:20 with de-ionized water. Fluoride (F^-) was measured by an ion-sensitive electrode. Hydrogen sulfide was determined potentiometrically by means of an ion-sensitive needle electrode and a reference electrode. The calibration of this method was carried out by adding Na_2S to oxygen-free „Sørensen"-buffer solutions with different pH values. This method is suitable for determining H_2S concentrations below 100 µmol/l. For sediments containing higher concentrations of H_2S 2.5 ml of sediment were introduced into 5 ml of SAOB buffer solution and the H_2S concentrations determined potentiometrically. Dissolved inorganic carbon (DIC) and non-purchable organic carbon (NPOC and DOC) were measured using a Shimadzu 5050 TOC analyzer. For the analysis of DIC the pore water samples were treated with phosphoric acid and the evolved CO_2 selectively detected by infrared. The concentrations of NPOC were obtained by first extruding CO_2 from HCl-acidified pore water samples with the carrier gas (synthetic air) and subsequent infrared detection of the CO_2 evolved during combustion at 680°C.

For the detection of methane 25 µl of the headspace gas were injected into a gas-chromatograph. The concentrations of methane measured were then related to the sediment porosity determined.

The remaining pore water was acidified with $HNO_3^-{}_{(suprapure)}$ to a pH value of 2 for storing and subsequent determination of cations by ICP-AES and AAS. All pore water samples are maintained at 4°C until further analyses at the University of Bremen.

Shipboard Results

On this cruise a total of 14 stations was examined geochemically including 5 gravity cores and 14 multicorer cores (see Table 1 and 2). Additionally, nutrient system as well as in the water column samples obtained during two profiles with the Rosette.

Of the geochemically investigated multicorer cores recovered on the 1300 m isobath transect the northernmost stations GeoB 4904 (off northern Gabon) and GeoB 4905 (off Cameroon) show the lowest mineralization rates of organic matter as indicated by the pore water profiles of nitrate, phosphate and ammonium. Denitrification in these deposits is completed at a sediment depth of approximately 5 to 6 cm (Figure 38). In most of the other examined multicorer cores pore water nitrate is completely consumed between depths of 2 to 3 cm below the sediment surface. For comparison the pore water data of GeoB 4904-6 and GeoB 4913-3 (northern Congo Fan) are illustrated in Figure 38.

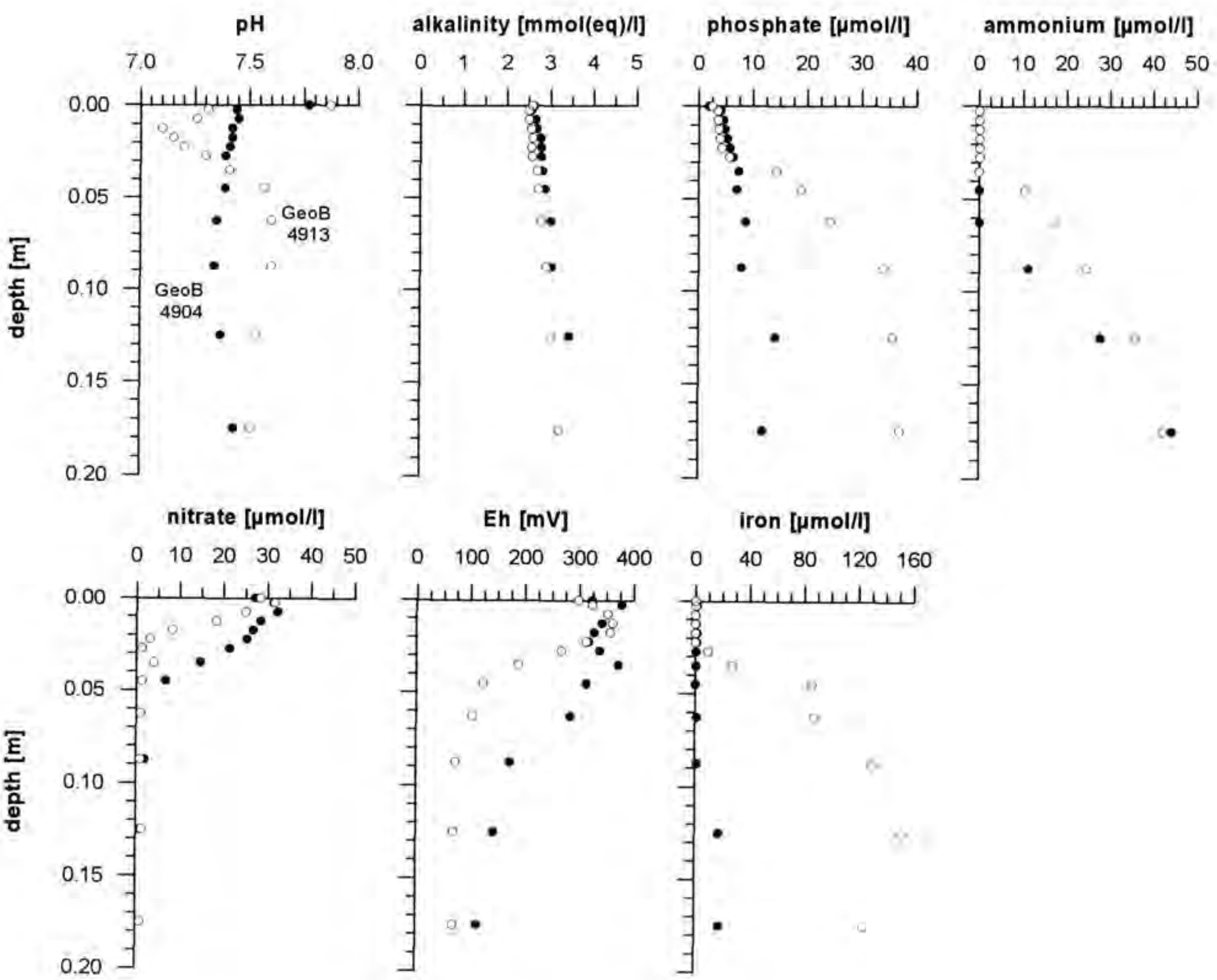

Figure 38: Pore water concentration profiles of the multicorer cores GeoB 4904-6 and GeoB 4913-3.

On a transect perpendicular to the continental margin off Gabon (GeoB 4906, 4907 and 4908; profile 1) the nutrient pore water profiles of the analyzed multicorer cores display the typically decreasing biogeochemical reactivity with increasing water depth (on the basis of nitrate pore water profiles). This trend is not observed for the stations examined on the Congo Fan where the deeper sampling location (GeoB 4914; 3970 m water depth) has a shallower depth of completed denitrification than site GeoB 4913 at 1300 m water depth.

With respect to anaerobic biogeochemical processes the pore water profiles of sulfate for all five examined gravity cores (Figure 39) show that station GeoB 4913 has the steepest gradient of pore water sulfate. The 'depth of no sulfate' has, however, only been reached in core GeoB 4914-3 at a sediment depth of about 15 m.

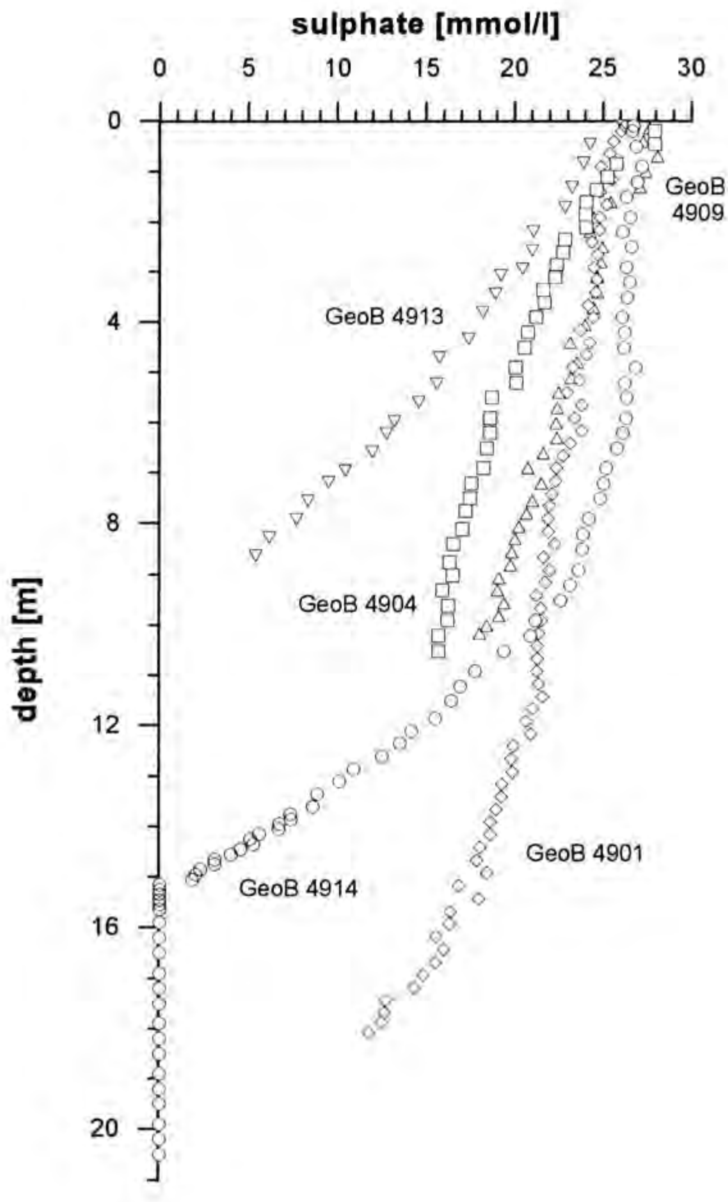

Figure 39: Sulfate pore water concentration profiles for the five gravity cores examined on this cruise - GeoB 4901-9, 4904-5, 4909-6, 4913-5 and 4914-3.

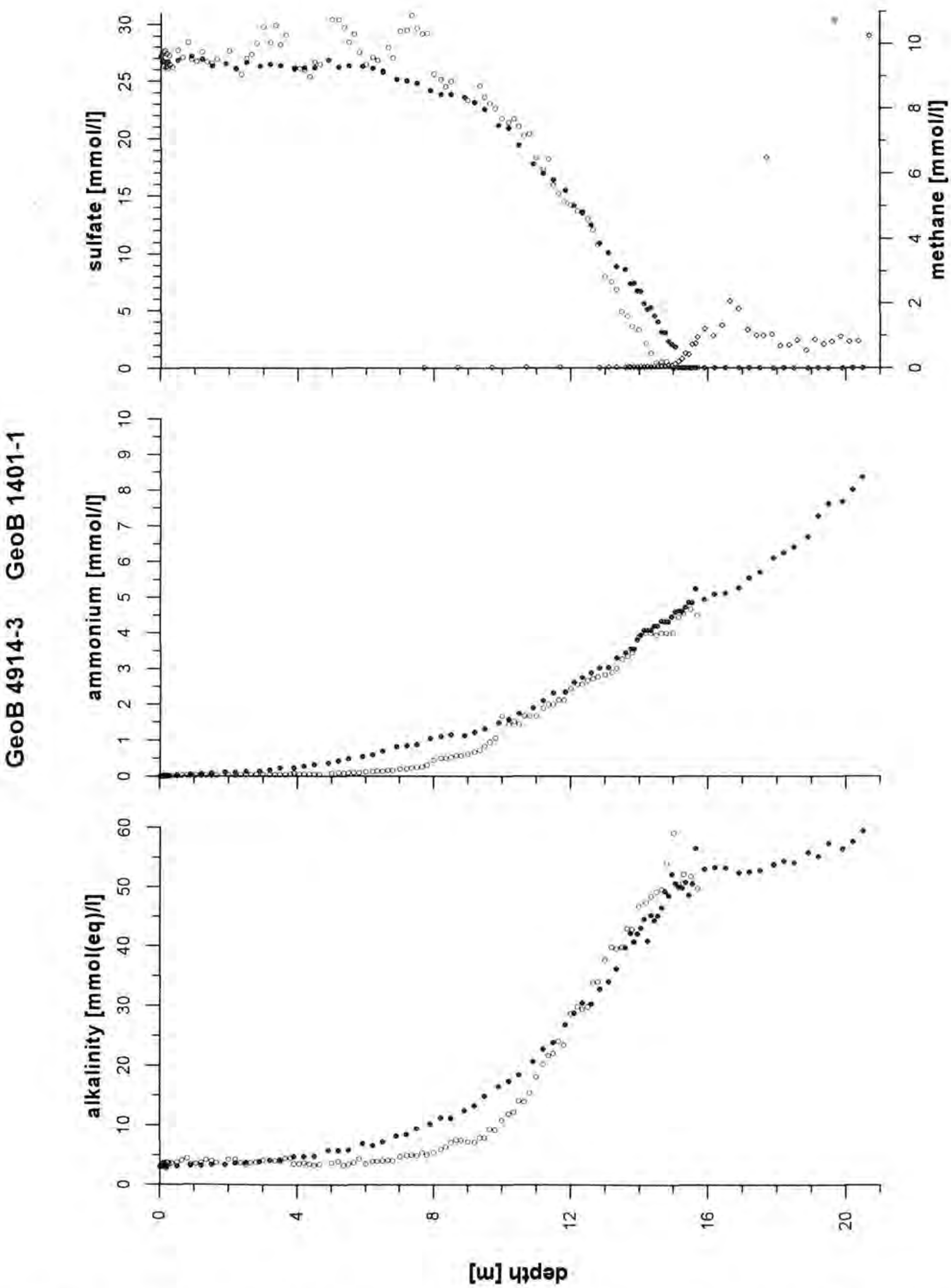

Figure 40: Pore water concentration profiles of alkalinity, ammonium, sulfate and methane for GeoB 4914-3 and GeoB 1401-1 which was recovered from the same site during former Meteor cruise M 16/1 in 1991.

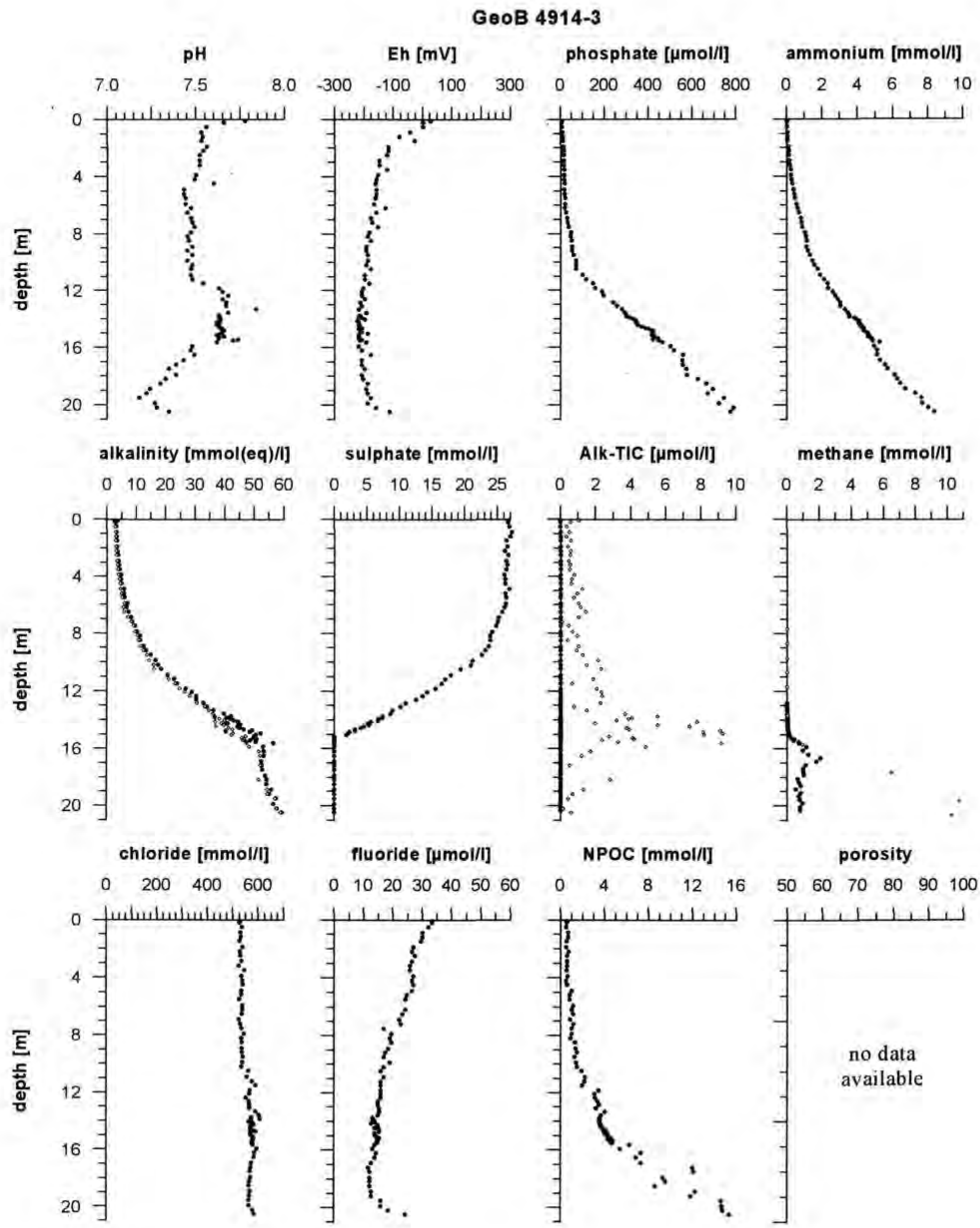

Figure 41: Pore water concentration profiles for core GeoB 4914-3.

The pore water concentration profiles of core GeoB 4914-3 are in good agreement with those determined for core GeoB 1401-1 which was recovered from the same site during Meteor cruise M 16/1 in 1991 (Figure 40). Also the ikaite crystals found in core GeoB 1401-1 are present in GeoB 4914-3 at a depth of about 14.4 m. For GeoB 1401-1 measurements of methane were not available. The detection of methane in the lower portion of core GeoB 4914-3 diffusing upward to the sediment depth where pore water sulfate goes to zero (see Figure 40) is clear evidence that deep sulfate reduction at this site is not dominated by the degradation of organic matter but by the anaerobic oxidation of upward diffusing methane. The pore water concentration profiles measured for this core as well as the sulfate reduction rates and isotopic composition of methane determined by the biogeochemistry group on the same core (compare chapter 4.5.3) will be the basis for modelling the nonsteady-state diagenetic processes that are believed to have been initiated by a submarine landslide.

Besides core GeoB 4914-3 also the sulfate pore water profile for gravity core GeoB 4901-9 shows indications of nonsteady-state diagenetic conditions. The preliminary stratigraphy suggests that this approximately 19 m long core represents a more or less undisturbed sequence of high sedimentation rates covering the last 200.000 years (compare chapter 4.3). High resolution examinations of the solid phase might, therefore, offer a valuable archive of short-term climatically induced fluctuations in sedimentation on the Niger Fan.

In Figure 41 the pore water concentration profiles of gravity core GeoB 4914-3 are illustrated. A comparison of alkalinity with the DIC values reveals deviations around the sulfate-methane transition zone which image the profile of hydrogen sulfide when plotted as differences against core depth. This deviation between alkalinity and DIC is due to hydrogen sulfide which is also titrated when determining alkalinity. In core GeoB 4901-9 there are no significant differences between alkalinity and DIC because the hydrogen sulfide concentrations in these cores are an order of magnitude lower than in core GeoB 4714-3.

4.5.3 Sulfate Reduction Rates

(T.G. Ferdelman, B. Strotmann)

Background

The oxidation of organic carbon by dissimilatory sulfate reducing bacteria is thought to be the principal terminal process of anaerobic respiration in continental margin sediments (Jørgensen, 1982). In some high productivity environments, particularly upwelling zones, sulfate reduction is the dominant pathway of organic carbon decomposition to CO_2 (Thamdrup and Canfield, 1996). Fortunately, and in contrast to the measurement of most other respiratory processes in marine sediments, a robust and relatively simple method for the determination of dissimilatory sulfate reduction exists with the application of the $^{35}SO_4^{2-}$ tracer method to undisturbed whole-cores of sediment (Jørgensen, 1978; Fossing and Jørgensen, 1989).

In 1996 we visited the continental margin of Southwest Africa as part of the M 34/2 cruise and made a series of sulfate reduction rate measurements in both the surface sediments and in two gravity cores. In the surface sediments, we observed that the pattern of sulfate reduction rate intensity was consistent with the strength of coastal upwelling intensity (Ferdelman et al., 1998). Depth-integrated sulfate reduction rates were also strongly correlated with surface organic carbon concentrations. Sulfate reduction was estimated to account for between 26 and 78% of the published rates of total oxygen consumption for these sediments; therefore, a significant fraction of organic matter degradation was remineralized anaerobically through sulfate reduction. We also applied the $^{35}SO_4^{2-}$-tracer method to measurements of sulfate reduction rate activity in two gravity cores whose length extended through the methane-sulfate transition zone (Fossing et al., 1998). In the gravity cores we observed that sulfate reduction generally decreased to below detection within the uppermost meters of sediment but exhibited a peak at the methane-sulfate transition. This deep sulfate reduction, associated with the oxidation of upward diffusing methane, represented between 3 and 11% of the total areal sulfate reduction measured at these sites. However, sulfate reduction at this boundary represented approximately 100% of *net* sulfate reduction as measured by the diffusive flux of sulfate into the sediments. We also observed that the isotopic composition of methane across the sulfate-methane transition exhibited a very striking depletion in ^{13}C, probably due to intense recycling between CO_2 and CH_4 in this zone.

Goal

The goals of our research activity on the M 41/1 research cruise was to extend our measurements of sulfate reduction rate measurements along the continental margin of western Africa north of the Angola-Benguela Front in both surface (0-30 cm) and deep (0 to 20 m) sediments. One particular goal was to revisit the old site GeoB 1401 on the Congo Fan in co-operation with the GeoB Geochemistry Group, in order to explore biogeochemical processes operating on deeper sediments (and thus, longer time scales) by examining sulfate reduction rates, sulfur isotope distributions, and methane isotope distributions in selected gravity core samples. The second goal was to expand our net of surface sulfate reduction rates along the continental margin. Of particular interest, was the changeover in composition of the sediments from mostly marine derived organic matter south of Walvis Ridge, to more terrestrially influenced sediments. The Congo Fan is of special interest in this regard. We were also interested in obtaining sediments for gamma spectroscopic analysis of ^{210}Pb, in order to evaluate sediment accumulation and mixing rates.

Methods

Surface Sediment (20 - 30 cm)

- *(1) Sulfate Reduction Rates*

  Sub-cores of up to 30 cm length were obtained from the stations listed in Table 5 from multi-core samples. Where possible, three sub-cores were taken from two different deployments of the multi-corer. In addition, at stations where the free-falling in situ flux chamber "Elinor" was deployed a sub-core was obtained after recovery from Elinor's box core sample. The sub-cores were immediately removed to the incubator (3-4°C). Two to four of the sub-cores were then subsequently injected at centimeter intervals with tracer amounts of $^{35}SO_4^{2-}$ and incubated for 12 hours at 3 - 4 °C. After incubation the samples were fixed. The samples await further processing and analysis in Bremen.

- *(2) ^{210}Pb-Distributions*

  Two large multi-core samples were obtained from each station and sub-sampled at one centimeter intervals. A selection of theses samples will be analyzed by ultra-low level gamma spectroscopy in Bremen for the purpose of determining ^{210}Pb and ^{226}Ra distributions in the surface sediment.

Table 5: List of stations where sub-samples for sulfate reduction rates measurements were taken, both for the surface sediment using the whole-core method (from multi-cores and the Elinor chamber) and for the gravity cores.

	Sulfate Reduction Rate Measurements		
Station, *GeoB-*	**Multi Core**	**Elinor**	**Gravity Core**
4901	2	1	-
4903	2	-	-
4904	2	1	11 m, every meter
4905	2	-	-
4906	2	1	-
4909	2	1	-
4912	2	-	-
4913	3	1	9 m, every meter
4914	3	-	20.6 m, < 50 cm
4915	2	-	-
4916	2	-	-
4917	2	1	-
4918	2	-	-
4919	2	-	-

Gravity Cores

- *(1) Sediment Sampling*

  Sediment sampling was accomplished in close co-operation with the sediment processing performed by the GeoB Geochemistry group. Solid phase sediment was obtained from the "Achiv" split of each meter piece of gravity core sediment. Sub-samples of pore water were obtained from the pore waters pressed by the GeoB Geochemistry group. Three gravity cores were sampled. Two cores, GeoB 4904 and 4913 were sampled at approximately 1 meter intervals. Core GeoB 4914 (former Station GeoB 1041), which exhibited a sulfate-methane at approximately 1450 cm, was sampled more thoroughly. The two meters covering the methane-sulfate transition zone were sampled every 10 cm, otherwise the core was sampled approximately every 50 cm.

- *(2) Sulfate Reduction Rates*

  During the cold-room processing of three of the gravity cores by the GeoB Geochemistry group, mini-cores were taken from selected depths. The mini-cores were then subsequently injected with tracer amounts of $^{35}SO_4^{2-}$ sealed with a butyl stopper, placed in a gas-tight, argon filled bag and incubated at 3-4 °C. Incubation times ran between 3 and 8 days.

- *(3) Methane and Dissolved Inorganic Carbon Isotope Composition*

  At station GeoB 4914 mini-cores (ca. 3 ml sediment) were taken and immediately preserved for the later determination of $^{13}CH_4/^{14}CH_4$ ratios. Pore waters (2 ml) from the equivalent depths were frozen for later determination of $^{13}CO_2/^{14}CO_2$.

- *(4) Low Molecular Weight Carboxylic Acids*

  At station GeoB 4914 pore waters (2 ml) were obtained and stored frozen for later processing and analysis in Bremen.

- *(5) Stable Sulfur Isotopes*

  Sediment plugs (3-4 ml) from all three gravity cores were obtained for later analysis of the stable isotopic composition of sulfur in pyrite, acid-volatile sulfur and organic sulfur, preserved in 20% zinc acetate solution, and frozen. Five ml of pore waters from corresponding depths were fixed with $ZnCl_2$ and frozen for later isotopic analysis of sulfate and sulfide. Processing and analysis of samples will take place in Bremen and Oldenburg in co-operation with Dr. Micheal Böttcher (MPI).

- *(6) Bacterial Abundance and Diversity*

  Samples (200 mg) were taken and preserved in paraformaldehyde for later quantification of bacterial numbers. Larger samples (3 to 5 ml) of sediment were frozen without treatment for the later characterization of microbial diversity in selected samples using molecular techniques (in conjunction with Dr. Gerard Muyzer, MPI). In addition a set of samples were taken from core 4914 to examine for the possible presence of "crocetane" -- a possible biomarker for the microbial community located at the methane-sulfate transition (with Dr. Carsten Schubert, MPI).

4.6 Phytoplankton Investigations

(M 41/1: A. Brune, V. Diekamp, G. Lavik, A. Meyer, R. Schneider, T. Wagner)
(M 41/2: S. Drachenberg, O. Esper, S. Gerhardt, M. Segl, N. Zatloukal)

Sampling for Chlorophyll-a Measurements

For the determination of chlorophyll-a concentration in the surface waters, 0,5l of seawater was collected usually three times a day from the ship's clean seawater pump system with the inlet at 3,5 meter water depth. The water was filtered through glass fibre filters and frozen at minus 20°C. Chlorophyll-a measurements by means of photometry will be carried out in the laboratories at the University of Bremen.

The chlorophyll-a data gives information on the seasonal and regional variation in,- and distribution of primary productivity and thereby allowing a calibration of satellite data for chlorophyll estimation Table 6.

Pumped net samples

During the cruise plankton was sampled from surface waters (Table 7). The shipboard clean seawater pump system was used to filter between 2000 and 5000 liters through a net with a mesh size of 10 mm (sampling locations and times are listed below). The sampling was mostly done during day-light hours and the amount of seawater that was filtered depended on the amount of plankton caught in the net. When the water flow ceased due to the material closing the net openings, the plankton was washed into plastic bottles and the sampling was continued with the cleaned net. The wet plankton samples from one day was collected in one bottle and frozen at -20°C. The plankton material will be investigated for the bulk composition of the biogenic detritus in order to quantify the ratios opal, organic carbon and carbonate produced by the near-surface plankton communities. The marine organic material will be further analyzed. In particular, it is planned to determine the stable isotopes and individual organic compounds which can be related to specific phytoplankton organisms.

Table 6: Sampling locations of chlorophyll-a data.

N°	Date M41/1:	UTC-Time	Latitude	Longitude	Water depth	Sal. (‰)	Temp (°C)
1	22.02.98	13:14	1° 0,27N	7°09,67W	5150	34.62	29.6
2	22.02.98	13:14	1° 0,27N	7°09,67W	5150	34.62	29.6
3	22.02.98	18:22	1°4,08N	6°15,22W	5137	34.67	29.6
4	22.02.98	18:22	1°4,08N	6°15,22W	5137	34.67	29.6
5	23.02.98	07:24	1°14,24N	3°51,93W	5099	34.66	29.6
6	23.02.98	07:24	1°14,24N	3°51,93W	5099	34.66	29.6
7	23.02.98	11:12	1°17,06N	3°13,11W	5110	34.71	29.7
8	23.02.98	11:12	1°17,06N	3°13,11W	5110	34.71	29.7
9	23.02.98	17:18	1°21,91N	2°03,85W	5064	34.62	30.1
10	23.02.98	17:18	1°21,91N	2°03,85W	5064	34.62	30.1
11	24.02.98	07:41	1°39,56N	0°45,07E	4743	34.71	29.7
12	24.02.98	07:41	1°39,56N	0°45,07E	4743	34.71	29.7
13	24.02.98	13:40	1°49,96N	1°56,45E	4541	34.7	29.8
14	24.02.98	13:40	1°49,96N	1°56,45E	4541	34.7	29.8
15	24.02.98	17:35	1°51,81N	2°43,08E	4372	34.66	29.8
16	24.02.98	17:35	1°51,81N	2°43,08E	4372	34.66	29.8
17	25.02.98	08:08	1°23,28N	5°36,12E	3633	33.2	29.5
18	25.02.98	08:08	1°23,28N	5°36,12E	3633	33.2	29.5
19	25.02.98	11:10	1°54,91N	5°50,00E	3437	32.8	29.9
20	25.02.98	11:10	1°54,91N	5°50,00E	3437	32.8	29.9
21	25.02.98	17:26	2°40,14N	6°37,25E	2247	30.28	29.8
22	25.02.98	17:26	2°40,14N	6°37,25E	2247	30.28	29.8
23	26.02.98	07:41	2°40,74N	6°43,15E	2186	29.38	29.6
24	26.02.98	07:41	2°40,74N	6°43,15E	2186	29.38	29.6
25	26.02.98	11:05	2°40,88N	6°41,65E	2155	30.24	29.7
26	26.02.98	11:05	2°40,88N	6°41,65E	2155	30.24	29.7
27	26.02.98	17:47	2°40,77N	6°43,94E	2199	30.08	29.8
28	26.02.98	17:47	2°40,77N	6°43,94E	2199	30.08	29.8
29	27.02.98	06:55	2°21,22N	6°01,74E	3232	30.93	29.8
30	27.02.98	06:55	2°21,22N	6°01,74E	3232	30.93	29.8
31	27.02.98	11:08	2°14,80N	6°33,33E	3079	30.81	29.8
32	27.02.98	11:08	2°14,80N	6°33,33E	3079	30.81	29.8
33	27.02.98	17:21	1°59,92N	7°45,83E	2572	30.56	29.8
34	27.02.98	17:21	1°59,92N	7°45,83E	2572	30.56	29.8
35	28.02.98	08:35	0°58,59N	8°27,49E	2246	30.95	29.8
36	28.02.98	08:35	0°58,59N	8°27,49E	2246	30.95	29.8
37	28.02.98	11:21	0°57,40N	8°52,75E	1296	30.6	30
38	28.02.98	11:21	0°57,40N	8°52,75E	1296	30.6	30
39	28.02.98	17:19	0°57,63N	8°52,75E	1348	30.54	30.1
40	28.02.98	17:19	0°57,63N	8°52,75E	1348	30.54	30.1
41	01.03.98	07:15	2°30,04N	9°23,42E	1329	28.68	30

Table 6: continued

N°	Date	UTC-Time	Latitude	Longitude	Water depth	Sal. (‰)	Temp (°C)
42	01.03.98	07:15	2°30,04N	9°23,42E	1329	28.68	30
43	02.03.98	07:18	0°41,16S	8°22,94E	1252	30.35	29.5
44	02.03.98	07:18	0°41,16S	8°22,94E	1252	30.35	29.5
45	02.03.98	11:18	0°37,54S	8°01,52E	2068	31.06	29.9
46	02.03.98	11:18	0°37,54S	8°01,52E	2068	31.06	29.9
47	02.03.98	17:24	0°40,56S	7°12,50E	2800	32.27	29.7
48	02.03.98	17:24	0°40,56S	7°12,50E	2800	32.27	29.7
49	03.03.98	09:06	0°39,86 S	7°33,13 E	2577	32.34	29.7
50	03.03.98	09:06	0°39,86 S	7°33,13 E	2577	32.34	29.7
51	03.03.98	11:33	0°38,46 S	8°0,69 E	2083	31.27	30.1
52	03.03.98	11:33	0°38,46 S	8°0,69 E	2083	31.27	30.1
53	03.03.98	17:36	0°57,74 S	8°22,93 E	831	30.54	30.1
54	03.03.98	17:36	0°57,74 S	8°22,93 E	831	30.54	30.1
55	04.03.98	07:33	2°11,73 S	8°20,72 E	2315	32.94	29.5
56	04.03.98	07:33	2°11,73 S	8°20,72 E	2315	32.94	29.5
57	04.03.98	11:36	2°27,96 S	7°42,16 E	3492	33.18	29.9
58	04.03.98	11:36	2°27,96 S	7°42,16 E	3492	33.18	29.9
59	04.03.98	17:40	2°19,00 S	8°4,05 E	3002	33.37	29.7
60	04.03.98	17:40	2°19,00 S	8°4,05 E	3002	33.37	29.7
61	05.03.98	07:09	2°3,17 S	8°37,86 E	1244	32.7	29.6
62	05.03.98	07:09	2°3,17 S	8°37,86 E	1244	32.7	29.6
63	05.03.98	11:14	2°4,28 S	8°37,84 E	1292	32.47	29.6
64	05.03.98	11:14	2°4,28 S	8°37,84 E	1292	32.47	29.6
65	05.03.98	17:31	3°1,98 S	9°18,63 E	768	33.22	29.9
66	05.03.98	17:31	3°1,98 S	9°18,63 E	768	33.22	29.9
67	06.03.98	14:29	5°29,74 S	11°3,10 E	1333	26.63	29.2
68	06.03.98	14:29	5°29,74 S	11°3,10 E	1333	26.63	29.2
69	06.03.98	17:44	5°30,17 S	11°4,33 E	1304	29.67	29.3
70	06.03.98	17:44	5°30,17 S	11°4,33 E	1304	29.67	29.3
71	07.03.98	07:27	6°41,25 S	9°16,23 E	3823	35.33	28.7
72	07.03.98	07:27	6°41,25 S	9°16,23 E	3823	35.33	28.7
73	07.03.98	11:03	6°55,97 S	9°0,02 E	4058	35.25	29.2
74	07.03.98	11:03	6°55,97 S	9°0,02 E	4058	35.25	29.2
75	07.03.98	17:34	6°56,00 S	8°59,99 E	3974	35.38	29.6
76	07.03.98	17:34	6°56,00 S	8°59,99 E	3975	35.39	30.6
77	08.03.98	07:54	5°48,64 S	10°48,77 E	1779	25.43	29,5
78	08.03.98	07:54	5°48,64 S	10°48,77 E	1780	25.44	29,6
79	08.03.98	11:22	5°32,89 S	11°5,26 E	1247	26.62	28.9
80	08.03.98	11:22	5°32,89 S	11°5,26 E	1247	26.62	28.9
81	08.03.98	17:33	6°42,83 S	11°29,19 E	733	28.2	30.1
82	08.03.98	17:33	6°42,83 S	11°29,19 E	733	28.2	30.1
83	09.03.98	07:36	8°35,37 S	12°1,38 E	2144	35.58	29.2
84	09.03.98	07:36	8°35,37 S	12°1,38 E	2144	35.58	29.2

Table 6: continued

N°	Date	UTC-Time	Latitude	Longitude	Water depth	Sal. (‰)	Temp (°C)
85	09.03.98	11:27	9°6,82 S	12°7,86 E	1784	35.6	29.5
86	09.03.98	11:27	9°6,82 S	12°7,86 E	1784	35.6	29.5
87	09.03.98	17:27	10°13,40 S	12°21,69 E	1736	35.54	29.5
88	09.03.98	17:27	10°13,40 S	12°21,69 E	1736	35.54	29.5
89	10.03.98	07:38	11°25,75 S	12°40,42 E	1761	35.58	28.7
90	10.03.98	07:38	11°25,75 S	12°40,42 E	1761	35.58	28.7
91	10.03.98	11:19	11°54,36 S	12°57,81 E	1504	35.67	28.8
92	10.03.98	11:19	11°54,36 S	12°57,81 E	1504	35.67	28.8
93	10.03.98	17:29	12°1,03 S	13°1,71 E	1303	35.64	28.8
94	10.03.98	17:29	12°1,03 S	13°1,71 E	1303	35.64	28.8
95	11.03.98	07:32	12°5,01 S	13°0,09 E	1352	35.69	28.6
96	11.03.98	07:32	12°5,01 S	13°0,09 E	1352	35.69	28.6
97	11.03.98	11:00	11°52,96 S	13°3,55 E	1339	35.72	28.8
98	11.03.98	11:00	11°52,96 S	13°3,55 E	1339	35.72	28.8
99	11.03.98	17:31	10°47,33 S	12°30,33 E	1694	35.69	29.6
100	11.03.98	17:31	10°47,33 S	12°30,33 E	1694	35.69	29.6
101	12.03.98	07:20	8°28,33 S	11°20,45 E	2549	35.5	29.5
102	12.03.98	07:20	8°28,33 S	11°20,45 E	2549	35.5	29.5
103	12.03.98	11:17	7°48,20 S	11°0,13 E	2367	35.5	29.7
104	12.03.98	11:17	7°48,20 S	11°0,13 E	2367	35.5	29.7
105	12.03.98	17:23	6°47,83 S	10°30,0 E	2731	26.74	30.6
106	12.03.98	17:23	6°47,83 S	10°30,0 E	2731	26.74	30.6
107	13.03.98	07:22	6°56,01 S	8°59,95 E	3976	35.25	29.5
108	13.03.98	07:22	6°56,01 S	8°59,95 E	3976	35.25	29.5
	M41/2:						
1	20.03.98	12:15	02°10.28'S	00°41.81'E	4363	33.88	29.9
2	20.03.98	17:20	02°27.50'S	00°15.30'W	4681	33.98	29.7
3	21.03.98	07:47	03°16.14'S	02°56.28'W	4912	34.65	28.8
4	21.03.98	11:51	03°30.93'S	03°40.03'W	4818	34.57	29.1
5	21.03.98	18:05	03°22.46'S	04°48.45'W	4522	34.49	29.1
6	22.03.98	07:19	04°47.70'S	07°14.60'W	4197	34.61	28.6
7	22.03.98	13:12	05°10.98'S	08°19.50'W	3743	34.75	29.0
8	22.03.98	18:00	05°30.34'S	09°13.87'W	3530	35.40	28.8
9	23.03.98	08:22	06°16.90'S	11°21.90'W	3576	36.15	28.5
10	23.03.98	13:59	06°24.54'S	11°19.66'W	3362	36.11	28.4
11	24.03.98	08:53	06°58.14'S	12°14.80'W	3271	36.15	28.2
12	24.03.98	13:23	07°06.54'S	12°38.36'W	1697 ?	36.15	28.1
13	24.03.98	20:17	07°05.57'S	12°56.66'W	4355	36.29	27.9
14	25.03.98	09:18	07°26.36'S	13°14.84'W	2446	36.13	27.8
15	25.03.98	20:28	07°30.10'S	13°24.83'W	3523	36.16	27.9
16	26.03.98	10:48	07°43.44'S	13°26.84'W	3945	36.16	27.7
17	27.03.98	17:10	07°45.78'S	14°26.21'W	2844	?	?
18	28.03.98	09:06	07°46.47'S	13°25.63'W	3754	36.14	27.6

Table 6: continued

N°	Date	UTC-Time	Latitude	Longitude	Water depth	Sal. (‰)	Temp (°C)
19	28.03.98	13:54	07°52.01'S	13°25.79'W	3454	36.17	27.8
20	29.03.98	09:35	08°03.28'S	13°25.03'W	3456	36.19	27.6
21	29.03.98	14:00	08°19.94'S	13°35.90'W	3585	36.22	27.6
22	30.03.98	09:15	08°19.90'S	13°35.90'W	?	36.38	27.4
23	31.03.98	09:11	08°33.48'S	13°33.15'W	2598	36.43	27.3
24	03.04.98	09:05	09°41.68'S	13°04.83'W	1569	36.55	27.0
25	04.04.98	10:38	09°43.85'S	12°07.70'W	1243	36.48	27.1
26	05.04.98	09:15	09°53.04'S	13°04.86'W	1998	?	?
27	07.04.98	09:02	10°42.92'S	13°02.90'W	3481	36.52	27.1
28	09.04.98	10:35	12°55.96'S	15°41.53'W	3404	?	?
29	10.04.98	09:50	13°57.02'S	19°01.21'W	4550	?	26.3
30	11.04.98	10:48	15°22.67'S	23°42.82'W	?	?	26.6
31	11.04.98	21:26	15°59.54'S	25°44.72'W	?	?	27.2
32	12.04.98	10:12	16°43.74'S	28°11.27'W	?	37.40	27.4
33	12.04.98	20:19	17°18.41'S	30°06.58'W	4827	37.48	28.4
34	13.04.98	10:02	18°05.97'S	32°45.23'W	4440	37.51	28.3

This type of data is needed to compare marine plankton production in the surface waters of different high productivity systems with the fluxes of biogenic particles caught in sediment traps and found in surface sediments beneath high productivity areas.

Table 7a: Pumped net samples for bulk analyses (M41/1).

	Start			Stop	
Sample No.	Date (UTC)	Time (UTC)	Lat. Long.	Lat. Long.	Water [m³]
1	22.02.	13:30	01°00.4'N / 07°07.7'W	01°04.9'N / 06°03.5'W	2.46
2	23.02.	08:00	01°14.0'N / 03°56.3'W	01°27.8'N / 01°45.5'W	5.15
3	24.02.	07:50	01°39.7'N / 00°46.9'W	01°53.5'N / 02°58.9'W	5.09
4	25.02.	07:30	01°21.9'N / 05°31.9'E	02°40.8'N / 06°43.9'E	4.75
5	26.02.	07:24	02°40.8'N / 06°43.1'E	02°36.2'N / 06°33.9'E	2.34
6	27.02.	06:58	02°21.2'N / 06°01.8'E	01°56.8'N / 08°01.2'E	2.02
7	28.02	08:58	00°58.3'N / 08°31.6'E	00°57.5'N / 08°52.9'E	4.17
8	01.03.	04:03	02°30.4'N / 09°23.4'E	02°29.9'N / 09°23.4'E	1.92
9	02.03.	07:07	00°41.2'N / 08°23.0'E	00°42.5'S / 06°50.3'E	4.55
10	03.03.	13:21	00°40.8'S / 08°19.9'E	01°39.0'S / 00°34.3'E	3.34
11	04.03.	05:55	02°04.4'S / 08°37.5'E	02°19.0'S / 08°04.1'E	6.49
12	05.03.	06.32	02°07.0'S / 08°31.5'E	03°01.9'S / 09°18.6'E	4.38
13	06.03.	14:19	05°29.6'S / 11°01.4'E	05°29.9'S / 11°29.9'E	2.81
14	07.03.	07:07	06°39.1'S / 09°19.5'E	06°49.9'S/ 09°14.6'E	6.55
15	09.03.	10:30	08°56.5'S / 12°05.6'E	10°10.2'S / 12°41.1'E	4.30
16	10:03.	09:20	11°44.6'S / 12°40.3'E	12°23.3'S / 12°52.8'E	5.19
17	11.03.98	14:15	11°15.0'S / 12°44.4'E	08°23.8'S / 11°18.1'E	7.22

Table 7b: Pumped net samples for bulk analyses (M41/2).

Sample No.	Start Date (UTC)	Time (UTC)	Lat.	Long.	Stop Lat.	Long.	Water [m³]
1	20.03.98	07:13	2°02.28'S	1°09.10'W	2°29.12'S	0°20.65'W	1.18
2	21.03.98	06:57	3°13.41'S	2°47.20'W	3°56.70'S	4°51.91'W	1.22
3	22.03.98	07:02	4°46.70'S	7°11.70'W	5°31.40'S	9°16.16'W	2.6
4	24.03.98	09:35	6°58.20'S	12°14.70'W	7°05.50'S	12°55.70'W	4.76
5	25.03.98	09:15	7°26.41'S	13°14.88'W	7°31.48'S	13°25.91'W	3.84
7	28.03.98	09:20	7°46.39'S	13°25.72'W	7°57.96'S	13°23.93'W	5.48
8	29.03.98	09:30	8°03.27'S	13°25.06'W	8°07.92'S	13°26.87'W	5.29
9	30.03.98	09.12	8°19.81'S	13°35.82'W	8°19.55'S	13°13.27'W	5.60
10	31.03.98	09:06	8°34.05'S	13°33.48'W	8°45.10'S	13°29.50'W	4.93
11	01.04.98	08:54	9°00.80'S	13°27.40'W	9°10.09'S	13°25.09'W	5.04
12	02.04.98	12:19	9°12.19'S	13°16.56'W	9°29.30'S	13°13.59'W	3.50
13	03.04.98	09:01	9°41.60'S	13°04.80'W	9°43.90'S	12°50.30'W	5.02
14	04.04.98	10:09	9°43.76'S	12°07.80'W	9°53.21'S	13°04.80'W	10.09
15	05.04.98	09:40	9°53.19'S	13°04.80'W	10°04.20'S	13°11.00'W	5.69
16	06.04.98	09:04	10°17.52'S	13°10.10'W	10°29.20'S	13°09.18'W	6.64
17	07.04.98	09:15	10°44.55'S	13°01.99'W	10°58.97'S	13°02.30'W	4.85
18	08.04.98	11:51	11°48.87'S	14°15.66'W	12°23.58'S	13°56.29'W	5.46
20	10.04.98	11:35	14°02.79'S	19°20.43'W	14°29.81'S	20°48.92'W	3.90
21	11.04.98	10:32	15°21.93'S	23°40.04'W	15°57.84'S	25°38.98'W	5.38
22	12.04.98	10:14	16°43.91'S	28°11.81'W	17°18.32'S	30°06.28'W	5.02

Table 7c: Pumped net samples for diatom investigations (M41/2).

Sample no.	Start Date (UTC)	Time (UTC)	Lat.	Long.	Stop Lat.	Long.	Water [m³]
1	20.03.98	17:49	02°29.12'S	00°20.65'W	03°13.33'S	02°46.99'W	2.34
2	21.03.98	18:25	03°56.70'S	04°51.90'W	04°46.70'S	07°11.50'W	2.27
3	22.03.98	18:11	05°30.61'S	09°14.47'W	06°16.90'S	11°02.19'W	0.90
4	24.03.98	20:17	07°05.50'S	12°55.60'W	07°25.57'S	13°14.34'W	3.71
5	25.03.98	20:54	07°39.93'S	12°27.78'W	07°43.83'S	13°26.78'W	5.35
6	27.03.98	18:10	07°45.78'S	14°26.21'W	07°46.45'S	13°25.64'W	?
7	28.03.98	20:55	07°57.90'S	13°23.90'W	08°02.99'S	13°25.18'W	4.49
8	29.03.98	20:47	08°07.91'S	13°26.88'W	08°19.40'S	13°35.63'W	5.92
9	30.03.98	21:00	08°19.56'S	13°13.26'W	08°34.04'S	13°33.48'W	4.36
10	31.03.98	19:25	08°45.10'S	13°29.50'W	09°00.78'S	13°27.40'W	6.46
11	01.04.98	21:16	09°10.02'S	13°25.02'W	09°18.19'S	13°16.55'W	7.22
12	02.04.98	20:45	09°29.30'S	13°13.59'W	09°41.60'S	13°04.80'W	5.37
13	03.04.98	19:46	09°43.90'S	12°50.20'W	09°43.76'S	12°07.85'W	6.34
14	05.04.98	23:34	10°04.20'S	13°11.00'W	10°17.53'S	13°10.13'W	4.15
15	06.04.98	22:59	10°29.77'S	13°08.69'W	10°42.04'S	13°03.33'W	4.81
16	07.04.98	19:18	10°58.96'S	13°02.30'W	11°48.68'S	14°15.78'W	7.72
17	08.04.98	23:06	12°23.58'S	13°56.32'W	12°55.44'S	15°39.92'W	5.21
18	10.04.98	19:30	14°30.10'S	20°49.97'W	15°21.91'S	23°39.97'W	7.48
19	11.04.98	20:55	15°57.84'S	25°38.98'W	16°43.19'S	28°09.46'W	6.01
20	12.04.98	20:15	17°18.39'S	30°06.50'W	18°05.34'S	32°43.31'W	6.45

During the night, samples for the analysis of the diatom assemblage were collected in the same way. These samples were poisoned with formaldehyde solution and stored at 4°C.

Dinoflagellates

One of the major groups in the marine phytoplankton community are the dinoflagellates. They are unicellular biflagellate organisms, which develop two different stages during their life cycle: a motile, cellulosic stage ('theca') and a resting cyst stage in which the cyst is, in most cases, organic-walled although calcareous cysts are also known („calcispheres"). As an exception, the species *Thoracosphaera heimii* develops a calcareous-walled coccoid vegetative stage rather than a calcareous cyst stage during its life cycle.

During the cruise, phytoplankton samples were taken from the water column at different depths ranging from surface waters to 100 m. They were scanned for the content of living dinoflagellates, especially calcareous cysts, with regard to their lateral and vertical distribution in the investigated water column. The interaction between the species associations and the related environmental parameters such as salinity, temperature and light is of special interest, as this may allow a better paleoceanographic interpretation of fossil assemblages of dinoflagellate cysts in the underlying sedimentary record. For comparison of the distribution of dinoflagellates in the water column with that in surface sediment samples, multicorer cores were also obtained.

Between stations, surface water was sampled with the ships membrane pump (5 m depth) three times per day for about 4 hours (morning, midday, afternoon, Table 8). The water was continuously passed over a 100 µm filter to remove larger plankton and the water containing particles ranging in size from 100 µm to 10 µm was collected in a 1 l vessel. This remaining liter of seawater was filtered down through a 5 µm polycarbonate filter to 100 ml. For culturing experiments, the filtered water was investigated for thecate dinoflagellates, their calcareous cysts and the vegetative-coccoid *Th. heimii*. Individual specimens were selected and placed in polyterene Cell Wells™ with different culture media (f/2 35 ‰, K 35 ‰, filtered seawater and mixtures of culture media and seawater). In this way, unicellular cultures were established, using the local day/night cycle and temperatures between 20 °C and 25 °C. After isolation of living forms, the filtered residue was stored for transportation together with the used filters in 250 ml NALGENE polycarbonate flasks, fixed with 5,5 ml Formaldehyde (37 %) in the dark at 4 °C.

At almost every station water samples were taken with the Rosette (Multi Water Sampler MWS, Kat. No. 436918A) with 18 10 l NISKIN bottles in combination with a Seacat SBE 19-02 CTD Recorder to locate the chlorophyll-a maximum. At first 40 l of

Table 8a: Surface water samples for dinoflagellate analyses. Sampling with 10µm membrane pump filtration

Sample No. M41/1	Start and End of Filtration UTC	Start / End of Filtration Latitude N/S	Start / End of Filtration Longitude E/W	Water Depth (m)	Water Temperature (C°)	Salinity (‰)	Volume of filtered water (l)	Remarks
2/18/c	22:18 23:54	13°32,78'N 13°12,50'N	17°54,95'W 17°54,96'W	2883	22,3	35,47	213	
2/22/b	13:15 17:00	01°00,29'N 01°03,00'N	07°09,29'W 06°30,95'W	5149	29,6	34,62	384	
2/22/c	17:58 21:32	01°03,82'N 01°06,60'N	06°19,71'W 05°40,01'W	5138	29,6	34,68	375	
2/23/a	06:36 08:58	01°13,64'N 01°15,66'N	04°00,76'W 03°34,18'W	5158	29,6	34,63	359	
2/23/b	10:04 14:03	01°16,04'N 01°19,33'N	03°25,62'W 02°41,18'W	5111	29,6	34,59	443	
2/23/c	15:21 18:56	01°20,41'N 01°23,81'N	02°26,30'W 01°44,93'W	5075	30,1	34,67	435	
2/24/a	06:26 09:58	01°37,87'N 01°42,46'N	00°29,53'E 01°12,58'E	4787	29,8	34,72	496	
2/24/b	11:00 14:29	01°43,70'N 01°47,93'N	01°24,80'E 02°06,08'E	4634	29,7	34,73	508	
2/24/c	16:20 20:01	01°50,25'N 01°54,85'N	02°28,05'E 03°12,40'E	4429	29,8	34,72	546	
2/25/a	06:47 10:14	01°25,01'N 01°44,96'N	05°21,41'E 05°45,69'E	3627	29,7	33,48	457	
2/25/b	11:00 14:35	01°53,18'N 02°27,31'N	05°49,30'E 06°08,03'E	3428	29,9	32,80	481	
2/25/c	15:57 18:59	02°35,89'N 02°42,13'N	06°21,23'E 06°46,40'E	2499	29,9	30,40	420	
2/26/b	09:02 14:13	02°41,42'N 02°41,56'N	06°41,63'E 06°46,50'E	2147	29,7	30,06	450	
2/26/c	18:22 22:00	02°38,13'N 02°23,25'N	06°38,57'E 06°01,88'E	2224	29,8	30,34	447	
2/27/b	08:59 13:00	02°19,86'N 02°10,33'N	06°08,63'E 06°55,04'E	3159	29,8	30,89	462	
2/27/c	15:13 19:30	02°05,06'N 01°55,00'N	07°20,89'E 08°10,20'E	2795	29,9	30,87	519	
2/28/a	05:21 08:51	01°18,70'N 00°58,33'N	08°09,98'E 08°30,45'E	2413	29,8	31,37	463	
3/01/a	07:29 08:43	02°28,44'N 02°14,93'N	09°22,87'E 09°18,46'E	1328	30,0	28,69	075	Circulation Pump
3/01/c	17:22 22:56	00°55,33'N 00°04,97'S	08°52,62'E 08°35,06'E	1166	30,2	28,72	396	„
3/02/b	13:22 19:21	00°37,35'S 00°42,65'S	07°59,13'E 06°50,20'E	2110	30,0	31,14	288	„
3/03/a	08:40 14:51	00°40,29'S 00°41,02'S	07°28,17'E 08°22,79'E	2610	29,7	32,38	382	„
3/03/c	16:12 23:16	00°42,11'S 01°58,64'S	08°22,70'E 08°41,68'E	1270	30,4	30,11	320	„
3/04/a	07:22 11:42	02°10,95'S 02°27,49'S	08°22,49'E 07°41,94'E	2249	29,5	32,92	407	„
3/05/a	06:34 10:18	02°06,87'S 02°04,31'S	08°31,81'E 08°37,77'E	1774	29,5	32,72	304	„
3/05/b	12:05 16:24	02°08,62'S 02°50,88'S	08°40,61'E 09°10,75'E	1210	29,5	32,56	589	„
3/05/c	17:40 22:09	03°03,49'S 03°43,85'S	09°19,71'E 09°47,09'E	734	29,8	33,16	734	„
3/06/b	13:25 14:53	05°28,04'S 05°29,96'S	10°58,66'E 11°04,38'E	1296	29,0	26,29	130	
3/07/a	06:40 09:28	06°36,17'S 06°56,13'S	09°24,01'E 09°00,06'E	3813	28,9	34,09	354	
3/08/a	06:18 10:16	06°02,50'S 05°29,91'S	10°37,16'E 11°04,17'E	2168	30,0	27,12	229	
3/08/b	11:31 14:00	05°34,50'S 06°00,91'S	11°05,85'E 11°14,87'E	1210	28,7	26,62	206	
3/09/b	10:54 17:07	09°00,63'S 10°09,73'S	12°06,56'E 12°20,95'E	1785	29,1	35,47	585	
3/10/a	08:33 11:10	11°35,74'S 11°54,36'S	12°40,36'E 12°55,83'E	1723	28,6	35,62	166	

Table 8a: continued

Sample No. M41/1	Start and End of Filtration UTC	Start / End of Filtration Latitude N/S	Start / End of Filtration Longitude E/W	Water Depth (m)	Water Temperature (C°)	Salinity (‰)	Volume of filtered water (l)	Remarks
3/10/c	17:22 22:26	11°59,82'S 12°50,35'S	13°02,17'E 12°41,77'E	1302	28,8	35,67	393	
3/11/b	10:59 15:35	11°53,20'S 11°06,43'S	13°03,67'E 12°40,00'E	1330	28,9	35,72	460	
3/11/c	16:59 20:03	10°52,60'S 10°22,97'S	12°33,00'E 12°18,03'E	1542	29,7	35,67	259	
3/12/a	06:18 10:00	08°38,94'S 08°03,10'S	11°25,75'E 11°06,65'E	2530	29,5	35,48	277	
3/ 12/b	11:19 14:54	07°47,87'S 07°12,57'S	10°59,95'E 10°42,35'E	2383	29,6	35,50	282	
3/13/c	19:12 00:15	04°59,19'S 04°13,80'S	08°46,85'E 08°41,76'E	3717	29,3	32,57	444	
3/14/a	07:14 10:22	03°06,92'S 02°37,26'S	08°34,26'E 08°30,83'E	2237	29,3	32,92	508	
3/14/b	12:34 15:44	02°16,34'S 01°47,53'S	08°28,45'E 08°25,30'E	1874	29,7	32,56	369	
3/14/c	16:49 19:31	01°37,56'S 01°11,03'S	08°24,26'E 08°21,24'E	1365	29,6	32,23	358	

Table 8b: Surface water samples for dinoflagellate analyses. Sampling with 10µm membrane pump filtration (M41/2).

Sample No. M41/2	Date 1998	Start of filtration Time UTC	Latitude N/S	Longitude E/W	End of filtration Time UTC	Latitude N/S	Longitude E/W	Water Temp. [C°]	Sal. (‰)	Volume of filtered water [l]
3/20/b	20.03	10:11	2°3,14'S	1°5,43'E	15:10	2°20,70'S	0°7,15'E	29,6	33,89	476
3/20/c	20.03	15:44	2°22,11'S	0°2,62'E	19:02	2°33,33'S	0°34,45'W	29,8	34,07	437
3/21/a	21.03	07:27	3°15,02'S	2°52,33'W	11:07	3°27,98'S	3°31,80'W	29,0	34,59	400
3/21/b	21.03	11:57	3°31,19'S	3°40,77'W	15:58	3°47,09'S	4°24,95'W	29,5	34,58	463
3/21/c	21.03	16:07	3°47,60'S	4°26,45'W	20:07	4°3,35'S	5°10,49'W	29,2	34,46	454
3/22/a	22.03	07:25	4°48,15'S	7°15,54'W	11:25	5°3,94'S	7°59,80'W	28,5	34,63	425
3/22/b	22.03	12:10	5°6,89'S	8°7,99'W	15:29	5°19,91'S	8°44,62'W	28,9	34,75	386
3/22/c	22.03	16:12	5°22,74'S	8°52,39'W	19:33	5°35,97'S	9°29,45'W	29,1	35,08	425
3/23/abc	23.03	09:48 14:16 19:19	6°17,49'S 6°24,75'S 6°33,02'S	11°21,79'W 11°19,63'W 11°18,19'W	10:34 15:06 19:48	6°23,90'S 6°32,34'S 6°37,27'S	11°20,43'W 11°18,60'W 11°17,69'W	28,5 28,4 28,4	36,15 36,11 36,11	136 109 51
3/24/a	24.03	09:35	6°58,15'S	12°14,72'W	13:20	7°7,27'S	12°38,07'W	28,2	36,16	494
3/26/c	26.03	15:51	7°44,38'S	13°27,24'W	19:37	7°47,62'S	13°59,56'W	27,8	36,14	381
3/30/c	30.03	15:50	8°22,84'S	13°35,78'W	18:51	8°19,17'S	13°13,24'W	27,5	36,38	313
4/6/c	06.04	18:22	10°23,27'S	13°10,32'W	19:30	10°28,75'S	13°10,68'W	27,6	36,48	260
4/7/b	07.04	13:13 17:31	10°47,74'S 10°53,60'S	13°2,26'W 13°1,09'W	14:11 18:18	10°52,91'S 10°58,77'S	13°2,29'W 13°2,64'W	27,5 27,5	36,50 36,52	153 81
4/8/b	08.04	13:09	11°48,95'S	14°15,53'W	17:04	12°15,04'S	13°50,40'W	27,3	36,58	389
4/8/c	08.04	17:17	12°16,49'S	13°48,97'W	19:26	12°23,64'S	13°56,64'W	26,9	36,65	282
4/9/b	09.04	16:07	12°56,69'S	15°43,99'W	20:11	13°10,56'S	16°29,39'W	27,1	36,60	423
4/10/a	10.04	10:21	13°58,71'S	19°6,98'W	14:17	14°12,02'S	19°50,51'W	26,9	36,93	446
4/10/b	10.04	14:40	14°13,33'S	19°54,71'W	18:57	14°28,29'S	20°43,77'W	27,2	36,76	478
4/11/a	11.04	08:33	15°15,00'S	23°17,41'W	12:23	15°28,20'S	24°1,09'W	27,3	36,95	490
4/12/a	12.04	08:11	16°36,85'S	27°48,28'W	12:18	16°50,93'S	28°35,01'W	27,9	37,40	377
4/12/b	12.04	12:30	16°51,58'S	28°37,28'W	17:01	17°7,20'S	29°29,13'W	28,3	37,41	592
4/12/c	12.04	17:42	17°09,45'S	29°36,69'W	20:19	17°18,45'S	30°06,65'W	28,6	37,47	409

Table 9a: Water samples for dinoflagellate analysis from 10 L Niskin bottles different water depths. Filtration with 5µm polycarbonate filters (M 41/1).

Sample No M41/1	Date	Time UTC	Water Depth [m]	Volume of filtered water [l]	Latitude N/S	Longitude E/W	Temp. [°C]	Salinity (‰)
Station 4901-3								
10m	26.02.	20:32	2183	38	2°40,85'N 6°43,73'E	30,3	27,9	
20m				38,5			29,9	30,1
50m				38,5			21,5	31,6
100m				38			18,9	31,5
Station 4903-1								
10m	27.02.	19:50	2385	39	1°55,00'N 8°10,10'E	30,1	28,3	
20m				38,5			29,9	29,5
50m				38,5			21,5	32,3
100m				39			18,9	32,1
Station 4904-3								
10m	28.02	11:36	1344	38,5	0,57,69'N	8°52,76'E	29,8	27,3
20m				38,4			30,1	27,7
50m				39,4			22,5	32,3
100m				38,8			19,1	32,2
Station 4905-1								
10m	01.03.	03:16	1325	38,3	2°30,13'N 9°23,49'E	30,2	25,9	
20m				38,8			29,6	27,6
50m				37,5			27,8	32,3
100m				39,3			18,8	32,3
Station 4907-1								
10m	02.03.	09:55	2057	28,2	0°37,52'S	8°01,80'E	30,1	28,8
20m				39,0			29,2	29,2
50m				37,5			22,7	32,4
100m				39,3			19,6	32,5
Station 4908-1								
10m	02.03.	19:36	3029	28,2	0°44,61'S	6°50,27'E	29,6	29,4
30m				39,2			27,0	31,0
40m				39,0			21,9	32,5
100m				39,2			19,1	32,4
Station 4909-2								
10m	04.03.	00:50	1307	39,0	2°04,31'S	8°37,63'E	29,5	29,6
30m				39,0			23,8	32,3
40m				38,5			22,9	32,5
100m				39,0			19,7	32,5
Station 4910-1								
10m	04.03.	14:40	3000	38,6	2°18,85'S	8°04,07'E	29,7	30,2
20m				18,8			26,6	31,7
30m				19,8			23,5	32,2
40m				19,2			22,4	32,3
50m				17,5			21,8	32,4
100m				39,6			18,4	32,4
Station 4912-1								
10m	05.03.	22:21	1306	39,2	3°43,85'S	9°47,09'E	29,3	30,2
20m				18,0			24,3	32,1
30m				20,3			23,5	32,3
40m				20,3			22,0	32,4
50m				18,0			21,3	32,5
100m				39,5			18,3	32,5
Station 4913-2								
10m	06.03.	15:03	1295	37,5	5°29,95'S	11°04,34'E	29,4	29,3
20m				37,8			24,3	32,1
40m				36,8			21,9	32,2
100m				39,0			17,9	32,4
Station 4914-1								
10m	07.03.	09:40	3979	37,2	6°56,06'S	8°59,89'E	26,2	32,1
20m				35,5			23,3	32,3
40m				37,0			19,7	32,3
100m				39,3			17,4	32,5

Table 9a: continued

Sample No M41/1	Date	Time UTC	Water Depth [m]	Volume of filtered water [l]	Latitude N/S	Longitude E/W	Temp. [°C]	Salinity (‰)
Station 4915-1								
10m	07.03.	23:45	1306	37,4	7°45,01'S	11°52,01'E	29,0	32,1
20m				37,4			22,8	32,2
40m				38,7			19,8	32,3
100m				39,5			18,3	32,3
Station 4916-1								
10m	09.03.	20:04	1300	38,5	10°10,16'S	12°41,06'E	28,6	31,9
20m				39,0			27,2	32,0
40m				38,6			21,8	32,0
100m				39,2			18,5	32,3
Station 4917-3								
10m	10.03.	12:21	1298	38,7	11°54,43'S	13°04,37'E	28,9	32,3
20m				39,1			28,6	32,3
40m				38,6			23,7	32,2
100m				39,1			18,5	32,4
Station 4918-1								
10m	10.03.	22:40	1347	37,0	12°50,20'S	12°41,75'E	27,6	32,1
20m				38,0			26,7	32,3
40m				21,1			21,7	32,5
100m				39,6			17,3	32,5

Table 9b: Water samples for dinoflagellate analyses (filtration with 5µm polycarbonate filters) and coccolithophore analyses (filtration with 45µm Cellulose Nitrate filters) from 10 L NISKIN bottles at about 10, 20, 50, 100, 150 and 200m water depth (M 41/2).

Sample No. M41/2	Time UTC	Water depth [m]	Filtered water Dinos [l]	Filtered water Coccos [l]	Water temp. [°C]	Latitude N/S	Longitude E/W
5001-2	09:22-09:36	10	38	2	29.7	02°02,15'S	01°09,16'E
(20.03.98)		20	38	2	28.8		
		50	38	2	24.1		
		100	38	2	18.3		
		150	-	2	18.6		
		200	-	2	17.8		
5002-4	14:45-15:05	10	38	2	28.1	08°08,81'S	14°32,04'W
(27.03.98)		20	38	2	28.0		
		50	38	2	26.4		
		90	38	2	21.5		
		150	-	2	17.5		
		200	-	2	15.0		
5008-1	11:09-11:29	10	38	2	26.9	12°55,79'S	15°41,06'W
(09.04.98)		20	38	2	26.8		
		50	38	2	26.6		
		100	32,5	2	22.3		
		150	-	2	19.0		
		200	-	2	16.8		

water were collected at each of the four standard depths 10 m, 20 m, 50 m and 100 m. As the CTD data showed that the chlorophyll-a maximum occurs at about 40 m depth in the area studied, the 50 m interval was shifted to 40 m (Table 9). The obtained seawater was sieved through a 100 µm mesh-sieve (DIN 4188), filtered down to 100 ml with a 5µm pore size polycarbonate filter and then treated in the same way as the samples collected with the membrane pump.

All stored water samples and filters will be prepared for Scanning Electron Microscopy (SEM) in Bremen, for investigation of the composition and regional distribution of dinoflagellate communities in the South Atlantic.

In addition, sediment samples were taken at every station from one large core (9,5 cm diameter) of the multicorer (Table 1). The core was cut into slices of 1 cm, which were placed in petri dishes and stored at 4 °C.

The distribution patterns of the dinoflagellate cysts in the surface sediment in relation to environmental characteristics of the overlying water column are of interest and subject to further examination.

Dinofagellates have been observed in every water sample. The most occurred up to a depth of about 40 –50 m, they became very rare towards 100 m. Thecate dinoflagellates and the vegetative-coccoid *Th. heimii* were present in almost every sample. An increase of thecate dinoflagellates was observed in samples with high salinity. *"Sphaerodinella" albatrosiana* also became very frequent in water with higher salinity and *"Sphaerodinella" tuberosa* could also be found. Cysts of *Orthopitonella granifera* were abundant in samples with a low salinity.

At the end of the cruise the Cell Wells™ were scanned. In a number of cells excystment of most cysts has been observed, some resulting in the production of a sufficient number of motile specimen and new cysts, especially cultures with *Th. heimii* and *O. granifera*. The reproduction was very successful in cells with culture medium K.

The cultures will be used for germination experiments in the laboratory at Bremen university which will be carried out under controlled laboratory conditions in order to obtain information on the processes influencing cyst formation.

Coccolithophorids

Coccolithophorids together with other planktonic organisms form the basis of marine ecosystems. Their distribution in sediments is relatively well known, but information on their abundance, ecology and physiology in surface waters is rare. Their occurrence and distribution is directly dependent on the hydrography of the water masses. Fossil remains of coccolithophorids are important indicators for the reconstruction of previous ecological conditions of the water masses. Studying the ecological conditions for the composition and distribution of coccolithophore communities in the eastern Equatorial Atlantic will improve our knowledge about the paleoceanographic and climatic evolution of late Quaternary coccolith-assemblages. As part of the long-range investigations carried out under the Special Research Project 261 in the South Atlantic an extensive water sampling program was conducted during transit periods and station work of M 41/1. The focus of research interest during Meteor Cruise 41 was placed on

Table 10a: Nannoplankton Water Samples (M 41/1).

GeoB No.	Date 1998	Equipment	Time (UTC)	Location Latitude	Location Longitude	Water Depth (m)	Sampling Depth (m)	Water Temp. (°)	Salinity (‰)	Filter Vol. (ltr)	Sample No./Remarks
Off GAMBIA											
--------	18.02.	MP		13°33,4'N	17°54.9'W	2717	5	22.2	35.47	0.8	1+ subsample 2 (1.0L)/ Strong dust supply
EQUATORIAL TRANSECT IVORY COAST - BENIN											
--------	22.02.	MP	13.30	01°00,1'N	07°11,3'W	5144	5	29.6	34.62	2.1	3
--------	22.02.	MP	19.50	01°05,3'N	05°58.8'W	5148	5	29.6	34.68	2.1	4
--------	23.02.	MP	05.45	01°13,1'N	04°10.0'W	5105	5	29.7	34.70	2.1	5
--------	23.02.	MP	15.30	01°20,5'N	02°25.9'W	5074	5	30.1	34.63	2.1	6
--------	24.02.	MP	05.40	01°36,9'N	00°20.5'E	4813	5	29.8	34.73	2.1	7
--------	24.02.	MP	17.17	01°47,7'N	02°03.9'E	4524	5	29.8	34.68	2.1	8
--------	24.02.	MP	22.13	01°55,2'N	03°38.9'E	4162	5	29.7	34.49	2.1	9
--------	25.02.	MP	05.50	01°28,2'N	05°10.6'E	4162	5	29.7	34.49	2.1	10
--------	25.02.	MP	13.00	02°13,5'N	05°58.3'E	3282	5	30.0	31.96	2.0	11
EASTERN NIGER FAN											
4901	26.02.	MP	20.25	02°40,9'N	06°43.7'E	2183	5	29.8	30.33	1.6	12
4901-3	26.02.	ROS18	20.32	02°40,9'N	06°43.7'E	2183	10	30.1	30.44	2.0	13
							20	30.2	34.37	2.0	14
							50	20.6	36.00	2.0	15
							100	17.9	35.83	2.0	16
							150	15.5	35.58	2.0	17
							200	14.5	35.44	2.0	18
4902	27.02.	MP	00:05	02°21.2'N	06°01.8'E	3222	5	29.9	30.88	2.0	19
4902-1	27.02.	ROS18	00:05	02°21.2'N	06°01.8'E	3222	10	30.1	31.02	2.0	20
							20	30.1	34.33	2.0	21
							50	20.2	36.11	2.0	22
							100	17.2	36.65	2.0	23
							150	15.9	35.65	2.0	24
							200	14.7	35.44	2.0	25
NE off SAN THOMÉ											
--------	27.02.	MP	13.09	02°09,8'N	06°56.8'E	2914	5	29.8	30.73	1,56	26
4903	27.02.	MP	19:50	01°54.9'N	08°10.5'E	2384	5	29.9	30.63	1.0	27+ subsample 34 (1.0l)
4903-1	27.02.	ROS18	19:50	01°54.9'N	08°10.5'E	2384	10	30.3	31.60	2.0	28
							20	30.4	33.03	2.0	29
							50	20.7	36.16	2.0	30
							100	18.0	35.87	2.0	31
							150	16.0	35.68	2.0	32
							200	14.8	35.50	2.0	33
OFF NORTHERN GABON (Bight of Biafra)											
--------	28.02.	MP	05.25	01°18,7'N	08°09.9'E	2413	5	29.8	30.37	2.0	35
4904	28.02.	MP	11:36	01°57.6'N	08°52.8'E	1344	5	30.0	30.61	2.0	36
4904-3	28.02.	ROS18	11:36	01°57.6'N	08°52.8'E	1344	10	30.1	30.62	2.0	37
							20	30.1	30.80	2.0	38
							50	21.5	36.09	2.0	39
							100	17.6	35.87	2.0	40
							150	15.4	35.60	2.0	41
							200	15.0	35.53	2.0	42
OFF CAMEROON											
4905	01.03.	CP	03:16	02°30.1'N	09°23.5'E	1325	5	30.0	28.68	1.5	43/Supply from circular pump!
4905-3	01.03.	ROS18	03:16	02°30.1'N	09°23.5'E	1325	10	30.3	28.74	2.0	44
							20	30.3	30.47	2.0	45
							50	20.8	35.99	2.0	46
							100	17.7	35.76	2.0	47
							150	15.0	35.60	2.0	48
							200	14.4	35.44	2.0	49

Table 10a: continued

GeoB No.	Date 1998	Equipment	Time (UTC)	Location Latitude Longitude	Water Depth (m)	Sampling Depth (m)	Water Temp. (°)	Salinity (‰)	Filter Vol. (ltr)	Sample No./Remarks
OFF GABON (Profile 1)										
4906	02.03.	CP	03:10	00°41.4'S08°22.6'E	1278	5	29.6	30.45	1.6	50/Supply from circular pump!
4906-2	02.03	ROS18	03:10	00°41.4'S08°22.6'E	1278	10	30.0	31.49	2.0	51
						20	29.6	32.25	2.0	52
						50	21.1	36.24	2.0	53
						100	17.9	35.87	2.0	54
						150	15.8	35.65	2.0	55
						200	15.2	35.56	2.0	56
4907	02.03.	CP	09:55	00°37.5'S08°01.8'E	2057	5	30.4	31.00	1.56	57/Supply from circular pump!
4907-1	02.03	ROS18	09:55	00°37.5'S08°01.8'E	2057	10	30.0	31.18	2.0	58
						20	30.0	32.34	2.0	59
						50	22.0	36.05	2.0	60
						100	18.4	35.95	2.0	61
						150	16.0	35.68	2.0	62
						200	15.0	35.50	2.0	63
4908	02.03.	CP	19:36	00°42.6'S06°50.3'E	3029	5	29.6	32.37	2.0	64/Supply from circular pump!
4908-1	02.03	ROS18	19:36	00°42.6'S06°50.3'E	3029	10	29.8	32.77	2.0	65
						30	28.0	34.02	2.0	66
						40	21.4	36.23	2.0	67
						100	17.8	35.92	2.0	68
						150	16.0	35.68	2.0	69
						200	14.7	35.48	2.0	70
OFF GABON (Profile 2)										
--------	03.03.	CP	19.25	01°18,0'S08°26.4'E	190	5	30.0	30.96	2.0	71/Supply from circular pump!
4909	04.03.	CP	00.50	02°04.3'S08°37.7'E	1303	5	30.0	32.41	2.0	72/Supply from circular pump!
4909-2	04.03	ROS18	00.50	02°04.3'S08°37.7'E	1303	10	29.9	32.91	2.0	73
						30	24.8	35.09	2.0	74
						40	22.6	36.15	2.0	75
						100	18.6	36.00	2.0	76
						150	16.3	35.66	2.0	77
						200	14.9	35.50	2.0	78
--------	04.03.	CP	10.00	02°22,5'S07°55.9'E	3202	5	29.6	33.34	2.0	79/Supply from circular pump!
4910	04.03.	CP	14.40	02°18.9'S08°04.1'E	3000	5	29.8	32.41	1.47	80/Supply from circular pump!
4910-1	04.03	ROS18	14.40	02°18.9'S08°04.1'E	3000	10	29.9	33.51	2.0	81
						20	29.1	33.40	2.0	82
						50	20.4	35.89	2.0	83
						100	17.4	35.83	2.0	84
						150	15,8	35.64	2.0	85
						200	14.6	35.84	2.0	86
4911	04.03.	CP	02.40	02°08.2'S08°28.7'E	1950	5	29.7	33.09	1.6	87/Supply from circular pump!
OFF SOUTH GABON										
--------	05.03.	CP	17.03	02°57,3'S09°15.4'E	1008	5	29.8	33.16	2.0	88/Supply from circular pump!
4912	05.03.	CP	22.21	03°43.9'S09°47.1'E	1306	5	29.8		1.47	89/Supply from circular pump!
4912-1	05.03	ROS18	22.21	03°43.9'S09°47.1'E	1306	10	29.9	33.30	2.0	90
						20	25.8	35.58	2.0	91
						50	21.1	35.90	2.0	92
						100	18.0	35.91	2.0	93
						150	16.4	35.69	2.0	94
						200	14.6	35.46	2.0	95
NORTHERN CONGO FAN										
4913	06.03.	MP	15.03	05°29.9'S11°04.3'E	1299	5	29.1	26.6	1.0	96+103 (1.0l)
4913-2	06.03	ROS18	15.03	05°29.9'S11°04.3'E	1299	10	29.9	32.35	2.0	97
						20	24.8	35.53	2.0	98
						40	21.2	35.55	2.0	99
						100	16.6	35.67	2.0	100
						150	15.2	35.54	2.0	101
						200	14.4	35.43	2.0	102

Table 10a: continued

GeoB No.	Date 1998	Equipment	Time (UTC)	Location Latitude Longitude	Water Depth (m)	Sampling Depth (m)	Water Temp. (°)	Salinity (‰)	Filter Vol. (ltr)	Sample No./Remarks
SOUTHERN CONGO FAN (GeoB 1009, 1401)										
———	07.03.	MP	03.10	06°07,3'S10°07.5'E	3215	5	28.9	27.53	1.0	104+subsample 112 (0.9l)
4914	07.03.	MP	09.40	06°56.1'S08°59.9'E	3979	5	29.1	35.33	2.0	105
4914-1	07.03	ROS18	09.40	06°56.1'S08°59.9'E	3979	10	29.3	35.41	2.0	106
						20	23.6	35.58	2.0	107
						40	19.7	35.64	2.0	108
						100	16.8	35.71	2.0	109
						150	15.5	35.59	2.0	110
						200	14.7	35.47	2.0	111
OFF ANGOLA										
--------	08.03.	MP	18.22	06°52.3'S11°32.4'E	794	5	30.0	29.08	2.0	113
4915	08.03.	MP	23:45	07°45.0'S11°52.0'E	1306	5	29.5	35.48	2.0	114
4915-1	08.03	ROS18	23:45	07°45.0'S11°52.0'E	1306	10	29.7	35.57	2.0	115
						20	24.1	35.41	2.0	116+subsample 121 (1.0l)
						40	19.6	35.51	2.0	117
						100	17.2	35.72	2.0	118
						150	15.5	35.56	2.0	119
						200	14.5	35.44	2.0	120
4916	09.03.	MP	20:04	10°10.2'S12°41.1'E	1300	5	29.2	35.57	2.0	122
4916-1	09.03	ROS18	20:04	10°10.2'S12°41.1'E	1300	10	29.3	35.57	2.0	123
						20	27.3	35.62	1.75	124
						40	20.7	35.73	2.0	125
						100	17.5	35.65	2.0	126
						150	16.3	35.64	2.0	127
						200	14.4	35.41	2.0	128
--------	10.03.	MP		11°10.2'S12°40.6'E	1501	5	29.2	35.69	2.0	129
4917	10.03.	MP	12.21	11°54.4'S13°04.4'E	1298	5	29.2	35.60	2.0	130
4917-3	10.03	ROS18	12.21	11°54.4'S13°04.4'E	1298	10	29.0	35.72	2.0	131
						20	27.3	35.62	2.0	132
						40	25.2	35.51	2.0	133
						100	15.9	35.62	2.0	134
						150	14.8	35.50	2.0	135
						200	14.0	35.37	2.0	136
4918	10.03.	MP	22.40	12°50.4'S12°41.7'E	1347	5	27.5	35.46	2.0	137
4918-1	10.03	ROS18	22.40	12°50.4'S12°41.7'E	134	10	27.5	35.36	2.0	138
						20	26.8	35.47	1.6	139
						40	21.6	35.59	2.0	140+subsample 144 (1l)
						100	16.5	35.63	2.0	141
						150	14.5	35.43	2.0	142
						200	13.6	35.32	2.0	143
--------	11.03.	MP	17.03	10°51.9'S12°32.6'E	1590	5	29.7	35.67	2.0	145
--------	11.03.	MP	23.00	09°52.8'S12°07.7'E	2009	5	29.6	35.58	2.0	146
--------	12.03.	MP	03.53	09°04.2'S11°38.4'E	2313	5	29.1	35.74	2.0	147
--------	12.03.	MP	10.03	08°00.6'S11°06.3'E	2579	5	29.5	35.52	2.0	148
--------	12.03.	MP	16.07	07°00.4'S10°36.6'E	2503	5	30.6	27.22	2.0	149
SOUTHERN CONGO FAN										
4919	12.03.	MP	20.53	06°23.9'S10°18.2'E	3053	5	30.5	27.27	2.0	150
NORTHERN CONGO FAN										
———	13.03.	MP	10.57	06°29.4'S08°57.0'E	3906	5	29.4	31.50	2.0	151
———	13.03.	MP	19.05	05°00.2'S08°47.0'E	3717	5	29.3	32.42	1.55	152
OFF GABON										
--------	14.03.	MP	10.04	02°40.1'S08°31.2'E	1643	5	29.5	33.03	2.0	153
--------	14.03.	MP	14.33	01°58.2'S09°26.5'E	1825	5	29.5	32.14	2.0	154

Table 10b: Nannoplankton surface water sampling (M 41/2).

No.	Date 1998	Time [UTC]	GeoB No.	Water depth [m]	Sample depth [m]	Geographic position Latitude N/S	Longitude E/W	Water temp. [°C]	Salinity [psu]	Filter quantity [l]
1	20.03.	10:12	-	4680	5	02°03.11'S	01°05.45'E	29.6	33.89	1
2	20.03.	16:27	-	4750	-"-	02°24.48'S	00°05.29'W	29.7	34.07	2
3	21.03.	07:19	-	4730	-"-	03°14.50'S	02°50.82'W	28.7	34.70	2
4	21.03.	15:19	-	4705	-"-	03°44.43'S	04°17,68'W	29.2	34.46	2
5	22.03.	07:35	-	4184	-"-	04°48.72'S	07°17.25'W	28.6	34.63	2
6	22.03.	18:08	-	3528	-"-	05°30.38'S	09°13.87'W	28.8	35.40	2
7	23.03.	08:26	119TDS	4917	-"-	06°16.95'S	11°21.98'W	28.4	36.15	2
8	24.03.	15:29	124TDS	2958	-"-	07°03.92'S	12°39.45'W	28.1	36.15	2
9	25.03.	10:30	128KDS	4500	-"-	07°26.73'S	13°23.61'W	27.8	36.15	2
10	26.03.	20:35	-	2910	-"-	07°47,91'S	14°07,40'W	27.8	36.22	2
11	27.03.	9:27	5002	2852	-"-	08°08,59'S	14°32,50'W	27.6	36.36	2
12	01.04.	11:33	162TDS	2404	-"-	09°04,43'S	13°27,03'W	27.1	36.45	2
13	01.04.	22:30	5004	2789	-"-	09°09,98'S	13°20,48'W	-	36.45	2
14	04.04.	13:42	-	307	-"-	09°46,31'S	12°06,64'W	-	36.50	2
15	04.04.	17:33	5006	3243	-"-	09°45,55'S	12°22,12'W	27.6	36.48	2
16	06.04.	10:20	-	3102	-"-	10°19,04'S	13°09,21'W	27.3	36.47	2
17	08.04.	19:39	5007	3668	-"-	12°23,63'S	13°56,34'W	26.8	36.68	2
18	09.04.	14:03	5008	3406	-"-	12°55,82'S	15°41,12'W	27.1	36.61	2
19	10.04.	10:46	-	4500	-"-	14°00,07'S	19°11,22'W	26.4	36.90	2
20	10.04.	21:15	-	-	-"-	14°35,22'S	21°07,86'W	27.2	36.78	2
21	11.04.	08:33	-	5045	-"-	15°14,87'S	23°17,16'W	27.3	36.95	2
22	11.04.	18:26	-	5058	-"-	15°49,08'S	25°10,16'W	27.8	37.31	2
23	12.04.	02:23	-	-	-"-	16°16,44'S	26°40,66'W	27.7	37.36	2
24	12.04.	12:09	-	4983	-"-	16°50,40'S	28°33,34'W	28.2	37.41	2
25	12.04.	23:07	-	4842	-"-	17°27,91'S	30°38,25'W	28.8	37.55	2

the horizontal and vertical sampling of the different surface water masses of the eastern Equatorial Atlantic.

On M 41/1 samples were taken at 19 stations from a Rosette equipped with 18 Niskin bottles (10 lt.) of six individual water depths (in general 10 m, 20 m, 40 m, 100 m,150 m, and 200 m). In addition, 25 surface water samples were obtained from about 5 m water depth using the ships membrane pump system along two transects. Sample positions of surface and deeper waters obtained during Meteor Cruise 41/1 are listed in Table 10a. Transect one parallels the Equator at 1° to 3° N covering the area from 3° W to 10° E, close to the coastline of Cameroon. This transect extends a water sample profile obtained between 28° and 22° W during Meteor Cruise 29-3 in the central Equatorial Atlantic towards the African continent (SCHULZ ET AL., 1995). Transect two follows the West African continental margin from 3° N to 12° S off Angola.

At 3 stations during cruise M 41/2, water samples of 2 l were taken from NISKIN bottles of the rosette at 200 m, 150 m, 100 m, 50 m, 20 m and 10 m water depth (Table 9b). In addition, 25 surface water samples were taken from the vessel's membrane pump system at about 5 m water depth along the whole cruise (Table 10b), except of some territories off Gabon, Cameroon, and Brazil. Samples were taken about every second longitude plus every latitude, that means once or twice a day depending on vessel speed and course. To compare the coccolith communities in the water column with the assemblages found in surface sediments beneath, on all Multicorer stations surface sediment samples were taken (Table 3) and simultaneously a water sample from the vessel's membrane pump system was taken.

Generally, two liters of each water sample were immediately filtered through a cellulose nitrate filter (0.45 µm pore size, 25 mm diameter) using a ship board vacuum pump. Filters were dried at 45 °C for 12-24 hours without further washing, rinsing or chemical conservation. In order to maintain the samples dry they were sealed in a plastic film after addition of silica gel. Shorebase, the samples will be examined for the composition and the distribution of coccolithophorids using a Scanning Electron Microscope (SEM). Species composition and abundances will be determined by identification and counting on measured filter transects.

4.7 CTD Profiling

(M 41/1: J. Klump, R. Schneider)
(M 41/2: S. Drachenberg, O. Esper, M. Segl)

To obtain information about the hydrographic conditions at the sites surveyed, a SEA BIRD SBE 19 CTD profiler was used at 18 stations. Equipped with a solid-state data storage unit, this device can be deployed together with the multicorer, or any other suitable sampling device, without being connected to shipboard instruments. It was attached to the cable 50 m above the multicorer. The SBE 19 is equipped with sensors for pressure, conductivity, temperature, dissolved oxygen, and UV fluorescence. The raw data were read out immediately after each deployment and standard plots of temperature, salinity, dissolved oxygen, and fluorescence, all plotted versus pressure, attached to the station protocol.

The structure of the upper water column varied considerably along the cruise track. The depth extent of the surface mixed layer is influenced by the amount of river run-off, which produces a marked freshening of the upper-most water layer, and the intensity of upwelling, which shallows the thermocline. In general, the surface mixed layer is only of the order of 10 to 20 m thick

Below the surface mixed layer, other water bodies can be found. In places the structure of the upper 400 m of the water column can be quite complex. At depths of about 700 m to 1700 m we found Antarctic Intermediate Water (AAIW). At deeper stations we also encountered North Atlantic Deep Water (NADW), which is characterized by high salinity, although it has almost the same temperature as AAIW. The identification of water masses was aided by plotting potential temperature against salinity.

Along the cruise track from the Niger Fan, across the Congo Fan, along the Angolan coast the oxygen minimum zone at about 300 m depth became more an more pronounced. Local oxygen minima are often associated with local chlorophyll maxima, which might be the sinking remnants of phytoplankton blooms. At most stations the global chlorophyll maximum was found at a depth of 40 m, which corresponds roughly with the base of the thermocline. Off Angola, the thermocline is only weakly developed due to upwelling of cold, nutrient rich water. The remineralization of carbon exported from the euphotic zone by micro-organisms in the water column leads to an intensification of the oxygen minimum zone.

The structure of the upper water column varied from the Guinea Basin to the Mid-Atlantic Ridge Regions. The depth extent of the surface mixed layer in the Guinea Basin is influenced by the intensity of upwelling, which shallows the thermocline to about 40m. At the Mid Atlantic Ridge stations, the thickness of the surface mixed layer is about 60m.

Below the surface mixed layer, we clearly see the oxygen maximum zone between 50 and 100m water depth together with the chlorophyll maximum. This depth corresponds roughly with the base of the thermocline. Only in the Guinea Basin we see a twofold chlorophyll maximum. At depths of about 700 m to 1700 m we find Antarctic Intermediate Water (AAIW) on top of North Atlantic Deep Water (NADW).

4.8 Sampling of Eolian Dust

(J.-B. Stuut, G. Lavik)

During the cruise eolian dust was sampled during several intervals shown in Figure 42. Dust sampling was allowed during the whole length of the cruise since territorial regulations do not apply to the atmosphere. However, depending on relative wind direction and -strength only several intervals were suitable for sampling. The length of the intervals was chosen either based on dust load (filters full) or on wind regime. In order to avoid pollution from particles delivered by the chimney of the ship no sampling was done when the relative wind direction was in between 130° and 230°, and while at station. Sampling started on 14/2 and was continued until 11/3. For more details on the sampling intervals see Table 11.

The dust samplers consist of a vacuum-cleaner motor and a frame to put the filter on. The size of the filters is 20.3·24.5 cm. One of the dust samplers has a "critical-flow

Table 11: Dust samples taken during M 41/1.

Sample No.	Start/End	Date	Time	Longitude	Latitude	Total
D1	Start	14.02.98	16:23	32°24,64 N	9°54,32 W	
D1	End	14.02.98	23:00	31°25 N	10°55 W	
D1	Start	15.02.98	11:50	29°25 N	12°36 W	
D1	End	15.02.98	17:00	28°29,28 N	13°26,54 W	11hr47min
D2	Start	15.02.98	17:25	28°25,15 N	13°30,45 W	
D2	End	15.02.98	22:30	27°35,35 N	14°19,29 W	
D2	Start	16.02.98	9:30	25°49,74 N	16°02,21 W	
D2	End	16.02.98	15:00	24°55,75 N	16°53,12 W	10hr35min
D3	Start	16.02.98	15:20	24°55,75 N	16°53,12 W	
D3	End	16.02.98	17:00	24°40 N	16°62 W	
D3	Start	17.02.98	7:30	21°40,90 N	17°55,14 W	
D3	End	17.02.98	14:10	20°16,47 N	17°55,08 W	8hr20
D4	Start	17.02.98	14:35	20°11,72 N	17°54,91 W	
D4	End	17.02.98	19:00	19°16,4 N	17°54,8 W	4hr25min
D5	Start	18.02.98	8:00	16°22,72 N	17°54,95 W	
D5	End	18.02.98	13:00	15°37,01 N	17°54,93 W	5hrs
D6	Start	18.02.98	13:20	15°37,01 N	17°54,93 W	
D6	End	18.02.98	16:05	14°57,11 N	17°55,16 W	2hr45min
D7	Start	18.02.98	16:25	14°57,11 N	17°55,16 W	
D7	End	18.02.98	18:25	14°26,28 N	17°55,08 W	2hrs
D8	Start	18.02.98	18:30	14°26,28 N	17°55,08 W	
D8	End	18.02.98	22:55	13°24,41 N	17°54,88 W	4hr25min
D9	Start	19.02.98	8:15	11°26,18 N	17°52,40 W	
D9	End	19.02.98	9:55	11°08,86 N	17°41,01 W	
D9	Start	19.02.98	16:35	10°02,94 N	16°58,02 W	
D9	End	19.02.98	22:18	09°05,77 N	16°14,01 W	7hr33min
D10	Start	20.02.98	8:21	07°44,01 N	14°42,64 W	
D10	End	20.02.98	15:20	06°47,15 N	13°38,69 W	7hrs
D11	Start	20.02.98	15:39	06°45,41 N	13°36,79 W	
D11	End	20.02.98	22:35	05°49,06 N	12°34,01 W	7hrs
D12	Start	21.02.98	8:28	04°31,61 N	11°07,83 W	
D12	End	21.02.98	21:36	02°53,38 N	09°18,72 W	13hr8min
D13	Start	22.02.98	8:44	01°30,57 N	07°46,81 W	
D13	End	22.02.98	19:11	01°04,74 N	06°06,00 W	9hr27min
D14	Start	23.02.98	8:27	01°14,27 N	03°51,40 W	
D14	End	23.02.98	19:23	01°23,23 N	01°51,20 W	10hr56min
D15	Start	23.02.98	19:23	01°23,23 N	01°51,20 W	
D15	End	24.02.98	8:12	01°38,90 N	00°39,12 E	12hr49min
D16	Start	24.02.98	8:12	01°38,90 N	00°39,12 E	
D16	End	24.02.98	18:04	01°51,14 N	02°36.84 E	9hr52min
D17	Start	26.02.98	10:39	02°39,27 N	06°40,17 E	
D17	End	26.02.98	15:51	02°40,96 N	06°43,40 E	
D17	Start	26.02.98	18:55	02°40,23 N	06°43,22 E	
D17	End	26.02.98	23:00	02°24,00 N	06°03.00 E	8hr50min
D18	Start	27.02.98	16:15	02°04,87 N	07°21,72 E	
D18	End	27.02.98	20:27	01°55,09 N	08°09,92 E	

Table 11: continued

Sample No.	Start/End	Date	Time	Longitude	Latitude	Total
D18	Start	28.02.98	4:25	01°40,35 N	08°09,97 E	
D18	End	28.02.98	7:52	01°01,80 N	08°10,00 E	7hr39min
D19	Start	28.02.98	19:12	00°58,41 N	08°53,16 E	
D19	End	01.03.98	3:59	02°30,00 N	09°23,30 E	8hr47min
D20	Start	01.03.98	9:15	02°19,94 N	09°20,09 E	
D20	End	01.03.98	17:00	00°56,71 N	08°52,82 E	7hr45min
D21	Start	03.03.98	17:06	00°41,31 S	08°22,64 E	
D21	End	04.03.98	1:12	02°03,87 S	08°38,72 E	8hr6min
D22	Start	05.03.98	12:40	02°04,73 S	08°37,87 E	
D22	End	05.03.98	23:15	03°43,82 S	09°47,09 E	10hr35min
D23	Start	06.03.98	20:12	05°30,50 S	11°03,61 E	
D23	End	07.03.98	9:52	06°50,41 S	09°02,24 E	13hr40min
D24	Start	08.03.98	15:54	06°12,50 S	11°18,95 E	
D24	End	09.03.98	0:20	07°44,94 S	11°51,27 E	
D24	Start	09.03.98	5:15	07°46,98 S	11°52,40 E	
D24	End	09.03.98	18:35	10°14,35 S	12°22,25 E	21hr46min
D25	Start	11.03.98	14:27	11°28,09 S	12°50,92 E	
D25	End	11.03.98	23:45	~09°55 S	~12°08 E	9hr48min

ventouri" which forces a flux of 1.13 m^3 per minute. The flux of the other dust collector normally is calculated by measuring the pressure drop over the filter but due to computer breakdown this could not be established. The flux is estimated to be about 2 m^3 per minute.

At each sampling interval the two dust collectors were used, each with its own particular type of filter. Glass-fibre filters were used for future studies with stress on the organic content of the eolian dust. After sampling, these filters were wrapped in aluminum foil and stored at —20°C. Organic-geochemistry measurements will be carried out at the biogeochemical department at NIOZ.

Cellulose filters were used in order to be able to study the terrigenous fraction part of the eolian dust. These filters were stored at room temperature. The siliciclastic fraction of the eolian dust will be obtained by dissolving the filter in H_2O_2. Clay mineralogy will be studied using XRD (NIOZ). Grain-size distributions will be measured using a laser particle sizer, major elements will be analyzed using XRF and ICP (Utrecht University).

5 Weather and Meteorological Conditions during the Cruise

(C. Joppich)

The weather at the beginning of the cruise was dominated by a high over France and Spain. Strong easterly winds occurred in the western Mediterranean, growing up to

Bathymetric map of the equatorial Atlantic with locations of dust samples taken during M 41/1

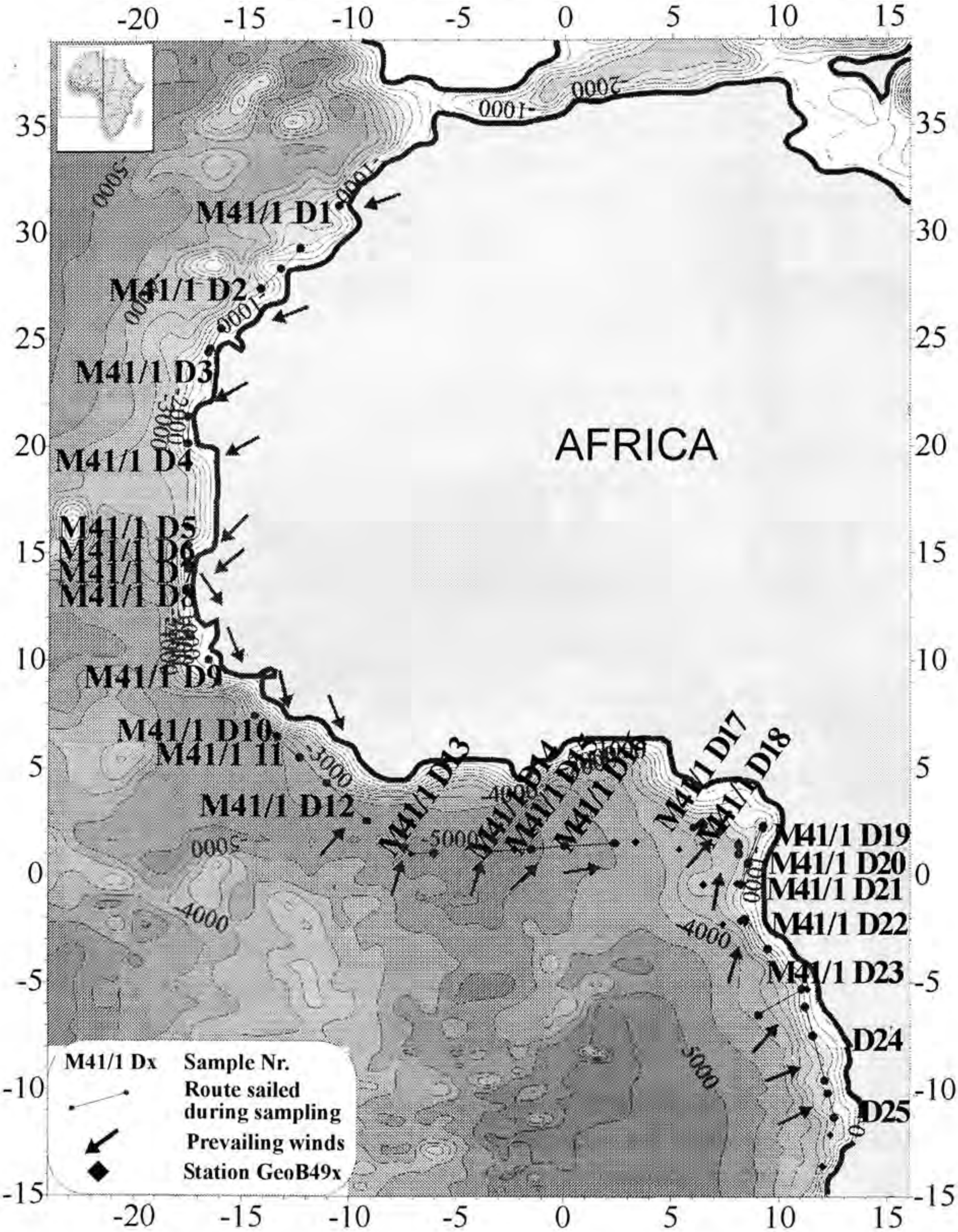

Fig. 42: Bathymetric map of the eastern equatorial Atlantic Ocean showing the positions of dust samples taken during M 41/1.

Bft 8 in the strait of Gibraltar for a short time. Soon after passing Gibraltar winds calmed down to Bft 4. Near the coast of Morocco fog patches arose for a few hours. On the way to the Canary Islands northeasterly trade winds were weak due to a strong high over Algeria. From Canary Islands to Cape Verde the trade winds blew mostly parallel to the coast line, from northerly to northeasterly directions. During daytime the observed wind-speed rarely exceeded Bft 4, because the direction of the sea-breeze was opposite to the geostrophic wind. At night the wind-speed grew up to Bft 5 due to an amplifying effect of a moderate land-breeze. In the subtropical region the sky was free of clouds for several days, but there was a lot of dust in the air, reducing surface visibility sometimes below 5 km.

After passing Cape Verde, the cold Canary Current lost his influence and the sea surface temperature soon reached tropical values of 28 to 30 °C. The wind blew moderate (Bft 4) from northwesterly directions, parallel to the coastline of Sierra Leone. In the night from 20th to 21st of February METEOR crossed the intertropical convergence zone (ITCZ) at a latitude of about 5 degrees north.

The following days winds mostly blew from southerly to southwesterly directions with Bft 3 or Bft 4. Several times rain-showers of different intensity occurred. In vicinity of showers the wind veered northwest and freshened up to Bft 5.

A special meteorological phenomenon appeared in the forenoon of 23rd of February. Several severe rain-showers could be observed in the vicinity of METEOR and altogether three whirlwinds with associated water spouts developed in a distance of about 6 to 10 miles. Their appearance was like a needle prick down from the Cumulonimbus to the sea surface.

In the Gulf of Guinea and the Bight of Bonny it was cloudy but only few showers occurred. The air-temperature was similar to the water-temperature of 29 to 30 °C. Near the islands Principe and Sao Tome widespread mist or haze was present. Prevailing southwesterly winds did not exceed Bft 4 (only weak monsoon effects).

South of the equator similar weather conditions occurred. Winds mostly blew from south to southwest, veering west in showers and increasing to Bft 5 for a short time in their vicinity. In the same time, a well developed subtropical high over the southern Atlantic Ocean induced a strong southeasterly trade wind west of Namibia, which was modified to a moderate southerly to westerly breeze at the western coast of Angola. Therefore the weather at the southernmost part of the cruise was affected by these subtropical conditions. Showers occurred only over land near the coast line due to diurnal heating.

On the way back to Libreville some showers passed through north of 6.00 N and squalls from variable directions grew up to Bft 7 for a short time.

During the entire cruise the swell rarely exceeded 1.5 meters, only at the southernmost part, south of about 10.00 S, the swell reached values of 2.0 meters for a time, due to strong cyclic activity in the west-wind-belt over the southern Atlantic Ocean and strong southeasterly tradewinds south of 20.00 S.

The water-temperatures north of 15.00 N corresponded to the mean, but in the gulf of Guinea and south of it the observed water-temperatures were 1.0 to 1.5 C above the monthly mean values of many years.

6 Acknowledgements

The overall successful and always harmonic course of this journey needs to be attributed to Captain Stefan Bülow and his crew. No matter in which area, beginning with navigation, engine, work deck, electricity, electronics, kitchen, laundry, as well as steward services and metal works on deck, we always were attentively cared for. All scientific and private wishes were fulfilled, regardless if they were usual or unconventional, possible or almost impossible. It was always obvious that all 65 people on board worked on a common task. For this we would like to thank everybody involved.

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