MARS HUMAN SCIENCE EXPLORATION AND RESOURCE UTILIZATION: THE DICHOTOMY BOUNDARY DEUTERONILUS MENSAE EXPLORATION ZONE

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The Dichotomy Boundary Deuteronilus Mensae (DBDM) Exploration Zone (EZ) (39.11˚ N, 23.199˚ E) combines: 1) Fundamental MEPAG scientific objectives for the exploration of Mars (geology, atmosphere/climate history, hydrology, astrobiology)(1-6; 8-18); 2) Samples/questions from each of the three major geologic eras (Noachian, Hesperian, Amazonian); 3) The certainty of ISRU (I), including access to abundant stores of water ice mapped by SHARAD (16); and 4) Civil Engineering (CE) opportunities, including manipulating material/ice and reducing reliance on Earth supplies. We combine these four themes into the term *Science/ICE*. We illustrate the *Science/ICE* theme in the selection of our current top priority EZ along the DB (Figure 1), among numerous candidate DB EZ sites we have investigated (Figure 2).

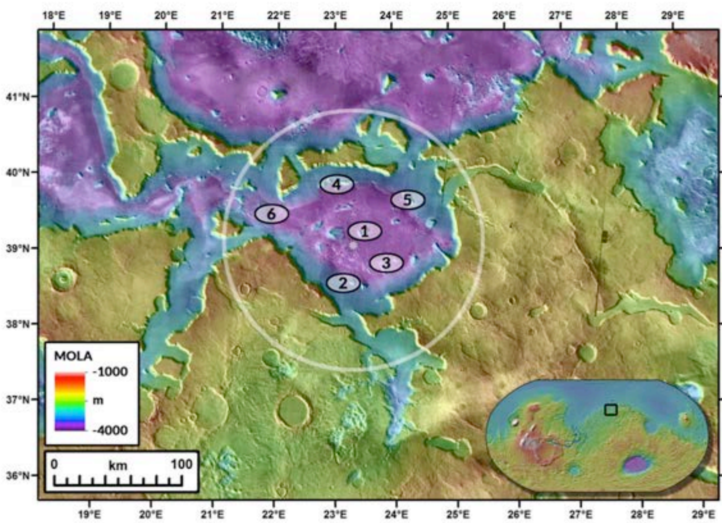

Figure 1. The Dichotomy Boundary Deuteronilus Mensae (DBDM) Exploration Zone (EZ) outlined as a circle of 100 km radius, with the Landing Site/Surface Field Station (denoted by star) centrally located and slightly separated to assure safe descent and ascent. Science and Resource ROIs (always combined) are indicated by numbers and described in the text. For geological units within EZ, see (18); floor is HNps (smooth plains); LDA is Ada (debris aprons); Flat plateaus are Nplsu (upper smooth plateau material). Basemap is a THEMIS daytime IR mosaic overlain on MOLA gridded topography.

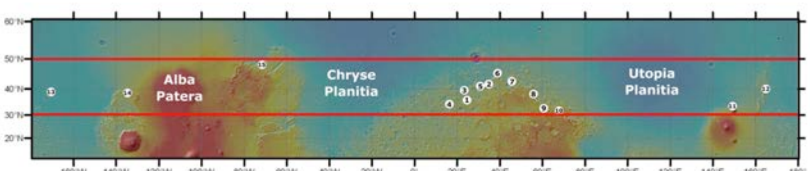

Figure 2: Location of additional EZs with similar objectives that have been investigated. See references for guide.

EZ Rationale: Science goals/ROIs are based on abundant study and analysis by our group (see selected references), span the entire geologic history of Mars, and include: 1) *Amazonian* climate record and nature of glacial processes in Latitude-Dependent Mantle (LDM) deposits on the crater floor, and ice in Lobate Debris Aprons (LDA) and Lineated Valley Fill (LVF); 2) *Hesperian/Noachian* Ridged Plains (NHr), composition and mode of emplacement (basaltic talus in LDA), and possibility of a northern lowlands ocean. 3) *Noachian* crustal composition, diversity, history of alteration (hydrothermal, groundwater, surface, subsurface; relation to global remote sensing signatures), climate history (comparison of A/H/N suite of rocks), and origin of the dichotomy boundary (shocked rocks from Borealis basin?) in surface materials and LDA talus.

All of our Science ROIs (Figure 1) are in the same areas as our I/CE ROIs as the LDAs and surrounding terrains provide access to water and CE tasks for surface manipulation, resource access and infrastructure emplacement and protection. This DBDM/EZ *Science/ICE* concept is very robust as it has abundant backup EZs (Figure 2) for exploring trade space and optimizing science and engineering synergism.

ISRU Activities: These activities should focus on life support and mission support. Water ice is the most important commodity, and the most important factors are: *grade* (how clean or chemically contaminated is the product) and *concentration* (how much ice per kg of debris "waste"), followed very closely by *site logistics and extraction feasibility*. Atmospheric modeling suggests ice cement at shallow depths, and layered deposits similar to the LDM are prominent on the floor and may provide relatively pure ice or ice lenses. The key locations for water ice resources, however, are the LDA, shown by SHARAD results to be *high-grade*, *high concentration* (nearly pure) water ice, lying below less than 10-15 meters of sublimation till, itself a major resource for construction and shelter, as well as of fundamental scientific interest.

Science-Resource ROI 1: Located nearby the landing site, this ROI is represented by the Noachian-aged crater central peak, uplifting and exposing deeper crustal material, and by LDM fragments that expose the climate record and are a potential water resource. **Science-Resource ROI 2:** Base of the LDA with water ice resources at shallow depths and a rock material suite that will include samples brought from the broader region to the south. **Science-Resource ROI 3:** Extensive flat-lying LDM several tens of meters thick, containing an Amazonian climate record and nearly pure ice intercalated with ice-cemented debris. **Science-Resource ROI 4:** Distinctive LDA protruding through ridge representing potential peak ring of Noachian-aged crater (Figure 3). Access to water ice in near subsurface and suite of samples from terrain to the north. **Science-Resource ROI 5:** Ridge representing potential peak ring of Noachian-aged crater; LDA banked behind with LDA lobes on both sides of the outcrop of ancient crustal material. **Science-Resource ROI 6:** Outlet from Noachian-aged crater floor to west provides access to additional LDA and wrinkle-ridge-like structure that may mark the location of ancient lavas.

We utilize our Apollo experience in site selection and mission operations and engage our Immersive Virtual Reality (IVR) capability (7) in visualizing mission concepts and architectures, Landing Site selection, Surface Field Station placement, traverse planning, and resource extraction planning. We also engage IVR in EDL, surface operations and public impact and outreach assessments. Detailed exploration concepts are being developed for each ROI.

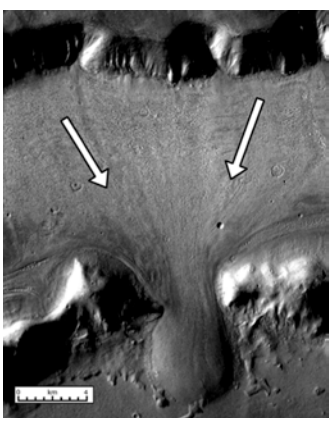

Figure 3. LDA at ROI 4

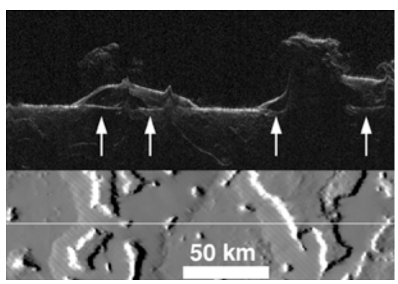

Figure 4. SHARAD profile N-S across central DBDM EZ (16).

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