Global Dust From The Deflation Of The Medusae Fossae Formation On Mars. L. Ojha[1], K. Lewis[1], S. Karunatillake[2], and M.E. Schmidt[3], [1]Department of Earth and Planetary Sciences. Johns Hopkins University (luju@jhu.edu), [2]Department of Geology and Geophysics, Louisiana State University. [3]Department of Earth Sciences, Brock University.

Introduction: Dust is ubiquitous on Mars and plays a key role in contemporary atmospheric and surface processes. Ancient volcanic, impact, and fluvial processes were probably the main sources of dust on early Mars. In the present climate, eolian abrasion and deflation of rocks, particularly relatively soft sedimentary units are likely the most pervasive and active dust-forming mechanism (*1*). Martian dust is globally enriched in sulfur (S) and chlorine (Cl) relative to locally derived soils and has a distinct mean S:Cl ratio of 3.7$\pm$0.7 (*2–4*). Here, we identify a potential source region for modern Martian dust based on analysis of global elemental abundance data. We show that the Medusae Fossae Formation (MFF), a large sedimentary unit near the planet's equator, has the highest abundance of S and Cl on the Martian surface, and provides the best chemical match to surface measurements of Martian dust. Based on volume estimates of the eroded materials from the MFF, along with the enrichment of elemental S and Cl, and overall geochemical similarity, we propose that long term deflation of the MFF has been a primary contributor to the global Martian dust reservoir.

Methods: We compare the geochemistry of dust observed by in situ rovers, with the Martian shallow subsurface composition as determined with Mars Odyssey gamma ray spectrometer (GRS) observations. The sulfur (S) map is derived from the cumulative gamma spectra of the two mapping periods from 8 June 2002 to 2 April 2005 and 30 April 2005 to 22 March 2006. The regional extent is limited to the mid-to-low latitudes, since the gamma spectral peaks corresponding to S are derived from neutron-nuclei interactions in the Martian regolith, while the neutron spectra are affected by the sharp increase in H abundance at higher latitudes (*5*). For consistency with recent work, we use the latest forward-model derived chemical maps from the gamma spectral mapping periods.

Results: The highest enrichment of S on Mars is found to be within the MFF and surrounding areas (Fig. 1). Previous results also indicate high chlorine concentrations across the MFF deposits (*6*) (Fig. 1). We estimate a mean over the MFF of 2.62 $\pm$ 0.24 wt% sulfur and 0.65 $\pm$ 0.04 wt% chlorine. The global average abundance of S and Cl on Mars is 2.17 $\pm$ 0.23 wt% and 0.47 $\pm$ 0.03 wt% respectively, making the MFF enriched in S and Cl by a factor of 1.2 and 1.4 respectively. Combining these datasets, we calculate an average molar S:Cl ratio of 4.0 for the MFF, which falls within the range of S:Cl ratios observed for the Martian dust (*2*) (3.0 – 4.4) (Fig. 2). The MFF is not the only region on Mars with an S:Cl ratio within this range (Fig. 2), however the MFF is the only region on Mars with significant enrichment of both S and Cl, as well as an S:Cl ratio that is consistent with the Martian dust (Fig. 2). The statistical significance of S and Cl at the MFF was evaluated using an improvised test parameter (*7*) that factors the uncertainty in the GRS measurement into the calculation. The results from this test suggest that the S and Cl at the MFF are statistically significant (directional deviation of 94-98%) from the rest of Mars mapped by GRS.

MER and MSL also provide abundances of many other elements in the Martian dust (*2–4*, *8*). Although no other elements in the dust quantifiable by the Alpha

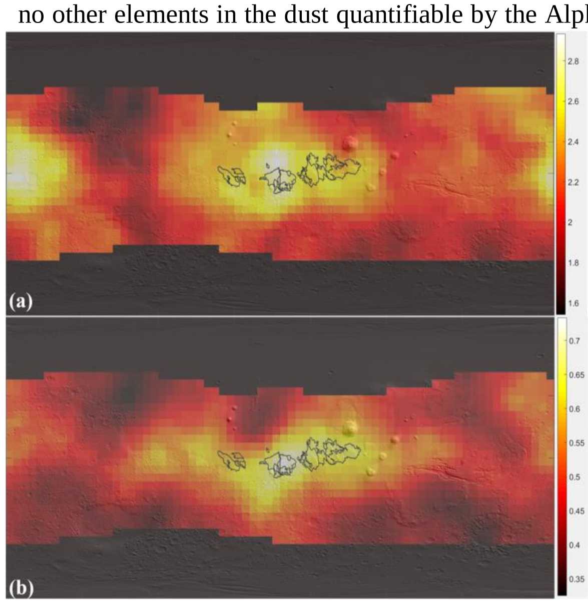

Fig. 1. *GRS derived elemental abundance maps for S (a) and Cl (b) in weight percentages. The outlines of the MFF is shown in black.*

Particle X-Ray Spectrometer (APXS) on MSL exhibit the same level of enrichment relative to other local materials (*2*), we may still compare their measured abundance to global GRS values. To address the systematic differences between the GRS and APXS data, we used ratios of mass fractions instead of the mass fractions themselves to assess the geochemical similarity between the bulk regolith of Mars and the Martian dust. As with APXS measurements of the dust, no other elements that we examined from GRS data (K, Fe, Ca, and Al) exhibited any distinct trends in the MFF. Large portions of the planet may match the elemental chemistry of Martian dust if only one or few elements are considered. However, in considering additional elements, those regions on Mars that match the Martian dust become more restricted. The only region on Mars that falls within the range observed for Martian dust for each of Si, Fe, Ca, K, S, and Cl lies within the MFF. Among the extensive MFF deposits, the area that produces the best fit to the dust chemistry consists of several GRS pixels in the area surrounding Apollinaris Patera.

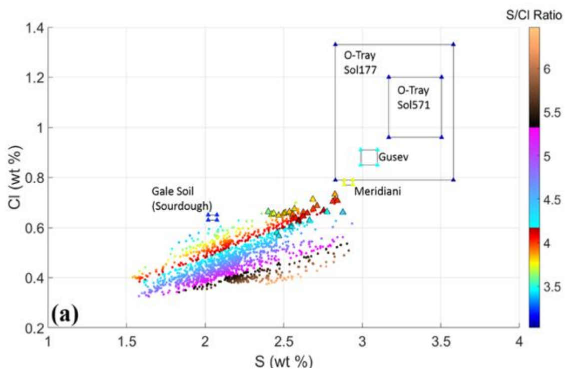

Fig. 2. *S/Cl ratio in color as a function of S and Cl for every pixel within the GRS mapped regions of Mars. The points with triangle outlines correspond to the GRS observations that fall within the MFF. The rectangular boxes represent the S and Cl abundances observed in situ.*

Discussion: The highest chlorine and sulfur abundance on Mars is found to be at the MFF, although the GRS-estimated abundance of S and Cl in the MFF is still lower than *in-situ* measurements of air-fall dust by ~30% (Fig. 2). This apparent difference in the absolute abundance of S and Cl between the MFF and the Martian airfall dust can be largely attributed to the differences in the spatial sampling scale. The relatively coarse resolution of GRS (several hundred kilometers) causes a spatial averaging effect, which will subdue the highest abundances within each pixel. Further, it is possible that eolian abrasion preferentially erodes the most S- and Cl-rich portions of the MFF, and concentration of the most soluble components (S and Cl) into the finest-grained fraction of the MFF could further cause the dust to have higher enrichment in S and Cl compared to GRS measurements. Regardless of the reasons for this enrichment, there are no other regions on Mars with the same level of both S and Cl enrichment as the MFF.

Based on the volume of materials estimated to have been eroded from the MFF, we can conservatively estimate MFF's contribution to the present-day dust inventory of Mars. The areal extent of the MFF currently exceeds 2×10^6 km^2 but may have covered an area(*9*, *10*) greater than 5×10^6 km^2. The current mean thickness of the MFF (*9*) exceeds 600 m. A comparable mean thickness between 100 – 600 m over the eroded areas would imply an eroded volume exceeding $3\times10^5 – 1.8\times10^6$ km^3. If distributed globally, this eroded volume of the MFF would be equivalent to 2 – 12 m of global layer of dust.

Despite the huge volume of eroded mass from the MFF, the lack of abundant bedforms around the MFF suggests that most of the materials being eroded are fine-grained enough to be suspended in the atmosphere and transported long distances (<10s μm). Further evidence for the fine-grained nature of the MFF is evident by the lack of boulders along erosional scarps(*11*, *12*), and extensive yardang fields which typically result from aeolian abrasion of fine-grained, lithologically weak deposits. The fine-grained nature of the MFF along with the estimates of MFF's volumetric denudation, observations of enrichment of S and Cl, and the convergence of S/Cl ratio with known dust observations collectively suggest that the MFF represents a significant contributor to the global dust inventory, resolving a major unknown in the source-to-sink pathways of the Martian dust cycle. While we propose here that the MFF is a net source for the Martian dust reservoir, it is possible that other sedimentary deposits on Mars have formed in part as net sinks for atmospheric dust that became lithified through interaction with ice or water in the ancient past. In the arid modern climate of Mars, dust may not undergo significant lithification, but may be redistributed across the surface over time, and may end up concentrated in areas of net deposition, such as the Arabia and Tharsis regions. If the primary source of modern Martian dust is indeed the MFF, then APXS measurements also provide *in situ* chemical information about that unit, a probable pyroclastic deposit on Mars. Given the extreme scale of this deposit and the likely volatile abundance involved in its eruption, the formation of the MFF would have been a significant event in the evolution of the Martian climate and atmosphere.

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