



## **Non-invasive localization of organic matter in soil aggregates using SR- $\mu$ CT**

Stephan Peth (1), Anneka Mordhorst (2), Claire Chenu (3), Daniel Uteau Puschmann (1), Patricia Garnier (4), Naoise Nunan (3), Valerie Pot (4), Felix Beckmann (5), and Malte Ogurreck (5)

(1) University of Kassel, Soil Science, Witzenhausen, Germany (peth@uni-kassel.de), (2) University of Kiel, Institute of Plant Nutrition and Soil Science, Kiel, Germany, (3) INRA, Centre de Grignon, Biogéochimie et écologie des milieux continentaux, Grignon, France, (4) INRA, Centre de Grignon, UMR environnement et grandes cultures, Grignon, France, (5) GKSS-Research Centre, Geesthacht, Germany

Knowledge of the location of soil organic matter (SOM) and its spatial association to soil structure is an important step in improving modeling approaches for simulating organic matter turnover processes. Advanced models for carbon mineralization are able to account for the 3D distribution of SOM which is assumed to influence mineralisation. However, their application is still limited by the fact that no method exists to non-invasively determine the 3D spatial distribution of SOM in structured soils.

SR-based X-ray microtomography (SR- $\mu$ CT) is an advanced and promising tool in gaining knowledge on the 3-dimensional organization of soil phases (minerals, organic matter, water, air) which on a voxel level could be implemented into spatially explicit models. However, since the contrast of linear attenuation coefficients of soil organic matter on the one hand and mineral components and water on the other hand are relatively low, especially when materials are finely dispersed, organic matter within the soil pore space is often not resolved in ordinary X-ray absorption contrast imaging. To circumvent this problem we have developed a staining procedure for organic matter using Osmium-tetroxide since Osmium is an element with an absorption edge at a higher X-ray energy level. Osmium is known from transmission electron microscopy analysis (TEM) to stain organic matter specifically and irreversibly while having an absorption edge at approximately 74 keV.

We report on the application of a novel Osmium vapor staining method to analyze differences in organic matter content and identify small scale spatial distribution of SOM in soil aggregates. To achieve this we have taken soil aggregate samples (6-8 mm across) obtained from arable soils differing in soil management. Aggregate samples were investigated by synchrotron-based X-ray microtomography (SR- $\mu$ CT) after staining the sample with Osmium-tetroxide (OsO<sub>4</sub>) vapor. We utilized the monochromatic X-ray beam to locate osmium bound to SOM in the stained soil aggregate samples by scanning the aggregates at different photon energies: 30 keV at which the attenuation contrast is optimal for distinguishing other soil constituents, 70 keV (below the absorption of osmium) and 78 keV (above the absorption edge of osmium). The results suggest that particulate organic matter, which was not visibly by scanning samples at energy levels optimal for resolving soil structure (30 keV), was identified after osmium staining and scanning the samples at energy levels just below (70 keV) and above (78 keV) the absorption edge of Osmium. Subtracting the images below from the images above the osmium edged we were able to isolate stained particulate organic matter which otherwise would have been wrongly interpreted as pore space without staining. Combining both pore space and organic matter distribution we are able to investigate the association of SOM with soil structure.