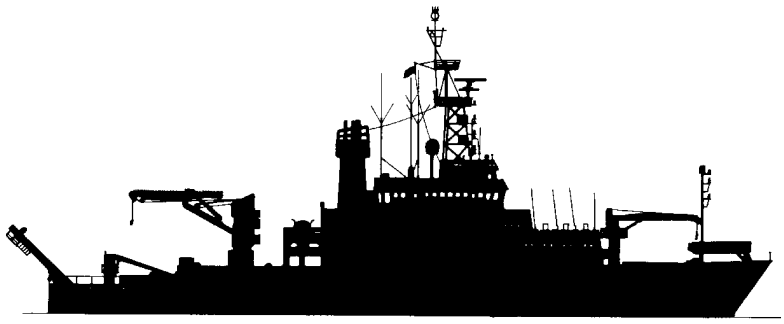
Meteor-Cruise M 76 / 3A

Short Cruise Report

Chief scientist: Prof. Dr. Volkhard Spiess
MARUM: Center for Marine Environmental Sciences,
Bremen University, Germany

Walvis Bay (Namibia) - Walvis Bay)
June 7th - July 13th, 2008



SHORT CRUISE REPORT R/V METEOR Cruise M76/3a

Dates: 07.06.2008 (Walvis Bay) - 13.07.2008 (Walvis Bay)
Chief Scientist: Prof. Dr. Volkhard Spiess
Institutions:

MARUM: Center for Marine Environmental Sciences, Bremen University, Germany
IFREMER: Ifremer Centre de Brest, Marine Geosciences, Plouzané, France
CNRS: Centre national de la recherche scientifique, Paris, France

Objectives:

The main objectives of R/V Meteor Cruise M76/3a were to investigate the controls of fluid and gas migration, the accumulation of free gas in and beneath the gas hydrate stability zone, and the geochemical and microbiological interactions at the sediment-water interface, with the help of high-resolution seismo-acoustic mapping, video observations and sediment coring on the West African continental margin. Main questions include on one hand the influence of facies, grain size, and permeability variations within the sediment; and on the other, the effect of salt tectonic deformation on gas accumulation and migration. Different lithological settings were selected for comparative multi-scale investigations with swath bathymetric, sediment echo-sounder, multichannel seismic, and backscatter systems as well as geological and bio-geochemical sampling. The immediate products of the cruise were a complete picture of the structural and sedimentary framework; near-3D images of vent sites, migration pathways and gas reservoirs; the identification of areas of recent vent activity, an overview information for subsequent ROV work during leg M76/3b and a quantification and characterization of active vent sites and shallow gas hydrate deposits in the light of different geological conditions. A close cooperation with IFREMER, Brest allows extended expertise especially in the fields of carbonate precipitation, biogeochemistry, microbiology, biology, monitoring and modelling.

Cruise narrative:

R/V Meteor left the port of Walvis Bay, Namibia, on June 7th, 2008 after successfully loading the last containers and placing the AUV and multichannel seismic equipment on deck. Although several pieces of luggage were still missing, the service suitcase for the Parasound system turned up just in time. Therefore, the a technician accompanied us for an extended upgrade work during the following days of transit, planning to leave the ship during an extra call in a West African port, after the sediment echosounder was functioning properly. Following an AUV test just off Walvis Bay, transit to the north commenced in the evening of June 7th. The scientific crew consisted of German, French, Peruvian, Chinese, and Hungarian colleagues.

The first area of investigation was reached on June 10th, a region of intense salt tectonics at 11°S. Underway bathymetric data had revealed an interesting polygonal surface morphology, and as the Parasound system was still not running reliably at this time, we spent a day with bathymetric surveying and subsequent seismic profiling. On June 12th we sailed with seismics towards Luanda, where we studied fluid seepage structures on the upper slope, associated with deformation, numerous small pockmarks, faulting as well as mounds covered with corals, using seismic and video

observations. The site appeared suitable for a first AUV test, which had however to be stopped due to technical problems.

As technical problems on the echosounder functionality continued, Meteor sailed on June 14th towards the first main working area in Angolan waters ("Salt Diapirs"), reaching it in the evening of June 15th. It is located at the western border of the continental margin, the shape of which is controlled by salt and raft tectonics. Upward moving salt in the subsurface has created a rough seafloor topography of several hundred meters elevation. Our goal was to find active fluid and gas vent sites with the help of seismic, bathymetric and sediment echosounder systems, as well as to verify their activity by video observations and coring. To that end, seismic profiles were recorded along tracks complementary to those acquired during previous two R/V Meteor expeditions.

At one location, a rugged seafloor with massive carbonate blocks and plates as well as single tube worms were seen in the video observation, indicating low but recent seep activity. A second video survey above a diapir revealed normal deep sea sediments with traces of venting. Gravity coring at both locations supported the video results. At another diapir, where pockmark-like features were selected for sampling with the help of the now functioning Parasound system, sediment cores showed indications of seep activity over longer time periods. After a final 2-day test of the echosounder and the acquisition of further seismic profiles, work was interrupted on June 19th for a transit and port call in Luanda. Research was continued in the working area on June 21st. Following an unsuccessful AUV test, several diapiric structures were video-surveyed. Visual observations could not confirm seep activity indications from sediment cores and from seismic data. The clearest indication of seepage was delivered by the Parasound system in form of a gas flare (free gas bubbles in the water column) on the seaward side of the deformation zone.

On the way to the deeper Congo Fan, a seismic transit profile was shot and an ikaite-containing core was successfully taken at the westernmost position of the cruise. Subsequent bathymetric and echosounder profiles were then recorded in Gabonese waters within the "sand facies" area after another half-day transit, starting on Tuesday 24th. This region is characterized by a widespread presence of sandy layers in shallow depths imagable by Parasound, displaying high reflection amplitudes possibly due to elevated gas charge. As we find it likely that such shallow gas occurrences cause frequent and widespread seep activity, we searched for appropriate sampling sites. Due to a major failure of the seismic compressor, originally planned seismic profiles had to be replaced by an echosounder overview survey on June 25th. This was followed by gravity coring at pockmark sites further to the east, which had been discovered during previous R/V Meteor cruises. Coring was quite successful by collecting large pieces and volume of gas hydrates.

The "Pockmark" target area received its name from numerous unique giant pockmark structures, depressions on the seafloor of some tens of meters depth and several hundreds of meters diameter. Bathymetric data provided a handle on the size and number of these pockmarks, and allowed to identify a number of new ones, to subsequently characterize them with Parasound subseafloor imaging, and to identify several gas flares. At the site of an intense gas plume, the shallow occurrence of gas hydrates as well as living chemosynthetic fauna further documented recent and ongoing activity. Profiling until June 28th raised the number of newly-discovered flares to 5 - a sign of continuous and widespread seepage.

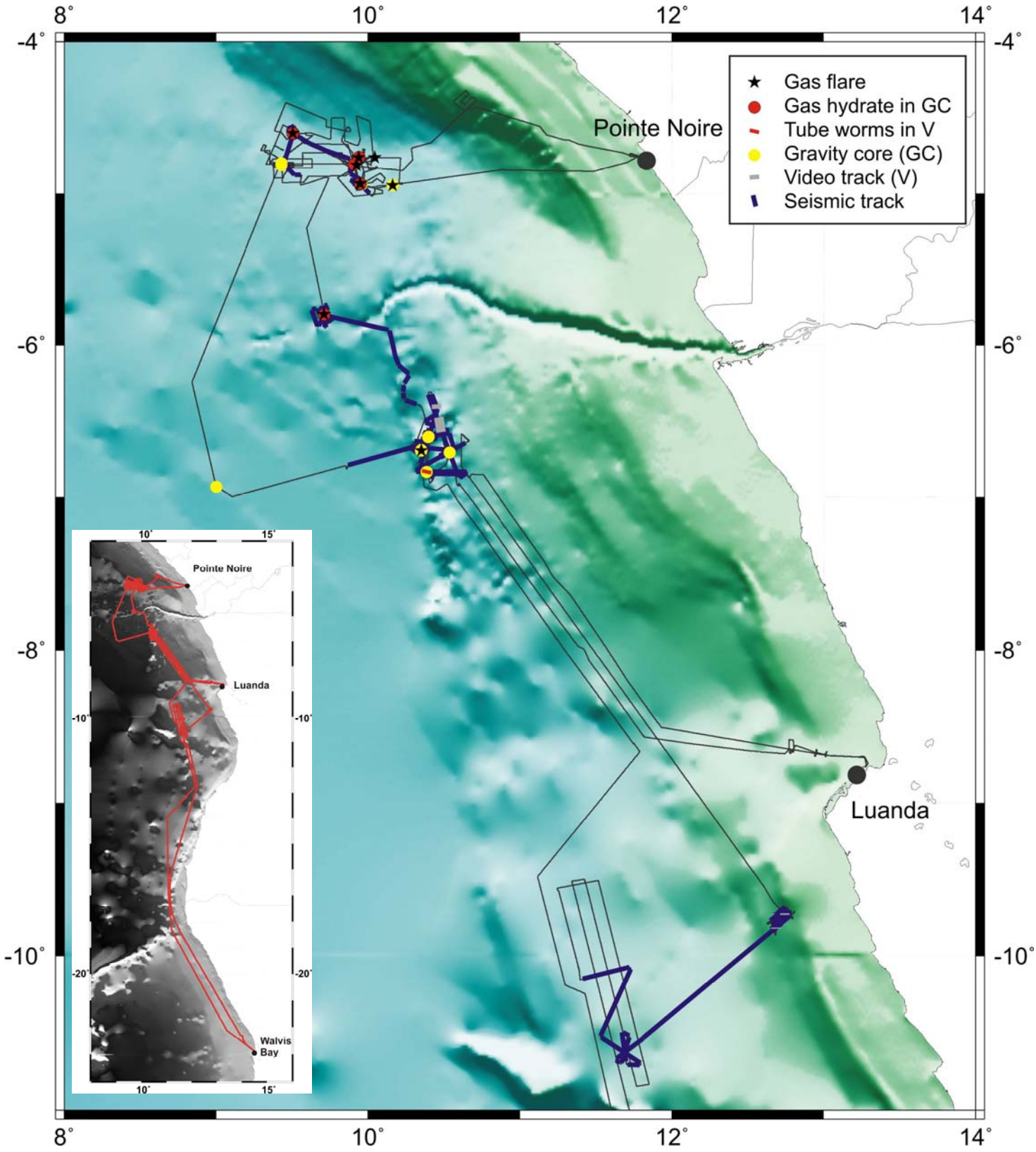
Several gravity cores were taken between June 30th and July 3rd. The cores were quite successful in recovering carbonates, hydrates and traces of fauna, but revealed

an extreme spatial variability. Core lengths varied at one location between 0 and 8 m, and core material ranged from purely hemipelagic sediment to material mixed with massive carbonate and gas hydrate; even though the corer was positioned to the same coordinate with just a few meters of positioning inaccuracy. Six stations served to confirm hydroacoustic vent indications as well as to recover seep-related, shallow sample material. Two of them were free of gas hydrates, others at the pockmarks provided carbonates and gas hydrates. In three cores these were found primarily close to the surface, down to approximately 3 m depth. In-situ temperature measurements at the gravity corer revealed anomalies which indicate active fluid flux and hydrate instability within the surface deposits. Another last attempt to deploy the AUV failed at Hydrate Hole on July 3rd.

Research permission for Congolese waters arrived just in time to enable a short working period at the Regab pockmark site. It took full effect with the embarkation of a Congolese observer on July 4th in the port of Pointe Noire after a half-day transit, where a replacement compressor had arrived from Germany via airfreight. We left port within a few hours, heading for a one-day seismic survey across the pockmark and sand-facies areas, before departing for the Regab site.

The last days of the expedition were spent at Regab. The afternoon of July 5th brought two successful gravity cores of up to 2 m each, which recovered gas hydrates and carbonates. The remaining time was used to track vent mechanisms with the help of a network of seismic profiles. The immediate vicinity of the Congo Canyon, the complex local tectonics, and the variable distribution of different sediment types make it a challenge to interpret the data; the circumstances appear to differ principally from those in the pockmark area in the north and thus make the site optimal for a comparison. We concluded our work with a seismic transit profile towards the south in the night of July 8th. Despite bad weather and heavy seas, R/V Meteor arrived in Walvis Bay on July 12th in time, but departure from the working area had to be rescheduled to half a day earlier.

In total, 29 very good cores were recovered with sediments containing large amounts of carbonates and gas hydrates, more than 7 gas flares were verified in the water column, and 8 days of seismic profiling (out of 14 planned days) were carried out during M76/3a. Furthermore, 7 TV-sled missions and 10 AUV deployments were included, the latter unfortunately without success. Our results demonstrated that seep activity is widespread and typical of this continental margin, and subsequent research will both focus on the seismo-acoustic characterization of seepage in the region as well as the study and the intercomparison of several seep locations with the help of carbonate, gas hydrate and microbiological samples.



Location of seismic profiles, sampling work, and seafloor video observations, as well as sites with indication of active seepage during cruise M76-3a (07.06. - 13.07. 2008.). Insert: overview map of working area and track lines of R/V METEOR during the cruise.