

## Prospects for Subsurface Energy, Water, and Life on Mars

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From the perspective of a terrestrial geologist, Mars is a planet with familiar features including polar caps, glaciers, volcanoes, and a vast sedimentary rock record, as well as dried river beds, ancient lake basins, and evidence for long lost seas. Given the richness of the geologic record exposed to remote sensing instruments, it is easy to focus our attention and exploration efforts on that 2D surface world. But, small glimpses of subsurface materials and environments in terrains exhumed by impact craters, in addition to theoretical models and simple deductive geologic work all point to a vast and perhaps more intriguing subsurface environment on Mars. The upper (~10 km of) crust is likely composed of relatively porous volcanoclastic and impactite rocks and, because of the planet's lower surface gravity (38% of Earth's), a large amount of pore volume probably exists to much greater depth than occurs on Earth. This vast, 3D subsurface environment contains subsurface water and ice, and would have been (or still is) an excellent environment for the interaction between reactive rocks with various types of fluids, both containing various nutrients and possibilities for energy sources to drive a subsurface biosphere. In fact, the subsurface environment has probably always been the most habitable part of Mars since the magnetic field shut off c.a. 4.1 billion years ago, exposing the surface to an intense batch of UV radiation, solar energetic particles and cosmic rays. Life may have never had the chance to get started at the Martian surface and if it did, it might have retreated necessarily to the subsurface environment. It is not unreasonable to suggest that microbial life could survive or thrive there even today. But the subsurface is not critical for microbial life only –it could be the key to human exploration as well. When humans colonize Mars, we will require many natural resources, chief among them H<sub>2</sub>O. One of the driving factors for planning future human missions is proximity to water resources in 3D space. Surface water resources are too high latitude (i.e. the poles), but subsurface ice exists to much lower latitudes. In addition, hydrated rocks in the shallow crust (e.g. hydrous sulfates, clays and carbonates) could provide huge amounts of extractable water. A key element of future mission planning will be resolving how to choose a site for major exploration build-up in a location that meets the requirements for resource extraction, but also honors the most inspiring science agenda possible.

Keywords: Deep Biosphere, Subsurface Life, Mars