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Organic matter accretion on soil mineral surfaces is decoupled from specific surface area

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It is often assumed that soil organic matter associates with fine mineral soil particles depending on their surface properties. In soils with a low content of clay-sized mineral particles, the present organic matter has less reactive mineral surface area available than in clay-rich soils. How does soil texture impact the sequestration and microspatial arrangement of soil organic matter? In this study, we analyzed the amount and microspatial distribution of mineral-associated organic matter in the topsoil (0-20 cm) of an arable Cambisol with a gradient in soil texture (clay-sized particles 6-34 %). The samples originated from the agricultural research site in Scheyern (SE Germany) which was homogeneously managed and supplied with organic matter. X-ray diffraction showed a comparable clay mineralogy throughout the whole soil texture range. We obtained the density fraction >1.6 g cm^{-3} to remove particulate organic matter and split this fraction into fine silt-sized (2-6.3 μm) and clay-sized (0.2-2 μm) fractions. Our results show that the mineral-associated soil organic carbon (SOC) concentration of the fine silt and clay-sized fractions was higher in low clay soils with 6 % clay (80 mg g^{-1}) than at 14 % clay (40 mg g^{-1}). In high clay soils with 14 to 34 % clay, the SOC of these fine fractions was at a constant level of approximately 40 mg g^{-1}.The spatial element distribution of the organo-mineral associations in the clay-sized fraction was determined by the secondary ion distributions of $^{16}O^-$, $^{12}C_2^-$, and $^{12}C^{14}N^-$ at a lateral resolution of approximately 100 nm and a field of view of 30 μm x 30 μm with nanoscale secondary ion mass spectrometry (NanoSIMS). Based on the NanoSIMS measurements, we quantified the microspatial coverage of the patchy-distributed organic matter coatings on the mineral surfaces through image analysis using a multichannel machine-learning segmentation. We found a constant coverage of 9.3 $\pm$ 0.9 % organic matter coatings on the mineral surfaces for all soil textures. The $\Delta^{14}C$ was lower in the clay-sized fractions of the high clay soils (69 ‰) than in the low clay soils (114 ‰) suggesting a higher turnover of SOC in the high clay soils. In conclusion, the fine fraction of the low clay soil could sequester more SOC than the high clay soil compensating for its low mass and surface contribution to the bulk soil while the organic matter covered the same proportion of mineral surface. This suggests piled-up accumulations of organic matter in the low clay soils indicating a sequestration of organic matter that is decoupled from its lower reactive mineral surface area.