



## **From water to land – mutual succession of microbial mats and soils at a freshwater lake in maritime Antarctica**

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The remoteness of Antarctica offers the perfect environment for the investigation of fundamental biogeochemical processes and developments of terrestrial ecosystems. On James Ross Island, located in the Weddell Sea west of the Antarctic Peninsula, climate conditions are too harsh to provide a home for vascular plants or for terrestrial animals. The combination of mean annual air temperatures of about 7 °C, huge annual amplitudes in temperature and a remarkable aridity gives habitat only for cryptogams like lichens, terrestrial algae, mosses and cyanobacteria. The northern part of the island, Ulu Peninsula, represents one of the largest ice-free areas of the Antarctic Peninsula region and therefore allows studying soil development together with microbial succession in a pristine environment with a pleasantly low rate of civilizing interference.

In this setting, we examined the changes in biogeochemistry at succession gradients from lake sediments extending to regularly flooded areas and terrestrial areas covered with biological soil crusts. We subjected the sediments to fractionation according to density and grain-size and found a clear domination of sand-sized particles with more than 60 % and a noteworthy percentage of clay-sized particles with 10 to 18 % in all samples. With less than 1 % particulate organic matter, we detected only little contribution of particulate biological residues. This indicates the pivotal role of mineral-associated organic carbon in the clay-sized fraction and the particulate organic matter in the sequestration of organic carbon in these soils. Carbon and nitrogen contents of the bulk soil samples followed the gradient with lowest amounts of the elements in the permanently submerged lake sediments. This indicates that the persistent rinsing with fresh water impedes the development of microorganisms and leaches the nutrients and contrasts the fact that soils and sediments close to fresh water lakes represent the sites with largest amounts of organic carbon on James Ross Island. The analysis of biomarkers in the extracted free lipids reflected the gradient as well. They showed a pronounced difference between with steady contact to the fresh water of the lake and sites with an incipient vegetation. The submerged sediments are dominated by  $\beta$ -sitosterol, a common plant marker, but under these climate conditions widely used by algae and fungi. This limits its use as indicator of plants or points to a possible adaption to the harsh conditions for terrestrial life in this climate. Sites with more distance to the fresh water contained also brassicasterol and campesterol, typical metabolites of algae. Diglycerides and triglycerides were also present, giving notice of cold adaption mechanisms. Our findings point to the decisive role fresh water plays for the development of phytoplankton communities in cold environments and their adaption mechanisms towards colonization of terrestrial habitats.