REVISITING THE INTERPRETATION OF THORIUM ABUNDANCES AT HANSTEEN ALPHA.

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Introduction: Hansteen Alpha is one of the few remaining locations on the Moon thought to be formed by highlands volcanism [1]. Hansteen Alpha is a triangular shaped feature located in the southern portion of Oceanus Procellarum (12°W, 50°S) and its size is ~25 km on each side. As described by Hawke et al. [1], there is clear evidence that: 1) Hansteen Alpha was emplaced by extrusive volcanic processes; and 2) it was formed by a viscous lava that should be enriched in Th. However, in the study of Hawke et al. using available Lunar Prospector (LP) Th data, it was concluded that the Hansteen Alpha region was not greatly enriched in Th as would be expected for a highly evolved, viscous lava. It was further concluded based on other compositional data that the magma that formed Hansteen Alpha did not correspond to any known rock type.

Here we revisit the interpretation of Th abundances at Hansteen Alpha for a couple of reasons. First, the size of Hansteen Alpha is smaller than the spatial resolution of the LP Gamma-ray Spectrometer (LP-GRS) from which the Th abundances were derived. Therefore, the LP-GRS pixels covering Hansteen Alpha may not truly represent the Th abundance of the Hansteen Alpha feature. Second, recent work [2] has led to a much greater understanding of the Th spatial distribution for small-area features on the lunar surface. In particular, using forward modeling techniques, we have developed the ability to obtain information about Th abundances for features that are at or smaller than the FWHM spatial resolution (~[80 km]^2) of the LP-GRS data.

Forward Modeling: Forward modeling of planetary gamma-ray data is a process where surface abundances are first estimated using available information (e.g., measured abundance distribution, geologic map information, and/or higher resolution Clementine composition information for other elements). The expected gamma-ray flux from this assumed abundance distribution is then propagated through the entire instrument response to get simulated data. The simulated data are compared to the measured data and, if needed, the modeled abundance distribution is iteratively modified until a match is achieved between the modeled and measured data. This type of forward modeling has been successfully carried out for both gamma-ray measurements of the Moon [2] and neutron measurements of Mars [3].

To proceed with the forward modeling of the Hansteen Alpha region, we use information from both the LP-GRS Th maps and Clementine Spectral Reflectance (CSR) FeO maps [4] as shown in Figs. 1 and 2. When the two maps are compared, the central portion of the image shows a FeO/Th anticorrelation similar to what was documented for other nearside locations of the Moon [2]. The high-FeO regions in the northern portion of the map are mare basalts with lower Th and the high-Th regions are ejecta from Billy and Hansteen craters that have lower FeO abundances than the surrounding mare basalt. We note that this pattern is not seen in the far eastern portion of the mapped region.

If we then assume that the FeO/Th anticorrelation exists on CSR spatial scales at least for the central portion of the mapped area, we can use the CSR data to delineate regions of high and low Th abundances (Fig. 3). Further, we can use the CSR Fe map to delineate a third region that is the Hansteen Alpha feature. Based on the original Th map, we assume that regions 1 and 2 have Th abundances of 3 and 5 μg/g, respectively. Finally, to test whether Hansteen Alpha is highly enriched in Th, we can model region 3 as having either moderate (5 μg/g) or high (25 μg/g) Th abundances.

Results: Fig. 4 shows the modeled distribution when Hansteen Alpha is assumed to have a very high Th abundance of 25 μg/g. In contrast, Fig. 5 shows the results when Hansteen Alpha is assumed to have a Th abundance of 5 μg/g, which is similar to the surrounding non-mare regions. When these results are compared with the measured data in Fig. 1, it is clearly seen that the centroid of the central Th enhancement is better matched when Hansteen Alpha is assumed to have a very high Th abundance. In particular, the centroid in both Figs. 1 and 4 is halfway between Hansteen crater and Hansteen Alpha. This result can be understood in the following way. Even though Hansteen Alpha is small compared to the spatial footprint, if it has a large enough Th abundance compared to the surrounding region, it will shift the distribution east from Hansteen crater in the measured data. Conversely, if Hansteen Alpha has an abundance that is no different than the surrounding non-mare material, then its influence will not be noticed due to its small size, which is the case in Fig. 5.

Discussion: While this analysis does not rigorously prove that Hansteen Alpha has Th abundances in the range of 25 μg/g, it is highly suggestive that this is indeed the case. If Hansteen Alpha has Th abundances in the range of 25 μg/g, then it may represent a highly evolved highland composition, in contrast to earlier conclusions [1]. Further work to be done includes carrying out a spatial deconvolution analysis of the region, which is complementary to the forward modeling analysis done here. In addition, other elements measured using LP-GRS, such as Si, should be studied to see if they are consistent with Hansteen Alpha having a composition of highly evolved material.

References: [1] Hawke, B. R. et al., *JGR*, 108 (#E7), 10.1029/2002JE002013, 2003; [2] Lawrence et al., *JGR*, 108 (#E9), 10.1029/2003JE002050, 2003; [3] Prettyman et al., *JGR*, submitted, 2003; [4] Lucey et al., *JGR*, 105 (#E8), 20297, 2000.

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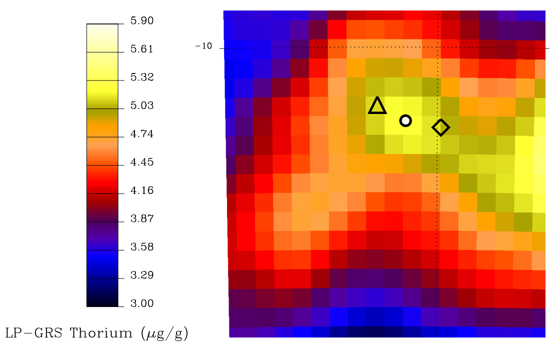

Fig. 1: Map of Th abundances in the region containing Hansteen Alpha. The triangle shows the location of Hansteen crater and the diamond shows the location of Hansteen Alpha. The circle shows the centroid of the central Th enhancement. These symbols are repeated in each of the following figures.

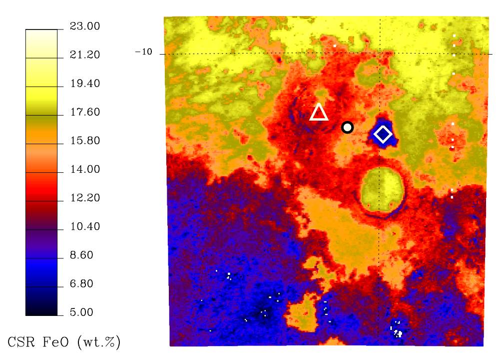

Fig. 2: Map of CSR FeO abundances in the Hansteen Alpha region. Here, Hansteen Alpha is clearly seen as the low-FeO region north of Billy crater and southeast of Hansteen crater.

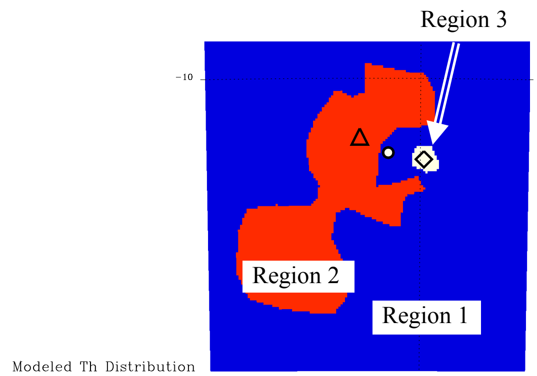

Fig. 3: Map of the assumed Th composition for the forward model. Assumed abundances are: Region 1 = 3 μg/g; Region 2 = 5 μg/g; Region 3 = 25 or 5 μg/g.

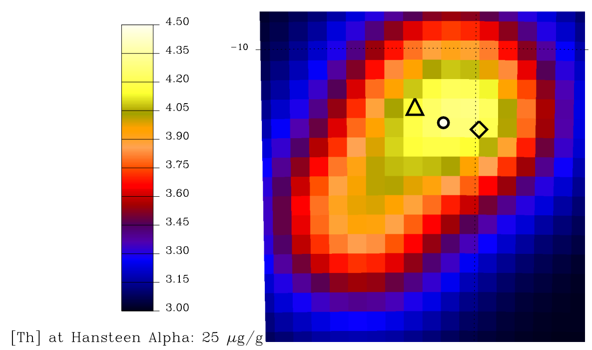

Fig. 4: Simulated Th map when Hansteen Alpha has a Th abundance of 25 μg/g.

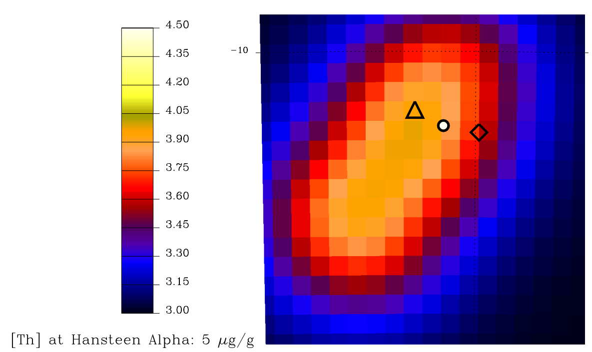

Fig. 5: Simulated Th map when Hansteen Alpha has a Th abundance of 5 μg/g.