DID MARS EVER HAVE A LIVELY UNDERGROUND SCENE? NEW VIEWS ON THE HABITABILITY OF THE MARTIAN SUBSURFACE. J. R. Michalski[1-2] [1]Planetary Science Institute, Tucson, Arizona (michalski@psi.edu) [2]Natural History Museum, London, UK.

Introduction: By the time eukaryotic life or photosynthesis evolved on Earth, the Martian surface had become extremely inhospitable – cold, hyperarid, acidic, oxidizing and bathed in UV radiation. But, the subsurface of Mars could potentially have contained a vast microbial biosphere. Data from recent missions have revealed spectacular views of materials exhumed from the subsurface by impact craters. Those data show that all the necessary ingredients for life (Figure 1) existed at depth on Mars, some of which include carbon for biomass, fluids as solvents, nutrients for growth and sustenance, and a favorable thermal regime. Exhumed terrains contain carbonates, complex, mixed-layer (typically Fe-rich) clays of probable hydrothermal origins, and juxtaposed primary minerals, suggesting that chemical gradients were present. In this abstract, I evaluate new evidence suggesting that the subsurface is, and has likely always been, the most habitable part of Mars.

Geology of the Martian subsurface: The geology of the Martian subsurface can be constrained through a combination of theoretical and empirical data. For example, theoretical estimates indicate subsurface porosity (necessary for significant fluids to exist) is much greater on Mars than on Earth due to Mars' lower gravity [1]. In fact, an amount of aqueous fluid equivalent to 100s of meters of surface ocean (an equivalent global layer or EGL 100s of meters thick) could easily be stored in pore space, even at great depth [2] (Figure 1). The observation of 1000s of examples of alteration minerals exhumed from depth by meteor impacts indicates that subsurface fluids have in fact altered mafic protoliths at depth [3]. However, in many cases, mafic minerals are also exhumed from depth [4], suggesting that alteration is far from complete; chemical energy available from buried (and generally Fe-rich) igneous rocks would not have been exhausted. Consistent with the observation of hydrothermal minerals from depth, modeled ancient thermal gradients are sufficient to have allowed hydrothermal activity at depth [5]. Interestingly, because the thermal gradients were likely lower than on Earth, habitable subsurface range would have existed to a greater depth on Mars than on Earth [2]. In summary, recent observations suggest that the Martian subsurface was likely the most habitable environment on the planet and that it could have supported and ancient, deep biosphere.

Future exploration: The current dialogue surrounding in-situ exploration on and sample return from Mars is largely focused on exploration of sedimentary environments. However, rocks representing deep subsurface environments should be strongly considered as important targets for astrobiology on Mars. Such targets could include hydrothermally altered rocks uplifted by meteor impact from the deep subsurface or could be rocks that formed from subsurface fluids that beached the surface in deep basins, possibly carrying with them evidence of subsurface habitability.

References: [1] Clifford, S. M. et al. (2010), JGR 115, E07001. [2] Michalski, J. R. et al. (2013), Nature Geo., 6, 133-138. [3] Ehlmann, B. L. et al. (2011), Nature 479, 53-60. [4] Skok, J.R. et al. (2012), JGR 117, E11 [5] McGovern, P. J. et al. (20040, JGR 109, 1-5.

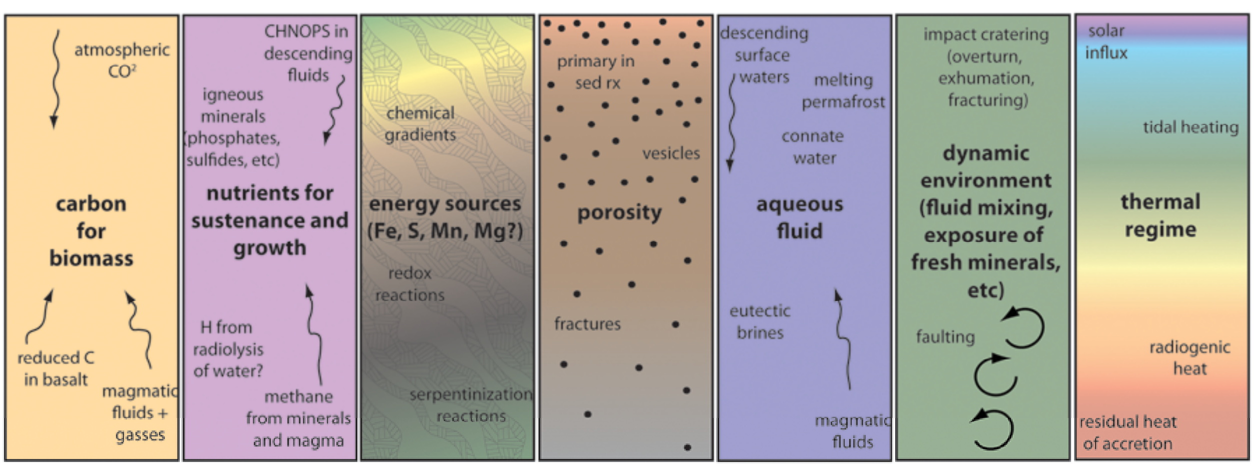

Figure 1: The ingredients required to form and sustain a deep biosphere might be summarized into these seven categories.