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An interdisciplinary approach to decipher different phases of soil formation using root abundances and geochemical methods

Guido Wiesenberg and Martina Gocke

University of Zurich, Geography Department, Winterthurerstrasse 190, 8057 Zurich, Switzerland
(guido.wiesenberg@geo.uzh.ch)

Pedogenic processes are commonly thought to be restricted mainly to the uppermost few dm of soils. However, often processes like water infiltration and - more obviously - rooting lead to much deeper penetration of soil, soil parent material and, if present, paleosols. The extent to which root penetration and subsequent organic matter incorporation, release of root exudates and microbial activity influence the general chemical and physical properties of deeper soil horizons remains largely unknown.
We determined the lateral extent of root-derived overprint of the soil parent material as well as the overprint of the chemical properties in paleosols by combining root quantities obtained in the field with a large variety of inorganic and organic chemical as well as microbial properties in bulk soils and rhizosphere samples. Soils, soil parent material and paleosols were sampled along a transect from The Netherlands via Germany and Hungary towards Serbia, where soil and underlying loess, sand, and paleosol profiles were excavated in pits of 2 m to 13 m depth. Root counting on horizontal levels and profile walls during field campaigns, assisted by three-dimensional X-ray microtomographic scanning of undisturbed samples, enabled the quantitative assessment of recent and ancient root systems. Ages were determined by 14C dating for the latter, and by OSL dating for sediments, respectively. The bulk elemental composition of soils, sediments and paleosols and molecular structure of organic matter therein helped to quantitatively assess the root-related overprint in different depth intervals.
The results point to the significance of deep roots as a soil forming factor extending into soil parent material, as well as the overprint of geochemical proxies in paleosols due to intense root penetration at various phases after burial. The shown examples highlight potential pitfalls in assessing rooted soil and paleosol profiles and their ages, and provide potential solutions for proper data interpretation.