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Habitable Macro and Micro-environments on Mars: implications for the search for martian life

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The creation of habitable conditions on both Mars and Earth had the same requirement: availability of liquid water, a source of carbon and nutrients and a source of energy. On the early planets the necessary elements for creating life and feeding it once formed were abundant, as were different sources of energy (chemical, sunlight, etc.). The most critical constraint was the availability of liquid water at temperatures conducive to the synthesis of biomolecules and the first primitive cells. According to this scenario, the Earth was potentially habitable by about 4.4 Ga when there is evidence for oceans. Given its smaller size, Mars cooled faster than the Earth and was potentially habitable before the Earth. However, the results from the various orbital and surface Mars missions are pointing to the fact that probably early Mars never had oceans although liquid water existed at some stage on its surface. Moreover, it appears that its surface probably became inhabitable more rapidly than previously believed (between 4.2-4.0 Ga).

We know that life arose on an ocean-covered Earth, although with a slightly different tectonic configuration than the Earth of today (lack of exposed cratons surrounded by shallow continental platforms). However, is it necessary for a planet to be ocean-covered for life to appear? How much water is necessary and for how long? Given an estimation of about 10 My necessary for the appearance of life (Lazcano and Miller, 1994), any martian environment that could have retained liquid water for that period of time could potentially have seen the birth of new life forms. In this scenario, life may have originated at numerous, isolated points on the surface of Mars potentially leading to substantial heterogeneity.

From a microbial point of view, the nature of large-scale environments is, however, basically irrelevant. Given the size of individual microbial cells ($< = 1\ \mu$m) a micro-environment of a few tens of microns is sufficiently large – for a limited period until the supply of carbon, nutrients or energy runs out. They can thus exist in microscopic habitats, and even transient habitats, if there is some way for them to be replenished. On the early Earth, such habitats included the pore spaces in water saturated sediments and subaqueous (and even transiently exposed) sediment/rock surfaces (Westall et al., 2006; Westall and Southam, 2006). Although these early microbes were widespread, their physical and chemical expression was very subtle in the sense that they formed heterogeneously distributed, small colonies or biofilms that are visible microscopically only with difficulty. Moreover, the relatively inefficient metabolisms of the early microbes meant that the biomass (quantity of organic carbon) was low. It is to be expected that potential martian life, whether extinct or extant, would be equally subtle in physical and chemical expression. Therefore it may not be possible to find definitive traces of life with an *in situ* robotic mission and sample return missions will be necessary.