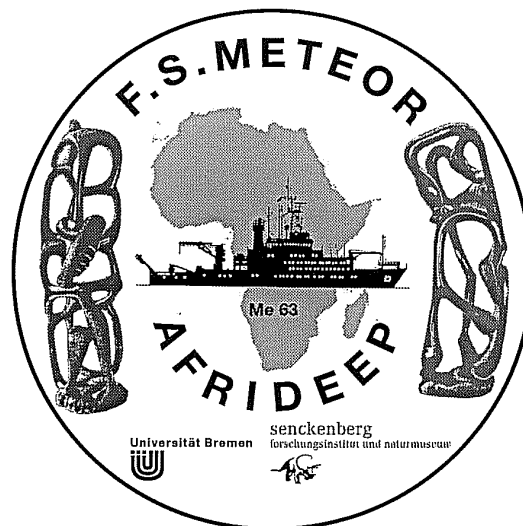


METEOR-Berichte 09-3

Southwestern Indian Ocean – Eastern Atlantic Ocean

Cruise No. 63

January 24 – March 30, 2005
Cape Town (South Africa) – Mindelo (Cabo Verde)



Michael Türkay and Jürgen Pätzold

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2009

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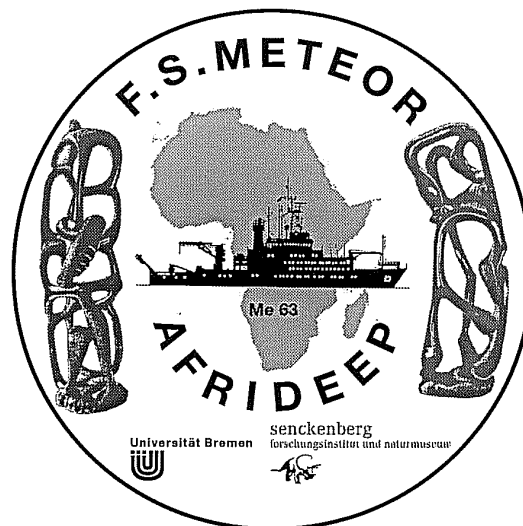
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2009

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Abstract

The overall aims of the METEOR cruise 63 (AFRIDEEP) were gathering basic data from the deep sea around Africa. While leg 1 concentrated on a sedimentological and paleoclimatic description of the SE-African current system along the continental slope of South Africa and Mozambique, leg 2 was devoted to the description and understanding of biodiversity patterns of the deep sea basins (> 5000m) in the Eastern Atlantic (Cape-, Angola- and Guinea-Basins). The work during leg 1 concentrated on hydroacoustic and seismic surveys as well as collection sediment cores. During leg 2 all size classes of deep sea benthos from microbes to megafauna were collected with a set of water samplers, grabs and trawls. All operations were successful and the material collected is being processed in the home laboratories.

Zusammenfassung

Die Fahrt 63 (AFRIDEEP) von F. S. METEOR hatte zum Ziel, Grundlagendaten aus der Tiefsee der Gewässer um Afrika zu sammeln. Fahrtabschnitt 1 befasste sich mit der sedimentologischen und paläoklimatisch beeinflussten Beschreibung des SE-afrikanischen Strömungssystems entlang der Kontinentallänge von Südafrika und Mozambique. Fahrtabschnitt 2 widmete sich der Erfassung und dem Verstehen von Biodiversitätsmustern der Tiefseebecken (> 5000m) des östlichen Atlantik (Kap-, Angola- und Guinea-Becken). Die Arbeiten des ersten Abschnittes wurden mit hydroakustischen und seismischen Methoden durchgeführt, sowie Sedimentkerne gezogen. Während des zweiten Fahrtabschnittes wurden alle Größenklassen des Benthos von Mikroorganismen bis zur Megafauna mit Hilfe von Wasserschöpfern, Greifern und Trawls gesammelt. Alle Probenahmen waren erfolgreich und das Material wird derzeit in den Heimatlabors ausgewertet.

Research Objectives

The Meteor Cruise 63 dealt with two different subjects. One of these is the climate history of the Agulhas current as well as the reconstruction of the late Pleistocene and holocene climate development. The second subject dealt with biodiversity gradients in the abyssal deep sea of the Atlantic Ocean. The Cruise 63 of R. V. "Meteor" was thus aiming at producing basic data on the marine environment in the deep sea around Africa and help to understand short- and long-term variability of these factors.

Research Objectives M63/1

The scientific objectives of RV METEOR cruise M63/1 were to carry out geological, geophysical, and geochemical studies along the continental slope of South Africa and Mozambique. Operations were carried out in three different working areas, i.e., the Tugela Cone, the Limpopo Cone, and the Zambezi Cone. The three working areas along the continental slope of Africa were located between 30°S and 18°S (Fig. 1). The scientific studies were carried out in the territorial waters of South Africa and Mozambique. The major aims of the cruise were to carry out hydroacoustic and seismic surveys and to collect sediment cores. Water and plankton samples as well as surface-sediment samples were collected for calibration purposes. The ultimate goal of

the project is to carry out an integrative and multidisciplinary reconstruction of paleoclimatic changes in the southwestern Indian Ocean, including the continental climate history of southern Africa and in the northern Natal Basin. The investigations also include geophysical analyses of the structural elements and the mechanisms of sedimentation on the deep sea fans of the Limpopo and Sambesi Rivers. The submarine sediment cores of the three river systems were expected to reveal high-resolution sediment records under the influence of the Mozambique Current and the Agulhas Current. The cruise was originally planned to begin on January 24, 2005. Due to technical problems the cruise started on February 1, 2005 in Cape Town and also ended in Cape Town, South Africa, on February 23, 2005.

Research Objectives M63/2

The Biodiversity of the deep sea is not well documented. This statement especially applies to the abyssal basins, the fauna of which has never been studied in detail. To date only very few, mostly single, stations have been sampled in individual basins. During Meteor 63 leg 2 three deep sea basins of the eastern Atlantic were examined, in order to get an idea on the variability of biodiversity within and among basins: One location in the Cape- and Angola-Basins, respectively, as well as three locations in the Guinea-Basin. A sufficient number of replicates ensured that the fauna at the sampling locations was recorded more representatively than it would have been possible through single samples. This scheme aimed at comparing inter-basin variability of the diversity with the inter-basin one. Sampling included all size classes of benthos, i. e. nanobenthos (microbes and protists), meiofauna, macrofauna, and megafauna. The diversity differences will be recorded by classical taxonomic as well as genetic methods for which appropriate subsampling has been performed on board ship. In order to allow correlation to biotic and abiotic parameters the following environmental data were recorded: Salinity and temperature on the bottom of the sampling sites (by probes attached to bottom touching gear), sediment properties (grain size, TOC, TC, Pigment content, pH and eH profiles). The expected results will allow to understand the order of magnitude of the deep sea biodiversity as compared to total biodiversity and also the environmental factors controlling these quantitative figures and differences.

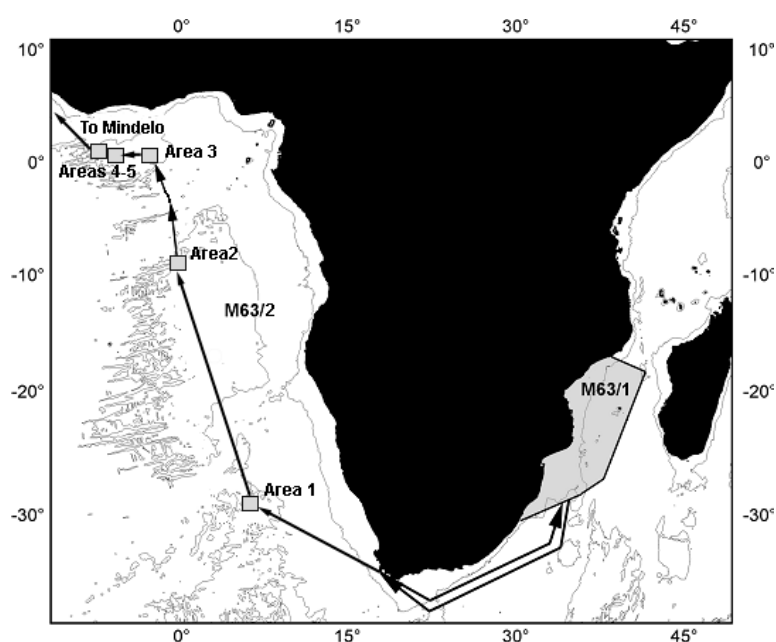


Fig. 1: Working areas during Meteor-Cruise 63

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METEOR-Berichte 09-3

Southwestern Indian Ocean – Eastern Atlantic Ocean

PART 1

Cruise No. 63, Leg 1

January 24 – February 23, 2005
Cape Town – Cape Town (South Africa)



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WHOI	Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA	

1.2 Research Program

In comparison to the knowledge on climate variations in the tropical Indian Ocean and Atlantic Ocean little is known about the climate variability in the southwestern Indian Ocean. Little evidence is available on the variability of the hydrography and biological production on decadal to millennial timescales derived from marine sediments. While the Agulhas Current determines the flow of warm water masses from the Indian Ocean into the South Atlantic, the deep basins of the southwestern Indian Ocean are characterised by the northward flow of intermediate and deep water masses from the Southern Ocean. Marine paleo-indicators from sediment cores may reveal important information about the impact of tropical water masses from the Indian Ocean on climate variability in surface waters of the South Atlantic and on the variability of intermediate and deep water mass circulation deriving from the Antarctic Ocean to the subtropical ocean. In addition, the study of continuous time series from the continental margin of southeast Africa will provide results on the fluvial vs. eolian input of terrigenous mineral components and palynological studies will give important information on climate variability in the southern hemisphere as well as on possible links between circulation changes in the Agulhas Current system and climate conditions in southern Africa. In order to carry out such reconstructions a calibration or at least a comparison between different paleo-environmental indicators with modern climatological conditions is needed. Up to date, no sufficient data sets are available covering the wide spatial area of the Agulhas Current for this comparison.

During the cruise leg plankton samples from the water column as well as sediment surface samples and sediment cores were retrieved. The collection of samples was performed during the expedition with RV METEOR along the continental slope of southeast Africa in the southwestern Indian Ocean. The sample material will be used for reconstructions of the variability of temperature in surface waters and circulation of intermediate and deep water masses. Sediments from the deep-sea fans of the rivers Sambesi, Limpopo, and Tugela were collected and studied for high-resolution temporal reconstructions of the late Pleistocene and Holocene climate history of South Africa. These areas characterised by high sedimentation rates are important sites for the global carbon cycle due to high accumulation rates of terrestrial and marine organic matter. Profiling hydroacoustic surveys and high-resolution shallow-seismic surveys across the continental slope of southeast Africa provided evidence on the sedimentary structures and facies of the deep-sea fans and the interfingering of marine biogenic with terrigenous sediment sequences, and also give hints on the sequences of turbidites or mass flows.

The major goal of the project is to carry out an integrative and multidisciplinary reconstruction of paleoclimatic changes in the southwestern Indian Ocean including the continental climate history of southern Africa and its impact on the sediment transport along the continental slope of southeast Africa and in the northern Natal Basin.

The reconstruction of the conditions of vegetation and weathering in South Africa will be performed by the study of marine sediments and variations in fluvial input through the rivers Tugela, Limpopo and Sambesi. To improve the paleoceanographic reconstructions beyond the available investigations a new data set of the applied paleoenvironmental indicators, based on a wide spatial coverage which is calibrated against modern environmental conditions, will be established. The investigations will also include geophysical analyses of the structural elements

and the mechanisms of sedimentation on the deep-sea fans of the rivers Limpopo and Sambesi (Working areas B and C).

One aim of the cruise was the retrieval of surface sediments with wide spatial coverage, that will allow sufficient “proxy calibration” of the utilized sedimentological, geochemical, and isotopic parameters from sediment cores. This was supported by a comprehensive sampling of the water column for investigation of plankton distribution (e.g., chlorophyll, C_{org} - and opal contents), as well as for oxygen isotopic composition of dissolved inorganic carbon and particulate organic carbon. In addition, stable isotope ratios and Mg/Ca ratios of ambient foraminifera were determined for this calibration. Moreover, the environmental conditions determining the individual assemblages of certain microfossil groups will be studied to enable their application for detailed paleoceanographic reconstructions in the working area and in the adjacent South Atlantic. The latter is important because a lot of the floral and faunal climate signal in the South Atlantic is governed by Indian Ocean waters. Organic matter should be separated into different biomarker compounds which can be associated to certain marine plankton organisms or to groups of land plants. For all these parameters, the typical distribution pattern for the coastal and oceanic part of the Agulhas Current, as well as for the fluvial input should be determined. The focus of the gravity coring program was on depth transects in the range between 500 to 2000 m water depth. This depth range provided the highest sedimentation rates on the slope.

The major biological and micropaleontological objective of this cruise was a better understanding of the distribution of microfossil groups (coccolithophorids, foraminifera, diatoms, radiolaria, and dinoflagellates) in the water column and surface sediments in relation to the ambient physical and chemical properties of the surface and deep-ocean off South Africa. Moreover, measurements of chlorophyll, bulk organic carbon, carbonate and biogenic opal as well as alkenones will allow to determine the general geochemical composition of phytoplankton in surface waters. Again, the purpose of these geochemical analyses is to better quantify the relationship of phytoplankton composition in the water column and surface sediments to the particular oceanographic and geochemical conditions, like temperature, salinity, nutrient content as well as to transport regimes and preservational conditions that prevail off South Africa.

The bathymetric, sediment-echographic, and seismic survey was integrated into the running work program during the expedition. Besides the continuous recording of PARASOUND and HYDROSWEEP data during the whole cruise selected profiles for seismic surveys were carried out on the submarine fans of Limpopo and Sambesi rivers, which will revealed a first image of sediment accumulation and sediment transport patterns. After the cruise the PARASOUND data and the bathymetric HYDROSWEEP imaging together with the sedimentological and geological results will be included in a regional interpretation of sediment structures and processes.

As the principal basis for any further retrieval of sediment cores, the near surface physical sediment structures, imaging effects of paleoceanographic and paleoclimatic variability in the sedimentation processes, are continuously recorded with the PARASOUND echosounder system. Its digital data acquisition was performed with the PARADIGMA system developed at Bremen University. In addition, a detailed survey of the seafloor topography will contribute to the visualisation of the setting of Late Quaternary sediments in the working area.

For the complete sediment core material detailed core logs of the compressional wave velocity, the magnetic susceptibility and, as a measure of density and porosity, of the electrical conductivity were determined. The measurements are already carried out onboard to retain the *in-situ*

conditions in optimal approximation. Among other purposes, these physical properties of the sediments together with rock magnetic and geochemical properties can be used for basin-wide or regional correlation and serve as identifiers for paleoclimatic and paleoceanographic induced variations characteristic for certain sedimentary sequences. Together with the biostratigraphic, isotopic and lithologic variations, in particular the rock magnetic analyses provided valuable information for the chronostratigraphic model of all retrieved sediment cores.

Among others, the aim of the geochemical and geophysical investigations was detailed examination of the early diagenetic modification of the primary composition and the rock magnetic properties of the sediment within the sulfate/methane transition zone (SMT). For this purpose the pore water were retrieved to determine the current geochemical zonation/environment of the sediments as well as the depth position of the SMT. A further major goal was the high-resolution sampling of the sedimentary solid phase and the adequate storage of the sediment samples for subsequent wet chemical and mineralogical analyses. Besides the assessment of the extent of diagenetic overprint these solid phase samples will also be used to reconstruct variations in the input of primary sediment components over glacial/interglacial timescales as a result of changes in sea level, ocean circulation and climate in the catchment area of the examined river fan systems.

1.3 Narrative of the Cruise

After a few weeks in port, R/V METEOR left Cape Town, South Africa, on the early afternoon of Tuesday, February 1, 2005, beginning the first leg of Cruise M63/1. The scientific shipboard party consisted of 26 scientific colleagues, including 19 colleagues from the Universities of Bremen and Kiel, one scientist from the Alfred Wegener Institute for Polar and Marine Research (AWI), Bremerhaven, one scientist from the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) in Hannover, one scientist from Woods Hole Oceanographic Institute, USA, two young scientists from the Universities of Cape Town and Kwazulu-Natal, South Africa, as well as two colleagues from the Deutscher Wetterdienst (DWD) in Hamburg.

The scientific objectives of R/V METEOR cruise M63/1 were to carry out geological, geophysical, and geochemical studies along the continental slope of South Africa and Mozambique. Operations were carried out in three different working areas, i.e., the Tugela Cone (Area A), the Limpopo Cone (Area B), and the Zambezi Cone (Area C). The three working areas along the continental slope of Africa are located between 30°S and 18°S (Fig. 1.1). Scientific studies were carried out in the territorial waters of South Africa and Mozambique. The major aims of the cruise were to carry out hydroacoustic and seismic surveys and to collect sediment cores. Water and plankton samples as well as surface-sediment samples were collected for calibration purposes. The ultimate goal of the project is to carry out an integrative and multidisciplinary reconstruction of paleoclimatic changes in the southwestern Indian Ocean, including the continental climate history of southern Africa and in the northern Natal Basin. The investigations also include geophysical analyses of the structural elements and the mechanisms of sedimentation on the deep sea fans of the Limpopo and Sambesi Rivers. The submarine sediment cores of the three river systems were expected to reveal high-resolution sediment records under the influence of the Mozambique Current and the Agulhas Current. The cruise was originally planned to begin on

January 24, 2005. Due to technical problems the cruise started on February 1, 2005 in Cape Town and also ended in Cape Town, South Africa, on February 23, 2005.

In the early afternoon of 1 February 2005 the R/V METEOR left the harbor of Cape Town after a few short tests and sailed eastward toward the Indian Ocean. At 20° east longitude, near Cape Agulhas, we crossed from the Atlantic into the Indian Ocean and cruised along the continental margin toward the first target area northeast of Durban, which we reached on Saturday, 5 February 2005. The trip was slowed by the fact that the ship had to sail against the Agulhas Current. Because of the limited time, we restricted our work in the first study area off Tugela, at around 30°S, to a short run with PARASOUND und HYDROSWEEP to search for possible sampling stations in water depths of 1000 to 2500m. The survey map shows deeply cut canyons in the southern and eastern area off the Tugela estuary. A young sediment cover is not present. Only older sediment packages are found here. To the northeast, however, we were able to identify appropriate sampling stations with younger sediment cover, where we planned to come to take a sediment core on the return trip to Cape Town.

During the night of the 5 to 6 of February 2005, we left the South African waters and began our work off the Limpopo around the latitude of Maputo. There, on the morning of February 6, the first successful geological sampling of the sea floor was carried out with the multicorer and gravity corer, as well as sampling of the water column with the rosette and the multinet. After the usual technical preparations and tests, the first five seismic profiles were carried out on the shallow continental slope off the Limpopo Estuary. The profiles indicate uniform depositional conditions with prominent current-influenced sediment bodies. Near-surface sediment bodies show a clear leveling effect, which indicates high current activity in this area. Subsequent profiles brought us nearer to the shelf and estuary.

On the afternoon of 8 February 2005 we departed the area off the Limpopo and made a course for the third study area of the leg. We reached the sediment fans of the Zambezi during the night of the 9 to 10 of February 2005 and began the work there with a long seismic profile. We sailed initially over a large area that was characterized by multiple slump layers, and therefore decided against taking any sediment cores in the area. On leaving the area, sailing eastward, the first appropriate station was identified and sampled at a water depth of 1725m. In order to obtain an overview of the sediment fan in the short remaining available time, we relocated to a profile with a northeasterly trend and carried out a depth profile of around 1300 meters, extending to the shelf, where various sampling stations were conducted. A northeasterly measurement survey led us into an area of presently inactive canyons, yielding an additional successful coring station on the upper continental slope.

On Sunday, 13 February 2005 we reached the most northerly and easterly point of the cruise at around 18°S and 37°20'E. The weather conditions were relatively good. The wind and swell had abated and enabled smooth work on deck. With the station work, however, we had to repeatedly struggle against strong currents. At these shallow water depths, in places only a few hundred meters deep, the accurate positioning of the sampling tools was difficult. Seismic profiles and geological station work were alternately carried out. Sampling with the gravity corer in water depths between 400 and 700m near the estuary of the Zambezi was particularly successful. We were able to spend a total of 6.5 days working in this marine area. On Wednesday, 16 February 2005 the R/V METEOR left the study area off the Zambezi on a southern course for the 1400 nm return journey. This transit was interrupted by two previously identified sampling locations south

of the Limpopo and northeast of the Tugela. The work was complemented by a further seismic profile in the central part of the Limpopo Fan. Station work for the cruise was concluded at 6:00 a.m. on 20 February 2005 with a gravity core in the deep Natal Basin at around 3000m water depth. The R/V METEOR reached the harbor of Cape Town two days later on Wednesday, 23 February 2005, where the cruise came to an end. The last containers with scientific equipment were unloaded to the pier and sent back to the home institute. The ship was handed over to the arriving scientists for the second leg of cruise M63.

Of the original 30 days planned for the cruise, only 21 were available for the actual expedition at sea, of which a significant portion were needed for transit time to and from the area around 18°S. Unfortunately there was not enough time to survey and sample the Zambezi Canyon in the eastern part of the Zambezi Fan. The original plan had included searching for channel and levee sediments there. Furthermore, plans for sampling deeper stations in the Mozambique Strait and in the Agulhas Current outside of the sediment fans of the rivers had to be cancelled. There was also insufficient time for detailed survey work with PARASOUND and HYDROSWEEEP off the Tugela River.

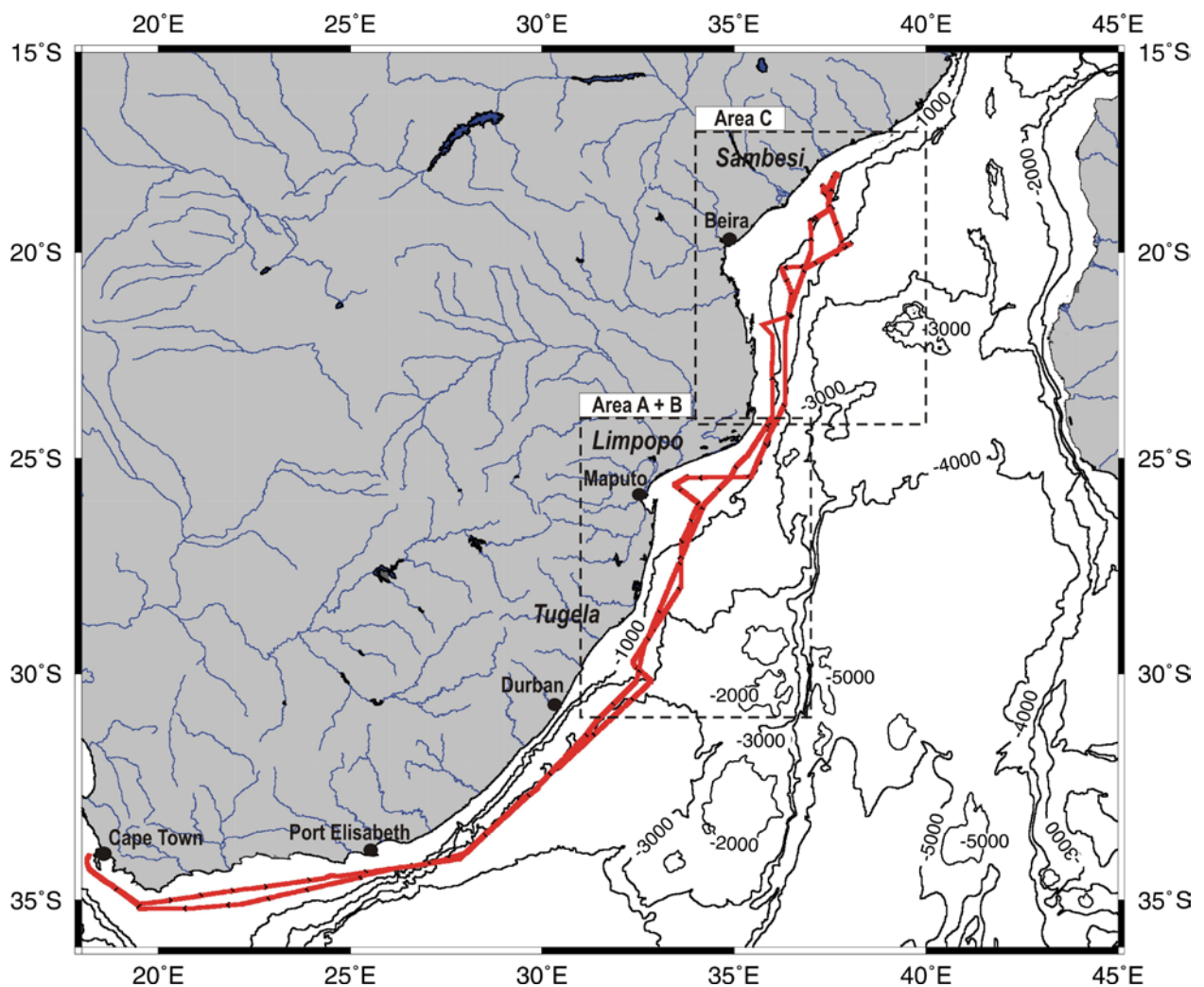


Fig. 1.1: Track line and working areas of R/V METEOR cruise during M63/1.

1.4 Preliminary Results

1.4.1 Hydroacoustic Systems and Multichannel Seismics

(V. Spieß, T. Vogt, T. Schwenk, A. Gerriets, K. Hirsch, T. Mehring)

In this section, seismic observations from all three working areas (Area A-C) are described. PARASOUND and HYDROSWEEEP data were recorded during the whole cruise from Cape Town up to the Zambezi River and back to Cape Town, which was mainly carried out on the SE African upper continental slope.

The narrow-beam PARASOUND sediment echosounder was operated at a frequency of 4 kHz. Its footprint size is only about 7% of the water depth and both vertical and lateral resolution is significantly improved compared to conventional echosounding systems. Depth penetration depends on the type of sediments, seafloor morphology and other factors and is typically limited to 50-200 m. PARASOUND data were filtered and printed with custom software.

The multibeam swathsounder HYDROSWEEEP operates at a frequency of 15.5 kHz and provides an image of seafloor topography with a path width of twice the water depth. As the PARASOUND system, HYDROSWEEEP is hull-mounted on R/V METEOR and was routinely used on Cruise M63/1.

The Bremen multichannel seismic system is specifically designed to acquire high resolution seismic data through optimizing all system components and procedural parameters. Different seismic sources (2 GI-Guns, 10-300 Hz; watergun, 100-1600 Hz) are shot in an alternating mode, providing different types of seismic data with different depth penetration and resolution. The streamer had an active length of 600 m. Processing of seismic data was carried out with custom software as well as with the commercial software package VISTA for Windows.

1.4.2. Geophysical Profiling

(V. Spieß, T. Vogt, T. Schwenk, A. Gerriets, K. Hirsch, T. Mehring)

During R/V METEOR Cruise M63/1, 15 multichannel seismic profiles were recorded with a total length of 600 nm (1125 km) with 87.000 shots of watergun and GI-Gun sources. Profile parameters are listed in Table 1.1. During the cruise, the hull-mounted PARASOUND and HYDROSWEEEP systems were operated continuously, and a complete hydro-acoustic data set is available.

Three working areas A, B and C (Figure 1.1) were visited. Study Area A, on the Tugela Cone, is located at 28°S latitude. Area B in the central part at latitudes around 26°S is situated off the Limpopo River, and Area C, the northernmost working area between 18°S to 22°S latitude, covers the Zambezi Fan. The main focus of seismic surveys was chosen to be in Area C with 9 of 15 profiles, since the Zambezi Fan seemed to be the most promising area to find very high Holocene sedimentation rates, while both the Limpopo and Tugela margin appeared to be starving from recent terrigenous sediment supply.

In the Limpopo Cone (Area B) six multichannel seismic profiles were collected with GI-Guns and watergun, which were complemented by sediment echosounding and bathymetric swath mapping. In Area A (Tugela Cone) only the digital sediment echosounder system PARASOUND and swath bathymetry (HYDROSWEEEP) was used to gain a geologic overview.

Tab. 1.1: List of all seismic profiles during R/V METEOR M63/1.

Profile	Start Latitude	Start Longitude	Date	Time (UTC)	End Latitude	End Longitude	Date	Time (UTC)	Course	Number of shots	Length [nm]
GeoB 05-001	26°23,90'S	33°54,14'E	06/02/05	18:24	26°10,32'S	34°01,26'E	06/02/05	23:20	22	2955	22,5
GeoB 05-002	26°10,32'S	34°01,26'E	06/02/05	23:20	25°37,16'S	33°26,73'E	07/02/05	07:38	310	4952	43
GeoB 05-003	25°36,36'S	33°27,42'E	07/02/05	07:53	25°27,06'S	33°45,97'E	07/02/05	11:45	60	2224	18
GeoB 05-004	25°27,16'S	33°47,62'E	07/02/05	20:39	25°25,87'S	35°24,74'E	08/02/05	12:03	85	9423	87
GeoB 05-005	21°00,10'S	36°29,96'E	09/02/05	16:37	20°24,48'S	36°14,32'E	10/02/05	03:47	335	6365	40
GeoB 05-006	20°23,74'S	36°14,97'E	10/02/05	04:02	20°21,49'S	36°34,31'E	10/02/05	08:48	80	2855	18
GeoB 05-007	20°21,49'S	36°34,31'E	10/02/05	08:48	20°21,60'S	36°54,68'E	10/02/05	13:46	90	2945	18,5
GeoB 05-008	19°49,30'S	37°48,98'E	11/02/05	16:03	18°23,26'S	37°18,80'E	12/02/05	11:21	340	11186	92
GeoB 05-009	18°04,42'S	37°39,21'E	13/02/05	12:08	18°49,83'S	37°26,90'E	13/02/05	22:55	200	6347	46,5
GeoB 05-010	18°56,15'S	37°30,20'E	14/02/05	06:54	19°18,17'S	36°51,93'E	14/02/05	15:12	235	4187	42
GeoB 05-011	19°05,37'S	36°59,34'E	14/02/05	22:19	20°00,40'S	37°00,03'E	15/02/05	09:05	180	11558	54,5
GeoB 05-012	21°33,90'S	36°28,83'E	16/02/05	00:16	21°49,90'S	35°48,73'E	16/02/05	08:59	250	9185	42
GeoB 05-013	21°51,52'S	35°48,46'E	16/02/05	09:18	22°01,07'S	35°58,90'E	16/02/05	11:38	135	2479	13,5
GeoB 05-014	25°19,02'S	34°58,50'E	17/02/05	06:58	26°03,90'S	34°13,80'E	17/02/05	16:22	225	10123	59,5
GeoB 05-015	26°03,90'S	34°13,80'E	17/02/05	16:22	26°06,60'S	34°12,50'E	17/02/05	16:50	210	546	3
										Σ87330	Σ 600

1.4.2.1 Tugela and Limpopo Cone (Areas A and B)

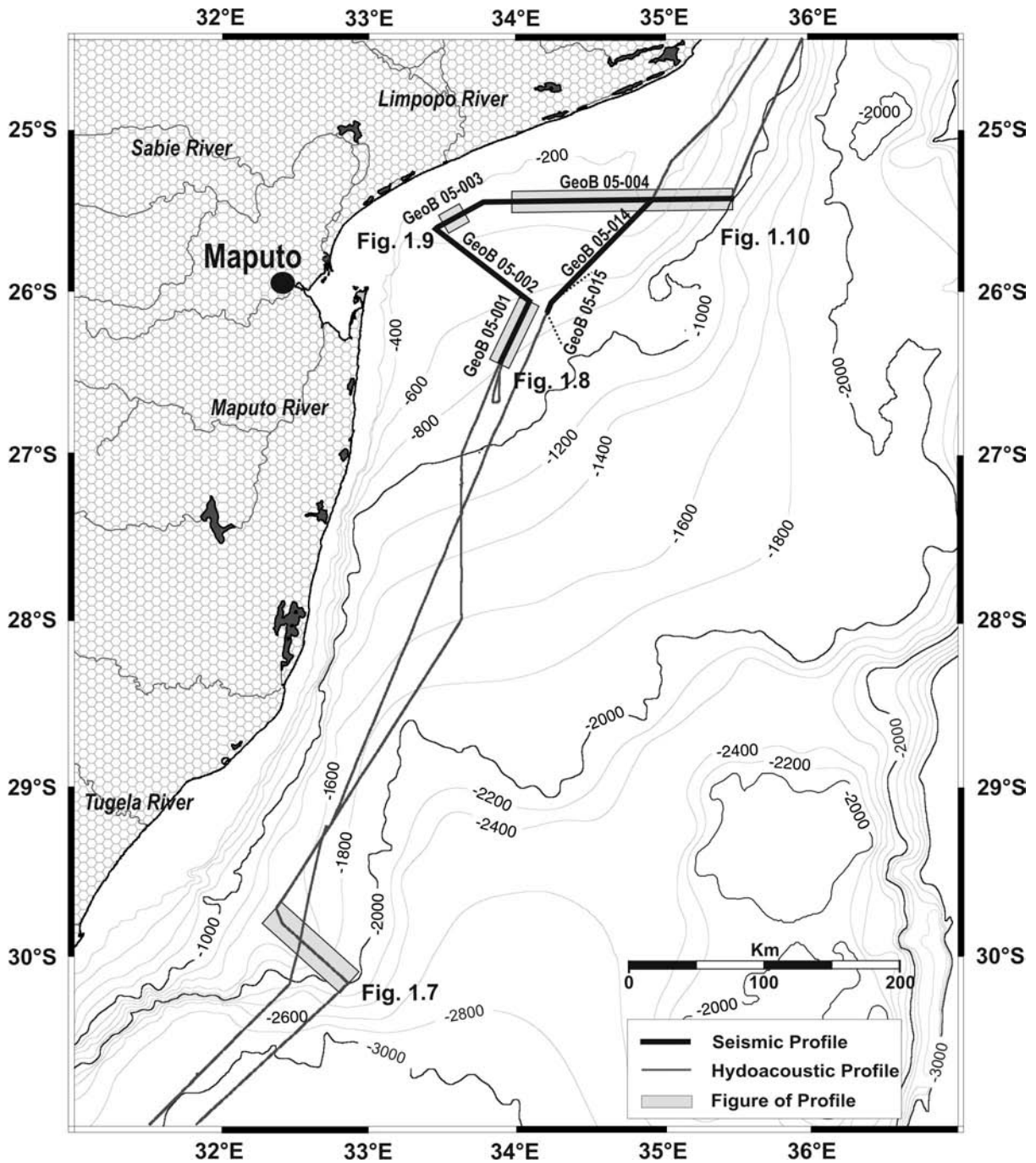


Fig. 1.2: Track chart of Areas A and B with all seismic profiles for the Tugela and the Limpopo Cone.

The 70 km long PARASOUND profile recorded at the Tugela Cone across the continental slope (Fig. 1.2) starts in a water depth of 2000 m, close to the northern edge of the Natal Valley, a smaller marine basin, and ends in a water depth of 1450 m (Fig. 1.7). The southeastern and central parts show steeper topography. In the northwestern section the slope gradient decreases towards a nearly horizontal sea floor. Upslope, several incisions of 100-300 m depth have been crossed. The pronounced incisions are located at kilometer 15, 35 and 50, with numerous smaller

incisions in between. The PARASOUND signal shows a low penetration depth of at most 25 m, indicating coarse grain size and high impedance contrast at the sea floor. This observation is in agreement with a possible presence of stronger bottom currents which are known to generally affect sedimentation processes in this region.

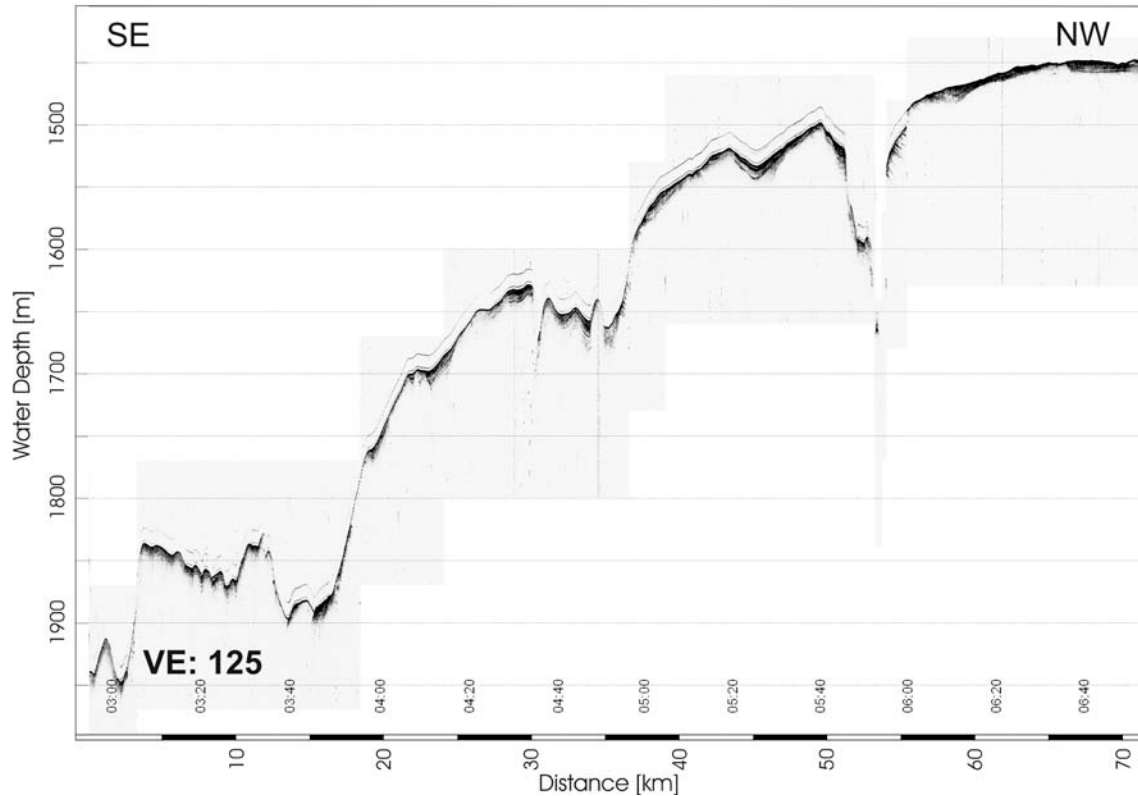


Fig. 1.3: PARASOUND-Profile across the continental slope at the Tugela Cone characterized by low signal penetration depth. Several incisions are observed (for location of profile see lower section of Fig. 1.2).

Multichannel seismic Line GeoB05-001 (Fig.1.4) is located in the area of the Limpopo Cone in water depths of approximately 700 m. The sea floor shows a smooth topography slowly ascending in NNW direction. The profile reveals several sedimentary deposits, which packages in the uppermost part are mostly uniformly layered, and vary in thickness laterally at greater sub-bottom depth. The average thickness of this part is about 140 ms (about 100 m). This part is characterized by higher reflectivity. Especially a horizon directly beneath the sea floor occurs as a layer with high reflection amplitudes. At greater sub-bottom depth more transparent deposits, probably quite homogeneous in their properties, occur. As a result, layer packages of relatively weak amplitudes are developed. Single reflectors of higher amplitudes are intercalated in different depths, e.g. at 1300 ms and 1450 ms. These layers are truncated after few kilometres in both directions.

Line GeoB05-003 is 33 km long and directly located off the Limpopo River mouth. Figure 1.5 shows a 13 km long portion from the middle part of this profile. The sea floor in this outer shelf region is very smooth. The sedimentary deposits show almost horizontal stratification. Three units can be distinguished: the uppermost unit reaches a thickness of about 130 ms (~95 m) and

is characterized by higher reflectivity. Beneath, a second unit of 250 ms thickness contains some distinct layers of high reflection amplitudes as well as layer packages of relatively weak amplitudes. The base of the second unit more or less marks a transition to a unit of significantly lower reflection amplitudes beneath. A notable feature appears in the centre of Figure 1.5.

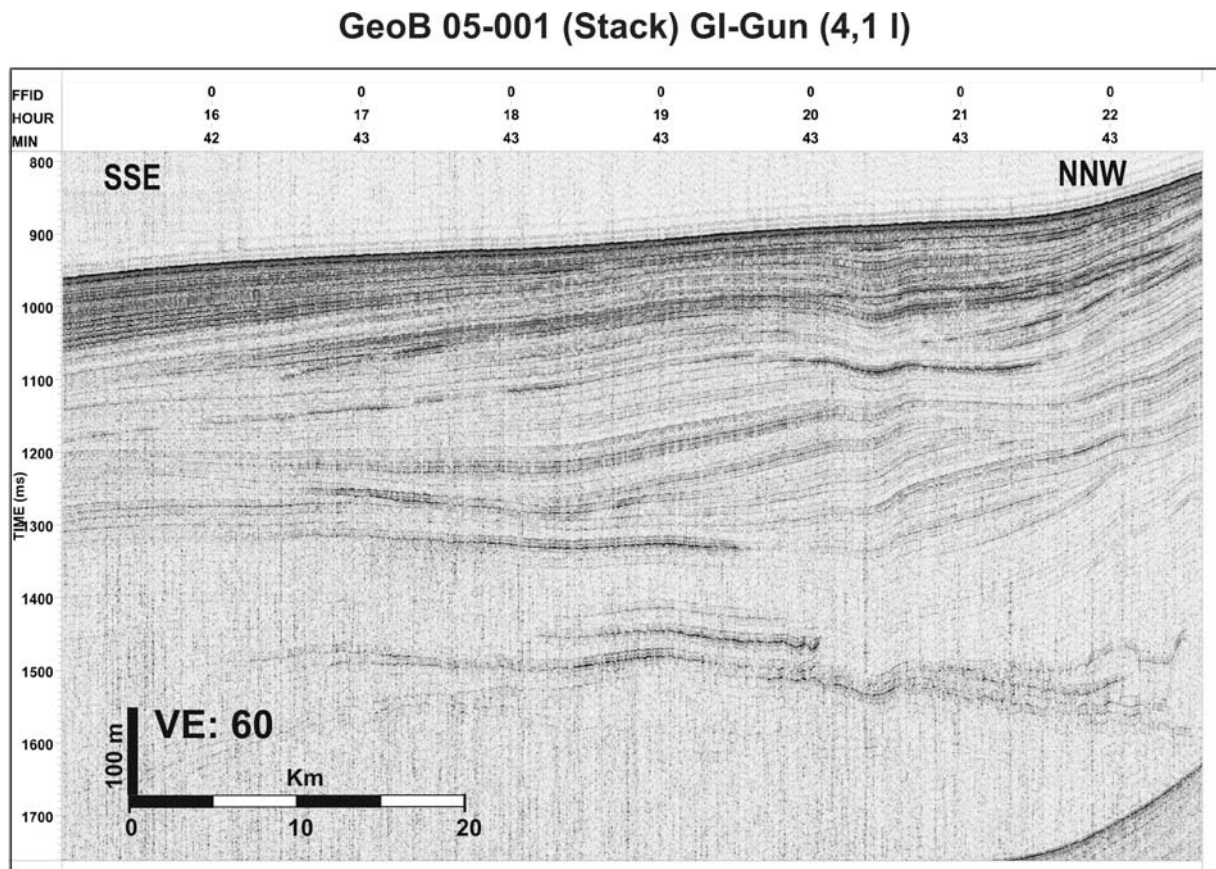


Fig. 1.4: Multichannel seismic profile GeoB05-001 from the southern part of the Limpopo Cone in water depths of around 700 m.

Furthermore, a package of unusually inclined and converging reflector elements between CMP 400 and 800, and buried beneath almost 100 m of undisturbed sediments may represent a channel fill. Typical structures related to canyon transport and significant riverine, terrigenous sediment input could not be found in the seismic data throughout the complete sediment column.

Figure 1.6 represents a 90 km long PARASOUND profile as part of multichannel Line GeoB05-004. It is oriented from W to E and provides a cross-section of Limpopo Cone and the Inharrime Terrace. The PARASOUND profile starts in a water depth of 400 m and shows a gentle eastward ascend of the sea floor to a water depth of 180 m. The seafloor is relatively smooth. The penetration depth decreases from west to east with a maximum of about 25 m at km 15 and a minimum of less than 5 m around km 70. This wedge-shaped deposit may indicate a decrease of sedimentation rate towards the shelf in conjunction with a grain size increase, possibly due enhanced winnowing. The bottom of the sedimentary wedge is defined by a distinct strong reflector, and a

lack of clear structure beneath. In the western portion of the line, two active faults may exist, offsetting the shallowest sediment package by a few meters each.

GeoB 05-003 (Stack) Gi-Gun (4,1 I)

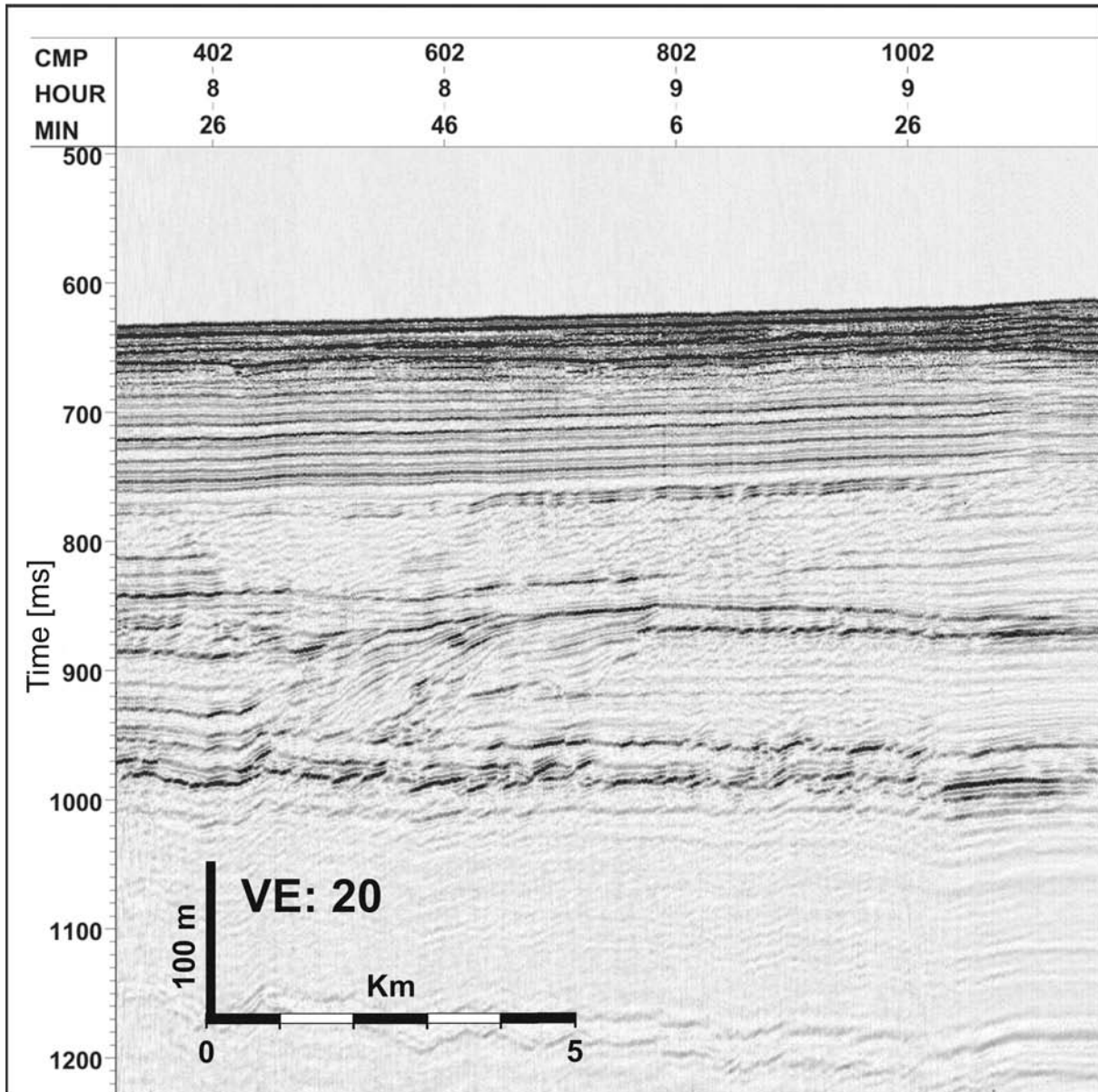


Fig. 1.5: Multichannel seismic profile GeoB05-003 from the central part of the Limpopo Cone (Area B) characterized by horizontal continuity in sedimentation patterns. A zone of apparently inclined layering is buried beneath almost 100 m of undisturbed sediment and may indicate a channel fill.

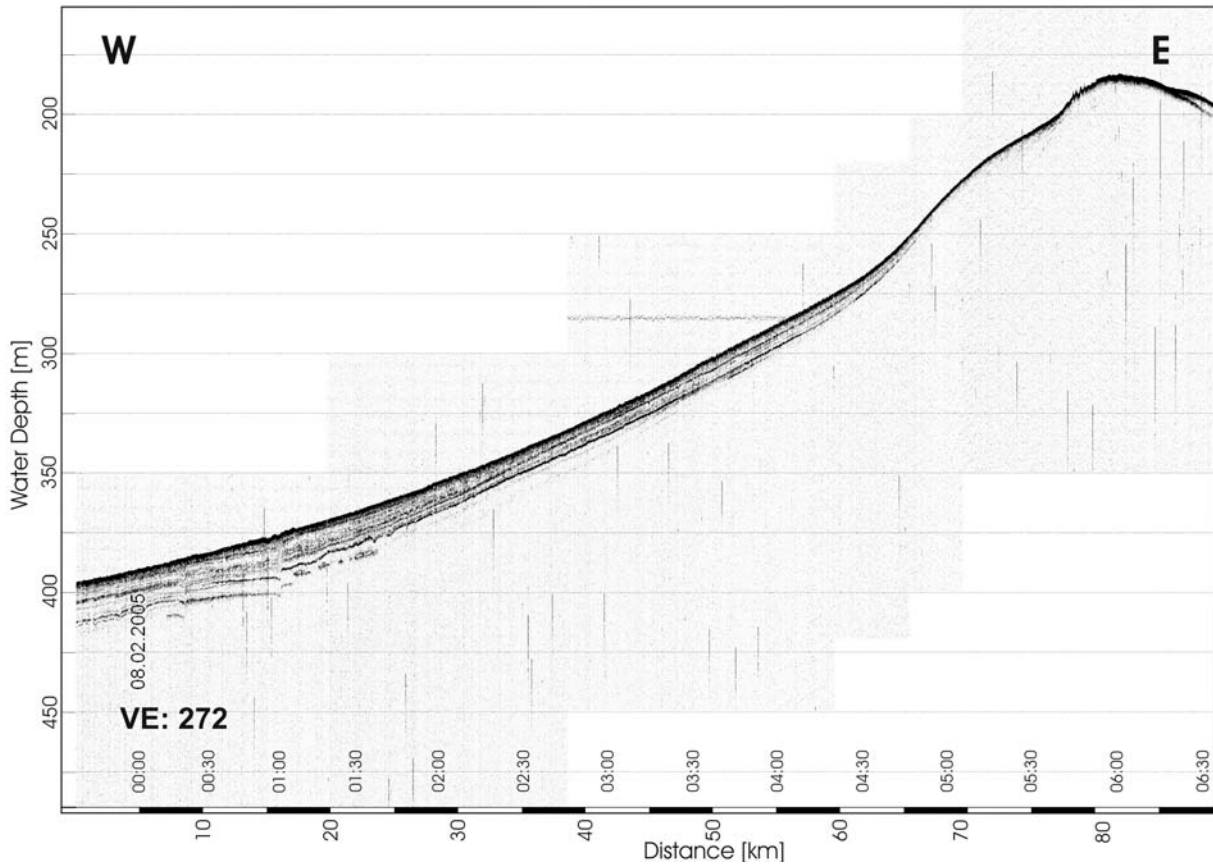


Fig. 1.6: PARASOUND-Image of Line GeoB05-004 from central part of the Limpopo Cone.

1.4.2.2 Zambezi Fan (Area C)

Most of the seismic lines of Cruise M63/1 were acquired in the area off the Zambezi River (Fig. 1.7). Sediment structures were most clearly influenced by terrigenous sediment input, which had been the main objective of survey and sampling activity during the cruise.

Line GeoB05-005 (Fig. 1.8) is located at the continental slope south of the Zambezi Fan (Fig. 1.7). The seismic data were acquired in water depths of 1200 to 1600 m. Seafloor topography is very rough and, especially the NNW part, frequently interrupted by V-shaped depressions. Some transparent lenses at CMP 1200 to CMP 1900, intercalated between stronger reflectors, probably indicate the presence of slump deposits. The sediment body in the southeastern part reveals in the upper 180 ms TWT layers of high signal energy. Between CMP's 300 and 800, a buried V-shaped sediment body with complex lateral and vertical structures may indicate refilling of an old trough or channel. Another channel-like structure or trough appears at the surface between CMP's 300-500. A pronounced blanking zone at CMP 1500 masks deeper reflections beneath 2000 ms TWT.

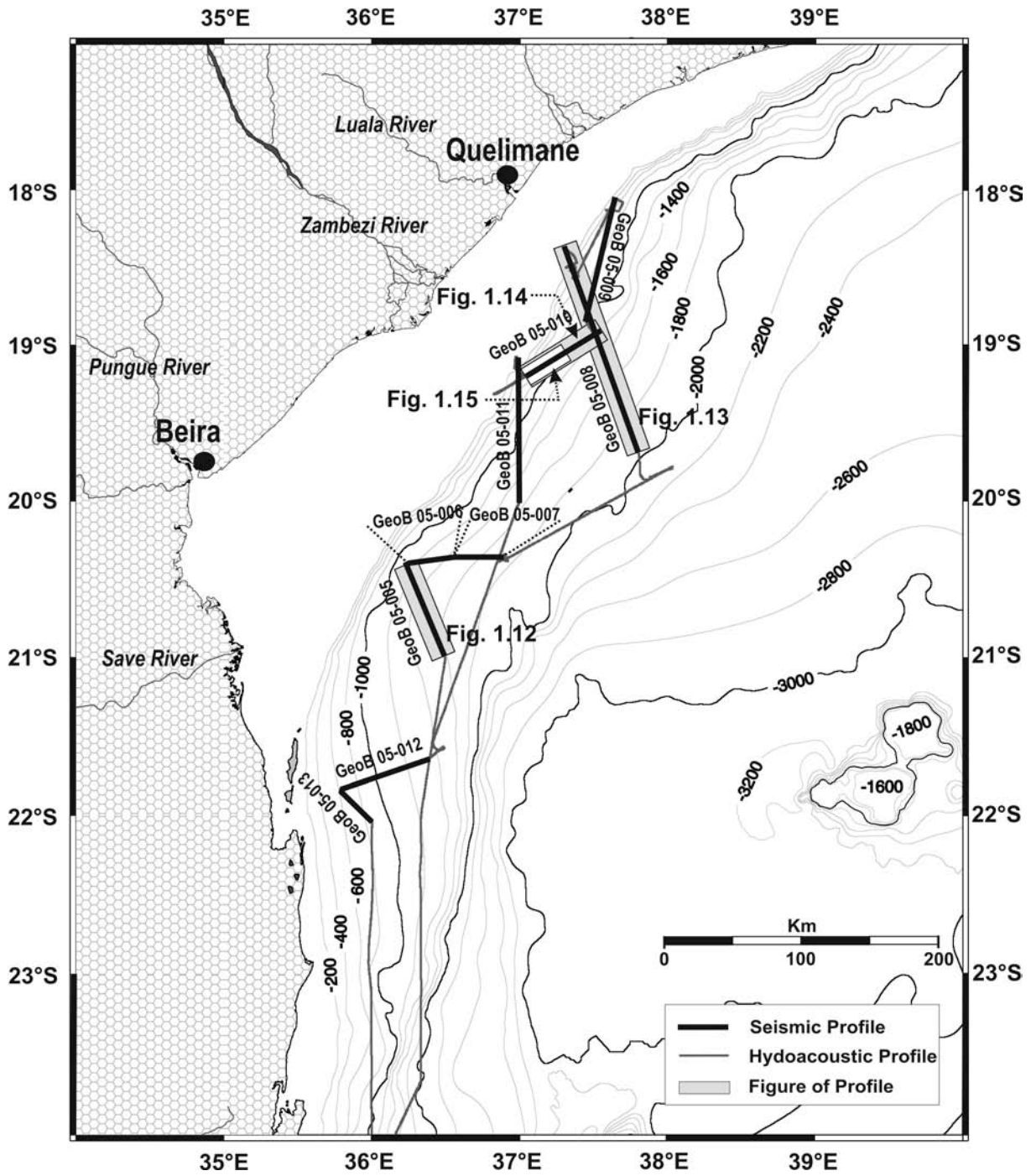


Fig. 1.7: Track chart and seismic profiles in Area C (Zambezi Fan).

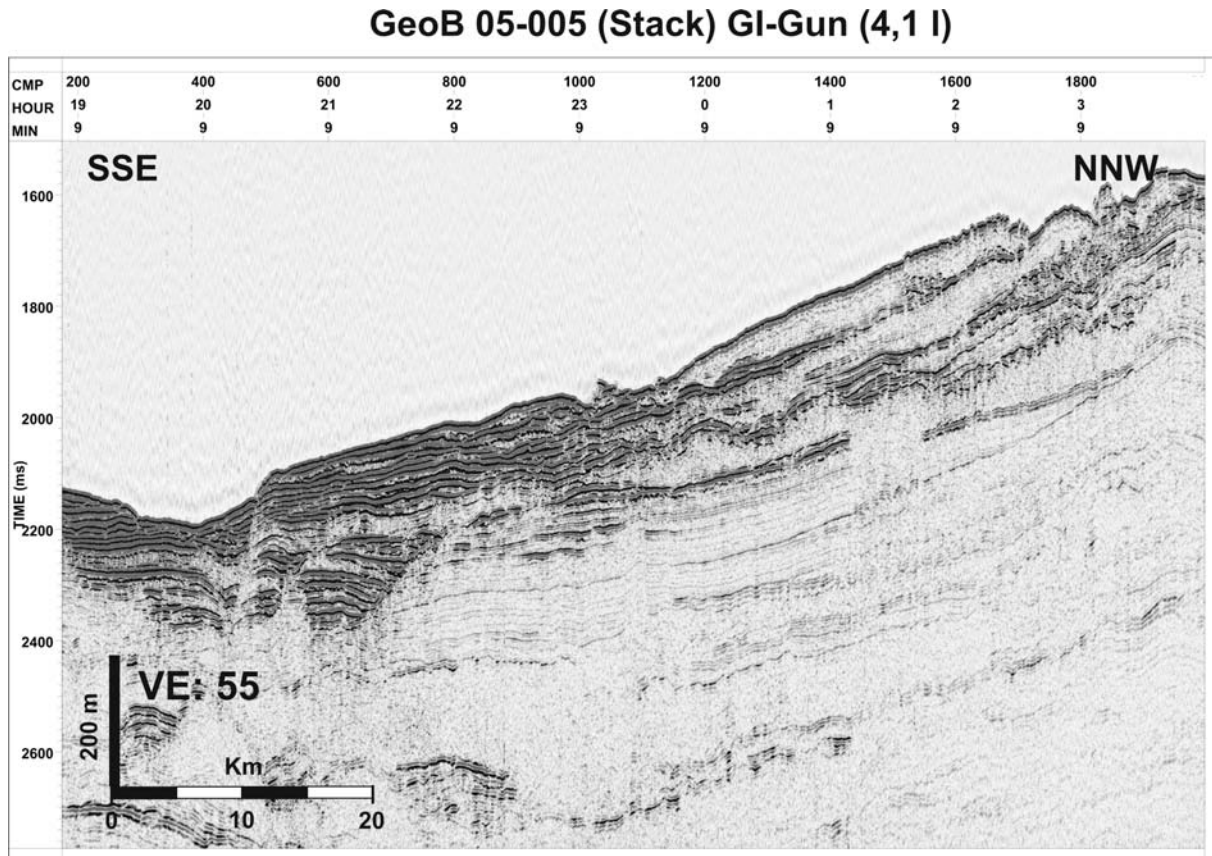


Fig. 1.8: Multichannel seismic profile GeoB05-005 from southern part of the Zambezi Fan, dominated by pronounced slump deposits and disturbed sediment layers.

The PARASOUND data of Line GeoB05-008 are shown in Figure 1.9. It is 160 km long and oriented from SSE to NNW, located east of the Zambezi estuary mouth. The PARASOUND profile starts in a water depth of 2000 m and shows a gentle northward ascend of the sea floor up to a water depth of 100 m. The penetration depth of the PARASOUND signal varies from 10 m near the shelf break, to 40 m in the central part of the profile with water depths between 800-1300 m. Numerous incisions of variable dimensions up to 100 m depth are noticeable features in this central section down to 1800 m water depth. This slope section was also a target for sampling by gravity corer. The closeup of core station GeoB 9309 (Fig. 1.9) shows for this position a well stratified sediment package of 45 m thickness. The deposits show few stronger reflectors intercalated with weaker reflectors or rather transparent layers.

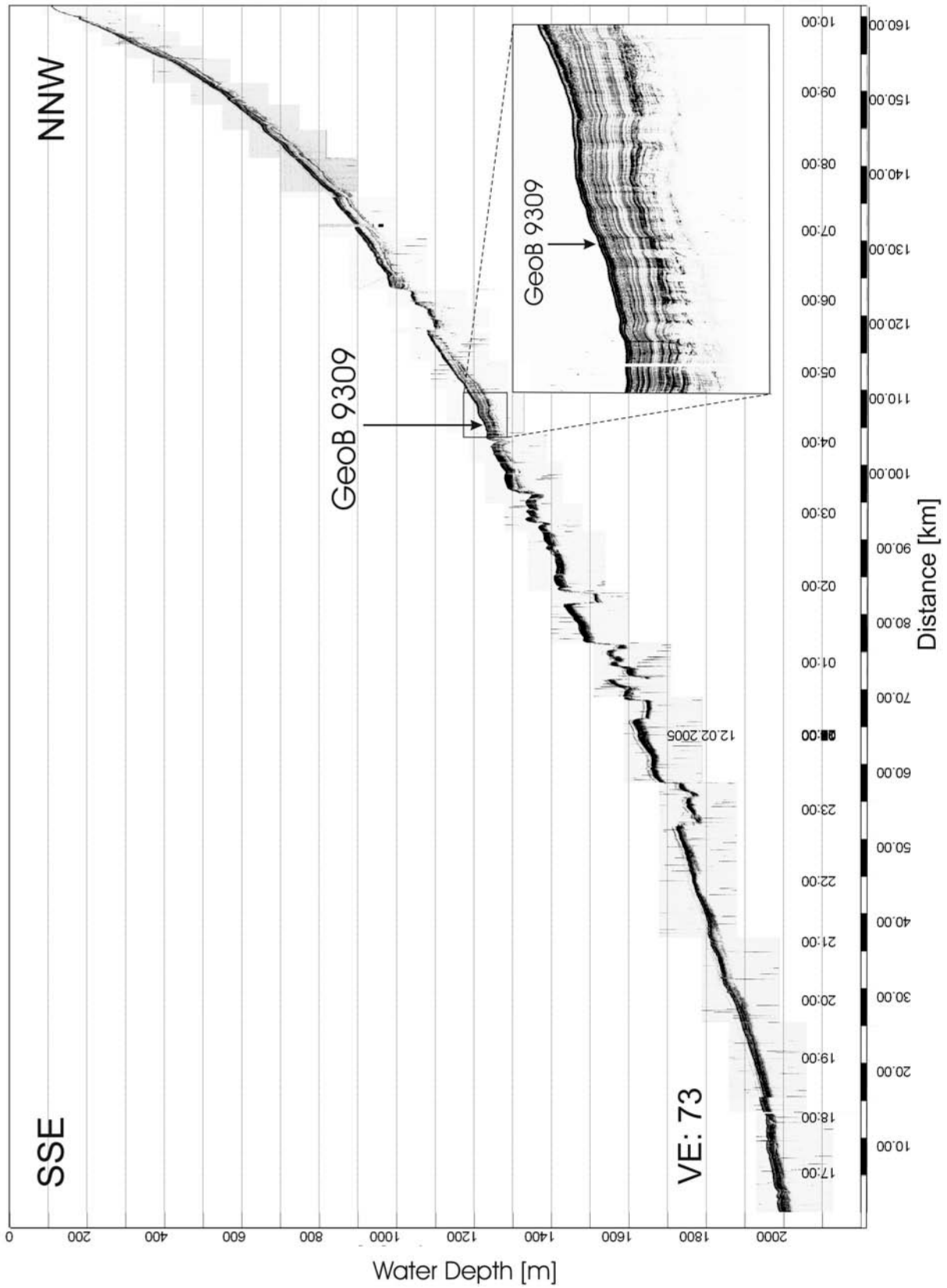


Fig. 1.9: PARASOUND image of multichannel seismic profile Geob05-005 from eastern part of the Zambezi Fan.

Multichannel seismic Line GeoB05-010 (Fig. 1.10) reveals the main sedimentary structures off the mouth of the Zambezi estuary (Fig. 1.7) close to the shelf edge. From shallow water down to 900 m (1200 ms at CMP 800), seafloor topography is smooth. At greater water depth several smaller incisions occur at the sea floor. Towards the southwest, a near-surface zone of decreased reflection amplitudes reveals as a lens-shaped sediment body with a relatively sharp transition to a zone of stronger reflectors at CMP 950. This sigmoidal sediment packet extends over a distance of about 50 km between CMP 950 and 2100. The greatest thickness with 140 m at CMP 1740 occurs at the uppermost slope in water depths of about 340 m (400 ms TWT). Downslope the thickness of this sediment body decreases gradually.

Figure 1.11 shows the PARASOUND image of multichannel seismic Line GeoB05-010 from CMP 1000 up to the shelf break over a distance of 37 km in NE-SW direction. The penetration depth of the PARASOUND signal ranges from a few meters on the shelf to about 50 m in water depths deeper than 500 m. The sea floor topography in this section is very smooth. Only some smaller incisions occur in the uppermost part in water depths between 100 m and 170 m. This section of the continental slope was also a target for gravity core sampling. The coring station GeoB 9310 is located in a water depth of about 550 m (Fig. 1.11). The close up shows the sea floor as a stronger reflector with a more transparent zone beneath.

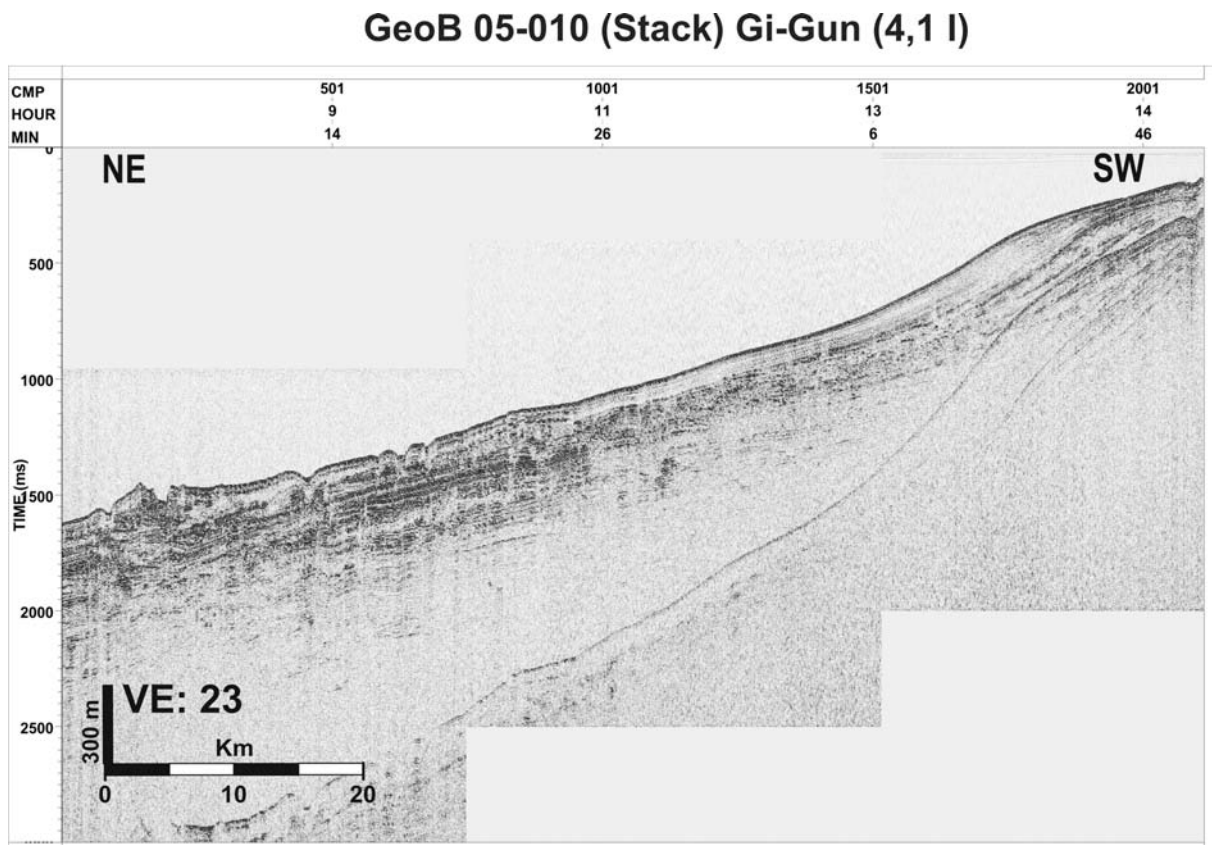


Fig. 1.10: Multichannel seismic profile GeoB05-010 in the vicinity of the shelf break, directly in front of the Zambezi estuary mouth.

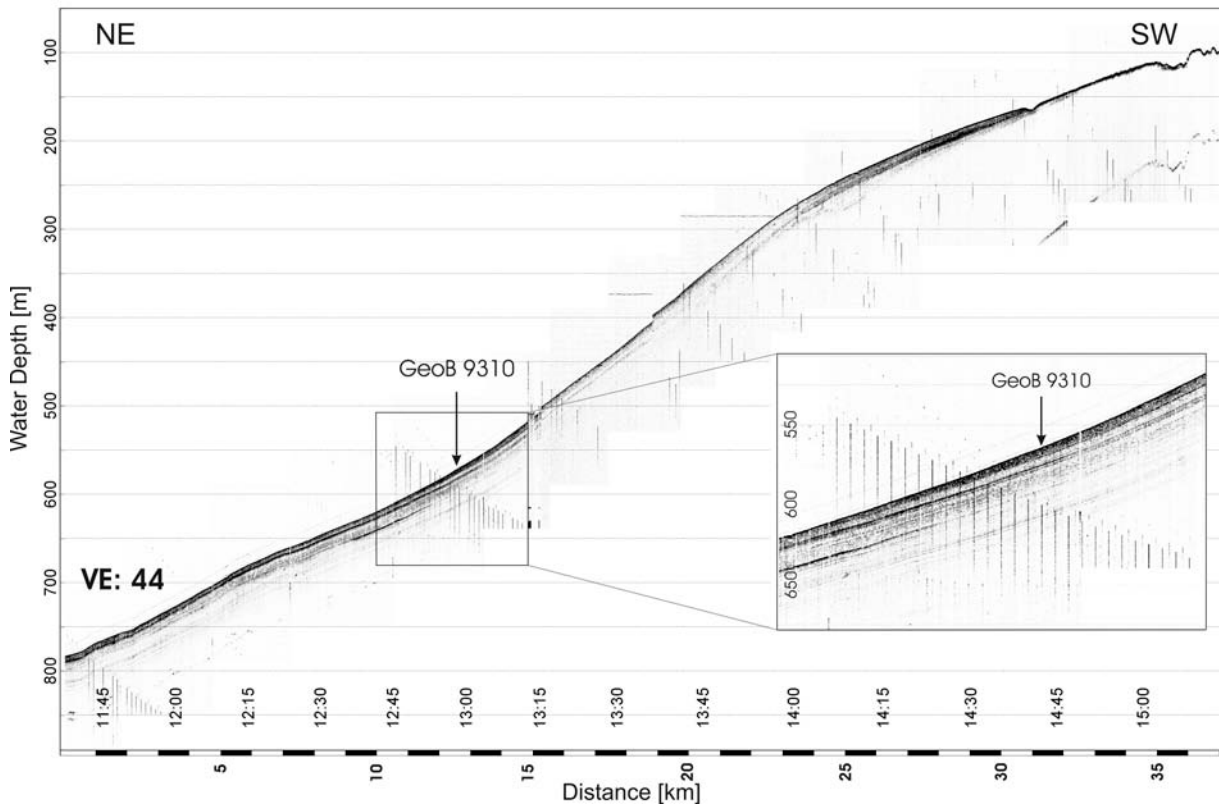


Fig. 1.11: PARASOUND image of multichannel seismic profile GeoB05-010.

A second short reflector segment of high signal energy occurs in the lower left corner of the closeup. This reflector terminates after 3 km in both directions. Between these two layers, weaker reflectors or almost transparent layers are intercalated. In Figure 1.10 of multichannel seismic Line GeoB05-010, CMP 1500 defines the core location. This figure indicates the position of station GeoB 9310 more or less in the centre of the sigmoidal sediment package, which, however, does not appear at all in the PARASOUND image, but is rather identified as an area of highest accumulation rate in the seismic line.

1.4.3 Sedimentology

(U. Bleil, K. Enneking, Chr. Hilgenfeldt, S. Kasten, M. Klann, H. Kuhlmann, A. Lückge, Chr. März, E. Schefuß, R. Schneider, A. Steinbach, E. Susek, S. Weldeab, N. Zatloukal)

1.4.3.1 Sediment Sampling with Gravity Corer

During cruise M63/1 24 sediment cores on 14 stations were recovered using the gravity corer SL-18, SL-12, SL-9, and SL-6 (Table 1.2 and Figures 1.12 and 1.13). At 9 of these stations additional sediment cores were taken for geochemistry purposes (Table 1.4, Chapter 1.4.5). Once the core was retrieved on the deck, the core liners were cut into 1 m segments, closed with caps at both ends and inscribed according to the scheme applied at the Geosciences Department, University Bremen.

All cores were cut along-core in two half pieces: one archive and one work-half. The sediments were described and photos were taking. For color scanning, a MINOLTA 2006d hand-held spectrophotometer was used to measure percent reflectance values of sediment color over the visible light range between 400 nm and 700 nm. The digital reflectance data of the spectrophotometer readings were routinely obtained from the surfaces of split archive halves immediately after the core opening to provide a continuous record of the sediment color variation. From the work-half three parallel series of syringe samples (10 cm³) were taken at intervals of 5 cm. These samples were taken for the measurements and determination of stable isotopes, foraminiferal assemblages, organic geochemistry, and trace element analyses on foraminiferal tests.

The preliminary lithologic summary of the sediments retrieved with gravity corer is based on visual description and color scanner data. A compilation of color scans from selected gravity cores is shown in Figs. 1.14, 1.15, and 1.16). Core descriptions are published in the extended version of this cruise report in the «BERICHTE aus dem Fachbereich Geowissenschaften der Universität Bremen, Report and Preliminary Results of Meteor Cruise M63/1, 2008». There, figures representing the main lithologies, their color according to the MUNSELL soil color chart, and the sedimentary structure as well as color scanner readings of the ratio 700 nm/400 nm (red/blue ratio) and L* of the core sediments are also presented.

Tab. 1.2: List of gravity cores (SL) retrieved during M63/1.

GeoB No.	Equipment	Latitude S	Longitude E	Water Depth (m)	Sediment Recovery (cm)	Remarks
9301-2	SL 12	26°25.4'	33°52.6'	692	---	no recovery, core barrel bent
9301-3	SL 6	26°27.4'	33°52.2'	695	570	upper 10-20 cm lost
9301-6	SL 9	26°29.1'	33°52.2'	701	732	
9302-1	SL 6	25°25.6'	33°47.8'	423	46	
9302-2	SL 9	25°25.8'	33°48.0'	425	802	
9302-3	SL 12	25°25.8'	33°47.6'	424	908	
9303-2	SL 12	20°21.6'	36°53.9'	1725	735	
9303-3	SL 12	20°21.4'	36°53.8'	1725	735	
9304-1	SL 12	19°51.3'	37°52.9'	2071	732	
9304-2	SL 18	19°51.9'	37°52.6'	2031	830	
9306-2	SL 6	18°31.0'	37°21.7'	334	536	
9307-1	SL 12	18°34.0'	37°22.9'	560	---	no recovery
9307-2	SL 9	18°33.8'	37°22.9'	548	636	
9307-3	SL 9	18°33.9'	37°22.8'	542	651	
9308-2	SL 9	18°07.8'	37°35.9'	501	705	
9308-6	SL 12	18°08.0'	37°36.1'	522	826	
9309-1	SL 12	18°55.8'	37°30.7'	1216	642	
9310-3	SL 9	19°12.0'	37°02.6'	546	592	top of core lost
9310-4	SL 12	19°12.1'	37°02.5'	543	675	
9311-1	SL 12	21°33.1'	36°24.8'	1407	750	
9311-2	SL 12	21°32.8'	36°24.8'	1410	698	
9312-5	SL 12	27°21.0'	33°36.9'	1295	261	
9313-1	SL 12	29°13.0'	32°44.0'	1636	---	no recovery, core barrel bent
9313-2	SL 6	29°13.0'	32°44.0'	1635	161	
9314-2	SL 6	30°43.0'	31°49.6'	2950		
9314-3	SL 12	30°42.6'	31°49.3'	2950	647	
9315-1	SL 12	32°31.1'	29°53.6'	3010	636	

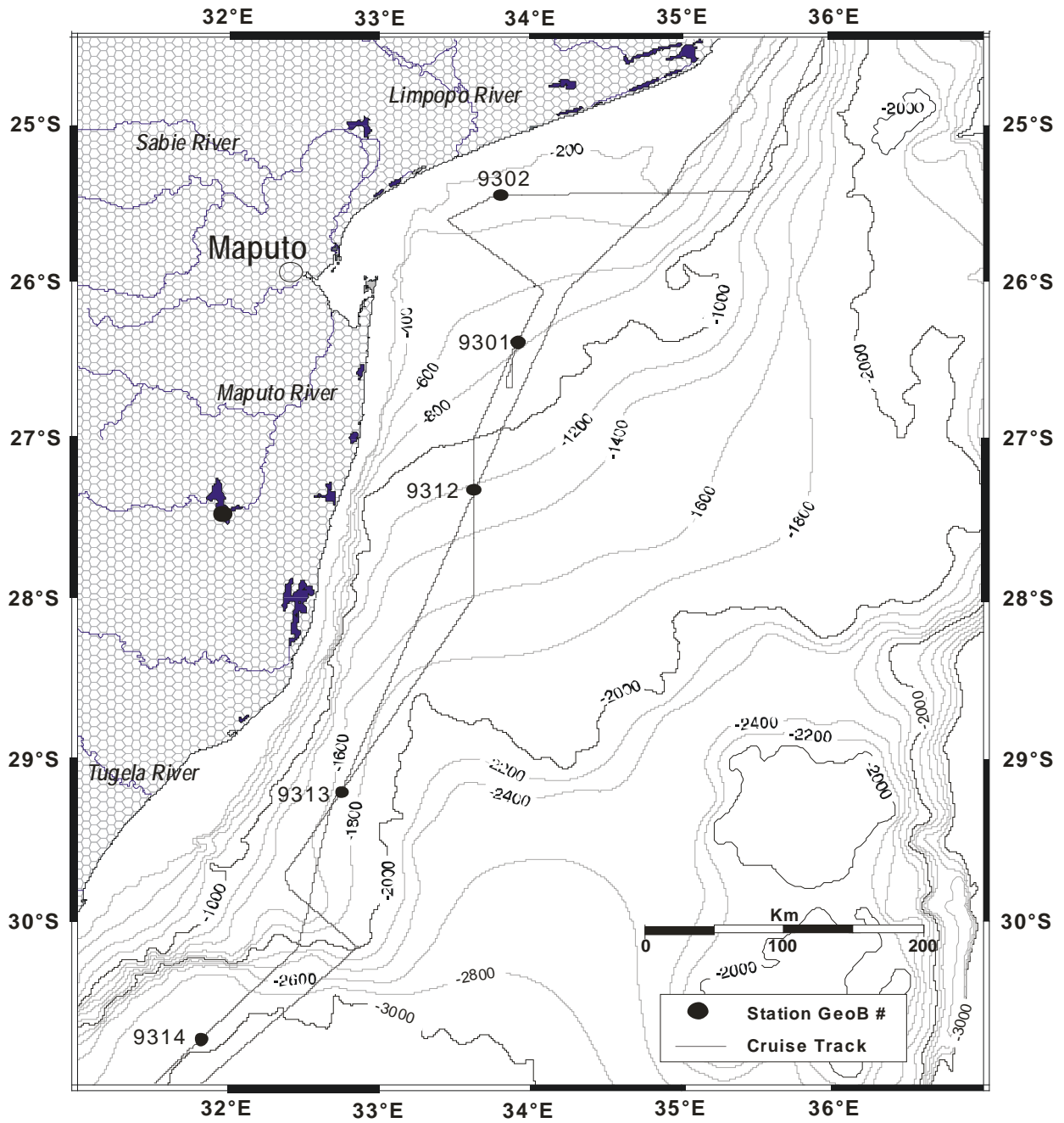


Fig. 1.12: Sites of gravity cores collected off the Tugela River and Limpopo River during M63/1.

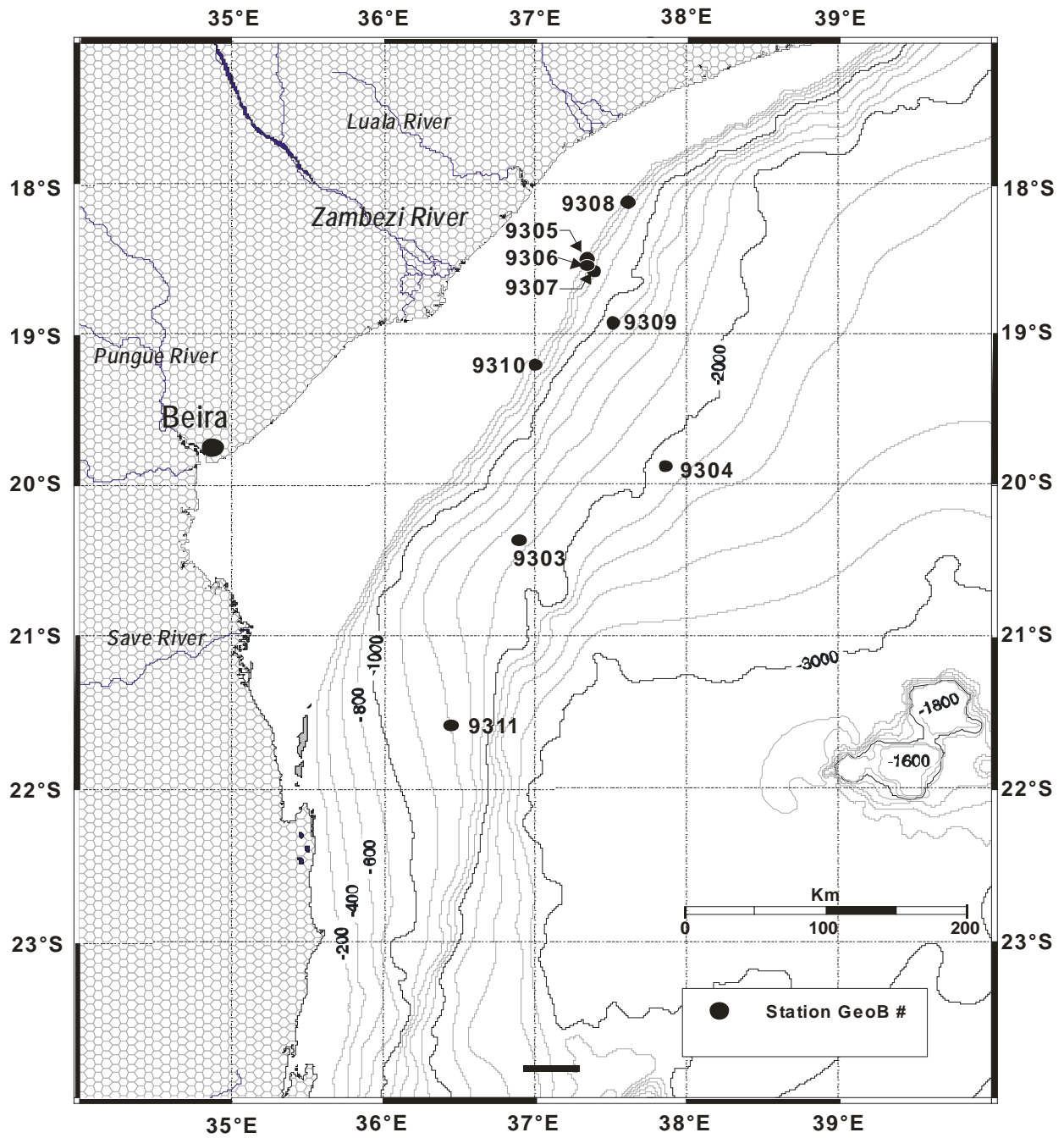


Fig. 1.13: Sites of gravity cores collected off the Zambezi River during M63/1.

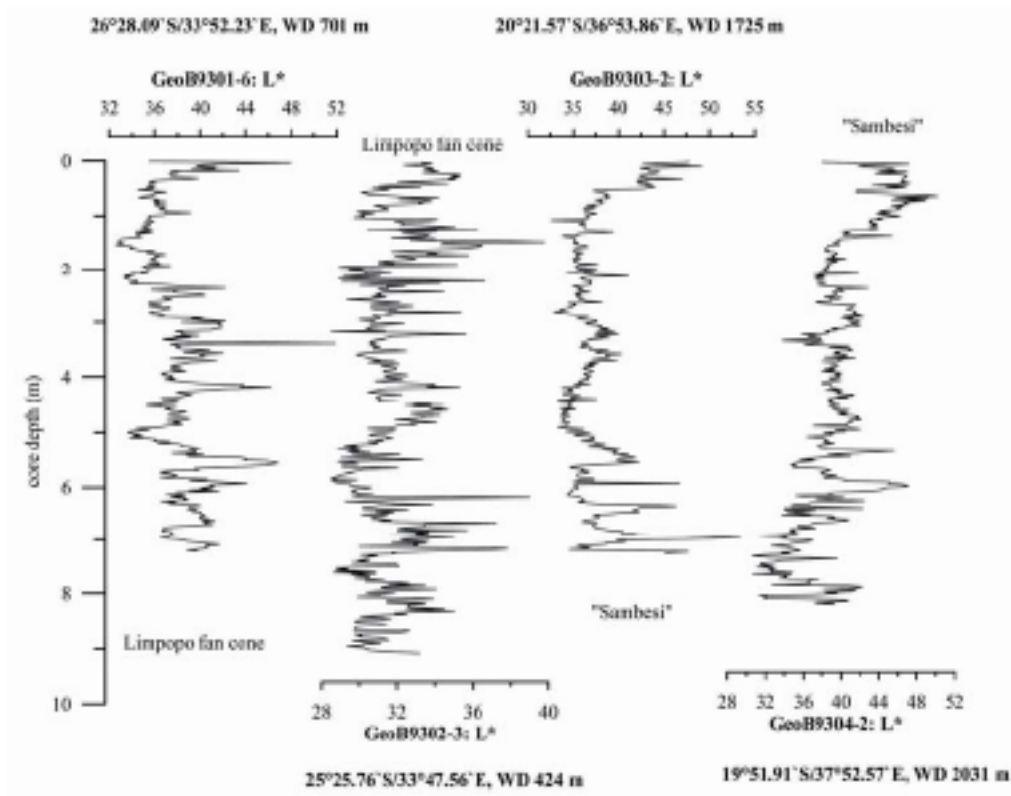


Fig. 1.14: Lightness (L^*) of sediment cores from the Limpopo Fan (GeoB 9301-6 and 9302-3) and the Sambesi Fan (GeoB9303-2 and 9304-2).

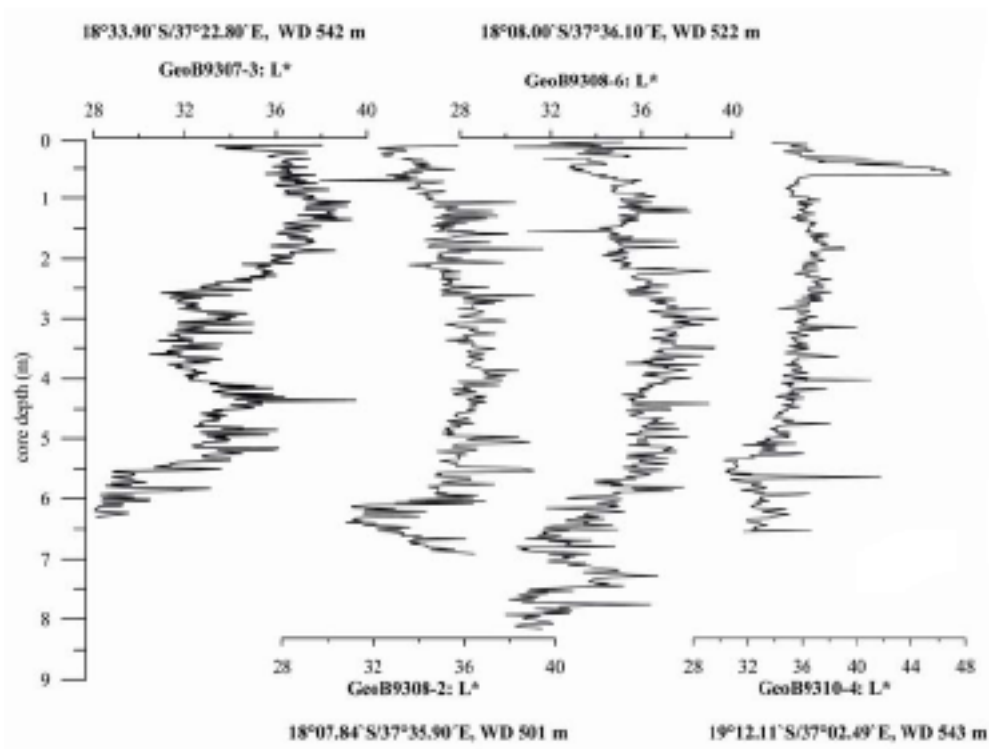


Fig. 1.15: Lightness (L^*) of sediment cores from the Sambesi Fan (GeoB 9307-3, 9308-2, 9308-6, and 9310-4).

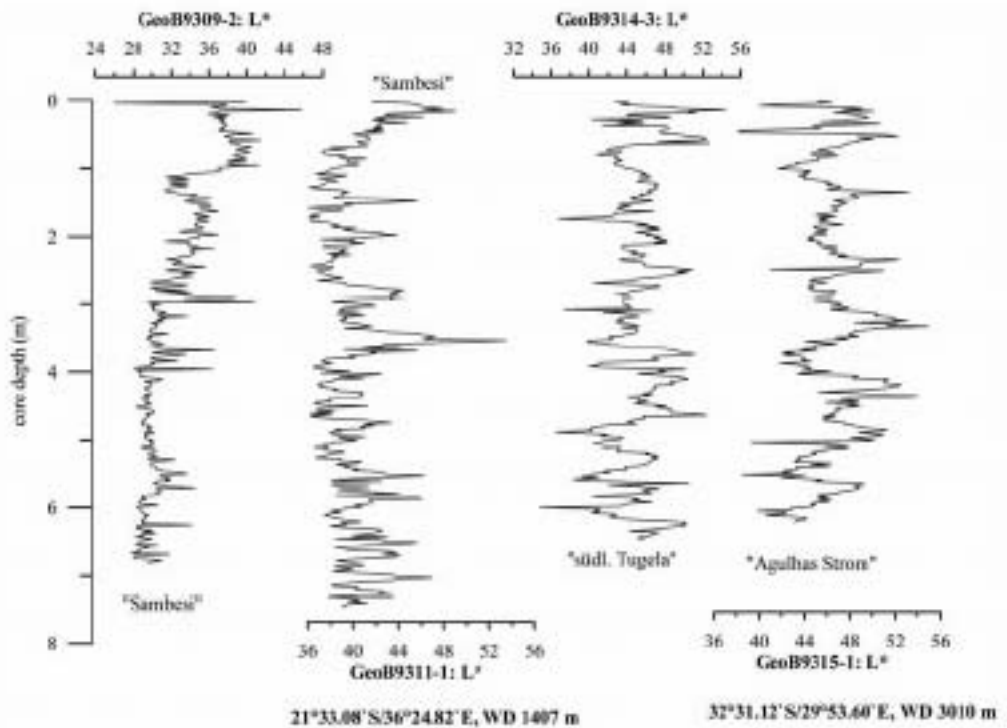


Fig. 1.16: Lightness (L^*) of sediment cores from the Sambesi Fan (GeoB9307-3, 9308-2, 9308-6, and 9310-4).

1.4.3.2 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 8 tubes of 10 cm and 4 smaller tubes of 5 cm in diameter. The multicorer was used at 14 stations. In one case the system failed due to the underlying sediments, but mostly the core recovery was good, typically 11 to 12 tubes were filled, and the quality was very good with a mean of 30 cm of sediment that was recovered.

At each multicorer station, the overlying bottom water of one of the large tubes was sampled for stable isotope measurements. The general distribution of the samples to the different disciplines was as follows:

- 2 large tubes for foraminifera
- 1 large tube for biomarkers
- 2 large tube for dinoflagellates
- 1 large tube for geochemistry
- 1 large tube for elemental analyses
- 1 large tube as archive
- 1 small tube for C_{org}
- 1 small tube for geochemistry
- 1 small tube for geophysics
- 1 small tube for coccoliths.

Each core except the archive was sampled in 1 cm intervals. The C_{org} and biomarker samples and one set for dinoflagellates were frozen immediately after collection at -20°C . All other samples were kept at $+4^{\circ}\text{C}$. The top 10 cm of the cores used for investigations on foraminifera

were stained with a solution of 1g of rose bengal in 1 L ethanol. The archive cores were fixed in the tubes and carried in upright position at +4 °C or frozen (f) to the core repository.

Tab. 1.3: Multicorer (MUC) sampling during M63/1.

Station GeoB	Water Depth (m)	Re- covery (cm)	Corg.	Archive frozen (f)	Bio- Mark.	Cocc.	Geochem.	Forams	Geophys.	Dinofl.	Elements
9301-1	690	25	1	-	1	1	2	2	-	1	1
9302-4	424	20	-	-	-	-	-	-	1	-	-
9302-5	424	37	1	1 (f)	1	1	2	2	-	2	1
9303-1	1727	30	1	1	1	1	2	2	1	2	1
9304-3	2024	37	1	1	1	1	2	2	1	2	1
9305-1	150	0	-	-	-	-	-	-	-	-	-
9305-2	150	0	-	-	-	-	-	-	-	-	-
9306-1	347	35	1	2 (1 f)	1	1	-	2	1	2	1
9307-4	573	32	1	1	1	1	2	2	1	2	1
9308-1	507	42	1	1	1	1	2	2	1	2	1
9309-3	1231	33	1	1	1	1	2	1	1	2	1
9310-1	560	30	1	1	1	1	2	2	1	2	1
9311-3	1407	23	1	1	1	1	2	2	1	2	1
9312-1	1293	32	-	3 (f)	-	-	-	-	-	-	-
9312-2	1294	32	1	1	1	1	-	2	1	2	1
9313-3	1632	32	1	2 (1 f)	1	1	-	1	1	2	1
9314-1	2958	30	1	1	1	-	-	1	1	2	1

1.4.4 Physical Properties Studies

(U. Bleil, C. Hilgenfeldt, A. Steinbach)

The sediment series recovered during R/V METEOR Cruise M63/1 by gravity coring were subject to routine geophysical shipboard measurements performed on closed full cores or – when selected for geochemical studies – on open core halves (GeoB 9301-3, 9302-2, 9303-3, 9304-1, 9307-2, 9309-1, 9310-3, 9311-2, 9314-2). Three basic parameters have been determined,

- magnetic volume susceptibility κ ,
- electric resistivity R_s as a measure of porosity and density, and
- spectral light reflectance.

These properties, provided as high-resolution core logs with a standard spacing of 1 cm for electric resistivity and magnetic susceptibility and 0.01 cm for light reflectance, are closely related to sediment lithology. They were measured with a customized GEOTEK Multi-Sensor Core Logger (MSCL) utilizing a stepper motor to convey core segments along the track and through a series of sensors. Positions and lengths are automatically recorded. The logging data are controlled and rapidly collated by the system's computer terminal. In addition, oriented cube samples for shore based rock- and paleomagnetic studies were regularly taken at 5 cm intervals from the sediment sequences retrieved.

1.4.4.1 Physical Background and Experimental Techniques

Magnetic 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 magnetic induction B , absolute and relative permeabilities μ_0 and μ_r , magnetizing field H , magnetic volume susceptibility κ and 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 $-15 \cdot 10^{-6}$ (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. Enhanced susceptibilities indicate higher concentrations of lithogenic or authigenic components. This relation may serve for correlating sedimentary sequences deposited under similar global or regional conditions.

The MSCL core logger is mounted with a commercial BARTINGTON M.S.2 susceptibility meter with a 140 mm loop sensor. Due to the sensor's size, its sensitivity extends over a core interval of about 8 cm. Consequently, sharp susceptibility changes in the sediment column will appear smoothed in the κ core log and thin layers such as ashes cannot appropriately be resolved. In order to make an accurate end correction at the top and base of each segment and to assess the drift of the susceptibility meter, a spacer of 29.5 cm length was placed between each segment during the measurement procedure. The measurements taken at the center of the spacer were used to assess and compensate the instrument drift. During post-processing all data related to void sections have been removed to provide a continuous composite core log.

Electrical Resistivity and Porosity

The electrical sediment resistivity R_s was determined using an inductive non-contact sensor. The system applies high frequency magnetic fields by a transmitter coil inducing electrical eddy currents in the sediment which are proportional to conductivity. Their secondary field is recorded and yields raw and calibrated data for conductivity and resistivity. Porosity was calculated according to the empirical Archie's equation

$$R_s/R_w = \kappa \cdot \phi^{-m}$$

where the ratio of sediment resistivity R_s and pore water resistivity R_w can be approximated by a power function of porosity ϕ . 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)

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

with a pore water density ρ_f of 1030 kg/m^3 and a matrix density ρ_m of 2670 kg/m^3 . For a uniform treatment of all cores, these empirical coefficients were not adapted to individual sediment lithologies. Yet, relative porosity and density changes should be well documented.

The resistivity sensor averages over approximately 12 cm core length. A platinum thermometer inserted into a segment continuously measures sediment temperature for temperature compensation. Absolute sensor calibrations using a series of saline standards are performed before each core log. For subsequent drift and segment end correction, 29.5 cm long insulating spacers were placed between segments during logging. Thus, the characteristic decay of the eddy currents near the end caps was separately recorded for each segment and corrected on basis of a model curve. This method provides a continuous composite record.

Light Reflectance

Spectral light reflectance is a measure of the relative amount of light reflected by a material under incident white light. It is expressed within an absolute range from 0 (minimum) to 255 (maximum) and specified as average value for the red (600-700 nm), green (500-600 nm) and blue (400-500 nm) color bands (RGB system). The reflectance properties of sediments relate to their chemistry and structure and are dominated by pigmented trace constituents, typically Fe and Mn bearing minerals (clays, oxides, sulfides) and organic enrichments. Reflectance logs provide high-resolution records of terrigenous content (total reflectance) and redox state (red/blue ratio). Scanned at high spatial resolution, reflectance images provide sharp, undistorted, true-color core photographs scarcely affected by undesirable artifacts known from classical core photography (shadows, reflections etc.).

The digital imaging module of the GEOTEK MSCL consists of a camera containing three separate 3 x 1024 pixel CCD detectors mounted in the focal planes of split light beams ~40 cm above the surface of the sediment and equipped with red, green and blue dichroic filters. The camera captures consecutive, strictly orthogonal line images of the bypassing split core surface. The sediment is illuminated from above by two white fluorescent tubes. Freshly cut archive halves were carefully leveled to prevent shadows from residual surface roughness. All cores were scanned at an axial resolution setting of 100, corresponding to 1 row of pixels for every 100 μm in core depth. The resolution achieved across the core is about equivalent. The brightest part of each core was selected to determine a lens aperture which allows the entire core to be measured on the same setting without saturating any of the color channels. Each reflectance value is calibrated against the range defined by a white tile (white calibration) and a closed lens cap (black calibration). Color test cards were measured before and after each core to determine and linearly correct drift effects of the CCD sensors.

A specialized post-processing software performs all necessary image corrections and calculations. The processing starts out by cropping end cap and cavity sections and by removing spurious color stripes caused by a non-uniform response of individual color channels. This task is efficiently solved by normalizing the mean of each core column of data to the same core average. The individual segment images are then merged into a full core image and numerically compressed in various ways. The median value of each data row was chosen as representative reflectance value in the depth series of red, green and blue reflectance, total reflectance (mean value of R, G and B) and for the red/blue ratio.

Contrast enhanced color images were produced to improve the identification of layers, gradients and textures. For this purpose, the RGB images were transformed to the hue, saturation and value (HSV) color system. The intensity elements were replaced by ranks, linearly contracted

to the range of 0 to 1. The HSV data were finally transformed back into the original RGB coordinate system.

1.4.4.2 Shipboard Results

General characteristics of the physical properties measurements are summarized in Figure 1.17. Each diagram is divided into groups of regionally adjacent cores. In relatively shallow water (< 1000 m) mean porosities vary widely from about 50% (Site GeoB 9301 in the Limpopo River realm) to 65% (Site GeoB 9308 in the northern Zambezi Cone). Jointly, mean densities span from about 1600 to 1850 kg/m³. Below around 1000 m water depth a though vague trend of decreasing porosities (increasing densities) to deeper waters extends over approximately the same range of variabilities. Overall, magnetic susceptibilities are remarkably high, at least compared to the African continental margin in the Atlantic at similar latitudes. In water depths of less than 1000 m, the highest mean of about $650 \cdot 10^{-6}$ SI was observed in the Limpopo River region (Site GeoB 9302), a lowest mean of about $300 \cdot 10^{-6}$ SI in the northern Zambezi Cone (Site GeoB 9308). In deeper waters average susceptibilities fluctuate around this low mean (with exception of Site GeoB 9314, Tugela River region) indicating no systematic relationship to water depth.

The susceptibility records of all sediment series recovered reveal show more or less distinct cyclic amplitude variations. However, in the two southern working areas A (Tugela River region) and B (Limpopo River region) the records bear no obvious characteristics of climate controlled cyclicities (perhaps with exception of Site GeoB 9314). Therefore, an age assignment for these deposits would be purely speculative at present.

In comparison, susceptibility records of the sediment series retrieved from the different areas of the Zambezi Cone display relatively clear features of Milankovic cycles. Typically elevated susceptibility signals during cold periods imply a distinctly enhanced influx of terrigenous material during relative sea level low-stands possibly combined with a reduced oceanic productivity. Ages tentatively assigned from these patterns would result in sedimentation rates ranging from an average minimum of around 5.5 cm/kyr (Sites GeoB 9303 and 9304) to an average maximum of about 25 cm/kyr (Site 9308). At most sites sedimentation rates are clearly lower during Holocene, marine oxygen isotope stages (MIS) 3 and 5 than in MIS 2 and 4. Notable exceptions from this general trend were found at Sites GeoB 9308 and 9310 with overall highest sedimentation rates of about 37 and 26 cm/kyr during Holocene dropping to about 15 and 18 cm/kyr in MIS 2, respectively. The oldest sediments in the Zambezi Cone area reaching at least into MIS 6 were apparently recovered at Site GeoB 9303. Evidently, all these preliminary estimates need to be confirmed by more sophisticated shore based investigations.

A most interesting feature in the susceptibility record of the Site GeoB 9309 sediments is a drastic decrease of the signal intensity to less than half of its average level at around 5.5 m core depth. Such phenomena have frequently been encountered in the continental margin deposits off the Rio de la Plata River estuary in the South Atlantic. There, they reflect an intense dissolution of the primary magnetic mineral assemblage caused by diagenetic processes in the sulfate-methane transition (SMT) zone. As indicated by the shipboard geochemical results (see Chapter 1.4.5), a similar situation should exist at Site GeoB 9309. However, this is a singular finding as

no other sediment series recovered during Cruise M63/1 revealed any obvious indications for a diagenetic alteration of the magnetic mineral inventory.

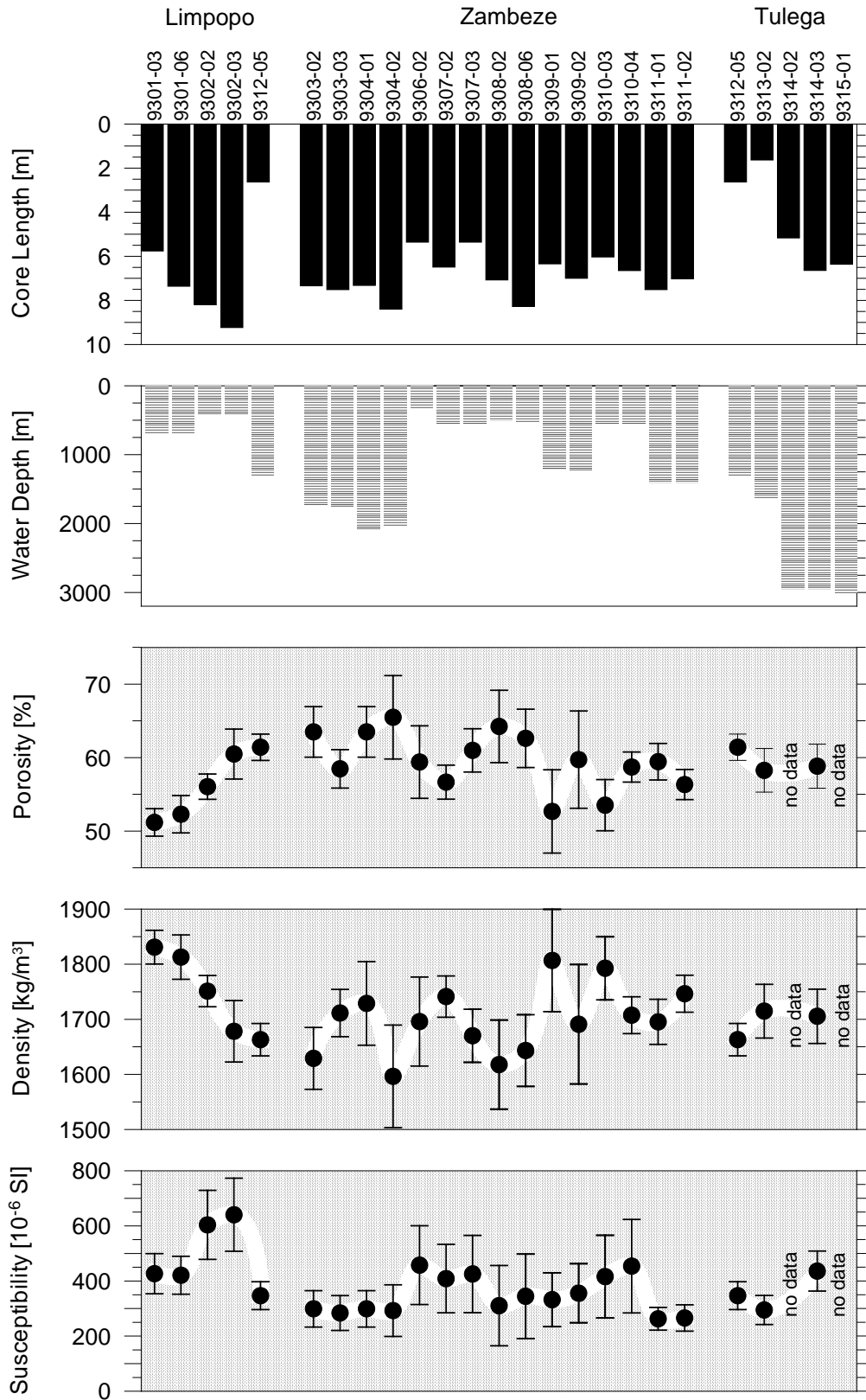


Fig. 1.17: Mean porosities, densities, and magnetic susceptibilities of cores GeoB 9301-03 through GeoB 9315-01 compared to variations in water depth at the coring sites and core recovery. The vertical bars denote standard deviations.

1.4.5 Geochemistry

(S. Kasten, K. Enneking, Chr. März)

The focus of geochemical investigations carried out during this cruise was a detailed examination of the diagenetic alteration of the primary composition and the rock magnetic properties of the sediment across the iron redox boundary and within the sulfate/methane transition zone (SMT) or the zone of anaerobic oxidation of methane (AOM), respectively. In this context, a major task is the documentation of the sequence of iron oxide and iron sulfide mineralization which typically result in the destruction and/or the formation of (paleo-)magnetic signals. Of particular importance is an evaluation of their specific potential to reconstruct redox environments and the extent of early diagenetic overprint in the course of changing paleoceanographic conditions. Furthermore, we seek to decipher the conditions and mechanisms controlling the formation of the sulfur isotopic composition of various dissolved and solid-phase sulfur compounds. Besides these investigations of diagenetic modification of the initial sediment composition we also aim at reconstructing variations in the input of primary sediment components over glacial/interglacial time-scales as a result of changes in sea level, ocean circulation and climate in the catchment areas of the examined river fan systems. For these purposes high-resolution sampling and analyses of the pore water and the sedimentary solid phase were performed which will be combined with and complemented by various diagnostic magnetic attributes (see Chapter 1.4.4).

Pore Water Chemistry - Methods of Pore Water Sampling and Analysis

To prevent a warming of the sediments on board all cores were transferred into the cooling room immediately after recovery and maintained at a temperature of about +4°C. The cores from the MUC were processed within a few hours within a glove box under argon atmosphere. Two samples of the supernatant bottom water were taken and filtered for subsequent analyses. The remaining bottom water was carefully removed from the multicorer tube by means of a siphon 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 1 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 and 5 ml syringe samples were taken from every cut segment surface for methane analysis. These sediment samples were transferred into headspace vials containing 20 ml of a saturated NaCl solution and stored at a temperature of –20°C. For the extraction of pore water both rhizon samplers and Teflon-squeezers were used. The first four gravity cores (GeoB 9301-3, 9302-2, 9303-3 and 9304-1) were subjected to rhizon sampling. Rhizons were punched into the sediment through holes drilled into the liner wall and left there for several hours. For the extraction of pore water by pressure filtration and solid-phase sampling all gravity cores were cut lengthwise into two halves and processed in the cooling room in a glove box under argon atmosphere. PH and Eh were determined on the working halves and sediment samples were taken every 25 cm for pressure filtration. The Teflon-squeezers were operated with argon at a pressure gradually increasing up to 5 bar. The pore water was retrieved through 0.2 µm cellulose acetate membrane filters. Depending on the porosity and compressibility of the sediments, the amount of pore water recovered ranged between 5 and 20 ml. Solid phase samples for total digestions, sequential extractions and mineralogical analyses

were taken at 10 cm intervals and kept in gas-tight glass bottles under argon atmosphere. The storage temperature of these sediment samples was -20°C .

Pore water analyses of the following parameters were carried out during this cruise: Eh, pH, temperature, ammonium, alkalinity, phosphate, iron (Fe^{2+}) and hydrogen sulfide. Eh and pH were determined with punch-in electrodes before the sediment structure was disturbed by sampling for pressure filtration. Ammonium was measured using a conductivity method. Alkalinity was calculated from a volumetric analysis by titration of 1 ml of the pore water samples with 0.01, 0.05 or 0.1 M HCl, respectively. For the analyses of dissolved iron (Fe^{2+}) sub-samples of 1 ml were taken within the glove box, immediately complexed with 50 μl of “Ferrospectral“ and determined photometrically. The analyses of phosphate as well as hydrogen sulfide were also performed photometrically.

For further analyses at the University of Bremen, aliquots of the remaining pore water samples were diluted 1:10 and acidified with HNO_3 (suprapure) for determination of cations (Ca, Mg, Sr, K, Ba, S, Mn, Si, B, Li) by ICP-AES and AAS. Additionally, 1.5 ml subsamples of the pore water were added to a ZnAc solution (600 μl) to fix all hydrogen sulfide present as ZnS for later analysis – including sulfur isotopes. Subsamples for sulfate and chloride determinations were diluted 1:20 and stored frozen for ion chromatography (HPLC) analyses at the University of Bremen.

A complete overview of sampling procedures and analytical techniques used on board and in the laboratories at the University of Bremen is available on www.uni-bremen.geochemie.de.

Shipboard Results – Pore Water Chemistry

During this cruise 8 multicorer cores and 9 gravity cores were sampled and investigated in detail for pore water chemistry. From all gravity cores pore water was extracted by pressure filtration. In addition, pore water was retrieved by the rhizon technique from the first four gravity cores (GeoB 9301-3, 9302-2, 9303-3 and 9304-1). All sites sampled geochemically, including parameters analysed on board as well as aliquots of pore-water and solid-phase samples taken and stored for further analyses in Bremen are listed in Table 1.4.

Tab. 1.4: Sites investigated geochemically during this cruise, including parameters analysed on board and aliquots of samples taken and stored for further analysis.

Station		Water depth [m]	Mode of pore water extraction	Eh	pH	Alkal.	NH_4	Fe^{2+}	PO_4^{3-}	HS^-	HS^- (ZnAc)	CH_4 (headspace)	SO_4, Cl (1:20)	ICP (1:10)	solid-phase (under argon)
GeoB 9301-1	MUC	695	Pressure filtra.	x	x	x	x	x	x				x	x	
GeoB 9301-3	SL	695	Pressure filtra.	x	x	x	x	x	x			x	x	x	x
"			Rhizons			x	x		x						
GeoB 9302-2	SL	425	Pressure filtra.	x	x	x	x	x	x			x	x	x	x
"			Rhizons			x	x		x						
GeoB 9302-5	MUC	425	Pressure filtra.	x	x	x	x	x	x				x	x	
GeoB 9303-1	MUC	1724	Pressure filtra.	x	x	x	x	x	x				x	x	
GeoB 9303-3	SL	1724	Pressure filtra.	x	x	x	x	x	x			x	x	x	x
"			Rhizons			x	x		x						
GeoB 9304-1	SL	2024	Pressure filtra.	x	x	x	x	x	x			x	x	x	x
"			Rhizons			x	x		x						
GeoB 9304-3	MUC	2024	Pressure filtra.	x	x	x	x	x	x				x	x	
GeoB 9307-2	SL	550	Pressure filtra.	x	x	x	x	x	x			x	x	x	x
GeoB 9307-4	MUC	550	Pressure filtra.	x	x	x	x	x	x				x	x	
GeoB 9309-1	SL	1219	Pressure filtra.	x	x	x	x	x	x	x	x	x	x	x	x
GeoB 9309-3	MUC	1219	Pressure filtra.	x	x	x	x	x	x				x	x	
GeoB 9310-1	MUC	548	Pressure filtra.	x	x	x	x	x	x				x	x	
GeoB 9310-3	SL	548	Pressure filtra.	x	x	x	x	x	x			x	x	x	x
GeoB 9311-2	SL	1406	Pressure filtra.	x	x	x	x	x	x			x	x	x	x
GeoB 9311-3	MUC	1406	Pressure filtra.	x	x	x	x	x	x				x	x	
GeoB 9314-2	SL	2958	Pressure filtra.	x	x	x	x	x	x			x	x	x	x

1.4.6 Water and Plankton Studies

1.4.6.1 CTD Profiling Water

(R. Schneider, R. Thomas)

While surface temperature and salinity data from the ships thermosalinograph can be used to create sea surface temperature (SST) and sea surface salinity (SSS) fields for the hydrographic situation during the cruise, deep-water profiles are needed from CTD (current, temperature and depth probe) data as well as salinity and fluorescence profiles. From the CTD data temperature-salinity plots can be created in order to identify the water masses present at each CTD station. To get current information about the hydrographic conditions in the region of the Agulhas Current system, a Seabird SBE-2069 CTD profiler was used at 12 stations during cruise M63/1. Usually, it was attached to the wire 50 m above the multicorer or 20 m above the multinet in order to obtain information about the actual depth of the chlorophyll maximum depth layer for sampling with the rosette later on. The raw data of each down- and upcast were transferred to a PC. The locations of CTD deployments are reported in the station protocol (Table 1.5).

Figure 1.18 gives an example for a typical CTD-profile for a station at 400 m water depth close to the Sambesi mouth area. The upper 60 meter of the water column are characterized by very warm temperatures between 24 and 28°C and slightly reduced salinities of about 35 psu, typical for the thick upper warm layer in the Equatorial Indian Ocean. A well expressed thermocline exists between 50 and 60 m water depth, wherein temperatures decrease below 20°C and a sharp gradient with increasing salinities to about 35.4 psu exists. At about 40 to 50 m water depth, just above the density gradient associated with the thermocline, a chlorophyll maximum appears. This feature was documented at each CTD station in water depths between 50 and 75 m. Below the thermocline temperature continues to decrease to about 15°C, while salinities stay at highest levels down to about 200 to 300 m water depth.

A second profile shows the conditions in the oligotrophic more offshore region (Figure 1.19) down to about 2000 m water depth. Similar to figure 1.18, the upper water column is characterized by a thick low salinity and warm temperature mixed layer, with well expressed thermocline and salinity gradient towards higher values underneath. Also a deep chlorophyll maximum is indicated by the fluorescence measurements at the thermocline depth. As in the more inshore site shown in figure 1.19, a strong salinity maximum forms between 150 and 300 m water depth with values of 0.6 to 0.9 psu higher than above below and this maximum, respectively. The temperature progressively decreases to about 15 to 12°C at these depths. A deeper water mass that can be distinguished by its temperature and salinity characteristics at levels between 800 and 1400 m water depth, where the temperature further drops from 10 to 4°C while salinities are slightly higher in this interval compared to the two salinity minima at the top and the bottom of this layer. Below 1400 m water depth temperatures decrease only slightly by 1 to 2°C down to the end of this profile at 2000 m water depth, while salinity values show only a subtle increase by about 0.1 psu. These values are typical for the deeper water mass in the Mozambique Channel.

Tab. 1.5: CTD stations during M63/1.

GeoB No.	Latitude S	Longitude E	Water Depth (m)	Remarks
9301-1	26°23.1'	33°54.1'	690	CTD 50 m above MUC
9302-4	25°25.7'	33°47.3'	423	CTD 50 m above MUC
9304-3	19°51.8'	37°52.6'	2033	CTD 50 m above MUC, Chlorophyll max. 65-72 m
9305-1	18°29.1'	37°20.9'	148	no recovery
9305-2	18°29.1'	37°21.0'	145	no recovery
9306-1	18°31.1'	37°21.8'	345	CTD 50 m above MUC, Chlorophyll max. 41 m
9307-4	18°33.9'	37°22.9'	550	CTD 50 m above MUC, Chlorophyll max. 45-60 m
9308-1	18°07.8'	37°35.9'	503	
9309-3	18°55.7'	37°31.0'	1232	
9310-1	19°12.1'	37°02.6'	560	
9311-3	21°33.7'	36°25.2'	1409	CTD 50 m above MUC, Chlorophyll max. 63 m
9312-1	27°21.1'	33°36.8'	1289	CTD 50 m above MUC
9313-3	29°13.1'	32°43.9'	1635	CTD 50 m above MUC, Chlorophyll max. 71 m
9314-1	30°43.2'	31°49.3'	2955	no data at CTD recorded

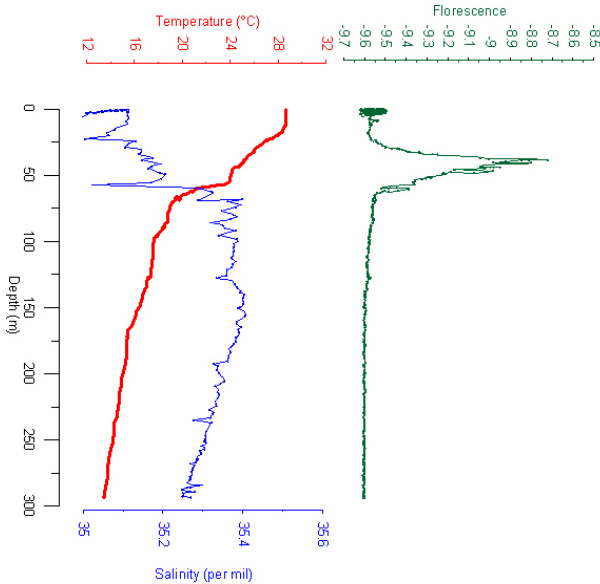


Fig. 1.18: CTD profile at station GeoB 9306-1 in 400 m water depth off the Sambesi River.

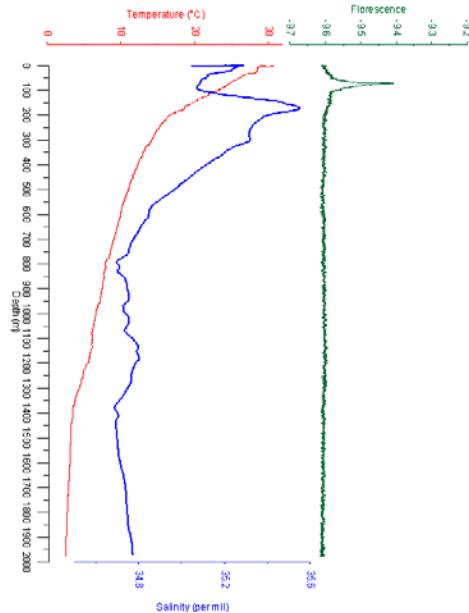


Fig. 1.19: CTD profile at station GeoB 9304-3 in 2000 m water depth off the Sambesi River.

1.4.6.2a Plankton Sampling Using a Multiple Closing Net

(M. Klann, H. Kuhlmann)

Plankton was sampled with a multiple closing net (abbr. MN; Fa. HYDROBIOS) with 0.25 m² opening and 64 µm mesh size. It was used for vertical hauls at 9 sites (Table 1.16). Each haul sampled depth intervals from 300-200, 200-100, 100-50, 50-30 and 30-0 m.

The samples containing mostly zooplankton and some phytoplankton were carefully rinsed with seawater into KAUTEX bottles, fixed with mercury chloride for the reduction of bacterial degradation, and stored at +4°C. The samples will be used for detailed investigation of plankton distribution. In combination stable isotope ratios and Mg/Ca ratios of ambient foraminifera will be measured for calibration. The environmental conditions determining the individual assemblages of certain microfossil groups will be studied to enable their application for paleoceanographic reconstructions.

Tab. 1.6: Plankton samples from multiple closing net (MN) during M63/1.

Station GeoB	Water Depth (m)	Chlorophyll Maximum (m)	Position		Remarks
			Latitude	Longitude	
9301-5	690	40	26°28.1'S	33°52.2'E	300-200 m, net damaged
9303-4	1727	70	29°21.5'S	36°53.8'E	
9304-5	2024	65-72	19°51.8'S	37°52.6'E	
9308-3	507	30-100	18°07.8'S	37°36.0'E	
9309-5	1219	45	18°55.5'S	37°31.4'E	
9311-5	1406	63	21°34.9'S	36°26.6'E	
9312-4	1294	57	27°21.0'S	33°36.7'E	200-100 m, net damaged
9313-5	1632	71	29°13.7'S	32°43.1'E	
9314-4	2956	no data	30°42.3'S	31°49.3'E	

1.4.6.2b Plankton Sampling for Suspended Particulate Organic Matter

(E. Schefuß)

To analyse the distributions of algal lipids and their isotopic signatures, surface water suspended particulate organic matter was sampled using the vessel's membrane pump (Tab. 1.7). The water was filtered through glass fibre filters (GMF 5, Sartorius AG). After sampling, the filters were wrapped in aluminium foil and stored at -20°C. To determine the isotopic fractionation between the surface water and the lipids, two 30 ml water samples were taken at each sampling transect, one at the beginning and one at the end. The water samples were not poisoned. The water bottles were sealed with wax and stored at +4°C. The water samples are numbered according to the filter samples, #-A for the sample taken at the start of a sample transect and #-B for the sample taken at its end.

Tab. 1.7: List of suspended particulate organic matter samples. Sea surface temperature (SST) and sea surface salinity (SSS) are derived from the shipboard thermosalinograph.

Sample No.	Date 2005	Time (UTC)	Latitude	Longitude	SST °C	SSS psu	Vol. L
0	01.02.	<i>blank</i>					
1	Start	02.02.	11:46	35°06.5'S 21°48.08'E	20.1	35.1	27
	Stop	02.02.	12:21	35°06.1'S 21°54.27'E	20.5	35.1	
2	Start	02.02.	15:06	35°02.7'S 22°23.1'E	20.6	35.3	91
	Stop	02.02.	16:21	35°00.2'S 22°36.3'E	20.3	35.3	
3	Start	02.02.	19:18	34°54.6'S 23°06.2'E	19.7	35.3	56
	Stop	02.02.	20:02	34°53.2'S 23°13.1'E	19.9	35.4	
4	Start	03.02.	08:17	34°24.4'S 25°50.0'E	19.5	35.2	46
	Stop	03.02.	08:52	34°22.9'S 25°57.8'E	19.9	35.3	
5	Start	03.02.	12:23	34°15.1'S 26°39.5'E	23.6	35.3	45
	Stop	03.02.	13:03	34°13.9'S 26°46.1'E	24.6	35.3	
6	Start	03.02.	16:01	34°07.9'S 27°16.6'E	26.2	35.3	128
	Stop	03.02.	16:49	34°06.8'S 27°23.2'E	26.1	35.3	
7	Start	04.02.	08:16	32°34.8'S 29°49.0'E	25.5	35.4	160
	Stop	04.02.	09:03	32°29.0'S 29°56.7'E	25.9	35.4	
8	Start	04.02.	13:37	31°54.3'S 30°40.4'E	27.3	35.4	222
	Stop	04.02.	14:46	31°45.8'S 30°51.1'E	27.2	35.4	
9	Start	04.02.	19:13	31°12.1'S 31°33.4'E	27.2	35.3	248
	Stop	04.02.	20:32	31°01.7'S 31°46.5'E	27.3	35.4	
10	Start	05.02.	09:27	29°21.1'S 32°38.1'E	27.2	35.4	222
	Stop	05.02.	10:35	29°10.5'S 32°46.0'E	27.3	35.4	
11	Start	05.02.	15:23	28°26.3'S 33°18.1'E	26.9	35.4	166
	Stop	05.02.	16:12	28°18.8'S 33°23.5'E	26.9	35.5	
12	Start	05.02.	19:09	27°48.1'S 33°36.9'E	27.0	35.4	156
	Stop	05.02.	19:54	27°39.0'S 33°36.9'E	27.2	35.4	
13	Start	06.02.	04:12	26°23.2'S 33°54.3'E	26.6	35.4	125
	Stop	06.02.	05:05	26°23.9'S 33°53.9'E	26.5	35.4	
14	Start	06.02.	15:11	26°37.1'S 33°50.3'E	26.7	35.4	167
	Stop	06.02.	16:18	26°32.8'S 33°51.6'E	26.7	35.4	
15	Start	06.02.	19:37	26°19.2'S 33°57.0'E	26.5	35.4	218
	Stop	06.02.	21:18	26°12.3'S 34°00.3'E	26.5	35.4	
16	Start	07.02.	09:10	25°33.8'S 33°32.7'E	27.5	35.4	168
	Stop	07.02.	10:23	25°31.0'S 33°38.2'E	27.6	35.4	
17	Start	07.02.	12:00	25°26.7'S 33°46.6'E	27.6	35.4	145
	Stop	07.02.	12:53	25°25.5'S 33°48.9'E	27.9	35.4	
18	Start	07.02.	18:47	25°26.1'S 33°45.5'E	27.4	35.5	4*
	Stop	07.02.	20:09	25°27.2'S 33°45.7'E	27.3	35.6	
19	Start	08.02.	08:26	25°26.2'S 35°02.9'E	27.3	35.4	225
	Stop	08.02.	10:21	25°26.0'S 35°14.3'E	28.1	35.4	
20	Start	08.02.	14:00	25°14.4'S 35°31.9'E	28.1	35.5	232
	Stop	08.02.	15:22	25°01.7'S 35°38.0'E	27.9	35.5	
21	Start	08.02.	19:44	24°21.5'S 35°58.3'E	27.2	35.5	257
	Stop	08.02.	21:12	24°08.2'S 36°05.3'E	27.2	35.5	
22	Start	09.02.	10:27	21°46.3'S 36°22.3'E	28.1	35.2	230
	Stop	09.02.	11:41	21°31.9'S 36°24.8'E	27.8	35.2	
23	Start	09.02.	15:21	21°02.2'S 36°29.6'E	28.1	35.1	203
	Stop	09.02.	16:53	20°59.3'S 36°29.6'E	28.0	35.1	
24	Start	09.02.	19:51	20°54.1'S 36°27.4'E	27.7	35.2	185
	Stop	09.02.	21:07	20°50.0'S 36°25.6'E	27.6	35.1	
25	Start	10.02.	07:23	20°22.1'S 36°28.6'E	27.8	35.2	187
	Stop	10.02.	08:41	20°21.5'S 36°33.9'E	27.8	35.2	

Tab. 1.7: continued

Sample No.	Date 2005	Time (UTC)	Latitude	Longitude	SST °C	SSS psu	Vol. L	
26	Start	10.02.	13:45	20°21.6'S	36°54.7'E	28.3	35.1	197
	Stop	10.02.	14:53	20°21.3'S	36°53.9'E	28.5	35.1	
27	Start	10.02.	22:18	20°22.6'S	36°53.1'E	28.3	35.1	277
	Stop	11.02.	00:07	20°14.4'S	37°09.6'E	28.3	35.3	
28	Start	11.02.	10:31	19°51.9'S	37°52.6'E	28.5	35.3	175
	Stop	11.02.	11:31	19°51.9'S	37°52.7'E	28.5	35.3	
29	Start	11.02.	16:14	19°48.6'S	37°49.0'E	28.6	35.3	254
	Stop	11.02.	17:54	19°42.2'S	37°48.6'E	28.5	35.1	
30	Start	11.02.	20:11	19°33.2'S	37°45.2'E	28.8	35.1	202
	Stop	11.02.	21:21	19°28.7'S	37°43.5'E	28.9	35.1	
31	Start	12.02.	10:05	18°28.7'S	37°20.8'E	28.4	35.2	198
	Stop	12.02.	11:33	18°22.7'S	37°18.6'E	28.8	35.0	
32	Start	12.02.	13:54	18°29.0'S	37°21.1'E	28.5	35.2	180
	Stop	12.02.	15:17	18°31.4'S	37°20.8'E	28.3	35.2	
33	Start	12.02.	18:41	18°33.9'S	37°22.7'E	28.0	35.2	222
	Stop	12.02.	20:02	18°34.3'S	37°23.2'E	28.0	35.2	
34	Start	13.02.	11:00	18°06.9'S	37°37.4'E	28.3	35.1	177
	Stop	13.02.	12:00	18°03.4'S	37°39.0'E	28.7	35.1	
35	Start	13.02.	15:25	18°18.5'S	37°35.0'E	28.4	35.2	317
	Stop	13.02.	18:00	18°29.5'S	37°32.2'E	28.1	35.2	
36	Start	14.02.	12:16	19°10.1'S	37°05.8'E	28.2	35.2	179
	Stop	14.02.	13:48	19°14.2'S	36°58.8'E	27.8	35.2	
37	Start	14.02.	15:22	19°18.5'S	36°51.4'E	27.7	35.2	139
	Stop	14.02.	16:24	19°17.7'S	36°52.1'E	27.7	35.1	
38	Start	14.02.	17:59	19°12.1'S	37°02.6'E	28.2	35.2	226
	Stop	14.02.	19:53	19°12.1'S	37°02.6'E	28.0	35.2	
39	Start	15.02.	07:52	19°53.5'S	37°00.0'E	28.5	35.3	278
	Stop	15.02.	09:27	20°02.0'S	36°59.2'E	28.3	35.3	
40	Start	15.02.	12:09	20°31.7'S	36°47.9'E	28.4	35.3	221
	Stop	15.02.	13:13	20°44.5'S	36°43.1'E	28.3	35.3	
41	Start	15.02.	16:55	21°28.4'S	36°26.3'E	28.1	35.3	201
	Stop	15.02.	17:59	21°33.1'S	36°24.9'E	28.3	35.3	
42	Start	16.02.	09:15	21°51.2'S	35°48.3'E	28.2	35.2	202
	Stop	16.02.	10:24	21°56.1'S	35°53.4'E	28.2	35.2	
43	Start	16.02.	13:46	22°19.5'S	36°00.4'E	28.5	35.3	364
	Stop	16.02.	16:16	22°46.6'S	35°59.1'E	27.8	35.2	
44	Start	16.02.	19:07	23°19.6'S	35°59.9'E	27.9	35.2	267
	Stop	16.02.	20:40	23°37.6'S	36°00.1'E	27.8	35.2	
45	Start	17.02.	09:31	25°33.4'S	34°46.9'E	27.2	35.3	192
	Stop	17.02.	10:58	25°40.4'S	34°39.3'E	26.5	35.3	
46	Start	17.02.	13:25	25°51.0'S	34°27.8'E	27.7	35.5	207
	Stop	17.02.	14:35	25°55.7'S	34°22.7'E	28.5	35.3	
47	Start	17.02.	20:21	26°40.6'S	33°56.2'E	27.3	35.5	201
	Stop	17.02.	21:28	26°54.0'S	33°49.4'E	27.9	35.3	
48	Start	18.02.	02:32	27°21.0'S	33°36.9'E	27.8	35.3	249
	Stop	18.02.	04:08	27°21.0'S	33°36.8'E	27.8	35.3	
49	Start	18.02.	12:54	28°47.2'S	32°56.2'E	26.4	35.5	344
	Stop	18.02.	14:41	29°09.3'S	32°45.9'E	26.8	35.4	
50	Start	18.02.	20:28	29°15.8'S	32°41.3'E	26.7	35.4	208
	Stop	18.02.	21:25	29°27.6'S	32°37.7'E	26.4	35.3	
51	Start	19.02.	10:40	30°42.8'S	31°49.4'E	26.8	35.4	255
	Stop	19.02.	12:02	30°42.4'S	31°49.1'E	26.8	35.4	

Tab. 1.7: continued

Sample No.	Date 2005	Time (UTC)	Latitude	Longitude	SST °C	SSS psu	Vol. L	
52	Start	19.02.	13:40	30°47.0'S	31°44.6'E	26.8	35.5	305
	Stop	19.02.	15:11	30°58.3'S	31°31.8'E	26.5	35.5	
53	Start	19.02.	17:17	31°17.1'S	31°13.4'E	25.7	35.5	254
	Stop	19.02.	18:33	31°29.1'S	31°01.8'E	26.3	35.5	
54	Start	20.02.	10:28	33°22.2'S	28°47.5'E	25.1	35.5	293
	Stop	20.02.	11:52	33°35.3'S	28°30.6'E	26.8	35.4	
55	Start	20.02.	14:50	34°02.8'S	27°54.6'E	26.0	35.4	300
	Stop	20.02.	16:15	34°09.1'S	27°32.7'E	25.9	35.4	
56	Start	20.02.	20:02	34°16.8'S	26°24.1'E	18.8	35.2	190
	Stop	20.02.	21:30	34°19.6'S	26°01.3'E	18.6	35.1	
57	Start	21.02.	09:14	34°39.4'S	23°14.4'E	20.0	35.3	149
	Stop	21.02.	10:49	34°41.3'S	22°58.3'E	20.1	35.2	
58	Start	21.02.	12:53	34°43.7'S	22°37.1'E	20.4	35.2	40
	Stop	21.02.	14:30	34°45.4'S	22°22.8'E	20.0	35.2	
59	Start	21.02.	16:11	34°46.6'S	22°07.9'E	19.5	35.1	80
	Stop	21.02.	17:50	34°48.0'S	21°55.2'E	20.7	35.2	
60	Start	21.02.	blank					

* Pump failure

1.4.6.3 Dinoflagellates

(N. Zatloukal, E. Susek)

Organic- and calcareous-walled dinoflagellate cysts are useful tools for the reconstruction of paleoceanographic conditions. They may be used to reconstruct surface water conditions such as sea surface temperatures (SST), sea surface salinities (SSS), stratification of the upper water column and nutrient content (Vink et al. 2001, Meier et al. 2004, Esper et al. 2004) as well as oxygen concentrations of deep the ocean bottom waters (Zonneveld et al. 2005). Recently it has been discovered that the isotopic composition of the wall of the calcareous dinoflagellate cyst *Thoracosphaera heimii* reflects the temperature conditions of the upper water column where it is formed; the deep chlorophyll maximum (Zonneveld 2004). In comparison to the presently available extensive knowledge about the distribution and ecology of organic- and calcareous-walled dinoflagellate cysts in the Atlantic Ocean, Mediterranean Sea, Arabian Sea and Southern Oceans, no information is available about the southwest Indian Ocean, notably the Agulhas Current system. To use dinoflagellate cysts to reconstruct the role of influence of tropical surface water masses as well as the variability of the intermediate and deep water circulation of the region in relationship to climate change detailed information of the cyst distribution in surface sediments, surface waters as well as the isotopic composition of *T. heimii* cysts *in situ*, is required. This information will form the basis for achievement of valuable information on the climatic variability of the southern Hemisphere as well as the relationship between regional palaeoceanographic changes and the climate variability of southern Africa. In order to achieve this information the following samples have been gathered.

Distribution of organic- and calcareous-walled dinoflagellate cysts in modern surface sediments

The major micropaleontological objective of surface sediment sampling is to achieve a better understanding of the biology and fossilisation of organic- and calcareous-walled dinoflagellate

cysts in the water column and surface sediments off eastern southern Africa. Distribution of cysts in the water column and surface sediments will be related to physical and chemical properties of the surface and deep-ocean at the Agulhas Current and Sambesi/Limpopo deep-sea fans. Surface sediments have been scanned for living dinoflagellate cysts to determine their cyst-motile relationship and to form the basis of the establishment of cultures that will be use for future growth experiments.

Multicorer

During this cruise 14 multicorers have been collected (Table 1.8). The surface sediments (0-2 cm) of 9.5 cm diameter cores were sampled and stored in dark 125 ml NALGENE HDPE flasks together with about 60 ml of bottom water. Sediments will be used for incubation experiments and the establishing of unicellular cultures. At several stations a second core was cut into sections of 1cm and stored plastic petri-dishes and at + 4°C. During the cruise surface sediments were scanned for living cysts in order to establish unicellular cultures.

Isotopic composition of Thoracospaera heimii

To determine if the method of measuring the isotopic composition of *T. heimii* is applicable in the southwestern Indian Ocean, *in situ* measurements are required. For this *T. heimii* are isolated from deep chlorophyll maximum waters.

Tab. 1.8: MUC samples taken for dinoflagellates study during M63/1.

MUC GeoB	Date 2005	Bottom Contact	Latitude	Longitude	Water Depth (m)	Core Length (cm)
9301-1	06.02.	03:53	26°22,8'S	33°54,5'E	690	29
9302-5	07.02.	16:24	25°25,8'S	33°47,4'E	423	30
9303-1	10.02.	16:01	20°21,6'S	36°53,8'E	1727	29
9304-4	11.02.	13:03	19°51,8'S	37°52,4'E	2023	30
9306-1	12.02.	15:47	18°31,1'S	37°21,7'E	338	25
9307-5	12.02.	23:03	18°34,0'S	37°22,9'E	355	32
9308-1	13.02.	05:39	18°07,8'S	37°35,9'E	507	36
9309-3	14.02.	03:50	18°55,7'S	37°31,0'E	1231	35
9310-1	14.02.	17:31	19°12,9'S	37°02,7'E	560	27
9311-3	15.02.	21:03	21°34,3'S	36°25,8'E	1419	13
9312-2	18.02.	02:41	27°21,0'S	38°36,9'E	1285	31
9312-1	18.02.	-	27°21,0'S	33°36,8'E	1293	31
9313-3	18.02.	18:10	29°13,0'S	32°44,0'E	1632	30
9314-1	19.02.	06:42	30°42,2'S	31°49,3'E	2957	24

Rosette water sampler

To isolate *T. heimii* from deep chlorophyll maximum at 12 stations water samples were taken with the Rosette (Multi Water Sampler MWS, Kat. No 436918A) with 18 x 10 L Niskin bottles from deep chlorophyll maximum. Deep chlorophyll maximum depth was established previously using CTD Recorder. The obtained seawater was continuously passed over the 75 µm, 40 µm and 20 µm-mesh sieves and then filtered over a 10 µm gauze using vacuum pump system, thereby collecting the 10-20 µm particles (including *T. heimii*). The obtained material was col-

lected on a 5 µm polycarbonate filters and dried in petri-dishes. The material will be used in University of Bremen to measure isotopic composition of *T. heimii*. Additionally water in 30 ml bottles was collected from each water sampling to measure isotope. PH measurement of sampled water was also provided.

Tab. 1.9: Water samples for dinoflagellate analysis (rosette water sampler casts).

GeoB Station	Date 2005	Time (UTC)	Latitude	Longitude	Water Depth (m)	Bottle Depth (m)	pH	Vol. Filtered [L]
9301-4	06.02.	08:53-09:02	26°27,5'S	33°52,2'E	695	40	7,95-8,10	40
9302-6	07.02.	17:57-17:12	25°25,8'S	33°47,4'E	425	75	8,00	165
9303-5	10.02.	21:42-21:54	20°22,2'S	36°52,0'E	1731	70	7,95	170
9304-4	11.02.	14:08-14:21	19°51,6'S	37°52,4'E	2023	65	8,07	170
9306-3	12.02.	17:31-17:39	18°31,1'S	37°22,2'E	338	41	8,07	175
9307-5	12.02.	23:38-23:47	18°33,8'S	37°22,9'E	545	45	8,12	175
9308-5	13.02.	09:12-09:30	18°09,3'S	37°36,8'E	497	65	8,11	80
9309-3	14.02.	04:38-04:48	18°55,5'S	37°31,5'E	1246	45	8,00	175
9310-2	14.02.	18:17-18:26	19°12,0'S	37°02,6'E	553	44	8,12	170
9311-3	15.02.	21:59-22:08	21°34,2'S	36°25,7'E	1412	63	8,10	165
9312-3	18.02.	02:42-02:51	27°21,0'S	33°36,9'E	1296	56	8,21	175
9313-4	18.02.	13:16-13:25	29°13,4'S	32°43,7'E	1632	71	8,23	175

1.4.6.4 Coccolithophorids

(N. Zatloukal, E. Susek, K-H. Baumann)

Coccolithophores which are autotrophic, marine algae (Prymnesiophyceae), form a major component of the oceanic microplankton and are one of the main open ocean primary producers. Their cell surfaces are covered by minute external calcite scales with a complex ornamentation. These coccoliths constitute the single most important component of the deep-sea sediments and provide floral and biomarker signals for interpreting global change in the geological record. Therefore, they are extensively used in paleoecological and paleoceanographical studies (e.g. McIntire and Bé, 1967; Winter and Siesser, 1994).

Knowledge of their living occurrences as well as their distribution in surface sediments is a prerequisite for palaeoecological and palaeoceanographical studies using coccoliths as proxies in Quaternary sediments. However, the environmental parameters that control their distribution are still poorly understood. In addition, there is not much known about their distribution and occurrence of coccolithophores in the region of SW Indian Ocean.

Therefore, an investigation of coccolithophores from the upper centimeter of surface sediment in the SW Indian Ocean was carried out. The obtained material will be used for studies on the distribution and composition of the coccolithophore communities.

Tab. 1.10: MUC samples for coccolithophorids.

MUC GeoB	Date 2005	Bottom contact	Latitude	Longitude	Water depth (m)
9301-1	06.02.	03:53	26°22,8'S	33°54,5'E	690
9302-5	07.02.	16:24	25°25,8'S	33°47,4'E	423
9303-1	10.02.	16:01	20°21,6'S	36°53,8'E	1727
9304-4	11.02.	13:03	19°51,8'S	37°52,4'E	2023
9306-1	12.02.	15:47	18°31,1'S	37°21,7'E	338
9307-5	12.02.	23:03	18°34,0'S	37°22,9'E	355
9308-1	13.02.	05:39	18°07,8'S	37°35,9'E	507
9309-3	14.02.	03:50	18°55,7'S	37°31,0'E	1231
9310-1	14.02.	17:31	19°12,9'S	37°02,7'E	560
9311-3	15.02.	21:03	21°34,3'S	36°25,8'E	1419
9312-2	18.02.	02:41	27°21,0'S	38°36,9'E	1285
9312-1	18.02.	-	27°21,0'S	33°36,8'E	1293
9313-3	18.02.	18:10	29°13,0'S	32°44,0'E	1632
9314-1	19.02.	06:42	30°42,2'S	31°49,3'E	2957

1.4.7 Aerosol Sampling

(E. Schefuß)

Sampling of aerosols was conducted along the entire cruise track of M63/1 (Tab. 1.11). For this purpose, two high-volume aerosol samplers were installed on a platform in the ship's mast. The samplers were equipped with a wind-direction sensor system to prevent contamination from the ship's exhaust. Sampling was stopped when the relative wind deviated more than 90° from the ship's heading or wind speed was low. A timer recorded the elapsed runtime during the sampling intervals. The samplers were calibrated to sample about 70 m³ per hour. Two kinds of filters were used to collect aerosol samples. One sampler held a cellulose filter (Whatman, Type 41), while the other contained a pre-combusted (400°C) glass-fibre filter (Whatman, GF/A). The filters were changed once a day. After sampling, each glass-fibre filter was wrapped in aluminium foil and stored at -4°C. The cellulose filters were stored in plastic zip-lock bags. The glass-fibre filters will be used for bulk and compound-specific organic-geochemical and -isotopic analyses, while the cellulose filters will be investigated for distributions of major and trace elements, grain size and clay mineral distributions. For comparison, data from the ship's meteorological system were collected. These data contain information about the ship's position, its course and speed, the real and apparent wind direction and speed, air and water temperature, air pressure and humidity.

Tab. 1.11: Aerosol samples collected at M63/1.

Aerosol samples No.	Date 2005	Time (UTC)	Latitude	Longitude	Duration (h)	
0	blank	01.02.				
1	Start	01.02.	12:53	33°53.92'S	18°17.10'E	23.6
	Stop	02.02.	13:00	35°05.58'S	22°02.73'E	
2	Start	02.02.	13:00	35°05.58'S	22°02.73'E	8.5
	Stop	03.02.	13:45	34°12.55'S	26°53.03'E	
3	Start	03.02.	13:45	34°12.55'S	26°53.03'E	3.5
	Stop	04.02.	14:26	31°48.06'S	30°48.16'E	
4	Start	04.02.	14:26	31°48.06'S	30°48.16'E	0.0
	Stop	05.02.	14:09	28°37.38'S	33°09.95'E	
5	Start	05.02.	14:09	28°37.38'S	33°09.95'E	9.9
	Stop	06.02.	14:22	26°39.94'S	33°49.77'E	
6	Start	06.02.	14:22	26°39.94'S	33°49.77'E	4.4
	Stop	07.02.	15:08	25°25.70'S	33°47.89'E	
7	Start	07.02.	15:08	25°25.70'S	33°47.89'E	21.1
	Stop	08.02.	05:31	25°10.81'S	35°33.58'E	
8	Start	08.02.	05:31	25°10.81'S	35°33.58'E	20.2
	Stop	09.02.	10:52	21°40.06'S	36°23.26'E	
9	Start	09.02.	10:52	21°40.06'S	36°23.26'E	11.3
	Stop	10.02.	11:51	20°21.49'S	36°46.88'E	
10	Start	10.02.	11:51	20°21.49'S	36°46.88'E	18.3
	Stop	11.02.	12:50	19°51.75'S	37°52.66'E	

Aerosol samples No.	Date 2005	Time (UTC)	Latitude	Longitude	Duration (h)	
12	Start	12.02.	12:07	18°22.06'S	37°18.12'E	16.6
	Stop	13.02.	11:19	18°05.80'S	37°37.88'E	
13	Start	13.02.	11:19	18°05.80'S	37°37.88'E	25.5
	Stop	14.02.	14:57	19°17.51'S	36°53.08'E	
14	Start	14.02.	14:57	19°17.51'S	36°53.08'E	19.1
	Stop	15.02.	13:33	20°48.52'S	36°41.60'E	
15	Start	15.02.	13:33	20°48.52'S	36°41.60'E	7.6
	Stop	16.02.	12:53	22°09.50'S	36°00.10'E	
16	Start	16.02.	12:53	22°09.50'S	36°00.10'E	21.7
	Stop	17.02.	13:46	25°52.44'S	34°26.26'E	
17	Start	17.02.	13:46	25°52.44'S	34°26.26'E	6.1
	Stop	18.02.	13:49	28°58.47'S	32°50.94'E	
18	Start	18.02.	13:49	28°58.47'S	32°50.94'E	13.0
	Stop	19.02.	13:26	30°49.10'S	31°42.33'E	
19	Start	19.02.	13:26	30°49.10'S	31°42.33'E	17.8
	Stop	20.02.	14:27	33°59.31'S	27°59.27'E	
20	Start	20.02.	14:27	33°59.31'S	27°59.27'E	0.1
	Stop	21.02.	15:00	34°45.36'S	22°18.18'E	
21	Start	21.02.	15:00	34°45.36'S	22°18.18'E	10.8
	Stop	22.02.	11:17	35°04.41'S	19°34.71'E	
22	blank	22.02.				

1.5 Ship's Meteorological Station

(G. Kahl, T. Truscheit)

When R/V METEOR left Cape Town, South Africa, on February 1, 2005, the synoptic situation was dominated by a low-pressure system of 1000 hPa on the Atlantic coast of South Africa, near the Namibian border. This contrasted to a wedge of high pressure at 1015 hPa just south of Cape Town, so that southeasterlies of near gale force (7 Bft) were encountered when the ship sailed along the Cape Peninsula.

The wedge of high pressure then strengthened to a high of 1020 hPa extending along the southeastern South African coast before moving eastward, so that our vessel also experienced strong headwinds the next day (East 6 Bft). Then in the evening, however, a new low of 1010 hPa formed along the coast, and moved northeastward at a faster pace than the ship. This resulted in southwesterlies of 6 Bft on February 3. These persisted through February 6 when they subsided to 5 Bft and retreated to the southeast, and so did not impede the beginning of sampling in the area of the Limpopo Cone (Working area B).

Meanwhile, another low of 1005 hPa had formed around the southern coast of South Africa. This low moved northeasterly as well, but it moved inland and so its influence on the ship was negligible. The high had moved eastward so that light easterly winds were observed as the ship was underway to working area C, where light to moderate southeasterlies were experienced. The

synoptic situation was dominated by interdiurnal variability of lows on the coast of neighbouring Madagascar.

On February 16 a southward course was set for the return voyage to Cape Town, stopping for a few hours of sampling in working areas off the Limpopo and the Tugela (working areas B and A) on the way. Again, there was a high of 1020 hPa strengthening later to 1035 hPa southeast of South Africa, extending in a wedge of up to 1015 hPa near our position. This wedge weakened slowly because of the strengthening of the high from which it extended, and so the vessel experienced southeasterlies of 5 Bft when north of the high pressure axis and northeasterlies when south of that axis on February 18, 2005.

Meanwhile, still another low had developed on the South African coast, this one heading for the Antarctic and intensifying on its way. On February 19, our ship passed by a secondary low located in coastal waters. Still another low had made its appearance on the southern coast of the continent, moving to the northeast. So it was necessary to pass this one as well, with northeasterly winds being felt up to then.

Moderate to strong southeasterlies were forecast for the last days at sea, and the only really strong winds encountered were the southeasterlies as we passed the Cape Peninsula again. The R/V METEOR made port at Cape Town on February 23, 2005.

Much thought had been given before the cruise to tropical depressions and the role they might play. Historical statistics showed that the cruise would be undertaken during the Mauritius Storm Season. And, in fact, tropical twisters did materialize as important features of the synoptic map. Luckily, however, they were not highly intense and they were limited to the area off the eastern coast of Madagascar. Therefore, only an indirect influence on the weather situation in the ship's working areas was observed in the form of minor interdiurnal variation in the wind speed in the working area off the Zambezi River (working area C). It was fortunate for the vessel and the expedition that these storms did not have a greater impact.

1.6 Station List

Meteor No.	GeoB No.	Date	Equipment	Time at Seafloor (UTC)	Latitude S	Longitude E	Water Depth (m)	Sediment Recovery (cm)	Remarks
2005		2005							
<u>Limpopo Fan, Area B</u>									
1	9301-1	06.02.	MUC+CTD	04:48	26°23.7'	33°54.0'	690	25	max. 716 m, CTD 50 m above MUC
	9301-2		SL 12	06:34	26°25.4'	33°52.6'	692	---	no recovery, core barrel bent
	9301-3		SL 6	08:00	26°27.4'	33°52.2'	695	570	upper 10-20 cm lost
	9301-4		ROS	09:00	26°27.6'	33°52.2'	695	---	max. 40 m, 18 x10 L
	9301-5		MN	10:09	26°28.3'	33°52.2'	697		max. 300 m
	9301-6		SL 9	10:46	26°29.1'	33°52.2'	701	732	
3	9302-1	07.02.	SL 6	13:25	25°25.6'	33°47.8'	423	46	
	9302-2		SL 9	14:32	25°25.8'	33°48.0'	425	802	
	9302-3		SL 12	15:55	25°25.8'	33°47.6'	424	908	
	9302-4		MUC+CTD	16:39	25°25.7'	33°47.3'	423	28	CTD 50 m above MUC, 1 small tube recovery
	9302-5		MUC	17:22	25°25.9'	33°47.1'	425	33	
	9302-6		ROS	18:04	25°26.3'	33°47.8'	425	---	max. 75 m, 18 x10 L, Chlorophyll max. 71 m
<u>Sambesi Fan, Area C</u>									
6	9303-1	10.02	MUC	16:01	20°21.7'	36°53.9'	1725	30	
	9303-2		SL 12	17:47	20°21.6'	36°53.9'	1725	735	
	9303-3		SL 12	19:39	20°21.4'	36°53.8'	1725	735	
	9303-4		MN+CTD	20:50	20°22.0'	36°53.1'	1725	---	CTD 20 m above MN, 270 m, Chl. max. 70 m
	9303-5		ROS	21:45	20°23.1'	36°51.6'	1725	---	max. 70 m, 18 x 10 L
7	9304-1	11.02.	SL 12	08:00	19°51.3'	37°52.9'	2071	732	
	9304-2		SL 18	10:33	19°51.9'	37°52.6'	2031	830	
	9304-3		MUC+CTD	12:54	19°51.8'	37°52.6'	2033	37	CTD 50 m above MUC, Chlorophyll max. 65-72 m
	9304-4		ROS	14:16	19°51.8'	37°52.2'	2022	---	max. 65 m, 17 x 10 L
	9304-5		MN	14:40	19°51.8'	37°51.2'	2018	---	max. 300 m
10	9305-1	12.02.	MUC+CTD	14:09	18°29.1'	37°20.9'	148	---	no recovery
	9305-2	12.02.	MUC+CTD	14:40	18°29.1'	37°21.0'	149	---	no recovery
	9306-1	12.02.	MUC+CTD	15:50	18°31.1'	37°21.8'	345	35	CTD 50 m above MUC, Chlorophyll max. 41 m
	9306-2		SL 6	16:41	18°31.0'	37°21.7'	334	536	
	9306-3		ROS	17:34	18°31.1'	37°22.4'	402	---	max. 41 m, 18 x 10 L
11	9307-1	12.02.	SL 12	19:02	18°34.0'	37°22.9'	560	---	no recovery
	9307-2		SL 9	21:02	18°33.8'	37°22.9'	548	636	
	9307-3		SL 9	22:11	18°33.9'	37°22.8'	542	651	
	9307-4		MUC+CTD	23:03	18°33.9'	37°22.9'	550	32	CTD 50 m above MUC, Chlorophyll max. 45-60 m
	9307-5		ROS	23:41	18°33.9'	37°22.9'	550	---	max. 45 m, 18 x 10 L

1.6 Station List (continued)

Meteor No. 2005	GeoB No.	Date 2005	Equipment	Time at Seafloor (UTC)	Latitude S	Longitude E	Water Depth (m)	Sediment Recovery (cm)	Remarks
<u>Sambesi Fan, Area C</u>									
12	9308-1	13.02.	MUC+CTD	05:39	18°07.8'	37°35.9'	503	42	
	9308-2		SL 9	06:32	18°07.8'	37°35.9'	501	705	
	9308-3		MN	07:38	18°07.9'	37°35.8'	519	32	max. 300 m
	9308-4		CTD	08:25	18°08.4'	37°36.3'	555	---	max. 100 m
	9308-5		ROS	09:16	18°09.3'	37°36.7'	610	---	max. 65 m, 18 x 10 L
	9308-6		SL 12	10:01	18°08.0'	37°36.1'	522	826	
14	9309-1	14.02.	SL 12	01:13	18°55.8'	37°30.7'	1216	642	
	9309-2		SL 12	02:30	18°55.7'	37°31.0'	1233	697	
	9309-3		MUC+CTD	03:51	18°55.7'	37°31.0'	1232	33	
	9309-4		ROS	04:40	18°55.5'	37°31.5'	1247	---	max. 45 m, 18 x 10 L
	9309-5		MN	05:00	18°55.4'	37°31.5'	1248	---	max. 300 m
16	9310-1	14.02	MUC+CTD	17:48	19°12.1'	37°02.6'	560	---	
	9310-2		ROS	18:18	19°12.1'	37°02.6'	552	---	max. 44 m, 18 x 10 L
	9310-3		SL 9	18:53	19°12.0'	37°02.6'	546	592	top of core lost, overpenetration
	9310-4		SL 12	19:50	19°12.1'	37°02.5'	543	675	
18	9311-1	15.02.	SL 12	17:48	21°33.1'	36°24.8'	1407	750	
	9311-2		SL 12	19:19	21°32.8'	36°24.8'	1410	698	
	9311-3		MUC+CTD	21:03	21°33.7'	36°25.2'	1409	23	CTD 50 m above MUC, Chlorophyll max. 63 m
	9311-4		ROS	21:59	21°34.5'	36°26.0'	1412	---	max. 63 m, 18 x 10 L
	9311-5		MN	22:30	21°34.8'	33°26.5'	1419	---	max. 300 m
<u>South of Limpopo Fan, Area B</u>									
21	9312-1	18.02.	MUC+CTD	00:48	27°21.1'	33°36.8'	1289	32	recovery 4 large tubes, CTD 50 m above MUC
	9312-2		MUC	02:06	27°21.0'	33°36.9'	1295	32	
	9312-3		ROS	02:41	27°21.0'	33°36.9'	1296	---	max. 56 m, 18 x 10 L
	9312-4		MN	03:10	27°21.0'	33°36.7'	1296	---	300 m, net damaged 200 - 100 m
	9312-5		SL 12	04:34	27°21.0'	33°36.9'	1295	261	
<u>North of Tugela Cone, Area A</u>									
22	9313-1	18.02.	SL 12	15:33	29°13.0'	32°44.0'	1636	---	no recovery, core barrel bent
	9313-2		SL 6	16:51	29°13.0'	32°44.0'	1635	161	
	9313-3		MUC+CTD	18:01	29°13.1'	32°43.9'	1635	32	CTD 50 m above MUC, Chlorophyll max. 71 m
	9313-4		ROS	19:16	29°13.7'	32°43.4'	1627	---	max. 80 m, 18 x 10 L
	9313-5		MN	19:32	29°13.7'	32°43.1'	1625	---	max. 300 m

1.6 Station List (continued)

Meteor No.	GeoB No.	Date	Equipment	Time at Seafloor (UTC)	Latitude S	Longitude E	Water Depth (m)	Sediment Recovery (cm)	Remarks
2005		2005							
South of Tugela Cone, Area A									
23	9314-1	19.02.	MUC+CTD	06:42	30°43.2'	31°49.3'	2955		no data at CTD recorded three tubes empty
	9314-2		SL 6	08:57	30°43.0'	31°49.6'	2950		
	9314-3		SL 12	11:16	30°42.6'	31°49.3'	2950	647	
	9314-4		MN	12:13	30°42.3'	31°49.3'	2962	---	max. 300 m
Aulhas Current									
24	9315-1	20.02	SL 12	03:11	32°31.1'	29°53.6'	3010	636	

Abbreviations:

CTD	Conductivity-temperature-depth profiler
ROS	Rosette water sampler (18 NISKIN bottles with 10 L each)
MN	Multi closing net (5 nets)
MUC	Multicorer (with 8 large and 4 small tubes)
SL	Gravity corer (with 6, 12, 15, or 18 m core barrel)

1.7 Acknowledgements

The scientific party aboard R/V METEOR during leg 1 of cruise M63 gratefully acknowledges the friendly cooperation and efficient technical assistance of Captain N. Jacobi, his officers and crew who substantially contributed to the overall scientific success of this cruise.

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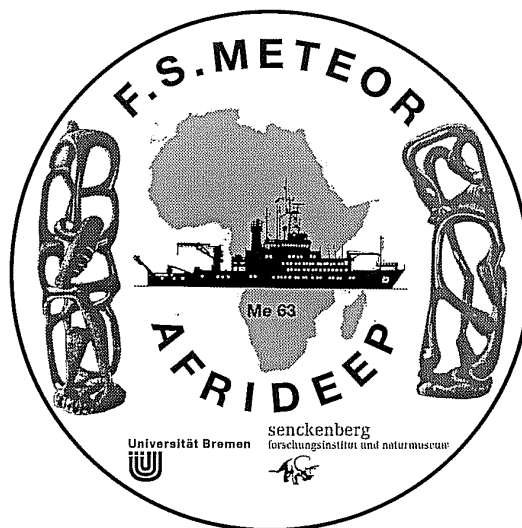
METEOR-Berichte 09-3

Southwestern Indian Ocean – Eastern Atlantic Ocean

PART 2

Cruise No. 63, Leg 2

February 25 – March 30, 2005
Cape Town (South Africa) – Mindelo (Cabo Verde)



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2.2 Research program

(M. Türkay, P. Martínez Arbizu)

General setting

The expedition dealt with species composition, biogeography and with diversity and dominance patterns along a latitudinal transect in the southeastern Atlantic ocean. Samples were gathered from more than 5000m depth in the northern Cape Basin, northern Angola Basin and Guinea Basin. In a total of 5 working areas, sampling was performed for organisms of all size classes (Nanobiota to Megafauna). Deep-sea sediment samples were secured for measurements of abiotic and biochemical parameters in the home laboratory, to correlate these data with biological factors using community based multivariate statistics. The collected organisms will be identified to species and will be introduced into current phylogenetic revisions. Comparison of the faunal composition of different deep sea basins will allow us to understand the size of the distribution areas of individual species and thus help to define biogeographic regions.

Especially the hypothesis formulated on the basis of the results of DIVA 1 (M 48/1) as to the correlation of benthic deep sea diversity and productivity holds in a large scale comparison. For this purpose, stations at different latitudes were compared. Areas with similar primary production in the water column ought to have a similar benthic diversity (see Kröncke & Türkay 2004 for earlier results).

Further, it was tested to see if the Walvis Rise and the Guinea sill form a biogeographic barrier for the deep sea fauna. The results of DIVA 1 indicated that the faunal elements known from the southern Angola Basin differed markedly from those of the Cape Basin. At this early stage, this impression was confirmed through sampling during Me-63/2, but further analysis is required before anything firm can be said.

The DIVA expeditions represent a German contribution to the multinational "Census of the Abyssal Marine Life" programme (CeDAMAr) which aims to compare and understand global abyssal biodiversity and biogeographic patterns. CeDAMAr is the abyssal component of the Census of Marine Life.

Microbiology

The investigations at the MPI for Marine Microbiology will focus on the bacteria in the upper sediment layers of the abyssal basins. The 16S rRNA gene approach involves the isolation of DNA, amplification and cloning of 16S rRNA genes to get via the 16S rRNA gene sequence an information on the microbial biodiversity and via the clone frequency an indicator for species

richness. In a second approach the RNA will be analysed to picture the active microbial community. These studies will be linked with the biogeochemical studies and hydrogeographical data to correlate the physical environment with the species diversity and richness.

Protists

Knowledge on the faunal diversity of abyssal protists remain, with the exception of Foraminiferans, rudimentary. The reason for this is that sampling and analysing schemes used up to present times were not adequate to tackle the real diversity.

Therefore, during M63/2 comparative studies on the occurrence and quantitative importance of nanoprotists, which are potentially important bacterivorous component of deep sea sediments, were performed. Subsequent laboratory culturing experiments will increase the knowledge of deep sea protist diversity. Besides this, they will help to understand the role of nanoprotists in the deep sea food web.

During the expedition and the subsequent investigations in the home laboratory the following subjects were or will be targeted:

- Comparative investigations on qualitative structure and quantitative significance of the nanoprotists as potentially important bacterivorous component of deep sea sediments.
- Qualitative and quantitative investigations in cooperation with microbiologists for discovering the function of microbial components in the food web of the deep sea.
- Cooperation with meio- and macrobenthologists for estimating the predation pressure and regulating mechanisms of higher trophic levels.
- Culturing experiments for increasing the knowledge of protist diversity (Succession analyses: Starting on board, continuation in the lab).

Meio-, Macro- und Megafauna

These investigations were targetted towards gathering information on the abundance and diversity figures from the three large eastern Atlantic deep sea basins. All working groups will tackle the same questions:

- How many species per surface unit (species diversity) and species per number of individuals (species richness) are present along the transects ?
- How large is the area of a species ?
- How does the species presence change along the transects ?
- Which corellations exist between the number of species and environmental factors ?
- How similar is the fauna of the three examined deep sea basins ?

Sampling scheme

Because of the loss of time due to the change of the end port from Abijan to Mindelo and the extra time needed for bunkering at Walvis Baai, the research programme had to be reduced. It was decided to work in 4 research Areas: (1) Northern Cape Basin, (2) NW Angola Basin, (3) Guinea

Basin east, and (4) Guinea Basin west. The main research areas were scheduled to be sampled by 7 multicorers, 7 box corers, 2 epibenthic sledges and 2 Agassiz trawls. HYDROSWEEP was to be used on short extra transects, but more regularly during the use of towed gear on the sea bed. As the Angola Basin had already been sampled earlier, area 2 was considered only as a reference position and received a lower sampling effort, viz only 5 multicorers, no box corers, 1 epibenthic sledge and 1 Agassiz trawl, respectively. By following this program, we made sure to spend most of the time in the hitherto unexplored Guinea Basin. As sampling went much smoother than expected a fifth area, about 67 nm west of area 4 at the margin of the Guinea Basin could be sampled with a reduced, but complete effort (6 multicorers, 6 box corers, 1 epibenthic sledge, 1 Agassiz trawl).

All gear was used jointly by all participating groups and the samples processed according to the specific subjects. Where applicable, the fauna was preserved for subsequent study in the home laboratories. Also sediment samples were dried and frozen for subsequent analysis.

2.3 Narrative of the Cruise

(M.Türkay)

METEOR left Cape Town on February 25, 2005 at 17.36 UTC towards Walvis Baai in order to get bunker, because no fuel was available at Cape Town. Walvis Baai was reached on February 28, 2005 and the vessel was moored at 08.00 UTC. After bunkering, the port was left at 12.00 UTC and the vessel headed on a southwesterly course towards the first working area that was situated a distance of 490 nm in the northern Cape Basin. Winds around BFT 5 from SE directions prevailed during the travel, the swell from the same direction was moderate.

Operations in the first working area started on the early afternoon of March 2, 2005 with box-corer sampling. The first deployment was successful and the two subsequent ones were as well. The mud was sieved through meshes with a minimum size of 0.3 mm and contained a good number of remarkable animal species. After the third corer a bathymetric profile was taken with hydrosweep in order to get a map of the sea bottom, indicating a depth between 5000 and 5100m. Parasound records showed that the sediment was clearly layered, sloping in some areas. Therefore it was decided to continue grabbing and trawling in this specific area. After the end of the mapping the box-corer sampling continued, starting at 01.38 UTC on March 3, 2005 and ending on 14.55 of the same day. All five deployments of this series were successful. After the last box-corer was on deck, a sampling series with 7 deployments of the multicorer was started. Of these, 6 were successful, the last one was empty. Multicorer sampling ended on March 4, 2005 at 09.30 UTC. During the transit towards the deployment position of the epibenthic sledge, another 2 hours of Hydrosweep/Parasound profiling was done in order to complete the data acquisition for the map of the investigation area. Next, the epibenthic sledge was lowered and towed for about 15 minutes on the sea bottom. The actual bottom contact was much longer and amounted to about 2 hours on the sea bed. After the first, a second sledge was lowered and remained at the sea bottom for a similar time. Both samples were rich in fauna and thus can be considered as successful. The operation ended at 02.14 UTC on March 5, 2005. After this, *METEOR* headed towards the deployment point of our next gear, the Agassiz-trawl which was reached at 04.40 UTC on the same day and where the operation started. The gear was lowered astern by using the

A-frame. During the deployment two surface plankton-samples were taken with an open ("Bongo"-type) net. A second trawl was lowered from 19.14 UTC on and was operated for the whole night until it was recovered at 06.36 UTC on March 6, 2005. Both samplings were successful and recovered a fauna that was dominated by deposit feeders. During the second operation at night, 2 surface plankton net samples were taken, which proved to be much more diverse than the catch at daytime.

Because of the loss of time caused by the bunkering at Walvis Baai, it was decided that Area 2 (northern Angola Basin) would not receive the effort of a full station. As there is good information on the macrobenthos from our last cruise (Me 48/2000), we refrained at all from using box-corers. The number of multicorers was reduced to two and a single epibenthic sledge and Agassiz-trawl deployment were planned, respectively. After 1159 nm area 2 was reached on March 10, 2005 and operations started at 04.30 UTC, again by bathymetric profiling with hydrosweep, indicating a depth range around 5600m. The weather had not changed very much and moderate sea and swell prevailed with winds from SSE at force 4-5, occasionally 6 Bft. As the first gear deployed, the Agassiz-trawl started at 07.32 UTC. The sample brought back on deck at 20.36 UTC of the same day was very poor and reflected the low nutrient situation of this offshore area. During the trawling operation, three plankton samples were taken near the surface. The trawl was followed by the epibenthic sledge, which was in the water at 23.20 UTC. The operation lasted for about 8 hours so that the gear was safely recovered with a good sample on March 11, 2005 at 07.38 UTC. Shortly after, at 08.20 UTC a series of 5 multicorer deployments were started. While the first sampling was successful, the second one came back upside down and without sample. This corer was repeated. The next 3 deployments were again successful while the last one came up on March 12 at 02.50 UTC again empty and with a damaged frame resulting in the lack of one core for the rest of sampling. A short surface sampling for plankton followed, and from 03.00 to 04.40 a Hydrosweep/Parasound profile concluded work in area 2.

After the end of profiling, *METEOR* headed towards working area 3 in the eastern Guinea Basin, which was reached after 611 nm on March 14, 2005 at 05.30 UTC. During the journey the wind had decreased steadily and in the working area southerly winds prevailed with forces of 1-4, mainly around 2-3 Bft. This and only slight swell made work very agreeable. Operations started with mapping. By the end of the Hydrosweep/Parasound-profile at 09.10 UTC we began deploying the first box-corer. After having observed a too low tension on the ground, the corer came up empty, indeed. It had closed, but there was no sediment in the box. During the following two deployments it was attempted to push the box into the sediment at a higher speed, but the result was also negative. At this point it was concluded that the sediment must have been too hard to allow enough penetration, the sampling with this gear was stopped and we decided to try and see if the multicorer would be more successful because of the smaller core-diameter. At 16.56 UTC we deployed the first multicorer that came up at 19.11 UTC with a good sample. The texture of the sediment confirmed our thoughts regarding the reason of failure of the box-corer. Under a few centimetres of soft mud, a densely packed layer of hard material (predominantly foraminiferans) must have hindered the penetration. It was decided to continue the series of 7 multicorer samples and look for a better position for the box-corer with the help of Parasound during trawling. Most of the following multicorer samples were fully successful. In one instance the cores were only half filled and the last deployment brought only little sediment back. The whole sampling series was concluded on March 15, 2005 at 10.34 UTC. At 12.00 UTC we began

lowering the epibenthic sledge. After about 8 hours, at 20.23 UTC it was safely recovered. After saving the sample, a second deployment started at 20.56 UTC continuing the track that had been sampled before. The gear was safely back on deck on March 16, 2005 at 04.30 UTC. Both samples taken with the sledge proved quite rich and diverse. During the second deployment of the sledge, one surface plankton-sample was taken. After steaming to an appropriate position, which was about 20 nm away, lowering of the Agassiz-trawl began at 07.06 UTC. The operation took the whole day including of 3 hours of trawling the sea bed and the trawl came back with a good and rich sample at 18.50 UTC. A second deployment started at 21.03 UTC and took the whole night. The gear was back on March 17, 2005 at 09.04 UTC. The catch of this second haul was similar to the first one, but it included some more species. During the night two surface plankton-samples were also taken, which proved to be very rich and diverse. Also during these hauls Parasound was regularly observed and two areas were identified in which the layering of the sediment looked less packed. After the end of trawling, we returned to the closest one of these areas and deployed the box-corer at 10.30 UTC. The gear returned on deck at 12.46 UTC with a perfect sample, so it was decided to stay at this location and take the remaining 6 samples here. All of these were successful. Sampling in Area 3 ended on March 18, 2005 at 04.22 UTC. A number of short Hydrosweep/Parasound profiles served to close gaps in the map of the area. At 06.05 UTC we headed towards working area 4 in the western Guinea Basin.

Area 4 was reached on March 18, 2005 at 20.34 UTC. Mapping with Hydrosweep/Parasound was started 23 nm before getting to the target point. We arrived at this last one at 23.17 UTC and started sampling operations with the multicorer. All 7 deployments were successful so that we could move on to the box-corer on March 19, 2005 at 17.35 UTC, right after completing multicorer sampling. Further sampling went smoothly until the sixth box-corer, which had not closed and thus came up empty. This deployment was repeated and the following two attempts were again successful. The sediment consisted of soft mud with less foraminiferans than had been the case in area 3. Coring was finished at 13.15 UTC on March 20, 2005 when we switched to towed gear, first to the epibenthic sledge. The first one went from deck 14.17 UTC and was recovered at 22.01 UTC. Because of the flat bottom, the second one was deployed at the spot of recovery of the first at 22.25 UTC and returned without any problems the next day at 05.00 UTC. The samples brought in at this area were particularly diverse in species. After a short Hydrosweep profile taken in order to see if the sea bed was remaining flat, we deployed the Agassiz-trawl at 06.18 UTC and recovered it on deck at 18.11 UTC. A second deployment followed at 18.35 UTC with the gear back on deck on March 22, 2005 at 23.02 UTC. Both samples were quite diverse. A large, approximately 70 cm long brotulid fish caught in the second of these trawls was particularly remarkable and points to the availability of large food falls in this region. Otherwise, the fish captured were predominantly bathypelagic.

Because sampling had proceeded without any serious problems and since the ships speed during transit was fairly fast (13 knots), about two days time were saved compared to our original plans. It was decided to use this extra time for sampling in a supplementary area to the west of area 4 and at the western margin of the Guinea Basin. The distance of this Area 5 from Area 4 was 67 nm and this was reached on March 22, 2005 at 13.34 UTC. On our way, mapping with Hydrosweep began at a distance of 20 nm before we reached the station target point. In order to get full coverage of gear and size classes of benthos we decided to use the towed equipment only once and reduce multicorer and box corer sample numbers to 6 each. First the Agassiz-trawl was

deployed immediately after reaching the target point. The gear was safely recovered the next day at 02.20 UTC. The catch brought back on board was small and without any clearly dominant organisms. The epibenthic sledge was operated directly after the trawl from 03.25 UTC to 09.53 UTC. After this, coring started with the first multicorer being deployed at 10.28 UTC. All 6 operations were successful and lasted until March 24, 2005 00.40 UTC. Following this, 6 deployments of the box corer followed, which were successfully completed at 15.23 UTC. After the end of gear operations about 2.5 hours were used for a Hydrosweep profile aimed at closing gaps in the map of area 5 recorded so far. Mapping ended at 18.05 UTC when the vessel headed towards the port of Mindelo (Cape Verde Islands).

On March 30, 2005 at 07.00 UTC *METEOR* was moored at Mindelo port.

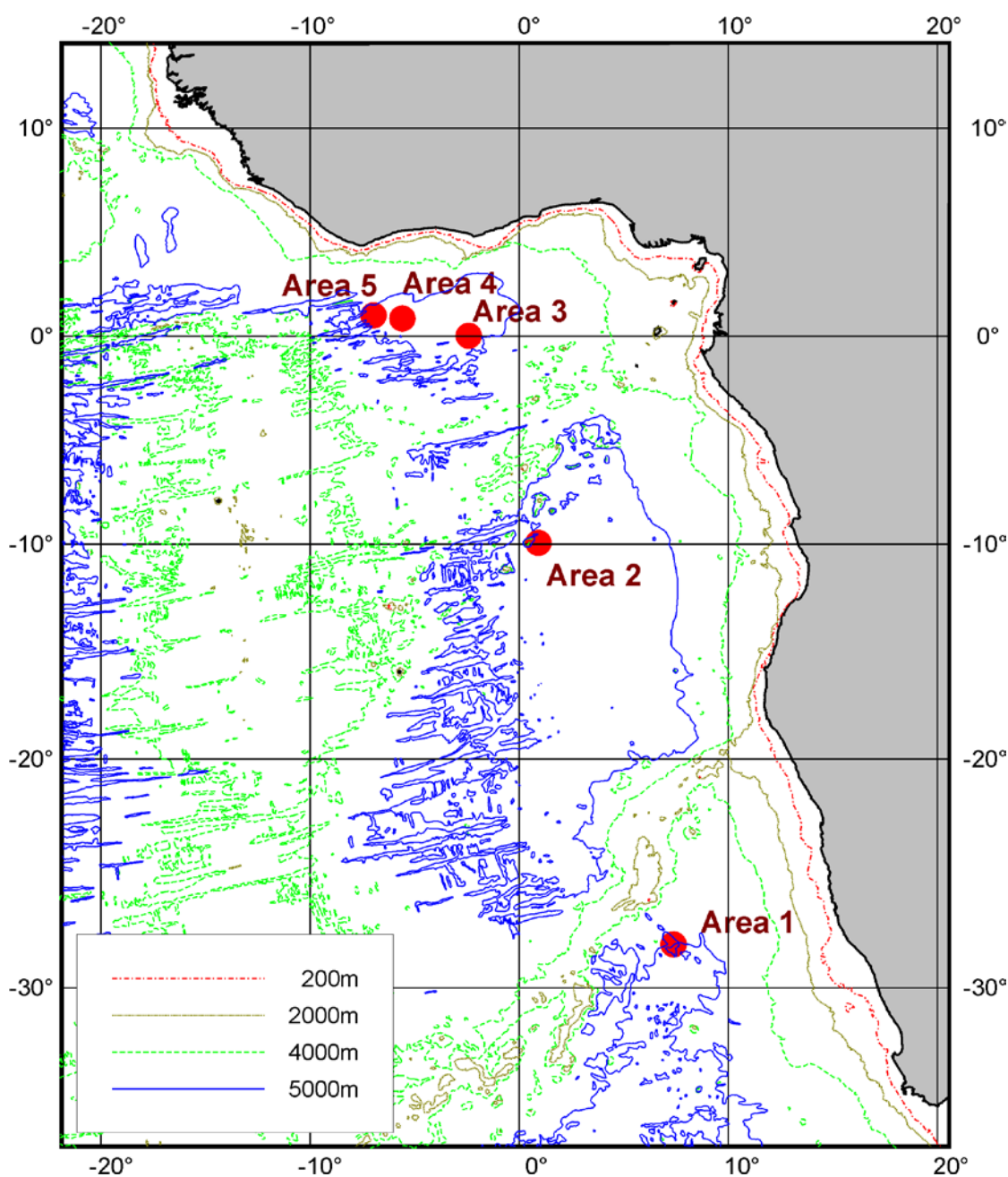


Fig. 2.1: Research areas during Meteor 63 Leg 2.

2.4 Preliminary Results

2.4.1 Sediment Parameters and Hydrographic Data

(M. Türkay, I. Kröncke, B. Köster, H. Reiss)

Introduction and objectives

The main objective of leg 2 was to investigate biodiversity gradients along a long transect in the eastern Atlantic with samples being taken in different basins (i. e. NE-Cape Basin, NW Angola Basin, Guinea Basin) for an inter-basin comparison. Within the Guinea Basin a 260 nm long transect in an environmentally homogeneous area was sampled at 3 subregions for an intra-basin comparison. In order to compare environmental parameters, nutrient contents of sediments, sedimentological parameters and hydrographic data have been recorded at every station. Preliminary results are presented here, the sediment parameters as such will be treated in detail elsewhere.

Sediment parameters

Sampling and sample treatment

Samples for sediment parameters were taken at areas 1 (Cape Basin), 3, 4 and 5 (all three Guinea Basin) (see Tab. 1 for details) by subsampling the first 3 box corers. Subsamples were taken with two plexiglas tubes (5 cm diameter) for sediment analyses ($>63\mu\text{m}$) and analyses of total organic carbon (TOC) and pigment contents, respectively. One of the tubes was also used to measure the pH and Eh profiles in the sediments using a Portamess Microprocessor (Knick, Germany). In addition, one tube (10 cm diameter) of each multicorer was used for analysis of TOC, total carbon (TC) and pigment contents.

The sediment from the tubes from the box corer and the multicorer was sliced into layers: surface sediment (uppermost 0.5 cm) to 5 cm depths in 0.5 cm slices, 5-15 cm depths in 1 cm slices and 15-20 cm depths in 5 cm slices. The samples for mud/sand, TOC and TC contents were dried on board ship at 55°C. Samples for pigment analyses were frozen at -20°C for future analysis in the home laboratory.

Sample analysis

For mud/sand content analyses, the sediment will be sieved in the lab over 63 μm mesh size. Sand and mud residue will be weighed and quantified.

For TOC and TC content analyses an aliquot of 10 mg (total sediment) will each be analysed using an "elementar" CHN analyser. Prior to analysis, the samples will be homogenised and kept in a dessicator with concentrated HCl underneath to eliminate the carbonate. Besides TOC the C/N ratio will be determined.

Phytopigments (e.g. Chlorophyll *a* and derivatives) will be extracted from 5 g sediment with 5 ml 90% acetone. After incubation of the suspension for 1 hour at 4°C in darkness it was mixed for 1 minute, followed by an ultrasonication in a water bath for 3 min at medium power. To remove particles the suspension will be centrifuged for 25 min at 1745 $\times g$ at 0°C. Pigments will be analysed in the supernatant by high performance liquid chromatography (HPLC) as described by Wallerstein & Liebezeit (1999). Standards (Sigma, Germany) were used for the quantification of chlorophyll *a* and pheophorbides.

Preliminary results

The sediment at all stations appeared to be almost pure clay. The Eh profiles of the sediment cores from the box cores showed that at all stations sediments were well oxidised down to 20 cm depth (96-164 mV at the surface, 120-240 mV in 20 cm depth). In the northern Cape Basin the upper 4-6 cm were very fluffy, the colour of the sediment was light brownish. In contrast, in the Guinea Basin the colour of the sediments was light beige to white. The soft fluffy layer was restricted to the upper 2-3 cm. The sediments contained a high percentage of globigerine foraminiferans. In some of the boxes slag originating from steamers was found. Informations on sediments from the Angola Basin can be found in Kröncke & Türkay (2003).

Tab. 2.1: Details of sampling stations for sediment parameters. KG = Box corer, MUC = multi-corer, TOC = total organic carbon, TC= total carbon.

Area	Stations	Gear	Grain size %>< 63µm	TOC (%)	TC (%)	C/N ratio	pigments	pH/Eh profiles
1	25-27	KG	●	●		●	●	●
1	33-39	MUC		●	●	●	●	
2	46-51	MUC		●	●	●	●	
3	67-69	KG	●	●		●	●	●
3	56-62	MUC		●	●	●	●	
4	81-83	KG	●	●		●	●	●
4	74-80	MUC		●	●	●	●	
5	101-103	KG	●	●		●	●	●
5	95-100	MUC		●	●	●	●	

Hydrographic data

Measurements

A self recording CTD probe (3" MCTD, Falmouth Sci Inc.) was fixed to the box corer or multi-corer while sampling. This enabled temperature and salinity profiles to be taken at the actual sampling location and close to the sea bottom during sampling. After recovery of the gear the data were retrieved and processed with MS-Excel. Measuring was done once at every research area, as the corer samples were taken very close to each other. Due to technical problems with the probe not every measurement resulted in a complete profile. In spite of continuing the measurements when no data were retrieved we could not get a complete profile in area 2 (Angola Basin). This was the same in area 3 (eastern Guinea Basin). Full profiles were recorded from areas 1 (station 28), 4 (station 83) and 5 (station 102). The result of the temperature and salinity profiles for the stations 28, 83 and 102 are presented in Figures 1 to 2. Original data are available upon request from the authors or can be downloaded from the internet page

www.senckenberg.de/DIVA and will be given to the German Oceanographic Data Centre (DOD) at Hamburg (www.bsh.de/Meereskunde/DOD/).

Preliminary results

The temperature in the upper 100 m of the water column at the Cape Basin (station 28) varied between 14 and 22.5°C and dropped continuously down to 4°C at 740 m. Temperatures of 1.2°C – 1.14°C were measured between 4,500 m water depth and the sea floor. In the Angola Basin the profile only covered the upper 1,928 metres. The surface water was warmer here, varying between 14 and 27.5°C in the upper 100 m. 4°C was recorded at 1,200 m, at the greatest depth from which data were recorded, i. e. 1,928 m, the temperature had dropped to 3.45°C. In the Guinea Basin temperatures were at 15.5 – 30°C in the upper 100 m. 4.5°C were reached at 1,000 m. In the two complete profiles the bottom layer from 4,000 m on showed a temperature range of 2.1-2.3°C.

The salinity in the surface layer was around 35.3 ‰ in the Cape Basin and dropped continuously down to 34.28 ‰ at about 730 m depths. Then it increased again up to 34.8 ‰ at about 1,800 m depth, in about 3,700 m salinity began to decrease again and at 4500m it had reached 34.7 ‰ and remained nearly constant up to the sea floor. In the Angola Basin the low salinity tongue was present with a minimum of 34.6 ‰ at about 800 m and a subsequent increase up to 1,500 m, where it reached again 35.1 ‰ remaining constant up to the end of the profile at 1,928 m. In the Guinea Basin salinity at the surface was around 36.4 ‰ at station 71 and 102. Also here the salinity showed a subsurface minimum at about 800 m in the first two stations and 720 m at the third one with around 34.5 ‰. Then salinity again increased to 34.9 ‰ and 35 ‰, respectively, at about 1,600 m, only slightly decreasing from there by about 0.1 ‰ to the ground. Details can be seen in Table 2 and Fig. 2.3.

Tab. 2.2: The maximal depth reached by the CTD-probe attached to the gear at sampled stations with corresponding temperature and salinity values.

Station	Depth [m]	T [°C]	S [‰]
28	5,113.7236	1.1424	34.6329
46	1,927.7008	3.4540	35.0516
71	2,090.3127	3.3198	34.9457
83	5,224.6631	2.0957	34.9224
102	5,524.9155	2.1087	34.5436

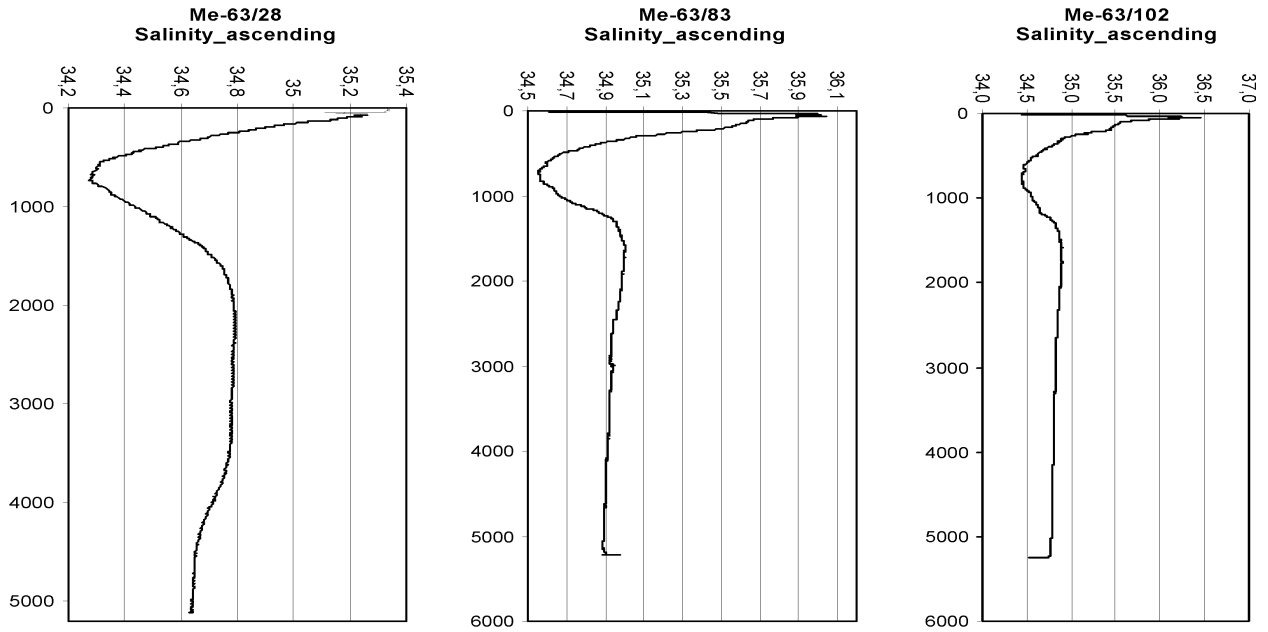


Fig. 2.2: CTD-Temperature-depth profiles at stations.

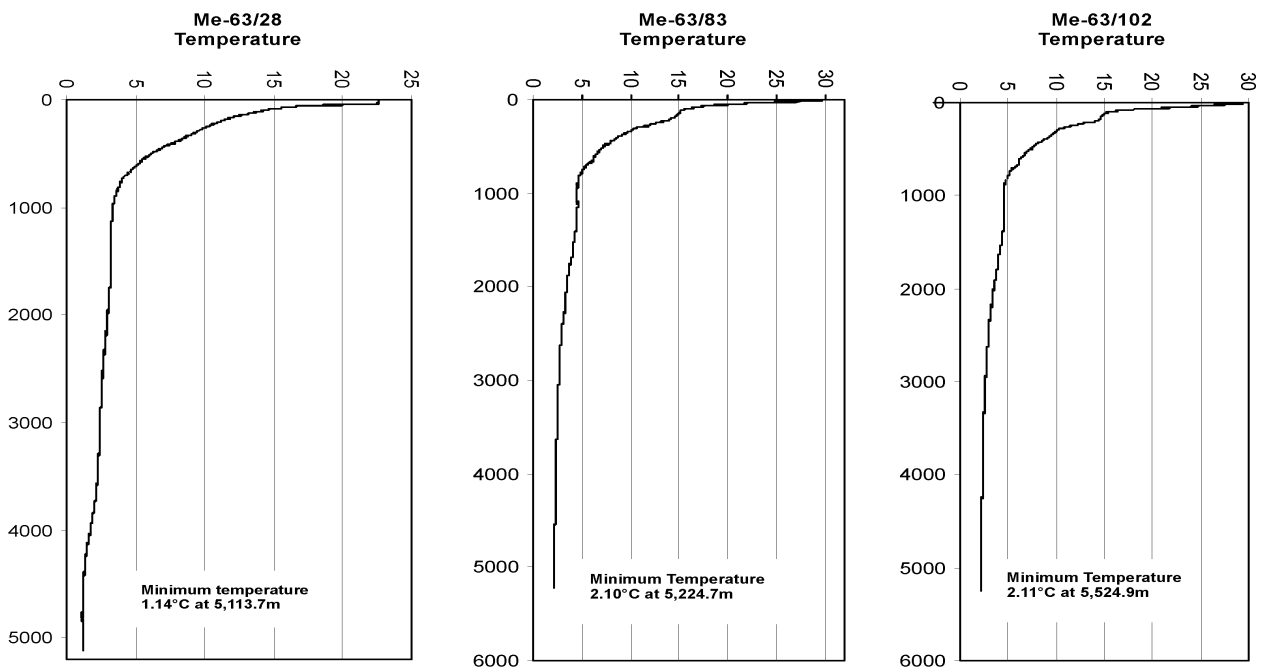


Fig. 2.3: CTD-Salinity-depth profiles at stations.

Discussion

Our results are in accordance with hydrographic data presented by Reid (1989) and discussed in Schmiedl et al. (1997) as well as reviewed by Reid (1996). In the Cape Basin the surface water is relatively cool and of southern origin. The subsurface decrease in salinity and temperature is influenced by the "South Atlantic Central Water", the "Antarctic Intermediate Water" and the "Upper Circumpolar Deep Water" which occur between 200 and 1,400 m water depth. The more

saline water masses >1,400m are of "North Atlantic Deep Water" (NADW) origin. Below this layer again less saline but colder water of Antarctic origin is detectable. In all other stations the subtropical and tropical surface water masses account for a high temperature and salinity of the upper layer. The following salinity minimum corresponds to the one observed in the Cape Basin and is filled by southern water masses. The lower layer below 1,400 m up to the bottom is formed by NADW and therefore is more saline and warmer. This is also the case in the Angola Basin as shown by the measurements during DIVA I (Cruise Me-48/1, 2000).

The difference between the bottom water regime in the Cape Basin and the Angola and Guinea Basins, respectively, is quite profound and it will be interesting to see if this is reflected by the deep sea fauna. On the other hand differences within the Guinea Basin are low concerning the temperature (difference of 0.013°C between station 83 and 102) while they are relatively high in the salinity (0.38 ‰). This snapshot, however, is not extensive enough to discuss broad scale variabilities.

2.4.2 Microbiology

(R. Schauer)

Introduction and methods

For studying the diversity of prokaryotes in the deep-sea sediment and in the water column 10-20 cm above the sediment, the multicorer was used. The cores were 60 cm high and had an inner diameter of 92 mm. At each station one core was taken for the microbiology. In total, 5 cores from the Cape Basin, 5 cores from the Angola Basin and 15 cores from three different areas in the Guinea Basin were analyzed. In order to isolate DNA, it is very important to keep the sediment cool. That is the reason why the cores were immediately stored at 4 °C. If the sediment temperature remains at 2-4 °C, the opportunity that bacteria survive is much improved, and therefore, the possibility to isolate DNA is higher. Further work was done in a 4 °C lab. Another important thing is to try to lessen contamination from other sources. This is very complicated, because bacteria and Archaea are almost everywhere. That is why all instruments which were used were cleaned with 96% ethanol before use. At first, a sample of the overlying water was taken with a sterile 60 ml syringe. After that, the core was separated in different layers. Five layers (A-E) with a maximum of 2 cm were taken, so that at least the sediment down to 10 cm was investigated. After cutting the layers, each one was divided into several sub samples (Tab. 2.3).

For quantitative estimates, MPNs (most probable number) were made. The sediment sample used was stored at 4 °C. For the MPNs a liquid medium was used. At each station 3 parallels of MPN were taken from the first layer (0-2 cm). Only from the Angola Basin were MPNs made from each layer. The samples at -80°C were used for DNA extraction. The DNA extraction was done with a Micro-Dismembrator and the Fast DNA SPIN Kit for soil. The DNA concentration was determined with an Eppendorf UV-Photometer. After the extraction, the DNA was put in 96% ethanol and could then be stored at room temperature. The other sub samples stored at -80 °C will be used for RNA extraction and for DAPI counting under the epifluorescence microscope. The gain DNA will be used to construct a 16 S ribosomal DNA (rDNA) clone

library. After sequencing the species or the domain will be known and therefore the diversity of the prokaryotes of the deep-sea sediment. The RNA will be translated in DNA through a reverse transcription. This DNA will also be used to construct another 16 S ribosomal DNA clone library. So, at the end it will be possible to compare the diversity with the activity of the prokaryotes of the deep sea sediment.

Tab. 2.3: Different sub samples, which were taken at each station.

station no.	tube	sample	inscription	storage
33	1 ml	sediment S	1A - 1E	-80°C
	2 ml	sediment S	2A - 2E	-80°C
	15 ml	sediment S	3A - 3E	-80°C
	15 ml	S - 10 ml for MPN	4A - 4E	4°C
	50 ml	sediment S	5A - 5E	-20°C
	50 ml	20 ml S + 20 ml EtOH	6A - 6E	-20°C
	50 ml	Water sample	7	-20°C
	15 ml	rest sediment	8A - 8E	-20°C

Primary results

Taking the sample and the sub sample at each station was very successful. On board, the DNA extraction has been carried out. The DNA could be extracted from each station from 3 to 5 cores. The concentration of the DNA from each layer of the sediment from the Cape Basin, Angola Basin and Guinea Basins are shown at Fig.1. The deep-sea sediment from the Angola Basin has the lowest DNA concentration comparing to the other two basins. Furthermore, it seems that the DNA concentration of the Angola basin is higher in the deeper layer, than in the upper layers. The Cape Basin and the Guinea Basin show higher DNA concentration, which are very similar. The sediment of the first layer (0-2 cm) has the highest or a high DNA concentration at both basins. So the DNA concentration maxima of the Cape Basin and the Guinea Basin are different to the maximum which was found at the Angola Basin. So, this could be an indication that the Angola basin has a completely different diversity as compared to the Cape Basin and Guinea Basin.

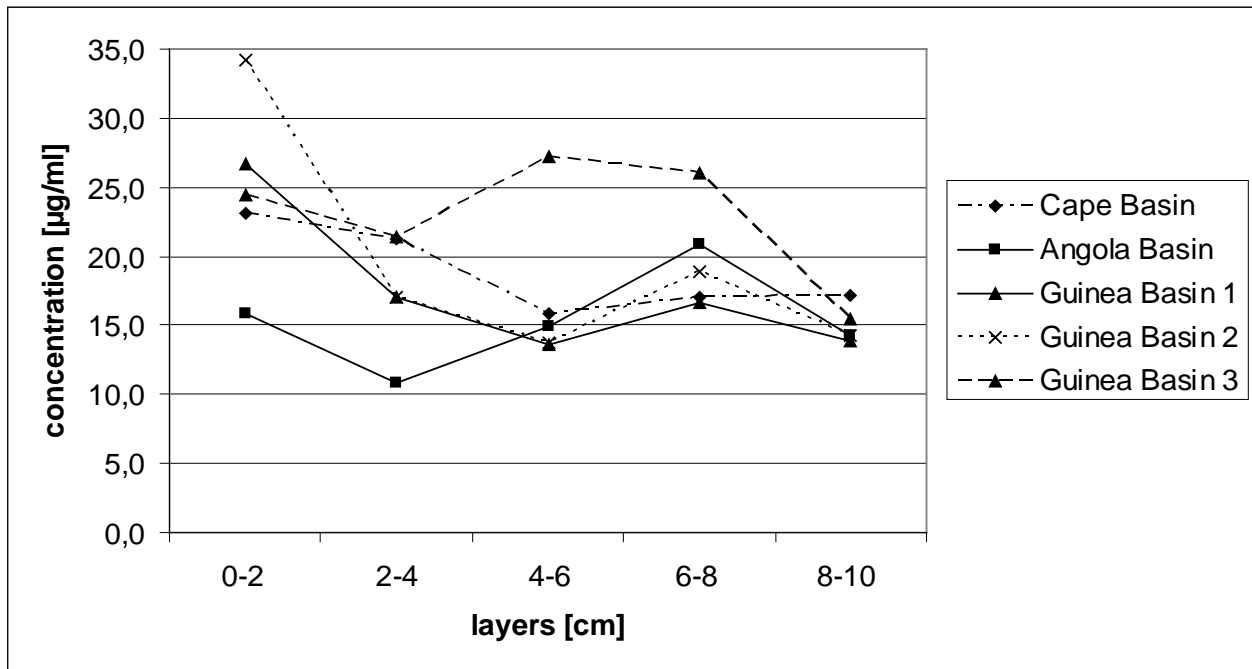


Fig. 2.4: DNA concentration from different layers at the Cape Basin, the Angola Basin and the Guinea Basin.

The DNA concentration is also different between the layers at all stations. This could show that each layer has a distinctive diversity, which are not similar to the diversity of the other layers. To verify this preliminary result, it is important to see the result of the 16 S ribosome DNA clone library.

The evaluation of the MPN could not be done on board, so that so far no results could be presented.

2.4.3 Protozoology

(K. Hausmann, H. Arndt, M. Weitere, F. Scheckenbach)

Introduction

According to the results from the deep-sea expeditions to the Mediterranean Sea (Hausmann et al. 2002a, b; Arndt et al. 2003) and to the Angola Basin in 2000 (Scheckenbach et al. 2005), a variety of protists exists in the deep-sea sediments up to a depth of 5,400m. While the cruise in 2000 was aimed to analyse the diversity of deep-sea nanofauna within one and the same basin (Angola Basin), the aim of the present study was to compare the abundance and biodiversity of deep-sea protistan nanofauna in different basins of the South Atlantic with special reference to heterotrophic nanoflagellates. Only very few nanofauna species have up to now been recorded from depths deeper than 5,000m.

Though the deep-sea floor represents the largest part of the earth surface, very little is known about its most abundant eukaryotic inhabitants. Our morphological findings during the last expeditions showed that at least some widely distributed nanoflagellates of surface waters can

also be found in the deep sea. We analysed whether or not these flagellates are in contact with populations from surface waters. Our molecular comparisons on the basis of SSU rDNA of strains isolated from deep-sea sediments (> 5,000m depth) and surface waters revealed that some morphospecies obviously contain several cryptic species (sometimes with large distances). Some genotypes occur both in deep-sea as well as in surface waters and may even have a cosmopolitan distribution. We found at least one nanoprotozoan species to be most probably endemic to the deep sea (*Meteora sporadica*; Hausmann et al. 2002b). Specific distribution patterns of nanofauna genotypes within the Angola Basin could not be detected up to now.

Our studies of the present cruise addressed the following questions: 1) Do the different deep-sea basins in the Eastern South Atlantic separated by ridges possess a specific nanofauna community? 2) What is the importance of hard substrates for the distribution of benthic nanoprotozoans? 3) What is the genotype composition of nanoprotozoans in the deep sea? Are there completely new forms? 4) Do genotypes of one protozoan morphotype differ between the different basins? The studies should reveal first insights into the origin of the biodiversity of deep-sea nanoprotozoans.

Methods

The studies were carried out in the deep ultraoligotrophic abyssal plains of the Eastern South Atlantic: the Cape Abyssal Plain, the Angola Basin and the Guinea Basin. Sediment samples were taken from the five major stations of Meteor cruise 63/2 (see above).

Quantitative benthos samples were taken by a multicorer system (diameter of an individual core: 9.4cm). Only cores with undisturbed sediment and overlaying waters were used for the analysis. The top and the bottom of cores were closed on sampling so that contamination by organisms or cysts from other water layers could be neglected. Once on deck, corers were immediately sampled. Samples were taken from the overlaying water as well as from the upper 2mm sediment layer by means of a sterile syringe. Subsamples were kept at 4°C until further processing. In addition, hard substrates (about 1 cm³) were incubated for cultivation. Sterile plastic syringes were used to fill organisms into sterile 600ml- or 50ml-tissue-culture flasks. In the laboratory onboard, clonal cultures were established under sterile conditions from sediments, overlaying waters and hard substrates using a serial dilution method at 1 atm.

For quantitative estimates, two methods were used: live-counting of untreated samples (live-counting = LC) and cultivation of defined aliquots of the sample (liquid aliquot method = LAM). Live-counting was performed directly after sampling in a miniaturised version of a Sedgewick-Rafter chamber (area about 10mm x 45mm, height 0.2mm) filled by a calibrated micropipette (1µl - 10µl). Inspections and counting was done using a Zeiss Axioskop 50. A few microlitres of the sediment suspension were placed into the microchamber under the upright microscope. Only a very few protists were observed in chambers so that direct counts were of restricted quantitative value, although they can serve as the first direct estimate of deep-sea protistan abundance. Due to this limited quantitative resolution, the LAM was applied in addition. Subsamples of a few millilitres of the sediment suspension were added under sterile conditions into 50ml tissue culture flasks. To check for seldom occurring protists larger aliquots of the sediment suspension were added to sterile large tissue-culture flasks (600ml) which were filled with sterile seawater. In addition, 500ml aliquots of the overlaying water were incubated in 600ml-tissue-culture flasks. All cultures were supplied with a sterilised wheat or quinoa grain

or/and a droplet of sterilised and diluted yeast extract. Culture flasks and plates were incubated either at 2°C or 20°C, inspections were carried out using an inverted microscope every second day. The number of culture vessels containing a certain species allows an estimate of the abundance of organisms/cysts.

Additional subsamples were fixed for later electron-microscopical preparations or DAPI staining and counting under an epifluorescence microscope. Another set of subsamples was deep frozen (-80°C) immediately after sampling for later molecular biological studies.

Preliminary results

As a preliminary result, the following genera of heterotrophic flagellates have been recorded from the deep sea (>5,000m depth): *Amastigomonas*, *Ancyromonas*, *Bicosoeca*, *Bodo*, *Caecitellus*, *Cafeteria*, *Cercomonas*, *Massisteria*, *Monosiga*, *Neobodo*, *Paraphysomonas*, *Percolomonas*, *Pseudobodo*, *Rhizomonas*, *Rhynchomonas*, *Salpingoeca* and *Spumella*. We obtained the first records of choanoflagellates in the deep sea. We found several species which have to be further studied in detail. Some of them may be new species.

Direct counts revealed about 5 protists per cm³. These qualitative and quantitative studies offer the first record of ultraoligotrophic deep-sea nanobenthic communities of the Cape Abyssal Plain and the Guinea Basin and were very low compared to our comparative studies from the Mediterranean Sea. Generally, there are only data available for fixed samples which are due to artefacts connected with fixation (especially for registration of flagellates) and subsequent staining difficult to evaluate. Our experimental studies during the Cruise in 2000 revealed that changes of pressure and the changes of temperature had no significant effect on the abundance of tested species of the genera *Ancyromonas*, *Bodo*, *Cafeteria*, *Percolomonas*, and *Spumella*. This indicates that the sampling procedure should reveal reliable estimates of those species which can be cultured. Our direct records of living flagellates from sediment samples and samples from hard substrate support this result.

There are some major preliminary results of our study: 1) There were obvious differences in the species composition and species number appearing in samples of the three deep-sea basins. 2) Abundances of cultivable species showed a tendency to lowest values in the Angola Basin and highest in the Guinea Basin (area 3). 4) We present the first records of choanoflagellates from the deep sea. 5) There is a significant enrichment of nanofauna by at least two orders of magnitude on hard substrates compared to the surrounding soft bottom. The importance of these substrates (only a few centimetres in size) of both natural and anthropogenic origin has largely been ignored. Our results highlight hard substrates to form distinct habitats and hot spots of the microbial food web in the oligotrophic deep sea. Remarkably, more than half of these substrates originated from anthropogenic activity in South Atlantic deep-sea basins (>5,000m depth). Man continuously change the greatest part of our biosphere tremendously before we have started to understand its functioning. Further studies will be carried out to verify this conclusion.

There seems to be a world wide exchange of a certain number of flagellate species that includes also deep-sea ecosystems. This feature of nanofauna seems to be extraordinary compared to other deep-sea animals and is connected with their smallness, their ability to survive unpleasant conditions (e.g. scarcity of food) in cysts (diameter 2-8µm) which can be distributed by water and air, and with their ability to grow as fast as bacteria, when food conditions are temporally or locally enriched (e.g. by sedimented organic debris). A significant number of

deep-sea species occurs in the surface waters above the sediment indicating the close connection between pelagic and benthic nanofauna. Our conclusions are supported by molecular biological studies carried with nanofauna strains isolated from the depth of the Angola Basin during DIVA1.

In addition to life counts, samples for subsequent molecular biological studies at the University of Cologne have been collected and frozen. Our aim is to establish a clone library of heterotrophic flagellates from the deep-sea sediments to analyse for the first time the genotype diversity independent from cultivation in comparison with our records of cultivable nanoprotists from the deep sea. We expect completely new genotypes that do never appear alive at the surface and will probably never appear in cultures. During the cruise, we isolated several strains of heterotrophic protists for a subsequent cultivation in the lab in Cologne. These strains will be sequenced regarding their SSU rDNA; they will be a valuable qualitative test for the established clone library. The combination of different methods - life counts of the sediment, the cultivation of sediment aliquots, the isolation and characterization of selected deep-sea flagellates and the establishment of clone libraries – offers a unique possibility to receive detailed information on nanofauna life in the deep sea.

Fixed samples of sediment, overlaying waters and hard substrate from the sampled deep-sea areas will be used to analyze the abundance of DAPI-stained cells (bacteria and nanoprotists). In addition, we would like to analyse the surface structure of hard substrates by electron-microscopy and confocal laser-scanning-microscopy. We are optimistic to be the first who will be able to characterise the microbial food web in depths below 4,000m.

2.4.4 Benthic Foraminifera

(S. Müllegger)

I n t r o d u c t i o n

The aim of the investigations of the DIVA II cruise (Meteor 63/2) is to improve knowledge on the faunal diversity of abyssal plains in the southeast Atlantic. The diversity and frequency of deep sea benthic Foraminifera has been studied in some areas, but knowledge is still rudimentary. Therefore it is necessary to collect information on the composition of deep sea faunas. Two major aims concerning foraminifera will be addressed; the vertical distribution of foraminifera within the sediment and the quantitative analysis of biocenosis and thantocenosis of benthic Foraminifera.

M e t h o d s

Benthic Foraminifera were sampled with the multicorer (see chapter 2. 4. 5 Meiofauna) at 31 stations in 5 working areas. In the first working area in the Cape Basin, 11 cores were sampled, 9 cores were used from the Angola Basin and from the three working areas situated in the Guinea Basin 41 cores. In sum, 61 cores were sampled. When the multicorer sampling was 100 % successful, two sediment cores per station were reserved for the investigation of benthic foraminifera. At two stations the multicorer sampling was partly successful, thus just one core was available there (Table 2.4).

Tab. 2.4: List of samples from the multicorer used for benthic Foraminifera.

station number	core number	latitude	longitude	sampled sediment depth (mm)
33	C2	28° 06,7' S	07° 20,8' E	350
	C3	28° 06,7' S	07° 20,8' E	350
34	C2	28° 06,6' S	07° 20,8' E	300
	C3	28° 06,6' S	07° 20,8' E	300
35	C2	28° 06,8' S	07° 20,7' E	300
	C3	28° 06,8' S	07° 20,7' E	300
36	C6	28° 06,7' S	07° 20,9' E	350
	C7	28° 06,7' S	07° 20,9' E	350
37	C2	28° 06,7' S	07° 20,8' E	250
	C4	28° 06,7' S	07° 20,8' E	300
38	C2	28° 06,8' S	07° 20,8' E	300
	C3	28° 06,8' S	07° 20,8' E	300
46	C2	09° 55,9' S	00° 53,8' E	350
	C8	09° 55,9' S	00° 53,8' E	250
48	C8	09° 56,0' S	00° 54,0' E	250
	C12	09° 56,0' S	00° 54,0' E	350
49	C2	09° 56,0' S	00° 54,0' E	350
	C4	09° 56,0' S	00° 54,0' E	350
50	C2	09° 56,0' S	00° 54,2' E	300
	C3	09° 56,0' S	00° 54,2' E	300
51	C9	09° 55,9' S	00° 54,2' E	300
56	C2	00° 00,0' S	02° 25,0' W	300
	C7	00° 00,0' S	02° 25,0' W	350
57	C2	00° 00,1' S	02° 25,0' W	350
	C3	00° 00,1' S	02° 25,0' W	350
58	C1	00° 00,0' S	02° 25,0' W	450
59	C2	00° 00,1' S	02° 24,9' W	300
	C3	00° 00,1' S	02° 24,9' W	300
60	C2	00° 00,0' S	02° 25,1' W	300
	C3	00° 00,0' S	02° 25,1' W	300
61	C2	00° 00,0' S	02° 24,9' W	250
	C3	00° 00,0' S	02° 24,9' W	300
62	C2	00° 00,0' S	02° 25,0' W	300
	C3	00° 00,0' S	02° 25,0' W	300
74	C2	00° 50,0' N	05° 35,1' W	350
	C3	00° 50,0' N	05° 35,1' W	350
75	C2	00° 50,0' N	05° 35,0' W	350
	C3	00° 50,0' N	05° 35,0' W	350
76	C2	00° 50,0' N	05° 35,0' W	300
	C3	00° 50,0' N	05° 35,0' W	300
77	C2	00° 50,0' N	05° 35,0' W	350
	C3	00° 50,0' N	05° 35,0' W	350
78	C2	00° 50,1' N	05° 35,1' W	300
	C4	00° 50,1' N	05° 35,1' W	350

Tab. 2.4: List of samples from the multicorer used for benthic Foraminifera (continued).

station number	core number	latitude	longitude	sampled sediment depth (mm)
79	C2	00° 50,0' N	05° 35,1' W	350
	C3	00° 50,0' N	05° 35,1' W	350
80	C2	00° 50,0' N	05° 35,0' W	350
	C3	00° 50,0' N	05° 35,0' W	350
95	C2	00° 37,4' N	06° 28,0' W	300
	C3	00° 37,4' N	06° 28,0' W	300
96	C2	00° 37,2' N	06° 28,0' W	250
	C3	00° 37,2' N	06° 28,0' W	250
97	C2	00° 37,2' N	06° 28,1' W	300
	C3	00° 37,2' N	06° 28,1' W	300
98	C2	00° 37,2' N	06° 28,1' W	350
	C3	00° 37,2' N	06° 28,1' W	350
99	C2	00° 37,2' N	06° 28,2' W	250
	C3	00° 37,2' N	06° 28,2' W	300
100	C2	00° 37,2' N	06° 28,1' W	300
	C3	00° 37,2' N	06° 28,1' W	300

Immediately after sampling the cores were treated as follows:

- The overlying water was siphoned off with silicon tubing.
- Depending on the consistency of the sediment, the first sub samples (0 – 5, 5 – 10, 10 – 15 mm) of the sediment were sampled with a tube.
- Down to 50 mm sediment depth, the sub samples were taken in 5 mm slices.
- From 50 mm to 150 mm the sediment was sampled in 10 mm slices.
- The rest of the core was sampled in 50 mm slices.
- The remaining (less than 50 mm) sample was not used for further investigations.

The sub-samples were separately preserved in alcohol (96 %) stained with Rose Bengal (1g/l), in order to facilitate distinction between dead and living foraminifera. Further treatments of the samples will follow in the home lab. Samples will be wet sieved over 250, 125 and 63 µm mesh sizes. The dry residual of the different grain size fractions will be investigated for its content in benthic foraminifera. Living (stained) and dead specimens will be picked out from the samples and counted separately.

47 sub samples from three cores (see Tab.2.5) have already been sieved on board during the cruise. These samples were used for first qualitative observations.

Tab. 2.5: Subsamples examined on board Meteor during cruise 63/2.

Station	Core no	latitude	longitude	subsamples
35	C2	28° 06,8' S	7° 20,7' E	0 – 5 to 140 – 150 mm
50	C2	09° 56,0' S	0° 54,2' E	0 – 5 to 140 – 150 mm
56	C7	00° 00,0' S	2° 25,0' W	0 – 5 to 30 – 35 mm

First observations

No quantitative analysis was performed on board. All cores were bioturbated to a sediment depth of at least 50 mm. Thus the sediment is soft in its upper 50 – 100 mm and no lamination is visible. Qualitative examination of the sediment samples of the fraction >250 µm showed a high abundance of pelagic foraminifera tests which account for the main part of the sand size fractions of the sediment. This is especially true for the sediment sampled at stations in the Guinea basin. Nevertheless, benthic foraminifera are abundant in all the studied samples. Among the agglutinated species, the orders Astrorhizida and Lituolida seem to be well represented. But also species building a calcareous test occur. In this group, mainly the orders Miliolida and Lagenida were observed.

2.4.5 Metazoan Meiofauna

(P. Martínez Arbizu, K. George, W. Ahlrichs, M. Bruhn)

Introduction and Methods

Meiofauna comprises benthic-living organisms with body sizes between ~30µm and 1.0mm. This functional definition encompasses a remarkable number of different major taxa. These include protists like Foraminiferans, flagellates etc. and metazoans like Nematoda, Copepoda, Acari, Kinorhyncha, Loricifera, and Rotatoria. This part of the report deals with samples taken for the study of the metazoan organisms. The two most important groups of organisms with respect to abundance and number of species are the nematodes and the harpacticoid copepods. In this cruise we aim to obtain quantitative figures for the average density of meiofaunal organisms in the different southeastern Atlantic deep-sea basins and to estimate the variability. We also want to study the diversity of meiofauna in the sampled areas by measuring the alpha diversity (meaning here the number of different species per corer) and calculating species richness (number of species related to number of studied specimens). In a second step, we will compare the diversity of the basins to each other. We want to know how large the distributional ranges of deep-sea species are and if the Walvis Ridge and/or the Guinea Rise do act as biogeographic barriers for the distribution of the species. In order to do so we will analyse some selected groups at species level. For instance, we will examine some copepod families including some benthic harpacticoids, hyperbenthic cyclopinids and calanoids, along with some nematode families, tardigrades, and tantulocaridians. Some of the corers were devoted to the characterization of the substrates (see 2. 4. 1), like sediment composition, amount of organic carbon or amount of chlorophyll in the sediment. This information will help us to understand the variation in abundance and diversity within the deep-sea basins and link our results to general oceanographic processes. We will use multivariate statistics like canonical correspondence analysis and multidimensional scaling to correlate meiofauna community values to abiotic factors and to graphically display the similarity between the meiofauna communities of different basins to each other. We are also going to study how isolated the communities from different basins are to each other using genetic methods. For this work, DNA has been extracted from several samples which are to be used for DNA work when we come back home.

Meiofauna was sampled using a Multiple Corer (MUC). This gear is equipped with 12 plastic cores, each of approximately 60cm length and with an inner diameter of 94mm, thus covering an area of 69.36cm². The cores are closed immediately after sampling, providing in this way up to 12 quantitative, relatively undisturbed sediment samples per haul. The MUC is preferred for quantitative analysis of the density of small organisms because, contrary to other gears like e.g. box corers, it does not produce a bow wave when reaching the seafloor. The MUC was lowered at a speed of 1.5 meters per second until 100 over ground, then the speed was reduced without stopping to reach 0.3 m/s. After hitting the seabed, 5 meters of cable were lowered and the gear stood for 30 seconds on bottom. The gear was then lifted to 10 m over ground at a speed of 0,3 m/s and then continued lifting at a speed of 1.5m/s.

In order to avoid pseudoreplication, 5 to 7 MUC hauls were taken in each sampling area. We performed 33 multicorer deployments. Seven in the northern Cape Basin (area 1), 6 in the northern Angola Basin (area 2) and 20 in the Guinea Basin (areas 3-5). Five corers from each haul were devoted to the investigation of metazoan meiofauna accounting for 152 corers in total (Table 2.6). The upper 5cm of sediment were taken out and fixed in ~4% buffered formalin for further treatment in the laboratory. The overlying bottom water was filtered through a 40µm sieve and the remainder fixed together with the sediment sample. In addition, for the study of recent and fossil ostracoda one of the corers was sliced into 1cm slices and deep-frozen at -20°C. In the laboratory, the meiofauna will be extracted by centrifugation, using the colloidal gel Levasil®. Centrifugation is done 3 times at 4,000 rpm for 5 minutes.

In addition to the quantitative multicorer samples, subsamples from other gears will be used in the qualitative study of metazoan meiofauna. For example, the bottom water overlying the sediments collected by the Box-Corer was filtered through a 300 µm sieve and subsequently through a 40 µm sieve and the remainder fixed in formalin. The Epibenthic Sledge collected an important amount of hyperbenthic copepods which will be used for genetic investigations.

Tab. 2.6: Multicorer deployments and number of corers per treatment.

Area	Station	Depth	no. of corers (formalin)	no. of corers (ethanol)	no. of corers (frozen)
1	33	5035	5	2	0
1	34	5035	5	2	0
1	35	5033	5	2	0
1	36	5025	5	0	0
1	37	5038	5	2	1
1	38	5036	5	2	1
1	39	5035	0	0	0
2	46	5651	5	2	0
2	47	5646	0	0	0
2	48	5655	5	1	0
2	49	5649	5	1	0
2	50	5648	5	1	0
2	51	5648	2	0	0

Tab. 2.6: Multicorer deployments and number of corers per treatment (continued).

Area	Station	Depth	no. of corers (formalin)	no. of corers (ethanol)	no. of corers (frozen)
3	56	5064	5	0	0
3	57	5063	5	0	0
3	58	5060	5	0	0
3	59	5066	5	1	0
3	60	5063	5	0	0
3	61	5066	5	1	0
3	62	5062	5	1	1
4	74	5141	5	0	0
4	75	5139	5	0	0
4	76	5142	5	0	0
4	77	5138	5	0	0
4	78	5136	5	1	1
4	79	5140	5	1	0
4	80	5138	5	1	0
5	95	5165	5	0	0
5	96	5171	5	1	0
5	97	5168	5	0	0
5	98	5174	5	2	0
5	99	5173	5	1	0
5	100	5167	5	1	1
Total	33	deployments	152	26	5

Preliminary results

The quantitative samples will be analysed at our home institutes, so that no preliminary results are available now. Analysis of the boxcorer subsamples and the epibenthic sledge let us see some potential, great differences between the basins. The samples from the Cape Basin seem to yield very low abundances of metazoan meiofauna probably due to the very low food availability south of the Walvis Ridge. Samples from the Guinea Basin seem to yield a very abundant and diverse community. Epibenthic sledge samples from the Guinea Basin collected a very diverse fauna of calanoid copepods and cerviniid Harpacticoida. From this material, 9 DNA extractions from selected rare taxa were performed on board.

2.4.6 Macroinfauna collected from box cores

(I. Kröncke, F. J. Cristobo, E. Hendrycks, H. Reiss, P. Rios, J. I. Saiz-Salinas, V. Ugorri)

Introduction & Methodology

During METEOR cruise 63 leg 2, samples were taken at one station in the northern Cape Basin and three stations in the Guinea Basin (Fig. 1: map) in depths of 5033 to 5168 m.

Analysis of these box core samples will provide data to address the following questions: structure of sediments, density and biomass of the infauna, species composition and turnover along latitudinal gradients.

A 0.25 m² USNEL box corer was used for sampling. It takes quantitative samples of the sea bottom with the organisms residing on top and within the substrate. The goal was to collect 7 box core samples at each station in order to reach a representative overview of the species composition (Sanders 1968) (see Tab. 2.7). Three of the 7 box cores were used for the study of biomass and trophic composition of infauna. For this approach the upper 20 cm of the sediment were sieved through stacked 1 mm, 0.5 mm and 0.3 mm screens and preserved as 0.5 mm and 0.3 mm fractions. Additionally, sediment cores were taken from each of the three boxes to analyse sediment parameters such as contents of mud, total organic carbon and pigments (see chapter: Sediment parameters and hydrographic data). For taxonomy only the remaining four box cores were used. Part of these boxes were divided into twenty-four subcores 10 x 10 cm (modified after Hessler and Jumars 1974) in order to evaluate the impact of a more gentle sample processing method on the percentage of identifiable animals. The upper 10 cm were sieved as described above.

All samples were fixed in 4% formalin in seawater. Sorting, weighing and taxonomic analysis of samples will be done in the home laboratories.

Tab. 2.7: Box corer deployments.

Basin	work- ing area	station numbers	depth (m)	gear	no. of deploy- ments	no. of successful de- ployments
Cape Basin	1	25-32	5033	KG	7	7
Guinea Basin		53-55	5063	KG	3	0
Guinea Basin	3	67-73	5060	KG	7	7
Guinea Basin	4	81-88	5139	KG	8	7
Guinea Basin	5	101-106	5168	KG	7	7

Observations & Preliminary Results

Sediments

The sediment at all stations appeared to be almost pure clay. Sediments at all stations were well oxidised down to a measured depth of 20 cm. In the northern Cape Basin the upper 4-6 cm were very fluffy, the colour of the sediment was light brownish. In contrast, in the Guinea Basin the colour of the sediments was light beige to white. The soft fluffy layer was restricted to the upper 2-3 cm. The sediments contained a high percentage of globularian foraminiferans. In some of the

boxes slag was found. Informations on sediments from the Angola Basin can be found in Kröncke and Türkay (2003).

Fauna

In general, the fauna observed in a preliminary analysis of the 1 mm fraction is of small body size and with mostly white and transparent colours. The dominant group belongs to Polychaeta, typical of soft-bottom habitats, which were found in almost all replicates of the sampling sites (see Tab.2.8). Bivalves and amphipods were also represented in all working areas. The presence of Echinodermata, mostly ophiuroids, is remarkable in the sampling sites of the northern Cape Basin. By contrast, cnidarians and sipunculans were absent from this area and also the bivalves were poorly represented. On the other hand, in the Guinea Basin there were no echinoderms, but cnidarians and sipunculans were abundant and characteristic for these bottoms.

1. CNIDARIA

This group is mainly represented by stolonial colonies of thecate hydrozoans over molluscs shells. It seems that the absence of hard substrates in the deep bottoms sampled forces settlement on dead pteropodian shells and on bivalve shells both dead and living specimens. Cnidarians were present in all sampled areas of Guinea Basin and absent in Cape Basin; this fact may be correlated with the availability of bivalve shells as a hard substrate for settlement.

2. SIPUNCULA & ECHIURA

A total of 5 species of sipunculans and echiurans and about 15 specimens have been found in the box-core samples. They belong to the genera *Apionsoma*, *Onchnesoma*, *Nephasoma*, which most likely are already known from the deep-sea fauna. The echiuran was partly damaged. Most of the specimens were coming from Working Areas 3, 4 and 5. At this stage, Working Area 1 seems to be quite poor in sipunculan and echiuran species. In general, sipunculans display low densities and low biomass figures, especially when we take into account the large abundances of some trawl samples of Working Areas 4 and 5. Concerning biomass, there is a remarkable exception (i.e. sampling site 88), where a large sipunculan specimen (about 10 cm long) of the genus *Nephasoma* was collected. This fact corroborates the importance of sipunculans in some of the biomass peaks detected in this Working Area 3.

Tab. 2.8: Occurrence of taxonomic groups in number of boxes per station.

FAUNA BOX-CORER - Me 63-2	Cape Basin Area 1	Guinea Basin Area 3	Guinea Basin Area 4	Guinea Basin Area 5
01- Cnidaria		5/7	1/7	1/6
02- Sipuncula		4/7	3/7	2/6
03- Echiurida		1/7	1/7	
04- Caudofoveata			1/7	
05- Gastropoda	1/7		1/7	
06- Bivalvia	1/7	5/7	1/7	3/6
07- Scaphopoda		1/7		

Tab. 2.8: Occurrence of taxonomic groups in number of boxes per station (continued).

FAUNA BOX-CORER - Me 63-2	Cape Basin Area 1	Guinea Basin Area 3	Guinea Basin Area 4	Guinea Basin Area 5
08- Polychaeta	6/7	3/7	7/7	5/6
09- Tanaidacea		1/7	1/7	1/6
10- Isopoda			3/7	3/6
11- Amphipoda	3/7	1/7	1/7	2/6
12- Bryozoa	2/7			
13- Ophiuroidea	5/7			
14- Holothuroidea	2/7			1/6
15- Ascidiacea	2/7			

3. MOLLUSCA

Molluscs were the second most abundant group after the polychaetes, both in number of specimens and in species numbers, with the bivalves being the dominant group among them.

a. Caudofoveata

Only one specimen of Caudofoveata has been found in the 1 mm fraction to this point. The presence (working area 4 in the Guinea Basin) may be increased after the sorting of the smaller fractions, since they are not rare in the kind of bottoms investigated.

b. Gastropoda

The Gastropoda are poorly represented in the samples. One species found is a detritivore opisthobranch cephalaspid which prefers this kind of silty substrate. The other species is a member of the Pyramidellidae, which often live associated with other benthic species as ectoparasites, feeding on the body fluids with its proboscis.

c. Bivalvia

The presence of bivalves in the box-corer samples has been constant in all the areas, with a larger abundance and species richness in the Guinea Basin, working areas 3 and 5. Almost all the species belong to the Protobranchia, with taxodont hinge. They are mostly detritivores. One specimen of Septibranchia was found in the 1 mm fraction of the sampling site 103 from working area 5.

d. Scaphopoda

Only one specimen of scaphopode was found in the box-corer samples after a preliminary analysis in working area 3 in the Guinea Basin. However other samples contained empty shells of this mollusc.

4. POLYCHAETA

There is no doubt that the polychaetes are the best represented taxa both in terms of abundance and species richness. Their presence remains constant in all the sampling sites from the 4 working areas investigated, with members of the following groups: Glyceridae, Ophelidae,

Nephtidae, Paraonida, Serpulidae, among others. The presence of a serpulid with a large shell and with a square section is remarkable, as hard substrates are very rare in these muds.

5. PERACARIDA

a. Tanaidacea

Single Tanaidacea were found in the boxes from the Guinea Basin.

b. Isopoda

Single isopods were also found in samples from the Guinea Basin.

c. Amphipoda

The amphipods at this preliminary stage have not been numerous in the box core samples, with a total of only 6 specimens. However, the possibility exists that more specimens will be found after careful sorting of the 1 mm fraction.

So far, 3-4 families are represented, including the benthic families Oedicerotidae and the Phoxocephalidae. An amphipod of unknown familial placement has been discovered, which may prove to be new to science. Also of interest, the suborder Ingolfiellidae is represented by a single, complete specimen. This find may be of particular interest, in that it may be a new species and may prove to be the deepest record for this rare group.

6. BRYOZOA

One single colony of bryozoans was present in the first sample taken in the Cape Basin. It is an erect colony and branched of a Gimnolaemata Cheilostomate, with alternate zooids in pairs and with the presence of ovicells.

7. ECHINODERMATA

The echinoderms are an abundant group in the Cape Basin, mainly by ophiuroids which are present in almost all the replicates. By contrast, echinoderms are almost absent in Guinea Basin. Two holothuroids of small size were collected in the Cape Basin with the absence of podia and with a net of dermal sclerites.

8. ASCIDIACEA

Two small specimens were found in sampling sites 30 and 31 corresponding to Cape Basin. They exhibited a thin tunica and were semi-translucent. The presence of silt debris in the lower part of the specimens indicates that they are partly burrowed in the mud bottom.

2.4.7 Macroepifauna represented in sledge-samples

(N. Brenke, S. Brix, J. Guerrero-Kommritz, E. Hendrycks, S. Kaiser, U. Mühlenhardt-Siegel, M. Rudschewski, M. Schüller)

Introduction and methods

The epibenthic sledge (EBS) is a proven gear for sampling small benthic macrofauna. The sledge is equipped with an epinet (below) and a supranet (above). The mesh size of the nets is 500 μ m. The cod ends are equipped with net-buckets containing a 300 μ m mesh window (Brenke, 2005). For the employment in warm, tropical waters, a special cooling box was mounted around the net-buckets. This way the samples were kept at a constantly low temperature, which is essential for DNA-extractions.

Sampling consisted of a total of eight employments in three different areas: Northern Cape Basin (area 1), Northern Angola Basin (area 2) and Guinea Basin (area 3). All of them were successful. The samples were taken in a depth range between 5000m and 5500 m. The operation time was 6h-9h, the trawl distance ranged between 583m and 4176m. In contrast to the EBS used during the Diva-1 expedition (Brandt et al., in progress), this sledge was equipped with 2 additional measuring devices (flowmeters, acoustic pinger). With these devices, we were able to calculate a reliable trawl distance (Fig. 2.5).

In the Angola Basin and Cape Basin, we collected a sample size of 2-3 litres, in marked contrast to the Guinea Basin, where the catch was remarkably larger (>120 litres). Upon recovery of the sledge, the samples were immediately transferred into a cooling-container (1-2°C). There they were suspended in precooled seawater, sieved over 300 μ m mesh size and fixed in ethanol (96% @ 2°C). This procedure was repeated several times to slowly raise the concentration of ethanol.

After 48 hours the samples were partly sorted. While most animals were preliminarily identified to the order or family level, the isopods were determined to species level. The identified specimens were used for DNA extraction. This consisted of dissecting 2 or 3 pereopods of each individual. For extraction, the *DNA Minikit QIAamp* from *Qiagen* was used. The DNA content was analysed by a BIOphotometer from *Eppendorf*. All extracts yielded enough DNA for further molecular work.

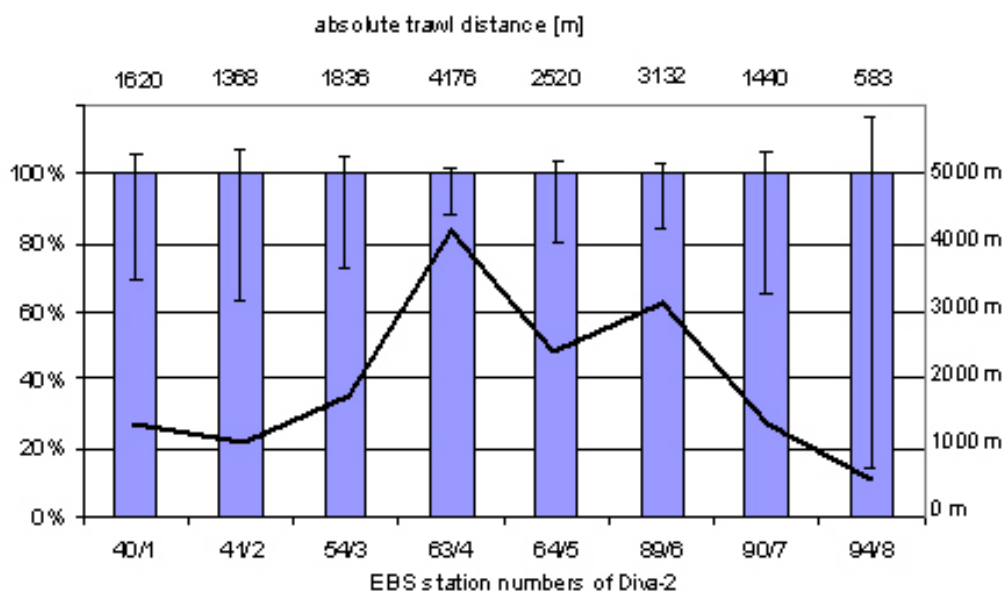


Fig. 2.5: Absolute (m) and relative (%) EBS trawl distance per station, expedition DIVA 2.

Preliminary results

Our preliminary examinations of the material reveal that we have more than 15 different invertebrate taxa represented in the collections. As expected from our previous results of the Diva-1 expedition, the samples were dominated by copepods and polychaetes. The peracarid crustaceans were also well represented (Fig. 2.6).

Tanaidacea

All three suborders are represented in the samples. The typical deep-sea families Neotanaidae, Pseudotanaidae and Agathotanaididae are the dominant taxa. Swimming males of leptognathids were also captured.

Cumacea

The following cumacean families are represented in the epibenthic sledge samples: Leuconidae, Nannastacidae, Diastylidae and Lampropidae. The genus *Leucon* (Leuconidae) was most abundant. New species are expected.

Polychaeta

As expected, a great diversity in families was observed during the first investigations. The Maldanidae were most abundant together with the Spionidae and Hesionidae. As previously known from former expeditions, the samples contain more vagile polychaetes than sessile, an observation which is supported by the preliminary results of this expedition.

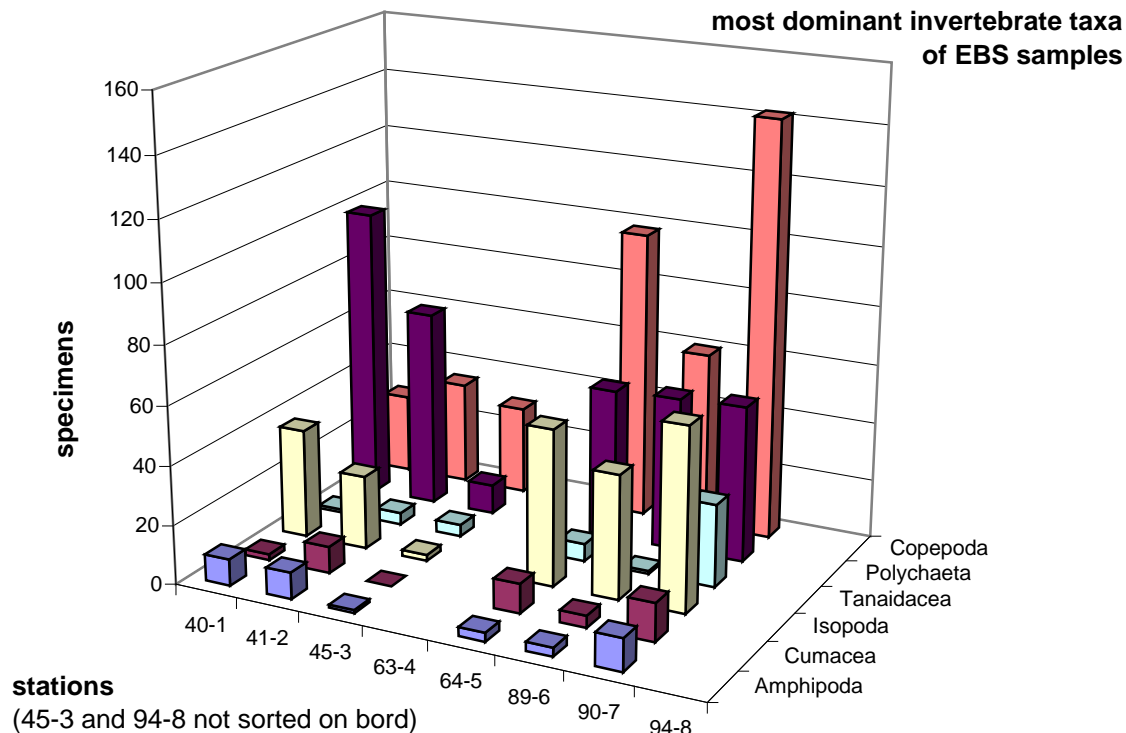


Fig. 2.6: Preliminary number of individuals of high abundant taxa from EBS samples, DIVA 2.

Isopoda

Up to now over 250 specimens from ten different isopod families were found in the samples. As expected, the family Munnopsidiidae is strongly represented with six sub-families. Twelve species were identified that were previously found during the Diva-1 expedition. Four further species were identified as new to science. A total number of 2000 isopod specimens is possible, based on estimates from the sorted samples in relation to the remaining, unsorted ones.

DNA extractions have been accomplished from the sorted, identified specimens. First results show only minute contaminations by proteins and carbohydrates. Therefore comprehensive genetic data are expected from approximately 10% of collected specimens.

Amphipoda

The following families are represented in the collections: Phoxocephalidae (*Leptophoxoides* the most common genus), Corophiidae, Oedicerotidae, Lysianassidae, Eusiridae (genera *Cleonardo*, *Rhachotropis*), and Pardaliscidae (*Octomana*). There are a few taxa of unknown status, which may be new to science. Since the vast majority of the collections are still unsorted, we expect many more amphipods to be found. It is interesting to note that many of these families are carnivorous and most likely epibenthic predators, with good swimming abilities. The few exceptions are the Oedicerotidae, and the Phoxocephalidae, which are benthic and fossorial in habit. The pardaliscid genus *Octomana* Hendrycks and Conlan, 2003 was described from the north-east Pacific and discovered also in the Angola Basin during Diva-1.

2.4.8 Mega-Epifauna

(M. Türkay, E. Hendrycks, J. I. Saiz Salinas, K. Pietratus, W. Rosenboom)

Introduction and methods

The Mega-Epifauna was collected with a modified Agassiz-trawl. The reason for using this gear was that it can catch regardless of possible turns in the water column during lowering. Compared to a conventional beam trawl this gear has the disadvantage of the upper edge of the net opening being flush with the lower one instead of reaching over it. Consequently, highly mobile animals, such as fish and squid, can escape from the net opening when stirred up by the bottom rope. Thus, there is some selectivity for catching slow and hemisessile to sessile bottom animals, while mobile ones are underrepresented. The long lowering and heaving times, however, call for this type of robust approach, as a conventional beam trawl, if reaching the bottom upside down, could have caused the loss of a whole day of ship's time.

This gear was already used successfully during DIVA I (Meteor 48/1, 2000). The 3.5m- long beam is in an anterior central position in the sledges. The runners are joined to each other at the posterior sledge end in which a weight is attached within the gear, in order to force the runners down to the bottom (see Fig.2.7). The crowfoot is made of steel ropes rather than of chains and a tickler chain is attached at the basal two thirds of it. The net has on both sides a ground rope equipped with chains, the mesh size in the cod end measures 1 cm between stretched meshes. As in earlier cases a weak link was present between the main rope and the gear and a security rope attached the main rope to one side of the sledge. This arrangement allows the secure recovery of

the gear and net in case the trawl gets caught on the sea bottom. In this case the weak link breaks and the security rope disarticulates the loose connection between beam and sledges, which are then still attached to the crowfoot and the net can usually be safely recovered. This was, however, never the case during the whole expedition, as the gear did not get caught.

To keep the net stretched, it was deployed with the ship steaming at 3 knots. After 200 m of fore-rope a weight of 500 kg was inserted onto the rope and lowering was continued. Based on our earlier experience, we paid out a rope length of 1.8 times the water depth. The sea bed was trawled for 2.5 to 3.5 hours at 2 knots, which equals a trawling distance of approximately 7,500 - 13,000 m and a trawled area of at least 26,300 - 45,500 m². These are minimum values as it cannot be predicted exactly when the gear arrived at the sea bottom and when it left it. The trawl was used twice at every full station, and once at the two short stations in the Angola Basin and the westernmost Guinea Basin. Table 2.9 gives a summary of stations at which the Agassiz trawl was deployed and also contains information about the trawling time on the sea bed.

To make results comparable in a semiquantitative way, we calculated the trawled distance (**Dist**) for every deployment. The formula for this is:

$$\text{Dist} = 6377 * \arccos [\cos (90\text{-Lat1}) * \cos (90\text{-Lat2}) + \sin (90\text{-Lat1}) * \sin (90\text{-Lat2}) * \cos (\text{Long1}\text{-Long2})]$$

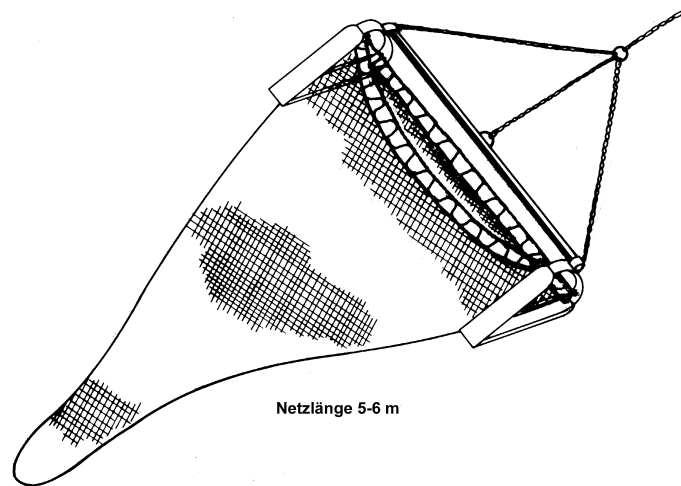
As 6377 is the radius of the earth in km , the results are in km

Tab. 2.9: Details of trawling stations.

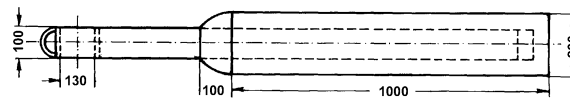
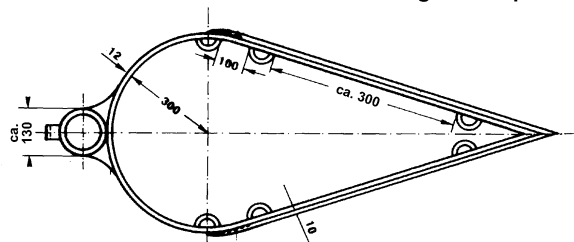
Area	Station	Depth	Time on seabed	Trawled distance
1	42	5089-5082 m	2 h 32 min	9.56 km = 5.16 nm
1	43	5077-5076 m	2 h 27 min	9.1 km = 4.91 nm
2	44	5672-5646 m	3 h 02 min	11.38 km = 6.15 nm
3	65	5076-5051 m	2 h 57 min	12,01 km = 6.49 nm
3	66	5052-5054 m	3 h 02 min	12,45 km =6.72 nm
4	91	5141-5139 m	3 h	11,36 km = 6,13 nm
4	92	5144-5142 m	3 h 07 min	13,06 km = 7,05 nm
5	93	5217-5168	3 h	12,1 km = 6,53 nm

The trawl surely reaches the bottom before we stop lowering and still stays there for a while after the start of heaving. Because the only exactly measurable times are the ones referring to the end of lowering and the starting of heaving, we define the period between them as trawling time. The tracks of this distance have been plotted (see Fig. 2.8). The distance calculated from the two positions at those times is thus the minimum value for which we can be sure that we were trawl-

ing the sea bed. In case that the course had to be changed due to bottom conditions during trawling (Stat. 93, see Fig. 2.8e), the distance has been calculated separately for the two branches and summed up. The real distance is certainly larger.



Sledge of deep sea trawl



Beam

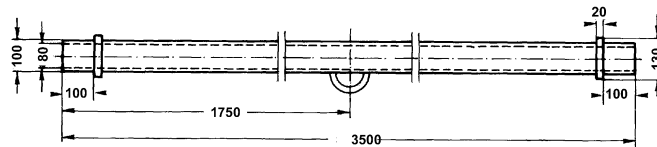


Fig. 2.7: Construction of the AGASSIZ-Trawl used during *METEOR* 63 leg 2. All measurements in mm.

Qualitative results

Sampling was successful at all stations. Dominant organism taxa were fish, echinoderms, bivalves, and actinians. Other animal groups were present at times, but irregularly. The individual trawls can be described as follows:

Area 1 (Northern Cape Basin)

Station 42: Predominantly brittle stars (Ophiuroidea), large actinians, some starfish, sea-cucumbers and fishes (coryphaenids, nemichthyids of the genus *Avocettina*, gonostomatids probably of the genus *Cyclothone*, and an argyropelecid probably caught from the water column), a perfect specimen of the genus *Gigantocypris* (Ostracoda), a complete specimen of an unknown hyperiid amphipod (most likely caught from the water column), very few bathypelagic shrimps, stones and slags. Also one sipunculan (*Phascolion* sp.) was observed inside a mud ball with gametes. Station 43: Similar to 42, but more additionally melamphaid fish (*Poromitra* sp.).

Area 2 (Northern Angola Basin)

Station 44: Small catch with nothing dominant inside. One long stalked sea pen (*Umbellula* sp., most probably *koellikeri*), carnivorous sponges, parts of hexactinellid sponges, shrimp (*Systellaspis*), starfish, a few fish (*Barbantus*, *Stenopteryx*, *Cyclothone*) and several echiurans, some of them quite damaged without proboscises. Also, some empty polychaete tubes were collected, which in DIVA 1 was a particular habitat for some sipunculans.

Area 3 (Guinea Basin east)

Station 65: Relatively small catch dominated by fish (predominantly *Malacocephalus*) and starfish (e. g. *Styrcaster*), some shrimps (*Plesiopenaeus*, *AcanthePHYra*), one actinian, a few sea cucumbers, bivalves.

Station 66: Similar to 65, but a bit larger, clearly dominated by fish (predominantly brotulids, ateleopids, coryphaenids) and starfish, some shrimps (*AcanthePHYra*), one polychelid decapod (*Willemoesia*), a few sea cucumbers, actinians, hexactinellid sponges.

Area 4 (Guinea Basin west 1)

Station 91: Catch dominated by starfish, further contents were sea cucumbers and a few brittle stars, clams, ca. 30 specimens of a large species of sipunculan (about 10 cm long), belonging to the genus *Nephasoma* sp., aristeid prawn, 2 complete hyperiids, possibly *Lanceola*, which is a deep-sea genus, and bathypelagic fish.

Station 92: Similar to previous one, but less starfish, next to starfish in numbers were sea cucumbers, hexactinellid and carnivorous sponges, actinian, pennatulid (*Umbellula*), giant ostracod (*Gigantocypris*), also around 30 specimens of large sipunculans of the genus *Nephasoma*, fish (bathypelagic, but also bottom dwelling brotulids, including a very large one).

Area 5 (Guinea Basin west 2)

Station 93: Small catch without any dominant organisms, most numerous were starfish and sea cucumbers, also large sipunculans of the genus *Nephasoma* sp. furthermore oplophorid shrimp (*Acantheephyra*), a perfect gammaridean amphipod (*Cyphocaris* sp.), squids, fish (mostly bathypelagic, but also brotulids and coryphaenids)

As can be seen from these preliminary results, the trawling resulted in records of a diverse megafauna. Most species were only represented with one to very few specimens, which attain quite large sizes. On a global view the Cape Basin fauna differed significantly from that trawled in all other regions by the dominance of deposit feeders over scavengers and predators. In the Angola Basin and also the Guinea Basin the number of deposit feeders was dramatically lower than that of scavengers and carnivores. The northwestern Angola Basin was the poorest in terms of numbers of specimens and diversity.

More specific results will be available after the analysis of faunal composition, abundances and biomasses at the home laboratory.

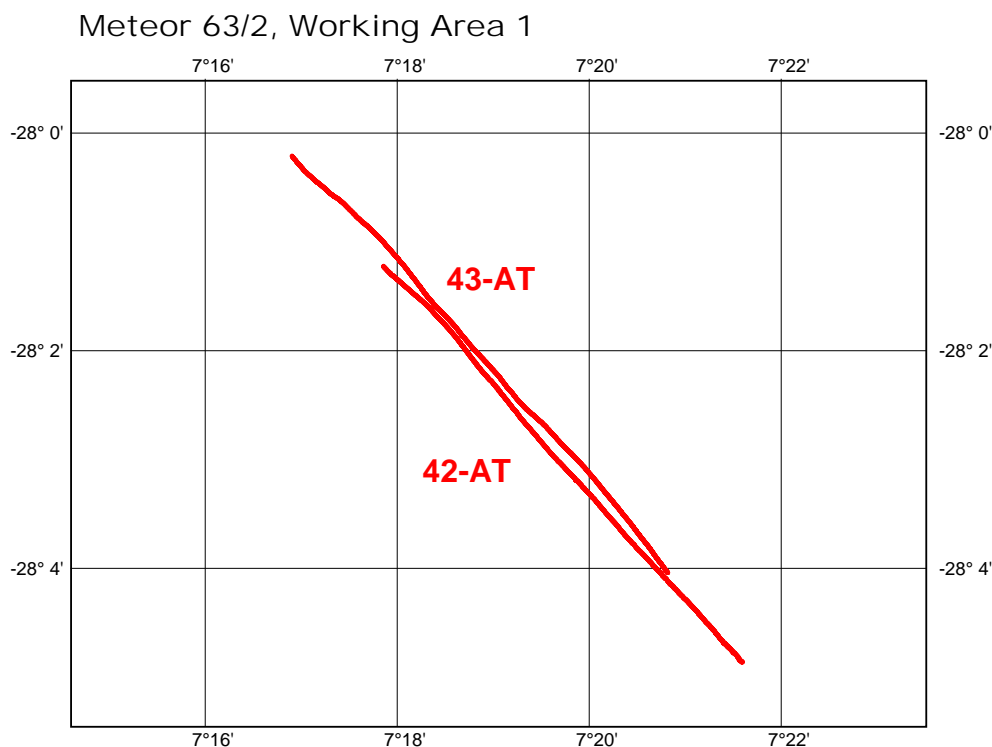


Fig. 2.8a: Trawling tracks in Area 1 (Northern Cape Basin).

Meteor 63/2, Working Area 2

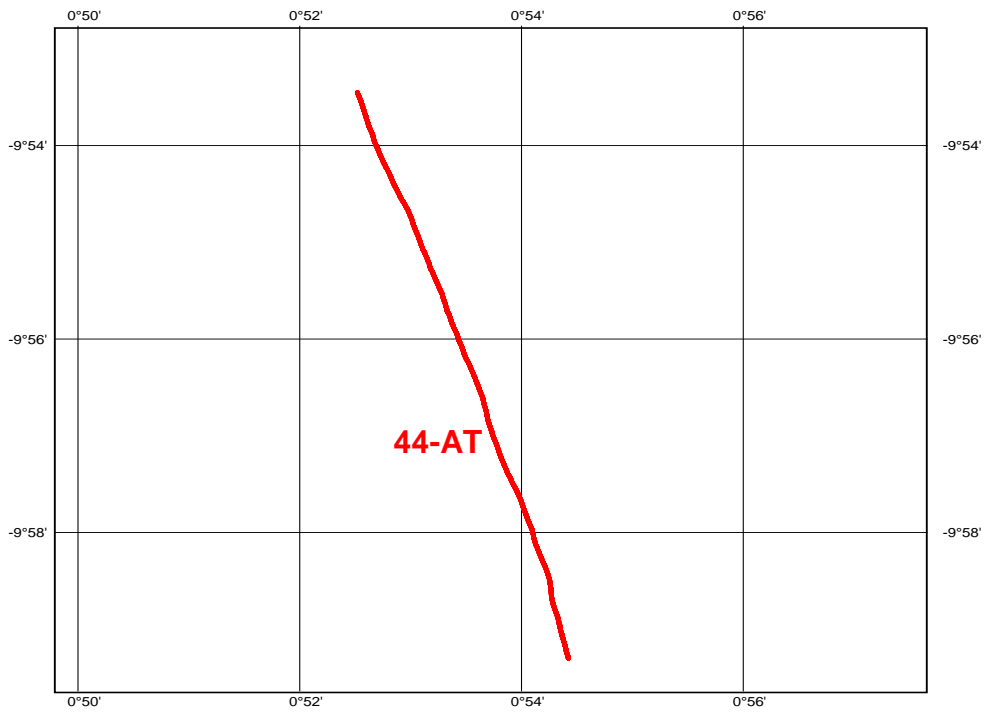


Fig. 2.8b:
Trawling track in working area 2 (Northwestern Angola Basin).

Meteor 63/2, Working Area 3

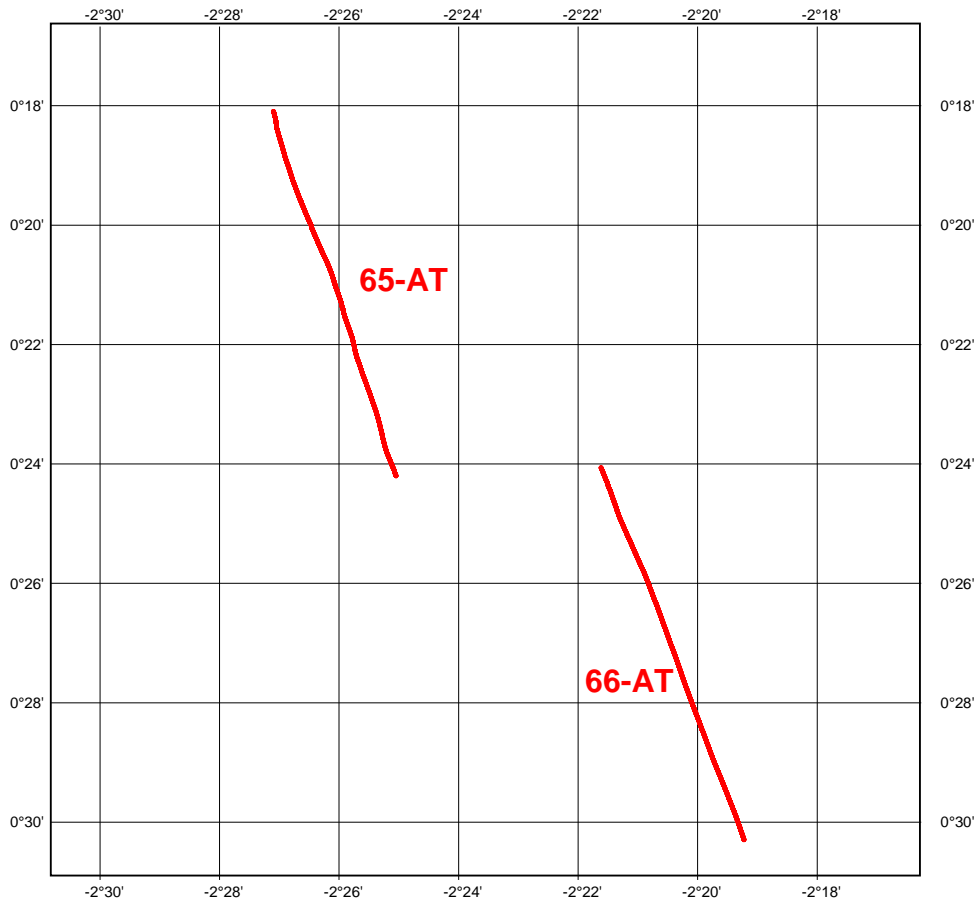


Fig. 2.8c:
Trawling tracks in working area 3 (Eastern Guinea Basin).

Meteor 63/2; Working Area 4

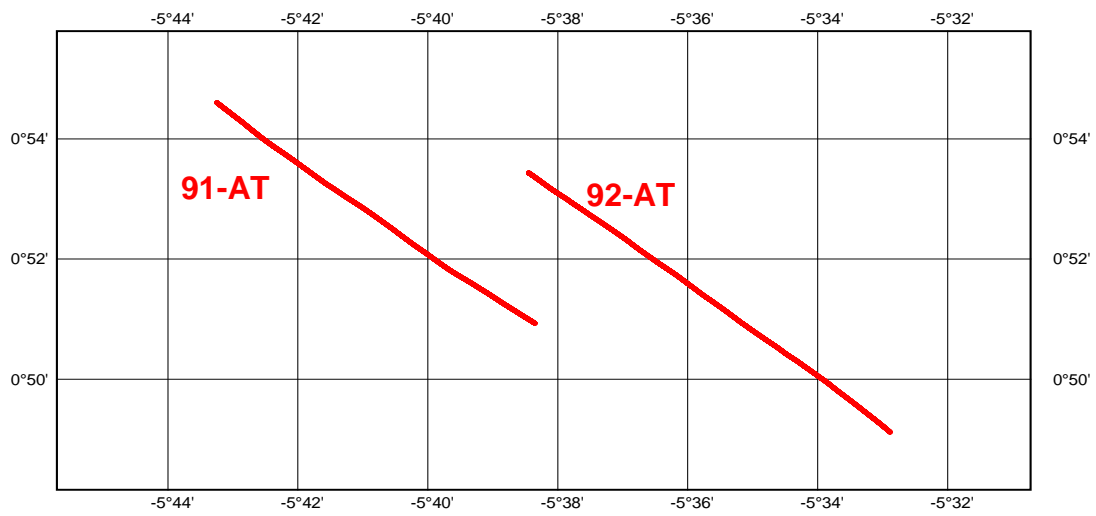


Fig. 2.8d: Trawling tracks in working area 4 (Western Guinea Basin).

Meteor 63/2; Working Area 5

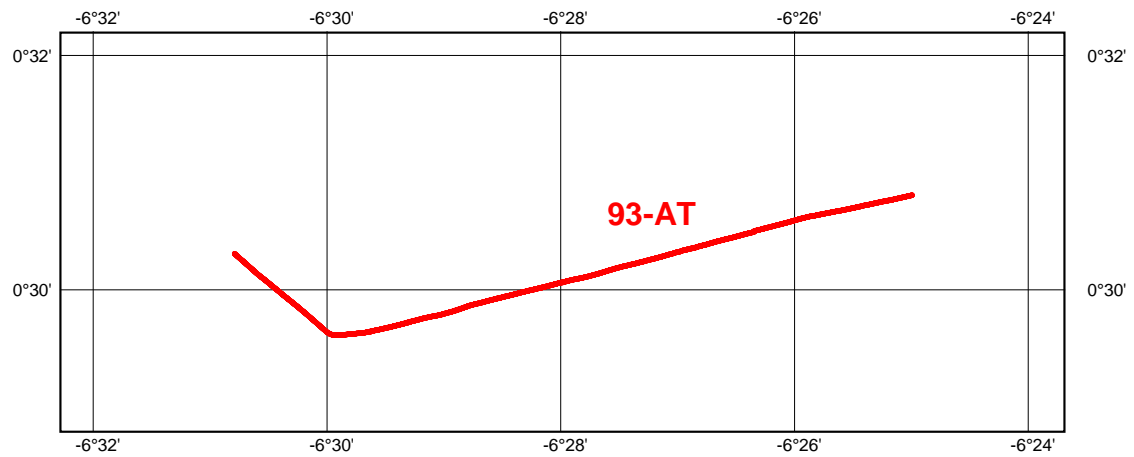


Fig. 2.8e: Trawling track in working area 5 (Western Guinea Basin).

2.5 Ship's Meteorological Station

(G. Kahl, T. Truscheit)

When R. V. *METEOR* left Cape Town, South Africa, on February 25th, 2005, the South Atlantic Subtropical High 1022 hPa was centred at 32 S 3 E. It was opposed by a static low 1008 hPa in the continent fueled by the heat of the day. So strong southeasterly winds greeted the ship when she put out to sea, but these proved to be short lived as they were local.

On the way to Walvis Bay where *METEOR* called on February 28th there were southerly winds of 5 Bft parallel to the coast which the ship adhered to. Sometimes 6 Bft were being observed. In Walvis Bay, a low had developed on the coast slightly north of the town as it does every now and then during spring and summer. It produced southwesterly winds of 3 Bft and a high amount of cloudiness during the hours spent bunkering there.

Southeasterly winds of 5 Bft to 6 Bft prevailed on the way into the Cape Basin, the first area of work, too. The Subtropical High had retained its position but had been strengthened to over 1025 hPa.

While sampling was in progress a flat low developed northwest of *METEOR*'s position, moving east to southeast past her and bringing the force of the southeasterlies up to 6 Bft on March 4th. The low then moved on into the continent slowly. As the Subtropical High was being replaced by the next one coming up from the southwest there were only light southeasterlies on March 5th.

The next day, the Cape Basin was left and the ship voyaged north over the Walvis Ridge to the Angola Basin.

While on the way, on March 7th the atmospheric boundary between the temperate latitudes and the tropics made itself being felt not on the sea surface, but it showed up while probing the air by radiosonde: a sounding that went up to 22.787 m height recorded a maximum wind of 47.4 m/sec at a height where atmospheric pressure was only 170 hPa. So the radiosonde had passed near the core of a Jet Stream.

On the surface, the research vessel experienced the Southeast Trades of 4 Bft to 5 Bft. This was the same for the two days sampling was done in the Angola Basin. The trades followed their normal pattern in that a maximum was reached every evening. This pattern remained the same until March 14th when *METEOR* was entering the Guinea Basin. Sampling was done there on three positions along the Equator, and it went on until March 24th when scientific work had to stop in order for the ship being able to reach Mindelo in time.

At first, winds were light from the southeast, the ITC being active to the west and cloud clusters arising near the mouth of the Congo River being active to the east. Later, the winds veered southwest sometimes, but still wind forces of 2 Bft to 4 Bft prevailed. While the activity of the ITC elongated east there was no change in mean wind velocity, but on a few occasions a shower would come along and the wind would blow into it, going up to 7 Bft on a 10 minutes-mean wind velocity for half an hour or the like.

While on the voyage to Mindelo, the first thing was to go through the ITC. This lasted until March 26th. Light southerly winds prevailed as they had done so before. Then, however, things changed: Light northerly winds gave way to the Northeast Trades at last, but only during the last two days of the *METEOR* cruise Me62/2.

2.6 Station List, Meteor 63 Leg 2

Station	Lat. Start	Long. Start	Lat. End	Long. End	Depth	Time UTC	Date
25 KG	28° 6,7560' S	07° 20,9070' E			5028	14.35	2. III. 2005
26 KG	28° 6,6730' S	07° 20,8030' E			5031	17.40	2. III. 2005
28 KG	28° 6,6770' S	07° 20,8260' E			5043	02.09	3. III. 2005
29 KG	28° 6,7140' S	07° 20,8120' E			5038	05.17	3. III. 2005
30 KG	28° 6,6570' S	07° 20,8400' E			5042	08.15	3. III. 2005
31 KG	28° 6,7380' S	07° 20,8440' E			5039	11.05	3. III. 2005
32 KG	28° 6,8040' S	07° 20,8610' E			5045	13.45	3. III. 2005
33 MUC	28° 6,7260' S	07° 20,7720' E			5050	16.31	3. III. 2005
34 MUC	28° 6,6580' S	07° 20,8330' E			5030	19.17	3. III. 2005
35 MUC	28° 6,7640' S	07° 20,6610' E			5022	21.57	3. III. 2005
36 MUC	28° 6,7290' S	07° 20,8520' E			5040	00.34	4. III. 2005
37 MUC	28° 6,7040' S	07° 20,8170' E			5030	03.08	4. III. 2005
38 MUC	28° 6,7810' S	07° 20,8240' E			5037	05.47	4. III. 2005
39 MUC	28° 6,7740' S	07° 20,7490' E			5035	08.12	4. III. 2005
40 EBS	28° 3,0690' S	07° 19,8000' E	28° 3,2390' S	07° 19,8110' E	5062-5052	16.02-18.32	4. III. 2005
41 EBS	28° 4,0550' S	07° 20,4960' E	28° 4,1720' S	07° 20,7240' E	5058-5060	00.13-02.10	5. III. 2005
42 AT	28° 0,2060' S	07° 16,9050' E	28° 4,0290' S	07° 20,8210' E	5089-5082	10.10-12.42	5. III. 2005
42 PN-1	27° 52,0770' S	07° 8,5910' E	27° 52,2380' S	07° 8,7670' E	surface	06.30-06.35	5. III. 2005
42 PN-2	28° 1,5000' S	07° 18,3200' E	28° 1,8360' S	07° 18,6650' E	surface	11.00-11.14	5. III. 2005
43 PN-1	27° 55,9860' S	07° 12,6620' E	27° 56,7030' S	07° 13,3100' E	surface	21.51-22.10	5. III. 2005
43 PN-2	27° 56,7030' S	07° 13,3100' E	27° 57,2560' S	07° 13,8020' E	surface	22.10-22.25	5. III. 2005
43 AT	28° 1,2270' S	07° 17,8580' E	28° 4,8560' S	07° 21,5990' E	5077-5076	00.18-02.45	6. III. 2005
44-PN	09° 46,92' S	00° 50,37' E			surface	10.40-10.50	10. III. 2005
44 AT	09° 53,4480' S	00° 52,5190' E	09° 59,2890' S	00° 54,4250' E	5672-5646	13.08-16.10	10. III. 2005
45 EBS	09° 53,0770' S	00° 52,6260' E	09° 53,7910' S	00° 53,6350' E	5647-5655	02.06-05.20	11. III. 2005
46 MUC	09° 55,9530' S	00° 53,8010' E			5648	09.38	11. III. 2005
47 MUC	09° 56,1650' S	00° 54,1010' E			5647	12.36	11. III. 2005
49 MUC	09° 56,0000' S	00° 53,9830' E			5649	19.31	11. III. 2005
50 MUC	09° 56,0220' S	00° 54,1880' E			5653	22.24	11. III. 2005
51 MUC	09° 56,0670' S	00° 54,2050' E			5649	01.24	12. III. 2005
52 PN	09° 56,0490' S	00° 54,0240' E	09° 55,9370' S	00° 54,6920' E	surface	03.00-03.15	12. III. 2005
53 KG	00° 0,1670' S	02° 25,0260' W			5062	10.17	14. III. 2005
54 KG	00° 0,0670' S	02° 25,0310' W			5062	12.50	14. III. 2005
55 KG	00° 0,0000' N	02° 25,0730' W			5067	15.35	14. III. 2005
56 MUC	00° 0,0270' S	02° 24,9820' W			5064	18.04	14. III. 2005
57 MUC	00° 0,0040' S	02° 25,0210' W			5064	20.32	14. III. 2005
58 MUC	00° 0,0350' S	02° 25,0280' W			5065	23.14	14. III. 2005
59 MUC	00° 0,1190' S	02° 24,8010' W			5063	01.47	15. III. 2005
60 MUC	00° 0,0010' S	02° 25,0050' W			5064	04.19	15. III. 2005

Station	Lat_Start	Long_Start	Lat_End	Long_End	Depth	Time_UTC	Date
61 MUC	00° 0,0310' S	02° 24,9340' W			5062	06.55	15. III. 2005
62 MUC	00° 0,0430' S	02° 24,9910' W			5062	09.12	15. III. 2005
63 EBS	00° 8,7800' S	02° 28,7500' W	00° 8,2120' S	02° 28,7330' W	5051-5048	16.36-18.32	15. III. 2005
64 EBS	00° 13,2550' S	02° 29,9210' W	00° 13,2200' S	02° 29,4560' W	5055-5053	01.17-02.27	16. III. 2005
65 AT	00° 18,1220' S	02° 27,0910' W	00° 24,2640' S	02° 25,0370' W	5076-5051	11.55-14.52	16. III. 2005
66 AT	00° 24,0640' S	02° 21,6150' W	00° 30,3300' S	02° 19,2170' W	5052-5054	02.10-05.12	17. III. 2005
66 PN-1	00° 26,1650' S	02° 20,7640' W	00° 26,4980' S	02° 20,6380' W	surface	03.10-03.20	17. III. 2005
66 PN-2	00° 26,4980' S	02° 20,6380' W	00° 24,7310' S	02° 21,3620' W	surface	03.20-03.30	17. III. 2005
66 PN-3	00° 24,7310' S	02° 21,3620' W	00° 27,1510' S	02° 20,4000' W	surface	03.30-03.40	17. III. 2005
66 PN-4	00° 27,1510' S	02° 20,4000' W	00° 27,4850' S	02° 20,2830' W	surface	03.40-03.50	17. III. 2005
67 KG	00° 26,6020' S	02° 20,5830' W			5058	11.34	17. III. 2005
68 KG	00° 26,7140' S	02° 20,5400' W			5056	14.02	17. III. 2005
69 KG	00° 26,7670' S	02° 20,5410' W			5058	16.30	17. III. 2005
70 KG	00° 26,7370' S	02° 20,5820' W			5061	19.08	17. III. 2005
71 KG	00° 26,8100' S	02° 20,4550' W			5062	21.58	17. III. 2005
72 KG	00° 26,7500' S	02° 20,5490' W			5059	00.33	18. III. 2005
73 KG	00° 26,7770' S	02° 20,5550' W			5059	03.05	18. III. 2005
74 MUC	00° 50,0390' N	05° 35,1240' W			5144	00.43	19. III. 2005
75 MUC	00° 50,0420' N	05° 35,0360' W			5139	03.10	19. III. 2005
76 MUC	00° 49,9540' N	05° 35,0360' W			5136	05.54	19. III. 2005
77 MUC	00° 50,0190' N	05° 35,0250' W			5142	08.22	19. III. 2005
78 MUC	00° 49,9710' N	05° 35,1100' W			5138	10.52	19. III. 2005
79 MUC	00° 50,0200' N	05° 35,0470' W			5139	13.30	19. III. 2005
80 MUC	00° 50,0000' N	05° 34,9700' W			5139	15.55	19. III. 2005
81 KG	00° 50,0390' N	05° 35,0290' W			5136	18.38	19. III. 2005
82 KG	00° 50,0700' N	05° 35,0360' W			5144	21.14	19. III. 2005
83 KG	00° 49,9940' N	05° 34,9650' W			5140	23.46	19. III. 2005
84 KG	00° 49,9850' N	05° 34,9850' W			5138	02.11	20. III. 2005
85 KG	00° 50,0090' N	05° 35,0050' W			5138	04.11	20. III. 2005
86 KG	00° 50,0270' N	05° 35,0170' W			5137	07.06	20. III. 2005
87 KG	00° 49,9850' N	05° 35,0860' W			5142	09.25	20. III. 2005
88 KG	00° 50,0060' N	05° 35,0650' W			5137	12.05	20. III. 2005
89 EBS	00° 42,9560' N	05° 31,2940' W	00° 42,9830' N	05° 31,2340' W	5141-5137	18.44-20.11	20. III. 2005
90 EBS	00° 40,4890' N	05° 29,7050' W	00° 40,4380' N	05° 29,6880' W	5144-5143	02.27-03.07	21. III. 2005
90 PN	00° 41,8230' N	05° 30,5670' W			Surface	23.58-00.40	20./21. III. 2005
91 AT	00° 50,9279' N	05° 38,3475' W	00° 54,6010' N	05° 43,2463' W	5141-5139	11.18-14.18	21. III. 2005
91 PN	00° 53,9036' N	05° 42,4132' W	00° 54,1890' N	05° 42,7570' W	Surface	13.45-14.00	21. III. 2005
92 AT	00° 53,4327' N	05° 38,4461' W	00° 49,1178' N	05° 32,8827' W	5144-5142	23.33-02.40	21./22. III. 2005
92 PN	00° 49,4440' N	05° 33,2565' W	00° 49,1178' N	05° 32,8827' W	Surface	02.27-02.40	22. III. 2005
93 PN-1	00° 35,22' N	06° 36,59' W			Surface	16.32-16.42	22. III. 2005
93 AT	00° 30,3112' N	06° 30,7920' W	00° 30,8084' N	06° 24,9907' W	5217-5168	19.12-22.12	22. III. 2005

Station	Lat_Start	Long_Start	Lat_End	Long_End	Depth	Time_UTC	Date
93 PN-2	00° 32,07' N	06° 22,09' W			Surface	00.04-00.14	23. III. 2005
94 EBS	00° 37,7102' N	06° 25,9419' W	00° 37,5872' N	06° 26,4452' W	5159-5163	07.04-07.20	23. III. 2005
95 MUC	00° 37,3630'	06° 28,0520' W			5170	11.34	23. III. 2005
96 MUC	00° 37,2060' N	06° 28,0060' W			5165	14.00	23. III. 2005
97 MUC	00° 37,2150' N	06° 28,1240' W			5170	16.23	23. III. 2005
98 MUC	00° 37,2170' N	06° 28,1200' W			5170	18.42	23. III. 2005
99 MUC	00° 37,2160' N	06° 28,1490' W			5168	21.00	23. III. 2005
100 MUC	00° 37,1970' N	06° 28,1300' W			5167	23.33	23. III. 2005
101 KG	00° 37,2300' N	06° 28,1400' W			5171	02.00	24. III. 2005
102 KG	00° 37,2510' N	06° 28,1350' W			5169	04.32	24. III. 2005
103 KG	00° 37,2490' N	06° 28,1280' W			5167	06.55	24. III. 2005
104 KG	00° 37,2610' N	06° 28,1060' W			5168	09.20	24. III. 2005
105 KG	00° 37,2660' N	06° 28,1190' W			5173	11.46	24. III. 2005
106 KG	00° 37,2330' N	06° 28,1310' W			5170	14.11	24. III. 2005

Abbreviations: AT = Agassiz-Trawl; ATP = AT towed pelagically; Bo = Plancton net, Bongo; ES = Epibenthic sledge; MC = Multicorer; KG = Box corer.

Depth measured by Parasound in NBS-mode, all depths corrected with Carter's tables.

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