AN IMPROVED METHOD FOR ESTIMATING THE THORIUM ABUNDANCES OF MARE BASALTS IN SOUTH POLE-AITKEN BASIN. J. J. Hagerty[1], D. J. Lawrence[2], and B. R. Hawke[3], [1]U.S.G.S., Astrogeology Research Program, Flagstaff, AZ 86001, email: jhagerty@lanl.gov. [2]Johns Hopkins University, Applied Physics Laboratory, Laurel, MD. [3]University of Hawai'i, Hawai'i Institute of Geophysics and Planetology, Honolulu, HI.

Introduction: Previous studies that have investigated thorium (Th) abundances 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 [2,4]. One of the main goals of this research is to determine if the basalt ponds in SPA contribute significantly to the elevated Th abundances within SPA basin. The fact that basalts represent partial melts from the underling lunar mantle, means that we can use the Th content of the SPA basalt ponds to understand better the Th content of the crust and mantle under SPA Basin.

We have shown in previous work [e.g., 5,6] 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. In areas that have high Th abundances, and thus high signal-to-noise ratios, our previous methodology works well. However, in areas with low Th abundances, the signal-to-noise ratio is much lower, thus increasing the probability of having noise-related artifacts in the LP-GRS Th maps. The presence of significant noise related artifacts can make it difficult to accurately evaluate the validity of a given forward model. Therefore, in an effort to significantly reduce the amount of noise in areas containing low Th abundances, we have employed the Pixon spatial deconvolution method described by Lawrence et al. [7].

The Pixon Method: The spatially adaptive, image restriction method, known as Pixon [8,9,10], is a deconvolution technique that seeks the smoothest possible image as constrained by both the original data and the data uncertainty (or noise). A unique feature of the Pixon method is that it uses variably-sized smooth patches, or Pixon elements, within the image in order to express the information content of the image. For example, if the variation within a large portion of the image can be attributed solely to noise, then the size of the Pixon element in this region would be relatively large. In contrast, regions containing statistically significant small-scale spatial variations will have smaller Pixon element sizes that capture larger amounts of information. In general, a set of Pixon elements for a given image represents the minimum set required to describe the image information content within the limits allowed by the noise [9].

Unfortunately, a spatial response function has not been calculated for the Pixon derived Th maps of the Moon, therefore, it is not possible to conduct forward modeling of the Pixon processed data. However, in areas with low signal-to-noise ratios, we can use the Pixon generated maps as an end point for evaluating forward models of the LP-GRS Th data. The validity of this methodology is enhanced by the fact that for other portions of the Moon, the Pixon processed maps match astonishingly well with and reinforce our forward modeling results [see 7].

While not ideal, the use of the Pixon derived maps as a modeling goal is currently the best way to remove the influence of noise-related artifacts in areas with low Th abundances. The incorporation of the Pixon method into our existing forward models allows us to use the forward modeling process, described below, to understand better the Th abundances of specific features and lithologies within SPA Basin.

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) [11]). 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 the spatial response of the LP-GRS, which produces a simulated Th abundance distribution. We then compare the simulated Th distribution to the Pixon processed data and iteratively adjust the simulated distribution until we achieve a match with the Pixon processed 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.

Results: Figure 1 shows the LP-GRS Th map for the easternmost basalt pond in SPA Basin (i.e., the pond at the center of Apollo Basin). Figure 2 shows the Pixon-derived Th map and Figure 3 shows our Pixon-based forward modeling results from this study. In our previous studies [12,13] we found that the uncontaminated portions of the easternmost basalt pond were consistent with a Th abundance of ≤ 1 ppm. Our revised forward modeling efforts provided abundances that were similar to those in our previous studies (i.e., 1.16 ± 0.20 ppm Th). When the improved forward modeling process is applied to all of the other basalt ponds in SPA Basin, we find that all of the uncontaminated basalt ponds in SPA still contain ≤ 1 ppm Th, as was suggested in our previous work [12,13]. However, we can now be certain that we are not recreating significant noise-related artifacts in our forward models, thus increasing our confidence in the forward modeling process.

Discussion and Conclusions: The observation that the uncontaminated basalt ponds within SPA Basin have ≤ 1 ppm Th, indicates that the parental basaltic magmas did not assimilate Th-rich, crustal materials during their ascent and therefore the basalt ponds provide compositional information about their basaltic source regions (at least with respect to Th). It is important to note that the uncontaminated ponds within SPA Basin are widely separated, have different major element compositions, and different relative ages [14]. This information, along with assumption that the partial melts were likely derived from various depths, indicates that the basaltic ponds represent unique portions of the far side lunar mantle. Because the ponds in SPA Basin are Th-poor, their source regions must have also been Th-poor, indicating that several different portions of the far side mantle had little or no Th at the time of melt production.

Acknowledgements: This work was supported by NASA through the Discovery Data Analysis Program grant W-7405-ENG-36 and was conducted under the auspices of the U. S. Department of Energy and the U.S. Department of the Interior.

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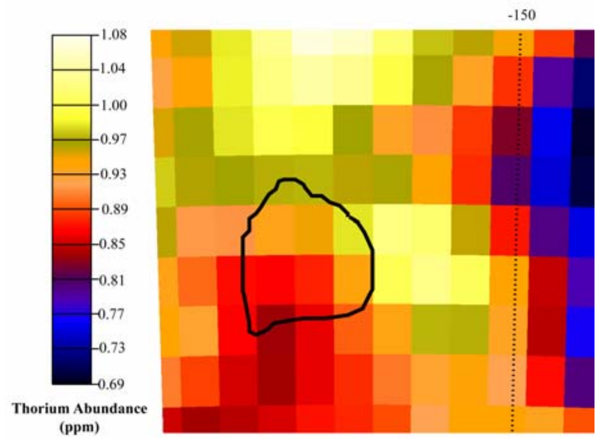

Figure 1. LP-GRS Th map for the easternmost basalt pond in SPA Basin. The area outlined in black represents the uncontaminated part of the basalt pond. Note the apparent Th enhancements to the north and east of the outlined area.

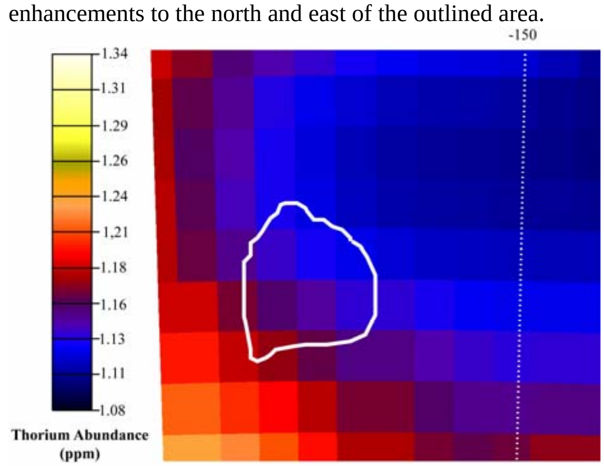

Figure 2. Pixon-generated Th map for the easternmost basalt pond in SPA Basin. The area outlined in white represents the uncontaminated part of the basalt pond.

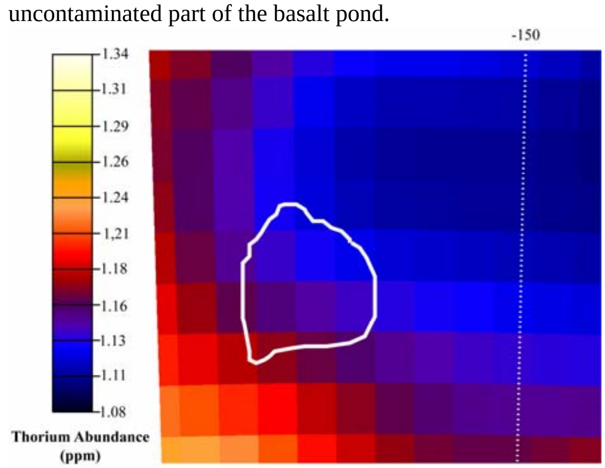

Figure 3. Th map as derived from the forward modeling discussed in this study. The area outlined in white has a Th abundance of 1.16 ± 0.20 ppm.