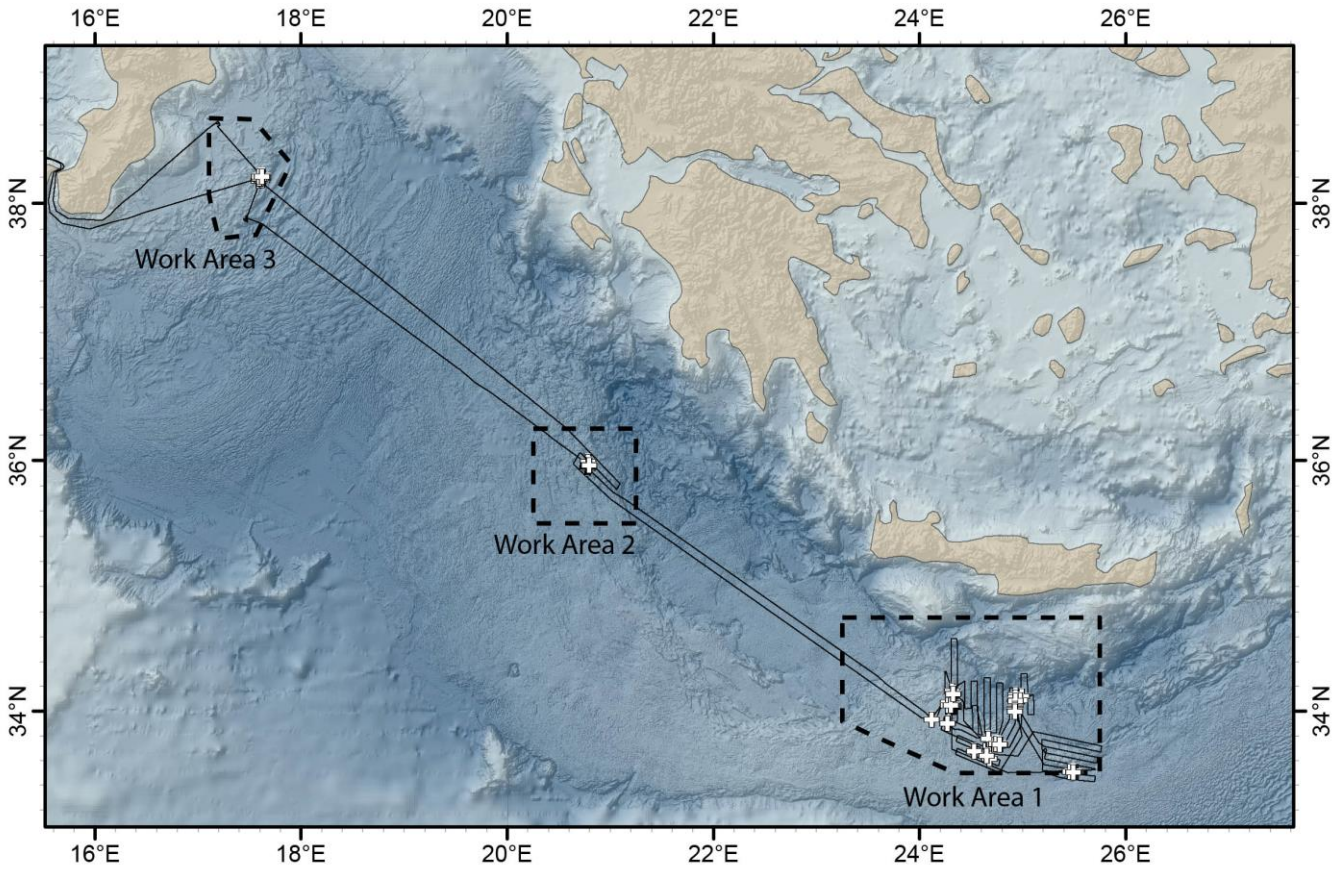
Prof. Dr. Gerhard Bohrmann
MARUM – Center for Marine
Environmental Sciences
and Department of Geosciences
Klagenfurter Str.
28359 Bremen – GERMANY
Tel. +49 421-218-65050
Email: gbohrmann@marum.de

Short Cruise Report
R/V SONNE – SO278 (GPF 19-2_007H)
Emden (Germany) – Emden (Germany)
October 12 – December 01, 2020
Chief Scientist: Gerhard Bohrmann
Captain: Lutz Mallon



Track lines and research areas in Italy and Greece of R/V SONNE Cruise SO278 from Emden to the eastern Mediterranean Sea and back to Emden, Germany.

Objectives

The Hellenic Subduction Zone, Eastern Mediterranean, represents an area where major faults south of Crete, well imaged geophysically and some associated with active mud volcanism, provide a window into the intermediate loop. The objectives of the expedition was to map faults and mud volcanoes by AUV (MARUM Seal5000) so that locations of extruded altered mud and fault gouge can be identified and sampled to study the origin of such materials, the degree of alteration, and the role in element budgets at the interface between geosphere and hydrosphere. Heat flow was proposed be measured complementarily.

Cruise Narrative

On Monday, 12 October 2020, R/V SONNE left its berth at the Südkai, Poller 16-20 in the Emden inland port, at 10:00 a.m. local time, to set out for the eastern Mediterranean, where marine geological studies are planned in Greece and Italy. The departure was preceded by 4 days of quarantine for all ship crew members and scientific participants, which were spent in single rooms in hotels in Leer without physical contact. Nevertheless, we stayed in contact via the internet and telephone and held a first video conference among the scientists. All participants were tested for the corona virus and after all tests were negative, the expedition was able to start. The crew and a vanguard of 3 scientists embarked on Saturday, 10 October on the SONNE, and the main group of scientists followed the day after. Our 6 containers with the scientific equipment had already been delivered from Bremen on Friday, 9 October, and had been loaded onto the ship at a place we had previously selected. After the arrival of the scientists on Sunday morning, 11 October, on SONNE, the containers were opened and most of the scientific equipment was distributed in the laboratories and on the working deck and tied down for the sea. After 4 days in the hotel almost all of us welcomed this physical work.

After a first night on the research ship in the port of Emden, it was time to cast off on Monday, 12 October at 10:00 a.m., and the SONNE moved away from the pier. After the SONNE had left the lock chamber, it followed the Ems estuary past the island of Borkum into the North Sea. On Tuesday, 13 October, the mandatory safety maneuver was carried out and that afternoon we started our daily series of lectures, which familiarize all scientists on board with the scientific topics of the voyage. The weather also played a role in the passage through the Biscay and got better and better on the journey along the Iberian Peninsula to the south. Consequently, we passed the Strait of Gibraltar into the Alboran Sea on Saturday, 17 October in glorious sunshine, and in the evening we were able to steam past the brightly lit METEOR at a distance of approximately 6 nautical miles.

In addition to setting up the equipment and laboratories, the transit route from Emden to the eastern Mediterranean was used to discuss the scientific program in order to be well prepared for the planned station work. The scientific crew counts 28 scientists, engineers, technicians and students from the universities of Bremen, Greifswald, Trieste and Athens. The expedition is part of the Bremen Cluster of Excellence "The Ocean Floor – Earth's Uncharted Interface" at MARUM. This region is characterized by the convergence of the Eurasian and African tectonic plates and has many characteristic elements of active fluid and mud flows. On the way to the destination south of Crete the border between Spain and Italy was crossed on Monday, 19 October. As it is said in the permission from the Italian authorities, recording of the hydro-acoustic systems started. On Tuesday, 20 October, the vessel passed Sardinia to the south on the way into the Tyrrhenian Sea. In the afternoon the cruise came through the Strait of Messina, the only up to 3 km wide strait between the Calabrian mainland and Sicily.

During the night the vessel reached first working area in the Calabrian accretionary wedge, where the Sartori mud volcano (MV) is located. With a diameter of 1 km and a height of 45 m, the Sartori mud volcano is a striking feature that belongs to the inner Pre-Messinian accretionary wedge. The entire area of the mud volcano, including some mud flows that flowed over the rim into the neighboring basins, can be seen in the 12 kHz data of the ship's multi-beam echo sounder due to

increased backscatter. Moreover, a high-resolution bathymetric map acquired from an AUV dive carried out during the METEOR expedition M112 shows this flat mud-pie structure in much greater detail. The 400 kHz multi-beam data from the AUV also show two round chimneys, each 180 m in diameter, which serve as pathways for mud ascending from the subsurface, which is then extruded at the sea floor and distributed horizontally. Station work started on the morning of Wednesday, 21 October, by taking heat flow measurements along a 10-point profile over the crater. Using a temperature lance, a temperature-depth profile was measured at each point down to a sediment depth of 5 m. A very high heat flow could be measured in both chimneys, although the eastern chimney is characterized by a larger heat gradient and has therefore been active more recently. In the afternoon the AUV tested for its upcoming dives and used the following night to acquire a grid of Parasound profiles over the mud volcano and its neighboring deep-sea regions. The aim was to map individual mud flow deposits of the volcano in order to be able to assign them to individual eruption events using also the correlation with gravity cores. On Thursday, 22 October two gravity cores were collected and two minicores, which were subsequently processed.

The first gravity core taken from the eastern, recently active, chimney area of the Sartori mud volcano sampled over 2 m of mud breccia, a very fine-grained gray sediment with numerous clasts ranging from mm to several cm in size. The sediment had a high proportion of finely distributed gas bubbles, which, based on the dessert “Mousse au chocolat”, the sedimentologists described as sediment with a “moussy” texture. Measurements of the gas showed mainly methane and, to a much lesser extent, ethane as the main components. Both gases, however, are already used up within the upper 20 cm due to the formation of H_2S by microbial anaerobic methane oxidation. After great difficulty the geochemists eventually succeeded in extracting pore water samples with a volume of a few milliliters from the very porous mud, which are necessary to carry out important chemical analyses. In addition to the alkalinity the salt content of the samples was also determined, which decreased significantly from 39 ‰ (seawater concentration) near the seabed to 15.5 ‰ in the lower core section. The lower salinity in the deeper sediments is most likely caused by the release of relatively fresh water from mineral reactions, similar to the processes known from clay mineral transformation. Since the uppermost section of the core is influenced by seawater the conclusion was that the mud breccia emerged a long time ago, and seawater subsequently diffused into the upper core section.

A second sediment core was taken about 3 nautical miles southwest of the Sartori MV and yielded pelagic sediments of the past 40,000 years. The age stems from the correlation of a tephra layer contained in the core with a dated tephra layer from other sediment cores of the area. On the evening of 22 October the cruise continued to the next working area in Greece, where three hydro-acoustic profiles across the mud volcanoes Aros, Novorossiyks and Prometheus were gathered on Friday, 23 October. Unfortunately, the hydroacoustic systems did not detect any active gas emissions from these features, and as a result the vessel continued steaming to our main working area south of Crete. Upon arrival on Saturday, 24 October, SONNE passed and surveyed numerous mud volcanoes from the Olimpi field. Today, 25 October, the MARUM AUV SEAL dove to the seabed for the first time and used its mutli-beam echo sounder to map in detail the Bergamo mud volcano, whose activity will be further investigated in the upcoming days.

The first dive of the AUV (Autonomous Underwater Vehicle) SEAL 5000 on **Sunday, 25 October** was watched with excitement by everyone on board. The bathymetry group went to work immediately and converted the data into a high-resolution bathymetric map and a map of the backscatter values. All were amazed about the accuracy with which the morphological structures of the Bergamo mud volcano suddenly lay in front of the scientists and how they, of course, immediately aroused requests for sampling. First, however, an observation profile with the on-board video sled (OFOS) over the mud volcano, which was carried out on **Monday, 26 October**, was supposed to clarify individual structures. The dive with the OFOS began on the plateau-like central elevation of the mud volcano. Based on the flow structures two outflow areas are visible and according areas of high backscatter provide evidence for extensive eastward flow from the eastern, younger outflow area

(several hundred meters). In the central area of the mud volcano typical mud breccias appeared with many clasts of solid rocks of various sizes in the OFOS video. Cracks in the mud caused by the movement of the mud flows often show gray colors, typical for reduced geochemical environments on their flanks, while the surface sediments are characterized by brownish colors common in oxygen-rich environments. Isolated tube worms and numerous shells of lucinid clams are evidence of chemosynthetic fauna that only occurs scattered about, and, hence, does not mark a center for fluid or gas outflow on the volcano.

Along the OFOS track, in a south-westerly direction, the western slope of the mud volcano went 80 m downhill, where several round craters with a diameter of 100-150 m and a depth of 20-40 m occurred, which appeared interesting not only because of their very low backscatter values. Extremely high backscatter values on the other hand exist around the edges of the craters and can be explained by the occurrence of strongly lithified sediments, while a selective carbonate precipitation seems to exist along traces of bioturbation. After the nightly mapping activity to the north, sediment cores were taken of the Bergamo and Napoli mud volcanoes on Tuesday, 26 October, from which primarily the pore water profiles were of interest. The Napoli mud volcano has increasing salt content with depth, which shows that the pore water is influenced by the Messinian salts occurring in the sediments below, while the pore water of the Bergamo mud volcano shows decreasing salinity to values of 10 ‰ in half a meter below seafloor, which indicates fluids from great depth.

Since **Wednesday, 28 October**, station work approximately 20 nautical miles north of the Olympi mud volcanic field was carried out in the so-called zone of the Inner Ridge. The Inner Ridge is laying between the actual accretionary wedge of the collision zone between Africa and Europe and the backstop of the continental margin of Crete in the north. Since Wednesday we have also carried out 2 AUV measurements and 2 heat flow profiles at specifically selected locations, and have taken 6 gravity cores and 4 multicores. From Wednesday evening, the wind increased for the first time to Beaufort wind strengths of 6 and gusts of up to 7, with a swell from west to northwest causing waves up to 3.5 m high. As a result, an AUV dive was postponed and mapping of the region of the United Nation's ridge became the program in the night from **Thursday, 29 October** to Friday with the ship's hydro-acoustic systems instead. On Reformation day, Saturday, 31 October, a profile measurement of a section along the Inner Ridge was carried out during the night with the heat flow probe, after several core stations were completed during the day. This morning, the AUV dove to a depth of 3,500 m for mapping and will only return to the ship with its measurement data shortly before it gets dark.

During the past week mud volcanoes of the Olimpi mud volcano field and the United Nations Ridge were intensively investigated. In principle, mud volcanoes transport a mixture of clay, rock fragments or clasts, water and gas. Due to its low density, the mixture is not stable in deeper sediment layers. The lithostatic pressure of the overlying sediment causes the mud to rise to the surface of the earth or to the seafloor along weak areas, e.g. tectonic faults, where it forms cone-like structures, which look similar to magmatic volcanoes. Mud volcanoes are particularly common on the Mediterranean ridge south of Crete, where the compressive stress field of the converging tectonic plates in particular promotes the rising of mud and the formation of mud volcanoes. For the Bremen ocean floor cluster, the exchange of fluids and gases from the mud volcanoes with the seawater, which will be investigated with our samples, is of particular importance. The small-scale distribution plays an important role in sampling, because the exchange of fluids and gases is very different in the chimney area of a mud volcano compared to older mud flow deposits or on sediments at the edge of the volcano. Therefore, the high-resolution bathymetric maps of the AUV surveys form an essential basis for very targeted sampling, which has only been possible since AUV mapping became technologically feasible. The advantage of targeted sampling with a high spatial resolution, which are conducted using the ship's own underwater navigation, was especially evident this week, because the pore waters from the sediment cores show very large deviations from the

salinity of the sea water (39 ‰), with brines with a concentration of 200 ‰ and freshened formation waters with a concentration of 10 ‰.

The AUV was used on **Monday, 02 November** to map the Monza mud volcano and on Wednesday, 04 November on the Milano mud volcano. This mapping work was carried out during the night, with the device going into the water in the evening when it was still bright and coming out the next morning shortly after sunrise at 6:30 a.m. During the day mainly sediment core sampling and multicorer / minicorer stations were caaried out for surface sediment sampling on the Bergamo, Moscow, Maidstone, Milano and Leipzig mud volcanoes. The diverse names of the mud volcanoes show that international teams discovered mud volcanoes here as early as the 1990s and helped to shape the term “marine mud volcanism”. The Monza mud volcano was measured on **Tuesday, 03 November** with a heat flow profile and on Wednesday, 04 November with an OFOS observation profile of the sea floor.

Thursday, 05 November was a special day as it was the 25th day at sea and thus marked the middle of the 50-day expedition. The time was used on the transit to the United Nations Ridge for a longer mapping survey. Although several mud volcanoes have been described from the United Nations Ridge, it was decided to map the Dublin mud volcano in more detail, on the grounds of its high backscatter values in the swath mapping. Since an atmospheric low (1012 hPa) south of Cyprus slowly shifted its center south-south-west and gave a strong northerly wind current with isolated showers and a sea with swells up to 2.5 m high on Friday and Saturday, unfortunately, an AUV dive was possible neither on **Friday, 06 November**, nor on Saturday. So, after an interesting OFOS sled profile on the ground and after a sampling with the gravity corer and multicorer, the eastern work area was left and the vessel steamed back west to the Olimpi field. During a survey it was also possible to hydro-acoustically detect an escape of free gas on the sea floor in 1800 m water depth for the first time this cruise, with gas bubbles rising to 400 m above the seafloor.

After the vessel left the work area south of Crete to the northwest on Saturday evening, 14 November, a smaller work area was reached southwest of the Peloponnese on Sunday, 15 November, after 20 hours of steaming. This area, located on the western Mediterranean ridge, is also very close to the border between the accretionary wedge and the tectonic backstop and is officially referred to as the “cobblestone region” due to its morphological phenomena. One of the objects of investigation on the seabed was the Nice mud volcano, whose central mud outlet area we mapped with the AUV during the night from **Sunday, 8, to Monday, 9 November**. While most of the mud volcanoes investigated so far have more dome-like structures, the Nice mud volcano forms a flat elevation. Its mud flow deposits appear to be significantly more water-bearing and have flown in all directions from the central ascent channel. The AUV map also showed that the youngest mud flows mainly flowed towards the south, which prompted us to expand the map with an additional AUV dive carried out in the night from **Friday, 13, to Saturday, 14 November**. It was MARUM AUV-SEAL's 100th dive. Like in other cases, the detailed bathymetry acquired with the AUV allowed to pursue the scientific goals with further, more targeted sampling. On the Nice mud volcano, for instance, measurements of two heat flow profiles could be assigned to distinct mud flow units stacked on top of each other. Moreover, the acoustically detected and further examined a gas plume located in a fault zone to the north of the Nice mud volcano. The water samples that were collected at this location on **Monday, 9 November**, as part of a CTD station, showed up to 90 times higher methane levels directly above the sea floor and up to 150 m above it. An AUV survey on Thursday, 12 November, was able to specify several gas seeps that were close together. Finally, an observation profile with the OFOS on Friday, 13 November, showed how the corresponding sources with chemosynthetic living organisms and authigenic carbonates are built up on the sea floor.

Another highlight of the week were the findings of circular depressions on the sea floor with a diameter of 50 - 400 m, which are reminiscent of sinkholes and which were observed in various places on the AUV maps. Although their origin is unclear, their genesis seems to be related to the subrosion of the Messinian salts in the subsurface. Many indications were found that they were

once filled with brine. Such a pit was examined, still filled with brine, on **Wednesday, 11 November**, with a gravity corer equipped with temperature sensors. The brine was characterized by a clearly defined halocline, below which the salt content jumped to 270 ‰ in the gravity corer and the temperature rose from 13.8° C to a constant value of 14.5° C. With increasing depth, a second sharp transition was measured to likely brine-rich waters, that caused a further temperature increase of more than 1° C. The initial methane and H_2S concentrations were correspondingly high, hence the scientists carried out the analyses of this gas-rich sediment core with great caution, working in fresh air on the open deck as far as possible. Further sediment samples were taken this week on the Nice, Milano, Monza, Gelendzhik and Heraklion mud volcanoes, the processing of which often kept the scientists busy until late at night.

In the last week of the cruise the vessel already left the main area of work, the Olimpi mud volcano field, to move west along the Mediterranean ridge to the so-called “cobblestone area”. Here an area of approx. 1500 km^2 previously mapped with the ship's own multi-beam echo-sounder on the transit to the main working area more than 3 weeks ago. The resulting backscatter map enabled the scientists to assign values of high backscatter to known mud volcanoes from the area. One mud volcano with particularly high backscatter intensity was noticed, which, according to the literature known to us, was unnamed and had never been properly investigated. As the high backscatter seemed to indicate that it could be one of the recently active mud volcanoes, we wanted to conduct more measurements at this location. An AUV dive started by carrying from **Sunday evening, 15 November**, to Monday morning. On **Monday, 16 November**, while waiting for the AUV data to become available, we sampled the central area of the mud volcano and a neighboring mud volcano with a gravity corer and a multicorer, with sampling locations based on the ship-acquired data. In the afternoon we were then able to use the newly acquired AUV map to plan a transect with heat flow measurements for the following night. From the map it also became clear that the previous coring stations had not been ideal, and had missed the crater area by several meters. On **Tuesday, 17 November**, we therefore took some more gravity and multicores, using the AUV data for crater-targeted location selection. This whole process showed once again how important AUV maps are for scientifically precise sampling. During the afternoon meeting the scientists discussed the positive results and also chose the name “Helios mud volcano” for the mud volcano, which will be used to use in future scientific publications.

As the pore water investigations have shown, the fluids of the Helios mud volcano, like some of the other mud volcanoes we have investigated so far, have a significantly lower salinity than the seawater. On Tuesday afternoon the Cobblestone area and started another transit to the Calabrian Arc in Italy. There, we sampling began with gravity and multi-corers in the vicinity of the Sartori mud volcano on the afternoon of **Wednesday, 18 November**. When selecting the stations for sampling mud flow deposits of different ages, an AUV backscatter map was used which was acquired during a previous cruise, and chose sampling sites based on different backscatter intensities. This succeeded quite well, as both, hemipelagic sediments with sapropel layers and individual volcanic ash with mud flow breccias, were cored.

The age determination of the mud flow deposits will be carried out in the Bremen laboratories in the future, using radiocarbon dating (mainly 14C) of carbonate grains and tephra layers in sediments which are above and below the mud flow deposits. In addition to the thus obtained sediment ages, the distribution of the magnetic susceptibility, which were already measured on board with the multisensor core logger, will be used to correlate stratigraphic horizons. The multisensor core logger is also used to measure the electrical conductivity of the sediments, which gives information on lithological parameters. On the afternoon of **Thursday, 19 November**, the station work of the cruise was stopped and we carried out a short survey profile over the Venere mud volcano, with the focus on mapping previously observed flares in the water column. 6 years ago, this mud volcano was the most active, showing gas emissions of variable intensity at 5 locations on the edge of the caldera and in the center. This time, 4 of the 5 locations were active and showed acoustic anomalies in the water column. On Friday, 20 November the ship was already on the way back to Germany, where the vessel arrived on Monday, 30 November in the port of Emden and the scientists disembarked on Tuesday, 01 December 2020.

Acknowledgements

R/V SONNE cruise SO278 to the Mediterranean Ridge was planned, coordinated and carried out by MARUM "Center for Marine Environmental Sciences" at the University of Bremen. The cruise was financed by the "Deutsche Forschungsgemeinschaft" (DFG) through the cluster of excellence "The Ocean Floor – Earth's Uncharted Interface" (EXC 2077) and though funds related to the GPF review procedure (GPF 20_1_054, Sartori MV plus). We would like to specially acknowledge the master of the vessel, Lutz Mallon and his crew for their continued contribution to a pleasant and professional atmosphere aboard R/V SONNE. Many thanks to the staff of the German Research Fleet Coordination Centre at the University of Hamburg and to the Logistic Department of MARUM (Marco Klann and Götz Ruhland). We also would like to thank our colleagues of the German embassies in Greece and Italy for supporting our request of research at the foreign ministries.

Cruise participants

Name	Discipline	Affiliation
Ahrlich, Frauke	AUV deployments	MARUM
Antoniou, Dimitra	Paleontology	OCEANUS
Behrend, Nele	Sedimentology	MARUM
Bohrmann, Gerhard, Prof.	Marine Geology/Chief scientist	GeoB/MARUM
Innocenti, Simone	Marine Geophysics	OGS
Coulibay, Osmane	Core technology	MARUM
Eijsink, Aagjie	Sedimentology	MARUM
Feddersen, Greta	Sedimentology	GeoB/MARUM
Gaide, Stefanie	Hydro-acoustics	GeoB/MARUM
Kaul, Norbert, Dr.	Geophysics	GeoB
König, Tabea	Geochemistry	IfGB
Krahl, Julia	Sedimentology	IfGG
Kürzinger, Victoria	Geology	MARUM
Lenius, Sven	Geology	GeoB/MARUM
Malnati, Janice	Gas geochemistry	GeoB
Marschall, Lara	Hydro-acoustics	GeoB/MARUM
Niederbockstruck, Bryan	Geology	GeoB/MARUM
Pormann, Simon	Geochemistry	MARUM
Rau, Svenja	Geotechnics	MARUM
Römer, Miriam	Hydro-acoustics	GeoB/MARUM
Schillai, Sophia	AUV-technology	MARUM
Spiesecke, Ulli	AUV-technology	MARUM
Streuff, Katharina, Dr.	Geology	GeoB
Tseng, Yiting	Oceanography	GeoB
Vejzovic, Ines	Hydro-acoustics	MARUM
Von Wahl, Till	AUV-technology	MARUM
Warnken, Niklas	Geophysics	GeoB
Witzleb, Antonia	Geochemistry	MARUM

GeoB Fachbereich Geowissenschaften der Universität Bremen, Klagenfurter Straße, D-28359 Bremen, German, https://www.geo.uni-bremen.de

IfGG Institut für Geographie und Geologie, Universität Greifswald, Germany, https://geo.uni-greifswald.de

IfGB Institut für Geographie / FB 8, Universität Bremen, Universitätsboulevard 13 D 28359 Bremen, Germany, https://www.geographie.uni-bremen.de

MARUM Zentrum für Marine Umweltwissenschaften, Universität Bremen, Leobener Straße, D-28359 Bremen, Germany, http://www.marum.de

OCEANUS Marine Geology and Physical Oceanography Laboratory, University of Patras, 265 04 Patras, Greece, http://www.upatras.gr/en/node/23

OGS Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Borgo Grotta Gigante 42/C - 34010 - Sgonico (TS), Italy, https://www.inogs.it

List of Stations

			Time (UTC)		On seafloor		
Date	St.	Instrument	on	off	Latitude	Longitude	Water
2020	SO278/		seafloor	seafloor	N	E	depth (m)
10.21.20	001-1	HF-20-1	04:40	04:57	38° 12.0120	17° 37.6758	1910
10.21.20	001-2	HF-20-2	05:23	05:40	38° 12.105	17° 37.4922	1904
10.21.20	001-3	HF-20-3	06:10	06:26	38° 12.2112	17° 37.3074	1872
10.21.20	001-4	HF-20-4	06:48	06:56	38° 12.2706	17° 37.1958	1866
10.21.20	001-5	HF-20-5	07:16	07:32	38° 12.3180	17° 37.1208	1862
10.21.20	001-6	HF-20-6	07:49	08:05	38° 12.3528	17° 37.0590	1864
10.21.20	001-7	HF-20-7	08:26	08:42	38° 12.3840	17° 36.9978	1862
10.21.20	001-8	HF-20-8	09:12	09:28	38° 12.4488	17° 36.8748	1870
10.21.20	001-9	HF-20-9	09:53	10:10	38° 12.5310	17° 36.7374	1902
10.21.20	001-10	HF-20-10	10:45	11:02	38° 12.6492	17° 36.5100	1929
10.22.20	002-1	MIC-01	05:25		38° 12.3231	17° 37.1254	1856
10.22.20	002-2	GC-01	07:04		38° 12.3211	17° 37.1133	1856
10.22.20	003-1	GC-02	09:28		38° 10.5465	17° 35.0194	2006
10.22.20	003-2	MIC-02	11:49		38° 10.5379	17° 35.0232	2006
10.24.20	004-1	CTD-01	18:51		33° 43.4037	24° 41.2066	1932
10.25.20	005-1	AUV-91	07:02	14:30	33° 44.8480	24° 44.9679	2000
10.26.20	006-1	MIC-03	09:05		33° 43.4002	24° 41.1968	1932
10.26.20	007-1	OFOS-01	12:39	16:16	33° 44.3669	24° 45.1340	1929
10.26.20	008-1	HF-21-1	18:20	18:36	33° 44.5927	24° 45.9459	2038
10.26.20	008-2	HF-21-2	19:05	19:12	33° 44.4855	24° 45.7387	2019
10.26.20	008-3	HF-21-3	19:39	19:46	33° 44.4005	24° 45.5411	2006
10.26.20	008-4	HF-21-4	20:14	20:29	33° 44.3310	24° 45.3604	1979
10.26.20	008-5	HF-21-5	20:54	21:00	33° 44.3155	24° 45.2000	1939
10.26.20	008-6	HF-21-6	21:15	21:32	33° 44.3137	24° 45.1447	1935
10.26.20	008-7	HF-21-7	21:51	22:07	33° 44.3154	24° 45.0501	1932
10.26.20	008-8	HF-21-8	22:33	22:57	33° 44.3083	24° 44.8685	1936
10.26.20	008-9	HF-21-9	23:20	23:27	33° 44.2887	24° 44.7265	1964
10.27.20	008-10	HF-21-10	00:00	00:16	33° 44.2720	24° 44.5054	2020
10.27.20	008-11	HF-21-11	00:44	01:01	33° 44.2727	24° 44.3632	2047
10.27.20	008-12	HF-21-12	01:31	01:47	33° 44.2699	24° 44.1883	2039
10.27.20	008-13	HF-21-13	02:24	02:40	33° 44.0896	24° 44.3852	2038
10.27.20	009-1	AUV-92	05:40	15:00	33° 43.9426	24° 45.5397	2000
10.27.20	010-1	GC-03	17:28		33° 43.4011	24° 41.1959	1933
10.27.20	011-1	GC-04	19:56		33° 44.3279	24° 45.0576	1930
10.27.20	011-2	MIC-04	22:08		33° 44.3282	24° 45.0503	1930

10.28.20	**012-1**	**GC-05**	11:26		34° 5.6769	24° 58.3945	3346
10.28.20	**012-2**	**GC-06**	13:47		34° 5.6740	24° 58.3909	3320
10.28.20	**012-3**	**MUC-01**	16:34		34° 5.6692	24° 58.4002	3354
10.28.20	**013-1**	**HF-22-1**	19:34	19:49	34° 7.9152	24° 55.6191	3062
10.28.20	**013-2**	**HF-22-2**	21:22	21:29	34° 6.8834	24° 55.6205	3059
10.28.20	**013-3**	**HF-22-3**	23:34	23:39	34° 5.5100	24° 55.6182	3527
10/29/20	**013-4**	**HF-22-4**	00:37	00:52	34° 5.0807	24° 55.6251	3522
10/29/20	**013-5**	**HF-22-5**	02:33	02:47	34° 3.9038	24° 55.6193	3105
10/29/20	**013-6**	**HF-22-6**	04:14	04:21	34° 2.9328	24° 55.6252	3194
10/29/20	**014-1**	**CTD-02**			34° 5.2402	24° 55.6173	3526
10/29/20	**015-1**	**GC-07**	11:13		34° 7.2990	24° 59.3087	2501
10/29/20	**015-2**	**MUC-02**	13:14		34° 7.3095	24° 59.3080	2501
10/29/20	**016-1**	**GC-08**	16:00		34° 3.8940	24° 55.6230	3105
10/30/20	**017-1**	**AUV-93**	15:49	03:55	34° 2.1918	24° 56.2485	
10/31/20	**018-1**	**GC-09**	07:36		34° 5.5130	24° 55.6306	3530
10/31/20	**018-2**	**MUC-03**	10:23		34° 5.5121	24° 55.6238	3552
10/31/20	**019-1**	**GC-10**	13:21		34° 5.3641	24° 58.3380	3532
10/31/20	**020-1**	**GC-11**	16:24		34° 5.0841	24° 55.6292	3521
10/31/20	**021-1**	**HF-23-1**	19:13	19:27	34° 2.1656	24° 55.5223	3045
10/31/20	**021-2**	**HF-23-2**	20:18	20:24	34° 1.7800	24° 55.5286	3085
10/31/20	**021-3**	**HF-23-3**	21:04	21:10	34° 1.5560	24° 55.5314	3080
10/31/20	**021-4**	**HF-23-4**	21:51	22:05	34° 1.3306	24° 55.5255	3103
10/31/20	**021-5**	**HF-23-5**	22:30	22:37	34° 1.2058	24° 55.5265	3109
11.01.20	**021-6**	**HF-23-6**	23:39	23:54	34° 0.7575	24° 55.5385	3004
11.01.20	**021-7**	**HF-23-7**	01:01		34° 0.2459	24° 55.5179	-
11.01.20	**021-8**	**HF-23-8**	01:54	02:09	33° 59.8672	24° 55.5059	2832
11.01.20	**022-1**	**AUV-94**	06:00	15:00	34° 5.4704	24° 51.4182	3500
11.02.20	**023-1**	**GC-12**	08:47		33° 44.3047	24° 44.8789	1934
11.02.20	**023-2**	**MUC-04**	10:31		33° 44.3047	24° 44.8756	1936
11.02.20	**024-1**	**MUC-05**	12:28		33° 44.3240	24° 44.2685	2041
11.02.20	**024-2**	**GC-13**	14:04		33° 44.3252	24° 44.2721	2038
11.02.20	**025-1**	**AUV-95**	16:55	04:00	33° 43.8375	24° 45.9512	2000
11.03.20	**026-1**	**GC-14**	06:19		33° 44.4080	24° 45.0100	1937
11.03.20	**026-2**	**MUC-06**	07:55		33° 44.4053	24° 45.0041	1936
11.03.20	**027-1**	**MUC-07**	10:49		33° 40.5950	24° 31.7173	1824
11.03.20	**027-2**	**GC-15**	12:10		33° 40.5934	24° 31.7192	1824
11.03.20	**028-1**	**GC-16**	14:50		33° 37.1155	24° 40.6466	1934
11.03.20	**028-2**	**MUC-08**	16:43		33° 37.1199	24° 40.6550	1933
11.03.20	**029-1**	**HF-24-1**	19:34	19:48	33° 44.1768	24° 44.4378	2064
11.03.20	**029-2**	**HF-24-2**	20:10	20:16	33° 44.1425	24° 44.3526	2059
11.03.20	**029-3**	**HF-24-3**	20:56	21:12	33° 44.0972	24° 43.9019	2017
11.03.20	**029-4**	**HF-24-4**	21:42	21:49	33° 44.0684	24° 43.6407	1932
11.03.20	**029-5**	**HF-24-5**	22:13	22:20	33° 44.0654	24° 43.5168	1922
11.03.20	**029-6**	**HF-24-6**	22:36	22:51	33° 44.0608	24° 43.4784	1928
11.03.20	**029-7**	**HF-24-7**	23:08	23:15	33° 44.0584	24° 43.4408	1932
11.03.20	**029-8**	**HF-24-8**	23:33	23:40	33° 44.0512	24° 43.3801	1946
11.04.20	**029-10**	**HF-24-10**	00:52	00:59	33° 44.0197	24° 43.0477	2017
11.04.20	**030-1**	**OFOS-02**	04:09	11:39	33° 44.1048	24° 43.3641	1962
11.04.20	**031-1**	**CTD-03**	13:51		33° 44.0551	24° 46.7760	1950
11.04.20	**032-1**	**AUV-96**	16:27	03:42	33° 44.2930	24° 45.6660	1929
11.05.20	**033-1**	**GC-17**	06:25		33° 46.7619	24° 40.0083	1933
11.05.20	**033-2**	**MUC-09**	08:06		33° 46.7698	24° 40.0135	1936
11.06.20	**034-1**	**CTD-04**	17:15		33° 30.6020	25° 29.2834	2260
11.06.20	**035-1**	**HF-25-1**	20:00	20:15	33° 30.6255	25° 30.8340	2424
11.06.20	**035-2**	**HF-25-2**	21:09	21:16	33° 30.6139	25° 30.2533	2357
11.06.20	**035-3**	**HF-25-3**	22:02	22:09	33° 30.6108	25° 29.8303	2322

11.06.20	**035-4**	**HF-25-4**	22:54	23:09	33° 30.5973	25° 29.4382	2283
11.06.20	**035-5**	**HF-25-5**	23:39	00:10	33° 30.5905	25° 29.2848	2266
11.07.20	**035-6**	**HF-25-6**	01:04	01:19	33° 30.5801	25° 28.6208	2370
11.07.20	**035-7**	**HF-25-7**	02:05	02:11	33° 30.5693	25° 28.1130	2390
11.07.20	**035-8**	**HF-25-8**	03:08	03:15	33° 30.5596	25° 27.5161	2384
11.07.20	**036-1**	**OFOS-03**	06:03	10:35	33° 30.6133	25° 30.2584	2353
11.07.20	**037-1**	**GC-18**	12:35		33° 30.5300	25° 29.3488	2269
11.07.20	**037-2**	**MUC-10**	14:30		33° 30.5338	25° 29.3433	2265
11.08.20	**038-1**	**AUV-97**	15:56	03:50	34° 3.2407	24° 19.7522	1770
11.09.20	**039-1**	**CTD-05**	07:59		34° 9.8608	24° 18.8319	1865
11.09.20	**040-1**	**GC-19**	10:29		34° 8.6759	24° 19.8500	1813
11.09.20	**040-2**	**MUC-11**	12:09		34° 8.6704	24° 19.8469	1812
11.09.20	**041-1**	**MUC-12**	14:52		34° 4.0199	24° 18.3729	1721
11.09.20	**041-2**	**GC-20**	16:14		34° 4.0197	24° 18.3724	1737
11.09.20	**042-1**	**HF-26-1**	18:09	18:24	34° 2.2030	24° 19.7304	1862
11.09.20	**042-2**	**HF-26-2**	18:55	19:01	34° 2.3640	24° 19.5954	1890
11.09.20	**042-3**	**HF-26-3**	19:47	19:54	34° 2.6683	24° 19.3503	1863
11.09.20	**042-4**	**HF-26-4**	20:46	21:02	34° 3.1060	24° 19.0236	1826
11.09.20	**042-5**	**HF-26-5**	21:49	21:56	34° 3.4949	24° 18.7209	1778
11.09.20	**042-6**	**HF-26-6**	22:50	23:05	34° 3.9654	24° 18.3559	1724
11.09.20	**042-7**	**HF-26-7**	23:22	23:39	34° 4.0183	24° 18.3670	1719
11.10.20	**042-8**	**HF-26-8**	00:16	00:23	34° 4.0851	24° 18.0321	1778
11.10.20	**042-9**	**HF-26-9**	01:17	01:32	34° 4.168	24° 17.534	1813
11.10.20	**042-10**	**HF-26-10**	02:21	02:35	34° 4.253	24° 17.055	1730
11.10.20	**042-11**	**HF-26-11**	03:22	03:29	34° 4.369	24° 16.395	1828
11.10.20	**043-1**	**GC-21**	09:19		33° 44.0642	24° 43.4720	1921
11.10.20	**043-2**	**MUC-13**	11:00		33° 44.0555	24° 43.4649	1926
11.10.20	**044-1**	**MUC-14**	12:57		33° 44.1332	24° 44.3584	2077
11.11.20	**045-1**	**AUV-98**	15:54	04:48	33° 38.8321	24° 39.4741	1900
11.11.20	**046-1**	**MUC-15**	07:50		33° 43.9413	24° 46.6527	1947
11.11.20	**046-2**	**GC-22**	09:22		33° 43.9440	24° 46.6507	1956
11.11.20	**047-1**	**OFOS-04**	11:28	15:00	33° 43.6734	24° 46.7582	1974
11.11.20	**048-1**	**CTD-06**	17:52		33° 38.3470	24° 38.8813	2066
11.11.20	**048-2**	**GC-23**	20:02		33° 38.3396	24° 38.8854	2081
11.12.20	**049-1**	**AUV-99**	06:31	15:51	34° 10.3020	24° 19.6680	1880
11.12.20	**050-1**	**HF-27-1**	18:37	18:52	34° 3.1401	24° 19.5456	1835
11.12.20	**050-2**	**HF-27-2**	19:23	19:30	34° 3.1081	24° 19.2642	1852
11.12.20	**050-3**	**HF-27-3**	20:10	20:16	34° 3.0782	24° 18.8448	1798
11.12.20	**050-4**	**HF-27-4**	20:47	21:01	34° 3.0783	24° 18.6277	1779
11.12.20	**050-5**	**HF-27-5**	21:28	21:34	34° 3.0600	24° 18.4096	1782
11.12.20	**050-6**	**HF-27-6**	22:06	22:13	34° 3.0394	24° 18.1671	1812
11.12.20	**050-7**	**HF-27-7**	22:46	23:01	34° 3.0307	24° 17.9774	1862
11.12.20	**050-8**	**HF-27-8**	23:44	23:59	34° 3.0145	24° 17.6826	1861
11/13/20	**050-9**	**HF-27-9**	00:38	00:44	34° 2.9850	24° 17.3367	1870
11/13/20	**050-10**	**HF-27-10**	01:20	01:34	34° 2.9675	24° 17.1417	1835
11/13/20	**050-11**	**HF-27-11**	02:12	02:18	34° 2.9398	24° 16.7831	1863
11/13/20	**050-12**	**HF-27-12**	02:51	03:06	34° 2.9224	24° 16.5109	1850
11/13/20	**051-1**	**GC-24**	05:37		33° 54.175	24° 16.155	1709
11/13/20	**051-2**	**MUC-16**	07:13		33° 54.175	24° 16.155	1696
11/13/20	**052-1**	**GC-25**	09:25		33° 56.195	24° 06.918	1714
11/13/20	**053-1**	**OFOS-05**	12:39	17:02	34° 9.8767	24° 18.8252	1845
11/13/20	**054-1**	**AUV-100**	20:15	08:27	34° 1.5900	24° 17.7840	1900
11/14/20	**055-1**	**GC-26**	10:34		34° 3.0369	24° 18.1749	1819
11/14/20	**055-2**	**MUC-17**	12:07		34° 3.0423	24° 18.1853	1811
11/14/20	**056-1**	**MUC-18**	14:24		34° 8.4602	24° 19.4397	1803

11/14/20	**056-2**	**GC-27**	15:52		34° 8.4602	24° 19.4452	1812
11/14/20	**057-1**	**MUC-19**	19:10		33° 56.1979	24° 6.9129	1722
11/15/20	**058-1**	**AUV-101**	17:30	05:22	35° 56.1453	20° 46.1814	2900
11/16/20	**059-1**	**MUC-20**	08:20		35° 58.1876	20° 47.1307	2754
11/16/20	**059-2**	**GC-28**	10:20		35° 58.1830	20° 47.1349	2753
11/16/20	**060-1**	**GC-29**	12:52		35° 56.6328	20° 46.4209	2762
11/16/20	**060-2**	**MUC-21**	15:09		35° 56.6307	20° 46.4177	2758
11/16/20	**061-1**	**GC-30**	17:30		35° 58.1104	20° 47.1807	2751
11/16/20	**062-1**	**HF-28-1**	19:55	20:09	35° 56.6163	20° 46.3936	2752
11/16/20	**062-2**	**HF-28-2**	21:10	21:16	35° 56.9206	20° 46.8480	2857
11/16/20	**062-3**	**HF-28-3**	22:15	22:30	35° 57.2829	20° 47.2499	2896
11/16/20	**062-4**	**HF-28-4**	23:21	23:27	35° 57.6615	20° 47.2093	2857
11/17/20	**062-5**	**HF-28-5**	00:18	00:33	35° 58.1142	20° 47.1804	2759
11/17/20	**062-6**	**HF-28-6**	00:48	00:54	35° 58.1663	20° 47.1516	2753
11/17/20	**062-7**	**HF-28-7**	01:10	01:24	35° 58.2332	20° 47.1467	2754
11/17/20	**062-8**	**HF-28-8**	02:14	02:20	35° 58.6275	20° 47.0925	2897
11/17/20	**062-9**	**HF-28-9**	03:07	03:13	35° 58.9949	20° 47.0373	2924
11/17/20	**062-10**	**HF-28-10**	04:07	04:14	35° 59.4604	20° 46.9801	2950
11/17/20	**063-1**	**MUC-22**	06:58		35° 58.1122	20° 47.1714	2753
11/17/20	**064-1**	**GC-31**	09:14		35° 57.7990	20° 47.5806	2867
11/18/20	**065-1**	**MUC-23**	07:30		38° 12.3198	17° 37.1085	1856
11/18/20	**066-1**	**GC-32**	09:20		38° 10.9078	17° 36.8892	1967
11/18/20	**066-2**	**MUC-24**	11:05		38° 10.9078	17° 36.8900	1950
11/18/20	**067-1**	**MUC-25**	13:05		38° 12.6008	17° 36.7804	1894
11/18/20	**068-1**	**MUC-26**	14:46		38° 12.3558	17° 36.7506	1865
11/18/20	**069-1**	**MUC-27**	16:30		38° 12.3759	17° 36.6447	1888
11/18/20	**070-1**	**GC-33**	17:58		38° 12.3616	17° 36.7491	1887
11/18/20	**071-1**	**HF-29-1**	19:35	19:50	38° 12.6143	17° 37.5099	1882
11/18/20	**071-2**	**HF-29-2**	20:07	20:14	38° 12.5607	17° 37.4466	1887
11/18/20	**071-3**	**HF-29-3**	20:29	20:44	38° 12.5069	17° 37.3907	1892
11/18/20	**071-4**	**HF-29-4**	21:08	21:23	38° 12.3872	17° 37.2384	1865
11/18/20	**071-5**	**HF-29-5**	21:48	22:02	38° 12.3290	17° 37.1273	1857
11/18/20	**071-6**	**HF-29-6**	22:38	23:11	38° 12.3525	17° 36.8520	1862
11/18/20	**071-7**	**HF-29-7**	23:29	23:44	38° 12.3579	17° 36.7617	1866
11/19/20	**071-8**	**HF-29-8**	00:04	00:20	38° 12.3745	17° 36.6502	1885
11/19/20	**071-9**	**HF-29-9**	00:59	01:13	38° 12.3898	17° 36.2472	1928
11/19/20	**071-10**	**HF-29-10**	01:53	02:08	38° 12.1337	17° 35.9655	1952
11/19/20	**071-11**	**HF-29-11**	02:53	03:07	38° 11.7104	17° 35.9710	1964
11/19/20	**071-12**	**HF-29-12**	03:42	03:58	38° 11.3961	17° 36.0058	1955
11/19/20	**072-1**	**GC-34**	05:49		38° 12.3766	17° 36.6434	1888
11/19/20	**073-1**	**GC-35**	07:52		38° 11.3728	17° 35.6644	1981
11/19/20	**073-2**	**MUC-28**	09:39		38° 11.3741	17° 35.6650	1980
11/19/20	**074-1**	**GC-36**	11:23		38° 11.6180	17° 36.1995	1977
11/19/20	**074-2**	**MUC-29**	13:29		38° 11.6248	17° 35.2064	1976
11/19/20	**075-1**	**GC-37**	15:06		38° 12.3388	17° 35.5201	1976
11/19/20	**076-1**	**MUC-30**	17:07		38° 12.3862	17° 36.9991	1858
11/19/20	**076-2**	**GC-38**	18:33		38° 12.3883	17° 37.0010	1858

AUV: 11 dives with MARUM AUV SEAL 5000
GC: 38 gravity corer stations
MUC 30 Multicoere stations
MIC 4 Minicorer stations
CTD: 6 stations CTD with hydro-casts
OFOS: 5 stations with the Ocean Floor Observation System
HF 10 stations for heat flow measurements
3,577 nm of multibeam and Parasound mapping