SHORT CRUISE REPORT

METEOR cruise M67/2

Dates:	March 15 – April 25, 2006
Port calls:	Cristobal – Tampico - Bridgetown
Chief scientists:	Prof. Volkhard Spiess (Leg 2a); Prof. Gerhard Bohrmann (Leg 2b)
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The R/V *Meteor* sailed from Pier 8 in Cristobal harbor, Panama at 6 pm on March 15 to transit through the Caribbean Sea to the Gulf of Mexico. The time required by the R/V *Meteor* in the port of Cristobal was short after crossing the Panama Canal through Balboa on the Pacific side; time at which 5 participants of the cruise M67/2 had boarded the ship. The crossing through the Panama Canal started on March 14. The *Meteor* reached the Caribbean Sea after leaving the last lock at Gatun on March 15 to come alongside the port of Cristobal. A container of the previous cruise leg belonging to the research institution 574 in Kiel was unloaded and 5 new containers from Bremen were loaded. All 27 scientists and technicians from Germany, Mexico, Colombia, China, Hungary and the US arrived onboard after midday and in this way we were able to sail from the port of Cristobal on the same day as planned.

The over four day transit period into the Gulf of Mexico was used on board to set the laboratories, and in part to feel acquainted with the new techniques on the R/V *Meteor* and in the frame of daily thematic seminars and work meetings to introduce the upcoming research activities to all participants. Since most of the time of the M67/2a cruise was spend in activities on the harbor, transit and preparation to collect and analyze samples on the first week, the second week was characterized by a dense program that included the geophysical survey with multichannel seismic, sidescan sonar, bathymetry and sediment, followed by the sampling of the water column and the seafloor.

The CTD with a 22 bottle rossette was the first equipment used on March 20 to support nanoplankton studies in the top 250 m depth in the water column and to determine the Barium tracer and the dissolved methane concentration in the deeper layers, its descent was used to calibrate the swath mapping echosounder with a sound profile characteristic for the Campeche Bay as well. This first equipment, was the only successful action of the cruise for a while. The fate of the days onboard not only seemed to be bewitched by technical difficulties and misshapen but it seemed problem-bearing for the gadget's first action. An intensive search for problems included the contacts, the cables and the software of all, the multichannel seismic, the sidescan sonar and the new echsounder as well, the new navigation sensors or the proficiency of the upgraded Parasound system.

Several short circuits were recognized in the connectors of the side scan sonar and the housing that had equal level of importance as the ongoing strong noise in the imaging of the seismic and that made it impossible to initiate the measurements. Over two days were devoted to find the errors, change the cables and connectors of the sidescan sonar and the cleaning of the seismic streamer connecting plugs was added on Thursday, after being exposed to saltwater, until the two equipments were considered fit to perform the tasks.

We were able to extend the bathymetry accomplished in the study area of the RV *Sonne* cruise SO 174 at sites with recorded asphalt and seepage by carrying out profiles successfully with the *Parasound*, the in the mean time once again working echosounder. The first measurements with the updated *Parasound* revealed several limitations that were overcome by the new capabilities and functions added and will provide an important tool with time in this study. Measurements and survey within the water column, imaging of gas

bubbles or optimal diagrams and form of signals are only a small glance of the required capabilities that this cruise will slowly require available for us to work in the upcoming days.

The bathymetric data of the new *Simrad* EM120 Echosounder gave us several things to wish among which a broader swath band is available through the availability of the box located in the keel that allows to record high quality data while sailing at more than 10 knots and allows to search in station and measure systematically with more comfort. In this way we concentrated in the area studied during SO 174 and accompanied the geophysical repairs with activities on station such as the sampling of the water column with the CTD/Rosette. It is in this way that we retrieved the first 5 m long gravity core sample with pelagic deep sea mud from the upper crater rim of the deep sea knoll „Chapopote“, sampling that took on this occasion from the stern on March 21.

While sailing in the area we could directly confirm the presence of oil drops and oil slicks in the surface. The surface mapping with Parasound/Echosounder should at the same time help to provide additional profiles to establish a basis and optimize the upcoming measurements and help to overcome the forecasted storm-phase of winds of strength of 10 while the sidescan sonar and seismic equipments are being repaired. This allowed us to recognize the infallible characteristics of the equipments that carry out hydrographic measurements under rough sea conditions that have greatly improved as in contrast with the past. With the right speed these measurements could be accomplished successfully even during the storm forecasted to reach wave heights of 4m, which is a great step for future work onboard the R/V *Meteor*.

It was over night from March 23 to 24 that the weather conditions improved and that the diminishing strength of winds throughout the day that we could get the seismic equipment back in water on the evening of March 24. We could then accomplish diverse profiles over seep locations in order to understand the complex geological conditions on the seafloor represented by the salt diapirism, sliding and strong deformation to interpret jointly with the oil and gas outflow to the superficial sediment layers.

Although there was little time to complete the geophysical survey work for the following ROV dives, we were able to produce overall very satisfying results. The untiring efforts of system operator and electronics technicians enabled the multibeam and Parasound systems to collect data of excellent quality and system failures common on previous *Meteor* cruises seem to be a thing of the past.

From March 27 to March 31 morning, the scheduled date for our arrival in Tampico, work focused on the acquisition of multi-channel seismic data in the Campeche Knolls area, which is characterized by asphalt deposits and sea surface oil slicks. In a renewed attempt to collect side-scan sonar data we successfully deployed the instrument and collected several hours worth of data on two interesting seafloor features before communication to the deep-towed fish ceased. Unable to resolve whether the source of the failure was located in the deep-sea wire, connectors, or electronics, we had to refrain from further deployments.

On the other hand, a suite of multi-channel seismic data were successfully acquired that, at least in the Chapopote area, will allow to characterize the area of asphalt deposition identified during R/V Sonne cruise SO 174. In addition, seismic data allowed us to identify sites of fluid flow and asphalt deposition on other knolls and ridges in the study area.

While preparing the side-scan sonar we had the opportunity to deploy a CTD cast with water sampler and a gravity core in an area of visible oil slicks on the sea surface on March 28. To our surprise, water samples contained traces of higher hydrocarbons and shore-based investigations will show if the sediments also contain a record of active seepage.

The remaining hours of M67/2a were spent on systematically documenting a number of oil slicks with seismic, multibeam, and *Parasound* surveys. All instruments were back on deck at 9:00 a.m. on March 30 and we concluded our scientific program with shallow water sampling in support of a coccolithophores study before we reached the pilot station at 7:00 a.m. on Friday morning March 31.

Due to problems with customs processing, we chosed the port of Altamira, about 30 nautical miles north of Tampico, for container loading and unloading, which we completed late Friday morning March 31. Several hours later we reached the dock in Tampico after steaming upriver and enjoying the view of a city shaped by the oil industry – shipyards, oil rig

construction, and factories alternated with austere settlements, all embedded in a tropical jungle. The evening saw the beginning of a 4-day port call in Tampico to exchange personnel – only six scientists from M67/2a stayed on board – and to conduct necessary repairs and maintenance work to the front thruster and bathymetry systems.

After most new cruise participants for M67/2b had boarded *Meteor* in Tampico on Saturday, April 1, scientists from Mexico and the United States arrived during Sunday, April 2. On board, installation of the *Quest* ROV system continued and a number of analytical instruments were set up in the laboratories. Numerous guests from the Tampico area, as well as from the German embassy in Mexico City participated in a reception on board *Meteor* on Sunday as well. Tours of the ship followed and from conversations with our guests it became obvious that there was a great deal of interest in the German research vessel and in our research activities in the Gulf of Mexico. Local media reported in great detail about the visit of *R/V Meteor* to Tampico.

Meteor's scheduled departure for leg M67/2b from Tampico on Monday, April 3 was delayed to 4:00 p.m. due to the late arrival of airfreight. In addition to cruise participants from Germany, Mexico, and the United States, seven engineers and technicians for bow thruster, dynamic positioning system, PARASOUND, and the multibeam system had joined us on board to conduct much needed repairs. These repairs and upgrades had become necessary after the many changes to the ship's systems during its time in the shipyard and will probably continue to affect subsequent legs as well.

Maintenance tasks to the vessel were completed late, after the technicians had disembarked at the pilot's station in Tampico at midnight, the vessel continued its transit to our study area in the northern Bay of Campeche. Underway collection of P*arasound* and multibeam bathymetry data continued until the morning of April 5. Sediments from an approximately 40 km long ridge characterized by numerous sea surface oil slicks were recovered at our first multi-corer station from a water depth of 2200 m. A first series of ROV dives with *Quest* was scheduled for the two following days. However, strong winds (6 to 7 Beaufort) in combination with a still nonfunctional bow thruster forced us to conduct alternative sampling activities. In addition, the program was curtailed by a failure of the video telemetry system, which led to a fairly extensive use of the gravity corer on Thursday, April 6. Excitement grew with recovery of the final sediment core, which contained patches and stringers of heavy oil in its core catcher. Pore water and gas analyses revealed geochemical gradients typical for anaerobic methane oxidation in the lower portion of the core.

Detailed multibeam mapping of the Chapopote deep-sea mound with a reduced beam width of 2 km and overlapping tracks followed during the night. The result, a much more detailed morphological map of Chapopote, convinced us to survey a second deep-sea mound similar to Chapopote and another potential dive target during the following day. However, a ROV dive scheduled for Saturday had to be cancelled due to technical problems with the vehicle. Excellent weather and calm seas allowed us instead to survey a natural sea-surface oil slick covering an area of 1.5-4 km^2 in the northeastern section above Chapopote. The slick was caused by rising droplets of oil originating from a water depth of almost 3000 m. We took advantage of the calm seas for documenting rising drops of oil and areas of increased occurrences of gas bubbles on the sea surface. Below the sea surface, we were able to document acoustic anomalies caused by ascending oil and gas bubbles in the water column using the new *Parasound* system. During the night, we finally succeeded in deploying the repaired TV-sled and received the first video images from the seafloor of knoll 2139. Previous side-scan sonar surveys had indicated the presence of asphalt deposits at this knoll, which was confirmed by the TV-sled. We have now documented asphalt deposits on four of the Campeche Knolls, which is an important step towards our goal of documenting the presumably large regional extent of asphalt volcanism. Gravity coring and deployments of the multi-corer completed our program for the weekend.

Technical problems with the ROV once again prevented a dive on Sunday, April 9 but were overcome by the end of the day thanks to a dedicated, all-day repair effort of the entire ROV team. The week before the Easter Weekend (April 10-14) focused completely on the deployment of ROV *Quest* realizing daily dives to the Chapopote asphalt volcano. Due to technical problems with the ROV, Monday's dive on April 10 was limited to only a little more

than one hour of bottom time but already demonstrated the vast opportunities the vehicle has to offer to science. Cold vents, previously known to us only from black and video images of rather poor quality, were now finally visible in great detail on high-resolution color video. An animal trap belonging to our Mexican colleagues was quickly deployed on the seafloor moments before the vehicle was forced to return to the surface.

The final breakthrough came with the second dive to the targeted asphalt volcano on Tuesday April 11. Several east-west transects across the central area of the previously discovered asphalt discharge site allowed to document details of the asphalt landscape, both in picture and by taking samples with *Quest's* two robotic arms. For the first time, we were able to grasp the three-dimensional geometry of the asphalt deposits, including branching flows and stacked layers as well as their bizarre colonization by communities of chemosynthetic organisms. The asphalt flows are extremely heterogeneous in nature. Similar to features known from flowing lava, there are blocky and fractured asphalt layers indicating varying degrees of alteration, which are covered by younger, less altered sheets showing clear indications for liquid flow. While the consistency of the, according to stratigraphic principles, older flows appears hard and brittle, younger layers are viscous and soft and proved difficult to sample with the ROV's robotic arms. Petrographic and geochemical analyses of the asphalt samples will now contribute to a better understanding of asphalt volcanism as a geologic phenomenon.

Following this first dive, we successfully sampled one of the asphalt layers using the gravity corer, which recovered a 70 cm long cylinder 10 cm in diameter containing asphalt in association with gas hydrate. This was an important discovery regarding processes allowing a colonization of the asphalt by chemosynthetic organisms and has implications for the microbially driven alteration of the asphalt deposits. Wednesday's dive on April 11 was focused on the deployment of several large in situ instruments using a specially designed elevator system, which was lowered to the seafloor using the ships deep-sea winch. We had planned to position the instruments with the ROV and return them to the elevator after completion of the measurements. Then, the elevator would have started its buoyancy-driven return to the sea surface. Unfortunately, a heavy rope broke during deployment and the elevator sank to the seafloor, which was documented both by its *Posidonia* navigation unit and the ship's *Parasound* system. Because the elevator had lost part of its flotation material, it did not return to the sea surface and we decided to use Thursday's dive on April 12 for a recovery attempt. During this extremely complex mission the ROV team successfully connected one of *Meteor's* deep-sea wires to the elevator, which was then hoisted back up to the surface. The second part of the 16 hour-long dive was used to take short sediment cores, so-called *push cores*, with *Quest's* robotic arm in carefully selected cold seep locations. This allowed us to conduct a variety of interdisciplinary geochemical and microbiological investigations on the first few centimeters of the sedimentary section. In addition to push cores, the ROV also retrieved various organisms as well as water and rock samples from the seafloor.

Wednesday night on April 13/14 was used to conduct a TV-sled survey along two transects near the northeastern crater of Chapopote in order to explore the area for additional dive targets. Asphalt was visible there as well and we decided to visit the area during Thursday's dive. For this dive, the ROV was outfitted with an autoclave tool, which makes it possible to take samples on the seafloor and seal them under in situ pressure conditions. We successfully sampled a piece of fresh asphalt and were able to determine gas content and composition by degassing the sample after retrieval under controlled conditions in the lab. Just like before, this dive of over 11 hours not only brought numerous samples of asphalt and chemosynthetic organisms, including tubeworms and mussels to the surface, but expanded our understanding of the structure of the asphalt-dominated deep-sea environment of Chapopote. It became clear that the deep-sea asphalt landscape with its bizarre biological communities represents an almost completely novel deep-sea habitat, which is controlled by the just as novel and poorly understood process of asphalt volcanism.

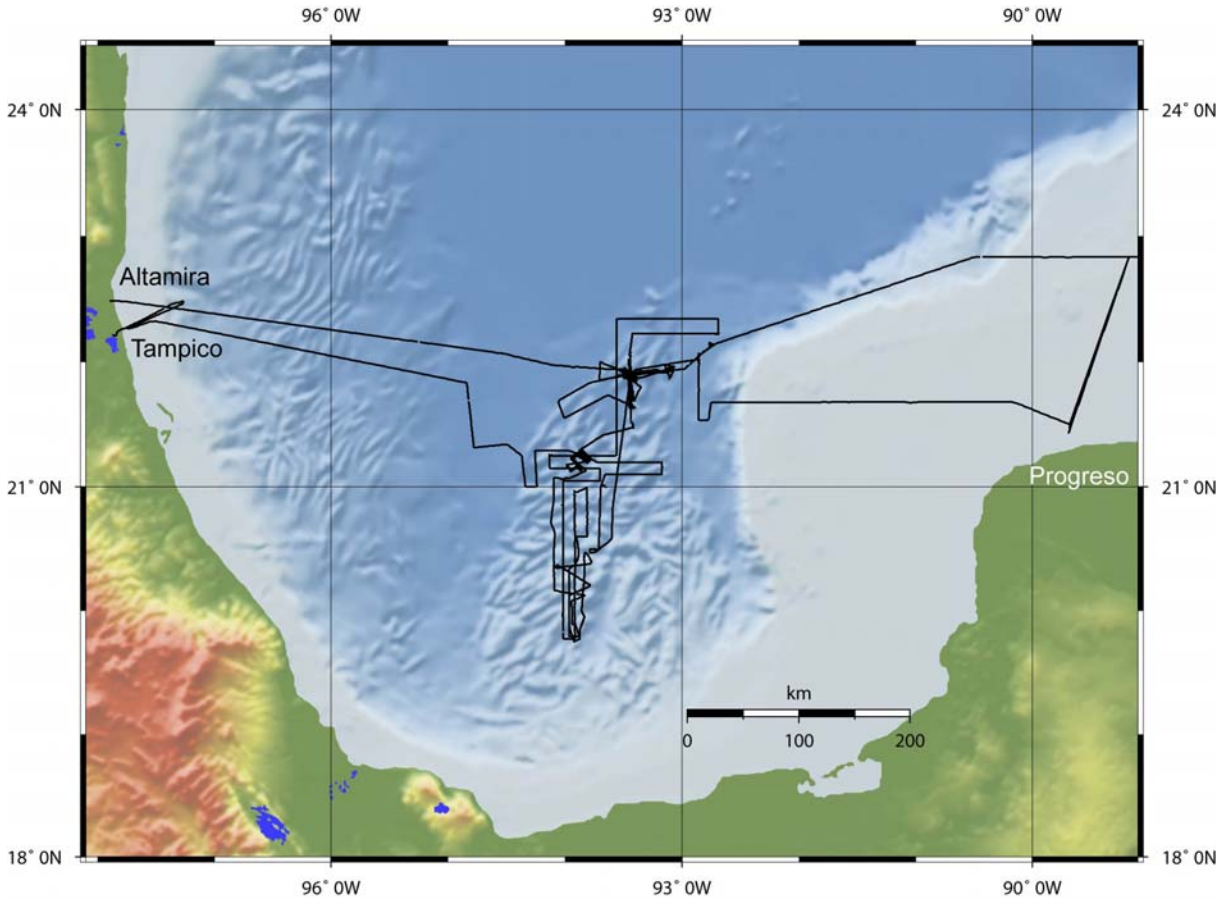
The last week of our research cruise our work was in the beginning quite labour intensive, however, this changed during the transit to Bridgetown and throughout Easter

days. First we tried to sample the deeper sediment of the active fluid- and gas seeps on the asphalt volcano *Chapopote* using the 3 meter long gravity corer on April 14. This happened with different stage of success, in which variable environments of the cold seeps could be sampled down to a depth of 1,5 m. One of the sediment cores contained oil-saturated sediment, which was underlain by clam shell layers. The shells were from chemosynthetic bivalves, which are known from submersible observations to be a characteristic species of the cold seep environments on the seafloor. Another gravity corer deployment recovered a pure 90 cm asphalt core. This core contained throughout pores filled with methane hydrate. Because methane hydrates are not stable under atmospheric conditions on deck, we observed bubbling methane escaping from the pores of the asphalt core.

After finishing the gravity coring, we performed the last dive of the cruise on April 15, which turned out to become the longest dive with more than 18 hours bottom time. Scientific aim of this dive was the investigation of geochemical gradients and fluxes of oily and ashalt-like seep sediments using different in-situ tools. To fulfill this task, RVO *Quest* was packed with instruments and scientific payload prior to deployment. Two devices – a benthic chamber and an in-situ pore water sampler, where initially parked at the seafloor to allow Quest to search for bacterial mats. These are abundant in the marginal areas of asphalt covered zones on the seafloor, and document very active zones. Here the in-situ devices where deployed, and a set of push cores was taken precisely positioned, which can only be achieved with an ROV or submersible. During recovery of the push cores from the sediment, rising oil drops were sometimes observed. During the second half of the dive, the benthic chamber was deployed onto a fresh-looking asphalt surface, being covered with a white bacterial mat. A large portion of oxygen depletion inside the chamber is probably due to a high microbial activity above the fresh asphalt, whereas the flux is most probably due to the asphalt itself.

Continuing the dive, a zone with rising gas bubbles through the water column was investigated. Although this area is situated only some 200 m apart from the last position, it shows a different cold seep habitat. The seafloor here consists of heavily altered asphalt, which is clearly recognizable due to the dark colour. Also, the biological facies of the active seeps is different. Tube worms are dominant aside to clams being known as chemosynthetic organisms, which are mixed with other sessile, coral or sponge-like organisms (see figure). Animals, such as crabs, snails or see cucumbers are abundant in this zone around 3000m as well. Gas bubbles detected in the water column were followed until their origin at the sea floor, where surprisingly gas hydrates of some cm thickness were found. Such hydrate structures were found at different gas bubble seeps and are probably connected to the free methane which immediately forms hydrate under high pressure in contact to the cold water.

During ascent of the ROV the rising gas bubbles could be followed at a distance around 20m, visible as an acoustic anomaly in the sonar, all the way up to 600 m depth. This confirmation of an active gas bubble ascent can be connected with those gas observations at Chapopote performed with the new 18 kHz Parasound System. After this exciting and scientifically very successful dive and a short following sampling campaign, we finished the scientific stations and *Meteor* steamed towards Progreso on Yucatan, where our Mexican and US American colleagues left during the Easter Sunday evening. The seven days lasting transit towards Barbados, where we arrived on schedule on Monday, April 24 the harbour in Bridgetown, we use for examination of the samples and scientific results, for the preparation of the cruise report, and for daily seminars to discuss the scientific results of the cruise. Although both legs M67-2a and 2b where dealing with a variety of technical problems, they where finished with mostly very successful results.



Track lines of R/V Meteor during cruise M67/2 (March 15 – April 25, 2006; Cristobal – Tampico – Bridgetown)

Scientific work/station work:

Multichannel seismic profile	42 lines
Sidescan Sonar	1 profile
CTD and hydrocasts	7 stations
Gravity corer	11 stations
TV-multicorer	5 stations
TV-sled deployments	3 profiles
ROV dives	5 dives