INVESTIGATING THE ORIGIN OF CIRCUM-CHRYSE (MARS) OLIVINE EXPOSURES THROUGH LOCALIZED GEOLOGIC AND STRATIGRAPHIC ANALYSES. M. R. Salvatore[1], M. D. Kraft[1], C. S. Edwards[2], and P. R. Christensen[1], [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, msalvatore@asu.edu; [2]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA.

Introduction: The formation of the martian outflow channels was likely dominated by massive outpourings of water from the subsurface, resulting in the formation of chaos terrain and channelized overland flow [1]. However, recent compositional studies have identified in-place mafic units within the circum-Chryse outflow channels [2,3] and chaos terrains [4,5], sparking discussion as to the geologic history of this material and its role in the formation and/or modification of these landscapes. Similar units were recently studied throughout the Uzboi-Ladon-Morava fluvial network [6] and validate this association further upstream. It is important to understand how these mafic exposures and fluvial systems are dependent on each other, which requires a clear understanding of the stratigraphy of these olivine-bearing units as well as their mode of emplacement. In this study, we investigate the morphological and compositional similarities between these mafic materials, discuss their possible origin, and identify a location in eastern Ares Vallis where the stratigraphy and context of one such exposure can be further elucidated.

Occurrences: Mafic exposures, consisting of elevated olivine concentrations relative to their surroundings, have been widely identified throughout the circum-Chryse region [2-6] (Fig. 1). These materials exhibit high albedos, high thermal inertias, and fractured and/or blocky surface morphologies that are most consistent with fractured in-place bedrock (Fig. 2) [2-6]. While these units appear to predate the most recent chaos and outflow channel activity [2,5], it is unclear whether these units predate, postdate, or co-evolved with the initial formation of these landscapes, as their stratigraphic relationships are largely obscured.

Possible Origins: Possible origins for these mafic bedrock units include one large (or numerous localized) volcanic unit(s), or one large (or numerous localized) impact melt sheet(s). Many olivine-bearing volcanic units have been previously identified across Mars and are largely associated with volcanic edifices [7], fractures associated with large impact basins [8], and other localized geologic settings. These volcanic units are typically small in spatial extent, and the possibility of a large, regionally extensive volcanic unit of consistent morphology and composition has not yet been definitively identified on Mars.

An extensive impact melt sheet has also been proposed to explain the occurrence of many olivine-bearing exposures identified throughout this region [9]. If one or more melt sheets are the source of this material, the olivine-enriched compositions would likely be derived from the mafic lower crust or upper mantle, as was suggested for the Isidis impact structure and the olivine-rich deposits in Nili Fossae [10].

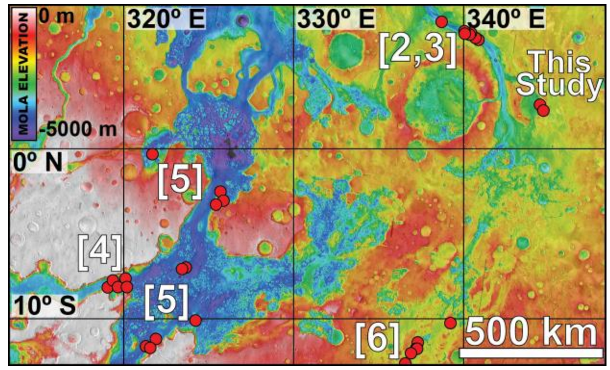

Figure 1. Olivine occurrences (red dots) in the chaotic terrain and outflow channels south of Chryse Planitia.

Eastern Ares Vallis: A newly identified olivine-rich exposure was identified along the eastern branch of Ares Vallis (Fig. 3). This unit is located in a host crater whose geologic history was previously investigated by [11]. We utilize the unique morphology and stratigraphic relationships present in this crater to investigate the possible modes of emplacement and timing of formation of this mafic unit. The crater floor exhibits patterns of irregular, flat-floored depressions connected by small channels within the crater, which was then bisected by the eastern branch of Ares Vallis [11]. The unique surface textures associated with this crater, informally referred to as "crater Y," were interpreted as alas-lake morphologies that are common in terrestrial thermokarst terrains [11]. The eastern half of crater Y is free of

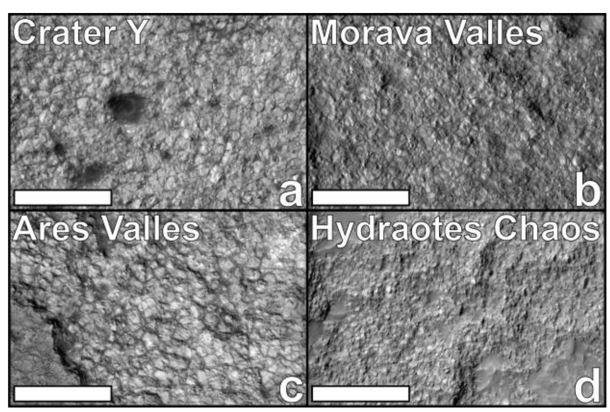

Figure 2. Morphology of regional olivine-bearing terrain. All scale bars are 100 m. (a) HiRISE ESP_016974_1825. (b) HiRISE ESP_011634_1645. (c) HiRISE ESP_022209_1870. (d) HiRISE PSP_008628_1800.

optically thick dust and exhibits strong spectral signatures related to olivine in both thermal- and near-infrared datasets, as well as evidence for hydrated phases beneath this olivine-rich unit.

Olivine-rich materials appear purple in decorrelation stretch (DCS) images of Thermal Emission Imaging System (THEMIS) bands 8, 7, and 5 (Fig. 3). However, these spectral signatures are inconsistent with pure olivine, and are most consistent with basaltic compositions that are enriched in olivine relative to other nearby units (Fig. 4). This olivine-rich unit is observed on both the flat-lying plateau surfaces as well as in flat-floored depressions, with spectrally and morphologically unique materials underlying this unit (green and orange material in Fig. 3). THEMIS and High Resolution Imaging Science Experiment (HiRISE) imagery indicate that this unit is only a few tens of meters thick, although its current thickness may be the result of substantial physical erosion and not indicative of its original thickness.

The identified spectral and morphological relationships suggest that the olivine-rich unit predates the formation of the thermokarst-like topographic features described in [11], and was likely emplaced on a flat, previously infilled crater surface. The original infilling of crater Y, based on current spectral and morphological data, appears to be sedimentary in nature, and may be derived from the early activity of Ares Vallis that was diverted to the east of crater Y. Several breaches in the eastern wall of crater Y support this hypothesis. The olivine-rich unit and thermokarst-like landscape were then bisected by the eastern branch of Ares Vallis, indicating that at least the most recent activity of Ares Vallis postdate the emplacement of the olivine-bearing unit and the formation of the thermokarst-like landforms.

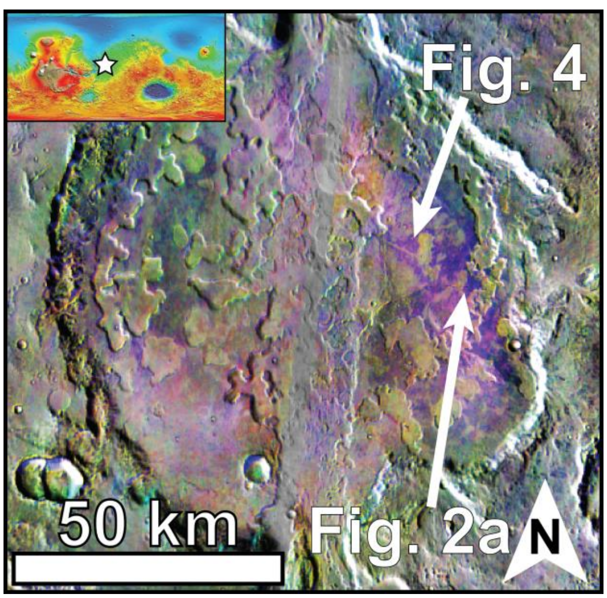

Figure 3. THEMIS DCS of bands 8, 7, and 5, of crater Y (centered at 2.5º N, 344.1º E). Olivine-rich materials appear purple. Olivine is observed on both plateau surfaces and on the floors of shallow depressions. Locations of the HiRISE image in Fig. 2a and the spectra shown in Fig. 4 are noted.

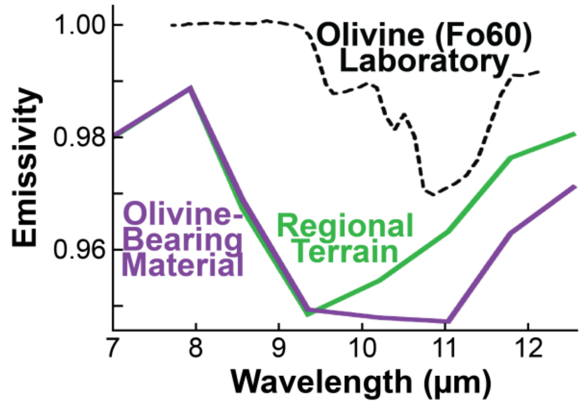

Figure 4. THEMIS-derived spectra of olivine-bearing material (purple) as compared to regional terrain (green) in crater Y. Colors roughly correspond to those in Fig. 3. A laboratory spectrum of pure olivine is provided for comparison.

Future Work: Several outstanding questions require additional investigation to further relate the olivine-rich exposures in crater Y to others in the circum-Chryse region. Are hydrated spectral signatures observed in association with other olivine-rich exposures? Is there any observed spectral variability between olivine-rich exposures? Is this olivine-rich unit confined to the interior of crater Y, or is there evidence of this unit outside the crater rim? Constraining the spatial distribution (horizontal and vertical) and spectral variability between units is vital towards determining the origin and subsequent geologic history of these exposures, and crater Y may be an essential element of this story.

Conclusions: The distribution and potential origin of the olivine-enriched exposures identified throughout the circum-Chryse chaos terrain and outflow channels is discussed. We identify a morphologically and spectrally similar exposure in crater Y, which predates the most recent catastrophic fluvial activity associated with the eastern branch of Ares Vallis. These new observations and stratigraphic relationships allow us to further constrain the chronology and origin of this unit with respect to other martian geologic processes. Additionally, the coevolution of these units with the fluvial landforms throughout the region is currently under investigation.

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