

The composition and mechanical properties of soil-derived Fe-OM co-precipitates at macro- and nanoscale

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Up to the present day, the high relevance of Fe oxides for elemental cycling in nature encourages scientists to conduct studies, in which Fe oxides precipitate in the presence of selected (in)organic compounds. Although these studies provide important insights into the impact of single compounds on the Fe oxide properties, it remains unclear to which extent these findings apply to Fe oxides that precipitate in natural systems, in which a multitude of (in)organic compounds coexists in constantly fluctuating relative proportions. We developed an experimental setup that allows for the lab-based production of Fe minerals that are expected to form at anoxic-oxic interfaces in soils. We assessed their bulk properties (XRD, FTIR-, Mössbauer spectroscopy) and their surface properties at the nm-scale (Nano-SIMS, AFM).

We identified Fe(III)-OM co-precipitates, whose elemental composition was controlled by the composition of the solution from which they precipitated. P and As were preferentially associated with these precipitates compared to Si. Nano-SIMS (spatial resolution ~50 nm) could not unequivocally resolve dedicated Fe-P- and Fe-As-phases. Unlike most humic substances that are commonly used as reference OM, the mineral-associated OM contained significant amounts of proteins and polysaccharides. The variable aggregate sizes (10 nm - >1 µm) and shapes (bulk vs. linear) of the Fe-OM co-precipitates had no measurable influence on the short-range crystalline order, which was generally very low, and on the mechanical surface properties, i.e. DMT modulus, adhesion, and deformation. The relative content in N and S increased with increasing aggregate size, which we relate to the actual mode of aggregation of Fe-OM co-precipitates in soil solutions at passage of the anoxic-oxic interface.