LANDING SITE AND EXPLORATION ZONE IN EASTERN MELAS CHASMA.

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Introduction: A favorable Exploration Zone (EZ) for future human missions to the surface of Mars should have these characteristics: (1) resources needed to keep humans alive, especially H_2O; (2) important science targets; (3) diverse regions of interest (ROIs) that can be reached within ~100 km of a central landing site; (4) a central landing site or multiple sites of at least 5 x 5 km area that are favorable for landing (low slopes, few meter-scale hazards, not covered by thick dust); (5) equatorial location for thermal management and ease of ascent from Mars surface; and (6) low elevation for ease of EDL with large masses and protection from radiation. Eastern Melas Chasm may be the region that best meets all of these criteria [1].

Recurring Slope Lineae (RSL) and/or polyhydrated sulfates for water: RSL are seasonal flows or seeps on warm Martian slopes. Observed gradual or incremental growth, fading, and yearly recurrence can be explained by seasonal seeps of water, probably salty [2-3]. They are narrow (<5 m), relatively dark markings on steep (25°–40°), low-albedo slopes, which appear and incrementally extend during warm seasons, fade when inactive, and recur in the same approximate or exact location over multiple Mars years. RSL lack clear water absorption spectral bands in Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) spectra, but the fans on which they terminate have distinctive color and spectral properties [4], and hydrated salts have been detected at some locations [5]. The lineae commonly follow small gullies, but few topographic changes have been detected via 30 cm/pixel images from the Mars Reconnaissance Orbiter (MRO) High Resolution Imaging Science Experiment (HiRISE). RSL are found in mid-latitude and equatorial regions, but are by far most common in the central and eastern troughs of Valles Marineris [6]. The equatorial RSL are especially active on sun-facing slopes, moving from north- to south-facing slopes and back to track the peak insolation.

There are several key gaps in our understanding of RSL. Most importantly, the origin of water to drive RSL flow is unknown. The time of day of active flow is also unknown. Most RSL locations are steep, rocky, low-albedo slopes, with daily peak surface temperatures typically >250 K, and commonly >273 K, in the active season, but there must be additional factors, because many times and places with these properties lack detectable RSL [7]. Laboratory experiments show that even minor amounts of water (5 wt. % and no liquid film on surface) can darken basaltic soils while producing only weak spectral features [8, 9]. These spectral features may be undetectable in CRISM spectra obtained from MRO's midafternoon orbit, due to partial dehydration and evaporation, except in rare times and places [5].

RSL are presently not understood well enough to plan ISRU for human exploration. It is not known whether >100 MT of useable water could be produced from RSL. These may be dense eutectic brines filling pore spaces, so new technologies will be needed to extract usable H, O_2 and H_2O. The water may have an atmospheric origin [10], in which case the RSL may mark locations favorable for ISRU extractiuon of water directly from the near-surface air.

Fortunately, Hesperian-age kieserite and polyhydrated sulfates dominate the south-southwest half of this EZ [11], perhaps from upwelling of groundwater [12]. This 3-km thick deposit is dominated by polyhydrated sulfates, suggesting a significant amount of bound water (up to 50% by volume) for potential ISRU. The alternative is to go to a middle-latitude location with clean, shallow ice [13, 14] and plan for cold winters.

Discussion of East Melas EZ: This region (see figure; center ~11.7 S, 290.0 E) is one of the largest low-elevation equatorial regions on Mars, with some areas below -5 km. This low elevation minimizes the challenge of landing large masses on Mars, and also reduces the radiation exposure [15]. In addition to RSL and/or hydrated sulfates for water, the mafic bedrock, regolith, and aeolian materials likely provide ample Fe, Al, Si, Ti and Mg. Cobble-sized or smaller rocks and bulk, loose reglolith are likely to be available for construction. There are mesas with steep sides that might be adapted for construction purposes. Wind magnitude in the Valles Marineris might produce engineering concerns but the proposed region is far from the canyon rims and modeled as moderate [16].

There are important science targets for investigation of both ancient and modern habitability and potential life, and a broad range of geologic processes. This region includes a great diversity of landforms, including layered bedrock with diverse compositions, high massifs with landslides, volcanic dikes, possible glacial landforms, possible lake deposits, impact craters, sand dunes and other aeolian deposits. The deep bedrock exposed in numerous locations is largely Noachian (>3.6 Ga), while the interior layered deposits are Hesperian and aeolian materials are Amazonian.

There have been many studies of minerlogy in Valles Marineris, including nearby Coprates Chasma and the SW Melas basin and surrounding [17] regions, with abundant phyllosilicates, sulfates, and other hydrated minerals. An unpublished CRISM analysis reveals a 2.21 μm absorption suggesting Al-rich phyllosilicate near the center of our EZ. CRISM full-resolution coverage of this EZ is only a few %.

The greatest engineering concern after water may be meter-scale EDL hazards. The available HiRISE image coverage is very sparse, a few % coverage, yet they show multiple 5x5 km flat areas with few boulders or scarps. Many of these flat areas are covered by small-scale aeolian bedforms, mostly <1 m high, and some appear indurated and eroded. Areas without aeolian bedforms tend to have more exposed boulders and slopes, but may be acceptable.

If East Melas is considered a promising region for a human EZ, then more CRISM and HIRISE coverage by MRO is clearly needed. A future orbiter could provide important new observations as well. JAXA is considering a future lander or rover to this region [18].

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Figure: THEMIS daytime-IR mosaic with proposed EZ (blue circle) and features of interest.