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Applying locally calculated partition coefficients for radiogenic heat sources and volatiles to interior evolution models of terrestrial planets

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The radiogenic elements K, Th, and U are large contributors to the heating inside a terrestrial planet. Because they act incompatible in solid mantle rocks, they prefer to gather in partial melt, which is generally less dense than the surrounding material and rises upwards. While rising, the melt transports the radiogenic heat sources and other incompatible elements towards the surface, where over time they accumulate inside the crust. The amount of the transported incompatible elements is heavily dependent on their degree of incompatibility in mantle rocks and therefore their mineral/melt partition coefficients. Despite the fact that partition coefficients can change by multiple orders of magnitudes from 0-15 GPa along a peridotite solidus (Schmidt and Noack, 2021), they were generally taken as constant in mantle evolution models due to a lack of high-pressure models and experimental data.

Based on the thermodynamic approach of Blundy et al. (1995), Schmidt and Noack (2021) modelled partition coefficients for sodium in clinopyroxene/melt from 0-15 GPa. As sodium has a very low strain in the M2 lattice site of clinopyroxene and is therefore very compatible, its partition coefficients can act as a reference to model the other elements from. In this study, we take the approach of Schmidt and Noack (2021) to model the partition coefficients of the above-mentioned heat producing elements and volatiles at local P-T conditions for partial melting events inside the mantle of terrestrial planets. We insert local bulk partition coefficients for an adequate mantle rock composition into a 1D interior evolution model of Mars. By comparing the results of the redistribution to models with constant partition coefficients, we can assess the impact of the locally calculated partition coefficients on the accuracy of models which deal with the thermal evolution of a planet and the enrichment of heat producing elements and volatiles inside the crust.

Blundy, J. et al. (1995): Sodium partitioning between clinopyroxene and silicate melts, J. Geophys. Res., 100, 15501-15515.

Schmidt, J.M. and Noack, L. (2021): Clinopyroxene/Melt Partitioning: Models for Higher Upper Mantle Pressures Applied to Sodium and Potassium, SysMea, vol 13 nr 3&4, to be published.