Microscale distribution and behavior of Th and K in late-stage melts and shock melts in olivine-phyric shergottites: Implications for the interpretation of remote sensing and in situ measurements of the martian surface. P. Burger¹, C. K. Shearer¹, H.E. Newsom¹, R.C. Reedy¹, and G.J. Taylor². ¹Institute of Meteoritics, Department of Earth and Planetary Science, University of New Mexico, Albuquerque, New Mexico 87131 ²University of Hawaii, 2525 Correa Road, Honolulu, HI 96822. (pvburger@unm.edu).

Introduction: Remotely sensed geochemical data provide extremely valuable information concerning the global distribution of elements on a planetary surface, and are valuable in the identification of major crustal terranes. Planetary geochemical maps of Mars for several elements such as Th, K, and Fe have been or are currently being prepared and have yielded significant insights into large-scale planetary processes [e.g., 1,2,3,4]. The most precise chemical information obtained by remote sensing thus far has been collected by Mars Odyssey, which characterized the Fe, Th and K concentrations across the entire surface of the planet. The Odyssey gamma-ray spectrometer (GRS) measures the abundances in the upper 10's of centimeters of the martian surface, which consists of soils and bedrock. It is critical to understand how surface processes affect the behavior of Th, REE, and K when interpreting these data. An important observation from the Mars Odyssey and various in situ missions (Pathfinder, MER) is that the Th and K in many of the Mars surface lithologies are not reflected in the martian meteorite collection (Figure 1). If the martian meteorites represent the crustal rocks on Mars then an enrichment mechanism is needed to obtain the higher abundances measured by the GRS. This variation has been attributed partially to surface and hydrothermal alteration of magmatic lithologies.

One possible explanation of the dichotomy between meteorites and surface collected data is that K and Th are enriched into the mesostasis, followed by the preferential alteration and erosion of this mesostasis, releasing the enriched elements into the soils. In this study, we combine electron and ion microprobe techniques in the analysis of Sm, Th, K, and major elements in both late stage-melt (mesostasis, melt inclusions) and shock-melt assemblages in martian meteorites. The intent of this study is to examine the variation in K and Th in components of martian meteorites that should be enriched in such incompatible elements and are more susceptible to surface/hydrothermal alteration. These data sets will contribute to a more accurate interpretation of remotely collected planetary data obtained through orbital or rover missions.

Analytical Methods: The initial samples analyzed in this study of martian meteorites are olivine-phyric shergottites: EETA79001, Y980459, and SaU005. Shock melt glass (lithology C in EETA79001, SaU005), mesostasis (Y980459), and melt inclusions (Y980459, SaU005) were analyzed in these meteorites. Analyses of melt inclusion avoided daughter crystals. These different lithologies were first identified by plane light microscopy and backscattered imaging using UNM's JEOL JXA 8200 electron microprobe (EMP) facilities. Major and minor (i.e. K) elements were determined by energy dispersive spectrometry, at an accelerating voltage of 15 kV, a beam current of 20 nA, using a spot size of 10 μm. Minor (K) and trace elements (Sm, Th) in the glasses were measured using the Cameca im7s 4f ion microprobe in the Institute of Meteoritics at the University of New Mexico. An O primary beam was used, operating at 12.5 kV. A primary beam current of 15 nA resulted in a spot size of ~15-20 μm. Isobaric interferences were minimized by energy filtering the secondary beam using a voltage offset of 75 V, and an energy window of ±25 V. Intensities of 147Sm and 232Th were normalized to known SiO2 concentration, previously analyzed using electron microprobe. Intensities were normalized to absolute concentrations using a set of six glasses of varying composition, both synthetic and natural. The calibration curve for Th had correlation coefficients of 0.992-0.999, while those for Sm had a value of 0.999. Concentrations of Th to 0.05 ppm are significant.

Results: Melt inclusions (in olivine) and mesostasis in Y980459 exhibited a range of major element compositions. The mesostasis were higher in Al2O3 and lower in SiO2 and Mg#. The high Al2O3 clearly reflects the delay in plagioclase crystallization as a result of crystallization kinetics. K and Th are higher in the mesostasis than in melt inclusions and both are substantially enriched relative to the bulk rock (Figure 2). Rao et al. [5] suggested that the shock melt that they defined as lithology C in EETA79001 was a mixture of fused lithology A, a plagioclase component, and martian soil. Variation in the trace element characteristics of this lithology tended to reflect mixtures of Lithology A and a plagioclase component [6]. Th and K for this shock produced lithology ranges from a concentration approximately equal to bulk EETA79001 lithologies A and B (300 to 400 ppm K and 0.07 to 0.15 ppm Th) to only slightly elevated values (Figure 2). The pure plagioclase component is substantially depleted in Th relative to lithology C[6]. Melt inclusions from olivine in SaU005 consist of “glass”, pyroxene, and a silica-rich phase [7]. The
SiO₂ content of the “glass” is relatively high and ranges from 66-71 wt.%. Th and K in the melt inclusion “glass” are substantially higher than the SaU 005 bulk rock (Figure 2). REE abundances of the inclusions are enriched relative to the bulk rock by 2 to 10 times [8], whereas the K and Th exhibit similar to slightly higher enrichments (Figure 2). A comparison of all of these magmatic and impact lithologies indicate that Th is generally enriched to a greater degree than K.

**Discussion:** Several conclusions can be reached from this new Th and K data. First, even the more “evolved” components of the olivine-phyric shergottites do not reach the K and Th enrichment levels observed for the martian surface by remotely sensed or in situ missions. However, these enrichments for Th and K are substantial. It would be expected that for similar components in basaltic shergottites, the Th and K should overlap with values measured by missions. These “enriched” components may be more susceptible to surface/hydrothermal alteration and therefore may be a source for at least some of the surface lithologies that are enriched in Th and K. Second, the shock melt lithologies in EETA79001 do not exhibit the degree of Th and K enrichments observed in mesostasis and melt inclusions. Shock melting processes, even if they involve mixing of a small percentage of soil component, do not cause substantial enrichments of Th and K. Third, although Th and K are highly incompatible in magmatic systems, they appear to fractionate from one another. Th appears to be more incompatible during crystallization of the shergottitic basalts. This is indicated by bulk compositional data from the literature (Figure 1) in addition to our ion probe data. Finally, sample return of surface lithologies is an important next step in deciphering the dichotomy of martian surface revealed by martian meteorites and mission observations.