



Mechanisms of aggregation in carbonate-rich semi-arid soils

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In many semi-arid soils, lithogenic and/or secondary carbonates are important constituents of the mineral fraction. It has been observed that carbonates can strongly affect soil aggregation and some studies have shown that a less direct relationship exists between aggregation and organic matter (OM) dynamics in these soils. The mechanisms through which carbonates interfere with aggregation remain however unknown to a great extent.

In this work, we revise a series of works carried out to determine these mechanisms, and their consequences for organic matter stabilization in semi-arid Mediterranean land. In a first approach, we conducted a comparative incubation experiment in which a completely disaggregated Calcic Cambisol (20% clay, of which 10% were carbonates), a contiguous decarbonated terra-rosa (20% total clay) and a non-calcareous soil (10% clay) received similar amounts of added maize stubble. We studied the formation of macroaggregates in relation to the incorporation of added OM, using physical fractionation and isotopic analysis. Unlike in the decarbonated and the non-calcareous soils, in the calcareous soil there was little OM transfer from macroaggregates to microaggregates and macroaggregates decay was independent from OM decomposition. Such results suggested that, contrary to soils following the hierarchical model of aggregation, microaggregates may not be formed within macroaggregates and macroaggregates stabilization may rely mostly on inorganic processes in calcareous soils. A second experiment was then run to elucidate which inorganic processes may be responsible for this behaviour. The hypothesis of (i) a preferential accumulation of more reactive 2:1 clay minerals within stable aggregates and (ii) the existence of the accumulation of carbonates precipitates within and around newly formed macroaggregates in calcareous soils were tested in a short-term incubation with the previous calcareous soil and the decarbonated terra-rosa. Preferential accumulation of reactive clay minerals within stable aggregates was found in the two soils, revealing that this seems a ubiquitous mechanism in basic Ca-saturated soils. However, the fabric of macroaggregates, as studied through aggregates thin-sections, was found to be less porous in the calcareous soil compared to the terra-rosa, due to the presence of crystals of micrite and sparite. These results and the reduced transfer of added OM from macroaggregates to microaggregates in calcareous soil, suggests that the accumulation of carbonates crystals may be responsible for the slower turnover and greater average stability of macroaggregates in these soils. Finally, the concentration and isotopic signature of calcite-C was analyzed in aggregate-size classes and their clay fractions in another Calcic Cambisol before and after 7 years of continuous irrigation (double organic C concentration). Carbonates were less concentrated in the finest fractions (silt+clay size) and their signature was also lower after irrigation, indicating an accumulation of pedogenic carbonates in the finest soil fractions. The isotopic signature of clays was equal among aggregate-size classes, indicating an absence of any preferential accumulation of recently precipitated carbonates in these aggregates or a fast enough turnover of pedogenic carbonates to distribute these carbonates among aggregate-size classes.

We conclude that the accumulation of carbonates precipitates is a major force leading aggregates dynamics and OM stabilization in calcareous soils.