ESTIMATING THORIUM ABUNDANCES OF BASALT PONDS IN SOUTH POLE AITKEN BASIN: IMPLICATIONS FOR THE COMPOSITION OF THE FARSIDE LUNAR MANTLE. J. J. Hagerty[1], D. J. Lawrence[1], B. R. Hawke[2], D. T. Vaniman[3], R. C. Elphic[1], and W. C. Feldman[1], [1]Los Alamos National Laboratory, ISR-1, MS D466, Los Alamos, NM 87545, e-mail: jhagerty@lanl.gov, [2]University of Hawaii, Honolulu, HI 96822, [3]Los Alamos National Laboratory, EES-6, MS D462, Los Alamos, NM 87545.

Introduction: Previous studies of thorium (Th) in South Pole Aitken (SPA) basin [e.g., 1,2,3,4] have shown that the basin floor contains more Th than the surrounding Feldspathic Highlands Terrane (FHT) [2]. Determining the source of the relatively elevated Th levels in the basin floor has important implications for the geophysical and geochemical evolution of the Moon. For example, if the formation of SPA basin excavated a portion of the upper mantle [e.g., 5], the Th abundances measured in the floor of the basin could indicate that the farside lunar mantle was Th-rich at one time and by inference may have contained a KREEP component. The first step in evaluating the validity of this assertion is to determine the composition of the mantle that underlies SPA basin. We propose that the Th composition of the underlying mantle can be estimated by determining the Th composition of basalt ponds, which represent partial melts from the lunar mantle.

We have shown in previous work [e.g., 6,7,8] that it is possible to use forward modeling of Th data from the Lunar Prospector Gamma Ray Spectrometer (LP-GRS) to estimate the Th concentrations of specific features on the lunar surface. Given this information, the ultimate goal of our current study is to use forward modeling techniques to estimate the thorium content of basaltic ponds within SPA basin. The first pond that we investigated was the central basalt pond in Apollo crater, which is located in the northeastern portion of SPA basin. We started with this relatively large (8,335 km^2 [9]) basaltic unit because it is far from the northwest Th anomaly described by Lawrence et al. [4].

Forward Modeling: As part of the forward modeling process, we create a hypothetical geologic environment in which we can control the Th abundances of specific geologic features. However, in order to reconstruct a specific portion of the lunar surface, we must have important information about the region of interest. For example, we need to account for the various types of lithologies that could be present in the region by incorporating information from geologic maps and other remote sensing data sets (e.g., Clementine Spectral Reflectance (CSR) [10]). We must also know what Th abundances can be logically assigned to any given feature and/or lithology, which is why we use analyses from the lunar sample suite to constrain our Th estimates. Once we have reconstructed a specific geologic environment, we allow the expected gamma ray flux from this geologic environment to be propagated through a computerized version of the LP-GRS, which produces a simulated Th abundance distribution. We then compare the simulated Th distribution to the measured Th data and iteratively adjust the simulated distribution until we achieve a match with the measured data. This methodology not only allows us to estimate the Th content of specific geologic features, but it also allows us to determine how the Th content of a specific feature can influence the apparent Th distribution for the entire region. This type of forward modeling has been carried out for both gamma-ray measurements of the Moon [6,7,8] and neutron measurements of Mars [11].

In an attempt to model the Th abundance distribution for the central basalt pond in Apollo crater, we used shaded-relief maps [12], CSR FeO maps (Fig. 1) and geologic maps [13] of the region to identify specific lithologies and geologic units (Fig. 2). We find that there are at least 24 different lithologies and/or units within this region that must be accounted for, the most important of which is the Imbrian-aged basalt in the center of the scene (i.e., region 1 in Fig. 2). While constraining the upper and lower bounds of our Th estimates, we iteratively assign different Th abundances to each lithology and/or unit until we achieve a match with the measured data seen in Fig. 3.

Results: Figure 4 shows the Th abundance distribution that is produced when the basalt pond in Apollo crater contains ≤ 1 ppm Th. Figure 5 shows the Th abundance distribution if the basalt pond has > 1ppm Th. A comparison of Figs. 3, 4, and 5 shows that the Th abundance distribution for the entire region is best approximated when the basaltic pond has ≤ 1 ppm. It should be noted that there are several features in this region that appear to have elevated Th abundances. For example, we can only reproduce the Th distribution in Figure 3 when regions 2 and 11 (see Fig. 2) have > 2 ppm Th. Both of these features are mapped as material from Nectarian-aged craters [e.g., 13].

Discussion: The results from this study are consistent with the central basalt pond in Apollo crater having little or no Th. This result could be used to infer that the mantle that underlies SPA basin is not Th-rich. However, it could be argued that this basalt pond only represents a small portion of the underlying mantle and that other portions of the mantle could be Th-rich. For example, we do not know the depth from which this basalt pond was derived. Therefore, it is possible that the underlying mantle is heterogeneous and that different portions of the mantle contain different abundances of Th. For this reason we will continue to conduct forward modeling of additional basalt ponds in the SPA basin.

Conducting forward modeling of the other basalt ponds is important because geologic maps of the SPA basin, in conjunction with Clementine Spectral Reflectance (CSR) data [e.g., 14], show that the basalt ponds within SPA basin are of different ages, are separated by hundreds of kilometers, and appear to have different major element compositions. These characteristics indicate that the basalt ponds were derived from different source regions in the lunar mantle and therefore could provide compositional information about various portions of the farside mantle.

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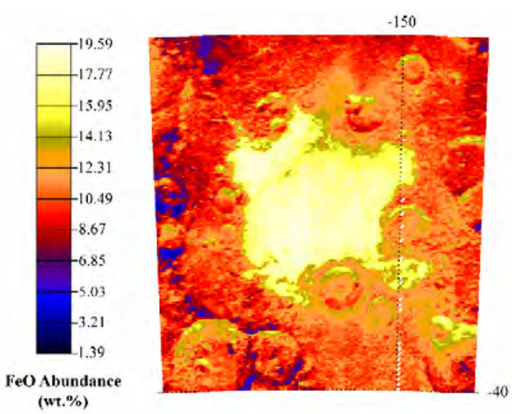

Figure 1. CSR FeO map of the central basalt pond in Apollo crater. The edges of the basalt pond were modeled as different units due to lateral mixing with the surrounding materials. The absolute FeO abundances from CSR may be overestimated by as much as 2 wt.% [15].

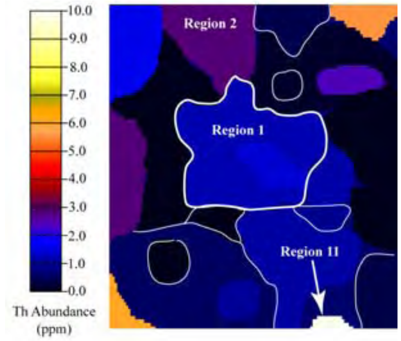

Figure 2. Map of modeled Th compositions used in the forward model. Region 1 = 0.9 ppm Th, Region 2 = 2.5 ppm Th, and Region 11 = 10 ppm Th (this value is overestimated by a factor of 2 to account for the small size of region 11).

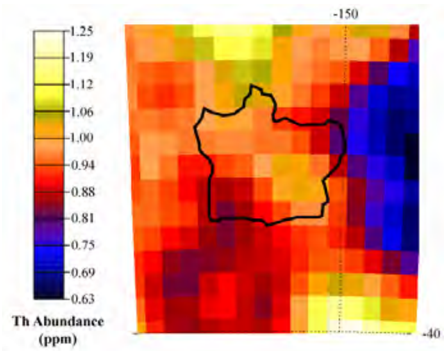

Figure 3. Map of LP-GRS Th data. The basalt pond is outlined in black.

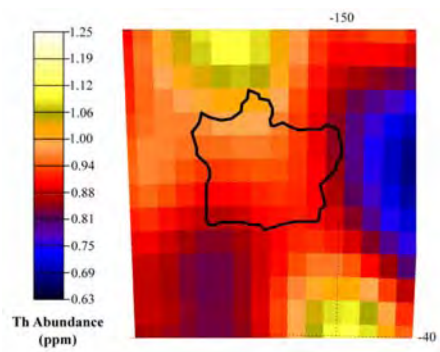

Figure 4. Simulated Th map where the basalt pond has 0.9 ppm Th.

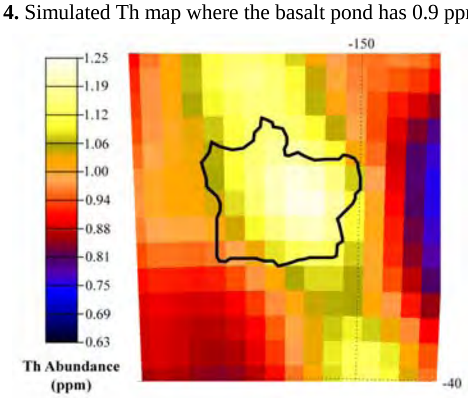

Figure 5. Simulated Th map where the basalt pond has 2.5 ppm Th.