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SOM genesis - microbial biomass fragments could be a significant source in newly exposed ecosystems

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Microbial biomass is generally regarded to be of low importance for soil organic matter formation. However, especially on freshly exposed surfaces 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.

To prove this hypothesis we traced the development of SOM in samples from the forefield of a receding glacier (Damma-glacier, Canton Uri, Switzerland). Soil samples were obtained from below the rooting zone at eight sampling spots with soil age of 1 to 120 years. Following transport to lab, samples were characterised by scanning electron microscopy (SEM), phospholipid fatty acid extraction, contact angle measurement and carbon and nitrogen content analysis.

In the scanning electron micrographs, number and surface area of bacterial cell wall fragments was quantified statistically by laying a 10*10 grid over pictures of size 32.5μm*32.5μm. Out of this, 10 fields were selected randomly and examined by 3 persons independently. Additionally elemental analysis on selected specimens was performed by energy dispersive X-ray spectroscopy (EDX).

Spectroscopic analysis (SEM-EDX) of anticipated bacterial cell wall fragments gave increasing amount of carbon and lower carbon to nitrogen ratio (C:N) compared to mineral surfaces. However, the high penetration depth of the electron beam always results in an average spectrum of the anticipated cell wall fragments and the mineral surface below them, so the signal of the biomass component is attenuated. Hence, the fragments observed in scanning electron micrographs can be confidently characterised to be of biological origin. Both number and total surface area of cell wall fragments per field of view increased from younger to older soils, resulting in a complete organic coverage of the surfaces in soils older than 64 years. The overall C:N and the water contact angle have been found to increase over the sequence. Especially at the first three sites, an extremely low C:N of 6 to 10 indicates that SOM is primarily consisting of bacterial remnants, i.e. bacterial cell wall fragments. PLFA analysis revealed that in the younger soils biomarkers for bacteria dominate, while only in older samples also markers for eukaryotic microorganisms, mosses, and plants appear. Furthermore, the ratio of bacterial to fungal biomarkers increases strongly over the sequence. This further indicates the significance of bacteria for SOM establishment in developing ecosystems.

In conclusion, the initial step of SOM formation seems to be mainly controlled by bacteria and their fragments after cell death. This could be due to bacterial colonisation of previously uncovered mineral surfaces and the short generation time of bacteria compared to fungi or plants. Thereby, a complete organic coating of most mineral particles is already established 64 years after deglaciation.