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Introduction: It has not been previously recognized that the lunar poles may be an environment conducive to pre-biotic chemistry. Production of organics from inorganic precursors requires source material, energy, and proper environmental conditions. The lunar poles may have all three.

Source Materials: Because of the Moon's low obliquity (1.56 degrees), topographic depressions at the lunar poles such as impact craters can be permanently shaded from the Sun [1]. Several workers have examined issues related the plausibility of permanently shaded regions acting as cold traps for volatiles propagating in the lunar atmosphere [2-7]. Modeling efforts have indicated surface and shallow subsurface temperatures low enough for deposits of ices as volatile as CO_2 to be stable for billion year timescales [7]. Model temperatures as low as 40K have been derived for diurnal average temperatures [7]. These temperatures, low enough to retain volatile ices for geologic time, are clearly low enough to trap volatiles. External sources for volatiles include comets, asteroids, IDP's and even giant molecular clouds through which the Solar System may occasionally pass. Lunar volatiles can include various volatile metals, but also the enigmatic volatile that drove lunar volcanism which may have operated as late as one to two billion years ago. The lunar environment may be able to produce water via reduction of lunar minerals by solar wind protons, with expelled oxygen combining with H to produce water molecules [2].

The Lunar Prospector mission detected high abundances of hydrogen at the lunar poles [8]. While this detection is widely interpreted to be due to the presence of a small percentage of water ice in the polar regolith, it is also possible that this is cold trapped solar wind hydrogen. While permanently shaded regions of the poles are hidden from direct sunlight, they are not hidden from the solar wind during passages of the Moon through the Earth's magnetotail. If extremely volatile hydrogen can be cold trapped, clearly the much less volatile C and N contained in the solar wind will also be trapped, providing feedstock for prebiotic reactions. Apollo soils contain on the order of 100 micrograms per gram of soil [9] , so a few milligrams per gram of H, C and N trapped on silicate grain surfaces in the lunar cold traps is plausible.

While the volatile inventory of the lunar poles excluding hydrogen is unknown, all plausible sources of the anomalous hydrogen are also sources of C and N, so the lunar poles almost certainly contain the material ingredients for pre-biotic chemical reactions to take place.

Energy: The lunar poles are illuminated both by interstellar Lyman-α UV radiation, and by galactic cosmic rays. Invoking UV radiation as an energy source may be problematic as Lyman-α can erode ices, as well as the fact that for many permanently shaded regions dayside reflections off nearby topographic highs can raise the temperature of uppermost few centimeters to levels unfavorable to ice retention. However, galactic cosmic rays emplace high energy protons and heavier charged nuclei into the upper several centimeters of the regolith which can break chemical bonds in ices creating radicals available for further reactions. The particle cascade resulting from heavy nuclei provide more charged particles deeper in the regolith for radical formation.

Environment: Experiments aimed at producing organics from UV-irradiated CHON-bearing ices suggest that some degree of temperature cycling is necessary for production [10]. Ices irradiated at low temperatures contain abundant radicals, which then react upon modest temperature elevation. The temperature cycling present in some cold traps due to diurnal, seasonal and longer cycles can provide this desired temperature fluctuation. Alternatively, macrometeorite impact can produce local heat pulses which may promote formation. Or, owing to the billion year timescales, simple low temperature diffusion may be adequate to promote organic formation.

Conclusions: The lunar poles likely contain the zeroth order ingredients necessary for production of organics in situ. The lunar polar fundamental conditions (silicate rich, organic poor) complement those of Titan (organic-rich, silicate poor) and provide a useful test for theories of organic formation. Direct study of this environment is attractive in part because of its proximity to the Earth which makes it more accessible than comets, organic rich asteroids or the outer planet satellites.

References: [1] Watson et al. (1961), *JGR 66*, 3033-3045. [2] Arnold, J. R. (1979), *JGR 84* 5659-5668. [3] Morgan, T.H, and D.E. Shemansky (1991), *JGR 96*, 1351-1367. [4] Ingersoll, et al. (1992), *Icarus 100*, 40-47. [5] Salvail, J.R. and F.P. Fanale (1994), *Icarus 111*, 441-455. [6] Butler, B.J. (1997), *JGR 102*, 19283-19291. [7] Vasavada et al. (1999), *Icarus 141*, 179-193. [8] Feldman, W. C. et al. (1998), *Science 281*, 1496-1500. [9] Mc Kay et al. (1991) in *Lunar Sourcebook*, Cambridge University Press. [10] Bernstein, M.P. et al. (1995) *Astrophys. J.*, 454, 327-344.