Geochemical niches of extremophile communities in an ephemeral acid rock drainage

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Acid rock drainage (ARD) occurs when metal sulfide minerals are exposed to surface conditions and begin to oxidize. This creates high concentrations of dissolved iron, other metals, and sulfuric acid, creating orange streams, seeps, and pools. These acidic, metal-rich sites host diverse microbial communities that includes extremophilic iron and sulfur oxidizers that take advantage of the abundant chemical energy from sulfide minerals and dissolved iron, and have adapted to extreme acidity and high metal concentrations. The Copper Flat mine is a historic copper mine located in the Hillsboro mining district in south-central New Mexico. It is a low-grade porphyry deposit where the primary copper mineralization is in the form of chalcopyrite veinlets. The mine operated at full production for 3 months in 1982, and was then placed on a care and maintenance plan to await an increase in the market price of copper, but was eventually decommissioned in the 1990s. At this site, there are two extremely acidic seeps that run only once or twice per year for no more than several weeks at a time, depending on monsoon precipitation. Year after year, a vibrant microbial community springs up when these seeps are actively running. However, we know little about the microorganisms that colonize these seeps, and how the ecology, biogeochemistry, and fate and transport of metals change during these seasonal wetting and drying cycles.

Here we present preliminary data the microbial communities present in one of the seeps that was running in June 2020. pH and specific conductivity of the seep varied from 1.54-1.95 and 9.01-6.32 mS/cm, respectively. Based on rRNA gene libraries from nine exploratory samples, seep sediments were dominated by populations related to known lithotrophic iron-and sulfur-oxidizing bacteria, acidophilic organoheterotrophs, diverse algae, and novel Proteobacteria and Thermoplasmatales-group Archaea that varied with the pH and salinity gradients in the seep. Bacteria and archaea related to Leptospirillum, Acidiphilum, Acidibacter, Ferrithrix, Cuniculiplasma, and Ferrimicrobium were consistently more abundant at the more acidic site, while Acidicapsa, Acidobacterium, and Alicyclobacillus dominated at the less acidic location. We hypothesize that these differences in community composition are due to differences in pH and metal content of the waste stream, which may represent the tolerances for each population with respect to their preferred geochemical niches in these ephemeral seeps. Future work aimed at understanding the ecological and geochemical constraints on these organisms can help us to better design passive remediation strategies and understand elemental cycling in ARD environments.

Keywords:
geomicrobiology, acid rock drainage, mining

2022 New Mexico Geological Society Annual Spring Meeting & Ft. Stanton Cave Conference
April 7-9, 2022, Macey Center, Socorro, NM
Online ISSN: 2834-5800