Human Exploration of Mars at Valles Marineris: The Past, Present, and Future of Life on Mars. A. Mojarro[1], G. Ruvkun[2], M. T. Zuber[1], and C. E. Carr[1-2,*], [1]MIT Department of Earth, Atmospheric and Planetary Sciences, Cambridge, MA, [2]MGH Department of Molecular Biology, Boston, MA. [*]Correspondence: chrisc@mit.edu

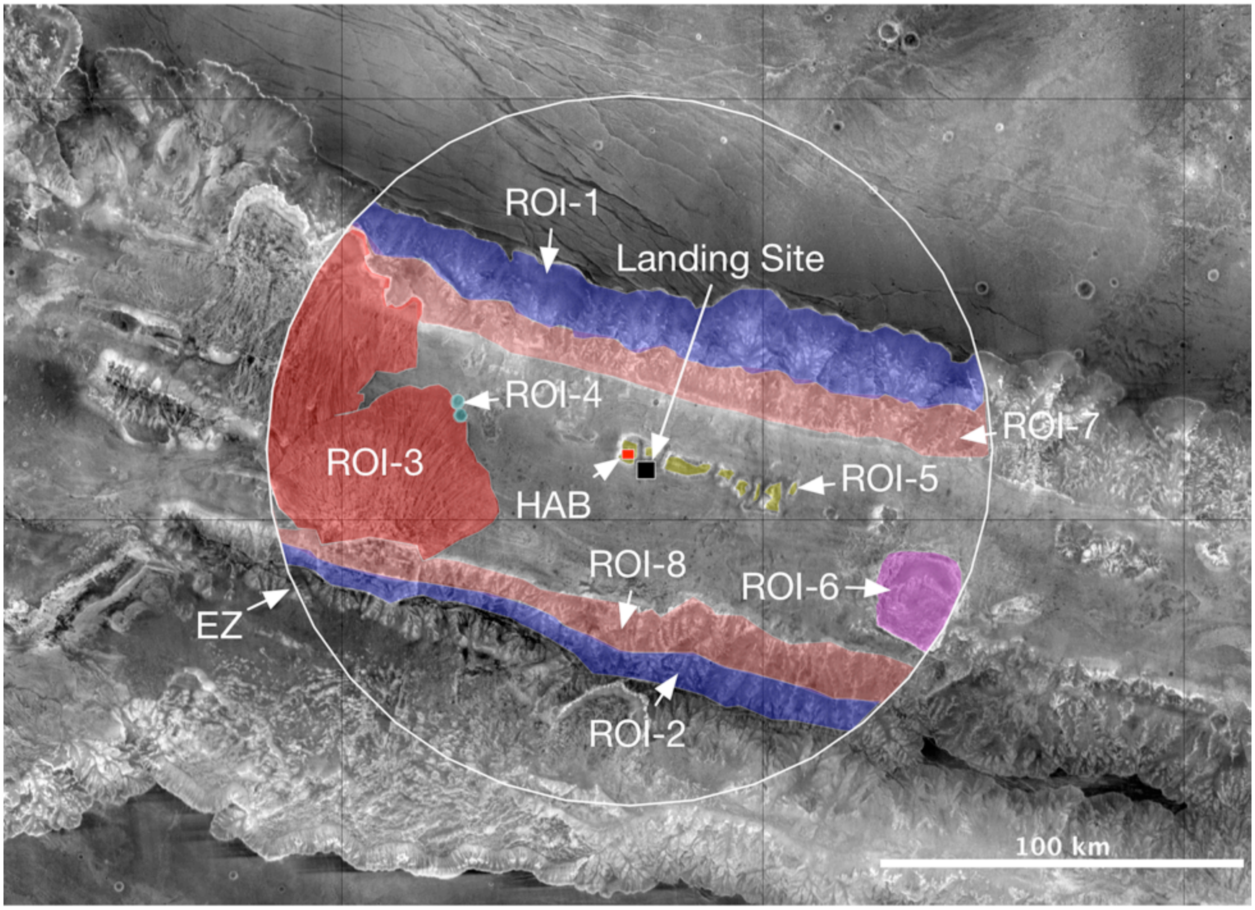

Figure 1. Our proposed exploration zone (EZ) in western Coprates Chasma, Valles Marineris, encompasses regions of interest (ROIs) relevant to the deep geologic history of Mars, the search for ancient or extant life, and a setting and resources that could support human habitation on Mars. Image data: JMars (ASU) with Night IR (NASA Mars Odyssey/THEMIS).

Introduction: Mars's grand canyon, Valles Marineris, is host to numerous preserved geologic features, modern atmospheric phenomena and potential subsurface aqueous activity favorable towards human habitation. Our proposed exploration zone is centered atop an inferred tilted fault block 1 km above the valley level in the western aspect of Coprates Chasma, 293.367°E -11.684°N. Within 100 km of our proposed landing site are several regions of scientific and engineering interest including: recurring slope lineae (RSL) [1], cross cutting alluvial fan deposits, tilted valley walls [2], impact craters, olivine deposits [3], clay mineral deposits [3] and exposed deep crustal lithologies [3]. Favorable environmental conditions include strong year-round solar insolation [1] and high atmospheric pressures [4].

Science: Key regions of interest (ROI) in the search for extant life on Mars are RSLs (ROI-1,2) [1], which may be fed by subsurface brine aquifers. The valley walls surrounding the habitable zone (HAB) contain a high concentration of RSLs which increases the likelihood for detection of an extant microbial ecosystem, if life ever took root on Mars and survived the Hesperian-Amazonian transition. Direct sampling of briny waters at RSL sites, combined with nucleic acid sequencing, along with corroborating evidence, could provide strong evidence of extant life on Mars [5-7]. RSLs are found on steep slopes, posing sampling challenges for existing robotic systems. However, humans, or Mars-adapted helicopters [8] or quadcopters [9] may be able to target these and other hard to reach ROIs.

Cross cutting alluvial fans (ROI-3) from opposite valley walls 42 km to the west of the habitable zone, Ophir Labes and younger Coprates Labes, are plausible regions for preserved organics and/or microfossils. The spreading geometry and flow distance of these alluvial fans indicate an aqueous origin [10] as opposed to dry granular flows [11]. Both fans appear to be a result of groundwater discharge which supports our subsurface aquifer theory. Organics or microfossils transported from the aquifer or valley walls could be preserved within the sediment and ideally buried deep enough to survive the harsh surface radiation environment [5, 12]. Futhermore, twin impact craters (ROI-4) at the north-east edge of Coprates labes could also harbor signs of ancient life. Recent literature has indentified impact glass formation as a potential preservation mechanism of biosignatures [13]. If the formation of Coprates labes and the twin impacts occurred within a timely geologic period, organics could be preserved beyond the surface limitations [12]. The proposed habitable zone and adjacent regions due east (ROI-5) are inferred to be tilted fault blocks [2] remnant from the rifting [14] or transextentional [15] event which initiated Valles Marineris. The vertical stratigraphy of Valles Mariners could easily be analyzed horizontally, spanning billions of years. Human explorers would walk along the depositional history during rifting/transextention and subsequent canyon incision and gaze into crustal lithologies and the corresponding thermal history. Lastly, another region of interest south west of the habitable zone (ROI-6) is an impact crater [2] with playa deposits from inferred groundwater discharges, possibly as a result of localized ground ice melting from the impact.

Resources: An easily exploitable water reservoir on Mars is critical to the success of a prolonged human exploration mission. RSL regions (ROI-1,2) are the obvious candidate sites for groundwater pumping assuming groundwater brine melts [1] and not deliquesence [16]. An alternative source is to directly harvest water from the atmosphere anywhere whitin the exploration zone (EZ). First observed by the Viking orbiters, morning ice fogs are a prevalent diurnal occurence [17] that could provide a reliable source of water directly from the atmosphere [18]. In addition, a dependable source of breathable oxygen is also required for a successful mission. A thick atmospheric column throughout the canyon floor [4] means higher outputs from an in-situ oxygen generator such as the Mars 2020 Rover's MOXIE instrument [19].

Renewable energies on Mars could supplement nuclear sources and provide energy security and independence for prolonged habitation. Although the winds at Valles Marineris have not been fully characterized, widespread migrating sand dunes in Melas Chasma [20] suggest strong winds may traverse the valley. Bioinspired vertical-axis wind turbines could possibly provide high efficiency wind energy and provide wind dampening immediately downwind [21] for protection of strong gusts. Accessible olivine deposits (ROI-5,7,8) [3] can act as a precursor source of methane [22], carbon fuels, and promote greenhouse gas buildup in the atmosphere [23]. Lastly, exposed crustal lithologies (ROI-1,2,7,8) [3] and chemically altered altered clay deposits [3] provide a rich variety of minable metals and clay minerals for in-situ 3d printing [24] of materials and agriculture feedstock.

Summary: Human exploration of Mars will lead to grander scientific discoveries over the current fleet of Mars exploration rovers. Increased mobility will open regions once inaccessible. If there is extant life on Mars, it may be in regions that are not accessible to rovers but might be accessed by human explorers. We belive our proposed landing site hosts a careful balance for scientific and engineering success.

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