MINERALOGY OF MARTIAN CRATERS WITH ALLUVIAL FANS VERSUS THOSE WITHOUT: INSIGHTS INTO THE CONTROLS ON MARTIAN ALLUVIAL FAN DISTRIBUTION.

E. T. Putnam[1] and M. C. Palucis[1], [1]Dartmouth College Dept. of Earth Sciences (Dept. of Earth Sciences, HB 6105, Dartmouth College, Hanover, NH, Ethan.T.Putnam.GR@dartmouth.edu)

Introduction: Valley networks, fans, and deltaic features have been interpreted as evidence for the past stability of large volumes of liquid water on the surface of Mars [e.g. 1,2,3]. However, fluvial activity appears to have not happened uniformly in time or space. Early studies suggested that much of Mars' valleys formed in the Noachian, coincident with the formation of widespread clays [4,5,6]. However, there also appears to have been a pulse in fluvial activity in the Hesperian [7,8] and potentially into the Late Hesperian to early Amazonian [9], when the mineralogical record would suggest little hydrous surface alteration [6]. Spatially, many similarly aged craters on the same terrains that would presumably have experienced similar climate conditions either contain or lack fans, suggesting that non-climate controls on fan formation and fluvial dissection may be necessary to explain fan distribution.

Orbital spectral observations have been used to study the mineralogy of the Martian surface in detail, revealing widespread and extensive evidence of alteration through interaction with liquid surface water [10]. As such, weathering extent of the crater rim may be a key control on fan formation by affecting sediment supply. Alternatively, if the fans took long periods of time to form, they might be expected to be associated with more abundant secondary minerals and less abundant easily-eroded primary minerals.

Methodology: To begin to test these hypotheses, we use spectroscopic data from the Mars Global Surveyor Thermal Emission Spectrometer (TES) and Mars Reconnaissance Orbiter Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) to broadly assess the mineralogy of a set of similarly aged craters, some of which have fans and some of which do not. Craters were chosen from three regions previously shown to host an abundance of alluvial fans in the Martian Southern Highlands (Figure 1) [8]: Margaritifer Terra, Terra Sabea, and Tyrrhena Terra. These regions are in a fairly restricted latitude band (15 to 30 ˚S) and are distributed broadly longitudinally.

TES mineral abundances (areal fraction) other than olivine are derived from the publicly available global results of [11]. TES olivine abundance comes from [12]. The TES thermal IR data were produced in [11] by applying a linear deconvolution model onto the spectra, yielding fractional abundances of minerals and through parameterization of spectral features in [12]. The strength of CRISM visual and near infrared (VNIR) spectral features and parameters vary non-linearly with mineral abundance, complicating the determination of mineral fractional abundances. With this caveat in mind, we generally use the strength of these parameters in concert with other relevant parameters and detection verification by hand for some, but do not directly estimate mineral areal fractions. All pixel data were downloaded from the ASU Java Mission-planning and Analysis for Remote Sensing (JMARS) GIS program at 4 pixels per degree (ppd) resolution.

A Python script then read both the list of chosen craters (defined using the lat/long of the crater center and its radius) and input pixels from JMARS and assigned pixels to each crater by determining if the pixel center was within the radius of the crater center. Parameter averages (e.g., TES High Si/Sheet Silicates, TES sulfate, TES thermal inertia, TES olivine, TES high and low Ca pyroxenes, TES dust cover, CRISM Multispectral Product (MSP) OLINDEX, BD1900, BD2100, BD2210, D2300, SINDEX) for each crater (both the entire crater and just its rim) were output for analysis, namely comparing craters with and without fans and between craters in different regions. We compared populations using Student's t tests with a threshold for significance of 0.005.

Results: Initial results from these analyses for TES high Si/sheet silicates are shown in Figure 2. In general, there were no statistically significant differences between crater mineralogy or thermal inertia in fan-hosting versus non-fan-hosting craters in our study region.

No comparison between regions had statistically significant differences in TES dust cover value, though the p value for the Margaritifer Terra-Tyrrhena Terra comparison was only 0.053 and the difference between averages was minor. Furthermore, though Tyrrhena Terra has the lowest dust cover value, it does not uniformly have the strongest spectral features in other parameters, as would be expected if the strength of spectral variations between regions was purely a product of different dust coverage. Together, these suggest that differences in dust cover cannot explain the observed differences in mineralogy. Variations in thermal inertia were statistically significant, though relatively minor (averages 242, 256, and 286 tiu), likely indicating that this difference probably does not reflect very physically different materials.

TES data processed by [11] is reported to have a detection limit of 0.1. With this standard, only two craters have average values for sheet silicates or sulfates above the detection limit, though 28 have individual pixels above 0.1, with the average fraction of pixels with detected high Si phases being 0.15. The TES olivine data used from [19] has a lower detection limit of ~5% fractional abundance. Numerous crater averages and pixels lie above the TES olivine and high and low Ca Pyroxene detection limits.

We found that there is no significant correlations between the TES olivine abundance and TES High Si phase abundance, suggesting that perhaps greater olivine abundance does not lead to greater amounts of altered minerals, or that the conversion of olivine in altered phases is complete enough to erase any correlation, though the generally lower values for sheet silicates versus igneous phases challenge this interpretation.

Discussion and Continuing Work: Initial results suggest that mineralogy is neither a control on nor product of fan formation in craters in the Martian southern highlands. If fan features formed through long-term interaction with liquid water, more alteration might be expected, suggesting qualitatively that alluvial fan formation took place over a relatively short timescale.

These results also suggest that crater mineralogy is controlled by broad scale regional factors more than by small scale factors. These broad scale controls could be climatic or due to compositional differences of the original crust.

Current work is focused on extending the number of craters used in this analysis, as well as using crater counting data to assess the relationships between crater age, mineralogy, and fan presence. Additionally, we can apply this methodology to study of the paleolake database from [3].

References: [1] Hynek, Brian M., Michael Beach, and Monica RT Hoke. JGR: Planets 115.E9 (2010). [2] Wray, J. J., et al. JGR: Planets 116.E1 (2011). [3] Goudge, Timothy A., et al. Icarus 219.1 (2012). [4] Carr, M.H., Clow, G.D. Icarus 48 (1981). [5] Sharp, R.P., Malin, M.C.. Channels on mars. Geol. Soc. Am. Bull. 86 (1975). [6] Bibring, J.-P., Langevin, Y., Mustard, J.F., Poulet, F., Arvidson, R., Gendrin, A., Gondet, B., Mangold, N., Pinet, P., Forget, F., others. Science 312 (2006). [7] Irwin, R.P., Howard, A.D., Craddock, R.A., Moore, J.M. JGR: Planets 110 (2005). [8] Howard, A.D., Moore, J.M., Irwin, R.P., 2005. JGR: Planets 110. [9] Grant, J.A., Wilson, S.A., Mangold, N., Calef, F., Grotzinger, J.P., 2014. GRL 41, 1142–1149. [10] Ehlmann, Bethany L., and Christopher S. Edwards. Ann. Rev. of Earth and Planetary Sciences 42 (2014). [11] Bandfield, Joshua L. JGR: Planets 107.E6 (2002). [12] Koeppen, William C., and Victoria E. Hamilton. *JGR: Planets* 113.E5 (2008).

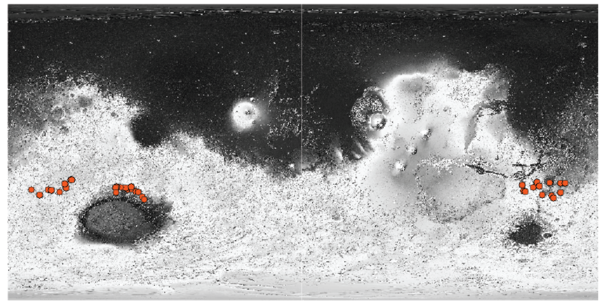

Figure 1: Distribution of craters studied (red dots), overlain on a MOLA elevation map.

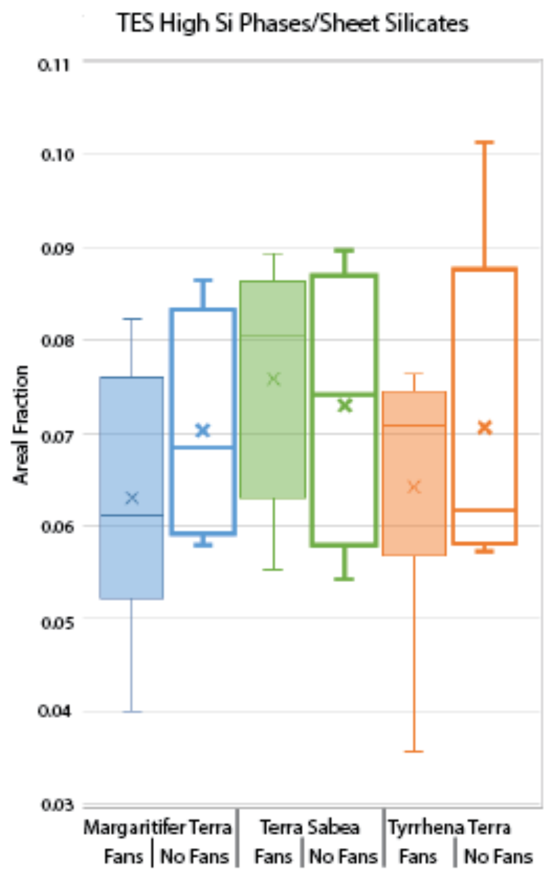

Figure 2: Comparison of TES High Si Phases/Sheet Silicates between craters (rim and crater floor) with fans and those without for the three study regions. Boxes represent first and third interquartile range and whiskers indicate maximum and minimum values. The horizontal lines and Xs represent the median and mean, respectively.