First Weekly Report M72/2
23.02.-04.03.07

The expedition M72/2 “MICROHAB” is dedicated to the study of anoxic microbial habitats on the continental margin of the Black Sea. The Black Sea is the largest anoxic basin on earth and provides unique conditions for the study of microbial habitats and controls on key anaerobic microbial processes in the element cycles. In the focus of the study proposed here are in situ measurements of fluxes and turnover of methane and sulfur at seep systems of the Black Sea, as well as an investigation of the microbial diversity and function in a permanently anoxic setting, especially that associated with fluid flow and gas seepage. In the Northern Black Sea, a large variety of active methane seeps have been identified at depths from 100-3000 m, including actively gas emitting mud volcanoes, and unique microbial reefs. The main objectives of MICROHAB are to map specific microbial habitats at high resolution, to quantify the composition, distribution and development of microbial communities in the permanently anoxic Black Sea, to and to obtain insight in element cycling and export at different types of fluid seeps in the Black Sea. The expedition “MICROHAB” contributes to the GEOTECHNOLOGIEN program “Methane in the Geo-Bio-System” MUMM II by studying the microbiology and biogeochemistry of methane and sulfur turnover by in situ technologies, as well as to Work Package “Anoxic microbial habitats” of the EU FP6 Integrated Project HERMES which deals with the biodiversity of hot spot ecosystems at Europe’s continental margins.

We left the harbor of Istanbul in the morning of the 23 February. Not even the relatively dense fog was able to hide the beauty of the Bosporus coastline. Unfortunately the Black Sea waited for us with strong winds and high waves so that the 28 new scientists on board chose a light dinner and early rest. We arrived at the first site, the gas seeps at the North-Western slope of the Crimea Peninsula in the evening of the 24 February. After spring-time temperatures in Istanbul, we had to accustom to -5°C outside. Due to technical problems with the ROV QUEST we started instead with a series of TV-guided multicorers across the oxic-anoxic boundary from 120 m water depth down to 170 m for our new partner in HERMES, the Ukrainian Institute of Biology of the Southern Seas (IBSS). Katya Ivanova from the Benthos Ecology Department looks for changes in the fauna with regard to oxygen availability.

Fig.1 TV-MUC sampling on the NW-slope of the Crimea peninsula. Right: Katya Ivanova of IBSS

On the 25 February the weather improved considerably and we planned the first dive of the AUV AsterX (Ifremer) carrying the multibeam echosounder Simrad EM2000 (GeoAzur) above the gas seeps in 150-300 m water depth on the slope of the Crimea peninsula. The aim was to map the famous carbonate reefs formed by methanotrophic microorganisms in this region. Unfortunately it was discovered that the AUV has severe technical problems, and our Ifremer team on board is working hard on solutions ever since.

Fig. 2 The AUV AsterX being tested by Laurent Artzner and Lorenzo Brignone

Instead we worked with the ship based Kongsberg EM 710 Multibeam to prepare the first ROV dive to the microbial reefs. The task was to do video-mosaicking and sampling of the METROL and GHOSTDABS fields which were the targets of many previous investigations of the microbial reefs focusing on their organic and inorganic geochemistry and geobiology. Due to the technical problems with ROV QUEST (MARUM) the video-mosaicking was canceled, but we obtained very interesting push cores from between a chimney field showing various forms of subsurface mats and microbial biofilms, and quite gassy sediments.

Fig. 3 Pushcoring at Crimean seeps. Left: subsurface mat in a push core. Right: happy scientists Alexey Kamyshny and Laura Wehrmann with their prey

We continued to the Sorokin Trough NE of Crimea on the 26 February. This area is known for its many active mud volcanoes, which have been previously studied by the TTR program (IOC/UNESCO) and during METEOR expedition M52 “Margasch”. We had planned to focus on the Dvurechenskii mud volcano (DMV), a flat-topped and very active mud volcano in the Sorokin Trough. The 27 and 28 February we spent mapping the mud volcano with the EM120 to plan the dives, and with deployment of gravity corers equipped with in situ temperature probes.

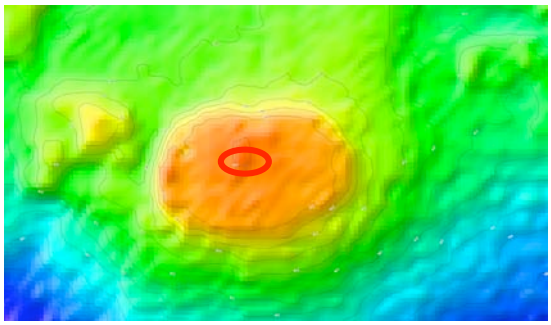


Fig. 4 Dvurechenski mud volcano.

As part of the HERMES program, Tom Feseker of IFREMER/AWI is studying the in situ temperatures of the surface and subsurface muds in relation to the morphology and chemistry of the mud volcano for a better idea of the fluid flow and its causes and effects. We have discovered a small elevation in the NE center of the mud volcano where relatively fresh mud flows are visible and free gas is escaping when the seafloor is touched by the ROV or our instruments. Tom was able to confirm that this is the warmest spot on the DMV by gravity coring. The ring marks the gassy mound, which we are currently sampling.

Between 1 and 4 March we have mainly concentrated on TV MUC and gravity core sampling of the center and Northern and Southern rim of the DMV. We are analyzing the biogeochemical signatures of various microbial and geochemical processes in sediments connected to methane turnover within and outside of the mud volcano. Thanks to the hard work of the ROV QUEST technical team on board, the deep-water robot QUEST of MARUM is currently diving to deploy the microsensor profiler measuring sulfide fluxes and pH profiles together with the temperature probe system along a transect from the active center to the outside of DMV. Despite the many technical problems we are making good progress with the work and have a good time on board supported by the excellent captain and crew of METEOR. With our best greetings to families, friends and colleagues on land – the MICROHAB team.

Fig. 5 Work on board METEOR. Upper panel: Tobias Mohr, Thomas Holler and Florence Schubotz sampling subsurface sediments for analyses of methane turnover. Lower panel: The temperature probe in in action; QUEST being prepared for a dive.

Second Weekly Report M72/2
03.03.-11.03.07

The second week of the expedition M72/2 started with an extremely exciting dive of the deep-water robot QUEST. The 150st dive of QUEST broke several records at once: it lasted 32 hours and 20 minutes, resulted in 72 microsensor profiles, 23 in situ temperature probe measurements and 10 pages Alamer dive report. And no, this was not a tour the force commanded by the chief scientist known for her immense sampling appetite – it was the practical decision of the QUEST team leader to avoid a recovery procedure at Beaufort 9. The Black Sea is full of surprises, among which are unpredictable storms that may last for 24 hours and then vanish as rapidly as they have started. This was the situation on the 4th March: the well-prepared dive protocol suggested a modest 3 profiler deployments and recovery after 11 hours bottom time at 08:00 in the morning of the 5th March. Facing 4 m high waves, the brave ROV team offered a continuous dive program as a birthday present to the chief scientist who had just turned 40. This unwanted change of the station plan (and birthday party scheduling) resulted in a beautiful data set on geosphere-biosphere interaction: One of our main scientific questions on the MICROHAB cruise is as to the influence of subsurface fluid flow velocity on microbial activity, especially with regard to consumption of the greenhouse gas methane.

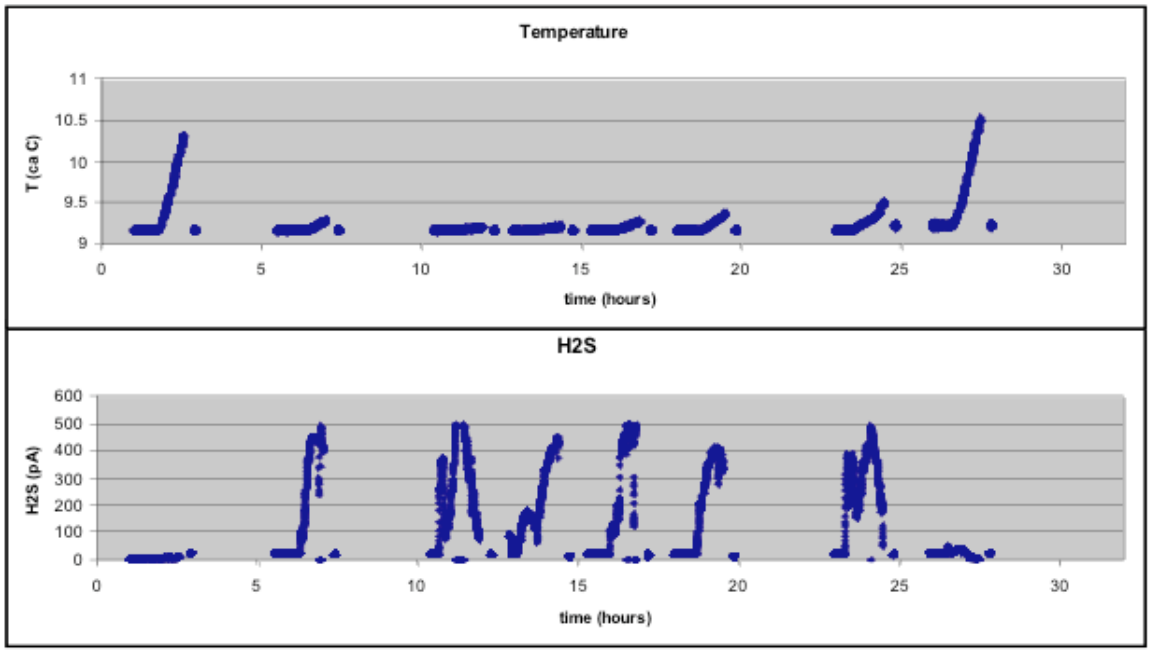


Fig. 1. The transect of dive 150 started and ended at the warm summit of the DMV, which shows the highest temperature anomalies in the sediments, but no sulfide production. In contrast, microbial methane consumption is very high at the geographical center (sampled at hour 7 and hour 24 of the dive) and at the rim (other measurements).

We use temperature and sediment geochemistry as indicators of fluid flow rates. At the summit of the Dvurechenski mud volcano a temperature anomaly indicates high upward flow rates of sulfate depleted, warm fluids suppressing the formation of gas hydrates at 2000 m water depth. With temperature probing and microsensor deployments (measuring sulfide as a product of microbial methane consumption), we carried out a transect from the active warm summit across the geographical center of the mud volcano to its Western Rim and back to the summit.

Fig. 1 shows the negative correlation between temperature increase in the sediments (related to fluid flow velocity) and sulfide production by the methanotrophic consortia in the sediments. In areas with high fluid flow rates the methanotrophs are flushed with sulfate-free subsurface water and methane passes from the deep to the hydrosphere. In the case of the Dvurechenski MV the warm summit is loaded with free gas bubbles, which are released upon minor pressure changes. Microbes cannot profit from this potential energy source because of their limitation in the electron acceptor sulfate. The muds and fluids of the summit are so warm that temperature increased significantly in the benthic chamber we deployed to measure methane flux from the seafloor to the hydrosphere on the DMV summit (Fig. 2). The benthic chamber encloses 250 cm^2 sediment. In parallel to the substantial temperature increase, methane concentrations increased by an order of magnitude within 8 hrs compared to the surrounding bottom water.

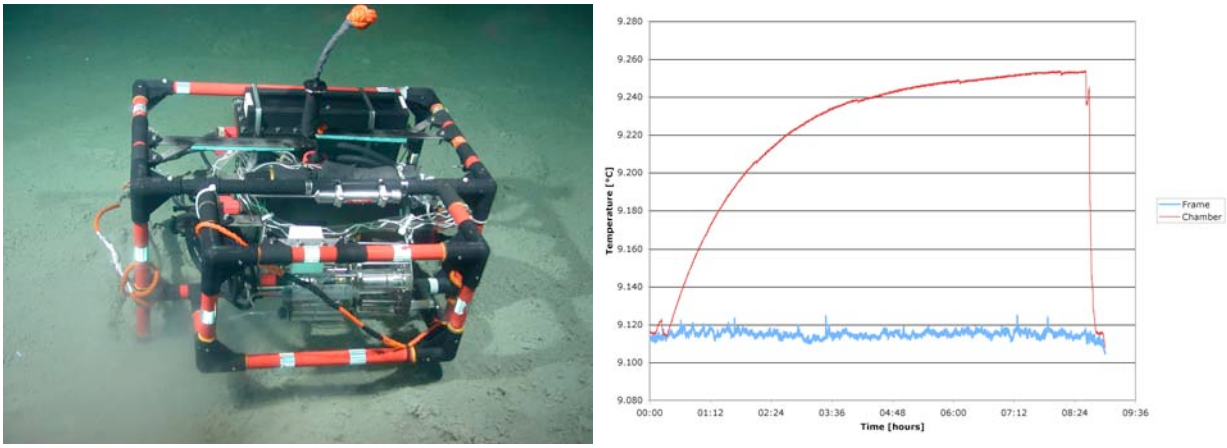
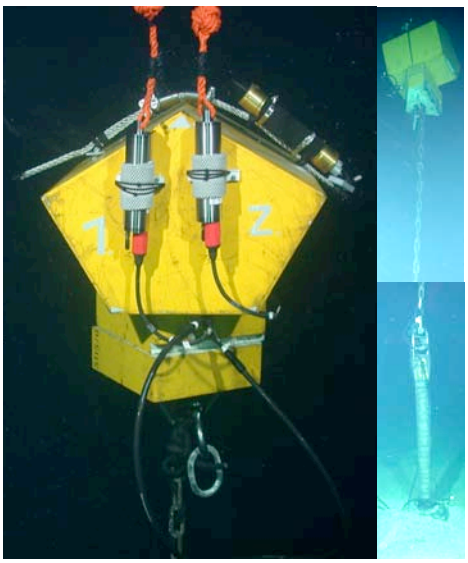


Fig. 2. The benthic chamber deployed at the summit of the Dvurechenski mud volcano. Right: The temperature record of within (red) and outside (blue) the chamber.

Fig. 3 Right: The long term temperature observatory deployed at the center of Dvurechenski mud volcano. Large image: the 2 temperature loggers recording subsurface temperature measurements every 70 cm down to 6 m sediment depth. Small image: the mooring with the submerged gravity core and the float with the temperature loggers 5 m in the water column. Bottom: the wood colonization deployment of project DIWOOD



Before we left the Dvurechenski mud volcano we deployed successfully a long-term subsurface temperature observatory (Fig. 3) similar to the one previously deployed by the fluid flow-working group of IFREMER-AWI at Haakon Mosby mud volcano. One temperature logger will be retrieved in a month from now by the working group of Gerhard Bohrmann (RCOM Bremen; M72/3), another one when we return in 2009. Another long term experiment is the deployment of wood for the future observation of its microbial degradation under anoxic conditions in comparison to the animal-microbe mediated degradation in oxic deep-sea habitats where the wood often attracts a high diversity of unique species – but also relatives of chemosynthetic animals as they are found at vents and seeps (project DIWOOD).

The transit around the Crimean peninsula to the seeps on the NW Crimean shelf at 240 m gave us finally some time to celebrate. And then another one of the birthday wishes came true...

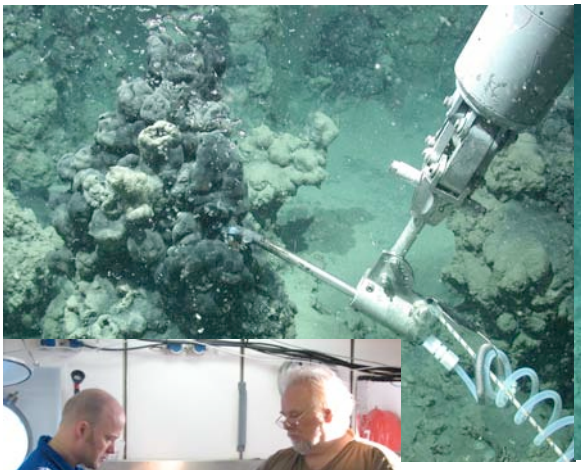
Fig. 4. ...an all MPI dive shift: Marc Viehweger at the arm, Patrick Meyer flying, Laura Wehrmann writing the dive protocol and recently turned 40 Antje Boetius happy ☺...

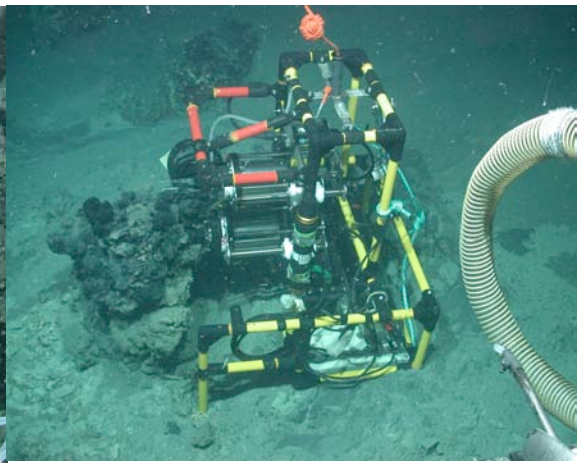
...ok, not all MPI, there are still some masked experts at the winch closely paying attention. Left: Phillip Franke, right: the QUEST team leader Götz Ruhland, both of MARUM

The last 4 days of the cruise were dedicated to in situ measurements of sulfide fluxes and methane consumption in the microbial reefs at the gas seeps on the Crimean shelf. We managed 3 12 hour dives with QUEST and worked both at the GHOSTDABS field discovered by scientists of the University Hamburg in 2001 as well as at the close-by METROL field discovered by the EU project METROL in 2004. The sidescan sonar of ROV QUEST was used to map the fields and the distributions of chimneys, which reach from a few cm above bottom to 4 m in height. The microbial reefs are the largest and densest accumulations of microbes known on earth and consist of methanotrophic archaea and a variety of associated bacteria. Anaerobic methane consumption

does not result in a large energy yield, hence, growth of microbes is extremely slow. A rough estimate suggests that the large chimneys may be a few 1000 years old. Unfortunately, large areas of these unique microbial reefs have been destroyed, probably by benthic trawling, which makes one wonder about the establishment of marine protected areas even for microbes.

Fig. 4 The unique methanotrophic reefs of the Black Sea. Left: Gas sampling above a microbial chimney. Right: in situ profiling of sulfide fluxes and pH with the horizontal microprofiler, Bottom: Two microbiologists sharing insight into anoxic microbial habitats: Thomas Holler of MPI and Barry Cragg of the University of Cardiff





We are now finished with station work and steaming back to Istanbul. It is good to be done and go home, but also a bit sad to leave without all of our goals achieved, despite the hard work of the French and German robot teams who gave their best to provide dive time. Definitely we would like to come back to continue with in situ biogeochemical and ecological investigations of the Sorokin Trough mud volcanoes and other interesting seeps of the Black Sea as soon as possible! For now we thank the captain and crew of METEOR for all their excellent help and support and send our best greetings to all friends and colleagues at home,

the MICROHAB team.