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Geo-pedological control of soil organic carbon and nitrogen stocks at the landscape scale

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Geo-pedology, here defined as soil type (or Reference Soil Group) and parent material, can have a major impact on ecosystem (vegetation and soil) functioning. Geo-pedology can therefore deeply influence soil organic matter (SOM) stock. Nonetheless, the effect of geo-pedology on soil organic C (SOC) and N stocks has seldom been investigated. Indeed, factors known to influence SOM stocks such as land use and climate frequently co-vary with geo-pedology, so that testing the influence on SOM stocks of the factor "geo-pedology" alone is challenging.
In this work, we studied SOM stocks of forest and cropland soils in a small landscape (17 km^2) of the Paris basin (AgroParisTech domain, Thiverval-Grignon, France). We collected soil samples (0-30 cm) in 50 forest and cropland plots, located in five geo-pedological contexts: Luvisols developed on loess deposit, Cambisols developed on hard limestone, Cambisols developed on shelly limestone, Cambisols developed on chalk and Cambisols developed on calcareous clay deposits. We then determined SOM stocks (organic C and total N) and SOM distribution across different particle size fractions (coarse sand, fine sand and silt-clay).
As expected, SOC stocks were much higher in forests ($\sim$ 83 tC ha-1) than in cultivated soils ($\sim$ 49 tC ha-1). Interestingly, Cambisols had higher SOC stocks than Luvisols (69 vs 56 tC ha-1) and the difference between SOC stocks in forest and cultivated soils was much higher for Cambisols compared to Luvisols. Within Cambisols, parent material did not influence SOC stocks but the interaction between parent material and land use was significant, indicating that the effect of land use on SOC stocks was modulated by parent material. Similar trends were observed for soil N stocks. Conversely, soil type and parent material did not control SOM distribution in soil size fractions, while forest soils showed a higher distribution of SOC and N in the sand-size fraction than cropland soils.
Overall, our study evidenced a geo-pedological control of SOM stocks and clearly indicates that the change in SOM stocks resulting from a land-use change is strongly modulated by soil type. A good knowledge of the Reference Soil Group distributions is therefore needed to reduce the uncertainty on SOC stock evolutions in a changing environment from the landscape to the global scale.