Life on serpentinized setting on the Earth and beyond

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Almost all the microbial ecosystems on present-day Earth are supported by photosynthesis including the subsurface biosphere. Organic carbons from the photosynthesis have been accumurated and delivered into the deep subsurface ecosystem. Oxygen and oxidative compounds also have distributed everywhere on the Earth through the water and contributed to creating chemical gradients that can support microbial energy metabolisms. Therefore, opportunities are rare to address microbial ecosystems that are isolated from the effects of photosynthesis, but those are canceled in several settings, one of which includes a serpentinized ecosystem.

Serpentinization is a process whereby water interacts with reduced mantle rock called peridotite to produce a new suite of minerals (e.g., serpentine), a highly alkaline fluid, and hydrogen. The hydrogen and carbon dioxide present in the system are thought to react under the highly reducing and alkaline conditions, leading to the formation of methane and hydrocarbons and the concomitant production of carbon monoxide, formate, formaldehyde and methanol. Given that the reduced compounds delivered from the water-rock reaction can support microbial energy metabolisms, such serpentinization systems have been viewed as potential habitats for early life or the other planetary bodies.

Studies of serpentinizing environments to date have shown that these ecosystems host extremely low-abundance microbial communities, which is presumably attributed to the multiple extremes: 1) the highly-alkaline condition of the fluid; 2) the extremely low concentrations of oxidants (electron acceptors); and, 3) the low levels of and nutrients (available carbon and phosphate). The Cedars located in northern California is one of the active terrestrial serpentinization sites. While there are about a hundred of springs in The Cedars area with a variety of differences in geochemistry (Figure 1), spring waters discharged from The Cedars generally have extremely high pH (11-12), very low Eh (–900 mV - –550 mV) values and are rich in Ca^{2+} (~1 mM), hydrogen and methane gas, and contain low levels of dissolved organic carbon, total inorganic carbon, ammonium, phosphate and electron acceptors (oxygen, nitrate, sulfate)
Here I present a diversity of unusual metabolisms and life strategies seen in the early Earth or other planetary bodies' analogue sites, those of which have been identified through the studies of geochemistry, microbial cultivation, genome centric metagenomics of The Cedars microbial communities. Furthermore, I discuss the constraints and driving forces lying in the deep subsurface serpentinized settings to make a living.

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