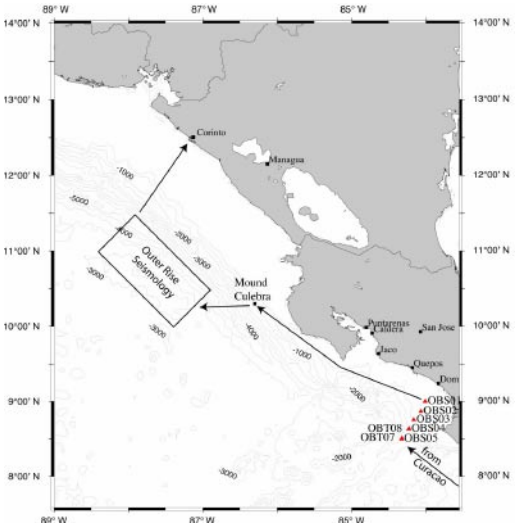
METEOR Expedition M66: To the edge of the American continent

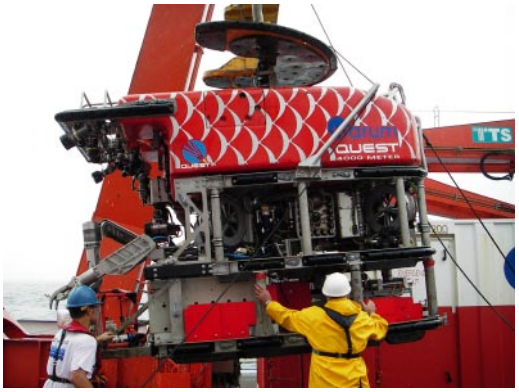
The METEOR Expedition M66 was one of the major expeditions in 2005 under leadership of IFM-GEOMAR. The expedition constitutes the main marine field expedition within the 2nd phase of the SFB 574 funded by the DFG. Five of seven legs were lead by chief scientists of the institute, comprising a total of 63 days ship-time. Leg-2a started from Curaçao with a transit section through the Caribbean to conduct oceanographic CTD stations and to prepare larger equipment for the subsequent cruise leg. After passing the Panama Canal, a geophysically oriented programme was carried out in the SFB574 working area off Costa Rica with deployments and recovery of OBS stations. 22 OBS/OBH and the deep sea observatory lander system (DOS Lander) were deployed for long-term records, addressing fluid flow and microseismicity in the subduction zone.



Right column: Working area off the coast of Costa Rica

The M66-2 Scientific party (Photo: H. v. Neuhoff)

During Leg-2b (Corinto, Costa Rica – Caldera, Nicaragua), the remotely operated vehicle (ROV) Quest operated by MARUM Bremen was used to sample carbonate mounds and mud diapirs off the coast of Costa Rica and Nicaragua. A total of 15 dives at six different geological targets, including slides, mounds and a pockmark-like structure at approximately 2000 m water depth,



The ROV Quest from MARUM on deployment from RV METEOR (Photo: H. v. Neuhoff)

were performed. Additional work included further lander deployments to study the fluid flow in the subduction area, with a main focus on the Quepos Slide, a landslide at 400 m water depth where fluids from greater depths are expelled into a nearly anoxic water column, leading to vast areas of the seafloor covered with bacterial mats. The CTD work during the cruise with a total of 37 stations also focussed on a grid above Quepos Slide, allowing an inventory of the vent-derived methane plume generated by the structure. Most of the other CTD-stations were used to resample stations already investigated several times during earlier expeditions of SFB 574 as part of a long-term survey of the methane flux from geological structures along the Middle American continental margin.

Amongst the main achievements of M66 Leg 2b are:

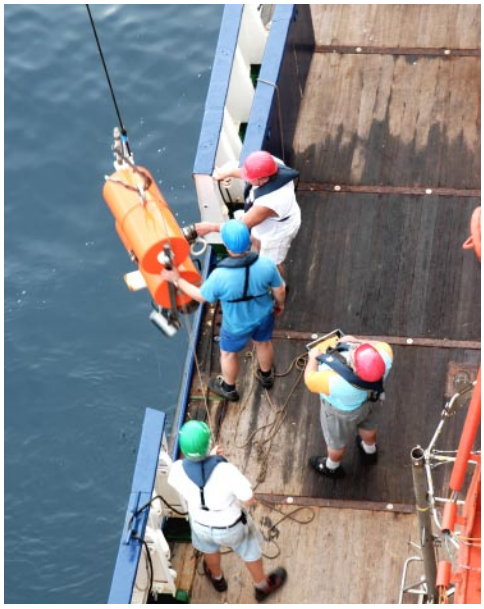
- The sampling of sediment core sections across the geochemical gradient at cold seep settings, which allow the 2-D modelling of fluid flow to determine the importance of non-vertical fluid circulation and convection cell formation within the sediments.
- The mapping of the active vent area at Jaco Scarp, dominated by vast fields of up to 2 m long *pogonophora* (Beard worms).
- The discovery of an active vent site in a pockmark-shaped depression, a geological structure not previously reported in the area.

Left column: Sampling of bacterial mats and tube worms with the ROV Quest , © MARUM.

During the following Leg 3a (Caldera, Costa – Caldera, Costa Rica), the deep drilling system RockDrill operated by the BGS (British Geological Survey) was used to recover cores from the tops of five carbonate mounds. A spectacular recovery of a 3.2 m long core from the top of Jaco Scar revealed the multiphase diagenetic evolution of a biotherm on top of a subducting seamount. In addition, using a Vibro-Coringsystem, clast rich, consolidated sediments were recovered from eight different mud volcanoes. The following leg was dedicated to completing the existing inventory of core material for further tephrachronological studies in the northern part of Central America. Several heat flow surveys were carried out on the slope of the Nicaragua continental margin.

Leg 4a started on Nov. 20th from the port of Corinto, Nicaragua. The scientific work began with an investigation of the outer rise of the subducting oceanic plate. From bathymetry and previous seismic sections it was known that deep-reaching faults within the Pacific plate are reactivated when the plate starts bending towards the deep sea trench. These faults allow large amounts of water to migrate downwards as deep as the upper mantle, where the water initiates transition of rock material into serpentine. The major goal of this Leg was to use seismic techniques to image changes of the physical properties of the upper mantle caused by hydration.

During Leg 2a, 22 Ocean-Bottom-Seismometers had been deployed in order to record possible micro-seismicity caused by reactivation of the faults and rock emplacement. Active wide angle seismic profiling should enable an evaluation of the velocity depth distribution within the oceanic plate, which should decrease compared to normal crust through the formation of serpentine. Preliminary onboard interpretation revealed velocities of 7.5 km/s in the upper mantle, which are an indication for the expected serpentine. Within the seismological network, 1892 earthquake events were detected within 58 days of recording, 123 of them could be located during the cruise with epicentres between 0 km and 30 km depth, which are laterally distributed from the outer rise towards the trench and underneath the continental slope. The analysis still lacks the knowledge of the exact three-dimensional velocity distribution to increase the precision of the epicentre locations, which will be provided from the ongoing modelling of the active seismic profiles. In addition high resolution seismic profiles were recorded along the continental slope to further investigate the surroundings of previously located mound structures. Deep towed multichannel seismic recordings and side scan sonar data revealed numerous mounds, which seemed to be at least in part related to faults within the slope. They provide the outlet of water



Recovery of an OBS System (Photo: H. v. Neuhoff)

released from the subducting oceanic plate. Hence the internal structure and connection to the deeper crustal layers are very important for the evaluation of the water circulation within the subduction zone. Finally, a second seismological network was deployed in front of the Nicaraguan and Costa Rican coasts, which prolongs onshore installations into the marine environment. These stations are dedicated to record earthquakes used to identify the location of the seismogenic zone in the area of transition between two different regimes of oceanic plate formation.

Before METEOR started its transit to the final port of Guayaquil, Ecuador, local fishermen approached the vessel to assist during rescue of a capsized fishing boat. After two hours, the cranes of METEOR could erect the boat again and mobile pumps were used to get rid of the seawater, before the fishing boat could be towed to port by their colleagues.

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