

Could bacterial residues be an important source of SOM? – A case study from a glacier forefield

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Recently, stocks of soil organic matter (SOM) have been shown to decrease in European soils and also worldwide, which compromises soil fertility and enhances emissions of carbon dioxide to the atmosphere. However, the general structure of SOM, and thereby the mechanisms behind its genesis and loss, remain unclear.

In this framework, microbial biomass is generally regarded to be of low importance for SOM formation. In particular on freshly exposed surfaces, however, bacteria colonize barren mineral surfaces faster than fungi or higher plants. Moreover, recent results indicate that bacterial cell wall fragments frequently occur on soil mineral surfaces and also accompany the microbial colonization of previously clean and sterile activated carbon surfaces after incubation in groundwater. Hence, we hypothesized that, at least, in the initial stages of soil formation bacteria and their fragments may play an important role in particulate SOM formation bearing in mind that most dead organic matter entering the soil is processed by bacteria.

This hypothesis was proven by tracing the development of SOM in a chronosequence with samples from the forefield of a receding glacier (Damma-glacier, Canton Uri, Switzerland) by scanning electron microscopy and other methods. The initially barren mineral surfaces have been shown to be rapidly covered with microbial residues as soil age increases. Moreover, this data compares well to growing C/N-ratios, water contact angles and fatty acid contents in earlier deglaciated samples.

Iron isotope fractionation in soil solutions of a Gleysol

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Analyses of Fe isotope compositions in a Gleysol with petrogleytic properties from NW Germany yielded bulk $\delta^{57}\text{Fe}$ values of +0.29‰ (Ah horizon, Fe_{total} ca. 50 g/kg) to -0.30‰ (Bg horizon, Fe_{total} ca. 320 g/kg). A special feature of this Gleysol is a local massive enrichment of Fe (hydr)oxides (comprising mostly goethite and ferrihydrite). In contrast to the overlying CrBg and Bg horizons, the 2Cr horizon which developed from glaciofluvial sands, is characterized by a relatively high $\delta^{57}\text{Fe}$ value of +0.22‰, but lowest total Fe amounts (ca. 7 g/kg).

To evaluate the relationship of Fe isotope composition of the four horizons and their soil solution, we sampled the soil solution at different depths during spring and autumn. Water of a nearby stream and Fe-rich precipitates in the stream sediments were additionally sampled.

The Fe isotope composition and Fe concentration of the soil solution strongly varied with both depth and abundance of Fe (hydr)oxides, but revealed little seasonal effects. We observed extremely low $\delta^{57}\text{Fe}$ values of -2.8‰ and Fe concentrations of ca. 3 mg/L in the soil solution of the CrBg horizon. In contrast, the soil solution obtained from the underlying sandy 2Cr horizon is characterized by $\delta^{57}\text{Fe}$ values of -1.5‰ and high Fe concentrations of up to 60 mg/L. The water of the adjacent stream showed $\delta^{57}\text{Fe}$ values of -0.03‰, whereas the Fe-rich precipitates in the stream bed are marked by a high $\delta^{57}\text{Fe}$ value of +0.55‰.

We conclude that the low $\delta^{57}\text{Fe}$ values in the soil solution are the result of preferential adsorption and precipitation of heavy Fe isotopes on abundant Fe (hydr)oxide phases in the CrBg horizon. The Fe-poor 2Cr horizon lacks this capability, therefore, higher $\delta^{57}\text{Fe}$ values and Fe concentrations are observed in its soil solution. For the Fe-rich precipitates of the stream, preferred removal of heavy Fe isotopes during precipitation entailed high $\delta^{57}\text{Fe}$ values.