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The Great Thermal Divergence and the slope break of the 660 phase transitions

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About 2.5 Ga ago, two distinct mantle sources for basalts developed: one with a lower mantle potential temperature (MPT) being today relatively depleted and feeding the mid-ocean ridges, and one with a higher MPT being relatively enriched and pluming today's ocean-island-basalt (OIB) volcanism (Condie et al., 2016). Previous to that, basalts record rather uniform MPTs corresponding to today's higher-temperature OIB reservoir. The cooler mantle domain started forming, when the slowly cooling thermally uniform mantle reached a MPT of 1550-1500 °C (Condie, 2018). We attribute this "Great Thermal Divergence" (Condie et al., 2016) to a transition from non-layered to layered mantle convection. For primitive mantle compositions, a 1530-adiabat propagates precisely to the high-temperature slope break of the 660 phase transition at about 1800 °C/23 GPa. Mantle with MPT higher than that does not experience the suppression of convective passage through the lower-upper mantle boundary, which results from the negative slope of the ringwoodite-to-perovskite-plus-periclase transition. We propose that mantle convection prior to 2.5 Ga was capable of stirring the whole mantle. A 660 phase transition with a negative slope formed only 2.5 Ga ago and thus established a thermomechanical boundary layer that allowed the formation of two thermally distinct mantle reservoirs.

Condie, K. et al. (2016): A great thermal divergence in the mantle beginning 2.5 Ga: Geochemical constraints from greenstone basalts and komatiites. Geoscience Frontiers, 7, 543-553.