Implications for formation mechanisms of methane hydrates and recommendations for the future researches in correlative anoxic basins: observations from R/V METEOR (IFM-GEOMAR) expedition in the Black Sea Cruise M72/4-2007

*Mustafa Toker, **Joerg Bialas, **Ingo Klauke, and Scientific crew of R/V METEOR cruise

*Istanbul Technical University, Eurasia Institute of Earth Sciences,
Ayazağa Campus, 34469, Maslak-Istanbul/Turkey
tokermu@itu.edu.tr.
**Leibniz Institute of Marine Sciences, University of Kiel (IFM-GEOMAR), Germany

This presentation describes the gas venting and related sedimentary structures in the N-Black Sea, mainly based on the work reports of the R/V Meteor Cruise M72/4/2007 in the Black Sea and some observations. The cruise obtained high quality geophysical data on sedimentary and gas venting structures in the N-Black Sea. When approaching this working area and while deploying the Ocean-Bottom-Seismometers (OBS) gas flares observed during the last leg M72-3 at Dvureshenskii mud volcano were checked by Parasound recordings and methane gas flares were detected. The large 32 l BOLT airguns provided an image of the deeper structure, which was accompanied by signals with higher frequency from a GI-airgun. A critical observation was a flare emitting from Odessa mud volcano, a structure located NE of the active Dvureshenskii to Nioz chain. From observations with the Parasound system the direction of water currents was well estimated and we had a good chance for positioning of the CTD inside the flare volume as well as outside of it.

The major task was dedicated to the scheduled investigations with the deep towed Sidescan Sonar. The online display of Sidescan and sub-bottom profiler data already provided a good impression of a numerous amount of mud flows, which occurred at varying positions in the Sorokin Trough. Among such are very recent slides as well as already covered older ones. Spectacular pictures of recent activities in the area are not only given by the flares observations but also by images of young slides. Within the Sidescan figure the large dimensions of such a structure were well imaged. With a length of more than 1500 m and a width of 450 m an enormous amount of debris has been moved. With the section view of the sub-bottom profiler the height of the sidewalls was measured to be almost 10 m, which sum up to about 7 million m^3 of sediment in motion. The near vertical steepness of the sidewalls indicated the young age of the slide. A good image of the sediment thickness and hence the deeper relief of the province was obtained. Seismic transparent zones underneath strong reflecting horizons were possible to image. These provided an image of the related fluid migration pathways.

Based on the above review of geophysical data, a rough examination and preliminary interpretation of the collected data well provide some critical highlights and specific approaches into an overall understanding of prevailing anomalies on all scales and lead to a better and deeper review of closed anoxic environments. Prominent gaseous anomalies and related depositional pecularities are shown to be common to deformations taking place on regional scale of the Black Sea. The extensive study of these points requires new parameters to be taken into account, such as tectonics and sedimentation, which are thought to have acted as interactive dynamic systems in affecting hydrate formation. Hence, these interactive systems well implicate for formation mechanisms of Methane hydrates in similar and correlative anoxic basins in the world. Tectono-sedimentary implications focus on methane hydrate phenomenon of the Black Sea. It is considered that their dissociation can be of critical importance to not only climate change, but also prevailing tectonic factors on all scales. Methane hydrates are not given sufficient attention in terms of tectonic and sedimentary interactions by the scientific community, particularly in the Black Sea region. For this reason, Methane hydrates and their prominent formation in the Black Sea are considered in terms of tectono-sedimentary factors, their occurrence and flux, in relation to seasonal variations and changes in Mediterranean-Black Sea circulation.

The Black Sea has a potential of the huge amount of anoxia and hydrocarbons. This potential is related to hydrological and sedimentological maturation of such a closed environment and may be also related to extensive tectonic uplift, subsidence, rapid sedimentation and uneven development of sedimentary overburden, especially in and along broadly widening shelves of N-delta margin, as different from the steep and narrow shelves in S-margin. This may suggest irregular seabed morphology, asymmetric tectonic factors and deformation patterns between margins, strongly affecting the formation styles of Methane hydrates. The large variation of seabed morphology through the Black Sea provides a potentially broad range of responses to climate change and resulting circulation, sediment, chemical, and biological cycles. Prediction of these changes needs to focus on potential environmental impact and coast-shelf-slope stability, resulting from tectonic and sedimentary changes.

The Black Sea region has unique physical, oceanographic, bathymetric, sedimentological and tectonic conditions, all of which may impact on the occurrence and dissociation of the Methane hydrates, which are known to exist in this region. Past and present studies show that the continental slopes and rises contain thick organic-rich sediment successions which, through biogenic processes, lead to the formation of Methane, depositional unstability and related interactions. In Black Sea, due to strong and asymmetric tectonic uplift and subsidence, particularly along the steep slope and narrow shelf sections of Turkish margin in S, pressure and temperature variations are strongly critical to Methane stability. Hence, Black Sea has a formation potential of both shallow and deep water hydrates as a function of changes in temperature. Low temperatures permit the formation of Methane hydrates in shallow water (uplifting sections). However, hydrostatic pressure as a controlling mechanism permits the formation of hydrates in deep water (subsiding sections). Formation mechanism of both shallow and deep water hydrates suggests that the variability of tectonic factors and the stability of the depositional successions have significant impact on hydrate dissociation, its subsequent escape into the atmosphere and thereby impact on climate change. Particularly, bottom simulating reflectors (BSR) are very sensitive to temperature and pressure changes and these reflectors are thought to have acted as natural thermometers showing local variations in pressure gradients.

Basic scientific implications addressed in this brief text well provide some critical recommendations for the future researches in similar and correlative anoxic basins. The most prominent one of these includes the extensive study of the seasonal variability of methane hydrate dissociation and its subsequent absorption in the water column and/or escape into the atmosphere. For that reason, it is necessary to acquire and integrate seismic reflection-refraction (velocity data), heat flow (crustal and sedimentary), tectonic (uplift-subsidence) and geochemical data for the evaluation of hydrate occurrence and distribution within the sediments. This is, since, essential to estimate the spatial variation in the vertical methane diffusion in comparisons of sediment and water column temperatures, heat flow, seismic profiles, and water column depth. Developing model sections and their calibration to evaluate sediment hydrate loading or overloading, hydrate destabilization through regional or global warming, and the fate of methane after hydrate destabilization are extremely needed. These model sections should be based on the laboratory thermodynamic model sections for dissociation of gas hydrates under meta-stable conditions in sediments, as well as on the laboratory elastic model sections of sediments containing pore waters and gas hydrates, including during dissociation. In addition to these, underwater acoustic sedimentology, basic sediment and water column chemistry to study microbial methanotrophic activity and its control on methane emissions should be conducted. Finally, the relative sediment-methane partition between water column and atmosphere must be accurately identified and thus, the seasonal and spatial variation of methane flux to the atmosphere between the Black Sea region and surrounding land masses can be established. All these parameters will serve to develop multi-disciplinary and multi-component researches on Methane hydrates and their long term monitoring in the Black Sea region.