INVESTIGATING THE STRATIGRAPHY AND THREE DIMENSIONAL STRUCTURE OF THE YOUNGEST LAVA FLOWS ON MARS USING THE SHARAD RADAR.

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Introduction: Elysium Planitia – situated between the equator to ~12°N and extending from 150° to 180° E - is considered to be the youngest volcanic plain on Mars [1]. Recent crater counts on individual lava units argue for multiple phases of activity over the last 230 Ma, with the most recent volcanic features dating to ~2 Ma [2]. The region also contains multiple channel systems interpreted to have been carved by the release of ground water (see [3]; [1]). In contrast to a volcanic origin, some authors [4,5] suggest that areas of Elysium Planitia represent the surface of a frozen sea capped with pack-ice. Elysium Planitia is therefore of high scientific interest, and understanding the relationships between the different units and their relative stratigraphy is essential to the interpretation of recent martian geologic history.

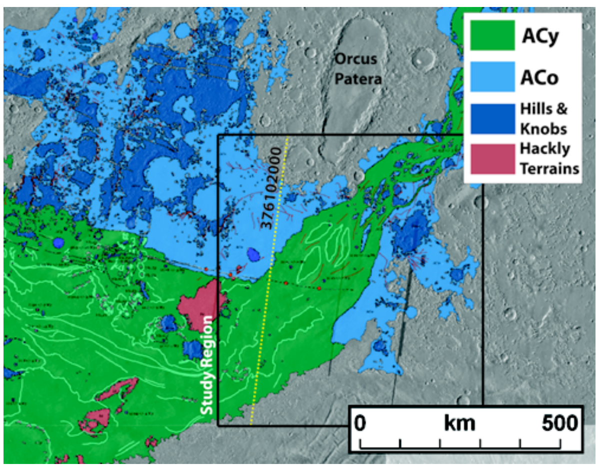

Fig. 1. Study region within Elysium Planitia. Geologic units correspond to mapping by Vaucher et al (2009). ***ACy*** *= Amazonian Cerberus young: Youngest volcanic surfaces.* ***ACo*** *= Amazonian Cerberus old: Stratigraphically older volcanic surfaces; both units have been modified by fluvial activity. Note orbital track for radargram shown in Fig. 2.*

Extensive geologic mapping of Elysium Planitia [6-9; 2] has provided detailed information concerning the stratigraphy of the major volcanic units in addition to the classification of other landforms attributed to volcanic (e.g. small shields), fluvial (e.g. outflow channels) and aeolian (e.g. yardangs) activity. Through the application of depth-diameter relationships applied to lava-embayed craters it is possible to derive measurements of lava thickness, which can be extrapolated to provide estimates of the volume of volcanic material [2]. However, this relies on assumptions regarding the spatial extend of subsurface layers, which can only be established along the boundaries of the uppermost unit. Orbital sounding radar provides a means to map buried layers associated with a contrast in dielectric permittivity and thus can be used to investigate the 3-D structure of the subsurface. We have followed up previous SHARAD studies of Elysium Planitia by [10] by conducting a focused SHARAD investigation of the eastern portion of the region between 0.5 - 12°N and 173 - 184°E (see Fig. 1)

SHARAD Radar: SHARAD is currently in operation onboard the *Mars Reconnaissance Orbiter*. The radar operates at 20 MHz center frequency (15m wavelength) with a 10 MHz bandwidth, and has a free-space vertical resolution of 15 m, equivalent to a 5 – 10 m vertical resolution for common silicic geological materials [11]. At this wavelength SHARAD is capable of probing hundreds of meters into the subsurface. With synthetic aperture focusing and dependent on the surface roughness, SHARAD has an along track spatial resolution of 0.75 – 1 km. Such spatial resolution and penetration ability are optimal for studying Elysium Planitia lava flows, which extend over hundreds of km and are estimated to be < 200 m thick within the study region [2].

Preliminary Results: Extensive subsurface reflectors are present beneath most smooth regions of the study area (corresponding to ACy and ACo in Fig. 1). Around 5% of the orbits surveyed to date contained a second, deeper subsurface reflector. Due to the extreme low relief of the region, the radargrams only contain minor off nadir clutter (Fig. 2a). Comparisons of the processed data with clutter simulations clearly demonstrate this (Fig. 2) and show that the reflectors at greater time delay than the surface are actual subsurface interfaces. Within multiple radar tracks centered at ~3.5°N there is an apparent break in the first subsurface reflector, where the northern reflector begins to dip downwards away from the horizontal and the southern reflector converges towards the surface (Fig. 2). This may be due to a thrust fault within a single geologic unit, or to a contact between volcanic/sedimentary units of different age. There is no associated surface expression either in the radargram or corresponding image datasets. This implies that a fault, if present, occurred prior to the emplacement of the uppermost layer.

The next stage of our research is to measure the time delay of the subsurface reflectors present within all radar tracks within the study area. This dataset will then be interpolated to generate a map of the spatial distribution of subsurface reflectors that can be compared with the geological maps to develop a more complete local stratigraphy. We also wish to understand the possible differences in origin (e.g., regolith or ground-ice layering between sequential lava flows versus a lava/sediment contact) of shallow subsurface dielectric interfaces detected in Amazonis [12] and Elysium Planitiae.

References: [1] Plescia, J. (2003) Icarus, 164, 79. [2] Vaucher J. et al (2009) Icarus, 204, 418. [3] Burr D et al (2002) Icarus, 159, 53. [4] Page D. P. and Murray J. P. (2006) Icarus 183, 46. [5] Murray J. P. et al (2005) Nature 434, 352. [6] Scott D. and Tanaka K (1986) map I-1802a, USGS. [7] Tanaka K et al (1992) Map I-2147, 1:5,000,000-scale, USGS. [8] Tanaka K et al (2005) Map 2888, USGS. [9] Werner S et al (2003) JGR 108, doi:10.1029/2002JE002020. [10] Safaeinili A. et al (2007) 7th int. Conf. Mars, 3206. [11] Seu R et al (2004) Planet Space Sci. 52, 157. [12] Campbell B. A. et al (2007) JGR, 113, doi: 10.1029/2008JE003177.

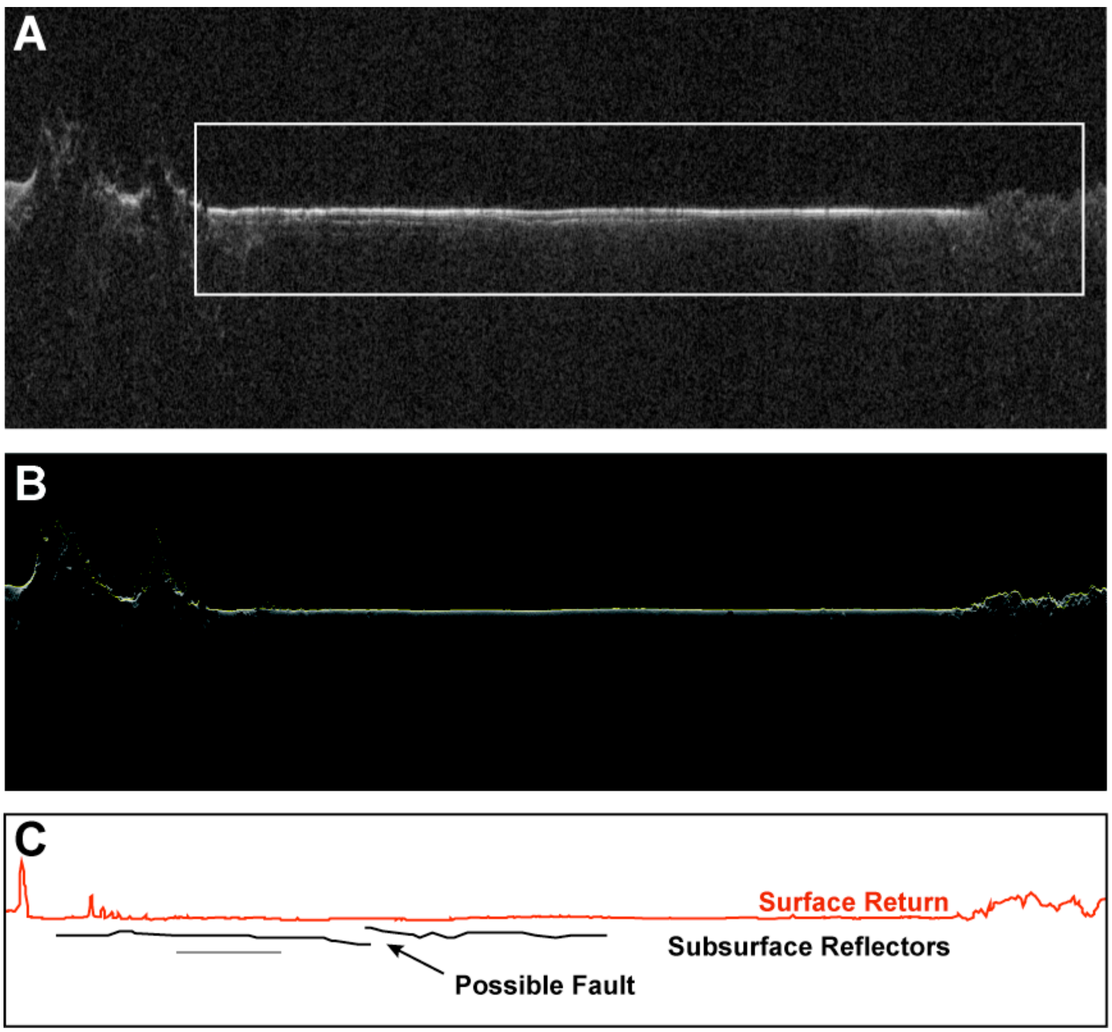

Fig 2. Examples of Subsurface reflectors in Elysium Planitia. Portion of focused radargram 376102000 centered at: 3.5° N, 175°E. B) Corresponding University of Texas clutter simulation. The reflectors below the surface in A are not present in the clutter simulation, demonstrating that these are real subsurface features. C) Sketch of the subsurface reflectors bounded by the white box in A. Note location of possible fault, this feature is also seen in multiple tracks to the east and west. North is to the left.