Lost City: Serpentinization and life

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The ultramafic-hosted Lost City Hydrothermal Field (LCHF) at 30°N on the Mid-Atlantic Ridge is characterized by a combination of extreme conditions never before seen in the marine environment. These conditions include venting of basic, 40-91°C, metal-poor hydrothermal fluids with high concentrations of dissolved H_2 (1-15 mmol/kg), CH_4 (1-2 mmol/kg), and other low molecular weight hydrocarbons[1-3].

The fluid chemistry is driven by fluid-rock reactions in the underlying ultramafic basement at temperatures up to 200°C. Hydrothermal activity has been ongoing for >30,000 years [3]. Egress and mixing of warm, pH 9-11 fluids with cold seawater forms carbonate chimneys that tower up to 60 m above the surrounding seafloor. Radiocarbon measurements of CH_4 show that the carbon source cannot be modern seawater biocarbonate [2]. Stable carbon and hydrogen isotopic compositions of short-chained hydrocarbons are compatible with production through serpentinization and Fisher-Tropsch type reactions and carbon being leached from the underlying mantle rocks during alteration processes [2].

The porous interiors of the vents, bathed in CO_2-absent fluids, provide novel niches dominated by a single phylotype of Lost City *Methanosarcinales* (LCMS) [4]. These organisms grow under significantly hotter and more extreme pH conditions than known to support any other methanogen or methanotroph. In chimneys with little or no venting, the LCMS group is replaced by a single phylotype of anaerobic methanotrophic *Archaea* (ANME-1) [4]. The ultramafic underpinnings of LCHF are compositionally similar to early Earth lavas erupted into primordial oceans. Resulting high pH vents may have been important prerequisites for life [5].

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Two diffusion mechanisms for Argon in K-feldspar?

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New argon diffusion data generated by laser depth profiling of laboratory experiments on gem quality K-feldspar, demonstrate two diffusion pathways, confimring earlier work on quartz (Watson and Cherniak 2003), and other minerals (Jay Thomas ref). Earlier noble gas depth profiling analyses have used 213nm and 266nm lasers capable of measuring profiles greater than 1 mictron deep, but it was notable that the surface analysis always contained anomalously high Ar concentrations, and spatial resolution better than 1 micron proved ellusive. Combined RBS and laser analyses of quartz demonstrate that the surface layer may contain a second shallow diffusion profile and this experiment was intended to test for a similar effect in K-feldspar.

The application of a 193nm Eximer laser to noble gas extraction has enabled us to analyse the upper micron of samples previously exposed to Ar at high pressure, and has the capability of measuring noble gas diffusion profiles at a spatial resolution approaching 0.1 microns. The new data shows that the surface layer which appeared as one or at most two anomalous points in earlier work is in fact a diffusion profile with a shape approximating to that expected for Fickian diffusion in a mineral lattice. The measurement of such profiles in K-feldspar allows us to compare the diffusion constants with empirically derived natural samples and laboratory stepped heating experiments used for Ar-Ar dating.

The argon diffusion parameters derived from the near surface in K-feldspar, like the diffusion parameters derived for quartz, have low activation energies and very low pre-exponential factor. This combination of parameters implies relatively slow diffusion rates under magmatic conditions, but diffusion rates which exceed those generally derived from stepped heating experiments close to the conventional closure temperature. The implications for thermochronology will be explored by comparing the variation of the two diffusion mechanisms with temperature.