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Change of soil organic matter quality and quantity by deep-rooting plants – a molecular approach

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Under predicted rising atmospheric CO_2 concentration, soils are discussed to potentially act as C sinks. Stability and long-term storage of soil OM are affected by both molecular structure of incorporated organic remains and environmental factors. It is increasingly accepted that roots contribute to significant portions of topsoil OM, whereas their role for C cycling is less known for depths » 1 m, i.e. the deep subsoil and underlying soil parent material like terrestrial sediments.

To trace root-related features and organic remains, transects were sampled from ancient (3–10 ky) and recent calcified roots (rhizoliths) via surrounding sediment towards sediment free of visible root remains, at two sites. At the Nussloch loess-paleosol sequence (SW Germany), transects were collected as intact cores and scanned by X-ray microtomography for visualization of rhizoliths and rhizosphere. Afterwards, cores were cut into concentric slices and, similar to rhizolith and sediment samples from the sandy deep subsoil at Sopron (NW Hungary), analyzed for suberin molecular markers.

Suberin biomarkers were found in both recent and ancient root systems, demonstrating their suitability to identify root-derived OM in terrestrial sediments with ages of several tens of ky. Varying relative portions of the respective suberin markers enabled the attribution of Sopron rhizoliths to oak origin, and assessment of the rhizosphere, which extended up to several cm. This confirms recent studies which demonstrated the possible postsedimentary incorporation of considerable amounts of root and rhizomicrobial remains in loess, based on biomarkers deriving either from plants and microorganisms (alkanes, fatty acids) or solely from microorganisms (GDGTs). 3D scanning of Nussloch rhizoliths and surrounding loess showed large channels of former root growth, whereas the root tissue was commonly degraded. Additionally, microtomography enabled assessment of abundant fine calcified roots as well as biopores remaining from fine roots. The total pore volume that was previously filled with root tissue accounted for up to 6.4% in depth intervals with abundant rhizoliths ($\geq$100 m-2), and less than 0.5% in depth intervals with scarce rhizoliths ($\leq$20 m-2).

These results show that root-derived OM may play an important role in terrestrial sediments even several meters below the respective (paleo)soil, and that sedimentary OM does not necessarily reflect solely the aboveground biomass of synsedimentary vegetation. Higher stability of root remains on one hand, and enhanced microbial activity in the rhizosphere on the other hand, may have considerable long-term consequences for C stocks in deep subsoil: roots do not necessarily contribute to C stabilization on centennial or millenial time scales, but rather led to a total C loss of 1.6 kg m-2 at Nussloch.