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Rock-Eval analysis of French forest soils: the influence of depth, soil and vegetation types on SOC thermal stability and bulk chemistry

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Soil organic matter (SOM) is the largest terrestrial carbon pool and SOM degradation has multiple consequences on key ecosystem properties like nutrients cycling, soil emissions of greenhouse gases or carbon sequestration potential. With the strong feedbacks between SOM and climate change, it becomes particularly urgent to develop reliable routine methodologies capable of indicating the turnover time of soil organic carbon (SOC) stocks.

Thermal analyses have been used to characterize SOM and among them, Rock-Eval 6 (RE6) analysis of soil has shown promising results in the determination of in-situ SOC biogeochemical stability. This technique combines a phase of pyrolysis followed by a phase of oxidation to provide information on both the SOC bulk chemistry and thermal stability.

We analyzed with RE6 a set of 495 soils samples from 102 permanent forest sites of the French national network for the long-term monitoring of forest ecosystems ("RENECOFOR" network). Along with covering pedoclimatic variability at a national level, these samples include a range of 5 depths up to 1 meter (0–10 cm, 10–20 cm, 20–40 cm, 40–80 cm and 80–100 cm). Using RE6 parameters that were previously shown to be correlated to short-term (hydrogen index, HI; T50 CH pyrolysis) or long-term (T50 CO_2 oxidation and HI) SOC persistence, and that characterize SOM bulk chemical composition (oxygen index, OI and HI), we tested the influence of depth (n = 5), soil class (n = 6) and vegetation type (n = 3; deciduous, coniferous-fir, coniferous-pine) on SOM thermal stability and bulk chemistry. Results showed that depth was the dominant discriminating factor, affecting significantly all RE6 parameters. With depth, we observed a decrease of the thermally labile SOC pool and an increase of the thermally stable SOC pool, along with an oxidation and a depletion of hydrogen-rich moieties of the SOC. Soil class and vegetation type had contrasted effects on the RE6 parameters but both affected significantly T50 CO_2 oxidation with, for instance, entic Podzols and dystric Cambisols containing relatively more thermally stable SOC in the deepest layer than hypereutric/calcaric Cambisols. Moreover, soils in deciduous plots contained a higher proportion of thermally stable SOC than soils in coniferous plots.

This study shows that RE6 analysis constitutes a fast and cost effective way to qualitatively estimate SOM turnover and to discuss its ecosystem drivers. It offers promising prospects towards a quantitative estimation of SOC turnover and the development of RE6-based indicators related to the size of the different SOC kinetic pools.