Understanding Elysium Planitia Through Statistical and Standard Radar Analysis.

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Introduction: In Elysium Planitia, late Amazonian lava flows cross cut by the Athabasca Valles outflow channel system represents the most recent fluvial and volcanic interaction on Mars [1]. Radar Statistical Reconnaissance (RSR) of this region [2-4] using Mars Reconnaissance Orbiter (MRO) Shallow Radar (SHARAD) observations indicates that different geologic facies may be identified by comparing their root-mean square height (RMSh), effective slope (S_{eff}), and coherent-to-incoherent power ratio (P_c/P_n). To complement this analysis, we carried out a survey of subsurface radar detections in the region to determine if the RMSh, S_{eff}, and P_c/P_n correlate with the detection of subsurface interfaces.

SHARAD: SHARAD emits a linear-frequency “chirped” pulse with a 10 MHz bandwidth centered at 20 MHz. This yields a 15-m free-space resolution prior to processing. [5] Processing of SHARAD data generally involves the application of a weighting function to reduce sidelobes, which reduces the effective free-space resolution to 25 m. After synthetic-aperture processing, the along-track resolution is set to 463 m (128 pixels per degree).

Methods: In the Athabasca region (**Fig. 1**; white outline), we identified and examined 451 2D radargrams. We also computed corresponding simulations of off-nadir and nadir surface returns (“cluttergrams”) to assist in clutter discrimination. We imported the radargrams and cluttergrams into the Geophysics by SeisWare™ (GSW) software to perform our analysis. We also imported the spatial extents of 17 geomorphically defined facies [3] to determine overlap in our analyses.

Our analysis includes mapping apparent subsurface reflectors, calculating time-delay differences between the surface and subsurface reflectors, and power ratios between the subsurface and surface reflections. We compared these data to the RMSh, S_{eff}, and P_c/P_n for each identified facies and geologic unit to determine any correlations between the datasets to complement the RSR analysis.

Results: Mapped subsurface reflectors (**Fig. 1**) coincide with two distinct facies: the Platy Continuum (gray) and Platy Undifferentiated (light blue) facies; three distinct geologic units: the Hesperian Transitional Unit (red), Cerberus Tholi Lava Unit (pink), and the Cerberus Plains Unit (light brown); and a generic basaltic region which encompasses the study region [3]. The difference in amplitude between the surface and subsurface ranges between ~0.1 - 32.8 dB, and is centered at ~15 dB.

The time-delay between surface and subsurface corresponding to individual facies varies only slightly. The time-delay difference between subsurface and surface within the Cerberus Tholi Lava unit ranges between 0.2 and 1.3 µs. The time-delay difference within the Cerberus Plains unit ranges between 0.1 and 1.7 µs with a peak occurrence at ~0.55 µs and a possible secondary peak at ~0.32 µs. Within the Platy Continuum facies, the time-delay difference ranges between 0.2 and

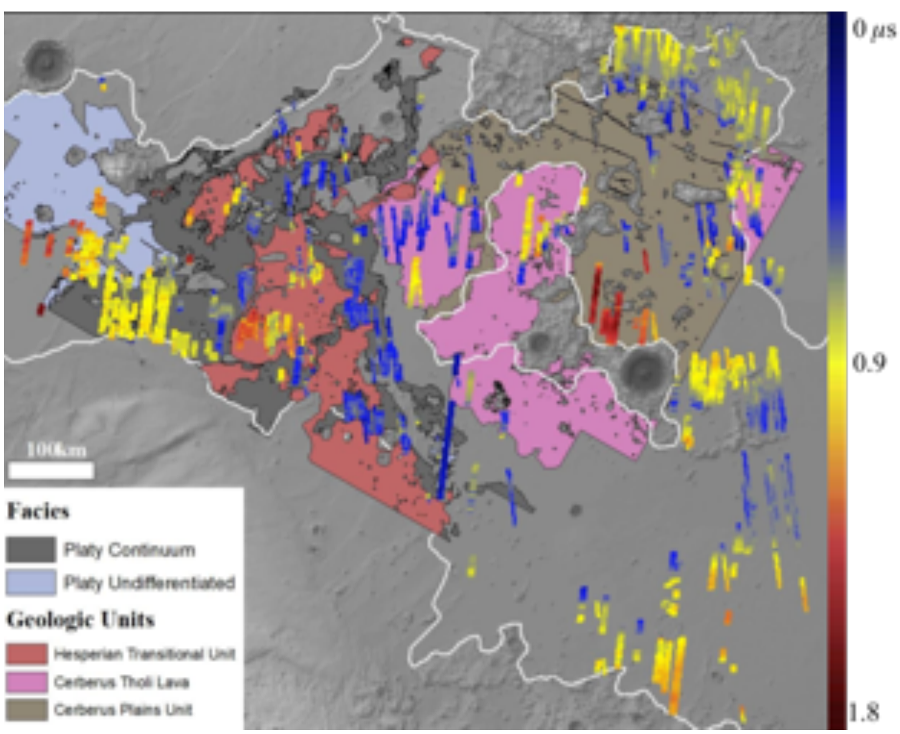

Figure 1. Our study area (centered at 3.5°N, 157.5°E) within the Elysium Planitia Region outlined in white. Depth (in µs from the surface) of the shallowest subsurface reflector is shown by the color bar to the right of the image. The MOLA 128 ppd hillshade is used as the basemap.

1.3 μs with peaks at ~5.5 μs and 8.6 μs. The time-delay difference within the Lava facies ranges between 0.2 and 1.8 μs with a well-defined single peak at 7.2 μs.

We calculated the power ratio (subsurface/surface) for each subsurface detection within each corresponding facies and geologic unit. Within the Cerberus Tholi Lava unit, the power ratio ranges between 0.75 and 9.2 dB with an average of 2.5 dB. The range of power ratio within the Cerberus Plains unit is between 0.61 and 14.3 dB with an average of a 2.3 dB. Within the Platy Continuum facies, the power ratio ranges between 0.77 and 21.7 dB with an average of 2.7 dB. The Platy Undifferentiated facies has the narrowest range of power ratio between 1.2 and 9.2 dB, with the highest average power ratio of 3.1 dB. Within the Hesperian Transitional unit, the power ratio ranges between 0.73 and 27.6 with an average of 2.3 dB.

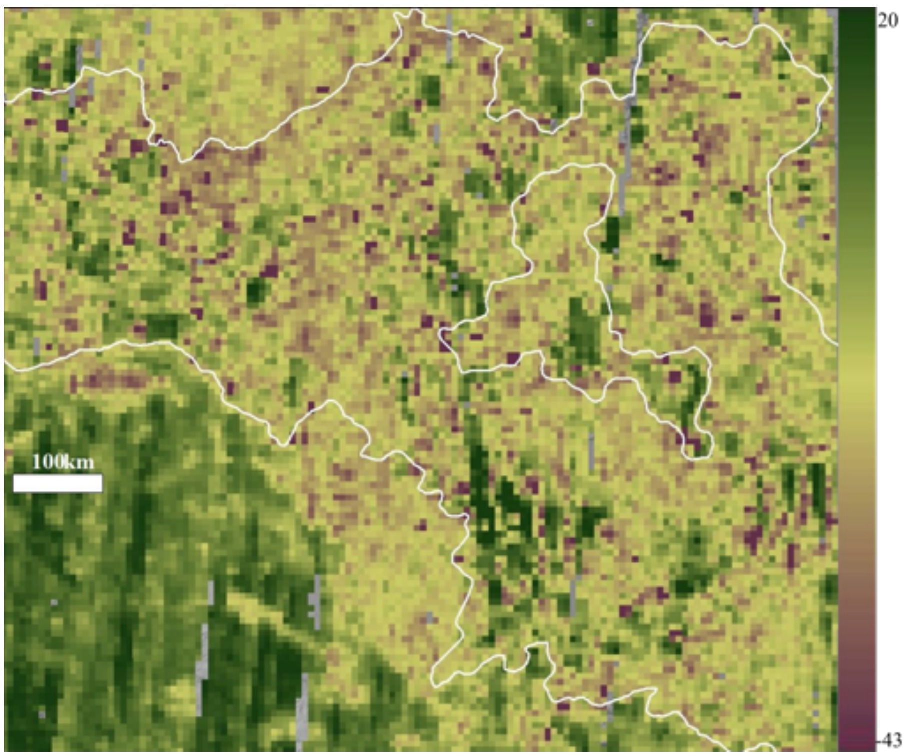

Figure 2. Our study region (centered at 3.5°N, 157.5°E and outlined in white) with RSR (P_c/P_n) data overlain. Very few subsurface reflectors are mapped in areas with the highest P_c/P_n ratios (dark green).

Discussion: Our analysis indicates that there are no discernible characteristics from standard radar analysis that help differentiate the various facies and geologic units in the region. However, there is some correlation between areas of high P_c/P_n values [4] and areas where no subsurface reflectors are mapped (Fig. 2). This work illustrates the utility of the RSR technique, as our preliminary analysis indicates that the P_c/P_n is capable of differentiating between distinct geologic units. Integrating the RSR data with mapped subsurface radar reflectors stands to increase our understanding of how different geologic materials affect the propagation of radar signals, which directly affects our ability to detect subsurface interfaces.

Future Work: In future work, we plan to depth-correct the radargrams assuming dielectric constants, ε_r' , of 6 and 9 representing the range of bedrock material, and the resulting thickness estimates will be integrated with the rest of our analysis.

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References: [1] J. P. Cassanelli and J. W. Head (2018) *Planet. and Space Sci.,* 158, 96-109. [2] C. Grima et al. (2014) *Planet. and Space Sci.,* 103, 191-204. [3] R. Miller et al. (2022) LPSC 53 (this conference). [4] C. Grima et al. (2022) LPSC 53 (this conference). [5] R. Seu et al. (2007) JGR: Planets 112.E5.