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Soil microaggregates: Effects of clay content on their 3D structure and pore architecture

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Most biogeochemical processes are regulated by soil structure, which can be studied at different scales. On a very small scale, soil microaggregates are considered to play an important role in soil functioning. Knowledge of their structure is therefore crucial for the understanding of many soil processes and functions, such as the storage and cycling of water, nutrients and organic matter. However, we know little about the microscale internal architecture of microaggregates, their formation and the mechanisms leading to the spatial organization of their various building units. The best method for structure analysis is computed microtomography, as this technique can provide detailed 3D (or even 4D) information on soil microstructure at high resolutions.

In this paper, we introduce possibilities to study and quantify the 3D architecture of microaggregates using high resolution X-ray microtomography at a resolution of approx. 500 nm. Since texture is known to exert a strong influence on the (micro-) structure of the soil, we investigated microaggregates with three different clay contents (n = 20 for each clay content) from a toposequence in Scheyern, Bavaria, which were isolated from the soil with a novel dry separation approach.

Our results show that aggregate volume, aggregate surface area and pore surface are similar across all clay contents. The content of macropores and maximal pore diameter also did not differ along this textural gradient. However, the total porosity of the microaggregates increased with clay content, as did pore surface normalized to aggregate volume. Further, the Euler number decreased with clay content, indicating a higher connectivity of the pore system.

These findings show that with increasing clay/decreasing sand content, the pore architecture of the studied microaggregates changed and that samples with high clay content had a more connective pore system and a higher pore surface area per aggregate volume, which facilitates higher process rates and faster transport of oxygen, water and nutrients. Possible feedback mechanisms on microaggregate formation and stabilization are discussed.