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High-resolution redox dynamics of iron and manganese as recorded in the sediments of Lake Zurich, Switzerland

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Trace metals, such as iron (Fe) and manganese (Mn), have received much attention in the last decades due to their redox-sensitive behaviour in the environment. In lakes, seasonal redox changes in the water column lead to biogeochemical cycling of Fe and Mn throughout the year. Under reducing conditions during stratification, they are (re)dissolved from the sediment. After water column (re)oxygenation during mixing, they precipitate and can be deposited and preserved in the lake sediment. In this case, they can serve as palaeoredox proxies.
Although the redox-sensitive behaviour of Fe and Mn is quite well understood, the relationship between high-resolution trace metal data and short-term oxygen level changes still need to be shown. Therefore, in this study, seasonal redox dynamics of Fe and Mn were reconstructed in sediment cores along a depth transect from the mesotrophic and dimictic Lake Zurich, based on detailed measurements using a X-ray fluorescence (XRF) core scanner. A sample resolution of 0.3 mm enabled a high-resolution, semi-quantitative record of trace metals in the retrieved sediment cores. The bi-annual lamination pattern (i.e. varves) in the sediment, which is especially well reflected in the cyclic calcium (Ca) XRF data, was used to establish a precise age model with seasonal resolution. This trace metal record could be correlated with a unique long-term monitoring data series of water column properties, including monthly oxygen data, which exist for different water depths since 1936.
The Fe signals were quite complex. As iron can be of detrital origin, as well as the product of redox-sensitive processes, the interpretation of the Fe concentration as palaeoredox proxy is not clearly determined. Peaks of Fe in fall/winter seemed to evidence traces of oxygen resupply. However, detrital inputs were also higher at this time of the year and high Ca intensities might lead to a dilution of Fe especially during summer time.
In contrast, the match of Mn maxima with higher oxygen levels shows that oxygenation events during the winter half-year could be traced precisely in the core obtained from the maximum depth (137 m). However, the disappearance of Mn peaks in cores from lower water depths strongly indicates geochemical focusing. This process was earlier described in lower temporal resolution in similar lake systems (e.g. Lake Baldegg, Switzerland) leading to a removal of Mn from shallower water depths and the enrichment in sediments at maximum lake depth.