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The biogeochemical development and community structure of desert potholes

K. Hughes and G. Southam

Dept. of Earth Sciences, University of Western Ontario, Ontario, Canada (khughes7@uwo.ca)

The purpose of this research is to examine the adaptations bacteria employ to survive oligotrophic conditions, and the contribution this bacterial community makes to its environment. The overall structure of life in the semi-arid desert of the Colorado Plateau is supported on a nutrient-poor sandstone substrate. To form a usable soil base the pioneering actions of micro-organisms are all important. Endolithic cyanobacteria form thin bands millimeters under the surface of the sandstone where they are protected from the UV flux. These layers occupy the pore space in the sandstone, initially providing a semi-permeable barrier which increases water retention at the surface and later, when the layers have been exhausted of nutrients, exfoliating the upper surface, creating the basic constituents of a sandy desert soil. This process of exfoliation occurs preferentially in local areas causing depressions known as "pot-holes". These bowl shaped depressions range in size representing a continuum of development. Larger potholes, which can be as deep as 2m, hold water through the dry season allowing for communities of plants and animals to persist.

This research focuses on the relationship between the bacterial community and the substrate during pothole formation. The biological community in the potholes can survive on nutrients already present in the potholes after artificial wetting with distilled deionised water. Diurnal cycling of both pH values and key nutrients was observed indicating the presence of a functioning biological community. pH values obtained in field work rose as high as 10 which is consistent with the ability of certain cyanobacteria to produce hydroxide ions as a by-product of photosynthesis. These cyanobacteria also nucleate the growth of calcite in alkaline environments. A laminated pore filling calcite cement of possible biogenic origin was observed using cathodoluminesence microscopy. Leaching experiments of the host sandstone showed increased solubility of silica and decreased solubility of calcium at higher pH, indicating that the biological

community is triggering both dissolution and cementation of the host rock.

The pothole community was also observed using a Focused Ion Beam Scanning Electron Microscope (FIB-SEM). Dried samples of pothole biofilm were collected and re-wetted with distilled deionised water to observe the growth of the bacterial community. FIB-SEM observations revealed that the community recovered from desiccation and formed many unusual structures under the persistent oligotrophic conditions. Work with community 16s RNA analysis is ongoing to compare the novel pothole communities with other bacterial communities found in the same area forming cryptobiotic crusts. Similarities between these two groups may indicate a progressive relationship from pothole soil-forming communities to more established cryptobiotic crust soil-trapping communities. Also, molecular biology techniques are being used to investigate the contributions of individual species to the overall community structure and function.

Although desert life is typically thought to be sparse, this study shows a complex bacterial community not only accomplishing its own survival but, through its unique adaptations, preparing the area for colonization by higher forms of life.