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Correlative imaging reveals holistic view of soil microenvironments

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The micro-environmental conditions in soil exert a major control on many ecosystem functions of soil. Their investigation in intact soil samples is impaired by methodological challenges in the joint investigation of structural heterogeneity that defines pathways for matter fluxes and biogeochemical heterogeneity that governs reaction patterns and microhabitats. Here we demonstrate how these challenges can be overcome with a novel protocol for correlative imaging based on image registration to combine three-dimensional microstructure analysis of X-ray tomography data with biogeochemical microscopic data of various modalities and scales (light microscopy, fluorescence microscopy, electron microscopy, secondary ion mass spectrometry). Correlative imaging of a microcosm study shows that the majority (75%) of bacteria are located in mesopores (<10μm). Furthermore they have a preference to forage near macropore surfaces and near fresh particulate organic matter. Ignoring the structural complexity coming from the third dimension is justified for metrics based on size and distances but leads to a substantial bias for metrics based on continuity. This versatile combination of imaging modalities with freely available software and protocols may open up completely new avenues for the investigation of many important biogeochemical and physical processes in structured soils.