Journal of Geophysical Research: Planets

Supporting Information for

Evidence for a Stratified Lunar Mantle Preserved within the South Pole – Aitken Basin

D. P. Moriarty III[1,2], R. N. Watkins[3], S. N. Valencia[1,2],
J. D. Kendall[1,4], A. J. Evans[5], N. Dygert[6], and N. E. Petro[1]

[1]NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD 20117.
[2]University of Maryland, 4296 Stadium Drive, College Park, MD 20742.
[3]Planetary Science Institute, 1700 East Fort Lowell Road, Tucson, AZ 85719.
[4]University of Maryland Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250.
[5]Brown University, 324 Brook Street, Providence, RI 02912.
[6]University of Tennessee, Knoxville, 1621 Cumberland Avenue, Knoxville, TN 37996.

]

Contents of this file

Introduction

This document includes figures and tables supporting the interpretations discussed in the manuscript. Relevant data sources are included in the Data and Methods Appendix.

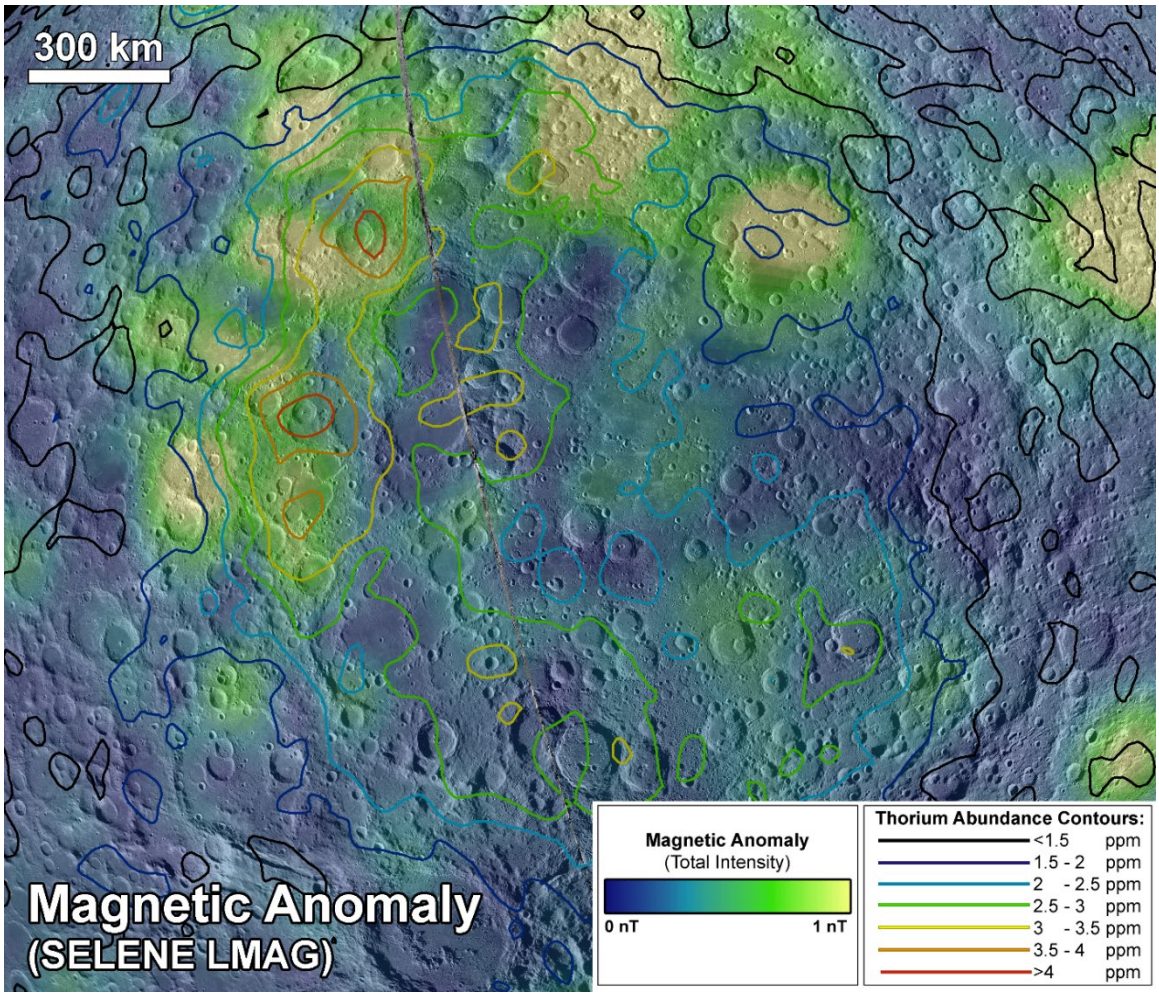

Figure S1. The magnetic anomaly total magnitude from the SELENE Lunar Magnetometer (LMAG) (Tsunakawa et al., 2010) is most elevated in the northwestern quadrant of the South Pole – Aitken Basin. Although the finer structure of the enhancement exhibits notable differences to the thorium distribution, both are elevated in the northwestern region of the basin.

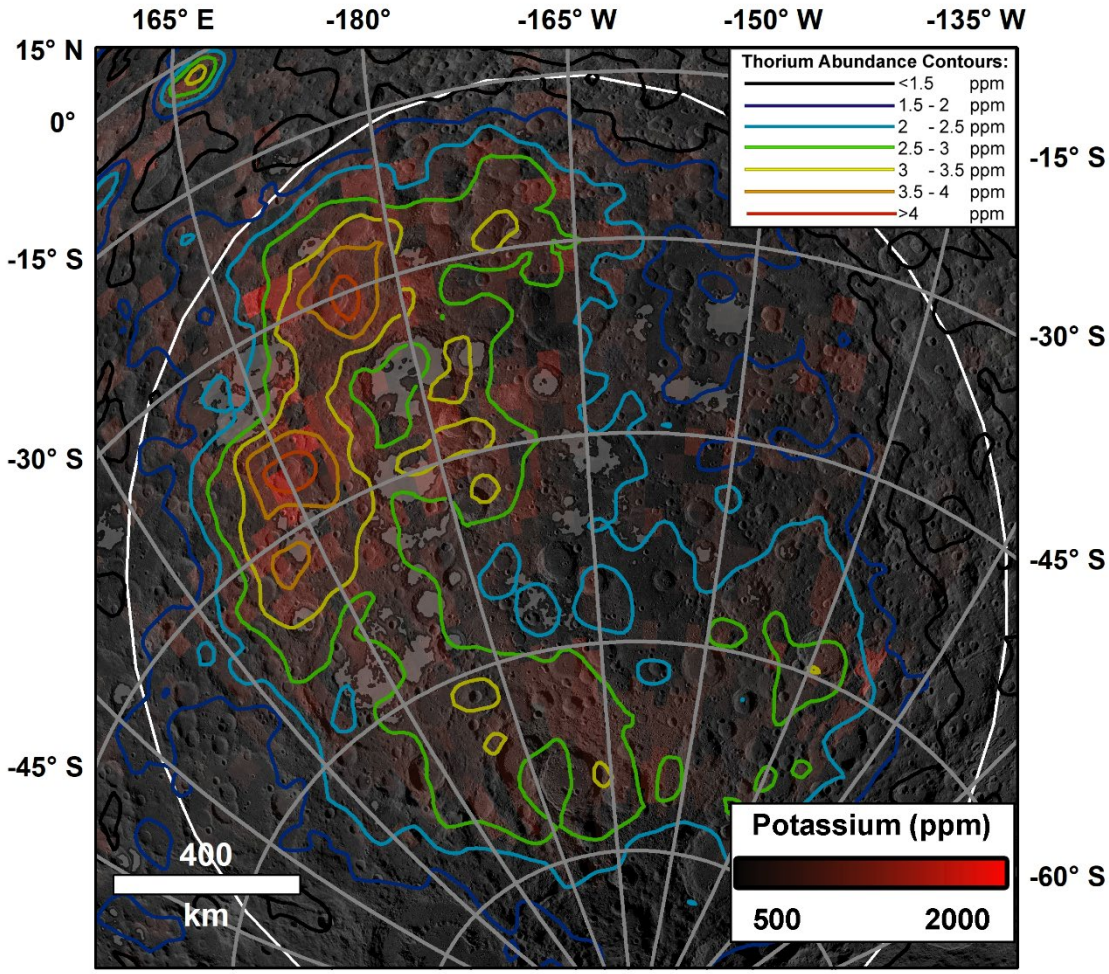

Figure S2. Potassium elemental abundance (Prettyman et al., 2002) compared to the thorium distribution across the South Pole – Aitken Basin. K appears spatially correlated with Th abundance. The topographic rim of SPA (Garrick-Bethell and Zuber, 2009) is indicated by the white ellipse. Areas resurfaced by mare basalts are shaded grey (Nelson et al., 2014).

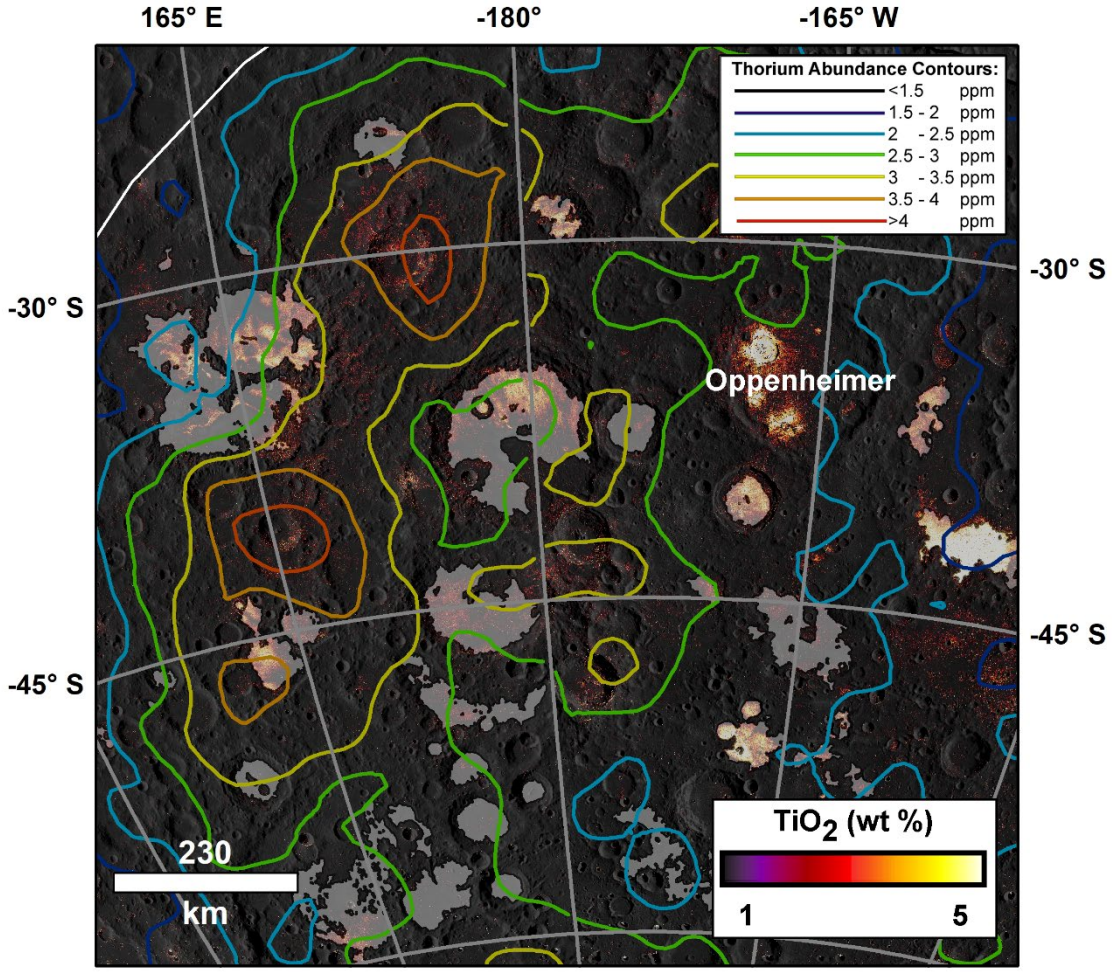

Figure S3. TiO2 weight percent (Sato et al., 2017) compared to the thorium distribution across the South Pole – Aitken Basin. TiO2 is primarily correlated with mare basalts and volcanic glasses (such as in Oppenheimer), but in non-volcanic areas is generally associated with regions exhibiting Th abundance >3 ppm, and is especially prevalent in the Th "hotspots" at Birkeland and Oresme V (>4 ppm Th). Areas resurfaced by mare basalts are shaded grey (Nelson et al., 2014).

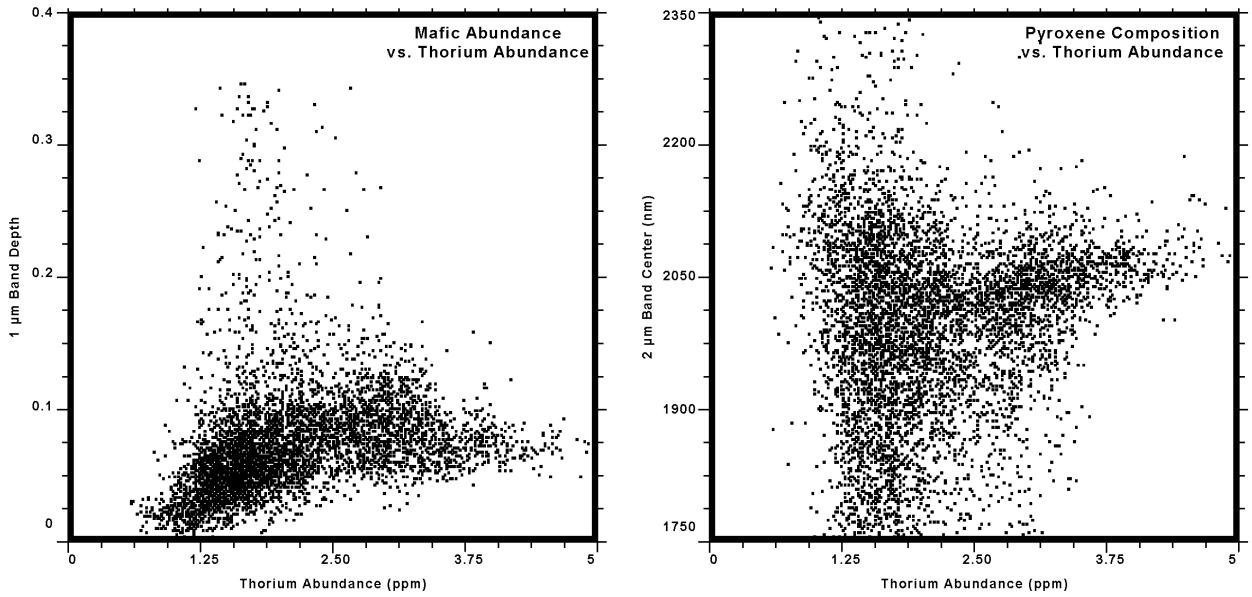

Figure S4. The relationship between thorium abundance (Lawrence et al., 2002b, x-axis) vs. M3 spectral parameters (Fig. 3) sensitive to mafic abundance (left) and pyroxene composition (right) for non-volcanic materials across the SPA region. While mafic abundance does not appear to be correlated with thorium abundance, pyroxene compositions of material with thorium >2.5 ppm exhibit a much narrower range than materials with thorium <2.5 ppm, indicating that thorium is associated with a specific lithology.

Sample/ Lithology	Low-Ca Pyroxene	High-Ca Pyroxene	Anorthite	Olivine	Oxides	Other
15058,248	29.3	33.8	30.1	0.1	2.3	4.4
15555,971	32.4	24.0	27.3	11.8	2.7	1.8
70017,541	17.7	34.8	25.7	1.5	17.7	2.6
70035,193	20.2	28.8	30.1	1.2	17.8	1.9
Late LMO Cumulates	30	20	40	-	10	-

Table S1. Modal Mineralogy of Lunar Rock and Mineral Characterization Consortium Basaltic Rocks (Isaacson et al., 2013) vs. a Modeled Late LMO Cumulate Assemblage (Elkins-Tanton et al., 2011).