standard-deviation level with the exception of the Th abundance for the Caloris basin interior, which is found to be 1.3 standard deviations larger than the northern-hemisphere average value.

[28] Unlike the analysis of *Peplowski et al.* [2011b], this analysis does not utilize the 911-keV gamma ray in the Th abundance calculation. That earlier work was based on the assumption that the 911-keV line originated entirely from Th for both the spacecraft-originating background and the planetary signal, a view supported by modeled planetary gamma-ray fluxes [*Reedy*, 1978] as well as previous analyses [e.g., *Evans et al.*, 2006]. Analysis of the behavior of the high-altitude 911-keV gamma ray as a function of time has identified an increase in its count rate and a change in its spectral shape following the solar particle event of 4 June 2011. The change in shape includes a shift in the peak position to lower energy (∼908 keV). As 911-keV Th gamma-ray emission is not excited by incident charged particles, these observations suggest that there is a previously unidentified source of 908-keV gamma rays originating from the excitation of spacecraft materials by incident charged particles. The low signal-to-noise ratio of the 911-keV Th peak makes spectral fitting challenging in this region, and the added complication of a time-dependent interfering peak at 908 keV adds large uncertainties to any Th abundance derived from the 911-keV peak. As a result, this peak has not been utilized in our determination of the Th abundance.

[29] The data used by *Peplowski et al.* [2011b] were collected prior to the 4 June 2011 event, so the post-flare increase in the 911-keV count rate was not a factor in that analysis. However, the presence of a 908-keV background in the post-flare data raises the possibility that non-flare-compromised data also included contributions from an unknown 908-keV source of gamma rays. This uncertainty introduces the prospect that the Th abundances derived from this gamma ray result in an overestimation of the planetary Th abundances. *Peplowski et al.* [2011b] found that the Th abundance derived from the 911-keV peak was larger than that derived from the 2615-keV peak, but the two values were consistent to within the errors of the measurements, and the final reported Th abundance was the average of the two values. In light of the possibility that there is an interfering peak in the 911-keV region, the *Peplowski et al.* [2011b] Th abundance derived from both the 2615- and 911-keV gamma rays (0.220 ± 0.060 ppm) was replaced by their value from the 2615-keV peak of 0.175 ± 0.070 ppm for the discussion in this paper (Table 4). The K/Th ratio of 5200 ± 1800 was likewise replaced by the value derived from the 2615-keV peak of 6600 ± 2800.

5. Potassium on the Surface of Mercury

5.1. Correlations With Major Geologic Units

[30] The observed variations in K over the surface of Mercury invite a comparison to the known geologic units on the surface. As the spatial resolution of the GRS is ∼1000 km over the mapped regions, only large geologic units are included in this comparison. These units include the northern volcanic floodplains that cover 6% of the total surface area of the planet [*Head et al.*, 2011] as well as the smooth plains interior to the 1,550-km-diameter Caloris impact basin. Outlines of these units are shown on the K abundance map in Figure 8. There is no clear correlation between the observed K abundances and the locations of these units, but the northern volcanic plains are generally higher in K than other regions. Analysis of orbital data from the MESSENGER X-ray Spectrometer (XRS) by *Weider et al.* [2012] demonstrate that the northern volcanic plains are also compositionally distinct (in terms of Mg, Al, S, and Ca) from the surrounding older terrain. A limited number of XRS measurements of the Caloris basin reveal an elemental composition for the interior basin plains that is similar to the composition of the northern volcanic plains unit, a result that is consistent with their similar spectral reflectance and color properties [*Denevi et al.*, 2009]. This similarity contrasts with the measured K abundances, which differ significantly between the northern volcanic plains and the Caloris basin interior. The plains interior to Caloris do not appear as a distinct region in the K abundance map. This result runs contrary to the interpretation of ground-based mid-infrared measurements that the Caloris basin interior plains have spectral features indicative of particularly high abundances of K-rich feldspar [*Sprague et al.*, 2009].

[31] To quantify possible correlations between the K abundance map and the geologic units discussed here, K abundances were calculated for subsets of the coverage area corresponding to the geologic regions of interest following the procedure outlined in section 4.4. As is the case for the regional Th measurements, the large footprint of the GRS on the surface results in the calculation of abundances from observations that include contributions from outside the regions of interest. As a result, the calculated abundances do not strictly correspond to the listed regions. Even with this complication, the results (Table 4) reinforce the conclusion that the northern volcanic plains are predominantly contained within the region of higher K. The Caloris basin interior has the lowest average K abundance of the regions considered, although it is within one standard deviation of the average abundance for the older terrain surrounding the northern volcanic plains.

5.2. Potassium- to-Thorium Ratio

[32] The abundances of relatively volatile elements on the surface of Mercury, including K, have important implications for our understanding of the formation and early evolution of the planet [e.g., *Taylor and Scott*, 2003]. GRS measurements of the present-day elemental composition of the surface can be used to test the validity of formation models for Mercury through a comparison with their predicted surface compositions. Processes that have modified modern abundances from their original values complicate these comparisons. For example, Mercury's surface has been subject to extensive volcanic activity [e.g., *Head et al.*, 2008], and volcanic processes are known to modify the abundances of incompatible elements such as K and Th. To avoid this complication, the ratio of the abundance of the moderately volatile K to that of Th, a refractory element, is frequently used as a proxy for the volatile inventory of a planet [e.g., *Prettyman et al.*, 2006; *Taylor et al.*, 2006]. On the Moon and Mars, the measured K/Th ratio is observed to be nearly constant over the surface, despite large regional variations in the absolute values for each element. This near uniformity is due to the incompatible nature of these elements during