

Thermo-chemical heterogeneity of continental lithospheric mantle: Examples from Europe, Siberia, North America, and Southern Africa

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I present models of lithosphere compositional heterogeneity in different tectonic provinces worldwide based on density structure and the non-thermal part of upper mantle Vs anomalies. To separate compositional heterogeneity of the lithospheric mantle, the effect of regional temperature variations on density and Vs is removed by applying regional temperature corrections, constrained by heat flow data.

Significant parts of Precambrian cratons of Laurasia are characterized by extremely low surface heat flow values ($<25\text{--}30\text{ mW/m}^2$), which implies the depth extent of the lithospheric keels down to 300–350 km, at least locally. These values are in apparent contradiction with a worldwide compilation of cratonic xenolith P-T arrays, which are usually consistent with surface heat flow of around 40 mW/m^2 and the lithosphere thickness of 200–250 km depth. Models of lithosphere density and seismic velocity structure indicate that xenoliths do not sample mantle with the lowest density and the highest velocity.

Density structure of continental lithosphere mantle correlates with crustal structure and surface tectonics. This observation is illustrated by examples from the East European and the Siberian cratons, where lateral variations in density structure of the lithospheric mantle are compared with petrological studies of mantle-derived xenoliths from the Fennoscandian and Siberian kimberlite provinces. The results indicate that in the Siberian craton isopycnicity is satisfied only in major kimberlite provinces. High lithosphere density in major sedimentary basins suggests the presence of eclogitic material.

Since the depth distribution of density anomalies is unknown, the analysis is complemented by seismic data in order to understand better geodynamic causes of mantle density heterogeneity. Temperature-corrected seismic velocity structure based on published high-resolution tomography models indicates a pronounced stratification of lithospheric mantle in many Precambrian terranes, in agreement with xenolith data. The lateral extent of depleted lithospheric keels diminishes with depth and, below a 150–200 km depth, may be significantly smaller than geological boundaries of the cratons.