R/V METEOR

Cruise M 72/5
Istanbul (Turkey) – Istanbul (Turkey)
14.05. – 04.06.2007

Short Cruise Report

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Participating Institutions

MPI-MM	Max Planck Institute for Marine Microbiology in Bremen
IOW	Institute for Baltic Research in Rostock
LMU	Ludwig Maximilians University of Munich
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover
RCOM	Research Centre Ocean Margins, Bremen
ICBM	Institute for Chemistry and Biology of the Sea, Oldenburg
GFZ	Geoforschungszentrum Potsdam
UCR	University of California, Riverside
IBSS	Institute of Biology of the Southern Seas, Sevastopol
GeoEcoMar	National Institute for Geology and GeoEcology, Bucharest
TPAO	Turkish Petroleum Company, Ankara.

Scientific objectives

The Black Sea is the largest anoxic basin on earth. High biological productivity in the oxygenated surface waters and a deep anoxic water body below the chemocline at 100–150 m water depth provide unique conditions for anaerobic microbial life, geochemical cycling and sedimentation processes which make the present day Black Sea a modern type locality for TOC-rich sedimentation and element cycling processes in the geological past. Cruise leg M 72/5 led to various shelf and deep water areas in Ukrainian and Turkish waters. The expedition aimed at investigating the biogeochemical turnover processes in the stratified water column and sediments around the chemocline and in the deep anoxic basins in order to gain a better understanding of the actual biogeochemical turnover processes, and also on the evolutionary history of fossil TOC-rich sediments. Another focus was put on investigating the paleo-climate of the Black Sea region in the Holocene and earlier periods. The major scientific interests were the following:

- Investigate the quantitative roles and the regulations of microbial redox processes at the chemocline such as
  - Effects of intrusion of Mediterranien (Bosporus) and fresh water (rivers)
  - Anareobic ammonia oxidation (anamox)
  - Microbial activities around the chemocline
  - Phototrophic sulfide oxidation below the oxic-anoxic interface
  - Mn and Fe redox cycles
  - Mineral formation in the chemocline: chemical vs. microbial processes (e.g. Fe phosphate, MnOx, barite)
- Analyse geochemical cycling processes in the sediment such as
  - C, Fe, and S iturmover n TOC-rich anoxic sediments
  - Reconstruction of the development of the Black Sea by using the sedimentary record of major and trace elements in different water depths
  - The Role of deep biosphere organisms in Black Sea sediments
- Study of paleoceanographic and paleoclimatological development of the Black Sea region.

Temporal development of the chemocline in the Holocene
The chemocline in the water column established after the latest ice age when Mediterranean sea water entered the Black Sea through the Bosporus due to the worldwide rising sea level. The chemocline initially established in central areas of the Black Sea in greater water depths than it is now. Information on the temporal development of the chemocline will be gained by interpretation of the Fe/Al ratios and the amount of reactive iron in Black Sea surface sediments (units I and II).

Microbial processes in the water column
The deposition of algal biomass entirely consumes oxygen below the chemocline, and further remineralisation of sinking organic material by sulfate reducing bacteria releases hydrogen sulfide and mineral nutrients such as ammonia and phosphate into the deep water. These sometimes energy-rich compounds accumulate and slowly ascend towards the chemocline due to turbulent deep-water mixing. At the chemocline, reduced substances such as sulphide, ammonia, methane and manganese ions meet oxidised substances such as oxygen, nitrite, nitrate or manganese oxide, which leads to perfect conditions for a multitude of redox processes. Some of these are catalysed by known procariotic organisms, such as the during Meteor expedition M51/4 discovered new pathway of direct anaerobic ammonia oxidation (“Anammox”) to N_2 instead of aerobic oxidation by nitrifying bacteria. Another example is the in the central Black Sea occurring oxidation of sulfide with CO_2 by photoautotrophic bacteria instead of oxidation with O_2 by chemoautotrophic sulfur bacteria. The identification and characterization of the anaerobic procariotic communities was a predominant goal of M 72/5.

Biogeochemistry of the sea floor
The succession of limnic, brackish and marine sediments leads to a complexity of element and mass transfers which is not yet entirely understood. The Fe-S system and coupled biogeochemical processes play here central roles, and the modification of the primary sediment composition is very important for an interpretation of the isotopic record of fossil sulfur. Earlier investigations of pore waters and sediments showed that element transfer from brackish sediments into underlying limnic layers leads to modifications of the Fe-S system signatures. The exceptional heavy isotopic values of the sedimentary sulfides may serve as a proxy for the in Black Sea sediments very important process of anaerobic oxidation of methane, which releases H_2S that migrates into deeper and also shallower sediment layers. However, the quantitative aspects of the processes of parallel diffusion (SO_4^{2-}, H_2S, FeII, MnII, CO_2, CH_4) in the Black Sea sedimentary system are not yet understood. With respect to this, the microbial reactions below the present-day sulfidization fronts in anoxic sediments, which for example is the zone of methanogenesis, gain major importance because they

associate with the establishing element transfers. The mechanistic and quantitative aspects of the linkages between the turnovers of metals and sulfur is still unclear.

Paleo climate
The sediments represent an archive of the evolution of the Black Sea and the development of the Holocene climate in the entire Black-Sea region. Fluvial material transported by rivers deposits in the Black Sea and thus archives climate signals originating from various climate regions of central Europe, southern Russia, Turkey and the Mediterranean. The fine-laminated sediments provide an excellent opportunity for high resolution analyses of the paleo-climate history.

Instruments

The sampling equipment included two CTD/rosette water samplers of different water sampling capacity, a special pump-CTD, deep-sea in-situ pumps, a 10 m long gravity corer, and a multi-corer for sampling undisturbed top layers of sediment. The pump-CTD was used for pumping chemocline water directly from precisely determined layers into the laboratories, where it passed various online sensors for geochemical parameters before it was sampled. Deep-sea in-situ pumps were used for the enrichment of particles and microorganisms on micro-pore filters in discrete water depths down to 2200 m depth. A luminometer served for measurements of light intensity around the chemocline. Sediments were surveyed for turbidites with an Atlas Parasound echosounder, bathymetry surveys were performed with a Kongsberg EM 120 multi-beam echosounder.

Cruise narrative

An advance group of scientists entered the ship in the morning of 12-May in Ambarli / Istanbul harbor when the loading of scientific equipment began. The loading went fast and we started immediately afterwards with setting up the laboratories and installing sampling equipment, while the rest of the group joined in the following day. An early set up of the equipment was very important because the first oceanographic station was planned for only a few hours after passing the Bosporus and transit times therefore would be very short.

In the morning of 14-May, we left port for a sea trial of the Kongsberg EM 710 Echosounder that had been serviced by Kongsberg in Ambarli harbor (not used during M 72/5). The sea trial happened around 40°49’N, 28°57’E in about 1200 m water depth in the Marmara Sea. It was completed in the afternoon and RV Meteor approached again the coast between Ambarli and Istanbul in order to meet a boat coming from shore that took over the leaving Kongsberg engineer and brought a new doctor to replace the former one who had already left in harbor because of health problems. After receiving permission for the passage, we entered Bosporus around 19:00 local time and passed the city of Istanbul which presented its skyline as a golden silhouette illuminated by the evening sun.

We began our research program with a transect of water column stations between the Bosporus opening and the central Black Sea which served for investigating the effects of Mediterranean sea water intrusion on biogeochemical and microbiological processes around the chemocline. According to the working permission by Turkish authorities, we started with the more centrally in the Black Sea located stations, while the peripheral part of the transect should wait until the end of the cruise. Around 11:00 a.m. 15-May, we reached the first oceanographic station at 42°20'N, 32°00'E where we performed our first pump-CTD cast. This station was followed by three other pump cast stations along the transect. This work ended in the early morning of 16-May at 42°50'N, 33°30'E.

After 4 hours of transit we reached an area around 42°22'N, 32°38'E in Ukrainian waters were we performed 3 hours of bathymetry mapping and Parasound profiling and established a station for extended water column work. We spent the following 2 days at that position with light measurements across the chemocline, a total of 6 CTD/rosette casts in various water depths, 1 pump-CTD cast and three in-situ pump deployments across the chemocline, 2 lowerings of the multi-corer and one of the gravity corer. As the sediments revealed to be inadequate for recovering undisturbed sedimentary sequences, we decided to search for a more promising area upslope to the northwest. The bathymetry/Parasound profiling on the way showed frequent erosion channels. A station for sediment coring was finally chosen at 43°26'N, 32°17'E, where we took one gravity core and one multi-core.

Between 19 and 21-May we worked our way up the slope to the north and across the shelf break west of the paleo-Dnepr delta with 6 stations in water depths between 1537 m and 75 m. Parasound profiling always preceded the sediment coring in order to avoid turbidites. Water column work was generally performed 0.5 nm off the coring sites. Lowerings at these 6 stations included a total of 5 CTD/rosette casts, one pump-CTD cast, 4 gravity cores, 10 multi-cores, 3 in-situ pump deployments and 2 light measurements.

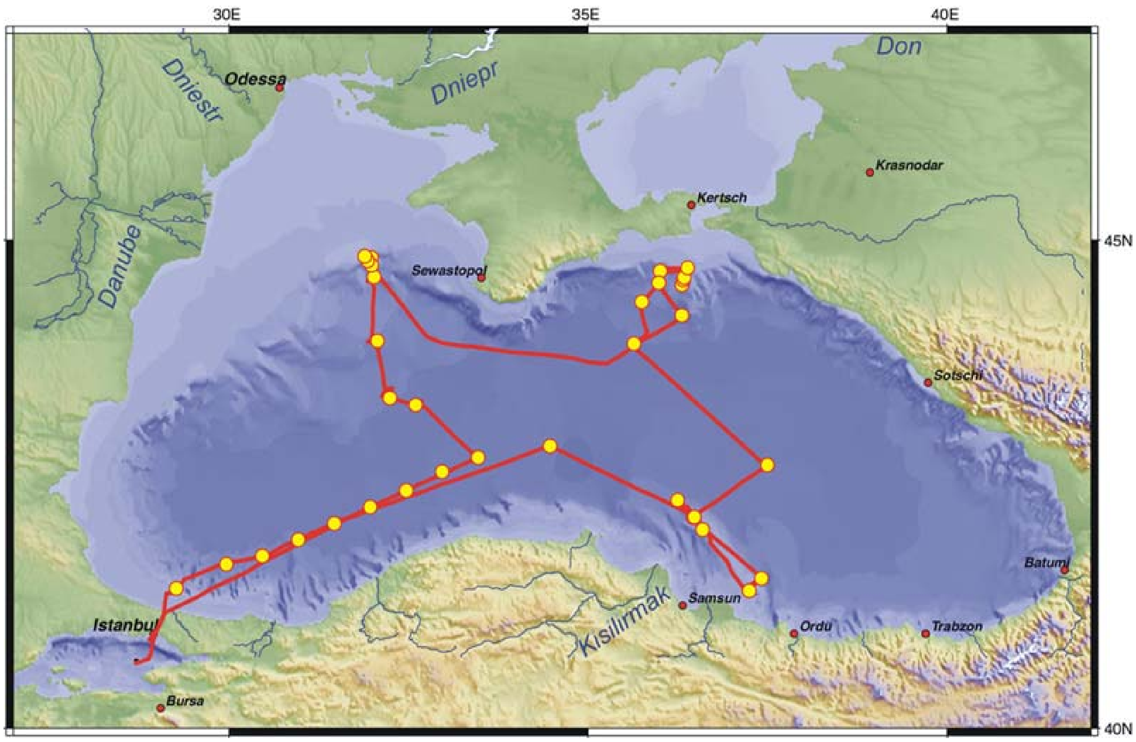
In the night of 21-May we left the paleo-Dnepr area, went around the Crimea peninsula and performed a bathymetry/Parasound profile starting from deep waters at 43°47.10'N, 35°20.16'E and heading north into shallow oxic bottom water areas at 44°43'N, 36°25'E. We determined 8 sampling locations along this transect at various water depths ranging from oxic bottom water conditions in 70 m down to the anoxic basin in 2000 m. We sampled this transect between 23 and 25-May with a total of 6 CTD/rosette casts, one pump-CTD cast, 8 gravity cores, 16 multi-cores and one light measurement.

We left this area, and with this also Ukrainian waters, in the evening of 25-May and entered again the Turkish Black Sea sector where we established another deep water station for extended water column work at 43°57.24' N, 35°38.46' E. This station was chosen because it was located within the eastern Black Sea gyre and thus presented an ideal counterpart to the water column work performed during 16/17-May in the western Basin gyre. Here we had four CTD/rosette casts, one pump-CTD, 3 in-situ pumps and one light measurement. We left this location in the afternoon of 27-May and reached Chagalsky Ridge north of Samsun (Turkey) in the evening.

A first bathymetry/Parasound survey covering a water depth range of 780 – 1980 m along the ridge revealed that the ridge slopes are widely covered by erosion channels while the crest offered promising locations for coring undisturbed sediments. We chose a station at 842 m water depth where we recovered in the morning of 28-May an extraordinary ~9 m long gravity core that showed a continuous sediment sequence throughout its length and included a sapropel layer in 8 m depth. This sapropel deposited 130 ka ago after the Eem glacial, and the recovery of a complete sedimentary record over that long time period is a real scientific highlight because this core will allow complete reconstruction of the Black Sea history. A second gravity core from roughly the same position showed turbidites indicating that patches of undisturbed sediment are small.

We left this position in the afternoon and continued our bathymetry/Parasound survey uphill along the ridge in southeasterly direction until we reached 212 m water depth. During the night to 29-May, we sampled the water column and sediments off the ridge in 1850 m water depth (one each of CTD/rosette, pump-CTD, gravity core, multi-core), before we returned to the ridge for coring a total of 4 stations along the crest in water depths between 210 m and 2000 m. In the night to 31-May, we returned to the 850 m position and performed detailed Parasound profiling where the Eem sapropel had been sampled three days before. The following daytime was entirely spent for coring, and at the end we recovered two more gravity cores containing Eem sapropel.

In the night to 01-June we moved from Chagalsky Ridge to a central position in the Black Sea at 42°57'N, 34°30' E where we performed final casts for deep-water CTD and pump-CTD. We left this station in the early afternoon with direction to midway of the water column transect between the Bosporus opening and the central Back Sea, which was only half sampled during the beginning of the cruise. Around midnight we reached the next station on this transect at 42°10'N, 31°30'E. During the following 24 hours we worked our way back towards the Bosporus opening with 4 more stops for pump-CTD casts. Scientific work ended in the early morning of 03-June at 41°35N, 29°25'E. We entered the Bosporus around noontime 03-May and reached the Marmara Sea in the afternoon where we waited until the next morning for harbor clearance. We entered Ambarli / Istanbul port 04-June around 08:00 a.m. and unloaded all scientific equipment until noontime. All scientists left the ship in the morning of 05-June.



Cruise track line and locations for sediment and water column sampling during Meteor expedition M 72/5 (14-May – 04-June, Istanbul – Istanbul).

Scientific program during Meteor Expedition M 72/5

Gravity corer	22 deployments
Multi-corer	38 deployments
CTD/Rosette	40 deployments
Pump-CTD	18 deployments
In-situ pumps	11 deployments
Luminometer	6 deployments
Parasound profiles	431 nm
Multi-beam echosounder profiles	431 nm

Black Sea EEZ sectors entered

14-May: Turkey
16-May: Ukraine
26-May: Turkey