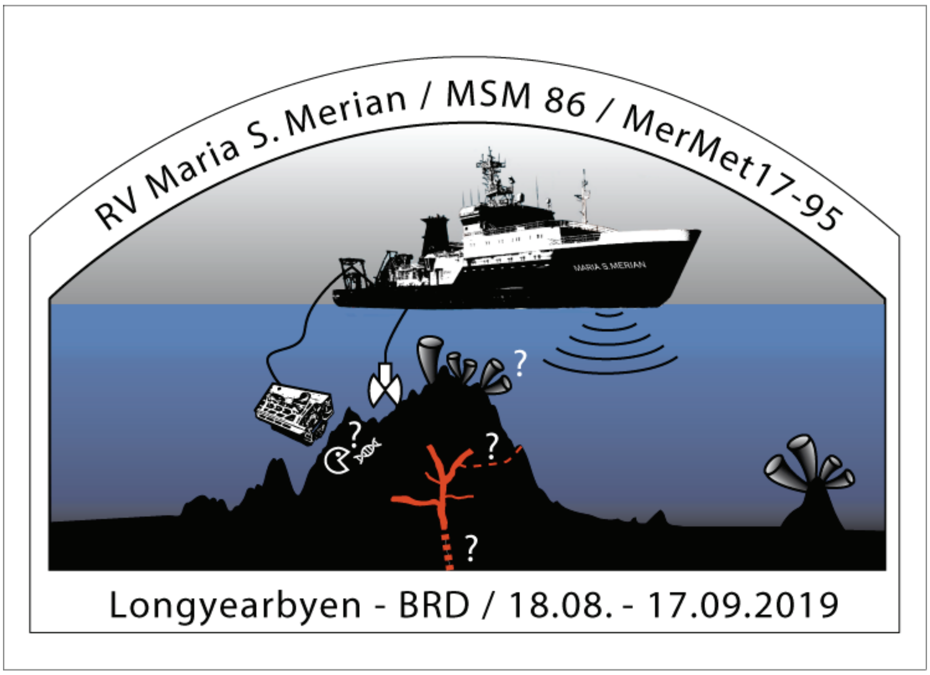
MARIA S. MERIAN-Berichte

Vesteris Seamount

Cruise No. MSM86

18.08.2019 – 17.09.2019,
Longyearbyen, Svalbard, Norway – Emden, Germany



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1. Summary

The research program of RV MARIA S. MERIAN cruise MSM86 Vesteris Seamount was aimed at improving our understanding of the evolution of Vesteris Seamount, a large and lone intraplate volcano in the Greenland Sea. We had also planned to sample other basement highs in the region to determine their age and origin. Our research objectives include (1) resolving mantle melting dynamics and source composition and their bearing for the geodynamic evolution of the northern North Atlantic, (2) reconstructing the volcanic growth of Vesteris Seamount and its partial destruction by slope failures, (3) investigating the diversity of sponges and the microbiomes they host at Vesteris Seamount and other basement highs, and (4) examining the colonization of volcanic rocks by microorganisms, including fungi and bacteria, and determining the relation between rock alteration and endolithic life. Our work focused on four main areas (1) the main edifice of the Vesteris Seamount, (2) the volcanic edifices along the Logi Ridge and Southern Seamount, (3) the northeastern area, and (4) Luise Boyd Seamount on the northern flank of Mohns Ridge.

Hydroacoustic surveys yielded high-resolution maps of bathymetric and backscatter properties of the seafloor. Geological and biological sampling was conducted using the ROV MARUM-SQUID (at Vesteris Seamount) and the TV-guided grab (in all four work areas). Rock sampling at Vesteris Seamount showed a predominance of effusive and pyroclastic rocks, the latter of which are particularly abundant in water depths <300 m. Basement in water depths >1000 m is commonly covered by diamictic muds with dropstones, so outcrops are discontinuous and scattered. The sediments contain occasional layers of ash or volcanic sand. In water depths < 300 m, thick spiculite mats, consisting of sponge needles and bryozoans are virtually continuous and make rock sampling difficult. The rocks we collected comprise vesicular alkali basalts, olivine-clinopyroxene bearing basanites and hyaloclastites, which are particularly abundant in the summit area.

Southern Seamount has steep flanks that lead from >2000 m to a large and flat plateau at 400 m water depth. Sampling the slopes yielded mostly muds and dropstones, but angular pieces of basaltic rock were also recovered. The plateau at the summit is not perfectly flat, as our maps clearly show scouring marks produced by drifting icebergs that grounded and eroded the top of the volcano. Similarly, Logi Ridge has a flat and iceberg-scoured plateau at 500 m water depth; its flanks are less steep. There are small volcanic cones in water depths >600 m. Sampling those cones and the slopes merely gave diamictic muds with dropstones.

In the northeastern area, we mapped two basement highs that are roundish features rising above the abyssal plain by more than 1000 m. The westernmost of the two yielded hydrothermally altered olivine gabbro, while the other one had Mn-oxide coated pieces of mantle peridotite next to small pieces of serpentinite und chrysotile veins embedded in mud. These results clearly indicate that both basement highs are not volcanic in origin but instead represent ocean core complexes that formed 40 Ma at the Mohns Ridge.

Much closer to the Mohns Ridge is the Luise Boyd Seamount, only 12 km north of the spreading axis. Our mapping and rock sampling indicates that Luise Boyd Seamount represents an off-axis seamount that formed along the flanks of the Mohns Ridge. We did not find evidence that the seamount represents a modern oceanic core complex analogous to those sampled in the northeastern area.

A total of 700 samples include 163 rocks, of which 122 are from Vesteris Seamount, and > 400 biological specimen. Number and quality of the samples are excellent and will open varied opportunities for post-cruise research.

Zusammenfassung

Das Arbeitsprogramm der FS MARIA S. MERIAN-Ausfahrt MSM86 zum Vesteris Seamount war im Wesentlichen auf das Verständnis der magmatischen und tektonischen Prozesse ausgerichtet, die bei der Bildung dieses großen ozeanischen Intraplattenvulkans eine Rolle spielten. Auch weitere Grundgebirgsaufbrüche in der Region sollten beprobt werden. Es ging bei unserer Forschung um (1) die Untersuchung der Schmelzbildungsdynamik und der Mantelquellenzusammensetzung sowie deren Implikationen für die Geodynamische Entwicklung im nördlichen Nordatlantik, (2) die Rekonstruktion von vulkanischem Aufbau und Flankenkollaps von Vesteris Seamount, (3) die Erfassung der Diversität der Schwämme und deren Mikrobiome und (4) die Untersuchung von Pilzen und Bakterien, die Hohlräume im vulkanischen Gestein besiedeln und der Beziehungen zwischen biologischer Aktivität und Gesteinsalteration.

Die Arbeitsgebiete der Fahrt teilen sich auf in (1) den Vesteris Seamount, (2) den Logi Rücken und südlichen Seamount, (3) das nordöstliches Gebiet mit unerforschten Riftbergen und (4) den Luise Boyd Seamount an der Nordflanke des Mohns Rückens. Die Bathymetrie aller drei Arbeitsgebiete wurden mittels Fächerecholot kartiert; biolologische und geologische Proben wurden mit dem Tauchroboter SQUID-MARUM (am Vesteris Seamount) und TV-Greifer (in allen vier Arbeitsgebieten) geborgen. Im Rahmen der Ausfahrt MSM86 zeigte sich, dass die geologischen Strukturen des Vesteris Seamounts sich im Wesentlichen aus Laven und vulkaniklastischen Lithologien zusammensetzen. Aufschlüsse des vulkanischen Basements sind in Wassertiefen >1000 m größtenteils von diamikten Tonen mit Dropstones bedeckt. Stellenweise finden sich dunkle vulkanische Aschen und Sande einschaltet. In Wassertiefen <300 m ist das Festgestein durch mehrerer 10er Zentimeter mächtige biogene Matten bedeckt, die vorwiegend aus Bryozoen und Schwammnadeln gestehen. Die Gesteinsproben vom Vesteris Seamount sind überwiegend blasige Alkalibasalte sowie porphyrische Basanite mit Olivin und Klinopyroxen. Vulkaniklastika sind vor allem Hyaloklastite, die im Gipfelbereich des Vulkans vorzuherrschen scheinen.

Die Topographie des südlichen Seamounts zeigt steile Flanken die von circa 2000 m bis zu einer Plateauebene bei 400 m Wassertiefe reichen. Das Plateau weist die deutliche

Kratzfurchen durch auf Grund gelaufene Eisberge auf. Die vulkanischen Gesteinsproben sind basaltisch und wahrscheinlich alkalisch. Ein Großteil der Gesteinsproben sind gerundet und metamorphen Ursprungs und werden als Dropstones interpretiert. Ähnlich beschaffen ist die Topographie des Logi-Rückens, dessen Gipfelplateau bei etwa 500 m Wassertiefe liegt. Die Hänge sind etwas weniger steil als am Southern Seamount. In Wassertiefen >600 m sind kegelförmige Strukturen vermutlich vulkanischen Ursprungs auszumachen. Die Beprobung der Kegel und Flanken ergab lediglich diamikte Tone und Dropstones.

Im nordöstlichen Arbeitsgebiet wurden zwei Strukturen bathymetrisch vermessen und mit dem TV-Greifer beprobt. Bei beiden Strukturen handelt es sich um mehrere km^2 große Areale mit Meerestiefen, die bis > 1000 m über der umgebenden Tiefseeebene liegen. Die Beprobung ergab sehr stark Mn-Oxid umkrustete Mantelperidotite vom südöstlichen der beiden Riftberge und alterierten Olivingabbro von der anderen Lokalität. Damit konnten beide Strukturen als Ozeanische Kernkomplexe identifiziert werden, die am sehr langsam spreizenden Mohns-Rücken vor ca. 40 Millionen Jahren exhumiert wurden.

Der Luise Boyd Seamount weist bathymetrisch drei Domänen auf: (1) eine glatte, schallweiche Gipfelregion, (2) eine Südostflanke, die deutlich durch Hangrutschungen geprägt ist, und (3) unregelmäßig geformten, schallharten Meeresboden, der auf Pillowlavahügel hinweist. Beprobung durch den TV-Greifer ergab, dass der Gipfelbereich durch diamikte Tone mit Dropstones geprägt ist, während Pillowbasalte in Domäne 3 anstehen. Auch von der sehr steilen Südostflanke, die von 500 m bis in >3000 m Wassertiefe reicht, konnten Basalte aus Talusfeldern geborgen werden.

Von 700 Proben sind 163 Gesteine, davon allein 122 vom Vesteris Seamount; dazu gehören über 400 biologische Proben. Anzahl und Qualität der Proben sind erstklassisch und liefern gute Voraussetzungen für vielfältige Forschungsarbeiten im Anschluss an die Ausfahrt.

2 Participants

2.1 Principal Investigators

Name	Institution
Bach, Wolfgang, Prof.	UB/MARUM
Peckmann, Jörn, Prof.	UHH
Karsten Haase, Prof.	GZN
Hentschel-Humeida, Ute	GEOMAR

2.2 Scientific Party

Name	Discipline	Institution
Bach, Wolfgang, Prof.	**Marine Geology/Chief Scientist**	**UB/MARUM**
Prof. Dr. Peckmann, Jörn L.	Geobiology	UHH
Bauer, Julia	Petrology/Geochemistry	GZN
Röhler, Aaron	Petrology/Geochemistry	UB
Schaarschmidt, Anna	Petrology/Geochemistry	GZN
Unger-Moreno, Katharina	Petrology/Geochemistry	UB
Dr. Birgel, Daniel	Geobiology	UHH
Kampen, Kristin	Geobiology	UHH
Dr. Snoeyenbos-West, Oona	Geobiology	NRM
Steger, Jan	Geobiology	UW
Kramer, Laura	Hydroacoustics	UB, MARUM
Strack, Anne	Hydroacoustics	GEOMAR
Dr. Slaby, Beate	(Micro)biology	GEOMAR
Caraite, Ieva	(Micro)biology	GEOMAR
Carvalho, Francisca	(Micro)biology	UBer
Dr. Rincon Tomas, Bianca	(Micro)biology	UGoe
Fabrizius, Eduard	TV guided grab	GEOMAR
Dr. Nowald, Nico	ROV	MARUM
Fröhlich, Siefke	ROV	MARUM
Schade, Tobias	ROV	MARUM
Vittori, Vincent	ROV	MARUM

2.3 Participating Institutions

UB	Fachbereich Geowissenschaften der Universität Bremen, Bremen, Germany
MARUM	Zentrum für Marine Umweltwissenschaften, Bremen, Germany
GZN	GeoZentrum Nordbayern, Friedrich-Alexander Universität Erlangen-Nürnberg, Erlangen, Germany
UH	Department of Geosciences and Geography, Faculty of Science, University of Helsinki, Finland
UHH	Fachbereich Geowissenschaften, Universität Hamburg, Germany
NRM	Museum of Natural History, Stockholm, Sweden
UW	University of Vienna, Vienna, Austria
UBer	University of Bergen, Bergen, Norway
UGoe	University of Göttingen, Göttingen, Germany

Fig. 2.1: Scientific participants of MSM86

GEOMAR Helmholtz-Zentrum für Ozeanforschung, Kiel, Germany

3 Research Program

3.1 Description of the Work Area

Vesteris Seamount is a young <0.6 Ma (Mertz and Renne, 1995) volcano and rests on ocean crust formed 40-45 Ma. It rises from the >3000-m deep floor of the Greenland Basin to 130 water depth. The lavas and volcanigenic sediments at and around Vesteris Seamount are highly alkaline and include basanites, tephrites, and phonolites (Haase and Devey, 1994; Haase et al., 1996). It is unclear if other basement highs in the region may also be young. For instance, Chernysheva and Kharin (2007) reported of extremely alkaline rocks of young age from Southern Seamount, located 80 n.m. southwest of Vesteris Seamount. This feature and other basement outcrops northeast of Vesteris Seamount were to be sampled in the course of cruise MSM86.

3.2 Aims of the Cruise

The research program of MSM86 had the main objective of mapping and sampling several basement outcrops in the Greenland Basin, specifically Vesteris Seamount, Logi Ridge and Southern Seamount, as well as suspected volcanic edifices northeast of Vesteris Seamount. The science party covers three disciplines, each of which has specific research aims and questions that are detailed below.

3.3 Agenda of the Cruise

The petrological questions and working hypothesis that will be addressed by the particpants from **the University of Bremen, Friedrich-Alexander Universität Erlangen-Nürnberg** and the **University of Helsinki** are

Vesteris Seamount consists of young, alkaline, enriched lavas that formed from CO_2-rich metasomatism of the mantle. We will use the trace element and isotope geochemistry of samples from Vesteris volcano to determine the geochemical signatures and changes in the melting regime with age. The sampling of distinct edifices of Vesteris allows to determine whether these changes occur gradually or if these changes are long-term in nature.

Lavas from Vesteris Seamount show increasing extents of partial melting with decreasing age implying that the seamount represents an early stage of rifting and potentially the initiation of a new spreading axis in the central Greenland Sea. We will use trace elements, Sr-Nd-Pb-U-Th-Ra isotope data combined with Ar-Ar age determinations of selected Vesteris samples to test whether the signatures change systematically from the deeper (i.e. older) to the shallower samples. We expect changes in the degree of melting of the Vesteris samples to be more apparent with the new data.

Lavas from Vesteris Seamount can be used to decipher the degree of fractionation, the timescales of magma storage and ascent, as well as the pressures and temperatures in a relatively thick oceanic lithosphere. The occurrence of fresh glasses, clinopyroxene and olivine phenocrystals in numerous samples from Vesteris allow to determine the rates of ascent and timescales of magma storage as well as the depth and temperatures of magma storage. We will develop a consistent model of magma evolution and ascent of an oceanic intraplate volcano.

The composition of the main eruptive center at Vesteris Seamount and the parasitic cones differ in their composition. Major element and trace element geochemistry of whole rocks, and glasses combined with detailed backscatter and bathymetric maps can be used to map the lithologies at Vesteris allowing for a consistent model of the ages and distribution of lava flows and volcaniclastic deposits at Vesteris Seamount.

The new bathymetry and lavas sampled from Southern Seamount and Logi Ridge can be used to determine the origin of these enigmatic structures. Major element and trace element geochemistry and age dating of the whole rocks and minerals sampled will reveal whether the flat-topped structures at the southern end of the Central Greenland Sea result from young volcanism subsequently eroded during the last glacial.

The structures in the northeastern working area reflect younger alkaline volcanism not related to the Mohns Ridge. The newly obtained bathymetry as well as major element, trace element and isotope geochemistry of samples from the northeastern working area, the northeastern basement outcrops and Luise Boyd Seamount will show whether the seamounts in the northeastern working area have tholeiitic, mid-ocean ridge like compositions or whether they are alkalic suggesting that Vesteris Seamount and the northern structures form from rifting of the oceanic lithosphere and represent the earliest stages of spreading in the central Greenland Sea.

Our research expedition was also aimed at contributing to the ongoing discoveries of diversity of sponges and their related microbiome. Vesteris Seamount comprises a typical example of a cold-water ground composed of a seemingly rich multispecific assemblage of demosponges very similar to what we know from the Schultz Massif which is found at the intersection between the Mohns- and Knipovich Ridges. Based on the investigations made by the University of Bergen at the Schultz Massif and the published records from Vesteris Seamount (Henrich et al. 1992) it seems like the astrophorid sponges *Geodia parva*, *G. hentscheli* and *Stelletta raphidiophora*, and hexactinellids or glass sponges *Schaudinnia rosea*, *Trichasterina borealis*, *Scyphidium septentrionale*, *Asconema* sp. and *Amphidiscella monai* are dominating the sponge fauna in both locations. Five deployments of the ocean floor observation system (OFOS) during ARKVII/1 revealed a pronounced faunal zonation into a summit zone between 130 and 260 m water depth, an upper slope zone from 260 m to 400 m and a lower slope zone in depth >400 m. Henrich et al. (1992) provide details of the faunal compositions that include varying proportions of bryozoans, crinoids, serpulids, and foraminifera. In each faunal community type, sponges are abundant, if not dominant. We aim to investigate the present distribution of sponge communities at Vesteris Seamount, including their community composition, their microbiota, and the associated biodiversity, the evolution of its constituent species, as well as the ecosystem functioning.

The main goals of the cruise participants from the **University of Bergen,** Norway, are to access the biodiversity, biogeographic patterns, associated fauna, genetic diversity and connectivity of the sponge communities in the Vesteris Seamount. We will look into the species composition and abundance with changing depth, water mass and substrate. Target species, such as *Geodia parva*, G. *hentscheli*, *Stelletta raphidiophora*, *Schaudinnia rosea*, *Trichasterina borealis*, *Scyphidium septentrionale*, *Asconema* spp. and *Amphidiscella monai,* will be used for studies of genetic connectivity and reproduction. This will allow us to place Vesteris Seamount in a sponge ground connectivity work into our Atlantic-wide analysis of sponge ground diversity/composition on seamounts, that is integrated into the SponGES™ funding from the European Union's Horizon 2020.

Studying the microbiomes of the sponges at Vesteris Seamount is one of the main tasks for the MSM86 cruise, as they are needed to understand the role of microorganisms in the metabolism of their respective sponge hosts. Current knowledge of sponge microbiology was obtained from a dozen sponge species from shallow water environments. Considering that an estimated 8500 species are validly described and that true taxonomic diversity is estimated to be much higher, only the very tip of the iceberg has been scratched. Similarly, the microbiomes of shallow-water, topical and temperate sponges have received much recent attention (Thomas et al., 2016), while those of deep-sea sponge species remain only poorly characterized. This task will therefore be conducted within a larger effort of my lab and other collaboration partners to establish a comprehensive reference database for deep-sea sponge microbiomes. We will employ next generation sequencing to assess both diversity and function of the microbiomes associated with Vesteris Seamount sponge species.

Cruise participants from **GEOMAR** Helmholtz Centre for Ocean Research Kiel, Germany, aim to provide an understanding on the physiology, metabolism and molecular mechanisms of interaction between marine sponges and their microbial partners. We seek to address the following **questions**:

i) What types of sponge-microbe associations (also termed "holobionts") await discovery in extreme marine environments, such as exemplified by the Vesteris Seamount in the Northern Atlantic?

ii) How does the sponge holobiont diversity at Vesteris Seamount compare to those of other Northern Atlantic sites that are currently being explored in the EU consortium SponGES?

iii) How are sponges and their associated microbiomes adapted to their environment? What is their functional role in the particular ecosystem that they live in?

iv) How can these systems be used in a sustainable manner for bioprospecting?

In detail, hexactinellid sponges are of special interest since they are characteristic of deep-sea areas and are difficult to access. Furthermore, they are primitive multicellular organisms in which previous studies from our time have discovered a particular and specific relationship with archaeal cells. Cruise participants from the **University of Göttingen**, Germany, aim to characterize and understand this relationship between archaea and hexactinellids, using living organisms from the Vesteris Seamount, as well as hexactinellid fossil records for a better understanding of the role of archaea in the development and metabolism of these sponges.

Microorganisms are not only found within sponges, they also inhabit the rocky substrate on top of which the bethic macrofauna flourishes. The Geobiology groups of the **University of Hamburg** and the **Museum of Natural History of Sweden** in Stockholm are particularly interested in learning more about fungi that were recently found in a vesicular basanite sample (Ivarsson et al., 2015).

Recent work has shown that fungi are a major part of the biota associated with seafloor basaltic rocks (Bengtson et al. 2017). However, little is known about the diversity and composition of the fungal communities and their structuring factors. Thus, it is unclear how fungi start to colonize this extreme environment. Potential sources can be surrounding seawater or intracrustal fluids. Furthermore, fungi that inhabit basalt rocks must be capable to thrive with low organic matter input and/or hyp- or anoxic conditions. Using different microscopic approaches, Ivarsson et al. (2016) could show that some fungi in the oceanic crust construct dense cobweb-like hyphal networks supporting the intensive contact with chemoautotrophic prokaryotes. The same authors hypothesized that these networks are interaction centers of anaerobic fungi and hydrogen-driven prokaryotic communities. The Vesteris Seamount basanites also revealed the presence of fossilized endolithic fungal communities colonizing the abundant vesicles (Ivarsson et al., 2015). These samples were from 727 m water depth at the southern part of the 15 km long, crescent-shape, NE-SW trending crest developed in the summit area of the volcano.

The new and more comprehensive sampling campaign in connection with cruise MSM86 will allow us to retrieve live fungi. This will not only allow us to constrain the phyogenetic affiliation of the rock-dwelling fungi, it will also allow us to look into fungal Mn-biomineralization and to identify inorganic and organic biomarkers of fungal bioalteration of marine volcanic rock.

The sampling strategy was based on the extensive multibeam surveys of MSM86 and previous cruises on a daily basis. The sampling was preferentially done by Remotely Operated Vehicle (ROV SQUID) and TV grab to ensure consistent and accurate sampling as well as structural and geological control of the sampling.

4 Narrative of the Cruise

(Beier, C., Bach W.,)

A delegation of scientists from the Universities of Bremen, Hamburg, Bergen, Erlangen-Nürnberg and Helsinki and the entire team of Remotely Operated Vehicle (ROV) MARUM SQUID arrived on the 15 and 16th of August. The rest of the scientific party joined on the evening of the 17th August 2019. During port stay and roadstead, the installations for the ROV were prepared, and the labs were readied for operations at sea.

On Sunday the 18th of August, RV MARIA S. MERIAN left roadstead at Longyearbyen harbour at 06:50 and reached the open sea through the Fjord at 09:30 at calm seas and no wind. The scientific program started at 07:45 with underway multibeam mapping. Heading NW from Longyearbyen we transited for 2.5 hours before stopping for an ROV test dive, which was successfully completed at 15:40. Our first mission was the recovery of a MeBo-plug and an autonomous monitoring platform installed during MSM57 on Vestnesa Ridge. Station MSM86_001 began at 07:30 on Monday the 19th. It was intended to recover both pieces of equipment with the ROV, but operation was put to a hold after electronic failure. The platform was recovered using the TV-guided grab, which was equipped with hooks, lowered, and maneuvered over the platform with the ship's DP system until the hooks had engaged. In the evening hours of the 19th August, the ROV was successfully lowered to the ocean floor, where it found and unscrewed the MeBo-plug. At 11:30 am on 19th August we started transiting towards the main working area at calm seas. During the early morning hours of the 21st of August a CTD cast was performed to record a sound velocity profile of the water column and collect deep-sea water. This station was followed by a hydroacoustic survey heading towards Vesteris Seamount. In the evening of the 21st of August and the morning of 22nd of August, we performed five TV grab stations before commencing the first ROV dive along the eastern flank of Vesteris Seamount in 500 to 600 m water depth. During the evening of the 22nd August and the early morning of the 23rd of August, five more TV grab stations were completed along the northern slope of Vesteris Seamount, followed by a CTD station and a multibeam transect. At noon on the 24th of August, the ROV dive was abandoned and a TV grab was lowered at the eastern ridge of Vesteris Seamount. A subsequent ROV test was done during the afternoon of the 23rd August followed by three TV grab stations at the western ridge of Vesteris Seamount. On the 24th of August a hydroacoustic survey was conducted, followed by five TV grab stations. Another hydroacoustic survey was carried out during the early morning hours of August 25th. That same day, we took six successful TV grabs in the vicinity of Vesteris Seamount prior to conducting a hydroacoustic survey of the shallow sections of Vesteris overnight using the Kongsberg EM712 multibeam system. We continued with four TV grabs on the southwestern flank of Vesteris Seamount but operations had to be abandoned due to increasing swell and winds and we performed a hydroacoustic survey towards the southern working area, where a multibeam survey was conducted during the August 27th and the early morning of August 28th to map Southern Seamount for the first time. At moderate seas and winds during the 28th of August we performed five TV grab stations from west to east on the Southern Seamount and a CTD station prior to surveying (EM122) back from Southern Seamount to Vesteris Seamount. Dive 042 of MARUM-SQUID took place during the daytime of August 29, followed by two TV grab stations along the northern parasitic cones of Vesteris Seamount in the evening hours. Winds increasing to 7 Bft and rising seas forced us to abandon work at Vesteris Seamount again. We headed to the northeastern working area and mapped (EM122) two seamounts there during the 30th of August and the early morning hours of the 31st of August. Based on the newly generated maps, we selected three locations for TV grab stations on the two seamounts in the northeastern area and conducted successful rock sampling there. During the night to the 1st September we transited back to Vesteris Seamount where fair weather allowed us to successfully conduct ROV dive 043 (station MSM_061ROV). After recovery of the ROV we did five TV grab and a CTD station prior to leaving the area again due to high seas and increasing winds. We headed ESE and performed a multibeam survey towards Luise Boyd Seamount at 72°N, 3°E just north of the Mohns Ridge. Seas were rough during transit und the hydroacoustic survey of Luise Boyd Seamount on September 2 and 3. In the late morning hours of the 3rd, we were able to start rock sampling and did four successful TV-grab stations followed by a CTD station just east of Luise Boyd Seamount. in the night from the 3rd to the 4th of September, we continued a hydroacoustic survey NW of Luise Boyd Seamount and in the morning of the 4th September we lowered two more TV grabs at the seamount. At noon that day, we started steaming back towards Vesteris Seamount where we arrived at 06:00 on the 5th of September and did two TV grab stations prior to ROV dive 044 in the central area of Vesteris Seamount. Four TV grab stations followed and during the night to the 6th September we continued our detailed hydroacoustic survey of Vesteris Seamount. During daytime, we performed ROV dive 45 at the northwestern flank of Vesteris Seamount followed by five TV grabs along the eastern and northern flanks of the volcano. On the 7th of September, another hydroacoustic survey and the final ROV dive on Vesteris Seamount were successfully completed. During the evening of the 7th we transited south to Logi Ridge, the easternmost part of which we surveyed hydroacoustically for the first time. Three TV grab stations along Logi Ridge were conducted in the morning of September 8th. Later that day, we completed our hydroacoustic survey at Logi Ridge and then started a long hydroacoustic survey back to Vesteris Seamount to bridge anoterh period of heavy seas there. During the 9th of September, the sea state improved a bit and two TV grabs and a CTD on Vesteris Seamount were carried out during the afternoon hours. During the night we performed a parasound survey over sedimented area southeast of Vesteris Seamount. In the morning of the 10th of September we lowered two final TV grabs on Vesteris Seamount prior to transiting to Southern Seamount where we did three more TV grab stations in the early morning hours. At 9:30 UTC we finished the working program at Southern Seamount and started transiting SE towards Jan Mayen. The scientific program ended at 9:05 am on the 11th September 2019 at 72°23.19'N, 11°22.57'W, the underway data collection was finalized at 13.09.2019 3:48 am at 64°48.40'N, 0°11.95'O. 64°48.40'N, 0°11.95'O. The vessel arrived in Emden on the 16th September 9:55 am UTC

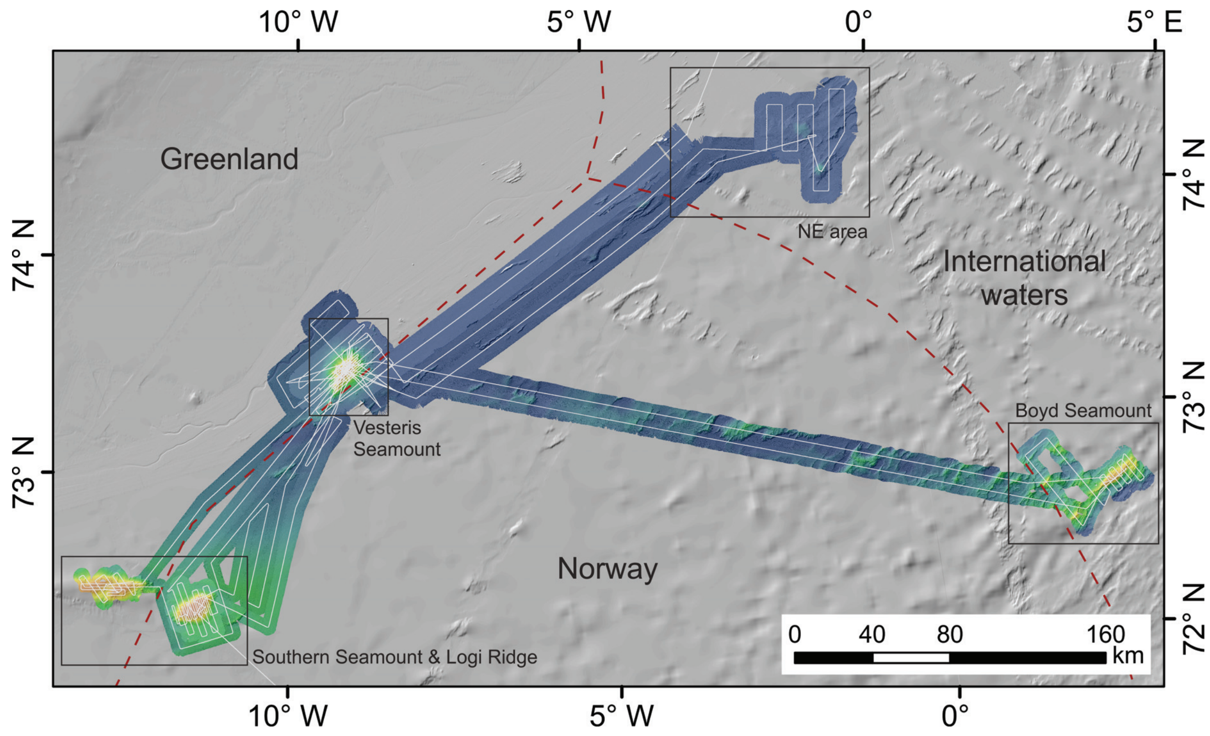

Fig. 4.1: Raw bathymetry of MBES EM122 acquired during MSM86. The location of the four study areas are marked by black frames. Background GEBCO data is shown as grey hillshade.

docking into the shipyard.

5 Preliminary Results

5.1 Operations

5.1.1 Hydroacoustic Work

(A. Strack, L. Kramer)

The hydroacoustic surveys carried out during MARIA S. MERIAN cruise MSM86 were aimed at acquiring detailed information of the areas of interest with respect to backscatter, bathymetry and water column information. This information was essential for the planning of the ROV MARUM-SQUID dives and the TV grab stations.

This cruise preparation relied on EM120 bathymetry (100-m resolution) which was acquired by RRS James Clark Ross during cruise JRC-51. The remapping of the Vesteris Seamount revealed unknown geomorphological details and a very high-resolution map of up to 5-m grid cell size based on the new MBES KONGSBERG EM712 system and the well-established MBES KONGSBERG EM122. The following hydroacoustic investigations were conducted during this cruise:

- Detailed mapping (5-15 m grid cell size) of Vesteris Seamount with the EM122 and EM712
- Detailed mapping (5-15 m grid cell size) of Southern Seamount with the EM122 and EM712
- Mapping (15 m grid cell size) of core complexes in the NE area with the EM122
- Mapping (15 m grid cell size) of Boyd Seamount with the EM122
- Acquisition of water column data to 1500 m water depth for the detection of potential gas flare
- Sub-bottom profiling at the western flank of Vesteris Seamount with the ATLAS PARASOUND P70
- High density & dual swath mapping and sub-bottom profiling along a total track length of more than 5360 km (about 280 hours of recording) the majority of which was performed at 8 kn.

During MARIA S. MERIAN cruise MSM86, the MBES KONGSBERG EM122 was operating almost continuously. The shallow to medium water MBES KONGSBERG EM712 system was only operating in water depths above about 1000 m. The parametric sub-bottom profiler ATLAS PARASOUND P70 was only used on the western flank of Vesteris Seamount as sub-bottom profiling was no main aim of this cruise. Hydroacoustic surveys were usually conducted with a vessel speed of maximum 6 kn, while for some few sub-bottom profiles, a reduced speed of about 4 kn was applied. During transits the vessel speed was increased to 8-12 kn, depending on weather conditions.

5.1.1.1 Multibeam Echosounder (MBES) Acquisition Devices and Settings

Two hull-mounted multibeam systems are available on-board RV MARIA S. MERIAN for bathymetric and backscatter mapping of the seafloor: a KONGSBERG EM122 for deep-water surveys and a KONGSBERG EM712 for shallow to medium waters.

The EM122 system is a deep-water MBES providing accurate bathymetric mapping down to full ocean depth. Basic components of the system are two linear transducer arrays in a Mills cross configuration with separate units for transmit and receive. The transducers of the EM122 are mounted in a blister-shaped fairing below the keel of RV MARIA S. MERIAN. The nominal sonar frequency of the EM122 is 12 kHz and a beam width configuration of 2° (TX) by 2° (RX) is installed. A swath angle of up to 150° and 288 beams per ping and a maximum coverage of 6 times the water depth can be reached, depending on the sound velocity and the character of the seafloor. The angular coverage sector and beam pointing angles may be set to vary automatically with depth according to achievable coverage. This maximizes the number of usable beams. The beam spacing can be chosen to be equidistant or equiangular at the seafloor, in addition a “high-density-equidistant” mode is available. Using this mode 432 independent depth values (soundings) are obtained perpendicular to the track for each ping. Using the 2-way-travel-time and the beam angle known for each beam, and considering the ray bending due to refraction in the water column by sound speed variations, depth and position are calculated for each beam. A combination of amplitude (for the central beams) and phase (slant beams) is used to provide a measurement accuracy practically independent of the beam pointing angle. The EM122 applies the “dual swath” technology which means that instead of one ping two pings are simultaneously transmitted and recorded, one slightly tilted forward and the second backward thus enabling a denser bottom coverage along track, or allowing for a higher survey speed. Therefore, with each record 864 independent depth values are achieved. The EM122 transmits CW (continuous wave) pulses in shallow modes and FM pulses in deep modes. FM or “chirp” pulses transmit more energy into the water, thus enabling greater ranges of the beams leading to a better across track coverage of the seafloor particularly at greater depths. Systems applying FM pulses require additional features of the motion reference unit as the acoustic signals travel a longer time through the water while the vessel is moving.

The EM712 of R/V MARIA S. MERIAN is a 0.5° by 0.5° broadband MBES, operating in the 40 to 100 kHz band. Maximum water depth of the system is up to 3000 m according to the specs; however, the most efficient depth range for the EM712 is less than 700 m. At these depths, it has a better resolution and a slightly wider swath than the EM122. For greater depths, the EM122 is the system of choice. Basic principles are identical to those of the EM122, the differences are the higher sonar frequency which also means considerably smaller transducer arrays, a beam footprint of 0.5° by 0.5°, a total swath width of up to 140° instead of 150° and the number of beams (256 instead of 288) and 400 soundings per ping instead of 432. While using the “dual swath” mode, 800 independent depth values per record are achieved. The EM712 applies CW (continuous wave) pulses in shallow modes and FM pulses in deep modes.

During cruise MSM86 the maximum swath width of both MBES systems was set to 120 degrees to improve data quality, reduce the amount of noisy data at the outer beams and increase the ping rate. Table 5.1.1 summarizes the specifications of both echosounders as well as the settings used during the cruise.

Table 5.1.1**:** System specification and settings during MSM86

System Specification	**EM712 shallow water**	**EM122 full ocean depth**
nominal frequency	100 kHz (67 – 103 kHz)	12 kHz (10.5 – 13 kHz)
swath width	140°	150°
no. of beams per swath	256	288
no. of soundings per swath	400	432
no. of swaths per ping	2	2
no. of soundings per ping	800	864
max. depth	2.000 m	11.000 m
available pulses	CW and FM	CW and FM
pulse lengths	CW: 0.2-2 ms FM: up to 120 ms	CW: 2, 5, 15 ms FM: up to 200 ms
Settings during cruise	**EM712 shallow water**	**EM122 full ocean depth**
swath width used	120°	120°
no. of beams per swath (water column)	256	288
high density equidistant Mode ON. Soundings per swath used for bathymetry & backscatter	400	432
Dual swath mode **ON**. No. of swaths per ping	2	2
Ping Mode	Auto	Auto
In Areas used	Shallow water depths (below 1000m) mainly at Vesteris Seamount and Southern Seamount	Area of Interest

Attributed Sensors (Navigation, Motion Data, Sound Velocity)

On RV MARIA S. MERIAN, a Seapath 320, an inertial motion-reference unit, which is augmented by two DGPS-signals, provides attitude data simultaneously to both MBES systems and the PS70 sub bottom profiler. The SEAPATH 320, in combination with the motion reference unit (KONGSBERG MRU 5+), generates motion data (roll, pitch and heave) as well as heading and Differential Global Positioning (DGPS). These data streams are applied to all hydroacoustic devices during this cruise.

Sound velocity profiles (SVP) were calculated from several CTD down-casts (n=5, Fig. 5.1.1.1). A Seabird 'sbe911+' CTD probe with a sampler rosette (multiple water sampler) equipped with Micro-SUBCONN underwater plug connectors was used to collect CTD (conductivity, temperature and pressure) data. SVPs were updated whenever feasible to provide accurate ray tracing during acquisition. However, we applied a final SVP correction during post processing.

Multibeam Data Processing

The free and open source software package MB-System (vers. 5.7.6beta5; Caress and Chayes, 1995) was used for bathymetric post-processing. The large amount of data acquired during this cruise impeded the processing of the whole dataset at the time leaving the vessel. Nevertheless, both EM122 and EM 712 data for Vesteris Seamount are fully processed. The final data cleaning and processing of bathymetry of the additional areas of interest (Southern Seamount, Boyd Seamount, NE areas) will be finished at the University of Bremen by students. The data are shown in Fig. 5.2.1.1-5.2.4.1. The following steps were applied to the entire surveys conducted:

- Preprocessing and converting the data to editable MB-format via *mbpreprocess*
- Applying correct SVP with *mbsvpselect*
- Applying tide correction by utilizing OSU Tidal Prediction Software (OTPS) distribution (http://volkov.oce.orst.edu/tides/otps.html)
- Manual editing of the dataset with the 3D *mbeditviz* tool
- Correcting amplitude (aka backscatter) and sidescan (time series) values based on a function of grazing angle with respect to the seafloor (slope) with *mbbackangle*
- Applying the changes to the raw files, creating processed files with *mbprocess*
- Grid the data, using netCDF (GMT) file format (Ryan et al., 2009)

The ESRI ArcGIS™ vers. 10.4 was used to create maps, slope and other morphometric analysis and a sustainable spatial data management of the data obtained during the cruise.

5.1.1.2 TELEDYNE ATLAS PARASOUND Sub-Bottom Profiler (SBP)

The hull-mounted TELEDYNE ATLAS PARASOUND P70 is a deep-sea parametric sub-bottom profiler (SBP) which utilizes the parametric effect based on non-linear relation of pressure and density during sonar propagation. Two high intensity waves with frequencies of ~18-20 kHz (aka primary high frequency, PHF) and a 22-24 kHz wave were used to create a so-called secondary high (about 40-42 kHz) and a secondary low frequency (SLF) of about 4 kHz. While the SLF is used for the sub-bottom profiling, the PHF signal can be recorded synchronously to image potential gas bubbles, plankton, fishes or nepheloid layers in the water column. The opening angle of the transducer array is 4° by 5°, which corresponds to a footprint size of about 7 % of the water depth. The ATLAS PARASTORE program is used for storing and displaying echograms, while the program ATLAS Hydromap Control (AHC) is used to set proper hydroacoustic settings during acquisition. During PARASOUND operations, data of the entire water column and sub-bottom are recorded and stored as vendor-specified *.asd files. The obtained data can be replayed in PARASTORE. Along with these raw files so-called *.ps3 and auxiliary data files were recorded for a certain given depth window. A further investigation of the recorded PARASOUND data was not conducted during this cruise.

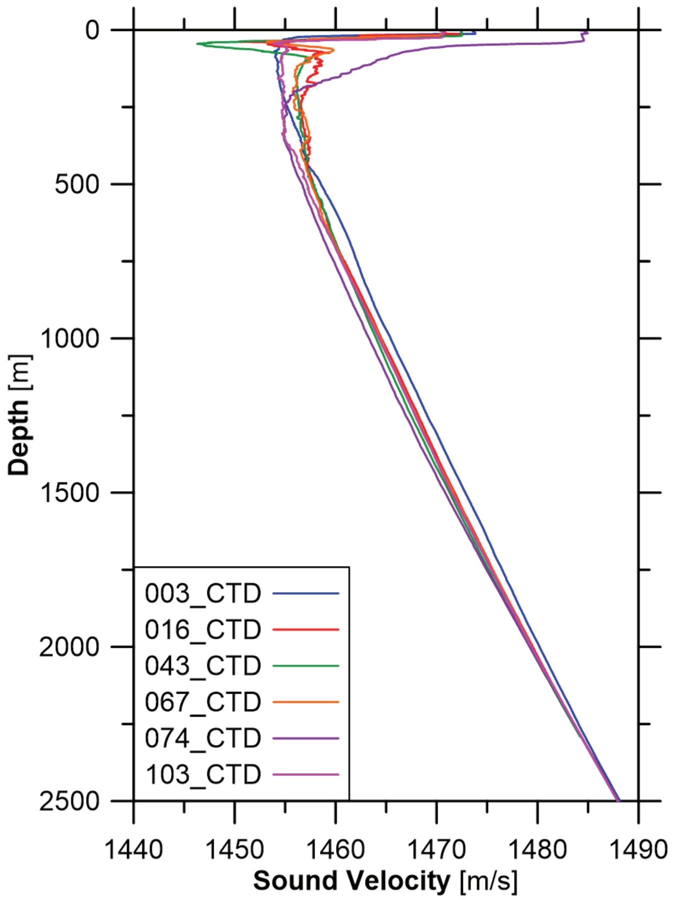

Fig. 5.1.1.1: CTD Sound velocity profiles from MSM86.

5.1.1.3 Hydroacoustic Data Management

Table 5.1.2 shows statistics of the conducted hydroacoustic surveys during MSM86 and illustrates the amount of storage data needed on the cruise.

Table 5.1.2: Hydroacoustic survey statistics

Hydroacoustic Device	**EM122**	**EM712**	**PS-P70**
Total Time	199.69 hours	52.66 hours	About 27.5 hours
Total Track Length	4370.95 km	652.93 km	About 340 km
Average Speed	21.89 km/hr 11.83 knots	12.40 km/hr 6.70 knots	7.4 km/h 4 knots
Min/Max Depth[1]	135.81/4335.93	135.03/2986.47	-
Raw Data Amount[2]	50.6 GB	21.2 GB	26.7 GB
Processed Data	78.4 GB	15.4 GB	-

[1] Min/Max Depth includes artificial spikes

[2] Raw Data includes MBES water column data

5.1.2 CTD

(A. Röhler, K. Unger-Moreno)

During Expedition MSM86 the ship-owned CTD (conductivity-temperature-depth) probe, combined with a Seabird SBE-32 Carousel Water Sampler equipped with 24 10-liter Niskin-Bottles, was used to recover water samples for the biology groups and generate sound velocity profiles (SVPs) for Multibeam Echosounder surveys (see chapter 5.1.1).

A Seabird™ SBE911plus (#09P41434-0791) CTD was used equipped with the following sensors, which were calibrated by the ship's technician shortly before the cruise:

Conductivity:	SBE 4c	#043141
Temperature:	SBE 3plus	#03P4479
Oxygen, x2:	SBE 43	#431100
Flourometer & Turbidity:	Eco-FL(RT)D	#FLTRD-572
Pump:	SBE 5T	#054514

The Device was connected via a SBE 11plus V2 (#11P41434-0717) Deck Unit and the software SBE SeaSave (Version 7.22) was used to control the operations.

Table 5.1.2: CTD profile locations

Station	Date (UTC)	Start (UTC)	Location	Start Position (Decimal Degrees)		Water depth [m]	End (UTC)	End Position (Decimal Degrees)		Water depth [m]	Waterdepth of samples [m]	comments	Number of Niskins (depths)
				Latitude	Longitude			Latitude	Longitude				
003_CTD	21.08.19	00:24	Vestnesa Ridge	74.541512	-3.244433	3601	02:37	74.541535	-3.244484	3601	3586, 3487, 170, 10	SVP Profile	11 (4 Depths)
016_CTD	23.08.19	01:22	Vesteris	73.650012	-9.082526	2922	03:13	73.649997	-9.082608	2921	2905, 2805, 170, 10	SVP Profile	11 (4 depths)
043_CTD	27.08.19	01:14	Southern Seamount	72.484486	-11.862027	2316	02:44	72.484487	-11.862065	2312	2290, 600, 10	SVP-Profile	10 (3 depths)
067_CTD	01.09.19	22:45	Northeastern Seamount (core complex)	73.511625	-8.884488	2104	00:06	73.5115	-8.885144	2100.1	2078, 1900, 1700, 1000, 500, 300, 10	SVP-Profile, End 02.09.2019	24 (7 depths)
074_CTD	03.09.19	16:38	Mohns Ridge	72.628311	2.73499	2628	18:18	72.628353	2.735047	2626.2	2609, 870, 720, 680, 10	SVP-Profile, Bottles 7,8,9 failed to close (720m)	12 (5 depths)
103_CTD	09.09.19	18:54	SW Vesteris	73.4354933	-9.5594679	2804	20:36	73.435621	-9.55945	2777	-	SVP-Profile	-

Sampling Strategy and Data Handling

Water samples for the biology groups were chosen to represent depth ranges from which biological samples have been obtained during ROV-Dives or TV-grab sampling in the different regions. In addition, bottom and surface water was always collected. The water obtained was further processed by filtration or used to rinse and store biological samples.

Using the recorded temperature- and salinity (inverted from conductivity) data, sound velocity profiles were extracted for the Multibeam-Echosounder (MBES) survey campaigns.

The turbidity sensor had been used to look for traces of hydrothermal plumes in the water column near Vesteris Seamount but no such anomalies could be detected. In total six CTD-casts were conducted during the expedition (see Table 5.1.2). The data will be made publicly available on PANGEA with the submission of the final cruise report.

Problems and Malfunctions

Even though calibration of the sensors was conducted shortly before the expedition, one of the two installed oxygen sensors showed irregularities. The sensor in question showed impossible variations starting with the first cast on Station MSM86_003CTD. Measured values jumped between negative and incredibly high measured concentrations randomly. Since the system is redundant and the second oxygen sensor behaved normally, no action was taken. This decision was also reached because oxygen data was not of importance neither to the scientific questions of the cruise, nor the SVPs used for hydroacoustics.

5.1.3 TV-guided Grab (TVG)

(C. Beier, E. Fabrizius)

The TV-guided grab (TVG) from the Helmholtz Zentrum für Ozeanforschung Kiel was operated on winch F2S2 of RV MARIA S. MERIAN on a glass fiber wire. During each station, the wire was equipped with a Sonardyne Type 8190 Wideband Mini Transponder 30m above the TVG to ensure exact sample localization. The TVG grab was lowered at 1ms^{-1} at water depths >100m to 50m above ground as determined by the EM122 multibeam system. The ship was usually operated at 0.1kn, in few cases the vessel was operated at speeds of up to 0.5kn. The sampling quantities ranged from few kg's of rock samples to up to 800 kg of material recovered from the ocean floor.

5.1.4 Remotely Operated Vehicle "ROV MARUM-Squid"

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

MARUM-Squid is a light work-class ROV manufactured by SAAB Seaeye (UK) for operations down to 2000 m (Fig 5.1.4.1). The ROV-system is realized on a comparably small footprint at a considerably low weight, and is shipped inside a single 20" ISO container. The system was adapted for marine research at MARUM and put into service in July 2015. The ROV was deployed at several sites along the Vesteris Seamount for video documentation, geological and biological sampling.

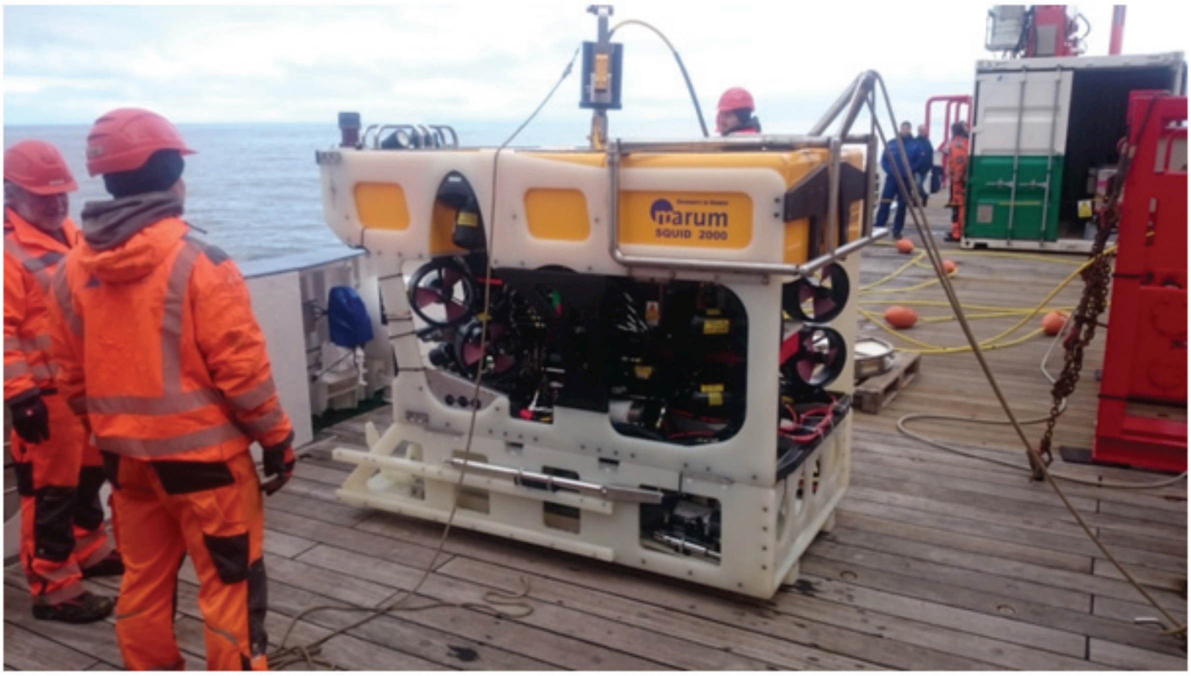

Fig. 5.1.4.1: ROV MARUM-Squid prior to deployment

Fig. 5.1.4.2: The *Decklabor* laboratory serving as ROV control room (left). View into the conference room with scientists joining the dive (right)

5.1.4.1 Mobilization

The system consists of three major components: the ROV, the winch with 2300 m supply cable (tether) and the topside equipment for power supply and control. During mobilization, the winch and the ROV were placed on the working deck of RV MARIA S. MERIAN. Unlike most ROV systems, MARUM-Squid has no dedicated control van in order to keep the system as small and compact as possible. Part of the concept is to use a ship laboratory and convert it into an operational control room for the ROV. The entire topside equipment including the 3kV transformer with corresponding filterbox and the portable flightcases containing devices for vehicle control, navigation, video display and data/video recording, were installed in the *Decklabor* of the vessel. A notebook with navigation map and online CTD data from the ROV, serves as a workstation for two scientists in the control room. For the remaining scientists, that cannot join the dive in the control room due to the limited space, the video of the ROVs HD-camera is streamed to the conference room of the vessel. Scientists in the conference room are able to coordinate activities with the scientists in the control room via VoIP communication. A navigation display with bathymatrical map and ROV position was also provided. This setup allows to make all information of the dive available to scientists outside the ROV control room (Fig. 5.1.4.2).

5.1.4.2 ROV

Dimensions and power

Vehicle dimensions are 2.1 x 1.2 x 1.9 m (L x B x H) and total weight of the ROV is 1.3 t. The transformer on the ROV converts 3kV to 500 V for the thrusters and hydraulics and 24 V for the low power devices such as cameras, Pan and Tilt unit or LEDs. Overall power of the ROV is 45 KW. The vehicle is equipped with a total of 11 thrusters - 8 horizontal thrusters providing a forward bollard pull of ~500 kgf and 3 vertical thrusters.

Navigation

MARUM-SQUID is equipped with a standard navigation sensor package such as a Valeport MiniPS depth sensor and a Tritech PA500 altimeter which measures the height of the ROV above the seafloor. These sensors are used for auto altitude and auto depth hold maneuvers with an accuracy of 10 cm. Furthermore, MARUM-Squid is equipped with two independent navigation devices, the 16CP and the MiniPOS, that can be used in alternation, providing a redundancy in case one of the device 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. Using the 16CP navigation pod, Auto Heading as well as Pitch/Roll hold are possible with the ROV. The CDL MiniPOS/NAV3 navigation system provides the same functions as the 16CP, but also allows advanced autofunctions like stationkeeping or displacement. Furthermore, the MiniPOS calculates an additional, absolute position of the ROV by using all vehicle sensors and an input from any USBL positioning system. The MiniPOS is a

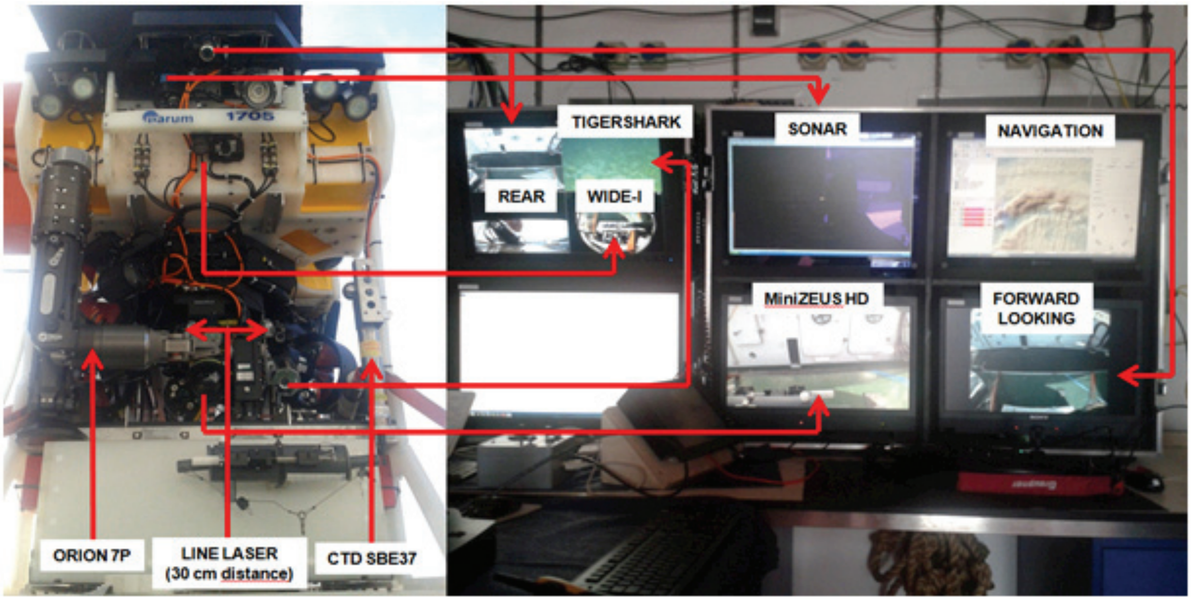

Fig. 5.1.4.3: Front of MARUM-Squid and video/navigation monitors in the *Decklabor*

fully self-contained Attitude Heading and Reference System (AHRS). It comprises a gyro compass 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 a RDI Workhorse Doppler Velocity Log (DVL) which increases 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. The device is installed on the upper porch for 360° obstacle detection/avoidance.

Cameras & Optics

The ROV is equipped with 5 cameras. Two PAL DSPL MultiseaCams serve as forward looking and rear looking camera. The latter monitors the orientation of the supply cable during operation. A vertically, on the front porched mounted DSPL Wide-I is giving a full overview of the area in front of the vehicle. An Imenco Tigersharks stills acquires images at a resolution of 13 megapixel and is mounted on the Pan and Tilt unit of the vehicle. The external flashgun of the stills is installed at a 45° angle on the upper porch. Main working camera is the Insite

Pacific MiniZEUS MKII, likewise mounted on the ROVs Pan and Tilt unit. The MiniZEUS is a full HD camera with a resolution of 2.38 megapixel. The MiniZEUS has an hemispherical dome port and a fully corrected optical lens with a 10 x optical zoom. The optical lens corrects for chromatic, geometric and radial distortion that occur when using optical systems underwater. Two Imenco Dusky Shark line lasers are installed on the Pan and Tilt unit. They project two parallel laser beams at a distance of 28 cm for size measurements of objects on the seafloor (Fig. 5.1.4.3).

Lights

The ROV comes with 6 x 24V dimmable LEDs at 3520 lumens. One pair is installed on the starboard side and the second pair on the port side of the ROV. The other two LEDs are placed on the Pan and Tilt unit and on the upper porch facing backwards towards the ROV umbilical.

Hydraulics

A 4.5kW integrated hydraulic power unit (iHPU) onboard the vehicle, provides a maximum operating pressure of 210 bar and a maximum flow rate of 11.6 l/min. The pump supplies the vehicle´s Orion 7P manipulator and the 7 station valve pack with hydraulic power.

The Orion 7P manipulator, manufactured by Schilling Robotics, is installed on the starboard side of the vehicle. It is a fully proportional, hydraulical manipulator with 7 degrees of freedom. The reach of the arm is 1.5 m and has a lifting capacity 68 kg. The Orion is remotely controlled via a Master Controller, which is a miniature of the Slave-Arm installed on the vehicle. The movement of the Master Controller directly translates into proportional movements of the Slave Arm, allowing precise operations in the centimeter range.

The Hydro-Lek HLK 73000 is a 7-station valvepack with solenoid valves to which a large variety of different hydraulic tools can be connected and operated. It is primarily used to open and close the sample box on the toolskid, mounted underneath the ROV.

Vehicle telemetry

The ROV uses a single mode fibre optic telemetry in combination with a Coarse Wave Division Multiplexer (CWDM). The CWDM increases the telemetry capabilities as it splits the light in several wavelength ranges that serve as individual channels for a variety of telemetry boards for video and data. The entire vehicle telemetry runs on one single mode fibre. Solely the MiniZEUS requires a dedicated fibre, due to the large bandwidth of the HD-SDI videosignal.

A Small Survey Pod with additional interfaces can be used for the integration of scientific sensors. Six ports for serial communication, a 1Gigabit Ethernet link for sensors that require a high bandwidth and 2 additional PAL video channels are available.

Positioning

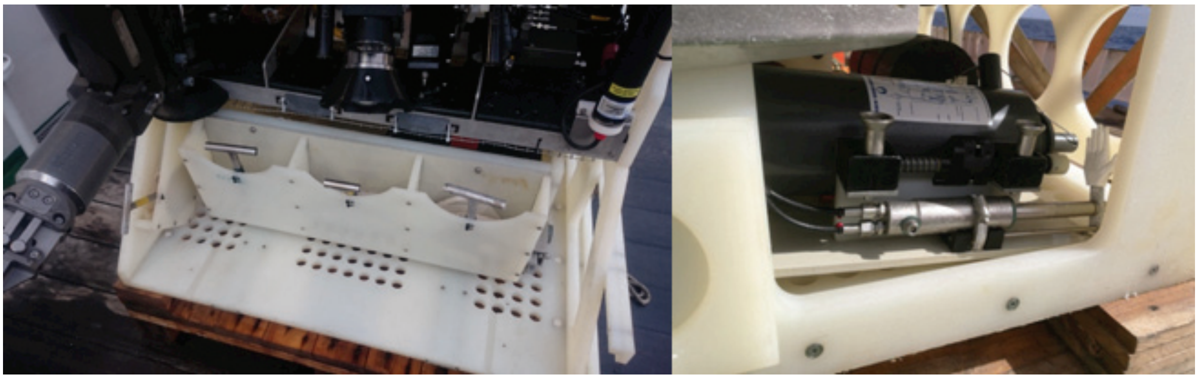

Fig. 5.1.4.4: Holsters for nets (left) and Niskin bottle (right) on the ROV

During the campaign, the USBL system Sonardyne Ranger II was used for positioning the ROV. The Ranger II data telegram was fed into the ROVs navigation computer and control system. In addition to the position provided by the USBL system, the MiniPOS inertial system of the ROV calculates its own position by using all vehicle sensors and the USBL input. Once the inertial system of the MiniPOS is calibrated, the Aided Navigation mode becomes active. When available, the MiniPOS sends precise position updates at a much higher frequency compared to USBL systems. Furthermore, the Aided Navigation allows the vehicle to go into the stationkeep mode, that holds the ROV on position without being displaced in X or Y direction by the currents. While stationkeeping, the vehicle can be shifted in any X and/or Y direction at given distances with an accuracy of 10 cm.

The Squid´s navigation software is a Plug-In called Posiview coded for the open source ArcGis software QGis. A georeferenced TIFF navigation map is used as the background, displaying the ship´s and ROV´s heading as well as their position on top of it.

Video and Data

All navigation data from the ROV and the vessel are stored in a separate navigation file by the Posiview Plug-In. The videos and still images contain a timestamp so they can be geo-referenced using the navigation file. The videos of the HD MiniZEUS and the tiling screen, showing the Wide-I-, Rear-, Tool-, and Still image camera, are recorded on hard-disk. Framegrabs in 5 second intervals are taken from the MiniZEUS camera and stored in the Flipbook.

5.1.4.3 Winch and Supply Cable

The winch was designed and constructed by Mac-Gregor Hatlapa and weighs 4.7 t including the cable. Overall dimensions are 2.1 x 1.9 x 1.9 m (L x B x H). Maximum Line-Pull is 2.5 t on the lower layer and maximum spooling velocity are 30 m/min. The 19 mm soft umbilical was manufactured by Norddeutsche Seekabelwerke (NSW) and has a total length of ~2300 m. The inner consists of three Aramid layers, resulting in a breaking strain of 120 kN and a safe working load of 20 kN. Three 4² copper conductors supply the ROV with electrical power and

7 drain wires serve as protective earth. A total of 6 loose fitted single mode fibres are available in pairs stored inside three individual metal tubes.

5.1.4.4 Topside Equipment

The 3kV topside transformer weighs 400 kg and its dimensions are 800 x 550 x 1500 mm (LxBxH). The transformer receives 400 V from the ship and converts them to 3000 VAC at 800 Hz to be supplied to the onboard transformer of the ROV. The corresponding filterbox, for compensating unwanted power peaks, weighs 100 kg and has a size of 400 x 600 x 1800 mm (LxBxH). All devices required to operate the ROV, such as the main computer with the control system, are installed into a double sized 19" flightcase. Two more flightcases with monitors displaying the ROVs cameras, the sonar and navigation map, are part of the topside equipment.

5.1.4.5 Tools

Samples collected from the seafloor or scientific tools like nets, can be stored in a sample box (600 x 900 x 320 mm, LxBxH) which can be opened and closed hydraulically (Fig. 5.4.4). The sample box is integrated in the front part of the toolskid, mounted underneath the ROV. The sample box has 5 single compartments and a Biobox with two individual compartments for storing live organisms. The Biobox is closed by a toplid and keeps the seawater inside even after recovery of the vehicle. During the dives, 2 nets were taken onboard in front holsters of the sample box. A knife was also installed in the front holster in case the ROV gets entangled in a long line or similar. A smaller, third net was installed later during the campaign in a side holster on the starboard side of the vehicle. To collect water, a 5l Niskin bottle was installed on the aft port side of the toolskid. The bottle was fired with an hydraulical closing mechanism. As a standard device, MARUM-Squid is equipped with a SeaBird SBE37 CTD probe, that measures oceanographic parameters such as temperature, salinity or oxygen.

5.1.4.6 Performance

During RV MARIA S. MERIAN cruise 86 , a total of 8 dives (#39 - #46) were carried out down to a maximum diving depth of 1203 m. Dive #39 was used as a test-dive to train deployment and recovery with the ship´s crew and as a general vehicle check while in the water. During dive #40 a "Circulation Obviation Retrofit Kit" (CORK) was recovered. The CORK was installed during RV MARIA S. MERIAN cruise 57 with the MeBo 70 drill-rig off Svalbard at 79°0.418N / 6°54.251E (MeBo station #127). It consists of a pressure-housing with a thread adapted to the MeBo drill-pipes and is equipped with temperature/salinity sensors and a pressure transducer. The unit was unscrewed from the drill-pipe with the manipulator and stored in dedicated holster on the front of the ROVs sample box.

Six scientific dives were carried out in the main working area at the Vesteris Seamount in depths between 157 m and 1150 m. MARUM-Squid spent ~32 hours at the seafloor for scientific documentation and sampling of sponges and rocks. The same amount of time is avaliable as MiniZEUS HD, and videos from the tiling screen, that were recorded for the duration of the scientific work program at the seafloor. In addition, 316 high resolution still pictures were taken and CTD data were continuously logged down and up the water column and all along the dive track on the seafloor.

The MiniPOS/NAV3 inertial system was sending either no, or wrong headings since the beginning of the campaign. The calibration routine was run several times at the seafloor in order to restore correct headings, however without success.

A series of low resistance values on the 24V bus system caused the line insulation monitoring system to shut down the vehicle during the deployment of dives #40 to #42. This made an extensive search for the reason necessary, including several deck and water dip tests. The resistance values became stable after the re-deployment of the ROV for dive #42 on the 29th of August.

The ship based DP "ROV follow" mode was activated when the ROV has reached the seafloor. If the ROV would leave a virtual circle of 10 m around its center, the ship would follow the ROV automatically at a given speed. A large part of coordinating ROV and ship the common way, consists in advising the vessel where to go, to stop and to continue the track via Intercom. The "ROV follow" mode takes over this workload, which eases the dive operation for the nautical crew and the ROV pilots.

5.1.5 Short Summaries of ROV Dives

(W. Bach, C. Beier)

Dive 041 / Station MSM86_010ROV

The ROV was on bottom at 08:22, we observed an inclined slope with mud and occasional rock fragments and sparse biota attached to rocky substrate consisting of sponges (Yellow sponge crusts, Schaudinnia, Clathria). The dive started at 73°30.583'N and 09°08.676'W at 670 m water depth. We drove 200 m distance up the slope and collected benthos and rocks. The heading while driving was 315 to 015. Collected were five sponge samples and seven rock samples. Most rock samples had benthic organisms attached. The benthos was dominated by sponges (poecilosclerid yellow crusts and Clathria as well as Schaudinnia and unindentified demosponges). Bryozoans were typically associated with sponges in small colonies that often developed on top of indurated masses of rocks that protruded from the seafloor. These appeared to be indurated chunks of mass waste deposits with dominant volcanic debris. Abundant shrimp and rare cnidarians (crinoids and brittle stars) were observed. The seafloor was mostly made up of pelagic sediments initially in the dive. The muddy surface was littered with rocky fragments and occasional accumulations of lapilli. Areas with mass wasted courser volcanic debris (to boulder-sized) were also passed. Those areas had more abundant and bigger sponges. Outcrops of in situ volcanic rocks were not encountered in the dive. The dive ended at 13:00 at a water depth of 516 m.

Dive 042 / Station MSM86_052ROV

The ROV was on bottom at 09:22 starting at an inclined slope with muddy sediment with sparse biota. The dive started at 73°31.08'N and 09°08.79'W at 300 m water depth. The landing site was upslope from where Dive 041 took place. We drove 50 m northeast across muddy slopes with scarce biota, mostly brittle stars. We turned north to climb up the steepest part of the outer crater wall. The lower reaches of the crater wall look very similar to the slopes of the debris fan we crossed before. Sponges are more abundant here. We collected two demosponges (1B, 2B) from a depth of 290 m and continue traversing up the slope. The biota richness increased markedly before we reached a perpendicular wall at 270 m depth. The wall exposed heavily Fe-stained rocks, apparently hydrothermally altered pyroclastic rocks or redeposited volcanic material. Despite countless attempts, only a very small rock sample (3R) could be retrieved from the wall. It turned out to be black coarse ash and small lapilli cemented by red crumbly Fe-oxyhydroxide. Joint surfaces in the outcrop show yellow scaling. We hypothesize that the wall represents the wall of a fissure that opened before the slope failed and was conduit of upwelling hydrothermal fluids (likely low-temperature). After the slope had failed the mineralized fissure wall was exposed and stands proud of the unindurated debris around it. We followed the wall (it strikes N-S) to the point where it disappears in the smooth slope and took a sample of the sediment (4S) with the mussel scoop and collected a slab of serpulid mat (5B) as well. A strange sponge with budding-like protrusions was also collected

(5B). Continuing further upslope in a northerly direction, we encountered another vertical wall at 245 m depth. This one also strikes N-S is >5-m high and exposes brecciated rock with reddish staining and cementation. An angular piece of volcanic rock (probably representing a lava flow unit) was retrieved (7R) and a sediment sample with abundant annelids was collected with the scoop net (8B). Away from the wall, the seafloor is almost continuously overgrown by dense colonies of bryozoans with sponges and crinoids as well as annelids. We came up the smooth slope to 210 m and collected seafloor samples through thick mats of bryozoans and serpulids. Recovered numerous black lapilli this way (sample 9R). We came off the seafloor with the sonar switched to widest range and see only smooth and gently sloping seafloor with a crater rim at 200 m and a cone-shaped structure on the rim that reached up to 180 m water depth. No rocky outcrops shallower than 245 m at all. The dive ended at 13:20 85 at a water depth of 180 m.

Dive 043 / Station MSM86_061ROV

The ROV was on bottom at 06:45, we started flying south and up sedimented and debris-littered slopes from 500 m to 420 m depth. We collected five sponge samples on our way (1B-5B) from depths between 477 and 436 meters. Sample 5B included a good-sized piece of volcanic rock to which a sponge was attached. We reached a vertical wall exposing volcanic strata at 420 m depth. Laminated pyroclastic rocks at 435 m depth are well-exposed, but could not be sampled due to the smoothness of the outcrop surface. We transected up the slope to 290 m depth, where the steep wall transitions into gentle slope, sedimented, and heavily colonized by sponges and bryozoans. We turned around to sample uppermost part of steep wall. Got several small pieces (6R) off a vertical cliff exposing what appears to be massive lava. Going down slope again and tried sampling massive rock from outcrop in several locations without any success. Finally landed on slope of talus pile underneath the vertical wall at 386 m depth and collected three pieces of rocks from the pile (7R). Then took a scoop sample of the sediment with rock pebbles (8R). Winch problems caused us to stay around 380 m depth for the final two hours of the dive. We collected sample 9R to 10R as well as a scoop sample of volcanic debris (11R) on our westward transit to the central volcanic neck.

Dive 044 / Station MSM86_081ROV

The ROV was on bottom at 10:30. After the Minipos was successfully calibrated, we began the survey at 11:00 going up a smooth slope to the west of landing site. We came up slope from 230 m to 160 m depth and collected four sponge samples (1B-3B,5B) and a scoop net (4S). No rocky basement was evident. Sample 1B (a spherical sponge) has a cm-size piece of volcanic rock attached to it. A scoop sample was mainly bio debris (bryozoans, sponge needles) but small pieces of volcanic rock (probably clasts from hyaloclastite) were also collected.

We flew to the east to inspect a steep, southwest-facing slope of the crescent shape wall around the central cone. The slopes are steep initially but feature no rocky outcrops. Starting at

180 m depth, 3 to 10 m high perpendicular walls rise up. Sampling them with the ROV claw was virtually impossible. Countless attempts yielded only small pieces of rock (6R). The rocks are brecciated and in places heavily iron-stained. A flappy sponge growing on one of the perpendicular walls was collected (sample 7B). We dropped a target for station MSM86_081-2TVG and continued to the northwest to examine another vertical wall that shows similar features. No sampling was possible there either. At 160 m depth, there is sudden transition to gently dipping smooth slope that is entirely covered by thick (>1 m) deposits of bio-debris. End of dive was at 15:07. (Sampling at the target position by TVG that same day showed that the rocks are hyaloclastites.)

Dive 045 / Station MSM86_086ROV

We arrived on bottom at 07:30 and Minipos calibration was completed at 08:00. A very rough terrain with near-vertical walls exposed pillow lavas. We flew up the slope in a northwesterly direction and took a sample of the pillow lava (1R). We continued up slope and came across a change in lithology to slabby rock, perhaps sheet flows. We took a rock sample (2R). A bit further up the slope, a steep-sided NW-trending ridge came up. Its NE side is made up of slabby lava, the SW side of the ridge appears to be a headwall of a rock fall. We sampled a hexactinellid sponge (3B), a piece of jointed lava (4R), and another sponge (branched, likely a carnivorous type; 5B) all from a small area at about 1125 m depth. A bit further up the slope, the terrain changed again to irregular and hummocky. A small outcrop exposes lobate flows (still photo). The upper reaches of the slope expose pillow lava and massive evidence for mass wasting. A piece of lava was collected from a head wall (6R) at a depth of 1100 m. The slope flattens at 1080 m and we continued flying on a NW course. We noticed a cone-like feature in the sonar and headed NE to explore it. The top of the small peak is at 1056 m. There is a notable change in the fauna, as there are very few sponges here. We sampled several pieces of brittle hyaloclastite (7R) and took a scoop sample of two very small sponges (8B). Further NW, a sample of hyaloclastite (9R) and a large piece of scoracious lava (10R) were collected. Approaching a pronounced ridge (NW-SE), the lava is more massive and slabby; at 1042 m depth, we collected a sample of it (11R) and took a scoop sample for biology (12B). Went down to 1075 m depth into a local depression SW of the ridge and collected two more sponge samples there (13B and 14B). The dive ended at 12:52.

Dive 046 / Station MSM86_094ROV

We were on bottom at 07:15; the landing site is a local depression between three volcanic cones, of which the two northermost ones were to be sampled. We went up the east-facing slope first and encountered discontinuously sedimented slopes with countless outcrop of mostly bulbous pillow lava. We flew up from 860 m to 803 m water depth and collected several sponge samples (1B, 2B, 4B, 7B) and a sample of pillow lava (3R) as well as platy volcaniclastic or sedimentary rocks (5R, 9R). A scoop sample (6S) yielded sediment with rubbly pieces of lava. The opposing slope was also sampled between 855 and 793 m water depth. The slope looks similar in that it predominantly exposes patchy sediment cover and pillow lava outcrops. We collected three more sponge samples (10B, 14B, 16B) and volcanic rocks, mostly lava. The lava types sampled include sheet flows and pillow flow. We finished the dive at 12:45.

5.2 Seafloor mapping

(W. Bach, C. Beier, L. Kramer, A. Strack)

The following section provides a first description of the geological structures in the four work areas. These interpretations are based on bathymetry and backscatter data as well as on results from rock sampling and video-footage of the TVG and ROV (Vesteris Seamount only).

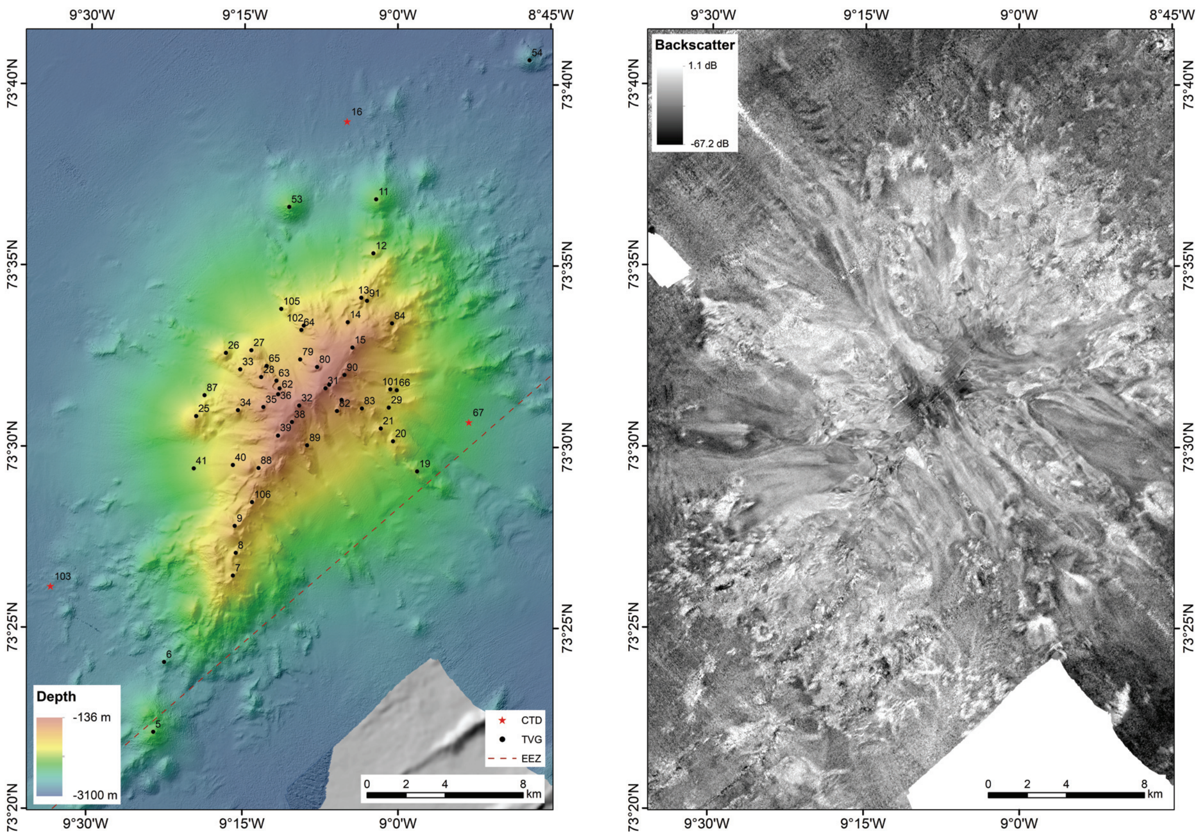

Fig. 5.2.1.1: Raw bathymetry of MBES EM122 and EM712 and backscatter imagery for Vesteris Seamount. Location of EEZ (red dashed line) and station numbers are plotted. Background GEBCO data is shown as grey hillshade.

5.2.1 Vesteris Seamount

The bathymetric obtained from the EM122 and EM712 hull mounted multibeam systems show that the structure of Vesteris Seamount is elongated in a North-South direction cut orthogonal by several volcanic ridges (Fig. 5.2.1.1). The new bathymetric imagery reveals a number of previously not recognized small volcanic cones, both on the central edifice and the flanks. Parasitic cones occur North and South of Vesteris Seamount but are covered by thick layers of sediment as evident from the backscatter imagery. The cones and ridges in the topmost part of Vesteris Seamount are covered by thick units of hyaloclastite that form steep outcrops and are underlain by pillow lavas and laminated pyroclastic rocks. We interpret the North-South elongated structure of Vesteris Seamount to reflect an initial spreading movement of the seamount. The hyaloclastites may be witnesses of fissure eruptions and lava fountaining. The East-West trending ridges partly display crater structures as well as volcanic ridges with steep flanks rising several of ten's of meters above the surrounding edifice. The ridges and cones in the central Vesteris Seamount area show hard reflectors in the newly obtained backscatter imagery. Particularly obvious in backscatter are bright spots corresponding to hummocky terrain in bathymetry. Those areas correspond to lightly and incompletely sedimented pillow mounds composed of fresh, glassy lava. Similarly obvious are debris flow fans that are due to flank collapse and extend from steep headwalls in depths <600 m to the floor of the basin. These collapse scars expose older basement in a number of places, which was also sampled. The occurrence of parasitic cones on all flanks of Vesteris Seamounts suggests that they may be situated on a radial stress field initiated by volcanic uplift.

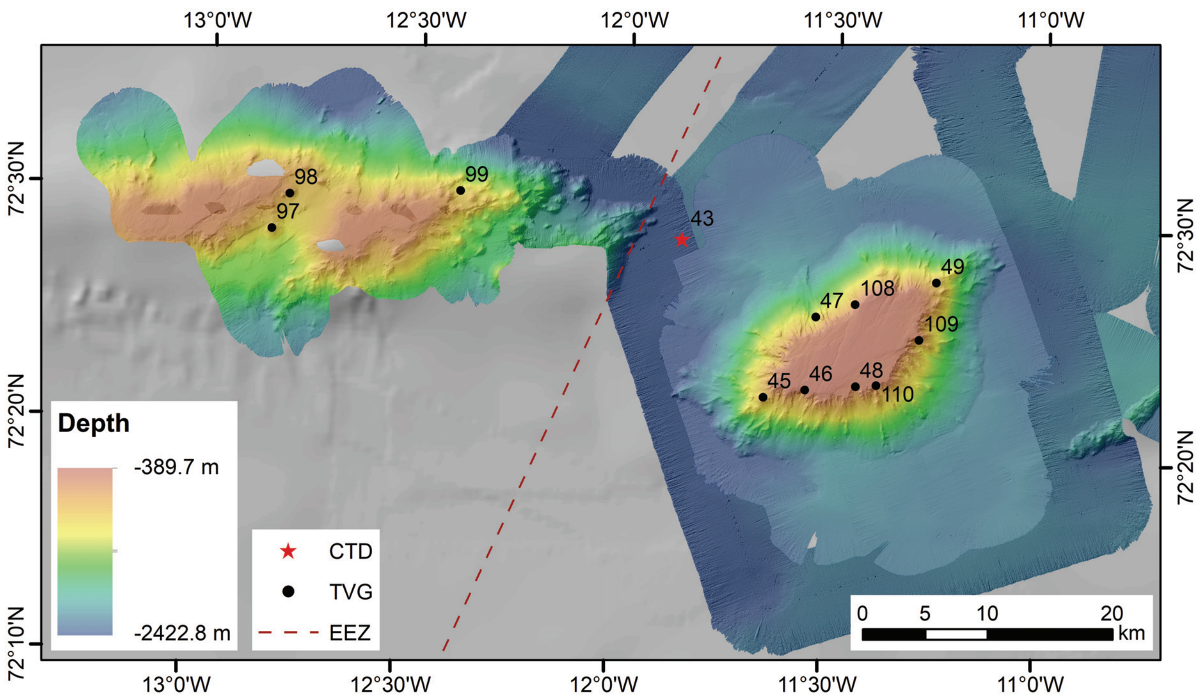

Fig. 5.2.2.1: Raw bathymetry of MBES EM122 for Southern Seamount and east Logi Ridge. Location of EEZ (red dashed line) and station numbers are plotted. Background GEBCO data is shown as grey hillshade.

5.2.2 Southern Seamount and Logi Ridge

The new bathymetric data from MSM86 reveal that the Southern Seamount and Logi Ridge rise from almost 3000 m to depths as shallow as 300 m with shallow flat tops (Fig. 5.2.2.1). Iceberg scourings were determined in the bathymetric imagery indicating that the Southern Seamount – unlike Vesteris Seamount – has likely not been active in the Pleistocene. The flanks of Southern Seamount are steep and gullied with debris flow deposits extending into the surrounding basin. The eastern part of Logi Ridge appears to consist of two large volcanic edifices striking in a SW-NE direction subparallel to the Southern Seamount. At water depths of >500m we did not observe any glacial erosion marks. In water depth >600 m small volcanic cones are visible in the hydroacoustic data, but the TVG station did not turn out any volcanic substrate, just diamicitic sediments. We interpret the Southern Seamount and the eastern Logi Ridge to consist of a series of volcanic centers that are aligned from West to East and all strike in a SW-NE direction. These volcanos were eroded during the Pleistocene and have not been magmatically active since.

5.2.3 Northeastern Area

The new bathymetry of the northeastern working area features ridges that run parallel to the Mohns Ridge and likely represent the tips of rotated fault blocks (Fig. 5.2.3.1). Those were not

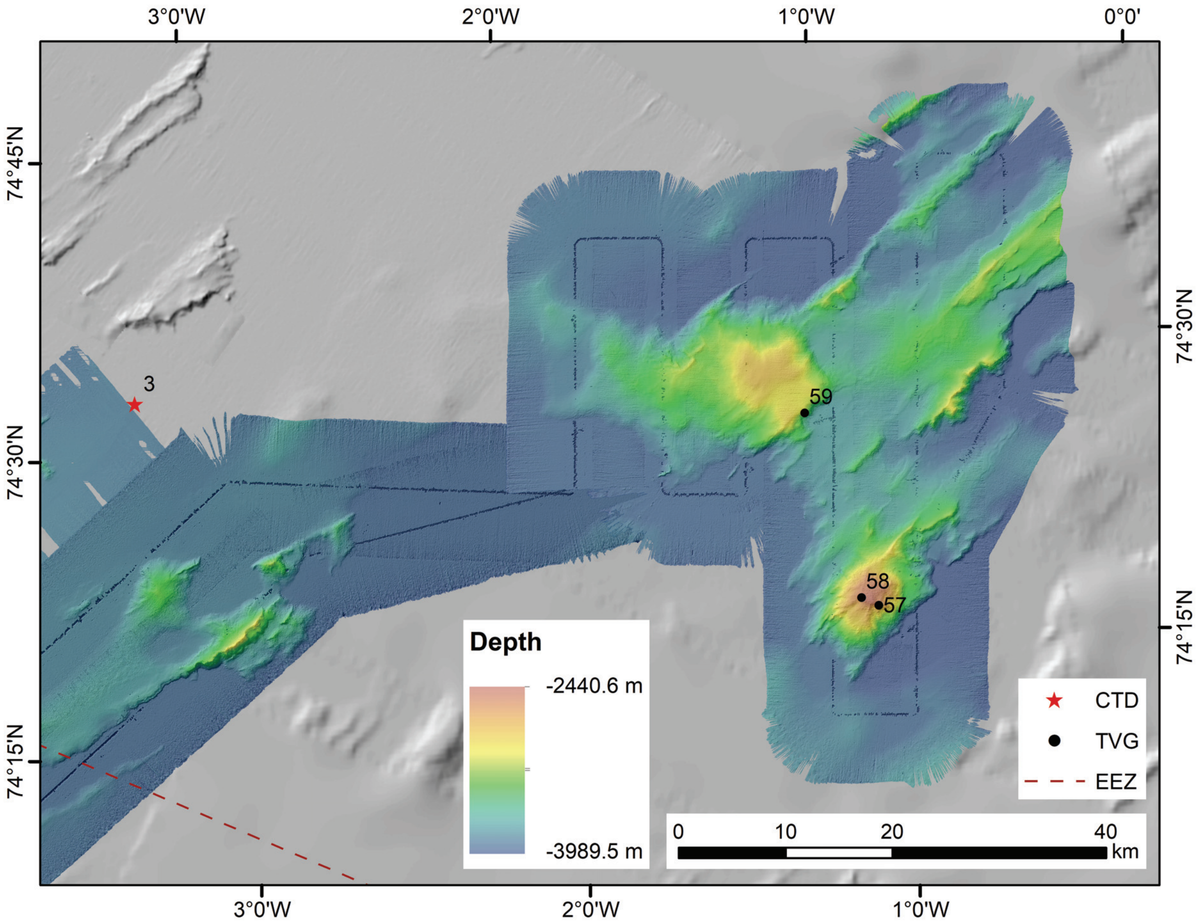

Fig. 5.2.3.1: Raw bathymetry of MBES EM122 for the NE area. Location of EEZ (red dashed line) and station numbers are plotted. Background GEBCO data is shown as grey hillshade.

sampled. In addition there are two seamounts (i.e., features rising more than 1000 m above the surrounding seafloor) that lack a preferred elongation. These could be volcanic features implying excess melting along the ridge. These seamounts are structurally similar to off-axis seamounts from modern mid-ocean ridges. The newly obtained backscatter images reveal that the reflections are relatively homogeneous suggesting covering by layers of deep-sea sediment. The hydroacoustic data was used to select steep sections with changing backscatter pattern for the TV grab stations. The occurrence of hard reflections was confirmed to represent outcrops of Mn-encrustations containing fragments of peridotite (057TVG). Another station (059TVG) on the westernmost of the two seamounts turned up hydrothermally altered olivine gabbro. These finding conclusively show that both seamounts are not of volcanic origin. Instead, they represent oceanic core complexes that expose lithospheric mantle and gabbroic intrusions along long-lived normal faults. Footwall rotation of these detachment faults gives rise to the smooth, turtle-back shape of these exposures. The occurrence of oceanic core complexes (OCCs) off-axis of the Mohns Ridge is not surprising, given the very slow spreading rate of this spreading center (< 8mm/yr half rate). Still, OCCs had so far not been reported from the northern North Atlantic. The two occurrences can be linked up with the Schultz Massif along a line that runs perpendicular to the strike of Mohns Ridge and the magnetic lineations in the eastern Norwegian-Greenland Basin. The Schultz Massif is also an OCC that had recently been exhumed in the inside corner of where Mohns Ridge bends into Knipovich Ridge. Our finding hence suggest that this particular segment of the Mohns-Knipovich Ridge system may have been volcanically starved for some time.

5.2.4 Luise Boyd Seamount Much closer to the Mohns Ridge is the Luise Boyd Seamount, only 12 km north from the spreading axis (Fig. 5.2.4.1). Hydroacoustically, three domains could be recognized at Luise Boyd Seamount: (1) a smooth and soft summit area, (2) a long and steep southeastern slope cluttered with erosional gullies that give witness to mass wasting event, and (3) a hummocky and hard terrain, which surrounds most of the summit area and resembles the appearance of pillow mounds. Sampling with the TV-guided grab yielded diamicitc muds and dropstones from the summit area and the expected pillow basalts from the hummocky terrain. Two samples of massive basalts were also recovered from talus piles on the steep southeast facing slope, which extends to the >3000 m deep rift valley floor. Luise Boyd Seamount is definitely volcanic in origin and may point to an episode of increased magma flux. The present-day rift valley floor is deep (>3500 m), indicating that the present-day magma flux is not increased.

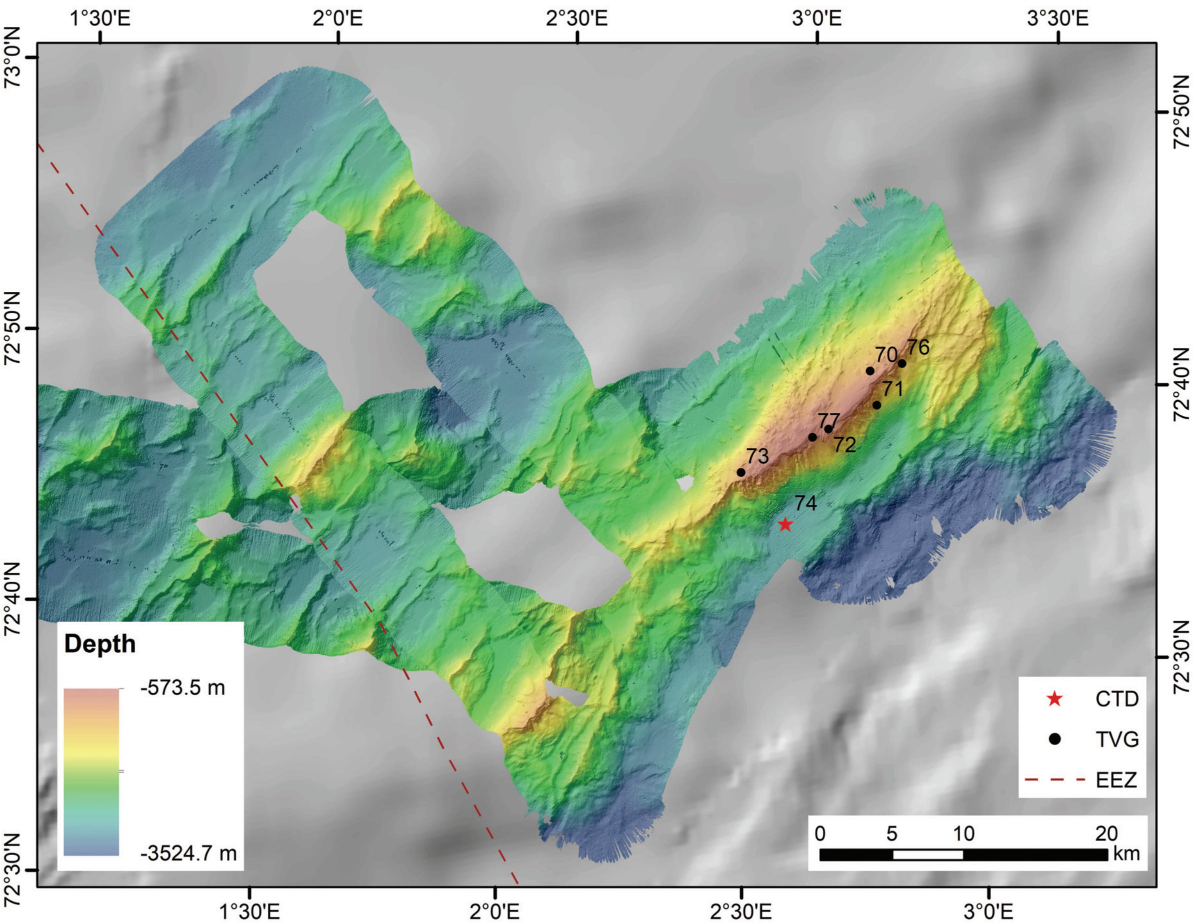

Fig. 5.2.4.1: Raw bathymetry of MBES EM122 for Luise Boyd Seamount. Location of EEZ (red dashed line) and station numbers are plotted. Background GEBCO data is shown as grey hillshade.

5.3 Petrological Sampling

(C. Beier, J. Bauer, A. Röhler, A. Schaarschmidt, K. Unger-Moreno, W. Bach)

5.3.1 Sampling and Methods

Igneous, sedimentary and biological samples during MSM86 were taken with the Remotely Operated Vehicle (MARUM-Squid) of the MARUM-ZENTRUM FÜR MARINE UMWELTWISSENSCHAFTEN in Bremen and with a video-guided grab (TVG) from GEOMAR HELMHOLTZ-ZENTRUM FÜR OZEANFORSCHUNG. Sample locations for the ROV (see 5.1.4) and the TV-guided grab (5.1.3) were selected based on hydroacoustic data (bathymetry and backscatter). Areas with high backscatter intensity or steep slopes were usually chosen, in order to increase the chances of sampling volcanic substrate. Visual observations made during the individual deployments provided detailed guiding in the collection of hard rock and biological samples. At Vesteris and Southern Seamount, most samples with the TV grab were successfully recovered from steep walls. On board, samples were cut, described and packed for petrological and geochemical analyses at the University of Bremen, the GeoZentrum Nordbayern, Friedrich-Alexander Universität Erlangen-Nürnberg and the University of Helsinki.

5.3.2 Petrological Observations and Preliminary Interpretations

The sampling strategies by TV grab and ROV MARUM-SQUID were adjusted to reflect the hydroacoustic survey observations on a daily basis (Fig. 2). ROV dive and TV grab localities were defined based on bathymetry (e.g., steep slopes) and backscatter intensity (bright=hard=exposed basement). This strategy principally worked out well, as most of the TVG stations were successful in retrieving volcanic rocks. During the entire cruise we performed 6 ROV dives recovering a total of 31 rock, 33 biological and 5 sedimentological samples). Seventy-three TV-grab stations gave 132 rock, 393 biological, and 107 sediment samples.

The preliminary results will be grouped according to the four working areas: Vesteris Seamount, Southern Seamount and Logi Ridge, Northeastern Area, and Luise Boyd Seamount (Figs. 5.2.1.1-5.2.4.1).

Vesteris Seamount

Igneous rock samples from the shallower part of Vesteris Seamount (<300 mbsl) are covered by biogenic sediments, sponge and bryozoan faunal communities. The samples recovered range from fresh glassy scoria (similar to lava balloons in some cases), to variably vesicular alkaline pillow and block lavas. Hyaloclastites and ashes occur frequently. Lavas sampled from cones and edifices along the southern flank of Vesteris Seamount consist of pillow lavas (009TVG, 010TVG), scoria (008TVG) and volcaniclastic sediments (028TVG, 032TVG, 038TVG) covered by biogenic sediments, thin layers of lapilli and ash, and FeOOH encrustations (Fig. 5.2.1.1). Cones shallower than 1000 mbsl frequently contained highly vesicular scoria, often glassy covered by thin layers of FeeOH crusts. Between depths from 2000-1000 mbsl we did not observe a systematically decreasing sediment coverage. Station 005TVG dominantly contained fine-grained, consolidated sediments with few basaltic pebbles. Fresh pillow lavas and fresh, glassy lapilli and scoria intercalated by foraminiferous ooze and biogenic sediments were recovered from the northern flank of Vesteris Seamount. Lavas and glasses are exclusively fresh and gas-rich extremely vesicular extending up to depths of almost 1600 mbsl (011TVG-015TVG). Lavas from the western flank partially consist of pumiceous, welded samples that are relatively SiO_2-rich in composition with abundant plagioclase and few clinopyroxene and amphiboles. Outcrops along the central part and the eastern and western flanks close to the central volcanic edifice (081ROV, 086ROV) are relatively steep and also show abundant hyaloclastites and pillow lavas (e.g., 101TVG, 106TVG). With decreasing depth, younger rocks appear and volcaniclastics samples (hyaloclastites and ash-rich sediments) become more abundant (081ROV). Fresh alkaline lavas and pumiceous samples occur along crater rims of the smaller eruptive centers of Vesteris Seamount on the top. The southwestern parasitic cones of Vesteris Seamount features vesicular alkali basalts and scoria with scoriaceous bombs being abundant. The lavas are generally covered by layers of both, volcaniclastic (039TVG, 041TVG) and biogenic (040TVG) sediments. The ROV dives (e.g., 061ROV) reveal that the flanks of the seamount are covered by thick biogenic and volcaniclastic sedimentary layers, which are interrupted by steep wall exposing pillow lavas, and hyaloclastites overlying layered volcaniclastic sequences (081ROV) and lava flows (061ROV). Dive 081ROV was performed on the central and eastern flank of Vesteris Seamount. The topmost part of the seamount consists of hydrothermally overprinted hyaloclastites forming dome like structures (081ROV, 081-2TVG). The eastern cones consist of fresh to mildly altered pillow lavas and grab 084TVG recovered numerous pillow lavas containing large pyroxenes and mafic xenoliths.

In summary, we observed that the rocks recovered from Vesteris Seamount range from vesicular alkali basalts and scoria to hyaloclastites and ashes. The shallower parts of the seamount <300 mbsl are dominated by volcaniclastic rocks formed by hydroclastic fragmentation, the flanks and parasitic cones of Vesteris Seamount display exposures of aphyric to phyric pillow lavas containing mostly plagioclase, clinopyroxene, and minor amounts of relatively fresh olivines.

Southern Seamount and Logi Ridge

Samples recovered from Southern Seamount (045TVG-049TVG) reveal that it is covered by a thick sedimentary layer containing numerous igneous and sedimentary dropstones. Station 047TVG (Fig. 5.1.2.1) was performed along a ridge on the northern part of the Southern Seamount and we found large volcanic ridges along with several canyon-like structures several ten's of meters in heights. The in-situ samples recovered are relatively fresh alkali basalts confirming that the Southern Seamount is indeed volcanic. Samples recovered from 048TVG and 049TVG are mostly glacial sedimentary and igneous, plutonic dropstones, however, both sampling stages on the south and east of the volcano also contained relatively fresh, non-rounded alkali basalts. The occurrence of relatively young, fresh igneous rock samples may be consistent with a relatively young age of the igneous edifice that was subsequently eroded during the Pleistocene and has not been active since.

Northeastern Area

Outcrops on the northeastern area are sparse, and most of the seamounts are covered with diamictic sediments with abundant dropstones (057TVG, 058TVG; Fig. 5.1.3.1). Few older outcrops covered with these sediments expose Mn-crusts and -concretions several ten's of centimeters in thickness. The cores of these encrustations commonly consist of strongly clay-altered mantle peridotite. Small fragments of serpentinized ultramafic rock samples, chrysotile veins, and clay (057TVG) were also recovered. Few Mn-crusts contain fragments of basalt and gabbro. We interpret the occurrence of peridotite in these samples to have formed an oceanic core complex, that formed close to the spreading axis, subsequently covered by Mn-crusts and glacial sediments. Station 059TVG revealed a few pieces of altered olivine gabbro, also indicative of an oceanic core complex; however, there was little to no Mn-crust coating observed.

Luise Boyd Seamount

Samples recovered from TV grab stations at Luise Boyd Seamount (070-073TVG) showed that the seamount is almost entirely covered by thick layers of diamictic sediments, numerous dropstones were recovered, however, three grabs (073TVG, 076TVG, 077TVG; Fig. 5.1.4.1) also contain microcrystalline lavas with few plagioclase and pyroxene phenocrysts. A single block of lava recovered from the northeastern flank of Luise Boyd Seamount contains large plagioclase phenocrysts and fresh olivine.

5.3.3 Expected Results – On-Shore Investigations

The petrology and geochemistry of the igneous samples from the Vesteris Seamount and the northern and southern edifices will be used to determine a large-scale model of the evolution of the central Greenland Sea. We will obtain mineral thermobarometric data and diffusion timescales on the fresh, igneous samples of Vesteris to determine the timescales and depths of magma evolution underneath Vesteris Seamount and compare these to results from volcanic edifices erupted on a much thicker crust (e.g., Iceland) and at similar melting degrees (e.g., Azores, Canary islands). The major element, trace element and isotope geochemistry will be used to test whether Vesteris Seamount and the northern and southern edifices, respectively, are the earliest magmatic edifices of a new spreading axis opening in the central Greenland Sea. Our new bathymetric data along with structural observations and igneous geochemistry will reveal how the structural evolution of an oceanic intraplate volcano influences magma composition. By systematically sampling the parasitic cones and the main edifice of Vesteris we will be able to develop a spatial and temporal model of the evolution of an oceanic intraplate volcano. We expect the igneous petrological and geochemical results to be part of three-four MSc-thesis and to be published in peer-reviewed international journals. We also aim at publishing a synthesis publication of the results as an overview relatively short after the cruise.

5.4 Biological Sampling and Investigations

(B. Slaby, J. Peckmann, I. Caraite, F. de Carvalho, B. Rincon Tomas, J. Steger)

5.4.1 Porifera

(B. Slaby, I. Caraite, F. de Carvalho, B. Rincon Tomas)

Sampling

Sponge specimens were collected during ROV MARUM-Squid and TV grab (GEOMAR, Kiel) deployments, seawater references were collected by CTD. Sponges were photographed and subsequently samples were fixed for various analyses by the different cruise participants (see Appendix C2 for details). For DNA extraction, sponge samples were frozen at -80°C. For RNA extraction, samples were fixed in RNAlater. Ethanol and/or formaldehyde fixation were used for taxonomic analyses and fluorescence in-situ hybridization (FISH). Glutaraldehyde fixation was used for electron microscopy samples. Some sponge samples were additionally embedded in Tissue-Tek for cryo-microtome thin-sections. 2 L of ambient seawater from the sponge collection site were filtered on 0.2 µm filters, which were subsequently frozen at -80°C. Additionally, sediment samples were collected and frozen at -80°C.

Preliminary and expected results

We sampled several distinct morphotypes of sponges (Porifera) at the different seamounts in the working area. Fig. 8.1 shows a selection of the most prominent species illustrating the much higher diversity than previously published (Henrich et al. 1992). Sponges of the genus *Geodia* were the most abundant in our sampling campaign (Tab. 5.4.1.1, Appendix C2) accounting for 152 samples followed by the genus *Stelletta* with 31 sampled specimens. In general, the collection is dominated by sponges of the class Demospongiae (278 samples), but by the ROV footage we can see that glass sponges (class Hexactinellida) are also very common and diverse in this area and we were able to collect samples of 54 specimens mainly of the order Lyssacinosida (40 samples). Additionally, we collected and observed other fauna, such as anemones, crinoids, amphipods, ascidian, crustaceans, bryozoans and polychaetes ("associated fauna" in Tab. 8.1). The key sponge species that structure the different seamount ecosystems will be taxonomically identified. Since sponges are acknowledged to possess a difficult taxonomy, we will implement a DNA-assisted taxonomic system by complementing classical taxonomic methods (morphology) with molecular tools (mtDNA COI barcodes) that may lead to the discovery of new and/or cryptic species.

Type	Class	Order	Family	Genus	Species	Number of samples
Porifera (337)	**Demospongiae** (278)	Tetractinellida (219)	Geodiidae (152)	*Geodia* (152)	*Geodia hentscheli*	55
					Geodia phlegraei	28
					Geodia parva	15
					Geodia sp.	54
			Ancorinidae (31)	*Stelletta* (31)	*Stelletta raphidiophora*	2
					Stelletta sp.	29
			Tetillidae	*Craniella*	*Craniella* sp.	19
			Theneidae	*Thenea*	*Thenea schmidti*	16
			Vulcanellidae	*Poecillastra*	*Poecillastra* sp.	1
		Poecilosclerida (18)	Coelosphaeridae	*Lissodendoryx*	*Lissodendoryx* sp.	11
			Cladorhizidae (5)	*Asbestopluma*	*Asbestopluma A. furcata*	4
				Cladorhiza	*Cladorhiza* sp.	1
			Hymedesmiidae	*Hymedesmia*	*Hymedesmia* sp.	1
						1
		Polymastiida (6)	Polymastiidae (6)	*Polymastia*	*Polymastia* sp.	5
				Tentorium	*Tentorium* sp.	1
		Dendroceratida	Dictyodendrillidae	*Spongionella*	*Spongionella* sp.	1
		Axinellida	Axinellidae			2
						32
	Hexactinellida (54)	Lyssacinosida (40)	Rossellidae (36)	*Schaudinnia*	*Schaudinnia* sp.	18
				Asconema	*Asconema* sp.	17
				Trichasterina	*Trichasterina* sp.	1
			Euplectellidae	*Amphidiscella*	*Amphidiscella* sp.	4
						14
	Calcarea					5
Water references						28
Sediment references						22
Spicule mat						1
Associated fauna						40

Table 5.4.1.1: Overview of samples related to porifera sampled during MSM86.

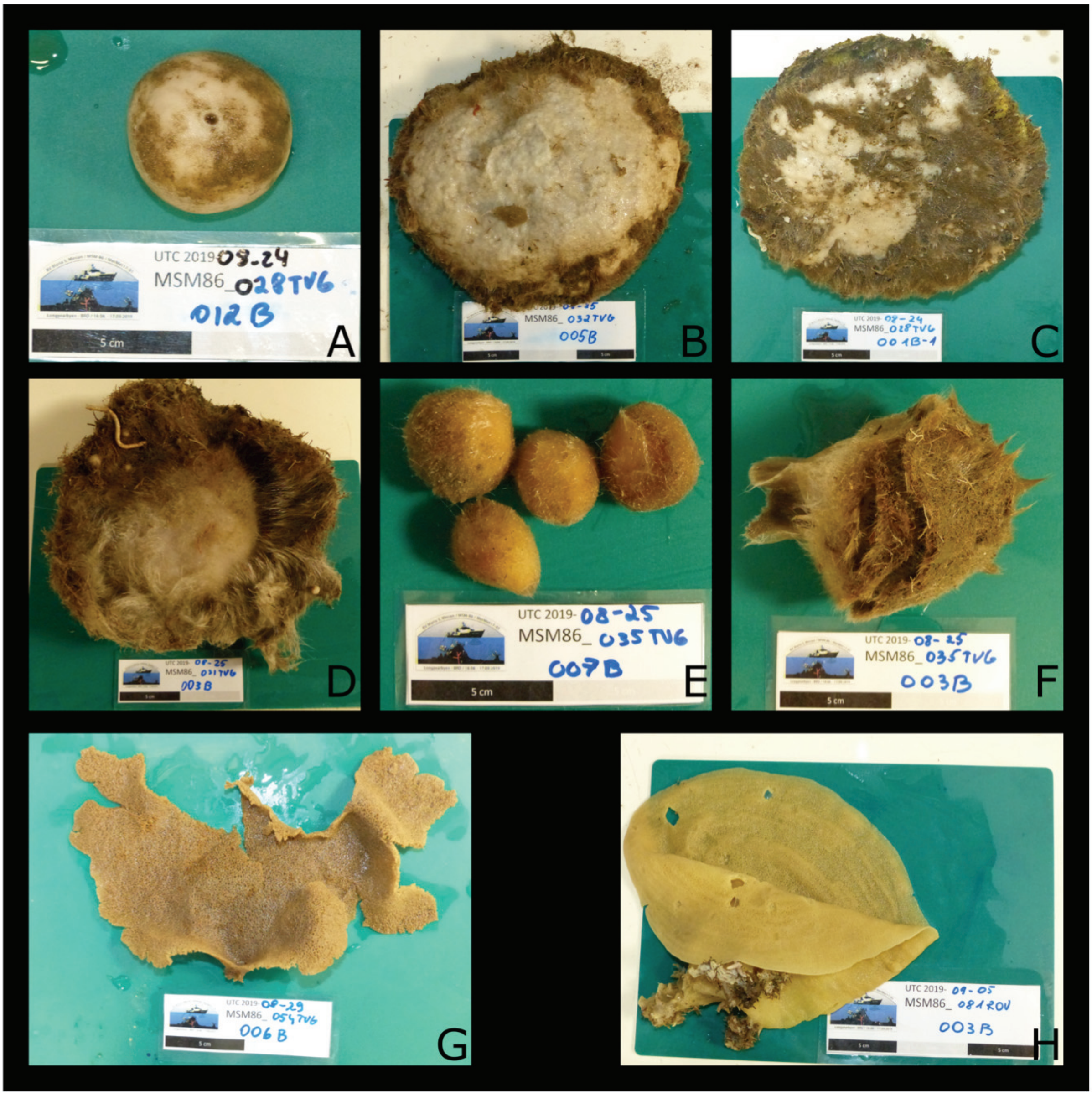

Fig. 5.4.1.1: A selection of the most prominent species sampled during MSM86. Specimens from three classes of Porifera were sampled: Demospongiae: A) *Geodia hentscheli*; B) *Geodia parva*; C) *Geodia phlegraei*; D) *Stelletta* sp.; E) *Craniella* sp.; F) *Thenea* sp.; G) *Poecillastra* sp.; H) a specimen of the family Axinellidae; I) *Lissodendoryx* sp.; J) *Asbestopluma* sp.; K) *Cladorhiza* sp.; L) and M) two specimens of different species of the genus *Polymastia*; N-T) specimens of other Demospongiae that could not be further identified on board. Calcarea: U-V) Calcarea specimens that could not be further identified on board. Hexactinellida: W) *Asconema* sp.; X) *Schaudinnia* sp.; Y) *Sychipidium* sp.

Diverse hexactinellids have been recovered from the various seamounts by ROV and TV grab, like *Asconema* spp. and *Schaudinnia* sp. among others. We expect to find a high amount of archaea in their tissues and find a particular association of the archaea to the base of the choanocytes as previously observed, by using geobiological approaches (e.g. biomarker analysis, FISH-based cell detection). Metagenomic analysis will provide then functional information on these microorganisms, giving us enough information to potentially understand the reason why these archaea accumulate in that specific area. Furthermore, we expect to find a

Fig. 5.4.1.1: continued.

record of archaea in the hexactinellid fossils and estimate the importance of these organisms in the development and evolution of Hexactinellida.

The resistance of sponge-associated microorganisms to cultivation requires usually the use of cultivation-independent methods to gain information on microbial diversity and function. To reveal the microbial diversity of the collected sponges and make comparisons with data from earlier sampling campaigns, amplicon sequencing of a maximum diversity of sponge species (along with seawater and sediment controls) will be performed following the EMP protocols for DNA extraction (http:// www.earthmicrobiome.org/). The V3-V4 region of the 16S rRNA gene will be chosen for PCR amplification. Amplicon data will be processed following established protocols. Additionally, the same DNA extracts may be used to assess associated microeukaryotic diversity, which includes fungi and unicellular eukaryotes, based on ITS-region amplicon sequencing. To get insights on the functional repertoire of the sponge

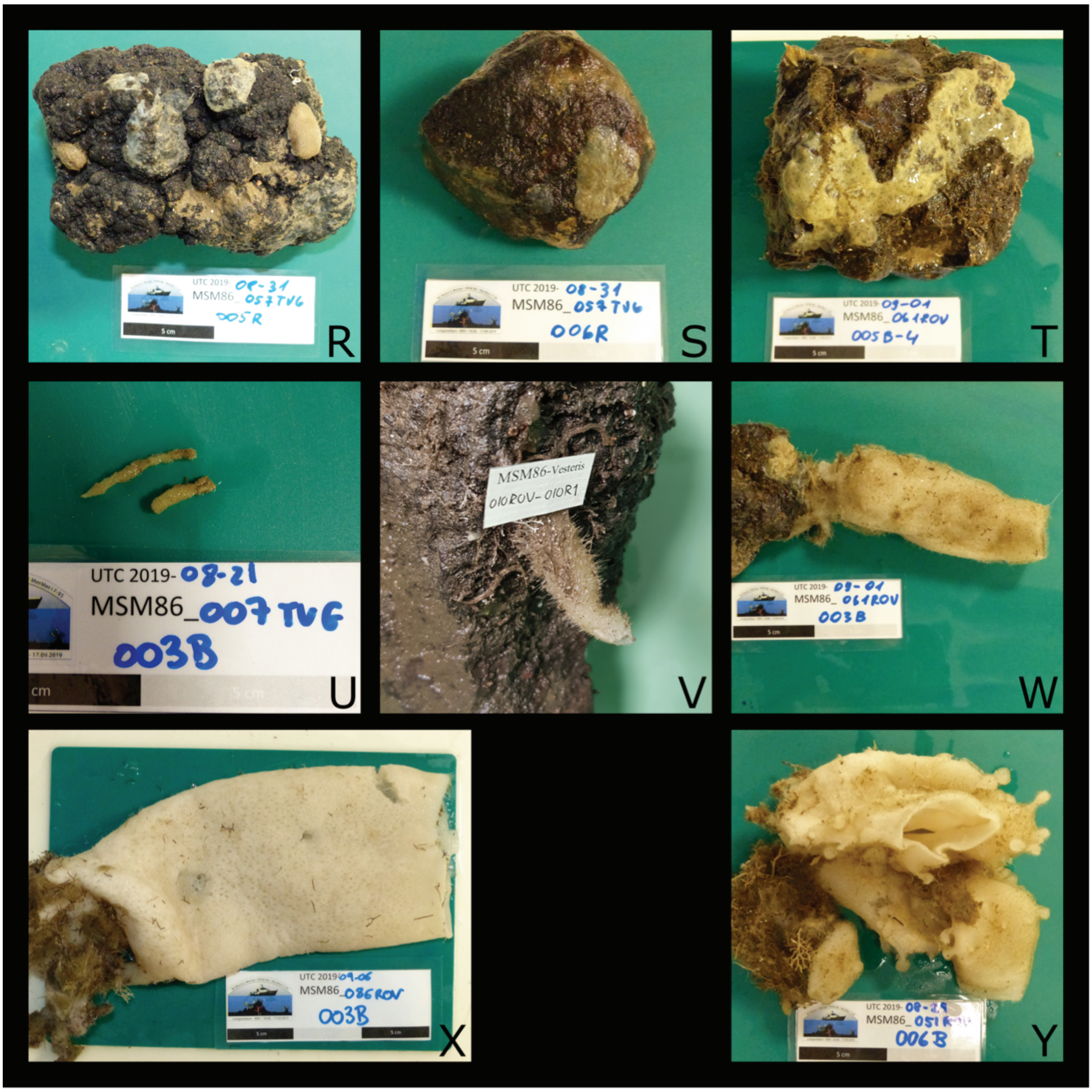

Fig. 5.4.1.1: continued.

microbiota, metagenomic sequencing will be conducted ideally from enriched microbial fractions. Shotgun sequencing libraries will be prepared and sequenced on the Illumina HiSeq platform. Sequence assembly, annotation, and functional gene prediction will be performed using state-of the art assemblers and pipelines. Relevant metadata (e.g. depth, temperature, oxygen) will be implemented to test specific scientific concepts on ecosystem function.

5.4.2 Other benthos (with a focus on molluscs)

(J. Steger, J. Peckmann)

Introduction and aims

The detailed account by Henrich et al. (1992) highlighted the presence of diverse, morphologically complex benthic communities at Vesteris Seamount and revealed a pronounced faunal zonation along the depth gradient from summit to deep slope areas. Seafloor image analysis was used to investigate the distribution of larger-sized, epibenthic communities, however, actual benthic samples needed for assessing the diversity and community composition of cryptic, small-sized and/or infaunal taxa were so far limited to a few box corer and TV-grab stations (Henrich et al. 1992).

Benthos is a good indicator of local environmental conditions, as most taxa are characterized by sessile lifestyles or limited mobility, coupled to often rather long lifespans. Molluscs in

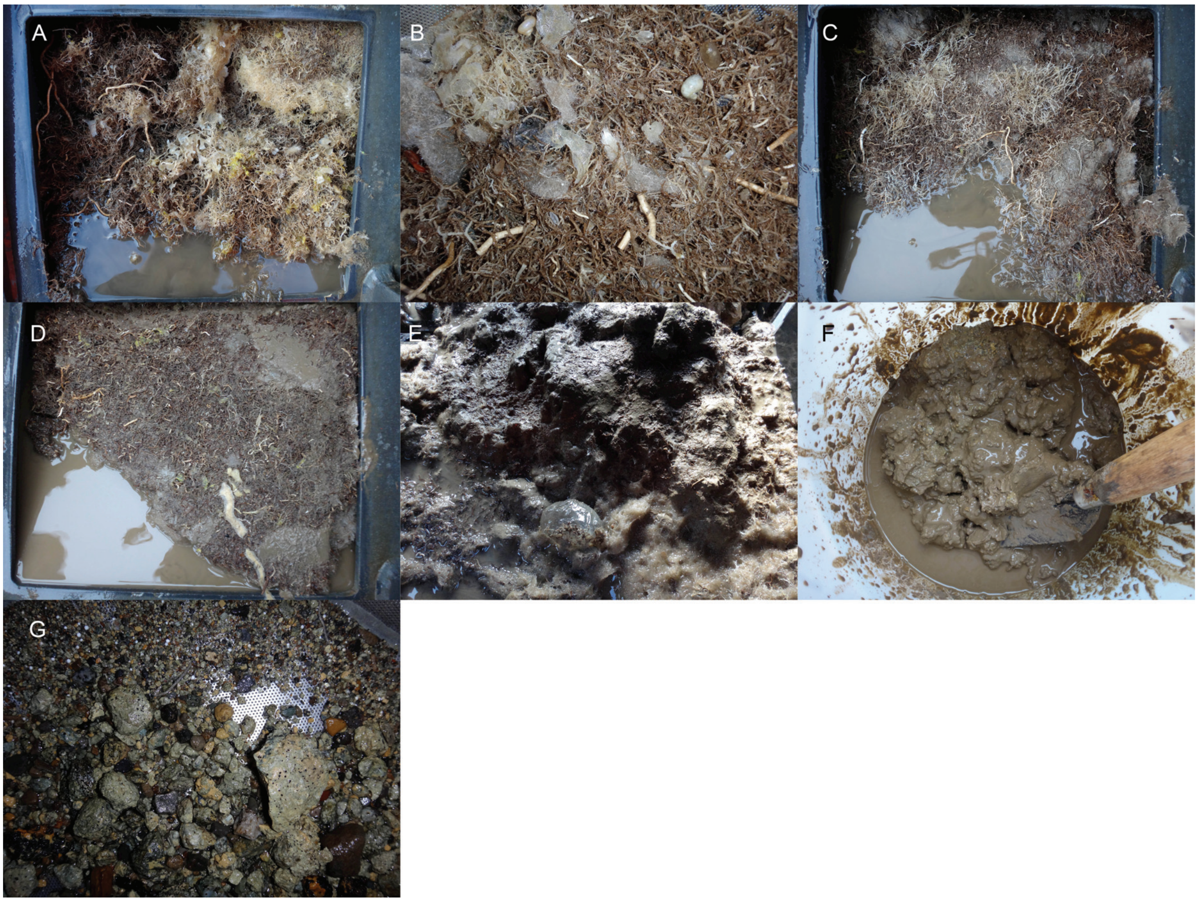

Fig. 5.4.2.1: Examples of sediment samples collected with the TV-grab at various depths and locations during MSM86. **A)** Stn. MSM86_080TVG, Vesteris Seamount Top West, 172 m water depth; **B)** same station, sediment sample taken for macrofauna analysis and sieved with 0.5 mm mesh size; **C)** Stn. MSM86_062TVG, Vesteris Seamount Top West, 363 m water depth; **D**) Stn. MSM86_063TVG, Vesteris Seamount Western Slope, 538 m water depth; **E)** Stn. MSM86_077TVG, Luise Boyd Seamount, 665 m water depth; **F)** MSM86_059TVG, north-east core complex area, 3094 m water depth, sediment sampled for macrofauna analysis; **G)** same as **F**, after sieving with 0.5 mm mesh size.

particular are a well-suited target to characterize and distinguish benthic habitats as they are ubiquitous, taxonomically and ecologically diverse and often have highly specialized lifestyles. In addition, most species produce a calcareous shell which usually preserves well in marine sediments and allows the *post mortem* identification to species-level. The taxonomically

Fig. 5.4.2.2: Examples of benthic voucher samples taken during MSM86. **A)** Two pink anemones attached to a volcanic rock (sample ID: MSM86_010ROV_ 004R_002). An encrusting sponge covers the upper central part of the rock; **B)** Rock densely covered by bright red anemones (sample ID: MSM86_106TVG_001B); **C)** Soft corals (sample ID: MSM86_012TVG_003B); **D)** Aplacophoran (Mollusca) (sample ID: MSM86_087TVG_005B); **E)** Stalked crinoid (sample ID: MSM86_ 005TVG_006B, photo courtesy I. Caraite); **F)** Shrimp (sample ID: MSM86_020TVG_001B).

identifiable molluscan shell accumulations found in surficial sediments – so-called death assemblages (DAs) – constitute natural, time-averaged archives of past community states (e.g. Kidwell 2007, 2009). The study of such death assemblages thus not only enables the detection of rare or patchily distributed species, which are unlikely to be found alive in a single sampling event, but also have the potential to detect past, unobserved community shifts when compared to the co-occurring living assemblage (Kidwell 2007, Tomašových et al. 2017).

During MSM86, numerous benthic samples were obtained by deployments of the TV-grab (TVG) and ROV MARUM-SQUID, covering different habitats and depth zones of Vesteris Seamount as well as other seamounts and core complexes in the working area (chapter 5.3.). While a dedicated team of experts aimed at studying the sponge assemblages and associated fauna from these samples (chapter 8.1), our goal was to assess (a) the species diversity and spatial distribution of other macrobenthos, particularly molluscs, (b) to gather for the first time quantitative information on macrobenthic assemblage composition in various habitats and depths (as relative abundance data), and (c) to collect voucher specimens of larger benthos for future taxonomic and potential molecular studies.

Sampling

For macrofauna and death assemblage composition, a few liters of surficial sediment from the TVG were collected, preferably before the grab was emptied on deck. Samples from TVG casts with very low quantities of sediment or highly disturbed sediment structure were also collected, but will only be used for qualitative analysis, e.g. faunistic inventories. Additional sediment samples were obtained using the scoop nets operated by ROV MARUM-SQUID. Sediments were sieved with 0.5 mm-mesh size and the retained material preserved in 10% borax-buffered formalin for later picking and identification in the lab at the University of Vienna, Austria. A few samples were preserved in absolute ethanol to yield specimens suitable for barcoding or molecular studies. For molluscan DAs, a subsample of the sieve residues was rinsed with freshwater and air-dried to avoid any alterations of biogenic carbonate debris due to storage in formalin. Small subsamples of untreated sediment were taken for grain size and organic matter analysis. Together with the TVG and ROV videos, these samples will help to characterize the benthic habitats.

In addition, any conspicuous benthic organisms contained in the grabs were preserved in either absolute ethanol for further taxonomic and/or molecular study (most cases), or borax-buffered formalin (few, mostly large-sized specimens).

Preliminary and expected results

In total 51 sediment samples for living macrofauna, 33 DA sediment samples, 45 samples for grain size and OM analysis, and 70 benthic voucher samples have been obtained from 60 TVG stations and 6 ROV dives (see Table. 8.2.1 for a detailed list of samples).

Stn. no.	Macrofauna Samples	Grain Size/OM Samples	Voucher Samples
MSM86_005TVG	007S	008S	006B
MSM86_007TVG	005S, 006S (EtOH)	005S	
MSM86_008TVG	020S		019B
MSM86_009TVG	009S	010S	008B
MSM86_010ROV			004R_002
MSM86_011TVG			008B, 009B
MSM86_012TVG			003B
MSM86_013TVG	011S		010B
MSM86_014TVG		003S	
MSM86_015TVG		006S	005B
MSM86_019TVG	021S, 022S (EtOH)	023S	020B
MSM86_020TVG			001B, 002B
MSM86_021TVG	003S (+ DA [= 004S])		002B
MSM86_022TVG	012S (+DA)	013S	011B
MSM86_025TVG	004S	003S	002B
MSM86_026TVG			002B, 003B
MSM86_027TVG	008S (+DA)	007S	006B
MSM86_028TVG	016S (+DA)	017S	015B
MSM86_029TVG			001B
MSM86_031TVG	015S (+DA)	016S	017B, 019B
MSM86_032TVG	018S (+DA)	019S	016B, 017B
MSM86_033TVG		003S	002B
MSM86_034TVG	004S (+ 2x DA)	005S	
MSM86_035TVG	009S (+DA)	010S	008B
MSM86_036TVG	004S	005S	003B (a and b)
MSM86_038TVG	013S	014S	012B
MSM86_039TVG	002S (+DA)	003S	001B
MSM86_040TVG	005S	006S	004B
MSM86_041TVG	010S (+DA)	011S	007B
MSM86_045TVG	023S (+DA)	024S	021B, 022B
MSM86_046TVG	019S (+DA)	018S	017B
MSM86_048TVG			002B
MSM86_049TVG	002S (+DA)	003S	001B
MSM86_052ROV	DA (004S, 008S)		002B, 004S, 008S
MSM86_053TVG	002S (+DA)	003S	001B
MSM86_054TVG	008S (+DA)	007S	
MSM86_057TVG	009S (+DA)	010S	008B
MSM86_059TVG	001S	002S	
MSM86_061ROV	011R, 008Ra (+DA)		
MSM86_062TVG	006S (+DA)	007S	005B
MSM86_063TVG	012S (+DA)	013S	011B
MSM86_065TVG	002S	003S	001B
MSM86_070TVG	009S (+DA)	010S	008B
MSM86_072TVG	011S (+DA)	012S	
MSM86_073TVG	006S (+DA)	007S	
MSM86_076TVG	001S (+DA)	002S	
MSM86_077TVG	006S (+DA)	007S	008B
MSM86_080TVG	022S (+DA)	023S	020B, 021B
MSM86_081ROV	004S	004S	
MSM86_082TVG	001S	002S	
MSM86_083TVG	008S (+DA)	009S	007B
MSM86_086ROV	012B		010R, 013B
MSM86_087TVG			003B, 004B, 005B
MSM86_088TVG			001B
MSM86_089TVG			001B, 002B
MSM86_090TVG	004S (EtOH)	008S	003B
MSM86_091TVG			007B
MSM86_094ROV	006S (+DA), 013S	006S	
MSM86_097TVG	002S (+DA)	003S	001B
MSM86_098TVG	024S (+DA)	025S	026B, 027B (a-c), 028B
MSM86_101TVG			002B, 003B
MSM86_102TVG	002S	003S	001B
MSM86_106TVG			001B
MSM86_108TVG			001B
MSM86_109TVG	001S (+DA)	002S	003B
MSM86_110TVG			001B

Table 5.4.2.1: List of samples for the study for macrobenthic assemblage composition, grain size/sediment organic matter content as well as benthic voucher samples taken during MSM86. Macrofauna samples were preserved in either 10% buffered formalin (no fixative indicated) or absolute ethanol (EtOH). The availability of dried sediment for the study of death assemblage is marked with "+DA".

The videos recorded by the TV-grab and during ROV dives showed a distinct vertical zonation and patchy distribution of habitat types in the study area which we expect to be reflected in benthic/molluscan assemblage composition. In general, samples from shallow, near summit to upper slope areas, particularly at Vesteris Seamount, were rich in live bryozoans and sponges (Fig. 5.4.2.1a-c), which formed a mat on top of a layer composed of dead bryozoan debris, sponge spicules, tubes of calcareous tube worms, some molluscan shells and light brown mud. The sediment samples from these areas are accordingly characterized a very high content of biogenic carbonate debris (Fig. 5.4.2.1b) and we will likely find species typically associated to the habitat forming taxa. Towards deeper areas, a trend of increasing proportions of sediment fine fraction and less habitat forming biota was evident (Fig. 5.4.2.1). The deepest stations (> 3000 m, in the northeastern core complex area) were characterized by muddy sediments or consolidated clays (Fig. 5.4.2.1f). Only very few macrobenthic organisms were found during the visual inspection of the sieve residues (Fig. 5.4.2.1g) and we expect a trend of decreasing species diversity with water depth, likely related to lower food availability and potentially also less habitat complexity.

Apart from the macrofauna and molluscan death assemblage samples that require thorough sorting and identification in the lab at the home University, we have collected voucher specimens of various benthic animals, including ascidians, amphipods, shrimps, brachiopods, chaetognaths, crinoids, ophiuroids, nemerteans, polychaetes, aplacophorans, bivalves and gastropods from the TV-grab and ROV samples (Figs. 5.4.2.2). These specimens will be made available to taxonomic experts for proper identification and further study.

Upon further processing in the lab, we expect the numerous benthic samples collected during MSM86 to provide new insights into the species inventory, diversity and assemblage composition of the study area and the association of assemblages to the various sampled habitat types.

5.5 Geobiological sampling

(J. Peckmann, D. Birgel, K. Kampen, O. Snoeyenbos-West)

Fungal communities of the oceanic crust including seamounts are poorly documented. The study focusing on the vesicular volcanic rock sampled during MSM86 will, for the first time, conduct a survey of the rock-associated fungi (both living and fossil) of Vesteris Seamount using culture-based methods and high-throughput sequencing, combined with ESEM microscopy, petrographic microscopy, fine scale mineralogical and crystallographic analyses (involving beamline 24 of DESY, Hamburg), pore space analysis, and lipid biomarkers.

Rock samples were collected in triplicate for nucleic acid extraction (RNA & DNA), in RNALater and 100% Ethanol. Fungal enrichments were initiated by inoculation of rock samples into PDA media containing antibiotics. Rock samples were also collected in sterile falcon tubes for later screening on various selective fungal media and for petrographic thin section preparation, using samples with different degrees of porosity, apparent different age, and from variable water depth. Questions and aims of the MSM86 Geobiology team are as follows:

(1) The phylogenetic affiliations of endolithic fungi will be determined. Is the expected dominance of zygomycetous fungi (Ivarsson et al. 2015) independent of lithology? Is the fungal diversity in the seawater similar to that found in the rock communities? Does it serve as a source of recruitment or not? (2) Do fungi enriched and cultivated from vesicular volcanic rock have the same morphology as the fossil endolithic fungi? Are lipid biomarkers from these cultivated fungi similar/the same as those obtained from in situ rock communities? (3) What are the associated prokaryote communities? (4) What is the function of porosity and permeability of vesicular volcanic rock for the dispersal of fungi? (5) How long does it take fungi to colonize the internal pore space of volcanic rock? What is the relation between the age of the respective rock and fungal biomass and diversity? How deep do fungi penetrate below rock surfaces? Do the fungal communities vary across space and time and/or with water depth? Is there evidence of fungal biogeography? (6) Are the fungi exclusively heteroorganotrophs? What is their role in manganese and iron oxidation? (7) Is there a relation between fungal colonization of pore space and the incrustation of rock surfaces (incrusting sponges, bryozoans) or the ingression of sedimentary fines including plankton into the pore space? (8) Which are the

mechanisms leading to fossilization of fungi? (9) The ultimate goal of the MSM86 Geobiology team is to assess the role of fungi in the alteration of suboceanic volcanic rock. What is the effect of fungal bioalteration on element cycling between the oceanic lithosphere and seawater? The answers to the questions above will allow to estimate the contribution and the effect of bioalteration of the oceanic crust on the upper geosphere – a process that has been reported to exist since the Paleoproterozoic (Bengston et al. 2017), but likely commenced soon after life had originated on Earth**.**

6 Ship's Meteorological Station

No meteorological station keeping was conducted.

7 Station List

Station No.		Date (UTC)	Start (UTC)	Location	Start Position (Decimal Degrees)		Water depth [m]	Ende (UTC)	End Position (Decimal Degrees)		Water depth [m]	Sample time (UTC)	Sample Position (Decimal Degrees)		Waterdepth of sample [m]	comments	Size/number of samples
Merian	*MARUM*				*Latitude*	*Longitude*			*Latitude*	*Longitude*			*Latitude*	*Longitude*			
MSM86_001-1_ROV		19.08.19	06:20	Vestnesa Ridge	79.005579	6.908392	1205	06:55	79.005587	6.908399	1206					Aborted due to technical problems	
MSM86_001-2_TVG		19.08.19	11:36	Vestnesa Ridge	79.006137	6.905167	1213	13:34	79.006247	6.904281	1213					TV-Grab used with hooks to salvage Measuring platform of Cruise MSM57	
MSM86_001-3_ROV		19.08.19	13:58	Vestnesa Ridge	79.006504	6.904711	1213	14:21	79.006497	6.90473	1213					Dive aborted due to technical problems	
MSM86_002_ROV	**Dive_040**	19.08.19	19:24	Vestnesa Ridge	79.006571	6.905143	1212	23:30	79.006799	6.902717	1210					Dive_040: ROV used to salvage SonarCork	-
MSM86_003_CTD		21.08.19	00:24	Vestnesa Ridge	74.541512	-3.244433	3601	02:37	74.541535	-3.244484	3601						Water Samples: 11 (4 Depths)
MSM86_004_MBES		21.08.19	02:58	Transit to Vesteris	74.54078	-3.248016	3600	18:12	73.383006	-9.22604	2552						
MSM86_005_TVG		21.08.19	18:49	Vesteris	73.367638	-9.393453	1884	20:39	73.369101	-9.39274	1887	19:55	73.368960	-9.392371	1882	black, fine basaltic lava	Biology: 6 Sediment: 2 Geology: 3
MSM86_006_TVG		21.08.19	21:31	Vesteris	73.401157	-9.376564	2385	23:28	73.401307	-9.376083	2349	22:30	73.401130	-9.375700	2353	porphyritic basalt	Geology: 1
MSM86_ 007_TVG		22.08.19	00:07	Vesteris	73.440673	-9.266039	977	01:23	73.441141	-9.266055	986	0:57	73.441030	-9.265800	989	fine grained sand, black vesicular lava	Biology: 4 Sediment: 2 Geology: 4
MSM86_ 008_TVG		22.08.19	01:56	Vesteris	73.45152	-9.262659	979	02:58	73.451521	-9.261526	952	2:33	73.451480	-9.261330	958	black, glassy scoria	Biology: 19 Sediment: 1 Geology: 1
MSM86_ 009_TVG		22.08.19	03:37	Vesteris	73.463998	-9.263547	738	04:23	73.463971	-9.263528	724	04:02	73.463880	-9.263230	731	pillow lava	Biology: 8 Sediment: 2 Geology: 1
MSM86_ 010_ROV	**Dive_041**	22.08.19	05:24	Vesteris	73.509514	-9.144789	603	14:36	73.510674	-9.148868	529					Dive_041: sponges, pillow lava, lapilli	Biology: 5 Water: 1 Geology: 6
MSM86_ 011_TVG		22.08.19	15:34	Vesteris	73.614061	-9.035181	1791	17:07	73.614071	-9.034969	1777	16:30	73.614160	-9.035220	1804	lava balloon, glassy pillow lava rim, fine-grained mud to silt	Biology: 9 Geology: 4
MSM86_ 012_TVG		22.08.19	17:48	Vesteris	73.589353	-9.039541	1399	19:29	73.589199	-9.039521	1408	18:56	73.589310	-9.039710	1417	aphyritic lava, rarely small crystals	Biology: 3 Geology: 1
MSM86_ 013_TVG		22.08.19	20:15	Vesteris	73.569114	-9.059061	857	21:22	73.568942	-9.059125	843	20:59	73.568880	-9.059360	844	black, vesicular fine-grained basalt, scoria, lapilli	Biology: 10 Sediment: 1 Geology: 4
MSM86_ 014_TVG		22.08.19	22:21	Vesteris	73.557854	-9.080938	604	23:25	73.557677	-9.080931	606	23:08	73.557600	-9.081300	550	black, glassy basalt	Biology: 1 Sediment: 1 Geology: 1
MSM86_ 015_TVG		22.08.19	23:52	Vesteris	73.546042	-9.072975	302	00:27	73.545942	-9.073231	297	00:14	73.545940	-9.073630	297	lapilli, black, glassy lava pieces	Biology: 5 Sediment: 1 Geology: 2
MSM86_ 016_CTD		23.08.19	01:22	Vesteris	73.650012	-9.082526	2922	03:13	73.649997	-9.082608	2921						Water: 11 (4 depths)
MSM86_ 017_MBES		23.08.19	04:02	Vesteris	73.730111	-8.890957	3084	11:15	73.632827	-9.075802	2707						
MSM86_ 018_ROV		23.08.19	12:07	Vesteris	73.518116	-9.145943	295	12:20	73.518142	-9.146008	298					test run	
MSM86_ 019_TVG		23.08.19	13:20	Vesteris	73.488948	-8.968776	1612	14:38	73.488987	-8.96889	1591	14:01	73.489110	-8.968920	1601	unconsolidated sediment, clasts of black vulcanite	Biology: 20 Sediment: 5
MSM86_ 020_TVG		23.08.19	17:01	Vesteris	73.502974	-9.007341	1142	18:05	73.503017	-9.007612	1149	17:37	73.502977	-9.007844	1156	black, glasy lava flow	Biology: 2 Geology: 1
MSM86_ 021_TVG		23.08.19	18:26	Vesteris	73.508447	-9.026851	962	19:46	73.508559	-9.027555	957	19:22	73.508700	-9.027630	953	black, vesicular and glassy lava flow	Biology: 2 Sediment: 2 Geology: 1
MSM86_ 022_TVG		23.08.19	20:22	Vesteris	73.52166	-9.090314	359	21:18	73.521727	-9.09097	357	21:03	73.521850	-9.091070	359	black to brown sediment	Biology: 11 Sediment: 3
MSM86_ 023_MBES		23.08.19	22:16	Vesteris	73.629732	-9.087991	2698	05:29	73.461323	-9.364351	1914					end 24.08.2019	
MSM86_ 024_MBES		24.08.19	08:52	Vesteris	73.46498	-9.349588	1787	14:02	73.474707	-9.100214	1645						
MSM86_ 025_TVG		24.08.19	14:37	Vesteris	73.514028	-9.326488	1049	15:51	73.514093	-9.325904	1062	15:21	73.514180	-9.326290	1057	rounded dropstones (gneiss?), black fine-grained to glassy volcanic pieces, muddy brown sediment	Biology: 2 Sediment: 3 Geology: 4
MSM86_ 026_TVG		24.08.19	16:28	Vesteris	73.543402	-9.278268	1092	17:49	73.54332	-9.278713	1076	17:21	73.543300	-9.278600	1076	porphyritic lava with diverse matrix	Biology: 4 Geology: 1
MSM86_ 027_TVG		24.08.19	18:22	Vesteris	73.545006	-9.233896	955	19:32	73.544585	-9.237455	951	19:07	73.544600	-9.237460	960	mafic, vesicular rock	Biology: 6 Sediment: 2 Geology: 1

Station No.		Date (UTC)	Start (UTC)	Location	Start Position (Decimal Degrees)		Water depth [m]	Ende (UTC)	End Position (Decimal Degrees)		Water depth [m]	Sample time (UTC)	Sample Position (Decimal Degrees)		Waterdepth of sample [m]	comments	Size/number of samples
Merian	*MARUM*				*Latitude*	*Longitude*			*Latitude*	*Longitude*			*Latitude*	*Longitude*			
MSM86_ 028_TVG		24.08.19	20:02	Vesteris	73.532556	-9.220978	555	20:56	73.532189	-9.221033	575	20:38	73.532270	-9.221360	575	black, porphyritic/glassy, vesicular lava. Volcanoclastic, layered rock	Biology: 15 Sediment: 2 Geology: 2
MSM86_ 029_TVG		24.08.19	21:38	Vesteris	73.518227	-9.146169	306	22:20	73.518319	-9.146123	304	22:01	73.518320	-9.014610	302	porphyritic lava with glassy matrix, lapilli	Biology: 1 Geology: 2
MSM86_ 030_MBES		24.08.19	22:50	Vesteris	73.476158	-9.097284	1603	07:14	73.452091	-8.782904	2856					end 25.08.2019	
MSM86_ 031_TVG		25.08.19	08:05	Vesteris	73.527214	-9.116766	163	09:09	73.527229	-9.116817	162	08:57	73.527200	-9.117300	161	Sediment with biomass	Biology: 16 Sediment: 3
MSM86_ 032_TVG		25.08.19	09:47	Vesteris	73.51945	-9.160004	139	10:15	73.519199	-9.159344	148	10:03	73.519210	-9.159700	145	volcanoclastic breccia. Black, fine-grained, vesicular, porphyritic lava with altered phenocrysts	Biology: 17 Sediment: 2 Geology: 3
MSM86_ 033_TVG		25.08.19	11:00	Vesteris	73.536033	-9.255824	944	12:26	73.535859	-9.254819	937	12:01	73.535800	-9.255300	923	Glassy & porphyritic, vesicular lava. Fine layered sedimentary rock.	Biology: 2 Sediment: 1 Geology: 3
MSM86_ 034_TVG		25.08.19	12:56	Vesteris	73.51732	-9.258675	765	13:53	73.51708	-9.258448	751	13:33	73.517000	-9.258800	747	dark, grey, fine-grained lava	Biology: 3 Sediment: 2 Geology: 2
MSM86_ 035_TVG		25.08.19	14:28	Vesteris	73.518461	-9.217871	352	15:02	73.518461	-9.217566	352	14:48	73.518460	-9.217580	352	very mafic lava	Biology: 8 Sediment: 2 Geology: 1
MSM86_ 036_TVG		25.08.19	15:31	Vesteris	73.524668	-9.193775	255	16:31	73.524442	-9.193452	257	16:19	73.524400	-9.193880	257	black to grey sediment	Biology: 3 Sediment: 3
MSM86_ 037_MBES		25.08.19	17:52	Vesteris	73.59033	-8.98336	1730	08:26	73.517637	-9.20658	343						
MSM86_ 038_TVG		26.08.19	08:59	Vesteris	73.511811	-9.171353	226	09:38	73.511754	-9.171337	222	09:24	73.511620	-9.171420	221	hydroclastic sediment. Dropstone	Biology: 12 Sediment: 3 Geology: 1
MSM86_ 039_TVG		26.08.19	10:37	Vesteris	73.505675	-9.194656	279	11:22	73.50563	-9.193701	279	11:10	73.505490	-9.193830	277	black, fine-grained basalt. Black to brown sediment with shells and lapilli	Biology: 1 Sediment: 3 Geology: 1
MSM86_ 040_TVG		26.08.19	12:03	Vesteris	73.492042	-9.267309	993	13:05	73.492042	-9.266392	983	12:38	73.491910	-9.266600	972	black, glassy and fine-grained, vesicular basalt and scoria. Porphyritic and glassy lava. Lapilli	Biology: 4 Sediment: 2 Geology: 5
MSM86_ 041_TVG		26.08.19	13:33	Vesteris	73.490564	-9.239644	517	14:36	73.490418	-9.239583	517	14:18	73.490270	-9.239730	517	fresh lava with vesicle bands and glassy crust. Few phenocrysts, pipe vesicles, scoria	Biology: 7 Sediment: 2 Geology: 3
MSM86_ 042_MBES		26.08.19	15:34	Transit from vesteris to Southern Seamount	73.490138	-9.239444	523	01:05	72.488327	-11.857303	2308					End 27.08.2019	
MSM86_ 043_CTD		27.08.19	01:14	Southern Seamount	72.484486	-11.862027	2316	02:44	72.484487	-11.862065	2312						Water: 10 (3 depths)
MSM86_ 044_MBES		27.08.19	03:12	Southern Seamount	72.484183	-11.773902	2218	07:41	72.343001	-11.695047	1927						
MSM86_ 045_TVG		28.08.19	08:10	Southern Seamount	72.373805	-11.653801	740	09:35	72.373605	-11.652335	704	09:10	72.373620	-11.652780	704	dark grey, reddish lava, manganese crusts, sediment	Biology: 22 Sediment:3 Geology: 4
MSM86_ 046_TVG		28.08.19	10:35	Southern Seamount	72.379852	-11.555534	551	11:27	72.380153	-11.554702	533	11:53	72.380150	-11.554700	536	black, fine-grained lava, dropstones	Biology: 17 Sediment: 2 Geology: 3
MSM86_ 047_TVG		28.08.19	12:16	Southern Seamount	72.43404	-11.53653	1202	14:45	72.432871	-11.53544	1060	14:18	72.432865	-11.535887	1057	breccia	Geology: 2
MSM86_ 048_TVG		28.08.19	15:25	Southern Seamount	72.384204	-11.434809	475	16:07	72.384004	-11.43475	497	15:52	72.384000	-11.435100	491	black, fine-grained lava, dropstones	Biology: 2 Sediment: 1 Geology: 2
MSM86_ 049_TVG		28.08.19	17:01	Southern Seamount	72.460929	-11.250906	739	17:49	72.460694	-11.251557	730	17:47	72.460697	-11.252000	733	fresh alkali basalt, dropstones	Biology: 2 Sediment: 1 Geology: 2
MSM86_ 050_MBES		28.08.19	18:29	Vesteris	72.454985	-11.208706	1262	06:10	73.511178	-9.15204	446						
MSM86_ 051_MBES		29.08.19	07:44	Vesteris	73.526524	-9.104157	226	08:31	73.513875	-9.178108	180						

Station No.		Date (UTC)	Start (UTC)	Location	Start Position (Decimal Degrees)		Water depth [m]	Ende (UTC)	End Position (Decimal Degrees)		Water depth [m]	Sample time (UTC)	Sample Position (Decimal Degrees)		Waterdepth of sample [m]	comments	Size/number of samples
Merian	MARUM				Latitude	Longitude			Latitude	Longitude			Latitude	Longitude			
MSM86_ 052_ROV	Dive_042	29.08.19	08:48	Vesteris	73.517712	-9.149006	295	13:50	73.520596	-9.145332	188					Dive_042: black, fine-grained lava, glassy crusts, lapilli	Biology: 4 Sediment: 2 Geology: 2
MSM86_ 053_TVG		29.08.19	14:48	Vesteris	73.610838	-9.175571	1759	16:52	73.610691	-9.177337	1787	16:14	73.610600	-9.176770	1778	dropstones	Biology: 1 Sediment: 3 Geology: 1
MSM86_ 054_TVG		29.08.19	17:52	Vesteris	73.678143	-8.785591	2676	19:56	73.678259	-8.785946	2648	18:57	73.678000	-8.784840	2687	manganese crust	Biology: 6 Sediment: 2 Geology: 1
MSM86_ 055_MBES		29.08.19	20:20	Transit Vesteris to NE area	73.680207	-8.74235	3007	10:03	74.430135	-2.023042	3651						
MSM86_ 056_MBES		30.08.19	10:13	Transit Vesteris to NE area	74.42639	-1.927422	3648	06:42	74.473175	-0.529609	3755						
MSM86_ 057_TVG		31.08.19	08:00	NE area	74.301139	-1.010206	2598	10:08	74.301718	-1.009478	2548	09:13	74.301760	-1.010020	2550	mantle complex, altered peridotites, gabbro, dunite & basalt with Manganese crusts	Biology: 8 Sediment: 2 Geology: 12
MSM86_ 058_TVG		31.08.19	11:00	NE area	74.310327	-1.060363	2462	13:13	74.31037	-1.060325	2466	12:19	74.310200	-1.060020	2462	manganese crust	Biology: 2 Geology: 1
MSM86_ 059_TVG		31.08.19	14:17	NE area	74.470181	-1.160346	3109	17:05	74.470317	-1.159962	3106	16:02	74.470100	-1.159400	3094	serpentinized olivine gabbro	Biology: 2 Geology: 1
MSM86_ 060_MBES		31.08.19	19:36	Vesteris	74.400553	-2.746831	3873	05:45	73.529119	-9.196616	518						
MSM86_ 061_ROV	Dive_043	01.09.19	05:59	Vesteris	73.528698	-9.193821	505	14:16	73.527348	-9.192554	407					Dive_043: porphyritic & fine-grained lava, lapilli	Biology: 5 Geology: 6
MSM86_ 062_TVG		01.09.19	14:29	Vesteris	73.52731	-9.191366	370	15:33	73.527196	-9.191285	367	15:18	73.527070	-9.191387	363	lava with layered vesicles, black glassy scoria	Biology: 5 Sediment: 3 Geology: 4
MSM86_ 063_TVG		01.09.19	16:11	Vesteris	73.530905	-9.196907	542	16:58	73.530732	-9.196907	535	16:42	73.530635	-9.196630	538	black, porphyritic and vesicular lavas	Biology: 11 Sediment: 2 Geology: 5
MSM86_ 064_TVG		01.09.19	17:41	Vesteris	73.553914	-9.154596	808	18:39	73.554109	-9.156735	843	18:15	73.554000	-9.156398	849	empty	-
MSM86_ 065_TVG		01.09.19	19:08	Vesteris	73.537112	-9.212699	751	20:26	73.537527	-9.212986	744	19:59	73.537381	-9.212626	793	grey, porphyritic volcanic rock	Biology: 1 Sediment: 2 Geology: 1
MSM86_ 066_TVG		01.09.19	21:11	Vesteris	73.526334	-9.003532	1175	22:16	73.526428	-9.002018	1180	21:44	73.526338	-9.001729	1132	finde-grained aphanitic lava	Geology: 1
MSM86_ 067_CTD		01.09.19	22:45	Vesteris	73.511625	-8.884488	2104	00:06	73.5115	-8.885144	2100					SVP	Water: 24 (7 depths)
MSM86_ 068_MBES		02.09.19	00:14	Boyd Seamount	73.510688	-8.860786	2236	21:47	72.569547	2.345133	1804						
MSM86_ 069_MBES		02.09.19	21:47	Boyd Seamount	72.569523	2.345017	1804	07:24	72.775248	3.089199	2093					End 03.09.2019	
MSM86_ 070_TVG		03.09.19	08:10	Boyd Seamount	72.711731	2.971778	845	09:10	72.711754	2.971774	846	08:45	72.711590	2.971340	851	dropstones	Biology: 8 Sediment: 3 Geology: 1
MSM86_ 071_TVG		03.09.19	09:55	Boyd Seamount	72.690723	2.968985	1367	12:06	72.689872	2.971592	1403	11:34	72.689750	2.971120	1448	empty	-
MSM86_ 072_TVG		03.09.19	12:37	Boyd Seamount	72.681101	2.862356	718	13:31	72.681141	2.862181	717	13:10	72.681100	2.861690	716	dropstones	Biology: 10 Sediment: 3 Geology: 1
MSM86_ 073_TVG		03.09.19	14:31	Boyd Seamount	72.665156	2.665257	868	15:34	72.665188	2.665063	866	15:08	72.665161	2.664586	827	porphyritic pillow lava, dropstones	Biology: 5 Sediment: 2 Geology: 2
MSM86_ 074_CTD		03.09.19	16:38	Boyd Seamount	72.628311	2.73499	2628	18:18	72.628353	2.735047	2626					SVP	Water 12 (5 depths)
MSM86_ 075_MBES		03.09.19	18:56	Boyd Seamount	72.573651	2.587361	2863	03:02	72.49862	2.21312	1843					End 04.09.2019	
MSM86_ 076_TVG		04.09.19	06:01	Boyd Seamount	72.711329	3.044053	1286	08:05	72.712235	3.039617	1207	07:33	72.712100	3.040020	1209	fine-grained aphanitic & tholeiitic basalt	Sediment: 2 Geology: 5

Station No.		Date (UTC)	Start (UTC)	Location	Start Position (Decimal Degrees)		Water depth [m]	Ende (UTC)	End Position (Decimal Degrees)		Water depth [m]	Sample time (UTC)	Sample Position (Decimal Degrees)		Waterdepth of sample [m]	comments	Size/number of samples
Merian	*MARUM*				*Latitude*	*Longitude*			*Latitude*	*Longitude*			*Latitude*	*Longitude*			
MSM86_ 077_TVG		04.09.19	09:03	Boyd Seamount	72.678473	2.816087	621	10:43	72.678156	2.825324	666	10:18	72.678050	2.825730	665	smal piece ov lava	Biology: 5 Sediment: 3 Geology: 1
MSM86_ 078_MBES		04.09.19	11:05	Vesteris	72.693701	2.724383	1503	06:00	73.541298	-9.088185	1744					End 05.06.2019	
MSM86_ 079_TVG		05.09.19	06:15	Vesteris	73.540547	-9.158116	752	07:25	73.540544	-9.158573	751	07:01	73.540470	-9.158290	756	deeper equivalent of basaltic lava	Biology: 2 Geology: 1
MSM86_ 080_TVG		05.09.19	07:56	Vesteris	73.537318	-9.13196	187	09:08	73.537052	-9.131266	171	08:57	73.536960	-9.130860	172		Biology: 21 Sediment: 2
MSM86_ 081_ROV	**Dive_044**	05.09.19	09:40	Vesteris	73.528979	-9.115199	163	15:34	73.528845	-9.112582	208					Dive_044: lava	Biology: 5 Sediment: 1 Geology: 1
MSM86_ 081-2_TVG		05.09.19	16:04	Vesteris	73.528787	-9.111307	212	16:38	73.528835	-9.111235	210	16:38	73.528830	-9.111200	210	hyaloclastite	Biology: 1 Geology: 2
MSM86_ 082_TVG		05.09.19	17:04	Vesteris	73.516859	-9.098935	502	17:43	73.516845	-9.098866	500	17:23	73.516750	-9.098610	498	altered vesicular lava, fresh lava with round vesicles, olivine phenocrysts	Biology: Sediment: 2 Geology: 4
MSM86_ 083_TVG		05.09.19	18:19	Vesteris	73.51768	-9.058541	786	19:07	73.51802	-9.058524	787	18:48	73.517920	-9.058190	785	fresh, vesicular alkaline lava, aphyritic pillow lava	Biology: 9 Sediment: 3 Geology: 2
MSM86_ 084_TVG		05.09.19	19:44	Vesteris	73.557201	-9.009679	833	21:00	73.557202	-9.009656	831	20:31	73.557070	-9.009356	836	pillow lava with big pyroxenes	Geology: 1
MSM86_ 085_MBES		05.09.19	21:16	Vesteris	73.559778	-8.957303	1469	04:19	73.481467	-8.974373	1901					End 06.09.2019	
MSM86_ 086_ROV	**Dive_045**	06.09.19	06:01	Vesteris	73.540712	-9.276288	1171	14:31	73.542648	-9.279805	1095					Dive_045: porphyritic trachyte, basanite, lava with altered phenocrysts	Biology: 6 Geology: 8
MSM86_ 087_TVG		06.09.19	14:54	Vesteris	73.523987	-9.312573	1450	16:06	73.523824	-9.312929	1429	15:34	73.523817	-9.312943	1399	vesicular lava	Biology: 5 Geology: 3
MSM86_ 088_TVG		06.09.19	16:40	Vesteris	73.490476	-9.224829	576	17:57	73.490625	-9.224644	563	17:41	73.490540	-9.225080	574	porphyritic lava with olivine phenocrysts	Biology: 4 Geology: 1
MSM86_ 089_TVG		06.09.19	18:30	Vesteris	73.501076	-9.14731	676	19:21	73.501078	-9.147209	668	19:01	73.501100	-9.146720	665	lapilli, scoria	Biology: 2 Geology: 2
MSM86_ 090_TVG		06.09.19	20:13	Vesteris	73.533325	-9.089258	262	20:56	73.533283	-9.086738	299	20:43	73.533320	-9.086375	299	lapilli, hyaloclastite, porphyritic lava	Biology: 3 Sediment: 2 Geology: 3
MSM86_ 091_TVG		06.09.19	21:34	Vesteris	73.567371	-9.05068	890	22:26	73.567381	-9.050349	899	21:59	73.567450	-9.050023	887	vesicular, porphyritic lava	Biology: 7 Sediment: Geology: 2
MSM86_ 092_MBES		06.09.19	22:29	Vesteris	73.567507	-9.050381	928	00:20	73.469091	-10.09493	2943					End 07.09.2019	
MSM86_ 093_PS		07.09.19	00:29	Vesteris	73.466151	-10.069373	2944	03:59	73.492253	-9.259722	897						
MSM86_ 094_ROV	**Dive_046**	07.09.19	04:52	Vesteris	73.552726	-9.009494	864	13:51	73.553287	-9.007346	836					Dive_046: vesicular lava, scoria with flow structure, lapilli	Biology: 7 Sediment: 2 Geology: 8
MSM86_ 095_MBES		07.09.19	13:57	Logi Ridge	73.552106	-9.015927	774	22:00:54	72.518042	-12.246825	1555						
MSM86_ 096_MBES		07.09.19	22:03	Logi Ridge	72.514406	-12.258215	1467	03:47	72.466309	-12.643454	513					End 08.09.2019	
MSM86_ 097_TVG		08.09.19	04:28	Logi Ridge	72.476184	-12.842027	823	05:38	72.47638	-12.839692	822	05:14	72.476360	-12.840200	821	sediment with black ash layers, dropstones	Biology: 1 Sediment: 3 Geology: 1
MSM86_ 098_TVG		08.09.19	06:22	Logi Ridge	72.501503	-12.802346	716	07:17	72.501853	-12.801774	703	06:57	72.501780	-12.802255	696		Biology: 25 Sediment: 3
MSM86_ 099_TVG		08.09.19	08:49	Logi Ridge	72.518632	-12.398391	1124	10:35	72.519113	-12.395582	1117	10:09	72.5109	-12.3959	1104	dropstones	Geology: 1
MSM86_ 100_MBES		08.09.19	12:02	Logi Ridge, Southern Seamount and area N of it	72.461112	-12.392197	1495	11:17	73.0843	-9.747897	2943					End 09.09.2019	
MSM86_ 101_TVG		09.09.19	14:21	Vesteris	73.526792	-9.012498	1014	15:12	73.526792	-9.012455	1014	14:46	73.5267	-9.0121	1016	vesicular, aphyritic lava	Biology: 3 Geology: 1

Station No.		Date (UTC)	Start (UTC)	Location	Start Position (Decimal Degrees)		Water depth [m]	Ende (UTC)	End Position (Decimal Degrees)		Water depth [m]	Sample time (UTC)	Sample Position (Decimal Degrees)		Waterdepth of sample [m]	comments	Size/number of samples
Merian	*MARUM*				*Latitude*	*Longitude*			*Latitude*	*Longitude*			*Latitude*	*Longitude*			
MSM86_ 102_TVG		09.09.19	15:51	Vesteris	73.555614	-9.153057	769	17:30	73.556029	-9.153125	795	17:08	73.5560	-9.1526	787	sediment with glassy ash layers, FeOOH crusts	Biology: 1 Sediment: 3 Geology: 1
MSM86_ 103_CTD		09.09.19	18:54	Vesteris	73.435397	-9.559522	2814	20:38	73.435563	-9.559367	2826					SVP	-
MSM86_ 104_MBES		09.09.19	20:54	Vesteris	73.437305	-9.603071	2851	04:13	73.741672	-9.705325	3021					End 10.09.2019	
MSM86_ 105_TVG		10.09.19	06:04	Vesteris	73.563673	-9.189877	1362	07:15	73.56362	-9.189588	1334	06:45	73.5636	-9.1892	1351	porphyritic basalt	Geology: 1
MSM86_ 106_TVG		10.09.19	08:29	Vesteris	73.475626	-9.233636	686	09:41	73.474812	-9.235807	737	09:23	73.4749	-9.2354	719	porphyritic lava	Biology: 1 Geology: 1
MSM86_ 107_MBES		10.09.19	10:26	Vesteris	73.390762	-9.384726	2477	01:51	72.50441	-11.081374	2149					End 11.09.2019	
MSM86_ 108_TVG		11.09.19	03:02	Southern Seamount	72.442817	-11.441587	577	04:32	72.442867	-11.443809	611	04:14	72.4428	-11.4434	601	Brecciated basalt with limestone matrix	Biology: 1 Geology: 1
MSM86_ 109_TVG		11.09.19	05:18	Southern Seamount	72.41943	-11.288033	561	06:44	72.419123	-11.288815	572	06:28	72.4190	-11.2885	569	lapilli	Biology: 1 Sediment: 2 Geology: 1
MSM86_ 110_TVG		11.09.19	07:23	Southern Seamount	72.385992	-11.386681	476	08:57	72.385522	-11.386512	515	08:41	72.3854	-11.3862	517		Biology: 1

8 Data and Sample Storage and Availability

All hydroacoustic data collected during MSM86 are currently being processed. Data are stored in facilities of the University of Bremen. Metadata of the onboard DSHIP-System will be uploaded to a World Data Center (e.g. PANGAEA) which provides a long-term archive and access to the data (contact: wbach@uni-bremen.de). Multi-beam field data are stored at the bathymetric data centre of the Bundesamt für Seeschiffahrt und Hydrografie, however, these data are protected until the end of 2020. The petrological samples are available at the University of Bremen and the GeoZentrum Nordbayern, Friedrich-Alexander-Universität Erlangen-Nürnberg, the biological sample material will be available at GEOMAR, the University of Bergen and Göttingen. The petrological and geochemical data will be published in peer-reviewed journals and will be available in international databases such as GEOROC and PetDB.

The collected sponge samples and corresponding sequence data will enter an inter-institutional reference collection of groundforming species that is currently being built within the EU consortium SponGES (collaborator Hans Tore Rapp). Sequencing data will be submitted to public databases such as NCBI GenBank.

All other benthos samples will be brought to the University of Vienna where they will be processed at the Department of Palaeontology. Voucher specimens will be archived according to the rules implemented by the DZMB and in communication with the "Materialarchiv".

Type	Database	Available	Free Access	Contact
		Date	Date	E-Mail
Raw data, multibeam data, DSHP	PANGAEA, BFSH	September 2019	September 2021	wbach@uni-bremen.de
Petrological samples	UB, GZN	September 2019	September 2021	wbach@uni-bremen.de karsten.haase@fau.de christoph.beier@helsinki.fi
Biological samples	GEOMAR, UBer, UGoe	September 2019	September 2021	bslaby@geomar.de jan.steger@univie.ac.at b.rincontomas@gmail.com francisca.carvalho@uib.no ieva.caraite@imbrsea.eu oonasnoeyenbos@gmail.com
Geobiological samples	UHH, NRM	September 2019	September 2021	joern.peckmann@uni-hamburg.de

9 Acknowledgements

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11 Appendices

Appendix A: Locales and description of rock samples

Appendix B: Locales and description of biological and sedimentary samples

Appendix C: Sample lists

C1: Petrology

C2: Biology