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Lithospheric models of the North American continent

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We constructed NACr14, a 3D model of the North American (NA) crust, based on the most recent seismic data from the USGS database. In comparison with the global crustal model CRUST 1.0, NACr14 is more heterogeneous, showing a larger spatial variability of the thickness and average velocities of the crustal layers. Velocities of the lower crust vary in a larger range than those of the other layers, while the thickness of all the three layers is on average between 11 and 13 km. The largest velocities of the crystalline crust (>6.6 km/s) reflect the presence of a 7.x layer (>7.0 km/s) in the lowermost part of the crust. Using NACr2014, a regional (NA07) and a global (SL201sv) tomography model, and gravity data, we apply an iterative technique, which jointly interprets seismic tomography and gravity data, to estimate temperature and compositional variations in the NA upper mantle. The results obtained demonstrate that temperature of the cratonic mantle is up to 150°C higher than when using a uniform compositional model. The differences between the two tomography models influence the results more strongly than possible changes of the depth distribution of compositional variations. Strong negative compositional density anomalies, corresponding to Mg # >92, characterize the upper mantle of the northwestern part of the Superior craton and the central part of the Slave and Churchill craton. The Proterozoic upper mantle of the western and more deformed part of the NA cratons, appears weakly depleted (Mg# ∼91) when NA07 is used, in agreement with the results based on the interpretation of xenolith data. When we use SL2013sv, the same areas are locally characterized by high density bodies, which might be interpreted as the effect due to fragments of subducted slabs, as those close to the suture of the Appalachians and Grenville province. We used the two thermal models to estimate the integrated strength and the effective elastic thickness (Te) of the lithosphere. In the peripheral parts of the cratons, as the Proterozoic Canadian Platform and Grenville, the integrated strength for model NA07 is ten times larger than in model SL2013sv, due to a model-dependent temperature difference of >200˚C in the uppermost mantle. In both models, Proterozoic regions reactivated by Meso-Cenozoic tectonics (e.g., Rocky Mountains and the Mississippi Embayment) show a weak lithosphere due to the absence of the mechanically strong part of the mantle lithospheric layer. Intraplate earthquakes are distributed along the edges of the cratons, characterized by a weak lithosphere or pronounced variations in integrated lithospheric strength and Te. In addition, the sum of the seismic moments shows that most of the energy is released by the weak lithosphere. These results suggest that the edges of the cratons are more prone to accumulation of tectonic stress and subsequent release by earthquakes, in comparison with the stable cratonic regions which resist deformation.