

## Plant root encrustation processes: insights from a multitechnique characterization strategy

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Root remains encrusted by secondary carbonates, e.g. carbonated rhizoliths, are common in many soils and terrestrial sediments from various environmental settings<sup>1</sup>. Rhizoliths usually exhibit a cylindrical shape and may have different sizes (from a few  $\mu\text{m}$  up to several cm)<sup>1</sup>. These objects have been known for ages and intensively used as paleoenvironmental proxies<sup>2</sup>. It is generally assumed that such encrustation is controlled or induced by complex organic-mineral interactions at the plant tissue scale. Yet, the precise mechanisms of rhizolith formation remain unclear.

Here, we report the multiscale and multitechnique characterization of natural rhizoliths at different stages of encrustation that have been sampled at different depths from a loess-paleosol sequence (Nussloch, SW Germany). The use of SEM and TEM to investigate rhizolith samples has offered a unique combination of chemical and structural information with submicrometer to nanometer spatial resolution, while solid-state <sup>13</sup>C NMR, liquid and gas chromatographic analyses have provided molecular-level information.

SEM and TEM observations reveal that the precipitation of secondary carbonates does not only occurs around, but also within the plant root cells and evidence the close relationships existing between organic and inorganic phases within these complex systems. The fine-scale preservation of root cellular ultrastructure with remarkable integrity observed for samples at all stages of encrustation has likely been promoted by this intra-cellular carbonate precipitation. In parallel, plant, fungal and microbial biomarker analyses, together with NMR and pyrolysis-LC- and GC-MS experiments have been performed on rhizolith and loess samples. Altogether, the results allow us to propose a general scenario for the mechanism of plant root encrustation by secondary carbonates in terrestrial sediments.

[1] Gocke M., *et al* 2011 *Chemical Geology*, **283**, 251-260 [2]  
Becze-Deak J., *et al* 1997 *Geoderma*, **76**, 221-252