BIOLOGICALLY MEDIATED ANAEROBIC METHANE OXIDATION – THE MISSING SINK IN AN ACTIVE MARTIAN METHANE CYCLE? R. L. Harris[1], B. L. Ehlmann[2,3], R. Bhartia[3], and T. C. Onstott[1]; [1]Dept. of Geosciences, Princeton University, Princeton, NJ 08544 (rlh6@princeton.edu, tullis@princeton.edu). [2]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91126 (ehlmann@caltech.edu). [3]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109 (rohit.bhartia@jpl.nasa.gov).

Numerous reports observing trace methane (CH_4) in the Martian atmosphere[1–5] including the recently published 5-year record of CH_4 seasonality in Gale Crater[6,7] have generated much consternation in our attempts to explain the temporal and spatial variability of this astrobiologically relevant greenhouse gas[8–13]. Several mechanisms have been suggested as potential sources for Martian CH_4, including the coupling of Fischer-Tropsch-type synthesis to serpentinization of ultramafic silicates[14], UV or metamorphic degradation of accreted organics[15,16], cometary impacts[17], and perhaps even biological methanogenesis[11,18,19], which on Earth accounts for nearly 95% of total CH_4 production[20]. While the potential of a biological source for CH_4 does warrant further investigation, it is important to consider that observed CH_4 needs not to have been of recent formation.

Perhaps more enigmatic than the origins of Martian CH_4 is its consumption. While conventionally suggested sinks of Martian CH_4 have been UV photolysis in the middle and upper atmosphere and oxidation by hydroxyl radicals near the surface[8], such loss mechanisms imply an atmospheric CH_4 residence time of ~300 years, which is significantly longer than observed CH_4 lifetimes on the order of months to years. Regolith adsorption has been proposed as a CH_4 sink to account for variability in seasonal background CH_4[21], but the model struggles to account for rapid consumption observed in high concentration plume events[1,5]. Furthermore, spatial heterogeneity in the distribution of atmospheric CH_4 suggests a greater subsurface flux rate than the rate of transport mixing, and much faster CH_4 mixing ratios relative to argon have been observed at Gale Crater[6], implying local processes affecting CH_4 variation that are not seen in inert gases. We must therefore consider alternative mechanisms to rapidly consume CH_4 as it is being outgassed from the subsurface.

On Earth, the anaerobic oxidation of methane (AOM) is chiefly a biologically mediated process responsible for consuming upwards of 88% of the net annual CH_4 flux from the subsurface[20]. AOM proceeds by running the bidirectional enzymes of the methanogenesis pathway in reverse, coupling CH_4 oxidation to the reduction of a variety of known electron acceptors such as sulfate, nitrate, nitrite, ferric iron, and manganese. This ancient metabolism is believed to have been one of the earliest to evolve in life on Earth between 3.8 and 4.1 Ga[22], perhaps coincidently with the Noachian period on Mars.

Marlow et al.[23] showed that AOM was not only was thermodynamically favorable on ancient Mars, but also identified Noachian outcrops that may have been conducive to AOM during their deposition. Given strong evidence for an active CH_4 cycle on modern Mars, it is worthwhile to assess methane release sites for redox boundaries which may presently support biological AOM. This talk aims to identify candidate sites where redox gradients may exist to allow for concurrent CH_4 seepage and AOM. We will also present preliminary findings on the bioenergetics of AOM metabolisms coupled to locally available oxidants – including speculative couplings to strong oxidants such as chlorate perchlorate salts – based on spectral data collected by the CRISM instrument on the Mars Reconnaissance Orbiter[24].

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