

The *R/V METEOR* Cruise M 60/3 (HYDROMAR I): Mineralogical, geochemical, and biological investigations of hydrothermal systems on the Mid-Atlantic Ridge between 14°45'N and 15°05'N

### **Narrative of the cruise**

The *R/V METEOR* cruise M60/3 took place from January 13 through February 14, 2004 from/to Fort de France (Martinique). On January 13 and 14 the scientific equipment was loaded onboard *R/V METEOR*. The main mapping and sampling tool, the ROV (Remotely Operated Vehicle) QUEST provided by the University of Bremen was built up and tested. Furthermore a harbour test of a new deployment frame was successfully carried out. On January 13 a reception was held onboard to which captain M. Kull, the *METEOR* Leitstelle and the chief scientist invited persons from port and local administration, scientists and the local news media. *R/V METEOR* left Fort de France on January 16 at 21:30 LT with 30 scientists from 4 countries onboard. The 1.5 days departure delay was due to the failure of an acoustic array which was basically necessary for underwater navigation of the ROV. We had to wait for a spare one which was sent from France.

The main working area of M60/3 is situated in international waters on the Mid-Atlantic Ridge (MAR) between 14°30'N and 15°05'N and 44°50'W and 45°10'W. Water depths in this area is between 1600 m and > 4000 m. *R/V METEOR* reached this area after a 4 days transit on January 20 at 20:00 LT. From January 20 – 26 the scientific work concentrated on the Logatchev hydrothermal field and its surroundings. This hydrothermal field lies on a small plateau on the eastern flank of the inner rift valley in 2900 m to 3060 m water depth. It is characterized by sites of active, high-T fluid emanation and sulfide precipitation as well as by inactive sites (see below). Bathymetric mapping with the HYDROSWEEP echosounding system mounted on the hull of *R/V METEOR*, ROV stations, TV-sled tracks, TV-grab sampling and water column measurements and sampling with CTD/rosette were carried out. On the evening of January 26 the Russian *R/V PROFESSOR LOGATCHEV* arrived as planned in the working area. After a visit of the German captain and some scientists on the *R/V PROFESSOR LOGATCHEV*, *R/V METEOR* moved to the second working area which is situated about 10 nm to the north. From January 27 – 29 we worked in an area close to a non-transform offset of the MAR carrying out bathymetric mapping, TV-sled tracks, TV-grab stations and water column measurements and sampling. Due to high swell the ROV QUEST could not be deployed in this area. The main scientific objective in working area II was to find sites of hydrothermal activity as well as to characterize the seafloor morphology and petrology of this tectonically active region. In the early morning of January 30 *R/V METEOR* returned to the Logatchev area at 14°45'N. Due to the fact that we already lost 1.5 days waiting in Fort de France and due to changing sea state conditions during which the ROV QUEST could not always be deployed we decided to use every time in the Logatchev field and not to go back to the northern working areas as previously planned. The scientific work

was continued from January 30 to February 9 in the Logatchev hydrothermal field and its surroundings.

In total 59 stations and 12 bathymetric profiles with a total length of 370 nm were carried out during M60/3. The ROV QUEST could be deployed during 9 stations. *R/V METEOR* returned to Fort de France on February 13, 2004. Unloading of the scientific equipment was finished on February 14, the day the M60/3 cruise finished.

### **Preliminary scientific results of cruise M60/3**

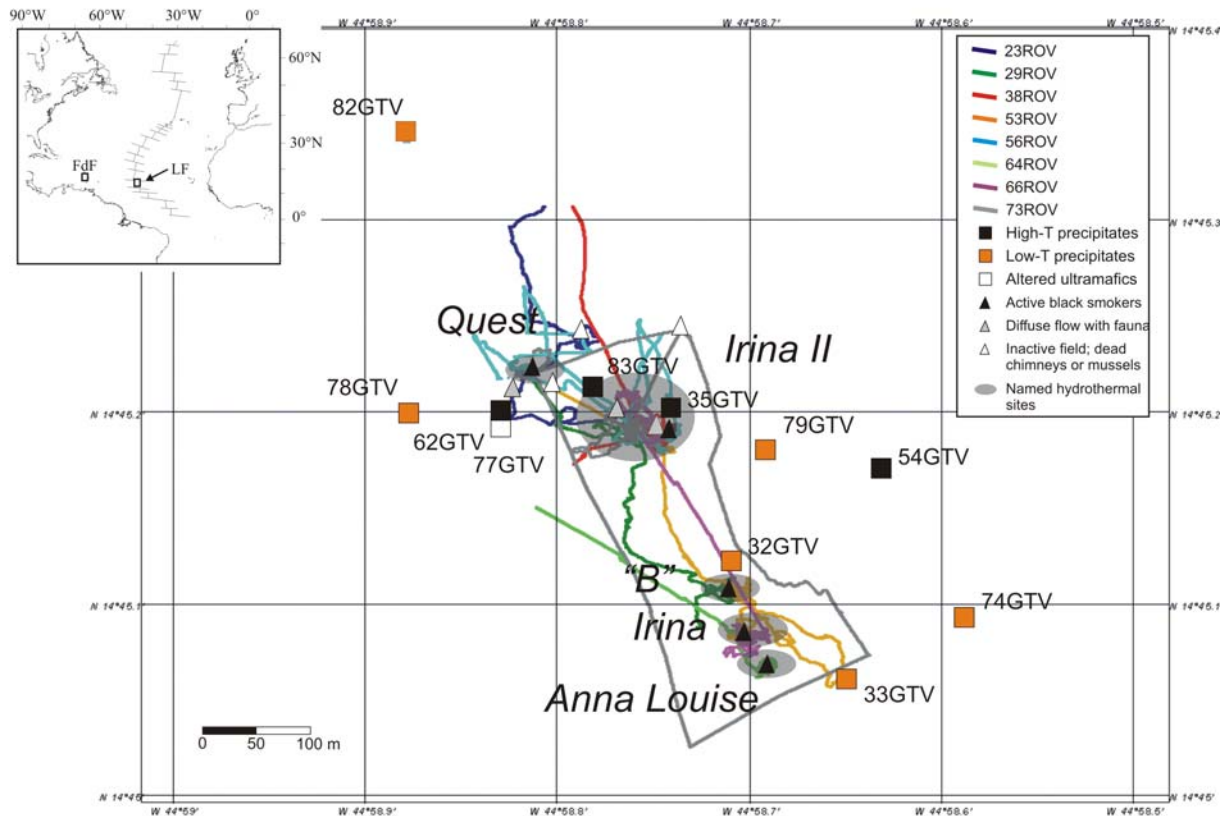
Extensive bathymetric and video mapping during the M60/3 cruise revealed three factors which appear to control the location of the Logatchev hydrothermal field: (1) cross-cutting faults, (2) young basaltic volcanism, and (3) slump structures forming probably thick talus deposits. Furthermore a new, but inactive hydrothermal field (Logatchev-4 at 14°42.38'N / 44°54.50'W) was discovered during M60/3. Our investigations show that hydrothermal circulation may have taken place throughout talus material and has altered peridotite debris. The heat is probably supplied from magmatic pools associated with basaltic melts localized underneath the adjacent rift valley and/or off-axis volcanic structures. Heat could also be provided by localized intrusion of melts (probably focussed along faults) into the peridotite. To date, a situation similar to that of the Logatchev area has only been found at 14°54'N / 44°55'W. The similarity of the local geological setting to that of the Logatchev area indicates that this region has hydrothermal potential.

Mapping and sampling with ROV QUEST and the TV-grab revealed that the Logatchev-1 hydrothermal field is larger than previously described. It extends at least 800 m in a NW-SE and probably more than 400 m in a SW-NE direction (Fig. 1). Two main areas of high-temperature (high-T) hydrothermal activity make up the central part of the field: an area of at least three „smoking craters“ (ANNA-LOUISE, IRINA and SITE „B“) and the large mound of IRINA II with black smoker chimneys at its top as well as the newly discovered QUEST smoking crater (Fig. 1). The smoking craters consist of a rampart-like rim that is 1-2 m high and a 2-3 m deep central depression. Dense mussel beds were absent in these environments. However, abundant microbial mats were seen at locations where the black smoke emanating from the sea floor was in regular contact with the surfaces. IRINA II consists of a mound (basal diameter of about 60 m) with steep slopes rising about 15 m above the surrounding seafloor. Four vertical chimneys a couple of meters high mark the top of the mound. In contrast to the smoking craters they are densely overgrown with and surrounded by mussels. QUEST is a newly discovered high-T, black smoke venting site situated about 130 m WNW (in 330° direction) of the active chimneys of IRINA II (Fig. 1).

Hydrothermal fluids (both high- and low-T) display similar patterns of their chemical composition suggesting the presence of a single fluid type. The emanating high-T fluids (sampled at black smokers) are strongly reducing have high methane and hydrogen contents

and low sulfide concentrations. Iron is the dominant dissolved and particle-bound metal. Methane and hydrogen but also precipitated metal sulfides are considered to be the major energy sources for the development of life in the Logatchev field.

Host rocks of the Logatchev field sampled by TV-grab and ROV were mainly serpentinized peridotites while basalts and gabbros (sometimes in magmatic contact with peridotite) occurred subordinately. Remarkable were samples of coarse grained websterites, orthopyroxenites and Opx-rich, pegmatoid norites, which were interpreted as magmatic cumulates from the crust/mantle transition zone. A large variety of hydrothermal precipitates were recovered including massive chalcopyrite chimneys, massive pyrite crusts, silicified breccias, abundant secondary Cu-sulfides (including native copper), red jaspers, abundant Fe-Mn-oxyhydroxides as well as atacamite and Mn-oxides. The occurrence of massive sulfides as crusts along the flanks of the deposit suggests that they might only be a thin veneer directly at or below the seafloor.



*Fig. 1: Detailed map of the Logatchev hydrothermal field drawn according to ROV and TV grab stations. Sites Anna Louise, Irina and „B“ are smoking craters, Irina II is a hydrothermal mound with an active black smoker complex on top, Quest is a newly discovered black smoke venting area similar to smoking craters. The boundary of the field previous to the cruise was between 14°45.05'N and 14°45.25'N as well as between 44°58.65'W and 44°58.80'W and is now extended. The small map shows the Logatchev field (LF) on the MAR and the starting and end port of M60/3 (Fort de France = FdF).*