

# Short Cruise Report R/V METEOR Cruise M72-4

25.04.2007 – 11.05.2007

Istanbul - Istanbul

## Introduction

In order to understand the mechanisms leading to the submarine discharge of methane-rich fluids and in order to quantify these processes knowledge of the pathways of methane from their point of formation via potential intermediate deposits to the seafloor is required. Despite many investigations in recent times little is known about the duration of the activity of seeps (Linke et al., 1999, Tryon and Brown, 1999) but strong variations have been observed. Suess et al. (2001) reported variations as strong as one magnitude within tidal and longer term changes of fluid venting. Even reversals (i.e. fluid influx instead of efflux) were observed by Tryon et al. (1999). Bohrmann et al. (2003) observed active venting at the Dvureshenskii mud volcano (Black Sea) deduced from temperature and fluid anomalies during R/V METEOR cruise M52/1cruise in 2002. In 2003, during the CRIMEA cruise active gas flares at the top of Dvurechenskii and Vodyanitskii mud volcanoes have been imaged using high frequency echo sounding (Greinert et al., 2006). Such flares were not known previously. All such observations indicate that there is a large variation in activity and hence methane output from marine vent sites, which are not yet fully understood or described with current process models. In order to overcome these shortcomings in our understanding of the underlying processes high resolution and ideally three-dimensional imaging of the distribution of fluid-escape locations and their underlying structure are needed. Such measurements using geo-acoustic and seismic tools were planned in the Sorokin Trough and in the Palaeo-Dnepr slope area.

The Sorokin Trough is located SE of the Crimean Peninsula. The 150 km by 50 km wide and about 2000 m deep depression is bounded in the East and south by the Shatskiy Rise and the Tetyaev Rise, respectively. Both ridges are of Cretaceous – Eocene age (Tugolesov, 1985). Since the Oligocene the trough was formed as a foredeep of the Crimean Mountains (Andreev, 1976). The movement of the Shatskiy Ridge and the Tetyaev Rise caused lateral compression in SE-NW direction, which favoured the formation of features such as mud volcanoes due to overpressuring of fluids that are generated by the decomposition of organic matter at depth. The fluids are believed to originate from the 5 to 6 km thick Maikop Formation, from which diapiric faults rise underneath the mud volcano locations (Limonov et al., 1997). Tugolesov (1985) could reveal an elongated pattern of the diapirs coaxial to the SW-NE direction of the Sorokin Trough. The morphology of the corresponding mud volcanoes is variable, dome shaped structures are observed as well as depressions that probably form by the collapse of mud volcanoes (Limonov et al., 1997). Flat mud-pie-type structures also exist next to cone-shaped mud volcanoes. The difference between these types is related to the fluid content of the rising mud. Where the feeder channel is expected, seismic images of the mud volcanoes are characterized by transparent zones, due to high reflectivity at gas bearing horizons (Krastel et al., 2003).

The Palaeo-Dnepr slope, on the other hand, is located to the Southwest of the Crimean Peninsula. Here the shelf is about 100 to 150 km wide. Water depth is from about 130 m to roughly 1000 m at the foot of the slope. This area is dominated by sediment input from large rivers (Danube and Dnepr) that form vast submarine fans on the continental slope and in the deep basin. The occurrence of large deep-sea fans in this part of the Black Sea is controlled by climate and sea-level change (Wong et al., 1994, Winguth et al. 2000, Popescu et al., 2001). The shelf slope is underlain by the Kalamite Ridge and bounded to the North by the Shtormavaya Graben (Robinson et al., 1996, Nikishin et al., 2003). A large number of active gas seeps have been found in this area (Naudts et al., 2005) in water depths of less than 725 metres, i.e. outside of the area of gas-hydrate stability. Although much of this gas is of biogenic origin, noble gas analyses of the fluids also indicate a deep origin of some of the fluids (ref.?). At present the deeper part of the Paleo-Dnepr slope is the only area of the Black Sea, where the occurrence of a BSR reflection has been described (Lüdmann et al., 2004, Zillmer et al., 2005).

## Cruise Narratives

A small group of four people already welcomed RV METEOR when it arrived in the port of Ambarli on 23<sup>rd</sup> April after a 10 hours delay due to closure of the Bosphorus. The group started their preparatory work for CTD installation right away. Another six people arrived in the morning of the 25<sup>th</sup> April

onboard, while two scientists and one Ukrainian observer continued their voyage from leg 72-3. Instrument set up continued during the 25<sup>th</sup>. When two Turkish and the second Ukrainian observer arrived in the evening the small 14 party of 14 people was completed. During the day several phone calls were done with representatives of the Turkish oil company TPAO. Due to 3-D seismic exploration work along the Turkish coast of the Black Sea all scientific work applications were denied at first hand. Continued discussion with the company resulted in a final permit for completion of four CTD stations planned on the transit from and towards Istanbul.

R/V METEOR left the port of Ambarli on 26<sup>th</sup> April on schedule but needed to drift in front of the Bosphorus until 02:00 hrs in the morning of 27<sup>th</sup> April before the passage could be done. At 09:00 hrs and 21:30 hrs the first two CTD stations of the transit towards the Sorokin Trough area were completed.

A third CTD was collected on 28<sup>th</sup> April 08:00 hrs right before the working area around the Dvureshenskii mud volcano was entered. Recording of Bathymetry and Parasound data started at 14:00 hrs. Unfortunately online display of the EM120 data showed some very strange relief structures, which proved to occur due to some internal system failure. After the fourth CTD, taken at the Dvureshenskii mud volcano, the first Ocean-Bottom-Seismometer (OBS) was deployed on 19:50 hrs.

18 OBS were deployed along two seismic profiles, one across the Dvureshenskii and neighbouring mud volcanoes in WSW – ENE direction, and a second perpendicular across the Dvureshenskii, until 01:30 hrs on the 29<sup>th</sup> April. Airgun shooting with two 32 l BOLT airguns and a second run with a 250/105 ccinch GI airgun were completed on 18:30 hrs on 30<sup>th</sup> April and accompanied by recordings from a short mini-streamer. During the operation unexpected flare indications were recorded across the Odessa mud volcano for the first time. Hence the decision was made to return for small experiment to this structure later.

The last OBS was recovered on 01<sup>st</sup> May 07:00 hrs. In the following a very dense parallel grid of lines across the Dvureshenskii was observed with the water column imaging of Parasound to check if the flares observed on the previous leg are still active with the same strength. From four flare observations direction and expansion of the flare were estimated and a set of 3 CDT stations were completed within and outside the flare. Ongoing problems with the EM120 forced to spend two hours of ship time for test measurements. In the evening 6 OBS were deployed across the Odessa mud volcano, prior to first deployment of the deep towed Sidescan sonar. Unfortunately the deep towed streamer could not be deployed as one of the control PCs was damaged during airfreight shipment and preparation of a replacement system was not completed. On the way towards the deployment position a new mud volcano was discovered, which we decided to name Balaklava,

From 23:30 hrs on 1<sup>st</sup> May until 06:10 hrs on the 3<sup>rd</sup> May mapping of the Sorokin Trough around the Dvureshenskii mud volcano with the 70 kHz Sidescan was continued. During this profiles a GI airgun could be deployed together with a 4 channel mini-streamer. Hardware repair of the EM120 provided a better seafloor image, but still water depth values drifted away from true depth time by time. Sidescan operation was interrupted due to a broken electric connector at the wet end of the deep sea cable. After further dry tests with the deep towed streamer and the replacement PC the Sidescan was deployed again on 21:30 hrs. A second prior unknown mud volcano was discovered during this survey, which will be referred under the name Karadag.

On 5<sup>th</sup> May the Sidescan operation was interrupted again at 13:30 hrs in order to recover the OBS after a short GI Airgun profile on top the instruments. All OBS were safely recovered on 21:00 hrs. After a shallow CTD cast the deep towed Sidescan and Streamer were deployed on 22 hrs. With respect to the observation scheme of the deep towed streamer waypoints of the lines were chosen to cross mud volcanoes Odessa, Dvureshenskii, Nioz and Nameless in their centre. Unfortunately the Posidonia system lost contact to the tow fish when some 4 km of cable or more were paid out. Hence the position of the tow fish needed to be estimated by map and depth observations and manual triangulation. Due to bottom currents the ship was called to sail off the scheduled track in order to tow the sonar fish across the selected seafloor structures, which was successful in most cases.

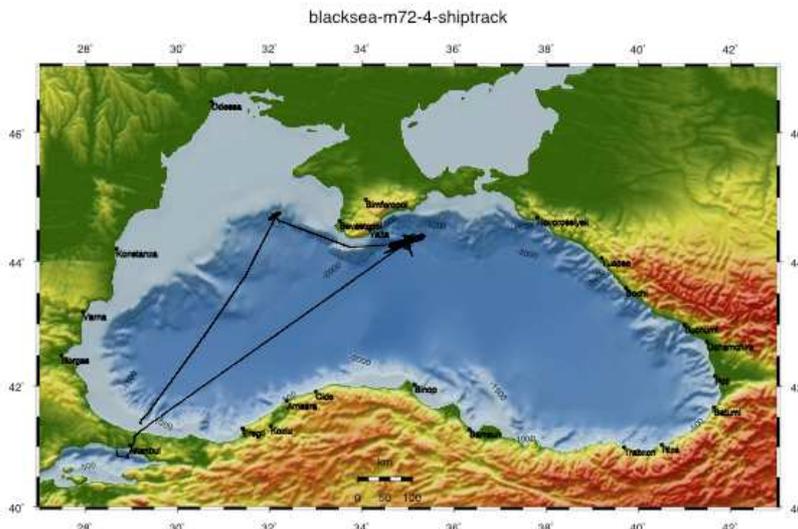
On May 7<sup>th</sup> the mapping operation with deep towed sidescan and deep towed streamer was completed and the instrument was recovered at 22:00 hrs. After completion of an additional CTD upwards the expected currents R/V METEOR left the Sorokin Trough working area and set course towards the Palaeo-Dnepr fan.

First bathymetric records in the morning of 8<sup>th</sup> May showed the remarkable depression of the Dnepr seafloor canyon, which had been observed on previous legs further to the Southern tip of the Crimean peninsula as well. Deployment of OBS across the top boundary of the gas hydrate stability field and the postulated position of possible buried diapirs the deep towed Sidescan and deep towed streamer were deployed again at 16:00 hrs.

After mapping an area with known temperature and chemical anomalies the deeper part of the slope was mapped in order to provide comparative data of seep locations. Unfortunately the EM710 multibeam for shallow water depth did not work as well. Hence we could not use the multibeam water column image of this unit for the flare documentation. Despite the efforts of the WTD service the EM120 still did tend to drift away with the depth values and consequently a lot of additional editing is required to recover at least part of the data. DeepTow operation was terminated at 11:45 hrs on 09<sup>th</sup> May. A final GI airgun profile was shot across the deployed OBS. All systems were recovered at 19:00 hrs. With a CTD station the operation in the Dnepr area was completed on 09<sup>th</sup> April 20:40 hrs.

R/V METEOR set course to Istanbul where voyage M72-4 will end in the port of Ambarli. The transit towards the Bosphorus was used to complete three additional CTD stations for overview purposes, which will be used to improve estimates of the Methane budget within the Black Sea.

As scheduled we arrived at the pilot station at 04:00 hrs on the 11<sup>th</sup> April. Nevertheless passage of the Bosphorus started at 14:00 hrs and R/V METEOR could finally dock in the port of Ambarli at 17:00 hrs.



Ship track of cruise M72-4

Kiel, 11.07.2007  
Dr. Jörg Bialas  
(Chief Scientist)