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Manganese cycles in Arctic marine sediments – Climate signals or diagenesis?

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In comparison to sediments from other parts of the world ocean, the inorganic geochemistry of Arctic Ocean sediments is poorly investigated. However, marked light to dark brown layers are well-known features of Quaternary Arctic sediments, and have been related to variable Mn contents. Brown layers represent intervals relatively rich in Mn (often > 1 wt.%), while yellowish-greyish intervals contain less Mn. As these brown layers are widespread in pelagic Quaternary deposits of the Arctic Ocean, there are attempts to use them as stratigraphic, age-equivalent marker horizons that are genetically related to global climate changes (e.g. Jakobsson et al., 2000; Löwemark et al., 2008). In the Arctic Ocean, other conventional stratigraphic methods often fail, therefore the use of Mn-rich layers as a chemostratigraphic tool seems to be a promising approach. However, several inorganic-geochemical and modelling studies of Mn cycles in the Arctic as well as in other parts of the world ocean have shown that multiple Mn layers in marine sediments can be created by non-steady state diagenetic processes, i.e. secondary Mn redistribution in the sediment due to microbially mediated dissolution-reprecipitation reactions (e.g. Li et al., 1969; Gobeil et al., 1997; Burdige, 2006; Katsev et al., 2006). Such biogeochemical processes can lead to rapid migration or fixation of redox boundaries in the sediment, resulting in the formation or (partial) destruction of metal-rich layers several thousands of years after sediment deposition. As this clearly would alter primary paleoenvironmental signals recorded in the sediments, we see an urgent need to unravel the real stratigraphic potential of Arctic Mn cycles before they are readily established as standard tools. For this purpose, we are studying Mn cycles in Arctic Ocean sediments recovered during R/V Polarstern expedition ARK XXIII/3 on the Mendeleev Ridge (East Siberian Sea). First results of pore water and sediment composition (analysed by ICP-OES and WD-XRF) indicate that certain Mn-rich layers are currently dissolving, while others are forming. This internal Mn re-distribution, while being more pronounced in some locations than in others, also has an impact on related trace metal distributions (e.g. Co, Cu, Ni, Mo). As Mn diagenesis obviously occurs in most cores studied so far (pelagic depositional areas unaffected by turbidites), we conclude that caution has to be taken when applying Mn layers as stratigraphic tools. In addition to more sensitive analyses (acid digestions and HR-ICP-MS measurements), we will apply methods like sequential Mn extraction, X-ray diffraction and electron microscopy to study these Mn-rich layers. These data will be put into a broader context by comparing them to parameters like magnetic susceptibility, grain size distribution, sediment colour or porosity. Hopefully, this will result in a better understanding of Mn biogeochemistry in the Arctic Ocean, including its application as paleoenvironmental proxy.

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