Vivianite formation and geochemical focusing of manganese and iron in Lake Arendsee (NE-Germany)

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Geochemical focusing is the redistribution process of redox-sensitive metals from shallower towards deeper sediments in aquatic ecosystems. Although potential element enrichments may have important consequences for the understanding of redox proxy formation and nutrient cycling, there is still little known about mechanisms and controlling factors. We tested how geochemical focusing affected the distribution of manganese (Mn), iron (Fe), and phosphorus (P) in sediments deposited during pre- and eutrophic conditions in the dimictic and 49.5 m deep Lake Arendsee (NE Germany). Thirteen about 40 cm long sediment cores were taken from different water depths and their elemental composition was determined by an XRF core scanning and ICP-OES. Sequential fractionation of Mn and Fe was used to differentiate between oxides and carbonates from non-reactive mineral phases. The lower part of the sediments comprised a non-varved section, deposited under mesotrophic conditions, with 2.5x- to 10x-times higher Mn and Fe contents, respectively, in sediments from great water depths compared to the same intervals from shallower water depths. Elevated Mn/Ti and Fe/Ti ratios confirmed the autochthonous origin of Mn and Fe. Because of high reactive Fe loads, up to 8x higher P contents were buried at the small area of the deepest sites due to vivianite (Fe-phosphate) authigenesis, microscopically identified as blue crystals. Burial of Mn during this period occurred via Mn-carbonate formation, possibly rhodochrosite, as indicated by high acid-soluble Mn contents. The upper sediment section comprised calcite and diatom varves deposited during eutrophic conditions from about 1940 onwards. Geochemical focusing of Fe stopped due to pyrite (FeS_2) formation, in sediments of all water depths. Our results suggest that geochemical focusing is probably characteristic for deep lakes, whereas the relatively flat bottom of Lake Arendsee demonstrates that little elevation differences are sufficient for that process to occur.