Upper-Mantle Velocity-Temperature Conversions and Composition at Regional and Continental Scales

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Two approaches are used to constrain upper-mantle mineralogy and composition on 1) a regional-scale in the Archean Superior Province and 2) on a continental-scale for North America.

Regional variations

For the regional study, joint datasets of Pn velocity from seismic refraction and heat flow are used. Seismic velocities are sensitive to both temperature and composition and values of Moho temperature from heat flow allow constraints on upper mantle composition. The good correlation between calculated Moho temperatures and Pn velocities show that variations of upper mantle composition are subdued at this scale. Quantitative analysis depends on two control variables, the Moho heat flow and the upper mantle composition. For all Moho heat flows, undepleted (clinopyroxene rich) mantle compositions do not allow a good fit to the data. For our preferred Moho heat flow of 15 mWm^{-2}, the best-fit mantle composition is slightly less depleted than models for average Archean subcontinental lithospheric mantle. In the Superior Province, this may be due to rejuvenation by melt-related metasomatism during Mid-Continental rifting.

Continent-scale variations

On the scale of the whole continent, simultaneously using constraints from heat flow, seismology, gravity and topography anomalies allows unprecedented coverage of compositional variations (in terms of Fe#) in the lithospheric mantle. Previously, continental-scale analyses of the upper-mantle thermochemical structure did not include the thermal constraints from heat flow and crustal heat production which are rather well sampled in many regions of the North American continent. The present inversions represent the first attempt to use the thermal constraints simultaneously with the gravity, topography, plate motion and geoid constraints on upper-mantle thermochemical structure. The effects of melt depletion on the density and seismic velocity of garnet are considered. The incorporation of the thermal dataset in the inversions provides greater confidence in the estimated variations in Fe#. Seismic wave velocity anomalies are checked for self-consistency with upper-mantle temperatures, which improves the resolution of compositional variations.