Cable Bacteria Impact Sediment Iron and Manganese Dynamics in a Seasonally-Hypoxic Marine Lake

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Cable bacteria have recently been identified in various sedimentary marine settings worldwide. These filamentous microbes mediate electrogenic sulphur oxidation (e-SOx), thus inducing electrical currents that run over centimetre scale distances in the seafloor.

Here we present results of a year-long monthly assessment of the impact of cable bacteria on sedimentary Fe and Mn dynamics at three sites along a depth gradient in a seasonally-hypoxic coastal marine lake (Grevelingen, The Netherlands). Fluorescence in situ hybridisation (FISH) shows the presence of cable bacteria at two sites in spring. Micro-sensor profiling (pH, H_2S, O_2) and pore water profiles of dissolved Mn, Fe^{2+}, Ca^{2+} and SO_4^{2-} reveal the geochemical fingerprint of e-SOx at these sites, i.e. a broad suboxic zone, characterised by a low pH, inducing dissolution of Ca/Mn carbonates and Fe sulphides.

As a result of the metabolic activity of cable bacteria, dissolved Mn and Fe^{2+} were released at depth. These solutes diffused upwards and were sequestered as Mn- and Fe-(oxyhydr)oxides near the sediment surface with Mn oxides acting as an oxidant for part of the upward diffusing Fe^{2+}.

Strikingly, the thickness of the iron oxide -rich surface layer in spring was greatest at the most hypoxic site, emphasising the key role of cable bacteria in creating oxidised surface sediments. Synchrotron XANES analyses confirm the seasonality in Fe-(oxyhydr)oxide formation and reveal that the sediment Mn oxides were of biogenic (birnessite) and abiotic (hausmannite) origin.

Following the onset of hypoxia in early summer, sediment Fe-(oxyhydr)oxides were mostly converted to Fe-sulphides, whereas the Mn oxides dissolved and the Mn was lost to the overlying water. From autumn, Beggiatoaceae mats colonised the sediment with little further change in sediment geochemistry. Our results confirm that cable bacteria can act as a key control on the coupled cycling of Fe and Mn in surface sediments of seasonally-hypoxic basins.