MAPPING THE THREE DIMENSIONAL STRATIGRAPHY OF THE AMAZONIAN GEOLOGICAL RECORD OF MARS AS PRESERVED IN ELYSIUM PLANITIA. G. A. Morgan[1] B. A. Campbell[1], L. M. Carter[2], J. J. Plaut[3], [1]Center for Earth and Planetary Studies, Smithsonian Institution, MRC 315, PO Box 37012, Washington, DC 20013-7012, morganga@si.edu, [2]NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA, [3]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109.

Introduction: Here we outline our strategy to map and characterize the subsurface units preserved within Elysium Planitia using the SHARAD radar sounder. This will follow up work already completed for the eastern portion of Elysium.

Situated between 10°S and 12°N and extending from 130 to 180°E, Elysium Planitia (see Fig. 1) is the youngest volcanic plain on Mars [e.g. 1-3]. Crater counts on volcanic units argue for multiple phases of activity over the last > 0.5 Gyrs, with the most recent volcanic features dated to ~2 Ma [4]. The region also contains some of the youngest outflow channels on the planet. These have been partially buried by recent lava flows, obscuring the channel morphological details. Multiple channel systems including the >1000 km long Marte Vallis are present across the region and are interpreted to have been carved by the release of deep ground water (several km deep, see, 3,5), possibly resulting in the development of paleolakes [6]. In contrast to extensive volcanism, some authors [7,8] suggest that areas of Elysium Planitia represent the surface of a frozen sea capped with pack-ice. Aeolian landforms (such as extensive yardang fields) are also present throughout the region and the southern edge of Elysium Planitia borders the wind eroded Medusae Fossae Formation.

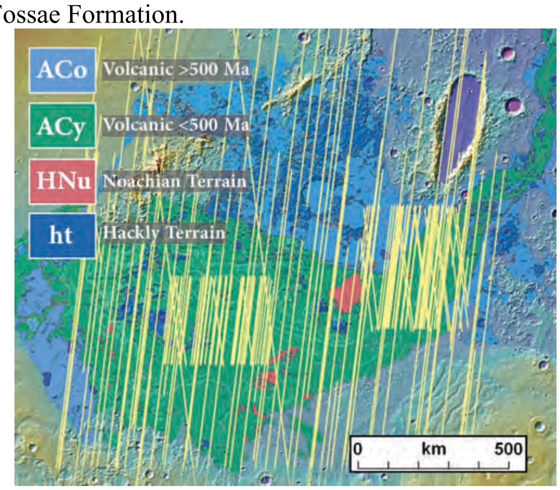

Fig. 1 Elysium Planitia. Yellow lines represent SHARAD tracks that will be used to map the subsurface. Geologic units correspond to mapping by Vaucher et al (2009). The mapping highlights the extensive volcanic units that cover the surface.

The oldest surfaces in the region consist of remnant Noachian terrain that forms isolated hills and knobs embayed by younger volcanic units [4]. Elysium Planitia has acted as a natural repository for volcanic, aeolian, fluvial and possibly lacustrine materials that have been deposited on the original Noachian terrain and have been capped by the latest lava flows. Thus, Elysium Planitia has recorded a complex array of geological activity spanning the length of the Amazonian. Understanding the different materials preserved and their relative stratigraphy is essential to our interpretation of recent martian geologic history, a period otherwise regarded as cold and dry [9].

Thus far, the majority of Mars datasets have restricted investigations to the volcanic geology preserved at the surface of Elysium Planitia. Here, with the use of SHARAD we are able to expand upon those studies and penetrate hundreds of meters into the subsurface to reconstruct the underlying structure. Sounding radar can also be used to infer the bulk compositional properties of geologic materials [see: 10-13]. We propose the first integration of Mars orbital remote sensing, Earth based radar and SHARAD datasets within a GIS environment to three dimensionally characterize and map the geological materials that comprise Elysium Planitia. The results of this work will be of consequence to a broad range of geological disciplines in addition to being critical in the assessment of Mars as an active planet.

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 [14]. 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 300 – 500 m. Such spatial and penetration resolution is optimal for mapping the multiple subsurface units underlying the thousands of km expanse of Elysium plains [15,16], which are estimated to be < 200 m thick [4]. In areas where DEMs can establish the thickness of geological units, time-delay values from sounding radar observations can be used to determine the dielectric permittivity of the material. This value can then be matched against laboratory studies of geological materials relevant to Mars. Measuring the loss tangent of dipping subsurface reflectors provides additional composition constraints [Campbell et al., 2008].

Elysium Planitia 3D Map: The mapping of eastern Elysium Planitia has already been completed. An example of one of the extensive reflectors identified in this study is shown in Fig. 2. This confirmed an earlier hypothesis [3, 5] that Cerberus Fossae is the source of Marte Vallis. The original eroded channels of Marte Vallis (now buried by ~ < 25 Ma aged lava [4]) were identified in the SHARAD data and found to begin abruptly adjacent to one another along an orientation that aligns with Cerberus Fossae to the west. This suggests that Cerberus Fossae extended ~ 200 km to the east prior to burial by the most recent phase of lava flows. Further down valley the Marte Vallis channels have cut through multiple subsurface reflectors. Assuming realistic values for the real dielectric permittivity of the material bounded by these horizons has enabled estimates of the minimum and maximum depths of the Marte Vallis channels to be made. This revealed that the outflow channel depths were tens of meters greater than previous estimates [4] but an order of magnitude lower than the Xanthe and Margaritifer Terra Hesperian outflow channels.

We are currently extending our mapping work to the west. Through this we will explore the extent of fluvial erosion across Elysium Planitia, the relationship between the different subsurface units and the volume of lava flows. Our work will generate a map of the spatial distribution of subsurface reflectors which will be integrated with all other available datasets including Earth based Arecibo radar data [17]. This will aid our interpretation of the SHARAD results and develop a more complete stratigraphy of the Amazonian material preserved within Elysium Planitia.

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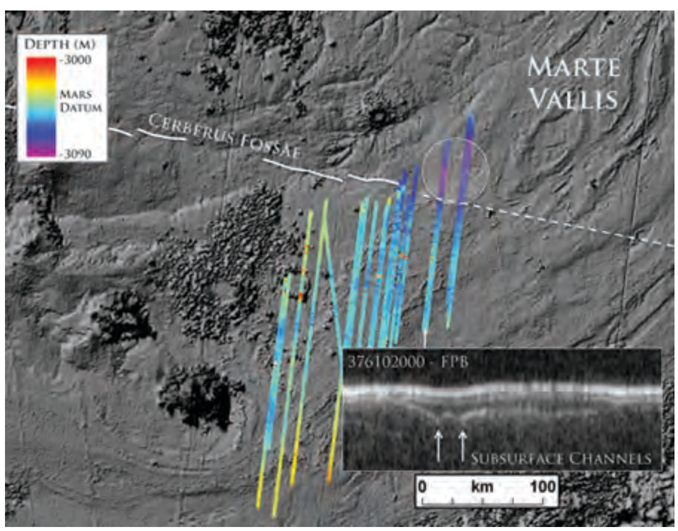

Fig 2. An example of a subsurface reflector mapped in multiple SHARAD tracks within Eastern Elysium. This reflector is interpreted to represent the base of a young lava flow. The elevation of the reflectors relative to the Mars datum has been estimated assuming a real permittivity of 8 (consistent with dense dry basalt) and subtracting the value from the MOLA gridded data. Subsurface channels are present north of the extrapolated position of Cerberus Fossae (dashed line) suggesting that Marte Vallis was sourced from the fracture system. Portion of focused radargram 376102000 centered at: 3.5° N, 175°E). Background is MOLA hillshade with 200 times vertical exaggeration to highlight the texture of the lava flows.