Martian Organic Synthesis by Electrochemical Reduction of Aqueous CO_2. A. Steele[1] L.G. Benning[2], R Wirth[2], M. Fries[3]. [1]Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Rd, Washington DC 20015. asteele@carnegiescience.edu 2- Geo-Forschungs Zentrum (GFZ) Interface Chemistry group, Potsdam, Germany. 3- NASA JSC, Houston Tx.

Introduction: The source and nature of carbon on Mars has been a subject of intense speculation. This proposal seeks to expand on a successful Mars fundamental research proposal that enabled analysis of eleven Martian meteorites, spanning ~4.2 Ga of Martian history (Steele et al., 2012a, 2012b). Ten of the meteorites contain macromolecular carbon (MMC) phases included within high temperature mineral phases, namely pyroxene and olivine hosted melt inclusions that contain mineral oxides and MMC. More recently analysis of the Tissint meteorite has shown the presence of organic carbon and nitrogen phases that again are coupled to the presence of spinel minerals (magnetite, illmenite etc). However, in the case of Tissint there is a reservoir of reduced carbon that is within feldspathic glass and does not appear to be associated with high temperature igneous processing.

More recently we have discovered that secondary fluid alteration of Martian basalts can generate organics and perchlorates through electrochemical reactions. Specifically, electrochemical reduction of aqueous CO_2 to organics and the electrochemical oxidation of brine to perchlorate. Both of these processes are well known and constrained in experimental systems and in the case of perchlorate is the major manufacturing process of this molecule.

While the efficiencies of conversion of a CO_2 containing brine to organics and perchlorate by corrosion of spinels cannot be modeled directly with the current data, it is a highly compelling explanation for several Martian phenomena including; the lack of atmospheric CO_2 and the missing carbonate debate; the presence of high and low molecular weight organics; the presence of methane in the atmosphere; the presence of perchlorates and the presence of hematite and the red coloration of the planet. Indeed it is this final observation that may indicate that the phenomena seen in a tiny subsample of 3 meteorites from Mars has global significance. The dimensions, heterogeneity of the minerals and fluid interactions as well as overlapping anodic and cathodic boundary layers in the features analyzed here show that natural systems may undertake electrochemical, electrocatalytic, electrosynthetic reactions in what is essentially an environmental nano/microfluidic device powered by corrosion processes. While discovered here in Martian samples a similar process would occur wherever igneous rocks encountered brines and therefore maybe a dominant process for the production of organics and possibly the primordial soup on early earth, Europa and Enceldedus. Indeed laboratory experiments that do not contain magnetite fail to generate the hydrogen needed to undertake methane production during serpentinization reactions. The missing link to this reaction maybe electrochemical energy and the production of hydrogen by galvanic processes.

References:

[1] A. Steele *et al.*, A Reduced Organic Carbon Component in Martian Basalts. *science*. **337**, 212–215 (2012).