A MULTI-PROXY STUDY OF CLIMATE AND ENVIRONMENTAL CHANGE FROM THE BORNHOLM BASIN (BALTIC SEA)

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Sediments accumulating in the modern Baltic Sea represent valuable archives of late Pleistocene and Holocene climate change as well as of climate-driven perturbations in the depositional environment and aquatic ecosystem structures of the Baltic Sea. In the Bornholm Basin, a ca. 84 m deep morphological depression close to the Danish straits, a 46 m-thick sediment sequence consisting of varved glacial clays and organic-rich mudstones was recovered during IODP Expedition 347 - "Baltic Sea Paleoenvironment" that allows a high-resolution study of paleoenvironmental and climate change of central Europe.

Results of our bulk organic-geochemical, isotope and lipid biomarker analyses demonstrate that the Baltic Sea experienced some drastic environmental and hydrological changes since the last deglaciation. Sediments that accumulated in the Baltic Ice Lake (13.500-10.300 yrs. BP), the Yoldia Sea (10.300-9.500 yrs. BP) and the Ancylus Lake (9.500-8.000 yrs. BP) generally consist of varved grey to dark-grey clay and greyish-brown silty clay that are characterized by low TOC contents varying between 0.1-1.6 wt%. These values indicate an overall low primary productivity and/or oxygenated bottom waters in the freshwater to brackish early Baltic Sea, which is in agreement with low total sulphur (TS) values. Low TOC/TN ratios ranging from 2.9-12.4 indicate that the majority of the organic matter is derived from an aquatic source. The mean annual air temperature (MAAT) had an average value of 6 °C based on the sedimentary distribution of branched GDGTs (Sun et al., 2011), which is in agreement with pollen based temperature reconstruction from the Little Belt region (Kotthoff, personal communication). The occurrence of low abundances of heterocyst glycolipids (HGs) indicate that N_2-fixing heterocystous cyanobacteria constituted a common but minor component of the phytoplankton community in the Baltic Sea since the last deglaciation.
With the transition to the Littorina Sea phase (8.000-3.000 yrs. BP), TOC values increase considerably, averaging 4.3 wt%. Two maxima with 6.1 and 7.7 % TOC occuring at depth of 4.6 and 9.1 mbsf, respectively, are time-equivalent to the Medieval Climate Anomaly (MCA) (1.250 – 950 yrs. a BP) and the Holocene Thermal Maximum (HTM) (7.000 - 5.000 yrs. BP). During these intervals, the bottom waters of the Bornholm Basin were likely anoxic to euxinic as evidenced by a strong increase in TS from 0.3 to 2.7 wt%, indicating increased rates of sulphate reduction and enhanced preservation of organic matter. This is in agreement with the generally fine lamination of the organic-rich mudstones deposited in this interval of the core. MAATs (based on the calibration by Sun et al., 2011) increased to 11 °C, which is consistent with a contemporaneous increase in TEX^{L}_{86}-based sea surface temperatures (SSTs) (based on the calibration by Kabel et al. 2012) to maximum temperatures of 22 °C during the HTM. A similar increase in TEX^{L}_{86}-based SST to values of 27°C has also been observed for the MCA. Both periods coincided with increased abundances of TOC, indicating higher primary productivity and more stagnant bottom waters in the Bornholm Basin. Interestingly, HGs substantially increase with the start of the Littorina Sea phase and they are particular

abundant during the HTM and MCA, suggesting an increased proliferation of cyanobacterial blooms with the establishment of a stratified water column and bottom water anoxia.

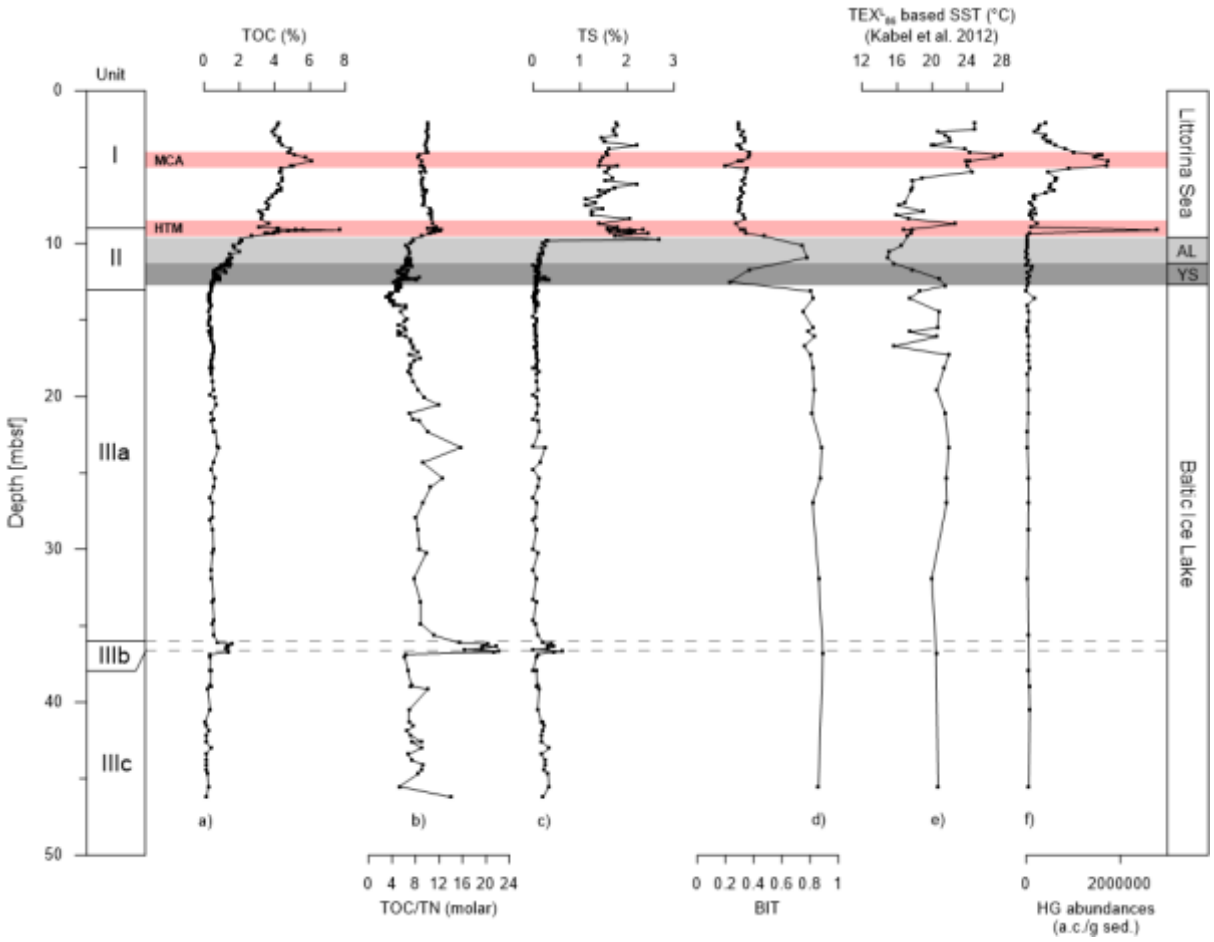

Figure 1: *Downcore profiles of (a) total organic carbon (TOC), (b) total organic carbon/ total nitrogen (TOC/TN), (c) total sulphur (TS), (d) branched and isoprenoid tetraether index (BIT), (e) TEX^{L}_{86}–based sea surface temperatures (SSTs) based on the calibration by Kabel et al. 2012 and (f) heterocyst glycolipids (HG) abundances from the Bornholm Basin (Baltic Sea). YS: Yoldia Sea (stage of the Baltic Sea history; 10.300-9.500 yrs. BP), AL: Ancylus Lake (stage of the Baltic Sea history; 9.500-8.000 yrs. BP), HTM: Holocene Thermal Maximum (7.000 - 5.000 yrs. BP), MCA: Medieval Climate Anomaly (1.250 – 950 yrs. a BP)*

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