COMPOSITIONALLY DISTINCT EJECTA BLANKETS IN SYRTIS MAJOR: IMPLICATIONS FOR ENVIRONMENTAL CHANGE.

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Introduction: The Syrtis Major region of Mars consists of Hesperian aged volcanic terrain [1] and has a low dust content that makes the region ideally suited for remote compositional analysis. Previous studies show that Syrtis Major is composed of pyroxene bearing basalts [2] with an enrichment in high calcium pyroxene (HCP) [3, Poulet et al, this meeting]. The TES instrument has observed regional spectral signatures compatible with a composition of 31% plagioclase, 29% HCP, 12% high silica phases, 7% olivine, plus a variety of accessory minerals [4]. Analysis of OMEGA data of 25 craters mostly larger than 6km in diameter has shown that some craters have ejecta highly enriched in HCP compared to the background surface (Type I) while others do not (Type II) [5]. Crater counts on the ejecta show that Type I craters are younger than 2Ga while Type II craters are older. It has been proposed that the crater ejecta composition of the Type I craters is due to a HCP enriched layer that peaks at 600 m depth [5].

We are interested in the timing of the transition from Type II to Type I ejecta, the reason for this difference in ejecta composition (e.g. atmospheric alteration or mixing with dust), and testing the hypothesis of compositional variation with depth. We used CRISM multispectral mapping strips [6] to measure nearly 400 craters as small as ~600 meters.

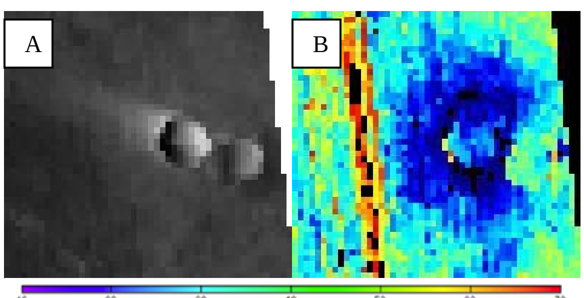

Figure 1. *A: CRISM mapping strip, B: MGM of strip showing LCP/(HCP+LCP) values. Blue is high HCP. Crater on left is typical Type I crater with HCP enriched ejecta. Crater on right is Type II with floor and ejecta blending in with the background values. Black pixels are invalid MGM results and the vertical red stripe is the result of an image artifact. Centered at 17.60N 70.77E. MSP000041C1_01*

Datasets and Methods: We use data is from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) instrument on the Mars Reconnaissance Orbiter (MRO). CRISM is a visible-infrared imaging spectrometer that is capable of high resolution targeted observations with 544 wavelengths and of imaging mapping strips using a selected 72 wavelengths ranging from 0.36-3.92µm. Using CRISM mapping strips with a resolution of 200 meters/pixel we get high resolution compositional information about the surface. We have analyzed 15 mapping strips over Syrtis Major ranging from 20ºN to 2ºS and 60ºE to 75ºE with a CRISM-specific adapted version of the Modified Gaussian Method (MGM) [3,7,8,10] to calculate an estimate of the relative abundance of high and low calcium pyroxene (LCP). Figure 1 shows a section of a mapping strip with the corresponding MGM result. For craters on these strips we have measured their diameter, noted the presence of HCP enriched ejecta, and recorded the diameter of enriched ejecta.

Results: We have identified 390 craters of which 249 show ejecta enriched in HCP, 120 show no enrichment and 21 are too ambiguous to classify and are not included in our crater count. Syrtis Major has a general MGM background of ~0.39 using a ratio of LCP/(LCP+HCP) [3] in OMEGA observations, with lower values indicating higher HCP content. Ejecta is considered enriched in HCP in CRISM images with values below ~0.20 and are typically near 0.05-0.15 for most enriched ejecta. The majority of unclassified craters are located in the enriched ejecta of nearby large craters where local enrichment becomes indiscernible.

Figure 2 shows cumulative crater distribution plots for all craters observed (blue points) and those with HCP enrichment (red points). The data for all craters is consistent with previous dating of Syrtis Major [1] while craters that show HCP enrichment correspond to the late Hesperian and confirms and will further refine the 2Ga [5] date suggested for the crater type division.

Considering only the craters with enriched ejecta we see a direct relationship between crater size and enriched ejecta radius, Figure 3. The diameter of HCP enriched ejecta increases with crater size, but not necessarily linearly. For a given crater size, a variety of enrichment diameters are observed.

The variation in enrichment size as a function of crater diameter is further shown in Figure 4. Here we plot the ratio of enriched ejecta radius to crater size as a function of crater radius. For a given radius we see a wide variation in enriched ejecta sizes.

Discussion: The observation of many small craters in Syrtis Major will produce a significant data set that will probe the subsurface at a variety of depths and allow for statistical dating methods. Figure 2 plots our initial attempt to relative date the transition from a Type II environment to a Type I environment, which is shown here as being near the Hesperian/Amazonian boundary. Additional crater observations will better constrain the date of this transition and may help link it to other large scale changes on Mars.

The measurements plotted in Figure 3 show the wide variation of enriched ejecta size for a single crater radius. This variation shows that there is not a simple relationship between these measurements. This variation may be a result of the cratering process, an effect of weathering, or erosion.

There are several explanations based on variations in the initial cratering process. The first is that the HCP enriched surface layer has a variable thickness depending on the location. Another is that the ejecta distances are controlled by local surface cohesion properties. For example, craters in pristine lava flows may produce different ejecta distances than a similar size crater in a preexisting ejecta blanket. Finally, the mixing of enriched ejecta with local soils may dampen the signal and cause the variation.

The variation may also be caused by a surface weathering process. It is unlikely that chemical weathering with atmospheric interaction is operating to reduce enrichment radii since the entire ejecta blanket will be altered at the upper surface simultaneously. Another possibility is that physical mixing of the HCP enriched ejecta with dust and sand from other locations. This mixing would have its greatest effect on the thinnest part of the ejecta, farthest from the crater and work its way in. Based on this model, the youngest craters would have the highest enrichment to crater size ratio and the oldest of the Type I craters would have the lowest ratios.

One of the main questions raised by this work is why there is a transition from Type II to Type I craters near 2Ga. If the shrinking HCP enriched ejecta scenario mentioned earlier is true, then the transition may just be the time when the enriched ejecta ratio diminishes to zero. Another possibility is that volcanic activity could have emplaced a HCP enriched layer at this time, though it would need to have occurred over the entire Syrtis Major complex. Finally the transition could be an alteration in atmospheric or environmental properties from one that could erase the HCP enrichment to one that preserves it.

References: [1] Hiesinger H. and Head J.W., (2004) JGR 109 E01004 [2] Mustard J. F. et al. (1997) *JGR*, 102, 25605-25616. [3] Kanner L. C. et al. (2007) Icarus., *187*, 442-456. [4] Rogers A.D. and Christensen P. R., (2007) JGR 112 E01003 [5] Baratoux D. (2007) JGR, 112, E08S05. [6] Murchie S. et al., (2007) JGR, 112, E05S03 [7] Sunshine J. M. et al. (1990) JGR, 95, 6955-6966. [8] Sunshine J. M. et al. (1993) JGR, 98, 9075-9087. [9] Hartmann W.K. (2005) Icarus 174 294-320 [10] Mustard J.F. (2007) 7th Mars Conf. 3230

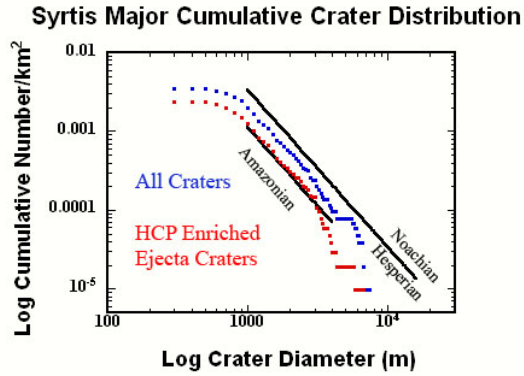

Figure 2. *Cumulative crater distribution plot. Plot shows number of craters larger than the given diameter. Mars geologic era boundaries based on work in Hartmann [9] Plot of craters cataloged in this study . HCP enriched ejecta craters show age of crater type transition.*

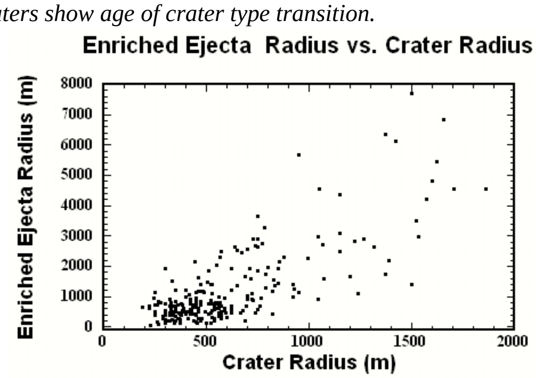

Figure 3. *Relationship between enriched ejecta radius and crater radius. Enriched ejecta radius measured from crater rim. Larger impacts create larger enrichment but with considerable variation.*

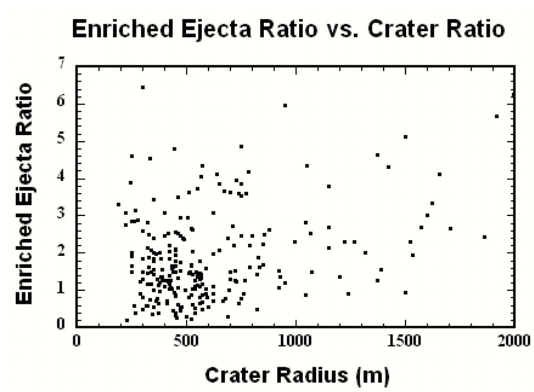

Figure 4. *Enriched ejecta ratio is the distance from the crater rim to the enriched ejecta edge divided by the crater radius. For a given crater size we see a wide variation in the enrichment ratio.*