

Remote sensing evidence for an ancient carbon-bearing crust on Mercury

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Supplemental Tables

Table S1. Summary of simulated thermal neutron signals over LRM.

Study Area	Measurements		Simulations ^a	
	Count Rate over LRM	Significance	No Statistics	Poisson Statistics ^b
A	+2.6±0.4%	6.3 σ	−0.04±0.05%	+0.1±1.4%
B	+1.6±0.5%	3.1 σ	−0.02±0.04%	+0.0±0.6%
C	+1.0±0.4%	2.4 σ	−0.04±0.04%	−0.0±0.7%

^a Calculated following the methodology described in the Methods section.

^b Mean and 1-standard-deviation values resulting from 100 distinct simulations and derived from Gaussian fits to the populations.

Table S2. Microscopic neutron absorption cross section (σ_a) for relevant elements, sorted by σ_a .

	σ_a [b]	Abundance [wt%]	References/Notes
Gd	22,800	1.5×10^{-4}	Derived from global Th concentration ¹²
Sm	10,100	1.1×10^{-4}	Derived from global Th concentration ¹²
Eu	5660	5.4×10^{-5}	Derived from global Th concentration ¹²
Cl	33.2	0.09–0.48	From Cl/Si value ¹⁹ and assumed Si abundance
Mn	13.4	0.02–0.22	Measured range ³ for assumed Si abundance
Th	7.34	2.2×10^{-5}	Mean Th concentration ²⁰
Ti	5.99	0.02–0.56	Measured range ³ for assumed Si abundance
U	3.38	9×10^{-6}	Mean U concentration ²⁰
Cr	3.04	0.02–0.71	Measured range ³ for assumed Si abundance
Fe	2.56	0.5–2.5	Measured range ⁴ for assumed Si abundance
K	2.06	0.025–0.25	Measured range ²¹
Na	0.528	2.1–5.6	Measured range ⁷ for assumed Si abundance
S	0.514	0.7–3.9	Measured range ⁴ for assumed Si abundance
Ca	0.436	1.2–7.4	Measured range ⁴ for assumed Si abundance
Al	0.234	2.7–8.9	Measured range ⁴ for assumed Si abundance
Si	0.165	24.6	Assumed value
Mg	0.063	3.4–19.7	Measured range ⁴ for assumed Si abundance
C	3.5×10^{-3}	<4.1	<i>Mean upper limit</i> ²²
O	1.9×10^{-4}	~45	Standard stoichiometry

Supplemental Figures

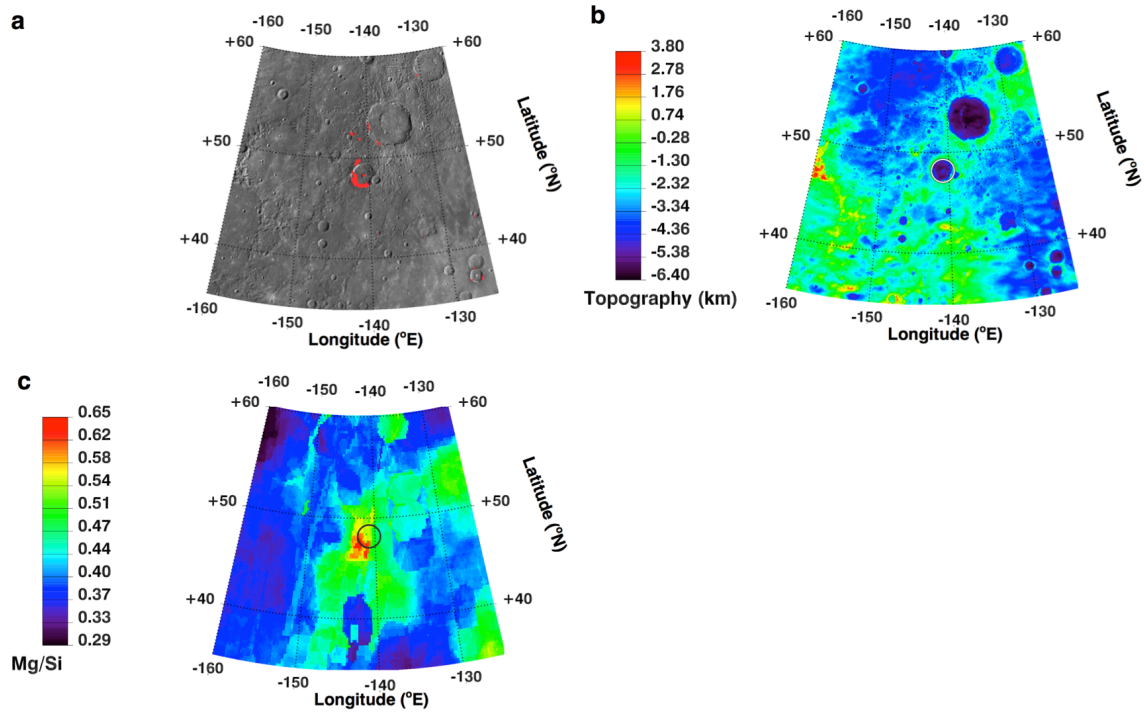


Figure S1. The full extent of study area A, a $\sim 10^6 \text{ km}^2$ region that includes the LRM A deposit. LRM A is located within central peak and rim of the 106-km-diameter Akutagawa crater (centered at 48.2° N , 219.1° E). **a**, LRM (in red) superimposed on an MDIS global mosaic produced from images acquired with the filter centered at 750 nm. **b**, Topography, given as elevation relative to a sphere of radius 2440 km, with the crater of interest outlined with a white circle. **c**, XRS-measured Mg/Si weight ratio, with the crater of interest outlined with a black circle.

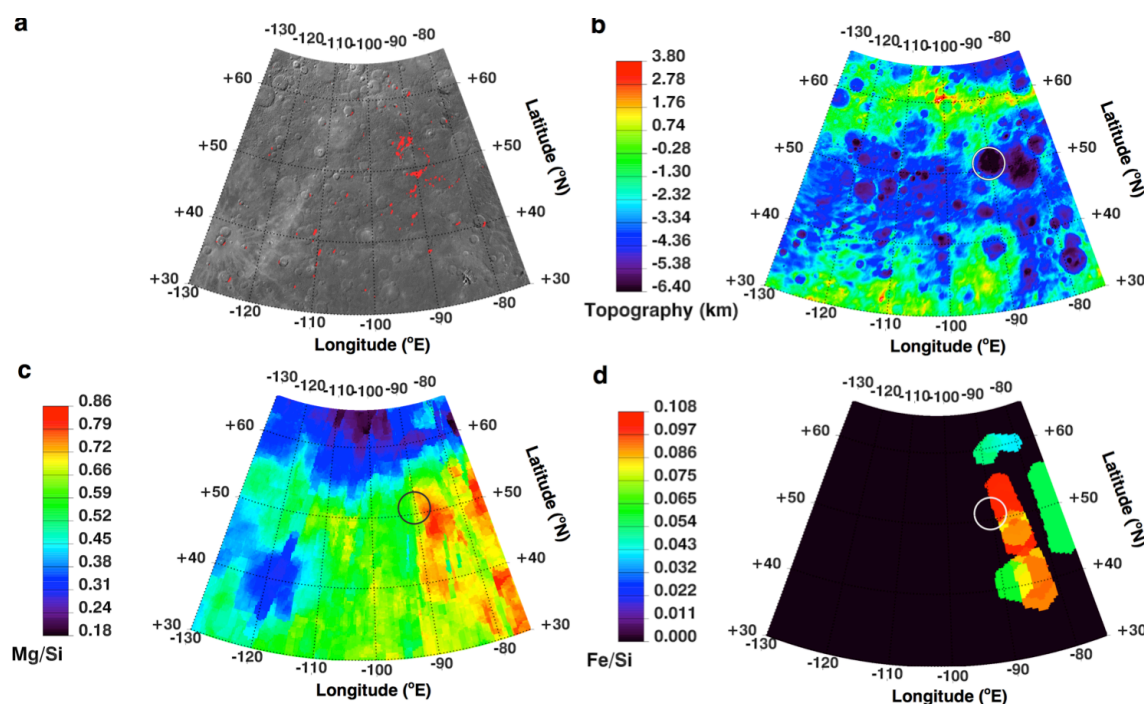


Figure S2. The full extent of study area B, a $\sim 3 \times 10^6 \text{ km}^2$ area that includes the LRM **B** deposit. LRM is found within the ejecta of Sholem-Aleichem crater (centered at 50.9° N , 269.7° E). **a**, LRM (in red) superimposed on an MDIS global mosaic produced from images acquired with the filter centered at 750 nm. **b**, Topography, given as elevation relative to a sphere of radius 2440 km, with the crater of interest outlined with a dashed white circle. **c**, XRS-measured Mg/Si weight ratio, with the crater of interest outlined with a black circle. **d**, XRS-measured Fe/Si weight ratio, with the crater of interest outlined with a white circle.

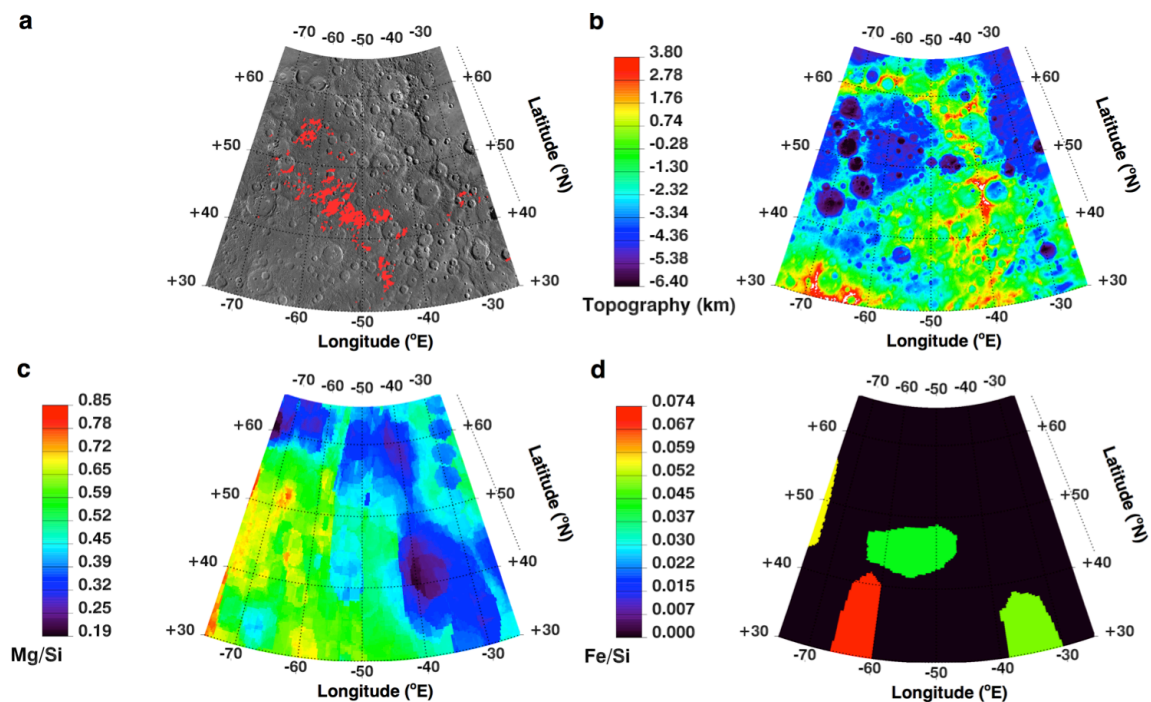


Figure S3. The full extent of study area C, a $\sim 3 \times 10^6 \text{ km}^2$ area that includes the LRM C deposit. **a**, LRM (in red) superimposed on an MDIS global mosaic produced from images acquired with the filter centered at 750 nm. **b**, Topography, given as elevation relative to a sphere of radius 2440 km. **c**, XRS-measured Mg/Si weight ratio. **d**, XRS-measured Fe/Si weight ratio. One XRS measurement, acquired during a solar flare that occurred on 16 September 2014, 05:07 UTC, coincides with the LRM C deposit.

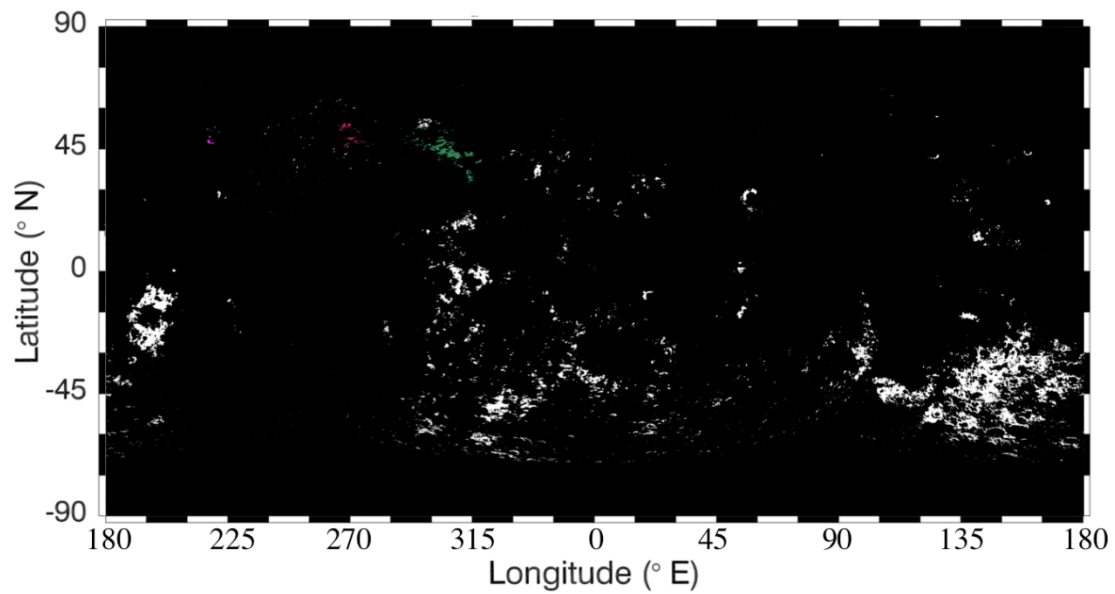


Figure S4. Global distribution of low-reflectance material (LRM) on Mercury.

Cylindrical equidistant projection. The LRM deposits in SA A, B, and C as sampled in the spectral data (Figure 1) are shown in purple, red, and green, respectively. See *Klima et al.* [2015] for details.

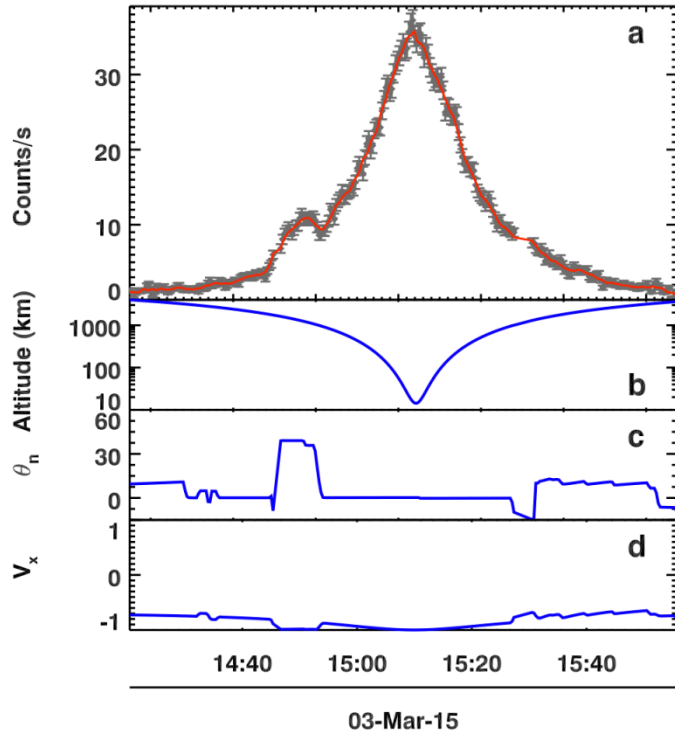


Figure S5. Time series of NS data and spacecraft ephemeris during orbit 3937. The data include low-altitude observations acquired over study area A. **a**, NS-measured count rates and one-standard-deviation errors, measured by from LG2, the detector with enhanced thermal neutrons when $V_x < -0.5$. **b**, Altitude of the spacecraft. **c**, Nadir angle (θ_n), a measure of the orientation of the NS relative to the surface. **d**, The x component of the spacecraft velocity (V_x).

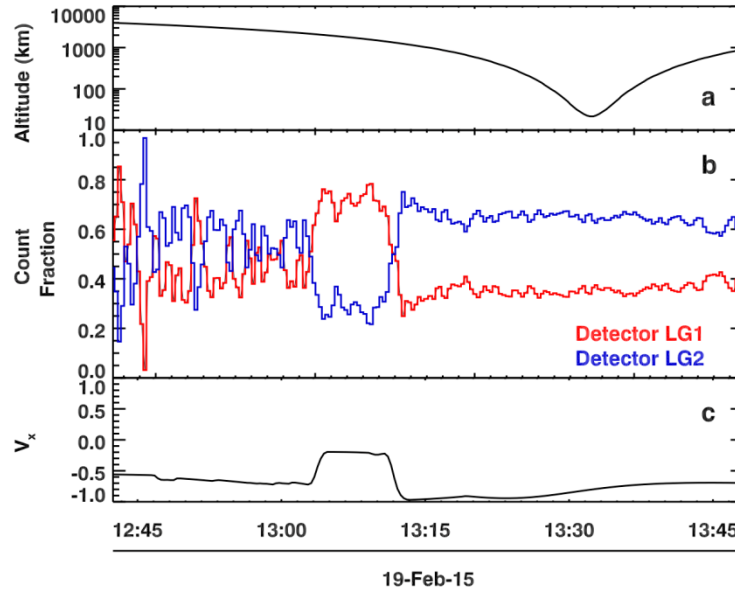


Figure S6. Time series of NS data and spacecraft ephemeris during orbit 3902. a, Altitude of the spacecraft. **b,** Fractional count rates for LG1 (red) and LG2 (blue), calculated as the measured count rate in that detector divided by the sum of the count rates in the two detectors. **c,** The x component of the spacecraft velocity V_x .

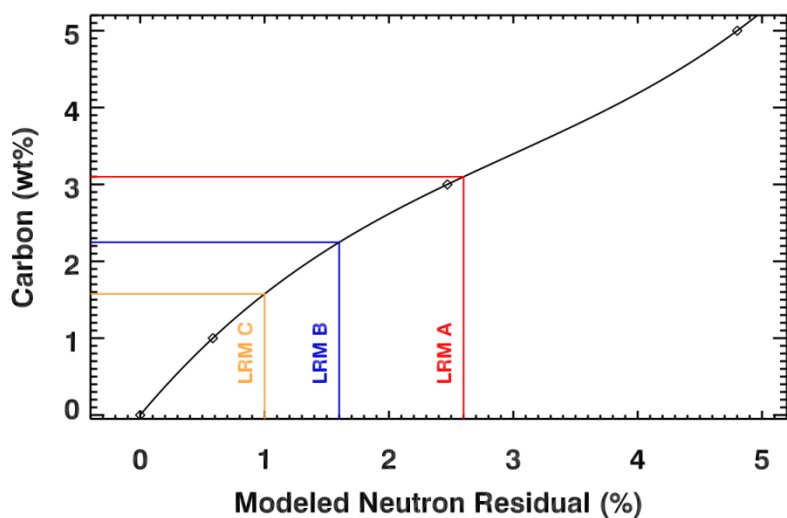


Figure S7. Modeled relationship between neutron residual and total carbon concentration. Colored lines denote the measured thermal neutron enhancements for each LRM deposit, and the corresponding C concentration derived from a fit (solid black line) to the modeled relationship (modeled values are diamonds).



Figure S8. Comparison of relative reflectance of the Moon and Mercury. The lunar mosaic was assembled from images taken with the 643 nm filter of the Lunar Reconnaissance Orbiter Camera Wide-Angle Camera. The Mercury mosaic was assembled from images taken with the 630 nm filter of the Mercury Dual Imaging System wide-angle camera. The Moon is centered on 0°N, 0°E. Mercury is centered at 0°N, 15°E.

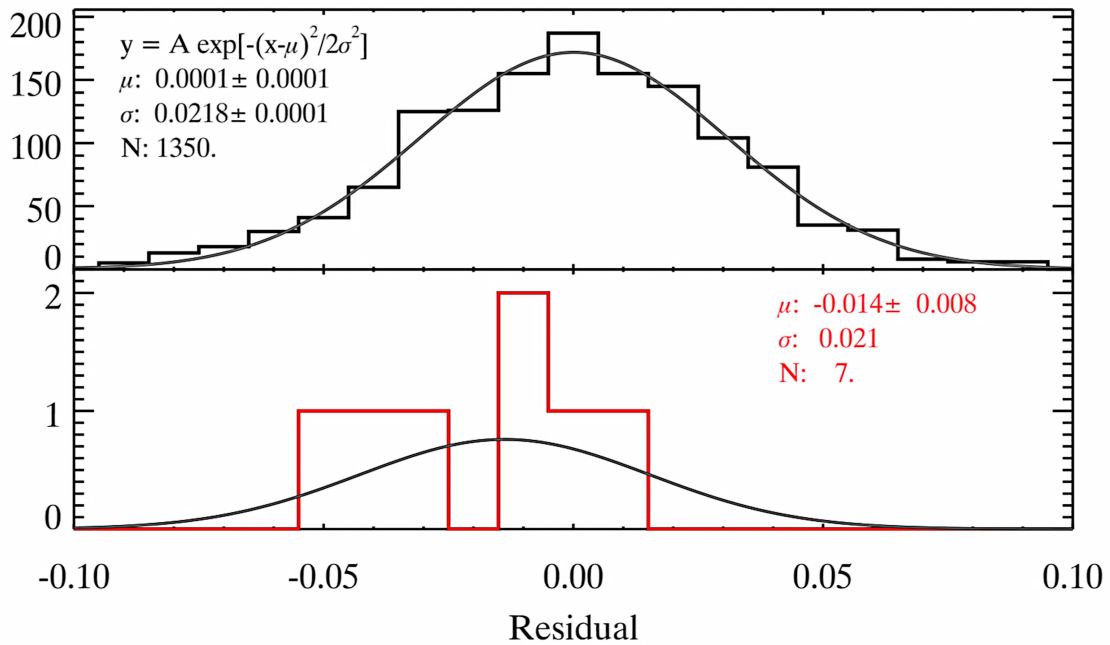


Figure S9. Histograms of the HPF-subtracted neutron measurements (residuals) for the Rachmaninoff pyroclastic deposit. All data for the study area are shown in black; data that sampled the halo of high-reflectance pyroclastic deposits (PD) surrounding a candidate volcanic vent are shown in red. For each histogram, a Gaussian function with a mean value μ and a width σ_g has been used to characterize the population of size N (grey line; see **Methods**). The PD sampling data show a negative mean residual (μ), corresponding to localized decrease in thermal-neutron count rates.