AN EMPIRICAL CALIBRATION TO CALCULATE THORIUM ABUNDANCES FROM THE LUNAR PROSPECTOR GAMMA-RAY DATA. Jeffrey J. Gillis[1], Larry A. Haskin[1] & Paul D. Spudis[2], 1. Washington University, St. Louis MO, 63130. 2. Lunar & Planetary Institute, Houston, TX, Gillis@levee.wustl.edu.

Introduction: The global distribution of thorium, now available from the Lunar Prospector mission, is crucial to evaluate petrologic models of the lunar crust [1,2], to understand processes of basin formation [2,3] and to provide improved regional context for samples [4]. Mapping the Th allows us to correlate Th concentrations with specific geologic units, which will yield information about local geologic processes. For this, however, *concentrations* of Th in lunar surface materials must be known. At this stage of data reduction, the Prospector team has provided only *gross count rates* [5], i.e., total counts per 32 seconds in the spectral region of the main thorium γ-ray (2.4 to 2.8 MeV). Eventually the Prospector team will provide Th concentrations derived from deconvolution of the γ-ray spectra, with proper attention to correction for absorption, knowledge of detector geometry, etc.

Too impatient to await completion of the data reduction, we offer a preliminary calibration based on the gross count rates, the results from the Apollo γ-ray experiments [6], and our knowledge of lunar soil compositions [4]. At the heart of this calibration is our assumption of a linear relationship between Th *net* count rate and Th concentration (but see Fig. 2 of [7]); i.e., no correction is attempted for γ-ray absorption coefficients for different regolith materials, subpixel Th variations, etc. This calibration will be least accurate for individual pixels for which Th concentrations are low, because the overall count rate in the 2.4 to 2.8 MeV range will be mainly from background, and deviations from the average background, whatever their cause, will be interpreted as contributions to the Th concentration. The calibration should be accurate at higher Th concentrations where the signal from the ^{232}Th 2.62 MeV γ-ray significantly exceeds the background.

Data: The γ-ray count rate map was obtained from http://nis-www.lanl.gov/nis-projects/lunar, Prospector internet web site. The image contains Th count rates in an equal-area projection, averaged into $5^o \times 5^o$ latitude/longitude bins, from –90 to 90 latitude and –180 to 180 longitude. These data have already undergone corrections for gain, dead time, cosmic-ray variations, and non-symmetric response of the instrument [5].

Method and Results: The regression used relates Prospector count rate to Th concentrations given for the regions overflown by the Apollo γ-ray experiments by [7] (Th concentrations that were calibrated empirically to soil data). Regions in the Apollo γ-ray data with good statistics and covering a range in Th concentration, were chosen as a reference to compare with γ-ray counts observed by Prospector for corresponding regions (Table 1). The regression (Fig. 1) meets the obvious constraint that most of the cluster of low Prospector count rates give Th concentrations >0. Thorium concentrations of lunar meteorite regolith breccias (believed to represent the lunar highlands far away from the Th-rich Procellarum KREEP Terrane [8]) and of Apollo soils were used as tests of the reasonableness of the slope and intercept of the regression. The median Th concentration for the low-Th cluster of highland pixels is ≈0.8 ppm, in rough agreement with the lunar meteorite regolith breccia average of 0.4 ± 0.2 ppm [9]. The 5^ox5^o pixel in the Prospector map that includes the Apollo 14 site (3.7^o S; 17.5^o W) is centered on 5.8^o S; 20^o W. The geologic map [10] of that region shows that the area consists of ≈60% Fra Mauro regolith and ≈40% mare basalt regolith. The Clementine–based iron map [11] shows 13.7% FeO and the Prospector γ-ray count corresponds to 8.6 ppm Th, consistent with those of a 60:40 mixture of Apollo 14 soil (10.4 wt.% FeO and 12.7 ppm, [4]) and Apollo 12 soil (18.8 wt.% FeO and 3.6 ppm, [4]) of 9.1 ppm Th and 13.8% FeO.

The Th concentration map is shown as Fig. 2, and at http://epsc.wustl.edu/admin/people/images/gillis1.html the full res version can be seen. We emphasize again that individual values at the lowest range of the Th concentrations may be significantly affected by the γ-ray background that only future refinements to the data can properly remove. For the present, we believe this calibration is a useful approximation.

Figure 2 shows Th concentrations of 8-9 ppm for the most Th-rich areas within the Procellarum KREEP Terrane [9]. The Montes Jura, Apennine bench, and portion of the Aristarchus Plateau also have high Th concentrations (6.5–7.5 ppm Th). The floor of South Pole-Aitken basin is modestly elevated in Th relative to the rest of the far side, with two areas within the basin (Van de Graff & area north of Chrétien) displaying up to ≈2.5 ppm Th. These two locations do not correspond uniquely with mare basalt but appear to be associated with SPA basin-floor material. Further geologic mapping in conjunction with the Clementine and calibrated Prospector data should help identify the geologic processes involved in producing the Procellarum Th and South Pole-Aitken Terranes.

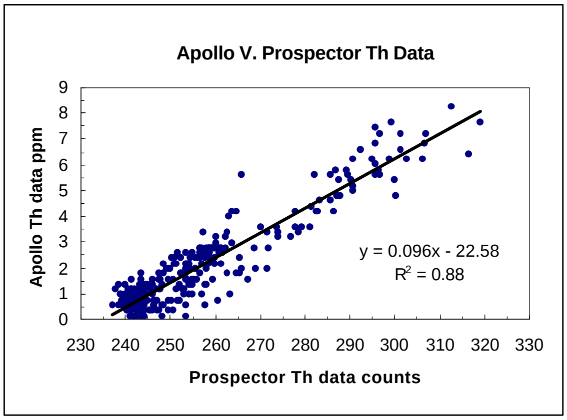
Acknowledgements: This work was supported by NAG5-6784 (BLJ) and NAG5-4172 (LAH). We thank D. Lawrence for making the global Prospector-derived Th count rate map available to us.

Region	Name	Th ppm ±σ	Th counts
3A	M. Fecunditatis	1.9 ± 0.2	131.2
35B	Van de Graff	2.7 ± 0.3	132.2
9B	O. Procellarum	4.1 ± 0.4	144.5
4A	M. Imbrium	5.4 ± 0.4	150.4
1A	M. Cognitum	6.1 ± 0.5	151.6
24A	Fra Mauro	8.0 ± 0.6	158.2

Table 1 lists Prospector Th counts and Apollo Th concentrations for corresponding locations. These Apollo regions [4] were used to define a relation between the two γ-ray data sets.

Figure 1 (right) displays the least-squares correlation between corresponding areas in both the Apollo and Prospector γ-ray data sets (>300 pts.).

References: [1] Warren, 1985, *Ann. Rev. Earth Planet. Science*, **13**, 201-240; [2] Spudis & Davis, 1986, *PLSC 17*, 84-90; [3] Haskin, 1998, *JGR*, **103**, 1679-1689; [4] Korotev, 1998, *JGR*, **103**, 1691-1701; [5] Lawrence et al., 1998, *Science*, **281**, 1484-1489; [6] Metzger et al., 1974, *PLSC 5*, 1067-1078; [7] Metzger et al., 1977, *PLSC 8*, 949-999; [6] Gillis & Spudis, 1998, *EOS*, **79**, F553; [8] Jolliff et al., *LPSC XXX*, this vol.; [9] Korotev, *LPSC XXX*, this vol; [10] Jolliff et al., *LPSC XXX*, this vol.; [11] Lucey et al., 1998, *JGR*, **103**, 3679-3699.



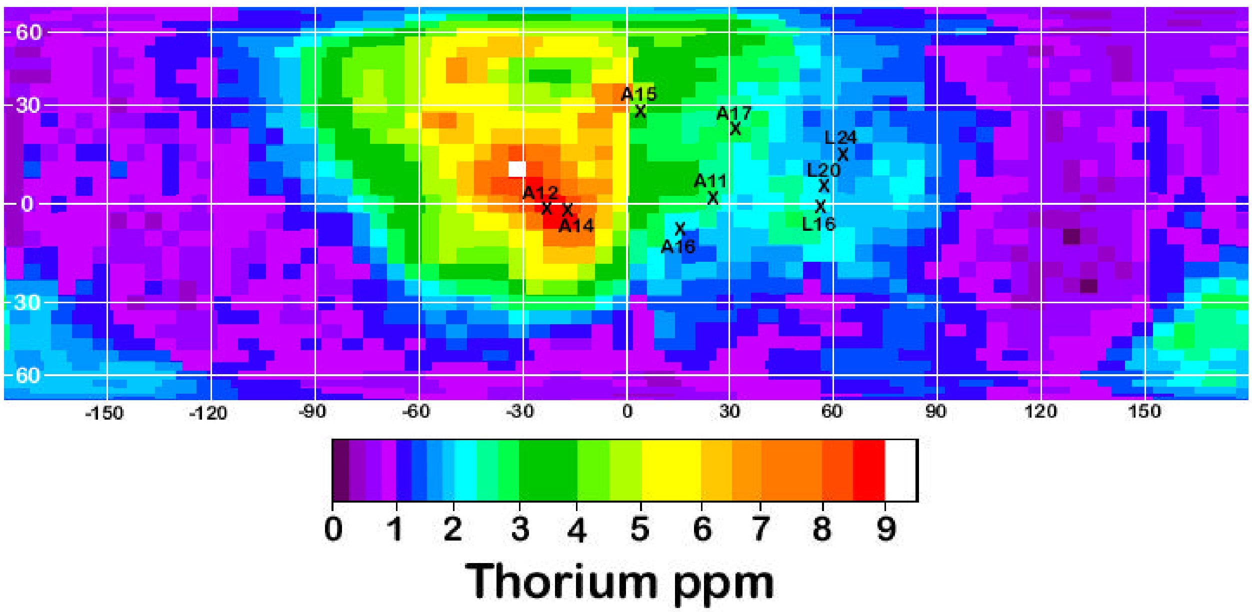


Figure 2 is the calculated Th ppm map using the correlation in Fig. 1 to convert the Prospector count rate data to Th concentrations. The image is in a cylindrical equal-area projection, covering –180 to 180 longitude and –90 to 90 latitude. The Apollo (A) and Luna (L) landing sites are illustrated for selenographic reference.