The interplay of microbially mediated and abiotic reactions in the biogeochemical Fe cycle

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Iron is essential to all living organisms and required for more proteins than any other metal in all the domains of life. Thus, the iron speciation and thereby its bioavailability controls the dynamics and functioning of ecosystems. Iron occurs in two redox states in the environment: oxidized ferric iron (Fe(III)) and reduced ferrous iron (Fe(II)). Due to its redox activity, iron can donate or accept electrons from C, N and S species, making it a major player in biogeochemical cycles. Many iron redox processes previously assumed to be purely abiotic are now known to also be microbially mediated. In fact, we are now aware that many abiotic and microbially mediated iron redox processes are interweaved and not mutually exclusive, compete with each other and are difficult to discern. In order to understand the network of reactions within the biogeochemical iron cycle it is therefore necessary to determine which abiotic or microbially mediated reactions are dominant under various environmental conditions and which factors determine their relative dominance. We outline the microbially mediated reactions different iron phases can undergo in hierarchical order of thermodynamically the most favourable reactions starting with oxygen and light-induced Fe redox processes through reactions with nitrogen-species and manganese oxides to sulphur compounds and also organics. This covers the range of possible iron reactions from environmental to laboratory conditions, important to a myriad of scientific disciplines ranging from geochemists to microbiologists. Considering the full network of interweaved abiotic and biotic reactions will provide a new basis how environmental iron cycling can be viewed and understood.