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The K and Th concentration in the Martian crust: insights from multi-scale analyses

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Abstract Text:

The univariate statistics of potassium (K) and thorium (Th) concentrations in the oceanic and continental crust of the Earth has been recently investigated from geochemical databases and airborne radiometric surveys [1]. This study demonstrates that the frequency distributions of these elements are scale-dependent. There are right-skewed for small-scale samples (typical volume of rocks analyzed for an individual sample in a dataset) but tend to be more symmetric for large-scale samples. The right-skewed behavior of K and Th is attributed to their incompatible behavior during partial melting or fractional crystallization. The scale-dependence and evolution toward normal distributions are a direct consequence of the central limit theorem applied to K and Th concentrations. The results of the results of this study may be applied to Mars, using the Mars Odyssey global maps of K and Th concentrations [2]. In light of available K, Th concentrations at the rock-scale (in-situ samples and martian meteorites), we infer that each "pixel" of these maps reflect a right-skewed distribution of K and Th concentrations at smaller-scales, where K and Th-poor rocks, such as basalts, are spatially dominant. In turn, K, and Th-rich rocks, such as those found by Curiosity at Gale crater [3], may occur globally, though their spatial extension must be limited to account for the values reported by Mars Odyssey. The global, but sparse occurrence of K, Th-rich rocks at the surface is consistent with a buried felsic crust, outcropping at the favor of tectonic or impact events. These conclusions will be discussed in the context of the inferred constraints about the structure of the martian crust from Insight data [4].

[1] Baratoux, et al., Earth and Space Science, in press. [2] Boynton et al. JGRP, doi:10.1029/2007JE002887. [3] Sautter et al. doi:10.1038/NGEO2474. [4] Knapmeyer-Endrun et al., Science, doi: 10.1126/science.abf8966

Plain-Language Summary:

The global maps of potassium (K) and thorium (Th) achieved by the Mars Odyssey mission are revisited in light of recent results on the frequency distributions of K and Th in the terrestrial crust. We demonstrate that the frequency distributions of the concentrations of these elements are scale-dependent, and generally evolve from right-skewed distributions toward normal distributions for increasing sample sizes. Extrapolating these results to Mars imply that K-poor and Th-poor rocks are spatially dominant at the surface of Mars, whereas sparse, but global occurrences of K and Th-rich rocks are necessary to account for Mars Odyssey results. These space occurrence of K and Th-rich rocks may reflect the existence of a buried and more evolved component of the martian crust. These conclusions will be discussed in the context of the inferred constraints about the structure of the martian crust from Insight data.

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