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Lateral heterogeneity and vertical stratification of cratonic lithospheric mantle

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We compare geophysical models for different cratons, with focus on structure and thermo-compositional heterogeneity of the lithospheric mantle. They include regional models of lithosphere density heterogeneity as constrained by free-board and satellite gravity data, thermal structure of the lithosphere based on surface heat flow data and supported by regional xenolith P-T arrays, and the non-thermal part of upper mantle seismic velocity heterogeneity based on joint analysis of thermal and seismic tomography data.

Density structure of the cratonic lithosphere constrained independently by free-board and satellite gravity shows significant lateral variations, that are well correlated with crustal structure, surface tectonics, and regional xenolith data. In all cratons for which we have data the Archean – early Proterozoic cratonic nuclei has lower density than Proterozoic sutures and intracratonic basins. However, xenoliths never sample most depleted lithospheric mantle of the Archean nuclei. We analyze correlations between mantle density, lithosphere tectono-thermal age and the emplacement age of kimberlites. We also present correlations between the crustal structure and the density structure of the lithospheric mantle.

Since the depth distribution of density anomalies cannot be constrained, we complement the analysis by seismic data. An analysis of temperature-corrected seismic velocity structure indicates strong vertical and lateral heterogeneity of the cratonic lithospheric mantle, with a pronounced stratification in many Precambrian terranes. We argue that a significant part of lateral and vertical heterogeneity of the cratonic lithosphere mantle can be explained by melt-metasomatism.