PROTONILUS MENSAE: CONTINUED ANALYSIS OF AN EXPLORATION ZONE ON THE NORTHERN PLANETARY DICHOTOMY OF MARS. PROSPECTS FOR FUTURE ROBOTIC AND HUMAN MISSIONS.

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Introduction: Previous missions to the surface of Mars cover a range of regions and geologic environments. We report on our ongoing study of a NASA exploration zone [1] to the east of Moreux Crater in the fretted terrain of Protonilus Mensae (Figure 1).

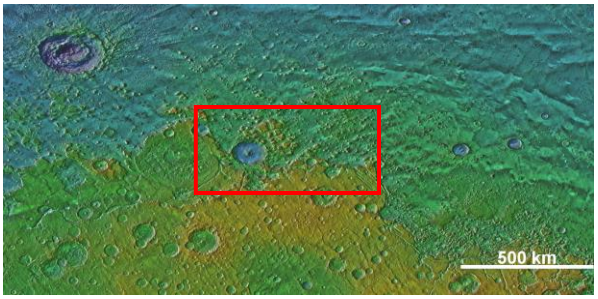

Figure 1a. Regional context. Figure 1b outlined in red.

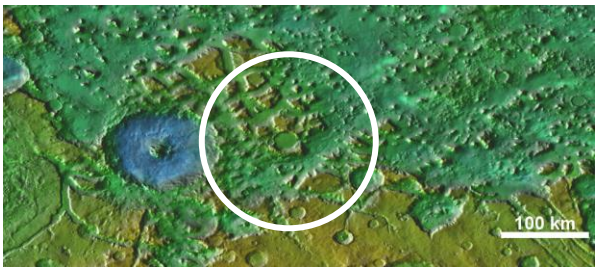

Figure 1b. Study area in Protonilus Mensae.

Geologic units (Figure 2). The oldest geologic unit in the area (mNh - brown) is the Middle Noachian highland unit. It comprises high-relief mesas separated by broad troughs and valleys. The next younger unit (HNt - dark yellow) is a more degraded Hesperian Noachian transition unit. Just within the limit of the EZ to the northeast is the Early Hesperian transition unit (eHt – dark orange). The Amazonian and Hesperian impact unit (AHi - yellow) is also represented in the area by Moreux Crater. The youngest unit is the Amazonian and Noachian apron unit (ANa – beige); the unit comprises a fretted network of Noachian mesas draped by ice-rich Amazonian materials.

Figure 2. Geologic context of the region [2].

Other features. This site is crosscut by a network fluvial and glacial valleys, of multiple scales, suitable for investigation. The unnamed outflow channels to the south contain lineated valley fill deposits from the regional glaciation events and are accessible for away missions.

There are a number of impact craters of varying scales in the area. Moreux Crater (~150 km) and LZ Crater (~35 km) are young, complex impact craters. Craters of this size can significantly alter the local geology/hydrology and are worth investigating. There are many simple craters to study in Protonilus Mensae which will also be a target for study.

Protonilus Mensae is located in a region of remnant magnetization as seen in MAG/ER data. Investigations of magnetic fields within samples may shed light on the issue of Mars' past magnetism and interior.

Human Exploraion Zone: The exploration zone concept for human exploration of Mars provides the opportunity to consider many new scientifically compelling areas for future missions. These exploration zones (EZ) offer a wide variety of scientific value, from astrobiology to geochronology, and direct new attention at the potential for resources, including access to useful materials and H2O in the form of ice or mineralogically bound H2O.

Astrobiology investigations may answer some of humanity's deepest scientific and philosophical questions. One of NASA's highest priorities is understanding if life ever arose, or even still exists, on Mars. Identifying areas with geomorphologic and/or chemical potential for preservation of biosignatures is central to the scientific goals for the EZ concept. A qualifying EZ will also provide outcrops that lead to understanding Mars' past and present. Observations can lead to inferences about the regional climate and past environments for the planet as a whole.

Establishing a semi-permanent base for reoccurring missions to Mars will require in situ resource utilization (ISRU). Possibly the most important commodity for a Mars missions will be H2O. Too heavy to transport from Earth, most water used by the astronauts for feedstock, civil engineering, and ascent fuel must be locally derived. Silicon and metals (Fe, Al, Ti, Mg, etc.) will need also be mined on site.

Protonilus Mensae EZ: The Protonilus Mensae EZ (centered at 47.770E, 41.996N) lies ~1800 km NW

from the Isidis Basin along the planetary dichotomy boundary, and encompasses a 100 km radius.

Mission Requirements: The proposed EZ lies at ~42°N, well within the ±50° latitudinal constraints. The average altitude (-2 km) is below the +2 km limit. Moderately low thermal inertia (~210 Jm-2K-1s-1/2) and moderately high albedo (~.161) signifies a relative lack of thick, fine grained dust deposits.

Landing Zone (LZ). A large area (~25 km2) to the northwest of the EZ center has been chosen as a reoccurring LZ. The area is relatively flat lying, contains few craters, and no inescapable bedforms are currently observed within the LZ.

Habitation Zone (HZ). At the center of the EZ lies the HZ, where a base of operations and infrastructure for reoccurring mission will be established.

Regions of Interest: The initial stages of site selection for human missions rely on the identification of regions of interest (ROI). An ROI must be within 100 km of the HZ; however, unmanned, base-operated rovers may be able to traverse farther and retrieve samples. ROIs qualify an EZ on the basis of science and/or resource value. There are many potential ROIs within the Mesopotamia EZ (Figure 3).

Science ROIs. Protonilus Mensae is a compelling site for astrobiology studies. The ANa unit (ROI 1), the multiple valley networks (ROI 2), and Moreux Crater (ROI 3) will be investigated for past and present signs of life. ANa may be a current refugium for life, as the thick ice deposits may create pressures conducive for liquid H2O, and possibly life. The valley networks are evidence for large amounts of past water flow and current H2O ice. Whether they were long lived enough to preserve, or even harbor, life is still to be determined. Moreux Crater offers a look at past atmospheric gasses trapped within its impact glass; impact glass is also a potential medium for biopreservation. Impact structures like Moreux can produce hydrothermal systems that persist for millions of years. This region may have been a nursery for early life on Mars. Hydrothermal systems have yet to be confirmed in or near the EZ.

Protonilus Mensae is also an intriguing site geologically. Units in the area range from Middle Noachian to Amazonian, providing a large range of time and environments to study. ROI 1 offers a chance to sample Noachian age rocks within the moraines and till eroded from the high-relief mesas. Three identifiable crustal units (mNh - ROI 4, HNt - ROI 5, EHt – ROI 6) will provide radiometric dating within the EZ to relate with the regional and global geologic context. Craters in the EZ are also of scientific interest. Moreux Crater (ROI 3) offers a look at a young, complex crater impacting into Noachian crust and possibly the ice-rich apron units as well. Several simple craters in the EZ will be investigated but are not considered ROIs.

ISRU ROIs. The ANa unit (ROI 1) offers a large supply of H2O ice. Previous studies using SHARAD radar data confirms these massif-draped apron deposits to contain one of the largest amounts of H2O ice on Mars accessible with current engineering parameters. The lineated valley fill features in the area (ROI 2) are also a geomorphic indication for large supplies of H2O ice. TES observations show sheet silicates/hi-Si glass within the EZ. They concentrated near Moreux Crater (ROI 3) possibly as impact glass.

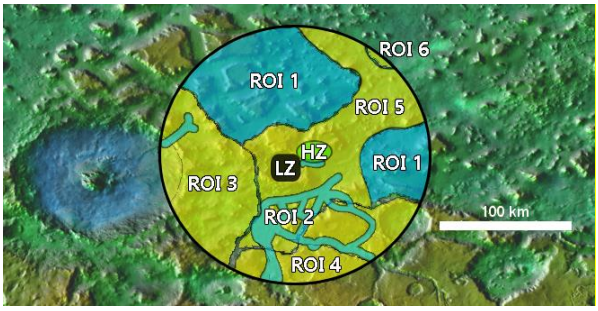

Figure 3. Science ROIs: yellow; ISRU ROIs: blue.

HIRISE, CRISM, and Future Datasets: There are abundant HIRISE and CRISM observations of the various units within the EZ (Figure 4); however, the area would benefit from more data. Current and future orbiting missions should target this area to enable future lander, rover, and human missions.

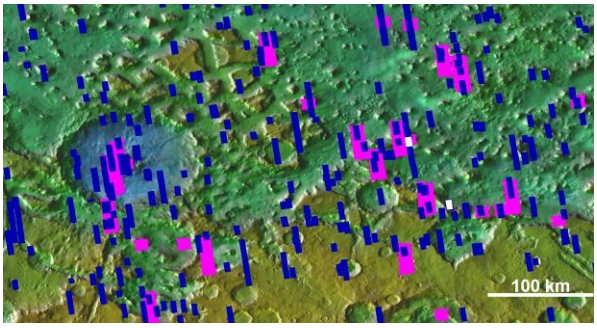

Figure 4. HiRISE (blue), HiRISE DTM (white), and CRISM (magenta) coverage in the EZ region.

Conclusions: The proposed human EZ Protonilus Mensae offers a new, scientifically intriguing region with abundant resources for future robotic and human missions to Mars.

References: [1] Gallegos and Newsom (2015) First Landing Site/Exploration Zone Meeting [2] Tanaka K. L. et al. (2014) USGS, Scientific Investigations Map 3292.