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Minerals as habitat: A special relationship between a microbe and its mineral

P.C. Bennett and A.A. Jones
The University of Texas, Austin, Texas, United States (pbennett@mail.utexas.edu)

For decades its been known that most of the subsurface microbial biomass is attached to mineral surfaces. But from there the assumption is often that the subsurface community is more or less homogeneously distributed within a steady-state habitat or redox environment, and that in a small volume of sediment, each mineral grain has the same community. We are finding however that this is not an accurate representation of the subsurface habitat in a polymineralic system. Each mineral type may support a unique community based on the nutrient and habitat requirements of the organism, and the nutrient and habitat potential of the mineral.

In a variety of settings we have documented a relationship between colonization, community and mineralogy, typically due to the presence of a nutrient or critical geochemical characteristic. In an oil-contaminated aquifer we found that many tested minerals (e.g. olivine) support scant microbial attachment, some (e.g. quartz) have a consistent, thin, but diverse attached community, while some have a very rich appearing biofilm. Different alkali feldspars with otherwise identical chemistries will have clearly different biofilm densities due to the presence of trace P or Fe. On crystalline basalt different minerals sustain dramatically different biofilms, differentiated at the scale of a few microns.

We have now documented that microbial populations from a mixed community, will, when offered a choice, select the mineral that is the best habitat. Biomat samples of a diverse mixed community from a sulfidic stream in Lower Kane Cave, Wyoming, USA were collected and inoculated into CDC biofilm growth chambers using artificial cave water with 0.8mM $S2O_3$= as the growth medium. In each experiment the stirred reaction chamber holds 8 rods each with triplicate mineral disks,. The mixed mat sample was allowed to react, grow, and attach under a variety of conditions, and then the mineral disks were recovered and biofilm mass measured, and the biofilm community characterized by pyrosequencing, and the surface alteration examined by SEM.

We find that each mineral type supports a unique microbial community linked to the habitat advantages it offers. Acidophilic sulfide oxidizers select quartz due to the lack of acid buffering or mobile toxic elements. Neutrophilic sulfide oxidizers in contrast avoid quartz and select carbonate minerals for the acid buffering capacity. Even similar carbonates supported different communities when there is a difference in nutrient content.

Ongoing research into the relationship between minerals and microbes is starting to provide hints of a developing new conceptual model where subsurface microbial communities are intimately linked to specific minerals as habitats that provide unique advantages. This suggests a fundamentally heterogeneous distribution of microbial communities controlled by mineralogy and nutrient requirements, where the mineral influences the microbial community, while the microbial community controls mineral weathering.