THE HABITABILITY POTENTIAL OF MARS E. G. Jones[1] C. H. Lineweaver[2], [1]Research School of Astronomy & Astrophysics, Australian National University, Mount Stromlo Observatory, Cotter Road, Canberra, ACT, 2611, Australia. eriita@mso.anu.edu.au. [2]Planetary Science Institute, Research School of Earth Sciences, Research School of Astronomy & Astrophysics, Australian National University. charley@mso.anu.edu.au.

Introduction: In [1] we presented a pressure-temperature representation model of the Earth. The purpose of developing this model was to quantify the habitability of liquid water on Earth and locate where uninhabited liquid water environments are. Water on Earth extends to ~75 km depth. We found that ~12% of the volume of the Earth where liquid water exists is known to host life. Thus, according to our current state of exploration, 88% of the volume of the Earth where liquid water exists, is not known to harbor life. Furthermore the terrestrial biosphere currently occupies a thin shell of ~1% the volume of the Earth. NASA's "follow the water" strategy for Mars exploration is based on the observation that all terrestrial life requires liquid water during some phase of its life cycle [2]. We are now developing a pressure-temperature model for Mars to refine this exploration strategy and identify where the environments are on Mars that may have liquid water and may be able to support terrestrial life.

Results: Our preliminary model [3] is shown in Fig. 1. It shows the regions of phase space that correspond to Martian environments (surface and subsurface), estimated from measurements and modeled geotherms. All Martian environments (brown) are superimposed on the phase diagram of water (blue). Overlaid on top is the phase space of life on Earth (green). This model shows the regions of phase space where there is both Mars, potential liquid water, and the pressure-temperature conditions that support terrestrial life. Studying where these three regions overlap provides a preliminary quantification of the potential Martian biosphere [3,4].

Fig. 1 shows the average Martian crustal geotherm of 4 K km^{-1} as a solid black line. The range of estimates for the present geotherm gradient of Mars is 2-20 K km^{-1}, depending on thermal conductivity and heat flow estimates [5,6,7]. The average geotherm intersects the 'active life region' (solid green) at ~9 m depth at T~ -20 ^{o}C. This is an estimate of the shallowest Martian environments that could host terrestrial life, provided liquid water is available. From Fig. 1 the conditions on the geotherm are too cold for 'ocean salinity water' (dotted blue line) at this depth. Brines may be liquid at the subzero temperatures encountered at ~9 m depth however water at such shallow depth would be in diffusive equilibrium with the atmosphere [8]. The average geotherm intersects 'active life' and 'ocean salinity water' at a depth of ~20 m and ~ 0 ^{o}C. Near-equatorial regions of Mars tend to be dry at this depth [9] but shallow water ice is present at |lat| >~ 50^{o}. The shallow boundary of the Martian biosphere is expected to vary locally, depending on the availability of water ice, solar insolation (both current and during previous epochs with different obliquities), and the presence of fines (thermal insulators) and porous rocks.

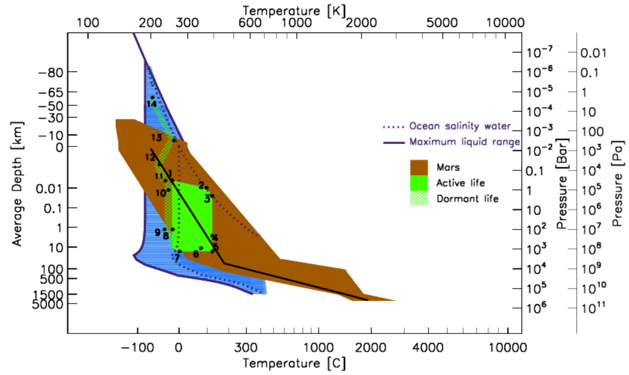

Figure 1.Preliminary Mars phase model. Superposition of inhabited terrestrial environments (in green) and all Martian environments (in brown) on the P-T diagram of water. The average Martian geotherm intersects the phase space of 'active life' and the phase space of 'ocean salinity water' between 20 m and 20 km depth. This provides a provisional estimate of the thickness of the potential Martian biosphere.

The lower boundary of the potential Martian biosphere can be estimated from Fig. 1. The average Martian geotherm encounters temperatures that are above the maximum temperature limit for life (122 ^{o}C, [10]) at ~20 km depth. From the variation in geothermal estimates for Mars – encompassed by the brown region – the same temperature can also be encountered along a 'cool' geotherm at ~ 90 km depth. It is plausible that liquid water or liquid brines could exist at these depths as they are well below the average base of the cryosphere at ~ 1 km depth. However the extreme limit of 90 km is at pressures above the highest pressure environment where we have found terrestrial life. However, pressure by itself does not look like a limiting factor for life [1].

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