CORRELATIONS BETWEEN OLIVINE ABUNDANCE AND THERMAL INERTIA: IMPLICATIONS FOR GLOBAL WEATHERING AND/OR ALTERATION ON MARS. V. E. Hamilton[1], M. L. McDowell[2], W. C. Koeppen[2], [1]Southwest Research Institute, 1050 Walnut St., Suite 300, Boulder, CO 80302, hamilton@boulder.swri.edu, [2]Hawai'i Inst. of Geophysics and Planetology, Univ. of Hawai'i, Honolulu, HI 96822.

Objective and Implication: The objective of this study is to determine whether materials on Mars exhibiting high olivine abundances are preferentially associated with rocky/outcrop units. Such an association may suggest that olivine has been preferentially weathered out of mafic sediments, including those previously assumed to represent primary basalts.

Introduction & Background: Surfaces on Mars having bulk mineralogies (determined from orbital spectroscopy) dominated by plagioclase and pyroxene+olivine have been characterized as basaltic and assumed to be relatively unaltered [e.g., 1-4]. The surface materials in several generally basaltic regions have been identified as containing relative enrichments of olivine [5-6]. Although these olivine-enriched areas have been cited as evidence that there has not been extensive aqueous alteration on the Martian surface [e.g., 7], chemical models/trends may indicate that virtually all surface materials observed via orbital spectroscopy have undergone some small amount of alteration/weathering [8].

Several of the best studied regions of olivine-enrichment occur in association with relatively high thermal inertia (rocky) units. These include materials near the Nili Fossae, Isidis Planitia, Ares Valles, Ganges and Eos Chasmata, Aurorae Planum, and Hellas and Argyre Planitiae [6, 9-13]. Examination of the mineralogies of materials in Argyre Planitia using orbital spectroscopy has shown that in that location, olivine-enriched outcrops are surrounded by relatively olivine-poor sediments [14], and this relationship was interpreted as suggesting that olivine is preferentially eroded out of rocky materials as they are converted to soil. Soils on the plains of Gusev crater are observed to be olivine-poor relative to the olivine-bearing Adirondack-class basaltic rocks that appear to dominate rock compositions on the plains [15-16]. [14] hypothesize that relations like these may be globally prevalent, which would suggest that Martian dark regions may once have contained greater abundances of olivine than they do today and thus do not represent primary igneous compositions.

Data and Methods: For the first phase of this study we use orbital data acquired by the Mars Global Surveyor Thermal Emission Spectrometer (TES). Normalized olivine abundances (total fraction of surface materials) are taken from the analysis of TES spectra by [17] and represent dust-free to slightly dusty surfaces (A = <0.20). We use daytime and nighttime bolometric thermal inertia values from the TES database [18]. Daytime inertias are derived from the bolometer pixels corresponding to the spectrometer pixels used to determine olivine abundance (OCKs 1583 - 8000), whereas nighttime inertias are derived from OCKs 1637 - 28213 (over 21,000,000 individual observations) and the mean values are binned at 8 ppd. Nighttime inertia data meet "medium to best" quality constraints, and the daytime data were selected to meet the "best" quality constraint (~956,000 observations, about half the number of observations for which olivine abundances were calculated).

Preliminary Results - TES olivine abundance vs. nighttime thermal inertia: Mean olivine abundance is plotted against mean nighttime thermal inertia in **Fig. 1**. The data are binned for comparison, because they were not acquired simultaneously. There is no positive correlation between these two parameters. A sparse tail of points trends toward high inertias at <10% mean olivine abundance.

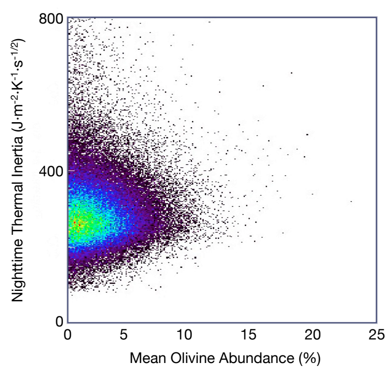

Figure 1. Intensity scatter plot of TES nighttime thermal inertia vs. mean olivine abundance.

Preliminary Results - TES olivine abundance vs. daytime thermal inertia: Olivine abundance is plotted against daytime thermal inertia in **Fig. 2**. (Olivine abundance shows a greater range than in **Fig. 1** because these are actual, not mean, values.) Despite thermal inertia being derived from a measurement obtained at the same time and location as the spectrum from which the olivine abundance was derived, there is no correlation between the two parameters. Overall, the scatterplot is very similar to that in **Fig. 1**. As observed for abundance vs. nighttime thermal inertia, there is a sparse tail of data points that displays higher inertias at lower (<25%) abundances. There is another sparse tail of data points with thermal inertias <400 $J \cdot m^{-2} \cdot K^{-1} \cdot s^{-1/2}$ extending to ~100% olivine abundance.

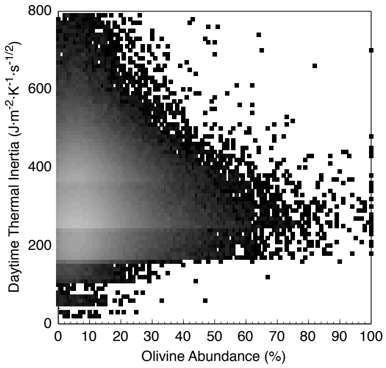

Figure 2. Intensity scatter plot of TES daytime thermal inertia vs. mean olivine abundance for locations with olivine % >0.

Discussion: The apparent lack of a positive correlation between thermal inertia and olivine abundance indicates that there is not a straightforward global relationship between olivine abundance and the mechanical and/or chemical weathering of bedrock outcrops that contributes to regolith formation on Mars.

We considered non-geological reasons for why the data may appear the way they do. Binning the data in **Fig. 1** at 8 ppd and using mean values for inertia and abundance may blur or dilute the relationship between thermal inertia and olivine abundance. However, if this were the case, plotting daytime thermal inertia against the olivine abundance derived from the same spot at the same time (**Fig. 2**) should have revealed a trend. Although the values of both inertia and abundance have uncertainties, these uncertainties are small relative to the range of values exhibited by the data and should not affect the comparison to the point of obscuring a real trend. The number of data points, as well as the fact that both data sets have been previously shown to exhibit correlations with other parameters, such as geography, elevation, latitude, and albedo [e.g., 17-18], also make this explanation unlikely.

There are inherent assumptions in these inertia/abundance comparisons. If we expect to see a positive correlation, we must assume that *all* surface materials would have to have been enriched in olivine in the past when they were presumably more physically massive. Furthermore, we also have to assume that *all* high inertia materials must have relatively high olivine abundances (i.e., there cannot be high inertia materials with low olivine abundances). And we have to assume no other geologic processes (e.g., mixing, embayment, etc.) are acting on the materials we are sampling. These likely are unrealistic assumptions. Prior studies have identified several bulk surface mineralogies that are correlated with large-scale morphology, geography, elevation, and/or relative age, suggesting they had differing primary igneous compositions [19]. Therefore, it is likely that not all Martian igneous lithologies had the same amount of olivine, or necessarily abundant olivine when emplaced. It is also reasonable to expect that lithologies with low primary olivine abundances can be present as rocky materials or outcrops, accounting for the points in **Figs. 1 & 2** with inertias >400 $J \cdot m^{-2} \cdot K^{-1} \cdot s^{-1/2}$ and minor to modest olivine abundances. Local- to regional scale studies also have shown that relatively high inertia materials are not necessarily enriched in olivine [e.g., 20].

Summary: TES data show no global trend between thermal inertia and olivine abundance. Based on these observations, it is premature to conclude that all surface lithologies were once significantly more mafic than they are today. However, the comparison shown here is not sufficient to conclude whether or not olivine is preferentially removed from the majority of olivine-bearing (-enriched) outcrops as they are broken down into finer materials. Studies like that of [14] are required in more locations, in part to determine if there is spectral evidence for high inertia materials with *low* olivine abundances also undergoing chemical weathering as they are converted into lower inertia sediments.

Ongoing Work: We are conducting site-specific studies using TES data and multispectral and temperature images from the 2001 Mars Odyssey Thermal Emission Imaging System (THEMIS). Local site studies will allow for a detailed look at the relationships between olivine abundance and thermophysical properties in regions dominated by olivine-enriched materials, removing the potentially confounding influence of olivine-poor lithologies.

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