HABITABLE NOACHIAN ENVIRONMENTS AND ABUNDANT RESOURCES IN THE MAWRTH VALLIS EXPLORATION ZONE. B. Horgan[1], D. Loizeau[2], F. Poulet[3], J. Bishop[4], E.Z. Noe Dobrea[5], W. Farrand[6], J. Michalski[5], C. Gross[7], J. Kleinhenz[8], D. Linne[8]. [1]Purdue University (briony@purdue.edu), [2]Université de Lyon, [3]IAS, CNRS/Univ. Paris Sud, [4]SETI Institute, [5]Planetary Science Institute, [6]Space Science Institute, [7]Freie Univeristät Berlin, [8]NASA/Glenn Research Center.

Brief Rationale: The plateau above the Mawrth Vallis outflow channel near 340.8°E, 24.3°N contains the most extensive exposed outcrop of clay-rich rocks on Mars. These rocks are thought to have been emplaced as sediments and weathered *in situ* to form clay-rich soils. The clays offer a promising and substantial resource for water extraction, as well as Fe, Al, and Si feedstock, and have high biosignature preservation potential. This site allows access to deep crustal rocks at the base of Mawrth Vallis, two dateable volcanic surfaces, and many ancient habitable surface and near-surface environments with diverse geochemistries.

Site Geology: The plateau surrounding Mawrth Vallis exhibits a thick stack (200m+) of light-toned layered deposits that have near-infrared spectral characteristics consistent with a variety of clay minerals [1-14]. These clay-rich layers extend over much of western Arabia Terra, and are thought to represent a sedimentary sequence [1]. The regional extent of the upper altered sequence is consistent with a sub-aerial weathering origin for the clays, either due to top-down leaching of the stack or weathering concurrent with sedimentation to form a paleosol sequence [4,12,14]. However, the large thickness of the stack compared to

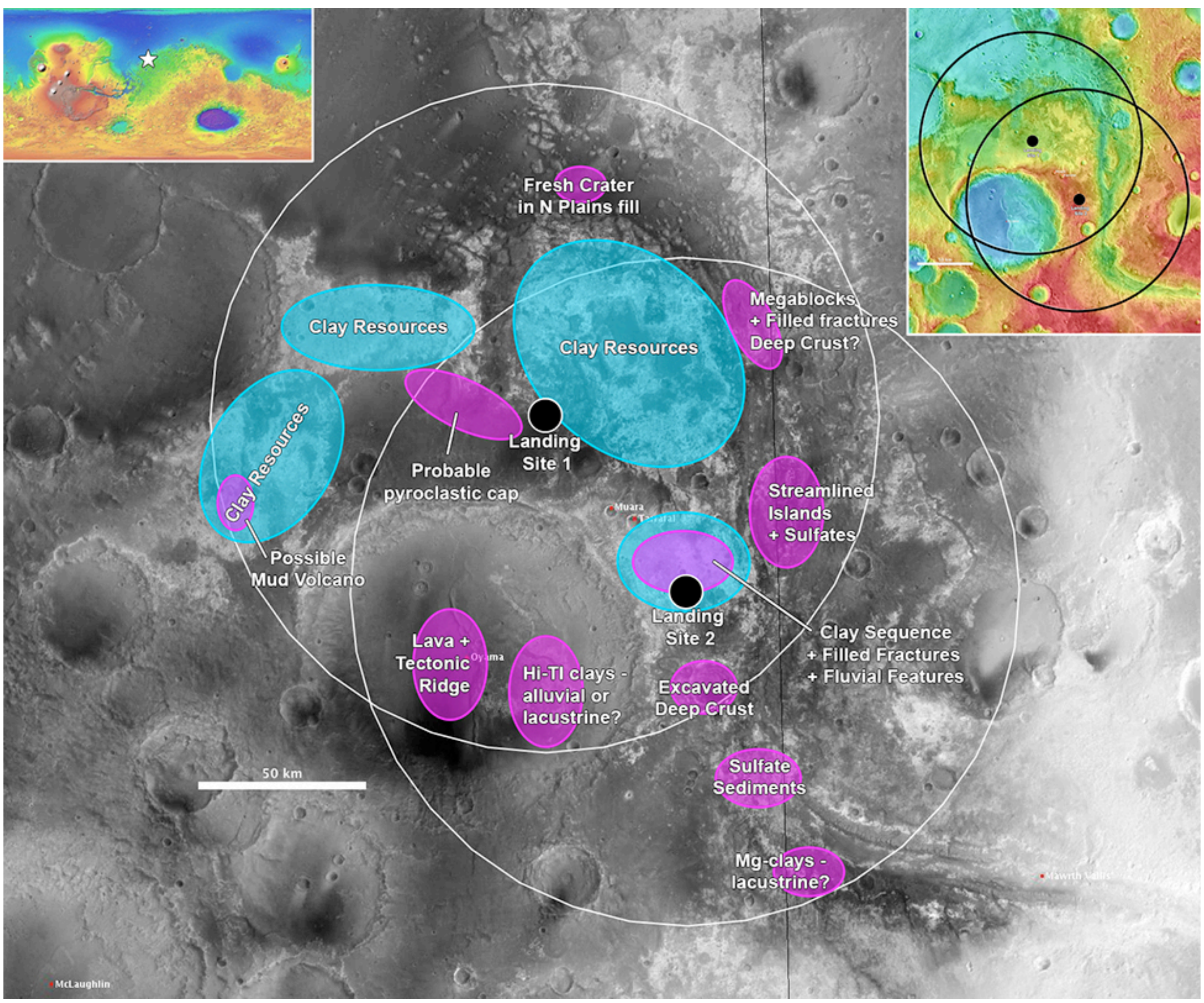

Figure 1: Mawrth Vallis Exploration Zone, HRSC red channel mosaic. Top left box shows location of site on MOLA global map, top right box shows local topography from MOLA. Blue circles indicate resource ROIs and pink circles indicate science ROIs. Landing Site 1 allows access to additional resource ROI's, the mouth of Mawrth Vallis, and the northern plains, while Landing Site 2 allows better access into Oyama Crater and to mineral deposits on the southern flanks of Mawrth Vallis.

other weathering profiles on Mars [15], the high mineralogical diveristy [3], and the presence of apparent unconformities and paleosurfaces within the units [7] are more consistent with a paleosol sequence [14,16].

The stratigraphy is divided into an upper unit containing mainly Al-phyllosilicates/hydrated silica and a lower Fe/Mg-smectite-rich unit. Within these units, variations in mineralogy include moderately weathered smectites, highly leached kaolins, Al/ferric acid sulfates, ferrous clays, and various poorly crystalline phases. An abundance of inverted channels preserved in the capping unit at the top of the sequence indicate aqueous processes that may have been active throughout the sequence [4,17]. Thus, these minerals likely formed in both soils and local aqueous environments (rivers, ponds, wetlands, lakes, aquifers, springs, etc.) with significant redox, pH, and saturation gradients providing clear energy pathways for microbes [18].

The age of the clays is constrained by a regional Early Hesperian dark capping unit of probable pyroclastic origin as well as several cratered paleosurfaces within the units, suggesting that the whole package was laid down between the Early and Late Noachian [6,16]. Thus, the Mawrth paleosol sequence has the potential to provide a record of ancient surface environments and, in particular, climate throughout the Noachian, more so than any other known site on Mars.

The Mawrth Vallis EZ also offers access to several other notable geologic features, including the dichotomy boundary and the outflow channel. Within Mawrth Vallis, there are streamlined islands potentially preserving flood deposits, sulfate sediments, fresh craters into northern lowlands materials, and co-occurring megablocks and filled fractures at several scales that may represent deep crust exposed by the outflows. Hydrothermal deposits may be present within halo-bonded fractures on the plateau, perhaps related to the Oyama impact during deposition of the sequence. Oyama Crater contains dateable lava flows, a regional tectonic ridge, and fluvially transported clays.

Biosignature Preservation Potential: Paleosol sequences have two key characteristics that promote preservation of biosignatures and organics: rapid burial, which protects buried materials from erosion, oxidation, and degradation at the surface, as well as high smectite clay content, which significantly decreases the permeability of sediments and protects against later degradation due to diagenetic processes [11,16]. Other local processes and/or environments within the soils can help to further enhance organic preservation, including reducing paleosols (e.g., wetlands) and silica deposition, both of which are inferred based on spectra at Mawrth [18]. Some of the redox reactions inferred at Mawrth may also be catalyzed by microbes, and thus may retain isotopic or physical biosignatures [19]. Concentration of biosignatures and organics may be locally enhanced in aqueous environments, especially reducing ponds or wetlands – for example, organic-bearing lignite/tonstein/seatearth deposits are not uncommon in paleosol sequences [16]. Elsewhere in the EZ, silica or sulfates in fractures as well as sulfate sediments could also facilitate biosignature preservation.

Resource Potential: The Mawrth region may represent one of the most valuable sites for exploration-related resources on Mars. Mixing models based on both near-IR and thermal-IR spectra of the Mawrth plateau surfaces suggest clay mineral abundances in excess of 50 wt.% [20-22], which is the largest clay abundance detected on Mars. Terrestrial analog paleosols from semi-arid environments typically contain anywhere from 35-100 wt.% clay minerals. In the thicker and more widespread lower unit, most of the clays are smectites, which have high water content suitable for extraction (5-20 wt.% [23]). Spectral unmixing of the lower unit also indicates a possible ferrihydrite component at ~15 wt.%, which would probably contribute similar levels of water [23], for a total of ~75 wt.% water-bearing minerals [20,21]. Spectral models support a high water content in these rocks, 7-9 wt.% at the surface [24]. The clay units could also be a good resource for iron, as they likely contains ferric (Fe/Mg-smectites) and ferrous (celadonite/glacuonite) clays [11], and iron sulfides [11,18,25]. The upper unit is modeled as a combination of kaolins (10-30 wt.%), smectite (20-40 wt.%), silica (5-15 wt.%), and ferrihydrite (5-15 wt.%) [22]. While the upper unit might produce less water than the lower unit, it could also be a valuable resource for aluminum and silicon.

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