can therefore be quantified from high-altitude data, beyond the range of detection for planet-originating signals (see Table 3). As S_N, S_B, and S_A are not present for radioactive elements, S_P is determined by simply subtracting S_R from the low-altitude measurement of interest.

[61] Stable elements are subject to backgrounds from S_N, S_B, and S_A. One of these backgrounds, S_B, can be removed using geometric information. S_B is a function of the spacecraft-incident GCR flux and therefore depends on both altitude and time. The altitude variations are due to occultation of GCRs by Mercury, and the time dependency is the result of variations in the GCR flux in response to varying solar conditions (e.g., *McKinney et al.* [2006] and discussion in section 3.3). The altitude dependence of S_B is characterized as

$$S_B(h) = S_B(\infty) \cdot [1 - \Omega(h)] \quad \text{(C1)}$$

where $\Omega(h)$ is the fractional solid angle of the planet as viewed by the GRS (see section 3.4). As $\Omega(h)$ describes the fraction of the 4π-sr field of view of the GRS that is filled by its horizon-to-horizon view of the surface, 1-$\Omega(h)$ describes the fraction that is unobstructed by Mercury, and by extension the fraction of the total GCR flux that has access to the spacecraft. $S_B(\infty)$ is quantified with the GRS data acquired near apoapsis (~15,500 km, Table 3), where $\Omega(h) \rightarrow 0$. The altitude-dependent model for $S_B(h)$ (equation (C1)) allows for the removal of $S_B(h)$ from the measured gamma-ray signal.

[62] Measurements of stable elements can also be contaminated by S_A, which describes the long-lived activation of spacecraft components by incident particles. S_A is dominated by contributions from spacecraft-incident solar flares, which under certain conditions can produce activation products in the spacecraft (e.g., ^{56}Fe(p, n)^{56}Co, $t_{1/2}$ = 77.2 d, and ^{48}Ti(p, n)^{48}V, $t_{1/2}$ = 15.9 d). Contributions from S_A are negated by omitting flare-compromised data from the analysis of elemental abundances when such activation products are present (Evans et al., submitted, 2012). However, S_A does not contribute to the Si and O gamma rays examined here.

[63] The final source of background signal for the stable elements is the excitation of spacecraft materials by planet-originating neutrons (S_N). S_N has the same altitude-dependence (equation (1)) as S_P when it originates from inelastic scattering, as is the case for the Si and O gamma rays examined here. S_N originating from neutron capture is complicated by the fact that thermal neutrons are gravitationally bound to Mercury and thus have a different altitude dependence than those originating from inelastic scattering. The fact that the inelastic scattering S_N backgrounds have the same altitude dependence as the signal of interest prevent utilizing the spacecraft ephemeris to remove the background from the measured signal, as was done for S_B (equation (C1)). Under certain circumstances, S_N can be removed by utilizing knowledge of the nuclear reaction cross sections for the elements under consideration (Peplowski et al., submitted, 2012), but for this analysis S_N was not removed from the data prior to analysis.

[64] The presence of S_N in the Si and O results presented here suggests the possibility that these results are dominated by spacecraft backgrounds. An early attempt to characterize S_N was carried out by *Rhodes et al.* [2011], who defined the background amplification factor (A_{BG}) to be the ratio of the low- to high-altitude count rates in the 1014-keV Al inelastic scattering peak. This peak was chosen because it was assumed, as a result of the large amount of Al surrounding the HPGe, that the measured Al peaks would be dominated by spacecraft-originating background. In the formalism presented here, this assumption would correspond to

$$A_{BG} = \frac{[S_P + S_N + S_B]^{LA}}{[S_B]^{HA}} \rightarrow \frac{S_N^{LA}}{S_B^{HA}} \quad \text{(C2)}$$

where HA and LA are the high- and low-altitude data selections, and $(S_P + S_N + S_B)^{LA} \rightarrow S_N^{LA}$ on the basis of the fact that $S_B^{LA} \ll (S_P + S_N)^{LA}$ (see Table 3) and the assumption that $S_N^{LA} \gg S_P^{LA}$ for gamma rays from Al [*Rhodes et al.*, 2011]. Analysis of the Al peak provided a background amplification factor of 2.10 ± 0.49. A more rigorous examination of the Al backgrounds (Peplowski et al., submitted, 2012) revealed that for Al, $S_P^{LA} \approx S_N^{LA}$, and therefore a value of 2.10 overestimates the background amplification factor.

[65] On the basis of MESSENGER X-Ray Spectrometer measurements indicating that abundances of Ti on the surface of Mercury are low [*Nittler et al.*, 2011], the 983-keV Ti peak meets the requirement of $S_N^{LA} \gg S_P^{LA}$ and was therefore used to determine an improved background amplification factor. Analysis of this peak (Figure C1) yields an amplification factor of 1.49 ± 0.10. Application of this background amplification factor provides $S_N = A_{BG} \times S_B$ values of 0.228 ± 0.029 and 0.434 ± 0.035 counts per minute for Si and O, respectively. These values correspond to S_N/S_P = 0.12 (Si) and S_N/S_P = 0.32 (O), which suggest that our Si and O count rate maps are derived primarily from signals from the planet, but those signals are mixed with nonzero background contributions.

[66] The background amplification factor method relies on the assumption that the value derived from the 983-keV Ti gamma ray is applicable to other elements. Since the inelastic scattering cross sections depend on the specific isotope in question as well as the energy of the gamma ray of interest, this assumption must be tested. Cross-section data for Ti, Si, and O were retrieved from the Evaluated Nuclear Data File (ENDF) [*Chadwick et al.*, 2011] database for the inelastic scattering reactions leading to the production of 983-keV Ti, 1779-keV Si, and 6129-keV O gamma rays. A comparison of the cross sections reveals that they are of similar magnitude, so the use of the Ti gamma ray to quantify the change in the Si and O gamma-ray backgrounds is valid. It should be noted that because the Ti line is of lower energy than the Si and O gamma rays of interest, it samples the neutron flux at lower energies. Since the neutron flux from the planet decreases with increasing energy [e.g., *Feldman et al.*, 1998], the 983-keV-derived amplification factor is an upper limit, and the actual values of S_N will be smaller, particularly for the 6129-keV O gamma ray.

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