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The role of soil organic carbon chemistry in soil aggregate formation and carbon preservation

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Increasing global soil organic carbon (SOC) stocks might be of key importance for climate change mitigation, while improving our knowledge of SOC and its management improves soil resilience and food security. The protection of SOC from microbial degradation and hence its preservation in soils is strongly influenced by two processes and their interplay: formation of primary organo-mineral (O-M) complexes via the sorption of dissolved organic carbon (DOC) to fine-grained soil minerals, and the aggregation of these to form micro and macroaggregates. To date research suggests that the chemistry of the SOC and the mineralogy of the soil matrix play a key role in the formation of O-M complexes and their stability against microbial degradation, but whether and to what extent these factors help control micro and macroaggregation are unknown. In this study we investigate how the chemistry of the SOC source affects the stability and aggregation of iron (oxyhydr)oxide O-M complexes. We determine the macroscopic and microscopic sorption behaviour of different SOC sources chosen to represent different functional group chemistries, using sorption isotherm experiments and STXM NEXAFS spectroscopy, and we conduct long-term aggregation experiments to track aggregate particle size using a novel Particle Size and Shape Analyzer technique. Currently there are two main models of soil aggregation: classical models where O-M complexes are building blocks for microaggregate formation, and contemporary models which propose that macroaggregates form first and microaggregates are formed within them and are then released as macroaggregates degrade. We find that the stability and aggregation modes of O-M complexes are a function of SOC chemistry, and that aggregation patterns are strongly influenced by the presence of microbial exudates and communities.