Anomalies of temperature and iron in the uppermost mantle

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Anomalies of temperature and composition in the Earth's mantle induce anomalies of density and seismic velocities. Seismic tomography models do not give access to temperature anomalies and compositional changes simultaneously. To infer these anomalies, one needs an additional data set, such as gravity data.

First, we invert gravity anomalies (EGM96) and a global S-wave velocity model (S16RLBM) for the ratio $\zeta = dln\rho/dlnV_s$, which relates relative density anomalies to relative S-wave velocity anomalies. Data are filtered for the spherical harmonic degrees 11 to 16, and calculations are made separately for oceanic and continental regions. The resulting model of ζ is significantly different for the sub-continental and sub-oceanic mantle. Below continents (oceans), ζ has positive values down to z=220 km (z=140 km). The absolute values of ζ are small, less than 0.05. If one accounts for anelasticity, these values are consistent with mineral physics experiments. A variety of tests suggest that this model is robust.

We then invert relative V_s-anomalies (δV_s) and ζ for anomalies of temperature (δT) and global iron ratio (δFe). Positive V_s-anomalies are associated with negative temperature variations and iron depletion. For instance, the temperature and iron anomalies associated with δV_s=3% and ζ=0.03 are about δT=-150K and δFe=-1.25%, respectively. We then compute values of δT and δFe in the uppermost mantle down to 300 km. Below oceans and tectonic continents, the mantle is nearly homogeneous i.e., the mean values of δT and δFe are close to zero. On the other hand, down to z=250 km old cratons are significantly colder than average mantle and depleted in iron: the mean values of δT and δFe reach -300K and -2.7%, respectively. This result is important since depletion in iron induces positive buoyancy that may balance the negative buoyancy induced by low temperatures.