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Solute flow in extremely stony forest soil: case study in Russian Far East

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Large impermeable objects like stones can drastically affect numerous soil properties. This contribution is mainly focused on hydrological issues. The original idea of series of field experiments was to visualize and quantify preferential flow paths in extremely stony forest soils on natural hillslopes in Vladivostok region, Russian Federation. This region is known for its intensive rain seasons (monsoon climate). For the purpose mentioned above two large-scale staining tracer experiments were carried out. Up to 200 l of dye solution were uniformly sprinkled over the area of 1 square meter using industrial pressure-calibrated nozzles. Two different tracers were utilized: common staining dye Brilliant Blue FCF and fluorescent dye Uranine. These substances were chosen due to their different staining mechanisms. First common dye solution (100 l) was applied, followed by the same amount of fluorescent dye solution. After full infiltration sequential upslope soil profiles were cut and flow patterns examined using common light for Brilliant Blue FCF and UV light for Uranine.

Flow patterns showed unexpected homogeneity, e.g., quite uniform staining profiles and absence of pronounced bundle-like preferential flow paths. Also, no biomat flow (upper layer) was observed. Excavation resulted in quite rough profiles due to large amount of stones; stone positions were reconstructed using shades obtained using digital photos obtained using angled lightening. All infiltration occurred via gaps between stones. Some funneled flow between huge boulders was observed in some cases. Minor differences were observed between two dyes patterns which suggest that infiltration paths were stable. Unfortunately, all observations were not possible for the deepest infiltrations parts because of excavation difficulties increasing with depth (maximum depth reached was around 1.2 m). Undisturbed soil samples were taken from these conducting zones, both stained and unstained portions of soil. However, only microsamples (volume up to 1.5 cm3) were possible due to narrow gaps, e.g., conventional sampling using stainless steel cores was not possible. All samples were scanned using high-resolution X-ray tomography device. Based on 3D pore structure transport properties of soil samples were determined using numerical simulations (pore-networks model and FDM solution of Stoke's equation). All infiltration patterns and numerical results are discussed in detail. Finally, a framework of hydrological modeling for extremely stony soils is provided.