Summary of the RV Meteor cruise M62/5 (7.11. – 29.12.04)

The process of plate accretion at mid-ocean ridges, once thought to occur in a relatively simple magmatic system, has been shown in recent years to possess many different facets (e.g. (Cannat 1996; Escartín and Lin 1998; Jokat, Ritzmann et al. 2003; Michael, Langmuir et al. 2003). This is particularly true at lower spreading rates, where upwelling of mantle beneath the ridges as a response to plate separation either becomes non-adiabatic or degenerates to 3D flow (Parmentier and Morgan 1990). In both cases the amount of magma supplied to some or all parts of the ridge decreases and tectonic movement takes up more of the plate spreading motion. It is exactly the interplay of magmatic and tectonic processes on the spreading axes which govern such features as their topography, their seismic activity, the location of hydrothermal vents and the extent to which the crust exchanges chemical components with the ocean. This interplay therefore has important implications for the hydrothermal marine biosphere and global chemical budgets.
The increasing heterogeneity in the accretion process with decreasing spreading rate means that we need to examine a far greater length of slow spreading ridges if we are to make meaningful or statistically significant statements about the role of these slow-spreaing ridges in global lithospheric and oceanographic processes. Unfortunately, it is exactly these slow-spreading ridges which, up to present, had been the least studied (only 10% of their total length have, for example, been surveyed for hydrothermal activity alone, (Baker and German 2004)).

To try and improve this situation for one of the least-known areas of the global spreading system, the Southern Mid-Atlantic Ridge, the German spreading axis community (DeRidge) via the German Science Foundation (DFG) has initiated a 6 year multi-cruise study of a 600 km-long stretch of spreading axis near the Island of Ascension between 7-11°S. The first cruise in this series (M62/5 of the German research vessel „Meteor“), aimed at gathering basic data about the area, returned to port at the end of 2004 with insights into the volcanology and tectonics of the Southern Atlantic Ridge system and the first clear signs of hydrothermal activity south of the equator in the Atlantic.

Fundamental questions which the DeRidge study aims to answer include:

- What is the characteristic spacing between hydrothermal vents in the Atlantic?
- How much seawater circulates through the crust each year?
- Is the fauna associated with hydrothermal systems in the South Atlantic more akin to fauna in the North Atlantic or Indian Oceans? Does the major equatorial Atlantic fracture zone complex act as an efficient barrier to hydrothermal species migration?
- Are intensity of tectonic fracturing and intensity of hydrothermalism significantly correlated?
- What do the boundaries between regions of tectonic spreading and regions of magmatic spreading within a segment look like?
- How far do lava flows travel on the Mid-Atlantic Ridge?

The essential groundwork for and a major component of such a project can only be accomplished with detailed side-scan and water-column information over the whole study area. TOBI, the British deep-towed sidescan sonar system for imagery the ocean floor (http://www.soc.soton.ac.uk/OED/index.php?page=tb), was deployed for the first time in this part of the Mid-Atlantic Ridge (MAR). Its ability to collect temperature and nephelometry coincident with the side-scan coverage provided basic information about the nature and activity of the seafloor.

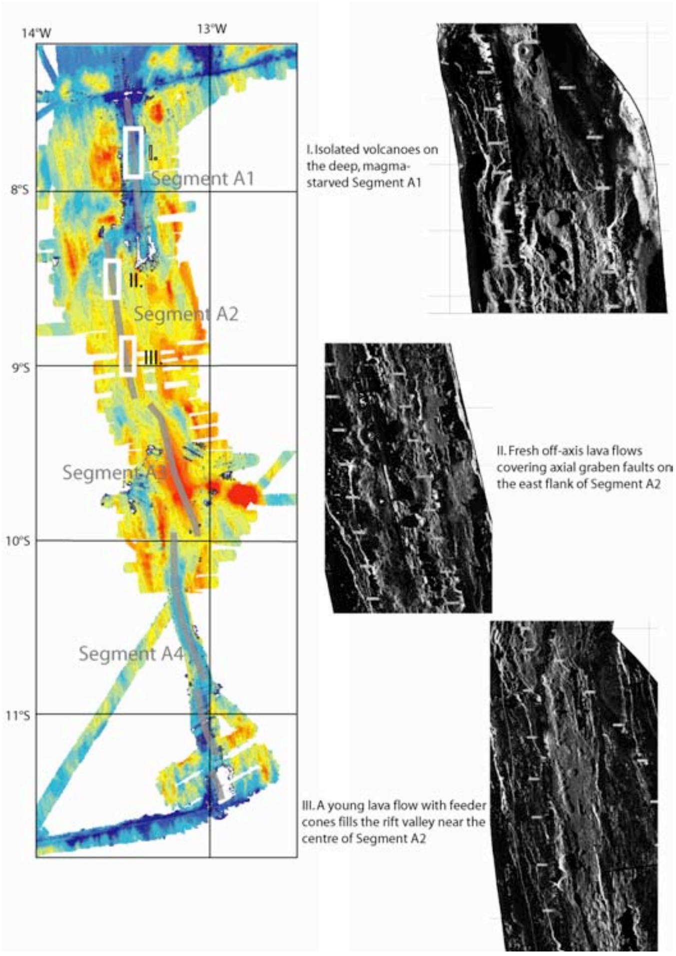

Figure 1: Bathymetry and selected side-scan images of the axial region near Ascension Island.

During the 12 day deployment approx. 6000km^2 of the spreading zone between the Ascension and Bode Verde Fracture Zones (Fig. 1) was imaged with TOBI. We found evidence for both magmatically and tectonically dominated spreading. Previous work (Minshull, Bruguier et al. 1998) had divided the area up into four major segments A1-A4 (see Figure 1). These segments have widely varying topography, suggesting that crustal thicknesses and hence rates of magma supply (Klein and Langmuir 1987) differ greatly from one to the other. The side-scan images confirmed this impression. The deep segment A1 is characterised by small within-axis volcanic ridges, some of which are topped by larger volcanoes showing a summit caldera (see Figure 1, image I). Backscatter information from the TOBI vehicle itself and autonomous backscatter recorders (MAPR - *M*iniature *A*utonomous *P*lume *R*ecorder, see http://www.pmel.noaa.gov/vents/PlumeStudies/MAPRposter.html) attached to the towing wire showed several signs of hydrothermal plumes in the water column, some of which confirmed previous information from a CTD profile in the area (German, Conelly et al. 2002). Segment A2 showed some of the youngest-looking flows (11.7 km long and 2.4 km wide) seen in the whole area (Figure 1, image II and III). Both off-axis (image II) and on-axis (image III) flows are seen to blanket fault scarps associated with the axial graben. In the case of the on-axis flow (image III) it does not appear to have been cut by any fault planes large enough to be visible at the resolution of the TOBI images (the mean pixel resolution is 6 m^2). Segment A3 is the shallowest segment and has been shown (Bruguier, Minshull et al. 2003) to have crustal thicknesses up to 11 km. The axial region is characterised by extensive sheet flows and the virtual absence of „hummocky terrain“, the typical feature of slow spreading ridges and representing the surface feature of a pillow volcano. The southern end of Segment A3 is marked by progressively deeper water and structural features characteristic of a propagating axial tip. A dextral non-transform ridge-jump to Segment A4 is accompanied by a large increase in axial depth and a return to volcanic features similar to those seen on Segment A1. Despite the fact that A4 is labelled as one segment, the side-scan data show several individual volcanic segments within the axial valley separated by non-transform displacements of up to 8 km.

Since 1984 water column surveys have provided evidence for at least 24 venting sites between 15°N and 38°N on the Mid-Atlantic Ridge (Baker and German 2004).

Information on active hydrothermalism on the southern MAR, including our target area 7-11°S, is still limited. Anomalies of total dissolved manganese (TDMn) >2 nmol/l compared to 0.5 nmol/l background values were found at many of the 13 conductivity-temperature-depth (CTD) hydrocast stations between 2-14°S carried out by German et al. (2002). Strongest anomalies were observed in the segment closest to Ascension Island, where TDMn anomalies coincided with optical backscatter anomalies. These data supported the presence of multiple discrete hydrothermal sources.

During the Meteor cruise, measurements with a CTD system additionally equipped with a transmissiometer and MAPR showed strong evidence for hydrothermal activity on a topographic high between 8°17’ S and 8°19’ S that rises to 2900 m depth from the rift valley floor at 3500 m.

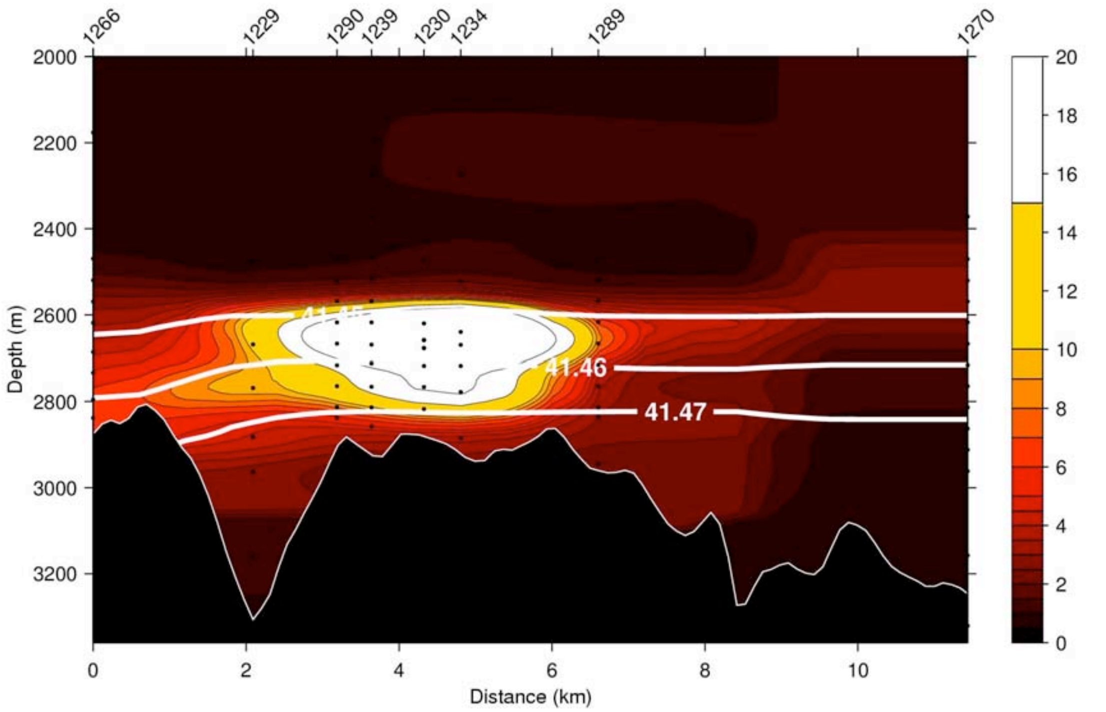

Fig. 2: Methane data from the „Cheating Bay“ area, along a S-N transect from 8°20’ to 8°15’S. Black dots indicate the water samples taken with a hydrocast. Methane values are presented as mmol/l.

High methane concentrations (up to 115 nmol/l) together with layers of increased light scattering in the vicinity of 8°18’S, 13°31’W (Fig. 2) indicate the presence of some sort of venting activity in this area (which we have named “Cheating Bay”). Although black smokers have not yet been directly observed, manganese concentrations of up to 25 nmol/l (pers. com. A. Koschinsky) in association with the peak in methane concentration and light scattering (Fig. 3) clearly demonstrate the hydrothermal nature of this water anomaly. Additionally, a temperature anomaly of 0.14°C 2m above the seafloor found during a ROV dive at the western flank of “Cheating Bay” is clearly related to an increasing heat transfer from a hydrothermal system below the surface. This higher temperature has caused an intense alteration of rocks and sediments (Fig. 4). This lead us to name the region the “Hydrothermal Nibelungen Field”.

An additional hydrothermal plume was mapped which does not appear to originate from “Cheating Bay”. At 8°10’ S a small but sharp plume in methane concentration (up to 9.7 nmol/l) was identified at 2000 m water depth along a E-W profile indicating a hydrothermal source probably located at the western slope of the rift valley (anomaly maximum at 8°10.00’S, 13°28.0’ W).

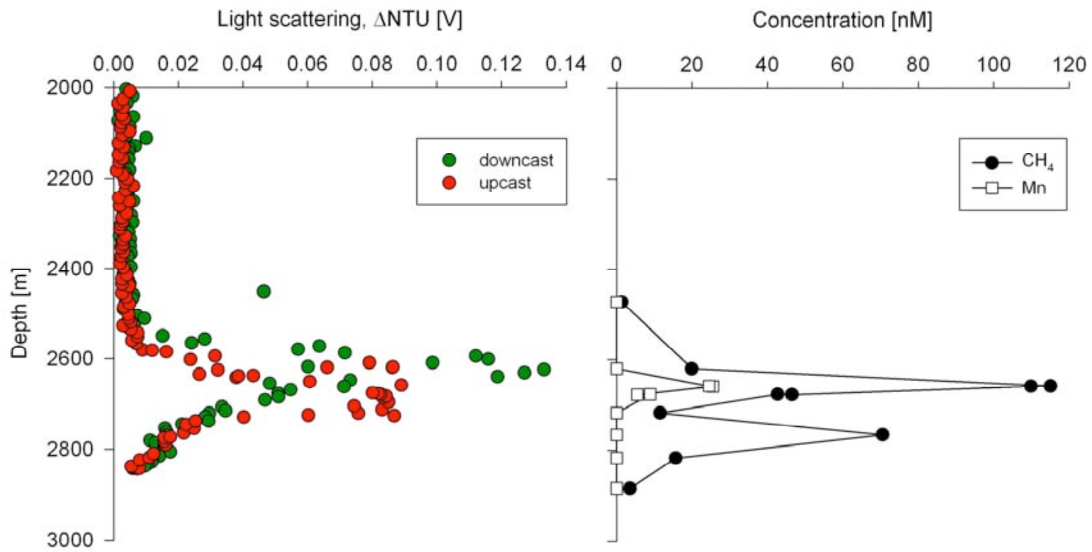

Fig. 3: Light scattering sensor, methane and total dissolved manganese (TDMn) data from the hydrocast station 1230 at 8°18.00’ S and 13°31.00’ W.

Fig. 4: Hydothermally altered and backed sediment observed on the rift valley flank close to the location of a T anomaly of 0.14°C.

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