Redistribution of radiogenic heat sources and volatiles from mantle to crust is controlled by planet size

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Melting processes inside the upper mantle are the primary reason for the enrichment of trace elements – such as heat producing elements or volatiles - in planetary crusts. Melt that is less dense than solid mantle rock and that is enriched with incompatible trace elements from the mantle rises towards the surface and leaves behind a depleted upper mantle. Mineral/melt partition coefficients help us quantifying the amount of the redistributed elements from solid rocks and therefore, in the case of heat producing elements or volatiles, their impact on thermal evolution and outgassing of a planet. Generally, partition coefficients are highly dependent on pressure, temperature, and melt composition, but due to a lack of high-pressure experiments and models, they were typically taken as constant in mantle evolution models. However, by applying a new partition coefficient scaling law that is applicable up to 12 GPa (Schmidt & Noack, 2021), it is now possible to take the pressure, temperature, and compositional effect on redistribution in mantle evolution models into account. In this study, we include the aforementioned partition coefficient model into an interior evolution model and show the variation of the partition coefficients depending on planetary body size. We quantify the effect on thermal evolution, crust production, and outgassing rate by investigating the redistribution of heat producing elements (K, Th, and U) and H2O specifically. Comparisons of the five planetary bodies Mercury, Venus, Earth, Moon, and Mars show that the planet size has a significant effect on the partition coefficients, which makes partition coefficients based on low-pressure experiments with an Earth-based composition quite inaccurate in interior evolution models. Since there is a rise in extrasolar planet modelling in the past years, this finding might also be relevant for interior evolution models of rocky exoplanets, as their possible chemical budget and HPE concentration can be inferred from the star and compared to rocky solar system bodies. Schmidt, J.M. and Noack, L. (2021): Clinopyroxene/Melt Partitioning: Models for Higher Upper Mantle Pressures Applied to Sodium and Potassium, SysMea, 13(3&4), 125-136.