

## Microbial organoarsenical production in geothermal systems

ANNETTE SUMMERS ENGEL<sup>1</sup>, LINDSEY R. JOHNSON<sup>1</sup>,  
AMITAVA ROY<sup>2</sup> AND GREGORY MERCHAN<sup>2</sup>

<sup>1</sup>Department of Geology & Geophysics, Louisiana State University, Baton Rouge, Louisiana 70803 USA

<sup>2</sup>J. Bennett Johnston, Sr., LSU Center for Advanced Microstructures and Devices, Baton Rouge, LA 70806

Microbial As cycling from non-sulfidic, circumneutral pH fluids above 50 °C is poorly understood because few natural systems exist. El Tatio Geyser Field, Chile, is one example where geothermal fluids discharge at local boiling (~86 °C) and As (III) progressively oxidizes to As (V) downstream. Although removal of As (III) from solution may be occurring through sorption onto organic matter or by photooxidation to As (V), changes in As speciation due to microbial metabolism were investigated, with a focus on the occurrence of organoarsenical compounds. There has been limited research on the presence, origin, or possible role of organoarsenicals in geothermal systems. Arsenic in mats and sediments was in the As (V) valence state, and XANES and EXAFS confirmed that As was not bound to S or occurred as an oxide mineral, but instead existed as inorganic As (V) weakly complexed to Fe oxyhydroxides and at least two organoarsenicals, dimethylarsinic acid (DMA), which signified methylated metabolites, and roxarsone, which was a proxy for other complex biological arsenicals like arsenobetaine. XANES spectra from the furthest downstream mats fit best with DMA, whereas upstream fits were best with roxarsone and comprised almost 50% of the mat As species. Methylated As is usually produced through detoxification, but complex As species could indicate novel pathways. From 16S rRNA gene sequences, *Chloroflexi* were the most prevalent in the mats, especially downstream. Phylogenies of arsenic oxidase (*aroA*)-like genes identified potential homologues from *Chloroflexi* genomes and fewer homologues affiliated with the *Proteobacteria*. No *Aquificales*, *Deinococci*, or *Chlorobi aroA*-like genes were retrieved. *Chloroflexi* are considered anoxygenic phototrophs, and have not been previously linked to phototrophic or even heterotrophic As (III) oxidation, and no known *Chloroflexi*-like *aroA*-like genes have been found from other geothermal or As-enriched environments. With some indication that *aroA* is used for detoxification by some *Proteobacteria*, the *Chloroflexi* communities downstream could be responsible for the identified methylated organo-arsenicals in the mats. This work provides an important perspective into the role of microbes in producing organoarsenical compounds in geothermal systems.

## The stability of phlogopite in the sub-continental lithospheric mantle: KCMASH±CO<sub>2</sub> vs. KMASH-CO<sub>2</sub>

A. ENGGIST\* AND R.W. LUTH

C. M. Scarfe Laboratory of Experimental Petrology,  
Department of Earth and Atmospheric Sciences,  
University of Alberta, Edmonton, AB, Canada  
(\*correspondence: andreas.enggist@ualberta.net)

Previously, we reported that in the phlogopite + magnesite system, phlogopite can be stable to a depth of 200 km in the presence of carbonate at a cooler lithospheric mantle geotherm of 40 mWm<sup>-2</sup>. At the base of a hotter sub-continental lithospheric mantle (SCLM), phlogopite and magnesite will react to form enstatite, olivine, garnet and hydrous, potassium- and CO<sub>2</sub>-rich melt [1, 2]. Here we present first results of phlogopite + diopside + enstatite ± carbonate.

### KCMASH

In the presence of pyroxenes, phlogopite is stable to 1300°C and 5.5 GPa and starts to break down at 6 GPa; amphibole becomes stable and coexists with remaining phlogopite to higher pressures, which is in agreement with [3]. The solidus is located at 1400 and 1350°C at 5 and 4 GPa, respectively, where phlogopite reacts out over a temperature range of about 50°C and garnet, enstatite, diopside, olivine and melt is in equilibrium.

### KCMASH-CO<sub>2</sub>

Adding carbonate to the pyroxene-bearing system lowers the thermal stability of phlogopite considerably: Phlogopite starts to react out at 4 GPa and ~950°C. An experiment at 6 GPa and 1000°C still contains phlogopite, which may reflect the sluggish kinetics of the breakdown reaction. Above the solidus, melt coexists with garnet, enstatite, diopside, and olivine. Melt quenches to amphibole and phlogopite of around 10 µm in size.

### KCMASH±CO<sub>2</sub> vs. KMASH-CO<sub>2</sub>

No hydrous solution was seen escaping from the capsules upon breach. Amphibole is the new phase occurring, either primary, to higher pressures, or, above solidus, as an additional quench product. First results indicate that in KCMASH-CO<sub>2</sub> and at SCLM conditions, phlogopite is stable to about 4.5 and < 4 GPa with a 40 and 44 mWm<sup>-2</sup> geotherm, respectively.

[1] Enggist *et al.* (2009) *Eos Trans. AGU* **90**(52) Abstract V51B-1669. [2] Enggist & Luth (2010) *GeoCanada2010*, expanded Abstract, 4p. [3] Sudo & Tatsumi (1990) *Geophys. Res. Lett.* **17**(1), 29–32.