Geophysical Research Abstracts
Vol. 16, EGU2014-5270, 2014
EGU General Assembly 2014

Submicron mineral structures control the stabilization of litter-derived organic matter in soils – A NanoSIMS study

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The sequestration of carbon and nitrogen by clay-sized particles in soils is well established. However, in the most cases, the complex structure of the organo-mineral associations remain a black box due to the common measurements of soil fractions as a whole. By combining nano-scale secondary ion mass spectrometry (NanoSIMS) with isotopic tracing it is possible to study the formation and spatial heterogeneity of organo-mineral associations. NanoSIMS enables the detection of up to seven secondary ion species (e.g. 13C-, 12N15N-, 27Al16O-, 56Fe16O-) simultaneously, to generate a submicron-scale image of the elemental and isotopic composition (e.g. 13C, 15N, Al and Fe) down to a lateral resolution of ∼150 nm. Therefore this technique can be used to study organo-mineral associations at the relevant scale.
The aim of our study was to follow the formation of organo-mineral associations over different time steps and the distribution of C and N by imaging the complex arrangement between soil mineral surfaces and litter-derived organic matter (OM). Parallel to the determination of the isotopic N and C composition of bulk soil and soil fractions (combined density and particle size fractionation) using isotope ratio mass spectrometry (IRMS), the spatial distribution of the OM was investigated by NanoSIMS analysis of the clay-sized fraction.
In our study we show that only some of the clay-sized surfaces bind OM. Surprisingly, less than 19% of the mineral areas visible by scanning electron microscopy and NanoSIMS show an OM attachment. We demonstrate that mineral clusters with rough surfaces exhibit the preferential binding spots for OM. By combining NanoSIMS and isotopic tracing, we distinguish between new labelled and pre-existing OM and show that new OM is preferentially attached to already present organo-mineral clusters.

Vogel, C., Mueller, C.W., Höschen, C., Buegger, F., Heister, K., Schulz, S., Schloter, M., Kögel-Knabner, I., 2014. Submicron structures provide preferential spots for carbon and nitrogen sequestration in soils. Nature Communications 5. doi:10.1038/ncomms3947