Influence of melting on the long-term thermo-chemical evolution of Earth's deep mantle

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Melting has always played a key role in Earth evolution. Early solidification of a magma ocean may have left the mantle compositionally stratified and may have continued in the form of a long-lived basal magma ocean (BMO). Ongoing upper mantle/transition zone melting, perhaps associated with water and carbonate, may have caused 'internal differentiation', resulting in dense enriched products that sink. Throughout Earth's history melting in the shallow mantle has produced crust, most of which was recycled into the interior and some of which may have segregated above the core-mantle boundary, joining possible enriched products from early differentiation, internal differentiation and BMO solidification to produce a Basal Melange (BAM). Here we investigate the thermal and chemical evolution of Earth's interior from the ~molten state to billions of years later using global-scale numerical simulation. Our previously-published models that included only oceanic crustal production and recycling (e.g. Nakagawa & Tackley, 2014) indicated that (i) a layer of subducted crust can rapidly build up above the CMB, (ii) early-formed layering above the CMB may have been necessary to avoid rapid early core cooling and a too-large present-day inner core, (iii) magmatism is the dominant heat transport mechanism early on, (iv) melting acts as a thermostat, buffering mantle temperature. Here we improve the models to handle deep melting including melt fractions of up to 100%, fractional melting using a eutectic model, segregation of melt and solid, and a parameterized magma ocean treatment at high melt fractions (using an eddy diffusivity based on mixing length theory, similar to previous 1-D treatments). We investigate and characterize the evolution of deep mantle structure in the limits of negatively buoyant melt and positively buoyant melt. We focus on the interplay of deep melting and melt migration, primordial layering, recycled crust and harzburgite, and products of upper mantle internal differentiation, in producing a heterogeneous deep mantle.

[1] Nakagawa, T., and P. J. Tackley (2014), Influence of combined primordial layering and recycled MORB on the coupled thermal evolution of Earth's mantle and core, *Geochem. Geophys. Geosyst.*, *in press*.