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Geogenic Organic Carbon - Traceable in deep subsoils?

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As the largest active terrestrial reservoir of organic carbon (OC), soils play an essential role in the global carbon cycle. Their response to rising global temperatures is of uttermost interest, having the potential to move and store an extensive amount of carbon within the climate system.

One of the critical aspects of soil OC is the turnover rate, which has been reported to decrease rapidly below the A horizon. While most studies have focused on processes that promote higher ages of organic matter including various stabilization mechanisms, recent observations suggest that part of the soil OC might already have been deposited with the sediment parent material, i.e. geogenic carbon and thus has turnover rates of millennia or longer. This could lead to underestimations of turnover rates and needs to be taken into account in biogeochemical models. This study aims to characterize geogenic OC and quantify its contribution to subsoils.

Deep soil cores (10 m) were collected from three different parent materials in central Germany: Pleistocene loess, Paleogene sand and red sandstone. These were analyzed using a set of geochemical methods, including bulk ^{14}C, selected lipid biomarkers, pyrolysis-GCMS and ^{13}C-CPMAS spectroscopy in order to characterize organic matter at multiple depth intervals and identify contributions of geogenic origin.

In the Pleistocene loess, apparent bulk ^{14}C ages increased with depth from 2,200 to 30,700 years BP, reflecting the depositional history of this relatively young sediment. The lipid analysis revealed multiple sections with high OC content and Carbon Preference Index (CPI) values (>13), suggesting the presence of paleosols. The oldest part yielded lower CPI values (<3.0), evidently phases where deposition was too rapid for pedological processes to take place. This was supported by ^{13}C-CPMAS NMR spectroscopy, demonstrating a highly degraded (alkyl-C rich) but soil like chemical composition of the OM. In these sections the organic matter is scarce and characterized by aliphatic compounds such as *n*-alkanes, possibly deposited along with the mineral material, and methyl ketones as well as monoaromatic compounds including benzene and toluene.

Apparent bulk ^{14}C ages of the Paleogene sand varied between 6,750 and 12,000 years, significantly younger than the deposition of the sediment (23-34 Mio. years BP). The samples were absent of *n*-alkanes and only small traces of fatty acids (2.67-0.59 μg/g dry weight) were detected, dominated by even long chain homologues. Young ages were also displayed by the red sandstone (about 245 Mio. years old), ranging between 12,760 and 17,400 years BP.

In summary, the hitherto investigations of the deep sediment cores of different parent material show a significant variance in age and composition of the OC for different parent material at various depths, owing to OC components deposited along with the sediment parent material mixed with more recently deposited biogenic carbon.