EPSC Abstracts
Vol. 8, EPSC2013-696, 2013
European Planetary Science Congress 2013

The Role of Water for Martian Habitability

R. Jaumann (1,2), D. Tirsch (1), E. Hauber (1), G. Erkeling (3), L. Le Deit (1), M. Sowe (2), S. Adeli (1), A. Petau (1), D. Reiss (3)

(1) DLR, Inst. of Planetary Research, Berlin, Germany, ralf.jaumann@dlr.de; (2) Freie Universitaet Berlin, Inst. of Geological Sciences, Berlin, Germany; (3) Westfälische Wilhelms-Universität, Institute of Planetology, Münster, Germany

Abstract

A study in context with the Helmholtz Alliance 'Planetary Evolution and Life' focused on the (temporary) existence of liquid water, and the likelihood that Mars has been or even is a habitable planet. Both geomorphological and mineralogical evidence point to the episodic availability of liquid water at the surface of Mars, and physical modeling and small-scale observations suggest that this is also true for more recent periods. Habitable conditions, however, were not uniform over space and time. Several key properties, such as the availability of standing bodies of water, surface runoff and the transportation of nutrients, were not constant, resulting in an inhomogeneous nature of the parameter space that needs to be considered in any habitability assessment. The planetary evolution of Mars led to environmental changes, which in turn affected its habitability potential. Similarly, considerable environmental and climate variations due to latitudinal or elevation effects combined with a diverse surface geology caused distinctively different local conditions that influenced the planet`s habitable potential.

Water and Martian Habitability

The history of water on Mars has been constantly revised and refined during the past years. Landforms such as widespread valley networks, fluvial deposits and associated assemblages of hydrated clay minerals led researchers to propose the hypothesis that the Martian climate was considerably warm and wet during the early history of Mars [e.g., 1, 2]. At the boundary between the Late Noachian and the Early Hesperian, environmental and climate conditions changed significantly and resulted in a transition towards a colder and dryer climate. The intensity of aqueous activity decreased throughout the Hesperian, including a transition from long-term and repeated precipitation-induced fluvial activity towards reduced, short-term, spatially isolated and groundwater-dominated fluvial erosion [e.g., 3, 4, 5, 6]. Figure 1 presents an exemplary valley network in Libya Montes, Mars, which has experience different types of water release mechanisms and various periods of activity and quiescence [4].

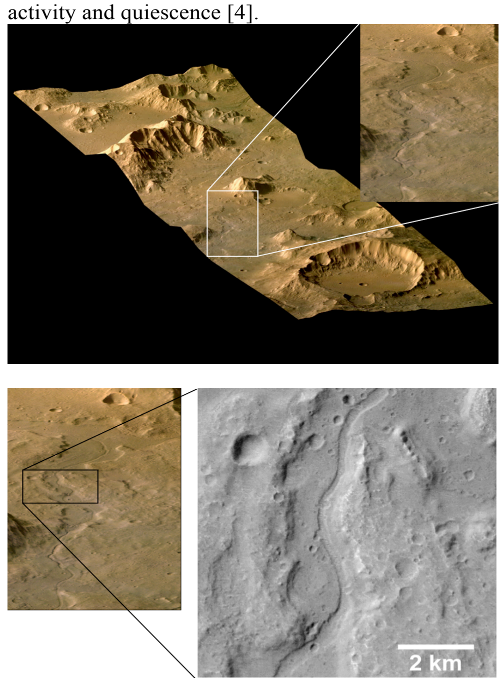

Fig. 1: Mars Express HRSC image of a valley system in Libya Montes. The valley exhibits an inner channel that shows erosional features of different ages [4].

Mars' climate history is still subject to debate. At the end of the Hesperian, fluvial erosion has mostly ceased and volcanic, aeolian and glacial processes are interpreted to be dominant on Mars.

The Early Amazonian was already characterized most likely by a cold and dry climate that was similar to the conditions on recent Mars. However, Mars' climate and aqueous history, in particular the timing of the termination of fluvial activity and the transition from precipitation-induced toward groundwater-dominated erosion, is still subject to debate.

Liquid water is the most basic known prerequisite for life. Although other factors such as energy and nutrients are also necessary, any geological approach to habitability must start with the identification of zones where liquid water is or was active. There is consensus among most researchers that the surface of Mars displays many morphological features indicative of liquid water [e.g., 7]. The occurrence of hydrated minerals suggests a wide range of surface alterations under the influence of prolonged liquid water [e.g., 8, 9] presumably providing nutrients, chemical energy and the necessary distribution mechanisms.

Based on these observations, Mars can be considered habitable with respect to water, at least partly, in space and time. Research in the HGF Alliance has confirmed the existence of liquid water on Mars and expanded the known database of aqueous environments. This encompasses both the early history of Mars (~4 to 3 billion years ago [4, 5, 9, 10]; and the very recent past (the last few million years [11, 12, 13]. Studies in context with Helmholtz Alliance ‘Planetary Evolution and Life’, as discussed above, have also constrained the duration of geological processes that rely on liquid water. Thus, modeling of flow transport processes revealed that the formation of deltas on Mars geologically requires only brief timespans [14] and, based on discharge estimates, the formation of erosional valleys also needs less than a million years and seems to have occurred only episodically [4,15].

Mineral assemblages and stratigraphic relationships of phyllosilicates suggest a development primarily under a neutral to alkaline environment during the Noachian Epoch under a subarid climate [e.g., 8]. However weathering and chemical alteration products indicate multiple alteration, erosion and aqueous episodes that at least provide temporally aqueous environments.

Recently formed gullies and alluvial fans might have experienced even shorter periods of liquid water (minutes to hours), as shown by the identification of debris flow deposits that were formed by short-lived high-energy mass-wasting events [11]. However, most gullies show morphological characteristics, which indicate that they were formed by repeated flow events involving fluvial-dominated processes, such as snow deposits melting during high-obliquity phases [11]. The surface of Mars shows many landforms that resemble cold-climate features on Earth. Permafrost on Earth is known to host rich habitats containing cold-adapted microbial communities. Permafrost environments on Mars might represent habitable zones if liquid water is present, e.g., as a consequence of freeze-thaw cycles. However, the results of the Alliance work indicate that scenarios without liquid water might also account for many of the observed morphological phenomena that are analogous to terrestrial permafrost landforms [12, 16].

The water- and ice-related environments on Mars are potential habitable places with respect to the fundamental environmental factor that requires at least episodic access to liquid water. Even with no adequate global climatic conditions, such as a long lasting warm and wet Mars, water- and ice-related surface processes occurred on an episodic timescale. However, the duration of the episodically appropriate conditions seems to be restricted to geologically relatively short periods.

References*:*

[1] Sagan, C., et al., Science, 181, 1045-1049, 1973. [2] Andrews-Hanna, J.C. and Lewis, K.W., JGR, 116, E02007, doi: 10.1029/2010JE003709, 2011.
[3] Harrison, K.P., and Grimm, R.E., JGR, 110, doi: 10.1029/2005JE002455, 2005.
[4] Jaumann, R., et al., Earth and Planetary Science Letters, 294, 272-290, 2010.
[5] Erkeling, G., et al., Earth and Planetary Science Letters, 294, 291-305, 2010.
[6] Carr, M.H., Philosphical Transactions of the Royal Society A, 370, 2193-2215, 2012.
[7] MarsChannelWorkingGroup, Geological Society of America Bulletin, 94(4), 1035–1054, 1983.
[8] Bibring, J.-P., et al., Science, 312, 400-404, 2006. [9] Bishop, J. L., et al., JGR, 118, 487-513, 2013.
[10] Erkeling, G., et al., Icarus, 219, 393-413, 2012.
[11] Reiss, D., et al., GRL 37(6), doi: 10.1029/2009gl042192, 2010.
[12] Ulrich, M., et al., JGR115(E10), doi: 10.1029/2010je003640, 2010.
[13] Raack, J., et al., Icarus, 219, 129-141, 2012.
[14] Kleinhans, M. G., et al., Earth and Planetary Science Letters, 294, 378-392, 2010.
[15] Jaumann, R., et al., GRL, 32, 16203, 2005, doi: 10.1029/2005GL023415.
[16] Hauber, E., et al., PSS, 57, 944-957, 2009.