



Mixing in mantle convection models with self-consistent plate tectonics and melting and crustal production: Application to mixing in the early Earth

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It is generally thought that the early Earth's mantle was hotter than today, which using conventional convective scalings should have led to vigorous convection and mixing. Geochemical observations, however, suggest that mixing was not as rapid as would be expected, leading to the suggestion that early Earth had stagnant lid convection (Debaille et al., EPSL 2013). Additionally, the mantle's thermal evolution is difficult to explain using conventional scalings because early heat loss would have been too rapid, which has led to the hypothesis that plate tectonics convection does not follow the conventional convective scalings (Korenaga, GRL 2003). One physical process that could be important in this context is partial melting leading to crustal production, which has been shown to have the major effects of buffering mantle temperature and carrying a significant fraction of the heat from hot mantle (Nakagawa and Tackley, EPSL 2012), making plate tectonics easier (Lourenco et al., submitted), and causing compositional differentiation of the mantle that can buffer core heat loss (Nakagawa and Tackley, GCubed 2010). Here, the influence of this process on mantle mixing is examined, using secular thermo-chemical models that simulate Earth's evolution over 4.5 billion years. Mixing is quantified both in terms of how rapidly stretching occurs, and in terms of dispersion: how rapidly initially close heterogeneities are dispersed horizontally and vertically through the mantle. These measures are quantified as a function of time through Earth's evolution. The results will then be related to geochemically-inferred mixing rates.