Meteor Berichte 05

Mid-Atlantic Expedition 2005

Cruise No. 64, Leg 2

Longterm study of hydrothermalism and biology at the Logatchev field, Mid-Atlantic Ridge at 14°45'N (revisit 2005; HYDROMAR II)

6 May – 6 June 2005, Fortaleza (Brazil) – Dakar (Senegal)

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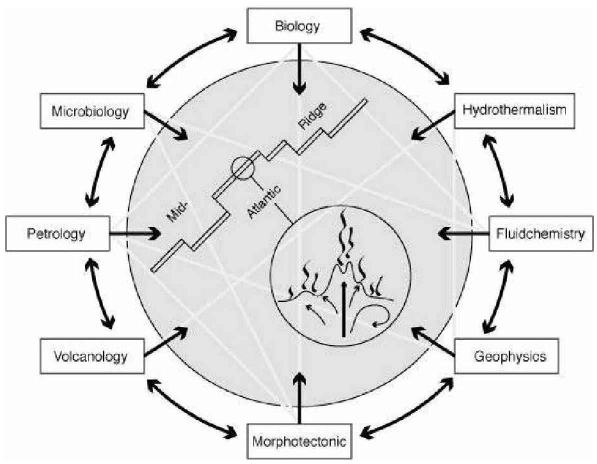

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Content

Summary

The R/V METEOR cruise M64/2 was the second German expedition to the hydrothermal active Logatchev field at 14°45’N which took place from May 6 through June 6, 2005 from Fortaleza/Brasil to Dakar/Senegal.

Further mapping and sampling as well as the first deployment of longterm monitoring stations were accomplished in the Logatchev Hydrothermal Field-1 (LHF-1) at 14°45’N on the Mid-Atlantic Ridge. The main working tools during our cruise were the deep-sea ROV “QUEST”, a TV-grab, a TV-sled and a hydrocast. At 14°45.047 N and 44°58’671 W we discovered a 5 m high active black smoker (site “A” after Gebruk et al., 1997) which has been named “Barad-Dûr” after the black tower of Mordor in the bestseller “Lord of the Rings”. Based on a video and photographic survey we were able to create a photomosaic of this tower as well as of the smoker complex at the IRINA II site. During a ROV survey northwest of the active QUEST site we found a new diffuse venting site at 14°45.31 N and 44°58.87 W.

Along CTD surveys above the LHF-1 a clearly defined plume in methane concentration (up to 0.3 µmol/L CH4) was identified between 2700 m and 2900 m waterdepth. Strong evidence was found for additional hydrothermal activity approximately 2 nm northwest of LHF-1. High hydrogen concentrations (> 50 nmol/L) together with a layer of increased light transmission at 3030 to 3080 m waterdepth indicate the presence of venting in this area.

During 9 ROV dives we sampled a large variety of sulfides and Fe-oxid-hydoxide crusts. In addition, 7 TV grab stations with serpentinized pyroxenites, Mn-crusts, silicified crusts and atacamites have completed the overall surface sampling in the area of LHF-1 which was a direct continuation of the work begun in 2004 during cruise M60/3. A total of 15 vent fluid samples were obtained with the ROV fluid sampling system. The sampled vent fluids are highly reduced and acidic indicating a low proportion of intermixed seawater. Lowest values obtained for fluid samples were 3.9 for pH and –370 mV for Eh. The highest in-situ temperature measured during this cruise was 350°C at Site “B”.

During this cruise, we also contributed to our ongoing studies of geobiological coupling at MAR vents by identifying and characterizing gradients in vent fluids in mussel beds, and collecting mussels along these gradients for analysis of the biomass and activity of the bacterial symbionts. *In-situ* microsensor measurements of O_2, pH, H_2S, T and, for the first time, H_2 were used to investigate the links between the geochemical energy supply from hydrothermal fluids and hydrothermal vent communities. These high-resolution microprofiles allow to determine the variability of hydrothermal fluid emission in space and time and its influences on vent communities.

An ocean bottom tiltmeter (OBT) and an ocean pressure meter (OBP) were deployed in the LHF-1 to monitore tidal loading, micro seismicity and recent tectonic processes over atime period of ≥ 1 year. In addition, we have placed a set of temperature loggers in mussel fields of the QUEST and IRINA II sites monitoring temperature variations in the biological community as possible indicator for changes in their living environment.

2.1 Participants

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2.2 Research Program

(K. S. Lackschewitz, H. Villinger)

The investigations of this cruise are a continuation of the program started between 14°45'N and 15°05'N on the Mid-Atlantic Ridge in 2004 (cruise M60/3). While in the 2004 cruise basic geochemical and biological studies were carried out in the Logatchev hydrothermal field, the emphasis of the 2005 cruise lies on the temporal variability of fluid emanations, fluid temperature and chemistry, microbial activities and associated fauna at selected hydrothermal vent sites. The overall goal of the proposed cruise is to advance the integrated study of the 14°45'N hydrothermal sites further through multi-disciplinary characterization and sampling at several sites. Biological, mineralogical and hydrological samples are to be taken in a well-characterized thermal environment so that the results on the samples can be interpreted in terms of the influence of the important environmental parameter temperature. The cruise is the second in a number of cruises within the 6-year SPP program, dedicated to a long-term study in this area to investigate medium-term variability in the hydrothermally active sites and the related geochemical and biological consequences.

Long-term monitoring of all relevant environmental parameters is essential to assess the temporal variability observed in the biogeochemistry of the hydrothermal field. The parameters are (a) temperature, (b) absolute pressure, (c) mean micro seismicity and (d) local sea floor tilt. We will observe correlation and coupling between hot fluid outflow, hydrothermal activity, tidal loading, micro seismicity and recent tectonic processes with high resolution of amplitudes and time. Additionally, a plume temperature profiler for mapping the extend of the hydrothermal plume, a distributed temperature sensing system for monitoring in particular biological communities at the sea floor, a ROV temperature lance with online data transfer over the ROV communication system up to the ship and a temperature calibration facility for the temperature sensors is provided. Temperature measurements, the use of sensors and the sampling of fluids to determine the chemical composition of the fluids, material fluxes and spatial and temporal gradients give the basic information to characterize the environment in which the ecosystem develops. Three groups are mainly interested in the characterization of free living microorganisms, which are involved in carbon and sulfur cycling in hydrothermal vent areas. Methane consuming communities are studied in hydrothermal fluids, sediments and crusts with a special focus on the process of anaerobic oxidation of methane and in close cooperation with the gas geochemistry group. Another group is predominantly interested in sulfur bacteria and in the influence of temperature on microbial communities, cooperating closely with the groups analyzing sulfur species and isotopes. Environmental genomics are applied to investigate the metabolic capabilities of these microbial communities, thereby focusing on the finding of new genes and unexpected metabolic properties. The development of symbiotic communities (bacteria and host fauna) is directly related to the chemical content and energy of the fluids. However, the pathway of interactions does not only involve influence of the fluids on the development of organism communities, but microorganisms and fauna also change the fluid chemistry due to their uptake and excretion of chemical compounds.

Samples for the biologists are chosen in cooperation with the geochemists measuring the different abiotic parameters. The samples are shared between the different groups, analyzed in close collaboration and the results will be finally evaluated in the context of all geochemical and microbiological findings with respect to the bio-geo coupling. The aim is to develop an overall model for the temporal and spatial development of the Logatchev hydrothermal ecosystem, which also includes control by general environmental parameters such as water depth and geological conditions.

2.3 Narrative of the cruise

(K.S. Lackschewitz)

The final preparations for cruise M64/2 were completed onboard the R/V METEOR in the harbour of Fortaleza (Brazil) between May 3 and 6. All 22 scientists of Leg M64/2 boarded the ship on May 5. A test of the ROV vehicle in the harbour was successfully carried out at midday on May 6.

The R/V METEOR cleared the port of Fortaleza in the afternoon of May 6 and began her transit to 13°30'N and 45°00'W. The scientists used the five-day transit to set up the laboratories and to test their sensors and water sampling equipment. Scientific work started in the afternoon of May 10 with a reference CTD hydrocast station at 13°30'N/45°00'W for sampling seawater from different waterdepths. Hydrosweep mapping along the ridge axis was carried out during the night. A 90 minute transit to our main working area, the Logatchev hydrothermal field (LHF-1; 14°45.20'N/44°58.80'S), was followed by a CTD hydrocast station to investigate the hydrothermal plume over the LHF-1.

In the morning of May 11 the first ROV station failed shortly after deployment due to communication problems between the ROV and the control container. Therefore, a hydrocast station was carried out SW of LHF-1 to investigate the hydrothermal plume dispersal in the water column. A TV-grab (222GTV) was taken about 300m SW of LHF-1 in order to sample the periphery. The samples comprised of serpentinized ultramafics, partly covered with Mn-crusts, and one rock with atacamite. The night of May 12 was filled with a MAPR (miniatur autonomous plume recorder) string jo-jo (5 MAPP's and 20 temperature loggers) to trace the turbidity anomalies of the hydrothermal plume in the area of LHF-1.4.

On May 12 another attempt of a ROV dive failed again due to communication problems. A TV-grab station taken ca. 50 m southwest of IRINA II sampled ultramafics and Mn crusts. In the afternoon we started our first successful ROV dive (224) during our cruise M64-2. After reaching the seafloor we obtained an acoustic signal from the homer beacon 12 which we set up as a reference station during the cruise M60-3 at the QUEST site. We set up another beacon (Nr. 14; 14°45,199'N/44°58,783'W) and an ocean bottom tilt meter (OBT) ca. 42 m southwest of beacon 12. Fluid samples and temperature measurements were taken at a small active black smoker close to the IRINA-II smoker complex.

We continued our geological program with a TV-sled track from the NE to the SW over the LHF-1 in order to find hydrothermal precipitates and map the distribution of ultramafics in this area. Another hydrocast station should further map the distribution of the hydrothermal plume in the water column, whereas a stationary MAPR string over this area should map the temporal variations of the proximal hydrothermal plume.

During May 13 a ROV deployment was not possible due to a high sea swell.

The night to the May 14 was filled with two TV-grab stations and one hydrocast station. 229 GTV was taken ca. 50 m west of ANNA LOUISE. The samples comprised of weakly indurated to higher indurated brownish sediment, dark grayish sediment with fine dispersed pyrite crystals, and several Mn-crusts . At station 230 GTV south of „A“ the samples consist of altered coarse-grained to pegmatoid orthopyroxenites. The hydrocast station (231CTD) sampled the hydrothermal plume ca. 200 m northwest of the QUEST site.
During dive 232ROV on May 14 biological and fluid samples were taken from a mussel field at the southern rim of the IRINA II compex. A special objective was a mussel transplant experiment. In this experiment we are investigating how the removal of the mussels from the vent fluids will influence them and their symbiotic bacteria. Before collecting the mussels, insitu measurements of several physico-chemical parameters were taken (oxygen, temperature, sulfide, hydrogen, pH) with a profiler module. In addition, fluid samples were taken.
Plume mapping with the CTD was carried out during the night of May 14 to 15. The northernmost CTD station detected three turbidity anomalies at 2700 m, 2900 m and 3050 m ca. 1.5 km NNW of the LHF-1 suggesting at least one other unknown hydrothermal source. A TV-grab (station 239) was taken ca. 250 m northeast of IRINA-II in order to sample the periphery of the LHF-1. Beside much sediment, crusts covered with atacamite and several pieces of talc were detected. On the sediment surface we found several mussel shells of *Bathymodyolus* and *Phymorhynchus*.

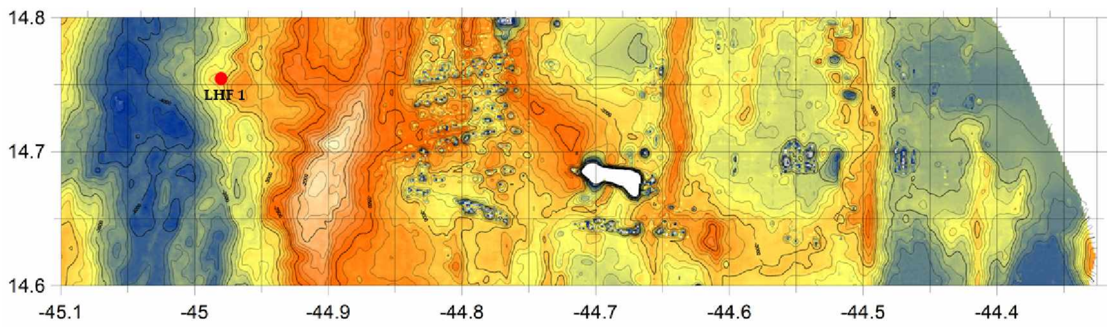


Fig. 2.1: Bathymetric map of the working area produced with Hydrosweep during the cruise M64/2. The location of the Logachev-1 hydrothermal field is indicated by the red dot.

Hydrosweep mapping along 5 profiles was carried out during the night of May 16 to 17. The objective was to map the upper ridge flank east of the Logatchev field (Fig. 2.1).
During dive 244ROV on May 17 the OBT was set up on a plain place together with beacon 14 to the SW of IRINA II. In the following we have continued the mussel transplant experiments of 232ROV by taking 5 nets with mussels and puting them in the inactive area of the OBT. Temperature measurements in the mussel field produced readings ranging between 5 and 50°C. Four hydrocast stations (stations 245 to 248) were carried out in the N of LHF-1. The objective of these stations was to investigate the distribution of the turbidity anomalies in 2700 m, 2900 m and 3050 m.
On May 18 station 249ROV was reserved for fluid sampling of black smokers at ANNA LOUISE and IRINA I. At both sites temperature measurements with an 8-channel temperature probe produced values of 205°C and 188°C, respectively. A TV-grab (st 250)

between IRINA II and site „B“ sampled a thick sediment unit showing colors from yellowish brown, reddish brown and green. A temperature measurement in the sediment yielded still 43°C. In addition, samples consist of silicified crusts and highly altered peridotites and pyroxenites.
The dive 252ROV on May 19 aimed at detailed mapping the southernmost area of LHF-1 including site „A“ which was not discovered during M60/3. After the installation of beacon 11 at IRINA I site we started our mapping profiles south of ANNA LOUISE. On the second profile we found a 5m high active black smoker which is related to site „A“, first described by Gebruk et al. (1997). We named this smoker „Barad-Dûr“ after the black tower of Mordor in the book „Lord of the Rings“. We sampled several sulfide fragments from the underlying mound of Barar-Dûr and another rock sample from the IRINA I site.
Four hydrocast station stations (253-256) during the night from May 19 to 20 mapped and sampled the plume in 2700 to 2800 m ca. 600 m to the northwest of LHF-1.
During the day of May 20 the dive ROV 257 placed 10 temperature loggers in the mussel field at IRINA II for longterm monitoring. Another main target of this dive was to sample fluids, sulfides and bacteria mats at site „B“. The onboard analyses of the fluids have shown a pH of 3.9. The following night two TV grab stations east and northeast of QUEST and a hydrocast station to the NNW of LHF-1 were carried out. The first TV grab (st. 258) sampled a few shells of the hydrothermal mussel species *Calyptogena* and several small peridotite pieces. The second TV-grab (st. 259) was empty. The hydrocast (st. 260) sampled 11 water samples from different water depth ca. 1.5 km NNW from LHF-1.
Station 261ROV on May 21 concentrated on fluid sampling at Site „A“ and IRINA. In addition, sulfides were sampled at both sites. During the night Hydrosweep mapping was continued on the upper ridge flank to the east.
During dive 263ROV on May 22 a special objective was a sampling program in the area of the Russian marker ANYA. We sampled two push cores for bacterial studies and mussels with a net. In addition, we set up a beacon (11) to provide a precise site location because the original position according to Gebruk et al. (2000) appeared to be northwest of IRINA II.
We continued our program with two hydrocast stations west of LHF-1. Both stations showed no turbidity anomalies, but water samples between 2700-2800 m have still minor methan anomalies.
During ROV station 266 on May 23 fluid parameters were measured directly above five places in a diffuse venting mussel field of IRINA II by the profiler module. After the investigation of this site we picked up beacon 11 near the marker „ANJA“ and placed it 10 m east of site „B“. In the following, we took fluid samples at a black smoker which is close to the sampled smoker of 257ROV. Temperature measurements at both sites show values of 350°C and 300°C..
Four hydrocast stations (st. 267-270) ca. 0.5-1 sm south and southeast of LHF-1 did not show a turbidity signal of the plume. However, we have still identified the plume by a slight increase of CH_4 in water samples between 2700-2800 m
On May 24 we started with a deployment of a 25 m longterm temperature mooring from the ship (st. 271). During the following ROV station 272 we repositioned this mooring in the region between IRINA I and ANNA LOUISE. Another target was the precise horizontal placement (angle of < 2°) of the OBT at beacon 14. In addition, we placed two push cores in

the mussel field of IRINA II for microbial experiments and we took some samples from an inactive smoker ENE of IRINA II.

Another four hydrocast stations (st. 273-276) have indicated that the eastern ridge flank acts as a boundary for the distribution of hydrothermal plume to the east and northeast.

During dive 277ROV on May 25 we placed again the profiler module in the diffuse venting mussel field at IRINA II. Temperature measurements showed values up to 140°C. In addition, a baited trap was deployed on the mussel bed close to the chimney complex. Detailed video images were recorded along two horizontal profiles of the eastern part of the chimney complex for constructing a photomosaic of this whole structure. Diffusely venting fluids were sampled at the chimney complex close to the area which was already sampled during M60-3 (st. 38ROV). Hydrothermal fauna were collected here also. At the end of the dive we mapped the area east of IRINA II along two profiles.

A TV-sled track (st. 278) was carried out 2 sm north of LHF-1 in order to find indications of an active vent field creating the hydrothermal plume in 3050 m water depth. Due to an electric failure this station was aborted shortly after the first profile. In following two hydrocast station were carried out above the QUEST vent site and ca. 3 sm NW of LHF-1.

The main target of dive 281ROV was a sampling program at the QUEST site. First we placed a benthic chamber on a mussel bed at IRINA II to measure H_2 and S^{2-} for several hours. At QUEST site we sampled fluids and a net of hydrothermal fauna at a diffuse venting mussel bed. At this site we placed also 9 longterm temperature monitoring loggers. In addition, we took fluid samples, temperatures and sulfide samples from a hot venting black smoker. During the following night Hydrosweep mapping was continued on the upper eastern ridge flank.

At dive 283ROV on May 27 we continued our work at QUEST site. We deployed two 8-channel temperature loggers in the main mussel bed and sampled diffuse fluids with 3 Niskin bottles. A camera survey over the mussel bed was made to produce a photomosaic. Next we placed the OPT on more stable ground and took the last net for the mussel bed experiment. In the following we finished our sampling program in IRINA II taking another fluid samples, temperatures at two vents and a net with shrimps. At the end of the dive we picked up the beacon 13 and the baited trap. The night to May 28 was filled with another TV-sled station (st. 284) which investigated the area northwest of LHF-1 along several profiles searching unknown hydrothermal sites.

After this TV-sled track our last ROV station (285ROV) explored and mapped the area northwest of QUEST site in order to find an unknown vent site. After several profiles we found a new diffuse venting site with several highly altered crusts ca. 150 m northwest of QUEST site.

Station work of cruise M64/2 was finished after this station and R/V Meteor started her transit to Dakar. R/V Meteor arrived the port of Dakar on June 4, at 06:00 am. All containers were brought to the pier and loaded there by the scientific and technical crew. The scientists of cruise M64/2 disembarked until the early evening of June 6, 2005.

2.4 Preliminary Results

2.4.1 Detailed geological studies of the Logatchev-1 hydrothermal field

(K.S. Lackschewitz, N. Augustin)

The geological setting and structure of the Logatchev-1 hydrothermal field (LHF-1), situated on a small plateau on the eastern flank of the inner rift valley at 14°45’ N, has been described by several workers (e.g., Krasnov et al. 1995; Gebruk et al., 1997). Extensive bathymetric and video mapping of the LHF during the first RV Meteor cruise M60/3 have revealed the main factors of its tectonic control (Kuhn et al., 2004). Detailed sampling has allowed study of the interrelationship of geological, geochemical and biological processes of an ultramafic-hosted hydrothermal system.

The present detailed work carried out during the second RV Meteor cruise M64/2 resulted in a further mapping and sampling as well as the first deployments of long term monitoring stations (Fig. 2.2).

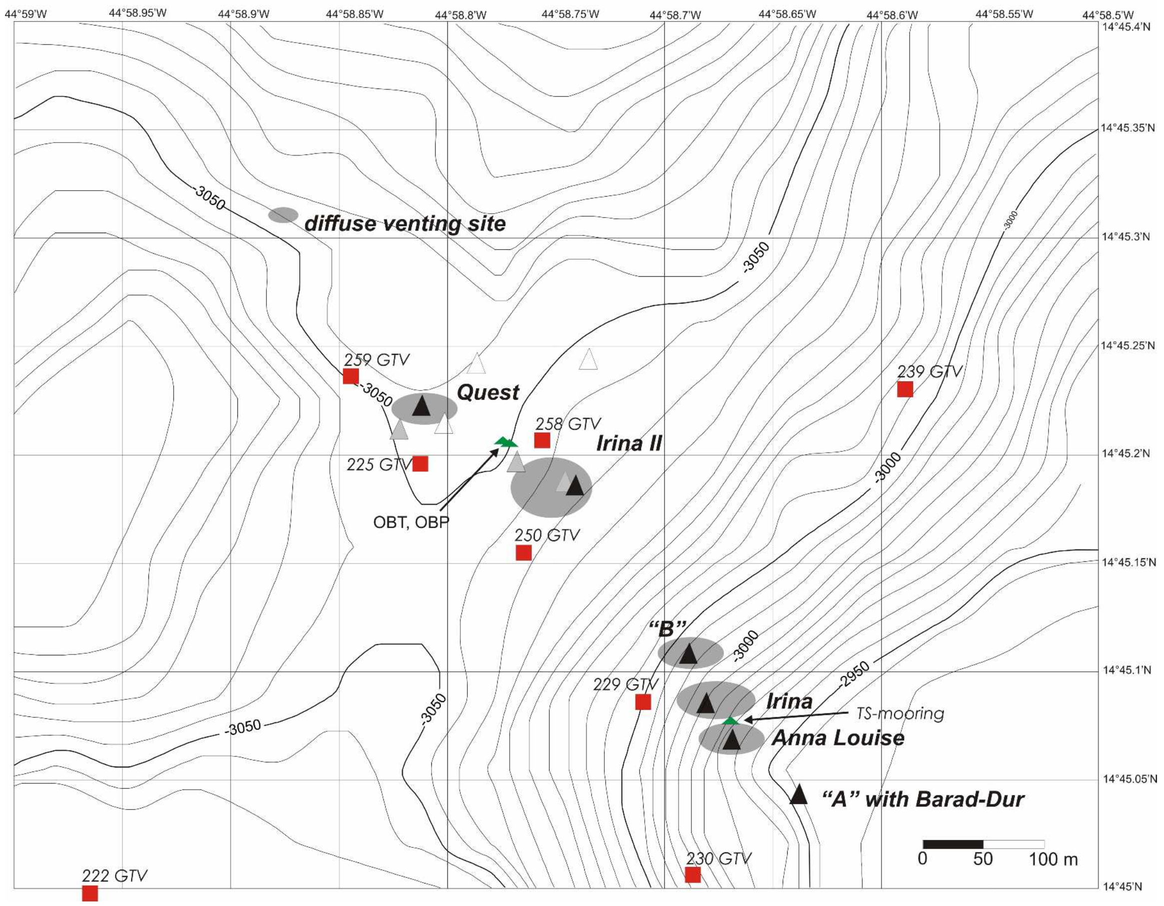


Fig. 2.2: Logatchev-1 hydrothermal field with long-term monitoring and TV-Grab stations (GTV) carried out during M64/2. A new diffuse venting-site is located NW of QUEST.

The LHF-1 extends at least 800 m in a NW-SE and probably more than 400 m in a SW-NE direction as previously described by Kuhn et al. (2004). At the southeastern end of LHF-1 we discovered the 5m high black smoker of Site“ A“ which was previously identified by Gebruk et al. (1997). We gave this smoker the name „Barad-Dûr“ after the black tower of Mordor in the book „Lord of the Rings“. Barad-Dûr is sitting on a 3 m-high mound of chimney talus. There were no mussel beds at this site, and hydrothermal fauna was restricted to shrimps and crabs on the upper part of the smoker. A photographic and video survey obtained by the ROV proved to be adequate for preparing a photomosaic of the structure (Fig. 2.3).

Hydrothermal fluids were sampled here for the first time. The marker „MB“ indicates this site as a reference fluid sampling station (see Appendix 2). In addition, several chimney fragments were sampled at the base of Barad-Dûr. The area northwest of site „A“ is characterised by the three hydrothermal sites ANNA LOUISE, IRINA und „B“ consisting of smoking craters. At ANNA LOUISE black smoke was intensely venting from the chimneys on the crater rim and from holes in the ground within the crater. Strong bottom currents resulted in almost horizontal plume dispersal to the south. Therefore, the so-called „Candelabrum“ chimney on the southern rim of the crater (Kuhn et al., 2004) was hidden from view during most of our observations. A 25 m-long temperature sensor mooring, which we have set up between ANNA LOUISE and IRINA, should measure the temperature variations of the plume dispersal over several months. Hot fluids and chimney fragments were sampled from a black smoker on the northern crater rim of ANNA LOUISE. Other fluid and rock samples were taken also at IRINA and „B“. We deposited a marker „MA“ at the sampled smoker of site „B“ and a marker „MD“ at the sampled smoker of site IRINA. Temperature measurements of the fluids have shown values of 205°C for ANNA LOUISE, 177°C for IRINA (at marker „MD“) and 350°C for site „B“ (at marker „MA“). Another small smoker at site „B“ has revealed a temperature of 300°C.

Fig. 2.3: Photomosaic of Barad-Dûr (Site A).

The largest site in the LHF-1 is IRINA II which was one of main targets of our biological studies. IRINA II consists of a mound with steep slopes rising about 15 m above the surrounding seafloor. A chimney complex, ca. 2 m high, marks the top of the mound. Based on a video and photographic survey we were able to create a photomosaic of this smoker complex (Fig. 2.4). A sonar scan shows clearly the different chimney structures.

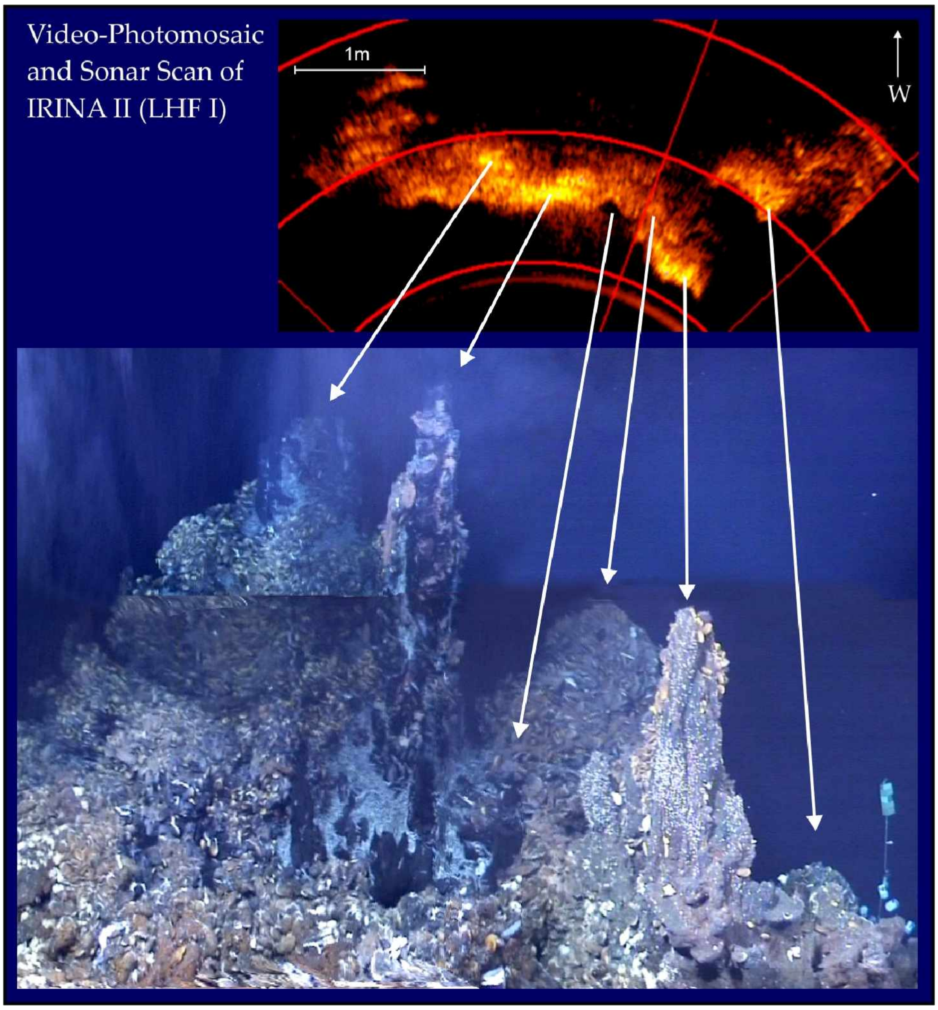


Fig. 2.4: Photomosaic and Sonar Scan of the eastern IRINA II chimney complex.

Most of the chimneys are densely overgrown with mussels (*Bathymodiolus*). Shrimps (*Rimicaris exoculata*) are highly concentrated over low-temperature fluids along the sides of the chimneys. The chimney complex is surrounded by densely populated mussel beds and by small active and inactive chimneys. Temperature measurements at a small active chimney on the northwestern side yielded values of up to 170°C, whereas a small chimney in between the complex revealed values of up to 225°C. These chimneys were also sampled for hot fluids. The mussel beds around the chimney complex are characterized by diffuse venting fluids. The temperatures of these emanating fluids, which were measured by a profiler module have shown a temperature range of 2.6° to 8°C (see chapter 2.4.10). We placed ten temperature loggers on a mussel bed at the southeastern side of the smoker complex to monitore the diffuse venting fluids for several months. A special objective was a mussel transplant experiment. In this experiment we are investigating how the removal of the mussels from the vent fluids will influence them and their symbiotic bacteria (see chapter 2.4.9).

As already described by Kuhn et al. (2004) the area around the Russian marker ANJA is located at a slope approximately 30 m northwest of the IRINA II-complex. This marker identifies a site called ANJA'S GARDEN in Gebruk et al. (2000) and these authors described that it occurs a 100 m northwest of IRINA-II. Based on our precise DVL navigation, we assume that the Gebruk et al. (2000) description of the ANJA marker location is incorrect. At the ANJA marker we found clusters of living and dead *Bathymodiolus* shells together with shimmering water. Visual observations during our dives in this area indicated that vesicomyid clams might be present. However, a ROV sample taken from the area of an old marker „C", which is located close to the ANJA marker, revealed only *Bathymodiolus* shells.
Just north of the IRINA II mound we placed an Ocean Bottom Tiltmeter (OBT) and an Ocean Bottom Pressuremeter (OBP) as longterm monitoring stations (see chapter 2.4.5) close to the new LHF-1 reference beacon 14 (14°45.199'N / 44°58.783'W).
The QUEST site, which was newly discovered during our first Meteor cruise M60/3 (Kuhn et al., 2004), is situated ca. 130 m WNW of the chimney complex of IRINA II. It is characterized by a smoking crater surrounded by several small active chimneys. Fluids and chimney fragments were sampled from a small black smoker on the northeastern side of the crater indicated by the marker „MC". We have measured here fluid temperatures up to 285°C. Elongated clusters of mussels occur southeast of the smoking crater. ROV samples revealed that the mussels consists of abundant juvenile forms which is in contrast to the high abundance of adult forms at IRINA II. A temperature logger (#3), which we deployed here on the M60/3 cruise, showed values of up to 12°C. Therefore, we placed here nine 1-channel temperature loggers and two 8-channel temperature loggers for longterm measurements.
Mapping the area north of QUEST site with the ROV revealed sediments with ripple marks intercalated by several ultramafic outcrops. At ca. 150 m northwest of the QUEST site we found a diffuse venting site with highly altered ultramafics confirming a larger extent of LHF-1 similar to the observation made by Kuhn et al. (2004).

2.4.2 ROV deployments

(G. Ruhland and ROV-Team)

The remotely operated deep diving robot QUEST is an electrical 4000 m rated, work class ROV, which is operated by MARUM, University of Bremen, since May 2003. The vehicle has been manufactured by Schilling Robotics, Davis, USA. The total QUEST system weights 45 tons (including the vehicle, control van, workshop van, winch, 5000 m umbilical, launch-and-recovery-frame, and two transportation vans, all 20-feet-size). The 5000 m of 17.6mm NSW umbilical is stored and managed by an electrical MacArtney Cormac winch. No hydraulic connections have to be installed during mobilisation.
QUEST's first use within SPP1144 took place during Rv METEOR leg M60/3 in January 2004. The leg M64/2 is the second task of QUEST in the Logachev Hydrothermal Vent Field. The technical innovations of the ROV provided a flexible and highly adaptable platform for scientific sampling and observation tasks and therefore played a major role to the scientific success aboard RV METEOR. Since the previous leg new features have been additionally installed including the highly integrated USBL positioning system, based on the French

IXSEA-GAPS inertial Navigation and Positioning system. However, due to a malfunction of the GAPS system Inertial Navigation and Positioning could be used only very limited. In addition, QUEST uses a Doppler velocity log (DVL) to perform StationKeep or Displacement mode, automatically controlled 3D positioning, and other auto control functions. Navigational purposes were supported by an array of Sonardyne HF beacons set in the vent field. An additional frame installed in the ship's A-frame enables much smoother and safe handling of the ROV during launch and recovery.

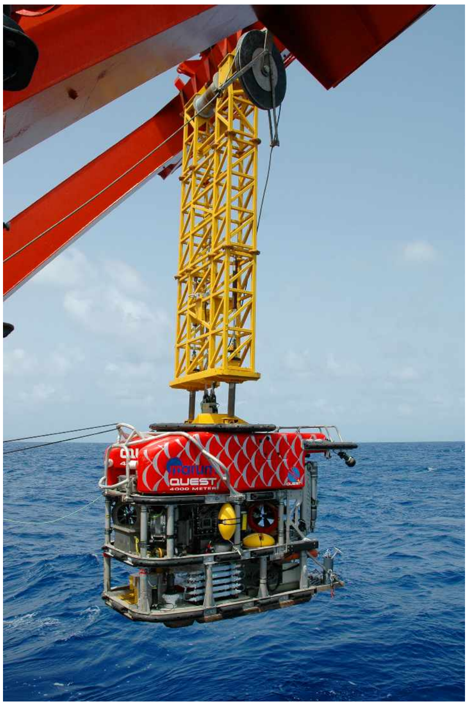


Fig. 2.5: Launching of the ROV with an additional frame at the aft (Photo: D. Garbe-Schönberg).

The QUEST system can be precisely controlled with its 60 kW electric propulsion system and is operated as free-flying vehicle. No tether management system (TMS) has to be operated at the same time the ROV is working. The collection of biological and geological samples and the pumping of fluids could be done with two installed robotic arms. While the RIGMASTER manipulator can lift and handle devices or samples up to 250 kg, the ORION manipulator is used to handle probes or work on delicate tasks.
A set of video and still picture cameras together with a 2.4 kW light suite provides possibilities for video mapping and photo mosaicing. Therefore two green lasers which are installed parallel to each other can be used as size relation. Due to a water leak the Insite Pacific ATLAS camera could be used on the first four dives only.
Besides cameras and manipulators, the scientific equipment installed during leg M64/2 constisted of a CTD with turbidity and high-temperature sensors, which could be used only on three dives due to a water intrusion in the housing. A set of niskin bottles, a 675 kHz scanning sonar, a sample drawbox and several different sampling tools such as "hand" nets and grabbing devices complete the installed equipment.

The scientific data base system used at MARUM feeds all ROV- and ship-based science and logging channels into an adapted real-time database system (DAVIS-ROV). The QUEST control system provides transparent access to all RS-232 data and video channels. During operation data and video has be distributed by the real-time database via the ship's network system in different laboratories and supply the scientists with data from their own devices. Dive summaries containing all data of interest including video and digital still photographs were compiled after each dive. Using the database's export capabilities in combination with the software product "ADELIE" developed at IFREMER, GIS based plots, data graphs and divetrack maps containing time and position-referenced scientific data, video and images were available shortly after or even during the dives.
Post-cruise data archival will be hosted by the information system PANGAEA (www.pangaea.de) at the World Data Center for Marine Environmental Sciences (WDC-MARE), which is operated on a long-term base by MARUM, University of Bremen, and the Foundation Alfred Wegener Institute for Polar and Marine Research, Bremerhaven (AWI).
During leg M64/2 QUEST could be successfully deployed 15 times while 14 of these dives reached the bottom. Launch and recovery has been done at sea states up to 2.5 m and winds of up to 6 bft.. Total bottom time of 110 hours could be achieved at depths of 2950 to 3050m. The planned scientific program could be finished completely during the leg. Beneath scientific sampling and photo mosaicing the current working map could be improved and completed in some parts. Two scientific devices, an ocean bottom tiltmeter (OBT) and an ocean bottom pressure sensor (OBP) had been transported with the ROV to the bottom and installed during the dives. 24 temperature loggers for a yearly monitoring program were also distributed in mussel fields. A profiler frame and a benthic chamber had been successfully transported and set with the ROV several times for a daily monitoring.
During all operations, the crew of RV METEOR provided a very successful and smooth handling on deck, excellent navigation and professional technical support to fulfill the scientific tasks required.

2.4.3 OFOS deployments

(N. Augustin, H.-H. Gennerich, K.S. Lackschewitz, H. Marbler, T. Pape, S. Weber, G. Schroll)

A total of 3 TV-sled stations were carried out in the vicinity of LHF-1. The objectives of the OFOS (Ocean Floor Observation System) stations were to find signs of unknown hydrothermal activity.
The IFM-GEOMAR TV-sled was equipped with a BENTHOS photo camera and flash, a SONY digital camcorder and a FSI 3'' memory CTD probe. During our first OFOS-station 226 we have mapped a NW-SE profile between 14°45.4'N / 44°58.35'W and 14°44.85'N / 44°59.1' W crossing site „B“ of LHF-1 (Fig. 2.6). The beginning of the profile is characterized by a talus field followed by sediments, where we found four temperature anomalies with an increase of 0.03°C. One of this anomalies is close to 239GTV-station showing a temperature of the sampled sediments of 43°C onboard. When we crossed site „B“ no sign of hydothermal activity was visible. However, we have measured a temperature anomaly of

0.06°C. The area southeast of LHF-1 is characterized by sediments, some talus and an ultramafic outcrop showing a temperature anomaly of 0.025°C.

Station 278OFOS was carried out to investigate observations during M64-2 stations 238CTD; 253CTD and 273CTD, where physico-chemical parameters in the water column suggested a yet undiscovered fluid source different from the known black smokers of the LHF. The OFOS was equipped with one MTL (Miniature Temperature Logger; see chapter 2.4.5) and one MAPR (Miniature Autonomous Plume Recorder; see chapter 2.4.6.2). Due to cable problems station 278OFOS was interrupted early after 1.5 hrs.
Consequently the area between LHF and the water chemical anomaly in it's northwest was the target of the next OFOS survey, station 284OFOS. This time OFOS, bottom control weight and deep-sea cable were equipped with a dense array of 5 MAPRs, 20 MTLs and 1 CTD between the seafloor and up to 100 m above it, with singular extra sensors in 125 m and 170 m height.
Same as station 226OFOS, also stations 278OFOS and 284OFOS did not show any hints to hydrothermal activities by visual observations. The CTD results of these stations are presented and discussed in chapter 2.4.6.2.

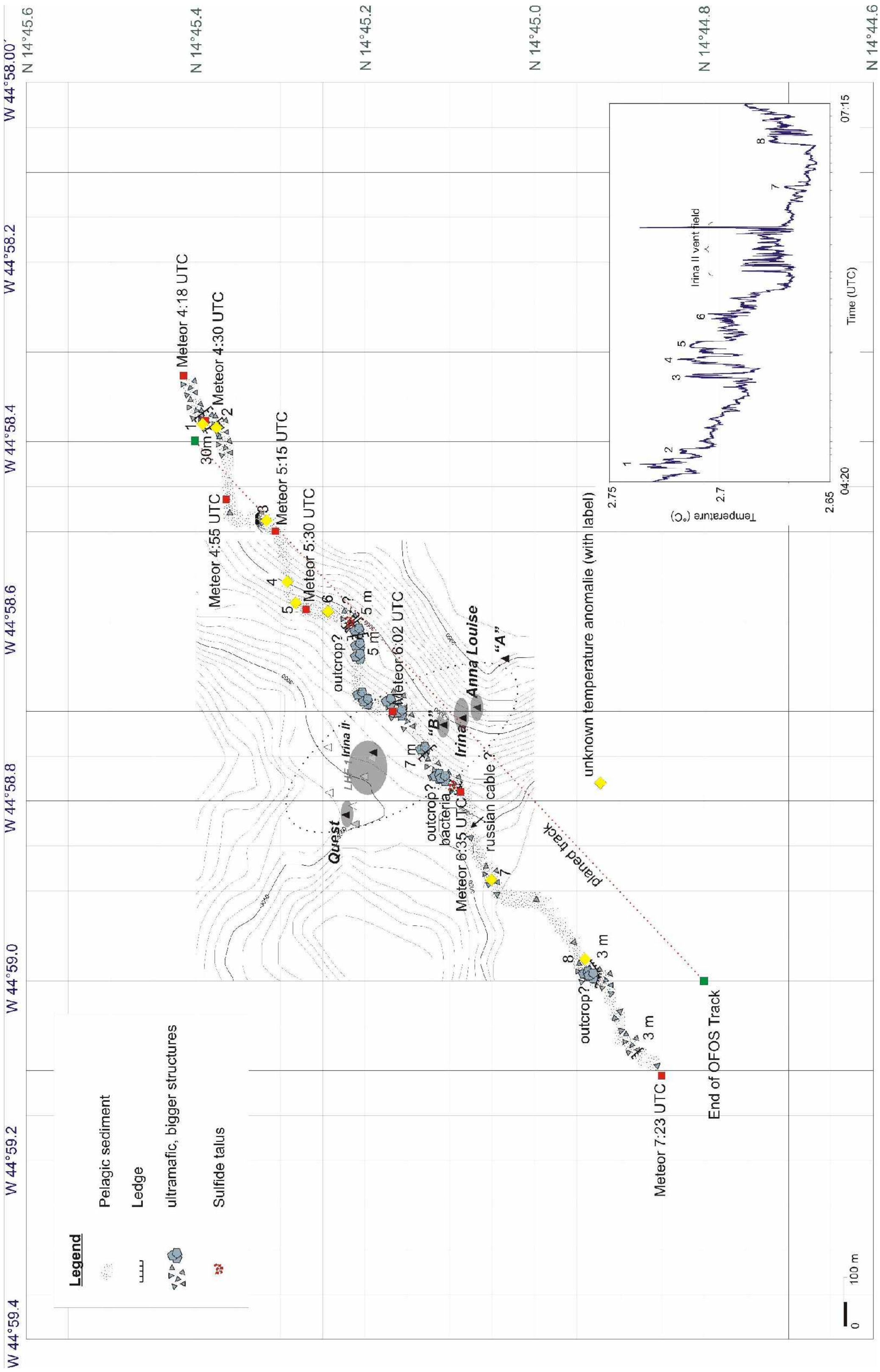


Fig. 2.6: Track of 226OFOS in the vicinity of the active Logatchev-1 hydrothermal field. Insert: Water temperature versus time-diagram of OFOS station 226 showing several distinct temperature anomalies between 0.025 and 0.06°C.

2.4.4 Description of rocks and hydrothermal precipitates

(N. Augustin, H. Strauss)

During cruise M64/2 a total of 14 ROV dives and 8 TV-grab stations recovered geological samples from the seafloor. Information on all sampling stations is given in Table 2.1. A more detailed description of the individual samples is provided in Appendices 4 and 5.

Tab. 2.1: List of geological samples with geographical positions of individual stations.

Lat	Long	Station	Sample types
14°44.99´N	44°58.97´W	222 GTV	serpentinized pyroxenites
14°45.19´N	44°58.82´W	225 GTV	serpentinized pyroxenites, Mn-crusts
14°45.08´N	44°58.72`W	229 GTV	silicified crusts, consolidated sediments, sulfidic muds
14°45.01´N	44°58.68´W	230 GTV	Mn-coated pyroxenites, weakly weathered
14°45.23´N	44°58.58´W	239 GTV	atacamite and silicified crusts
14°45.18'N	44°58.73'W	244 ROV	altered sulfide breccia
14°45.16´N	44°58.77´W	250 GTV	strongly altered peridotites and pyroxenites, quartz-veins
14°45.04'N	44°58.63'W	252 ROV	sulfides chimney-pieces
14°45.12'N	44°58.70'W	257 ROV	Fe-oxide-hydroxide crusts, sulfides
14°45.21´N	44°58.76´W	258 GTV	some Mn-Coated serpentinite pebbles
14°45.24´N	44°58.84´W	259 GTV	GTV empty
14°45.06'N	44°58.64'W	261 ROV	sulfide chimney
14°45,10'N	44°58,67'W	266 ROV	sulfides
14°45.20'N	44°58.74'W	272 ROV	iron-oxide and -hydroxide crusts
14°45.20'N	44°58.74'W	277 ROV	sulfides
14°45.21'N	44°58.81'W	281 ROV	sulfides
14°45,32'N,	44°58,84'W	285 ROV	Fe-oxide, -hydroxide crusts and mud

In general, serpentinized peridotites represent the host rocks of the Logatchev field. Remarkable are samples of coarse grained orthopyroxenites, which are interpreted as magmatic cumulates from the crust/mantle transition zone. Apart from these host rocks, a large variety of hydrothermal samples were collected, confirming the observations made in 2004 during Meteor cruise M60/3. Samples include pieces of active and inactive chimneys, massive sulfides, silicified breccias and crusts, hydrothermal sediments, abundant secondary Cu-sulfides, hematite impregnated serpentinites, abundant Fe-Mn-oxyhydroxides as well as atacamite and Mn-oxides.

Several TV grabs (222GTV, 225GTV, 239GTV, 250GTV and 258GTV) recovered variably altered serpentinized pyroxenites (Fig. 2.7), some of which were coated with a thin Mn-oxide layer. Of these, 250GTV recovered strongly altered peridotites and pyroxenites (a 25cm thick layer). In situ temperatures measured in the unconsolidated material onboard yielded

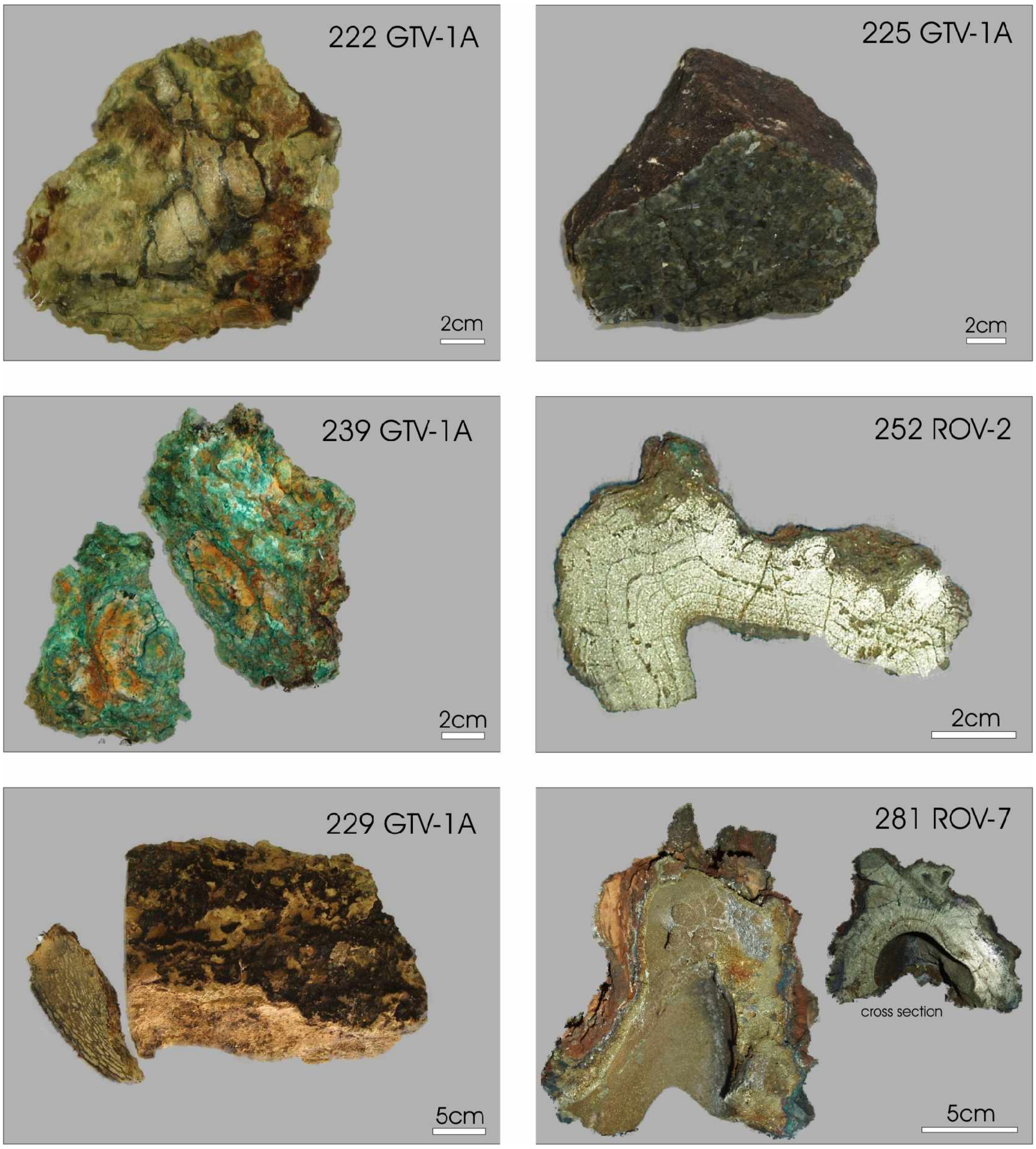


Fig. 2.7: Geological samples recovered during GTV and ROV stations: 222GTV-1A: altered serpentinized pyroxenite; 225GTV-1A: serpentinzed pyroxenite; 239GTV-1A: atacamite crust; 252ROV-2: chimney piece, collected at IRINA I, composed of layers of chalcopyrite; 229GTV-1A: reddish silicified crust with dark brown Mn-oxide coating; 281ROV-7: chimney piece, collected at QUEST site, composed of chalcopyrite with Cu-sulphide rich outer layers

temperatures up to 43°C. This shows that hot fluids circulate beneath the sediment without necessarily venting at the seafloor. 239GTV recovered similar material (this time a 10cm thin and cold layer), with thick atacamite-crusts, hematite impregnated serpentinites, talc and serpentine-breeze. This suggests the presence of an old inactive fluid-pathway. 258GTV contained reddish pelagic sediment, some Mn-coated serpentinite pebbles and empty *Calyptogena* shells**.** 259GTV grabbed a large boulder, was opened again, and returned empty.

Geological sampling during the various ROV dives recovered mainly sulphide samples, either from active or inactive chimneys and/or sulphide talus samples. Most massive sulphide pieces were composed of chalcopyrite, sometimes displaying a distinctive layering. Other samples comprise more porous chalcopyrite rich interior portions and clearly layered parts towards the outer rim. Occasionally, different fluid conduits could be recognized. The outer rim of all sulphide pieces was generally covered with a thin Fe-oxide coating. 252ROV recovered a large number of pieces which, apart from chalcopyrite as major sulphide, contain abundant colourful copper-rich sulphide minerals (Fig. 2.7). During 261ROV, a fresh sulphide piece comprising largely chalcopyrite was collected from the Barad-Dur chimney at Site A. Further chimney pieces, composed mainly of chalcopyrite and showing individual orifices (Fig. 2.7), were recovered from IRINA II (277ROV) and the QUEST Site (281ROV**)**.

2.4.5 Environmental parameters and longterm monitoring

(M. Fabian, H.-H. Gennerich)

Deployment of long term monitoring instruments

The ocean bottom tiltmeter (OBT) is a platform tiltmeter with two perpendicular axis, X, Y (Fig. 2.8). It has also a high performance MEMS (Micro-Electro-Mechanical-System) accelerometer whose axis is aligned parallel to the OBTs vertical axis and measures total gravity g. The photo shows the OBT in the laboratory of RV Meteor. The OBT uses a biaxial bubble tilt sensor of type Applied Geomechanics Inc. 756. The single-axis accelerometer is of type Kistler Servo K-Beam 8330A2.5 .

The OBT will record local sea floor tilt caused by e.g. tectonics, tidal loading, changes in hydrothermal and deeper magma-plume activity and soil movements like landslides with 1 micro radiant resolution and 6 second sampling interval. Acceleration caused by e.g. micro seismicity, earthquakes or tremors will be measured with $10^{-5} m/s^2$ resolution at 0.75 seconds sampling rate. The aluminium frame consists of a rectangular triangle base plate with a tripod and a frame for handling. The larger titanium pressure tube houses batteries, data logger and electronics. The smaller aluminium tube is fixed to the base plate and contains the sensors. The OBT has a deep sea spirit level for levelling the instrument. A good coupling of the instrument to the ground is necessary.

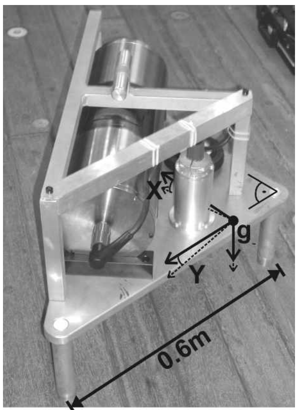


Fig. 2.8: OBT

The OBT was deployed (14°,45.201’N, 44°,58.784’W, 3053m depth; see Fig. 2.9) in the LHF south east of “QUEST” site and west of site “IRINA II” (see Appendix 1). For navigation purposes and to facilitate revisiting an acoustic beacon (No. 14) was placed at this station (see chapter 2.4.1). The OBT was installed on the hilltop of a rock pile by firmly and carefully pressing and moving the legs of the instrument. Orientation of the +Y-axis with respect to the directions of the compass is 295°±3°. The place of the OBT is apart vent sites that measurements are not influenced by hot fluids.

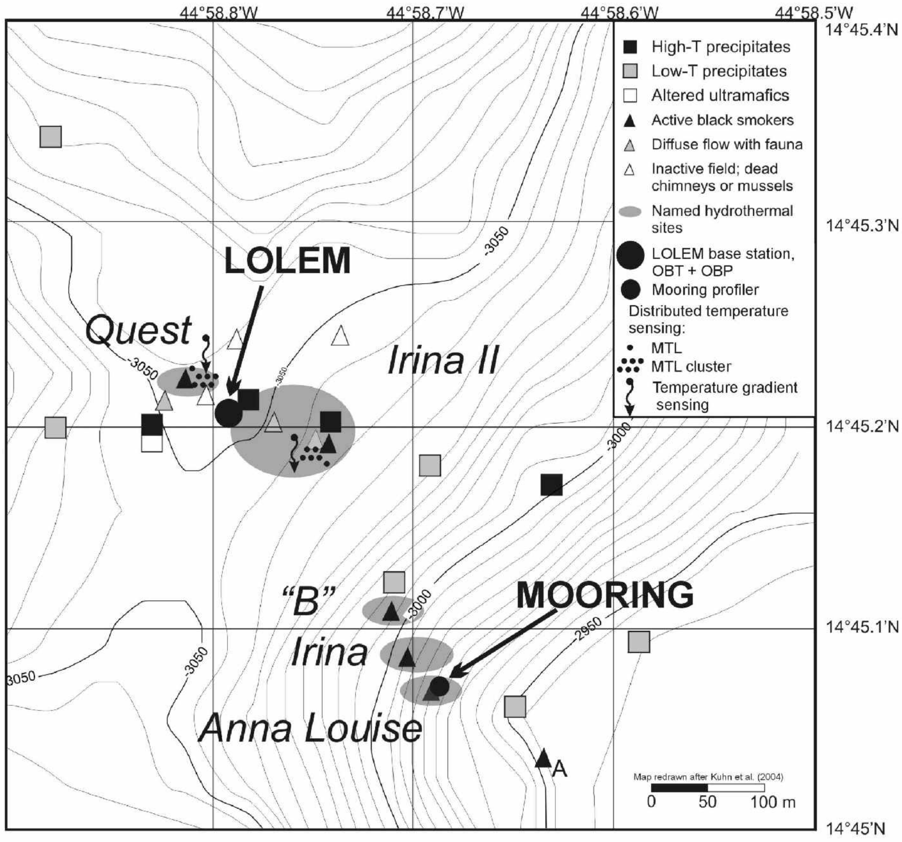


Fig. 2.9: The map shows the location where monitoring systems were installed. QUEST and IRINA II were equipped with temperature loggers, OBT and OBP and MOORING with the bottom water monitoring profiler.

The Ocean Bottom Pressuremeter (OBP), which was deployed close to the OPT (Fig. 2.10), measures changes in the water pressure at the sea floor very precisely to get exact local information about tides and level changes due to subsidence or uplift of the seafloor, indicating tectonic magmatic or hydrothermal activities. The OBP was designed very robust with a strong frame on three short legs and the pressure cases installed with clambs inside. The instrumentation consists of 3 pressure cases with a Brancker XR-420 data logger with built-in temperature sensor, a lithium battery pack (10,5 V, 56 Ah) and a Paroscientific Digiquarz pressure gauge.

This base station was configured to sample pressure and temperature at 2 min intervalls. A 30 s pressure integration time was chosen providing a pressure resolution > 1 mm water column. This base station was brought to the sea floor (19.05.05, station 244ROV dive 52) and repositioned to it's final position (22.05.05, station 263ROV; dive 57). Crucial for the choice of the position was a location where no level changes due to sinking of the instrument into the sediment or due to redeposition of sediments was expected. The final deployment position shows only minor ripples indicating little sediment transport and closeby outcropping solidified material suggests only thin sediment cover.

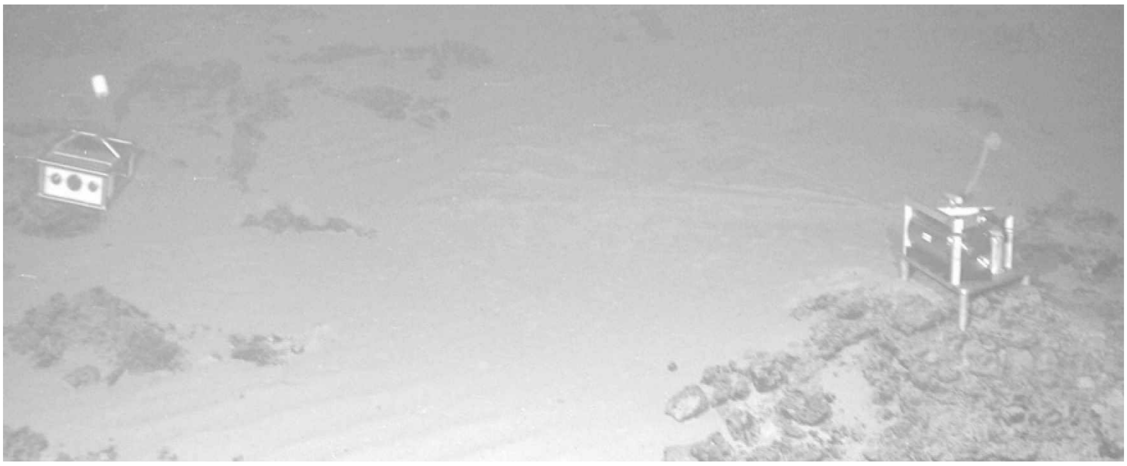
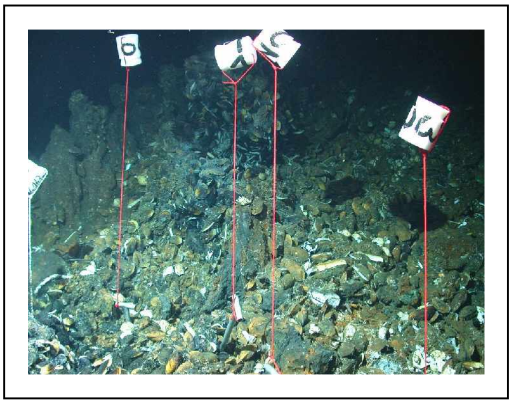


Fig. 2.10: OBP (left) and OBT (right) deployed at their final positions west of IRINA II.

The distributed temperature sensing instrumentation monitors temperature variations in the biological communities as an indicator for changes in their living environment due to variations in hydrothermal activity. So the deployment locations were chosen at spots of focussed biological and fluid sampling investigations.

The set of instruments consists of 20 1-channel temperature loggers (MTL) inserted into 40 cm long T-shaped steel tubes for easy ROV-deployments and four units each of a 8-channel temperature lance connected to a data logger with a 1 m cable. The temperature resolution is < 1 mK at an absolute accuracy < 5 mK. The 1-channel loggers were set up to sample at 6 min intervals, the 8-channel loggers at 2 min intervals.

The first set of instruments consisting of 10 1-channel loggers sequentially numbered from #1854200 to #1854209 was labeled with 10 cm buoyant cylinders #0 to #9. They were deployed (20.05.05, station 257ROV, dive 55) in the IRINA II mussel field (Fig. 2.11) The arrangement was installed in two parallel lines of 5 loggers each perpendicular to the mussel field's length axis until the rim of the mussel covered area. Shimmering water indicates elevated water temperature above the mussel field.



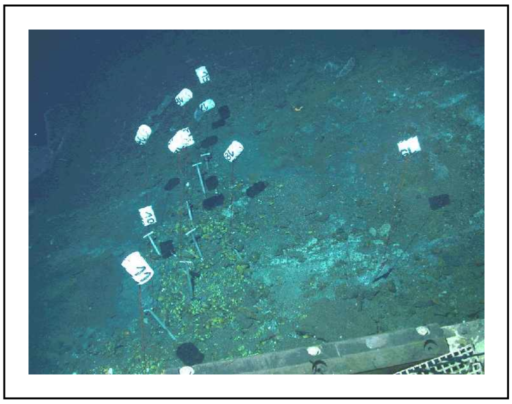
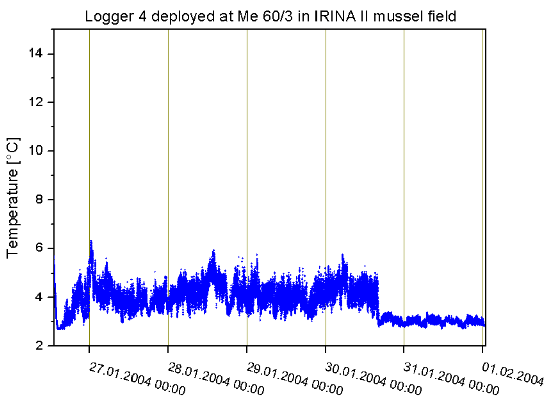


Fig. 2.11: Part of the 1-channel temperature logger array in IRINA II mussel field (left) and QUEST mussel field (right).

The second set of 10 MTLs (#1854210 to #1854219) labelled as #10 to #19 was deployed (30.05.05 station 281ROV, dive 61)) in the QUEST mussel field (Fig. 2.11) which has an extension of about 0.6 x 3 m . The loggers were arranged along the field's length axis spaced < 0.5 m with an additional cross profile and one extra logger 1 m beside in a bacteria mat.
Two 8-channel loggers (#10295, #10298) were placed (31.05.05, station 283, dive 62) horizontally and vertically at the same location where the mussel field shows maximum thickness. An other set of two 8-channel loggers (#10296, #10297) was placed in the same configuration in the IRINA II mussel field, ca. 4 m beside the 1-channel logger array.
Two MTLs deployed during cruise M60/3 were recovered from the IRINA II and QUEST site mussel fields. Data show in a 1 week time series periodic changes in temperature up to 6°C resp. 12°C with a periodicity which seems to be related to the ocean tides or multipliers of it.



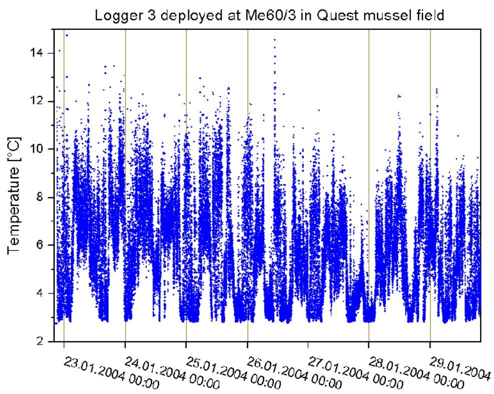


Fig. 2.12: Temperature time series in IRINA II (left) and QUEST (right) mussel field.

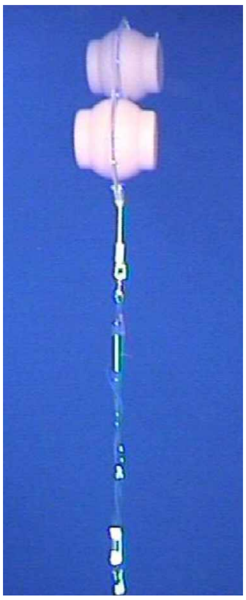


Fig. 2.13: The BWPM

The bottom water profile monitor (BWPM) will register the variation of the bottom water temperature caused by changes in hydrothermal activity and water currents.
The BWPM is constructed as a mooring where two 17' glass balloons with a total buoyancy of 56 kg are connected by a 25 m long rope to a bottom weight of 100 kg (Fig. 2.13). A 25 m long sensor cable with 24 temperature sensors 1 m spaced and a Brancker XR-420-T24 24 channel data logger are attached to it. Acoustic beacon #15 was also attached to the mooring 20 m above the sea floor for easy finding and general navigation purposes in the Logatchev hydrothermal field. The logger is configured to register the temperature in 1 min time intervals at 24 equidistant positions equally spaced by 1 m at a temperature resolution of better than 1 mK and an absolute accuracy of 5 mK.
The BWPM was lowered to the sea floor with the oceanographic wire, an additional weight of 300 kg and an acoustic releaser. The ROV collected the mooring from the sea floor by grabbing into a prepared loop of buoyant rope attached to the bottom weight and transported it to the final position between the black smokers and smoking craters of ANNA LOUISE and IRINA I. While the location is in the vicinity of these highly active areas to get significant signals, the BWPM keeps outside the high temperature vents.

Environmental mapping and online tools

The ROV temperature lance is intended to measure real time temperature at spots of interest as well as the gradient and width of the temperature anomalies. It is designed as a 0.5 m long lance with 8 evenly (4 cm) spaced temperature sensors inside and connected to a 8-channel logger. The logger provides a RS-232 data stream, which is transmitted in real time through the ROV-cable to the ship.
The lance measured temperatures of up to 210 °C in a black smoker at ANNA LOUISE. Additonally mussel fields and bacteria mats were probed. Finally the connector at the lance broke as it was not sufficiently robust for the ROV handling; it will be replaced by a stronger one for the next cruise.

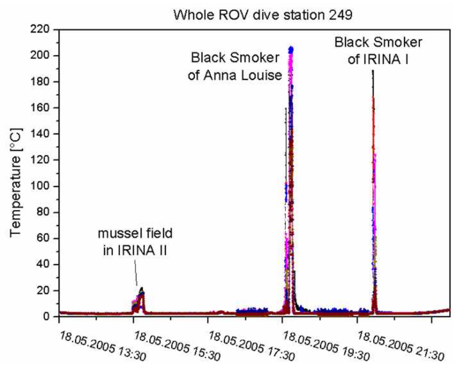
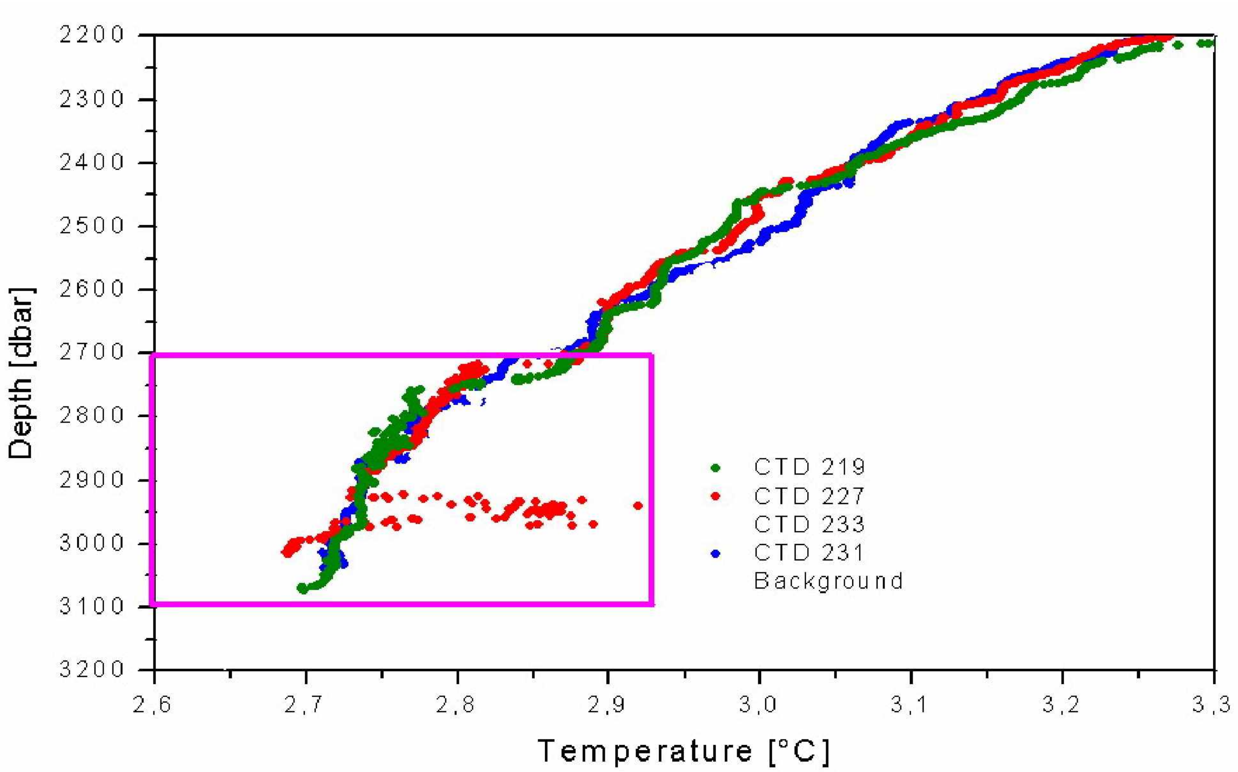


Fig. 2.14: 8-channel ROV-temperature lance placed in the black smoker of ANNA LOUISE (left) and the results (right).

With the plume temperature profiler the water column is scanned for signs of a hydrothermal plume. For this purpose a set of MAPRs and 20 miniature temperature loggers (MTL) were attached to the oceanographic wire and towed through the water column while the ship was steaming slowly at 0.5 knts.
During station 223 a grid of 4 equally spaced parallel profiles covering an area of about 4 km^2 above the Logatchev hydrothermal vent field was surveyed. MAPRs and MTLs were attached over a length of 600 m. The TowYo approached the sea floor to 50-100 m with an amplitude of 200 m. During station 228 the variation of temperature and turbidity were recorded in the center location of station 223.
All surveys revealed that the upper plume between 2700 m and 3000 m is very clearly visible by increased turbidity in MAPR and CTD data. At the same time a sudden decrease in temperature gradient compared to the normal gradient is observed. The signal in the temperature is less obvious than the one in the turbidity.



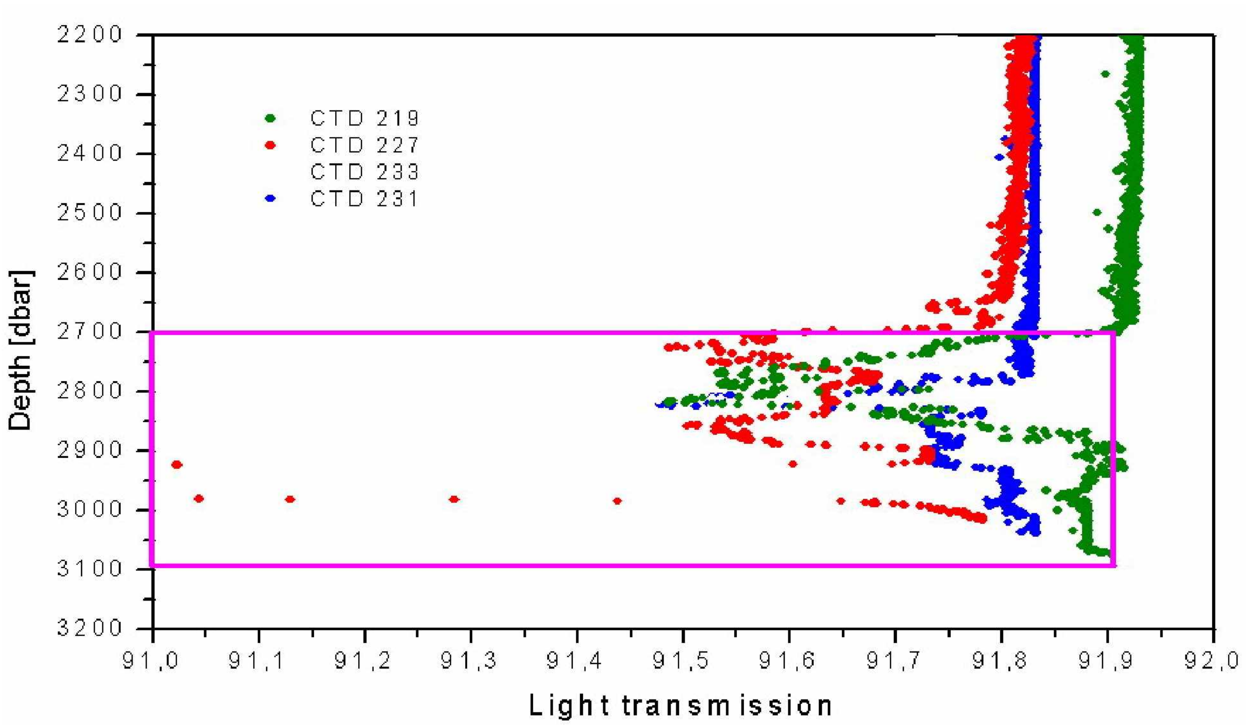


Fig. 2.15: Comparison of temperature and turbidity signal at the same time and position in the upper plume above the Logatchev hydrothermal field in a depth of 2700 to 3000m, indicating it's easier recognition by turbidity measurements.

At station 284 the OFOS was used to follow the sea floor with a constant distance of 2 m, while observing the sea floor for indicators of hydrothermal activity. A set of 20 MTLs and 5 MAPRs were attached to the wire and to the bottom distance control weight below the OFOS. This way the bottom water column of 100 m was surveyed in detail on three parallel tracks evenly spaced by 100 m.

Different from the upper plume, a bottom water plume could be identified in the interval between 2-10 m above the seafloor. This bottom plume is seldom visible by increased turbidity, but can be easily identified by temperature signals of 30 mK to 50 mK. The bottom plume seems to indicate hydrothermal activity from diffuse venting sites, which don't produce big amounts of particles like the black smokers do. Thus future cruise could be guided by observing the temperature anomalies in that depth interval to find diffuse venting sites.

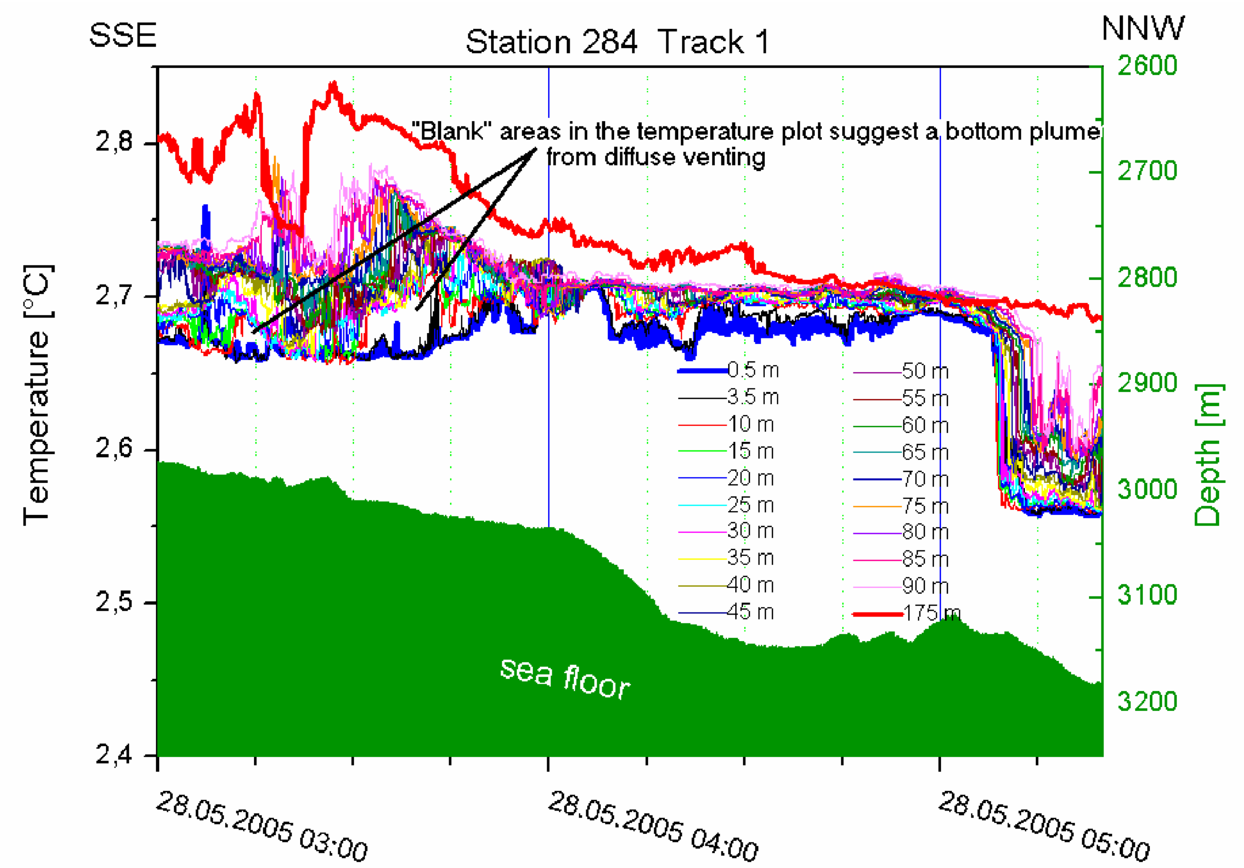


Fig. 2.16: Several "blank" areas in the temperature graph between the bottom sensor and sensors of more than 10 m above the sea floor indicate diffuse venting, as was proved by finding in the vicinity of the marked spots. No turbidity anomaly was found in these cases. Future investigations of the Logatchev hydrothermal field could be guided by this finding.

Results from station 226 suggest to have a closer look to an area 500 - 1000 m to the NW of the Logatchev vent area for diffuse venting sites.

More about the physical observations in the water column can be found in a separate section "plume mapping" in this report, because the operations of CTD and MAPR were conducted in close collaboration with scientists from the gas and fluid chemistry group.

2.4.6 Physico-chemical characterization of the Logatchev hydrothermal field

2.4.6.1 Gas chemistry

(T. Pape, G. Schroll)

During a previous cruise to the Logatchev hydrothermal venting site with R/V METEOR in 2004 (M60/3) comprehensive analysis was performed for the gas chemical characterization of hydrothermal fluids and plumes. This work yielded gas concentrations and stable isotope signatures of CH_4 and H_2 of numerous fluids sampled at distinct emanation points. Considerable differences in absolute and relative gas concentrations, and fluid temperatures (calculated from stable isotope composition of H_2) between the distinct fluids could be shown (Kuhn et al., 2004). Water column investigations revealed a distribution of hydrothermal signatures covering the water depth range from 2.500 to 3.000 m. However, due to a limited number of hydrocasts these data did not allow for a detailed characterization of the horizontal distribution of the entire hydrothermal plume.

Main objectives of the gas chemistry analysis performed during M64/2 were to determine the composition of distinct fluids and the vertical and horizontal extension of the gas plume in the water column above the Logatchev field, both with emphasis on variations compared to the earlier investigation. For this purpose, samples of hydrothermal fluids and plumes were recovered during several ROV dives and CTD stations and analysed for the concentrations of the main reactive gases hydrogen and methane. These investigations aimed to detect the gas chemical cyclicity of the Logatchev hydrothermal vent system. Reported here are preliminary results of CTD-profiling and gas analysis.

Samples and methods

During M64/2 34 CTD stations were conducted for measurements of conductivity, temperature, salinity, and light transmission of the water column. A map illustrating the positions of the stations is given in chapter 2.4.6.1. CTD data were recorded for the entire water column using a SEABIRD CTD Type 911 equipped with a light transmission sensor. At 19 stations water samples were taken with a rosette of 23 10 L Niskin bottles for on board analysis of concentrations of H_2 and CH_4. Fluid and near-bottom water samples were obtained by a fluid sampling system or Niskin bottles during 12 ROV dives. Subsamples were stored for onshore measurements of stable carbon isotopic compositions of CH_4 and H_2. In total, 146 samples from the water column and 35 vent associated water and fluid samples were recovered for analyses of dissolved gases (Table 2.1).

Table 2.1 Water sample list for CTD- and ROV-stations

Station	Long. N	Lat. W	No. of samples	HC	H_2	$\delta^{13}CH_4$	$\delta^{2}H_2$
CTD							
217	13°30,0´	45°00,0´	12	12	11		
219	14°45,2´	44°58,8´	12	12	11		
221	14°45,1´	44°58,9´	12	12	12		
227	14°45,1´	44°58,7´	10	9	8		
231	14°45,3´	44°58,9´	11	11	11	10	
242	14°46,0´	44°58,8´	5	5	3	3	
248	14°46,0´	44°59,0´	11	11	9	10	
253	14°46,1´	44°59,2´	10	10	8	8	
260	14°46,0´	44°59,1´	11	11	9	10	
264	14°45,2´	45°01,0´	6	6	6	5	
267	14°44,0´	44°59,0´	4	4	2	4	
268	14°44,0´	44°58,0´	4	4	4	4	
269	14°44,4´	44°57,0´	3	4	1	2	
270	14°44,5´	44°57,5´	4	4	3	4	
273	14°46,0´	44°59,2´	10	10	10	10	
274	14°45,1´	44°58,1´	4	3	3	3	
275	14°44,4´	44°57,2´	3	3	2	1	
276	14°45,7´	44°57,5´	4	3	3	3	
279	14°45,4´	44°58,9´	10	10	10	10	
total: 19			**146**	**144**	**126**	**87**	
ROV							
224			2	1	2	2	
232			4	2	4	2	
249			4	2	4	4	2
257			2	1	2	2	
261			7	5	7	4	
263			1	1	1	1	
266			4	2	4	4	
272			1	1	1		
277			2	1	2	2	
281			4	2	4	3	
283			2	2	2	2	
285			2	2	2	2	
total: 12			**35**	**22**	**35**	**28**	**2**

HC = CH_4 and C_2- to C_4-hydrocarbons

The methods used for preparation and on board analysis of dissolved gases and storage of gas and water samples are described in the cruise report of M64/1 in detail. Briefly, volatile dissolved hydrocarbons (C_1 to C_4) were extracted and concentrated deploying a purge and trap technique (Seifert et al., 1999). The trapped gases are released to a gas chromatograph (CARLO ERBA GC 6000) equipped with a packed stainless steel column and a flame ionisation detector (FID) and connected to a PC based data handling software to separate, detect and quantify individual compounds.

Dissolved hydrogen was extracted by applying a high grade vacuum in an ultrasonic bath and heating until boiling. Subsamples of the released gas were transferred from the degassing unit into the analytical system using a gas tight syringe. The analytical procedure was performed using a gas chromatograph (THERMO TRACE GC ultra) equipped with a packed stainless steel column and a pulse discharge detector (PDD). All analytical procedures were calibrated daily with commercial gas standards (LINDE).

For onshore analysis of stable carbon isotopes (^{13}C) of dissolved light hydrocarbons aliquots of gas samples obtained by the vacuum-ultrasonic technique were transferred through a septum into gastight glass ampoules filled with NaCl-saturated water. For selected water samples aliquots of the vacuum-extracted gas were frozen on molecular sieve 4Å under liquid nitrogen in a pre-vacuated glass vial for onshore measurements of stable hydrogen isotopes.

Preliminary results

Based on results obtained during previous water column investigations at the Logatchev hydrothermal field (LHF) CTD surveys were deployed above vent sites and at adjacent (max. about 3 nm) non-vent areas. Signatures of hydrothermal activity within the water column were monitored by anomalies in the transmission profiles and S/T diagrams (salinity vs. potential temperature). Generally, the hydrothermal anomalies in the working area are located at a water depth range between 2.700 and 2.900 m (Fig. 2.17).

The S/T diagrams indicate that the intrusions are derived from fluids depleted in salinity compared to sea water generating distinct water bodies of elevated temperatures (Fig. 2.18). At station CTD231, which was performed about 0.15 nm NW of the Black Smoker 'Quest', the hydrothermal plume peaked at 2.787 m depth.

Furthermore, a good correlation between transmission anomalies and the concentration

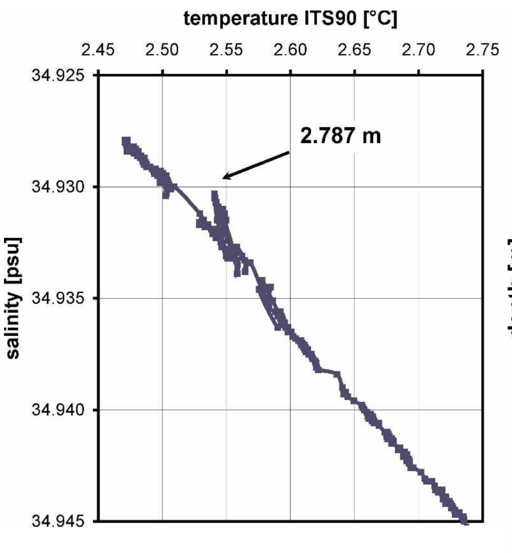


Fig. 2.17: Concentrations of H_2 and CH_4 in water samples of all CTD stations.

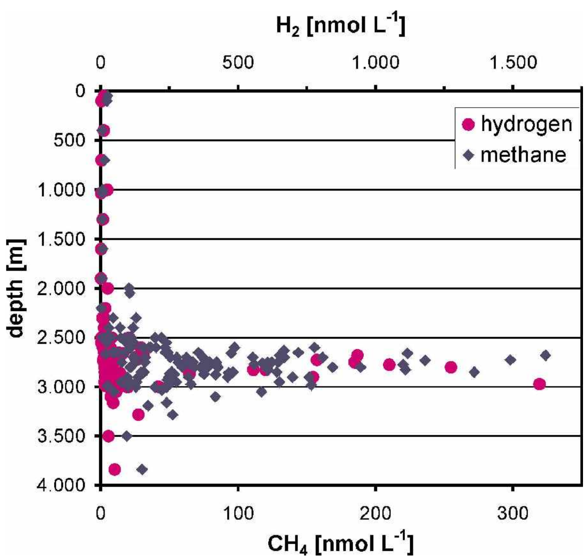


Fig. 2.18: S/T diagram of deep waters at station CTD 231, 2.550 to 2.960 m.

profiles of hydrogen and methane was found at this station (CTD231; Fig. 2.19). However, at some other CTD stations we found minor similarities between profiles of these physico-chemical parameters.

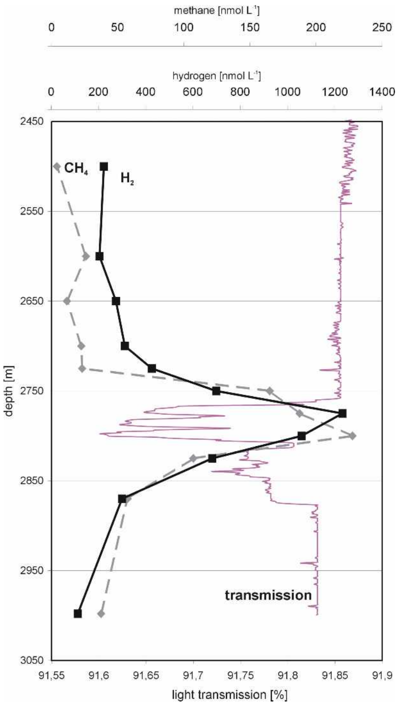


Fig. 2.19: Concentrations of H_2 and CH_4 and light transmission anomaly at station CTD231.

During M64/2 concentrations of dissolved gases obtained from CTD/rosette water samples revealed a considerable hydrothermal signature over a wide distribution area. A map illustrating the area where distinct anomalies in the turbidity profiles were observed is given in chapter 2.4.6.2, Fig.2.20. Highest concentrations of dissolved hydrogen and dissolved methane were observed for station CTD227 showing about 1.6 µmol L^{-1} H_2 (2.972 m depth) and about 0.3 µmol L^{-1} CH_4 (2.680 m), respectively. This station was positioned equidistant to the hot fluid emanation sites 'Irina' and 'Site A' and, as far as we know, these are the highest H_2 concentrations measured in the water column above the LHF.

Moreover, at station 238, where no water samples were taken, a slight transmission anomaly at 3.030 to 3.080 m accompanied by elevated concentrations of hydrogen in near bottom waters at the nearby station CTD273 was observed. Since both stations were located more than 2 nm NW off the LHF, these observations might be related to fluid emanation sites in the NW edge of the working area undiscovered so far. However, during ocean bottom observation tracks conducted with an OFOS system no hints for effusive or even diffusive vents were recognized (see chapter 2.4.3).

Water and fluid samples taken with 5 L Niskin bottles or a fluid sampling device (KIPS) directly at fluid emanation sites during ROV dives commonly showed very high concentrations of dissolved gases. In fluids obtained by putting the tip of the fluid sampling system directly into the outlet of black smokers, maximum concentrations of methane were 397.8 µmol L^{-1} (at Irina I, ROV249). Highest concentrations of dissolved methane in water samples taken with the ROV-based Niskins were found at the same site and accounted for 67.5 µmol L^{-1} (ROV261). Further insights into the variability in the gas chemistry of fluids at the LHF will be obtained after reevaluation of on board data and by stable isotopes analysis of the comprehensive sample set in the home lab.

2.4.6.2 Spatial distribution of the hydrothermal signature in the water column

(H. Marbler, T. Pape, H.-H. Gennerich, G. Schroll, S. Weber)

In order to determine the horizontal expansion and vertical structure of the hydrothermal plume at the Logatchev hydrothermal field (LHF) a plume-mapping was carried out.
During selected hydrocasts with CTD/rosette water sampler 25 measurements of the water column were conducted as one-point on-line measurements with CTD combined with light transmissiometer, associated MAPR (Miniature Autonomous Plume Recorder with turbidity, density and temperature sensors) and MTL (Miniature Temperature Logger). Time series measurements were also carried out with five MAPR and 20 MTL in different depths. A so-called "towyo-mapping" with MAPR and MTL was performed in four parallel S-N profiles over the vent field.
For seafloor observations combined with the determination of geophysical parameters of the near bottom plume an OFOS (Ocean Floor Observation System) combined with MAPR and temperature logger in defined levels were used (see Chapter 2.4.3).

Table 2.3: Station numbers with coordinates and the number of CTDs, MAPRs and temperature loggers

Station No.	Long. N	Lat. W	CTD	MAPR	Temperature-Logger
217 CTD	13°30,0´	45°0,0´	1	1	1
219 CTD	14°45,2´	44°58,8´	1	1	1
221 CTD	14°45,1´	44°58,9´	1	1	1
223 Logger	Track			5	20
226 OFOS			1		
227 CTD	14°45,1´	44°58,7´	1	1	1
228 Logger	14°45,1´	44°58,7´		5	20
233 CTD	14°45,3´	44°58,8´	1	1	1
242 CTD	14°46,0´	44°58,8´	1	1	1
245 CTD	14°45,9´	44°59,3´	1	1	1
246 CTD	14°46,4´	44°59,5´	1	1	1
253 CTD	14°46,1´	44°59,2´	1	1	1
254 CTD	14°45,9´	44°59,2´	1	1	1
255 CTD	14°45,7´	44°59,3´	1	1	1
256 CTD	14°45,4´	44°59,5´	1	1	1
260 CTD	14°46,0´	44°59,1´	1	1	1
264 CTD	14°45,2´	45°01,0´	1	1	1
265 CTD	14°44,0´	45°00,0´	1	1	1
267 CTD	14°44,0´	44°59,0´	1	1	1
268 CTD	14°44,0´	44°58,0´	1	1	1
269 CTD	14°44,4´	44°57,0´	1	1	1
270 CTD	14°44,5´	44°57,5´	1	1	1

Station No.	Long. N	Lat. W	CTD	MAPR	Temperature-Logger
273 CTD	14°46,0´	44°59,2´	1	1	1
274 CTD	14°45,1´	44°58,1´	1	1	1
275 CTD	14°44,4´	44°57,2´	1	1	1
276 CTD	14°45,7´	44°57,5´	1	1	1
278 OFOS			1		
279 CTD	14°45,4´	44°58,9´	1	1	1
280 CTD	14°47,0´	45°00,0´	1	1	1
284 OFOS	Track		1	5	20

Preliminary Results

During 25 CTD Stations (Tab. 2.3; Fig. 2.20) with associated MAPR (10 meters above the CTD) several turbidity anomalies were detected. Above LHF we observed turbidity plumes in two depths. One plume intrudes the water column between 2.620m to 2.800 m water depth and a second one was found between 2.920 m and 2.980 m (for example CTD219; Fig: 2.21). The latter is only observed in the close vicinity of LHF.

2 km northwest of LHF a continuation of the upper plume can be stated, while in the lower lewel a new strong turbidity plume was located between 2.750 m and 3.000 m (CTD 260; Fig. 2.21). This anomaly was observed in three CTD and MAPR stations. Between this northern anomalous zone (NAZ) and LHF the lower plume could not be detected, indicating that a different, while still unknown vent site as source exists. The near bottom plumes at NAZ and LHF consist of turbidity anomalies and very high CH_4 and H_2 values indicating individual hydrothermal sources at both locations.

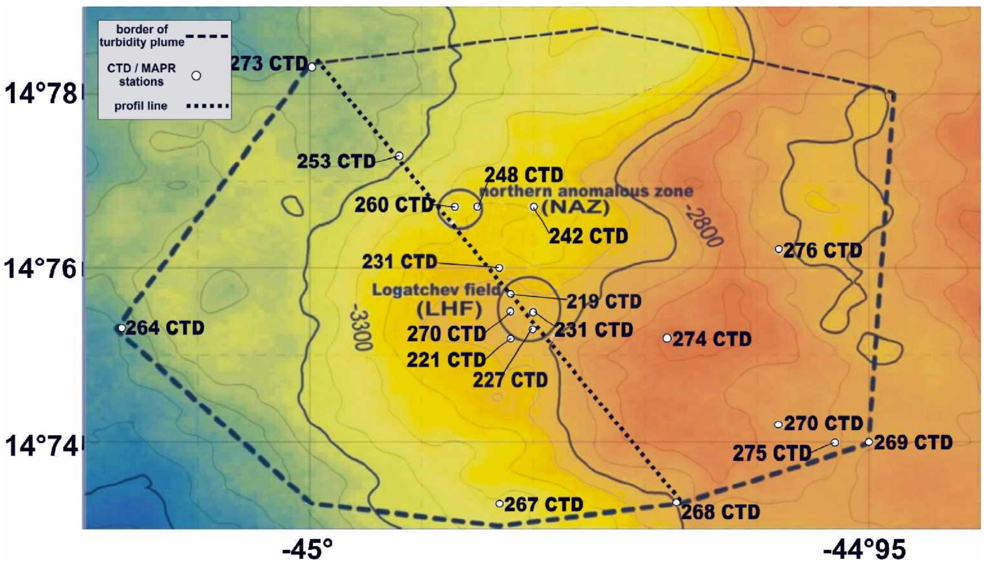
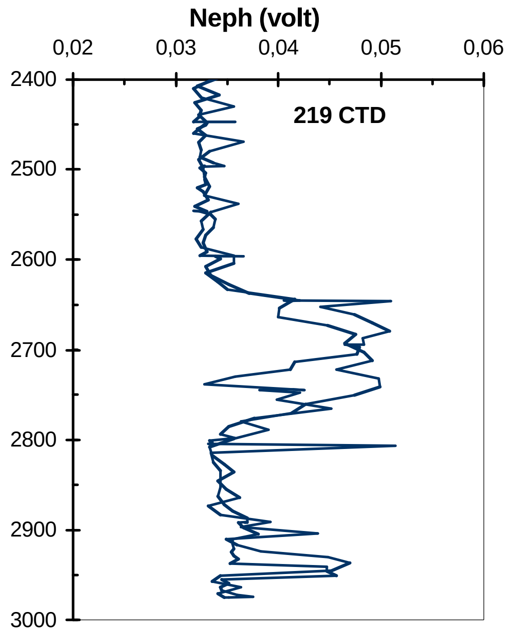


Fig. 2.20: Map of the CTD and MAPR stations (white dots) in the area of the Logatchev vent field and the northern anomalous zone. The dashed line around the area marks the zone of sites where a turbidity anomaly could be recognized. It links CTD stations with strongly reduced turbidity anomalies. The circles show zones, where near bottom turbidity was

observed. The dotted line through these zones marks the profile of the 2D- plume representation (figure 2.22).



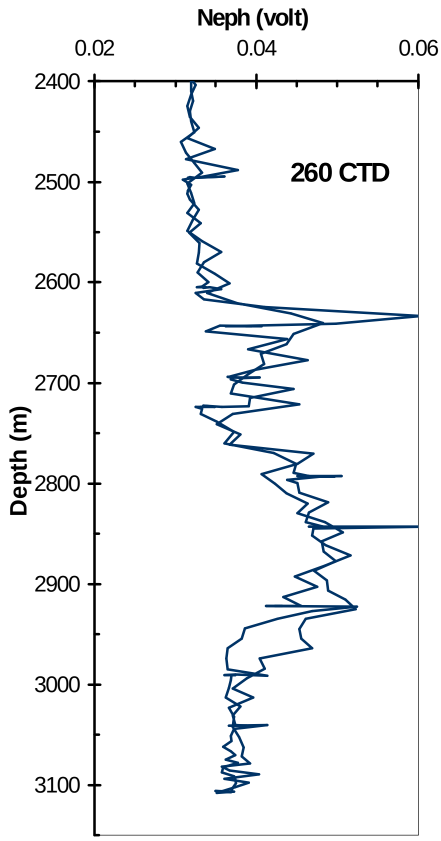


Fig. 2.21 : Turbidity (Nephelometer volts) vs. water depth from MAPR-data at CTD stations above the Logatchev vent field (219CTD) and at the northern anomalous zone (260CTD).

With an array of CTD stations and associated MAPR the extension of the turbidity plumes was mapped. A CTD reference station was conducted some km west of the studying area. In the map (Fig. 2.20) the lateral extent of the upper plume is illustrated by a strong dashed line. Close to the individual fields (LHF and NAZ) the extension of the local lower plume is added by a circle.

The strongest turbidity signal is generally observed in the upper plume at 2700 m to 2900 m depth. The disappearance of the turbidity plume in a distance of some km from the vent is explained by the sinking of Fe-oxides, Fe-oxihydroxides and Mn-oxides not too far from their origin.

The SSE-NNW profile (see map fig. 2.20) of the hydrothermal plume through the Logatchev field and the northern zone shown in Fig. 2.22 is based on the interpretation of 11 CTD-MAPR stations. The cross-section shows a stratification of the turbidity plume especially above the Logatchev field with an extra turbidity plume closer to the seafloor.

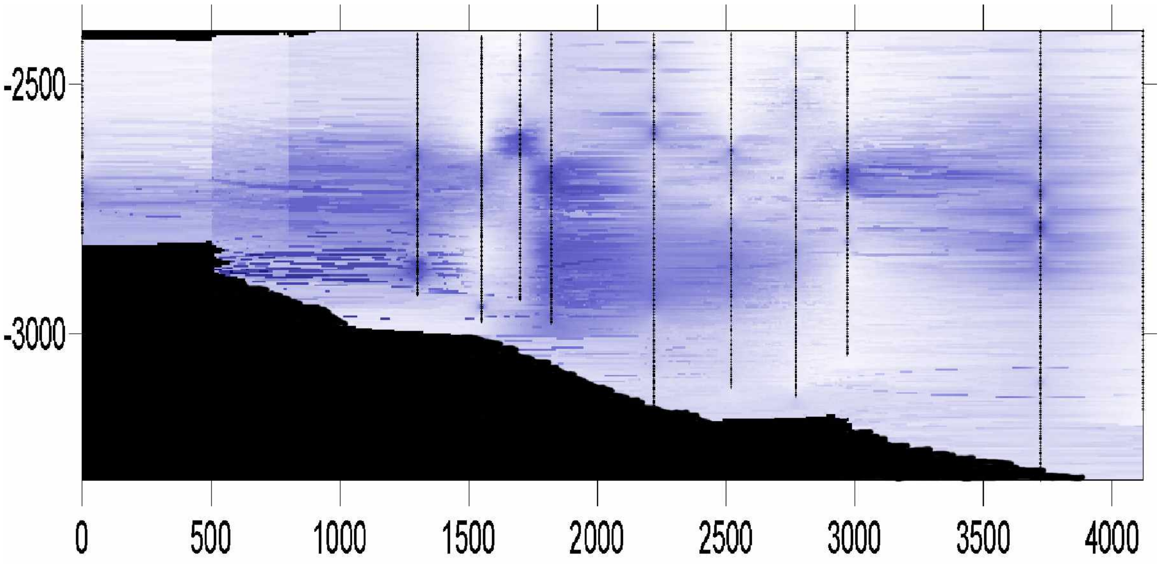


Fig. 2.22: SSE-NNW profile of the hydrothermal plume covering the LHF and the northern zone. The shading indicates the intensity of the turbidity, the y-axis shows the water depth (m) and the x-axis the distance (m) from the first CTD-MAPR station of this profile in the SSE. The Logatchev vent field is situated at about 1300 m distance and the northern zone at 2300 m in the profile.Vertical black lines indicate the location of the CTD and MAPR station, on which this visualization is based.

To record the time variations within different plume levels in the water column a station with five MAPR and 20 MTL was carried out above the LHF during an eight hour station. Large time variations were observed especially in the lower part of the plume, like 75 and 175 m above the seafloor. Within the water depth between 2.700 m to 2.625 m (250 and 325 m above the seafloor) the turbidity level is less variable, which indicates a homogenous distribution of hydrothermal fluid in this level of the water column. In this buoyant plume the turbidity spreads within a distinct depths range.

2.4.7 Fluid chemistry

(M. Amini, D. Garbe-Schönberg, H. Marbler, K. Schmidt, H. Strauss)

One of the major objectives for cruise M64/2 was the detailed investigation of spatial and temporal variations in fluid composition within the Logatchev hydrothermal field. Re-sampling of all sites visited during M60/3 in 2004 and complete coverage of all known Logatchev vent sites could be accomplished during this leg.

Three different types of samples were collected for chemical and isotopic analyses: (1) water column samples from the CTD/Rosette, equipped with 24 Niskin flasks à 10 l volume; (2) samples from discharging vent sites collected with three Niskin flasks (5 l volume), mounted at the front of the MARUM ROV QUEST; (3) in situ-vent fluid samples collected with the new Kiel Pumping System (KIPS: 15 bottles à 675 ml).

Fluid Sampling System (KIPS)

For in situ-sampling of hydrothermal fluids directly from inside the vent orifices a pumped flow-through system (Kiel Pumping System, KIPS) mounted on the ROV's starboard back side was used.

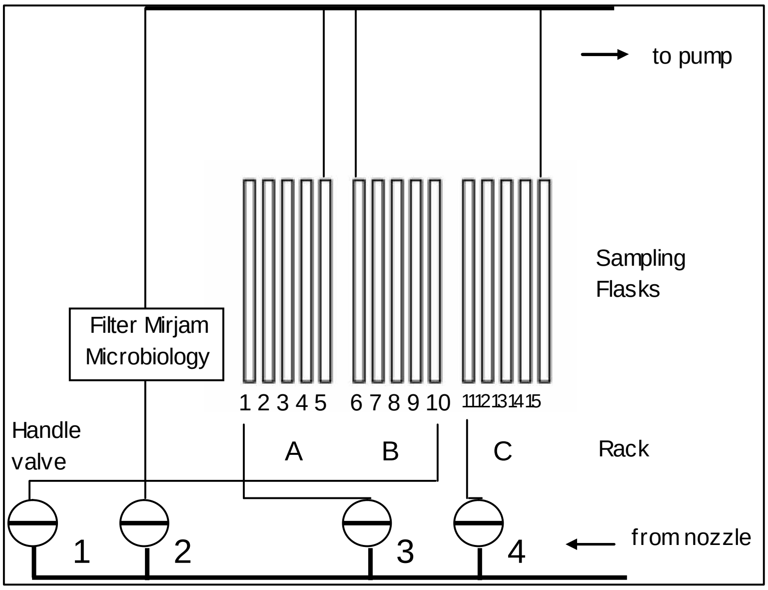


Figure 2.24: Schematic configuration of the KIPS fluid sampling system for e.g., Station 249ROV.

The system is newly constructed and entirely made of inert materials (Teflon, titanium). Samples are collected via bent titanium nozzle of 50 cm length which can be directly inserted into the vent orifice by the ROV`s manipulator arm (Fig. 2.25). Parallel to the nozzle is an on-line temperature probe monitoring the *in situ*-temperature at the point of sampling. Coiled PFA tubing connects the nozzle to 4 handle-operated open-close valves (Fig. 2.24) allowing the distribution of the vent fluids directly to either a series of PFA sampling flasks or an in-line filter holder for microbiological studies or a remotely controlled multiport valve (PETP/ PTFE) driven by a ROV actuator (Schilling, U.S.A). The valve control software is fully integrated in the ROV control system (MARUM, Bremen). The multiport valve in its current design has 18 ports which can be connected to 15 single PFA Teflon flasks (675 ml volume each, Nalgene, USA). A deep sea pump with nominal 3 l/min is mounted downstream to the sampling flasks with the outlet tube ending on the porch at the front-size of the ROV so that outflowing shimmering water could be observed during pumping. The flasks are mounted in three racks A-C, with every rack containing five horizontally positioned bottles, allowing an easy transfer of the racks to the laboratory where sub-sampling was done. Each bottle can be equipped with check valves at the inlet and outlet. An additional multiport valve for a series of microbiology filter units can be connected as a slave valve to one of the free positions (#16-18) of the first multiport valve.

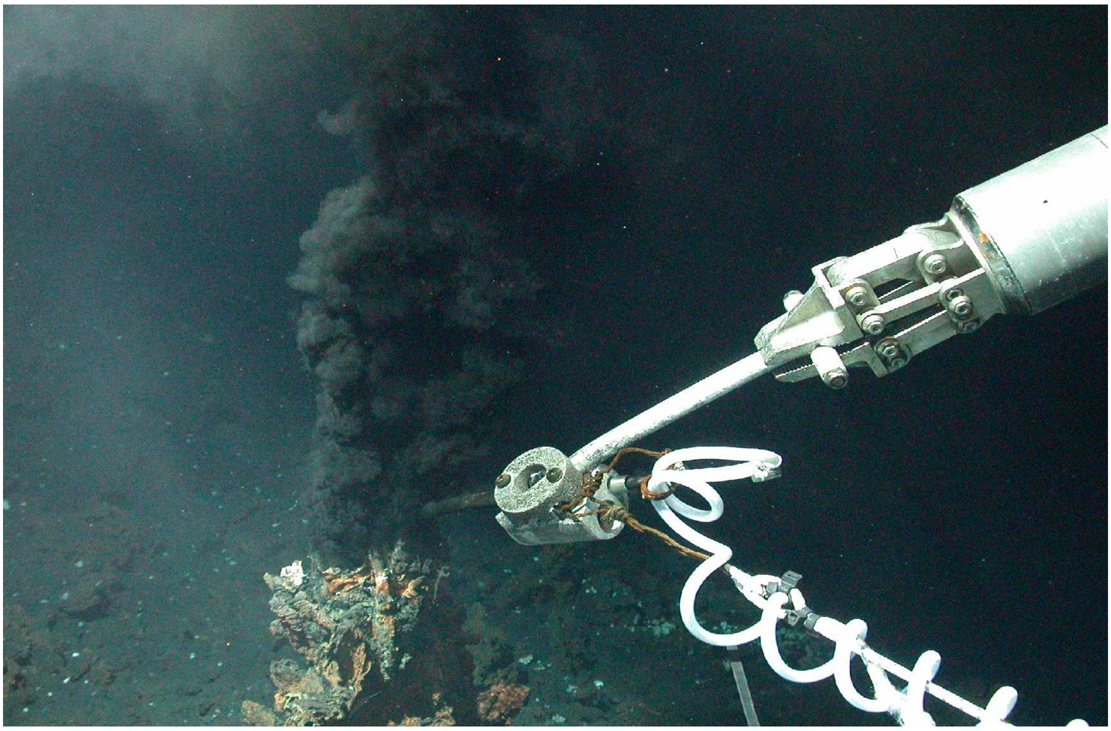


Figure 2.25: Fluid sampling at Site “B” (257ROV-7) with KIPS.

A pre-cruise inquiry on sample volumes needed for their investigations was made in cooperation with the participating groups and resulted in a total of 625 ml sample volume per location. On basis of this information, the pumping system was originally designed for filling 1-2 bottles (0.7-1.5 litres) at one sampling location. However, it turned out during this cruise that it was necessary to fill 5 bottles (3.5 litres) at every site in order to fullfill the many fluid sample reQUESTs. As a consequence, total pumping time increased to 1 hour per site for a full exchange of pre-filled bottom seawater in the 5 flasks. Another consequence was that 5 flasks could not be homogenized prior to sub-sampling. The final KIPS configuration during M64/2 was: Handle valve #1 connected to either Rack A (5 bottles in series) or to the multiport valve; handle #2 connected to the microbiology filter unit; handle #3 connected to Rack B (3 or 5 bottles); handle #4 connected to Rack C (3 or 5 bottles).

Fluid Sampling and Sample Preparation

A total of 90 water column samples, 15 fluid samples obtained with the ROV fluid sampling system, and 5 ROV Niskin samples were collected (see Appendix 6).

Water Column Samples

Based on the depth profiles for temperature, salinity and light transmission, samples were collected at different depths with the CTD/Rosette system, covering the vertical distribution of the hydrothermal plume. Sampling of these waters was performed directly after recovery of the CTD/Rosette system.

Immediately after sampling, pH and Eh were measured. Subsequently, and depending upon future chemical analyses, non-filtered subsamples (with aliquots either non-acidified or acidified to a pH of 2 with suprapure HCl) were stored at 4°C.
Barium sulphate was precipitated from sample aliquots (addition of barium chloride solution at pH 2) for measuring the sulphur and oxygen isotopic compositions of dissolved sulphate. For selected CTD stations, untreated water samples were collected for measuring the oxygen and hydrogen isotopic composition of these waters.

For the CTD stations in the vicinity of active vents, samples have been collected for the analysis of amino acids in the dissolved and particulate organic material. Water samples were filtered through GF/F glass fibre filters and the filters wrapped in aluminium foil and frozen at -20°C. The organic compounds in the filtrate were concentrated by means of solid phase extraction onto C18 and SCX phases and subsequently stored at -20°C. For selected profiles throughout the water column an aliquot of the samples has been frozen at -20°C for later analysis of the ammonium concentration and its nitrogen isotopic composition.

Vent Fluid Samples

Immediately after recovery of the ROV, all three Niskin flasks (N1, N2, N3) and all bottles from the KIPS were sub-sampled.

Aliquots were sub-sampled for the following chemical and isotopic analyses: free gas and dissolved gases (CH_4, H_2, abundance and isotopic composition, approx. 1000 ml), total dissolved and particulate major and trace elements (2x 50ml), isotopic composition of Ca (25 ml), high precision alkalinity (250 ml), selected anions (50 ml), sulphate (1 ml) and sulphide (abundance and isotope geochemistry, 400 ml), dissolved inorganic carbon (abundance and isotopic composition, 30 ml), amino acids (2x 75 ml), ammonium (abundance and nitrogen isotopes, 60 ml), and aliquots for subsequent filtration (500-1000ml) and microbiological cultivation work.

On small unfiltered aliquots (30 ml), ph, Eh, total Fe and Fe-II, S^{2-}, and dissolved silica were measured directly after sampling for all samples.

For all other chemical analyses, fluid samples were pressure-filtrated with Nitrogen (99.999%) at 1 bar through pre-cleaned 0.2 µm Nuclepore PC membrane filters by means of polycarbonate filtration units (Sartorius, Germany). The filtrates were separated into aliquots for voltammetric and ICP analyses and acidified to pH 1 with 100 µl subboiled concentrated nitric acid per 50 ml (ICP) and with suprapure HCl to pH 2 (voltammetry), respectively. Procedural blanks were processed in regular intervals. All work was done in a class 100 clean bench (Slee, Germany) using only all-plastic labware (polypropylene, polycarbonate, PFA Teflon). Rinse water was ultrapure (>18.2 Mohm), dispensed from a Millipore Milli-Q system.

For selected samples, about 200 ml of fluid were filled into specially pre-cleaned bottles and immediately deep-frozen at -20°C. These samples are shipped in frozen state for the determination of organic metal complexation in the home laboratory of the project partner Dr. Sylvia Sander (University of Otago, New Zealand). Some representative samples were deep-frozen or poisoned with $HgCl_2$, respectively, as conservation for organic analyses in the home laboratory.

After return to the home laboratories at University of Kiel selected samples will be analysed for major (Mg, Ca, Ba, Sr, Na, K, Si, Fe, Mn, B, Cl) and trace element composition (e.g., I, Br, Li, Al, Cs, Ba, Sr, Y-REE, Fe, Mn, Cr, V, Cu, Co, Ni, Pb, U, Mo, As, Sb, W, PGE) by ICP-OES (Spectro Ciros SOP CCD) and ICP-MS using both collision-cell quadrupole (Agilent 7500cs) and high-resolution sector-field based instrumentation (Micromass PlasmaTrace2).

At IUB in Bremen, voltammetry will be used for further trace metal analyses (Zn, Cd, Pb, Cu, Co, Ni, Ti, V, Mo, U, Tl, Pt). ICP-MS and ICP-OES measurements of minor elements and trace metals (see above) will be carried out as well for interlaboratory comparison. Li and Na will be analysed by flame photometry, and photometric methods will be used to determine anionic compounds (silicate, phosphate, sulfate, chloride). The duplicate coverage of some elements with different methods will be used for the evaluation of the methods and the data. The determination of organic complexation of Fe, Cu, and Zn (S. Sander, Univ. Otago) will be done by voltammetric ligand titration.
At the Westfälische Wilhelms-Universität Münster, sulphur (sulphides, sulphates), oxygen (sulphates, fluid samples), and hydrogen (fluid samples) isotope measurements will be performed.

At the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) in Hannover the amino acid concentrations (HPLC-FD) and their racemization (GC-FID) as well as their isotopic composition (GC-irmMS) will be analysed for selected samples. Additionally, the ammonium concentration and its nitrogen isotopic composition will be investigated. For a set of samples the concentration and carbon isotopic composition of the dissolved inorganic carbon will be analysed by a Finnigan Gasbench-Delta Plus-MS coupling.

At IFM-Geomar in Kiel the isotopic composition of Ca and Sr as well as U for selected samples will be determined by TIMS and MC-ICPMS. Alkalinity will be determined to high precision.

On-board analyses

pH and Eh Measurements

For all samples collected with either the CTD/Rosette, the Niskin flasks or the Kiel Fluid Pumping System (KIPS), pH and Eh measurements were performed on unfiltered sample aliquots immediately after sampling. Measurements were carried out with WTW electrodes (Ag/AgCl reference electrode).

Chloride Titration

In order to determine whether or not phase separation affected the chemical composition of the hydrothermal fluids, fluid samples from hot vents collected during ROV dives, either with Niskin bottles or with the Kiel Fluid Sampling System, were subjected to chloride concentration analysis. Measurements were performed as titration with 0.1 mM $AgNO_3$-solution, using fluorescene-sodium as the indicator. For reference, samples from a water column profile were also analyzed.

Photometric Determination of Dissolved Inorganic Silica

Silica tends to be enriched in hydrothermal fluids (e.g., van Damm, 2004). Hence, fluid samples and selected CDT/Rosette water column samples were analyzed for their abundance of dissolved silica. The analysis of dissolved silicon compounds in seawater and hydrothermal fluids is based on the formation of α-silicomolybdic acid via complexation of the dissolved silica with ammoniumheptamolybdate (e.g., Grasshoff et al., 1999). Concentration measurements were performed with a biochrom Libra S12 spectral photometer at an extinction of 810 nm. Silica contents in water column samples were measured both in filtered and non-filtered samples. No significant difference was detected.

Photometric Determination of Iron Concentrations

The principle of this method is the determination of an orange-red ferroin complex, which is formed by Fe(II) ions in the fluid sample with 1,10-phenantroline in a pH range of 3-5. In addition to a quantification of Fe(II), it is also possible to measure the Fe_{tot} fraction in the sample by reducing all Fe with ascorbic acid. Fe(III) is determined as difference between Fe_{tot} and Fe(II). Analyses were carried out with a biochrom Libra S12 spectral photometer and the absorption was measured at 511 nm. Fe concentrations were measured only in filtered samples of hydrothermal fluids. The detection limit is about 0.1 ppm. Samples with concentrations above 100 ppm were measured in diluted samples.

Voltammetric Determination of Trace Element Concentrations

For onboard sulfide and trace metal concentration analyses, the electrochemical method of voltammetry was used. Voltammetry is able to differentiate between different redox species and (in combination with UV digestion of the water samples) free and complexed forms of ions in solution and is highly sensitive. All the voltammetric measurements were performed using a Metrohm system comprising a 757 VA Computrace run with a standard PC, an 813 Compact Autosampler and two 765 Dosimats. The three-electrode configuration consisted of the multi-mode electrode (MME) as the working electrode, an Ag/AgCl reference electrode (3 mol l^{-1} KCl), and a platinum wire as the auxiliary electrode.

Immediately after recovery, the unfiltered fluid samples were analysed for total dissolved sulfide in alkaline solution using the method after Metrohm Application Bulletin 199/3e. Filtered aliquots were submitted to a digestion process in a UV Digestor (Model 705, Metrohm), which contains a high pressure mercury lamp (500 W), decomposing organic metal complexes. After 1 hour UV irradiation, the total content of Mn, Zn, Cu, Cd, and Pb in all fluid samples and Fe in selected water column samples were determined by the standard addition method. For Fe, the highly sensitive cathodic stripping voltammetric method of Obata and van den Berg (2001) using 2,3-dihydroxinaphthalene as complexing agent was applied in samples with low Fe concentrations, while photometry was used for samples with high Fe concentrations (>0.1 ppm). Mn concentrations were determined using anodic stripping voltammetry in an alkaline ammonia buffer solution (Locatelle and Torsi, 2001). For Cu, Pb, Cd, and Zn analyses samples were buffered at pH 4.6 with 1 M acetate buffer solution and measured by ASV (Application Bulletin Metrohm 231/2).

Titration of Alkalinity

Alkalinity was determined onboard for samples of very less amounts and for a cross check with later analyses due to potential modifications by H2S oxidation and/or CaCO3 precipitation.
The measurements are carried out by a titration device after Galina Pavlova. 1 ml of sample was added to 4 ml of Millipore water and 0.02 ml of the indicator (mixture of methylorange and methylenblue). The mixture was titrated by 0.01M HCl until a stable redish colour appears. The released CO2 and H2S respectively was outgassed/displaced by N2. The results are averages of at least three replicated measurements. Analytical uncertainties are in the range of less than 0.7 %.

Results from On-Board Analyses

Vent Fluids

The chemical and isotopic characterization of hydrothermal vent fluids is strongly dependent upon the sampling procedure and the sampling location inside the orifice. Dilution of the emanating hydrothermal fluid by turbulent mixing with ambient seawater within the vent orifice is always likely. In order to qualitatively assess the contribution from seawater, a number of analytical parameters, such as Eh, pH and chloride have been measured on-board. A final quantification of the fluid contribution from a hydrothermal source will be performed by using Mg concentrations (hydrothermal endmember Mg = 0, seawater endmember Mg = 55 mM). Mg will be measured in the home laboratories.

The sampled vent fluids are highly reducing and acidic (Fig. 2.26), indicating a low proportion of intermixed oxic seawater. Lowest values obtained for fluid samples were 3.89 for pH and –370 mV for Eh. The highest in-situ temperature measured during this cruise was 350°C (Site “B”), which is nearly identical to the published value from Douville et al. (2002).

Sulfide. The measured dissolved sulfide concentration ranges between 0,5 mM and 2,5 mM for samples directly collected at the vent sites. The published values for ultramafic-hosted hydrothermal fields range between 0,8 mM and 1 mM for the Logatchev Field and Rainbow, respectively (Douville et al., 2002).

Chlorinity. Measured chloride concentrations are slightly lowered compared to seawater (max. 10%). This may indicate phase separation, which must happen in the supercritical region (water depth >3000 m, critical point: 405°C/300bar).

Silica. The silica concentrations range between 0,8 mM und 4 mM and show significant differences between individual sites (Fig. 2.27). Higher concentrations seem to be reflected in more complex vent architectures (IRINA II and possibly Site “A”). The variations between individual sites confirm the trend observed for the samples collected during the M60/3 cruise.

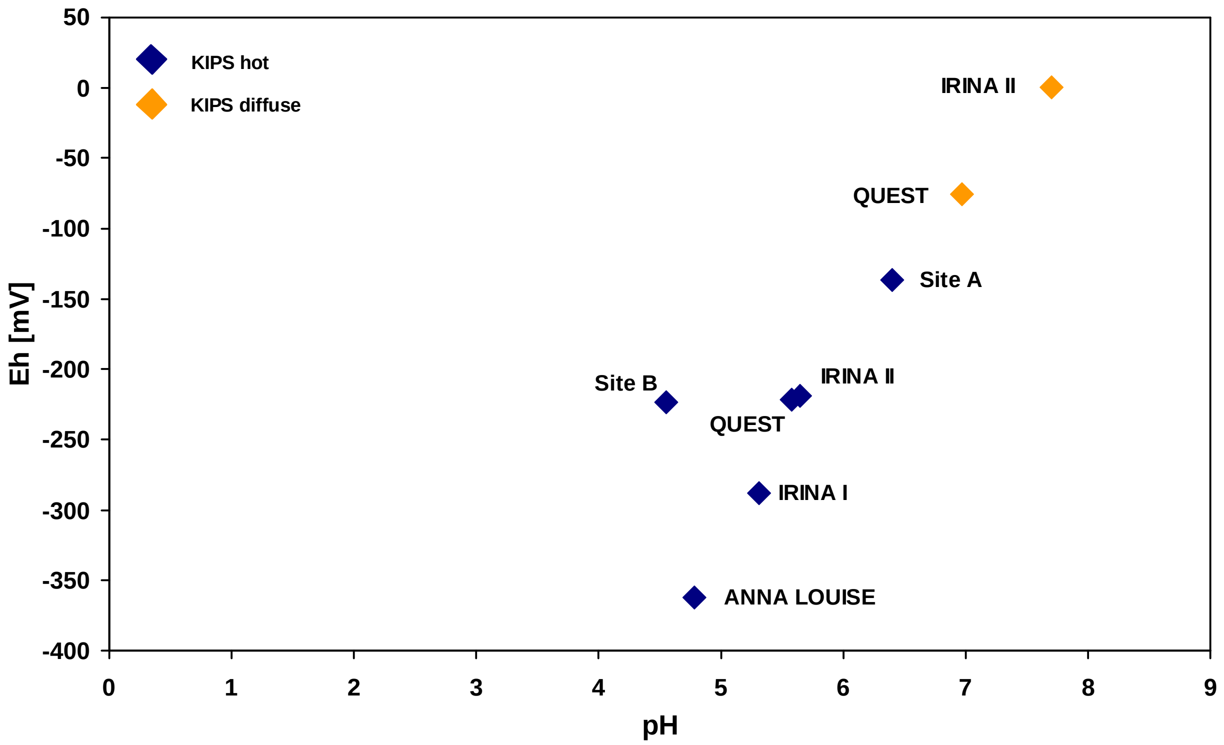


Fig. 2.26: Plot of pH and Eh for fluid samples obtained with the fluid sampling system (KIPS).

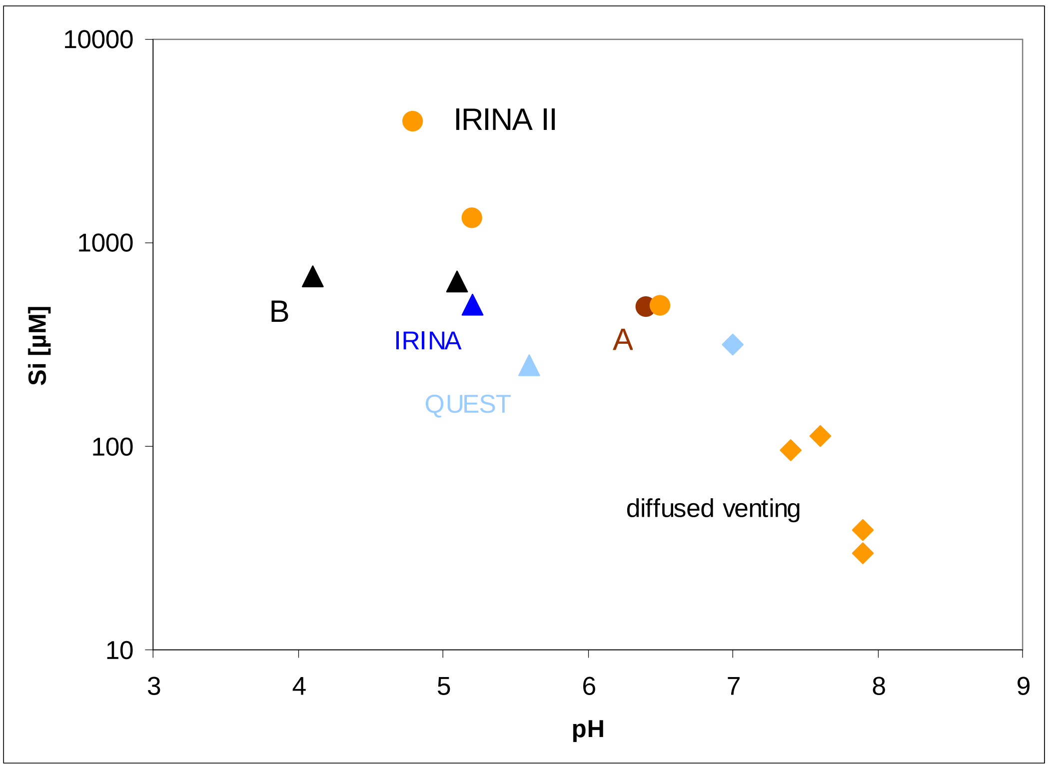


Fig. 2.27: Plot of Si vs pH for KIPS fluid samples. Fluid samples from IRINA II and Site A are characterized by elevated Si concentrations.

Trace metals. Spatial variations can also be seen in the concentrations of Zn and Cu. The highest concentrations were measured at IRINA II (Zn: 4 µM; Cu: 5,1 µM), the lowest at IRINA I and QUEST (less than 1 µM). The low concentrations compared to published data are probably caused by the strong bounding of these chalcophile elements in the precipitating sulfide particles before and during the sampling.

Fe/Mn ratios differ also between the individual sites. For Site "B" and QUEST the highest ever reported values for MAR were found (Fe/Mn=18, Fig. 2.28), resulting from very high total dissolved Fe concentrations up to 2,5 mM (more than 90% as reduced Fe^{2+}). These not yet endmember-corrected Fe data are in the same range as the calculated endmember concentration for the M60/3 fluids.

Diffuse vent fluids sampled at IRINA II and QUEST show intermediate compositions between hot fluids and seawater. They were partly significantly reducing (Eh of –200 mV) and slightly acidic (pH of 6.5). The silica enrichment at IRINA II (see above) can also be seen in the diffuse fluids. Measured sulfide concentrations range between 0,5 µM and 6 µM.

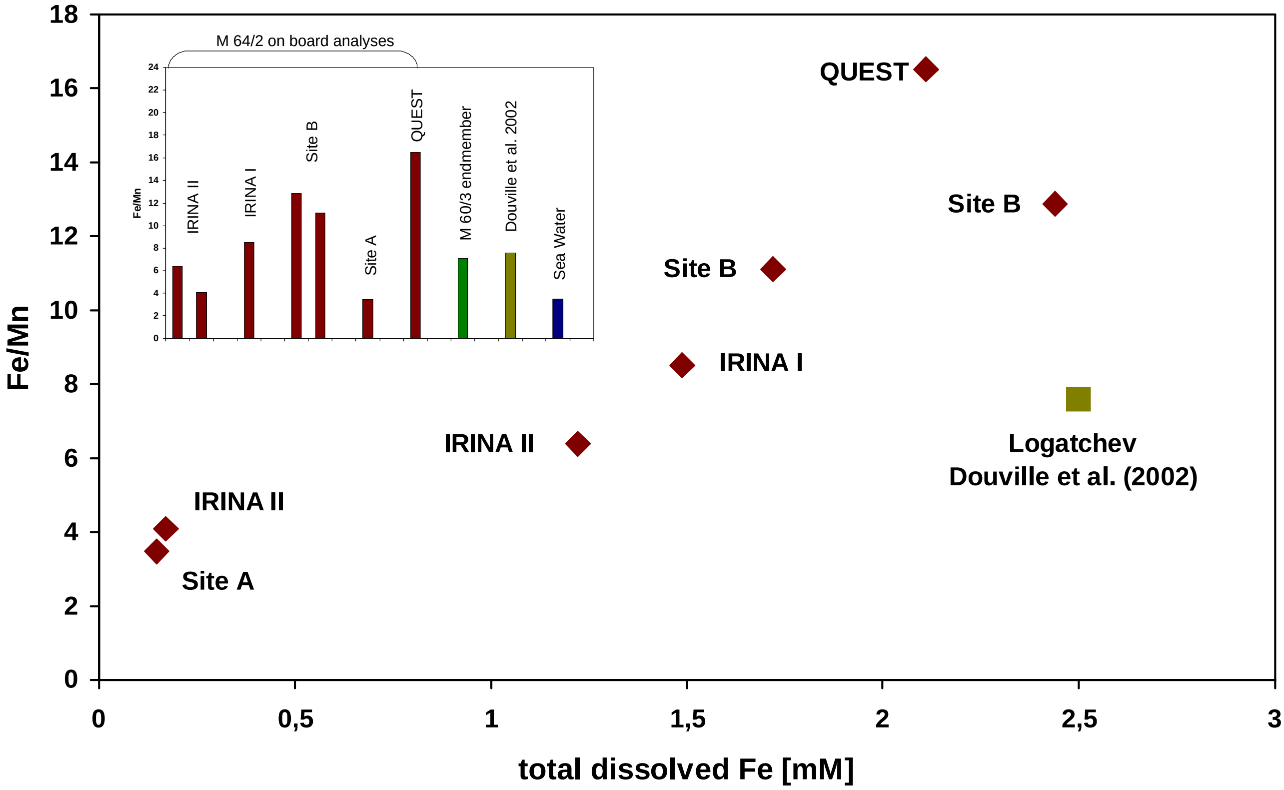


Fig. 2.28: Plot of Fe/Mn vs total dissolved Fe. Insert shows Fe/Mn ratios in comparison to data from M60/3 and Douville et al. (2002).

Alkalinity: The results are listed in table. …As expected the alkalinity of the CTD samples as well as of the diffuse vent samples range between 2.0 and 2.3, which is in accordance with the value of 2.33 yielded for IAPSO and the averaged CTD samples.

Samples taken from smoking vent sites are decreased to more than a quarter of the reference value varying from 0.5 to 1 mM. These values have to be checked and elaborated by potentiometric titration afterwards. Furthermore contributions of carbonate and borate/silicate have to be identified.

Water Column Profiles

As Eh measurements are a fast and relatively simple analytical tool, they were used as the first measurement following the recovery of CTD water column samples in order to search for hydrothermal plume indications. For several stations, Eh minima clearly correlate with maxima of other hydrothermal tracers analysed, such as methane, and hydrogen. Mn and Fe will be analysed in the on-shore labs for a further characterization of the chemical signature of the plume .

2.4.8 Marine microbiology

(A. Gärtner, M. Perner)

The aim of the cruise was the collection of microbial communities from the Logatchev I hydrothermal vent field (LHF I) at 14°45 N in order to perform:

a) Molecular analyses of the microbial community structure (in the home lab)
   - Construction of clone libraries using the 16S rDNA gene (Archaea and Bacteria);
   - 16S rDNA gene targeted DGGE (Archaea and Bacteria).
   - FISH (Fluorescence in situ Hybridization)
   - Functional gene analyses based on key enzymes of CO_2-fixation pathways.
b) Cultivation based experiments using specific media (started on board and continued in the home lab)
   - Selective media for autotrophic microorganisms using various electron donors (H_2, H_2S, S°, S_2O_3, Fe^{2+}, CH_4) as well as suitable electron acceptors (O_2, NO_3, Fe^{3+}, Mn^{4+}, S°, S_2O_3) in the presence of CO_2.
   - Selective media for aerobic and anaerobic heterotrophic microorganisms.
   - Incubations along a temperature gradient (20-80°C)
c) On board microscopic observations of microorganisms inhabiting freshly taken samples.
d) In situ cultivation – Nets of porous material were deployed for settlement of local microorganisms:
   - Two nets of porous substrate were positioned above a mussel field with shimmering water at IRINA II and collected after 48 hours. One net was positioned directly above a site of diffusive fluid emanations of the mussel field. The other served as a reference and was placed over a part that had been cleared of mussels within the vicinity of shimmering water. Cultivation experiments using this porous material have begun on board (see b). Molecular analyses of the microbial community that was absorbed by the porous material will be conducted in the home lab.
   - Five substrate nets were placed along the temperature sensor mooring positioned between IRINA I and ANNA LOUISE. The nets are located at a height of 2.5m, 5m,

7.5m, 10m and 20m depth above the seafloor. They will be collected in 6 months time and treated as the 2 day deployments were.

Results

a) Molecular analyses of the microbial community structure of hydrothermal vent systems will be conducted in the home lab. Samples were taken via the fluid sampling system from diffusive vents as well as from fluids of black smokers during ROV cruises. Other samples represent hydrothermally influenced rocks and sediments which were retrieved via the TV-grab and the ROV. The samples were frozen at -20°C and fixed for further treatment. Plume samples were taken using the CTD. These samples were filtered and immediately frozen at -20°C or fixed for further processing. A microbiological sample list is shown in the Appendix 7.

b) The samples mentioned above were also used for obtaining enrichment cultures. For these purposes selective media as indicated above were used. Growth was monitored by microscopic observation. Autotrophic as well as heterotrophic microorganisms in culture include various morphotypes. Further processing will be conducted in the laboratory at home with the aim to obtain pure cultures.
In cultures that were enriched with hot hydrothermal vent fluid hyperthermophilic microorganisms were observed (Fig. 2.29). They grew at 92°C on acetate with hydrogen and iron(III).

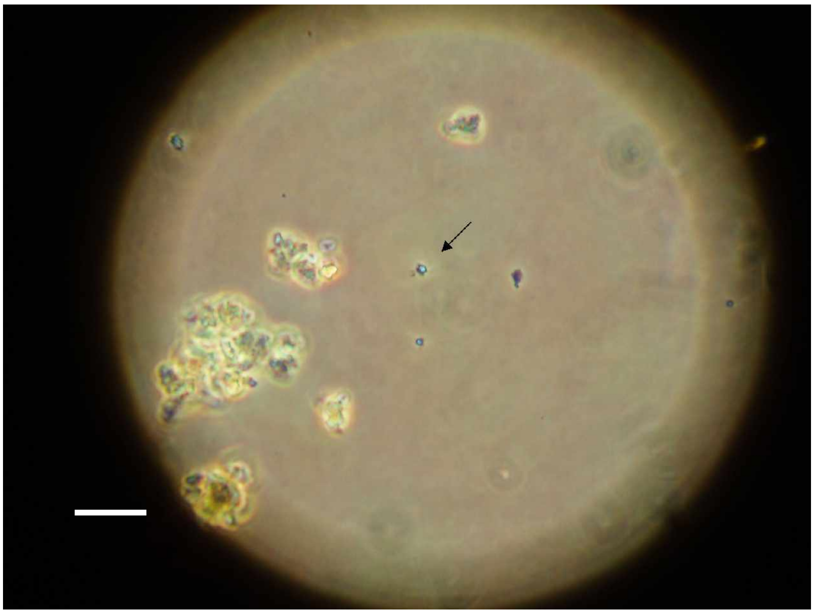


Fig. 2.29: Microscopic picture from hyperthermophilic microorganisms in culture. The sample originates from hot hydrothermal vent fluid. This microorganism grows on acetate with hydrogen and iron at 92°C. Scale bar 10µm.

c) Microscopic observations of microorganisms inhabiting freshly taken samples revealed heterogenous morphotypes. A white “microbial mat” (Fig. 2.30A) with shimmering water was discovered between IRINA II and site “B” (257ROV). Microscopic observations revealed that the white flocs observed are not microorganisms but substrate to which filamentous bacteria are attached to (Fig. 2.30B).

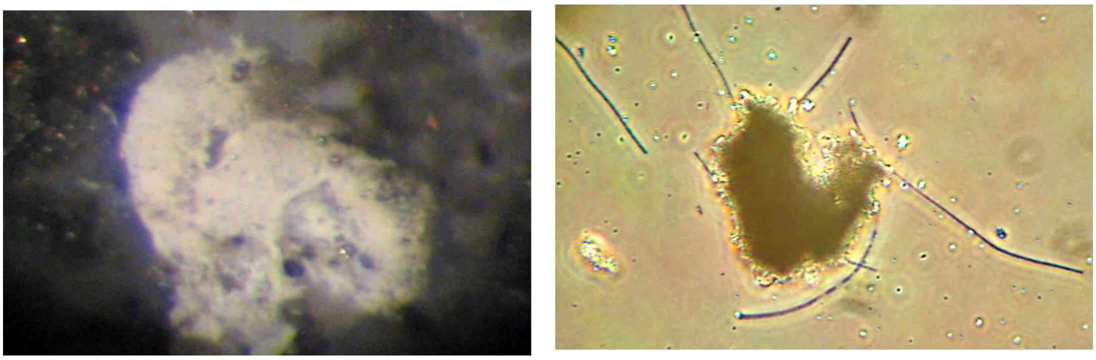


Fig. 2.30: Pictures showing the “microbial mat” positioned between IRINA II and site “B” (257ROV). (A) Stereo microscopic picture of white “microbial mat” (scale bar 2mm) and (B) showing the attachment of filaments to the white floc (scale bar 10µm).

Further microscopic analysis revealed that these filaments consist of single bacteria chained together (Fig. 2.31A). This sample generally exhibited heterogenous morphotypes of microorganisms such as cocci, rods, or spiril shaped ones. Grey sediment collected from the border of the IRINA I crater (252ROV-4) showed amongst rods and cocci also morphotypes resembling spirochaetes (Fig. 2.31B).

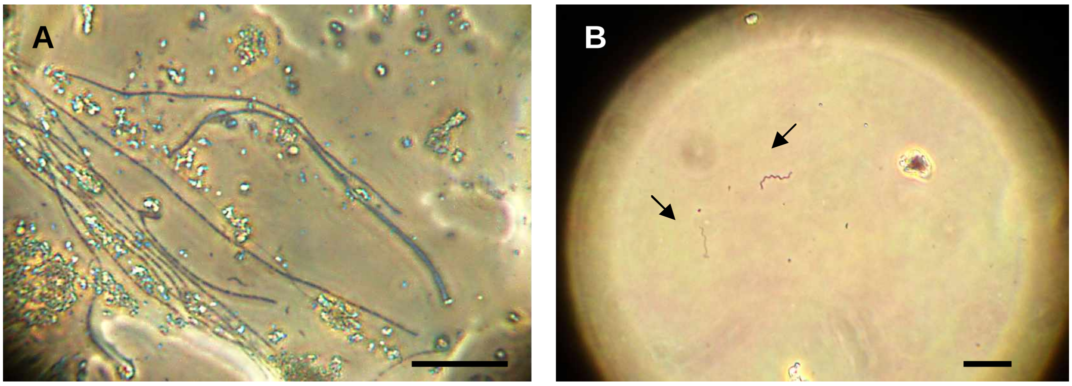


Fig. 2.31: (A) Microscopic picture from the “microbial mat” showing filaments comprising single bacteria chained together (scale bar 10µm)**.** (B) Microscopic picture from grey sediment collected from the outer rim of the IRINA I crater (252ROV-4) showing spirochaetes (scale bar 10µm).

2.4.9 Hydrothermal symbioses

(N. Dubilier, F. Zielinski)

Our main goal for this cruise was to investigate the transfer of energy from vent fluids to the dominant members of the faunal community at Logatchev, the mussels *Bathymodiolus puteoserpentis*. These mussels have greatly reduced guts, and their main source of nutrition are symbiotic bacteria that live in their gills. Two types of symbionts coexist in the gill cells: thiotrophic bacteria that use reduced sulfur compounds such as sulfide as an energy source and fix CO_2 as a carbon source, and methanotrophic bacteria that use methane as both an energy and carbon source. The energy sources for the mussel symbioses are delivered by the hydrothermal fluids that carry high concentrations of sulfide, methane, and other reduced compounds. The dilution of these effluents with ambient seawater leads to gradients in sulfide and methane concentrations that vary over time and space. These gradients play a major role in determining the biomass, activity and productivity of the vent community. We have defined these interactions between hydrothermal and biological processes as the geobiological coupling between vent fluids and symbiotic primary producers.

During this cruise, we contributed to our ongoing studies of geobiological coupling at MAR vents by identifying and characterizing gradients in vent fluids in mussel beds, and collecting mussels along these gradients for analysis of the biomass and activity of the bacterial symbionts. To collect geochemical data at a scale relevant to the mussel community, we worked in close collaboration with the fluid chemistry group, temperature logger group, and in situ group on mussel beds from three sites at Logatchev, two sites at IRINA II and one at QUEST. Site 1 at IRINA II was located relatively high on the IRINA II mound, close to the active black smokers on top of the IRINA II complex. This site was completely dominated by *Bathymodiolus* mussels that formed a dense bed of several layers thickness with no empty shells visible. Site 2 was lower on the IRINA mound, south of the large chimney complex, and close to the small active black chimney. At this site, 2 mussel beds separated by only a few meters were sampled: the mussel bed at Site 2A appeared less active with many empty mussel shells and high abundances of gastropod snails and ophiurid sea stars covering the mussels, which were rusty brown in color. In contrast, the mussels at Site 2B appeared to be thriving, with little coverage by other animals, and the mussel shells shiny dark-brown to black in color. Site 3 at QUEST was a mussel bed located southeast of the active smoker at QUEST. This site was characterized by high abundances of juvenile mussels. Shimmering water was observed at all collection sites, and shrimp were regularly observed at the bottom layers of the mussel beds. A summary of collections sites and geochemical data is provided in Table 2.5.

A further major goal during our cruise was to study how the removal of mussels from fluid gradients affects the symbiosis. In a so-called transplant experiment, we collected mussels at Site 1 on the IRINA II complex and placed them at a site far removed from any obvious vent fluids (Beacon 14, Fig. 2.32).

Mussels were collected using the ROV manipulator arm in nets (40 cm length with a 20 cm diameter opening, mesh size 1000 µm) with a net-covered lid that could be closed after collecting the mussels, to prevent predators such as vent crabs from entering the nets or mussels from escaping from the nets. Nets were recovered from the Beacon 14 site 1, 2, 5, 7, and 10 days after collection at Site 1 and prepared on board for morphological and molecular analysis in the home laboratory. For on board analysis of methane oxidation rates, gill tissues were incubated in radioactive methane for up to 8 hours and the decrease in methane in the incubation over time determined in collaboration with Janine Felden (MPI-Bremen) from the in situ group (Fig. 2.33). No significant decrease in methane oxidation rates occurred for up to 2 days after removal of the mussels from vent fluids, but after 5 days, methane oxidation rates decreased by at least 60%. This indicates that the symbionts are not digested by the mussels and remain fully active during the early stages of starvation, but become less active during the later stages of starvation, possibly because of partial digestion by their hosts. Our home laboratory analyses will show if this assumption is supported by morphological and molecular data.

Table 2.5: Mussel collection sites and corresponding in situ, temperature, and fluid data.

site	location	purpose	mussel sample	Profiler data	temperature data		fluid data				
				station number	station number	logger #	station number	$[CH_4]$ [µM]	$[H_2]$ [µM]	$[S^{2-}]$ [µM]	[pH]
1	**IRINA II mussel bed**	mussel transplantation experiment	**252 ROV/6** (0 days) **244 ROV/7** (1 day) **244 ROV/6** (2 days) **244 ROV/8** (5 days) **244 ROV/9** (7 days) **244 ROV/10** (10 days)	232 ROV/4(a) 244 ROV/1	249 ROV/1 249 ROV/2 249 ROV/3 249 ROV/4 249 ROV/6 257 ROV/1	online online online online 4143 0-9	232 ROV/7	**3,06**	**5,44**	max. 0,4	7,86
2A	**IRINA II mussel bed**	mussel collection	**232 ROV/5**	232 ROV/1	232 ROV/4 232 ROV/6	online 4144	232 ROV/3	**1,63**	**1,36**	max. 0,16	7,92
2B	**IRINA II mussel bed**	mussel collection	**266 ROV/7**	266 ROV/1 266 ROV/2 266 ROV/3 266 ROV/4 266 ROV/5 277 ROV/?	None		266 ROV/6	**15,04**	**5,89**	6	7,63
3	**QUEST mussel bed**	mussel collection	**281 ROV/3**	None	281 ROV/4	10-19	281 ROV/2	**63,68**	**4,20**	70	6,97
-	**IRINA II near dome structure**	shrimp collection	**272 ROV/6**	None	None		None				
-	**IRINA II near dome structure**	shrimp collection	**283 ROV/7**	None	None		None				

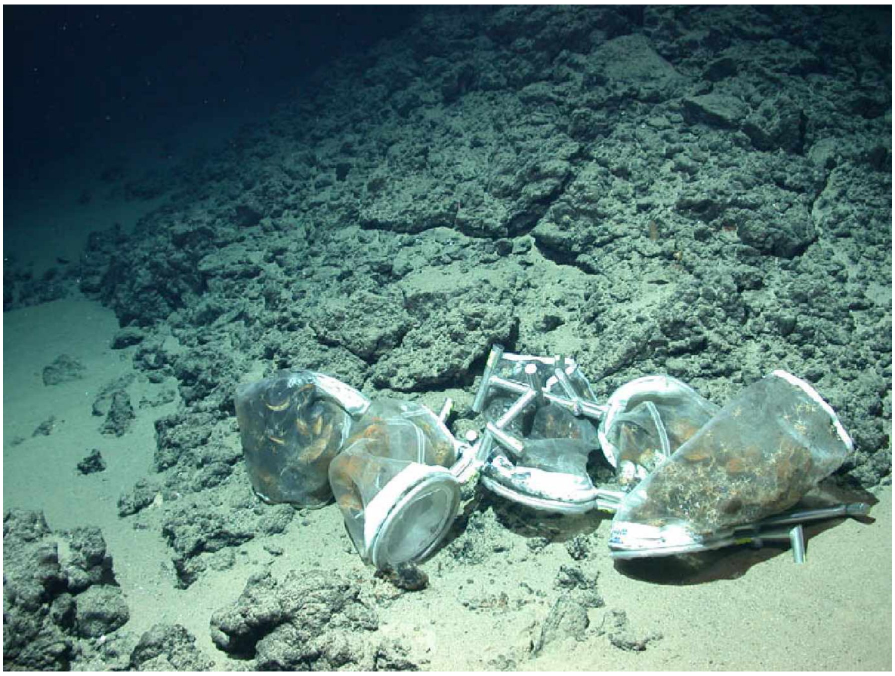


Fig. 2.32: Site at Beacon 14 where mussels were transplanted from Site 1 on the IRINA II complex to remove them from hydrothermal activity.

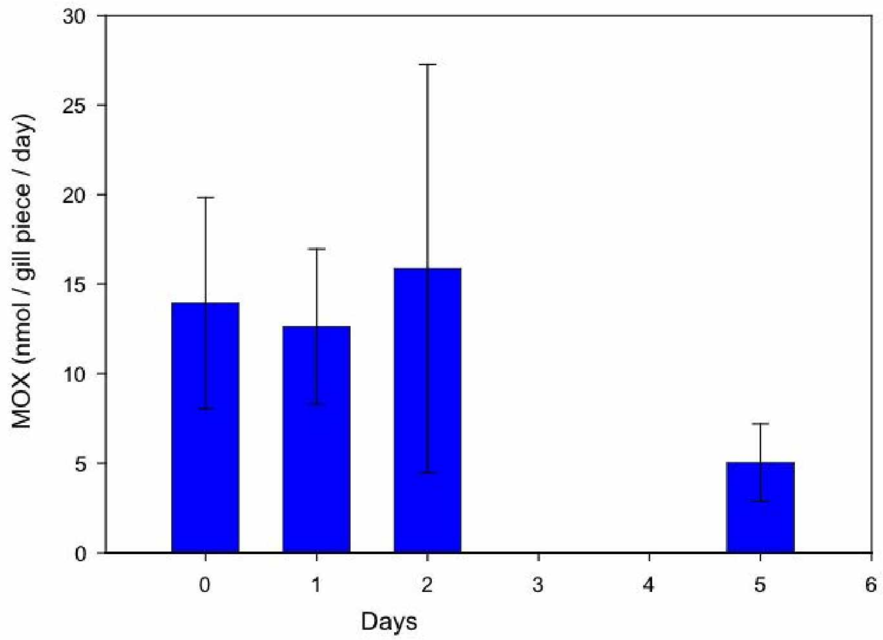


Fig. 2.33: Oxidation rates of methane in gills of *Bathymodiolus puteoserpentis* mussels removed from vent fluids for up to 5 days. Data for 7 and 10 days is currently being analysed.

In addition to our studies on the *Bathymodiolus* mussels, shrimp were collected from the IRINA II chimney complex, using the nets described above and the ROV manipulator arm. After recovery, the shrimp were stored in chilled sea water for up to 4 hours before specimens belonging to the genus *Rimicaris* were dissected and fixed on board for analysis in the home laboratory. The symbionts of these shrimp, that are abundant on their appendages and in their gill chamber, will be investigated using morphological and molecular techniques. Attempts to collect live vesicomyid clams that reportedly occur in the vicinity of the ANYA marker were not successful, and only empty *Bathymodiolus* shells were found in our collection nets. Live thyasirid clams, of which only a few specimens were found in the ANYA area during the last HYDROMAR cruise, were not observed during this cruise.

2.4.10 Fluid dynamic and microbial processes

(F. Wenzhöfer, J. Felden, M. Viehweger)

The main goal of this study was the investigation of physico-chemical gradients at water-substrate interphases and microbial processes at selected habitats. *In-situ* microsensor measurements of O_2, pH, H_2S, T and, for the first time, H_2 were used to investigate the links between the geochemical energy supply from hydrothermal fluids and hydrothermal vent communities. These high-resolution microprofiles allow to determine the variability of hydrothermal fluid emission in space and time and its influences on vent communities. With the aid of such fluid analyses (together with fluid sampling), habitats were selected for studying microbial turnover rates of methane, CO_2 fixation and thymidine incorporation.

Profiler and benthic chamber deployments

To investigate the small scale fluid dynamics at vent mussel fields two benthic lander modules, a profiler and a chamber, have been constructed to be deployed and operated by the ROV. The autonomous profiler module (Fig. 2.34; Wenzhöfer et al., 2000) hosted 2

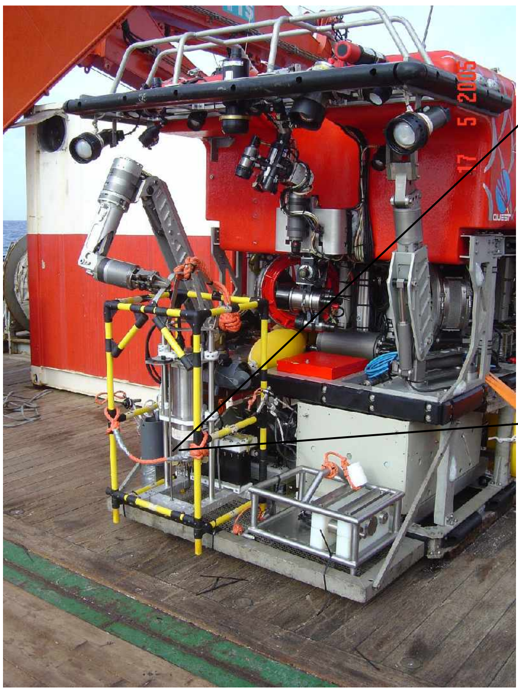


Fig. 2.34: Profiler for *in situ* fluid dynamics measurements. (A) Profiler module fixed on the ROV porch for deployment. (B) Magnification of the mounted electrodes (O_2, pH, H_2S, T, and H_2)

O_2, 1 temperature (Pt100, UST Umweltsensortechnik GmbH, Geschwenda, Germany), 2 pH, 3 H_2S and for the first time 1 H_2 microelectrodes (UNISENSE, Denmark). If not specifically mentioned all electrodes have been constructed in our laboratory in Bremen. During the deployments measurements were taken every second to study the short-time variations within diffuse fluid fluxes above a mussel bed (Fig. 2.35).

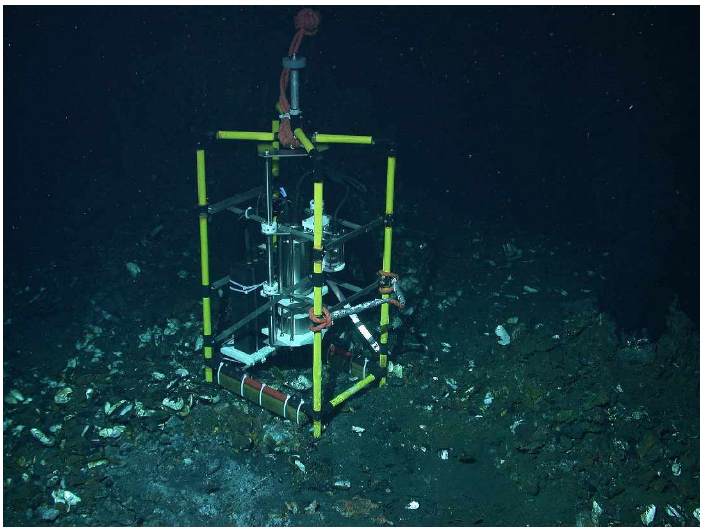


Figure 2.35: Profiler placed on a mussel bed at IRINA II.

The benthic chamber module is a modified version of the free-falling chamber lander previously used to study benthic processes in the deep-sea (Wenzhöfer and Glud, 2002). This small benthic module consists of a circular chamber, an electronic cylinder, a water sampling system and a battery which can be operated by the ROV. The chamber encloses an area of ca. 285 cm^2 together with 15 cm of overlying bottom water. Two microelectrodes (1 H_2S and 1 H_2) mounted in the chamber lid monitor the concentration change in the enclosed water body while at preprogrammed time intervals 5 water samples (each 50 ml) were retrieved for later analyses of O_2, DIC and other elements.
All in situ measurements were performed at IRINA II along a gradient of different diffuse fluid flows (Tab. 2.6).

Microbial activity measurements
Rates of aerobic methane oxidation, chemoautotrophic production (CO_2 fixation) and bacterial growth (Thymidine incorporation) were measured on hot and diffuse fluid samples taken by the ROV (Niskin bottles mounted on the tool sledge and fluid sampling system) and CTD-Rosette (Tab. 2.6). Samples were processed directly after the recovery of the sampling devices or stored shortly at 4°C. After adding the tracer, all samples were incubated for 6 hours to 5 days at 4, 20, 60 and 80ºC, respectively. Activity was counted in degassed samples on a liquid scintillation counter. Rates of aerobic methane oxidation, CO_2 fixation and Thymidine incorporation will be calculated back home after determining the dry weight of the incubated biomass, the dissolved inorganic carbon concentration in the fluids and the tracer activity.
Additionally microbial rate measurements and incubation experiments were carried out on mussel gills, sediments and rock particles.

Preliminary results

All electrode signals showed a highly fluctuating signal over time when placed on a diffuse venting mussel bed. However, the maximum signal change varied within the same mussel field on a distance of a few decimeters. As an example temperature signals from 4 different sites from a mussel bed at IRINA II are shown in figure 2.36. The ambient temperature of the bottom water was 2.6ºC while the maximum temperature above a mussel bed with visually shimmering water was 6.5ºC. At occasions where warmer fluids pour out electrode signals of H_2S and H_2 increased while O_2 electrodes showed a distinct reduction. The exact concentration changes will be calculated back home, after analyzing the calibration solutions. All electrode signal readings, however, revealed a highly dynamic diffuse fluid venting with space and time.

Table 2.6: Overview of sampled stations for Profiler and benthic chamber deployments, aerobic methane oxidation (MOx), chemoautotrophic production (CO_2 fixation) and bacterial growth rates (Thymidine incorporation).

Station	Profiler	Chamber	MOx	CO_2 fixation	Thymidine incorporation
217 CTD			X	X	X
232 ROV	X (2 sites)				
242 CTD			X		
244 ROV	X				
249 ROV			X		
257 ROV			X	X	X
266 ROV	X (5 sites)		X		
270 CTD			X	X	X
272 ROV			X	X	X
277 ROV	X		X		
281 ROV		X	X		
283 ROV			X		

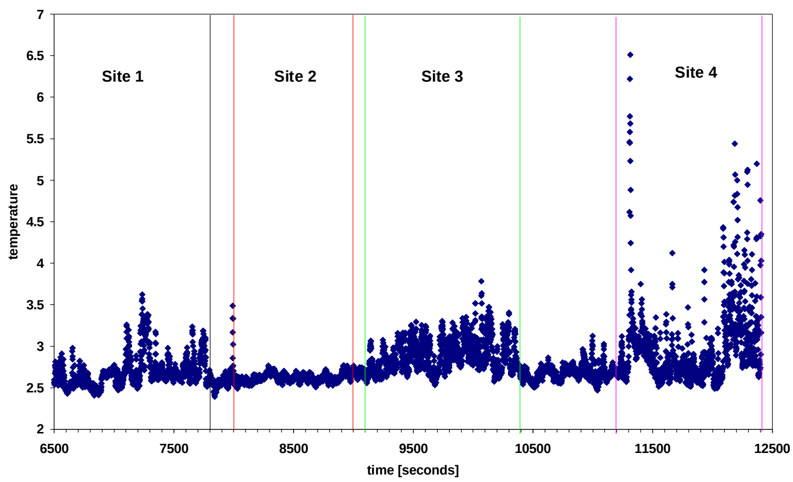


Fig. 2.36: In situ temperature at 4 different sites above a mussel field at IRINA II

2.4.11 Metagenomics

(A. Meyerdierks)

The aim of the participation in cruise M64/2 to the Logatchev hydrothermal field was the sampling of free living microbial communities at few characteristic hydrothermally influenced sites with high biomass for metagenome analyses. Preferred samples were sediments and microbial mats as several grams of a microbial mat or several hundred grams of sediment contain generally sufficient cells for a metagenome study. The samples should be taken in a systematic way, e.g. by the ROV, at well characterised sites.

Methods

Upon retrieval, each sample was divided in several parts. Sediment cores were sectioned into 1 cm or 2 cm slices prior to further treatment. Sediment samples were fixed with 60% ethanol in phosphate buffered saline (PBS) and 2-3% formaldehyde (FA)/PBS, respectively, for cell count determination, and community structure analysis. The major part of the sample was deep frozen for DNA extraction (-20°C) in the home laboratory. Small parts of rocks, crusts and sulfide samples were fixed with 1% FA/PBS for community structure analysis, and the other part of the sample was again deep frozen for DNA extraction. Microorganisms in fluid and plume samples were fixed with 1% FA/PBS or left untreated prior to a concentration of the cells on polycarbonate membrane filters (0.22 µm) or in a Sartobran 300 filter unit.

Samples and Preliminary Results

Samples were taken at different characteristic sites by the ROV, the CTD-rosette sampler, and the TV-grab, and included the following material:

1) Two sediment cores were taken in an area exhibiting a white surface, close to the “marker Anya” (263ROV, Fig. 2.37a and b). Temperature measurement by the environmental parameters group (2.3.5) revealed 52°C at a depth of about 25 cm below seafloor. The analysis of fluid, taken with Niskin bottles above this site, by the gas chromatography group (2.3.6), indicated elevated methane and hydrogen values. The sediment had a sulfidic smell.

   Additionally, a sediment core (20 cm) was taken close to the mussel bed found in the QUEST area at a side also covered with a white film (283ROV).
2) Other sediment samples (5 stations) were taken by the TV-grab (229GTV, 239GTV and 250GTV), or sampled, together with mussels, in a net taken at QUEST (281ROV). One sediment sample was collected 88 m south of IRINA II at a field, again covered with a white film, using a shovel with lid (252ROV, Fig. 2.37c). Here, the temperature on top of the sediment was about 27°C, determined by the environmental parameters group (2.3.5). Shimmering water was observed, and microscopic analysis by the microbiology group revealed a diverse microbial community supposedly associated with the white matrix (see chapter 2.3.8).

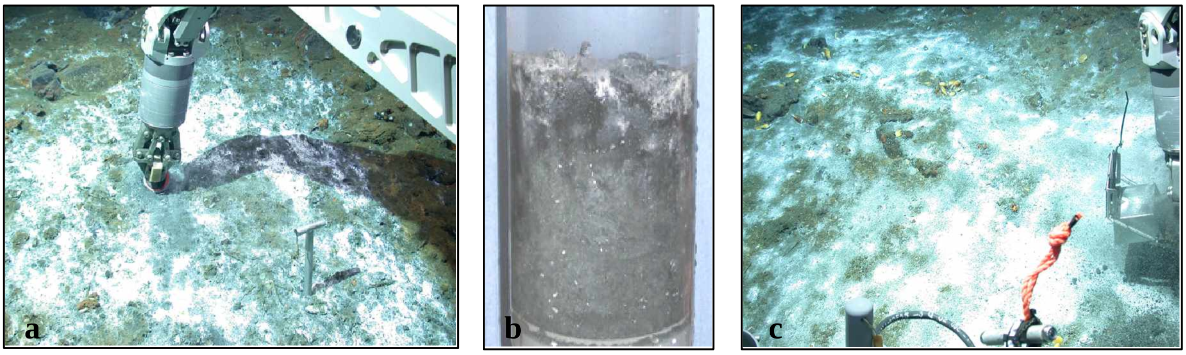


Fig. 2.37: a) Sampling of sediment cores with a push corer and temperature measurement at a field exhibiting a white surface layer close to the marker “Anya”. b) Sediment core before sectioning. c) Sampling of sediment with the shovel, south of IRINA II.

3) Sulfide structures, crust and rock samples (8 stations) were collected by the gripper of the ROV, and found in TV-grab contents and nets after mussel sampling.
4) Hydrothermal fluids were obtained using Niskin bottles (6 stations) or by participating in the fluid sampling system (chapter 2.3.7; 4 stations). Up to 6 l diffuse flow, sampled with Niskin bottles, and up to 1.4 l derived from the fluid sampling system were filtered for DNA extraction. Two samples were derived from a black smoker (261ROV).
5) Hydrothermal plume (2 stations) was collected using the CTD-rosette sampler. About 42 l of hydrothermal plume from 242CTD (water depth 2770 m) and about 79 l of plume sampled during 270CTD (water depth 2800) were filtered for DNA extraction.
6) Finally, mussel byssus and its associated microbial community (2 stations) was sampled by scraping byssus from mussel shells (232ROV, 281ROV).

2.4.12 Marine zoology

(J. Stecher)

Zoological samples were taken at 36 stations, representing 7 hydrothermal active sites and 8 non hydrothermal active locations (see Appendix 8).

The Smoker-Complex and Chimney Habitat

The highest biodiversity was observed at the IRINA II site. Three of the chimneys, characterised by shimmering water, were covered by *Bathymodiolus puteoserpents*, whereas only one was dominated by dense shrimps-aggregations of *Rimicaris* cf. *exoculatus* (Fig. 2.38). Additionally *Chorocaris* and *Mirocaris* were observed here. At this chimney the fluids showed maximum temperatures of 170°C (277ROV, 283ROV). Obviously those shrimps were clearly less abundant at the small separate smoker on the southern end of the smoker-complex. Here the fluids showed maximum temperature of 225°C (224ROV).

Concerning the distinct patched settlement of different species at chimneys one remarkable feature is worth while to mention. The northern chimney was clearly separated into two sections, the side, facing to active venting was covered by dense aggregation of *Bathymodiolus puteoserpents* whereas the far side was only overcast with clutches of gastropods (Fig. 2.39).

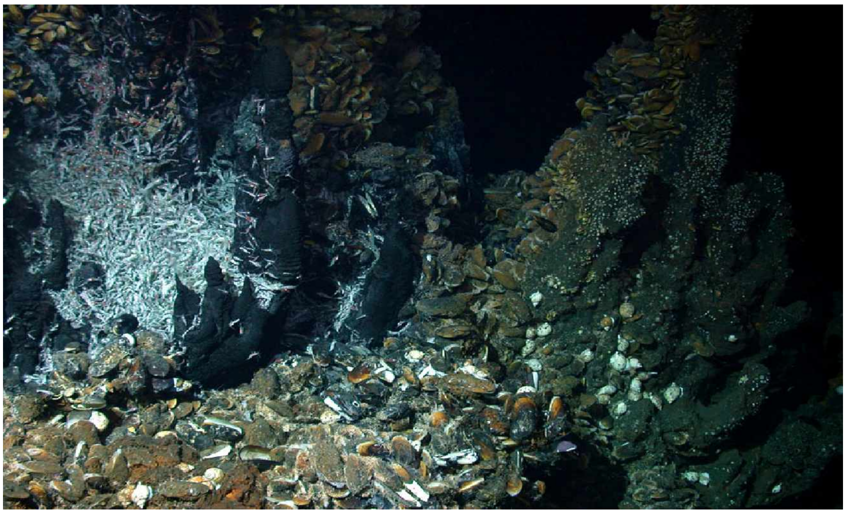


Fig. 2.38: The “Shrimps gap” and the northern chimney (right) at the E-wall of the smoker-complex at IRINA II.

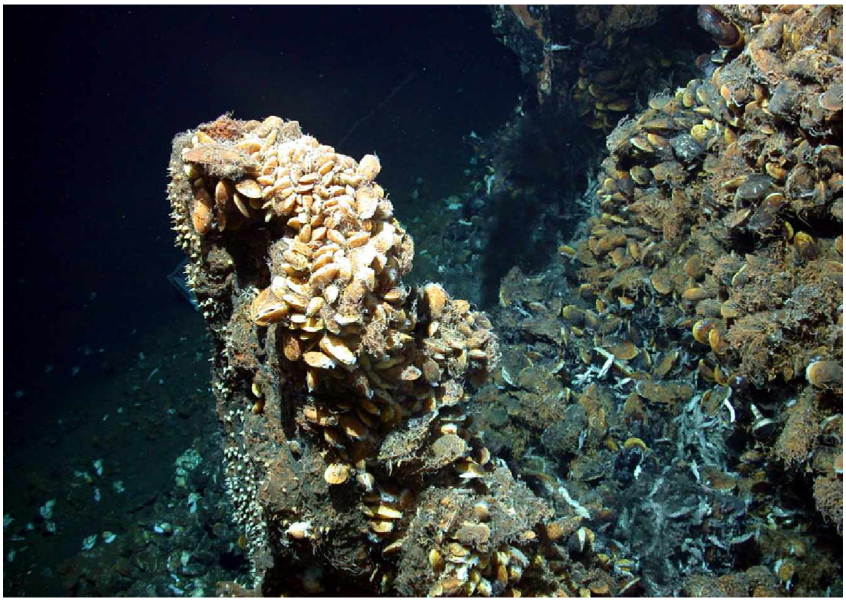


Fig. 2.39: Northern chimney of the smoker-complex of IRINA II: One half covered by *Bathymodiolus puteoserpentis* facing towards active venting, and the far side only spread by clutches of gastropods.

In the western forefront of the smoker-complex we found a well established *Bathymodiolus puteoserpentis*- association. Its length-width dimension was approximately 4m x 3m. In comparison with the mussel association of the smoker-complex this assemblage showed own characteristics based on its accompanied fauna. The brittle starfish *Ophioctenlla acies* and the snail *Phymorhynchus* cf. *moskalevi* were clearly more abundant in the forefront assemblage as thus at the smoker-complex itself. Dense aggregation of shrimps, comparable to those of the smoker-complex were absent. Specimen of *Alcinocaris* and *Mirocaris* were more frequently observed here. They inhabited the mussel field in slightly abundances between the mussels. Additionally chaetopterid,and terebellid annelidsas well as *Archinome* c.f. *rosacea* lived within the byssus of *Bathymodiolus puteoserpentis*. The vent endemic fish *Pachyara thermophilus* was only seen here in the IRINA II site of LHF I. Two more typical species, which belong to the accompanied fauna were the decapod crustaceans *Segonzacia mesatlantica* and the squat lobster *Munidopsis crassa*. Whereas *Segonzacia mesatlantica* was widely distributed at the smoker-complex as well on the mussel field, *Munidopsis crassa* was clearly patched. *Munidopsis crassa* was manly observed in inactive regions at the northeast side of the smoker-complex, where an extinct field of dead mussels was located. In contrast *Segonzacia mesatlantica* was observed in the vicinity of shimmering water with temperatures ranging from 3°C to 8°C.

The fauna became impoverished at site “A”. Live specimens were only seen at the single active chimney Barad-Dûr. Single shrimps inhabited the tip region of the chimney where black fluids emerged. Additionally see-anemones (actinaria) were sitting here. Right in the vicinity of emerging fluids specimens of the gastropod *Peltospira smaragdina* were sampled. Those snails were also found at black smokers of IRINA II. Furthermore the vent crab

Segonzacia mesatlantica was seen on flanges in 4-5m height as well at the bottom of the chimney. An expanded mussel field with live *Bathymodiolus* specimens, comparable to this of IRINA II was not found. At the bottom only several actinians were seen.

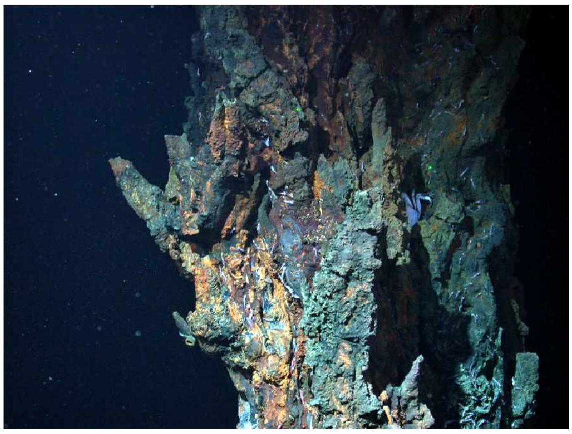
The "Smoking-Crater"-Habitat

With the exception of the "QUEST" site the biodiversity at the smoking craters was very low, comparable with that of the smoker Barad-Dûr. Only at the little smokers of the crater rim we found a vent fauna, consisting the shrimp *Rimicaris exoculata* and the bythograeid crab *Segonzacia mesatlantica*. In the periphery of the smokers actinaria were regularly observed as well as fishes of the family Bythitidae, mainly *Cataetyx* c.f. *laticeps*. The less abundances of crustaceans were documented at site "B", were we measured the highest fluid temperatures with 300°C up to 350°C. At "IRINA I", where the temperatures of fluids were significantly lower (177°C) shrimps and crabs were more abundant. On the other hand actinians were obviously more abundant in the vicinity of smokers at site "B" (Fig. 2.40).

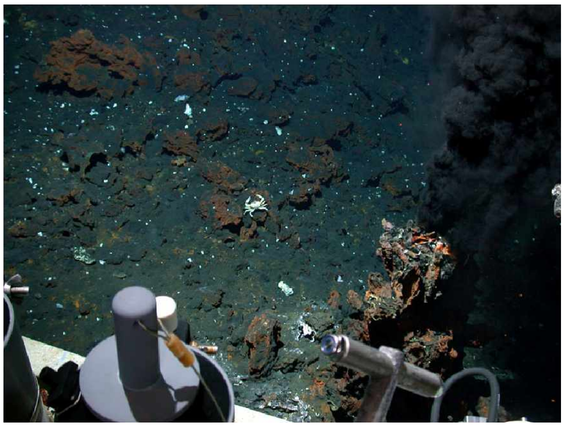
Live *Bathymodiolus puteoserpentis* mussels patches we found only in the "QUEST" site. One major patch, which was accurate investigated covered an area of 3m x 1m. These assemblage was characterised by juveniles mussels. They covered not only the float of at the temperature logger No3, which was left back on Meteor cruise M60/3, additionally we found them living among adults within the mussel field. This indicated that recruitment processes were successful during the last one and a half year. The accompanied fauna was similar with those of the "IRINA II" mussel field. Only *Phymorhynchus mosalevi* was less abundant at the "QUEST" site. The temperature of its diffuse fluids exceeds not over 12 °C. Therefore the diffuse fluids were slightly wormer than those of the mussel field of "IRINA II". Whereas the major mussel patch was approximately 3m away from the cater rim, several much smaller mussel patches (20-30cm in diameter) were located in the vicinity of little active smokers directly at the crater's rim. Comparable distribution patterns of patched mussels we also found in "IRINA I". Unfortunately the *Bathymodiolus*-population was dead, only some live specimens were noticed at the bottom of the active smokers at the crater's rim (Fig. 2.40).

a

b



c



d

Fig. 2.40: Assemblages at different habitats of LHF I: Shells of dead *Bathymodiolus* specimens of IRNIA I (a), shrimps, *Segonzacia mesatlantica*, and a single actinia at ANNA-LOUISE (b), Barad-Dûr of site “A” inhabited by shrimps and *Segonzacia mesatlantica* (c), little actinians and *Segonzacia mesatlantica* at site “B” (d).

Size-Frequency Distributions of Bathymodiolus puteoserpentis

During the transplantation experiment 6 nets were collected, laid beside the mussel field and recovered after a fixed time schedule (see 2.3.9 hydrothermal symbiosis). One more net was excluded for the experiment, because its recovery exceeded the time schedule. All *Bathymodiolus* specimens were shipboard measured and length were used for size-frequency analysis. Hence to the transplantation experiment 243 *Bathymodiolus puteoserpentis* specimens were measured. Additionally 61 specimens were retrieved from the same mussel field by two samples (232ROV-5, 266ROV-7), 5m away from the transplantation experiment spot, nearby the T-logger # 4 from the Meteor cruise M60/3 (Tab. 2.7, Fig. 2.41, Fig. 2.42). These samples are comparable with the station 38ROV-4, taken on M60/3.

Table 2.7: Samples used for size-frequency analysis of *Bathymodiolus* puteoserpentis, retrieved from the mussel-field IRINA II.

Station	total number of *Bathymodiolus puteoserpentis*	Location
244 ROV# 6, Net No 6	54	"IRINA II" mussel-site 2 (transplantation-experiment), northern end of the field
244 ROV# 7, Net No 4	37	
244 ROV# 8, Net No 2	34	
244 ROV# 9, Net No 8	38	
244 ROV#10, Net No 10	22	
252 ROV# 6, Net No 9	66	
232 ROV# 5	18	"IRINA II", mussel-site 1, southern end of the field
266 ROV# 7	43	
Total number	304	

Additionally four more nets of *Bathymodiolus* were taken. One at the E-wall of the smoker-complex (277ROV-6), and three at the "QUEST"-site (263ROV-6, 281ROV-3, 285ROV-5). Only those animals (126 individuals) were shipboard measured, which were chosen for molecular biological studies. Detailed statistics will follow in the institute's lab.

The size-frequency distribution within the mussel field of "IRINA II" showed clearly one broader peak of mussels from 6cm up to 11 cm length. Within the population at the northern end of the field one more little peak is obviously. It consists of young mussels which did not exceed a length of 4cm. These distribution patterns indicated, that recruitment processes were successfully in the past. Additionally the mortality seemed to be relative low, because only one slightly peak of dead shells was noticed.

Nevertheless it seemed to be that recently recruitment processes were severely limited over the last year, since the T-logger # 4, which was placed during Meteor cruise M60/3, was not overgrown by any Bathymodiolus specimens. For comparison, the growth of young mussels at T-logger # 3 of the "QUEST" site indicated that recently recruitment processes are still active.

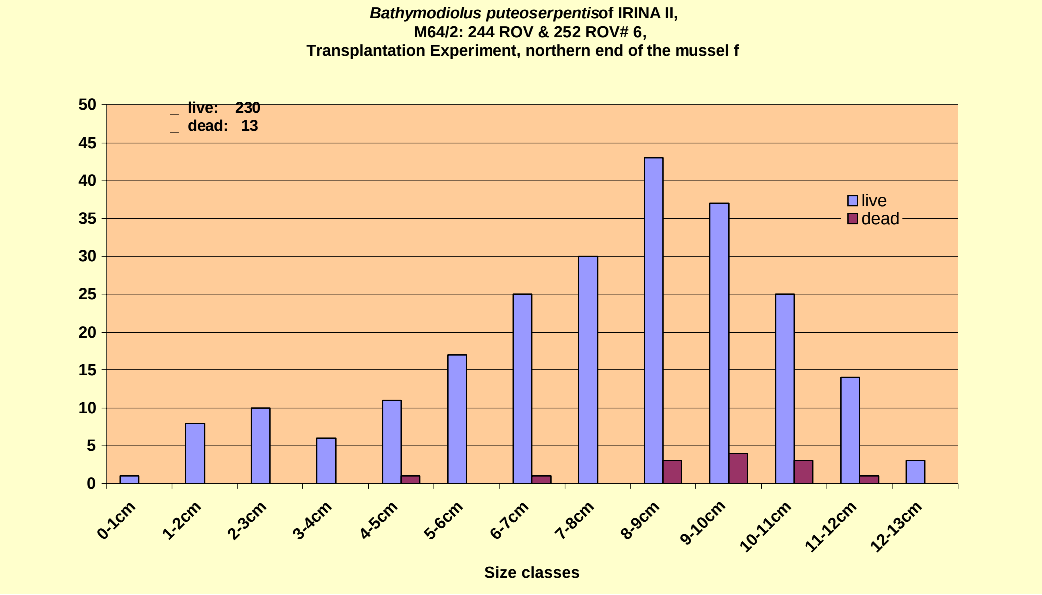


Fig. 2.41: Size-frequency distribution of *Bathymodiolus puteoserpentis* at the northern end of the mussel field in IRINA II during Meteor cruise M64/2.

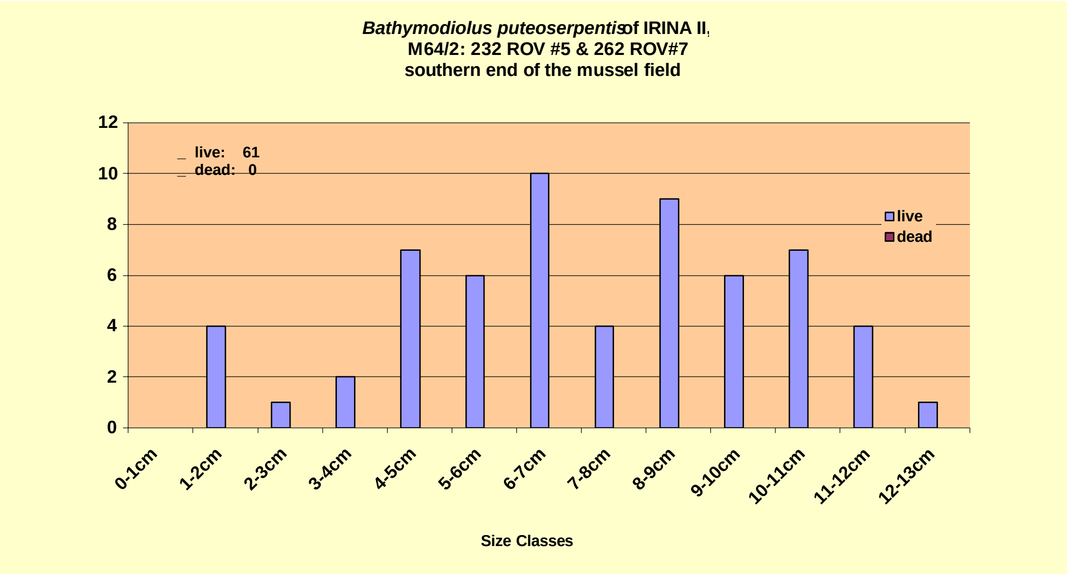


Fig. 2.42: Size-frequency distribution of *Bathymodiolus puteoserpentis* at the southern end of the mussel field in IRINA II during Meteor cruise M64/2

"ANYA GARDEN"

Kuhn et al. (2004) described the disagreement between the positioning of "ANYA´S GARDEN" given by Gebruk et al. (2000) and their results during the HYDROMAR I cruise of M60/3. It can be stated as save that the maker "ANYA" is located 30 m northwest of the "IRINA II" site. Starting at this maker, and going the slope upwards to east, we found during our station 263ROV several structures like *Bathymodiolus* patches with shimmering water, microbial mats and several outcrops, which were in agreement with the Gebruk´s description of "ANYA´s GARDEN" (Fig. 2.43). Nevertheless live vesicomyid and thyasirid clams we did not noticed here. Vesicomyid shells we retrieved only at station 258GTV, approx. 20m N of "IRINA II" (see chapter 2.3.1; Fig. 2.2). Because during Meteor cruise M60/3 shells of vesicomyid and thyasirid clams were documented nearby this slope, it seemed to be that changes happened, which we could not interpret at this state of knowledge. Instead of this we flew at the slope over large mussel fields consisting of dead *Bathymodiolus* shells, which were inhabited by the snail *Phymorhynchus moskalevi* as well by the squat lobster *Munidopsis crassa*. Here we observed the most *Munidopsis* at LHF-1 especially on outcrops. So we are sure, that the position of "ANYA´s GARDEN" given by Gebruk et al. (2000) is incorrect. "ANYA´s GARDEN" is located at a slope northwest of the "IRINA II" site and hence to the ecofaunistical results it can be regarded as the north-western branch of "IRINA II".

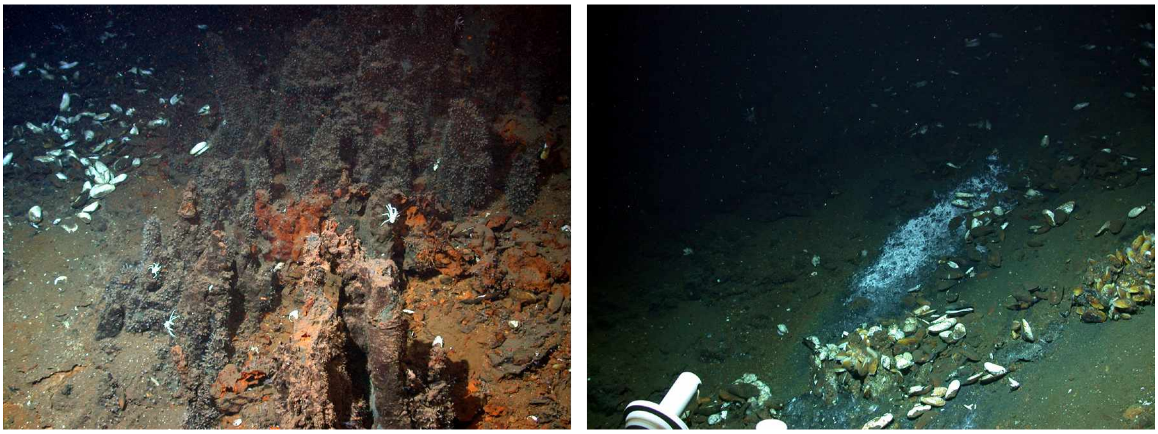


Fig. 2.43: Slope northwest of the "IRINA II" site, possible "ANYA`s GARDEN". Left: Dying mussel population with single outcrop settled by *Munidopsis crassa*. Right: Microbial mats with live *Bathymodiolus puteoserpentis* patches.

2.5 Weather conditions

(W. T. Ochsenhirt)

In the afternoon of May 06 2005 FS METEOR left the port of Fortaleza for leg M64/2. The weather to the beginning of the voyage was dominated by a ridge of a subtropical high in the Southwest Atlantic and METEOR encountered south-easterly trade winds of 4 to 5 Bft.
One day later, in the early morning, near 01° South a first larger cloud belt associated with showers was passed.
On the next day METEOR crossed the ITCZ (**I**nter **T**ropical **C**onvergence **Z**one) accompanied by frequent and heavy showers and gusty winds up to Bft 6 from variable directions. The normal wind direction outside of the tropical shower area was southeast at first and became east to northeast later. Wind speeds without disturbances ranged from 4 to 5 Bft.
The northern edge of the ITCZ extended from 08°N 15°W to 07°N 38°W during this period.
METEOR arrived in the area of investigation near 14,8°N 45,0°W on May 10 in the afternoon. This region was still under the influence of the tradewindsystem and steady easterly winds of 4 to 6 Bft predominated with most frequent wind speed of Bft 5.
On some days the wind decreased to Bft 3. During the whole time of station work the weather was mostly fair with only few periods of light precipitation.
The swell came from easterly directions with height of 1.5 to 2 m, in cases of two swells from different origin up to 3m.
In the evening of May 29 METEOR left the working area with easterly course to Dakar. On the transit the centre of the subtropical high was just south of the Azores. Easterly winds of about 5 Bft backed to Northeast and North and decreased gradually.
In the forenoon of June 04 the voyage ended in the port of Dakar.

2.6 Acknowledgments

We would like to thank Captain Kull and his crew for their professionality and exceptionally hard work during the cruise, which contributed to the success of the expedtion. Furthermore, we acknowledge the professional patronage of the German Ministry of Foreign Affairs as well as Captain Berkenheger at the Leitstelle Meteor.
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