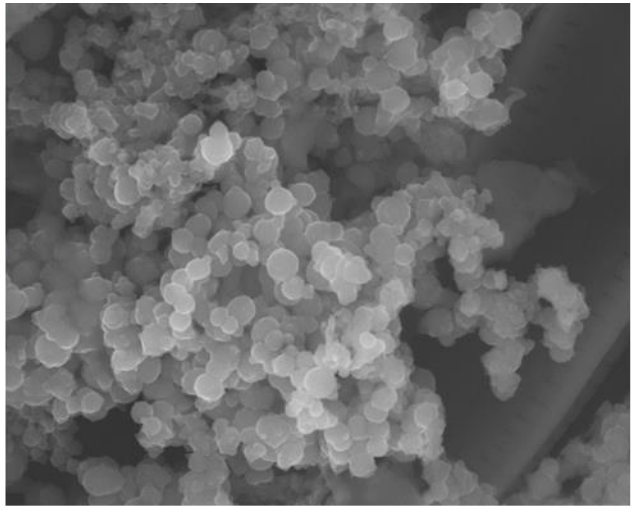
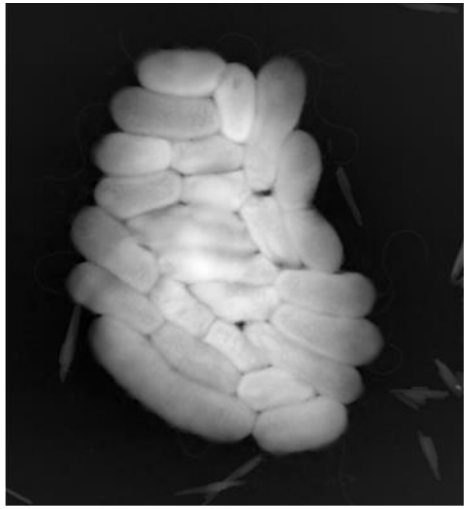
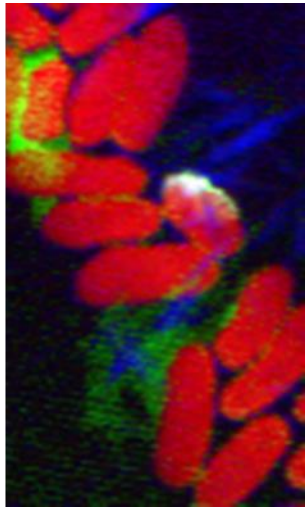
Institut für Geowissenschaften
Friedrich-Schiller-Universität Jena
Hydrogeologie

Imaging organo-mineral associations of creek sediments



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Objectives

1 To image distribution and composition of natural organic matter coatings on mineral surfaces

- are Fe oxides or clay minerals the most important sorbents for OM?
- is the coverage patchy or are particles fully coated by OM?
- are mineral surfaces saturated with organic matter?
- how are S and P distributed across mineral surfaces?

Synchrotron based XRF with a spatial resolution of 50 nm at excitation energies of 320 eV and 2550 eV

2 To prove the existence of inner-sphere Fe-O-P complexes between Fe oxides and phosphates

- implications for sorptive fractionation, i.e. the turnover of proteins, lipids, and polysaccharides
- implications for desorption and bioavailability of P

μNEXAFS at the P K-edge with a spatial resolution of 200 nm

Material

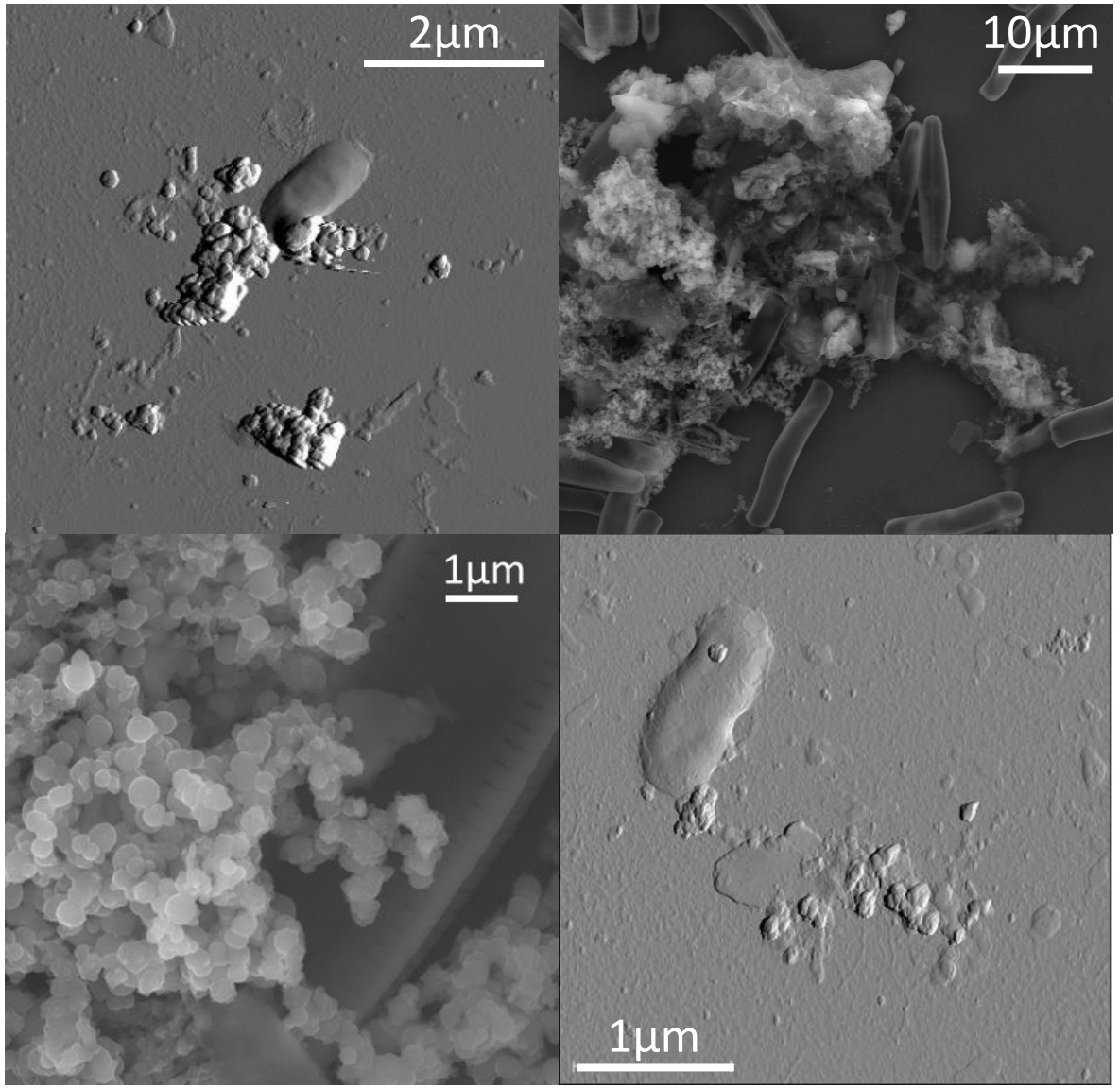
To better understand soils, we investigated surface water flocs and fresh sediments of a creek:

The creek is supposed to serve as a reference for a system with a much higher microbial versus plant derived organic matter input than soils

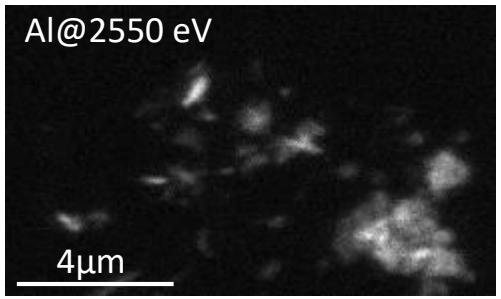
pH 6.4
Ferrihydrite, clay minerals, diatoms
OM: EPS of bacteria and diatoms

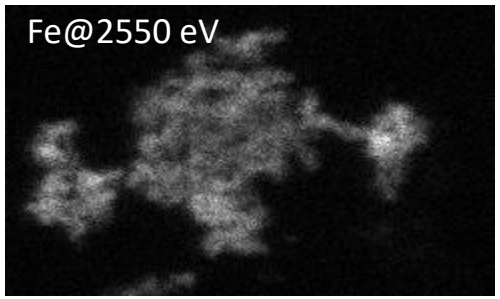
Material

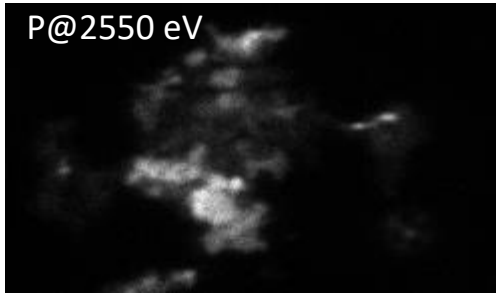
… in fact we found Fe oxides and clay particles often in close vicinity to bacterial cells or diatoms

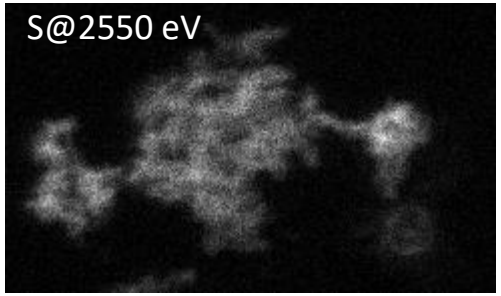


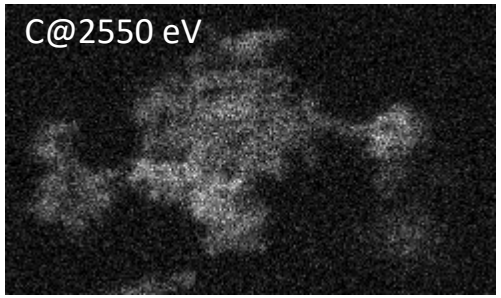
X-ray fluorescence at 320 eV and 2550 eV at 50 nm steps

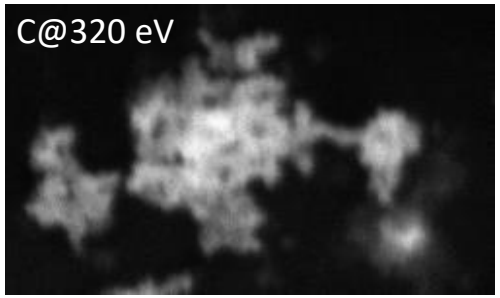


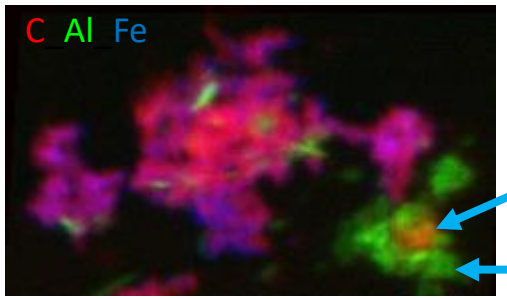






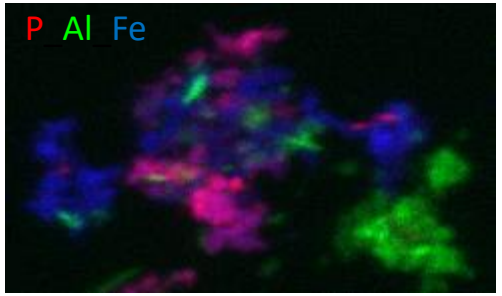


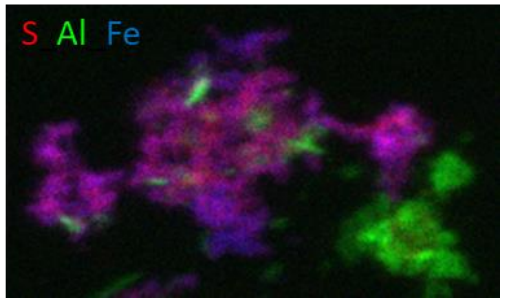




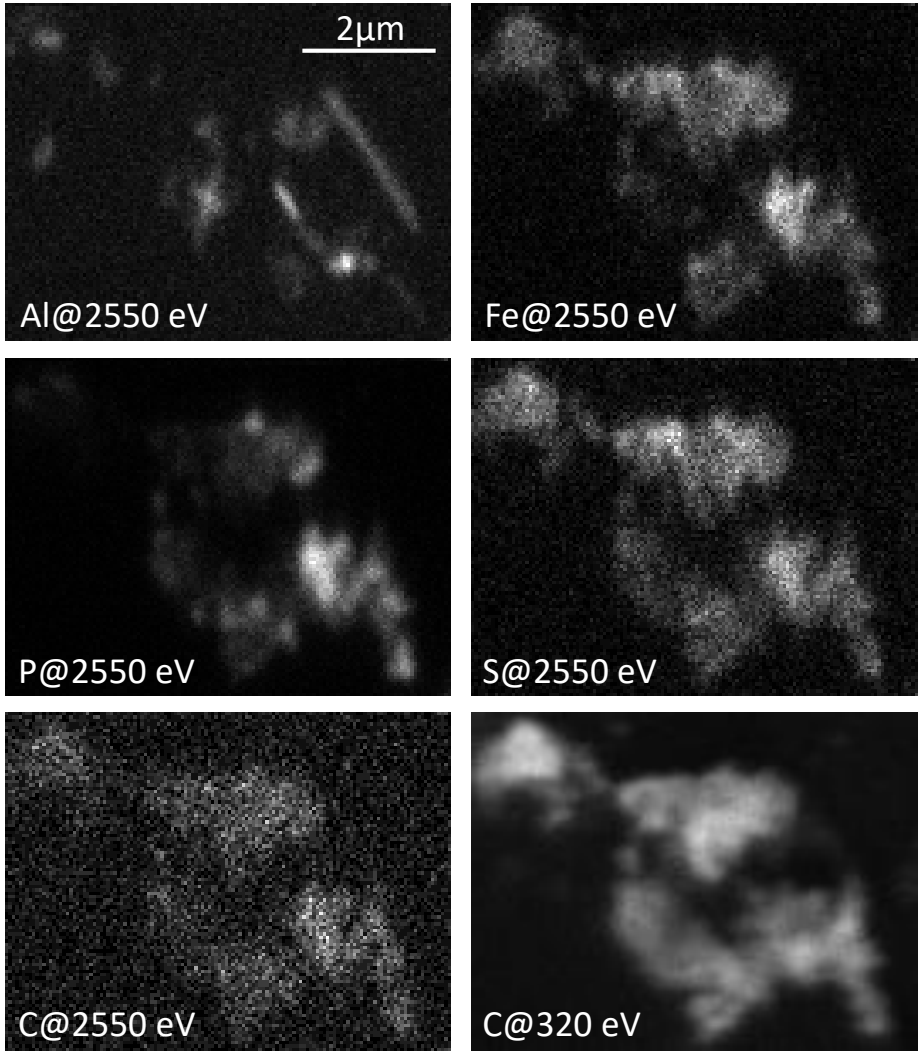
OM in clay mineral aggregate

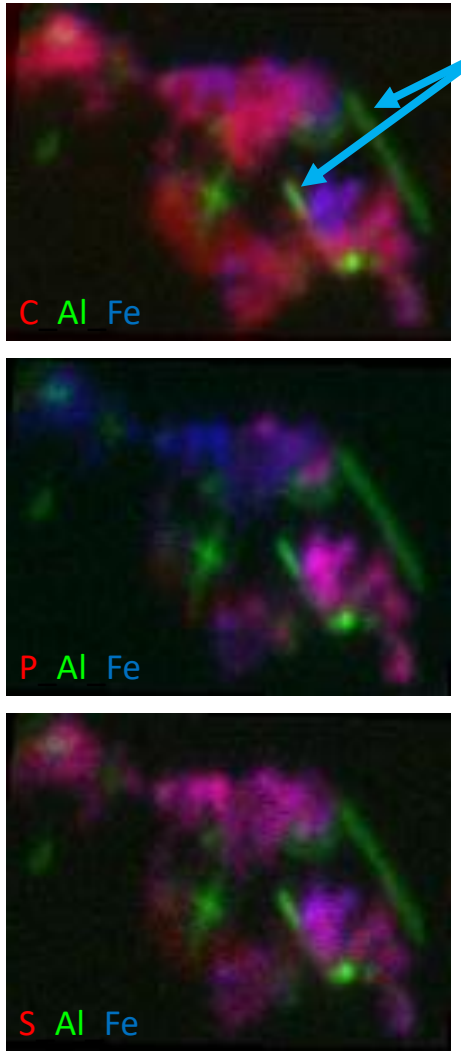
clay minerals with low C signal





X-ray fluorescence at 320 eV and 2550 eV at 50 nm steps





clay minerals without detectable C signal

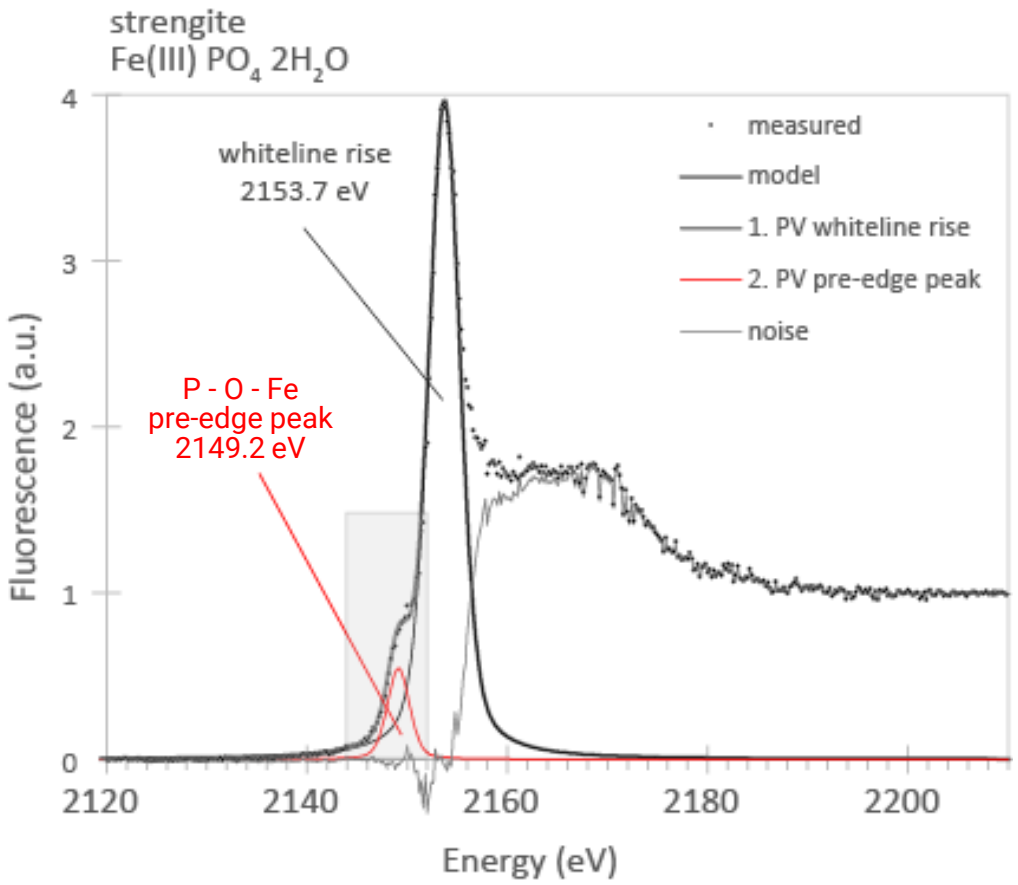
➡ most Fe oxides are completely covered with OM

➡ clay minerals are often uncovered or have less thick coatings

➡ S and C are generally co-located, but S does not occur on clay minerals

➡ P covers ~1/3 of the Fe oxides and never occurs without organic matter or on clay minerals

P K-edge NEXAFS



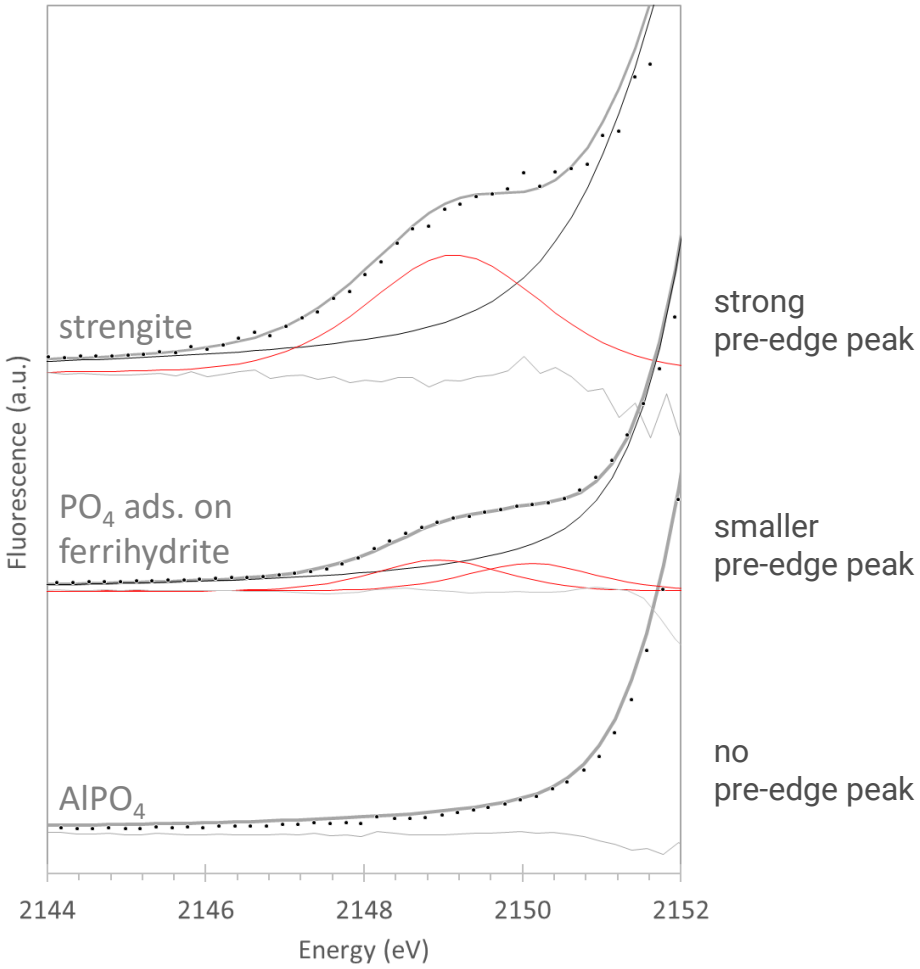
A pre-edge peak at ~2149 eV is indicative of inner-sphere P-O-Fe bonds

To prove the existence of a pre-edge peak:

… we modelled the whiteline rise by a pseudovoigt curve and the pre-edge peak by one or two additional pseudovoigt curves

P K-edge NEXAFS: pre-edge peaks

References

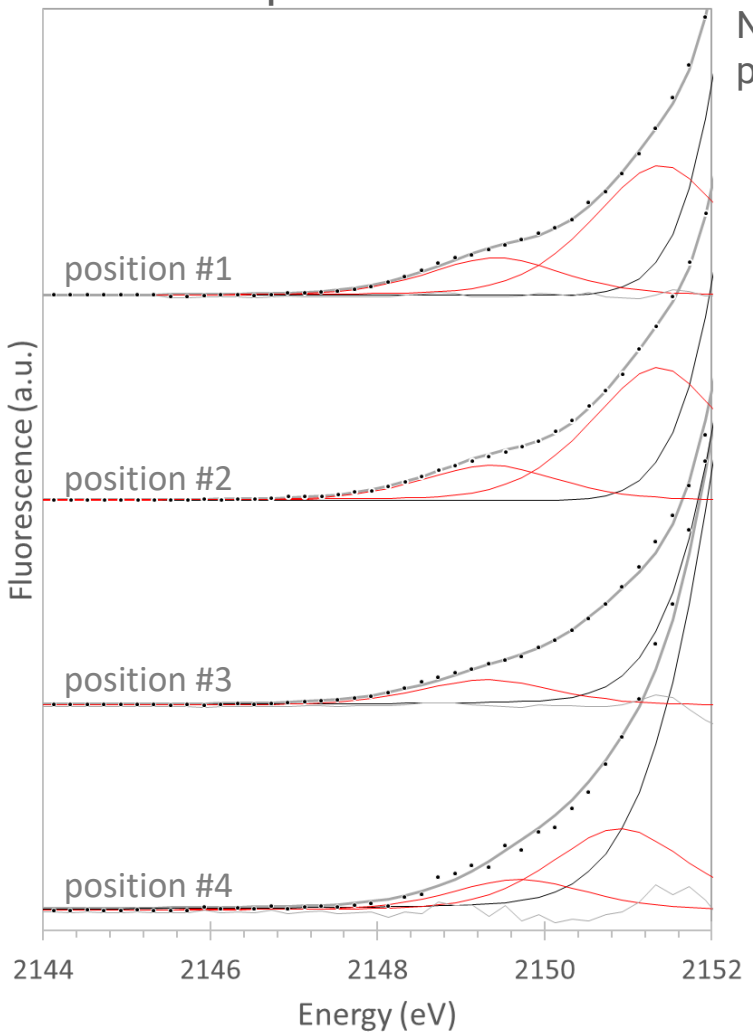


strong pre-edge peak

smaller pre-edge peak

no pre-edge peak

Creek samples



NEXAFS on different sample positions with Fe and P

➡ inner-sphere P-O-Fe bonds are common on the Fe oxides of the creek

conclusions

➡ P, S and OM are preferentially associated with Fe oxides, whereas clay minerals show no P- and S-signals, and no or lower C-signals

> combined effect of high specific surface area, reactive OH-groups, and aggregate formation of Fe oxides

➡ The Fe oxides of the creek are saturated with OM

➡ S and P never occur without C. This leads us assume that we see mainly organic S and P on the Fe oxides. However, spectroscopic evidence is pending.

➡ Strong inner-sphere P-O-Fe bonds are common on the Fe oxides of the creek

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Thank you for your attention!

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