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Constraints from Earth's budget on mantle dynamics

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The recent years have seen an increase in the number of proposed models to explain the Earth mantle dynamics: while two extreme end-members have been ruled out (upper and lower mantle convecting separately from each other, and pure, whole mantle convection), several replacement possibilities have been raised. The underlying idea behind these models is that, among the identified reservoirs in the Earth, we lack a clearly-identified reservoir that is enriched in radiogenic elements, as is required to account for our current estimate of the Earth budget. This reservoir would be responsible for the peculiar geochemical signature in some OIBs like Hawaii, but would be rarely sampled at the surface. In this study, given our current knowledge of mass- and heat-budget for the Bulk Silicate Earth from geochemical, cosmochemical and geodynamical observations and constraints, we quantify the radiogenic heat enrichment of the 'unknown' subset to balance the budget. We highlight the inherent trade-off between heat production rate and mass of the unknown subset. From this analysis, we investigate the dynamical consequences in four specific cases, when the unknown subset coincides with a deep layer above the CMB with a thickness of respectively 150, 500, 1000 and 1600 km. We perform 2D thermochemical convection simulations, and discuss the viability of the four cases against several criteria: stability of the deep layer through time, topography of the interface, effective density profile, intrinsic chemical density and heat flux at the CMB.