EVIDENCE FOR A WIDESPREAD OLIVINE-RICH LAYER ON MARS: IDENTIFICATION OF A GLOBAL IMPACT EJECTA DEPOSIT? C. S. Edwards[1] and P. R. Christensen[1], [1]Arizona State University, School of Earth and Space Exploration, Mars Space Flight Facility, PO BOX 876305, Tempe, AZ, 85287-6305, christopher.edwards@asu.edu.

Introduction:

Olivine-rich basalts have been mapped and characterized extensively on Mars, both globally [1-3] and locally [4-9] with a variety of proposed formation mechanisms. Additionally, at the Mars Exploration Rover Sprit landing site, Adirondack Class rocks have a consistently high (~15-20%) olivine abundance as compared to the less consolidated regolith and soil [10, 11]. McSween *et al.* [10] concluded that this class of rocks is representative of primitive mantle magmas that were erupted on the surface as picritic basalts. Edwards *et al*. [6] have proposed a similar mechanism for the emplacement of a laterally extensive but relatively thin layer of olivine-rich basalts (>15% areal abundance) near the bottom of Ganges and Eos Chasmas.

This unit was identified using Thermal Emission Imaging System (THEMIS) multispectral data and further characterized using THEMIS thermal inertia [12] and was found to be primarily associated with the rockiest material in the region indicating that it is not unconsolidated mobile sediment but rather an in-place rocky unit. Additionally, Thermal Emission Spectrometer (TES, [13]) data were also used to classify this unit as being composed of ~Fo_{68}, which is similar to other rocky olivine bearing units identified elsewhere on the planet [e.g. 4, 5, 8].

In this study, we continue the work that Edwards *et al.* [6] initiated by following and mapping the thin (~200m thick) olivine-rich layer originally identified in Ganges and Eos Chasmas in all directions where it is most likely to crop out. We map this unit to be at a minimum five times more laterally extensive than previously documented (Figure 1), possibly on a global or semi-global scale if identifications of material (those identified in this study and others [e.g. 5, 8, 11]) with similar characteristics (e.g. thickness, morphology, composition, rockiness) at similar elevations are accepted as related [6]. Even at five times larger, the formation mechanism originally proposed for this layer [6] must be called into question. It is unlikely that a series of lava flows could be responsible for the thin, laterally extensive layer of olivine-rich material (identified in this study) that occurred early in the planetary evolution of Mars.

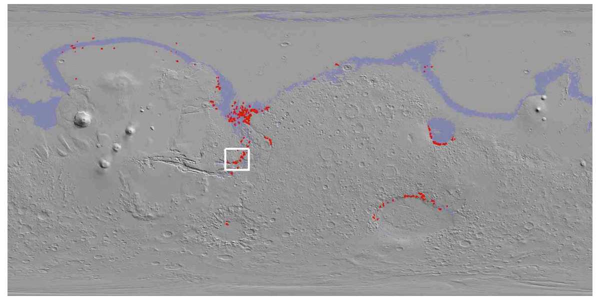

Figure 1. Map of preliminary locations (red) that fall within the -3900m to -3600m elevation range (blue). The white box is the previous study region of Edwards *et al.* [6].

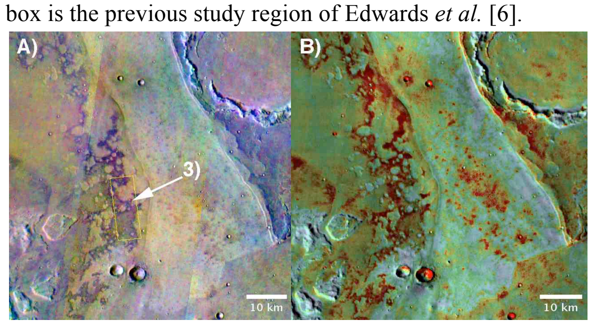

Figure 2. Example outcrop location centered at ~327.5E, 23.73N. A) THEMIS decorrelation stretch of bands 8, 7, and 5 where olivine is identified as purple tones. B) THEMIS colorized nighttime temperature over daytime temperature mosaic, where red tones correspond to high thermal inertias (~820 $Jm^{-2}K^{-1}s^{-1/2}$) and blue tones correspond to low thermal inertias (~200 $Jm^{-2}K^{-1}s^{-1/2}$).

Methods:

Similar methods to those used by Edwards *et al.* [6] were employed to identify and characterize the outcrops, utilizing THEMIS multispectral (Figure 2A), THEMIS thermal inertia (Figure 2B), and Compact Reconnaissance Imaging Spectrometer for Mars (CRISM, [14]) data where available. A TES spectral index following Koeppen and Hamilton [3] was also used to highlight the composition of olivine (Fo_{58-74}) where the outcrop was large enough and high quality TES data were available. Additionally, High Resolution Imaging Science Experiment (HiRISE, [15], Figure 3) data were used to characterize the fine-scale morphology of the outcrops.

In order to limit the search region, we chose locations that fit with the previously determined elevation range (Figure 1, [6]) and conducted an exhaustive search following the layer as far as possible from the Ganges and Eos Chasmas location. In addition to having an olivine signature in one of the compositional datasets, the location was also required to have a relatively elevated thermal inertia to be mapped as a positive identification. Additionally, we have attempted to

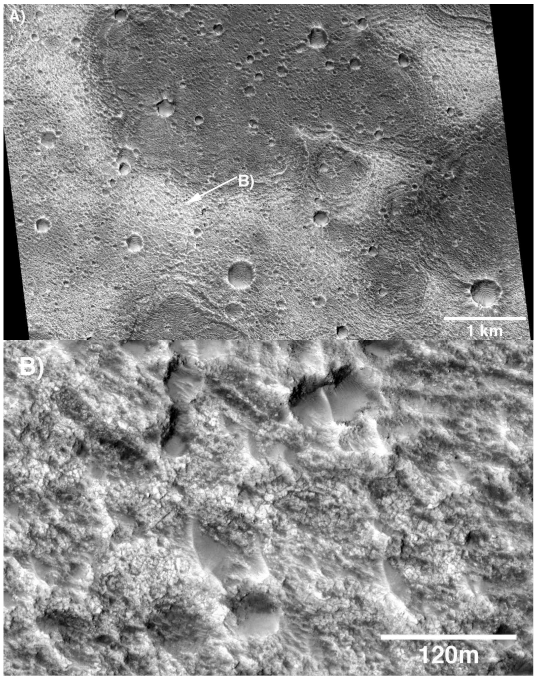

Figure 3. HiRISE image (PSP_009788_2040) of the olivine-rich and poor units. A) The lightest toned units in this image correspond to the olivine bearing materials, where darker tones correspond to olivine-poor materials. B) Full resolution section of figure 3A, where a pitted, blocky, and fractured texture is exhibited and is common to many olivine-rich outcrops.

identify other olivine bearing layers at various elevations throughout the Valles Marineris canyon system and have not positively identified any other occurrences in the stratigraphic section.

Discussion:

Relatively thin (typically <200m thick) outcrops of high olivine content (>15% areal abundance), intermediate olivine composition (~Fo_{58}-Fo_{74}), and elevated thermal inertia (typically >500 $Jm^{-2}K^{-1}s^{-1/2}$) are commonly present in the -3900 to -3600m elevation range on Mars and provide a compelling argument to interpret a link between the various outcrop locations. While Koeppen and Hamilton [3] proposed that a global or semi-global layer may exist, we present the first compelling evidence for such a layer in this study. The identification of a large-scale olivine-rich layer has significant implications for the evolution of Mars regardless of its associated formation mechanism.

The stratigraphic location of this global or semi-global layer (e.g. near the bottom of Valles Marineris) necessitates that its formation occurred early in martian history. The identification of similar material in the walls of Hellas Basin further strengthens this argument and provides a link across thousands of kilometers. While the nature of the material in the Hellas Basin walls is not well constrained and any materials present pre-impact have undergone a complicated geologic history (e.g. fracturing, uplift, weathering, alteration, etc.), the possibility that these materials pre-date the Hellas impact event is significant and may be consistent with some of the oldest exposed material on the planet.

We propose that this laterally extensive layer is the result of a mega-impact event that occurred early in Mars history, prior to the intense cratering of the southern highlands. The composition of this material is consistent with the crystallization of a melt derived from the martian mantle [16]. If a sufficiently large bolide impacted the planet, such as one that is hypothesized to have created the northern lowlands [e.g. 17, 18], it is likely that the mantle would be entrained as ejecta [19, 20]. Alternatively, if the event were large enough, it could create a magma ocean, erasing all record of the impact basin [19, 21]. In either case, with large fractions of the planet melting [19, 21] or the dispersal of mantle material [20], the result is likely to be geologically distinct material similar to that identified in this study.

Irrespective of the possibility that this is a global layer, we propose that the most likely scenario for the formation of this layer with the aforementioned characteristics and extent is related to a mega-impact event. The implications of this layer are far-reaching and could help place constraints on planetary evolution, early Mars topography, and large basin forming events.

References:

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