MAWRTH VALLIS – PROPOSED LANDING SITE FOR EXOMARS 2018/2020 – C. Gross[1], F. Poulet[2], J. Michalski[3], B. Horgan[4] and J. L. Bishop[5] [1]Institute of Geological Sciences, Planetary Sciences and Remote Sensing Group, Freie Universität Berlin, Germany (christoph.gross@fu-berlin.de); [2]Institut d'Astrophysique Spatiale, Paris-Sud University, Orsay, France; [3]Dept. of Earth Sciences, Natural History Museum, London, UK; [4]Purdue University, Purdue, USA; [5]SETI Institute & NASA-ARC, Mountain View, CA 94043, USA.

Introduction: The primary objective of ESA's ExoMars 2018 mission, which will launch in 2018 (with a backup in 2020), is to characterize the habitability of a site on Mars through detailed analyses of the composition and geological context of surface materials including drilling capabilities. We evaluated the value of a possible landing site in the Mawrth Vallis region of Mars that is targeted directly on some of the most geologically and astrobiologically enticing materials in the Solar System. The analysis of this landing site was presented during a dedicated workshop on 21-22 October 2015 at ESA/ESTEC, where the final four landing sites characteristics and merits were discussed in addition to their EDL capabilities. Unfortuntately, no safe entry corridor exists for Mawrth Vallis for the 2018 launch, removing Mawrth Vallis from the final list of landing sites. As Mawrth Vallis could still serve as a backup for a potential 2020 launch opportunity, we present here a short overview of the ExoMars ellipse (Fig. 1) to strengthen the merits of this high-level astrobiological region that fulfills the science requirements and the expectations of the ExoMars mission.

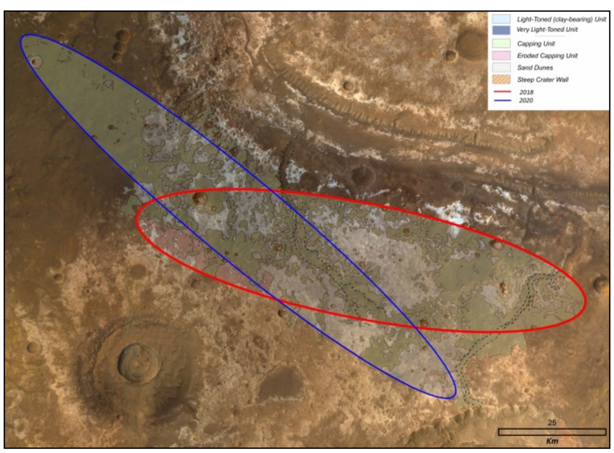

Figure 1: Geological Map of the target area at Mawrth Vallis with landing ellipses (red 2018/blue 2020).

Context: The proposed landing site at Mawrth Vallis is located at the boundary of the cratered Noachian terrains and the northern lowlands at ~25°N and 20°W. Here, OMEGA and CRISM discovered abundant Fe- and Al-bearing phyllosilicates associated with layered outcrops, as well as Si-OH phases and sulphates. The region is very well studied (>40 peer-reviewed scientific publications) and presents the greatest mineralogical diversity on Mars yet known and is, as a consequence a lithologically diverse site that captured multiple environments such as ancient crustal bedrock and remobilized sediments. Mawrth Vallis opens up the opportunity to sample an extremely ancient section of the Martian stratigraphy and to probe rocks from an important and enigmatic epoch of Mars and our solar system - from the deep Noachian up into the Hesperian.

The ellipses for 2018 and 2020 were selected to fulfill the safety criteria of the EDL system. Due to the large landing site ellipse (120 km by ~30 km), the only possible safe region is found in the south of the channel (Fig. 1). The ellipse center was then selected to optimize the coverage of the clay-rich layered rocky unit, that is the main target of the mission.

Geologic History: A stack of light-toned layered deposits, reaching thicknesses of >200m comprise the plateau surrounding the Mawrth Vallis channel. The layered deposits display near-infrared spectral characteristics consistent with various clay minerals [1-11] which are also observed in numerous outcrops in the western Arabia Terra region. The clay rich deposits are interpreted as a sedimentary sequence [4,10].

The Mawrth Vallis region is characterized by a complex geologic history including long-lasting water activity, leading to various depositional settings as summarized below. Starting with the progressive deposition and alteration of sediments (smectites) in the Early to Middle Noachian, then surface erosion by the Mawrth Vallis outflow channel and by valleys on the plateau as well as the development of fractures in the clay unit in the Middle and Late Noachian. Continued surface weathering and probable acidic leaching of surface layers (whitnessed by kaolins, alunite, ferrous clays) has occurred as well as local precipitation of sulfates (jarosites) and probable fluid circulation in fractures. This upper altered sequence is consistent with a sub-aerial weathering origin for the clays, either due to top-down leaching or weathering concurrent with sedimentation to form a paleosol sequence [12]. This unit is followed by the deposition of the dark cap rock unit, presumabely volcanic/pyroclastic deposits imposing the end of the aquous alteration in the Early Hesperian. Finally, wind erosion leads to the continuous exhumation of the deposits in the Hesperian and Amazonian producing fresh surfaces and outcrops.

Biosignature Potentiality and Preservation Potential: One of the main goals of the ExoMars mission is the search for life, presumably past life. In this respect, Mawrth Vallis also presents favorable conditions. Phyllosilicates are composed of silicate sheets with charged surfaces that provide convenient reaction surfaces. Furthermore, metal ions in the clay matrix attract nucleotides that may have played a crucial role in the early origin and evolution of life [13,14]. Also, clays are very good preservers of organic material and provide the necessary conditions for preserving potential biosignatures over long periods due to their relative resistance against weathering (impermeability). To date, there has been no detection of mixed layer clays at Mawrth Vallis that indicate that biosignatures could be degraded by thermal processing such as diagenisis. So if microbes ever populated Mawrth, their biosignatures would have had a good chance of being retained in the phyllosilicate and hydrated silicate deposits. In addition to this, the dark cap rock unit was deposited on top of the clays, shielding the underlying strata from radiation and protecting them from quick erosion.

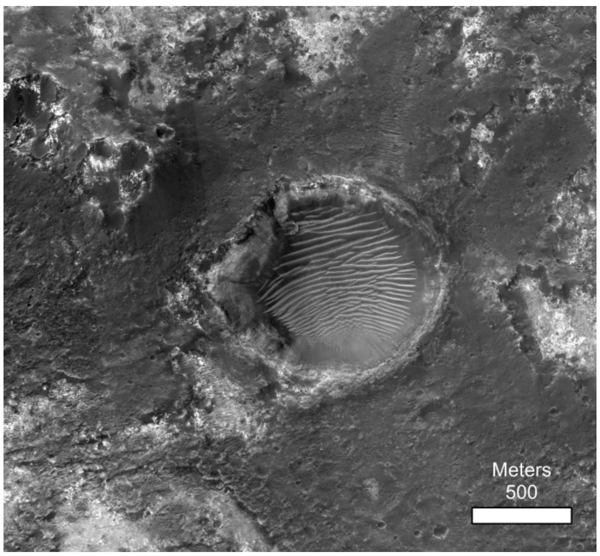

Figure 2: An impact crater with layered material in the crater walls, surrounded by the dark cap rock unit. Clearly visible are the light-toned outcrops where the cap unit is missing.

Soils are highly habitable environments. In paleosols, high clay contents lead to the preservation of organics. Reducing soils cause immediate preservation of organics and lead to concentrated organics in wetlands. The reduced paleosols at Mawrth should be an excellent target for the in situ search of organics and biosignatures.

Two major units were mapped inside the ellipse (Fig. 1): clay-rich outcrops and the dark capping unit. Recent HiRISE observations show (Fig. 2 and 3), that also within the dark cap rock unit, phyllosilicate-bearing light-toned deposits are present and accessible through small erosive windows and smaller impact craters. This fact reduces the driving distances from the potential touch-down point to the sample locations. In general, driving distances to places of interest are less than 1 km in the 2018 and 2020 ellipses.

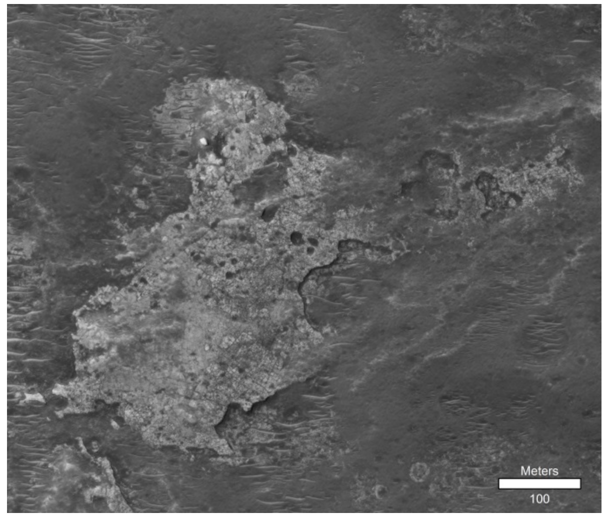

Figure 3: Light-toned phyllosilicate-bearing material excavated from the dark cap rock unit, HiRISE image ESP_043637_2030.

Why Mawrth Vallis is such a promising target:

1. Mineralogically greatest diversity on Mars.
2. Lithologically diverse site capturing multiple environments (deposition, alteration, erosion).
3. Ancient crustal bedrock and remobilized sediments present in situ.
4. Reducing conditions, silica and very high clay contents indicate high preservation potential.
5. Consistent with a paleosol sequence ending in a wetlands-like environment.
6. Fresh surfaces due to continuous erosion, shielding by dark cap unit and no diagenetic overprinting.
7. Possibility to sample material in one of the sites with the greatest likelihood of having had a habitable environment.
8. Possibility to sample rocks from the deep Noachian up through the global transition into the Hesperian.

References: [1] Poulet et al. (2005), Nature 438, 623–627. [2] Loizeau et al. (2007) JGR 112, E08S08. [3] Bishop et al. (2008) Science 321, 830. [4] Noe Dobrea et al. (2010) JGR 115, E00D19 [5] Michalski & Noe Dobrea (2007) Geol. 35, 10. [6] Loizeau et al. (2010) Icarus 205, 396-418. [7] Farrand et al. (2009) Icarus 204, 478-488. [8] Wray et al. (2010) Icarus 209, 416-421.[9] Bishop et al. (2013) PSS 86, 130-149. [10] Michalski et al. (2013) Icarus 226, 816-840. [11] Michalski et al. (2010) Astrobio. 10, 687-703. [12] Retallack et al. (2000) GSA Sp. Pap. 344. [13] Odom et al. (1979) J. Mol. Evol. 12, 365-367. [14] Lawless et al. (1985) Origins of Life and Evolution of the Biosphere, Vol 15, Issue 2, pp 77-88.