Interactions between microbial communities and their geologic environment at the Costa Rica active margin

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The reciprocal feedbacks between microorganisms and their environment have governed much of the coevolution of the biosphere, geosphere, and atmosphere throughout geological time. Evidence from the rock record highlights massive shifts in redox chemistry, trace metal availability, and primitive respiration during ancient Earth that may have been driven at least partially by changes in plate tectonics and volcanism. Our understanding of how deep subsurface processes in modern environments influence the trajectory of microbial evolution is limited. To better characterize the interactions between microorganisms and their environment, we sequenced 35 metagenomes from microbial communities along the Costa Rica volcanic arc, where sites varied significantly in terms of pH (0.85 to 9.75), temperature (26 to 88°C), sulfate concentrations (0.03 to 99.2 mM), and molecular hydrogen (<0.001 to 11.7 mM).

Diverse pathways of carbon fixation were observed across most samples, including the Calvin-Benson Cycle and the Wood-Ljungdahl pathway. Network analysis showed sulfate and hydrogen negatively correlated with genes invovled in these pathways, including cbb3-type cytochrome c oxidase. Sulfate also had a negative relationship with glycolysis, indicating that nutrient release from the deep subsurface may play a role in shaping both chemolithotrophic and heterotrophic communities at the surface.