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Reconstruction of soil organic carbon build-up and dynamics using compound-specific radiocarbon analysis of lake sediments

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With ∼1500 Gt, Soil Organic Carbon (SOC) is the second largest active carbon pool in the world and plays an important role in the global carbon cycle. However, there are still many uncertainties about the reactivity of the SOC pool in response to climatic and environmental changes. In this respect, especially the role of refractory SOC is important, as this pool is ultimately responsible for long-term carbon storage. It is, for instance, still uncertain how fast the large amount of terrigenous carbon at higher latitudes was accumulated after deglaciation, and if this build-up is still ongoing or not. To understand the longer-term dynamics of this large carbon pool, one needs to resort to sedimentary records, as experiments are not possible at the time scales involved.
In order to gain more insight into SOC dynamics, we expand on the successful approach of Smittenberg et al. [1] by analyzing soil-derived molecular compounds preserved in a well-dated sedimentary record. When compared to the depositional age of the sediment, the age of the terrestrial lipids and organic carbon fractions gives an average residence time of these lipids and fractions in the SOC pool. Changes in the age-differential between sediment and soil-derived organic compounds over time give an estimate of SOC build-up and evolution.
Lake sedimentary organic matter consists of a mixture between aquatic and terrigenous compounds. Therefore, compounds with an unequivocal terrigenous source need to be isolated from the total lipid extract. We are targeting higher plant waxes (long chain n-alkanes and fatty acids) and branched GDGTs produced by soil bacteria. These compounds may be regarded as resilient because of their chemical properties: they are relatively non-reactive and are hydrophobic and therefore may easily become unavailable for biological breakdown.
For the isolation and purification of these compounds semi-preparative High-Performance Liquid Chromatography - Mass Spectrometry and preparative capillary Gas Chromatography are used. Radiocarbon dating is performed using an Accelerator Mass Spectrometer interfaced with a gas source, allowing the analysis of very small samples [2].
The investigated area is located on Andoya, Lofoten, Norway (69°N). Since a large portion of terrigenous carbon is stored at higher latitudes we chose to take samples from three lakes in that area. This region was deglaciated shortly after the last glacial maximum, and the lakes have a long sedimentary record of 22000 yr B.P, which is unique for Scandinavia.
We present selected biomarker profiles and a number of radiocarbon dates from bulk samples, (macrofossils) and isolated compounds from a 5.5 m long lake sediment core covering the time from after deglaciation to present. This data are compared with other sedimentary, paleo-environmental and –climatic information available from the cores with the final aim to improve our understanding of the Holocene evolution of the SOC pool at high latitudes.

References

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[2] M. Ruff, et al., Radiocarbon 49 (2007) 307.