



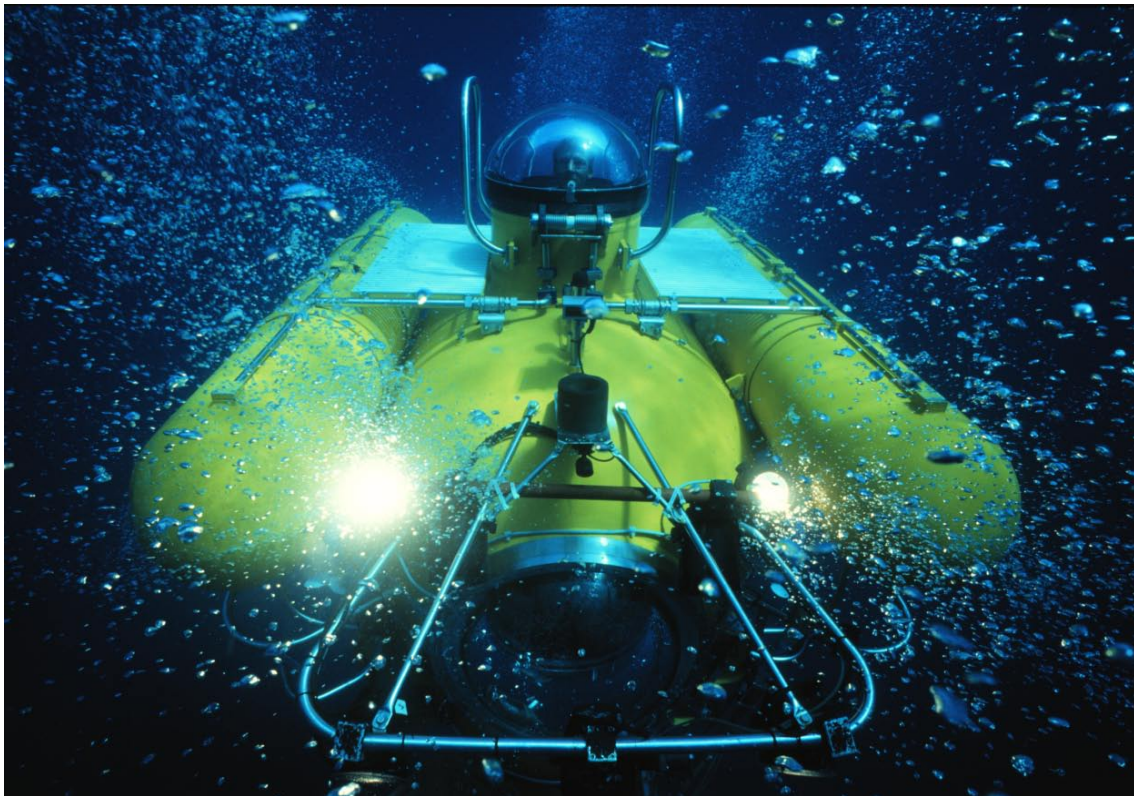
**IFM-GEOMAR**

Leibniz-Institut für Meereswissenschaften  
an der Universität Kiel

# **IFM-GEOMAR Report 2006**

**From the Seafloor to the Atmosphere**

**- Marine Sciences at IFM-GEOMAR Kiel -**



## **IFM-GEOMAR Report 2006**

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Cover photo: Submersible JAGO diving in the Indian Ocean (Jürgen Schauer, IFM-GEOMAR).  
Inner cover: s.a.

## Preface

Three years after the merger of IfM and GEOMAR, the decision to merge the two institutes has proven to be a strategic and scientific success. The reputation and profile of IFM-GEOMAR has increased tremendously and has established Kiel as a major centre of marine sciences in Germany and Europe. One indicator of the success of the new institute is the so-called "DFG-ranking", published by the German Research Foundation (DFG). For the period 2002-2004, IFM-GEOMAR was by far the most successful non-university research institute in terms of DFG-project funding. An important milestone for the strategic development of the institute is represented by the positive funding decision for the excellence cluster "The Future Ocean". In this project, IFM-GEOMAR cooperates with six different faculties of the University of Kiel, the Kiel Institute for the World Economy and the Muthesius College of Fine Arts. The cluster, which has a budget of 36 Mio. Euros for a 5-year period, will cover a wide range of topics including chances and risks of the future ocean such as ocean acidification, marine resources and the consequences of climate change. Four of the 14 new junior research groups will be located at IFM-GEOMAR. The generous funding of "Future Ocean" will enable the creation of about 100 new high-profile jobs in Kiel.

Progress has also been made in the area of research infrastructure. The new Technology and Logistics Centre (TLC) of IFM-GEOMAR opened as the new central basis for the development and maintenance of instrumentation, as well as for the technical preparation of seagoing expeditions. The first large device that found its new home in the TLC is the submersible "Jago" the only manned research submersible in Germany. "Jago" was acquired by IFM-GEOMAR in January and provides an attractive platform for multi-disciplinary marine research. In addition, the construction of a Remotely Operated Vehicle (ROV) with a diving capability of 6000m started recently. The ROV will be available for the marine research community in late 2007. Other large-scale facilities such as offshore mesocosms and an Autonomous



Underwater Vehicle (AUV) are also being developed.

On the scientific side, plans for a new collaborative research centre (SFB) on "Climate-Biogeochemistry Interactions in the Tropical Oceans" are well developed. The review of the pre-proposal was very encouraging and the on-site review and the funding decision are expected for 2007.

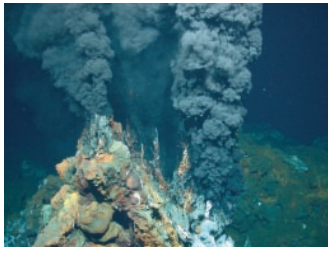
Overall, the developments in marine sciences in Kiel and particularly at IFM-GEOMAR have been extremely positive during the past year. Due to successful proposals and generous additional support by the State of Schleswig-Holstein, the institute now enjoys a solid foundation with which it can strive for continued excellence in marine research. We are confident that we can further strengthen our leadership position over the next few years in order to establish IFM-GEOMAR as a "National Centre for Marine Sciences" with high international visibility.

This report provides a short overview of the major developments and scientific highlights during the past year. Detailed statistical information can be found in the appendices. I hope that you will enjoy reading the "IFM-GEOMAR Highlights 2006".

Kiel, October 2007

A handwritten signature in black ink, which appears to be "P. Herzig". The signature is stylized and written in a cursive-like font.

**Prof. Peter M. Herzig**  
**Director**



A black smoker in the Turtle Pits hydrothermal field. (© MARUM).

## Investigations of seafloor hydrothermal systems

A major research focus within Research Division 4 is the investigation of seafloor hydrothermal systems in various tectonic settings such as arcs, seamounts and mid ocean ridges. Within the frame of the 6-years Priority Programme 1144 of the German Research Foundation (DFG) "From Mantle to Ocean: Energy, Material and Life cycles at Spreading axes" we focused our studies on mid ocean ridge systems in the Atlantic. Other recent and future areas of interest include the Aeolian Arc in the Tyrrhenian Sea (Mediterranean) and the Woodlark rift system northeast of Australia.

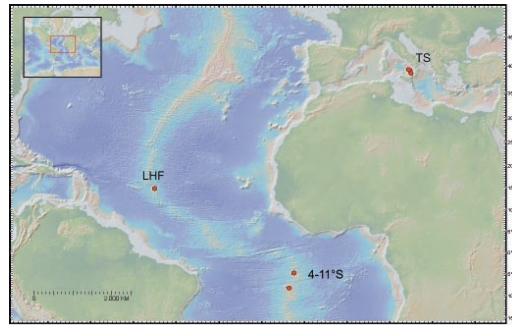


Fig. 1: Location of selected hydrothermal fields currently studied by RD4 (LHF = Logatchev field; TS = Tyrrhenian Sea)

The principal scientific purpose of participants from the research unit Magmatic and Hydrothermal Systems (MuHS) is to elucidate the interrelationship of geological and hydrothermal processes in high- and low-temperature hydrothermal system associated with felsic, mafic and ultramafic host rocks. In the following we will summarize our most recent research:

**Logatchev Hydrothermal Field at 15°N**  
Logatchev is situated on a small plateau within the rift valley of the slow-spreading Mid-Atlantic Ridge (MAR) at 14°45'N. This part of the MAR is dominated by ultramafics (mantle rocks) with subordinate basaltic material – largely in the rift valley. While mantle rocks cover a substantial part of the ocean floor along ultra-slow and slow-spreading ridges their influence on ocean chemistry and hydrothermal activity is not well constrained. The Logatchev field is one of only a few ultramafic-hosted hydrothermal systems found so far.

Extensive bathymetric and video mapping during the HYDROMAR I, II, and IV cruises revealed three factors which

appear to control the location of the Logatchev hydrothermal fields: (1) cross-cutting faults, (2) young basaltic magmatism, and (3) slump structures. Our investigations indicate that hydrothermal circulation takes place through ultramafic and mafic talus material and is most likely related to large slumps. The heat driving hydrothermal convection is probably supplied from magmatic pools associated with intrusions underneath the adjacent rift valley and/or off-axis volcanic structures.

Differences in the morphology of the vent structures and their geochemical and mineralogical composition are related to the different outflow temperatures as a consequence of sub-seafloor mixing and cooling processes and subsequent mineral precipitation. Geochemical and mineralogical investigations of hydrothermal precipitates indicate a three-stage process of mineral formation: 1. precipitation from high-T (ca. 350°C) fluids forms primary Cu-sulfides; 2. cooling of these fluids or reaction of primary Cu-sulfides with medium-T fluids ( $\leq 250^\circ\text{C}$ ) results in Au-rich, and Cu-rich secondary sulfides; 3. reaction of sulfides with cold seawater forms supergene Cu-sulfides. Stages 1 and 2 indicate that the chemical composition of emanating fluids and related precipitates depends on fluid-sulfide reactions in the shallow subseafloor. Osmium isotopes and trace element analyses of sulfides and altered rocks indicate that both mafic and ultramafic host rocks contribute to the geochemical inventory of this hydrothermal field which in turn has major implications for the fluid chemistry and vent fauna. Trace element geochemistry also shows indications for melt rock interaction in this area. Recent drilling has shown that the amount of mafic material at Logatchev is higher than previously thought, and that minor sulfides occur down to 10 m depth, however, it is not yet clear if these are in-situ or transported sulfides. Clay-rich alteration is extremely widespread and their investigation will help to understand the processes taking place in the sub-seafloor.

### New Hydrothermal Fields between 4° and 11°S on the MAR.

Active hydrothermalism along the southern MAR was, until the start of SPP1144, unknown. As was the hydrothermal input of the southern MAR to the global heat and mass transfer to the ocean. The priority programme has distinctly changed this situation. Since its inception, three hydrothermal areas have been identified and sampled. At 4°48'S, in 3000 m water depth, four closely-spaced vent fields (the high-temperature sites "Turtle Pits", "Red Lion" and "Comfortless Cove" and the diffuse low-temperature "Wide-awake" site) occur along a flat (total relief 50 m), volcanically and tectonically active 2 km section of the ridge. Two of these systems, "Turtle Pits" and "Comfortless Cove", seem to be related to recent magmatic activity. The location of individual vent sites seems to be tectonically controlled as indicated in high-resolution bathymetry. Detailed investigations of the "Turtle Pits" sulfides indicate that a dramatic change in the redox-chemistry of the fluids, from oxidizing to reducing conditions, must have occurred in the past (Fig. 2). If these changes, that are distinct from those at other vent sites, are related to the magmatic activity needs to be confirmed.

During our first cruise at the southern Mid-Atlantic Ridge in 2004 we found strong evidence for hydrothermal activity in 2900 m water depth at 8°18'S although black smokers were not directly observed. In 2006, we discovered the active vent site (Nibelungen field) using Eh<sup>-</sup> and photo-mapping capabilities of the autonomous underwater vehicle "ABE" from Woods Hole Oceanographic Institution. ROV dives revealed active and inactive vent sites along a steep slope at 2905 m water depth. The active vent site resembles the ones found in the ultramafic-hosted Logatchev hydrothermal field at 15°N. Mineralogical studies of breccia samples from the crater wall of "Drachenschlund" revealed serpentinites as one of the main components, although the immediate surrounding is largely composed of pillow basalt.

Further to the south, at 9°33'S, hydrothermal activity is located at 1500 m water depth and is associated with fresh pillow lavas, sheet flows, lava

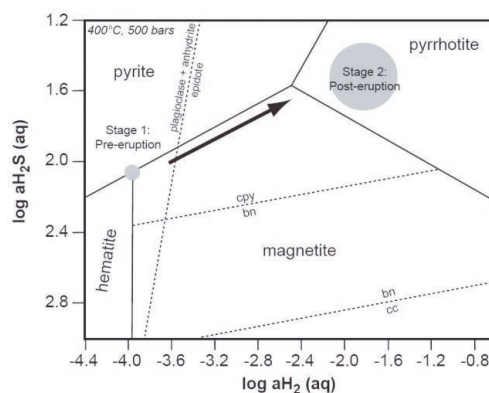
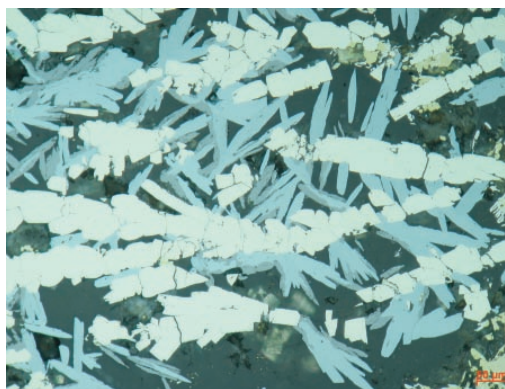


Fig. 2: a) (top) Primary sulfide intergrowth with hematite-magnetite and pyrite from Turtle Pits. b) (bottom) Activity diagram showing possible evolution of the hydrothermal systems with time.

lakes, and collapse structures. This is very unusual, since these volcanic features are commonly found on fast spreading ridges, not slow spreading ridges. This seems to indicate enhanced magma supply to the spreading segment. Low-temperature, diffuse hydrothermal activity is abundant in the area as are large extinct hydrothermal mounds suggesting more vigorous hydrothermalism in the past. All sites are located east of a large NNW trending escarpment flanking horst and graben structures (Fig. 3). Both high- and low-temperature venting on the southern Mid-Atlantic ridge appear to be strongly controlled temporally and spatially by tectonics and recent volcanism.

### Tyrrhenian Sea

Another research topic is the formation of hydrothermal systems in island arc settings. Land-based geology indicates that a large number of economic massive sulfide deposits, the equivalent of modern black smoker systems, formed in a shallow water (< 1000 m) calc-alkalic arc environment. These deposits are extremely valuable because boiling of the hydrothermal fluids enriches the precious metals Au and Ag in these deposits. In many respects, deposition of metals in the shallow water environment can be compared to the formation of epithermal deposits in subaerial

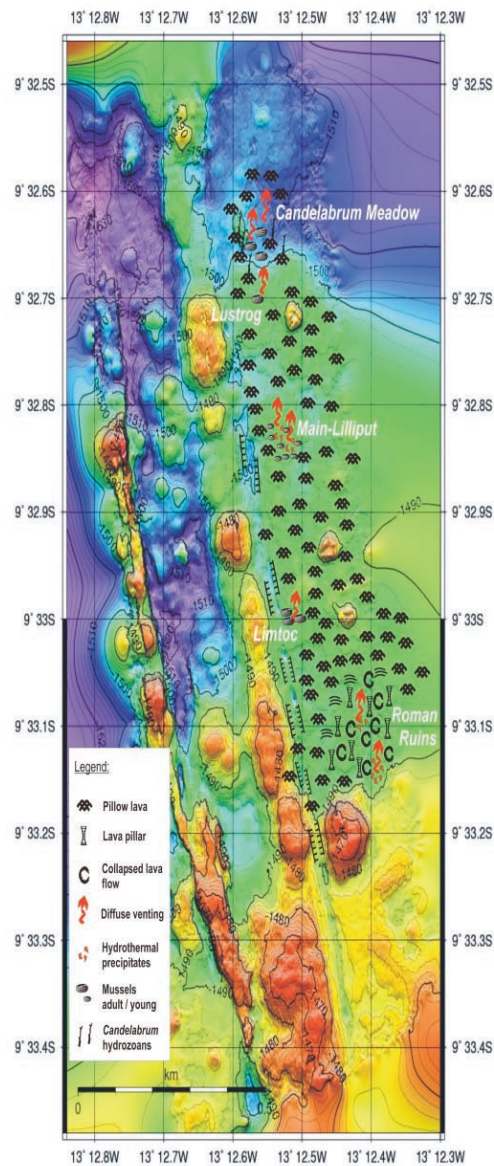


Fig. 3: High-resolution (AUV-mounted) bathymetry of the Liliput site showing tectonic control of individual vent sites.

volcanic arcs on land suggesting that there is a continuum between submarine massive sulfide and subaerial epithermal deposits. This working hypothesis is in contrast to common knowledge indicating a distinction of these deposit types. The southeastern Tyrrhenian Sea represents a prime locality to study the formation of shallow seafloor deposits in such a calc-alkalic arc setting.

Currently three different sites have been recognized in the area, however, geological information (e.g. distribution of vent sites, tectonic, and alteration of the host rocks) is lacking. Detailed investigations on these four sites will provide an ideal basis for the development and testing of new genetic models explaining the formation of shallow water, precious metal-rich marine massive sulfide deposits. In an initial stage a ROV-based expedition was mounted in 2006 to map the geology and the distribution of individual vent fields and to find suitable targets for a drilling cruise in August 2007, which will address the formation of these deposits. Recent hydrothermal activity was observed at Palinuro Seamount, a site previously thought to be inactive (Fig. 4). Some of the hydrothermal activity at the Panarea vulcano is clearly related to explosion craters in shallow water indicating a close hydrothermal/magmatic link (Fig 4).

**Klas Lackschewitz and Sven Petersen**



Fig. 4: Top: Active fluid flow indicated by Vestimentiferan tubeworms at Palinuro Seamount. Bottom: Active gas discharge associated with sulfide deposition and bacterial mats at Panarea.