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Archean lithosphere in time and space: geophysical evidence on lateral and vertical heterogeneity in Siberia

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ARTEMIEVA, Irina[1*] ; HERCEG, Matija[1] ; CHEREPANOVA, Yulia[1] ; THYBO, Hans[1]
ARTEMIEVA, Irina[1*] ; HERCEG, Matija[1] ; CHEREPANOVA, Yulia[1] ; THYBO, Hans[1]

[1]IGN, University of Copenhagen
[1]IGN, University of Copenhagen

We present geophysical models for Precambrian cratons, including the structure of the crust and the lithospheric mantle, and the thermal structure of the Precambrian lithosphere based on surface heat flow data. A particular focus is on thermo-compositional heterogeneity of the lithospheric mantle. It is modelled as a non-thermal part of upper mantle seismic velocity heterogeneity based on a joint analysis of thermal and seismic tomography data, and as lithosphere density heterogeneity as constrained by free-board and satellite gravity data. The results are compared with xenolith data from the Siberian kimberlite provinces.

An analysis of surface heat flow indicates that many Precambrian cratons (particularly Siberia) are characterized by extremely low surface heat flow (<25-30 mW/m2), which is in apparent contradiction with a worldwide compilation of cratonic xenolith P-T arrays. In regions with very low heat flow, the depth extent of the lithospheric keels locally may reach the depth of 300-350 km.

An analysis of temperature-corrected seismic velocity structure indicates strong vertical and lateral heterogeneity of the cratonic lithospheric mantle. The lateral extent of depleted lithospheric keels diminishes with depth and, below a 150-200 km depth, is significantly smaller than geological boundaries of the cratons. In the Siberian craton, Proterozoic sutures and intracratonic basins are manifested by an increase in mantle density as compared to light and strongly depleted lithospheric mantle of the Archean nuclei.

We demonstrate that density structure of the cratonic lithosphere is well correlated with crustal structure and surface tectonics. The analysis of lithosphere seismic velocity and density structure allows for speculations on processes which formed and modified the Archean lithosphere.

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