SHORT CRUISE REPORT

R. V. M E T E O R

Cruise 51, Leg 4

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Bremen / Germany

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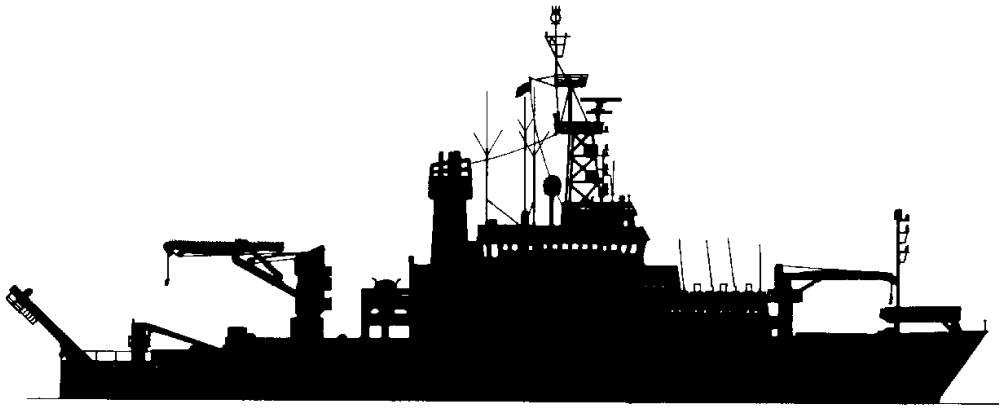


Scientific prospectus

The Black Sea and the adjacent Sea of Marmara as isolated marginal seas react particularly sensitive to paleoenvironmental changes. Late glacial to Holocene marine and lacustrine sediments of the Black Sea and the Sea of Marmara therefore provide a unique opportunity for high resolution paleoclimate investigations. Detailed sedimentological analyses of both the marine sediments deposited since the early Holocene and the late glacial limnic sediments are planned. The main focus will lie on analyses of the terrigenous sediment input, which is in the main study area on the northwestern continental slope dominated by fluvial material supplied by the Danube river and therefore contains climate signals from southeast and central Europe. Through complementary studies of sediment cores from the southwestern Black Sea and the Sea of Marmara, we plan to achieve a link to the Mediterranean climate system.

The expected high resolution paleoclimate records provide the potential to study Holocene climate variations on up to interannual/decadal time-scales. Through comparisons with other high resolution records both from the continent (e.g., Greenland ice-cores and lake sediments/tree-rings from Europe) and the marine realm (e.g., Arabian Sea, eastern Mediterranean Sea, and Red Sea), we aim to detect global or at least hemispheric climate signals (e.g., ENSO and NAO) in order to contribute to a better understanding of their long-term variability.

The Holocene sedimentary sequences of the Black Sea which were deposited predominately under anoxic conditions provide a unique opportunity to study biogeochemical budgets in relation to the Holocene climate evolution with highest temporal resolution. This specific sedimentary environment resulted in thinly laminated sediments that contain mainly annual layers for the last ca. 7500 years. The type-locality for TOC-rich deposits in the geological past, the Black Sea provides an ideal area to study biogeochemical cycles. Through the multi-disciplinary approach combining solid and liquid phase analyses on high-resolution sediment profiles and in the water column with mirobial process analyses and modeling, will contribute to the understanding of biogeochemical processes leading to the development of specific element signals during sediment formation under oxic and anoxic conditions.

Sediment sampling and onboard sedimentological core description

Sediments were sampled with a multicorer and a gravity corer at 26 stations in the Sea of Marmara, the NW, and SW Black Sea after detailed surveys with the shipboard PARASOUND system. In the Sea of Marmara 3 multicores and 6 gravity cores were retrieved . In the NW Black Sea, we recovered 22 multicores and 19 gravity cores along a depth transect from the deep basin at ca. 2200 m water depth to the shelf just above the shelf break (ca. 80 m water depth). Additionally, in the SW Black Sea sampling area 6 multicores and 7 gravity cores mainly from mid-water depth at the continental slope were retrieved.

We recovered gravity cores from three stations within the Sea of Marmara. Sediments mainly consist of homogenous muddy clay to clay with some shell fragments, occasionally

interrupted by thin probably turbiditic silt and sand layers. In two cores, characteristic dark organic-rich intervals were observed in the upper part of the sequence.

In the NW Black Sea sediment, cores were recovered on a depth transect from the deep basin to the NW Black Sea shelf. The cores from the continental slope all show a similar undisturbed sequence of fine grained sediments with a finely laminated interval at the top and homogenous to (mostly) cm-scale laminated sediments further downcore. At varying core depths one or two completely black or patchy black/gray intevals with enrichments of sulfidic minerals reflecting reduction zones can be noted. Two additional cores were recovered from the NW Black Sea shelf at water depth of 118 and 168 m. In both cores sediments are characterised by a notably homogenous sequence of mud with abundant shells and shell fragments of bivalves and gastropods. Maximum 2 cm thick silt/sand layer probably represent turbidites and/or storm layers.

Only one sediment core was opened and sedimentologically described from the SW Black Sea, located at a water depth of 1300 m. Sediments are characterised by an intercalation of cm-thick homogenous clay intervals and thinner finely laminated sequences of predominantely light laminae in the upper part and dark laminae further downcore. The lowermost part of the core reveals homogenous clays without a pronounced lamination.

BioGeochemistry, inorganic geochemistry, organic geochemistry, and microbiology

Sediment and pore water samples have been taken from short multi corer cores and long gravity cores to analyse them for solid and dissolved constituents and gases as well as the bacterial community structure. In situ pore water measurements of pH and hydrogen sulfide and shipbord measurements of alkalinity, ammonium and methane from gravity cores reflect the different microbial processes going on in the sediment-pore water system.

Most of the analytical work on the recovered samples will be done in the home laboratories.

Main, minor and trace element signatures of sediments will be analyzed in high time resolution in cores recovered in the Marmara Sea and on a transect between the shelf and deep sea of the Black Sea to follow changes in the depositional environment and the origin of the detrital terrigeneous components. Additionally, sedimentary solid phases and interstitial waters were and will be investigated to characterize early diagenetic processes. This is related to modifications of sulfur- and metal-bearing sedimentary phases caused by the development of an anoxic water column.

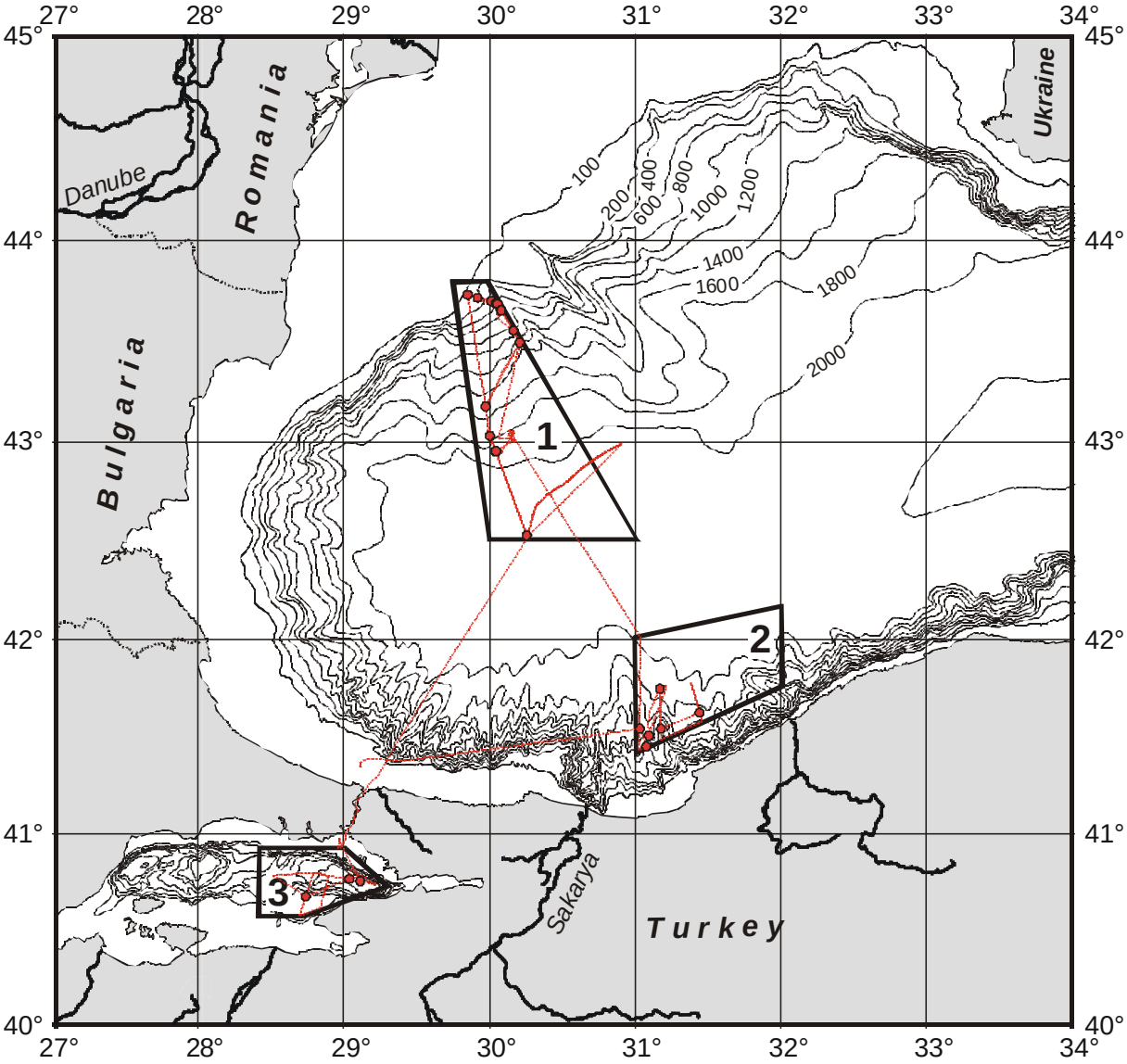
The geochemical characterization of sediments will look for element signatures characteristic for the paleoenvironment (connection to the Mediterranean; changes in salinity; water column anoxia) and will be combined with a characterization of water colum salinity based on an analysis of the diatoom community. Additional informations on the depositional environment and possible diagenetic overprints will be obtained from a bulk and molecular characterization of the organic matter. The biogeochemical processes in the deeper sediments will provide quantitative information about the superimposition of the sedimentary signatures by microbial and diagenetic processes. This includes the quantitative importance of sulfate

reduction, methane oxidation and element fluxes in the pore waters. The authigenic mineral phases will be characterized by analysis of their magnetic properties, XRD, stable isotope techniques and chemical extraction procedures. We prepared sediments to measure bacterial sulfate reduction rates (SRR) on Multicores (MUCs) on 19 Stations. Additionally, samples for measurements of SRR and anaerobic methane oxidation rates were incubated from 4 long Gravity Cores (GeoB stations 7602, 7605, 7618 and 7620). To do this sediments were incubated with ^{35}S and ^{14}C tracers onbord and will be measured and evaluated in the home laboratory.

An additional part of the biogeochemical and molecular biological investigations was a detailed analysis of processes in the coupled N-C-S-Mn-Fe cycles at the redoxcline in the water column of the Black Sea. Particulate, bacterial and dissolved material was sampled at several stations with flow-through pumps and will be analyzed for sulfur species, main and characteristic trace elements as well as the type of organic material. It is also planed to follow the degradation of organic matter and mineral formation and dissolution processes in the water column as a function of water depth, to extract information about element signatures typical for anoxic basins. The microbiological and molecular biological investigations will focus on the relation between microorganisms and biogeochemical processes in the water column and the sediment to increase our knowledge on the abundance and activity of microbes in a permanently stratified water body. Essentially all of this work has to be completed in the home-based laboratories.

These highly inter- and intradisciplinary studies will create a data base which will result in complex models on biogeochemical element cycling in the water column and the sediments.

Overview map: Sampling areas and ship route M51/4

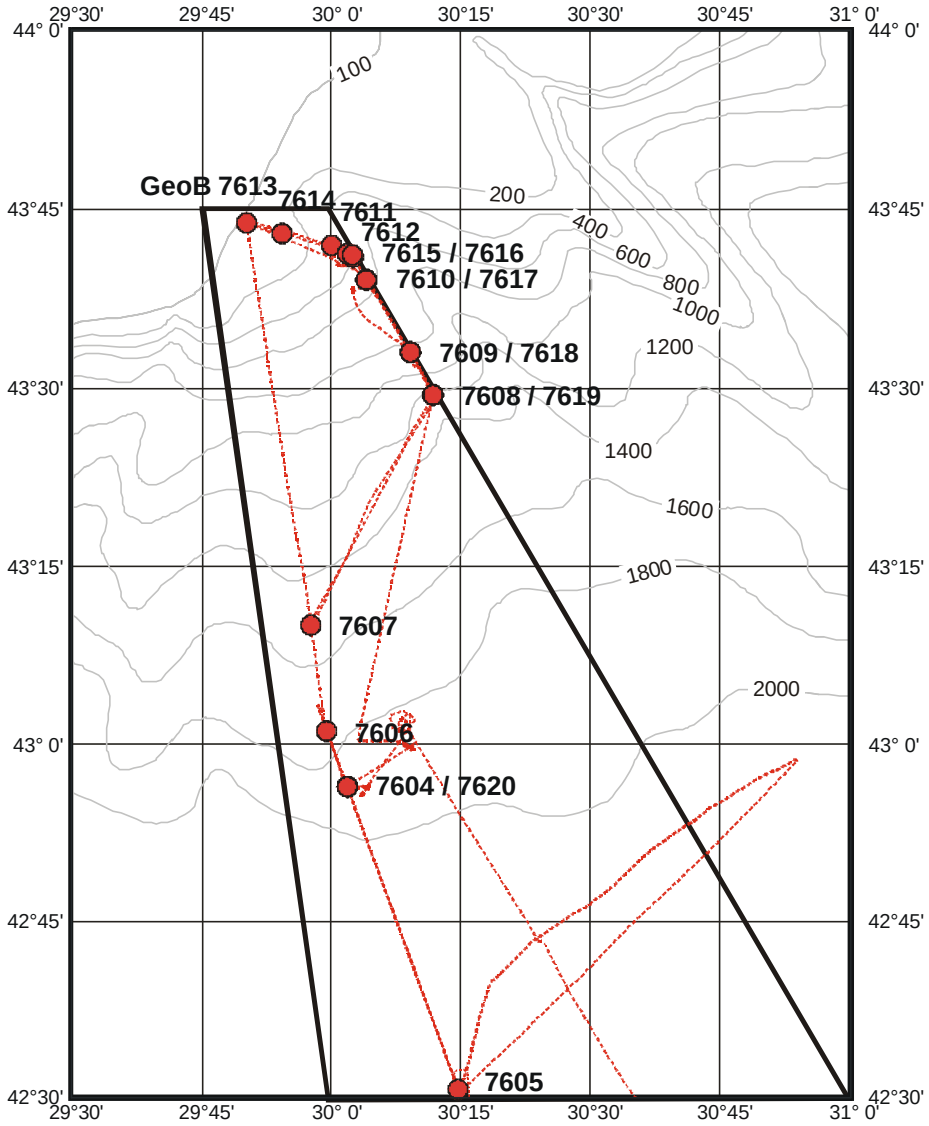


Boxes define sampling areas:
1. NW. Black Sea
2. SW. Black Sea
3. Sea of Marmara)

ship route

sampling stations

1. NW. Black Sea (continental slope):



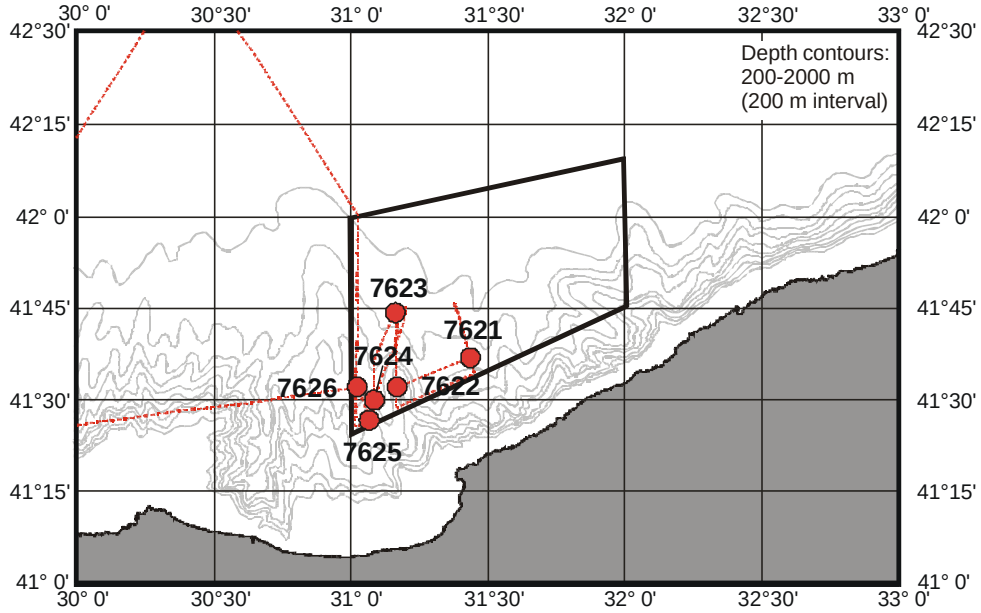
Box defines approximate sampling area outside the 12-miles zone off Bulgaria.and Romania

Geographic coordinates: ca. **43°45´N, 29°45`E; 43°45´N, 30°00´E; 42°30´N; 30°00´E; 42°30´N, 31°00´E**

ship route

GeoB sampling stations

2. SW Black Sea (continental slope off Turkey):



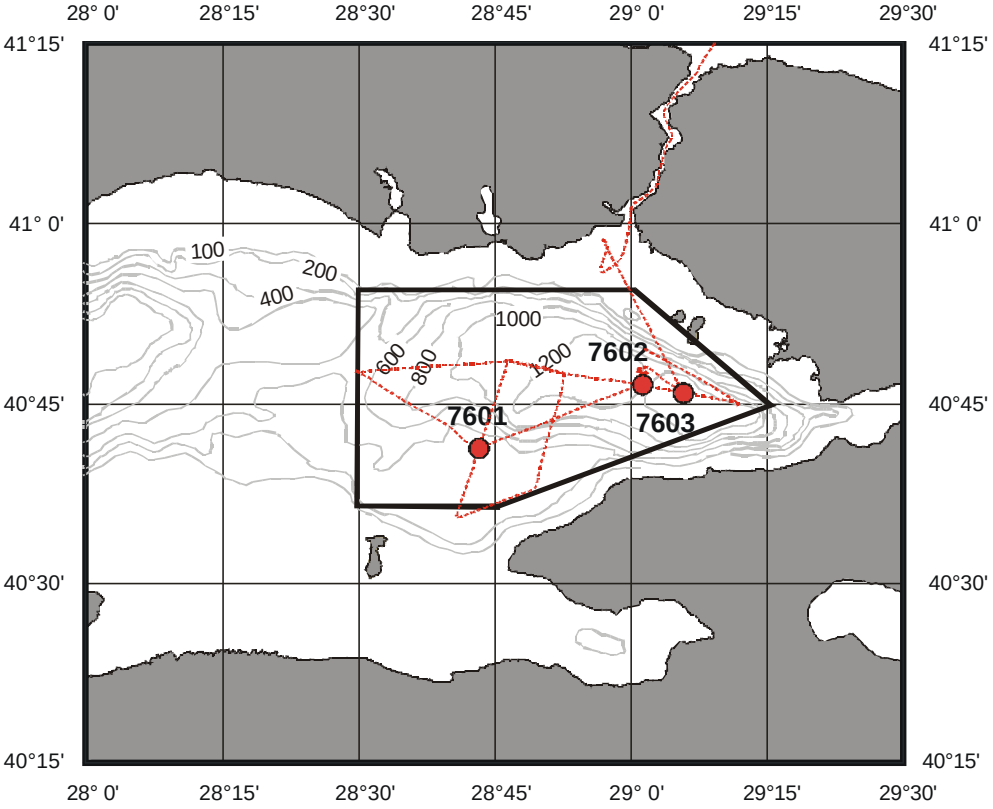
Box defines approximate sampling area on the continental slope off the Turkish coast.

Geographic coordinates: ca. **42°00´N, 31°00´E; 42°10´N, 32°00´E; 41°40´N; 32°00´E; 41°20´N, 31°00´E**

ship route

GeoB sampling stations

3. Sea of Marmara:



Box defines approximate sampling area in the eastern basin of the Marmara Sea off the Turkish coast.

Geographic ccordinates: ca. **40°55´N, 28°30´E; 40°55´N; 29°00´E; 40°45´N, 29°15´E; 40°35´N, 28°45´E; 40°35´N, 28°30´E**

ship route

GeoB sampling stations