

Characterizing Rock-Water Interactions in a Simulated Martian Aquifer Parker Castleberry¹ and Ralph Harvey², ¹Case Western Reserve University, Department of Biochemistry (email: pxc191@case.edu), ²Case Western Reserve University, Department of Earth, Environmental and Planetary Science.

Introduction: Biomarkers, are compounds that indicate current and/or past biological activity and as such are of great interest when exploring the potential habitability of Mars throughout its history. One proposed biosignature are long-chain organic compounds thought to be unique to biological activity. Such organics make a good biosignature because they are relatively easily detectable and preservable, allowing them to persist for millions of years after biological activity has ceased. One major disadvantage however is that the possible production of these molecules through purely inorganic (non-biological) processes has not been broadly explored. Both simple and complex organics can be produced through abiotic processes such as Fischer-Tropsch reactions [1]. These kind of reactions are known to occur on Earth in wet, warm settings (such as within mid-ocean ridges) where brine, rock and dissolved carbon dioxide can mix. Distinguishing between the abiotic and biological sources for any organics produced, however, is difficult for Earth where microorganisms have effectively colonized every available niche. Extending such studies to Mars, where biological activity may have been much less pervasive, requires a detailed understanding of the full range of products produced during non-biological creation. To improve our understanding of abiotic synthesis of organics, we have begun an experiment to simulate possible abiotic reactions, mixing brine and a si-

mulated martian crustal material under temperatures and pressures consistent with conditions in the Martian subsurface where such a brine would be stable. After a period of time we will characterize both the resulting brine and the secondary minerals and compounds produced, with a particular focus on any new organic compounds that may have been produced.

The scenario we hope to simulate is set on modern Mars (the last few million years) rather than the ancient past (billions of years ago when the weathering and chemical reaction regime would have been very different). We identified target conditions appropriate for modern Mars where temperatures and pressures allow a liquid brine to be stable and reach with an "open" martian crust (not so deep that fractures within the regolith are closed by plastic flow). Recent work by [2] suggested a broad temperature and pressure envelope for such conditions (taking into account a range of brine compositions and obliquity-driven climatic changes for Mars) (Fig. 1). We chose the center of that envelope as our target physical conditions for our simulation (roughly 85°C, 120 Bars).

Methods: To recreate these conditions we have built two reactors of identical design (Fig. 2). These chambers are based on some used to simulate CO₂ sequestration within the terrestrial crust [3]. The reactors are designed to contain small volumes of martian

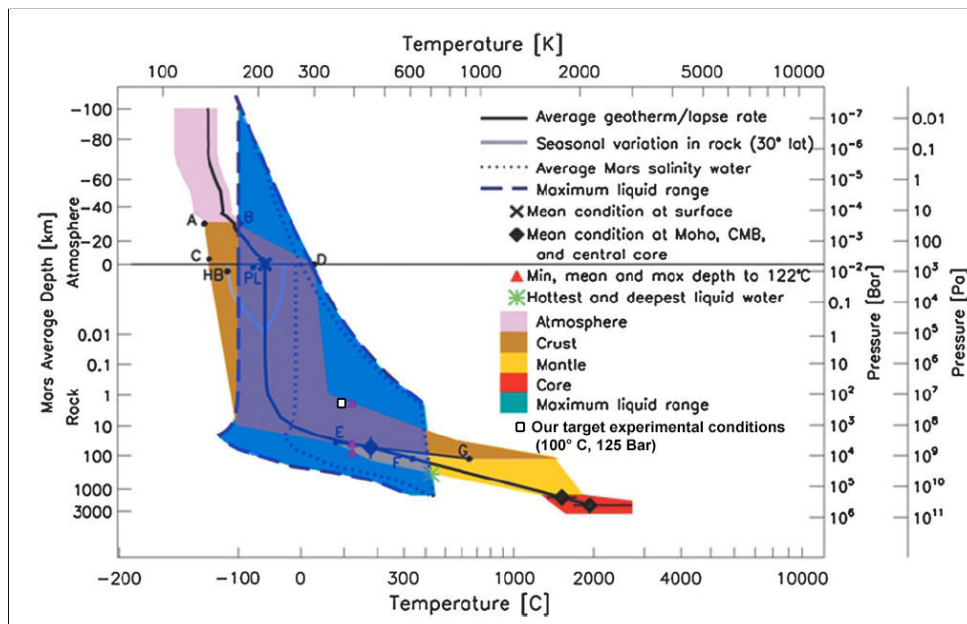


Fig. 2 Pressures, temperatures and depth of the Martian atmosphere and crust, from [2]. Our experimental conditions are the white marker, and suggested stability range for liquid brines is in blue.

crust simulant with about 10 times the volume of brine and then charged with dry CO₂ gas to appropriate pressure conditions. This also saturates the chamber and reactants with CO₂ to simulate the current martian atmosphere. Resistance heaters surrounding the reaction chambers then allow us to reach our preferred experimental conditions, simulating an aquifer approximately 2 km beneath the Martian surface. The reactors were constructed of non-reactive Grade-2 Titanium tube with nickel Alloy-400 fittings (some fittings are stainless steel to reduce cost, but these were used only where they would not contact the reactants). To minimize organic contamination, reactants were handled under clean conditions and minimal contact with plastics, and all materials and the reactors were rinsed with a 10% hydrogen peroxide solution prior to closure of the reactors.

As in any such experiment, we've had to make some difficult choices concerning the composition of our martian crustal simulant and brine. Where possible such choices were based on common assumptions from the literature. As a crustal analog, we chose a crushed mixture of basalt (the Ferrar dolerite) with added olivine and iron oxides (from an alpine peridotite nodule). This composition can be considered a simulant either of an olivine-phyric shergottite or a basaltic lithology with added eolian olivine.

Choosing and creating a brine composition was challenging. In the end, we chose two different brines for our two reactors. The first brine chosen was that described in [4], where experimental reactions between simulated martian crust and distilled water produced model brines for Mars. Our second brine is a derivative of the first. Given evidence (in the form of gullies on crater walls) for possible ephemeral surface brines on the Martian surface, we chose to simulate a "hyper-saline" brine that might leak out of an underground

aquifer. Such brines have been hypothesized as the result of long term cryoconcentration on Mars [5]. To produce this brine we are cryo-concentrating our initial mixture using a freeze-dryer.

Discussion: Our experiment simulates an event (such as a marsquake or impact) that opens up fresh volcanic rock or regolith to an existing brine aquifer. Understanding the implications of such an event on modern Mars, both in terms of secondary minerals and in terms of any organics produced, is important for future exploration of that planet's surface. As of this writing our first chamber has been running for about two weeks and we hope to continue the run for up to 60 days. Our second chamber (loaded with the same crustal simulant but a cryoconcentrate brine) will be loaded shortly and run for a similar duration. After opening, solids will be analyzed using X-ray diffraction and electron microprobe techniques and fluids will be analyzed for organic content at NASA's Goddard Space Center using a sophisticated liquid chromatography TOF-SIMS instrument.

References: [1] Potter J.; Rankin A. H.; Treloar P. J. (2004) *Lithos*, 75 issue 3-4, 311-330. [2] Jones, E. G.; Lineweaver, C. H.; Clarke, J. D. (2011) *Astrobiology*, 1017-1033. [3] N. B. Janda et. al. (2001) netl.doe.gov [4] Bullock M. A.; Moore J. M.; Mellon M. T. (2004) *Icarus*, 170, 404-423. [5] Burt D. M. and Knauth L. P. (2002) *Icarus*, 158, 267-271.

Acknowledgements: The work described here is a SAGES capstone senior research project for PC, supported by a grant from Case Western's SOURCE program. PC would like to profusely thank the following scientists who are helping with this project: D. Glavin, M. Fries, M. Bullock, M. Mellon, B. Saylor, Julie B., Ruth J., G. Matisoff, L. Knauth, B. Shaw, R. Viggiano.

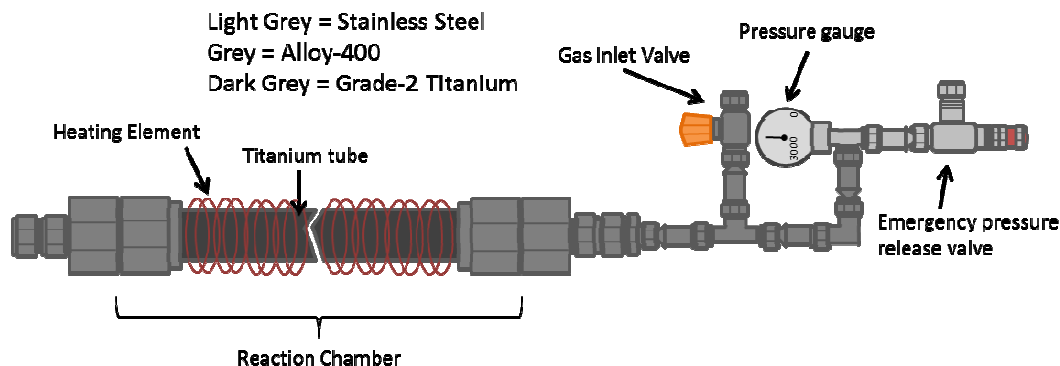


Fig. 2 A diagram of our reaction chamber. The reaction chamber will be covered with insulation when in use.