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Organic Acids Exuded by Pioneering Fungi from a Glacier Forefield Help to Weather the Granitic Sediments

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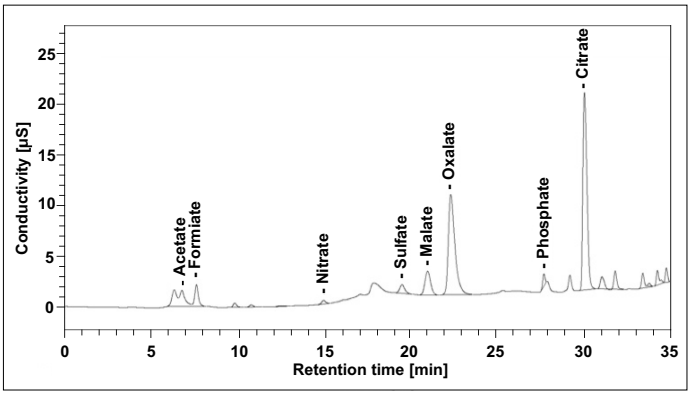
Glaciers are retreating worldwide due to global climate change. In Europe, alpine glaciers lost about half of their total surface area and their total volume within the last 150 years. Consequently, fresh rock sediments are exposed at the surface and subjected to weathering processes.

Rock surfaces that are freshly exposed to the atmosphere become rapidly colonized by microbial communities as the first settlers. In particular, granitic sediments of glacier forefields are inhabited by a large variety of microorganisms, such as bacteria, cyanobacteria, archaea, green algae and fungi. As no plants grow during the first years after the glacier has retreated, the carbon found does not originate from autochthonous plants. Cell-wall remnants and exudates of green algae and cyanobacteria are most likely the major primary carbon source in this environment, in addition to deposition (*e.g.* pollen) and the ancient recalcitrant organic matter.

Damma Glacier with forefield, situation of October 2007: 1 Glacier tongue, 2 side moraine, 3 frontal moraine from 1992, 4 glacier forefield younger than 15 years, 5 glacier forefield older than 50 years. The studies were conducted in association with the 'BigLink' project of the Competence Center Environment and Sustainability of the ETH Domain (CCES), S. M. Bernasconi *et al*., *Vadose Zone J.* **2011**, *10*, 867. Photo by G. Furrer



Ion chromatogram of exuded organic and inorganic anions of *Mucor hiemalis*. The fungus was raised in a solution which contained the cell-wall component pectin as the only carbohydrate source.

A set of fungal species isolated from fine granitic sediment of the non-vegetated forefield of the Damma Glacier in the central Swiss Alps showed a high potential to weather powdered granite material in batch experiments. In particular, the zygomycete fungi *Mucor hiemalis, Mortierella alpina, Umbelopsis isabellina* and the ascomycete fungus *Penicillium chrysogenum* dissolved the granite powder most efficiently. It was shown that the high concentrations of Ca, Fe, Mg and Mn in the solutions were the result of the release of high amounts of organic acids, mainly citrate, malate and oxalate.

Concentrations of the organic acids in the treatment solutions were analyzed by ion chromatography on a Dionex ICS-3000, using an IonPac AS19 analytical column. An IonPac AG19 guard column and an IonPac AG11-HC guard column were used as pre-columns to improve run quality. Cell temperature of the conductivity detector was set to 35 °C and column temperature to 30 °C. Separation of the organic acids in the columns was achieved using a NaOH gradient, with a detection limit of 0.15 mg l^{-1}.

In a consecutive study we showed that the patterns of released organic acids are dependent on the sources of carbohydrate. **In particular, pollen and remnants of algal cells can trigger the exudation of organic acids of fungi in order to promote the weathering of minerals and to make nutrients available.**

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