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Experimental inflow of groundwater induces a 'biogeochemical regime shift' in iron rich and acidic sediments

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In acid mine drainage (AMD) polluted lakes, sediments may show a stable iron- or sulphate-reducing regime. We tested the hypothesis that increased inflow of groundwater can trigger a shift between these regimes. Schwertmannite bearing sediment, rich in iron (40-43 %), sulphur (2.5 %), and carbon (4.5 %), was sampled from an acidic mine lake, and percolated (0, 5 and 20 L m^2 a^1) with two solutions (1/1 mmol L^{-1} vs. 10/15 mmol L^{-1} sulphate/ferrous iron, pH 5) in sediment columns. A DOC source was added after 46 days ($\sim$2.5 mmol C L^{-1}) to ease the carbon limitation of reductive processes. The sediment remained in an iron reducing and acidic regime during percolation without DOC. Percolation at a high rate and addition of DOC raised pH values in schwertmannite rich layers from 2.8 to 4.5 – 5. Schwertmannite transformation to goethite partly accelerated by a factor of $>$2 but effectively buffered proton consumption only at the low percolation rate. Input of dissolved ferrous iron and sulphate reduced the mobilization of ferrous iron from the sediment. With pH increase, iron reduction slowed relative to CO_2 production, sulphate was reduced, and iron sulphides were formed. Input of alkalinity and electron donors by percolation thus shifted the biogeochemical regime from iron to sulphate reduction. Similar regime shifts can be expected for other sediments containing immobile proton or redox buffers when exposed to the advective input of alkalinity and acidity, or electron acceptors and donors.