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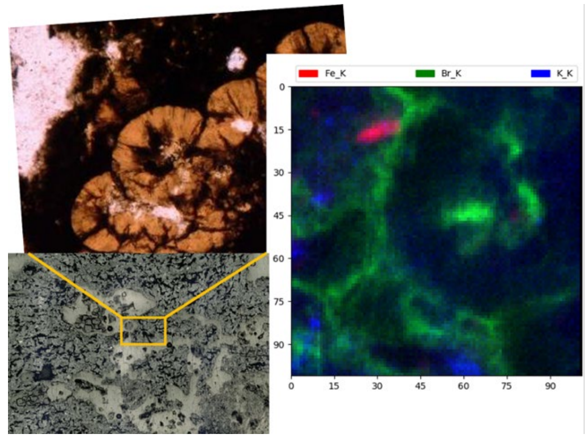

Imaging redox-conditions for microbial life in tar-oil contaminated soils

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Tar contaminated soils can be found on former coking plants, oil and gas works, and wood preservation sites. As a result, tens of thousands of tar waste sites worldwide still threaten the environment. Tar is a highly viscous and complex mixture of several thousand compounds such as aliphatic, mono- and polyaromatic hydrocarbons, nitrogen, sulfur, phenols, cyanides, sulfates, and sulfides, often associated with heavy metals. Although tar is generally described as toxic and recalcitrant, certain specialized archaea, bacteria, and fungi were found to degrade tar in lab experiments. However, recent research has evidenced that organic matter degradation is not primarily driven by recalcitrance but by environmental factors, the formation of organo-mineral associations, and the accessibility of the substrate to microorganisms or their enzymes.

On a tar-oil spill at a former brown coal processing site, we observed that the grass-overgrown margin of the spill contained 2-5 times more microbial biomass than the uncontaminated control technosol. To understand the causes of the unexpectedly dense microbial colonization and presumably high tar degradation, we investigated the tar composition (TPH, PAH, metals), hydraulic properties, and 2D pore space geometry using SEM images of thin sections. X-ray fluorescence (XRF) imaging has been used to map the heterogeneous elemental composition within the tar matrix, identifying a wide range of metals, such as Ca, Fe, Cu, As, Pb, and more. At the same time, µXANES were collected to analyze the aeration within the tar-rich areas between the pores.

Our data show that tar infiltration into the relocatic technosol has dramatically increased the overall porosity, primarily by increasing the number of large pores > 50µm. Although aeration must be good in these pores, XANES measurements indicate reduced Fe and Mn phases in the low-porosity regions of the contaminated layers. Accordingly, lower degradation than in the well-aerated areas rates must be assumed here.

Figure 1: Visible light images of a section from the tar-spill (left) and an XRF map showing the heterogeneous distribution of Fe, Br, and K within the scanned area of 200 x 200 µm^2, step size 2 µm.