Biogeochemical carbon cycling at sites associated with active continental serpentinization: The Tablelands, Newfoundland, Canada

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The Tablelands in Newfoundland, Canada contain terrestrial peridotite-hosted groundwater springs associated with serpentinization. These springs act as windows into subsurface systems and provide insight into their biogeochemistry. However, at sites where ultra-basic water pools and mixes with overland flow, the reactions in the pools must be considered when trying to source organic compounds. We will present data from a pool (WHC2) located in the Tablelands to determine the biogeochemical carbon transformations at this mixing site.

The ultra-basic, reducing groundwater springs had higher concentrations of alkanes (C_1-C_4) and organic acids (acetate and formate) than the overland flow, suggesting that these organics originated from the groundwater source. A two-component mixing model was developed to predict what the concentrations of alkanes and organic acids would be in the WHC2 pool based on physical mixing of groundwater and overland flow. Acetate and C_2-C_4 alkane concentrations were fairly well predicted by the mixing model, suggesting little consumption or production of this organic acid and these alkanes in the pool. However, methane concentrations were under predicted by the model at one sampling point in the pool, suggesting production of methane at this site. At the same sampling location, formate concentrations were over predicted by the model, suggesting that formate was being consumed in the pool. The water at these sampling times was highly reducing; therefore, oxidation of formate was not likely responsible for the consumption of formate. Organic acid fermentation using formate is one possible sink for formate and source for methane. However, the genomic data from the site has shown little evidence for microbial methanogenesis.

Geochemical measurements of the carbon in the pool can help elucidate the most dominant source of methane. On a Bernard plot (C_1/C_{2+} vs. $\delta^{13}C_{CH4}$ (‰)) the alkanes measured at the springs plot in the thermogenic region. However, this plot cannot be used as the sole diagnostic tool because the microbial methane in at least two studies of thermophilic methanogens would plot outside of the microbial field on this plot. The carbon isotope fractionation between inorganic carbon and methane ($\alpha C_{DIC\text{-}CH4}$) was within range of acetate fermentation and the $\alpha C_{DIC\text{-}CH4}$ from putative abiogenic methane from the Precambrian. Further elucidation of methane source will require δ^2H measurements of H_2O and CH_4.

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