Post-depositional manganese mobilization during the last glacial period in sediments of the eastern Pacific Ocean

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Studies have provided compelling evidence that the Pacific Ocean has experienced substantial glacial/interglacial changes in bottom-water oxygenation. While the deep Pacific Ocean is currently well oxygenated, bottom-water oxygen concentrations (O2bw) were most likely lower during the last glacial period (LGP), which must have caused a much more compressed redox zonation in the sediments than at present.

We have sequentially leached mobilizable MnO_2 and various Fe (oxyhydr)oxides and used transport-reaction modelling in order to reconstruct past redox changes in sediments of the NE Pacific. We have investigated six sites situated in various contract areas for the exploration of polymetallic nodules within the Clarion-Clipperton Zone (CCZ) and one site located in a protected area (APEI3) north of the CCZ. We found bulk sediment Mn maxima of up to 1 wt% in the upper 10 cm of the sediments at all sites except for the APEI3 site. Mobilizable Mn(IV) was the dominant Mn phase representing more than 70% of bulk Mn. As oxygen penetration depths of more than 0.5 m currently do not allow for the formation of authigenic Mn(IV) in the surface sediments of the CCZ, we postulate that lower O2bw during the LGP caused a compressed redox zonation where authigenic Mn(IV) precipitated at a shallow oxic-suboxic redox boundary. Transport-reaction modelling reveals that at O2bw of 35 µM, which were suggested to have prevailed during the LGP, the oxic-suboxic redox boundary is located in the upper 5 cm of the sediments. A distinct mobilizable Mn(IV) maximum was not found in the surface sediments of the APEI3 site indicating that the redox zonation was not as condensed during the LGP at this site due to two- to threefold lower organic carbon burial rates. Our results suggest that oxygen-deprived bottom water conditions prevailed on a basin-wide scale during the LGP and were associated with significantly different rates of biogeochemical processes and element fluxes in sediments of the NE Pacific than today.