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Rhizoliths in loess – a new tool to estimate post-sedimentary incorporation of organic matter in terrestrial environments

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Pedogenic (secondary) carbonates are a typical feature of soils in arid and semiarid regions. In calcareous parent material, they are formed by dissolution of lithogenic (primary) carbonate and recrystallization with soil CO_2. Usually, hundreds to thousands of years are necessary for complete recrystallization of primary $CaCO_3$. δ^{13}C of pedogenic carbonates reflects the photosynthetic pathway of the predominant local vegetation, because secondary $CaCO_3$ is formed in isotopic equilibrium with soil CO_2 released by root and rhizomicrobial respiration. Therefore, δ^{13}C of pedogenic carbonates is used for paleoenvironmental reconstructions.

Rhizoliths are a special form of pedogenic carbonate formed by encrustation of plant roots by recrystallized carbonate. While the organic part of the root is mainly degraded during decomposition, carbonatic, bone-like structures remain in the terrestrial sediments. They occur locally abundant in calcareous sediments like loess. In contrast to very long formation of other types of pedogenic carbonates, these calcified roots are built probably within a few decades or even years. They are thought to be formed after sedimentation and can be followed continuously in loess profiles over a depth of 8m (Nussloch, Germany).

Radiocarbon ages indicate an age of 3-4 ka for rhizolith organic matter and carbonate, while the surrounding loess was sedimented 13-20 ka before present. Due to their high frequency in the Nussloch loess profile (app. 10-20 rhizoliths m^{-2}) it can be assumed that rhizodeposits led to a significant contribution of post-sedimentary organic matter in the loess. Stable carbon isotopic (δ^{13}C) signatures and other parameters did not show obvious differences between loess and rhizolith organic matter due to potentially similar biogenic sources. An estimation of the post-sedimentary organic matter has been performed using molecular proxies, which allowed for a differentiation of the different biogenic sources. These parameters included alkane and fatty acid compositions and molecular proxies based on these organic matter fractions.

The molecular patterns clearly showed a significant contribution of root-derived organic matter in loess adjacent to roots even in a distance of 5 cm. First estimations of post-sedimentary root-derived organic matter based on the amounts of unsaturated fatty acids yielded a high contribution of root-derived organic matter near the roots and decreasing amounts with increasing distance to roots, which accounted to least 10-20% even in a distance of 5 cm. Depending on alkane distribution patterns different biogenic sources of rhizoliths could be determined that also varied in their contribution of root-derived components in the vicinity of roots.

We present an approach, how post-sedimentary incorporation of higher plant biomass can be assessed in terrestrial sediments and discuss the following corrections for paleoenvironmental and paleoclimatic reconstructions that follow these findings.