RADIOLYTIC HYDROGEN PRODUCTION ON NOACHIAN MARS. J.D. Tarnas[1], J.F. Mustard[1], B. Sherwood Lollar[2], M.S. Bramble[1] [1]Brown University Department of Earth, Environmental, and Planetary Sciences (jesse_tarnas@brown.edu, 324 Brook Street, Box 1846, Providence RI, 02906), [2]University of Toronto Department of Earth Sciences.

Introduction: Radiolytic hydrogen production sustains deep subsurface microbial communities on Earth [1,2] and is estimated to produce [1.6-4.7] × 10^{10} moles H_2 per year in the Precambrian cratons [2], based on measurements of H_2 concentrations in deep groundwaters [1,3]. It has also been proposed as a precursor to current methane production on Mars [4]. Here we model H_2 production on Noachian Mars.

Modeling: Our model of Noachian H_2 production includes radioactive element concentrations extrapolated from measurements of modern Mars by *Mars Odyssey*'s GRS [5], a spatially resolved cryosphere depth model based on Noachian heat flux [6,7] and surface temperature [8] models, and modeled Mars porosity [9] using parameter values derived from GRAIL [10] scaled to Mars gravity. Subsurface H_2 of greatest biological interest is produced beneath the cryosphere and megaregolith bases, as megaregolith contains high fracture apertures, permeability, and porosity relative to underlying bedrock [11], making it the region of highest groundwater content and subcryospheric H_2 production. We define this region as the subcryospheric hypermegaregolith-base zone (SHZ). H_2 may be dissolved in SHZ groundwaters in concentrations >0.05-10 nM, which is sufficient to sustain microorganisms [12], depending on the H_2 diffusion rate through water, ice, and megaregolith rock, as well as its solubility in water in the low temperature, high pressure conditions immediately beneath the cryosphere.

Results: We find the Noachian cryosphere and subcryosphere both produce the same order of magnitude total H_2 as the Precambrian craton estimates ([0.72-2.40] × 10^{10}, [2.63-6.23] × 10^{10} moles per year, respectively). As shown in Figure 1, the SHZ contributes [0.35-1.13] × 10^{10} moles per year to the total subcryospheric H_2 production, assuming a 3 km depth megaregolith base. Using a brine-filled pore space increases H_2 production [13,14], as does assuming an alternative porosity model [11]. Cryospheric H_2 may diffuse through the surface, or be trapped beneath impermeable layers of ice or rock, or potentially stored in H_2 clathrates [15].

Discussion: Dissolution of H_2 into groundwater was likely highest in the SHZ, which has high porosity, permeability, and fracture aperture. The concentration of H_2 dissolved in this groundwater depends on Noachian groundwater volume and distribution, the diffusion rate of H_2 through water, ice, and megaregolith, and the solubility of H_2 under high pressure, low temperature conditions. The best locations for deep subsurface life on Noachian Mars

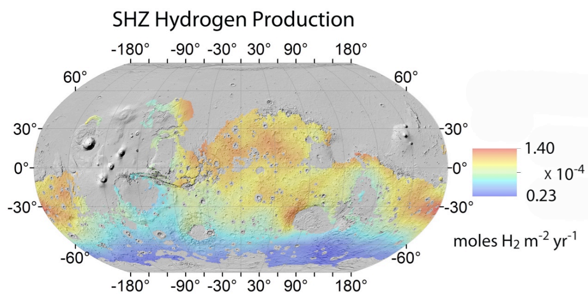

Fig 1: Modeled hydrogen production via radiolysis in the Noachian subcryospheric hypermegaregolith zone (SHZ) assuming 30% initial porosity.

would therefore be regions in which radioactive element concentrations are high and the thickness of the SHZ is minimized, which equates to higher dissolved H_2 concentrations. Alternatively, if there exists a mechanism for trapping large volumes of H_2 gas in the subsurface, these gas traps would have significant biological potential.

Conclusions: During the Noachian, radiolysis of pore water in the martian crust produced H_2 in volumes potentially sufficient to sustain microbial communities in the SHZ, depending on the diffusion of H_2 through water, ice, and megaregolith, as well as the solubility of H_2 under low temperature, high pressure conditions. Though it has received limited attention from the community, post-production behavior of H_2 is also important to consider in the context of serpentinization-derived H_2. Here we have demonstrated that radiolysis produced H_2 in biologically significant quantities during the Noachian. Comprehensive models of subsurface Noachian H_2 availability must therefore include radiolytic and serpentinization-derived H_2, as well as characterization of post-production H_2 behavior, which will determine concentration scenarios for both dissolved and gaseous subsurface H_2.

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