Mn/Ca ratios as proxy for benthic ecosystem oxygenation: culturing study and field observations of *Ammonia tepida*

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The Mn/Ca ratios of benthic foraminifera represent an emerging proxy to trace past ocean hypoxia (O_2 < 63 µmol/L). The redox element manganese is soluble in its reduced form (Mn^{2+}), therefore Mn can be incorporated into the tests of benthic foraminifera under low oxygen conditions. We studied, in laboratory experiments and by *in situ* recent observations, the mechanisms controlling this potential proxy. We studied *Ammonia tepida*, a dominant taxon in coastal environments subject to seasonal hypoxia. In our laboratory experiments, specimens of *A. tepida* were cultured in hypoxic seawater with constant concentrations of Mn^{2+} for a range of concentrations similar to those found in modern coastal benthic ecosystems. Single-chamber measurements of Mn/Ca obtained by laser ablation ICP-MS (LA-ICP-MS), show incorporation of Mn into tests of *A. tepida* as a linear function of seawater Mn^{2+} concentration. Moreover, these results highlight the degree of variability in Mn/Ca ratios due to calcification mechanisms (intrinsic factors). A comparison of pore water Mn^{2+} and foraminiferal Mn/Ca ratios suggest that living specimens of *A. tepida* from Lake Grevelingen (Netherlands) respect the partitioning curve determined in experimental conditions. Mn/Ca intra-test variability (i.e., measurement of multiple chambers of the same specimen by LA-ICP-MS) is much larger than explainable by intrinsic factors. In fact, the monthly pore water measurements of Lake Grevelingen show a large seasonal variability of Mn^{2+}, which is reflected by the high intra-test variability of Mn/Ca in *A. tepida* sampled in different months. In spite of the complexity of the involved factors for the formation of the proxy signal, foraminiferal Mn/Ca ratios appear to have a potential to reconstruct the variability of pore water Mn^{2+}, which is ultimately linked to benthic ecosystem oxygenation.