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The different roles of desert soil microorganisms in atmospheric gas turnover

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Soil microorganisms play a major role in the turnover of most atmospheric gases and are key to understanding ecosystem functions such as carbon and nitrogen fixation, methanogenesis, methanotrophy and the production and consumption of other greenhouse gases. In dryland ecosystems plant cover is limited, permitting the development of a unique microbial mat termed biological soil crust (biocrust), which is responsible for most ecosystem functions, including primary production. While the importance of cyanobacteria living in biocrusts in carbon and nitrogen fixation has been acknowledged for many years now, the role of other bacteria and archaea in controlling biogeochemical cycles in general, and gas turnover in particular, remained understudied until recently.

In this presentation I will highlight some of the lesser known ecosystem functions of biocrusts, specifically giving attention to non-cyanobacterial members of desert soils. Through a combination of gas measurements and carbon isotope analysis with molecular approaches such as environmental gene expression analysis and ^{18}O-based RNA stable isotope probing coupled with high-throughput sequencing, we show that biocrusts harbour two functionally distinct microbial communities, which resuscitate in a successional manner following rehydration. The top half of the biocrust remains oxic when wet and the succession following hydration is characterised by a rapid decline of the dominant Actinomycetales, which are then replaced by Sphingobacteriales and several Alphaproteobacteria (Rhizobiales, Rhodobacterales, Rhodospirillales and Rubrobacteriales). Cyanobacteria, the conspicuous members of biocrusts on the other hand, only constitute a fraction of these active microbes. The succession in the anaerobic part of the crust begins with activation of Bacillales, which are later replaced by Clostridiales. Aerobic methane oxidation in desserts is carried out by a unique and uncharacterised group of methanotrophs, which are only found in the bulk soil but are absent in the biocrust. Following wetting of the soil, methane oxidation ceases due to oxygen limitation and is replaced by methanogensis, which occurs in the bottom part of the biocrust. Methanogens of the type Methanosarcina and Methanocella are the last to resuscitate and produce methane from hydrogen and COth. Lastly, I will show evidence for the involvement of non-cyanobacterial diazotrophs in nitrogen fixation in mature biocrusts.

Our studies show that deserts host a diverse microbial community whose members display complex interactions and perform various biogeochemical processes as they resuscitate from dormancy. Furthermore we demonstrate the importance of understanding the links between functional responses of desert microbes and community formation in the face of environmental change. This is of crucial importance if we aim to predict and mitigate the consequences of desertification.