Martian subsurface biomes: how detectable are they?

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Prior papers examining the habitability of Mars or life on Mars originally focused on surface dwelling photosynthetic or chemolithotrophic microorganisms but over the last ten years have emphasized subpermafrost ecologies. Many papers derive biomass concentrations based upon a bulk energy fluence estimates ($Jg^{-3}s^{-1}$) divided by an assumed maintenance energy flux ($Jcell^{-1}s^{-1}$). Derived on the assumption that oxidants are entirely derived from the atmosphere or oxidized surface rocks and in a few papers that reductants, H_2 and CO, are derived from the atmosphere and that they are transported to the subsurface by gas diffusion, basal melting of the cryosphere and hydrothermal fluid circulation. Radiolysis of ice and water, however, provides a subsurface source of H_2, H_2O_2, OH and O_2 at a rate of nM yr^{-1}, which is greater than the surface fluence and keeps the subsurface biosphere from approaching ergonic death [1]. The potential energy flux can be 10^{4-5} greater if it is concentrated in highly fractured and porous rock, e.g. beneath impact structures. This rate of 10^{-11} $Jg^{-3}s^{-1}$ is comparable to that estimated for hydrothermal activity and weathering reactions. Anaerobic metabolites, e.g. CH_4, N_2 and H_2S, will be trapped as hydrates in a thickening cryosphere; whereas He and H_2, will diffuse through the permafrost/cryopeg zone. Within the subphotic dissociation zone the upper surface of the cryosphere evaporates, the hydrates exsolve and the trapped gases will also diffuse to the surface. At the interface where H_2, CH_4 and H_2S encounters O_2 diffusing downward from the Martian atmosphere, oxidation of reduced gas phases could produce acidic solutions that could amend subsurface brine volumes by melting the permafrost. Terrestrial analogs of this interface should exist and merit investigation as they are more accessible to near future robotic missions than the deep subsurface of Mars.

References

[1] L-H Lin, J. Hall, J. Lippmann-Pipke, J. A. Ward, B. Sherwood Lollar, M. DeFlaun, R. Rothmel, D. Moser, T. M. Gihring, B. Mislowack and T.C. Onstott (2005) Geochemistry Geophysics Geosystems **6**, doi:10.1029/2004GC000907.