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Linking crustal heterogeneity to the tectonic history: the case study of the Siberian craton and West Siberian Basin based on new regional crustal model

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We present and discuss the new model of the structure of the crust in two large tectonic regions of Siberia, the Paleozoic West Siberian Basin and the Precambrian Siberian craton. Our regional crustal model is based on compilation "from scratch" of all available, old and newly acquired, reliable seismic data. It includes the results of seismic reflection and refraction surveys (in particular, 41 DSS profiles ranging in length from 300 to 3000 km recorded both with nuclear (PNE) and chemical shots), as well as receiver functions studies. Seismic structure of the crust is digitized along the seismic profiles with a 50 km lateral spacing that is comparable with the resolution of seismic models. To limit accumulation of uncontrolled uncertainties, we have omitted crustal studies based on potential field modeling, tectonic similarities, or interpolations of seismic reflection/refraction data published as contour maps. The resultant compilation provides a good regional data coverage that allows us to examine the crustal structure with spatial resolution of at least 2 deg for most of Siberia. This spatial resolution is similar to the resolution of a global crustal model CRUST 2.0 constrained on a 2x2 deg grid, and thus allows us to compare the new regional crustal model with the global model. In particular, we find that the regional and global crustal models differ everywhere: (i) by +/- 5 to10 km in crustal thickness, (ii) by -0.3 to +0.5 km/s in Pn velocity, (iii) by -5 to +10 km for the thickness of the lower crust, (iv) by +0.4+0.8 km/s for the average basement Vp velocity. Systematically, the strongest discrepancies between the regional seismic data and the global crustal model are observed for the kimberlite provinces and the Viluy paleorift of the Siberian craton (SC) and for the Ob paleorift of the West Siberian Basin (WSB).

The analysis of the correlation between the crustal structure and the tectonic settings indicates the following patterns. (1) Typically, the depth to Moho ranges from 35 to 40 km in most of the WSB, whereas it is ca. 43-45 km for most of the SC, locally reaching 55-58 km depth and reducing to less than 35 km in the Viluy basin. (2) There are significant variations in the thicknesses of the individual crustal layers. In particular, thickness of the lower crust varies from 5-10 km over significant parts of the WSB to 25-30 km beneath the diamondiferous kimberlite provinces of SC. A ca. 1000 km long belt that extends in the longitudinal direction across the SC has an unusually thick crust (47-58 km), bounded by normal, ca. 40-km thick crust. The belt has less than 10-km thick high-velocity (Vp>7.2 km/s) lower crustal layer. Low heat flow in the belt suggests that eclogitization in the crustal root was subdued, thus allowing preservation of the ultra thick, seismically distinguishable, crust. (3) Average Vp velocities in the basement range from 6.5 to 6.9 km/s with the highest values observed in the northern part of the Ob rift and beneath the Putorana Plateau of the Siberian trap province. (4) The upper mantle Pn velocity structure is strongly heterogeneous, with the values typically ranging from 7.7 to 8.6 km/s. The values of 8.0-8.2 km/s are typical for most of WSB with local highs reaching 8.4-8.5 km/s in the Ob rift and local lows of 7.7-8.0 km/s observed in some axial parts of the paleorifts; the values of 8.3-8.4 km/s are typical for most of the SC with the highest Pn velocities observed in some of the kimberlite provinces. The observed heterogeneity of the crustal structure of the WSB and SC reflects their tectono-thermal evolution and is well correlated with major tectonic and magmatic structures such as paleorifts, the Siberian trap province, and the kimberlite fields of SC.