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Rhizoliths in the loess-paleosol sequence of Nussloch (SW Germany): Differentiation between ancient and modern vegetation using n-alkanes

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Loess-paleosol sequences are important terrestrial archives for studying Quaternary climate changes. They often contain secondary carbonates which were formed under arid to semihumid climatic conditions. Rhizoliths, a special form of secondary carbonate, are formed by encrustation of plant roots with secondary carbonate, potentially leading to conservation of former root tissue and rhizodeposits. Probably, rhizoliths were formed after loess sedimentation, as suggested e.g. by their occurrence over several dm within a profile. Rhizoliths at the loess-paleosol sequence of Nussloch (SW Germany) were formed after cessation of loess deposition (younger than 12 kyears), and thus by different vegetation than synsedimentary loess organic matter (LOM). Further, the potential overprint of original LOM by postsedimentary deep-rooting plants was demonstrated on a molecular level, using lipid molecular proxies derived from n-alkanes and fatty acids. Especially in sediments with low organic carbon content like loess, this contribution of OM from sources (rhizodeposits of shrubs or trees) other than the synsedimentary grass vegetation might entail difficulties for paleoenvironmental studies using LOM. In few studies that mentioned this potential error, the overprint of LOM was attributed e.g. to percolating soil solution from the modern soil.

The aim of this work was to distinguish between rhizoliths as relicts of an ancient vegetation and roots of modern vegetation at the Nussloch site. Moreover, based on the occurrence of rhizoliths from 0.5 to $\sim$ 7 m, we hypothesized that rhizoliths from different depth can be derived from different source vegetation. Therefore, we compared n-alkane composition and molecular proxies of modern soil (Ap, Bw1 and Bw2 horizons) and roots therein, as well as rhizoliths and reference loess without visible root remains, which were taken at depth between 0.8 and 6.9 m below present surface.

The alkane distribution pattern with dominance of long chain odd homologues showed higher plant biomass as main source of OM in the whole sample set. The most abundant long chain alkane (LCA), which was used in previous studies for source apportionment of OM, differed between sample types: The alkanes in modern soil were dominated by C_{31}, confirming its former agricultural use (grass vegetation). In contrast, roots in modern soil were dominated either by C_{27} or C_{29} LCA, deriving from recent shrub vegetation. C_{31} as most abundant LCA in LOM was in agreement with the general assumption of loess deposition taking place during glacial periods with scarce grass cover. Rhizoliths, on the other hand, were dominated either by C_{29} or C_{31} LCA, making an attribution of their OM remains to one functional plant group impossible.

Molecular proxies of carbon preference index (CPI) and average chain length (ACL) allow for differentiation of fresh plant biomass (high values) and degraded plant biomass and microbial remains (low values). CPI and ACL were highest in aboveground biomass of the modern vegetation, while modern roots showed high ACL but lowest CPI values of the sample set, because of abundant microbial biomass connected to living roots. Slightly higher CPI in rhizoliths compared to modern roots indicated the rather good preservation of former root tissue by calcium carbonate encrustation, while even higher CPI in loess showed the aboveground biomass source of LOM. These differing ACL and CPI values, together with different most abundant LCA, suggest different biogenic sources for modern roots, rhizoliths, modern soil OM and LOM.

Together with previous data, these results imply that roots of modern vegetation are not the origin of postsedimentary incorporated OM in the loess-paleosol sequence of Nussloch. This postsedimentary overprint can be attributed clearly to deep-rooting plants which entered the sequence after loess deposition, but prior to modern soil development.