Importance of mineralogy and mineral properties on the dynamics, structure and evolution of Earth's deep mantle

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Seismic observations of the deep Earth reveal the presence of two large low shear velocity provinces (LLSVPs) that are typically inferred to be dense chemically-distinct material, as well as discontinuities that are typically linked to the post-perovskite (pPv) phase transition. Several possible origins of chemically-dense material have been proposed, including recycling of mid-ocean ridge basalt (MORB), primordial differentiation events, crystallisation of a basal magma ocean, or some combination of these creating a basal melange (BAM; Tackley 2012 Earth Sci. Rev.). Each of these possibilities would result in a different composition hence different mineralogy. In order to constrain this we have been running calculations of thermo-chemical mantle evolution over 4.5 billion years that include a self-consistent treatment of mineralogy based on free-energy minimization using the code Perple_X (Connolly, 2005 EPSL). This provides a framework to evaluate the influence of composition and mineralogy on the resulting thermo-chemical structures, and allows viable compositions to be constrained by comparison of resulting seismic structures to seismic tomographic models and other seismological observations. The numerical models also include melting-induced differentiation, plate tectonics induced by plastic yielding, core cooling and compressibility. Already-published results (Nakagawa et al., 2009 GCubed, 2010 PEPI, 2012 GCubed) already indicate the importance of exact MORB composition on the amount of MORB segregating above the CMB, which in turn influences mantle thermal structure and the evolution of the core and geodynamo. New results additionally include primordial material and will be reported here. By running O(1000s) calculations we are able to systematically constrain the possible combinations of composition and other physical properties that result in present-day structures that give a statistically good match to tomographic structures, as well as other observations such as the occurrence of the pPv phase transition.