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Visualization of soil structure modifications and infiltration patterns by ground-dwelling beetle larvae and moss vegetation

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An artificial catchment was constructed to study initial soil and ecosystem development. As a key process, the pore structure dynamics in the soil at the surface strongly influences erosion, infiltration, matter dynamics, and vegetation establishment. Little is known, however, about the first macropore formation in the very early stage. This presentation focuses on observations of soil structure modifications from ground beetles and moss vegetation and its effect on water flow at the surface comparing samples from three sites in the catchment.

The surface soil was sampled in cylindrical plastic rings (10 cm^3) down to 2.5 cm depth in two replicates along a vegetation gradient from dense moss cover to bare soil. Each sample contained also a cave from pioneering ground-dwelling beetles Cicindelidae. The samples were scanned with micro-X-ray computed tomography (at UFZ-Halle, Germany) with a resolution of 0.084 mm. The infiltration dynamics were visualized with neutron radiography (at Paul-Scherer-Institute, Switzerland) on two slab-type soil samples in 2D.

The burrowing activity of Cylindera arenaria viennensis lead to mostly vertical channels with a locally compacted wall, which is more pronounced in soil with weaker structure. Also isolated vesicular macro pores were found in the bottom part of the moss covered sample, more evenly distributed in the sparsely vegetated sample and in a depositional layer on top of bare soil. This might reflect a weak soil structure. A dense moss cover seems to stabilize the first centimetre of the soil such that caves were conserved even if in a decayed state. Also layer of erosion sediment was only visible in samples from non-vegetated patches.
The neutron radiograph series showed preferential flow in and around the cylindrical burrows. Water drop penetration time tests on air dry subsoil revealed water repellency, what probably contributes to the observed bypass flow. A dry and water repellent bottom part of the soil acted as internal barrier for water movement and water accumulated in the upper part near the surface; and water entered the burrow from the sides after a moisture saturation threshold was exceeded.

The observations demonstrate relatively high abiotic and biotic dynamics of soil pore structure in the soil surface even during the very early development stages. The structure formation has potentially great effects on changing runoff and infiltration by forming sealing layers or preferential flow paths.