SONNE-Berichte

Cold-Water Corals in the West Indian Ocean

Cruise No. SO306

August 8 – September 9, 2024
Port Louis (Mauritius) – Durban (South Africa)
CoWIO

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1 Cruise Summary

1.1 Summary in English

RV SONNE expedition SO306 focused on investigating the occurrence of cold-water corals (CWCs) in the West Indian Ocean. Although there was already evidence for the presence of CWCs and associated deep-sea ecosystems in this region, they remained largely unexplored, so this expedition was the first to focus specifically on CWC ecosystems in the West Indian Ocean. The main working areas were the slopes of the volcanic island of Mayotte and the East African continental slopes of Tanzania, Mozambique and South Africa. Particular attention was paid to the distribution, faunal composition and diversity, and vitality of these ecosystems under present and past environmental conditions. Based on hydroacoustic mapping, ROV video observations were conducted to allow for a detailed characterisation of the existing facies and fauna. These observations were complemented by studies on the structure and variability of the water column and its plankton communities and by an extensive seabed sampling (including long sediment cores). The expedition yielded several remarkable findings, such as (a) the discovery that CWCs are widespread in the region but rarely act as ecosystem engineers, (b) the identification of slide masses, which were previously described as "mound" structures, (c) the discovery of two mud volcanoes (MVs) off East Africa, where such structures were previously unknown, and (d) the discovery of diverse and colourful coral gardens on two previously undescribed seamounts off southern Mozambique. Overall, the expedition delivered excellent results, even if some of them turned out to be quite different from what was expected - a classic example of an exploratory research expedition.

1.2 Zusammenfassung

Im Mittelpunkt der Expedition SO306 des FS SONNE stand die Untersuchung des Vorkommens von Kaltwasserkorallen (KWK) im Westindischen Ozean. Obwohl es bereits Hinweise auf das Vorhandensein von KWK und assoziierten Tiefsee-Ökosystemen in dieser Region gab, blieben sie weitgehend unerforscht, so dass Expedition SO306 die erste war, die sich gezielt auf KWK-Ökosysteme im Westindischen Ozean konzentrierte. Die Hauptarbeitsgebiete waren die Hänge der Vulkaninsel Mayotte und die ostafrikanischen Kontinentalhänge von Tansania, Mosambik und Südafrika. Besonderes Augenmerk wurde auf die Verteilung, die Zusammensetzung und Vielfalt der Fauna sowie die Vitalität dieser Ökosysteme unter heutigen und früheren Umweltbedingungen gelegt. Auf der Grundlage hydroakustischer Kartierungen wurden ROV Videoerkundungen durchgeführt, um eine detaillierte Charakterisierung der vorhandenen Fazies und Fauna zu ermöglichen. Ergänzt wurden diese Beobachtungen durch Untersuchungen zur Struktur und Variabilität der Wassersäule und ihrer Planktongemeinschaften sowie durch umfangreiche Probenahmen am Meeresboden (einschließlich langer Sedimentkerne). Die Expedition erbrachte mehrere bemerkenswerte Ergebnisse, wie z.B. (a) die Entdeckung, dass KWK in der Region weit verbreitet sind, aber nur selten als Ökosystemingenieure fungieren, (b) die Identifizierung von Rutschmassen, die zuvor als „Hügel“-Strukturen beschrieben wurden, (c) die Entdeckung von zwei Schlammvulkanen vor Ostafrika, wo solche Strukturen zuvor unbekannt waren, und (d) die Entdeckung vielfältiger und farbenfroher Korallengärten auf zwei bisher ebenfalls nicht beschriebenen submarinen Vulkanen vor Süd-Mosambik. In der Summe hat diese Expedition hervorragende Ergebnisse geliefert, wenn auch z.T. ganz andere als erwartet – ein klassisches Beispiel für eine explorative Schiffsexpedition.

2 Participants

2.1 Principal Investigators

Name	Institution
Hebbeln, Dierk, Prof. Dr.	MARUM
Wienberg, Claudia, Dr.	MARUM
Freiwald, André, Prof. Dr.	SAM
Raddatz, Jacek, PD Dr.	GEOMAR
Flögel, Sascha, Dr.	GEOMAR

2.2 Scientific Party

Name	Discipline	Institution
Hebbeln, Dierk, Prof. Dr.	Chief Scientist	MARUM
Wienberg, Claudia, Dr.	Co-Chief Scientist	MARUM
Bazhenova, Evgenia, Dr.	Hydroacoustics	MARUM
Corbera, Guillem, Dr.	Marine Geology	MARUM
Greiffenhagen, Luis	Marine Geology	MARUM
Lagunova, Nadezhda	Hydrography - ADCP	MARUM
Dehning, Klaus	Marine Geology	MARUM
Meyer-Schack, Birgit	Marine Geology	MARUM
Ruhland, Götz	Marine Geology	MARUM
Ansorge, Malte	Marine Geology	MARUM
Bach, Alissa	Hydroacoustics	MARUM
Nowald, Nicolas, Dr.	ROV	MARUM
Leymann, Tom	ROV	MARUM
Fröhlich, Siefke	ROV	MARUM
Vittori, Vincent	ROV	MARUM
Freiwald, André, Prof. Dr.	Geobiology	SAM
Hoffman, Leon	Geobiology	SAM
Pfennings, Kai	Geobiology	SAM
Wilsenack, Maik	Geobiology	SAM
Brix-Elsig, Saskia, Dr.	Benthos Biology	SAM
Jeskulke, Karen	Benthos Biology	SAM
Korfhage, Severin	Benthos Biology	SAM
Raddatz, Jacek, PD Dr.	Hydrography - CTD	GEOMAR
Kniest, Jorit, Dr.	Hydrography - CTD	GEOMAR
Schwarz, Ralf	Benthic Lander	GEOMAR
Busse, Marc	Benthic Lander	GEOMAR
Gigli, Federico	Hydrography	NIOZ
Westbeek, Jara	Hydrography	NIOZ
Orejas, Covadonga, Dr.	Ecophysiology	IEO-CSIC
Gori, Andrea, Dr.	Ecophysiology	UB
Eberli, Gregor, Prof. Dr.	Sedimentology	RSMAS
Filander, Zoleka, Dr.	Benthos Biology	DFFE
Yahya, Saleh, Dr.	Marine Biology	DSFA
Shunula, Peter	Marine Biology	DSFA
Chioze, Ceiça	Marine Biology	InOM
Viadora, Rosário	Marine Biology	InOM
Kalvelage, Tim	Journalist	

Fig. 2.1 Scientific crew of expedition SO306 "CoWIO" on-board RV SONNE.

2.3 Participating Institutions

MARUM	Center for Marine Environmental Sciences, University of Bremen, Germany
SAM	Senckenberg am Meer, Wilhelmshaven, Germany
GEOMAR	Helmholtz Centre for Ocean Research, Kiel, Germany
DFFE	Department of Forestry, Fisheries & Environment, Cape Town, South Africa
DSFA	Deep Sea Fishing Authority, Zanzibar, Tanzania
IEO-CSIC	Spanish Institute of Oceanography Gijon, Spanish National Research Council, Spain
InOM	Oceanographic Institute of Mozambique, Maputo, Mozambique
NIOZ	Royal Netherlands Institute for Sea Research, Texel, The Netherlands
RSMAS	Rosenstiel School for Marine Sciences, University of Miami, USA
UB	University of Barcelona, Barcelona, Spain

3 Research Programme

3.1 Description of the Work Area

The West Indian Ocean is still a blank spot on the world map for many aspects of marine science. This is also true for the study of cold-water corals (CWCs) and their associated ecosystems. The few reports of CWC occurrences in this region are based on rather random and punctual sampling by a few expeditions between 1873 and 1988. However, predictive habitat modelling has indicated suitable habitats for reef-forming CWCs, particularly in the area around Madagascar and along the East African continental slope (Davies & Guinotte 2011). One of the main reasons for the very limited knowledge about the actual distribution of CWCs is the lack of high-resolution bathymetric maps as a basis for identifying potential CWC sites; low-resolution conventional nautical charts are often the only available bathymetric data base (Green et al. 2009). In combination with the limited availability of macrofauna samples, there was no suitable data to establish a general spatial distribution pattern of CWCs (and their associated fauna) for this region or even to estimate their species diversity and vitality. In addition, no information exists about the long-term, possibly climate-controlled development of the West Indian Ocean CWC ecosystems, since suitable sample material (e.g. coral-bearing sediment cores) is completely lacking.

For RV SONNE cruise SO306, following work areas in the West Indian Ocean were selected for detailed investigations: the Comoros archipelago (Mayotte; A) and the East African continental margin from Tanzania (B) along Mozambique (C and D) to South Africa (E; Fig. 3.1). As no studies of CWCs had been conducted in these regions prior to the expedition SO306, the work was largely exploratory in nature, but was nevertheless based on various earlier observations. For example, the area around the Comoros archipelago has the highest (though still low) number of reported coral findings within the West Indian Ocean (UNEP database; Cairns & Keller 1993; Rogers 1999; Zibrowius 1982; Zibrowius 1980). In addition, along the East African margin mound-like structures were identified on the northern flank of the Ruvuma Canyon and near the Limpopo estuary as part of seismic surveys during previous expeditions with RV METEOR (pers. comm. Dr. H. Keil and Dr. S. Wenau, Univ. of Bremen), which showed some similarities to CWC mounds in the Atlantic Ocean. And finally, the Kiel submersible JAGO discovered living corals on the flanks of the Ruvuma Canyon (pers. comm. K. Hissmann, JAGO team). Overall, all available reports and indirect evidence indicated the presence of CWCs in the West Indian Ocean in water depths between ~200 m and 900 m.

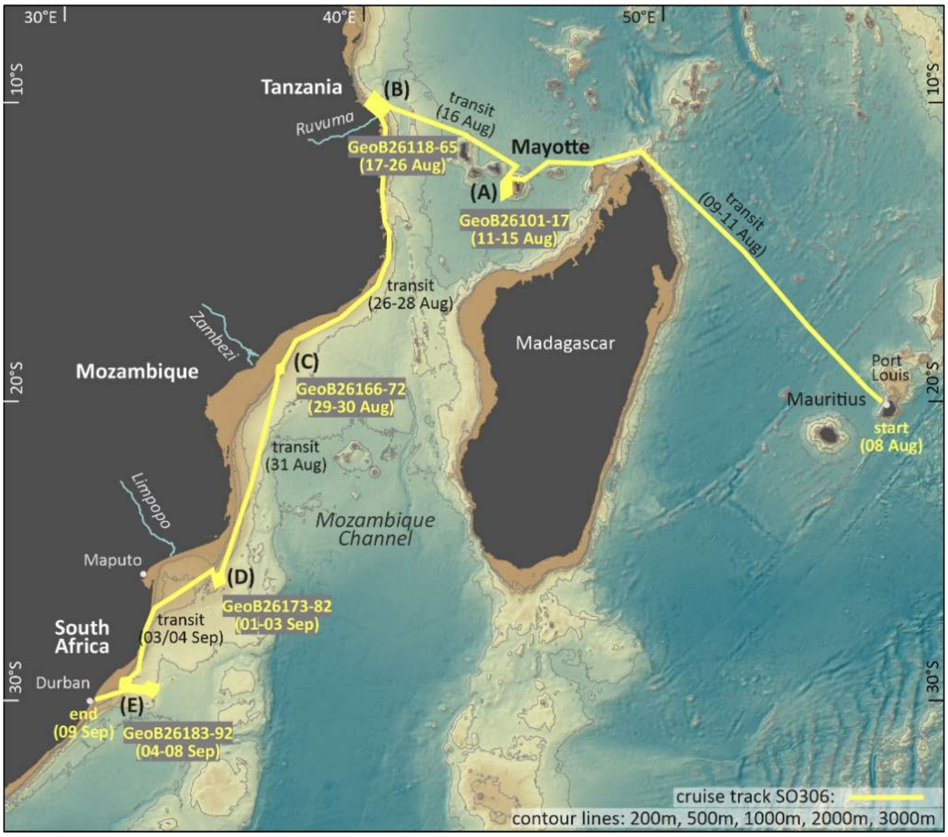

Fig. 3.1
Track chart of RV SONNE cruise SO306. The expedition started in Port Louis (Mauritius) on 08. August 2024 and ended in Durban (South Africa) on 09. September 2024. GeoB261xx indicate station numbers of the five working areas: (A) Mayotte, (B) Tanzania, (C) Mozambique off the Zambezi Delta, (D) Mozambique off the Limpopo river, and (E) South Africa.

3.2 Aims of the Cruise

The aim of the RV SONNE expedition SO306 was to systematically study the important bathyal CWC ecosystems in the West Indian Ocean for the first time with state-of-the-art marine technology, and to use the newly acquired data to analyse CWCs in the context of their global distribution and importance. The overarching goal of expedition SO306 was to gain a sound understanding of how environmental conditions and their temporal variability - often triggered by climate variability - affect the vitality of CWC ecosystems in the West Indian Ocean. The main were as follows: For the present-day situation, we aimed to (**i**) identify potential CWC habitats based on high-resolution mapping, (**ii**) conduct a systematic inventory of CWCs and their associated fauna through video mapping and faunal sampling, (**iii**) characterise controlling environmental factors through measurements of oceanographic parameters and water sampling in the immediate vicinity of

CWCs, and (**iv**) analyse o the plankton community as a relevant part of the trophic net. In order to reconstruct the response of CWCs to past climatic and environmental changes, further goals were to (**i**) identify past CWC growth phases using sediment cores collected from CWC mounds, (**ii**) reconstruct paleoenvironmental changes using so-called reference sediment cores collected from the flat seabed, and (**iii**) assess the environmental factors that controlled the emergence or decline of CWC reefs under different climatic conditions in the past.

3.3 Agenda of the Cruise

A standardized monitoring and sampling programme was carried out for each of the work areas selected for cruise SO306 (Fig. 3.1), starting with hydroacoustic mapping using the multibeam echosounder systems (MBES), the PARASOUND (PS) sub-bottom profiler and the Acoustic Doppler Current Profiler (ADCP). Based on the hydroacoustic mapping, a total of 13 video dives were conducted with the remotely operated vehicle ROV MARUM SQUID to characterise the existing facies and fauna in detail. These observations were complemented by studies of the structure and variability of the water column and its plankton communities using a CTD (14 single casts and 2 YoYo-CTD; supplemented by water sampling), a benthic lander system (2 deployments), and a multiple closing net (multinet; 7 stations). Special emphasis was placed on extensive surface sediment sampling using a video-guided giant box corer (TV-GBC) at 14 stations and an epibenthic sledge (EBS) at 11 stations. Long sediment cores were successfully retrieved with a gravity corer at 12 stations and will be used to study past environmental changes.

The Code of Conduct for Responsible Marine Research in the Deep Seas and High Seas (OSPAR) was fully respected during the cruise. Hydroacoustic mapping was not conducted in the known presence of marine mammals. Impacts on marine habitats were minimized through the use of video-guided and targeted sampling tools (ROV, TV-GBC), and all other seafloor sampling sites were carefully selected based on the video observations. All instruments deployed to the seafloor were successfully recovered. Samples and data were shared with the colleagues from Tanzania, Mozambique and South Africa, and further scientific collaborations were already planned during the cruise.

3.3.1 Deviations from the original cruise proposal

The preparation for this expedition was a challenge, as the countries whose exclusive economic zones were planned to be visited all had different regulations and requirements for applying for the various permits necessary to carry out the expedition (e.g. diplomatic clearances, additional permits, and contracts related to the Nagoya protocol). We managed to obtain most of the permits before the start of the cruise. However, communication with the authorities in the Comoros proved to be particularly difficult, as we did not receive a response to our enquiries until 10 months after we first made contact. As the sudden requests from the Comorian authorities could not be complied with because they reached us when we were already onboard, we were eventually denied the diplomatic clearance. However, this setback was successfully compensated for by extensive work around the island of Mayotte and off Tanzania. We had to spent a few more days than planned off Tanzania in particular, as the final research permit from Mozambique only arrived on the 27. August 2024. We also had to skip our northernmost working area off Mozambique due to ongoing riots onshore, which forced us to change our plans and select an alternative working area further south, off the Zambezi Delta. There, we were only able to work for one day as a storm was approaching the area. As Durban was our final destination, we used the last few days to work in an area off South Africa, but the prevailing strong currents and strong winds severely restricted sediment sampling in particular.

4 Narrative of the Cruise

Wednesday 06.08. - Sunday 11.08.2024 ◊ After two busy days of unloading containers, installing sampling gears on deck and preparing laboratories, RV SONNE left the harbour of Port Louis (Mauritius) on 8th of August at 8 am and set course to the first working area near the island of Mayotte (**A**; see Fig. 3.1). After three days of transit, we reached our first station in deep waters north of **Mayotte** on Sunday morning, where a first CTD-cast (**GeoB26101**) was conducted to obtain a sound velocity profile through the water column. Then, we started with some mapping transects to calibrate the EM122 MBES (**GeoB26102**).

Monday 12.08.2024 ◊ The night was spent to map (MBES/PS; **GeoB26103**) the western slope of the island while steaming along a line ~3 nm from the fringing coral reef of West Mayotte. Another CTD-station (**GeoB26104**) SW of the island preceded the first deployment of the ROV SQUID (**GeoB26105**). During the ROV dive, we observed a diverse fauna between black basaltic rocks and coarse sandy areas in 900-1000 m water depth. After the dive, one of the benthic SML landers was deployed to remain on the seafloor for several days to continuously collect hydrographic data (**GeoB26106**).

Tuesday 13.08.2024 ◊ During the night, we continued the hydroacoustic mapping (**GeoB26107**). After breakfast, the ROV was deployed close to the position where the dive the day before ended (**GeoB26108**). After only ~2 hours, the dive had to be aborted due to technical problems. In the afternoon, the TV-GBC, newly designed by MARUM, was successfully deployed for its maiden cast (**GeoB26109-1**). We continued with deployments of the EBS (**GeoB26109-2**) and the multinet (**GeoB26109-3**). The night was spent with a YoYo-CTD to continuously measure water mass properties through the water column across a full tidal cycle (**GeoB26110**).

Wednesday 14.08.2024 ◊ The day started with an ROV dive (**GeoB26111**) targeting a slightly deeper area off Mayotte (1100-1200 m depth). The ROV dived across sandy areas and large basaltic rocks. One striking observation was the presence of large patches of gorgonian rubble, which was surprising given the few living gorgonians in the area. As on the previous day, the station work was completed by deploying the EBS (**GeoB26112-1**) and the multinet (**GeoB26112-2**), followed by hydroacoustic mapping during the night (**GeoB26113**).

Thursday 15.08. & Friday 16.08.2024 ◊ The ROV was deployed in the morning (**GeoB26114**), this time targeting a comparably shallow site in 600-700 m depth. Diving upward a steep basaltic cliff, again a diverse fauna was observed, however with many more organisms compared to the previous dives in deeper waters. As this was the last day in the working area off SW Mayotte, we recovered the lander (**GeoB26115**) and finished the work with two more deployments of the EBS (**GeoB26116/17**). In the evening of 15. August, we started the transit towards Tanzania, which lasted roughly 30 hours.

Saturday 17.08.2024 ◊ At 6 am, we entered the work area off **Tanzania** (**B**; see Fig. 3.1) and started our station work with a CTD-cast down to ~2600 m water depth to obtain a sound velocity profile for hydroacoustic calibration and to collect water samples (**GeoB26118**). During the subsequent hydroacoustic mapping (MBES/PS; **GeoB26119**), which took us close to the

Tanzanian coast, some mound-like structures were detected at 250-450 m water depth. We deployed the TV-GBC and inspected two of the mapped "mounds" (and additionally sample one; **GeoB26120/21**). Both seabed structures appeared to result from slumping rather than being coral mounds. However, the shallower structure at 270 m depth revealed a rich benthic fauna (incl. corals) covering a rocky and steep landscape, which did not allow sampling (**GeoB26121**). After another CTD-cast (**GeoB26122**), the night was spent with hydroacoustic mapping (**GeoB26123**).

Sunday 18.08.2024 ◊ The bathymetric map produced during the night showed some more mound-like structures, but again these appeared to be the result of submarine landslides rather than CWC mounds. An ROV dive that began in the morning took us to a submarine canyon that may be a favoured habitat for CWCs (**GeoB26124**). Although we did not find any corals, we did find (and sample) numerous remains of plants (seagrass, mangrove leaves), demonstrating the important role of these channels in transporting carbon from the land and shallow waters towards the deep sea. In order to assess the different components of the regional trophic net, the ROV dive was followed by sampling with the TV-GBC (**GeoB26125/26**), multinet (**GeoB26127**), and EBS (**GeoB26128/29**).

Monday 19.08.2024 ◊ This day started with a big surprise. The overnight hydroacoustic mapping (**GeoB26130**) revealed a very conspicuous structure on the seafloor: a "mound" with a diameter of ~750 m and a height of 80 m. During the subsequent ROV dive (**GeoB26131**), it quickly became clear that this was a seepage site - a discovery that surprised everyone onboard. The seepage became obvious by the presence of authigenic carbonates, large accumulations of shells, and finally the discovery of large beds of live chemosymbiotic mussels near the eastern summit of the structure at a depth of ~870 m. Afterwards, we collected a seafloor sample with the TV-GBC (**GeoB26132**) from a very small sediment pocket on this structure. Then, we placed the benthic SML lander (**GeoB26133-2**) on the summit close to the living chemosymbiotic mussels and deployed the CTD twice (**GeoB26133-1/34**) to collect water samples at different depths of the seep structure, which is characterised by spatially very different benthic life: corals vs. mussels.

Tuesday 20.08.2024 ◊ The overnight hydroacoustic mapping (**GeoB26135**) showed no more of these structures, so we decided to conduct another ROV dive (**GeoB26136**) at the same seepage structure. The dive started at the eastern summit area, covered by the extensive mussel beds, and ended at the western summit characterised by rock outcrops and large boulders colonised by a variety of CWCs. Various rock samples and greenish mud collected by the ROV indicate that this 80 m high seep structure is a mud volcano (MV). Another carefully positioned TV-GBC (**GeoB26137**) followed by a multinet (**GeoB26138**) completed the sampling. During the night, we extended the hydroacoustic mapping (MBES/PS; **GeoB26139**) to the NE into deeper waters.

Wednesday 21.08.2024 ◊ This day was spent to collect sediment cores with the gravity corer, which will be used for paleoceanographic studies. We took four cores with recoveries between at water depths ranging from ~400 m to ~1500 m (**GeoB26140/41 & 43/44**). The transit between the coring sites was used to fill in some gaps in the MBES map (**GeoB26142**). During the day, the mapping team was able to identify several flares in the water column above this MV likely reflecting rising gas bubbles. They also identified the locations where these flares emanated from the seabed. During the night, we did a YoYo-CTD (**GeoB26145**) on top of one of these sites, hoping to record variations in the water column corresponding to the flares, but without success.

Thursday 22.08.2024 ◊ This day began with an unwelcome surprise: the combination of swell and currents (>1.5 kn) did not allow the planned deployment of the ROV. Instead, we took the opportunity to extend our MBES map to greater water depths and search for further mound structures (**GeoB26146**). In the afternoon, we recovered two more gravity cores (**GeoB26147/48**), before the night was again spend with hydroacoustic mapping (**GeoB26149**).

Friday 23.08.2024 ◊ With less swell and slower currents, the ROV was deployed after breakfast (**GeoB26150**). The target was once again the MV, which we named "**Mtwara mud volcano**" as suggested by our Tanzanian colleagues. During the dive, we again observed large mussel fields. Unfortunately, the currents increased and after a few hours of diving, we lost the data communication to the ROV. Without being able to control the ROV, the recovery in the strong current conditions (>1.5 kn) became quite tricky, but was successfully completed. Two further deployments of the TV-GBC on the MV allowed targeted sampling of a sandy patch (**GeoB26151**) and of a mussel field (**GeoB26152-1**). At the latter station, an additional CTD-cast was conducted to collect bottom water samples needed for aquaria experiments (**GeoB26152-2**). The night was again spent to extend our MBES map in search of additional seabed structures (**GeoB26153**).

Saturday 24.08.2024 ◊ Current velocities approaching 3 kn did not allow for an ROV dive at a shallow site in ~300 m water depth. Instead, we used the TV-GBC for a video survey (**GeoB26154**) and discovered a somewhat chaotic pattern of near-vertical walls up to 10 m high covered by rich benthic fauna (anemones, corals, etc.). Due to the absence of any seep fauna and authigenic carbonates, this structure has been interpreted as a mass wasting deposit. Sampling at this site was completed with the deployment of the EBS next to this structure (**GeoB26155**).

Sunday 25.08.2024 ◊ The overnight hydroacoustic mapping (**GeoB26156**) ended at the next CTD station in roughly 1800 m depth (**GeoB26157**), where we obtained a new sound velocity profile needed for the hydroacoustic calibration. Afterwards, we collected a gravity core at ~1650 m water depth (**GeoB26158**). We successfully recovered the lander from the MV, where it has recorded hydrographic data for almost one week (**GeoB26159**). A further deployment of the EBS at a deep station (**GeoB26160**) extended the depth transect covered with this instrument down to 1650 m. The night was spent with hydroacoustic mapping (**GeoB26161**).

Monday 26.08.2024 ◊ The newly discovered Mtwara MV lies above a major fault line and the MBES data obtained during the night revealed a second, circular structure with a little dome in its center at ~1600 m water depth. The wind was much weaker as the previous days, but due to the strong currents, it was not possible to use the ROV in this depth, therefore we inspected this structure with the TV-GBC (**GeoB26162**). We could not detect any seep fauna, but we saw several rocks similar to the authigenic carbonates discovered on the Mtwara MV. Unfortunately, sampling with the TV-GBC failed. From there, we moved on to an even deeper station at ~1800 m to collect another gravity core (**GeoB26163-1**) and to deploy the EBS (**GeoB26163-2**). The night was spent to complete the bathymetric map for our Tanzanian working area (**GeoB26164**).

Tuesday 27.08. – Thursday 29.08.2024 ◊ An ROV dive in the morning to investigate a steep canyon wall (>30° slope angle) in ~500 m water depth (**GeoB26165**) had to be aborted as the currents were still too strong to allow for a safe operation of the ROV. Upon recovery, we finally received the research permit for Mozambique and, consequently, we set the course south to start a ~2 days transit. On Thursday evening, we reached the next working area off **Mozambique** (**C**: off the Zambezi Delta; see Fig. 3.1), where station work commenced with deployments of the CTD (**GeoB26166-1**) and the multinet (**GeoB26166-2**). The night was used for hydroacoustic mapping (**GeoB26167**) of the area.

Friday 30.08.2024 ◊ The inspection of the MBES map produced during the night was disappointing at first glance: we only found some small elevations. However, some of the small elevations occurred along a straight line with one "conspicuous" kink. We deployed the TV-GBC (**GeoB26168**) and were surprised to see abundant small chimneys at the seabed, of which several could be collected by the TV-GBC. This observation led us to plan for an ROV dive in the afternoon. In between, we collected one gravity corer (**GeoB26169**) and one sample with the EBS (**GeoB26170**). The ROV dive (**GeoB26171**) revealed even more chimneys and also some bacterial mats, surrounded by some CWCs – now we were sure that we discovered another MV (later on named "**Zambezi mud volcano**" as suggested by our Mozambican colleagues). This was also supported by the analysis of the PS data from the previous night. After a final CTD-cast (**GeoB26172**), we left the area off Zambezi to continue our transit south because the weather forecast predicted bad weather conditions for this area for the coming days.

Saturday 31.08. – Sunday 01.09.2024 ◊ The night to Saturday was quite rough and during the day, RV SONNE was only slowly progressing southward because it had to fight against winds of >7 Bft and waves of up to 5 m in height. During the night to Sunday, the weather conditions improved and allowed to reach the new working area off south Mozambique (**D**: off the Limpopo Bay; see Fig. 3.1) on Sunday evening, where we started station work with a CTD-cast (**GeoB26173**) to obtain a regional sound velocity profile and to collect bottom water samples. The following night was spent with hydroacoustic mapping (**GeoB26174**), during which we detected a field of several rather shallow seamounts.

Monday 02.09.2024 ◊ In the morning, we started an ROV dive (**GeoB26175**) to a small ridge attached to the foot of a seamount in ~740 m water depth. Hoping for a sedimentary ridge formed by CWCs, we found a basaltic ridge colonised by very little benthic live. Possibly an indication that this lava flow has been put in place quite recently. Consequently, we ended this dive and moved to the top of this seamount, where ROV SQUID had its 100th dive (**GeoB26176)**. The top of this seamount in ~290-320 m depth was a perfect target for such a special dive: it was covered by the most colourful and diverse coral garden we had so far encountered during this expedition. Afterwards, we deployed the CTD for water sampling (**GeoB26177)** and the multinet for plankton sampling (**GeoB26178)**, followed by an overnight hydroacoustic mapping (**GeoB26179**).

Tuesday 03.09.2024 ◊ The ROV dive target planned for this day (**GeoB26180**) was a second seamount with an even shallower summit at 180 m water depth. As we slowly dived up the slope to reach the top, again encountering a colourful coral garden, we noticed that a surface buoy was anchored to the top. To prevent the ROV from becoming entangled in the buoy's anchor line, we decided to abort the dive. Once the ROV was safely back on deck, we left the sediment-starved seamount area and headed north, where the slope is covered by extensive drift deposits. There, we took two gravity cores at 1000 m (**GeoB26181**) and at 500 m water depth (**GeoB26182-1**) and an EBS sample (**GeoB26182-2**). We then began our transit south to our final working area off **South Africa** (**E**; see Fig. 3.1).

Wednesday 04.09.2024 ◊ What was supposed to be a full transit day ended already at 4 pm. Pushed by the wind (up to 10 Bft), waves (>3 m high), and strong currents (~4 kn), RV SONNE "sprinted" south. However, although, we reached our next working area off South Africa much earlier than expected, the weather conditions posed a problem for the planned work. An attempt to deploy the CTD had to be aborted and also the planned transects for hydroacoustic mapping (**GeoB26183**) had to be adjusted to be "doable" under these conditions.

Thursday 05.09.2024 ◊ The overnight mapping revealed some interesting mound-like structures. Despite the Agulhas Current rushing through the working area at >4 kn, we managed to deploy the

TV-GBC (**GeoB26184**) and during a one-hour video mapping, we observed a silty sandy seabed. Due to the strong currents, we missed our targeted "mound" structure and had to recover the TV-GBC. We planned for a second deployment of the TV-GBC (**GeoB26185**), this time reaching the seabed further upstream of our target structure, but strong bottom currents (>3 kn) made it difficult to identify objects on the seabed. In addition, just before the TV-GBC reached the targeted "mound" structure, part of the wire-guiding frame of the ship's crane broke off and the station had to be aborted. Increasing winds did not allow further deployment of the TV-GBC, instead the CTD (**GeoB26186**) and the multinet (**GeoB26187**) were deployed. During the night, we mapped an area closer to the coast (**GeoB26188**) in the hope being a bit better protected from the currents. However, this was not the case, instead the wind direction changed and we had to face strong winds and waves against the current, which made the situation even more difficult.

Friday 06.08.2024 ◊ Critical assessment of the wind and current situation in the morning revealed that seabed sampling in our target region would not be possible. Therefore, we decided to head to an area further offshore being less impacted by the Agulhas Current. At ~2 pm, we reached a suited station to collect a gravity core in ~1800 m water depth (**GeoB26189**). The night was spent with hydroacoustic mapping (**GeoB26190**).

Saturday 07.09.2024 ◊ Taking advantage of the greater water depths in this area, we started in the morning with a CTD-cast going down to ~2000 m (**GeoB26191**). After ~1 hour of transit, we reached the next station (**GeoB26192**), but the attempt to collect a gravity core failed because the core tube was bent when the corer hit a hard sediment layer. This was our final station for this expedition. We used the rather calm wind and wave situation to start storing the heavy equipment (ROV, TV-GBC, EBS, gravity corer) in the containers.

Sunday 08.09. & Monday 09.09. 2024 ◊ The day was spent to pack the laboratory equipment and the samples, clean the labs, and for a final science meeting, while RV SONNE was sailing to Durban. There, the expedition SO306 ended on 09. September at 1 pm with a few hours delay due to the again bad weather conditions hampering the transfer of the pilot to the vessel.

5 Preliminary Results

The preliminary results of the hydroacoustic mapping, hydrographic measurements, video observations and sediment/fauna sampling carried out during the RV SONNE expedition SO306 are based on a range of instrumentations (MBES/PS, ADCP, CTD-rosette, lander, ROV MARUM SQUID, TV-GBC, gravity corer, EBS). All instruments, including their technical specifications, operational set-up and list of deployments are presented in the Appendix. The Appendix also provides details on sample treatment and methodologies as well as detailed core descriptions (TV-GBC, gravity corer).

5.1 Mayotte

Reports from previous expeditions, taking dredge samples along the margins of Mayotte, provided clear indications for the presence of CWCs in this region. As we were asked to not get closer than 3 nm to the fringing coral reef around Mayotte, the southwestern margin of the island remained as the only accessible working area allowing to work in water depths <1000 m. The rocky slopes of the island, mainly made up of basaltic rocks, were settled by a diverse CWC community and many other marine invertebrates. In water depths between ~580 and 1330 m, we did not find any CWC reefs during ROV observations. However, a large accumulation of fresh-looking coral rubble could indicate the presence of a nearby reef. Large amounts of remains of gorgonians point to a quite recent mortality event, which was speculated to be related to severe earthquakes that were associated to the submarine eruption of the Fani Maoré volcano about 40 km east of Mayotte in 2018 (Puzenat et al. 2018). Beside mapping and ROV observations, we completed a diverse sampling and monitoring program (Fig. 5.1.1 shows the MBES overview map of the study area with all stations). In addition, we were asked by the Mayotte authorities to monitor marine mammals and sea turtles in the region during the day. However, during 5 days of monitoring we only had three confirmed whale sightings.

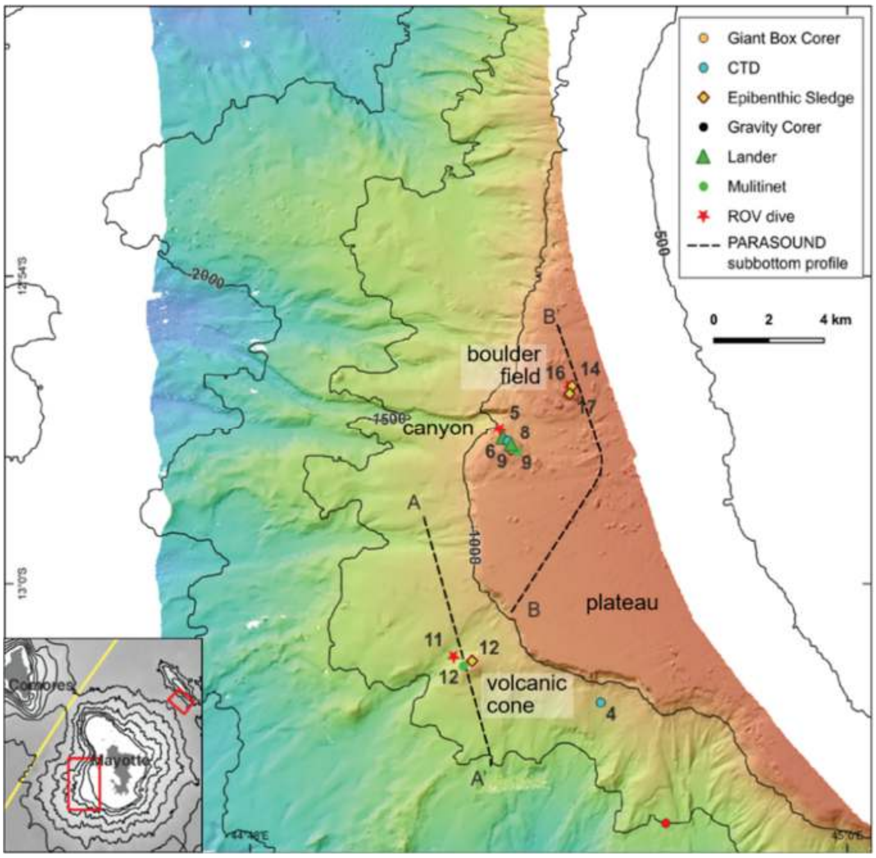

Fig. 5.1.1
Overview map of the SW Mayotte slope and plateau mapped by MBES (30x30 m horizontal resolution) during RV SONNE expedition SO306. The inset shows the position of the main working area SW of Mayotte and the area mapped for the MBES calibration in the NE of the island. A submarine plateau with boulders and blocks ends and a steep margin overlays the ridges and canyons of volcanic cone of SW Mayotte. Indicated are sampling positions (GeoB 261xx; see legend for gear symbols) and PARASOUND lines (dashed lines) presented in chapter 5.1.3.

5.1.1 Water Column Structure

Water column profiles were recorded at three sites in the area around Mayotte, utilising the CTD. This included a Yo-Yo cast that spanned 11 hours. All CTD casts (n=13) reveal a similar water column structure. The 3150 m of the water column investigated here exhibit the presence of different water masses, that enter the Comoros Basin solely from the north (Breitzke et al. 2017). The upper section of the water column is comprised of Tropical Surface Water (TSW) and Subtropical Surface Water (STSW), which are underlain by intermediate water masses such as the South Indian Central Water (SICW) and Red Sea Water (RSW). The North Indian Deep Water (NIDW) forms the deepest water mass in the northern Mozambique Channel (Fig. 5.1.2; Ullgren et al. 2012). The two surface water masses are characterized by a linear trend in the temperature-salinity relation, ranging from 27°C/34.9 PSU at the surface to about 15.5°C/35.3 PSU in water depths of 250 m. Furthermore, the surface waters reveal a decline in dissolved oxygen with increasing depth. The oxygen concentrations range from 6.2 mg/l at the surface to 3.5 mg/l at the transition to the intermediate water masses at ~250 m. This transition to the SICW is characterised by an inversion in the trends of salinity and dissolved oxygen concentration. The oxygen concentration increases and reaches a maximum of 5.5 mg/l at a depth of ~500 m. In contrast, the salinity decreases to 34.7 PSU down to a water depth of ~750 m (Fig. 5.1.2). The influence of the RSW around Mayotte is only minor and is manifested in a slight increase in salinity (~0.1 PSU) and a reduction in oxygen concentration to a minimum of 2.6 mg/l at ~1000 m water depth. Below a depth of 1000 m, the water column is characterised by the NIDW, which is defined by a decrease in temperature to 1.7°C and an increase in oxygen concentration to 5.1 mg/l, while salinity remains rather stable at ~34.75 PSU below 1250 m depth.

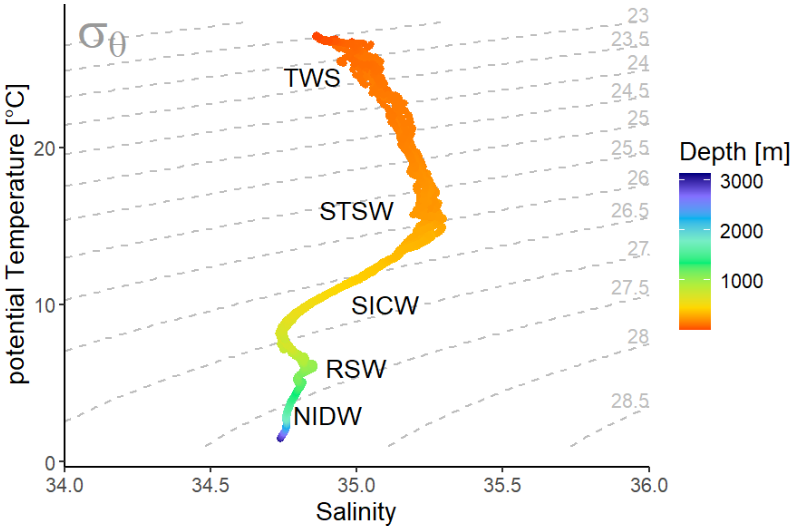

Fig. 5.1.2 Temperature-Salinity relation off Mayotte – CTD data from three sites around Mayotte including sigma-theta pycnoclines (density contours are plotted as the dashed grey lines). Water masses: Tropical Surface Water (TSW) and Subtropical Surface Water (STSW), South Indian Central Water (SICW), Red Sea Water (RSW), North Indian Deep Water (NIDW).

During the transit from the north to the SW of Mayotte island, variabilities in the current strength and direction in the waters around Mayotte were recorded with the ship's ADCP (Fig. 5.1.3). In the upper 200 m of the water column N and SW of Mayotte, the current velocity was relatively high, reaching 50 cm s^{-1}. Below 200 m depth, current velocities were generally low around 5 to 10 cm s^{-1}. However, at about 400 m depth, north of Mayotte the current velocity reached 30 cm s^{-1}.

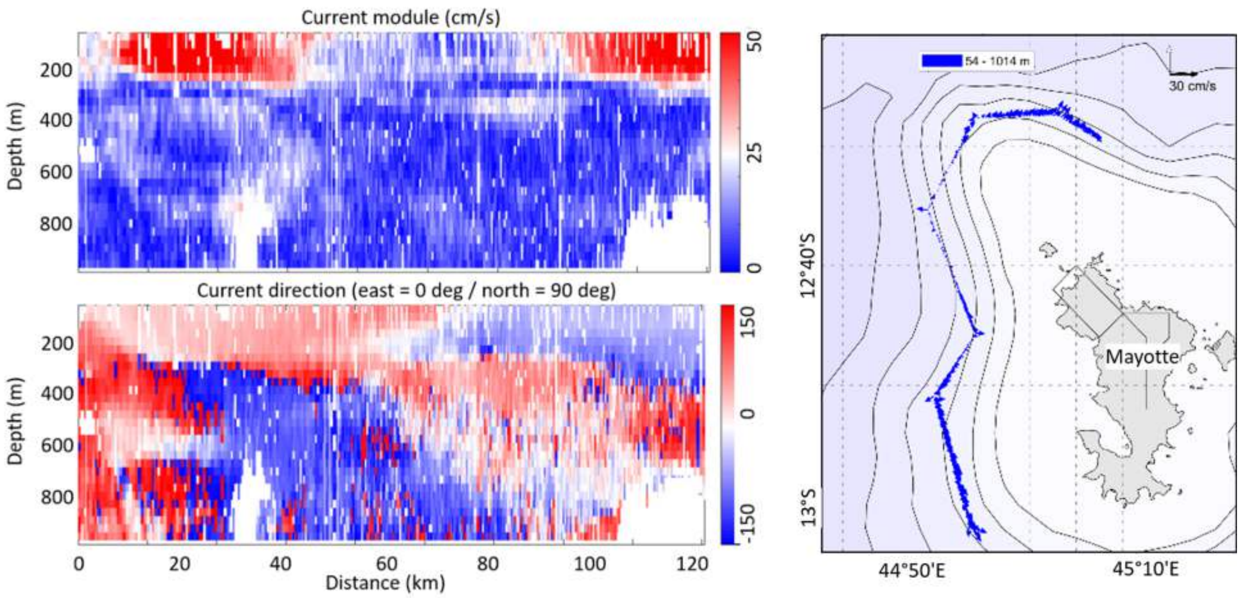

Fig. 5.1.3 (left) Current speed and direction and (right) average current velocity along the transit line from north to southwest of Mayotte obtained with the ship-based ADCP 38 kHz.

The water column of the central western part of Mayotte is characterized by generally lower velocities up to 10 cm s^{-1} with local intensifications of up to 35 cm s^{-1} at 200 and 350 m depth. In the upper 300 m of the water column, changes in current direction from NW in the north to SE in the southwest were observed. In the lower part of the water column changes in current direction from NE to SW and back to NE can be identified.

5.1.2 Time-Series Lander Data

To detect temporal oceanographic changes near the seafloor, a benthic lander system was deployed next to the first ROV dive (GeoB26105-1) for 69 hours at a depth of ~830 m, corresponding to the lower part of the SICW. Over three days, distinct changes in temperature, salinity and dissolved oxygen concentration with an average periodicity of ~12 hours were observed (Fig. 5.1.4). On average, temperature and salinity changed by ~1°C and 0.05 PSU, respectively, during such tidal cycle, which distinctly exceed the variations observed during the YoYo-CTD casts (cf. Dullo et al. 2018). The concentration of dissolved oxygen varied from 3.3 to 4.3 mg/l between the tides. In addition, the lander ADCP recorded current velocities ranging from almost 0 to up to 25 cm s^{-1} within 40 cm above the seabed (Fig. 5.1.4). Phases with enhanced current flow appeared roughly every 12 hours arriving from western direction. These internal tides are most likely induced by reflecting baroclinic tidal waves approaching Mayotte from the west.

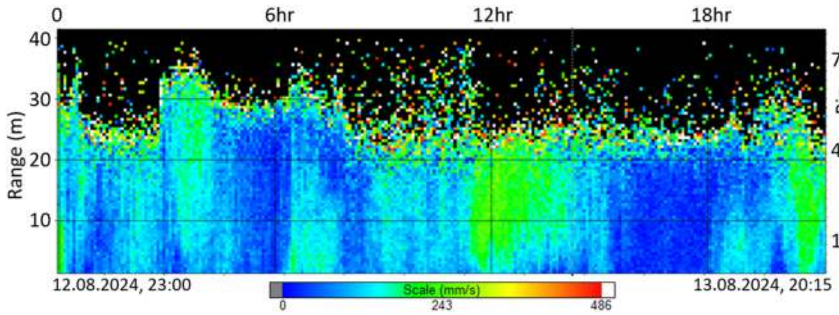

Fig. 5.1.4 Lander ADCP profile. Current velocity magnitudes of the last 22 h of the lander survey off Mayotte.

5.1.3 Bathymetry and Sub-Seafloor Structures

A digital elevation model of Mayotte island and its volcanic base constructed from 50x50 m gridding of MBES bathymetry and general description of the sea scape was published by Audru et al. (2006). During expedition SO306, new high-resolution MBES bathymetry was acquired on transit from the NE to the working area at the SW side of the island, where a slightly westward titling submarine plateau caps a heavily channelized lower slope of the volcanic edifice (Fig. 5.1.5). The slightly westward dipping plateau is situated at approximately 600-750 m water depth. It has a generally smooth surface but is in places dotted with large slabs, boulders, and blocks ranging in size from a few meters to >1 km and tens of meters in height. The plateau ends seaward with a sharp edge and a steep nearly 200 m high margin that is with its declivity and small-scale collapse features reminiscent of a carbonate platform margin. Striations and small channels indicate that the plateau was once subaerially exposed. The average subsidence rate is 19 cm kyr^{-1} (Camoin et al. 2004), which would make the plateau approx. 3 myrs in age (Audru et al. 2006). One possibility is that this plateau is an infilled atoll lagoon. One large canyon incises far into the plateau while all other large canyons of the lower slope terminate at the foot of the submarine plateau (Fig. 5.1.5). The plateau-reaching canyon has sharp vertical walls as it is typical for boundaries of margin collapses.

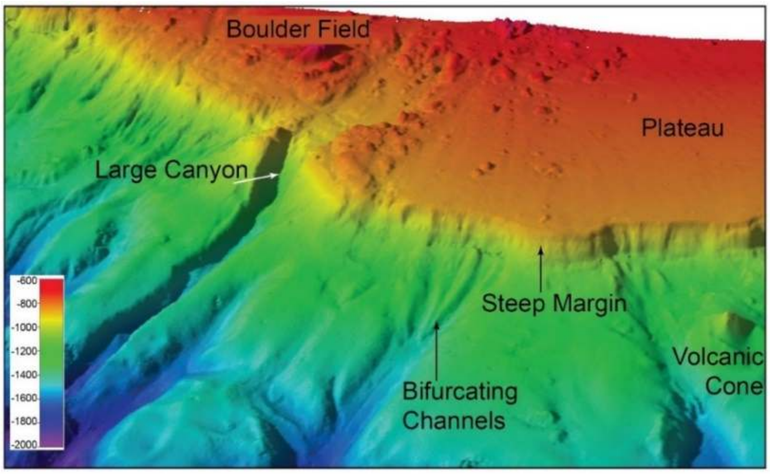

Fig. 5.1.5
3-D view of the study area, displaying the different geomorphologic elements described in the text.

The southern canyon wall and its adjacent flat plateau were one of the sites visited with the ROV, revealing the layered volcanic succession below a bioturbated sediment covered plateau (Fig. 5.1.6). Above the canyon head, the largest and most abundant boulders and blocks are situated, forming a seascape with towering blocks on the flat plateau. The slopes below the plateau are dissected by variable sized channels and large canyons as is typical for volcanic slopes. An approximately 500 m wide cone at around 1200 m water depth and knobby, downslope ridges are indicative of lava leakage on the side of the volcano. Boulder fields at the toe of the slope and slump scars on the slope document submarine mass wasting and the resultant deposition of mass transport complexes. Bifurcating of the channels in an up-dip direction, however, give evidence of water flow creating or at least deepening the channels and canyons. Based on the PARASOUND data, the channels do, however, not contain sediments and are thus mostly erosional (Fig. 5.1.6). The submarine plateau also mostly has a hard surface with very thin sediment cover and an occasional pocket of a few meters of sediment (Fig. 5.1.6).

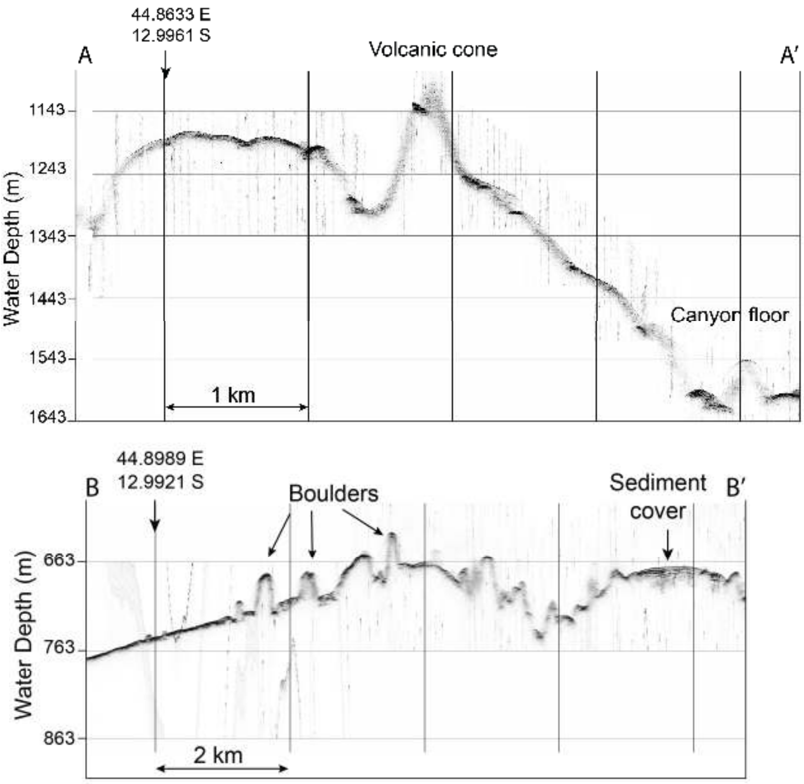

Fig. 5.1.6
(top) PARASOUND line from channelized slope area, illustrating the lack of sediment cover in channels. (bottom) PARASOUND line from the plateau with boulders and a sediment pocket between two boulders. Position of PARASOUND lines are indicated on the overview map in Fig. 5.1.1.

5.1.4 ROV Observations

In total four ROV dives were conducted on the volcanic plateau SW of Mayotte. This deep insular shelf was inspected by dredging during the BENTHEDI (1977) and the BIOMAGLO (2017) expeditions, and information on CWC samples can be retrieved from the online data repository of the Muséum national d'Histoire naturelle, Paris (MNHN). The ROV dives focused on two submarine slide scar structures and their flanks including some adjacent cones north and south of the canyon covering an overall depth range from ~580-1330 m depth.

ROV-Dive GeoB26105 (SQUID Dive 089) - The ROV dive reached the bottom at 906 m depth, where the sedimentary environment was dominated by pebbles and boulders of volcanic origin. The coarse sand cover between the pebbles and boulders comprise foraminifers, pelagic gastropod shells and coral rubble pieces. Some free-living, small solitary corals stick out from the sediment surface. The volcanic hard substrates provide habitat for a number of suspension feeder, such as encrusting sponges and ascidians, articulate and inarticulate brachiopods, stylasterids, serpulids and brittle stars (Fig. 5.1.7a). At 900 m depth, we crossed a field of meter-sized basalt boulders at the base of a 60 m high escarpment. Sandy sediment patches between the boulders showed ripple structures. The huge boulders displayed a very dispersed colonization of live and dead hexactinellid sponges. Interestingly, any of these erect organisms host one or several crinoids.

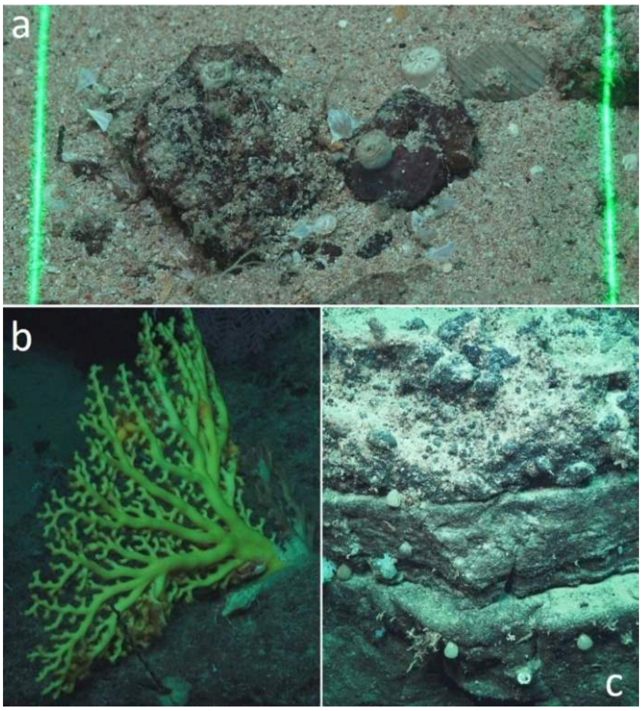

Fig. 5.1.7
(a) The sedimentary facies near the canyon head at 906 m depth. Basalt pebbles and coarse foraminifer sand admixed with pteropod and other mollusk remains and a solitary scleractinian in life position. Inarticulate brachiopods were attach-ed to the pebbles. Laser scale = 10 cm. (b) Live *Enallopsammia rostrata* colony at 864 m depth. Note the yellow tissue and the polyps pointing against the main residual current. Height of this colony is 30 cm. (c) A polymodal pyroclastic flow on top of a well-sorted fine-grained flow serves a substrate for several articulate brachiopods. Thickness of the central flow bed is 12 cm for scale.

On our track climbing up the escarpment, we saw and sampled our first *Enallopsammia rostrata* colony at 864 m depth (Fig. 5.1.7b). The tissue color is bright yellow and all polyps point against the main residual current. The escarpment consisted of different, alternating layers of fine-grained lava flows, polymodal pyroclastic flows and massive basalt outcrops which document repeated effusive eruptions (Fig. 5.1.7c). During the ascend along the escarpment, we came across >60 cm high and wide paramuriceid octocorals which hosted brittle stars, chirostylid decapods and crinoids and *Chrysogorgia* sp. octocoral colonies. Any *Chrysogorgia* encountered on this dive acted as domicile for one decapod and in one case also two orange colored nudibranchs. Other fixo-sessile organisms seen on the escarpment were farreid hexactinellid sponges, stylasterids and articulate brachiopods (Fig. 5.1.7c). The escarpment top was reached at 840 m depth and from here onwards the topography was relatively even, interrupted by few basalt blocks. This section yielded many 30 cm-large funnel-shaped euplectellid sponges, whose roof was closed by a sieve-like meshwork of megascleres. Interestingly, two shrimps live within the funnel body of the glass sponge, unable to ever leave their home. The dive ended at 837 m depth.

ROV-Dive GeoB26108 (SQUID Dive 090) - This ROV dive was dedicated to further explore the volcanic plateau for its CWC distribution pattern in continuation of the previous dive. The ROV reached the seabed at 773 m depth. The sediment facies comprised a weakly rippled coarse sand with large, about 70 cm high pennatulaceans as well as some *Hyalonema* glass sponges. Outcropping lava substrate with very rugged surfaces are inhabited by stylasterids. In one occasion, we collected an echinophorid sea urchin. As soon as pebbles of volcanic origin appeared, we encountered more *Chrysogorgia* colonies, which hosts a decapod inside (Fig. 5.1.8). Due to technical problems, we had to abort this dive at 773 m.

Fig. 5.1.8 Close-up of a decapod living within a C*hrysogorgia* octocoral colony at 773 m depth. Width of colony is 10 cm.

ROV-Dive GeoB26111 (SQUID Dive 091) – At this deepest dive off SW Mayotte, the ROV touched the seabed at the southern flank of a slide scar at 1333 m depth. The seabed consisted of sand admixed with CWC and gorgonian rubble. Larger grains were black or rusty coated, which is indicative for a long exposure time on the seabed. Dead trunks of *Hyalonema* glass sponges were common but their large stems composed of up to 30 cm long megascleres served as habitat for actiniarians, hydroids, hermit crabs, brittle stars. Very often a crinoid rested on top of the sponge stem. Upslope, the sediment-dominated area became interrupted by outcropping flat inclined basalt blocks with relatively smooth surfaces. These hard substrates host a diverse suite of other glass sponge species and *Chrysogorgia* colonies. The latter were inhabited by chirostylid decapods. At 1318 m depth, the relict sediment cover turned into a thin veneer over a crust-like substrate with cracks. These basalt blocks got higher as did the colonization by glass sponges and octocorals in 1326 m depth. First *Enallopsammia* colonies appeared at 1297 m depth. Their soft tissue colour is pale yellow to translucent and not bright yellow as seen in Dive 089 (Fig. 5.1.9a). Again, all corallites point against the main residual current. No competitive other organisms were found on the tissue-covered coral skeleton, except for gall-forming ascothoracid cirripeds. Infestation of others started on the tissue-barren skeleton near the colony bases. From 1291 m depth upslope, pronounced coral rubble pockets made by CWC and gorgonian remains became a prominent feature in this basaltic section. An intriguing example of the taphonomic fate of a recently died and fallen *Enallopsammia* colony is exemplified in Fig. 5.1.9b. At 1272 m depth, we encountered the first stalked crinoids, *Hyocrinus* c.f. *cyanae* jointly associated with erect glass sponges attached to the basalt basement (Fig. 5.1.9c). The inclined basalt-dominated slope, interrupted by small sediment pockets continues upslope to 1150 m. In total, the basalt-dominated wall encountered had a thickness of 177 m. The above-mentioned coral rubble accumulations trapped in the sediment pockets gain in frequency and thickness (Fig. 5.1.9d). Interestingly, the rubble is superiorly made of gorgonian skeleton remains, which generally have a limited fossilization potential, except for the stronger calcified holdfasts. Another megafaunal highlight was an about 1.4 m wide and 1.1 m high, fan-shaped keratoisidid bamboo coral colony at 1167 m depth (Fig. 5.1.9e). We also encountered a chrysogorgiid *Iridigorgia* sp. octocoral at 1165 m depth. At 1150 m depth the inclined basalt wall gave way to a gently inclined plain with outcropping volcanic rocks accentuated by a very rugged surface texture and larger but thin veneers of soft sediment. No change in faunal composition was observed here, same glass sponges, stalked crinoids, stylasterids and antipatharians. We stopped the dive at 1155 m depth.

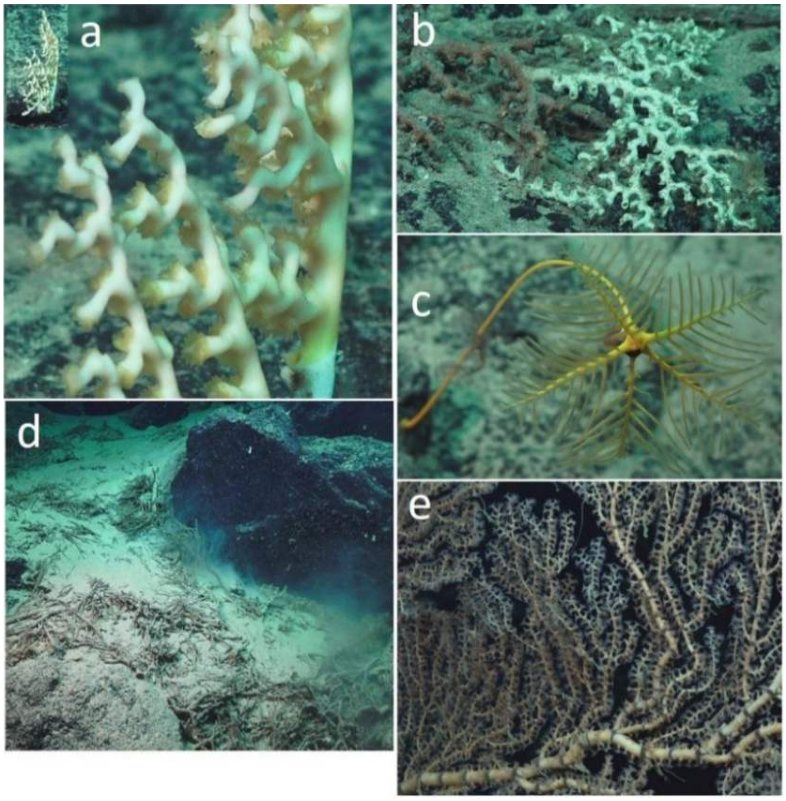

Fig. 5.1.9
(a) A 25 cm high *Enallopsammia* colony (insert image) and close-up displaying the corallite arrangement, polyp activity and tissue at 1297 m depth. (b) Different taphonomic stages of degradation in a recently died *Enallopsammia* colony at 1291 m depth (size of colony = 20 cm). (c) The crown of *Hyocrinus* c.f. *cyanae* from Mayotte at 1272 m depth. Height of specimen is 35 cm. (d) Example of one of the plenty gorgonian graveyards accumulated in sediment pockets at 1258 m depth. (e) Close-up of the large keratoisidid bamboo coral with its strongly calcified internodes. Some probably green bioluminescent solenogastrids clinged around the branches of this octocoral at 1167 m depth.

ROV-Dive GeoB26114 (SQUID Dive 92) - The objective of this dive was to compare the previous observations to this shallowest site off Mayotte. The target was an about 100 m high and 600x200 m wide cone with a flat top. The dive started at 696 m water depth. The sedimentary facies exhibited a gravelly-bioclastic sand whose components were mostly brownish stained which is indicative for a relict lag deposit (Fig. 5.1.10a). Recognizable components were CWC and stylasterid rubble, otoliths, mollusk hash and grains of volcanic origin surrounded by decimeter-sized crust-like boulders. Faunal elements in this sector near the base of the cone comprised large geryonid decapods and dispersed pennatulacean octocorals. The base of this volcanic cone was reached at 693 m depth. During an ascend of 87 meters, we encountered many dead gorgonians being parasitized by zoanthids, but also larger stylasterids, asteroids, holothurians and glass sponges covered by yellowish zoantharians or actinarians as symbionts (Kise et al. 2022). Live primnoid octocorals were seen from 664 m onwards. A remarkable consortium of stylasterids, another zoanthid species, stoloniferous octocorals and glass sponges with yellow zoanthids were documented at 657 m depth (Fig. 5.1.10b). First live *Enallopsammia rostrata* occurred at the same depth level.

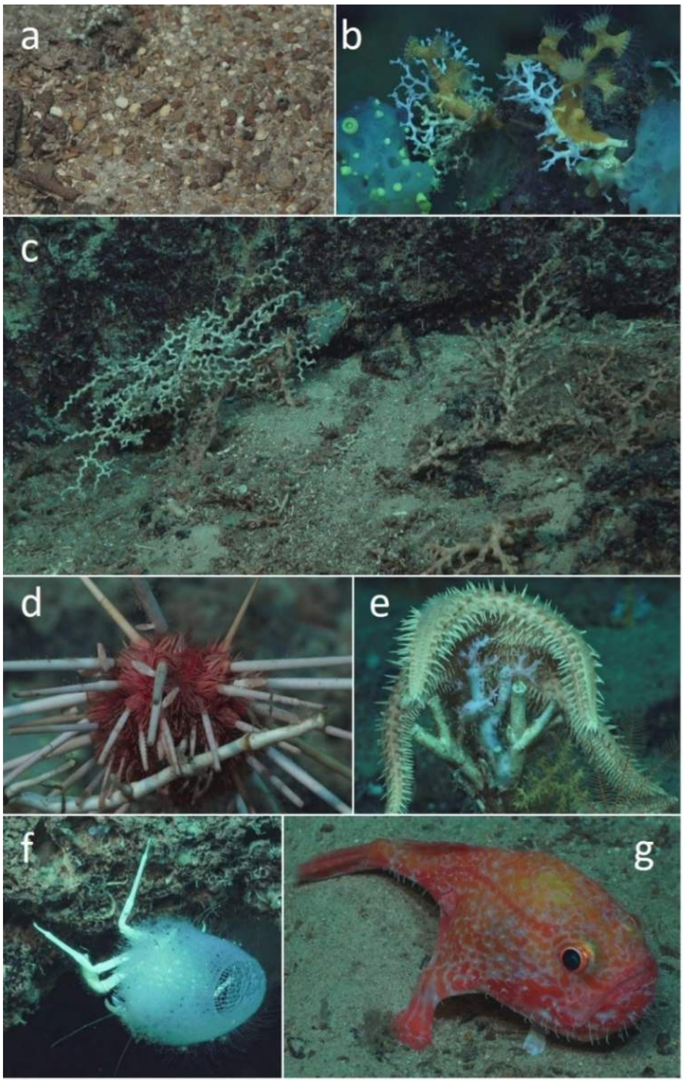

Fig. 5.1.10
(a) Close-up of the gravelly lag deposit at 696 m depth near the base of a volcanic cone. (b) A diverse assemblage of white stylasterids, brownish zoanthids and pale blue glass sponges with their yellow zoanthid symbionts. Diameter of zoanthid polyps is 0.8 cm. (c) Pure scleractinian rubble trapped in a sediment pocket at 635 m depth. Width of the *Madrepora* colony is 23 cm. (d) A cidaroid echinoid gnawing on a bamboo coral at 611 m depth. Note the lepadid cirripeds as passenger on the echinoid spines. (e) An asteroid has taken place on a nephtyid octocoral at 608 m depth. Scales: size of the cidaroid body = 5 cm; size of the asteroid = 8 cm. (f) A decapod with parts of a glass sponge as carry-on shelter (6 cm large specimen) at 605 m depth. (g) *Chaunax* sp. at 594 m depth.

Gorgonian rubble trapped in sediment pockets as described in the previous dive became more common from 644 m onwards. The first pure CWC scleractinian rubble bed including recently died *Madrepora* c.f. *oculata* colony was documented at 635 m depth (Fig. 5.1.10c). The basaltic wall turned into a flattened plateau at 606 m depth. The steep cone flank shows intercalated lava flows, including pillow basalts next to massive basalt strata. Near the top, smooth lava flows structured by prominent cooling cracks and fissures occur on top of pillow lava and mark the transition from the wall to the plateau. These top lava flows turn into a conglomerate of smaller crusts. The outer margin of the plateau was much more populated by suspension feeders, such as gorgonians but also their predators. We documented a cidaroid echinoid preying upon a bamboo coral (Fig. 5.1.10d) and an asteroid preying upon a nephtyid octocoral (Fig. 5.1.10e). At 605 m depth, we crossed a bowl-shaped block densely populated by glass sponges, octocorals, crinoids, serpulids, and a larger rose-coloured stylasterid. Noteworthy was the documentation of a decapod who uses a piece of a glass sponge as carry-on shelter (Fig. 5.1.10f). We saw this decapod-glass sponge association several times on the other dives but never so clear as shown from this place at 605 m depth. In the midst of the plateau at 595 m depth, a barely alive *Enallopsammia rostrata* colony was detected. Nearby, we observed a *Chaunax* sp. slowly crawling on the seabed (Fig. 5.1.10g). This genus is a characteristic fish found within or near CWC habitats (Ross & Quattrini 2007). Other common fishes on the plateau were *Grammicolepis brachiusculus, Nezumia* sp.

amongst several cusk eel species. By turning to a southern heading, we reached the edge of the plateau at 590 m depth where we found a large *Paragorgia* sp. colony that hosts several fleshy euryalid brittle stars, a decapod and crinoids. The dive ended at 589 m depth.

5.1.5 Sediment Sampling

Surface Samples - Benthic Invertebrate Fauna: Three surface sediment samples taken off Mayotte were suitable for analysing the dead faunal remains (thanatocoenosis): GeoB26109-1 (TV-GBC), GeoB26114-24 (ROV) and GeoB26116-2 (EBS). We assume that these surface sediments and its thanatocoenosis were deposited during (late) Holocene. All sediment samples contained predominantly greyish brown, medium-grained (0.5–1 mm) carbonate sand, with a smaller fraction of black volcanic coarse sand. The main contents were remains of planktonic and benthic foraminifera, fractured bryozoans, scleractinians and pteropod gastropods. The thanatocoenosis of the TV-GBC sample predominantly contained gastropods, bivalves and small scleractinians. Gastropods included spongivores in the family Fissurellidae (genera *Cornisepta* and *Fissurisepta*) and many detritivores and general carnivores (Fig. 5.1.11). Bivalves included common filter-feeders in the family Limopsidae (genus *Limopsis*, two specimens sampled alive) as well as some bivalve carnivores in the families Propeamussiidae and Lyonsiellidae (feeding on suspended organic matter and copepods). The scleractinian remains included solitary coral species in the families Caryophylliidae, Fungiacyathidae (*Fungiacyathus* spp.), Flabelidae (*Truncatoflabellum*), Deltocyathidae (*Deltocyathus* spp.), including two known species within the Turbinoliidae family (*Deltocyathoides* spp. and *Peponocyathu*s spp.) and one unknown turbinoliid (Fig. 5.1.11).

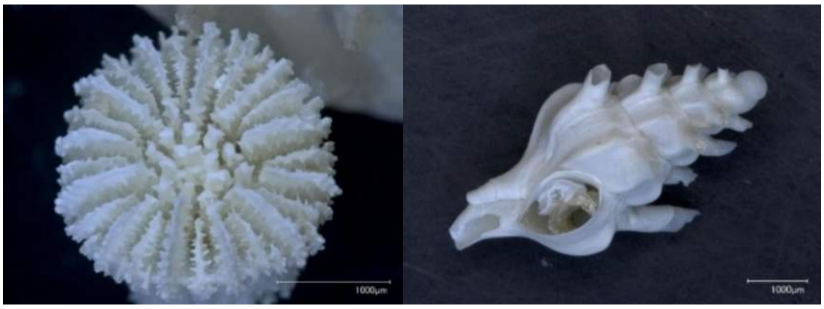

Fig. 5.1.11
(left) Solitary coral in the family Turbinoliidae, (right) Gastropod in the carnivorous family Muricidae (both TV-GBC GeoB26109-1, off SW Mayotte Island). Scale: 1000 µm.

The ROV sediment sample (~400 ml) was taken near colonies of scleractinians (specifically *Enallopsammia* spp.), octocorals and sponges; this was reflected in the mollusc shells in the sediment as they occur often as associated fauna (commensals, parasites, carnivores, and filter feeders and detritivores living on hard substrate including dead corals). Five species were encountered in the spongivore family of Fissurellidae (species in genera *Conisepta* (2), *Fissurisepta* (1), *Puncturella* (2)), with some of these species are not yet described. Many gastropod detritivores were found including three species in Anatomidae (genus *Anatoma*) and three species in Scissurellidae (genera *Sinezona* and *Scissurella*). Bivalves contained a set of epifaunal filter feeders (family Arcidae) and carnivores (families Propeamussiidae and Cuspidariidae). About 80 mollusc species were identified in the ROV sample. A significant set of these mollusc species will be new to science. The scleractinian fauna again included solitary caryophylliids. Various hydrozoan stylasterides were found (including several in cf. *Crypthelia* spp.). The thanatocoenosis from the EBS sample contained one erect scleractinian (*Caryophyllia* sp.) and again two species of the spongivorous gastropod genus *Cornisepta*.

5.2 Tanzania

A key objective of the work off southern Tanzania was to verify, if the mound-like seabed structures identified in hydroacoustic data obtained during RV METEOR expedition M75-2 were indeed CWC mounds. Already the inspection of the first structure with the TV-GBC revealed that this "mound" was rather a slump body. The same was found for more of these structures. Nevertheless, CWCs were commonly observed, although mainly occurring as single colonies and not forming reefs. MBES mapping revealed a distinct conical structure with a width of 750 m and a height of 80 m sitting above a major fault. The presence of chaotically layered carbonate blocks and porous carbonate crusts together with its peculiar seep-related fauna of chemosymbiotic mollusks observed during ROV dives clearly indicate this structure as a MV (named Mtwara MV). To our knowledge, this is the first MV described from the West Indian Ocean. Active flares were clearly detected by the MBES and PARASOUND emerging about 300 m above the MV. Visiting the sites where the flare emanated at 875-870 m water depth, we detected live *Bathymodiolus* beds and white bacterial mats on the plain pedestal, however, only a few gas bubbles rising up. No other anomalies in temperature, salinity or dissolved oxygen variations were detected. Overall, ROV diving was rather challenging in this region as the current speeds often exceeded 1 kn. Nevertheless, despite the difficult environmental conditions, three dives were conducted on the Mtwara MV and two (of which one was aborted) in the Tungue Canyon, where the downslope transport of terrestrial organic carbon was documented. Originally, we planned to work in this region for ~5 days, but finally we spent 10 days off Tanzania due to research permit issues with the Comoros and Mozambique (see chapter 4). During these days, we completed a diverse sampling and monitoring program, including the collection of a series of sediment cores (Fig. 5.2.1 shows MBES overview map of the study area with all stations).

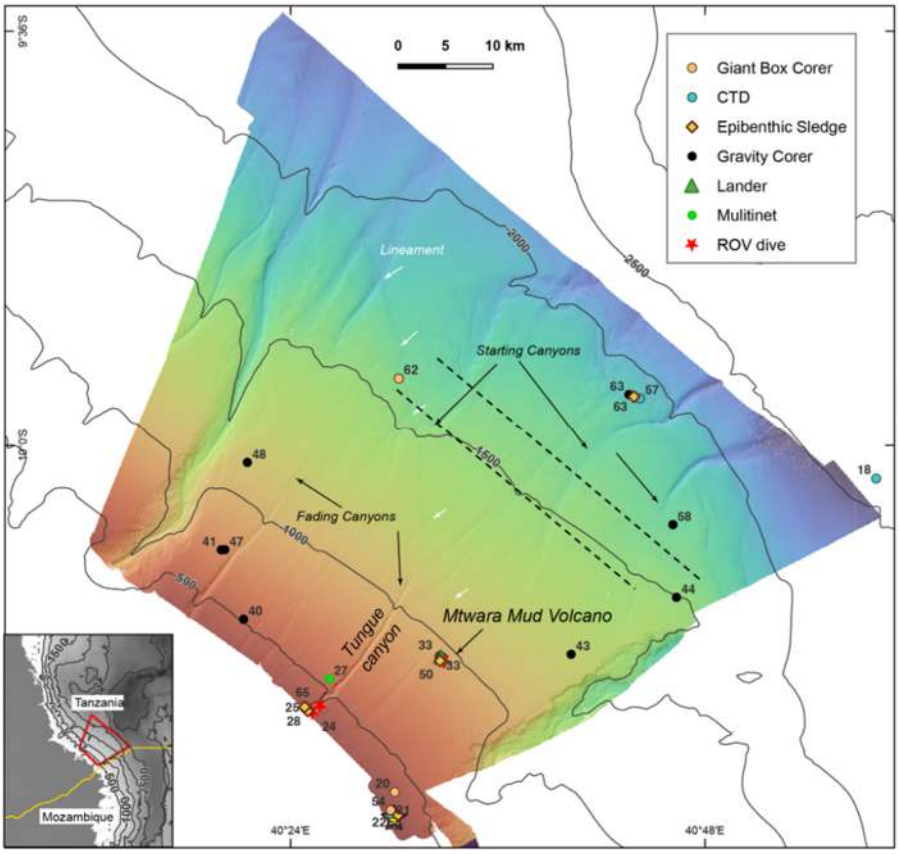

Fig. 5.2.1
Overview map of the Tanzania margin mapped by MBES during RV SONNE expedition SO306. The smooth slope is dissected by two large and several smaller canyons that either fade out downslope or begin downslope. The Mtwara mud volcano (height: 80 m, width: 750 m) is situated at the end of barely visible lineament (marked by the white arrows). Indicated are sampling positions (GeoB261xx; see legend for gear symbols) and PARASOUND lines (dashed lines) presented in chapter 5.2.3.

5.2.1 Water Column Structure

Five CTD casts and one 12-hour Yo-Yo cast were conducted in the working area off Tanzania. The structure of the water column was investigated to a depth of ~2500 m. Here, the observed water masses are identical to those documented off Mayotte, exhibiting an almost similar temperature-salinity relationship and distribution of dissolved oxygen throughout the water column (Fig. 5.2.2).

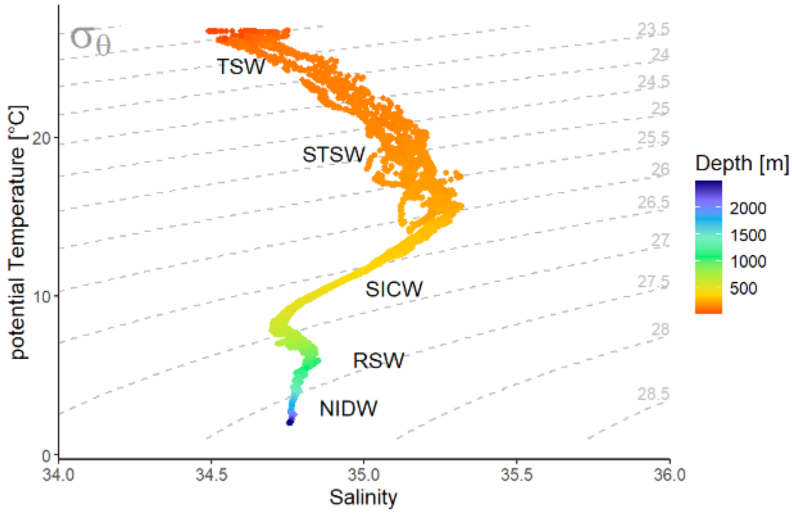

Fig. 5.2.2
Temperature-Salinity relation off Tanzania – CTD data from four sites off southern Tanzania including sigma-theta pycnoclines (density contours are plotted as the dashed grey lines); Water masses: Tropical Surface Water (TSW) and Subtropical Surface Water (STSW), South Indian Central Water (SICW), Red Sea Water (RSW), North Indian Deep Water (NIDW).

The ADCP data revealed that currents primarily flow to the NW (Fig. 5.2.3). The currents in the upper 150 m are very fast with a velocity of up to 60 cm s^{-1}. The water below 150 m is slower with a speed of 10 cm s^{-1}, but we observed a strong bottom current between 400 and 700 m depth with a speed of 40 cm s^{-1}. The whole northward flowing water body can be interpreted as the Eastern African Coastal Current (EACC).

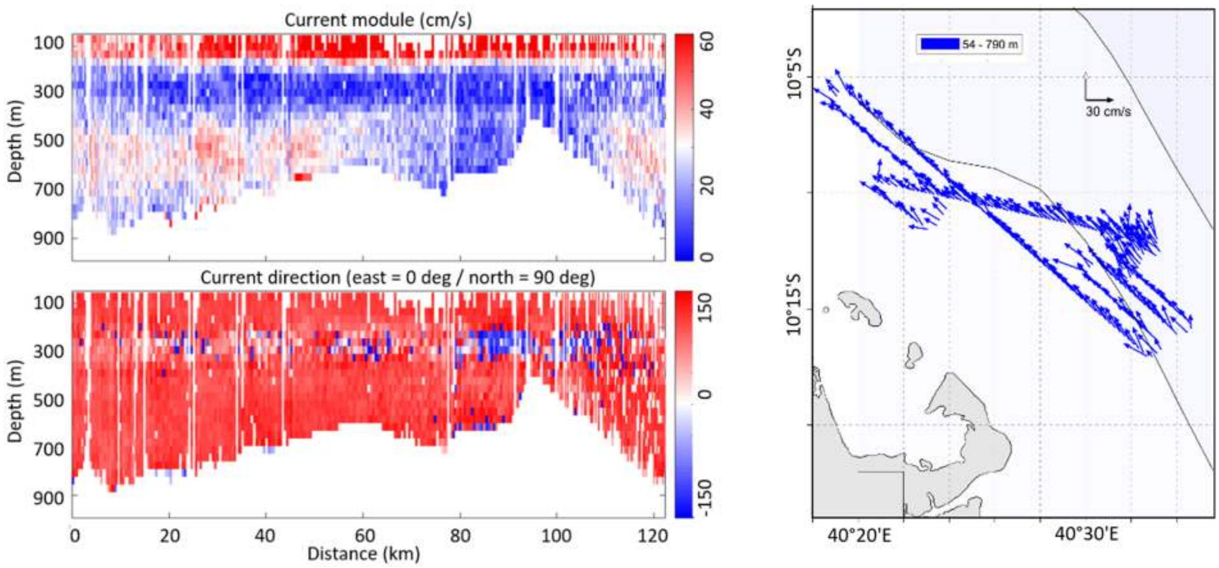

Fig. 5.2.3 (left) Current speed and direction measured by ADCP off Tanzania, (right) average current velocity along the mapping lines off southern Tanzania obtained with the ship-based ADCP 38 kHz.

5.2.2 Time-Series Lander Data

Off Tanzania, the lander was deployed on top of the Mtwara MV within the area of dense bivalve appearance. It was deployed for six days in a water depth of ~860 m, representing the lowermost part of the SICW. The monitored parameters exhibit oscillating patterns with a periodicity of ~12 hours. Observed tidal changes are distinctly smaller than those recorded off Mayotte. On average, the water temperature, salinity and oxygen concentration vary by 0.2°C, 0.02 PSU and 0.2 mg/l (Fig. 5.1.4), respectively. Recorded seawater pH values range from 7.3 to 7.5 with tidal variations of < 0.1. Such low values have previously been reported from cold seeps, pointing to gas venting around the lander position as suggested by the large occurrence of chemosymbiotic bivalves (*Bathymodiolus sp.*) and from multibeam imaging (cf. Dubilier et al. (1998), Bergquist et al. (2005), Louden & Kessler (2023)).

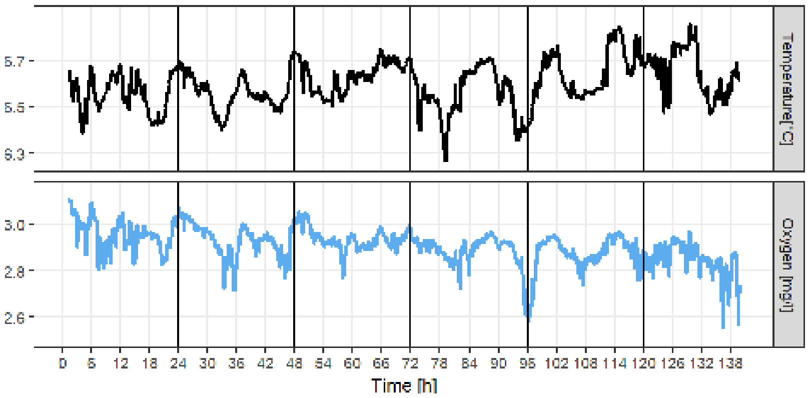

Fig. 5.2.4
Lander data Tanzania. Temperature and dissolved oxygen variations along ~140 h of lander deployment.

5.2.3 Bathymetry and Sub-Seafloor Structures

An area of ~3500 km^2 of the Tanzanian continental margin were mapped by the MBES EM122 (Fig. 5.2.5). Three geomorphological features were detected on the relatively smooth slope, whose declivity markedly increases at about 1800 m water depth. The first are canyons that dissect the slope from the coastline to the Mozambique Channel, while others fade out downslope or start at great water depth. Secondly, a faintly visible tectonic lineament cuts obliquely across the middle of the slope. And third, the Mtwara MV situated at the up-dip end of the lineament in 970 m water depth (Fig. 5.2.5). The mapped area is bounded in the south by a large canyon that runs from the Ruvuma delta to the Mozambique Channel (Fig. 5.2.5). Close to the northern boundary, a large, slightly meandering canyon dissects the entire mapped area. All the other canyons are smaller and limited in extent, of which two canyons (incl. the Tungue canyon) are connected to the shallow coastal system but fade out at around 1100 m water depth.

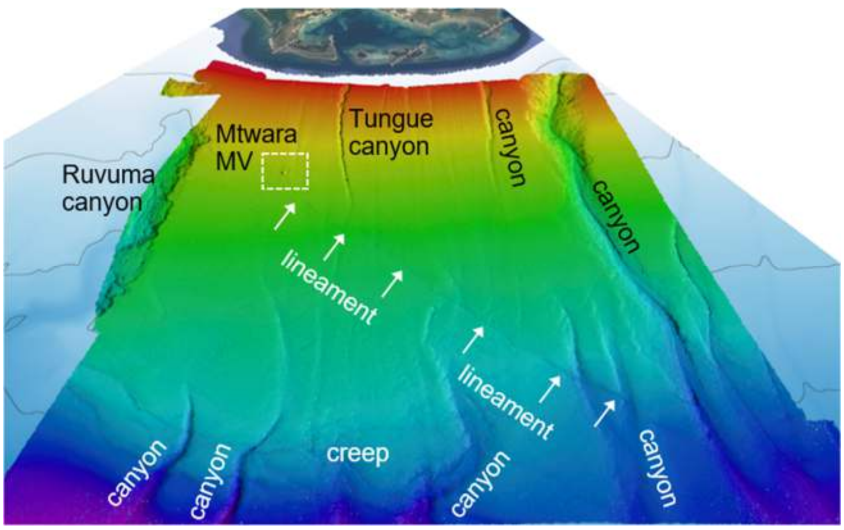

Fig. 5.2.5
The bathymetric map (40x40 m horizontal resolution) covers ~3500 km^2 of the seabed off southern Tanzania. The major features, the Mtwara MV, the lineament, the canyons, and the creep structures are clearly visible.

In contrast, the heads of new canyons begin incising the slope at around 1500 m water depth and consistently increase their depth downslope. Shallowing upstream is typical for canyons on the continental slope that are produced by headward erosion. A nearly N-S running lineament is indicated by a small offset in elevation that increases to the north. Along the lineament a shallow (5–10 m) round depression of ~500 m width is reminiscent of a filled in pockmark but a visual inspection with the TV-GBC did not provide any evidence of fauna and sediment typical for pockmarks. At the end of the lineament, we detected the 80 m high and ~750 m wide Mtwara MV, which is actively venting. Extensive mapping including two crosslines mapped at low speed of 2 kn revealed an off-center peak, a rim on the eastern side, and a moat on the north-western side of the MV (Fig. 5.2.6A). In addition, bubble release was observed hydro-acoustically as flares in the water column (Fig. 5.2.6B). Flares were visible on specific locations on the mound. Coordinates of these locations were used as landing points for the ROV, but only few bubbles were observed, most likely due to strong currents that deflected the outpouring bubbles. The high frequency PARASOUND, however, also imaged the bubbles in form of several hundred meters high diffuse reflections in the water column (Fig. 5.2.6C).

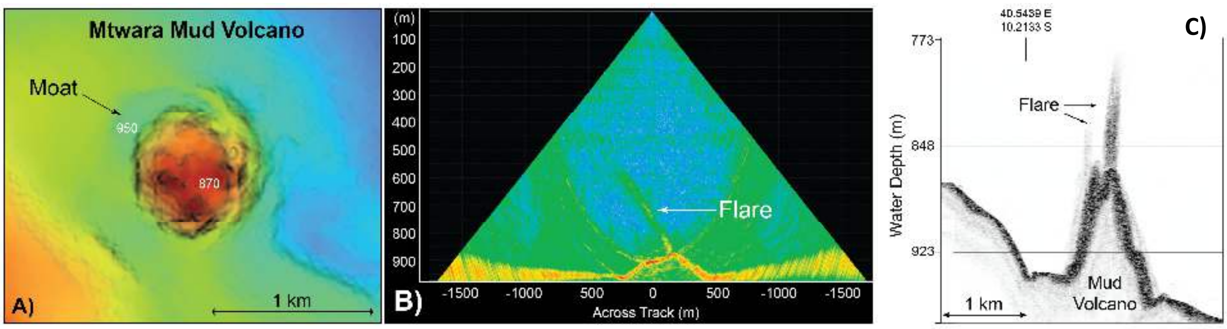

Fig. 5.2.6 (A) Detailed MBES bathymetry map (15x15 m horizontal resolution) of the Mtwara MV constructed from multiple passes. (B) Bubble release from the MV is detected hydro-acoustically as nearly 400 m high flares in the water column. (C) PARASOUND seismic image of the Mtwara MV and the flares from venting that are diffuse, upward decreasing reflections in the water column.

Besides the Mtwara MV and the canyons, the mapped area is smooth with little elevation changes, indicating a homogeneous sediment cover. Yet, over large portions the penetration of the PARASOUND acoustic signal was minimal and the seismic reflections are not horizontally layered but in the subsurface the slope succession displays geometries like folds and mounds when displayed with strong vertical exaggeration (Fig. 5.2.7). Two seismic facies dominate; the subsurface produces either an acoustically transparent facies or layered reflections. In some places, layered sections change laterally rapidly into transparent acoustic facies. For example, levees of the canyons consist of horizontally layered strata but the adjacent succession is transparent (Fig. 5.2.7). Sometimes the change from transparent to layered seismic facies occurs in a vertical sense, like across an unconformity (Fig. 5.2.7). In places the layered strata are slightly abraded at the top, possibly reflecting the acting of strong currents that also were encountered during the cruise. In other places the horizontally layered sediments abruptly terminated to what looks like inclined bedding due to creeping of the slope sediments. Some evidence of creeping is visible in the eastern, deeper portion of the mapped area. There, the slope is marked by some small, contour-parallel ridges, while no surface expression of creeping is seen in the smooth slope sections. In other places the layered facies changes into transparent facies. Jones et al. (2010) attributed such a seismic pattern to "acoustic turbidity" caused by the presence of gas. In the large smooth areas, the presence of gas could be a plausible explanation for the lack of acoustic images, as "gas blanking" can cause layered sediments to appear as transparent. Furthermore, some cores recovered contorted beds, documenting slumping. Thus, the large-scale transparent nature of the slope is likely a product of both, slumping and blanking by gas.

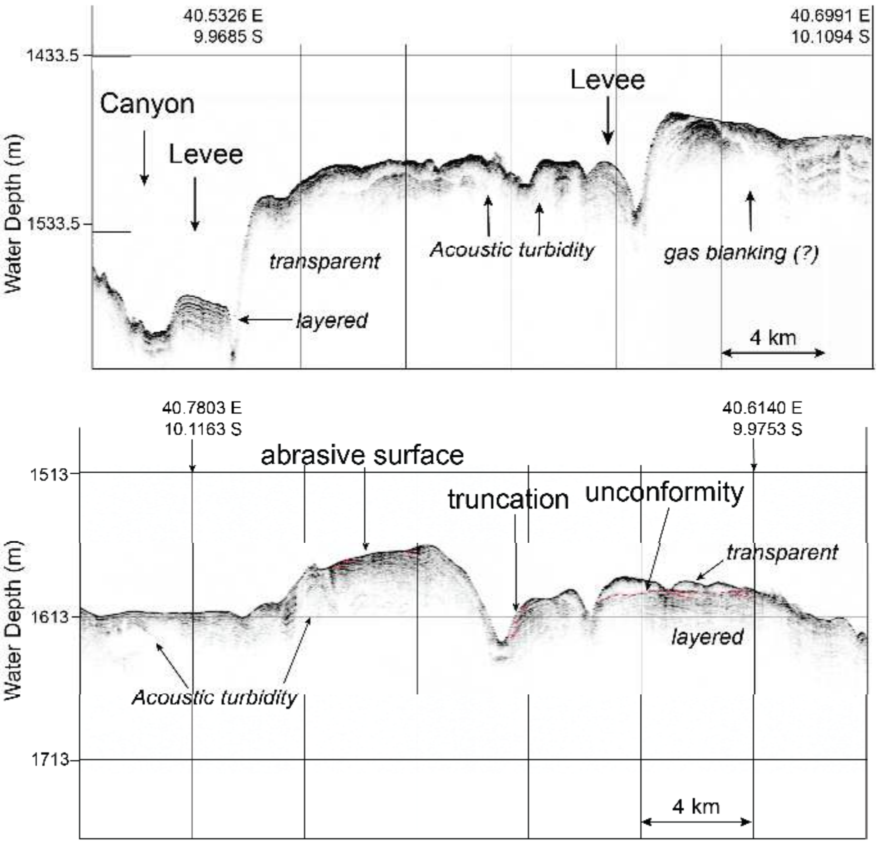

Fig. 5.2.7 (top) PARASOUND line illustrating seismic facies of the Tanzanian margin. Penetration depth is moderate and the seismic facies is either transparent or layered. The seismic reflections are in places disturbed by acoustic turbidity or probably blanking by gas. (bottom) PARASOUND line illustrating geometries of the sedimentary succession along the Tanzanian margin. Truncations are observed in canyons; an unconformity is overlain by a transparent package; slightly mounded strata are truncated to form an abrasive surface probably reflecting the strong currents in the region. Position of PARASOUND lines are indicated on the overview map in Fig. 5.2.1.

5.2.4 ROV Observations

The main task of the ROV dives was to provide ground truth information on the presence, ecological status and composition of CWCs off southern Tanzania. Five explorative ROV dives have been carried: two dives within the Tungue Canyon (of which the second one had to be aborted due to strong currents) and three dives on the Mtwara MV.

ROV-Dive GeoB26124 (SQUID Dive 093) - Tungue Canyon - The ROV dive began at 434 m depth in the thalweg of the Tungue Canyon. Visibility was very low due to a large sediment load held in suspension by the downslope flowing bottom currents. The canyon acted as collector for considerable amounts of rafted and transported seagrass leaves and other plant remains from the shore (Fig. 5.2.8a). We assume that remarkable amounts of organic carbon are highly concentrated in the canyon conduit and got rapidly transferred into the deep sea, thus fueling the food web with an additional food source. Due to a lower suspension load, visibility got increasingly better when starting the ascend of the northern canyon flank at 423 m depth. The few organisms seen were asteroids and parapagurid hermit crabs covered by zoanthids (Fig. 5.2.8b) and an irregular sea urchin who collected seagrass leaves (Fig. 5.2.8c). Further up the fully sedimented slope, we noted cerianthids and asteroids and a whip coral. Anthropogenic litter was visible in the form of plastic bags. Near the 353 m depth line, the canyon slope transited into the outer shelf plateau when suddenly orange coloured brittle stars with wrinkled arms appeared in larger numbers. The dive stopped at 332 m depth.

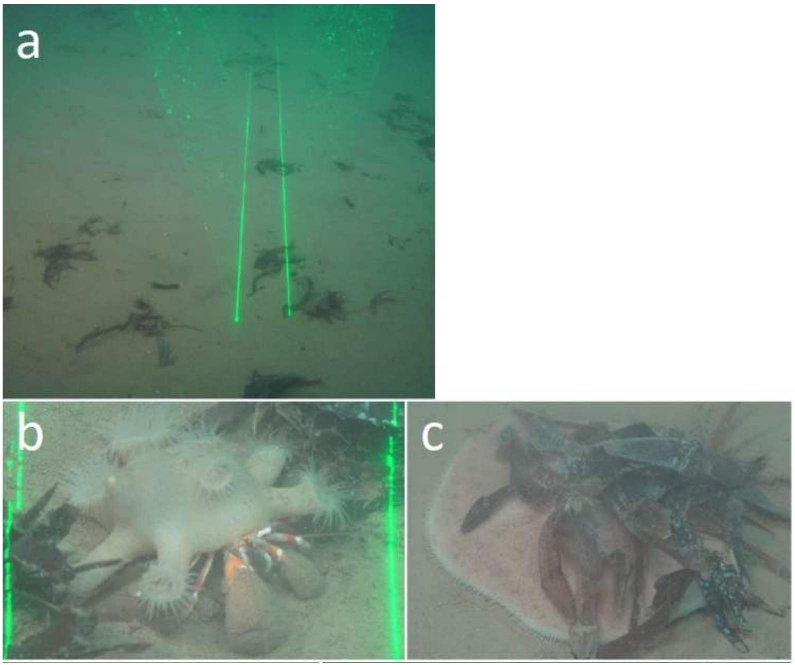

Fig. 5.2.8
(a) Impression of the suspended sediment transport in the thalweg of the canyon. Note the many plant remains being transported into the deep sea. Spacing of laser beams = 10 cm. (b) Parapagurid hermit crab wearing zoanthids. Note the bacterial mats covering the large subchela at 418 m depth (laser beams = 10 cm). (c) Seagrass leave-collecting irregular sea urchin at 388 m depth (diameter of the corona = 10 cm).

ROV-Dive GeoB26131 (SQUID Dive 094) – Mtwara MV - The dive started at 920 m depth. Individual large, meter-sized blocks with rugged surfaces were present. Some blocks show deep cracks. Current-exposed flanks of individual blocks were frequently colonized by diverse fan-shaped gorgonian assemblages. Few up to 30 cm high and up to 25 cm wide fan-shaped *Enallopsammia rostrata* colonies pointed with their polyps against the main residual current. This block field formed an outer rim and shallows up to 908 m depth. Sediment pockets contain single *Calyptogena* valves (length: 12 cm) and coral rubble. Individual blocks found in a depression behind the outer rim yielded plenty whip corals being guarded by a geryonid decapod. A small rampart at the base of a rock wall serves as depo-center of fine-grained sediment and strewn coral rubble. A steeply inclined hard rock wall ended at 910 m depth with a few meters wide gently-inclined terrace littered with coarse sand rich in brownish-stained biodetritus such as isidid internodes and large *Calyptogena* valves. At the base of the next upslope hardrock section dense live fauna comprised stylasterid colonies, whip octocorals, stoloniferous and primnoid octocorals, a solitary coral, brachiopods and 5 cm-large seep-related *Enigmaticolus* sp. snails. At 909 m depth, another steep inclined wall of chaotically deposited large blocks dominates the scenery, which were inhabited by dispersed but laterally large and up to 60 cm wide and 15 cm high *Enallopsammia rostrata* colony gardens and hydroids (Fig. 5.2.9a). In contrast to the first *Enallopsammia* encountered on this dive, the corals grew on top of the blocks and were not fan-shaped anymore. At 892 m depth the topography smoothened and more thick and platy crusts dominated the seabed. ROV sampling showed that the crusts are not strongly lithified as they are easy to break off with the manipulator. These crusts are made of carbonate and show a very porous creamy texture rich in vugs and associated aragonite needle cement. Between the carbonate blocks, we crossed a shell bed entirely made of *Bathymodiolus* valves, mostly in concave-up position (Fig. 5.2.9b). We followed this shell bed upslope and detected first patches of live *Bathymodiolus* at

890 m depth. At 885 m depth, the shell-covered seabed widens and the proportion of live mussels steadily increases. Even more than 1 m-high carbonate blocks were densely colonized by juvenile *Bathymodiolus*. We crossed a fringe composed of chaotically stapled often angular and meter-sized blocks. Behind this fringing blocky rim, a wider pedestal opened to us with a 100% *Bathymodiolus*-coverage of different size cohorts (Fig. 5.2.9c). The associated fauna consists of several large geryonid and majiid decapods, up to 12 cm large *Enigmatocolus* snails and white galatheid crabs. The large snails were grazed by tiny limpet snails, probably representing *Paralepetopsis* sp. Occasionally small reddish actiniarians, fly-trap anemones and small glassy pectinid bivalves occurred. Spots of whitish biofilms draped over the mussels, about 30 cm wide. At the edge of this chemosymbiotic mussel bed, plain patches of a stiff greenish clay and bacterial mats became prominent. The dive ended at 873 m depth.

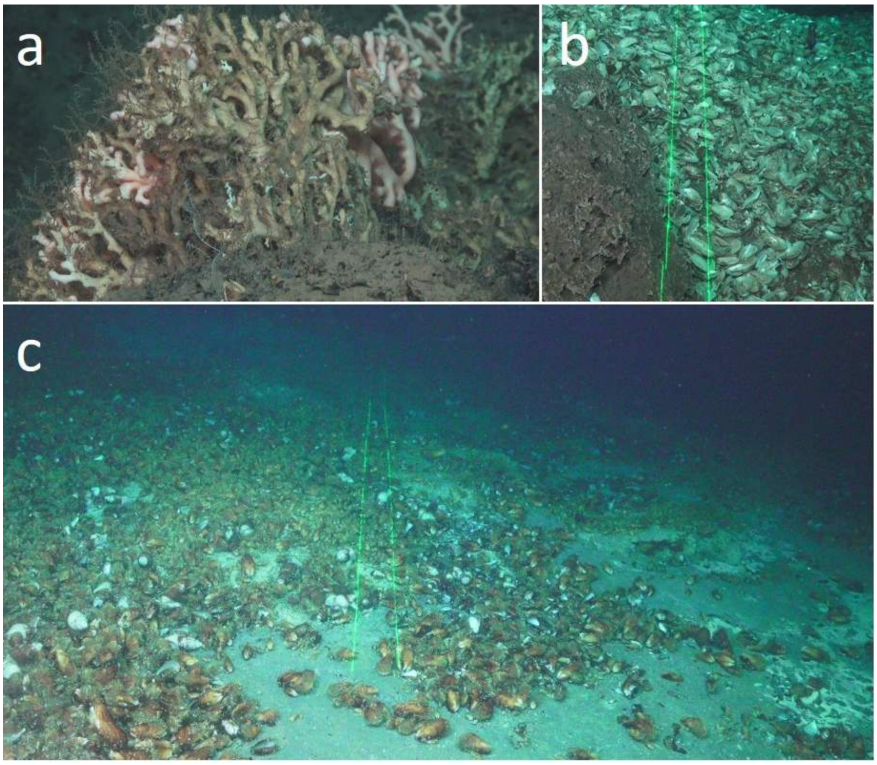

Fig. 5.2.9
(a) Partly alive *Enallopsammia rostrata* colony at 890 m depth (15 cm high). (b) Part of a large *Bathymodiolus* shell bed at 892 m depth. Note the overwhelmingly concave-up deposition of the valves (laser beams = 10 cm). (c) View on the seep pedestal with live *Bathymodiolus*, outcropping stiff greenish clay and bacterial mats to the lower right at 873 m depth (distance laser beams = 10 cm).

ROV-Dive GeoB26136 (SQUID Dive 095) - Mtwara MV - The dive started on top of the *Bathymodiolus* mussel bed at 875 m depth. Heading towards the west, the mussel bed faded off at 878 m depth and gave way to a plain sediment area covered by bivalve debris made of *Bathymodiolus, Calyptogena* and *Vesicomya*, and small polymict pebbles with many patches of the greenish stiff clay. Recently died colonies of *Solenosmilia variabilis* have been observed at 879 m depth (Fig. 5.2.10a). Further west, thin platy carbonate crusts appeared at 878 m depth. Larger crusts show live stylasterids, sponges and actiniarians. Here, the seabed forms a small depression and on the next upsloping sector, knobby and brownish stained crusts dominate the scenery covered by larger portions of *Solenosmilia* debris. We crossed a ridge covered largely by platy crusts and an abandoned chimney was discovered. Large but friable carbonates surrounded this former active seepage site at 876 m depth, where small primnoid octocorals and stylasterids were found. The chimney is a about 2 m wide and 1.5 m deep and contains a greyish stiff clay (Fig. 5.2.10b). The ROV team performed a mosaic flight over this pockmark to get a 3D-impression. Further to the west, the seabed deepened down to 878 m and larger platy cobbles were sampled from here. These brownish coloured slabs were extremely friable and broke easily during the sampling procedures. Larger slabs were colonized by larger octocorals and thin encrusting sponges. After a few meters, the seabed shallowed to 872 m depth and huge blocks in a chaotic arrangement dominate the scenery again. These blocks provide substrate for a diverse suspension feeder community comprising of several octocoral species, including a stoloniferous species with yellowish polyps and stolons firmly attached to the rock substrate, and *Enallopsammia pusilla* (Fig. 5.2.10c). From here the seabed slightly deepened and strewn carbonate crusts and sand patches, partly rippled, indicate episodic high hydrodynamic energies. Larger slabs are frequently colonized by live *Madrepora oculata* (Fig. 5.2.10d), hydroids and octocorals. Sampled crusts showed a porous texture and vugs are surrounded by very large aragonite needle cements. At 865 m depth isolated but large blocks provide habitat for scleractinians and a diverse suite of octocorals (Fig. 5.2.10e). Large, meter-sized whip bamboo corals and *Paragorgia* sp. were seen for the first time. The dive ended at the highest peak at 863 m depth in an area formed by large blocks.

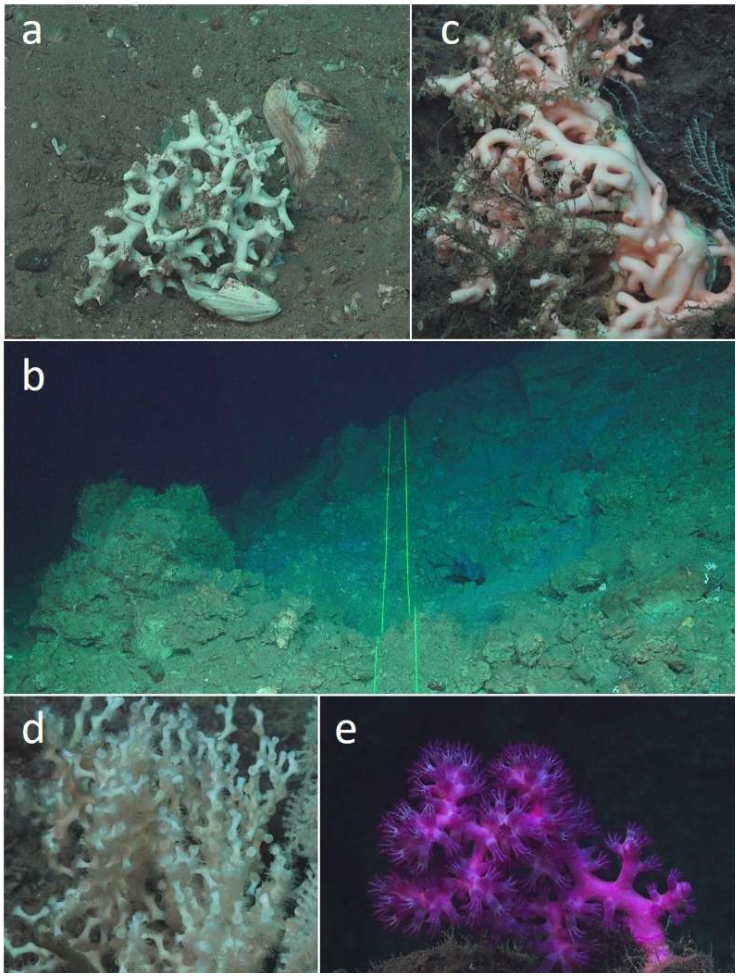

Fig. 5.2.10
(a) Freshly died *Solenosmilia* colony jointly with *Gigantidas* shells (size of the colony = 10 cm). (b) The circumference of an abandoned chimney is shown here with outcropping greyish stiff clays and being surrounded by very friable seep carbonates at 874 m depth (distance laser beams = 10 cm). (c) *Enallopsammia pusilla* at 871 m depth (20 cm high for scale). (d) Alive colony of *Madrepora oculata* at 874 m depth (15 cm wide). (e) Bright purple *Victorgorgia* octocoral colony at 871 m depth (15 cm wide).

ROV-Dive GeoB26150 (SQUID Dive 096) – Mtwara MV - The ROV dive started at 881 m depth in an area with outcropping stiff greenish clay covered with platy crust pebbles. Upslope at 871 m, the crusts turn into larger slabs followed by massive blocks deposited in a chaotic manner. On top of this ridge structure, we saw dispersed *Enallopsammia rostrata*. Behind the ridge, the seabed deepened to 883 m and was covered by a large *Bathymodiolus* shell bed on locally outcropping stiff greenish clay. Then, we encountered first patches of live *Bathymodiolus* amongst the shell bed. A 30 cm-large, rounded and lithified boulder was sampled. The shell bed faded off and gave way to a soft sediment plain littered with broken shell remains at 885 m depth. The ROV turned slightly towards shallower depths and crossed larger carbonate crusts and blocks covered by juvenile *Bathymodiolus* at 877 m depth. Behind this block rim, we came back to the pedestal of the two previous dives where a dense mussel bed is developed, of which adult and juvenile specimens were sampled. A few meters apart we found a thick, white bacterial mat at 870 m depth (Fig. 5.2.11).

Fig. 5.2.11
On the seepage pedestal at 870 m water depth live different size-cohorts of *Bathymodiolus* and a meter-sized wide bacterial mat were observed.

5.2.5 Sediment Sampling

Surface Samples - Benthic Invertebrate Fauna: Eight TV-GBC samples were successfully collected from the Tanzanian study area (see Appendix A5.1). Three TV-GBC were taken from silty siliciclastic sediments at 340-430 m water depth. Few mollusc shells and corals were found at these sites, some of them of shallow water habitats (like a coral in the genus *Fungia*).

Five TV-GBC were collected from deeper water depths (~870-915 m) on or near the Mtwara MV, of which the sediments in TV-GBC GeoB26132-1 were sorted on board for scleractinians and molluscs. Fourteen scleractinian species were identified (ten species in Caryophylliidae, *Conotrochus*, *Goniocorella* and *Trochocyathus* and three more in undetermined genera). Additionally, we identified species in the scleractinian families Dendrophylliidae and Turbinoliidae and in the genera *Enallopsammia* and *Solenosmilia*. We identified 120 species of molluscs, which suggests a high molluscan diversity in our relatively small subsample. Two bivalves of high interest were the chemosymbiotic species in the genera *Bathymodiolus* and *Gigantidas*. Other characteristic bivalves included a filter-feeding *Acesta* sp., at least three species in Vesicomyiidae (genera *Vesicomya*, and the chemosymbiotic *Isorropodon* and *Calyptogena* [?]), one lucinid species in the chemosymbiotic genus *Lucinoma*, and five species in the carnivorous family Cuspidariidae. Characteristic associated gastropod species in the *Bathymodiolus* beds were species in the genera *Enigmaticolus* (Fig. 5.2.12), *Paralepetopsis* and an unidentified Vetigastropod. Other interesting gastropods included the detritivores (e.g. Anatomidae), and many parasites of sponges (e.g., *Fissurisepta*, *Cornisepta*, *Puncturella* spp. in Fissurellidae), of sea anemones (e.g. *Epitonium* spp. in Epitoniidae), of echinoderms (Eulimidae spp.), of stylasterids (Pediculariidae sp.), and of hard corals (*Iphitus* sp. in Epitoniidae and three species in Architectonicidae). The mollusc thanatocoenosis in TV-GBC GeoB26132-1 reflects a typical cold seep environment with a large associated fauna in Cnidaria, Porifera and Echinodermata. The mollusc infauna includes few chemosymbiots and detritivores, the epifauna is dominated by parasites. We expect that many of these species are new to science.

Fig. 5.2.12
(left) Empty shell of *Enigmaticolus* sp. (TV-GBC GeoB26132-1, off Tanzania, cold seep location with *Bathymodiolus* beds). (right) Left valve of a bathymodiolin species in the genus *Gigantidas* (ROV GeoB26136-10, off Tanzania, cold seep environment).

TV-GBC GeoB26152-1 collected from the eastern top of the Mtwara MV was exceptional as it contained a ~9 cm thick surface layer made up of live *Bathymodiolus* sp. attached to each other by their byssus threads (Fig. 5.2.13). In total, 1030 individuals were counted and measured for shell length, with the largest individual measuring 90 mm. A length-frequency distribution was determined and individual length cohorts were identified by applying a Gaussian mixture model, which split the length-frequency distribution into separate normal distributions. Three distinct length cohorts were identified: C1 (17.5 ± 7.3 mm), C2 (34.0 ± 8.4 mm), and C3 (72.6 ± 6.7 mm; Fig. 5.2.13).). The length cohorts C1 and C2 are comparable to *Bathymodiolus childressi* from seep sites in the Gulf of Mexico with average annual growth rates of 17.28 mm/year (Arellano & Young, 2010), and could therefore represent mussels with ages of ~1-2 years. Cohort C3 aligns with a 4-years age class, while the 3-years cohort appears to be missing. However, further analysis is needed, as growth activity in *Bathymodiolus* sp. can vary significantly depending on life stage and environmental factors such as vent-driven temperature, nutrient fluxes and the activity of associated symbiotic bacteria (Schöne & Giere, 2005; Arellano & Young, 2010).

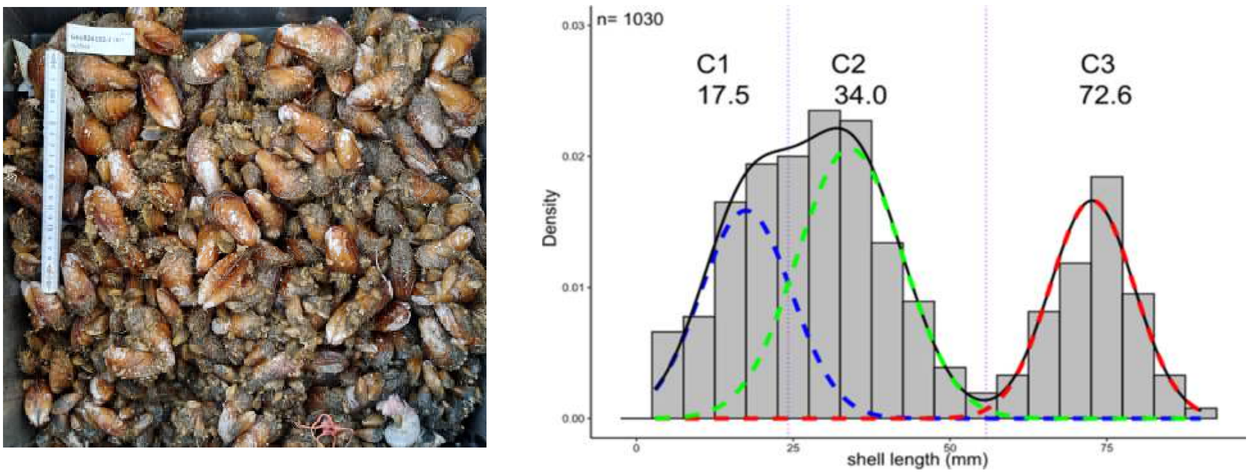

Fig. 5.2.13 (left) Photo of the surface of TV-GBC GeoB26152-1 covered with live *Bathymodiolus* sp. (right) Length-frequency distribution of *Bathymodiolus* sp.; length cohorts C1 (blue), C2 (green), and C3 (red) are based on a Gaussian mixture model.

Sediment Cores: In the South Tanzanian slope area, eight gravity cores were collected from a water depth transect spanning 424 m to 1819 m water depth. Core recoveries ranged between 0.3 and 8.4 m. All cores were split and visually described onboard and will be used for paleoceanographic investigations focusing on the long-term development of the paleo-environmental conditions in the region (for detailed description of all cores see Appendix A5.2).

5.2.6 Respiration Experiments with *Bathymodiolus* sp.

To explore their survival and conduct respiration experiments, specimens of *Bathymodiolus* sp. were collected by the ROV from the Mtwara MV and maintained in the aquarium (temperature 6.5°C) with water collected from 870 m water depth at the MV. After one day of acclimation, some of the mussels opened the shells and therefore, we decided to continue the experiments. A total of 15 mussels of different sizes (4 large, 6 medium, 5 small) have been selected for the experimental trials (Fig. 5.2.14). In half of them the epibiont fauna of the shells has been kept (Fig. 5.2.14b) and in half of them it has been removed (Fig. 5.2.14c), to explore (1) the respiration rates of specimens of different sizes and (2) the respiration rates of the mussels, with and without epibionts.

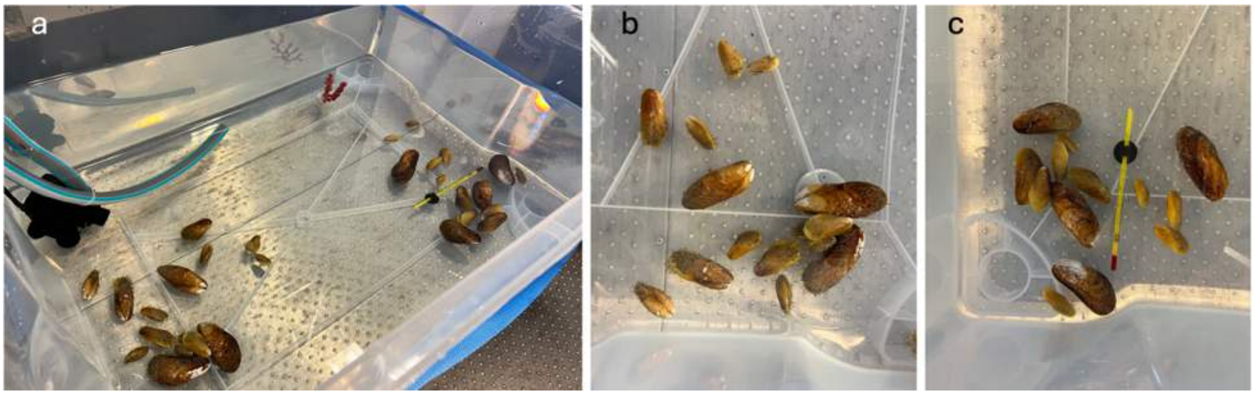

Fig. 5.2.14 (a) *Bathymodiolus* sp. specimens collected by the ROV from the Mtwara MV. Mussels were maintained in the aquarium for acclimations, (b) mussels with epibionts selected for the experimental trials, (c) mussels without epibionts selected for the experimental trials. Images: A. Gori.

Incubation time was selected after doing a first trial with a large specimen for three hours (specimen 6 in Fig. 5.2.15). Due to the low oxygen consumption displayed by that large specimen, it has been decided that the experiments should last 6 hours for the large mussels, 8 hours for the medium ones and 10 hours for the smaller ones.

Day	Speci-men	Incubation time (h)	Size	Shell length (cm)	O_2 respired (µmol O_2 d^{-1})
25.08.24	4	6	L	7.2	74.32
24.08.24	6	3	L	7.0	51.06
24.08.24	8	6	L	6.2	26.15
24.08.24	1	6	L	7.2	112.00
24.08.24	7	8	M	3.9	24.40
24.08.24	11	8	M	5.2	62.84
24.08.24	5	10	S	3.2	18.78
24.08.24	9	10	S	3.9	49.16
24.08.24	10	10	S	3.6	20.63
24.08.24	12	10	S	3.7	33.60
24.08.24	3	10	S	3.2	13.22
25.08.24	2	8	M	5.9	80.45
25.08.24	3	8	M	5.0	69.33
25.08.24	4	8	M	4.1	47.09
25.08.24	5	8	M	3.7	23.01

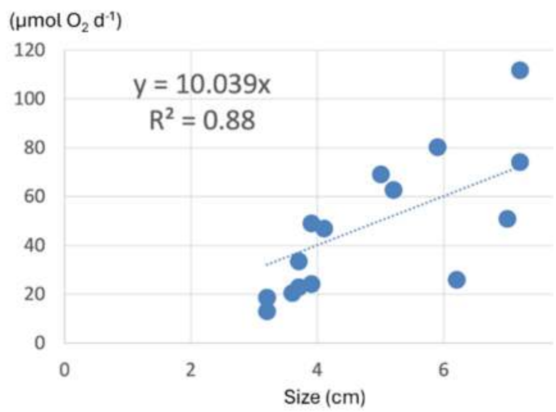

Fig. 5.2.15 (left) Table presenting respiration rates in µmol O_2 per day for the 15 measured specimens. The day of the experiment, specimen number, incubation time, size categories (small: S, medium: M, large: L) and shell length (cm) are included. Control values have been considered in the respiration rates. (right) Graph showing respiration rates (µmol O_2 per day) for *Bathymodiolus* sp. specimens according to their size.

Three controls have been incubated for each time frame, 2 with filtered sea water and one with unfiltered seawater. After 6, 8 and 10 hours, jars were opened and temperature and dissolved oxygen were measured in each chamber. Respiration rates of the fifteen measured specimens are presented in Fig. 5.2.15. Results revealed an increasing oxygen consumption from the smaller to the larger mussels (Fig. 5.2.15). Data need to be normalized by mussel biomass in the home lab.

5.3 Mozambique

Along the coast of Mozambique, we focused on two working areas: (1) off the Zambezi Delta (at 18°S) and (2) off the Limpopo river (at 25°S). Working off the Zambezi Delta was a kind of *déjà vu*: while searching for CWC ecosystems and coral mounds, we again discovered a MV (Zambezi mud volcano). MBES mapping revealed that "mound" structures detected during an earlier expedition arranged in a straight line with a clear bend on the MV. The PARASOUND data indicated a chaotic layering and during video observations with the TV-GBC and the ROV, lots of chimneys and some microbial mats were found. Active fluid flow in the area of the Zambezi margin is well known. For example, Deville et al. (2020) documented pockmarks, partly with active flares nearby, which is related to microbial methane-derived fluids, while no evidence for a thermogenic origin was found. In our second working area off the Limpopo river, our first target was a little ridge extending from the base of a seamount (SMT), which consist of probably rather fresh basalt only sparsely settled by benthic fauna. Near the top of this SMT and on a second neighbouring SMT, we observed colourful and highly diverse coral gardens during two ROV dives. A bit closer to the coast, where sediment input from the Limpopo river has formed a thick sedimentary wedge, we collected gravity cores and deployed the EBS to get an overview about the benthic fauna in this sedimentary setting, in contrast to the basaltic habitat at the SMT (Fig. 5.3.1a,b shows MBES overview maps with all stations).

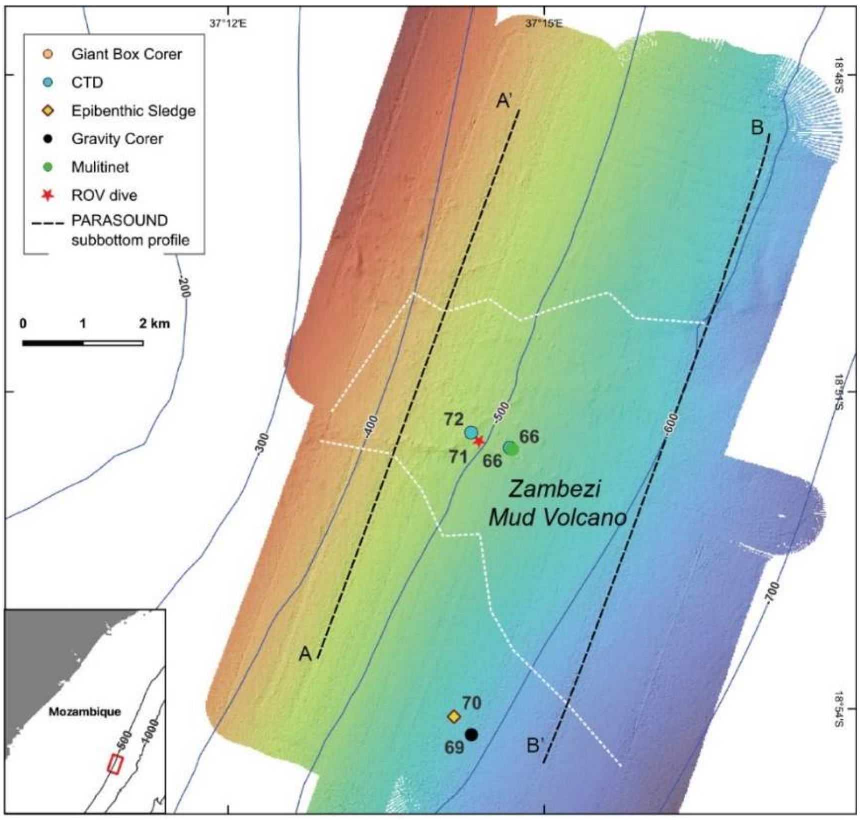

Fig. 5.3.1a
Overview map of the Mozambican margin at ~18°S (off Zambezi Delta) mapped by MBES (20x20 m horizontal resolution) during RV SONNE expedition SO306. The Zambezi mud volcano creates little relief on the seafloor (only small aligned mound structures), but on the PARASOUND seismic data the edge of the MV is sharp allowing to map its extension (1 x 2 km). The white dotted line depicts the boundary of the MV. Indicated are sampling positions (GeoB261xx; see legend for gear symbols) and PARASOUND lines (black dashed lines) presented in chapter 5.3.2.

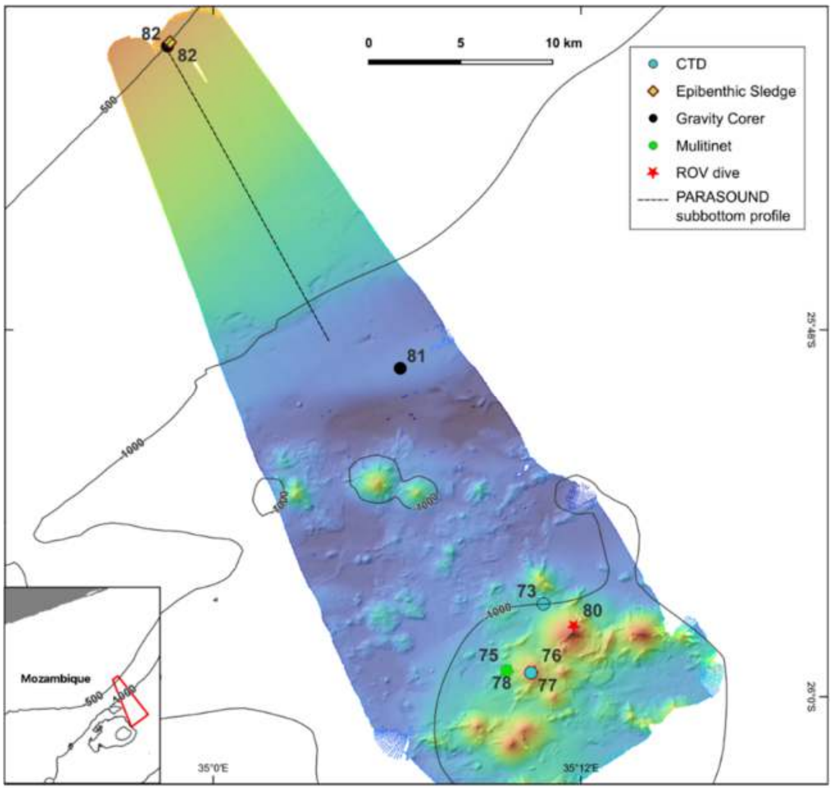

Fig. 5.3.1b
Overview map of the Mozambican margin at ~25°S (off Limpopo river) mapped by MBES (30x30 m horizontal resolution) during RV SONNE expedition SO306. The map shows the smooth slope followed at deeper depths by a field of seamounts. Strong currents prevent sedimentation in the seamount field but accumulate sediment drifts on the shallower slope. Inset: Moat around a volcanic cone (?) provides further evidence for strong currents. Indicated are sampling positions (GeoB261xx; see legend for gear symbols) and one PARASOUND line (black dashed lines) presented in chapter 5.3.2.

5.3.1 Water Column Structure

Two CTD casts were conducted in each of the two study areas at 18°S (down to 500 m water depth) and 25°S (down to 900 m water depth) along the Mozambican coast. Due to these rather shallow casts only the surface water masses (TSW, STSW) and the upper part of the underlying SICW are detectable within the CTD profiles (Fig. 5.3.2).

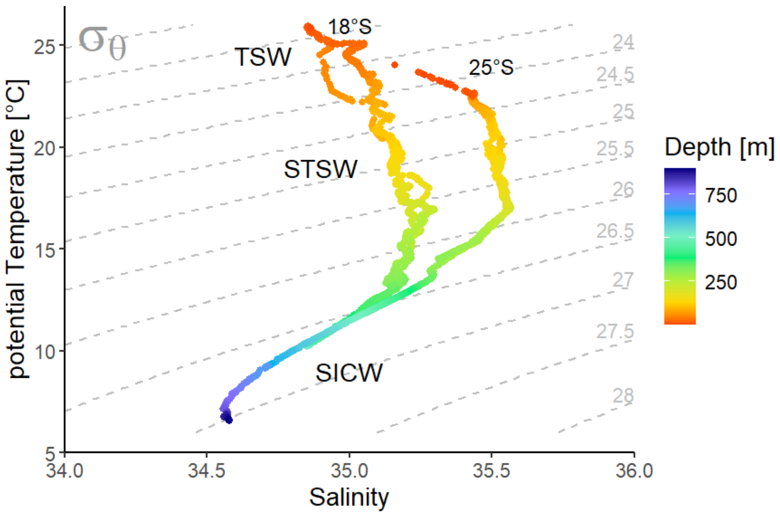

Fig. 5.3.2
Temperature-Salinity relations off Mozambique. CTD data from two sites in each of the two study areas (18°S and 25°S) including sigma-theta pycnoclines (density contours are plotted as dashed grey lines). Water masses: Tropical Surface Water (TSW), Subtropical Surface Water (STSW), and South Indian Central Water (SICW).

The variations in temperature, salinity and oxygen concentration at 18°S reveal a striking similarity to those observed off Mayotte and Tanzania. At 18°S, the salinity increases from 34.8 PSU at the surface to a maximum of 35.2 PSU at ~200 m, accompanied by a rapid decrease in oxygen from 6.4 mg/l to a minimum of 3.6 mg/l. Below 200 m these trends reverse for both parameters, reaching 34.8 PSU and 5.9 mg/l, respectively, at the end of the profiles. The thermocline emerges at shallower depths, at ~50 m, in contrast to ~ 100m observed in the two previous study areas. This suggests a lower contribution of TSW in the composition of the surface waters. The presence of the TSW continues to decline considerably to the south, as revealed by distinctly colder and more saline surface water conditions at 25°S. There, the concentration of dissolved oxygen also diminishes with increasing depth, although the rate of decline is considerably less pronounced. Within the upper 300 m, the oxygen declines from maximum 6.7 mg/l to minimum 5.2 mg/l. Below 300 m, the oxygen concentration rises again to 6.9 mg/l in the transition to the SICW. Interestingly, this is also the depth range in which the yellow CWC *Eguchipsammia* occurred frequently on the two SMTs.

ADCP data were recorded during a transit from the Ruvuma Canyon off Tanzania to offshore the Limpopo river in Mozambique (Fig. 5.3.3). The current velocities in the upper 200 m of the water column were quite high, mainly above 70 cm s^{-1}. In the lower part of the water column, velocities were much slower around 10-20 cm s^{-1}. ADCP data were recorded during a transit from the Ruvuma Canyon off Tanzania to offshore the Limpopo river in Mozambique (Fig. 5.3.3). The current velocities in the upper 200 m of the water column were quite high, mainly above 70 cm s^{-1}. In the lower part of the water column, velocities were much slower around 10-20 cm s^{-1}. The currents were primarily directed south-westward probably reflecting the Mozambique Current in the southern part, while northerly flowing currents in the north are attributed to the EACC. On the transit south, an interesting feature was an eddy, in which the currents switched direction to the north (Fig. 5.3.3). Another part of the data was recorded during a storm on 31. August 2024. During this period, we noticed an increase in the velocity of the currents throughout the observed water column.

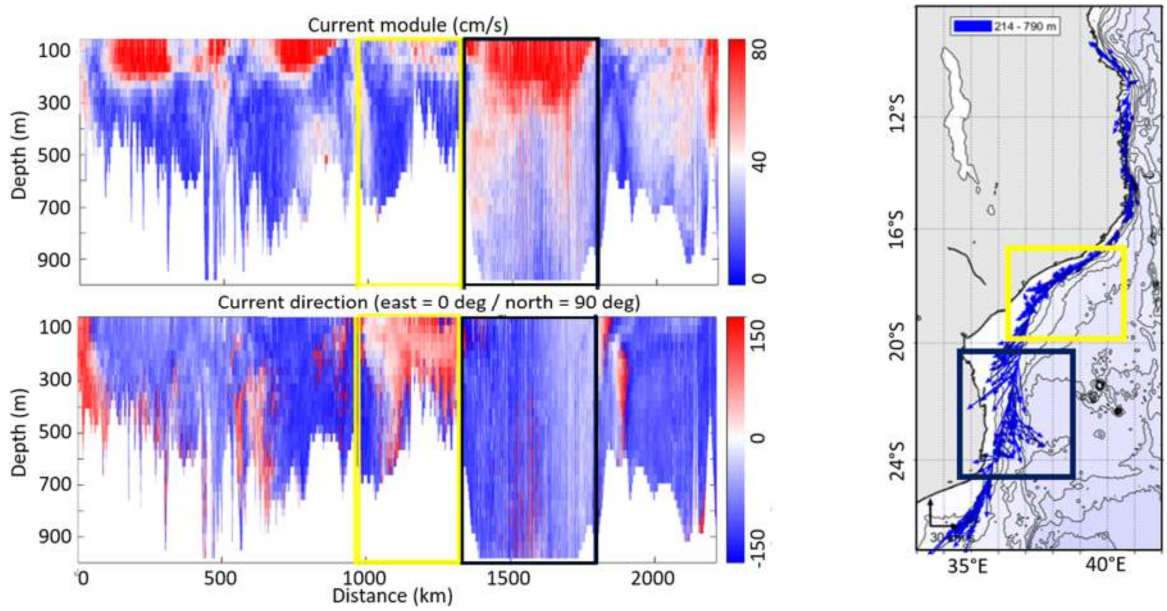

Fig. 5.3.3 (left) Current speed and direction, and (right) average current velocity along the transit line from Tanzania to Mozambique (ship-based ADCP 38 kHz). Yellow rectangle indicates the region, where an eddy was encountered. Dark blue rectangle indicates the area, where we encountered a storm (31.08.24).

5.3.2 Bathymetry and Sub-Seafloor Structures

<u>Mozambique at ~18°S (off Zambezi Delta)</u>: In this area, the inclined sigmoidal-shaped seafloor is overall smooth but displays a string of small mounds of few metres' height. They are aligned in a straight line down the slope with a small offset at a depth pf about 450 m. At this junction, the string of mounds starts to bend away from the fall line. ROV observation revealed that the small

mounds are the surface expression of the Zambezi MV. PARASOUND data imaged the sedimentary succession down to 40 m and in places 80 m depth below the seafloor, which provide a spectacular image of the MV and its root (Fig. 5.3.4). The continuous reflections of the sedimentary succession display diverse seismic facies and amplitude, which are cut by the chaotic seismic facies of the MV (Fig. 5.3.4). The ~2 km wide root of the MV has vertical sides and barely deforms the adjacent strata. At the surface, the MV expands about 1 km on the upslope side and about 2 km downslope (Fig. 5.3.4). None of the PARASOUND profiles show that the MV is covered by sediments, and no newly deposited sediments were observed during the ROV dive, which could be explained either by currents eroding the sediments, indeed there is evidence of strong currents (e.g., moats), or by a recent eruption of the MV.

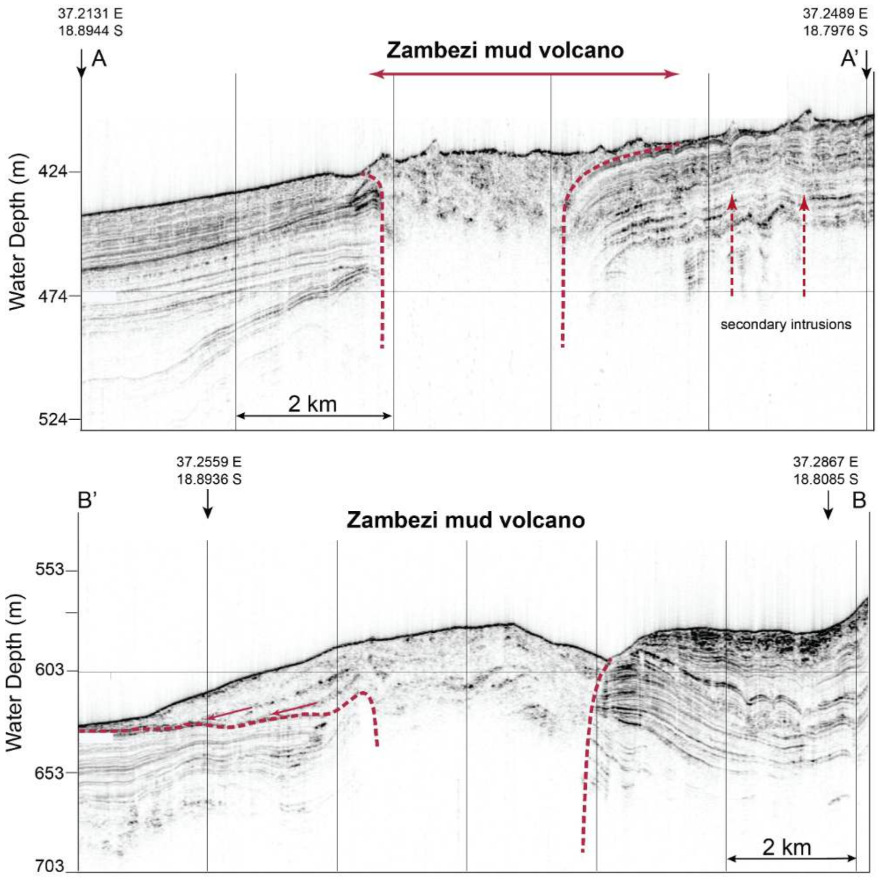

Fig. 5.3.4
(top) PARASOUND line displaying the intrusion of the Zambesi MV into the sediment of the Mozambique margin. (bottom) PARASOUND line displaying the flow of the Zambesi MV onto the slope sedimentary succession. The MV has no sediment cover and could, thus be a recent event. Position of PARASOUND lines are indicated on the overview map in Fig. 5.3.1a.

<u>Mozambique at ~25°S (off Limpopo River)</u>: In this area, we mapped the inclined slope of the continental margin and an offshore SMT field, which consists of a cluster of nine almost perfect cones (Fig. 5.3.5). The largest one is ~900 m tall with the crest just 100 m below the sea surface. Another cone 3 km to the southwest of this large one has knobs and ridges on the lower flank. PARASOUND data and ROV video pbservation revealed that little to no sediments were deposited in this SMT field and the individual SMTs seem to rise directly from the oceanic basement. Coarse sediment was recovered from crevasses, but the adjacent rocks were bare, indicating that currents remove the fine sediments. In the channel north of the SMT field, sediment accumulates and forms an elongated slightly mounded body that is interpreted as a contourite drift deposit. The geometries of the sediments on the slope (Fig. 5.3.6) is reminiscent of two thin plastered drifts (Miramontes et al. 2019, 2019a). Further evidence of current activity is the moat around a SMT, which with its deeper portion on the eastern side, suggests a dominant E-W current.

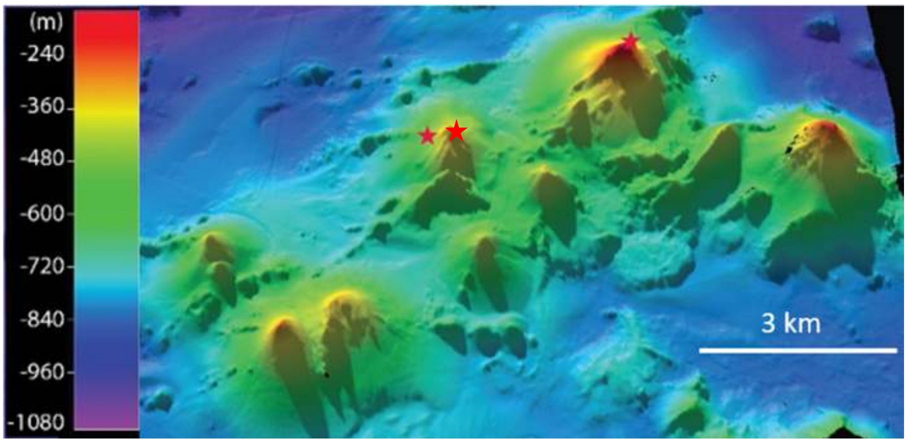

Fig. 5.3.5
3-D image of the seamount field at the southern end of the investigated area. The red stars indicate the location of the ROV dives.

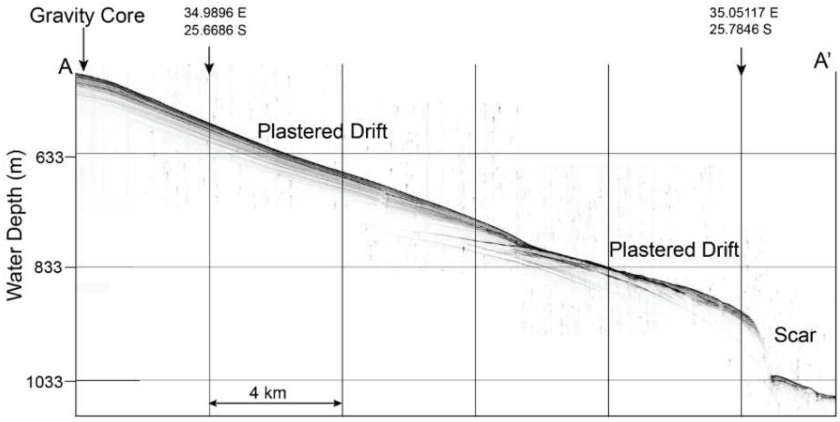

Fig. 5.3.6
PARASOUND line showing two convex sedimentary bodies that are identified as plastered drifts due to their slightly convex outward geometry. Position of gravity core GeoB26182-1 collected at ~500 m depth is indicated. Position of the PARASOUND line is indicated in Fig. 5.3.1b.

5.3.3 ROV Observations

ROV-Dive GeoB26170 (SQUID Dive 098) – slope off the Zambezi Delta - The ROV dive began at 490 m depth adjacent to one of the about 10 m high mounded seabed features lining up at the seabed. The seabed is made of a fluffy surface layer with many bushy and flexible benthic foraminifers, admixed with few *Madrepora* rubble. At 488 m depth, the first of many primnoid octocoral colonies were found. These colonies were attached to friable boulders which laid around dispersed at the base of the mounded feature. As a consistent pattern on this transect, several solitary corals, probably *Monohedotrochus* sp., thrive near the base of the primnoid holdfast. A spot with dozens of exposed remains of lithified chimneys appeared at 486 m depth (Fig. 5.3.7a). Associated to a partly alive *Madrepora* colony, were encrusting sponges, tubulariid and other hydroids, bryozoans, brittle stars and majid decapods. During the sampling of the chimneys, we saw a snake-like eel moving at the seabed (Fig. 5.3.7b).

Fig. 5.3.7 (a) Exhumed chimneys served as settling substrate for *Madrepora oculata* (colony width: 22 cm) and stylasterids at 486 m depth. (b) A snake-like eel (length: 80 cm) at 486 m depth.

Other fishes seen were few chlorophthalmids with a dark head, a bright body and dotted with dark spots. The proportion of the above-mentioned primnoid octocoral-solitary coral association got higher at 483 m depth (Fig. 5.3.8a). An egg capsule was firmly attached to some branches of the octocoral. Near the top of the mounded feature, which now could be assigned as a seep mound because of the masses of exhumed chimneys, we encountered a *Madrepora* rubble field in between the chimneys (Fig. 5.3.8b). A probably ranellid gastropod safeguarded her egg capsules which were attached in a nice pattern at the inner part of a broken chimney piece. We detected also chimneys in situ piercing out through the seabed (Fig. 5.3.8c). At the end of our transect, a site with spaghetti-like whitish blue bacterial mats was discovered. This mat was surrounded by dead dendrophylliid corals at 477 m depth (Fig. 5.3.8d).

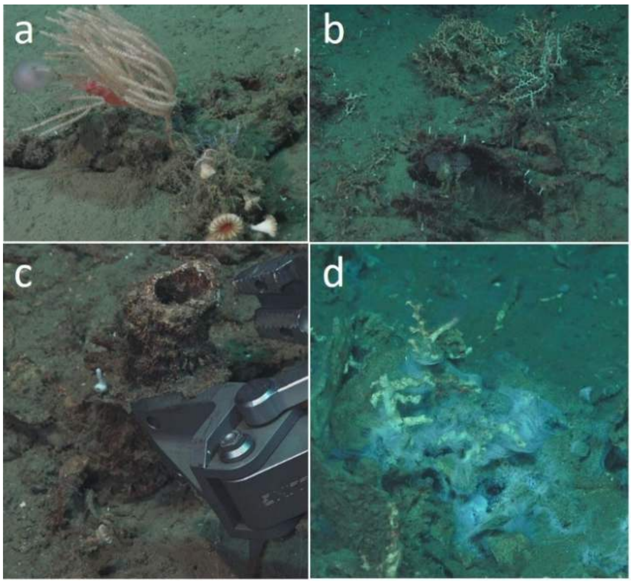

Fig. 5.3.8
(a) A characteristic arrangement of primnoid octocorals associated with solitary corals at 483 m depth. The shrimp is about 8 cm large. (b) *Madrepora* rubble field between exhumed chimneys at 479 m depth. Note the many small and stick-like stylasterids and the egg capsules laid down by a gastropod in the foreground. (c) Probing of an in-situ chimney with 4 cm in diameter at 479 m depth. (d) Whitish blue bacteria mat next to dead dendrophylliid corals at 477 m depth.

ROV-Dive GeoB26175 (SQUID Dive 099) – base of a SMT off the Limpopo Delta - Our dive target was to inspect the westernmost ridge at the base of a SMT at the 700 m depth, which strongly resembled CWC ridges attached to a volcanic plateau in the Mediterranean Sea (Wienberg et al. 2022). However, we got surprised by the spectacular seascape after the ROV had touched ground at 749 m depth. The ridge is entirely of volcanic origin, characterized by blistered lava crusts full of cracks, fissures and holes (Fig. 5.3.9a). We hardly saw any megafauna, except for purple antipatharians (Fig. 5.3.9b) and gorgonians. The sessile macrofauna, however, was dominated by small stylasterids. Brittle stars and tiny stalked crinoids were common constituents of the fissure fauna. The dive ended at 737 m depth.

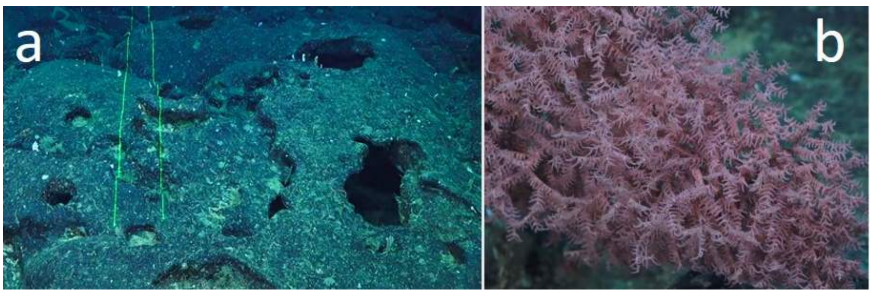

Fig. 5.3.9
(a) Impression of the blistered lava crusts at 745 m depth. (b) One of the very few antipa-tharian colonies seen at 745 m depth.

ROV-Dive GeoB26176 (SQUID Dive 100) – top of a SMT off the Limpopo Delta - The ROV touched ground in a real paradise of *Eguchipsammia* c.f. *gaditana*, a diverse suite of sponges, gorgonians and stylasterids about 100 m away from the highest point of the SMT in 327 m depth (Fig. 5.3.10a). All suspension feeders were firmly attached to a rough volcanic hard substrate. *Eguchipsammia* had bright yellow coloured polyps and soft tissue covering the uppermost few centimeters of the skeleton. While the smaller colonies with less than 20 cm diameter are mostly firmly attached to the rocks, larger colonies were found often free lying on the seabed with re-orientated growth of the surviving corallites. The sponges represented a characteristic rock sponge assemblage dominated by lithistids and other large Demospongia (Fig. 5.3.10b, c).

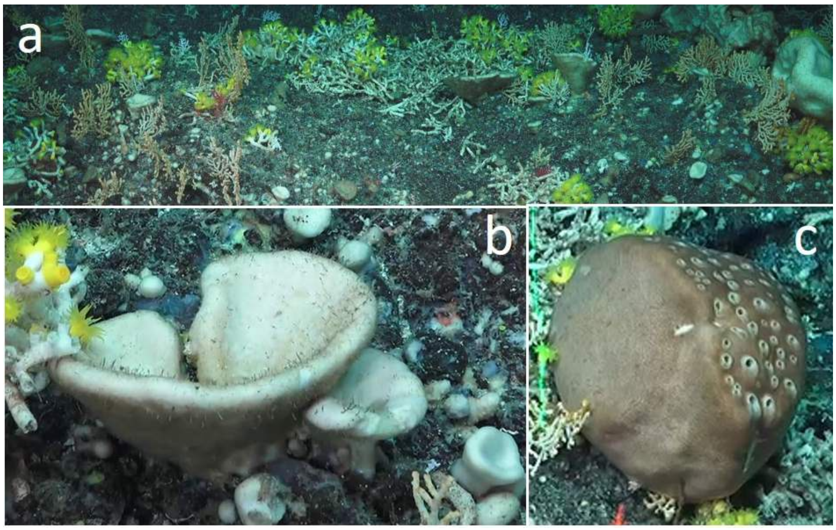

Fig. 5.3.10
(a) Panoramic view of the *Eguchipsammia*-gorgonian-rock sponge community at 327 m depth. The image width is about 1.5 m for scale. b) Different lithistid sponges at 327 m depth (width of the large cup-shaped specimen is 9 cm). c) Large, about 30 cm high demosponge with at pronounced set of osculae at 327 m depth.

First red coloured lace corals, probably belonging to *Hemicorallium* with translucent polyps (Fig. 5.3.11a), occurred next to the most common primnoid octocorals appeared (Fig. 5.3.11b). *Eguchipsammia* rubble patches became more prominent between 316 and 305 m depth (Fig. 5.3.11c). The rubble showed a mixture of dead corals and few still surviving colonies which laid unattached in these rubble pools. Here we also crossed a lost fishing long line.

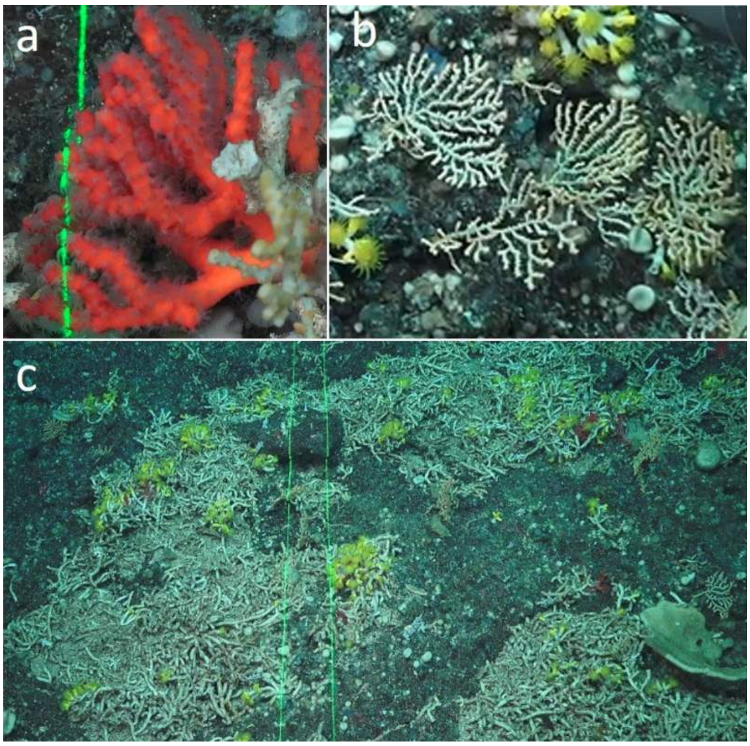

Fig. 5.3.11
(a) Bright red coloured lace coral with expanded polyps, probably *Hemicorallium*, forms colonies up to 10 cm high at 325 m depth. (b) A bunch of the most common primnoid octocoral colonies here at 327 m depth. (c) Impression of the *Eguchipsammia* rubble pools at 316 m depth (Spacing of laser beams = 10 cm).

At 292 m depth, the outer rim of the SMT was reached. The dendrophylliid corals were still present but much less common as before. Instead, masses of lithistid and other rock sponges dominate the scenery (Fig. 5.3.12a) accompanied – among others – by large (10 cm) pleurotomariid gastropods (*Bayerotrochus africanus*; Fig. 5.3.12b). Fishes encountered here were mostly *Pontinus nigerimum* resting in protected places within fissures, overhangs or cracks of the volcanic rocks and the snipefish *Notopogon xenosoma*.

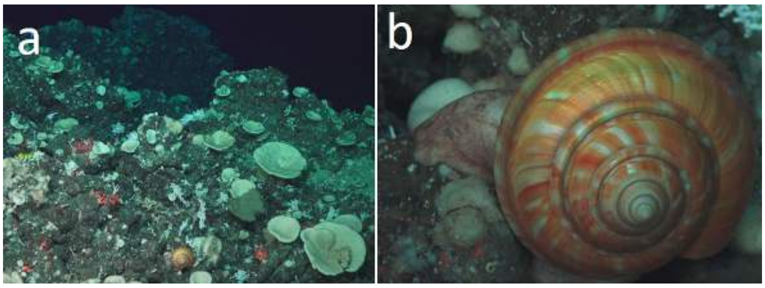

Fig. 5.3.12
(a) Lithistid rock sponge garden, lace corals and stylasterids at the upper rim of the SMT in 292 m depth. (b) This brownish gastropod belongs to the species *Bayerotrochus africanus* with a 10 cm wide conch.

ROV-Dive GeoB26180 (SQUID Dive 101) – large SMT off the Limpopo Delta - The dive started at 320 m depth close to the top of a large SMT located few miles NW of the previously investigated one. Also here, the *Eguchipsammia*-lithistid rock sponge assemblage as seen in the previous ROV dive prevailed. A major difference were the much larger reddish lace coral colonies, often attaining colony heights of 20 cm and largely diminished numbers of the primnoid octocorals. Remarkable was the diversity of stylasterids on this transect (Fig. 5.3.13b). A *Muraena* sp. was observed as she left her cave-like home to watch the ROV approaching (Fig. 5.3.13a). Larger patches of *Eguchipsammia* rubble appeared at 312 m depth and steadily more erect-branching stylasterids and a new antipatharian were seen at 307 m depth (Fig. T1c). Unfortunately, a mooring was detected by its buoy close to the vessel so that we halted the ROV dive for safety reasons at 307 m depth.

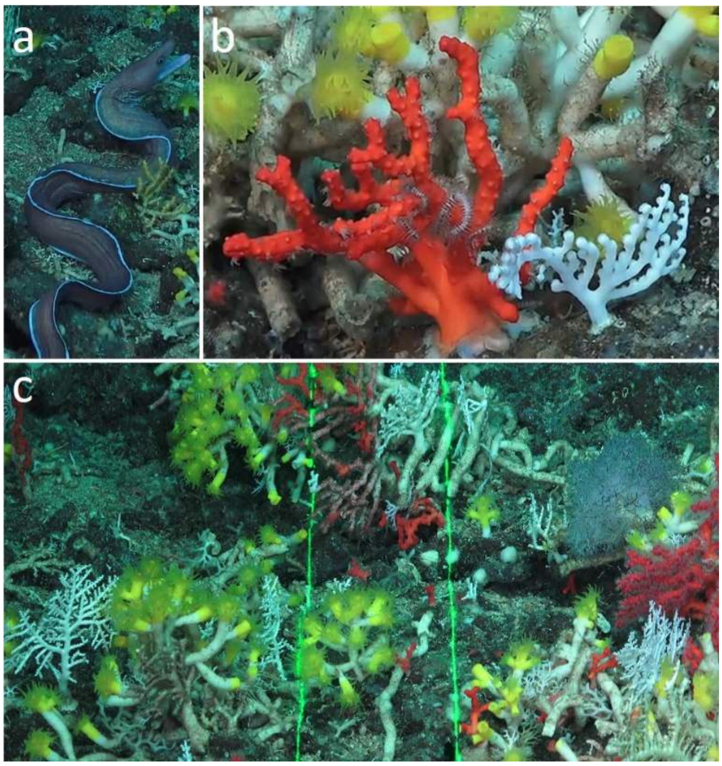

Fig. 5.3.13
(a) An about 1.1 m long *Muraena* had left her cave at 320 m depth. (b) An ensemble of lace corals, probably *Hemicorallium*, and a *Crypthelia* stylasterid (height of the lace coral is 5 cm). (c) Larger lace coral colonies, stylasterids and an antipatharian colony next to *Eguchipsammia* at 307 m depth (distance between laser lies: 10 cm).

5.3.4 Sediment Sampling

Surface samples – Benthic Invertebrate Fauna: Along the Mozambique continental margin, detailed information about the surface sediments and their macrofaunal composition only could be derived from one TV-GBC (GeoB26168-1; see Appendix 5.1) and two surface sediment samples collected by the ROV (GeoB 26175-4 and 26180-3; see Appendix 4). GeoB26168-1 taken from the Zambezi MV yielded a good recovery, but the fine muddy sediments were largely washed through the smallest mesh size (0.5 mm) used to analyse these sediments. In the coarser fraction, many smaller rocks were recovered including some pipe-shaped chimneys. The thanatocoenosis contained mostly protobranch bivalves from silty habitats like species in the genera *Nucula*, *Nuculana*, *Tindaria*, and *Bathyspinula* and species from muddy and low-oxygen habitats like those in the genera *Lucinoma* and *Vesicomya*. Gastropods at the location were predominantly carnivores in Conoidea.

ROV sample GeoB26175-4 obtained from a small sandy patch near the base of a SMT contained a small volume (200 ml) of sediment, which, however, showed a remarkably-high diversity of 56 gastropod species, but only 3 bivalve species and one polyplacophoran. The gastropods were dominated by parasites of sponges (families Fissurellidae, Triphoridae, and Cerithiopsidae), anemones and hard corals (family Epitoniidae), echinoderms (10 species in Eulimidae) and more general hosts (family Pyramidellidae). The bivalves included two species in the family Phylobryidae (*Adacnarca* sp. and *Neocardia* sp.). Both species are epifaunal filter feeders attached by byssus to elevated host fauna. A large number of stylasterids (Hydrozoa) were found; a brief inspection suggests about 10 species in the small sample. Whilst most of the species were left undetermined some were notionally placed in the genera *Crypthelia*, *Conopora* and *Stylaster* (Fig. 5.3.14). ROV sample GeoB26180-3 was taken near the summit of the SMT. A high diversity of living macrofauna was observed during the ROV surveys in the summit areas. Despite the high diversity of the observed living macrofauna, only 16 gastropods, one placophoran and 2 bivalves were found in the thanatocoenosis of our small sediment sample (400 ml). The gastropods were dominated by a majority of spongivores (families Fissurellidae and Triphoridae). It is still unclear why the malaco-diversity at the summit seems to be lower than near the base of the SMT, whereas the observed living fauna seem to follow a reverse pattern. The high diversity of stylasterids found at the base also could not be confirmed near the summit.

Fig. 5.3.14
(top) Hydrozoa, family Stylasteridae, *Crypthelia* sp., off Mozambique (ROV GeoB26175-4). (bottom) Hydrozoa, family Stylasteridae, genus and species not yet determined, off Mozambique (ROV GeoB26180-6).

Sediment cores: Three gravity cores were collected off Mozambique: one from the slope area off the Zambezi Delta (~18°S) at 580 m water depth (recovery: 6 m), and two from the southern slope (~25°S) at 500 and 1055 m water depth both with recoveries of ~8 m. The deeper core was probably collected from a contourite (for detailed core description see Appendix A5.2).

5.4 South Africa

In a recent paper, a number of potential CWC mounds were described from just outside the uThukela marine protected area (MPA; Green et al. 2022). Our aim was to verify this interpretation which was so far based on hydroacoustic data only. However, this proved to be very difficult as the Agulhas Current was flowing with a velocity of up to 5 kn through our working area. During two deployments of the TV-GBC, we got a few glimpses of the seabed and saw some larger blocks, which we interpret as slump bodies rather than coral mounds. As no surface samples could be acquired, this needs to be verified in the future. Approximately 50 nm further offshore, thus outside of the core of the Agulhas Current, we collected an almost 10 m long sediment core, which had much lighter and browner colours indicating an open marine setting compared to the typical olive-grey coloured cores, which we collected from the upper continental margin at other sites. With a deep CTD going down to ~2000 m, we finally encountered not only the AAIW, but also the NADW (Fig. 5.4.1 shows MBES overview map of the study area with all stations).

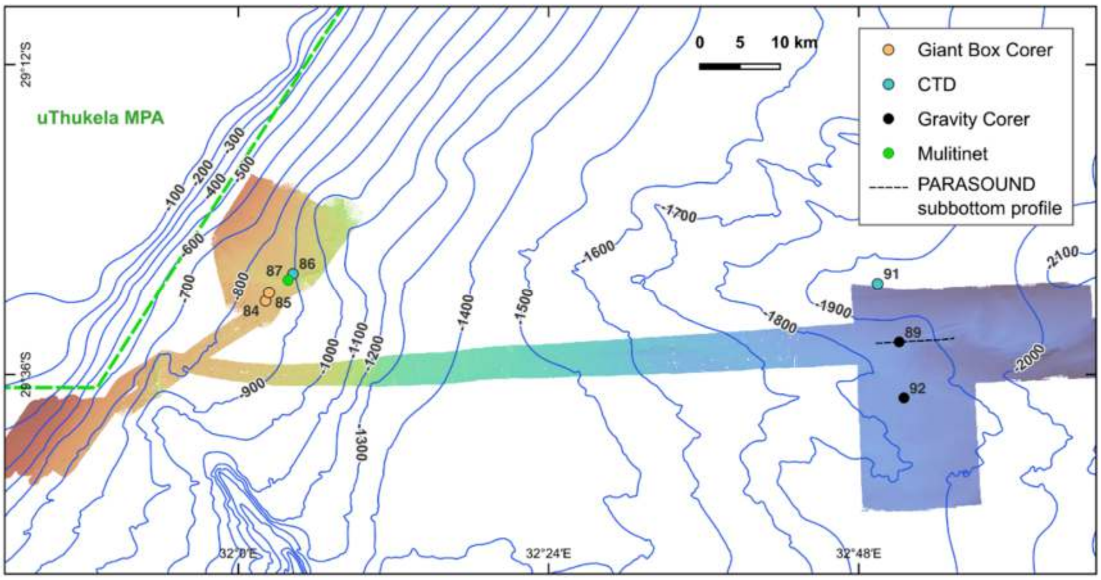

Fig. 5.4.1 Overview map of the South African margin mapped by MBES during RV SONNE expedition SO306. Two areas close to the uThukela Marine Protected Area (MPA; border marked by green dashed line) were mapped, as well as an area in deeper waters. Indicated are sampling positions (GeoB261xx; see legend for gear symbols) and one PARASOUND line (black dashed lines) presented in chapter 6.4.2.

5.4.1 Water Column Structure

Two CTD casts were conducted in the study area along the South African coast, encompassing water depths of ~2000 m. In contrast to the previously described shallow water masses (TSW, STSW, SICW), which enter the Mozambique Channel from the north, here we identified the Antarctic Intermediate Water (AAIW) and the underlying North Atlantic Deep Water (NADW, Ullgren et al. 2012; Fig. 5.4.2). In particular, the salinity increases with depth from 35.3 PSU at the surface (TSW) to a maximum of 35.6 PSU at ~200 m (STSW), accompanied by decrease in oxygen from 6.9 mg/l to a minimum of 5.5 mg/l. Below 200 m, these trends reverse for both parameters, reaching a salinity minimum of 34.4 PSU at 1000 m depth (AAIW) and an oxygen maximum of 6.8 mg/l between 500 m and 600 m (SICW). Below 1000 m the salinity rises slightly to 34.8 PSU until the end of the profile. The concentration of dissolved oxygen declines below 600 m and reaches its minimum of 4.3 mg/l at ~1300 m water depth at the transition from the AAIW to the NADW. Subsequently, the oxygen concentration rises again, reaching 6.2 mg/l in the bottom water. Water temperatures range from 22.5°C at the surface down to 2.4°C in ~2000 m depth and exhibit a thermocline at water depths of ~50 m.

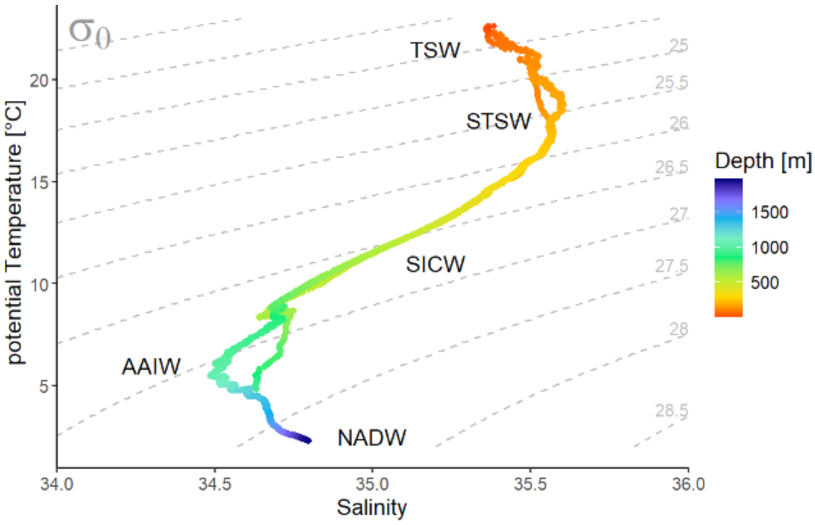

Fig. 5.4.2
Temperature-Salinity relation South Africa – CTD data including sigma-theta pycnoclines (density contours are plotted as the dashed grey lines) from two sites along the South African coast; Water masses: Tropical Surface Water (TSW), Subtropical Surface Water (STSW), South Indian Central Water (SICW), Antarctic Intermediate Water (AAIW), and North Atlantic Deep Water (NADW).

The water column to the east of South Africa is very heterogeneous. The strongest current there is the Agulhas Current, which moves the water column to the SW and has a velocity above 100 cm s^{-1} (Fig. 5.4.3). To the north of the area where we observed the Agulhas Current, the current direction is predominantly SW, but also some slower currents (about 50 cm s^{-1}) are present flowing to the NW, probably corresponding to eddies (Fig. 5.4.3).

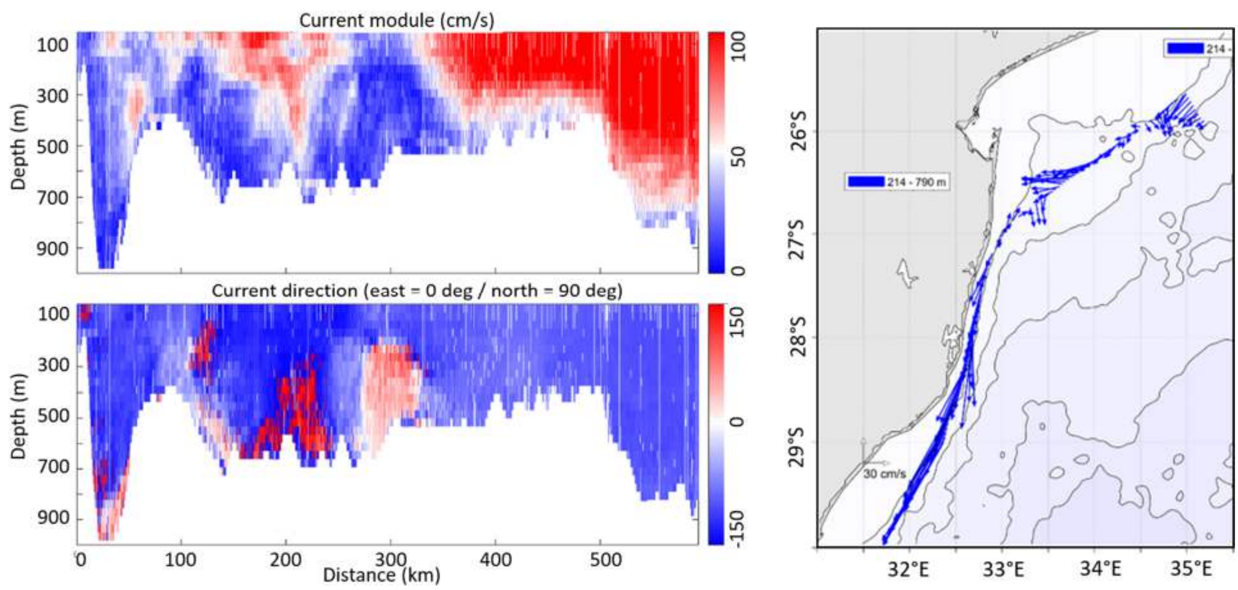

Fig. 5.4.3 (left) Current speed and direction, (right) average current velocity along the transit line from Mozambique to South Africa from ship-based ADCP 38 kHz.

5.4.2 Bathymetry and Sub-Seafloor Structures

The uThukela MPA and undersea cables restricted our mapping area but a site where potential CWC mounds have been reported was mapped (Fig. 5.4.1). Mound-like structures were detected, but strong currents prevented additional work. A further area to the southwest was mapped but yielded no structures. To avoid bad weather and strong currents, mapping was continued in deeper waters further east. There, we found a large lobe ornamented with dune-like structures and two highs with intervening lows (Figs. 5.4.4, 5.4.5).

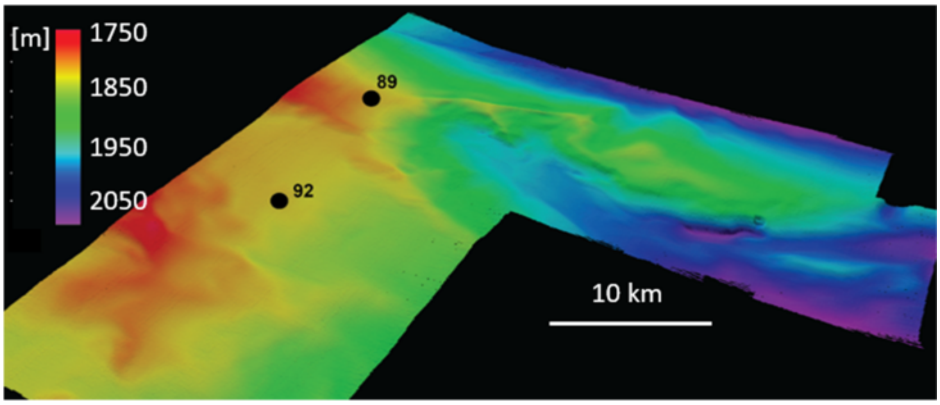

Fig. 5.4.4
3-D view of the deep-water area mapped off South Africa during SO306. Also shown is the location of two gravity core sites (GeoB26189, -92).

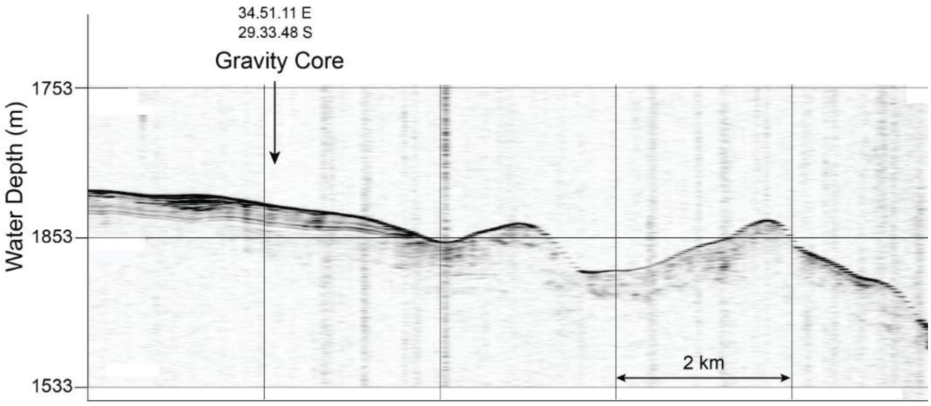

Fig. 5.4.5
PARASOUND seismic cross-profile showing the crest of the lobe with the location of the gravity core GeoB26189-1.

5.4.3 Sediment Sampling

Sediment cores - Two gravity coring attempts were made along the eastern South African slope, but the second one failed to recover any sediment. Although the PARASOUND seismic line showed a layered sedimentary environment, the corer did not penetrate the seafloor and the tube was bent. Core GeoB26189-1 was taken on the lobe at 1834 m water depth (see Fig. 5.4.5) and recovered 957 cm of fine-grained sediments with contourites (for a detailed core description see Appendix A5.2).

6 Station List SO306

Station (SO306)	GeoB-ID	Gear	Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)	Remark
Mayotte								
SO306_1-1	26101-1	CTD+ROS	11.08.24	08:09	12°25.103	45°31.838	3265	*sound velocity profiling; with mobile LADCP*
SO306_2-1	26102-1	MBES/PS	11.08.24	09:54	12°26.699	45°31.593	3415	*calibration mapping*
			11.08.24	14:31	12°26.641	45°31.684	3200	*end profile*
SO306_3-1	26103-1	MBES/PS	11.08.24	23:11	12°38.302	45°17.861	1269	*start*
			12.08.24	07:01	13°01.721	44°54.993	885	*end*
SO306_4-1	26104-1	CTD+ROS	12.08.24	07:55	13°02.306	44°55.047	1166	*water sampling; with mobile LADCP*
SO306_5-1	26105-1	ROV	12.08.24	10:33	12°56.978	44°53.015	951	***DIVE089**; start dive: 11:53*
			12.08.24	15:04	12°57.011	44°53.047	920	*end dive: 13:45; 9 samples*
SO306_6-1	26106-1	Lander	12.08.24	18:19	12°57.150	44°53.083	826	*lander deployment*
SO306_7-1	26107-1	MBES/PS	12.08.24	20:06	13°04.684	44°56.922	1540	*start*
			13.08.24	04:36	13°01.606	44°50.650	1432	*end*
SO306_8-1	26108-1	ROV	13.08.24	05:59	12°57.371	44°53.224	774	***DIVE090**; start dive: 06:55*
			13.08.24	09:39	12°57.389	44°53.272	770	*dive end: 08:35; aborted due to technical problems; 5 samples*
SO306_9-1	26109-1	TV-GBC	13.08.24	11:41	12°57.387	44°53.269	770	*recovery: 3-19 cm*
SO306_9-2	26109-2	EBS	13.08.24	13:53	12°57.387	44°53.240	775	*start*
			13.08.24	13:56	12°57.409	44°53.315	757	*end*
SO306_9-3	26109-3	MuNet	13.08.24	15:24	12°57.429	44°53.362	754	*sampling at 5 depth levels (0-500m)*
SO306_10-1	26110-1	CTD YoYo	13.08.24	16:39	12°57.224	44°53.182	790	*11 casts; water sampling at cast 11 (02:29); with mobile LADCP*
			14.08.24	03:00	12°57.232	44°53.182	788	
SO306_11-1	26111-1	ROV	14.08.24	05:51	13°01.410	44°52.088	1338	***DIVE091**; start dive: 07:24*
			14.08.24	13:51	13°01.578	44°52.316	1139	*end dive: 12:38; 14 samples*
SO306_12-1	26112-1	EBS	14.08.24	15:39	13°01.498	44°52.460	1124	*start*
			14.08.24	15:43	13°01.543	44°52.387	1126	*end*
SO306_12-2	26112-2	MuNet	14.08.24	17:08	13°01.595	44°52.290	1142	*sampling at 5 depth levels (0-500m)*
SO306_13-1	26113	MBES/PS	14.08.24	15:33	13°00.919	44°52.513	1249	*start*
			15.08.24	04:44	12°55.945	44°54.748	669	*end; profiling miles: 84 nm*
SO306_14-1	26114-1	ROV	15.08.24	05:26	12°56.126	44°54.423	680	***DIVE092**; start dive: 06:09*
			15.08.24	13:16	12°56.334	44°54.395	579	*end dive: 12:30; 24 samples*
SO306_15-1	26115-1	Lander	15.08.24	14:03	12°57.282	44°53.241	768	*lander recovery (see GeoB26106-1)*
SO306_16-1	26116-1	EBS	15.08.24	16:18	12°56.134	44°54.469	692	*start*
			15.08.24	16:26	12°56.196	44°54.579	686	*end*
SO306_17-1	26117-1	EBS	15.08.24	17:59	12°56.283	44°54.419	714	*start*
			15.08.24	18:03	12°56.319	44°54.380	542	*end*
Tanzania								
SO306_18-1	26118-1	CTD+ROS	17.08.24	03:53	10°01.927	40°57.911	2598	*sound velocity profiling; water sampling; with mobile LADCP*
SO306_19-1	26119-1	MBES/PS	17.08.24	07:15	10°14.542	40°38.476	1096	*start*
			17.08.24	11:00	10°22.125	40°31.332	362	*end; profiling miles: 27.9 nm*
SO306_20-1	26120-1	TV-GBC	17.08.24	12:10	10°20.072	40°30.038	372	*recovery: 0-20 cm*
SO306_21-1	26121-1	TV-GBC	17.08.24	13:44	10°21.138	40°29.822	274	*not released; video: boulders with corals*
SO306_22-1	26122-1	CTD+ROS	17.08.24	14:42	10°21.325	40°29.835	2719	*water sampling; with mobile LADCP*
SO306_23-1	26123-1	MBES/PS	17.08.24	15:19	10°20.095	40°29.996	3642	*start*
			18.08.24	03:54	10°12.292	40°23.165	439	*end; profiling miles: 94.1 nm*
SO306_24-1	26124-1	ROV	18.08.24	05:42	10°15.489	40°25.247	356	***DIVE093**; start dive: 06:09*
			18.08.24	11:01	10°15.205	40°24.848	354	*end dive: 10:24; 7 samples*
SO306_25-1	26125-1	TV-GBC	18.08.24	11:44	10°15.193	40°24.814	339	*recovery: 46 cm*
SO306_26-1	26126-1	TV-GBC	18.08.24	12:59	10°15.326	40°25.051	429	*recovery: 29 cm*
SO306_27-1	26127-1	MuNet	18.08.24	14:10	10°13.519	40°26.249	545	*sampling at 5 depth levels (0-500m)*
SO306_28-1	26128-1	EBS	18.08.24	16:54	10°15.237	40°25.119	441	*start*
			18.08.24	17:01	10°15.235	40°25.119	440	*end*
SO306_29-1	26129-1	EBS	18.08.24	18:29	10°15.037	40°24.951	350	*start*
			18.08.24	18:36	10°15.017	40°24.935	343	*end*

SO306_30-1	26130-1	MBES/PS	18.08.24	19:34	10°11.430	40°23.791	552	*start*
			19.08.24	04:40	10°12.535	40°30.647	839	*end; profiling miles: 71 nm*
SO306_31-1	26131-1	ROV	19.08.24	05:44	10°12.485	40°32.924	946	***DIVE094**; start dive: 06:59*
			19.08.24	13:37	10°12.396	40°32.816	963	*end dive: 12:13; 17 samples*
SO306_32-1	26132-1	TV-GBC	19.08.24	14:45	10°12.231	40°32.742	915	*recovery: 28 cm*
SO306_33-1	26133-1	CTD+ROS	19.08.24	16:17	10°12.263	40°32.711	862	*water sampling; with mobile LADCP*
SO306_33-2	26133-2	Lander	19.08.24	18:14	10°12.241	40°32.685	862	*lander deployment*
SO306_34-1	26134-1	CTD+ROS	19.08.24	19:28	10°12.266	40°32.737	920	*water sampling; with mobile LADCP*
SO306_35-1	26135-1	MBES/PS	19.08.24	20:40	10°12.931	40°31.927	859	*start*
			20.08.24	03:40	10°10.106	40°20.945	490	*end; profiling miles: 49 nm*
SO306_36-1	26136-1	ROV	20.08.24	05:34	10°12.521	40°32.847	942	***DIVE095**; start dive: 06:45*
			20.08.24	13:19	10°12.478	40°32.793	942	*end dive: 11:40; 18 samples*
SO306_37-1	26137-1	TV-GBC	20.08.24	14:26	10°12.222	40°32.663	868	*recovery: 10-20 cm*
SO306_38-1	26138-1	MuNet	20.08.24	15:46	10°12.300	40°32.675	891	*sampling at 5 depth levels (0-500m)*
SO306_39-1	26139-1	MBES/PS	20.08.24	16:57	10°13.452	40°32.492	868	*start*
			21.08.24	05:30	10° 09.963	40°20.741	483	*end; profiling miles: 49 nm*
SO306_40-1	26140-1	GC	21.08.24	06:07	10°10.068	40°21.283	424	*recovery: 577 cm; top lost (~20 cm)*
SO306_41-1	26141-1	GC	21.08.24	07:43	10° 06.052	40°19.992	765	*recovery: 665 cm; disturbed*
SO306_42-1	26142-1	MBES/PS	21.08.24	09:15	10°11.023	40°27.017	758	*start*
			21.08.24	09:44	10°13.545	40°29.933	748	*end; profiling miles: 3.9 nm*
SO306_43-1	26143-1	GC	21.08.24	11:35	10°12.096	40°40.247	1211	*recovery: 34 cm*
SO306_44-1	26144-1	GC	21.08.24	13:45	10°08.804	40°46.350	1492	*recovery: 404 cm*
SO306_45-1	26145-1	CTD YoYo	21.08.24	16:03	10°12.197	40°32.662	881	*12 casts; water sampling at cast 12 (03:00); with mobile LADCP*
			22.08.24	03:43	10°12.233	40°32.682	872	
SO306_46-1	26146-1	MBES/PS	22.08.24	06:53	10°11.101	40°32.681	869	*profiling miles: 44.1 nm*
			22.08.24	12:31	10°01.547	40°17.987	1302	*end profile*
SO306_47-1	26147-1	GC	22.08.24	13:36	10°06.042	40°20.200	771	*recovery: 546 cm*
SO306_48-1	26148-1	GC	22.08.24	15:20	10°00.993	40°21.504	1121	*recovery: 497 cm*
SO306_49-1	26149-1	MBES/PS	22.08.24	16:25	10°01.434	40°18.051	1308	*start*
			23.08.24	04:16	10°10.092	40°33.177	1083	*end; profiling miles: 94 nm*
SO306_50-1	26150-1	ROV	23.08.24	05:21	10°12.476	40°32.852	948	***DIVE096**; start dive: 07:24*
			23.08.24	12:04	10°12.583	40°32.932	941	*end dive: 10:01; 4 samples*
SO306_51-1	26151-1	TV-GBC	23.08.24	13:16	10°12.239	40°32.638	866	*recovery: 9-26 cm*
SO306_52-1	26152-1	TV-GBC	23.08.24	14:36	10°12.259	40°32.682	867	*recovery: 30 cm*
SO306_52-2	26152-2	CTD+ROS	23.08.24	15:52	10°12.282	40°32.707	905	*water sampling for experiments*
SO306_53-1	26153-1	MBES/PS	23.08.24	17:40	09°59.908	40°31.965	1468	*start*
			24.08.24	03:15	09°57.655	40°24.712	1350	*end; profiling miles: 78 nm*
SO306_54-1	26154-1	TV-GBC	24.08.24	08:25	10°21.118	40°29.802	274	*recovery: 0-14 cm; video-mapping*
SO306_55-1	26155-1	EBS	24.08.24	10:03	10°21.413	40°30.224	302	*start*
			24.08.24	10:16	10°21.460	40°30.258	302	*end; EBS damaged during dredging*
SO306_56-1	26156-1	MBES/PS	24.08.24	11:04	10°20.061	40°30.728	435	*start*
			25.08.24	06:49	09°57.685	40°44.399	1840	*end; profiling miles: 157 nm*
SO306_57-1	26157-1	CTD+ROS	25.08.24	07:42	09°57.224	40°44.228	1835	*sound velocity profiling*
SO306_58-1	26158-1	GC	25.08.24	10:13	10°04.597	40°46.140	1650	*recovery: 836 cm*
SO306_59-1	26159-1	Lander	25.08.24	12:50	10°12.280	40°32.744	?	*lander recovery (see GeoB26133-2)*
SO306_60-1	26160-1	EBS	25.08.24	14:46	10°12.478	40°32.665	937	*start*
			25.08.24	15:08	10°12.607	40°32.792	936	*end*
SO306_61-1	26161-1	MBES/PS	25.08.24	18:20	09°57.954	40°44.693	1870	*start*
			26.08.24	06:11	09°56.117	40°30.023	1563	*end; profiling miles: 97 nm*
SO306_62-1	26162-1	TV-GBC	26.08.24	09:11	09°56.075	40°30.271	1600	*not released; video-mapping*
SO306_63-1	26163-1	GC	26.08.24	13:00	09°57.004	40°43.595	1819	*recovery: 463 cm*
SO306_63-2	26163-1	EBS	26.08.24	16:20	09°57.125	40°43.889	1824	*start*
SO306_63-2	26163-2	EBS	26.08.24	16:32	09°57.128	40°43.888	1824	*end*
SO306_64-1	26164-1	MBES/PS	26.08.24	19:15	10°03.901	40°54.683	2354	*start*
			27.08.24	05:01	10°14.421	40°24.699	365	*end; profiling miles: 86 nm*
SO306_65-1	26165-1	ROV	27.08.24	05:45	10°15.093	40°25.698	460	***DIVE097**; bottom view: 07:00*
			27.08.24	08:57	10°14.989	40°25.635	490	*dive could not start due to strong currents*

Mozambique – off Zambezi

SO306_66-1	26166-1	CTD+ROS	29.08.24	16:40	18°51.529	37°14.673	513	*sampling at 5 depth levels (0-500m)*

SO306_66-2	26166-2	MuNet	29.08.24	17:35	18°51.544	37°14.697	512	*sampling at 5 depth levels (0-480m)*
SO306_67-1	26167-1	MBES/PS	29.08.24	18:50	18°52.260	37°16.993	657	*start*
			30.08.24	05:24	18°51.288	37°14.132	462	*end; profiling miles: 74 nm*
SO306_68-1	26168-1	TV-GBC	30.08.24	07:04	18°51.518	37°14.166	471	*recovery: 34 cm; video-mapping*
SO306_69-1	26169-1	GC	30.08.24	08:31	18°54.245	37°14.309	580	*recovery: 598 cm*
SO306_70-1	26170-1	EBS	30.08.24	10:37	18°54.074	37°14.144	577	*start*
			30.08.24	10:38	18°54.068	37°14.147	576	*end*
SO306_71-1	26171-1	ROV	30.08.24	12:10	18°51.467	37°14.380	486	***DIVE098**; start dive: 12:47*
			30.08.24	14:39	18°51.420	37°14.335	480	*end dive: 14:03; 8 samples*
SO306_72-1	26172-1	CTD+ROS	30.08.24	15:30	18°51.385	37°14.307	475	*water sampling; with mobile ADCP*
Mozambique – off Limpopo								
SO306_73-1	26173-1	CTD+ROS	01.09.24	16:43	25°56.962	35°10.772	906	*sound velocity profiling*
SO306_74-1	26174-1	MBES/PS	01.09.24	17:46	26°00.624	35°13.049	840	*start*
			02.09.24	4:04	26°02.407	35°07.059	1027	*end; profiling miles: 80.6 nm*
SO306_75-1	26175-1	ROV	02.09.24	05:29	25°59.140	35°9.602	742	***DIVE099**; start dive: 06:28*
			02.09.24	09:30	25°59.101	35°9.699	699	*end dive: 08:24*
SO306_76-1	26176-1	ROV	02.09.24	11:01	25°59.144	35°10.408	365	***DIVE100**; start dive: 11:26*
			02.09.24	14:12	25°59.159	35°10.419	363	*end dive: 13:41; 9 samples*
SO306_77-1	26177-1	CTD+ROS	02.09.24	14:48	25°59.209	35°10.360	296	*sound velocity profiling water sampling; with mobile LADCP*
SO306_78-1	26178-1	MuNet	02.09.24	16:07	25°59.147	35°09.572	748	*sampling at 5 depth levels (0-500m)*
SO306_79-1	26179-1	MBES/PS	02.09.24	17:34	25°57.115	35°13.644	925	*start*
			03.09.24	04:33	26°00.133	35°9.272	837	*end; profiling miles: 90 nm*
SO306_80-1	26180-1	ROV	03.09.24	06:00	25°57.673	35°11.754	371	***DIVE101**; start dive: 06:28*
			03.09.24	08:33	25°57.698	35°11.751	346	*end dive: 08:01; aborted due to buoy on top of SMT; 7 samples*
SO306_81-1	26181-1	GC	03.09.24	12:00	25°49.248	35°6.100	1055	*recovery: 858 cm*
SO306_82-1	26182-1	GC	03.09.24	14:52	25°38.733	34°58.507	500	*recovery: 843 cm*
SO306_82-2	26182-1	EBS	03.09.24	16:39	25°38.776	34°58.482	504	*start*
			03.09.24	16:42	25°38.739	34°58.508	505	*end*
South Africa								
SO306_83-1	26183-1	MBES/PS	04.09.24	18:55	29°22.050	32°03.466	723	*start*
			05.09.24	04:43	29°28.680	32°4.929	994	*end; profiling miles: 79.1 nm*
SO306_84-1	26184-1	TV-GBC	05.09.24	06:16	29°30.304	32°2.103	807	*video-mapping; no coring possible; aborted due to strong currents*
SO306_85-1	26185-1	TV-GBC	05.09.24	10:06	29°29.664	32°2.364	804	*video-mapping; aborted due to broken winch*
SO306_86-1	26186-1	CTD+ROS	05.09.24	11:56	29°28.199	32°4.218	943	*sound velocity profiling water sampling; with mobile LADCP*
SO306_87-1	26187-1	MuNet	05.09.24	13:34	29°28.685	32°3.839	971	*sampling at 5 depth levels (0-500m)*
SO306_88-1	26188-1	MBES/PS	05.09.24	15:31	29°38.251	31°50.437	686	*start*
			06.09.24	04:49	29°38.046	31°50.227	676	*end; profiling miles: 87 nm*
SO306_89-1	26189-1	GC	06.09.24	11:52	29°33.480	34°51.111	1835	*recovery: 957 cm*
SO306_90-1	26190-1	MBES/PS	06.09.24	12:59	29°33.083	32°53.784	1834	*start*
			07.09.24	06:24	29°29.023	32°49.440	676	*end; profiling miles: 139 nm*
SO306_91-1	26191-1	CTD+ROS	07.09.24	07:11	29°28.976	32°49.439	1963	*sound velocity profiling water sampling; with mobile LADCP*
SO306_92-1	26192-1	GC	07.09.24	09:44	29°37.787	32°51.476	1811	*tube bent; empty*

Abbreviations: WD, water depth; REC, recovery; CTD+ROS: CTD plus water sampler, MuNet: multinet, SML: satellite mini lander (GEOMAR), MBES/PS: surveys with Multibeam Echosounder and PARASOUND sub-bottom profiler, GC: gravity corer, TV-GBC: video-guided giant box corer, EBS: epibenthic sledge

7 Data and Sample Storage and Availability

A Short Cruise Report was compiled on-board at the end of the cruise. A final station list was submitted to PANGAEA. The cruise was conducted within the Exclusive Economic Zones of Mayotte (France), Tanzania, Mozambique, and South Africa. All shipboard data will be transferred to the PANGAEA database as soon as they are available and quality checked. Depending on the type of data and the progress of sample analysis, this will generally take 2-3 years, but not later than September 2027. The list below identifies the scientists responsible for accessing the different data and sample sets. Collaboration on the received data and samples is welcome and interested scientists are encouraged to contact the responsible persons listed below.

Type	Remark	Contact
Hydroacoustic Data	MBES (EM 122, EM 710), PARASOUND and ADCP data are stored at MARUM (Bremen). The raw data are submitted to BSH and PANGAEA.	Prof. Dr. D. Hebbeln (dhebbeln@marum.de) Dr. E. Bazhenova (ebazhenova@marum.de)
Hydrographic data (CTD and Lander)	CTD and lander data are stored and analysed at the GEOMAR (Kiel).	Dr. J. Raddatz (jraddatz@geomar.de)
Sediment Cores and Samples	All sediment cores and samples are stored at the MARUM GeoB core repository (Bremen).	Prof. Dr. D. Hebbeln (dhebbeln@marum.de) Dr. C. Wienberg (cwberg@marum.de)
Zoobenthos	Samples and metadata are stored at Senckenberg (Wilhelmshaven, Hamburg) and will be analysed in cooperation with the DZMB (Wilhelmshaven).	Prof. Dr. A. Freiwald (andre.freiwald@senckenberg.de) Dr. Saskia Brix-Elsig (saskia.brix-elsig@senckenberg.de)
Seafloor Imaging	Photo and video footage obtained by the ROV are stored at the MARUM (Bremen) and at Senckenberg am Meer (Wilhelmshaven).	Dr. C. Wienberg (cwberg@marum.de) Prof. Dr. A. Freiwald (andre.freiwald@senckenberg.de)

8 Acknowledgements

The Shipboard Scientific Party aboard RV SONNE during cruise SO306 would like to thank Captain Tilo Birnbaum, his officers and crew for their friendly and professional cooperation and very efficient technical support which contributed significantly to the overall scientific success of this cruise. The efforts of diplomatic corps at the German Embassies in Dar-es-Salaam, Maputo, Pretoria, and Paris and the Foreign Office in Berlin are greatly appreciated. We are grateful to the German Ministry of Education and Science (BMBF) for funding this project, incl. the funding of ship time on RV SONNE and the funding of ROV SQUID operations through grants 03G0306A, 03G0306B and 03G0306C. Finally, the German Research Fleet Coordination Centre (LDF) is thanked for logistical support.

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Appendix 1

A1 Underwater Hydroacoustics

(E. Bazhenova, A. Bach, G. Eberli, N. Lagunova)

A1.1 Attributed Sensors

Navigation (ship's position, speed over ground, course over ground) and motion (roll, pitch, heading, heave) data were provided using the Kongsberg Seatex Seapath 380-5+ sensor, which combines a 3710 DGNSS Receiver and an MRU 5+ inertial measurement unit. Usage of DGNSS corrections enabled high navigation accuracy during expedition SO306.

The hull-mounted sound velocity sensor Valeport MODUS SVS was used to provide real-time sound velocity measurements at the multi-beam transducer head. For every new working area and before starting station work, vertical sound velocity profiles (SVP) were obtained at CTD stations to correct the acoustic ray tracing during the MBES data acquisition and the USBL underwater positioning. Based on the CTD data, the speed of sound was recalculated as a function of temperature, salinity and pressure utilizing the Chen-Millero equation (1977).

A1.2 Ultra-Short Baseline (USBL)

Under-water positioning for ROV dives and various other instruments lowered to the seabed was provided using the SONARDYNE Ranger 2 USBL system designed for deep-water operations. Ranger 2 allows up to 10 subsea targets to be simultaneously tracked from a vessel. 1Hz position updates are achievable in any water depth. Standard output telegrams used during the ROV dives included (1) geographic coordinates as WGS84 longitude and latitude, and (2) heading, eastings and northings within the operational UTM zone.

A1.3 Multi-Beam Echosounder System (MBES)

Bathymetric mapping was performed using the Kongsberg EM122 multi-beam echosounder system (MBES) integrated with the motion and positioning system Seapath 380-5+. Raw bathymetry (*.all) data and, on demand, water-column (*.wcd) data were recorded using the Kongsberg SIS v.4.3.2 software package. Real-time data plotting in SIS allowed for the initial data coverage and quality control. A data acquisition log produced during the watches is available in Table A1.1.

MBES survey planning was primarily based on the regional and global bathymetric charts available (swIOBC, 2018; GEBCO, 2023). MBES mapping was generally conducted at 8 kn. To provide sufficient sounding density, survey lines were spaced to allow for 200% mapping coverage in deeper areas. As surveyed depths ranged from 200 to 3000 m, SIS depth mode "Automatic" was used along with the operating frequency of 12 kHz. Angular sector coverage was normally set to ±60 degrees during the surveys, and decreased to ±40 to 50 degrees during transit. To reduce acoustical interference with the hull-mounted sub-bottom profiler P70 and ADCP sensors (OS38 and OS75), the Kongsberg Synchronization Unit K-Sync was used.

The depths measured by the MBES are reported in respect to the water level. Only static draft was considered. No tidal corrections were applied during the data acquisition or data postprocessing. However, water-level variations in the region can reach up to 1.5 m as predicted by the NOAA model.

The raw bathymetry data (*.all) were imported into the QPS Qimera software v.2.6.2. The achieved sounding density at different depths allowed for gridding data at 20-40 m horizontal resolution. Data quality control included 1) verification that the SVP data were applied correctly based on the time and location; 2) blocking outer beams and in-turn data to ensure the best possible quality of the overlapping swaths, 3) manual point cloud cleaning if required. Additional cleaning is required for bathymetry data collected during transits. Obtained backscatter data needs further processing. Preliminary bathymetric grids were created for all the workings areas and exported as georeferenced *.tiff files (see A1.4). Additional grids with higher horizontal resolution were created for the ROV dive areas if increased sounding density had been achieved during multiple area crossing. QGIS software v.3.34.10 was utilized for the MBES line planning and preparation of the final overview maps.

Table A1.1 MBES Data Acquisition Log.

Date ddmmyy	Time (UTC)	Area	SIS project / Event	EM122	EM710	Notes	Operator
11.08.24	3:13	Mayotte	SO306_transitToSt1_start	v		used SVP profile from SO305-2	EB
11.08.24	5:52	Mayotte	SO306_transitToSt1_end	v			EB
11.08.24	6:35	Mayotte	Station 1_CTD_start				EB
11.08.24	9:15	Mayotte	Station 1_CTD_end			updated SVP profile in SIS	EB
11.08.24	10:17	Mayotte	SO306_EM122_calibration_start	v		angular offsets set to zeros	EB
11.08.24	14:32	Mayotte	SO306_EM122_calibration_end	v			EB
11.08.24	0:00	Mayotte	SO306_EM122_calibration_ transit to SW	v		started at waypoint, line count 019	GE
11.08.24	23:12	Mayotte	SO306_EM122_calibration_ transit to SW	v			GE
12.08.24	12:35	Mayotte	SO306_EM122_calibration_ transit to SW	v	v	updated SVP profile in SIS	EB
12.08.24	0:00	Mayotte	changed Installation Parameters for EM122			entered TX pitch offset in SIS for EM122	EB
12.08.24	19.07	Mayotte	SO306_Mayotte_mapping_start	v	v	forced depth larger than 1400	GE
12.08.24	20:05	Mayotte	SO306_Mayotte_mapping	v	v	EM710 changed angle back to 50	GE
13.08.24	2:05	Mayotte	SO306_Mayotte_mapping	v	v	EM710 stopped logging, system was turned off	AB
13.08.24	5:37	Mayotte	SO306_Mayotte_mapping_end	v			EB
14.08.24	2:29	Mayotte	CTD station			did not update SIS as the previous SVP went deeper	EB
14.08.24	18:06	Mayotte	SO306_Mayotte_mapping_start	v			GE
15.08.24	4:45	Mayotte	SO306_Mayotte_mapping_end	v			AB
15.08.24	18:40	Mayotte	SO306_Mayotte_mapping_ Transit2_start	v		stopped soundings at 2015 for calibration	GE
15.08.24	21:45	Mayotte	SO306_Mayotte_mapping_ Transit2_cont.	v		calbibration check Lines 80-82	AB
15.08.24	22:05	Mayotte	SO306_Mayotte_mapping_ Transit2_start	v		Start Line 82	AB
16.08.24	1:50	Mayotte	SO306_Mayotte_mapping_ Transit2_end	v		exit Mayotte EEZ, switched off the MBES	EB
17.08.24	4:40	Tanzania	CTD station at 2600 mwd	v	v	updated SVP profile in SIS	EB
17.08.24	5:00	Tanzania	SO306_Tanzania_mapping1_start	v			EB

17.08.24	8:40	Tanzania	SO306_Tanzania_mapping1	v	v	turn into line 1	EB
17.08.24	11:03	Tanzania	SO306_Tanzania_mapping1_end	v	v		
17.08.24		Tanzania	CTD station				
17.08.24	15:23	Tanzania	SO306_Tanzania_mapping2_start	v	v	skipped infill line at 19:35	GE
18.08.24	3:56	Tanzania	SO306_Tanzania_mapping2_end	v	v		
18.08.24	19:34	Tanzania	SO306_Tanzania_mapping3_start	v			AB
19.08.24	2:00	Tanzania	SO306_Tanzania_mapping3	v		changed angle to 65 deg	EB
19.08.24	2:56	Tanzania	SO306_Tanzania_mapping3	v		changed angle to 70 deg	EB
19.08.24	4:42	Tanzania	SO306_Tanzania_mapping3_end	v		stopped profile 7-6 to turn into the ROV pos.	EB
19.08.24		Tanzania	CTD station				
19.08.24	20:40	Tanzania	SO306_Tanzania_mapping4_start	v		with WCL	GE
20.08.24	1:00	Tanzania	SO306_Tanzania_mapping4	v		stopped logging WC	EB
20.08.24	1:46	Tanzania	SO306_Tanzania_mapping4_end	v		turn to Dive location	EB
20.08.24	14:34	Tanzania	SO306_Tanzania_WCL_start	v		logging WC at GKG station SO306_37	EB
20.08.24	16:38	Tanzania	SO306_Tanzania_WCL_end	v		SIS lines 0150-0155	GE
20.08.24	16:43	Tanzania	SO306_Tanzania_mapping5_start	v		with WCL, off at 18:14, on 20:16	GE
21.08.24	5:31	Tanzania	SO306_Tanzania_mapping5_end	v			EB
21.08.24	8:25	Tanzania	SO306_Tanzania_mapping_start	v		closing gap in SW	EB
21.08.24	10:56	Tanzania	SO306_Tanzania_mapping_end	v		closed the gap	AB
21.08.24	16:03	Tanzania	SO306_Tanzania_mapping	v		logging WC at CTD location	EB
22.08.24	5:08	Tanzania	SO306_Tanzania_mapping	v		stopped logging WC (lines 0209-0230)	EB
22.08.24	6:56	Tanzania	SO306_Tanzania_mapping6_start	v			EB
22.08.24	11:48	Tanzania	SO306_Tanzania_mapping7_start	v		starboard swath angle set to 70 °	AB
22.08.24	12:38	Tanzania	SO306_Tanzania_mapping7_stop	v		stopped between WP 2-3 for GC station	AB
22.08.24	14:10	Tanzania	SO306_Tanzania_mapping7	v		end of GC station, line 253 to close gap	EB
22.08.24	16:26	Tanzania	SO306_Tanzania_mapping7_resume	v		back to point between WP2-3	EB
22.08.24	22:07	Tanzania	SO306_Tanzania_mapping7	v		starboard swath angle set to 70 ° to fill gap	AB
22.08.24	22:30	Tanzania	SO306_Tanzania_mapping7	v		starboard swath angle set back to 60°	AB
23.08.24	2:55	Tanzania	SO306_Tanzania_mapping7_line286	v		turn into WP16, following the fault (?)	EB
23.08.24	4:19	Tanzania	SO306_Tanzania_mapping7_stop	v		arriving at Dive096 location	EB
23.08.24	17:27	Tanzania	SO306_Tanzania_mapping7_cont	v		contiuation of survey betwen WP10_11	GE
24.08.24	7:25	Tanzania	SO306_Tanzania_mapping7_crossline	v		**lines 0319-0320 across the canyon**	EB
24.08.24	3:16	Tanzania	SO306_Tanzania_mapping7_end	v		transit to Dive097 location	EB
24.08.24	5:52	Tanzania	SO306_Tanzania_mapping7_end	v_stop		at location	
24.08.24	10:53	Tanzania	SO306_Tanzania_mapping8_start	v		start from line 0328	EB
25.08.24	6:52	Tanzania	SO306_Tanzania_mapping8_stop	v		at location for CTD	GE
25.08.24	9:14	Tanzania	SO306_Tanzania_mapping8	v		updated SV profile in SIS	EB
25.08.24	18:08	Tanzania	SO306_Tanzania_mapping9_start	v			GE
26.08.24	2:20	Tanzania	SO306_Tanzania_mapping9	v		23	AB
26.08.24	2:20	Tanzania	SO306_Tanzania_mapping9	v		set starboard swath to 70°	AB

26.08.24	4:15	Tanzania	SO306_Tanzania_mapping_end	v		finished MBES profiles at line 0405	EB
26.08.24	6:13	Tanzania	SO306_Tanzania_mapping_pockmark	v		mapping of pockmark during approach	GE
26.08.24	9:16	Tanzania	SO306_Tanzania_mapping_pockmark	v		pockmark mapping ended	AB
26.08.24	19:06	Tanzania	SO306_Tanzania_mapping10_start	v			GE
26.08.24	19:06	Tanzania	SO306_Tanzania_mapping10	v		on lines 407-413 WCD was acquired during SO306_Tanzania_mappin g_pockmark	AB
27.08.24	1:56	Tanzania	SO306_Tanzania_mapping10_end	v		finished main lines, proceed with 10 kn	EB
		Tanzania	SO306_Tanzania_mapping	v		logging at Dive location	
27.08.24	5:00	Tanzania	SO306_ROV_Dive Site	v		WCL on for some minutes aroound 7:25	GE
27.08.24	8:22	Tanzania	SO306_ROV_Dive Site_end	v			GE
27.08.24	10:32	Transit	SO306_Tanzania_mapping11_Transit Mozambique	v		starting from line 450	GE
29.08.24	17:10	Transit	SO306_Tanzania_mapping11_Transit Mozambique	v		stop	EB
29.08.24	17:00	MozambiqueN	CTD station 26166	v	v	updated SV profile in SIS	EB
29.08.24	17:12	MozambiqueN	SO306_Mozambique_mapping1_start	v		strong amplitudes at central beam	EB
30.08.24	1:45	MozambiqueN	SO306_Mozambique_mapping1	v	v	started EM710 on line WP15-16	EB
30.08.24	2:00	MozambiqueN	SO306_Mozambique_mapping1	v	v	changed EM122 to SHALLOW PingMode	EB
30.08.24	16:05	MozambiqueN	SO306_Mozambique_mapping1_end	v	v	stopped logging EM710 after station work	EB
30.08.24	16:10	MozambiqueN	SO306_Mozambique_transit_start	v		changed EM122 to AUTO PingMode, bad weather; SV issues since midnight	EB
01.09.24	16:15	MozambiqueS	CTD station 26173-1	v	v	updated SV profile in SIS	EB
01.09.24	17:14	MozambiqueS	SO306_Mozambique_mapping2_start	v		SV issues above mounds	GE
02.09.24	5:37	MozambiqueS	SO306_Mozambique_mapping2_end	v		stopped logging at the Dive 099 location	EB
02.09.24	14:34	MozambiqueS	CTD station 26177	v		updated SV profile in SIS	EB
02.09.24	16:50	MozambiqueS	SO306_Mozambique_mapping4_start	v		SV issues start 18:56 and continues until 20:58	GE
03.09.24	5:24	MozambiqueS	SO306_Mozambique_mapping4_end	v		arrived at Dive 101 location	EB
03.09.24	9:00	MozambiqueS	SO306_Mozambique_mapping6_start	v		SV issues again on and off	GE
03.09.24	17:20	MozambiqueS	SO306_Mozambique_mapping6_end	v		started transit to South Africa	EB
04.09.24	0:00	SouthAfrica	SO306_SouthAfrica_mapping1_start	v		rough sea conditions	EB
04.09.24	21:19	SouthAfrica	SO306_SouthAfrica_mapping1	v		SV issue on and off	AB
05.09.24	5:00	SouthAfrica	SO306_SouthAfrica_mapping2_stop	v		arrived at GKG station	EB
05.09.24	11:34	SouthAfrica	CTD station 26186	v		updated SV profile in SIS	AB
05.09.24	15:30	SouthAfrica	SO306_SouthAfrica_mapping3_start	v			EB
06.09.24	1:10	SouthAfrica	SO306_SouthAfrica_mapping3	v		strong currents, ship can't keep course, interference with PS; reduce angle on line 22-23	EB
06.09.24	5:00	SouthAfrica	SO306_SouthAfrica_mapping3_end	v		proceed to GC station	EB
06.09.24	12:55	SouthAfrica	SO306_SouthAfrica_mapping4_start	v		SV issues	EB
07.09.24	6:23	SouthAfrica	SO306_SouthAfrica_mapping4_end	v		arrived at CTD location	EB
07.09.24	6:32	SouthAfrica	CTD station 26191	v		update SV profile in SIS	AB

EB: Evgenia Bazhenova, GE: Gregor Eberli, AB: Alissa Bach

A1.4 MBES Bathymetric Grids

Mayotte

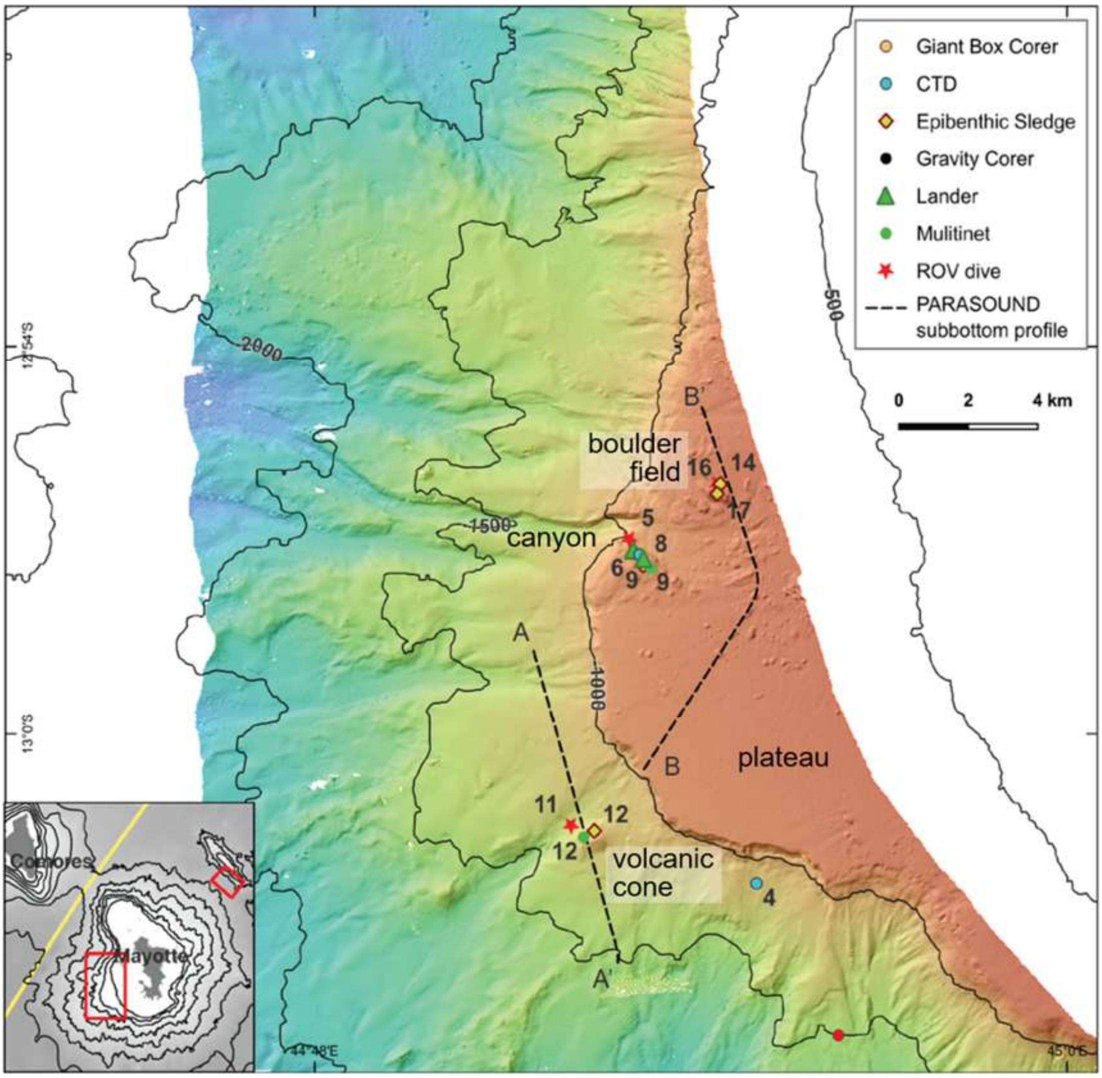


Fig. A1.1 Overview map of the SW Mayotte slope and plateau mapped by MBES (30x30 m horizontal resolution) during RV SONNE expedition SO306. The inset shows the position of the main working area SW of Mayotte and the area mapped for the MBES calibration in the NE of the island. A submarine plateau with boulders and blocks ends and a steep margin overlays the ridges and canyons of volcanic cone of SW Mayotte. Indicated are sampling positions (GeoB261xx; see legend for gear symbols) and PARASOUND lines (dashed lines) presented in chapter 5.1.3.

Tanzania ~10°S

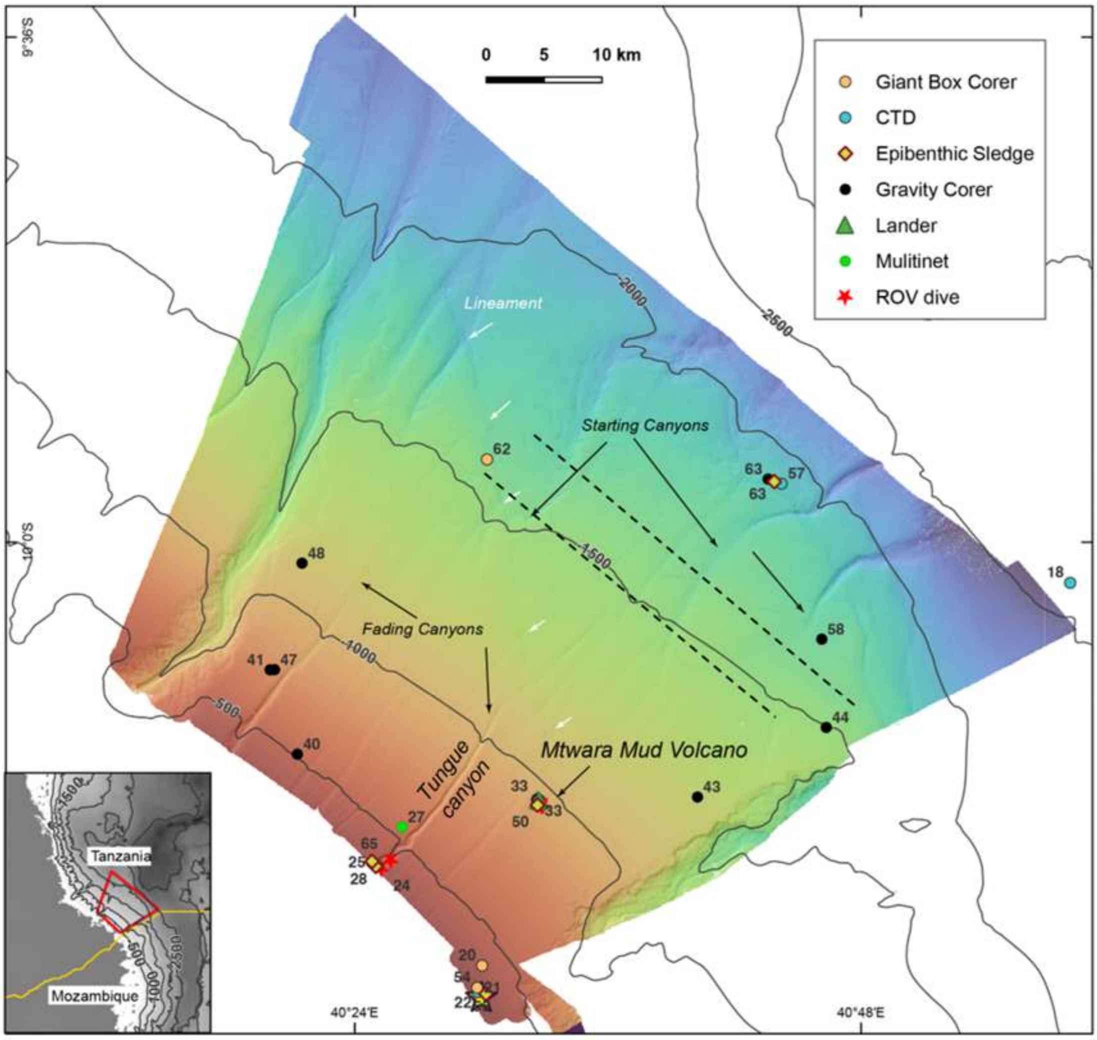


Fig. A1.2 Overview map of the Tanzania margin mapped by MBES during RV SONNE expedition SO306. The smooth slope is dissected by two large and several smaller canyons that either fade out downslope or begin downslope. The Mtwara mud volcano (height: 80 m, width: 750 m) is situated at the end of barely visible lineament (marked by the white arrows). Indicated are sampling positions (GeoB261xx; see legend for gear symbols) and PARASOUND lines (dashed lines) presented in chapter 5.2.3.

Mozambique ~18°S

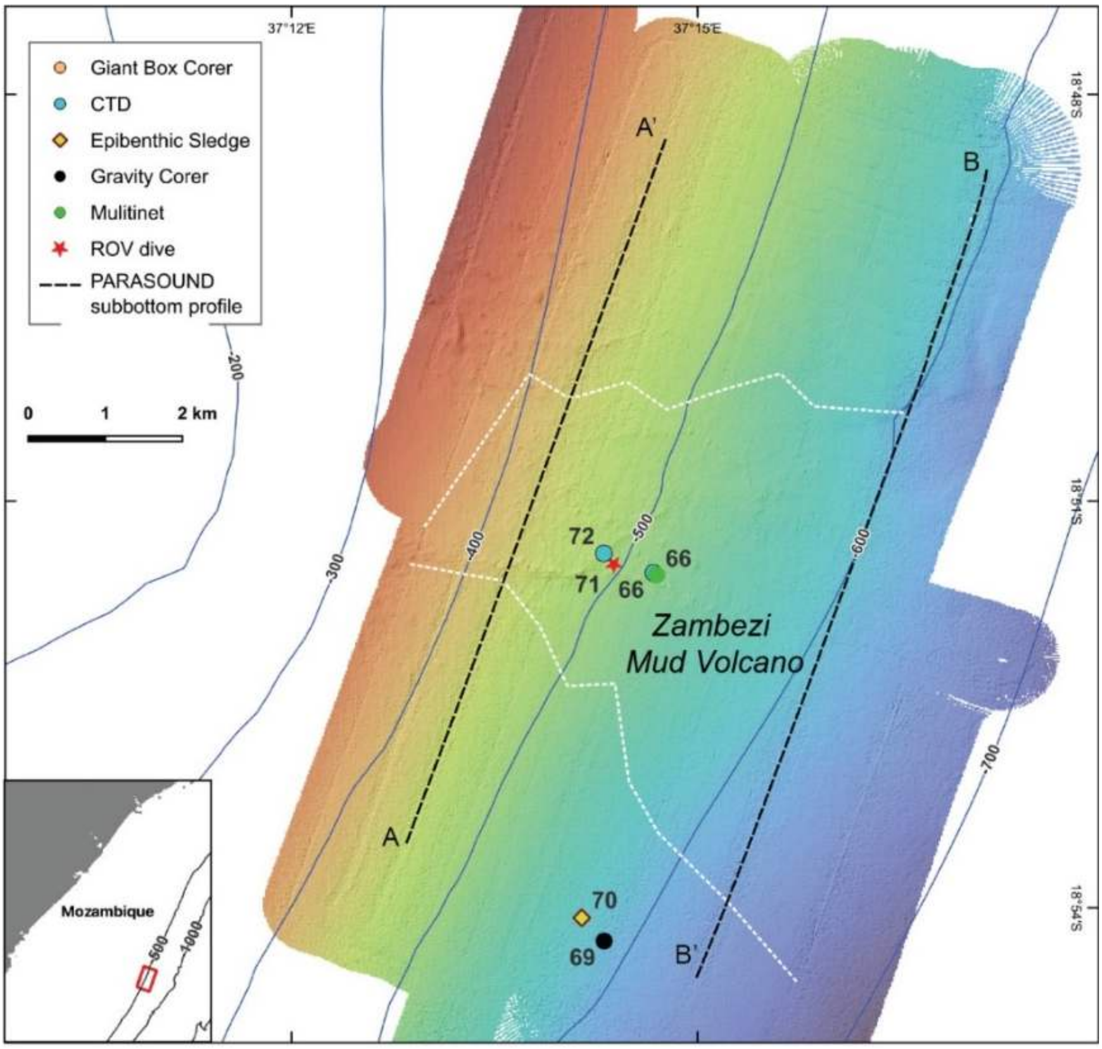


Fig. A1.3 Overview map of the Mozambican margin at ~18°S (off Zambezi Delta) mapped by MBES (20x20 m horizontal resolution) during RV SONNE expedition SO306. The Zambezi mud volcano creates little relief on the seafloor (only small aligned mound structures), but on the PARASOUND seismic data the edge of the MV is sharp allowing to map its extension (1 x 2 km). The white dotted line depicts the boundary of the MV. Indicated are sampling positions (GeoB261xx; see legend for gear symbols) and PARASOUND lines (black dashed lines) presented in chapter 5.3.2.

Mozambique ~25°S

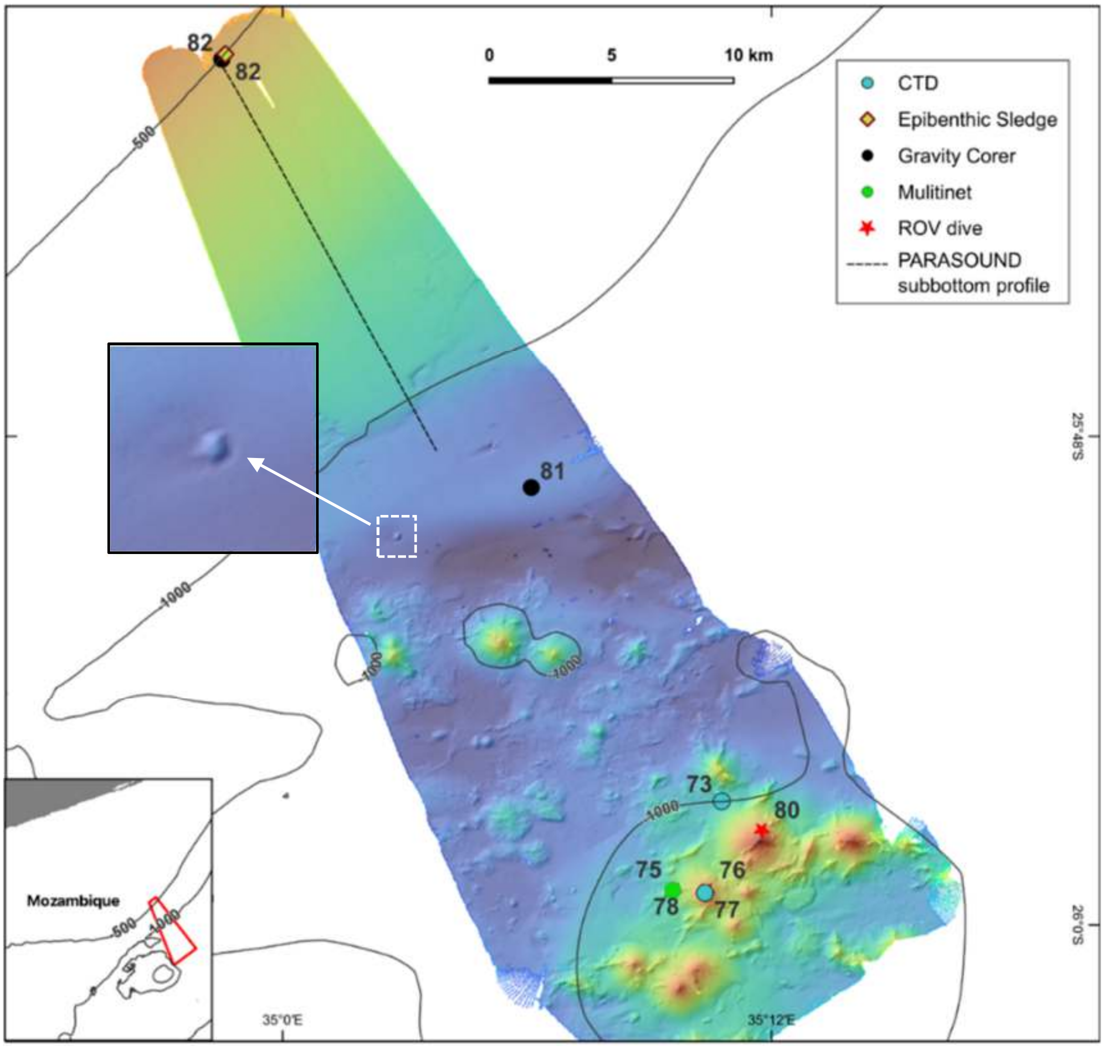


Fig. A1.4 Overview map of the Mozambican margin at ~25°S (off Limpopo river) mapped by MBES (30x30 m horizontal resolution) during RV SONNE expedition SO306. The map shows the smooth slope followed at deeper depths by a field of seamounts. Strong currents prevent sedimentation in the seamount field but accumulate sediment drifts on the shallower slope. Inset: Moat around a volcanic cone (?) provides further evidence for strong currents. Indicated are sampling positions (GeoB261xx; see legend for gear symbols) and one PARASOUND line (black dashed lines) presented in chapter 5.3.2.

South Africa

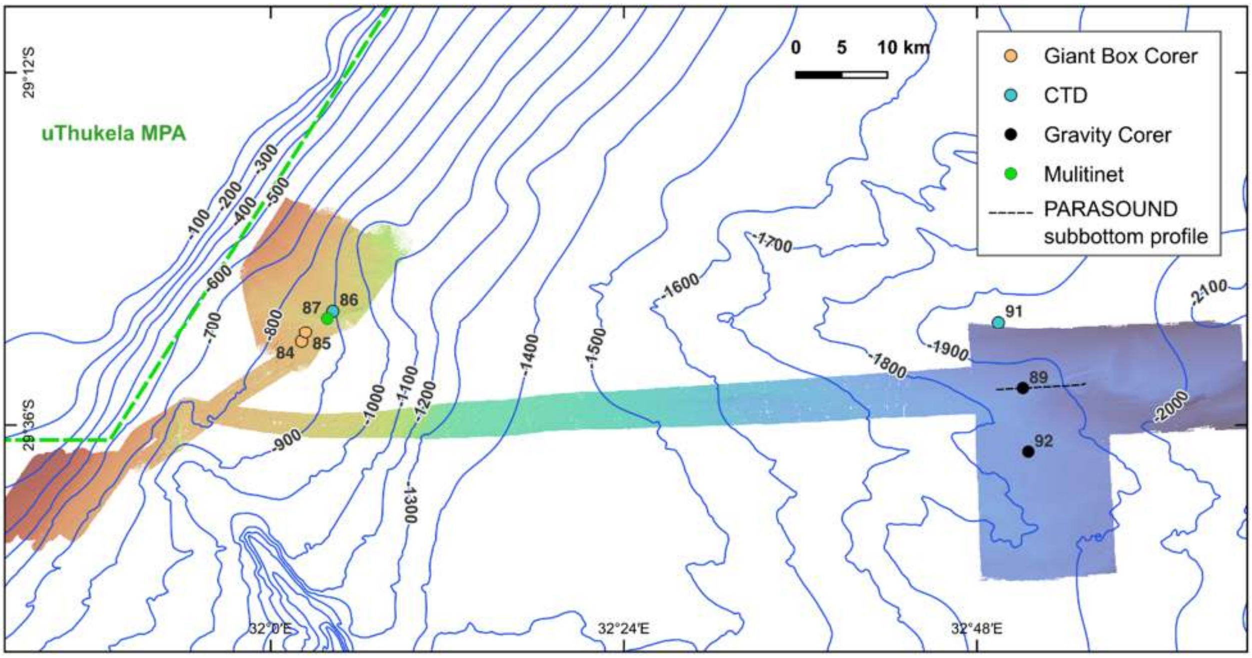


Fig. A1.5 Overview map of the South African margin mapped by MBES during RV SONNE expedition SO306. Two areas close to the uThukela Marine Protected Area (MPA; border marked by green dashed line) were mapped, as well as an area in deeper waters. Indicated are sampling positions (GeoB261xx; see legend for gear symbols) and one PARASOUND line (black dashed lines) presented in chapter 6.4.2.

A1.5 Calibration of the EM122 Echosounder

Following the transducer replacement in the dry dock in Singapore prior to the RV SONNE expedition SO305-2, the SO306 hydroacoustic team was requested to carry out measurements of the EM122 mount angles in the ship's reference frame (patch test; see below).

EM122 Calibration Report: Calibration lines were run on August 11, 2024, after entering the Mayotte waters (Fig. A1.6). Ship's speed was kept at 6 knots. Vertical sound velocity profile was obtained at CTD station GeoB26118-1 (SO306_18-1), reaching the depth of 3140 m. Prior to the survey, all MBES angular offsets in SIS software were set to zeros (Fig. A1.7).

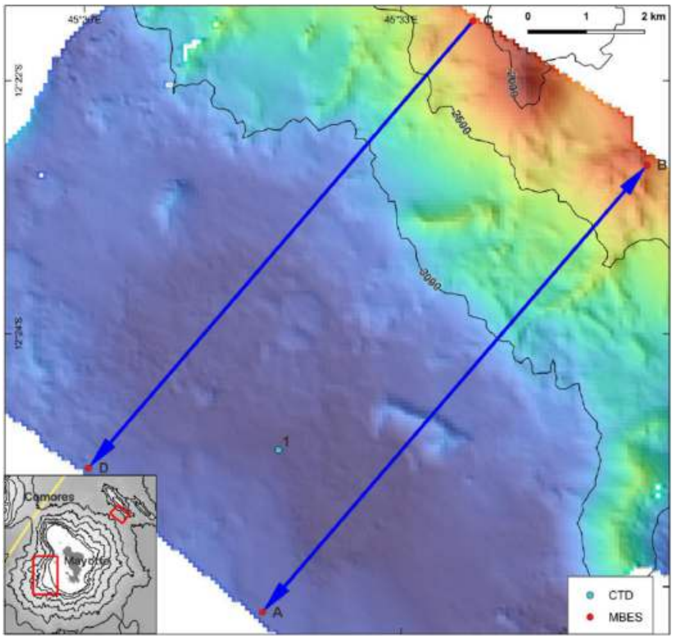


Fig. A1.6

Location of the EM122 calibration area to the NE from Mayotte during the SO306 expedition. Routes used to calibrate the angular offsets: 1) pitch – AB, BA; 2) roll – BA, CD; 3) yaw – CD, BA.

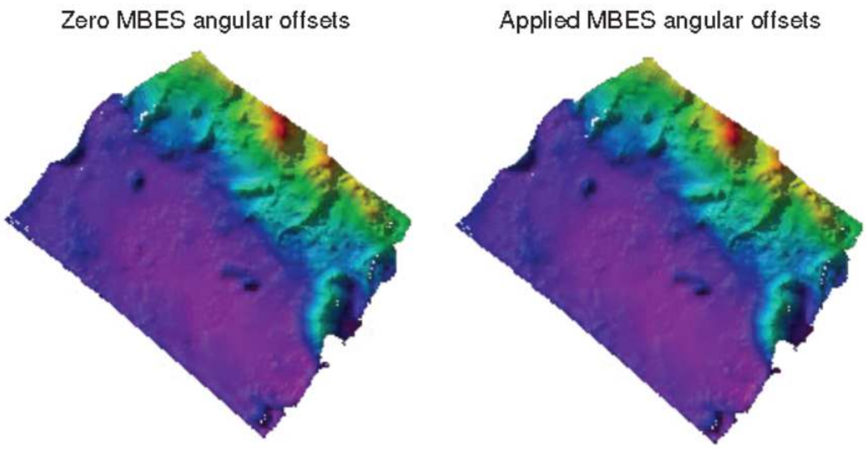
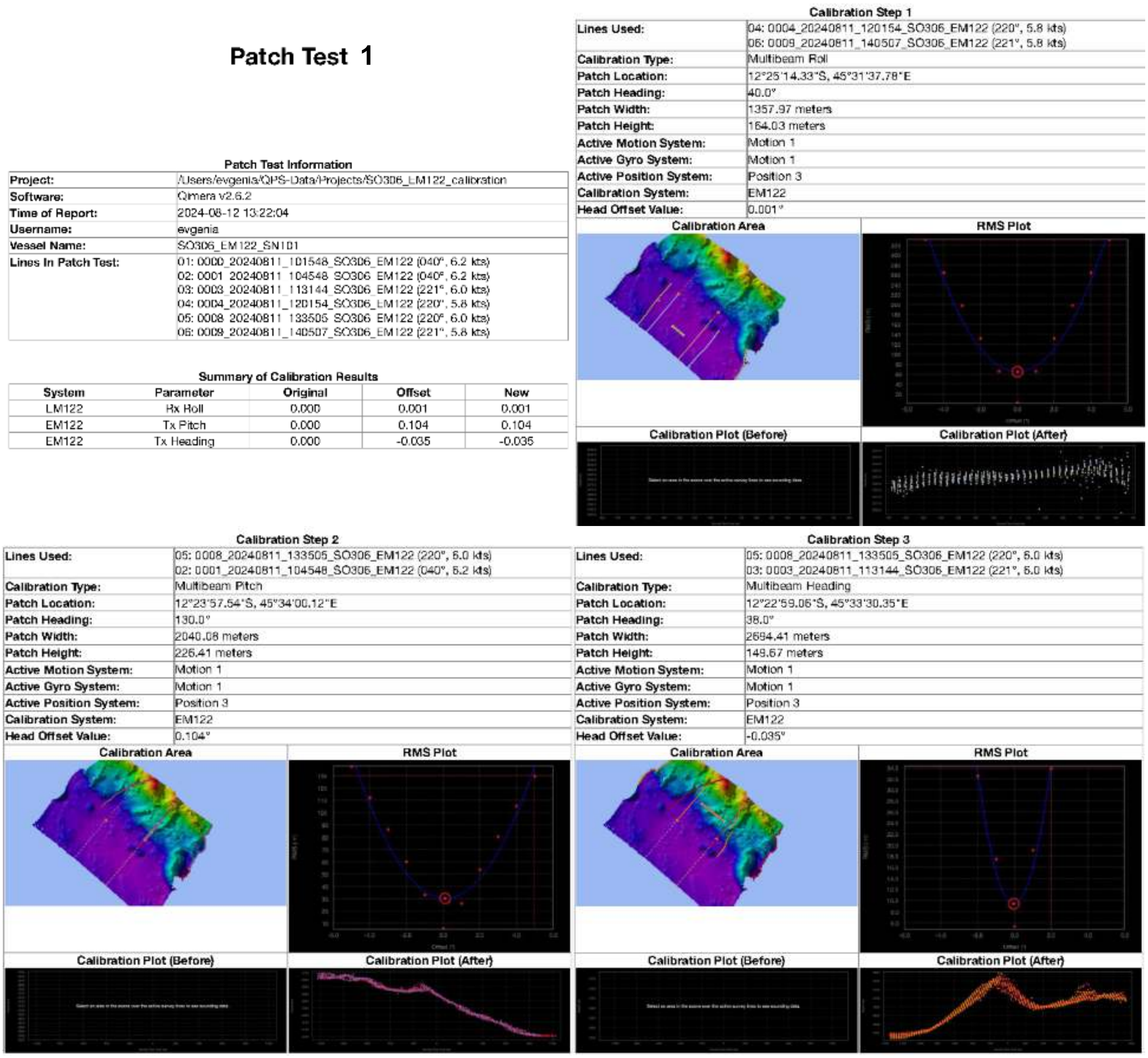


Fig. A1.7 Bathymetric data collected in the EM122 calibration area to the NE from Mayotte during the RV SONNE SO306 expedition.

MBES raw files (.all) were imported into QPS Qimera software v.2.6.2, postprocessed and run 3 times through the Patch Test tool. Detailed information about the pitch, roll and yaw calibration calculations is provided in the automatically generated Qimera report (see below). Calculated offsets (Table A1.2) were entered into SIS as Installation Parameters for the EM122 MBES (pitch, roll, heading). Standard deviation for each parameter did not increase the accuracy of the Seapath 380-5+ motion data (see the Seapath specifications).

Table A1.2 Calculated angular offsets (degrees) for the RV SONNE EM122 echosounder.

	RX roll	TX heading	TX pitch
Calibration 1	0.00	-0.04	0.10
Calibration 2	0.01	-0.01	0.09
Calibration 3	-0.01	-0.06	0.11
Mean	0.00	-0.04	0.10
Std	0.01	0.02	0.01



Patch Test 1

Patch Test Information

Project:	/Users/evgenia/QPS-Data/Projects/SO306_EM122_calibration
Software:	Qimera v2.6.2
Time of Report:	2024-08-12 13:22:04
Username:	evgenia
Vessel Name:	SO306_EM122_SN101
Lines In Patch Test:	01: 0000_20240811_101548_SO306_EM122 (040°, 6.2 kts) 02: 0001_20240811_104548_SO306_EM122 (040°, 6.2 kts) 03: 0003_20240811_113144_SO306_EM122 (221°, 6.0 kts) 04: 0004_20240811_120154_SO306_EM122 (220°, 5.8 kts) 05: 0008_20240811_133505_SO306_EM122 (220°, 6.0 kts) 06: 0009_20240811_140507_SO306_EM122 (221°, 5.8 kts)

Summary of Calibration Results

System	Parameter	Original	Offset	New
EM122	Rx Roll	0.000	0.001	0.001
EM122	Tx Pitch	0.000	0.104	0.104
EM122	Tx Heading	0.000	-0.035	-0.035

Calibration Step 1

Lines Used:	04: 0004_20240811_120154_SO306_EM122 (220°, 5.8 kts) 06: 0009_20240811_140507_SO306_EM122 (221°, 5.8 kts)
Calibration Type:	Multibeam Roll
Patch Location:	12°25'14.33"S, 45°31'37.78"E
Patch Heading:	40.0°
Patch Width:	1357.97 meters
Patch Height:	164.03 meters
Active Motion System:	Motion 1
Active Gyro System:	Motion 1
Active Position System:	Position 3
Calibration System:	EM122
Head Offset Value:	0.001°

Calibration Area | RMS Plot | Calibration Plot (Before) | Calibration Plot (After)

Calibration Step 2

Lines Used:	05: 0008_20240811_133505_SO306_EM122 (220°, 6.0 kts) 02: 0001_20240811_104548_SO306_EM122 (040°, 6.2 kts)
Calibration Type:	Multibeam Pitch
Patch Location:	12°23'57.54"S, 45°34'00.12"E
Patch Heading:	130.0°
Patch Width:	2040.08 meters
Patch Height:	226.41 meters
Active Motion System:	Motion 1
Active Gyro System:	Motion 1
Active Position System:	Position 3
Calibration System:	EM122
Head Offset Value:	0.104°

Calibration Area | RMS Plot | Calibration Plot (Before) | Calibration Plot (After)

Calibration Step 3

Lines Used:	05: 0008_20240811_133505_SO306_EM122 (220°, 6.0 kts) 03: 0003_20240811_113144_SO306_EM122 (221°, 6.0 kts)
Calibration Type:	Multibeam Heading
Patch Location:	12°22'59.06"S, 45°33'30.35"E
Patch Heading:	38.0°
Patch Width:	2694.41 meters
Patch Height:	149.67 meters
Active Motion System:	Motion 1
Active Gyro System:	Motion 1
Active Position System:	Position 3
Calibration System:	EM122
Head Offset Value:	-0.035°

Calibration Area | RMS Plot | Calibration Plot (Before) | Calibration Plot (After)

Patch Test 2

Patch Test Information

Project:	/Users/evgenia/QPS-Data/Projects/SO306_EM122_calibration
Software:	Qimera v2.6.2
Time of Report:	2024-08-12 13:48:25
Username:	evgenia
Vessel Name:	SO306_EM122_SN101
Lines In Patch Test:	01: 0000_20240811_101548_SO306_EM122 (040°, 6.2 kts) 02: 0001_20240811_104548_SO306_EM122 (040°, 6.2 kts) 03: 0003_20240811_113144_SO306_EM122 (221°, 6.0 kts) 04: 0004_20240811_120154_SO306_EM122 (220°, 5.8 kts) 05: 0008_20240811_133505_SO306_EM122 (220°, 6.0 kts) 06: 0009_20240811_140507_SO306_EM122 (221°, 5.8 kts)

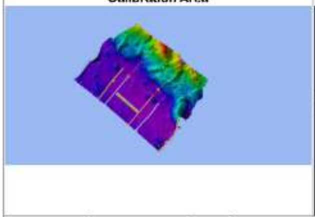
Summary of Calibration Results

System	Parameter	Original	Offset	New
EM122	Rx Roll	0.000	0.006	0.006
EM122	Tx Pitch	0.000	0.088	0.088
EM122	Tx Heading	0.000	-0.012	-0.012

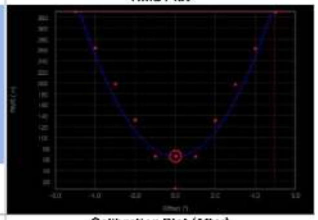
Calibration Step 1

Lines Used:	04: 0004_20240811_120154_SO306_EM122 (220°, 5.8 kts) 06: 0009_20240811_140507_SO306_EM122 (221°, 5.8 kts)
Calibration Type:	Multibeam Roll
Patch Location:	12°25'10.83"S, 45°31'33.98"E
Patch Heading:	41.0°
Patch Width:	3360.63 meters
Patch Height:	271.34 meters
Active Motion System:	Motion 1
Active Gyro System:	Motion 1
Active Position System:	Position 3
Calibration System:	EM122
Head Offset Value:	0.006°

Calibration Area

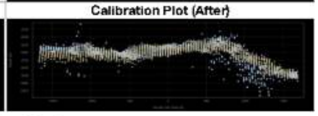


RMS Plot



Calibration Plot (Before)

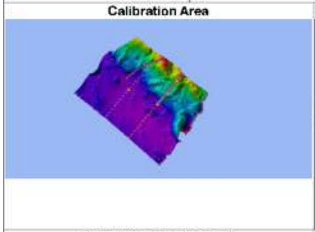
Calibration Plot (After)



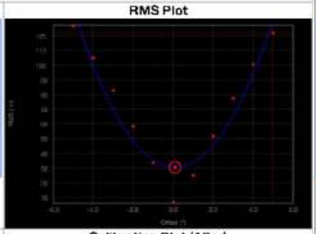
Calibration Step 2

Lines Used:	05: 0008_20240811_133505_SO306_EM122 (220°, 6.0 kts) 02: 0001_20240811_104548_SO306_EM122 (040°, 6.2 kts)
Calibration Type:	Multibeam Pitch
Patch Location:	12°23'36.18"S, 45°34'17.97"E
Patch Heading:	130.0°
Patch Width:	3853.59 meters
Patch Height:	195.75 meters
Active Motion System:	Motion 1
Active Gyro System:	Motion 1
Active Position System:	Position 3
Calibration System:	EM122
Head Offset Value:	0.088°

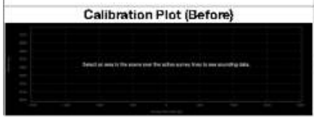
Calibration Area



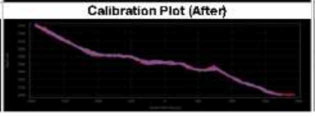
RMS Plot



Calibration Plot (Before)



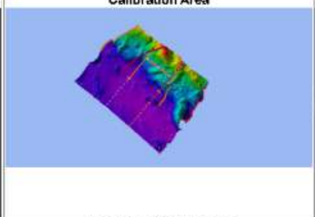
Calibration Plot (After)



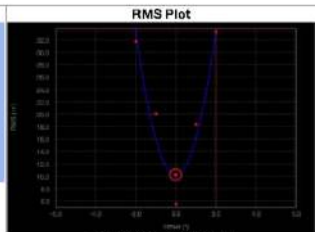
Calibration Step 3

Lines Used:	05: 0008_20240811_133505_SO306_EM122 (220°, 6.0 kts) 03: 0003_20240811_113144_SO306_EM122 (221°, 6.0 kts)
Calibration Type:	Multibeam Heading
Patch Location:	12°22'39.85"S, 45°33'40.21"E
Patch Heading:	217.0°
Patch Width:	3482.67 meters
Patch Height:	144.29 meters
Active Motion System:	Motion 1
Active Gyro System:	Motion 1
Active Position System:	Position 3
Calibration System:	EM122
Head Offset Value:	-0.012°

Calibration Area

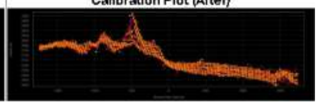


RMS Plot



Calibration Plot (Before)

Calibration Plot (After)



Patch Test 3

Patch Test Information

Project:	/Users/evgenia/QPS-Data/Projects/SO306_EM122_calibration
Software:	Qimera v2.6.2
Time of Report:	2024-08-12 14:04:29
Username:	evgenia
Vessel Name:	SO306_EM122_SN101
Lines In Patch Test:	01: 0000_20240811_101548_SO306_EM122 (040°, 6.2 kts) 02: 0001_20240811_104548_SO306_EM122 (040°, 6.2 kts) 03: 0003_20240811_113144_SO306_EM122 (221°, 6.0 kts) 04: 0004_20240811_120154_SO306_EM122 (220°, 5.8 kts) 05: 0008_20240811_133505_SO306_EM122 (220°, 6.0 kts) 06: 0009_20240811_140507_SO306_EM122 (221°, 5.8 kts)

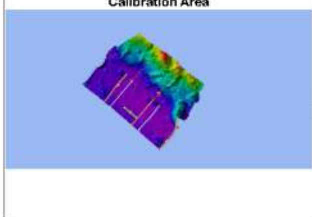
Summary of Calibration Results

System	Parameter	Original	Offset	New
EM122	Rx Roll	0.000	-0.013	-0.013
EM122	Tx Pitch	0.000	0.111	0.111
EM122	Tx Heading	0.000	-0.060	-0.060

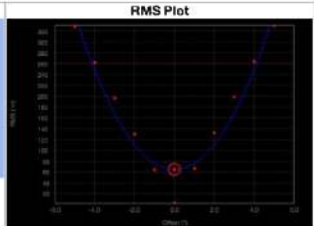
Calibration Step 1

Lines Used:	04: 0004_20240811_120154_SO306_EM122 (220°, 5.8 kts) 06: 0009_20240811_140507_SO306_EM122 (221°, 5.8 kts)
Calibration Type:	Multibeam Roll
Patch Location:	12°25'44.54"S, 45°31'32.72"E
Patch Heading:	40.0°
Patch Width:	2107.68 meters
Patch Height:	135.47 meters
Active Motion System:	Motion 1
Active Gyro System:	Motion 1
Active Position System:	Position 3
Calibration System:	EM122
Head Offset Value:	-0.013°

Calibration Area



RMS Plot

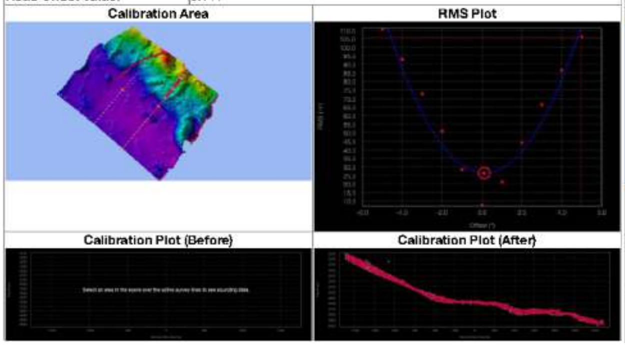


Calibration Plot (Before)

Calibration Plot (After)

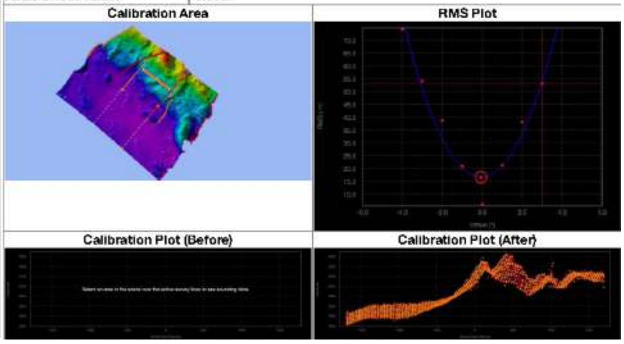
Calibration Step 2

Lines Used:	02: 0001_20240811_104548_SO306_EM122 (040°, 6.2 kts) 05: 0008_20240811_133505_SO306_EM122 (220°, 6.0 kts)
Calibration Type:	Multibeam Pitch
Patch Location:	12°23'17.53"S, 45°34'32.07"E
Patch Heading:	129.0°
Patch Width:	2577.77 meters
Patch Height:	270.93 meters
Active Motion System:	Motion 1
Active Gyro System:	Motion 1
Active Position System:	Position 3
Calibration System:	EM122
Head Offset Value:	0.111°



Calibration Step 3

Lines Used:	05: 0008_20240811_133505_SO306_EM122 (220°, 6.0 kts) 03: 0003_20240811_113144_SO306_EM122 (221°, 6.0 kts)
Calibration Type:	Multibeam Heading
Patch Location:	12°22'48.52"S, 45°33'36.14"E
Patch Heading:	397.0°
Patch Width:	3398.02 meters
Patch Height:	231.97 meters
Active Motion System:	Motion 1
Active Gyro System:	Motion 1
Active Position System:	Position 3
Calibration System:	EM122
Head Offset Value:	-0.050°



A1.6 ATLAS PARASOUND Sub-Bottom Profiler (SBP)

The ATLAS PARASOUND P70 is a sub-bottom profiler (SBP) mounted on the hull of the vessel and it operates using the parametric effect. The system emits two powerful acoustic signals, typically at frequencies between 18-20 kHz and 22-24 kHz. These primary frequencies interact to produce secondary signals, a high frequency of ~40-42 kHz and a low frequency (SLF) in the range of 2 kHz to 4 kHz. The secondary low frequency (SLF) is primarily used for sub-bottom profiling, enabling the system to penetrate the seabed and reveal the geological structures beneath it. While the low-frequency signal penetrates the seafloor, the high-frequency signal (PHF) is simultaneously captured to detect and analyse features in the water column above the seabed, including identifying biological elements like plankton and fish, detecting layers of suspended sediment, and tracking gas bubbles rising from the seafloor, which may indicate the presence of gas seeps.

The system takes continuous Sound Speed of the Vessel (SSV) readings from the C-Keel sensor located near the sonar transmission and receiver array. These SSV measurements are complemented by a static Sound Velocity Profile (SVP), set at 1500 meters per second (C-Mean), which acts as a baseline reference. The ATLAS PARASTORE software handles the storage and real-time display of the collected echograms. Meanwhile, the ATLAS HYDROMAP CONTROL (AHC) program is responsible for configuring and fine-tuning the sonar's hydroacoustic parameters, such as frequency settings, pulse length, and beam angles.

During operation, the system captures both the water column data and sub-bottom profiles, storing them in vendor-specific *.asd files. These files contain raw sonar data, which can later be processed and analysed through the PARASTORE platform. Additionally, pre-processed data is recorded in other formats, including *.ps3 and *.sgy files, which represent partially processed versions of the sonar signals, usually presented as envelope amplitudes or carrier frequency. These files are designed for more specific analysis over particular depth ranges. The*.sgy files are compatible with the SeaView software, which enables real-time visualization and processing of the data. During expedition SO306, PARASOUND data was collected almost continuously alongside the MBES survey and later utilized to select suitable locations for gravity core sampling.

A1.7 Acoustic Doppler Current Profiler (ADCP)

Data on current velocities and directions were rather continuously recorded by the two shipboard Acoustic Doppler Current Profiler (ADCP), the RDI Ocean Surveyor 38kHz and the RDI Ocean Surveyor 75kHz, both phased arrays. The systems are fully operational and require minimal operator interference. Data were acquired using the RDI software VMDAS (Vessel-Mount Data Acquisition). To avoid interference with the MBES signal, the ADCPs were set to ping with a delay relative to the MBES pings. The data were processed and visualized using software Cascade V. 7.2.

A1.8 Mobile Lowered Acoustic Doppler Current Profiler (LDACP)

A 300kHz self-contained Teledyne RD Instruments Workhorse Sentinel ADCP was fixed on the frame of the CTD. This setting is called a Lowered Acoustic Doppler Current Profiler (LADCP) and allows to collect full-depth profiles of current velocities at stations on which the LADCP collects data during CTD casts. During expedition SO306, the LADCP collected current velocity and echo intensity under the CTD frame during almost all CTD casts. Analysis of these data will take place in the home laboratory.

Chen et al. (1977): Speed of sound in seawater at high pressures. *J. Acoust. Soc. Am.* 62(5), pp. 1129-1135.

Dorschel et al. (2018): The Southwest Indian Ocean Bathymetric Compilation (swIOBC). Geochemisztry, Geophysics, Geosystems 19: 968-976.

GEBCO Compilation Group (2023): GEBCO 2023 Grid, doi:10.5285/f98b053b-0cbc-6c23-e053-6c86abc0af7b

Appendix 2

A2 Hydrography with CTD and Water Sampler

(J. Raddatz, J. Kniest, F. Gigli, J. Westbeek)

Conductivity-Temperature-Depth (CTD) casts were performed 16 times during expedition SO306, of which two times (off Mayotte and Tanzania) the CTD was deployed in a quasi-continuous mode for roughly 12 hrs (YoYo CTD) in order to constrain tidal dynamics in the water column structure as well as in the benthic regime. The shipboard's Seabird SBE 911+ CTD device (Fig. A2.1) is equipped with two temperature sensors, two conductivity sensors, one pressure sensors, one sound velocity sensors, two oxygen sensors (SBE 43), a fluorometer (WET LABS ECO-AFL/FL), a turbidity meter (WET LABS, ECO-NTU) and an altimeter. The deck unit SBE 11plus communicated with the underwater device. Live data was processed with the Sea-Bird software SBE SeaSave V.721e. Accurate positioning was guaranteed by attaching a high acoustic output power USBL transponder WMT 6G (SONARDYNE, 25 m above carousel). Additionally, a mobile LADCP was attached in order to retrieve changes in current strength and current direction in the water column (see A1.8). For the analysis and interpretation of the measurements, the downcast raw data were processed with "SBE Data Processing" software. For the analysis of the YoYo-CTD data, upcast and downcast data were processed separately. The CTD was lowered and heaved with 1 m/s.

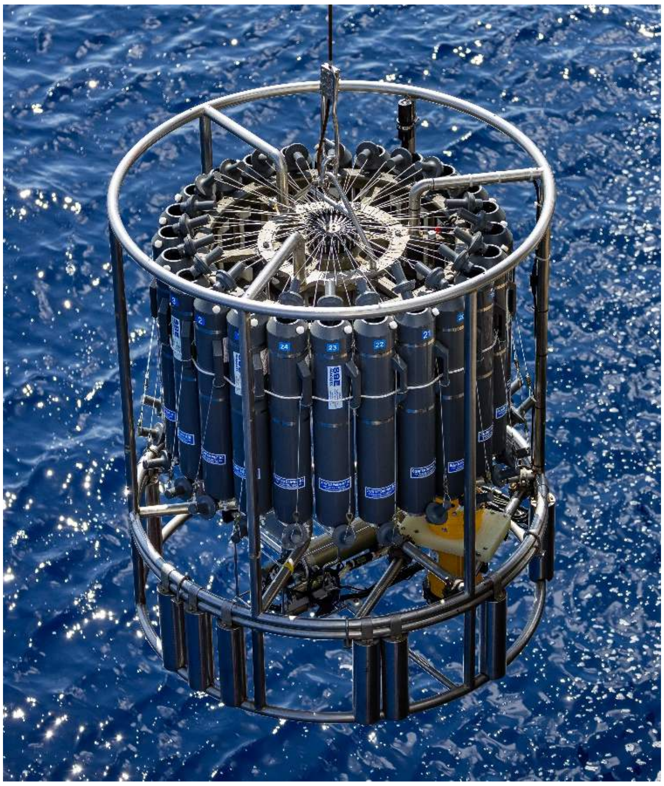


Fig. A2.1
CTD used during RV SONNE expedition SO306. The CTD was additionally equipped with 24 12-L- Niskin bottles for water sampling and an LADCP (yellow) for current measurements. Image: N. Mönnich.

Water samples were taken with the shipboard rosette SBE 32 carousel (see Table A2.1), equipped with twenty-four 12-L Niskin bottles, that were electronically triggered to close at given depths on the upcast of the CTD profiles. Generally, samples were taken at 10 m, ~100 m (NIOZ only), and/or at 5-10 m above the seafloor near suspected coral habitats. The objectives of the CTD casts and water sampling were to (i) produce sound-velocity profiles for the hydroacoustic data processing, (ii) characterize the water masses present in the areas, including terrigenous inputs, (iii) determine the carbonate system parameters, nitrogen and organic matter cycling, (iv) calibrate and develop paleo-proxies, and (v) retrieve *in situ* seawater for cultivation of collected marine organisms and eDNA analyses (for further details see A8.2).

Table A2.1 Types and amount of water samples taken via water sampling rosette.

Institutes (PIs)	Analyses	Purpose of water sampling	Volume
GEOMAR	$\delta^{18}O$, $\delta^{13}C$	Calibration of paleo-proxies, water mass identification	2*100 mL
GEOMAR, NIOZ	Nutrients, TA/DIC	Carbonate system parameters	2*100 mL, 2*100 mL, 1*1 L
GEOMAR	Trace and rare earth elements	Calibration of paleo-proxies, continental input	2*125 mL
GEOMAR	CH_4 concentrations and isotopic composition	Hydrocarbons in CWC reefs	2*100mL
NIOZ	SPM, OM, N and $d^{15}N$	Organic matter cycling	1*5L
IEO/UB	eDNA	Analysis of eDNA	3*2L

Water samples for stable oxygen/carbon isotopes, CH_4, dissolved inorganic carbon (DIC) and total alkalinity (TA) were poisoned with 50µl HgCl to stop biological activity. Samples for trace and rare earth elements were filtered with an AcroPAK 500 capsule filter (0.2mm) and subsequently acidified with 200µl concentrated HNO_3 (69%). Samples for nutrient measurements were frozen at -20°C onboard and samples for CH_4 were stored under a nitrogen gaseous headspace. Furthermore, seawater samples were processed in a filtration system equipped with GFF filters (47 and 25) and polycarbonate filters. The GFF filters are used for the subsequent measurements of organic matter composition of suspended particulate organic matter in seawater and surface sediment measuring C_{org}, N and their isotopes. The Polycarbonate filters are used to analyse suspended particulate matter (SPM) to calibrate optical and acoustic backscatter sensors.

Appendix 3

A3 Benthic Lander Systems

(J. Raddatz, J. Kniest, M. Busse, R. Schwarz)

The GEOMAR satellite lander modules (SML; Fig. A3.1) were deployed off Mayotte (for 69 hours) and off Tanzania (for 169 hours) after a reconnaissance survey with the ROV SQUID. By using these benthic lander systems, we can investigate the interconnection of biotic and abiotic processes on various scales in a 3D approach for the time span of up to a week (time restriction due to the cruise plan). Thus, the major focus is to significantly advance our current understanding of the interplay between important marine ecosystems and the hydrodynamical, biochemical, geomorphological boundary conditions, which led to the settlement of deep-sea/cold-water ecosystems. Other goals are to analyse the effect of marine ecosystems on the local hydrographic and biogeochemical settings and to study the spatial pattern of these ecosystems in relation to diurnal and small-scale spatial changes in the hydrodynamic, physical, chemical and biogeochemical environmental parameters**.** A comprehensive multidisciplinary dataset will be produced. Each lander module is equipped with a cluster of sensors and programmed to log: ADCP (current speed, current direction 600 kHz, 40m view width), CTD (conductivity, temperature, pressure), turbidity, dissolved oxygen, pH, chlorophyll fluorescence. A camera/launcher system was used for deploying the SLM on the seafloor (Fig A3.1), which was lowered with 0.5 m/s. The recovery of the SLM was realized with an acoustic releaser system.

Fig. A3.1
The GEOMAR satellite lander module (right) and the launcher system (left) to release the SLM on the seafloor. Image courtesy of N. Mönnich.

Appendix 4

A4 ROV MARUM SQUID

(N. Nowald, T. Leymann, V. Vittori, S. Fröhlich)

A4.1 Operational Concept & Mobilization

ROV MARUM-SQUID is a light work-class ROV manufactured by SAAB Seaeye (UK) for operations down to 2000 m. The system was adapted for marine research at MARUM and has been in operation since early 2016. The ROV system is shipped in a single 20" ISO container and consists of three main components: the vehicle equipped with 11 thrusters (dimension: 2.1 x 1.2 x 1.9 m, weight: 1.5 t), the winch with its supply cable (umbilical; dimension: 2.1 x 1.9 x 1.9 m, weight: 4.7 t including the cable), and the topside equipment for power supply and control.

The winch and the ROV were placed on the working deck of RV SONNE (Fig. A4.1), while the entire topside equipment (including the 3kV transformer and the portable flight cases) was installed in the "Nasslabor I" of the vessel. A workstation with Navigation-Display and Event-Logger for the documentation of the dive was provided for the three scientists in the ROV lab. The remaining scientists joined the operation from the conference room provided with a video stream from the ROVs main camera and a navigation screen, displaying the bathymetric map with ROV and ship positions. Scientists in the conference room and ROV lab were connected via VoIP link to coordinate their activities.

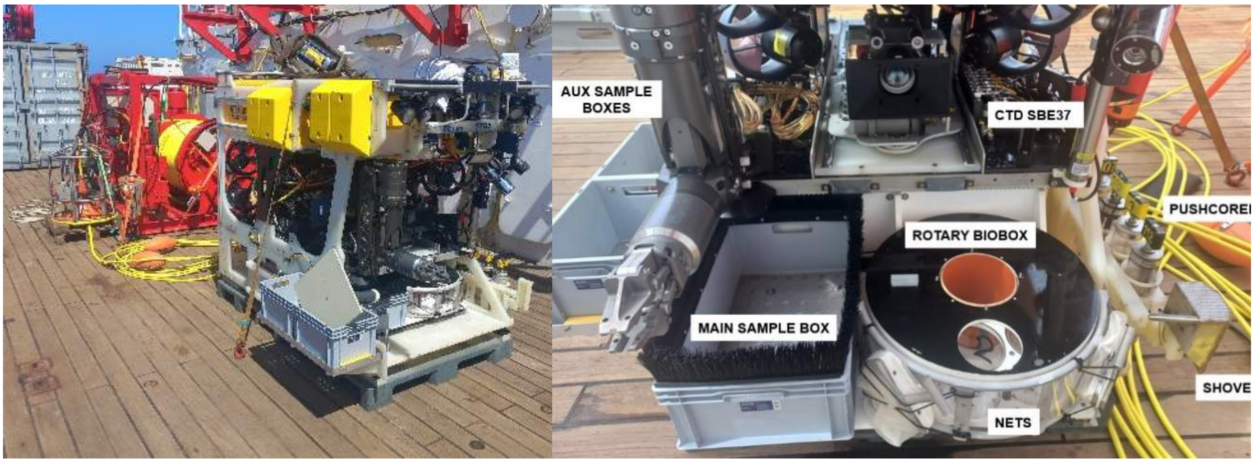


Fig. A4.1 (left) ROV MARUM-SQUID and the winch placed on the working deck of RV SONNE. (right) Tools and sample boxes installed on ROV MARUM-SQUID.

The vehicle was lowered with a crane into the water from the starboard side of RV SONNE and released via a lock-latch device. A chain of 5 floats attached to the soft-tether, keep the supply cable at surface. The depressor weight is attached 50 m behind the chain of floats to pull the rather light supply cable (180 g/m in seawater) straight down to prevent uncontrolled drift by currents. The actual operational radius of the ROV are 50 m (distance between depressor weight and vehicle). Once the depressor is in the water, the ROV starts diving while the winch pays out the supply cable in parallel. During operation, the depressor is kept ~25 m above and behind the ROV.

A4.2 Technical Specification

Navigation – MARUM-SQUID is equipped with standard navigation sensors (Valeport MiniPS depth sensor, Tritech PA500 altimeter), which are used for auto-altitude and auto-depth-hold functions with an accuracy of 10 cm, and with two independent navigation devices, which can be used alternatively if one of the devices fails. The 16CP navigation pod consists of an integrated 3D magnetometer (3D compass) with an embedded processor capable of calculating roll, pitch and yaw in real-time that allows auto-heading and pitch/roll hold with the ROV. The CDL MiniPOS/NAV3 navigation system further allows advanced auto-functions such as station keeping or displacement. In addition, the MiniPOS calculates an absolute position of the ROV by using all vehicle sensors and an input from any USBL positioning system. The MiniPOS is a fully self-contained Attitude Heading and Reference System (AHRS), which consists of a gyrocompass based around a Monolithic Ring Laser Gyrocompass (MRLG). Together with the MRLG, three axis accelerometers make the MiniPOS a full inertial system. The MiniPOS is coupled to an RDI Workhorse Doppler Velocity Log (DVL), which enhances the quality of the positioning when the ROV is operating close to the seafloor. The Tritech Seaking is a dual frequency forward-looking sonar operating at 325/675, kHz which is installed on the upper porch for 360° obstacle detection/avoidance.

Positioning – During expedition SO306, the ship-mounted SONARDYNE RANGER II USBL system was used to position the ROV. The USBL data telegram was fed into the ROV's navigation computer and control system. In addition to the position provided by the Ranger system, the MiniPOS calculates its own position by using all the vehicle sensors and the USBL input. Once the MiniPOS inertial system is calibrated, the Aided Navigation mode becomes active. When available, the MiniPOS sends accurate position updates at a much higher frequency compared to the USBL systems. In addition, Aided Navigation allows to keep the ROV in position without being displaced in X or Y direction by the currents and allows movement of the ROV in any X and/or Y direction at specified distances with an accuracy of 10 cm. The ROV´s navigation software is a plug-in called POSIVIEW coded for the open source software QGIS. A georeferenced TIFF navigation map is used as the background, on which the ship and ROV heading and position are displayed.

Lights – Six 24 V dimmable 3520 lumen LEDs are installed on the vehicle: 2 on the starboard side, 2 on the port side, 1 next to the main Pan & Tilt unit at the front, and 1 on the upper porch facing backwards towards the umbilical. The CONSTA-LED is a prototype LED developed in-house to improve the light quality on the ROV. The standard LEDs provide rather cold light, whereas the CONSTA-LED adds warmer colours to the spectra to make the lighting more natural. In addition to the CONSTA-LED, two other custom-designed LEDs built at MARUM with colour rendering indices of over 90 were installed on the vehicle to improve the light quality on the ROV.

Cameras and optics – The main scientific camera is a SULIS Z70, which is mounted on a Pan & Tilt unit at the front of the ROV together with two IMENCO Dusky Shark line lasers that project two parallel laser beams at a distance of 10 cm to measure the size of objects on the seafloor. The SULIS camera provides 4K UHD video resolution at 30 fps. A special feature of the SULIS camera is its hemispherical dome port and optical lens with a 12x optical zoom, which fully correct for chromatic, geometric and radial distortion (4K corner-to-corner resolution). The second scientific camera is the HD Lookdown. This is a prototype camera developed at MARUM with full HD resolution that monitors the area directly in front of the ROV from a quasi "top-down" perspective. Still images with a resolution of 14 megapixel have been taken with the IMENCO TIGERSHARK mounted on an auxiliary Pan & Tilt unit located on the upper port side of the ROV. An external flashgun, that is used when taking still images, is mounted at a 45° angle on the upper porch of the ROV. In addition, several PAL cameras are used as working cameras on the ROV such as a DSPL MultiseaCam with LED ring to monitor the closing process of the NISKIN bottles and a DSPL MultiseaCam to monitor the orientation of the supply cable in the water during operation.

Topside equipment – The 3kV topside transformer (dimension: 800 x 550 x 1500 mm, weight: 400 kg) receives 400 V from the ship and converts them into 3000 VAC at 800 Hz. The corresponding filter box (dimension: 400 x 600 x 1800 mm, weight: 100 kg) compensates for unwanted power peaks. All the equipment required to operate the ROV is installed in a double 19" flight case. A second flight case consists of a 43” monitor for the tiling to display all the overview cameras, software control and the sonar screen, and a 34” 4K monitor that displays the video from the SULIS camera. Two additional screens are mounted on either side of the video case, displaying a navigation map and the ROV control system GUI for the pilots. Several NUC computers for navigation etc. are also installed inside the video flight case.

Video-recording and data storage – All navigation data of the ROV (geographic position, depth, altitude, heading) and the ship's position and heading are stored in a separate navigation file by the POSIVIEW plug-in. CTD data and sonar recordings are recorded and made available as well. Three video sources are permanently recorded in HD quality on hard disk during the dives using MARUM DVR software, incl. the Sulis 4K signal downscaled to 1080p, the HD Lookdown camera and the so-called “Tiling”. The Tiling consists of different video sources, merged to one stream: the HD Lookdown, the preview video of the TIGERSHARK and the sonar screen. In addition, 4K videos from the SULIS camera can be recorded on demand on an AJA KI recorder. All videos and TIGERSHARK still images contain a timestamp for georeferencing using the navigation file.

A4.3 Payload and Tools

The vehicle is equipped with an Orion 7P manipulator (Schilling Robotics), which is installed on the starboard side of the vehicle. It is a fully proportional, hydraulic manipulator with 7 degrees of freedom, has a reach of 1.5 m and a lifting capacity 68 kg. The manipulator is remotely controlled via a Master Controller, which allows precise operations (e.g., sampling and use of tools) within centimetres. A variety of sampling tools was used during expedition SO306 (Fig. A4.1): (a) a SBE37 CTD probe to continuously measure hydrographic parameters (e.g., temperature, oxygen); (b) two hydraulically closing NISKIN bottles (volume: 5 L) to collect water; (c) four push corer (Ø: 80 mm, length: 300 mm) for sediment sampling; (d) a shovel for multiple sediment and faunal sampling; and (e) two nets (1 mm mesh size). All samples are stored in the main sample box, which is mounted on the hydraulically operated drawer of the ROV. A newly-developed Rotary Bio-Box, consisting of eight individual acrylic tubs (Ø: 150 mm, length: 170 mm) on a rotatable carousel, is located next to the main sample box (Fig. A4.1). The revolver type design allows the storage of organisms which remain in a seawater environment until they are removed from the tubs. Two auxiliary sample boxes (400 x 300 x 200 mm) are installed on the port side of the ROV, which are used for the storage of heavy samples such as rocks.

A4.4 Performance incl. Dive Statistics and List of Samples

During expedition SO306, thirteen dives were conducted with a total bottom time of ~40 hours (Table A4.1), during which 134 faunal and sediment samples were collected (Table A4.2). There were no major technical issues with the system. Most challenging part during the campaign were the high current velocities – especially off Mayotte and Tanzania, where current velocities reached up to 1.7 kn. Here, the ROV was deployed at current speeds of >1 kn, while the ship was drifting to prevent uncontrolled movement towards the rear of the vessel. However, during two dives off Tanzania, the ROV was drifted 550 m away from the vessel after reaching a water depth of 850 m. This caused an intense drag on the entire system (cable, depressor weight, vehicle), which is commonly operating within a radius of 100 m around the vessel, and made a controlled operation hardly possible. A dive in a Tanzanian canyon at 500 m depth had to be aborted as manoeuvring was not possible. Off Mozambique, surface currents were lower (~0.5 kn), however they increased significantly at depth around the seamount locations explored. No diving was possible in the last working area off South Africa, due to the very high current velocities of >4.5 kn.

Table A4.1 ROV MARUM SQUID dive statistics.

Station No. (GeoB)	Dive No.	Date (2024)	Launch (in water) Time (UTC)	Launch Position Lat ('S)	Launch Position Lon ('E)	Recovery (at sea surface) Position Lat ('S)	Recovery Position Lon ('E)	Recovery Time (UTC)	Bottom Time (UTC)	Depth range (m)	Remark *(ab: dive aborted)*
Mayotte											
26105-1	#089	12.08.	10:33	12°56.978	44°53.015	12°57.011	44°53.047	15:04	11:53-13:54 (2 h)	906-837	9 samples
26108-1	#090	13.08.	05:59	12°57.371	44°53.224	12°57.389	44°53.272	09:39	06:55-08:39 (1.7 h)	~773	5 samples (ab: techn. problem)
26111-1	#091	14.08.	05:51	13°01.410	44°52.088	13°01.578	44°52.316	13:51	07:24-12:42 (5.3 h)	1333-1155	14 samples
26114-1	#092	15.08.	05:26	12°56.126	44°54.423	12°56.334	44°54.395	13:16	06:09-12:36 (6.6 h)	696-589	24 samples
Tanzania											
26124-1 *Tungue*	#093	18.08.	05:42	10°15.489	40°25.247	10°15.205	40°24.848	11:01	06:28-10:26 (4 h)	434-332	7 samples
26131-1 *Mtwara*	#094	19.08.	05:44	10°12.485	40°32.924	10°12.396	40°32.816	13:37	06:59-12:13 (5.2 h)	920-873	17 samples
26136-1 *Mtwara*	#095	20.08.	05:34	10°12.521	40°32.847	10°12.478	40°32.793	13:19	06:44-11:43 (5 h)	878-863	18 samples
26150-1 *Mtwara*	#096	23.08.	05:21	10°12.476	40°32.852	10°12.583	40°32.932	12:04	07:26-10:04 (2.6 h)	881-870	4 samples (ab: techn. problem)
26165-1	#097	27.08.	05:46	10°15.093	40°25.698	10°14.989	40°25.635	08:57	./.	~460	(ab: strong currents)
Mozambique											
26171-1 *Zambezi*	#098	30.08.	12:10	18°51.467	37°14.380	18°51.420	37°14.335	14:39	12:47-14:03 (1.3 h)	490-477	8 samples
26175-1 *SMT-A*	#099	02.09.	05:29	25°59.140	35°09.602	25°59.101	35°09.699	09:30	06:28-08:28 (2 h)	749-737	3 samples (ab: strong currents)
26176-1 *SMT-A*	#100	02.09.	11:01	25°59.144	35°10.408	25°59.159	35°10.419	14:02	11:26-13:45 (2.3 h)	327-292	9 samples coral garden
26180-1 *SMT-B*	#101	03.09.	06:00	25°57.673	35°11.754	25°57.698	35°11.751	08:33	06:28-08:07 (1.7 h)	320-307	7 samples (ab: buoy)
								Σ	**39.7 hours**		**134 samples**

Table A4.2 List of samples collected with ROV MARUM SQUID (abbreviations: (RBB: Rotary Bio Box, *open RBB, Box: large open box, N: Niskin bottle, P: push corer).

Station (GeoB)	Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box	T (°C)	O2 (ml/l)
26105 - 1	**Dive #089 - SW Mayotte**									
26105 - 2	12.08.24	12:36	12° 57.080	44° 53.076	895	#1	erected sponge + crinoid	Box-1	7.3	2.6
26105 - 3	12.08.24	12:53	12° 57.080	44° 53.076	895	#2	fan-shaped *Enallopsammia*	Box-1	7.4	2.7
26105 - 4	12.08.24	12:56	12 57.080	44° 53.076	895	#3	soft coral	RBB-1	7.4	2.7
26105 - 5	12.08.24	12:58	12° 57.080	44° 53.076	895	#4	water sample (5L)	N	7.4	2.7
26105 - 6	12.08.24	13:09	12° 57.080	44° 53.076	895	#5	*Chrysogorgia* + decapod	RBB-6	7.4	2.7
26105 - 7	12.08.24	13:25	12° 57.080	44° 53.076	895	#6	large fan-shaped soft coral	Box-1	7.4	2.7
26105 - 8	12.08.24	13:31	12° 57.080	44° 53.076	895	#7	red brisingid seastar	RBB-5	7.4	2.7
26105 - 9	12.08.24	13:49	12° 57.118	44° 53.076	895	#8	white erected sponge	RBB-4	7.4	2.7
26105 - 10	12.08.24	13:52	12° 57.118	44° 53.076	895	#9	volcanic pebble	RBB-9*	7.4	2.7

Station (GeoB)	Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box	T (°C)	O2 (ml/l)
26108 - 1	**Dive #090 - SW Mayotte**									
26108 - 2	13.08.24	07:39	12° 57.399	44° 53.280	762	#1	large echinoid	RBB-4	7.6	2.8
26108 - 3	13.08.24	07:52	12° 57.407	44° 53.295	763	#2	stalked sponge	RBB-3	7.6	2.8
26108 - 4	13.08.24	08:32	12° 57.409	44° 53.302	763	#3	*Chrysogorgia* + decapod	RBB-2	7.5	2.8
26108 - 5	13.08.24	08:37	12° 57.410	44° 53.302	763	#4	water sample (5L)	N-1		
26108 - 6	13.08.24	08:38	12° 57.410	44° 53.302	763	#5	water sample (5L)	N-2		

Station (GeoB)	Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box	T (°C)	O2 (ml/l)
26111 - 1	**Dive #090 - SW Mayotte (deep site)**									
26111 - 2	14.08.24	07:49	13° 1.442	44° 52.129	1316	#1	dead sponge + crinoid	RBB-8	4.6	2.4
26111 - 3	14.08.24	08:07	13° 1.453	44° 52.134	1311	#2	erected sponge + decapod	RBB-7		
26111 - 4	14.08.24	08:18	13° 1.453	44° 52.134	1311	#3	*Chrysogorgia* + decapod	RBB-3		
26111 - 5	14.08.24	08:37	13° 1.463	44° 52.153	1301	#4	whip-like octocoral	RBB-2	4.7	2.4
26111 - 6	14.08.24	09:14	13° 1.478	44° 52.179	1280	#5	live scleractinian	RBB-9*	4.7	2.4
26111 - 7	14.08.24	09:31	13° 1.478	44° 52.179	1280	#6	water sample (5L)	N-1		
26111 - 8	14.08.24	09:32	13° 1.478	44° 52.179	1280	#7	water sample (5L)	N-2		
26111 - 9	14.08.24	9:56	13° 1.483	44° 52.184	1273	#8	net: coral rubble	Box-1	4.6	2.4
26111 - 10	14.08.24	10:05	13° 1.484	44° 52.186	1274	#9	net: dead scleractinian	RBB-9*		
26111 - 11	14.08.24	10:15	13° 1.484	44° 52.187	1274	#10	purple gorgonian	RBB-1	4.6	2.4
26111 - 12	14.08.24	11:27	13° 1.529	44° 52.254	1212	#11	dead fan-shaped octocoral	Box-1	5.0	2.2
26111 - 13	14.08.24	11:30	13° 1.529	44° 52.253	1212	#12	net: octocoral rubble	Box-1		
26111 - 14	14.08.24	12:33	13° 1.575	44° 52.327	1140	#13	test: with core catcher	P-4		
26111 - 15	14.08.24	12:37	13° 1.575	44° 52.327	1140	#14	test: without core catcher	P-1		

Station (GeoB)	Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box	T (°C)	O2 (ml/l)
26114 - 1	**Dive #092 - SW Mayotte (shallow site)**									
26114 - 2	15.08.24	06:55	12° 56.202	44° 54.455	671	#1	red Zoantharia	RBB-4	8.6	3.4
26114 - 3	15.08.24	07:01	12° 56.201	44° 54.455	672	#2	white scleractinia (?)	RBB-3	8.6	3.4
26114 - 4	15.08.24	07:04	12° 56.201	44° 54.455	672	#3	red Zoantharia on dead coral	RBB-2	8.6	3.4
26114 - 5	15.08.24	07:17	12° 56.207	44° 54.455	668	#4	water sample (2x 5L)	N-1/2	8.8	3.5
26114 - 6	15.08.24	07:23	12° 56.208	44° 54.456	668	#5	sponge + yellow Actinaria	RBB-9	8.8	3.5
26114 - 7	15.08.24	07:29	12° 56.207	44° 54.455	668	#6	red holothuroid	RBB-9	8.9	3.5
26114 - 8	15.08.24	07:45	12° 56.229	44° 54.459	656	#7	large white octocoral	RBB-8	8.9	3.5
26114 - 9	15.08.24	08:04	12° 56.242	44° 54.461	649	#8	yellow octocoral	RBB-7	8.9	3.5
26114 - 10	15.08.24	08:08	12° 56.242	44° 54.461	649	#9	red Zoantharia	RBB-7	8.9	3.5
26114 - 11	15.08.24	08:12	12° 56.242	44° 54.461	649	#10	fragile white coral skeleton	RBB-7	8.9	3.5
26114 - 12	15.08.24	08:22	12° 56.243	44° 54.462	649	#11	sponge + yellow Actinaria	RBB-7	8.9	3.5
26114 - 13	15.08.24	08:46	12° 56.264	44° 54.467	635	#12	thick dead coral rubble	Box-1	9.1	3.6
26114 - 14	15.08.24	09:08	12° 56.268	44° 54.466	627	#13	dead Scleractinia	Box-1	9.2	3.6
26114 - 15	15.08.24	09:16	12° 56.268	44° 54.466	627	#14	net: live thinly branched *Madrepora*	Box-1	9.2	3.7
26114 - 16	15.08.24	09:37	12° 56.280	44° 54.467	602	#15	red echinoid + bamboo coral	Box-1	9.5	3.8

26114 - 17	15.08.24	09:54	12° 56.283	44° 54.467	600	#16	large asteroid on coral skeleton with gorgonian	RBB-6	9.6	3.9
26114 - 18	15.08.24	10:09	12° 56.286	44° 54.468	602	#17	large rock with white sponge	Box-2	9.3	3.8
26114 - 19	15.08.24	10:19	12° 56.288	44° 54.469	598	#18	pink Stylasteridae	RBB-5	9.4	3.8
26114 - 20	15.08.24	10:23	12° 56.288	44° 54.468	598	#19	dead coral rubble	RBB-5	9.4	3.8
26114 - 21	15.08.24	10:52	12° 56.307	44° 54.478	592	#20	two small reddish rocks	Box-2	9.3	3.8
26114 - 22	15.08.24	11:15	12° 56.306	44° 54.453	588	#21	live white scleractinian (?)	RBB-0*	9.4	3.8
26114 - 23	15.08.24	11:33	12° 56.304	44° 54.453	587	#22	Zoantharia and stylasterid	RBB-0*		
26114 - 24	15.08.24	12:14	12° 56.315	44° 54.413	583	#23	net: soft sediment	Box-2	9.5	3.8
26114 - 25	15.08.24	12:29	12° 56.330	44° 54.414	583	#24	red *Paragorgia* + ophiurids	Box-1	9.5	3.8

Station (GeoB)	Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box	T (°C)	O2 (ml/l)
26124 - 1	**Dive #093 - Tanzania (Tungue canyon)**									
26124 - 2	18.08.24	07:19	10° 15.355	40° 25.073	429	#1	sea gras	RBB-1	11.3	4.0
26124 - 3	18.08.24	08:04	10° 15.281	40° 24.997	427	#2	mangrove leaf (?)	RBB-2	11.6	3.9
26124 - 4	18.08.24	08:22	10° 15.278	40° 24.967	419	#3	red leaf	RBB-3	11.6	3.9
26124 - 5	18.08.24	09:04	10° 15.249	40° 24.901	383	#4	echinoid + sea gras	RBB-4	11.9	3.9
26124 - 6	18.08.24	09:25	10° 15.233	40° 24.873	362	#5	asteriod	RBB-5	12.1	3.8
26124 - 7	18.08.24	09:43	10° 15.225	40° 24.873	350	#6	whip-like octocoral	RBB-6	12.8	3.8
26124 - 8	18.08.24	09:52	10° 15.225	40° 24.850	349	#7	ophiurid	RBB-7	12.0	3.8

Station (GeoB)	Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box	T (°C)	O2 (ml/l)
26131 - 1	**Dive #094 - Tanzania (Mtwara mud volcano)**									
26131 - 2	19.08.24	07:55	10° 12.234	40° 32.743	915	#1	coral rubble (collected with shovel)	RBB-7	6.6	2.1
26131 - 3	19.08.24	08:24	10° 12.237	40° 32.722	899	#2	large bivalve shell + coral rubble (shovel)	RBB-8	6.6	2.1
26131 - 4	19.08.24	08:37	10° 12.237	40° 32.732	899	#3	carbonatic rock	Box-2	6.6	2.2
26131 - 5	19.08.24	09:00	10° 12.239	40° 32.731	897	#4	living solitary coral	RBB-1	6.6	2.1
26131 - 6	19.08.24	09:07	10° 12.239	40° 32.731	897	#5	living bivalve	RBB-1	6.7	2.2
26131 - 7	19.08.24	09:27	10° 12.246	40° 32.719	879	#6	living *Enallopsammia* (broken in pieces)	RBB-2	6.7	2.2
26131 - 8	19.08.24	09:35	10° 12.246	40° 32.719	879	#7	carbonatic rock with coral fragments, black coating	Box-3	6.7	2.2
26131 - 9	19.08.24	09:36	10° 12.246	40° 32.719	879	#8	water sample (5L)	N-1	6.7	2.2
26131 - 10	19.08.24	09:45	10° 12.246	40° 32.718	880	#9	dead coral branch	RBB-3	6.7	2.2
26131 - 11	19.08.24	09:55	10° 12.246	40° 32.718	880	#10	dead coral framework (*Madrepora*?)	RBB-3	6.6	2.2
26131 - 12	19.08.24	09:56	10° 12.246	40° 32.718	880	#11	live/dead *Enallopsammia* + bivalve etc.	Box-1	6.6	2.2
26131 - 13	19.08.24	10:12	10° 12.248	40° 32.713	881	#12	seep carbonate, black coating	RBB-9*	6.6	2.2
26131 - 14	19.08.24	10:33	10° 12.253	40° 32.708	882	#13	shells of *Bathymodiolus*	RBB-4	6.6	2.2
26131 - 15	19.08.24	10:55	10° 12.256	40° 32.703	880	#14	net: live and dead *Bathymodiolus*	Box-1	6.6	2.2
26131 - 16	19.08.24	11:06	10° 12.258	40° 32.703	880	#15	three living gastropods (trochospiral)	RBB-5	6.6	2.2
26131 - 17	19.08.24	11:27	10° 12.256	40° 32.698	875	#16	water sample (5L)	N-2	6.6	2.2
26131 - 18	19.08.24	11:54	10° 12.246	40° 32.692	865	#17	living *Bathymodiolus*	RBB-6	6.7	2.2

Station (GeoB)	Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box	T (°C)	O2 (ml/l)
26136 - 1	**Dive #095 - Tanzania (Mtwara mud volcano)**						first 30 min. no sampling -> technical problems			
26136 - 2	20.08.24	07:19	10° 12.216	40° 32.660	873	#1	live *Solenosmilia* + bivalve	RBB-1	6.6	2.1
26136 - 3	20.08.24	07:29	10° 12.220	40° 32.656	873	#2	four different rocks	Box-2	6.5	2.1
26136 - 4	20.08.24	07:48	10° 12.228	40° 32.649	865	#3	dead *Solenosmilia* framework + sediment + rubble	RBB-2	6.6	2.1
26136 - 5	20.08.24	08:09	10° 12.235	40° 32.649	863	#4	part of collapsed chimney (mosaicking), 2 dark pebbles	RBB-9*	6.7	2.1
26136 - 6	20.08.24	09:05	10° 12.240	40° 32.617	868	#5	brownish rock	Box-3	6.6	2.1

26136	- 7	20.08.24	09:23	10° 12.242	40° 32.614	867	#6	fan-shaped octocoral with yellow Actinaria	RBB-3	6.6	2.1
26136	- 8	20.08.24	09:57	10° 12.240	40° 32.598	861	#7	live *Enallopsammia*	RBB-4		
26136	- 9	20.08.24	10:00	10° 12.240	40° 32.598	861	#8	yellow octocoral	RBB-5	6.6	2.1
26136	- 10	20.08.24	10:05	10° 12.240	40° 32.598	861	#9	bivalve shell	RBB-5	6.6	2.1
26136	- 11	20.08.24	10:15	10° 12.240	40° 32.598	861	#10	purple octocoral	RBB-5	6.6	2.1
26136	- 12	20.08.24	10:25	10° 12.247	40° 32.590	863	#11	net: live *Madrepora* + octocoral	Box-1	6.5	2.1
26136	- 13	20.08.24	10:34	10° 12.251	40° 32.584	856	#12	carbonatic rock (2 pieces)	Box-1		
26136	- 14	20.08.24	10:44	10° 12.251	40° 32.584	857	#13	soft sediment, 2x pushed	P-R1		
26136	- 15	20.08.24	10:54	10° 12.255	40° 32.581	855	#14	brachiopod + octocoral + *Enallopsammia*	RBB-6		
26136	- 16	20.08.24	11:05	10° 12.254	40° 32.581	855	#15	water sample (5L)	N-2		
26136	- 17	20.08.24	11:21	10° 12.257	40° 32.581	855	#16	whip bamboo coral	Box-1		
26136	- 18	20.08.24	11:24	10° 12.257	40° 32.581	855	#17	*Paragorgia* + ophiurid	Box-1		
26136	- 19	20.08.24	11:40	10° 12.253	40° 32.554	851	#18	water sample (5L)	N-1	6.7	2.2

Station (GeoB)		Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box	T (°C)	O2 (ml/l)
26150	**- 1**	**Dive #096 - Tanzania (Mtwara mud volcano)**						dive aborted due to technical problems			
26150	- 2	23.08.24	8:39	10° 12.261	40° 32.672	873	#1	live *Bathymodiolus*	RBB-1	6.9	2.1
26150	- 3	23.08.24	8:50	10° 12.262	40° 32.671	873	#2	large colonised rock	Box-1		
26150	- 4	23.08.24	9:30	10° 12.253	40° 32.684	862	#3	live *Bathymodiolus* + live gastropod	RBB-2/3	6.7	2.1
26150	- 5	23.08.24	9:44	10° 12.253	40° 32.683	861	#4	blackish sediment	P-1	6.7	2.1

Station (GeoB)		Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box	T (°C)	O2 (ml/l)
26171	**- 1**	**Dive0 #98 - Mozambique (Zambezi mud volcano)**									
26171	- 2	30.08.24	13:12	18° 51.391	37° 14.339	482	#1	live octocoral	RBB-1	10.0	4.3
26171	- 3	30.08.24	13:17	18° 51.391	37° 14.339	482	#2	rocks with live solitary corals	RBB-2	10.0	4.3
26171	- 4	30.08.24	13:28	18° 51.388	37° 14.339	482	#3	live *Madrepora* on chimney	Box-1	10.0	4.3
26171	- 5	30.08.24	13:29	18° 51.388	37° 14.339	482	#4	water sample (5L)	N-2	10.0	4.3
26171	- 6	30.08.24	13:43	18° 51.381	37° 14.312	477	#5	live octocoral + live solitary corals on rock	RBB-3	10.0	4.3
26171	- 7	30.08.24	13:51	18° 51.382	37° 14.304	473	#6	2x chimneys (collapsed+in situ)	Box-1	10.0	4.3
26171	- 8	30.08.24	13:59	18° 51.382	37° 14.302	472	#7	live octocoral + nudibranch (?)	RBB-4	10.0	4.3
26171	- 9	30.08.24	14:00	18° 51.382	37° 14.302	472	#8	water sample (5L)	N-1	10.0	4.3

Station (GeoB)		Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box -	T (°C)	O2 (ml/l)
26175	**- 1**	**Dive #099 - Mozambique (seamount A (base) off Maputo)**						dive aborted due to strong currents			
26175	- 2	02.09.24	6:56	25° 59.162	35° 9.544	738	#1	pink antipatharian	RBB-8	8.1	4.6
26175	- 3	02.09.24	7:08	25° 59.159	35° 9.553	738	#2	pink antipatharian	RBB-1	8.3	4.7
26175	- 4	02.09.24	7:19	25° 59.158	35° 9.559	737	#3	sediment (pillow lava pocket)	RBB-2	8.5	4.7

Station (GeoB)		Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box	T (°C)	O2 (ml/l)
26176	**- 1**	**Dive #100 - Mozambique (seamount A (top) off Maputo)**						strong downward currents			
26176	- 2	02.09.24	11:43	25° 59.179	35° 10.348	322	#1	yellow *Eguchipsammia*	RBB-1	13.9	4.5
26176	- 3	02.09.24	11:50	25° 59.179	35° 10.347	322	#2	octocoral + sponge	RBB-2		
26176	- 4	02.09.24	11:52	25° 59.179	35° 10.347	322	#3	water sample (5L)	N-1		
26176	- 5	02.09.24	11:59	25° 59.180	35° 10.348	320	#4	red octocoral + rose octocoral	RBB-3	13.9	4.3
26176	- 6	02.09.24	12:18	25° 59.186	35° 10.352	311	#5	coral rubble + live *Eguchipsammia*	Box-1 (net)	13.9	4.3
26176	- 7	02.09.24	12:49	25° 59.200	35° 10.364	289	#6	large gastropod	RBB-4	14.1	4.2
26176	- 8	02.09.24	13:10	25° 59.199	35° 10.364	289	#7	water sample (5L)	N-2	14.6	4.4
26176	- 9	02.09.24	13:21	25° 59.199	35° 10.364	289	#8	orange octocoral	RBB-5	14.4	4.4
26176	- 10	02.09.24	13:34	25° 59.199	35° 10.364	289	#9	red octocoral + stylasterid (was lying in RBB-9, open box)	RBB-6, RBB-9*	14.6	4.4

Station (GeoB)		Date (ddmmyy)	Time (UTC)	Latitude ('S)	Longitude ('E)	Depth (m)		Sample	Box	T (°C)	O2 (ml/l)
26180	**- 1**	**Dive #101 - Mozambique (seamount B off Maputo)**						dive aborted due to buoy on top of SMT			
26180	- 2	03.09.24	6:59	25° 57.743	35° 11.701	312	#1	live *Eguchipsammia* + octocoral	RBB-1	14.0	4.1
26180	- 3	03.09.24	7:14	25° 57.747	35° 11.701	308	#2	net: coral rubble + live *Eguchipsammia*	Box-1	14.5	4.1
26180	- 4	03.09.24	7:21	25° 57.747	35° 11.701	308	#3	live *Eguchipsammia* + red octocoral + stylasterid	RBB-2	14.4	4.1
26180	- 5	03.09.24	7:22	25° 57.747	35° 11.701	308	#4	water sample (5L)	N-1		
26180	- 6	03.09.24	7:41	25° 57.751	35° 11.700	303	#5	stylasterid	RBB-3		
26180	- 7	03.09.24	7:59	25° 57.751	35° 11.700	303	#6	rock + red octocoral	RBB-4	14.4	4.1
26180	- 8	03.09.24	8:00	25° 57.751	35° 11.700	303	#7	water sample (5L)	N-2		

Appendix 5

A5 Sediment Sampling

A5.1 TV-guided Giant Box Corer (TV-GBC)

(C. Wienberg, K. Dehning, Z. Filander, A. Freiwald, L. Greiffenhagen, D. Hebbeln, L. Hoffman, K. Pfennings, S. Yahya, B. Meyer-Schack, G. Ruhland, P. Shunula, J. Westbeek, M. Wilsenack)

A5.1.1 Technical and Operational Set-up

A giant box corer was the main sampling tool to obtain undisturbed surface sediments during RV SONNE expedition SO306. The sampling box has a diameter of 50 x 50 cm and a height of 55 cm. It was additionally equipped with a self-designed digital telemetry system on which a HD digital camera with a resolution of 1920 x 1080 pixels was installed (connected with a copper twisted pair network cable). The camera was mounted next to the box, while the telemetry system was installed above the box corer frame to compensate for a difference in height of 2.5 m between ready-to-operate ('open') and released ('closed') box corer (Fig. A5.1). The fibre cable was placed inside a plastic tube fixed at the telemetry housing, from which it is pulled out when the box corer is lifted from the seabed.

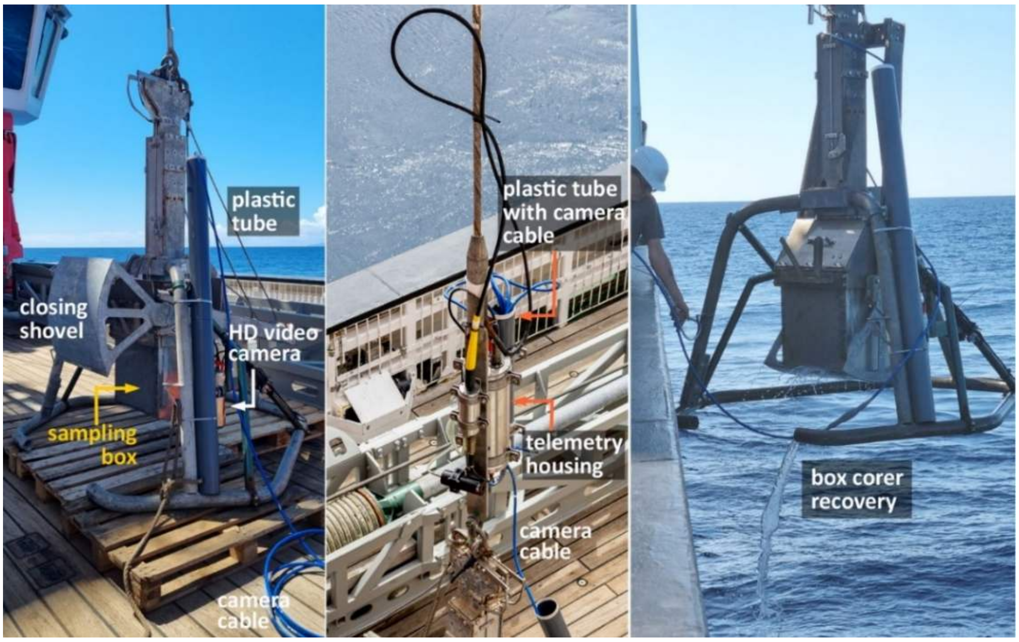


Fig. A5.1 (from left to right) Giant box corer equipped with a video camera mounted next to the sampling box. Set-up of the telemetry (mounted above the box corer frame) with the fibre cable placed inside of plastic tubes. Recovery of the TV-box corer onboard RV SONNE during expedition SO306.

The video camera enabled a targeted sampling of the seabed. In some cases, it has also been used for video mapping along a transect, with the vessel towing the lowered coring system at a maximum speed of 0.1-0.3 knots. The box corer was operated from a laboratory, where a winch operator manually adjusted the height of the box corer above the seafloor and placed the corer on the seabed once a promising target had been selected based on the video footage by the responsible scientists (Fig. A5.2).

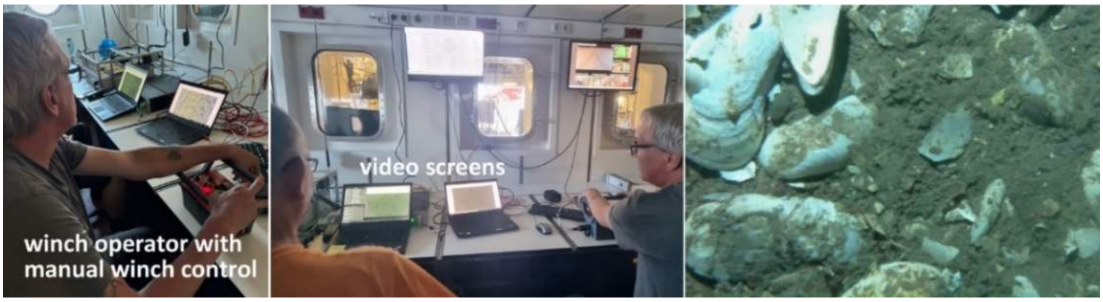


Fig. A5.2 (from left to right) Winch operator in the TV-GBC control laboratory. The video helps to select sampling sites. Screenshot showing a sampling site shortly before the box corer was placed on the seabed.

A5.1.2 List of Samples and Sampling Scheme

During RV SONNE expedition SO306, the TV-GBC was deployed at 14 stations (1x Mayotte, 10x Tanzania, 1x Mozambique, South Africa: 2x; Tables A5.1-A5.3); two times the TV-GBC did not release (Tanzania) and two times the TV-GBC could not be placed on the seabed due to strong currents (South Africa).

Table A5-1 List of TV-GBC collected during RV SONNE expedition SO306 off SW Mayotte.

GeoB-ID	Lat (S')	Lon (E')	Depth	Recovery	Remarks	Site
26109-1	12°57.387	44°53.269	770 m	~3-19 cm	foraminifera sand with few volcanoclastics	SW Mayotte

Table A5-2 List of TV-GBC collected during RV SONNE expedition SO306 off Tanzania.

GeoB-ID	Lat (S')	Lon (E')	Depth	Recovery	Remarks	Site
*26120-1	10°20.072	40°20.072	372 m	~0-20 cm	silty sand on crust; disturbed	shallow site
*26121-1	10°21.138	40°29.822	274 m	./.	not released; video showed large boulders with corals	shallow site
26125-1	10°15.193	40°24.814	339 m	46 cm	silty sand to silty clay	Tungue Canyon
26126-1	10°15.326	40°25.051	429 m	29 cm	sand to clayey silt	Tungue Canyon
*26132-1	10°12.231	40°32.742	915 m	28 cm	coral-bivalve rubble	Mtwara MV
*26137-1	10°12.222	40°32.663	868 m	10-20 cm	shell rubble on siliciclastic sand	Mtwara MV
*26151-1	10°12.239	40°32.638	866	9-26 cm	mud breccia	Mtwara MV
*26152-1	10°12.259	40°32.682	867	30 cm	*Bathymodiolus* layer	Mtwara MV
*26154-1	10°21.118	40°29.802	274	0-14 cm	sandy silt with bioclasts overgrown by bryozoan; video-mapping	shallow site
26162-1	9°56.075	40°30.271	1600	./.	not released; video showed bioturbated soft sediment with few small rocks; video-mapping	deep site

Table A5-1 List of TV-GBC collected during RV SONNE expedition SO306 off Mozambique.

GeoB-ID	Lat (S')	Lon (E')	Depth	Recovery	Remarks	Site
*26168-1	18°51.518	37°14.166'	471 m	~35 cm	mud breccia with chimneys	Zambezi MV

**deployment with Sonardyne, MV: mud volcano*

Before sampling, the sediment surface and sediment column of each core were photographed and described for its lithology and live/dead/fossil faunal content (a detailed sediment-fauna description of each box core is given in A5.1.2). The following standard sub-sampling scheme (see Fig. A5.3) was conducted on each successfully recovered box core:

a) Water sampling (2x 100 ml) (GEOMAR)
b) Rinsing of the remaining super-standing water to sample living fauna (SAM)
c) Collecting of living fauna from the sediment surface and fixation in 96% ethanol (SAM)
d) Surface sediment sampling (0-1 cm):
   - for further grain size analyses (200 cm^3) (MARUM)
   - for further foraminifera analyses (25 cm^3; stained with Bengalrose) (SAM)
   - for further eDNA analyses (3x Falcon tubes) (IEO-CSIC, UB)
   - as voucher sediments (25 cm^3; stained with Bengalrose) (InOM)
f) Sediment column sampling by 2 archive cores (12 cm in diameter) (MARUM)
g) Wet-sieving of remaining sediments for taxonomy (for details see A5.1.1) (SAM)

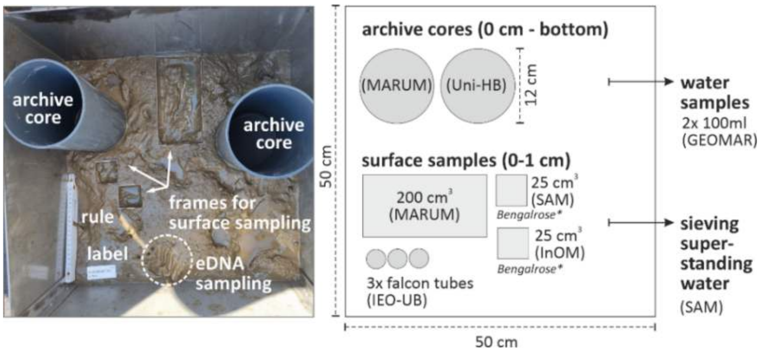


Fig. A5.3 Standard sampling scheme applied for TV-GBC collected during cruise SO306. Water samples: GEOMAR, surface samples (0-1 cm): MARUM, SAM, IEO-CSIC, UB, InOM (only off Mozambique), archive cores: MARUM, sieved material: SAM.

A5.1.3 Benthic Invertebrate Fauna Identified from Sediment Surface Samples

Surface sediment samples collected by the TV-GBC and ROV were sieved on deck with sea water using mesh sizes of 0.5, 1.0 and 5.0 mm. The sieved sediment fractions were washed with fresh water to remove the salt. Subsequently, the fractions were dried in an oven at 50°C for 24-72 hours, packed, and formally registered for processing at SAM (Wilhelmshaven). Several sediment fractions were sorted on board using low magnification microscopes (6-60x) for mollusc shells, small scleractinians and stylasterids. Most species in these classes were determined on board to the lowest possible taxonomic level. Family, genus and specific names were determined using literature available on board. Selected specimens were photographed on board with a confocal Keyence digital microscope (20-200x).

Live specimens, were first sent to the genetics sampling laboratory on board. Thereafter, large specimens were (i) photographed, (ii) dried in an oven (mostly octocorals, scleractinians, sponges, mytilids and rocks) for 24-48 hours at 50°C, (iii) packed for transport and (iv) registered for future processing at SAM. Selected live organisms (molluscs and actiniarians) collected by the ROV were fixated using 96% ethanol (denatured and/or undenatured), and/or 4% formalin solution stabilised with Borax. Samples on ethanol were stored in a freeze container.

Some 800 samples were registered in a list containing a (i) registration number from SAM, (ii) the GeoB station number, (iii) a generic area, (iv) a sample description, (v) the container type, and (v) fixation medium (mostly dry or ethanol). All Keyence and other photographs are available at SAM. The photographic files have systematic names that include the (GeoB) station number and a taxonomic or other description.

A5.1.4 Shell Size Measurements of *Bathymodiolus*

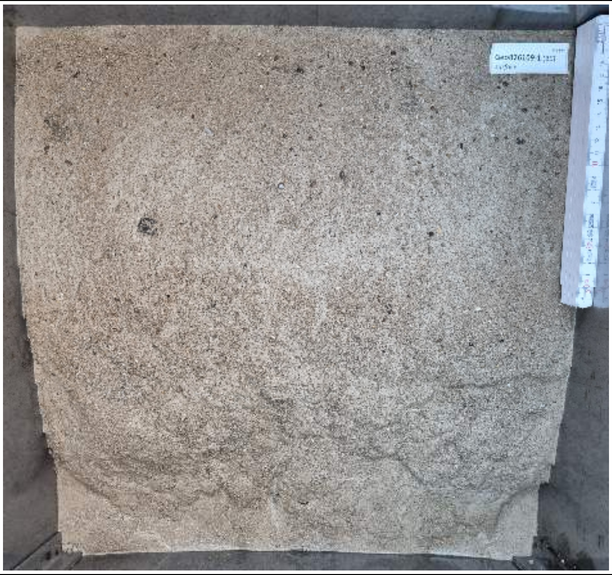
The surface of the TV-GBC GeoB26152-1 was characterized by a ~9 cm thick layer of live *Bathymodiolus* sp. The mussel surface layer was removed and mussels larger than ~5 mm were measured for shell length at the longest point from the hinge to the posterior margin with a caliper to the nearest millimetre. Measured mussels were stored at -20 °C, while the remaining smaller mussels were preserved in ethanol. A subsample of around 50 individuals was taken from the frozen sample and stored at -20 °C for genetic and other further analyses. The rest of the mussel were boiled and dissected to separate the shells from the soft parts. Shells were dried and stored for further analyses.

A5.1.5 Detailed Core Description (TV-GBC)

Mayotte

GeoB - ID				SONNE-ID				Latitude (S)		Longitude (E)		Water depth (m)
261	09	-	1	SO306	09	-	1	12°	57.387'	44°	53.269'	770

Water sampling		Water sieving	Surface sampling			Archive core		Sediment sieving
GEOMAR (2x 100ml)		SAM	MARUM (200 cm^3)	SAM (25 $cm^3_{Bengalrose}$)	IEO (3x Falcon)	MARUM	HB Uni	SAM
./.	./.	./.	X	X	./.	X	X	X



	Sediment surface
Lithology	coarse well-sorted foraminifera sand with few black gravel-sized volcanic clastics
Colour	10YR 5/2 greyish brown
Structure	./.
Living fauna	ophiuroid
Dead/Fossil	benthic & planktonic Foraminifera, Pteropoda, Bivalvia (small shells)
Remarks	tilted, washed surface

	Sediment column
Recovery	~3-19 cm
Lithology & Sublayers	0-15 cm: medium-coarse sand 15cm-bottom: fine coarse sand, increase in quartz & volcanoclastics
Colour	0-15cm: 10YR 5/2 greyish brown 15cm-bottom: 10YR 10/2
Living fauna	small ophiurid; Gastropoda (Nemeritidae); Bivalvia (*Limopsis*)
Dead/Fossil	Foraminifera, Pteropoda, Gastropoda, Bivalvia, Scaphopoda Brachiopoda, Scleractinia (cm-sized solitary)
Remarks	sediment sieved as bulk

Bivalvia: *Pseudamussium*, *Sinosipella*, Arcidae, *Limopsis*, *Cuspidaria*, *Dacrydium*, *Cetoconcha*, *Saxicavella*; **Gastropoda**: Pteropoda Atlanta, *Nemertea*, Vetigastropoda, Cancellariidae, *Ringicula*, *Fissurisepta*, *Cornisepta*, Columbellidae, Vetigastropoda, Muricidae, *Trophonopsis*, Naticidae, Conoidea

Tanzania

GeoB - ID				SONNE-ID				Latitude (S)		Longitude (E)		Water depth (m)
261	20	-	1	SO306	20	-	1	10°	20.072'	40°	30.038'	372

Water sampling		Water sieving	Surface sampling			Archive core		Sediment sieving
GEOMAR (2x 100ml)		SAM	MARUM (200 cm^3)	SAM (25 cm$^3_{Bengalrose}$)	IEO (3x Falcon)	MARUM	HB Uni	SAM
./.	./.	./.	./.	./.	./.	./.	./.	X

Sediment surface	
Lithology	silty sand with biogenic clasts, terrigenous grains (e.g., quartz)
Colour	5YR 3/4 darkish greyish brown
Structure	./.
Living fauna	./.
Dead/Fossil	Pteropoda
Remarks	no overstanding water surface washed out

Sediment column	
Recovery	~0-20 cm
Lithology & Sublayers	sandy mud (~20 cm) above hard crust composed of biogenic clasts and oyster shells
Colour	7.5YR 3/1 very dark grey
Living fauna	Polychaeta (for DZMB: DNA), "Schlonz"
Dead/Fossil	Foraminifera, Pteropoda, Bryozoa, Serpulida, Bivalvia (oysters), Scleractinia, Corallinaceae (red algae), Halimeda (green algae)
Remarks	sediment disturbed

Tanzania - Tungue Canyon

GeoB - ID				SONNE-ID				Latitude (S)		Longitude (E)		Water depth (m)
261	25	-	1	SO306	25	-	1	10°	15.193'	40°	24.814'	339

Water sampling		Water sieving	Surface sampling			Archive core		Sediment sieving
GEOMAR (2x 100ml)		SAM	MARUM (200 cm^3)	SAM (25 cm$^3_{Bengalrose}$)	IEO (3x Falcon)	MARUM	HB Uni	SAM
X	X	X	X	X	./.	X	X	X

Sediment surface	
Lithology	silty sand (upper 2 cm)
Colour	5YR 3/2 dark reddish brown
Structure	/
Living fauna	worm, Ophiurida
Dead/Fossil	Polychaeta (tube) Bivalvia (shells) otholits
Remarks	surface undisturbed ~10 cm overstanding water

Sediment column	
Recovery	46 cm
Lithology & Sublayers	2 – 25 cm: silty clay 25 – 46 cm: silty clay
Colour	2 – 46 cm: 10YR 3/1 very dark grey
Living fauna	./.
Dead/Fossil	Foraminifera, Bivalvia, Gastropoda
Remarks	bioturbation vertical and horizontal worm hole borings

Tanzania – Tungue Canyon

GeoB - ID				SONNE-ID				Latitude (S)		Longitude (E)		Water depth (m)
261	26	-	1	SO306	26	-	1	10°	15.326'	40°	25.051'	429

Water sampling		Water sieving	Surface sampling			Archive core		Sediment sieving
GEOMAR (2x 100ml)		SAM	MARUM (200 cm^3)	SAM (25 cm$^3_{Bengalrose}$)	IEO (3x Falcon)	MARUM	HB Uni	SAM
./.	./.	X	X	X	./.	X	X	X

Sediment surface	
Lithology	fine to medium silty sand
Colour	10YR 3/2 very dark greyish brown
Structure	large diagonal artificial crack due to coring operation (shackle with line)
Living fauna	Scleractinia (solitary coral)
Dead/Fossil	agglutinated worm tubes otholits Gastropoda black leafs
Remarks	upper cover opened during recovery operation -> no water sampling!

Sediment column	
Recovery	29 cm
Lithology & Sublayers	1 – 26 cm: clayey silt 26 – 29 cm: medium to coarse sand with siliciclastics (only in the deepest part of the box)
Colour	1 – 26 cm: 2.5Y 3/2 very dark greyish brown 26 – 29 cm: 2.5Y 5/1 grey
Living fauna	Bivalvia
Dead/Fossil	small shell fragments
Remarks	organic material, seed (?)

Tanzania – Mtwara mud volcano

GeoB - ID				SONNE-ID				Latitude (S)		Longitude (E)		Water depth (m)
261	32	-	1	SO306	32	-	1	10°	12.231'	40°	32.742'	915

Water sampling		Water sieving	Surface sampling			Archive core		Sediment sieving
GEOMAR (2x 100ml)		SAM	MARUM (200 cm^3)	SAM (25 cm$^3_{Bengalrose}$)	IEO (3x Falcon)	MARUM	HB Uni	SAM
./.	./.	X	X	X	X	X	X	X

	Sediment surface
Lithology	sandy silt, coral-bivalve rubble
Colour	10YR 3/6 dark yellowish brown
Structure	./.
Living fauna	Octocorallia
Dead/Fossil	Bivalvia (shells of seep (!) species), Scleractinia (*Enallopsammia*), one segment of Isididae (bamboo coral)
Remarks	coral rubble with black to brown coating

	Sediment column
Recovery	28 cm
Lithology & Sublayers	top – 2 cm: coarse coral rubble 2 – 28 cm: downcore size of bioclasts (corals, bivalve shells) is decreasing
Colour	10YR 5/4 yellowish brown changing downcore to 10YR 5/3 brown
Living fauna	./.
Dead/Fossil	Foraminifera, Porifera(?), Polychaeta, Brachiopoda, Scleractinia (mainly dendrophylliid rubble, one fragment covered by sponge), Gastropoda, Bivalvia (shells/shell hash, very large shell of ~15 cm)
Remarks	rocks with aragonite crystals

Bivalvia: *Huxleyia*, *Bentharca*, Pectinidae, *Limopsis*, *Thyasira*, *Vesicomya*, Isorropodon, Veneridae, *Cetoconcha*, *Cuspidaria*, *Lucinoma*, *Acesta*, *Gigantidas*, *Calyptogena*, *Bathymodiolus.* **Gastropoda**: *Puncturella*, *Paralepetopsis*, Tentaculus, Pseudococculinidae, Collonidae, Trochoidea, Skeneimorpha, Seguenzioidea, Vetigastropoda, Pediculariidae, Naticidae, Haloceras, *Janthina*, Fissurisepta, *Anatoma*, Newtoniellidae, Epitoniidae, *Triforiforma*, Eulimidae, Nassariidae, Conoidea, Architectonicidae, Mathildidae, Acteonidae. **Scleractinia**: *Enallopsammia*, *Solenosmilia*, Caryophylliidae, *Javanica*

Tanzania – Mtwara mud volcano

GeoB - ID				SONNE-ID				Latitude (S)		Longitude (E)		Water depth (m)
261	37	-	1	SO306	37	-	1	10°	12.222'	40°	32.663'	868

Water sampling		Water sieving	Surface sampling			Archive core		Sediment sieving
GEOMAR (2x 100ml)		SAM	MARUM (200 cm^3)	SAM (25 $cm^3_{Bengalrose}$)	IEO (3x Falcon)	MARUM	HB Uni	SAM
./.	./.	X	X	X	./.	X	X	X

	Sediment surface
Lithology	sandy silt
Colour	10YR 4/2 dark greyish brown
Structure	./.
Living fauna	Polychaeta, Actinaria, Stylasterida (on bivalve shell), Polychaeta (with agglutinated tube, on bivalve shell)
Dead/Fossil	Actinaria, Antipatharia, sea anemone, Bivalvia (*Bathymodiolus*, *Calyptogena*), Gastropoda (Neogastropoda), agglutinated worm tube
Remarks	tilted; seep fauna(!); thin branch of wood

	Sediment column
Recovery	10-20 cm
Lithology & Sublayers	top – 5 cm: shell layer & medium to coarse siliciclastic sand 5 - 13 cm: sandy silt 13 - 20 cm: shell hash layer
Colour	top - 5 cm: 10YR 4/2 dark grey. brown 5 - 20 cm: 5Y 4/1 dark grey
Living fauna	./.
Dead/Fossil	Bivalvia, Gastropoda, Scleractinia (*Madrepora* fragment)
Remarks	calcite gravel (~1 cm); large (6x3 cm) rounded, translucent pebble (probably quartz)

Bivalvia: *Lucinoma*, *Bathymodiolus* sp., *Isorropodon* sp.; **Gastropoda**: Neomphalida, *Epitonium*, *Coralliophila* sp., Buccunidae, Volutidae

Tanzania – Mtwara mud volcano

GeoB - ID				SONNE-ID				Latitude (S)		Longitude (E)		Water depth (m)
261	51	-	1	SO306	51	-	1	10°	12.239'	40°	32.638'	866

Water sampling		Water sieving	Surface sampling			Archive core		Sediment sieving
GEOMAR (2x 100ml)		SAM	MARUM (200 cm^3)	SAM (25 cm$^3_{Bengalrose}$)	IEO (3x Falcon)	MARUM	HB Uni	SAM
./.	./.	./.	X	X	X	X	X	X

	Sediment surface
Lithology	sandy silt
Colour	2.5Y 3/1 very dark grey
Structure	./.
Living fauna	one red Polychaeta (living in the sediment), small hydrozoans growing on mud breccia
Dead/Fossil	Polychaeta (abundant agglutinated worm tubes, concentrated in one patch), Pteropoda, Foraminifera (agglutinated colonising clasts), shell fragments,
Remarks	many mud breccia of different size, shape and colour; strong H_2S smell

	Sediment column
Recovery	9 – 26 cm
Lithology & Sublayers	no layers visible, but sampled in three layers (top-10 cm, 10-20 cm, 20 cm-bottom) for sieving
Colour	main sediment: 5Y 4/2 olive grey, anoxic sediment patches: 2.5Y 2/1 black
Living fauna	./.
Dead/Fossil	Hydrozoa, Stylasterida; Bivalvia (*Lucinoma*)
Remarks	strong H_2S smell

Tanzania – Mtwara mud volcano

GeoB - ID				SONNE-ID				Latitude (S)		Longitude (E)		Water depth (m)
261	52	-	1	SO306	52	-	1	10°	12.259'	40°	32.682'	867

Water sampling		Water sieving	Surface sampling			Archive core		Sediment sieving
GEOMAR (2x 100ml)		SAM	MARUM (200 cm^3)	SAM (25 cm$^3_{\text{Bengalrose}}$)	IEO (3x Falcon)	MARUM	HB Uni	SAM
./.	./.	./.	./.	X	./.	X	./.	X

Sediment surface	
Lithology	./.
Colour	sandy silt layer below shell layer: 2.5Y 4/2 dark greyish brown
Structure	./.
Living fauna	Polychaeta (several), Ophiurida (several), Bivalvia (*Bathymodiolus*, juvenile and adult), Gastropoda, Crustacea
Dead/Fossil	Bivalvia (shells)
Remarks	7-9 cm thick layer of living Bivalvia (*Bathymodiolus*) above sandy silt

Sediment column	
Recovery	9 cm shells + 30 cm sediment: 39
Lithology & Sublayers	no visible layers, living bivalves were collected separately
Colour	10YR 2/1 black
Living fauna	./.
Dead/Fossil	shell fragments throughout
Remarks	strong H_2S smell

Bivalvia: *Bathymodiolus*; **Gastropoda**: *Enigmaticolus*, *Paralepetopsis*, *Anatoma*, Propeamussiidae, *Skeneimorpha*

Tanzania

GeoB - ID				SONNE-ID				Latitude (S)		Longitude (E)		Water depth (m)
261	54	-	1	SO306	54	-	1	10°	21.118'	40°	29.802'	274

Water sampling		Water sieving	Surface sampling			Archive core		Sediment sieving
GEOMAR (2x 100ml)		SAM	MARUM (200 cm^3)	SAM (25 cm$^3_{Bengalrose}$)	IEO (3x Falcon)	MARUM	HB Uni	SAM
./.	./.	./.	./.	./.	./.	./.	./.	X

Sediment surface	
Lithology	silty fine sand
Colour	10YR 3/3 dark brown
Structure	./.
Living fauna	Polychaeta (in agglutinated worm tubes), Crustacea (hermit crab),
Dead/Fossil	Foraminifera (benthic), Polychaeta (chitin tube)
Remarks	tilted, sediment disturbed

no photo possible

Sediment column	
Recovery	0-14 cm
Lithology	silty fine sand
Colour	surface layer: 10YR 3/3 dark brown 2.5Y 3/2 very dark grey brown
Living fauna	Echinoidea (2x *Lovenia*)
Dead/Fossil	Polyplacophora, Brachiopoda, basal parts of Medusa, Scleractinia (fragments), Gastropoda, Bivalvia (fragments), Scleractinia (one solitary coral)
Remarks	abundant bioclasts: crusts made of coralline red algae and overgrown by Bryozoa, bioclasts composed of Scleractinia, Bryozoa, Serpulida, benthic Foraminifera

Bivalvia: *Abra*, Lucinidae, *Neilonella*, *Tindaria*, *Nucula*, *Sacella*, *Yoldiella*, *Bathyarca*, *Limopsis*, Propeamussiidae, *Spinosipella*, *Cardiomya*, *Limea*; **Gastropoda**: *Emarginula*, Vetigastropoda, Muricidae, Epitoniidae, Conoidea, *Danilia*, *Solariella*, *Capulus*, Architectonicidae, *Puncturella*, *Natica*, Vanikoridae, *Ringicula*, Cysticidae, Nassariidae; **Scaphopoda**: *Gadila*, *Cadulus*; **Scleractinia**: Caryophillia, *Balanophyllia* cf. *Diadamata*, Caryophilliidae, Dendrophyliidae, Turbinoliidae, *Fungia*?

Mozambique – Zambezi mud volcano

GeoB - ID				SONNE-ID				Latitude (S)		Longitude (E)		Water depth (m)
261	68	-	1	SO306	68	-	1	18°	51.518'	37°	14.166'	471

Water sampling		Water sieving	Surface sampling				Archive core		Sediment sieving
GEOMAR (2x 100ml)		SAM	MARUM (200 cm^3)	SAM (25 cm^3$_{Bengalrose}$)	InOM (25 cm^3$_{Bengalrose}$)	IEO (3x Falcon)	MARUM	HB Uni	SAM
./.	./.	X	X	X	X	X	X	X	X

Sediment surface	
Lithology	silty mud with blackish minerals
Colour	2.5Y 4/2 dark greyish brown
Structure	./.
Living fauna	Foraminifera (large, branching, in sediment), Serpulida, Polychaeta (agglutinated), Bryozoa, Hydrozoa, Actinaria (growing on crusts), Stylasterida, Scleractinia (solitary), Ophiurida, Crustacea (Verrucid)
Dead/Fossil	Foraminifera (agglutinated, cm-sized), Scyphozoa (base), Gastropoda (fragment), Bivalvia (chemosymbiontic), Scleractinia (solitary)
Remarks	abundant chimneys, fragments of autigenic carbonate crusts

Sediment column	
Recovery	34 cm
Lithology & Sublayers	top – 5 cm: silty mud 5 – 34 cm: stiff silty clay
Colour	top – 5 cm: 2.5Y 4/2 dark grey. brown 5 – 34 cm: very dark grey
Living fauna	Annelida (Sipunculida, boring in chimney tube)
Dead/Fossil	Bivalvia (fragments)
Remarks	3-6 cm: large (~20 cm long) chimney, 12 cm: grey crust, 14 cm: vertical chimney (~5 cm)

Bivalvia: *Nucula*, Nuculanidae, *Nuculana*, *Bathyspinula*, *Tindaria*, *Anadara*, *Lucinoma*, *Vesicomya*; **Gastropoda**: Trochoidea, Seguenziidae, Skeneidae, Muricidae, Nassariidae, Conoidea

A5.2 Gravity Corer (GC)

(C. Wienberg, M. Ansorge, G. Corbera, K. Dehning, G. Eberli, F. Gigli, L. Greiffenhagen, D. Hebbeln, B. Meyer-Schack, G. Ruhland, M. Wilsenack)

A5.2.1 Core Handling, List of Cores, GeoB Labelling Scheme, Core Imaging

A gravity corer with a steel pipe length of 6 or 12 m and a weight of ~1.7 tons was applied to recover long sediment sequences, which will be used for paleoceanographic studies. The gravity corer was deployed at 13 stations (8x Tanzania, 3x Mozambique, 2x South Africa; Table A5.4). Twelve coring attempts were successful with sediment recoveries ranging between 0.3 m and 9.6 m. Off South Africa, one coring attempt failed as the tube bent and no sediments had been recovered. Overall, ~73 core metres were recovered during the cruise SO306 (Table A5.4). Once on-board, the sediment cores were cut into 1-m-sections, closed with caps on both ends and labelled according to a GeoB standard scheme (Fig. A5.4).

Table A5.4 List of gravity cores collected during RV SONNE expedition SO306 (TAN: Tanzania, MOZ: Mozambique, ZA: South Africa).

GeoB-ID		Study Area	Lat (S')	Lon (E')	Depth	Recovery	CC	Remark
26140-1	GC6	TAN	10°10.968	40°21.283	424 m	5.77 m	yes	top lost
26141-1	GC12	TAN	10°06.052	40°19.992	765 m	6.65 m	yes	sediment lost between sections 3/4; presence of two large shallow-water corals
26143-1	GC6	TAN	10°12.996	40°40.247	1211 m	0.34 m	yes	
26144-1	GC6	TAN	10°08.804	40°46.350	1492 m	4.04 m	yes	
26147-1	GC12	TAN	10°06.042	40°20.200	771 m	5.46 m	yes	equivalent to GeoB26141-1
26148-1	GC12	TAN	10°00.993	40°21.504	1121 m	4.97 m	yes	
26158-1	GC12	TAN	10°04.597	40°46.140	1650 m	8.36 m	yes	
26163-1	GC12	TAN	9°57.004	40°43.595	1819 m	4.63 m	yes	
26169-1	GC12	MOZ	18°54.245	37°14.309	580 m	5.98 m	yes	
26181-1	GC12	MOZ	25°49.248	35°6.100	1055 m	8.58 m	yes	
26182-1	GC12	MOZ	25°38.733	34°58.507	500 m	8.43 m	yes	
26189-1	GC12	ZA	29°33.480	32°51.111	1835 m	9.57 m	yes	./.
26192-1	GC12	ZA	29°37.787	32°51.476	1811 m	./.	./.	tube bent, no sediments
					total	**72.78 m**		

All gravity cores were opened on-board (sawed lengthwise) and stored in archive boxes ('D-tubes'). The longitudinal split core sections were visually described and imaged using the SmartCIS 1600LS line scanning system of the MARUM GeoB Core Repository. Surfaces of each section were freshly scraped prior to imaging in order to capture the ephemeral nature of sedimentary features as some features oxidize within minutes. All images were acquired at a standard resolution of 500dpi. In order to retain the relative variability in sediment lightness throughout the expedition camera aperture was fixed at f/8. This aperture setting imaged most sediments without the need for further adjustment. All sections were scanned using two light sources in order to achieve best lighting situations and reduce potential shadow effects of rough surfaces. A white calibration of the system was done on daily basis using a standardized white tile. Absolute color reproduction of the line scan images is ensured through the automatic application of a IT8.7/2-target referenced ICC-profile built-in the steering software of the line scanner. Section images were directly saved to the curatical database system ExpeditionDIS as *.jpeg files. Output also included a tab-delimited text file with red, green, blue, lightness (%) values as well as red/blue ratios in 1 mm down-core resolution for each section. All sediment cores collected during cruise SO306 will be stored in the MARUM core repository at the University of Bremen and are made available for further sampling on request.

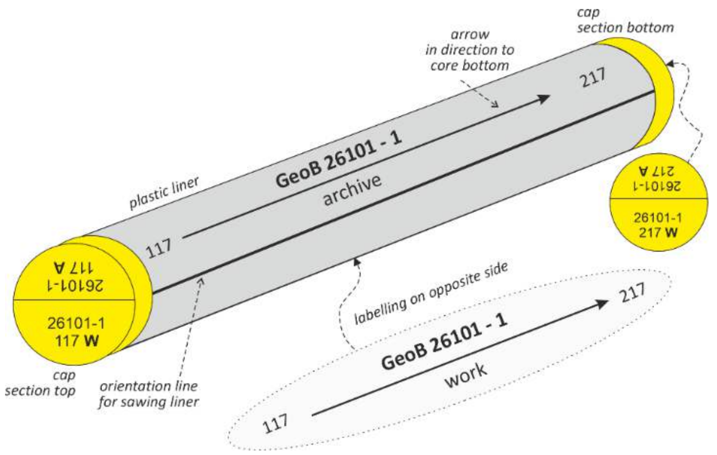
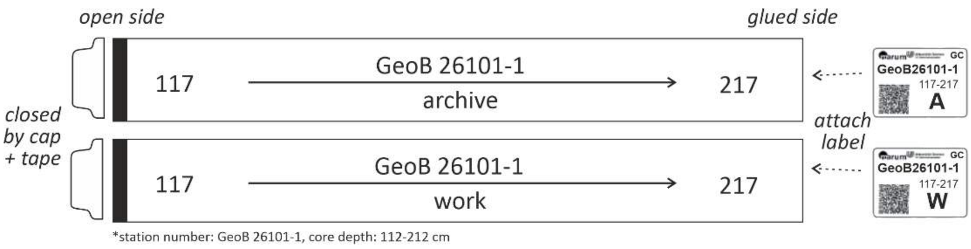


Fig. A5.4
The gravity corer is equipped with a plastic liner which is pulled out of the steel pipe after recovery. The plastic liner cut into 1-m-long core sections. The core sections are closed with caps on both ends and labelled according to a standard scheme for GeoB cores of the MARUM (Bremen). Each core section is cut lengthwise and stored in so-called 'D-tubes' (sse below).



A5.2.2 Detailed Core Description (GC) incl. Linescans

Gravity core GeoB26140-1 (427 m water depth, recovery 577 cm) Tanzania

Core GeoB26140-1 was obtained from 424 m water depth with a total recovery of 577 cm. However, the gravity corer penetrated too much into the seafloor and approximately the upper 20 cm of sediment were lost. The core mostly consists of dark grey to black silty clay with sand-sized calcareous biodetritus from 346 cm to the bottom of the core. These include echinoid fragments, scaphopods, bivalves and pteropods.

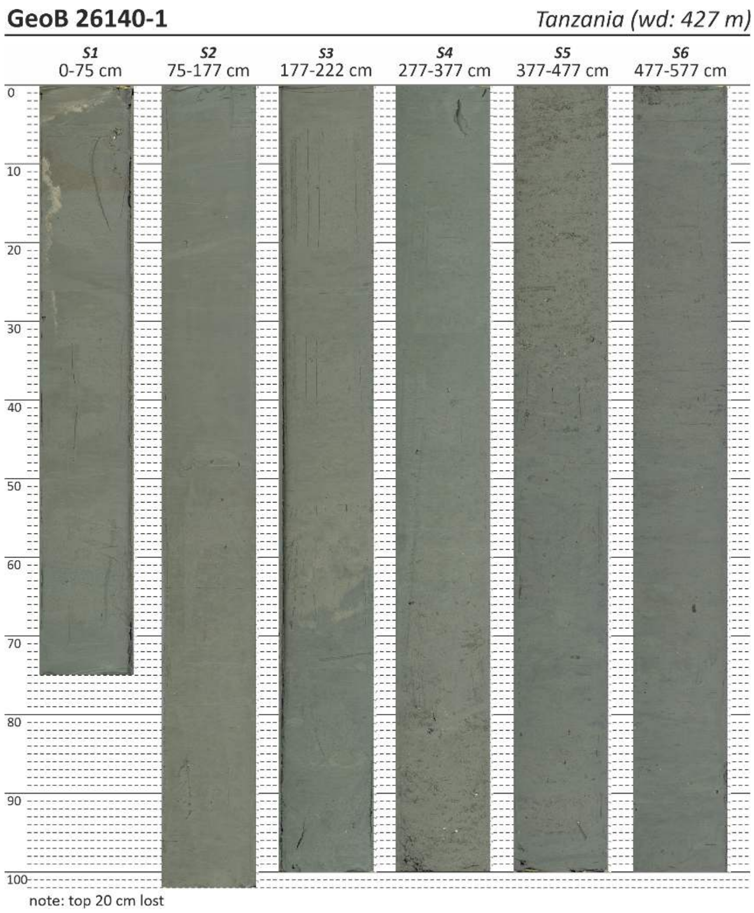


Fig. A5.5a Linescan of gravity core GeoB26140-1 collected off Tanzania.

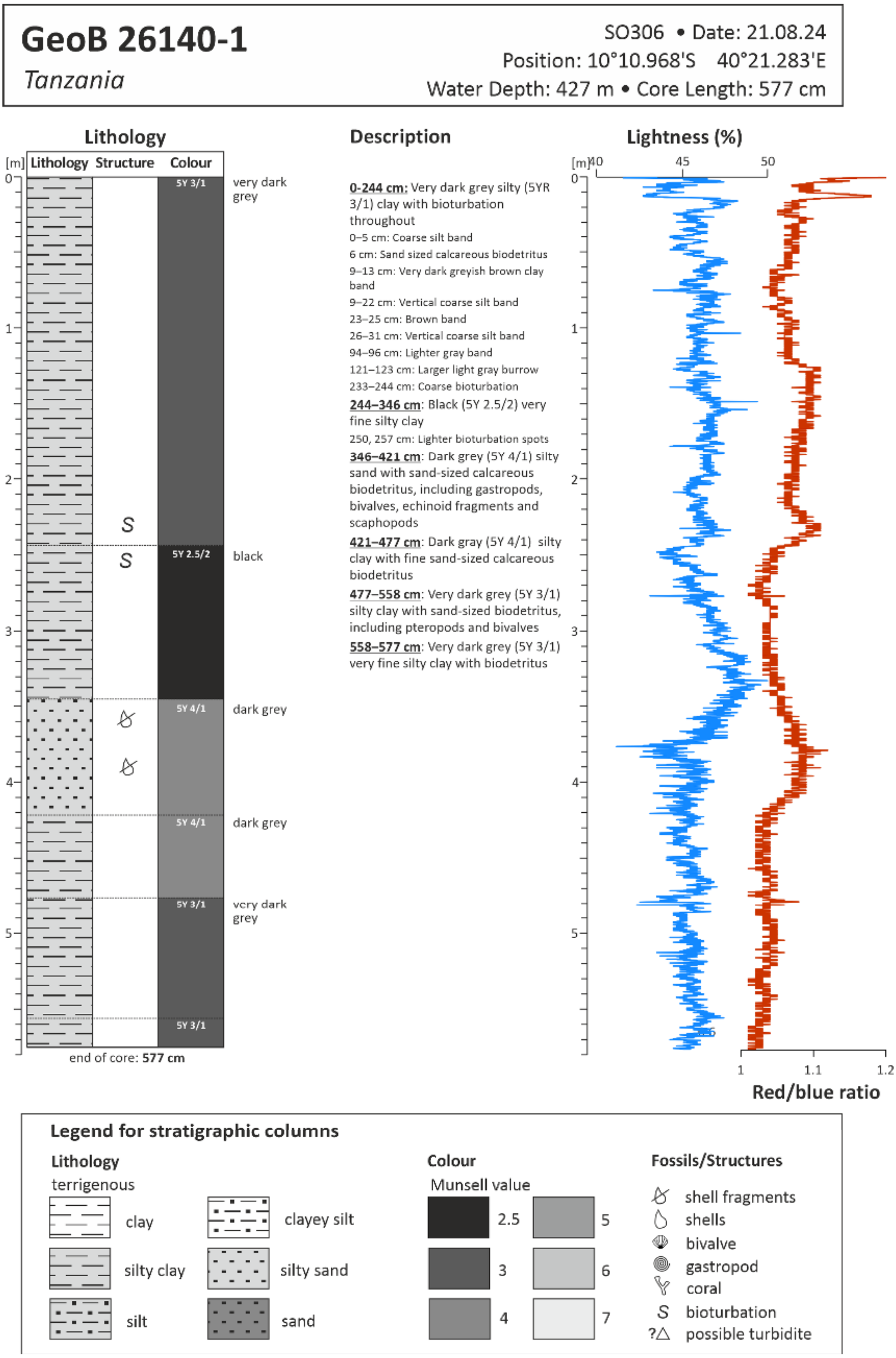


Fig. A5.5b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26140-1.

Gravity core GeoB26141-1 (765 m water depth, recovery 665 cm) Tanzania

Core GeoB26141-1 was collected from a part of the slope located between two submarine canyons, at 765 m water depth. During the extraction procedure of this core from the gravity corer part of de sediment between sections 3 and 4 was lost. In order to compensate for this, an equivalent core (GeoB26147-1) was acquired from almost the same location. Core GeoB26141-1 recovered 665 cm of sediment, generally composed of clay with the colour ranging from grey to black and varying abundances of foraminifera. Presence of large pteropod pockets, some small scaphopods and bivalves, mainly in the upper ~600 cm. Between 300 and 340 cm a small solitary coral of the genera *Stephanocyathus* sp. and two large pieces of shallow-water colonial scleractinian corals were found. The first piece was almost completely intact, while the second one was eroded and overgrown with serpulids, oysters and coralligenous algae. Down to 603 cm the sediments were dominated by very dark grey and dark olive grey clay with the presence of a pebble-sized calcareous algae. This was followed by a potential convoluted bedding slump of lighter and darker grey and black clay until the core bottom.

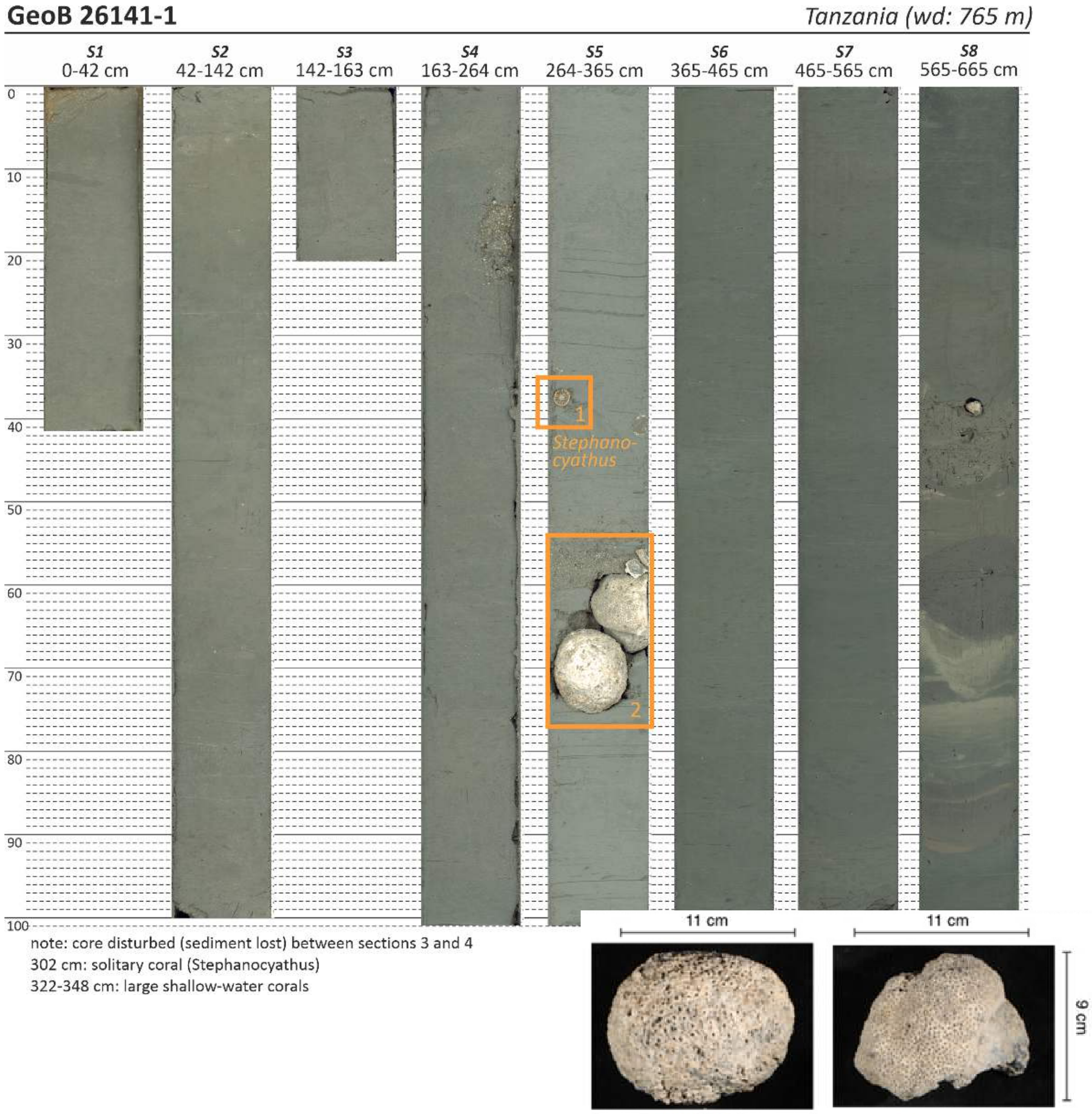


Fig. A5.6a Linescan of gravity core GeoB26141-1 collected off Tanzania. Photo of two shallow-water corals found at 315-340cm core depth.

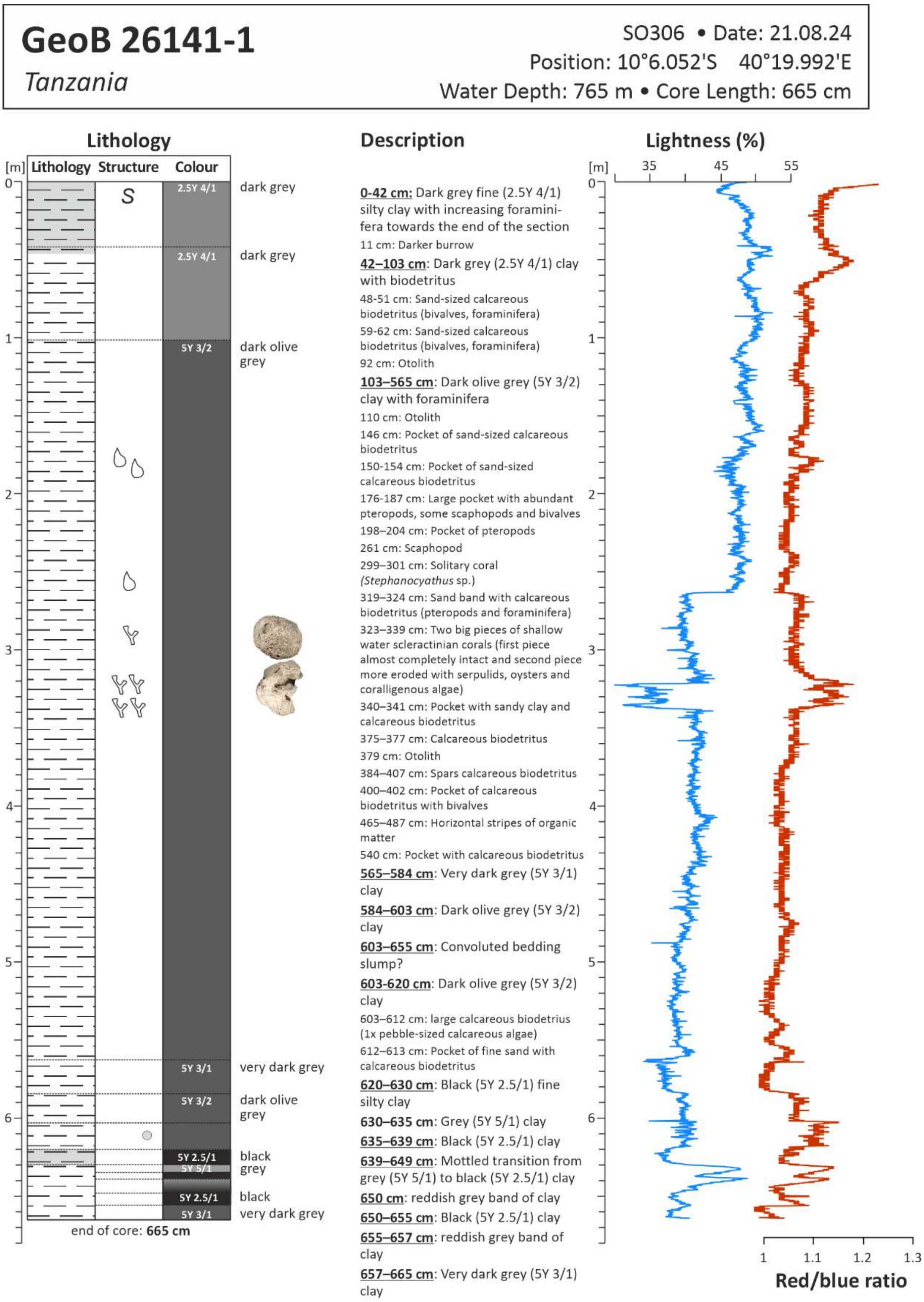


Fig. A5.6b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26141-1.

Gravity core GeoB26143-1 (1211 m water depth, recovery 34 cm) Tanzania

Core GeoB26143-1 was collected from the middle slope (1211 m water depth), but due to the extremely hardened black clay present in the upper seafloor layer, only 34 cm were recovered.

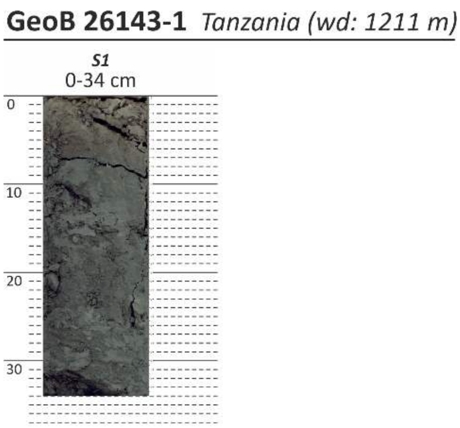


Fig. A5.7a Linescan of gravity core GeoB26143-1 collected off Tanzania.

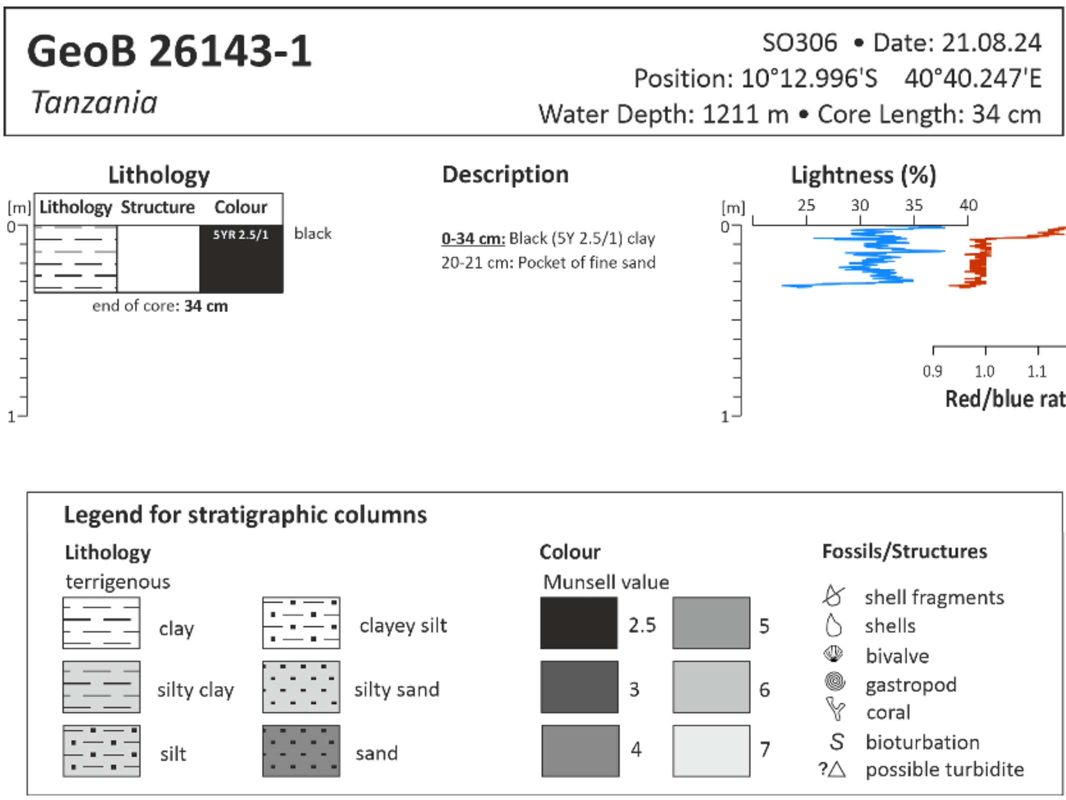


Fig. A5.7b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26143-1.

Gravity core GeoB26144-1 (1492 m water depth, recovery 412 cm) Tanzania

Core GeoB26144-1 was collected at 1492 m water depth with a total recovery of 412 cm. The upper part of this core consists of brownish sands, which gradually change to silt until ~137 cm, where the sediments start to be dominated by grey clay. This is followed by a drastic colour change from grey to dark greenish grey clay with sparse silt pockets. The sediment colour gets darker towards the core bottom, where it consists of black clay with large coarse sand pockets that suggest the presence of a slump.

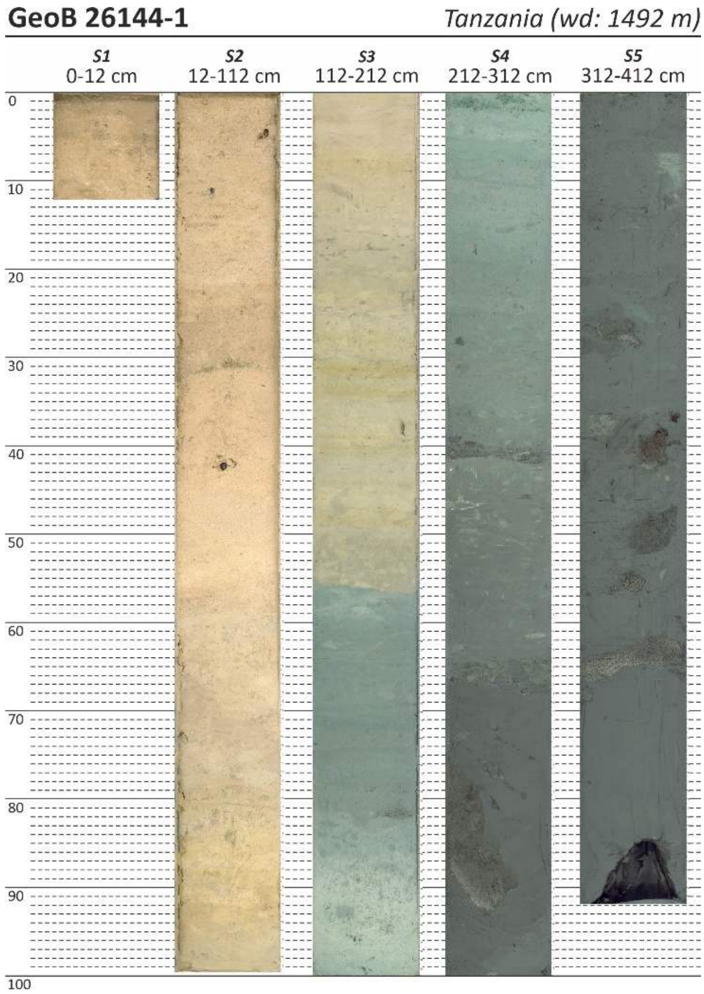


Fig. A5.8a Linescan of gravity core GeoB26144-1 collected off Tanzania.

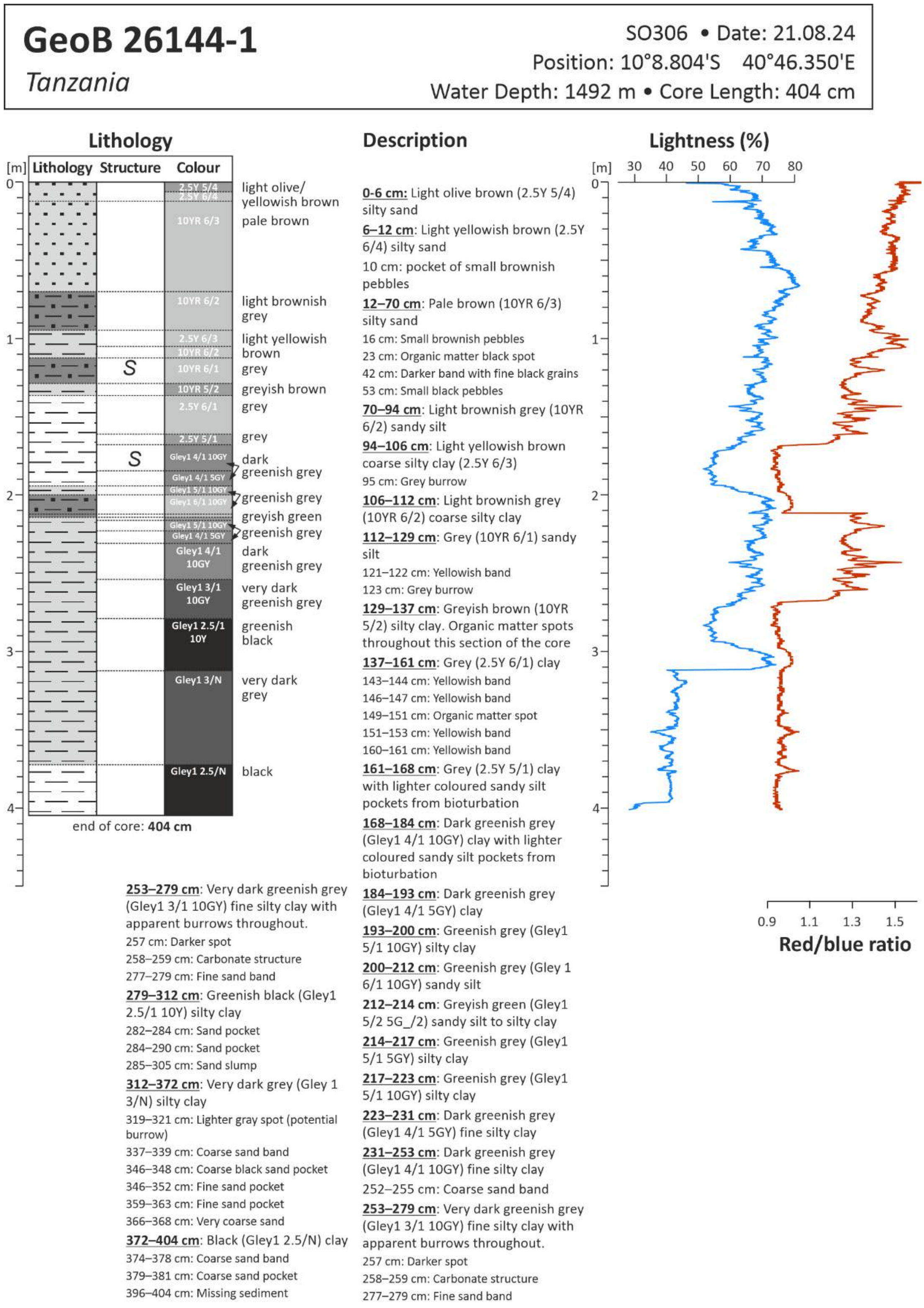


Fig. A5.8b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26144-1.

Gravity core GeoB26147-1 (771 m water depth, recovery 546 cm) Tanzania

Core GeoB26147-1 was collected from approximately the same water depth (771 m) as its equivalent core GeoB21641-1 and had a recovery of 546 cm of sediment. The latter was dominated by dark grey and dark olive gray silty clay that gets gradually darker and finer towards the core bottom, where the sediments were dominated by black clay. Presence of calcareous biodetritus pockets with foraminifera, pteropods and a bivalve shell from the family Nuculidae.

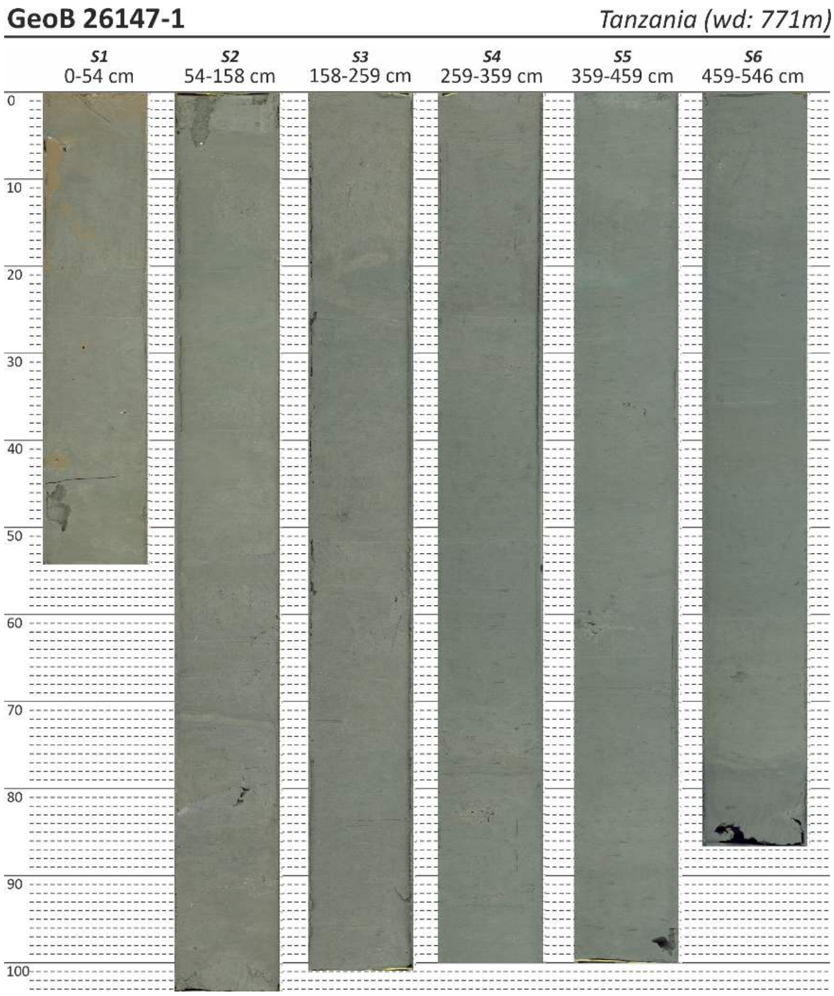


Fig. A5.9a Linescan of gravity core GeoB26147-1 collected off Tanzania.

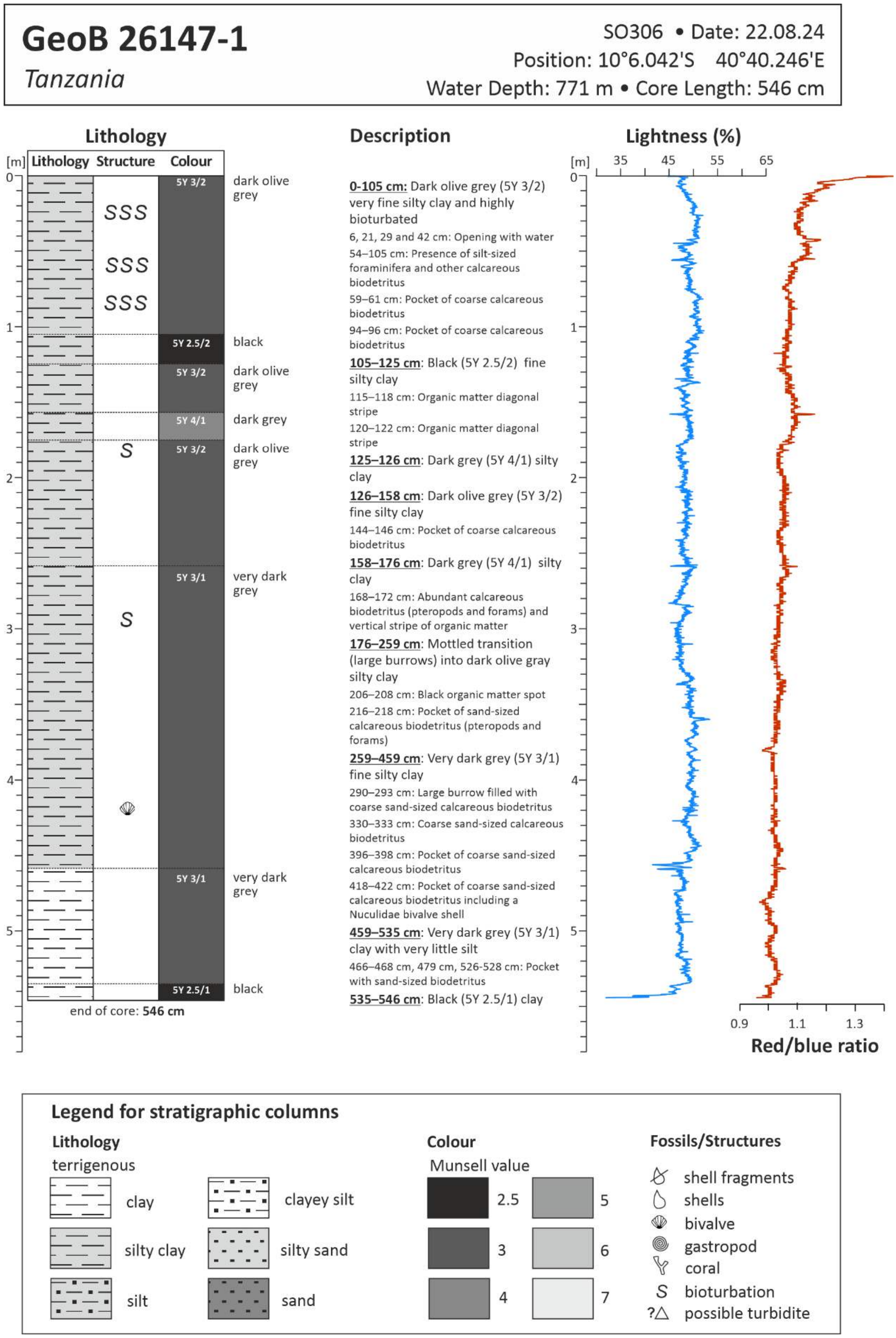


Fig. A5.9b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26147-1.

Gravity core GeoB26148-1 (1121 m water depth, recovery 497 cm) Tanzania

Core GeoB26148-1 was collected from the middle slope south of a submarine canyon, at 1121 m water depth with 5.01 m recovery. The sediment in the upper part of this core (0–361 cm) are dominated by grey to dark olive grey silty clay with calcareous biodetritus (mostly foraminifera and pteropods). Below 361 cm, the sediment gets finer and darker, oscillating between dark grey and black clay with some calcareous biodetritus. Presence of black organic detritus, potentially wood, at 420 cm.

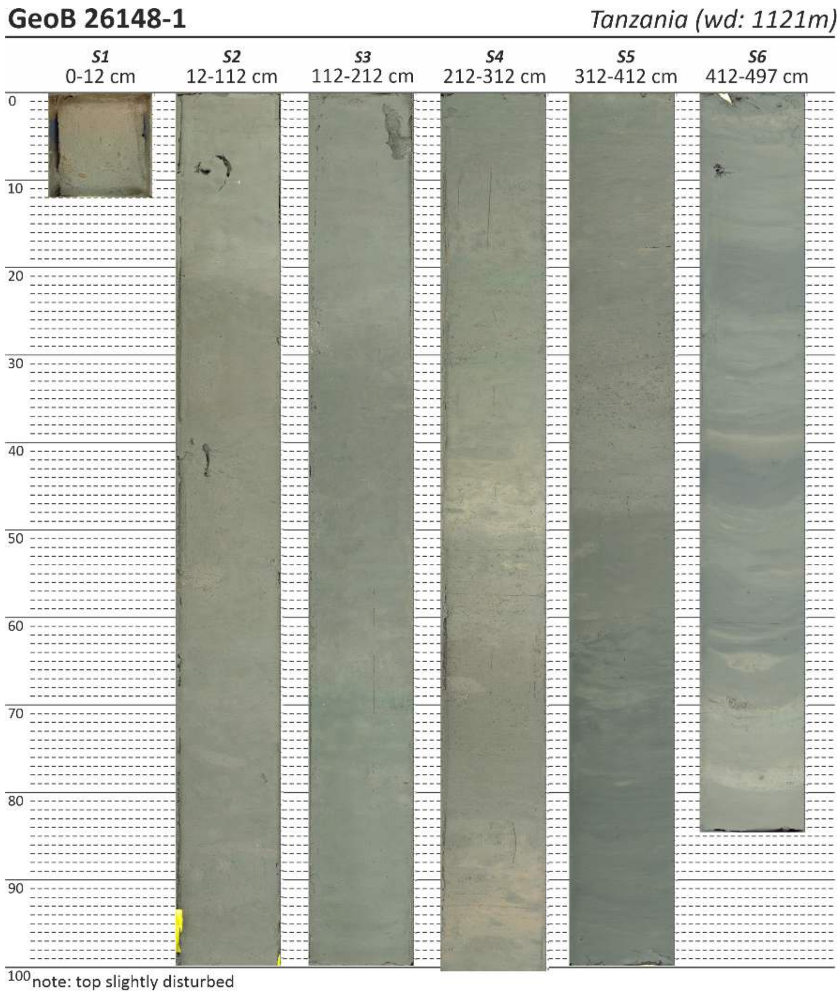


Fig. A5.10a Linescan of gravity core GeoB26148-1 collected off Tanzania.

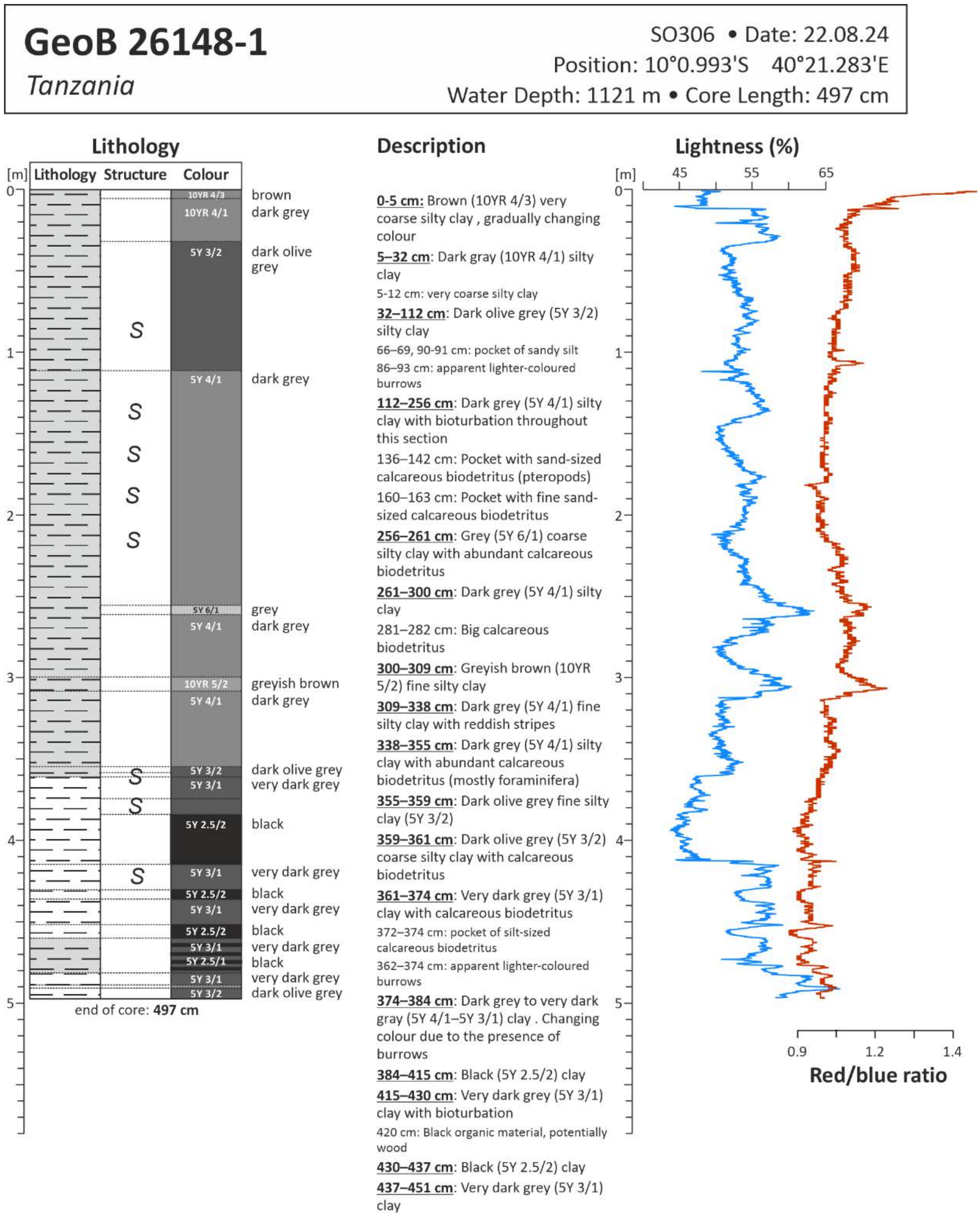


Fig. A5.10b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26148-1.

Gravity core GeoB26158-1 (1650 m water depth, recovery 836 cm) Tanzania

Core GeoB26158-1 was acquired from the deep slope, at 1650 m water depth with total recovery of 8.39 m. This core gradually changes both in colour from brown to grey at ~144 cm and in grainsize from sand to clay between 221 and 234 cm. Presence of a potential turbidite at ~23–25 cm. Abundant foraminifera and black grained minerals throughout the core. Between 580–590 cm a heavily layered sediment unit can be observed, consisting of grey and dark grey carbonate and siliciclastic sand that coarsens towards the base.

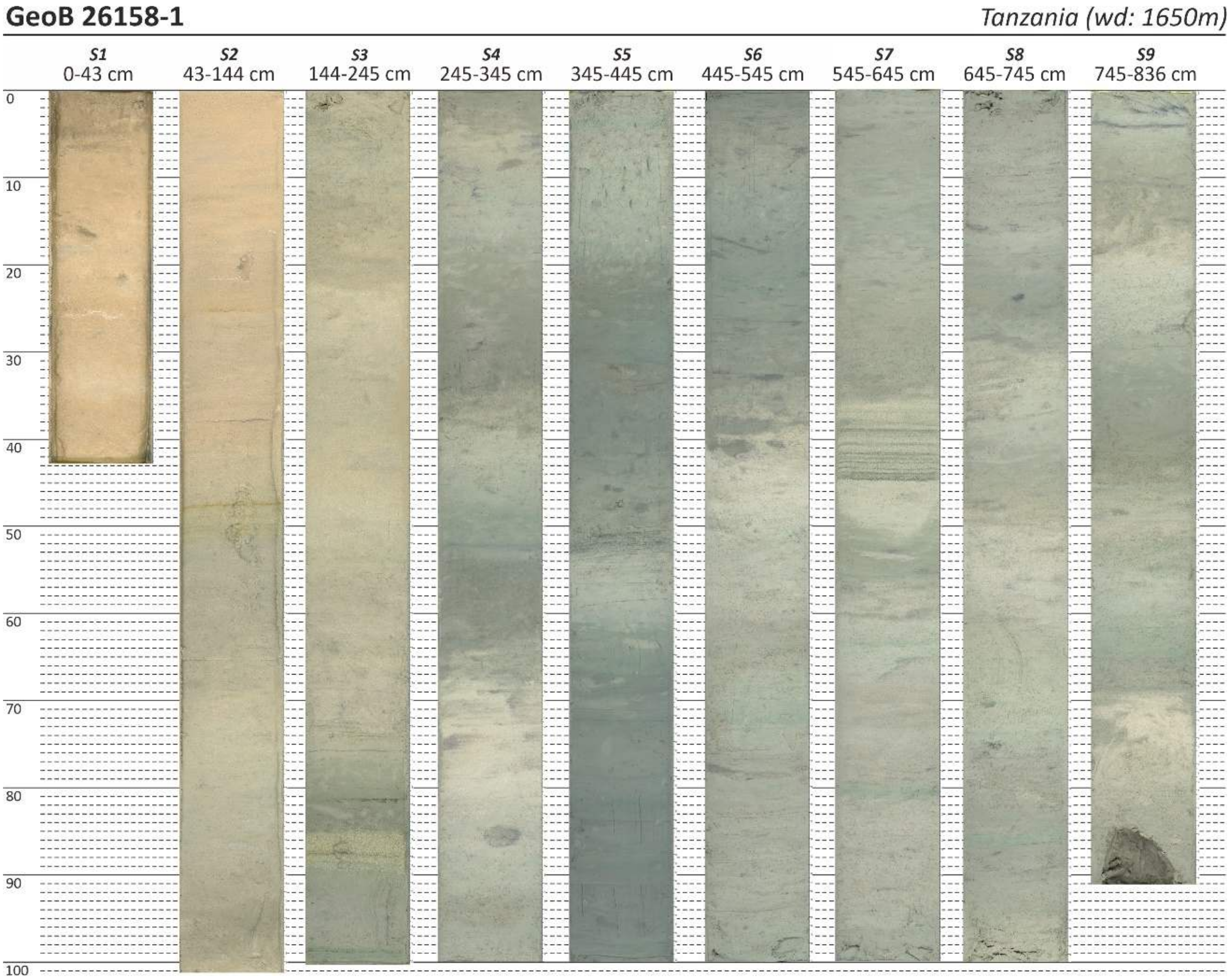


Fig. A5.11a Linescan of gravity core GeoB26158-1 collected off Tanzania.

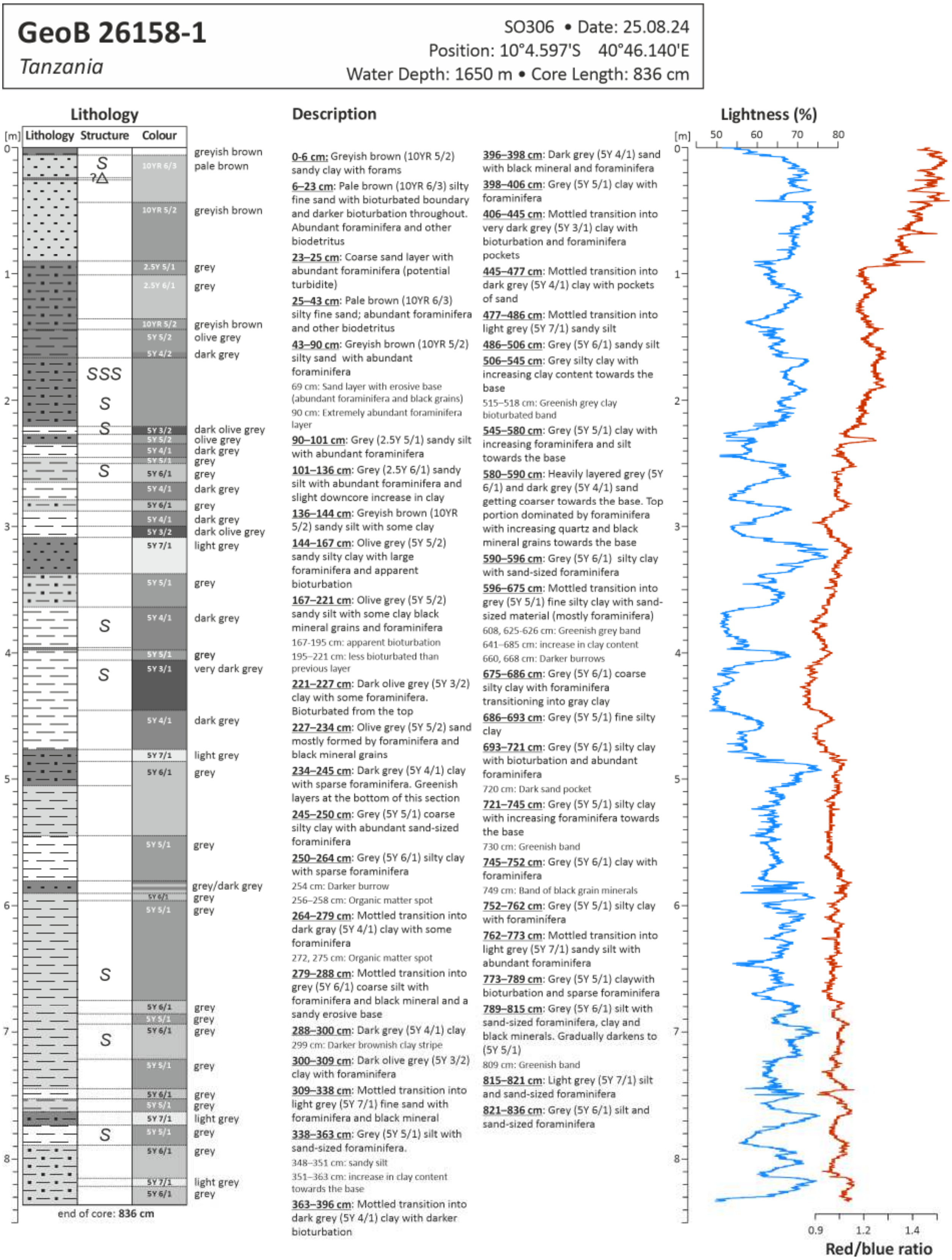


Fig. A5.11b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26158-1.

Gravity core GeoB26163-1 (1819 m water depth, recovery 436 cm) Tanzania

The deepest core acquired from the Tanzanian study area (GeoB26163-1) was retrieved from 1819 m water depth with a total recovery of 4.63 m. The sediment is generally dominated by silty clay and clay, with colours ranging from pale brown to very dark grey. Presence of dark greenish grey bands in the upper 200 cm and calcareous biodetritus (mostly foraminifera) throughout the core.

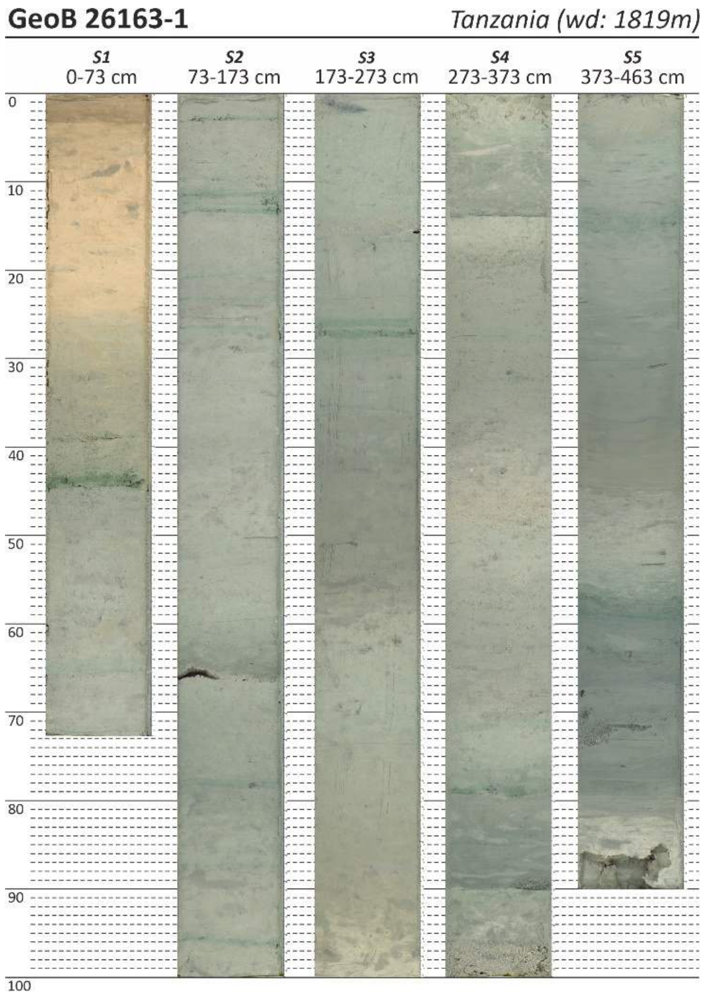


Fig. A5.12a Linescan of gravity core GeoB26163-1 collected off Tanzania.

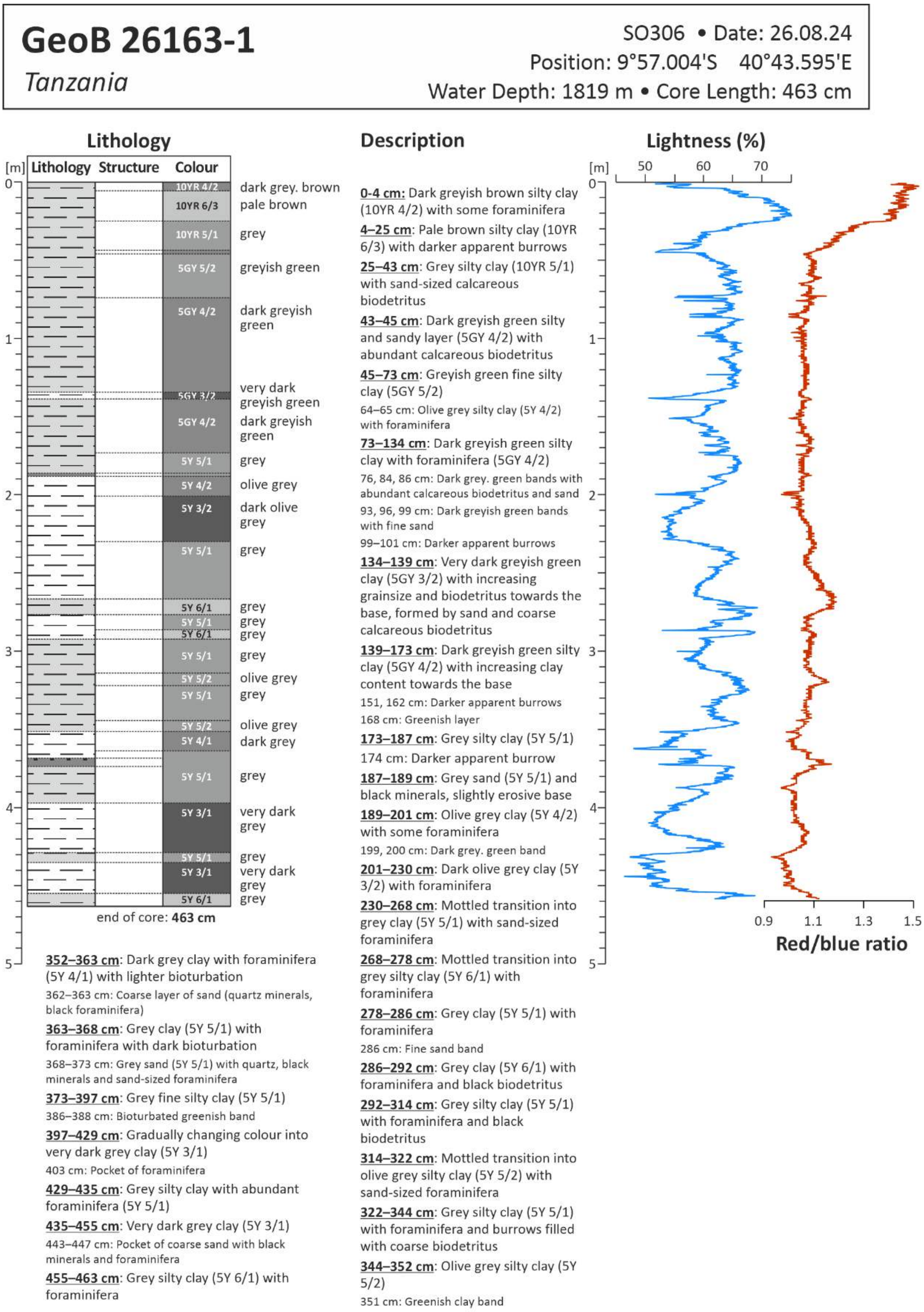


Fig. A5.12b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26163-1.

Gravity core GeoB26169-1 (580 m water depth, recovery 599 cm) Mozambique

Core GeoB26169-1 was acquired from the middle slope off the central coast of Mozambique at 580 m. It had a total recovery of 599 cm and consists of silty clay and clay that ranges in colour from dark olive gray to black.

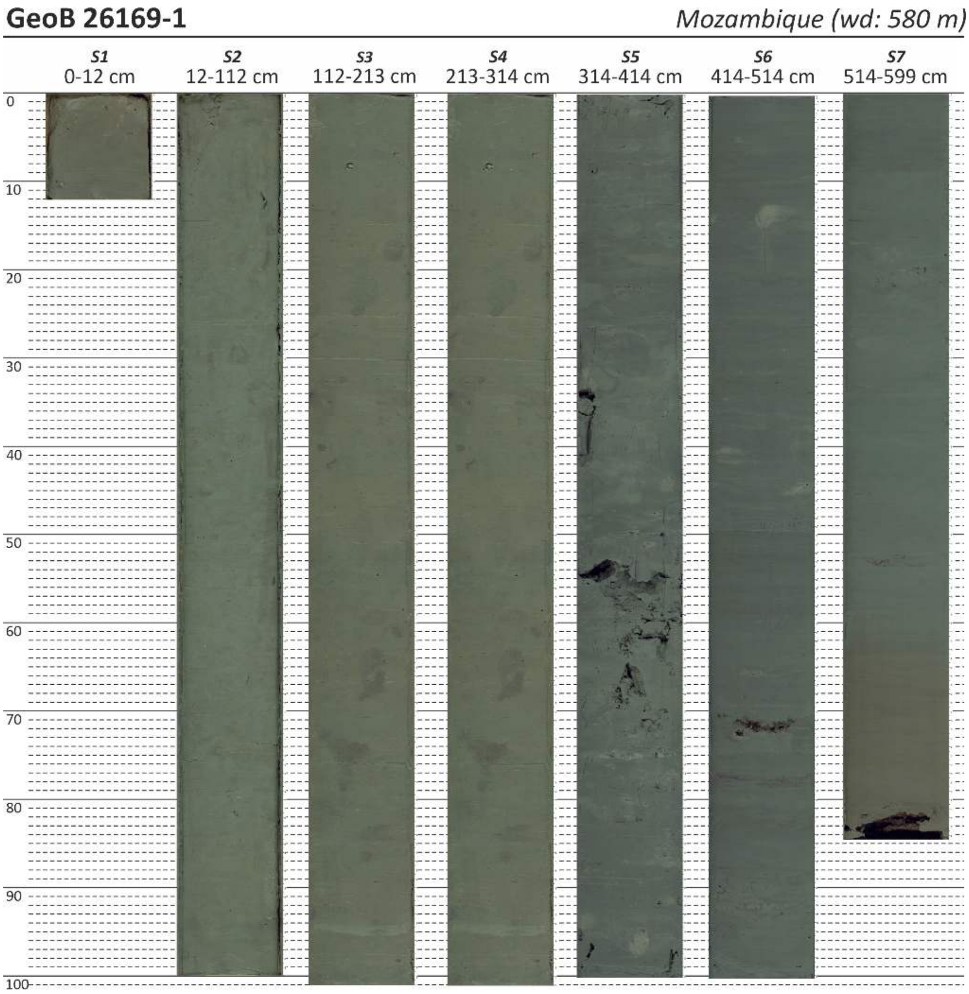


Fig. A5.13a Linescan of gravity core GeoB26169-1 collected off Mozambique.

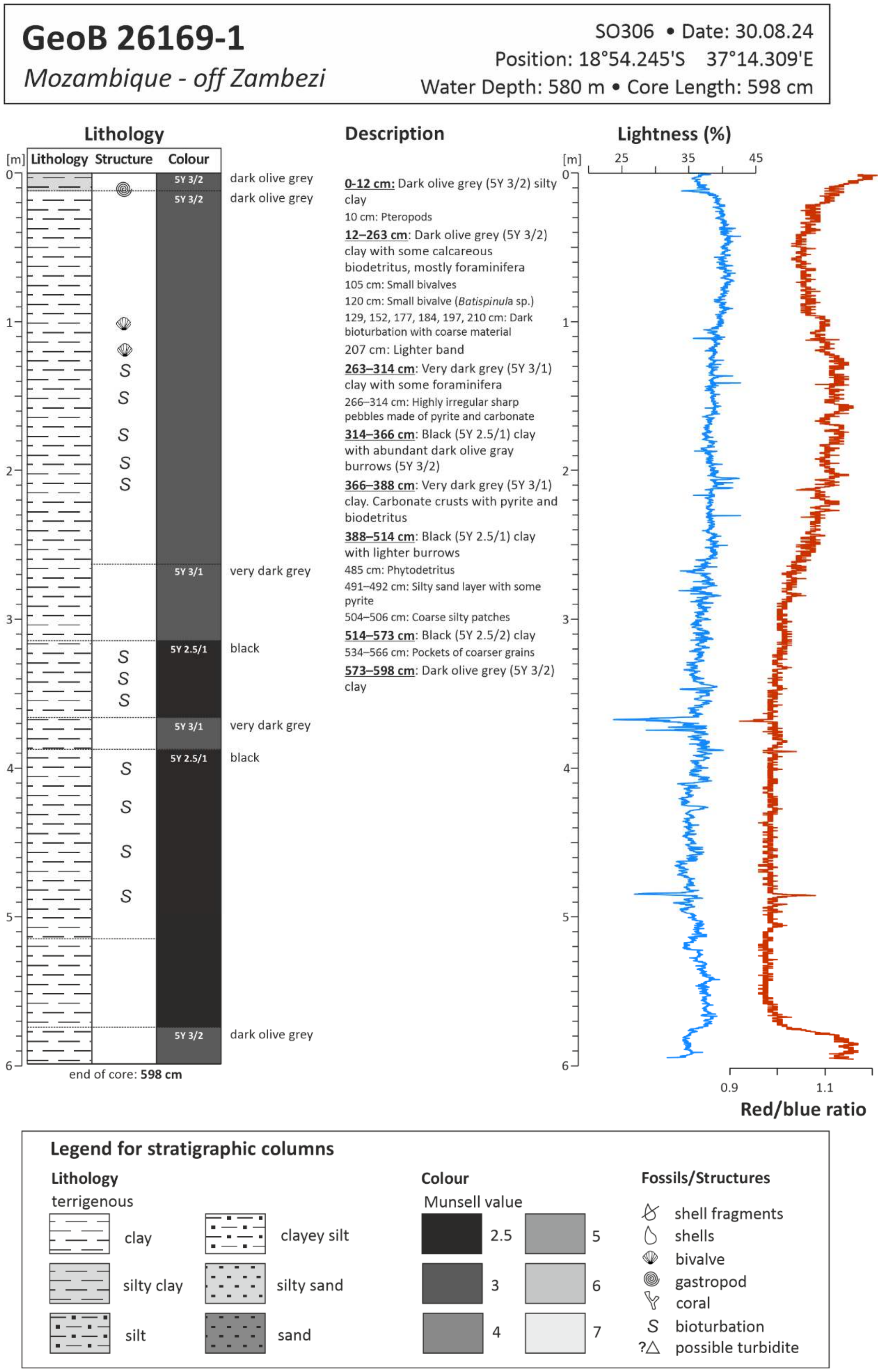


Fig. A5.13b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26169-1.

Gravity core GeoB26181-1 (1055 m water depth, recovery 858 cm) Mozambique

Core GeoB26181-1 was collected from the southern Mozambique slope at ~1055 m water depth. It had a total recovery of 8.58 m of olive grey to very dark grey clay with some silt. The whole core is heavily bioturbated and between 663 and 763 cm a potential contourite was identified.

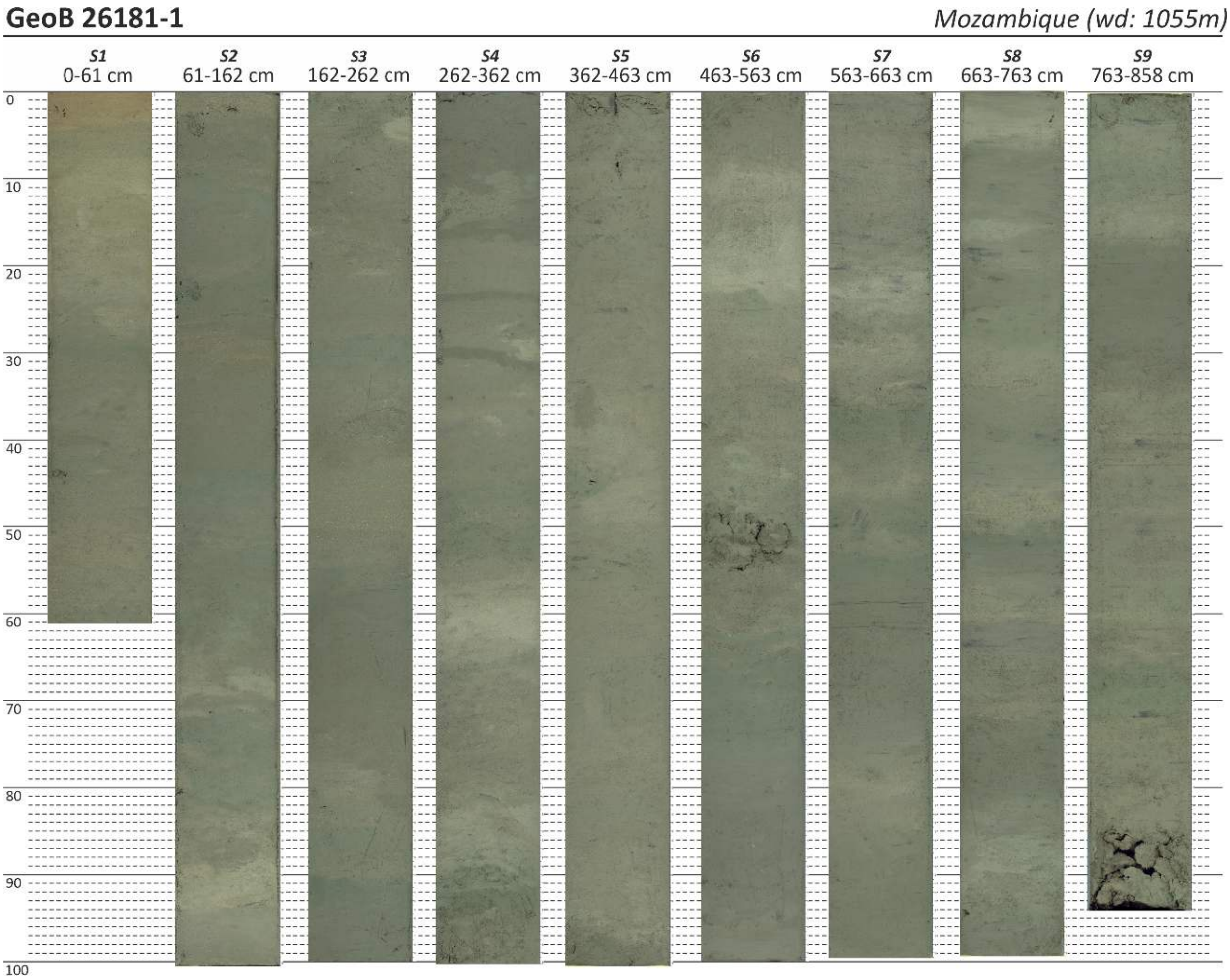


Fig. A5.14a Linescan of gravity core GeoB26181-1 collected off Mozambique.

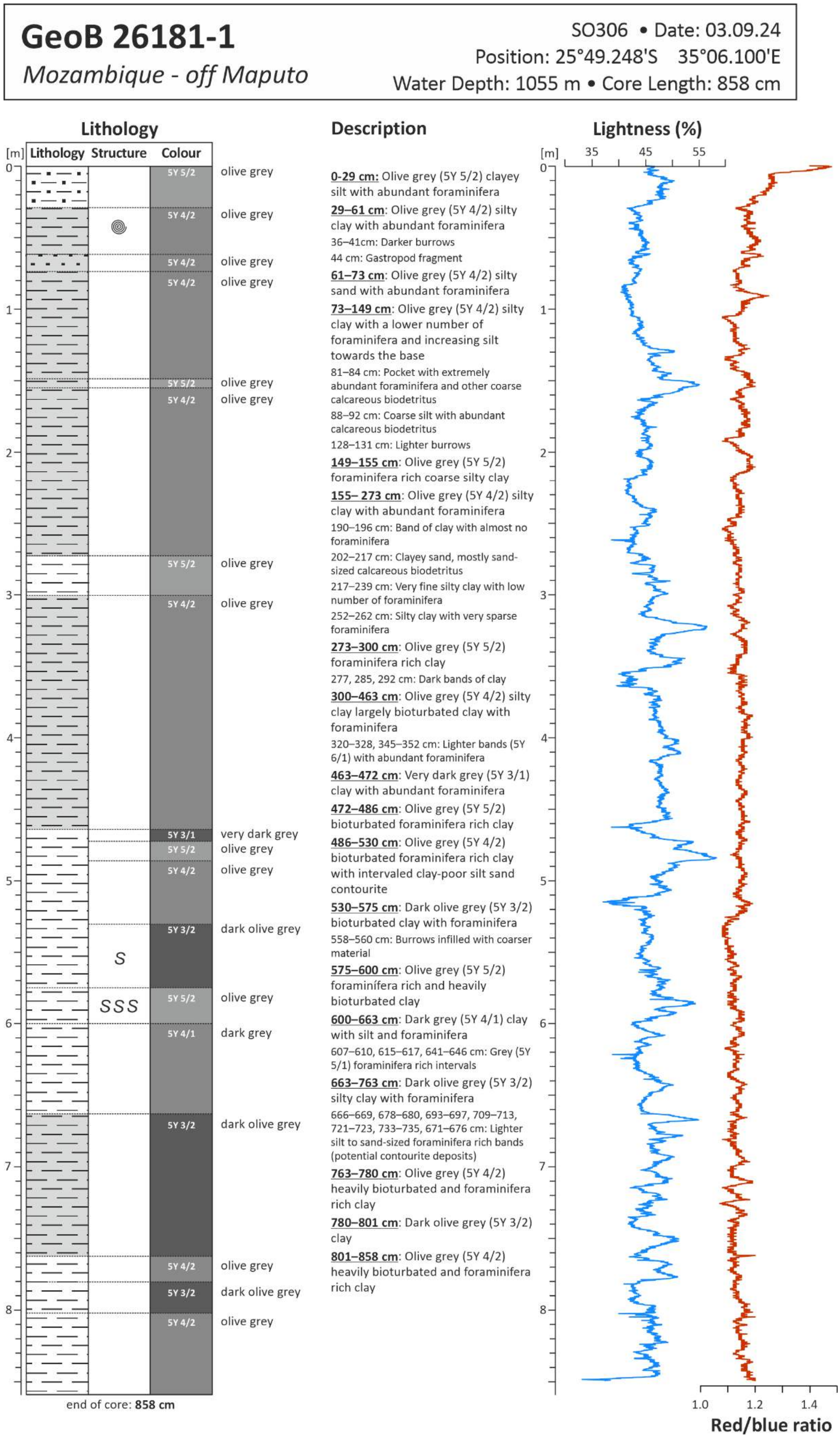


Fig. A5.14b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26181-1.

Gravity core GeoB26182-1 (500 m water depth, recovery 843 cm) Mozambique

Core GeoB26182-1 was obtained from 500 m water depth, with a total recovery of 843 cm. It was generally composed of dark olive grey silt to clay.

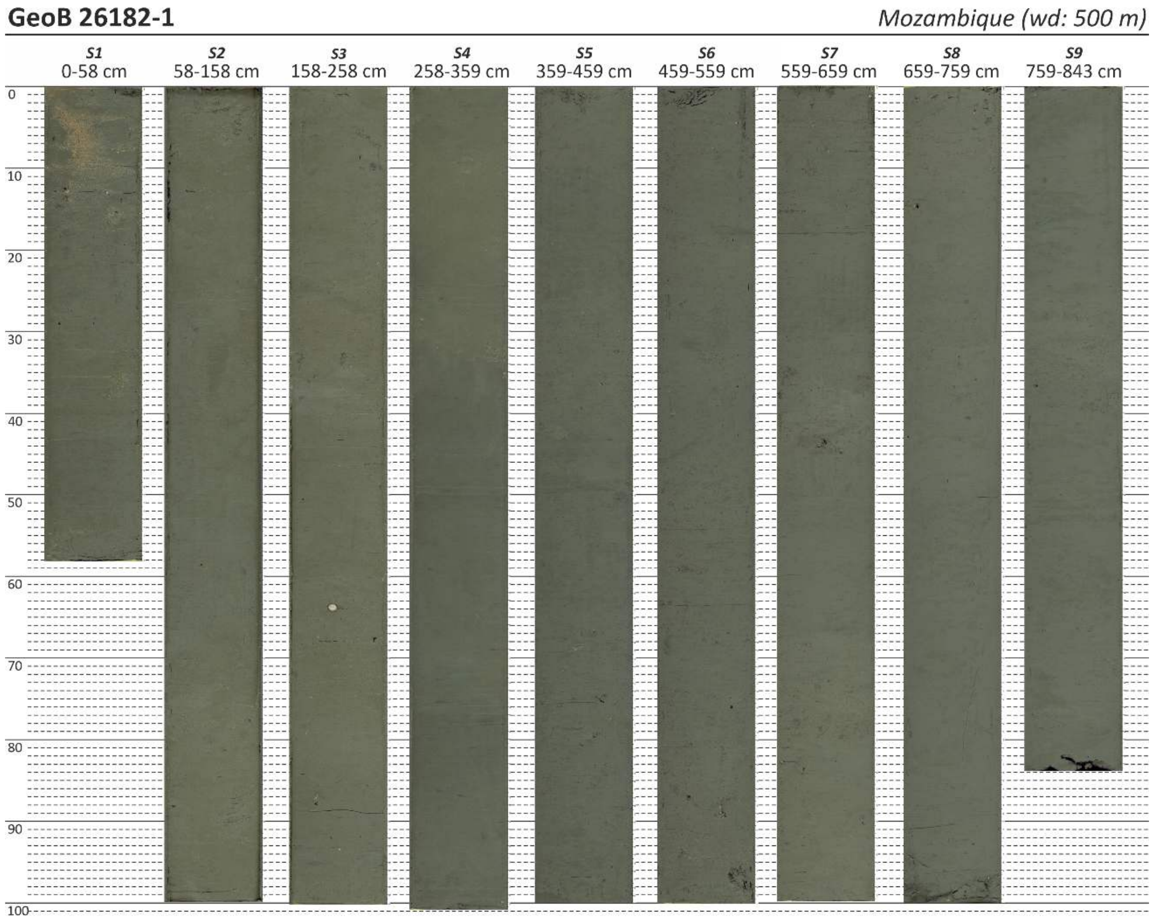


Fig. A5.15a Linescan of gravity core GeoB26182-1 collected off Mozambique.

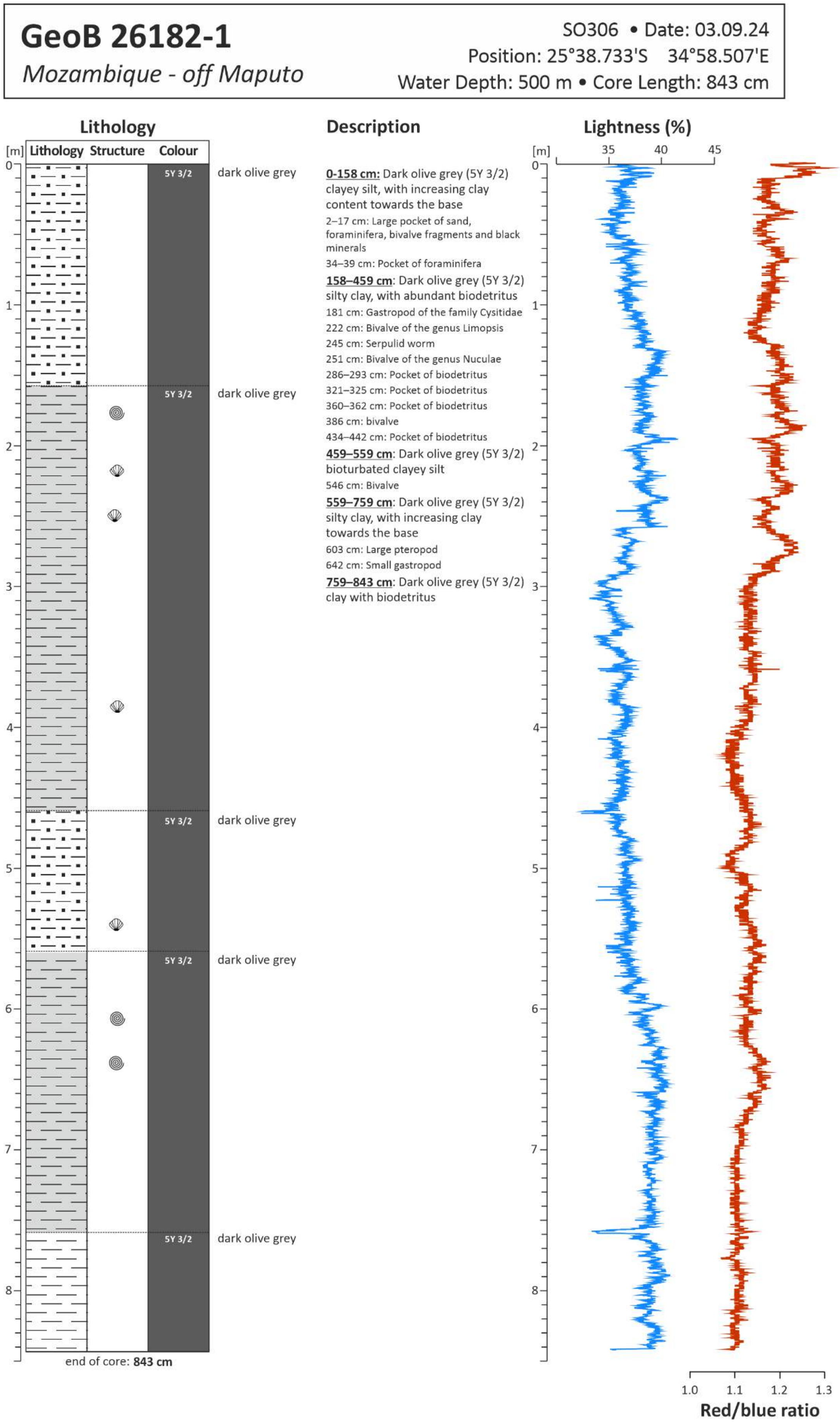


Fig. A5.15b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26182-1.

Gravity core GeoB26189-1 (1835 m water depth, recovery 955 cm) South Africa

Core GeoB26189-1 was collected on the lobe from 1834 m water depth and recovered 955 cm of fine-grained sediments with contourites. The sediments varied from pale brown clayey sand, at the core top, to very pale brown clay at 568 cm. The core contains high abundances of foraminifera down to 568 cm, with presence of organic matter bands between 244 and 400 cm and orange oxidized bands between 465 and 488 cm. From 568 cm to the core bottom the sediments are dominated by light brownish grey and grey clay with varying foraminifera abundances. Presence of organic matter spots at 876–883 and 885 cm

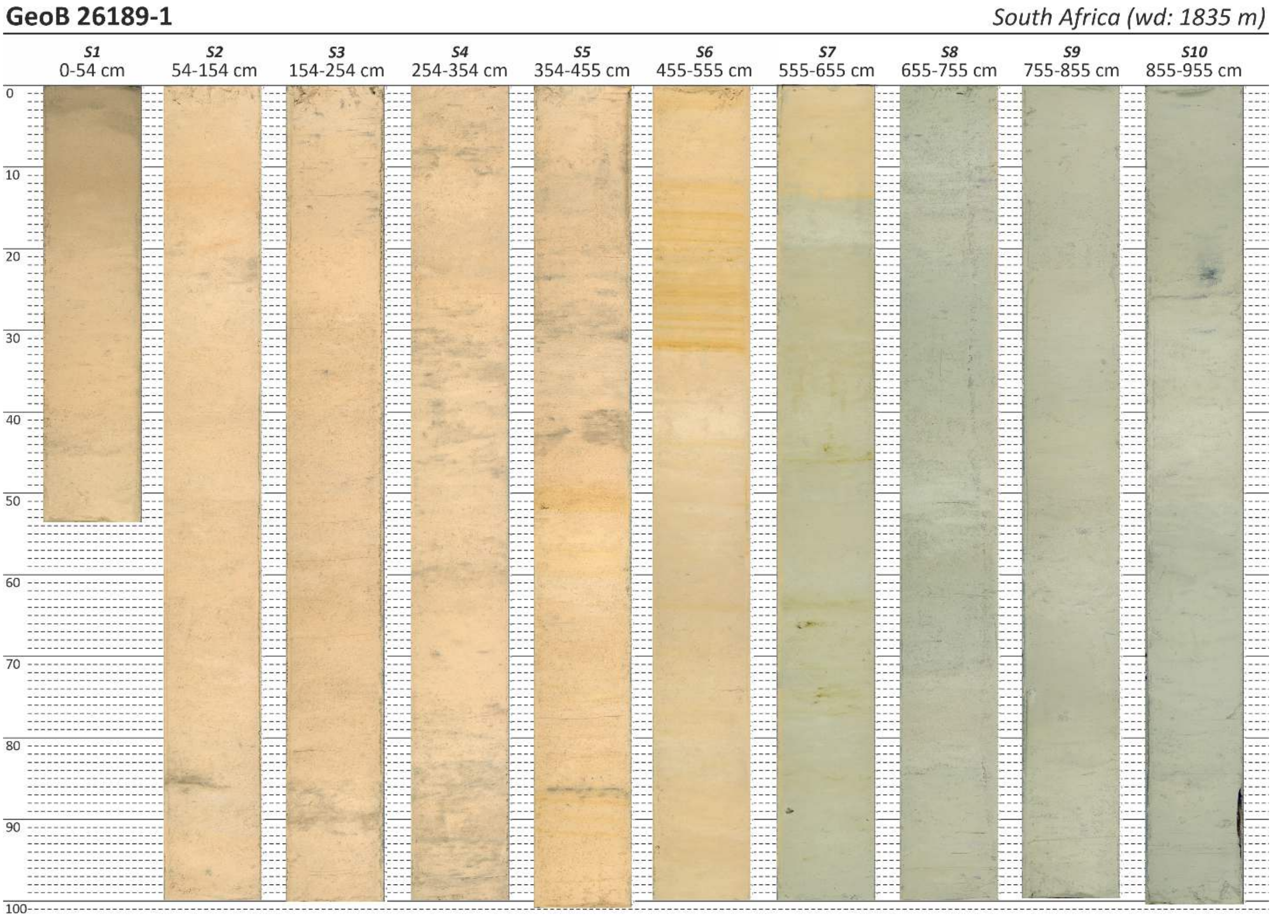


Fig. A5.16a Linescan of gravity core GeoB26189-1 collected off South Africa.

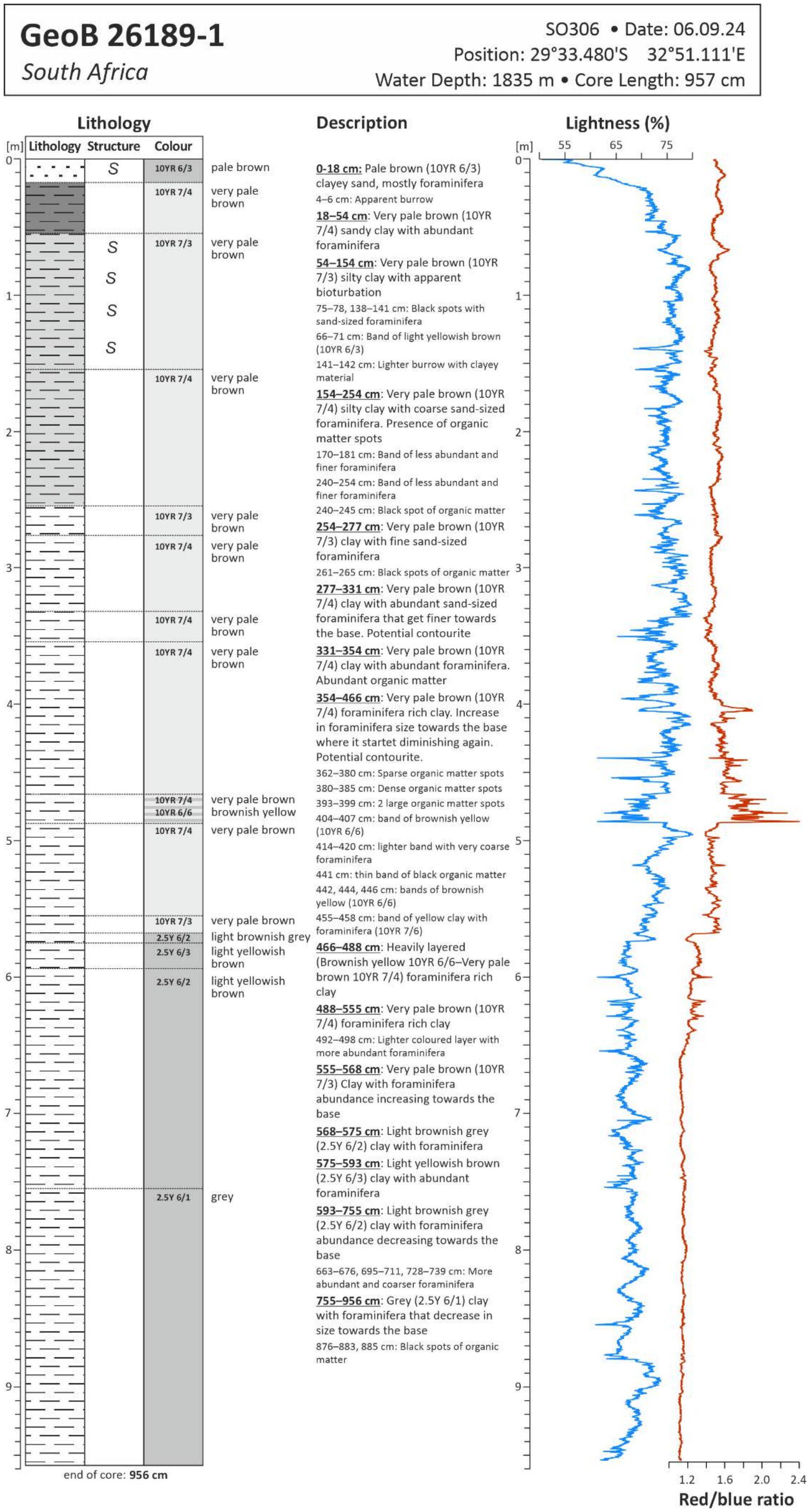


Fig. A5.16b Detailed core description, lightness-values and red/blue ratio of gravity core GeoB26189-1.

Appendix 6

A6 Epifauna Sampling with the Epibenthic Sledge (EBS)

(S. Brix, S. Korfhage, K. Jeskulke)

A6.1 Technical and Operational Set-up, List of Deployments

Epibenthic sledges (EBS) with a bottom shovel to open the sampler box door on the seafloor only, are proven sampling devices to collect macrofaunal organisms on and above the seafloor (Brandt & Barthel 1995, Kaiser & Brenke 2016). During SO306, a single, epi-sampler, named URSULA (following the design of Rothlisberg & Percy (1977)) was deployed at eleven stations (Fig. A6.1; Table A6.1). The EBS was equipped with a bracket to hold a SONARDYNE transponder during deployment. The mesh size of the net is 500 µm. The cod ends are equipped with net-buckets containing a 300-µm mesh window (Brenke, 2005). URSULA was additionally equipped with an Aandera Seaguard RCM DW CTD to further characterize environmental parameters of pressure, temperature, salinity, turbidity and current strength/current direction by the latter as well as seafloor habitat heterogeneity by the former. Landing of the EBS on ground and lift off ground were monitored by the vessels tension meter system. These times were later checked against the data from the SONARDYNE transponder system. The trawl lengths were calculated tracking the SONARDYNE positions "on ground" and "off ground" into the on board QGIS project and measuring the distance within QGIS.

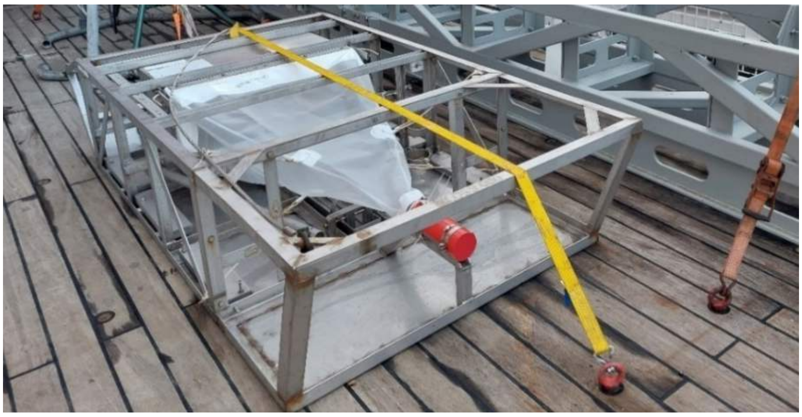


Fig. A6.1
(top) The epibenthic sledge URSULA onboard RV SONNE. Image: G. Ruhland. (left) Deployment of the EBS. Image: C. Wienberg.

The position of the EBS deployments equalled the ROV transect lines to enable a visual description of the sampled area by still and video imagery. If a deployment following the ROV track was not possible, EBS trawling position were chosen in close vicinity to the ROV stations by studying the MBES map of the referenced working areas. The EBS was deployed over the starboard side of RV SONNE following this protocol:

1. Vessel holding on DP on start position.
2. Lowering of the EBS with 0.5 m/s (max. 0.8 m/s) until 100 m over ground.
3. Winch stopped for 1-2 min to stop swinging of EBS.

4. Vessel moving forward on DP with 0.5 kn over ground, while lowering with 0.3 m/s until a cable length of water depth (m) plus 200-300 m was put out. Signal "on ground" noted as start trawl position.
5. Winch stop. Vessel moving with 0.5 kn over a previously defined distance allowing the defined track for the SONARDYNE signal of the EBS.
6. Vessel stop, holding position on DP.
7. Heaven with 0.3 m/s until EBS leaves seafloor ("off ground") and hangs in the water column.
8. Raise heaving speed to 1 m/s until about 100 m above seafloor.
9. On deck the EBS will be secured in a hanging position to enable cleaning of net prior to removal of cod end and empty of sediment in nets into rectangular rubber tubs.

Table A6.1 Epibenthic sledge stations conducted during RV SONNE expedition SO306. Information includes area, latitude and longitude (in degree), depth, time, and trawling distance.

Station (GeoB)	Area	Latitude start	Latitude end	Longitude start	Longitude end	Depth (m)	trawling distance (m)
26109-2	Mayotte	-12.96	-12.96	44.89	44.89	775	42
26112-1	Mayotte	-13.02	-13.03	44.87	44.87	1124	156
26116-1	Mayotte	-12.94	-12.94	44.91	44.91	691	241
26117-1	Mayotte	-12.94	-12.94	44.91	44.91	714	97
26128-1	Tanzania	-10.26	-10.25	40.42	40.42	426	189
26129-1	Tanzania	-10.25	-10.25	40.41	40.41	330	184
26155-1	Tanzania	-10.35	-10.36	40.50	40.50	300	338
26160-1	Tanzania	-10.21	-10.21	40.54	40.54	938	81
26163-2	Tanzania	-9.95	-9.95	40.73	40.73	1824	253
26170-1	Mozambique	-18.90	-18.90	37.23	37.24	581	165
26182-2	Mozambique	-25.65	-25.65	34.97	34.98	504	81

A6.2 Sample Treatment

The EBS samples were sieved over 300 µm in the climate lab at 8°C to ensure a complete cooling chain of the samples following the protocols described in Riehl et al. (2014). The temperature of the climate lab was adapted to the temperature data obtained by the CTD for the individual working areas to ensure keeping the abiotic conditions of the sampling area. Furthermore, water samples collected by the CTD rosette was used for sieving to ensure the same water conditions like in the environment. This allowed photography of specimens live picked during the sieving process (for example see Fig. A6.2).

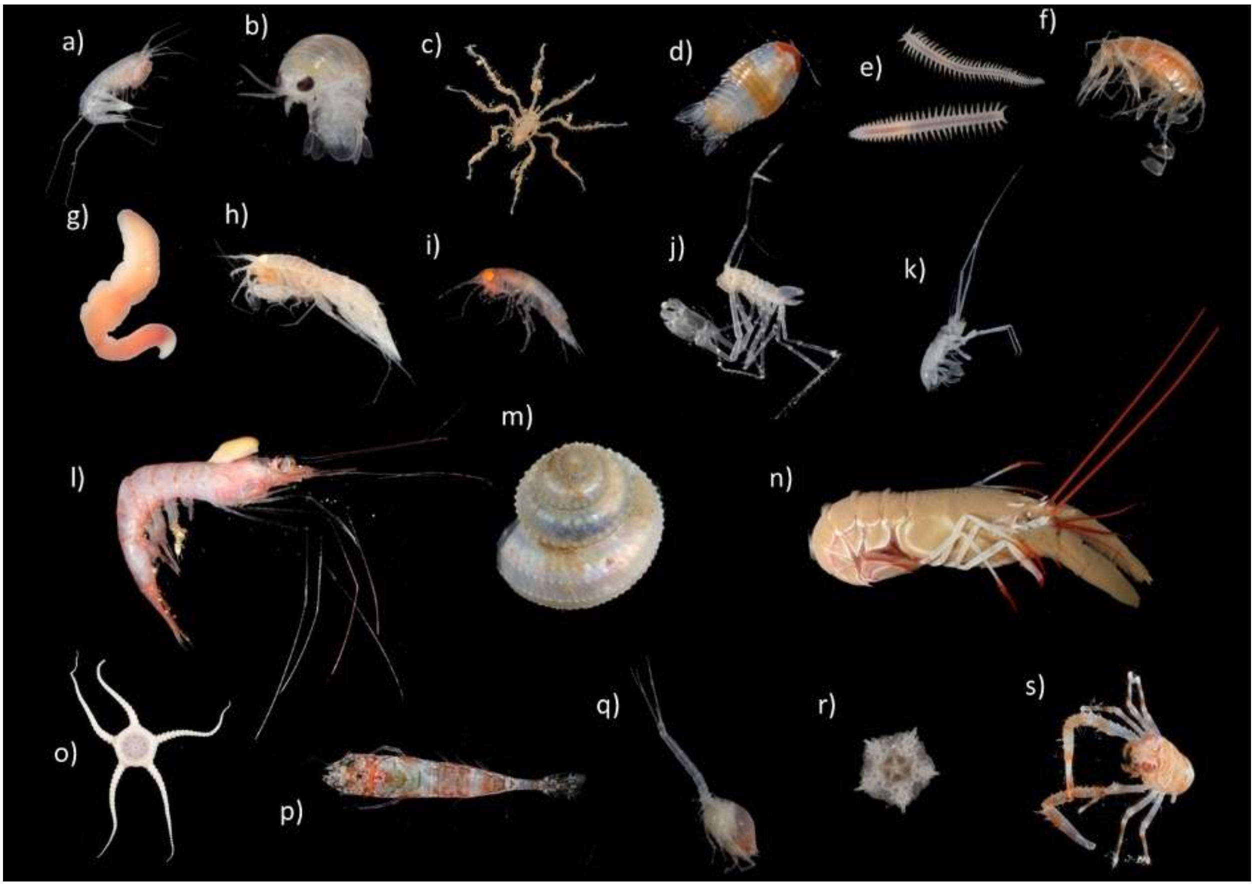


Fig. A6.2 Example photo plate for EBS macrofauna as potpourri from all EBS stations. a,f,h,i) Amphipoda, b) Isopoda, c) Pantopoda, D) Isopoda: Cymothoidea, e) Polychaeta, g) Nemertini, j) Isopoda: Munnidae, k) Isopoda: Munnopsidae, l) Decapoda: Caridea, m) Gastropoda, n) Decapoda, o) Ophiruoidea, p) Decapoda: Caridea, q) Cumacea, r) Asteroidea, s) Decapoda.

Brandt & Barthel (1995): An improved supra- and epibenthic sledge for catching Peracarida (Crustacea, Malacostraca). Ophelia 43 (1): 15-23

Brenke (2005): An epibenthic sledge for operations on marine soft bottom and bedrock. Marine Technology Society Journal 39 (2): 11-21

Kaiser & Brenke (2019): Chapter 9: Epibenthic sledges. In: Clarke, Consalevey & Rowden (eds) Biological sampling in the Deep Sea.

Rothlisberg & Percy (1977): An epibenthic sampler used to study the ontogeny of vertical migration of *Pandalus jordani*. (Decapoda, Caridea). Fishery Bull US 74: 994-997

Appendix 7

A7 Analysis of Cold-Water Coral Associated Fauna

(S. Brix, K. Jeskulke, S. Korfhage)

During the ROV dives, individual corals were sampled and stored in the Rotary Bio Boxes (RBB). The RBB do close properly, which ensured that the closed container brought the water up from the sampling site. After retrieval of the RBB on deck, each coral in the RBB was photographed, treated according to sample management process in the cooling room of the vessel and the water of the RBB was sieved over a 300 µm sieve. Larger specimens of the associated fauna were directly picked from the coral specimen and individually photographed. Specimens were fixed in 96% undenatured ethanol. The sieved samples are stored in 96% denatured ethanol and treated according to the cooling chain comparable with the EBS sample treatment (see A6; Riehl et al. 2014). Ideally, in each working area three specimens of the same coral taxon were sampled for associated fauna analysis. The sieved samples were sorted using a Leica MZ8 stereomicroscope "on ice" and identified on higher taxonomic level (Fig. A7.1). Species identification or lower taxonomic level identification will take place in the home laboratory at the DZMB in Hamburg. Selected individuals of the associated fauna will be used for DNA Barcoding (see A8.1).

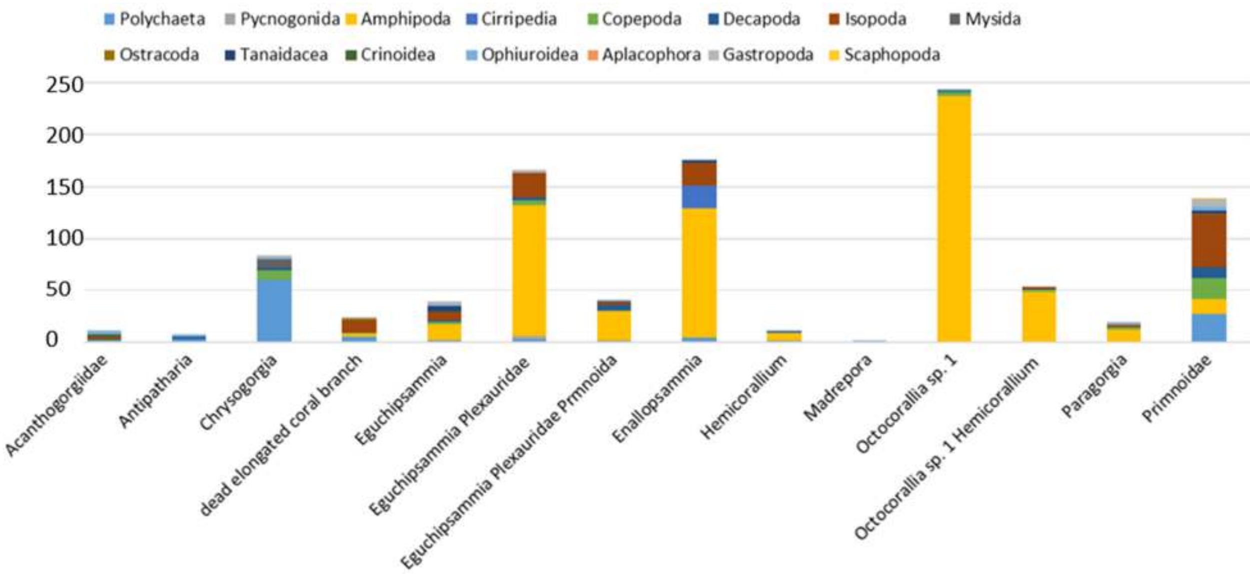


Fig. A7.1 Composition of coral associated faunal taxa per coral taxon or assemblage. Preliminary sorting results on board of all ROV casts with Rotary Bio Boxes from all working areas. In the home laboratory focus will be given on species identification per working area and coral taxon.

Riehl et al. (2014): Field and laboratory methods for DNA studies on deep−sea isopod crustaceans. Polish Polar Research vol. 35, no. 2, pp. 205–226, doi: 10.2478/popore−2014−0018

Appendix 8

A8 Treatment of Samples for Genetic Studies

(S. Brix, C. Orejas, A. Gori, S. Korfhage, K. Jeskulke)

A8.1 Genetic Fingerprinting

DNA barcoding data and data for population genetics will be implemented at SAM Wilhelmshaven and Hamburg. DNA isolates will be stored at DNA-Bank of Senckenberg and linked to the data via unique identifier. Sequences will be extracted at Macrogen Europe Laboratory (Amsterdam, The Netherlands). The laboratory will submit packed data files as a .zip file (.pdf, .txt, .ab1, .phd). Reference libraries will be established for barcoding and validation of MALDI-TOF MS data. Genetic data will be submitted to the Genbank and BOLD (Barcode of life) databases. Data processing will be performed using GENEIOUS, MEGA and RAxML-VI-HPC, processed data will be handled as .csv files. Raw and processed data will be submitted to BoLD (Barcode of life Database) and GenBank (.fasta standard for genetic data).

For the cold-water coral *Chrysogorgia sp.* collected off Mayotte, selected individuals of the associated fauna were already treated for DNA barcoding on board. Each voucher specimen was photographed (Fig. A8.1) and given a unique identifier, the Barcode of Life Database (BoLD) "field ID". DNA extraction of some specimens took place directly on board using the Machery and Nagel Tissue kit.

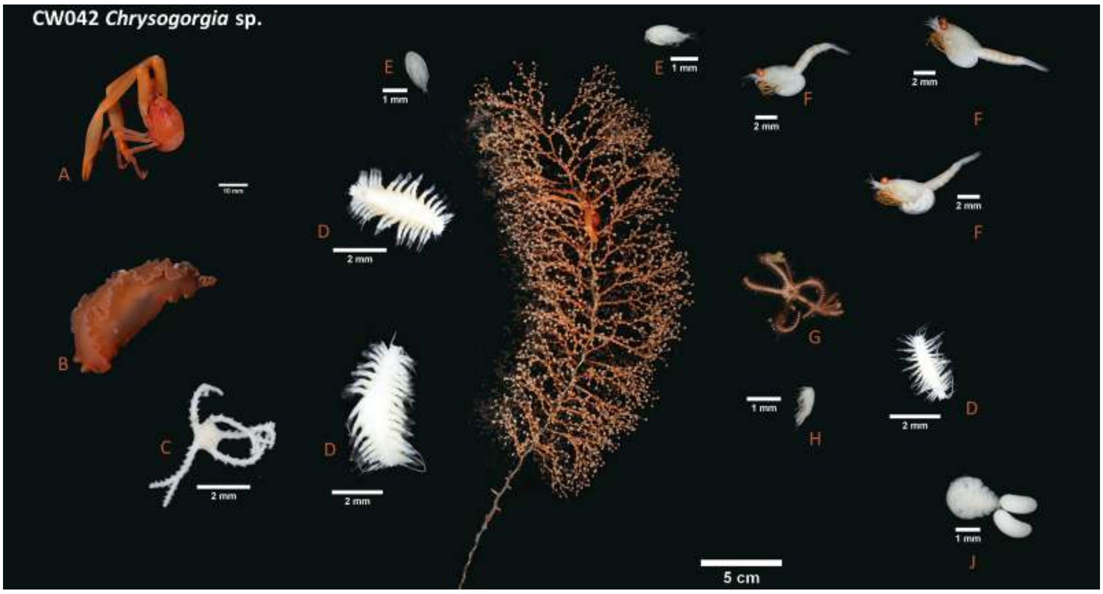


Fig. A8.1 *Chrysogorgia* as microhabitat and the description of the fauna association. We had three samples (replicates) of *Chrysogorgia* in Mayotte waters, which ensure a complete picture of the associated faunal elements. Here some examples: A) Decapod), B) Nudibranchia, C) Ophiuroidea, D) Polynoid polychaete, E) Calanoid copepod), F) Mysida, G) Ophiuroidea, H) Harpacticoid copepod, J) parasitic copepod (p.e. found on B).

A8.2 eDNA

Water samples collected by the ROV SQUID and the CTD rosette, and surface sediment samples collected with the TV-GBC have been sampled for eDNA analyses. Three replicate samples of the bottom water (3x2 L), plus a blank (1.5 L MilliQ water) have been filtered by means of a Peristaltic pump (Masterflex pump Easy-load II) set on 80 rpm (rounds per minute) (Fig. A8.2). The water was filtered through Sterivex-GP 2l and 0.22 µm filters. After filtration each filter was closed with the corresponding caps and included in separated sterile plastic bags. The three replicates were stored in a labelled plastic bag by -80°C. Surface sediment samples have been preserved in falcon tubes and stored at -20ºC. All eDNA analyses will be performed in the home laboratory.

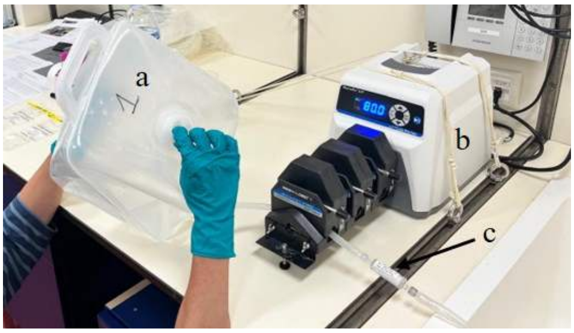


Fig. A8.2
Filtration set up for eDNA samples. (a) Water sample, (b) peristaltic pump, (c) filter. Image: A. Gori.

A single water sample for eDNA analyses has been collected in the working site of Mayotte, in a spot dominated by glass sponges. Off Tanzania, three water samples have been collected by the ROV and four by the CTD from sites on the Mtwara MV that were either dominated by *Bathymodiolus* sp. or by gorgonians. Two surface sediment samples have been collected from TV-GBC collected in the same area as the water samples. Five water samples (3x ROV, 2x CTD) have been collected in the working area off Mozambique, in seep and coral garden communities. Additionally, one sample of surface sediment has been collected from a TV-GBC (Table A8.1).

Table A10.1 Samples collected for eDNA analyses off **Tanzania (TAN) and off Mozambique (MOZ)**. Table included sampling day and site, station, gear, type of sample (Water: W, Sediment: S), number or replicates (B: Blanc/control), and volume filtered for each replicate.

Station (GeoB)	Gear	Date	Area	Site	Type of sample	Number of replicates	Volume filtered
26114-5	ROV		MAY	Volcanic plateau, are with glass sponges	W	2 + B	1.5L per replicate, 2L B
26122-1	CTD	17.08.24	TAN	*Bathymodiolus* sp. site	W	3 + B	2 L per replicate & 2L B
26131-1	ROV	19.08.24	TAN	*Bathymodiolus* sp. site	W	2 + B	1.5L per replicate, 2L B
26131-1	ROV	19.08.24	TAN	Area with gorgonians	W	2 + B	1.5L per replicate, 2L B
21633-1	CTD	19.08.24	TAN	*Bathymodiolus* sp. site	W	3 + B	2 L per replicate & 2L B
26134-1	CTD	19.08.24	TAN	Area with gorgonians	W	3 + B	2 L per replicate & 2L B
26132-1	TV-GBC	19.08.24	TAN	Mud volcano / Seep site	S	3	./.
26136-1	ROV	20.08.24	TAN	Area with gorgonians	W	2 + B	1.7 L per replicate + 2L B
26145-1	CTD	21.08.24	TAN	*Bathymodiolus* sp. site	W	3 + B	2 L per replicate & 2L B
26151-1	BC	23.08.24	TAN	Mud volcano / Seep site	S	3	./.
26168-1	BC	30.08.24	MOZ	Seep site	S	3	./.
26171-1	ROV	30.08.24	MOZ	Seep site	W	2 + B	2 L per replicate & 2L B
26171-2	CTD	30.08.24	MOZ	Seep site	W	3 + B	1.5L per replicate, 2L B
26176-1	ROV	02.09.24	MOZ	Area with corals & sponges	W	2 + B	2 L per replicate, 2L B
26177-1	CTD	02.09.24	MOZ	Area with corals & sponges	W	3 + B	2 L per replicate & 2L B
26180-1	ROV	03.09.24	MOZ	Area with corals & sponges	W	2 + B	2 L per replicate & 2L B

Appendix 9

A9 Plankton Sampling with a Multiple Closing Net (Multinet)

(C. Chioze, M. Ansorge, R. Viadora, D. Hebbeln)

A multiple closing net (Multinet; Fig. A9.1) has been used at seven stations during RV SONNE cruise SO306 (see Table A9.1). Together with the CTD measurements and with the water sample analysis, the Multinet samples allow a more comprehensive characterization of the vertical distribution of zooplankton communities in the West Indian Ocean. In addition, zooplankton samples will be used for stable isotope analyses, as zooplankton presumably plays a major role in the trophic net (see Appendix A10).

The Multinet (Hydro-Bios, Kiel, Germany) used during this cruise was made up of five individual 200 µm nets, that can be remotely controlled opened consecutively, thus, allowing the sampling of five different levels within the water column. The Multinet has an opening of 0.25 m^2 and was usually lowered to 500 m water depth with 0.3 m s^{-1} and pulled up with 0.3 m s^{-1}. At pre-selected levels heaving was stopped to open the next net.

Zooplankton samples used for taxonomic studies have been preserved with 7% of formalin and borax solution and stored at 4°C and will be further analysed in the home laboratories. For the treatment of zooplankton samples used for stable isotope analyses see Appendix A10.

Fig. A9.1
Multinet deployment during expedition SO306. Image: D. Hebbeln.

Table A9.1 Samples collected with the Multinet during the RV SONNE expedition SO306 (MAY: Mayotte, TAN: Tanzania, MOZ: Mozambique, ZA: South Africa).

Station (GeoB)	Area	Date/Time (ddmmyy - UTC)	Latitude ('S)	Longitude ('E)	Depth (m)	Level of water column sampled (m)				
						net1	net2	net3	net4	net5
26109-3	MAY	13.08.24 - 15:24	12°57.429	44°53.362	775	500-300	300-200	200-100	100-50	50-0
26112-2	MAY	14.08.24 - 15:39	13°01.595	44°52.290	1143	500-300	300-200	200-100	100-50	50-0
26127-3	TAN	18.08.24 - 14:10	10°13.517	40°26.247	544	500-300	300-200	200-100	100-50	50-0
26138-1	TAN	20.08.24 - 15:47	10°12.300	40°32.676	899	500-300	300-200	200-100	100-50	50-0
26166-2	MOZ	29.08.24 - 17:35	18°51.544	37°14.697	512	480-300	300-200	200-100	100-50	50-0
26178-1	MOZ	02.09.24 - 16:07	25°59.147	35°09.572	748	500-300	300-200	200-100	100-50	50-0
26187-1	ZA	05.09.24 - 13:34	29°28.685	32°03.839	971	500-300	300-200	200-100	100-50	50-0

Appendix 10

A10 Treatment of Samples for Benthic Trophic Level Studies

(C. Orejas, A. Gori)

For trophic level studies, specimens of the most abundant epibenthic megafauna organisms were collected, representing different trophic guilds in the CWC communities in the study areas. Organisms were sampled with the ROV SQUID and the TV-GBC. In addition, zooplankton was sampled with a multinet from five individual depth layers (0-500 m depth) in each study area (see Appendix A9).

Specimens (or fragments of the specimens for large organisms) were carefully cleaned in seawater, put in zip bags and/or vials and frozen at -80°C until stable isotope ($\delta^{13}C$ and $\delta^{15}N$) analyses will be performed in the home laboratory. Stable isotope composition will be assessed for the bulk tissue of organisms, as well as for specific components (amino acids and fatty acids) indicative for precise determination of some trophic sources.

A10.1 Cold-Water Coral Communities off Mayotte

A total of 36 individuals of various faunal species were collected during the four ROV dives for the study of their stable isotope ($\delta^{13}C$ and $\delta^{15}N$) composition. In addition, 31 and 22 samples were collected for the study of stable isotopes in aminoacids and fatty acids, respectively. Corals (Anthozoa) were the most sampled, especially gorgonians (Table A10.1).

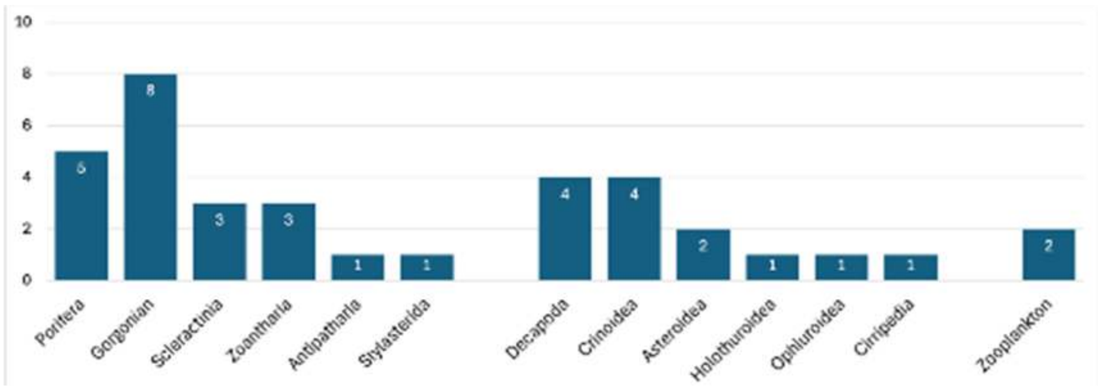


Fig. A10.1 Number of samples collected for each taxonomic group for the study of their stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) composition in Mayotte.

A10.2 Mud Volcano Communities off Tanzania

A total of 21 individuals of various faunal species were collected during the four ROV dives off Tanzania for studying their stable isotope (^{13}C and ^{15}N) composition (Table A10.2). In addition, 15 and 14 samples were collected for studying stable isotopes in aminoacids and fatty acids, respectively. Corals (Anthozoa) were the most sampled taxa, especially gorgonians, followed by bivalves (*Bathymodiolus* sp.).

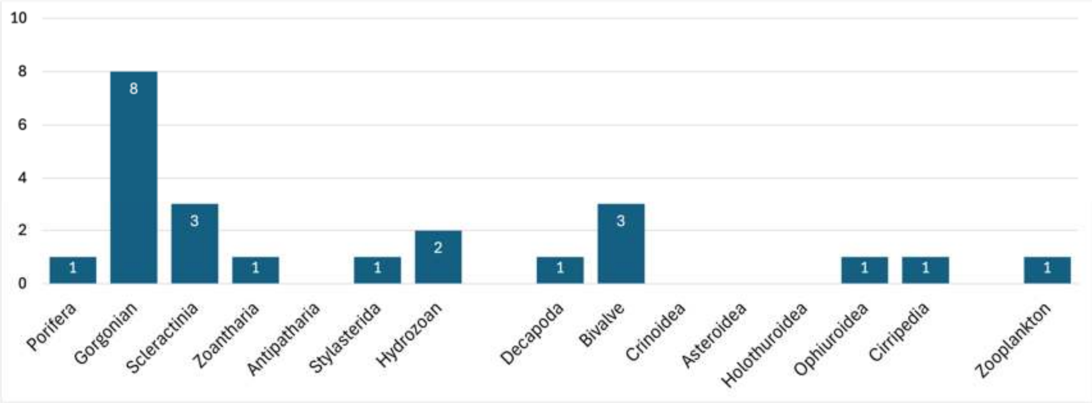


Fig. A10.2 Number of samples collected off Tanzania from each taxonomic group for stable isotope analyses (^{13}C and ^{15}N).

A10.3 Coral Gardens off Mozambique

A total of 25 individuals of various faunal species were collected during the four ROV dives for the study of their stable isotope (δ^{13}C and δ^{15}N) composition (Table A10.3). In addition, 23 and 19 samples were collected for the study of stable isotopes in aminoacids and fatty acids, respectively. Corals (Anthozoa) were the most sampled taxa, especially gorgonians..

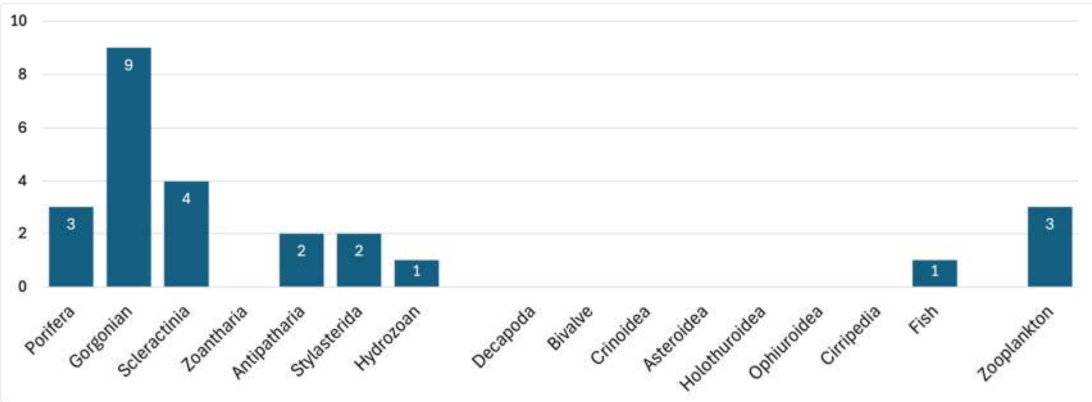


Fig. A10.3 Number of samples collected for each taxonomic group for the study of their stable isotopes (δ^{13}C and δ^{15}N) composition in Mozambique.

Appendix 11

A11 Aquaria Experiments

(C. Orejas, A. Gori)

Aquaria set-up: The aquaria set-up on-board comprised one tank for acclimation and maintenance of organisms (Fig. A11.1a) and a water bath for experimental incubations to assess respiration and food capture rates of coral species (Fig. A11.1b). Both were connected to chiller units (Teco TK2000) to maintain controlled water temperature.

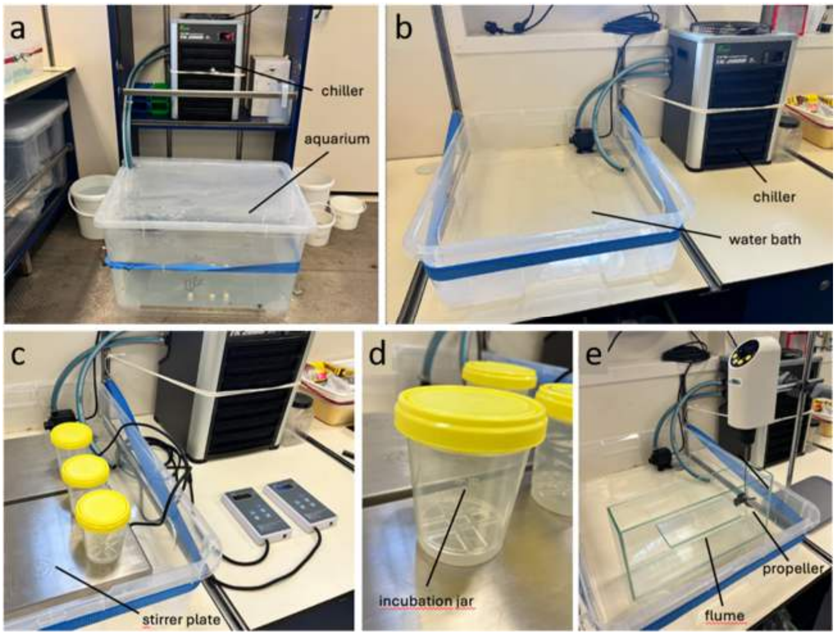


Fig. A11.1
(top) Aquaria set-up on-board. (a) tank for acclimation and maintenance of organisms and (b) a water bath for experimental incubations; both connected to a chiller to maintain water temperature. (bottom) The set-up to run incubations on board to assess (a) respiration rate using (b) closed jars, and (c) food capture rates of coral species. Images: A. Gori.

Experimental design: To run respiration experiments, two magnetic stirrer plates (Fig. A11.1c) are installed in the water bath to keep the water moving inside the jars (370 ml volume). Jars are used to keep the corals when performing the experimental incubations (Fig. A11.1d). Oxygen is measured in the jars at the beginning and the end of the incubations (time to be decided depending on the species and size of the specimens) with an optode sensor (Hach-Lange HQ 40b, precision 0.2 mg L^{-1}). To run food-capture experiments, four flume aquaria are installed in the water bath. A propeller in each flume allows for generating a constant water flow, which is measured with an electromagnetic current meter (AEM1-D, ALEC Electronics) (Fig. A11.1e).

A11.1 Mayotte - Maintenance of Three Cold-Water Coral Species in Aquaria

Four coral branches from three different species (2 *Enallopsammia rostrata*, 1 *Chrysogorgia* sp. and a purple gorgonian) (Fig. A11.2) were collected by the ROV and maintained in the aquarium to explore their survival. After two days, one of the two branches of *Enallopsammia rostrata* died and it was removed. The other three specimens were maintained but did not show any sign of acclimation, thus did not fully open their polyps.

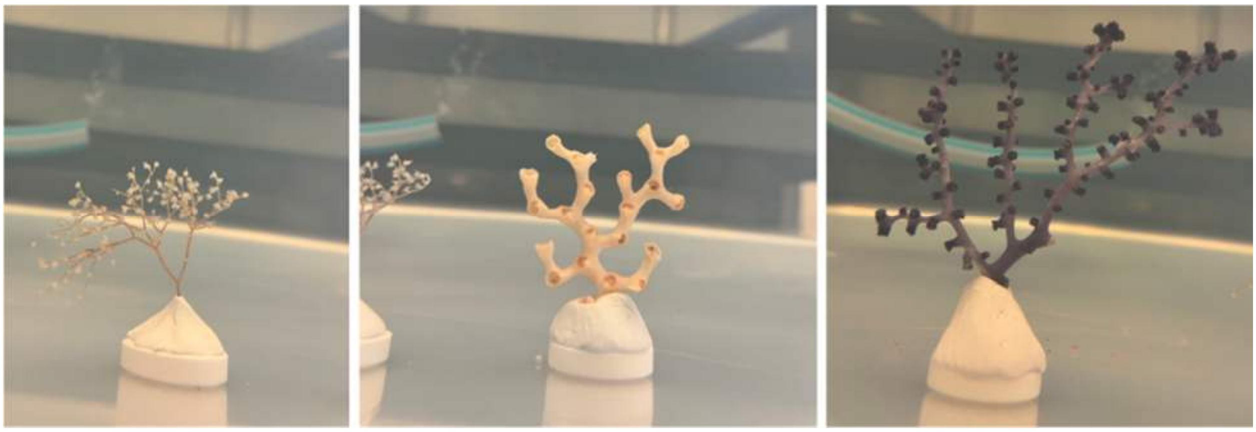


Fig. A11.2 (from left to right) *Chrysogorgia* sp., *Enallopsammia rostrata*, and a purple gorgonian collected by the ROV off SW Mayotte and maintained in the aquarium to explore their survival. Images: A. Gori.

A11.3 Mozambique - Maintenance of *Eguchipsammia* sp. in Aquaria

Specimens of the CWC *Eguchipsammia* sp. were collected by the ROV and maintained in the aquarium (temperature: 14ºC) to explore their survival (Fig. A11.3), and aiming to conduct respiration and feeding experiments. Polyps from three different colonies have been selected and experimental units (coral nubbins, two per colony) were prepared as well as control nubbins, using coral skeletons (Fig. A11.3).

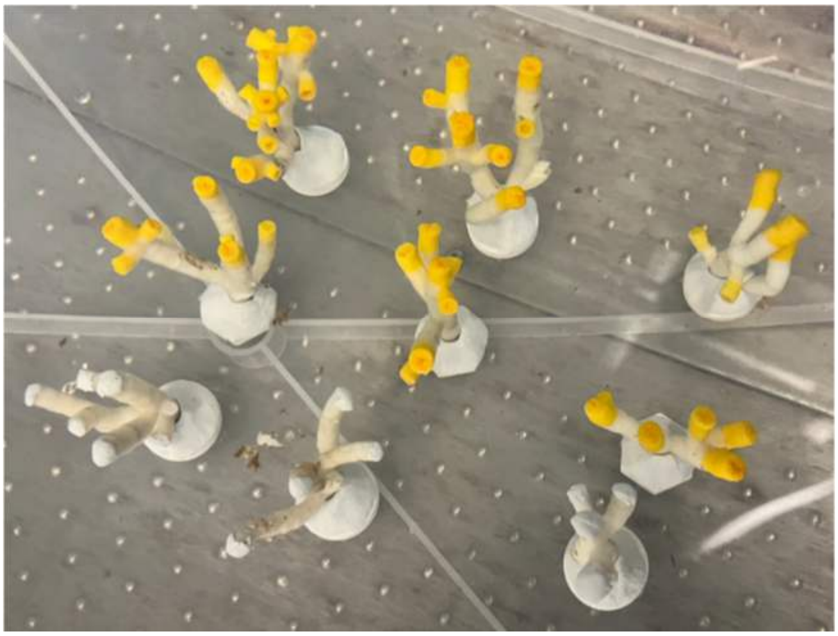


Fig. A11.3 *Eguchipsammia* sp. specimens collected by the ROV in Mozambique. Corals were maintained in the aquarium for acclimations. Image: A. Gori.

Corals were kept in the acclimation tank with regular water flow. The specimens have been feed one day after collection with *Artemia salina* nauplii. As the polyps remained closes, two days after collection polyps have been fed with a liquid extract from shrimps and *Artemia salina* nauplii, aiming to stimulate the coral specimens to expand the tentacles. After three days acclimation, corals did not expand the tentacles, although there were enough food particles in the aquaria. Therefore, respiration measurements could not be conducted.

Appendix 12

A12 Plant Sampling for Carbon Export Analyses

(C. Orejas, A. Gori, D. Hebbeln)

During the ROV dive (GeoB26124-1) to the Tungue Canyon off Tanzania, massive loads of plant remains such as mangrove leaves have been observed. Some of these plant remains have been collected (by ROV and EBS) to study the carbon export from terrestrial and marine vegetation to the deep-sea. The samples have been stored at -80ºC and will be processed in the home laboratory to calculate the biomass as well as the C content of the samples. The ROV images and the seafloor samples will be used to calculate the carbon per surface supplied by the phanerogams and mangrove leaves analysed.