OLYMPUS MONS: A PRIMARY TARGET FOR MARTIAN BIOLOGY. P. J. McGovern[1], Lunar and Planetary Institute, Universities Space Research Association, 3600 Bay Area Blvd. Houston, TX 77058, mcgovern@lpi.usra.edu.

Introduction: The immense Olympus Mons volcano on Mars has captivated the imaginations of several generations of planetary scientists and Mars enthusiasts. The striking profile of the 23-km-tall, 600-km-wide volcano has been attributed to movement of the edifice atop a weak basal layer [1-8]. Recently, a scenario invoked an overpressured decollement rooted in hydrated clay sediments to account for volcanic spreading [8]. Here I explore the implications of this scenario for establishing conditions for long term sustenance and preservation of microoganisms (hyperthermophile?) inside the decollement and adjacent portions of the edifice. I also address the accessibility of biological materials to sampling by surface missions.

Structure of Olympus Mons: Olympus Mons exhibits several characteristics and asymmetries that suggest preferential flank movement along a northwest-southeast (NW-SE) axis [8]. The edifice is elongated to the NW and shortened to the SE (Fig. 1). The NW is characterized by extension and low slopes, whereas the SE is dominated by compressional features and higher slopes. However, both flanks exhibit a concave-up profile that resembles a circus tent [8]. These features were interpreted as surface manifestations of a hydrated basal sediment layer consisting of phyllosilicates produced in the Noachian epoch [9-10] and deposited on the flanks of the Tharsis rise before edifice building commenced. This layer thickens downslope from Tharsis, explaining the length and tectonic asymmetries, and outward gradients in fluid content controlled by lithospheric flexure account for the circus tent shape [8]. The basal sediments may have been emplaced as massive fluvial deposits (megafans) analogous to the current deposits covering Amazonis Planitia [11].

Refuge for life? The basal decollement model proposed above requires the presence of liquid water deep within the volcano, where temperatures will be elevated due to the above-average thermal gradient (compared to non-volcanic regions, see [12]) and magmatic heat. Olympus Mons, and more generally the Tharsis region, have likely been a source of thermal and chemical energy for a large fraction of the planet's history. The deep flanks and basal decollement of Olympus Mons are shielded from exposure to ultraviolet radiation, extreme cold, adverse chemistry, and other surface conditions harmful to life. The deep interior of Olympus Mons thus constitutes a site favorable to the long-term maintenance of life on Mars [8, 13-14], perhaps in the form of lithoautotrophic organisms such as those discovered in Columbia River basalts [15]. Surface sites with connections to the deeper interior may yield access to this refuge (see below).

Temperature and Pressure Conditions on the Decollement: Models of lithospheric flexure can be used to estimate the depth to the basal decollement (atop the original lithosphere surface). Required model inputs include the effective elastic thickness of the lithosphere (T_e). Estimates of T_e from gravity/topography admittance yield the constraint $T_e > 70$ km [16] and a corresponding thermal gradient $dT/dz < 8$ K/km, where T (no subscript) is temperature and z is depth. For $T_e = 70$ km, the peak deflection w beneath the center of the edifice is about 30 km, but near the margin of the edifice at $r = 300$ km, w is approximately 20 km [13]. The thermal state on the decollement can be estimated from dT/dz making the conservative assumption that the only source of heat is from the ambient crustal heat flux (and also assuming a uniform surface temperature of 180 K). Such a calculation yields $T = 320$ K at $r = 300$ (beneath ~ 20 km of flexural moat-filling material, pressure $P \sim 190$ MPa) and $T = 600$ K at $r = 0$ (beneath ~ 53 km of combined moat-fill and edifice at $P \sim 540$ MPa). Thus, temperatures along the Olympus Mons decollement are at least above the freezing point of water, and very much so with increasing proximity to the center of the volcano.

The thermal gradient value from [16] is a broad-scale average reflecting the long-wavelength flexural response. Near the magmatic source of Olympus Mons, this value is likely augmented by direct magmatic heating. Furthermore, lateral heat transport by hydrothermal circulation in the edifice and and decollement will likely result in decollement temperatures substantially larger than those reported above. Thus, I conclude that biota living in Olympus Mons are likely to fall into the classifications thermophile or hyperthermophile. The pressure values reported above appear to be substantially higher than those encountered at "black smoker" vents at spreading ridges on Earth, but are comparable to those experienced in pore spaces beneath several kilometers of oceanic basement or sediment on Earth.

Access to Biological Targets: Several sites in the lowlands surrounding Olympus Mons may yield connections to the potential deep biosphere. At the base of the eastern flank of the edifice (A in Fig. 1), a long wrinkle ridge is the surface expression of a thrust fault that accommodates outward spreading of the edifice [5, 17]. Near this fault are several channels that may be the result of interactions between tectonic and fluvial activity [17-18]. Furthermore, MOLA pulsewidth data [19] identify plains with very smooth small-scale (< 100m baseline) slopes in this area. One such region was identified as a potential paleo-lake [17], where sedimentation from ponded water smoothed the slopes.

I suggest that these east flank structures that could place evidence of biological activity near the surface. The thrust fault may extend through a significant thickness of moat-filling edifice material, perhaps soling out in the decollement itself. Faults are well-known conduits for fluids on Earth, so such a fault on Mars may be exploited by pressurized fluids that occasionally erupt at the surface in channel-forming events, forming lakes that leave behind the observed smooth deposits. Samples of this fluid may be left behind near the surface, particularly if hydrothermal activity within the fault is ongoing. The relatively young age attributed to the fault (< 40 Ma [14]) suggests that ongoing activity is possible.

The proposed east flank sample site falls near the +1 km elevation contour. If a lower elevation is required for engineering reasons, an alternative may be to land northwest of the edifice (B in Fig. 1), in a smooth lowland region surrounded by aureole blocks that may also be a paleolake [17]. This region has elevations near -2 km. The differing tectonic and structural regime in this region, extension with landslides, as opposed to compressional in the east, may make it more difficult to access deep fluids. However, a survey of aureole blocks (former pieces of the edifice [7] may also yield samples of biological interest.

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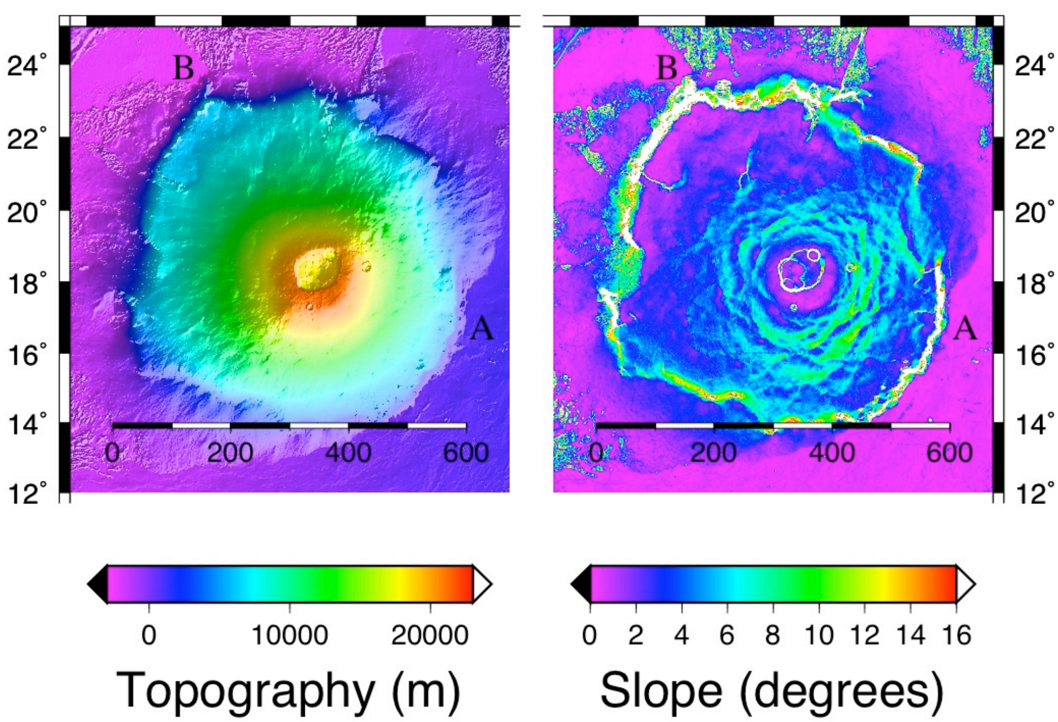

Figure 1. Topography (left, illuminated from the southeast) and slope (right) of Olympus Mons from MOLA 1/128th degree topography dataset [18]. Horizontal length scales are in km. Proposed landing sites are labeled east (A) and northwest (B) of the edifice.