

INVESTIGATING MAGMA-CRYOSPHERE INTERACTIONS AND OUTFLOW CHANNEL ACTIVITY IN HEBRUS VALLES AND HEPHAESTUS FOSSAE, MARS. S. Nerozzi¹, B. S. Tober², J. W. Holt², ¹Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin, Austin, TX 78757 (stefano.nerozzi@utexas.edu), ²Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ.

Introduction: Hebrus Valles (HV) and Hephaestus Fossae (HF) are well-preserved examples of Early Amazonian outflow channel systems in SE Utopia Planitia, Mars (17-25 °N, 118-129 °E, Fig. 1) carved into bed-rock. They exhibit a diverse set of morphologies indicating that they were formed by one or more liquid water outflow events, possibly due to magmatic intrusion, melting and cracking of the cryosphere [1-4]. However, little is known about their history, including both the origin and ultimate fate of the water and resulting sediments. This represents a significant gap in our understanding of geologic processes occurring in the Amazonian Period. Thanks to extensive coverage by recent datasets, it is now feasible to study the evolution of the HV-HF outflow channel systems with an integrated analysis of diverse, complementary data. This includes high-resolution visible imagery, surface and subsurface radar sounding, and stereo-derived digital terrain models (DTMs).

Methods: In a preliminary study of the HV-HF system, we identified five sample geologic facies based on morphological and thermophysical properties measured in the HV-HF study region (Fig. 1) by the context camera (CTX) on Mars Reconnaissance Orbiter and the Thermal Emission Imaging System (THEMIS) on Mars Odyssey. A geological facies is a classification term often used in stratigraphy and radar imaging to identify a body of rock with specific attributes that distinguishes it from adjacent rock.

We also analyzed Shallow Radar (SHARAD) profiles crossing HV, and traced subsurface reflectors. Clutter simulations based on high resolution DTMs allowed us to distinguish returns that appear in the subsurface but originate from off-nadir surface relief [5].

In addition to subsurface mapping, numerous studies have demonstrated the ability of reflectivity analysis to provide quantitative descriptions of scattering properties and dielectric permittivity of the surface and the shallow subsurface in SHARAD data [e.g., 6]. We applied similar techniques to a subset of SHARAD profiles crossing HV to obtain a quantitative description of near-surface reflectivity.

Preliminary study: Facies mapping and crater ages. Fig. 3 illustrates examples of five sample facies mapped in our preliminary study using CTX images. We identified a total of 23 facies within the HV-HF study region.

Subsurface radar sounding. A preliminary analysis

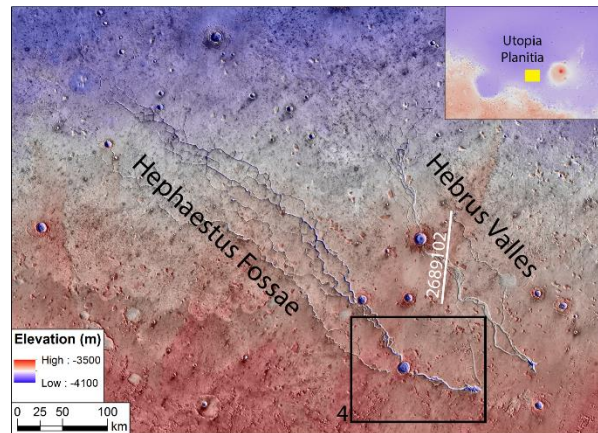


Figure 1: THEMIS IR Day mosaic overview of the study region in the broader context of Utopia Planitia. The black box indicates the location of Fig. 4, the white line indicates the radar profile ground track in Fig. 2.

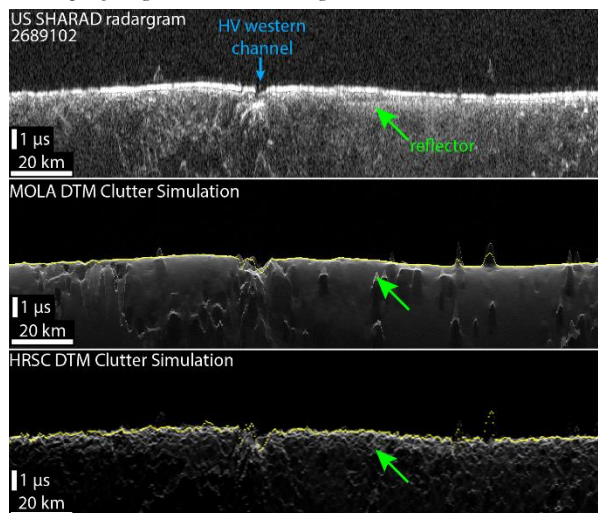


Figure 2: Sample of SHARAD profile showing a subsurface reflector. Clutter simulations below shows that only diffuse scattering is present at that location.

of 15 radar profiles in HV reveals the presence of subsurface interfaces in proximity to a wrinkle ridge (example in Fig. 2). This ridge is superimposed onto HV, meaning that its formation postdates the outflow activity. The average time delay of mapped reflectors corresponds to a minimum depth of ~45 m assuming a basaltic subsurface composition ($\epsilon' = 8.8$, [7]) to ~60 m assuming pure water ice ($\epsilon' = 3.1$ [e.g., 8]). The possible average depths of SHARAD subsurface reflectors is not compatible with the detection of the base of the resistant layer seen in nearby outcrops at <20 m depth. Moreover, reflectors appear to pinch-out or vary in depth consider-

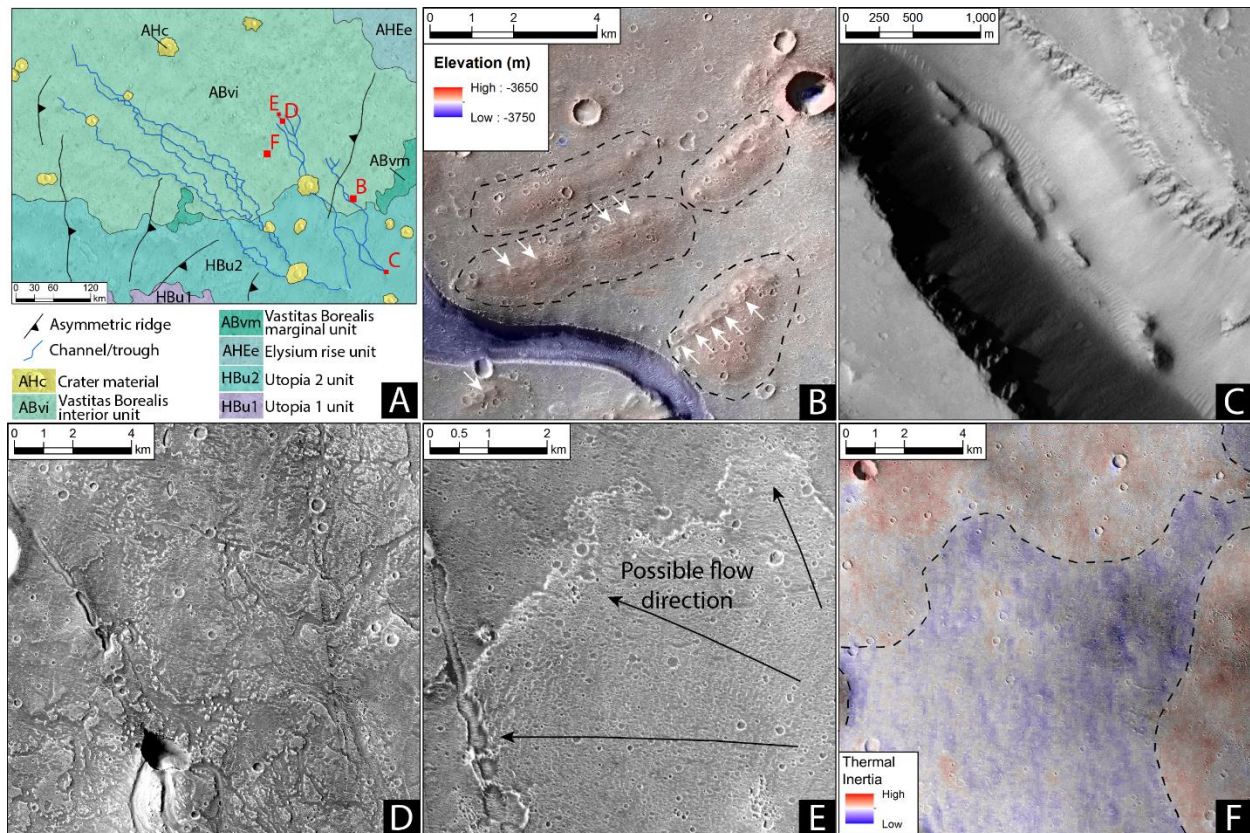


Figure 4: Re-digitized sample of the ref. [3] geologic map in the HV-HF region, with locations of geologic facies in other panels (red). (B) The pitted cone terrain (white arrows) and inflated terrain (black dashed line) often occur together; CTX DTM elevation basemap. (C) Linear ridge (within pit) facies. (D) Distributary channel-incised terrain, which cuts through the lobate and undulated rough terrain shown in panel E. (E) Lobate and undulated rough terrain, which is found only in the terminal region of HV. (F) Example of the low TI smooth terrain, bounded by lobate terrain with higher TI; the basemap is the THEMIS IR night mosaic.

ably, and are all located within the topographic expression of a wrinkle ridge, suggesting a structural, rather than stratigraphic, origin. An extensive analysis of all radar profiles in the region is needed to determine whether these reflectors correspond to the internal structure of the wrinkle ridge or an unrelated dielectric interface in the subsurface, such as the top of the ice table.

Surface radar reflectivity. Quantitative analysis of a subset of 24 profiles crossing knobbed terrains in HV reveals a strong variability in surface reflectivity (Fig. 4). This could be due to a more heterogeneous subsurface at site A that could result from a high-energy sedimentary environment, but a complete analysis including surface roughness is required to fully evaluate the data.

References: [1] Christiansen E.H. and Hopler J.A. (1987) *NASA Rep. Planet. Geol. & Geophys. Prog.*, 1986, 307-309. [3] Tanaka K.L. et al. (2005) *USGS, SIM2888*. [4] Rodriguez, J.A. et al. (2012) *GRL*, 39, L22201. [5] Choudhary, P. et al. (2016) *GRSL*, 13, 1285-1289. [6] Grima et al., 2012. [7] Nunes D.C. and Phillips R.J. (2006) *JGR*, 111, E06S2. [8] Heggy et al. (2008) *LPSC XXXIX*, Abstract #2471.

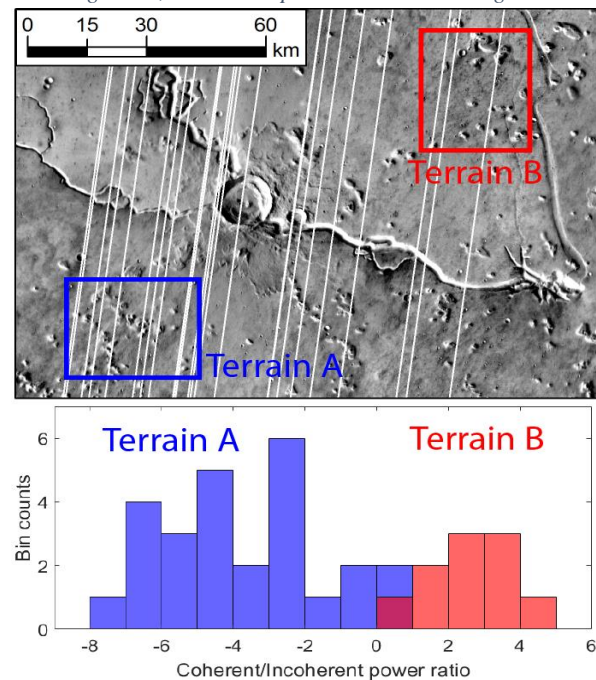


Figure 3: Preliminary test of coherent/incoherent power extraction from 24 SHARAD profiles (white lines).