

Merging isotopic and metagenomic data to predict Carbon and Nitrogen-fixation in hydrothermal biofilms

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Comparison of carbon and nitrogen isotopic compositions of hot spring biofilms reveals large differences that may depend on temperature, nutrient source, and microbial community composition. In fact, isotopic compositions of hydrothermal biofilms change dramatically within individual hot spring systems. This provides an opportunity to explore the diversity of natural carbon and nitrogen cycles if isotopic compositions can be linked with biological uptake and fixation pathways. Genes for the four major carbon fixing pathways are present in our metagenomic data from five different biofilms in the source and outflow of one spring ("Bison Pool", ranging from ~93° to ~57°C). Combining carbon isotopic data from the same biofilm samples used for metagenomic sequencing, with literature data on isotopic fractionation for C-fixing pathways at various temperatures yields predictions that can be tested with the metagenomic data. The strongest correlations are with the reverse tricarboxylic acid cycle at the highest temperatures, the acetyl coenzyme A pathway at mid range temperatures, and the pentose phosphate cycle in the photosynthetic zone. Likewise, trends in nitrogen isotopic composition for these communities, coupled with metagenomic data, reveal shifts in nitrogen uptake strategies and help pinpoint where nitrogen fixation occurs in hydrothermal systems.

Mechanistic controls on chemical variations in pyroxenes, amphiboles and micas

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The compositions of rock-forming minerals vary as a function of temperature and pressure. Examining these changes is a major part of petrology, and our geothermobarometers are, for the most part, based on thermodynamic analysis of these changes as a function of temperature and pressure. However, this approach does not address the causes of these variations in composition; I will attempt to do so here.

Pyroxenes, amphiboles and micas all consist of units of polymerized tetrahedra and polymerized octahedra. For these structures to be stable, these units must be dimensionally commensurate, and this commensurability must be maintained with changing temperature and pressure if the structure is to remain stable. However, aluminosilicate tetrahedra show much lower thermal expansion and much higher compressibilities than (Mg,Fe,Al)-containing octahedra, and with changing temperature and pressure, the dimensions of the tetrahedral and octahedral components of a structure change differentially. In order to maintain articulation between these two components of a structure, the site populations of the tetrahedra and octahedra change to maintain (1) commensurate dimensions, (2) *local* bond-valence requirements, and (3) electroneutrality. Here, I examine how the chemical compositions and site-ordering patterns in pyroxene, amphibole and mica structures are expected to change as a function of temperature and pressure in order to conform to the above requirements for stability, and compare the predictions with observed compositional variations.