Life in subglacial lavas as an analogue for life on Mars

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Basaltic subglacial volcanism is a process that is widespread on Earth that is also believed to have occurred on Mars. The interaction between erupting lava and overlying ice produces a number of environments that are available to microbial colonisation. These include active environments such as subglacial caldera lakes, and post-eruptive environments, notably subglacial lava flows (pillow basalts and hyaloclastites). Active subglacial volcanic systems commonly exist entirely within the subsurface several hundreds of meters below the ice. As a result, these environments on Mars would have been protected from UV radiation, surface desiccation and low temperatures. Additionally, post-eruptive subglacial lava environments that exist within dry Arctic climates can serve as an analogue to such environments on Mars when the surface environment was perhaps less limiting. We use Iceland and its examples of basaltic subglacial volcanic activity as an analogue for these proposed Martian environments. 16s rDNA metagenomic analysis was carried out on pillow basalt glass, interpillow material, and hyaloclastite lava from Askja central volcano, Iceland. Additionally, these lavas were used to test the viability of subglacial volcanic environments on Mars. Two components of the subglacial volcanic system that are beneficial to habitability are the overlying ice and the underlying geothermal heat source. An experiment was devised whereby Icelandic pillow basalt (and its residing microbial community) was placed inside a simulated subglacial volcanic system that incorporated an underlying heat source and overlying water-ice layer. This was incubated inside a Mars chamber with ~8mbar pressure Martian atmosphere and UV radiation for 1 week at -30°C. Viability was based on the ability to culture the *in situ* community after incubation. We found subglacial volcanism to be a highly suitable environment for life on Mars, with 76% survivability compared to the original microbial community.

Arsenic reactions and mobility along redox gradients in lake sediments

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Arsenic (As) and a suite of geochemical parameters were measured in sediment cores, as well as in porewater from four lakes spanning a range of redox and geochemical conditions. Inverse modeling of the porewater As profiles, using a one-dimensional transport-reaction equation, coupled to thermodynamic calculations and comparisons among the various porewater and solid phase profiles were used to identify reactions involving As and to estimate their kinetics.

In two of the lakes, whose bottom waters were oxygenated at the time of sampling, solid-phase and porewater profiles of As and Fe indicate that dissolved As was released to and scavenged from the porewater as a consequence of the reductive dissolution of Fe oxyhydroxides and the adsorption of As onto authigenic Fe oxyhydroxides, respectively. Kinetic modeling of the arsenic profiles indicates that the rate of As adsorption onto Fe oxyhydroxides in these two lakes is relatively slow and is consistent with the rates determined in laboratory experiments studying As adsorption onto synthetic Fe oxyhydroxides suspended in solutions containing dissolved organic matter [1].

In the two other lakes, whose bottom waters were sulfidic at the time of sampling, As removal from porewater occurred at depths where $FeS_{(s)}$ was being formed and where peaks in dissolved zero-valent sulfur ($\Sigma S(0)$) were observed. Thermodynamics predicts that porewaters were undersaturated with respect to all known solid As phases; it also predicts that some of the As^{III} in anoxic environments was oxidized by zero-valent sulfur to As^{V}, as suggested in a recent study where As equilibriums in anoxic laboratory systems were reinterpreted [2]. All these results are consistent with As removal from porewater by the adsorption of As^{V} onto $FeS_{(s)}$.

[1] Redman *et al*. (2002) *Environ. Sci. Technol.* **36**, 2889−2896. [2] Helz & Tossell (2008) *Geochim. Cosmochim. Acta* **72**, 4457−4468.