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A New thermal and compositional model of the North American lithosphere

M.T Tesauro (1), M.K Kaban (1), S.C Cloetingh (2), and W.M Mooney (3)

(1) GFZ, Earth Modelling, Potsdam, Germany (kaban@gfz-potsdam.de, +49 (331) 288 1172), (2) VU University, Amsterdam, Netherlands (sierd.cloetingh@vu.n), (3) USGS (mooney@usgs.gov)

We present a new thermal model for the upper mantle of North America. Seismic tomography data are often used to estimate thermal structure of the upper mantle. Goes and van der Lee (2002) have already presented such a model for North America. The main problem always related to these works is that variations of seismic velocities are associated with temperature variations, while composition of the mantle remains the same. Despite the effect of compositional changes on seismic velocities is likely less than the effect of temperature variations, it might be remarkable. As discussed in previous studies, the upper mantle under North America is characterized by strong compositional variations. In the present work we try for the first time to take into account the effect of composition using an integrative approach based on joint analysis of seismic and gravity data. We do this via an iterative adjustment of the model. Initially, upper mantle temperatures are directly estimated from the NA07 tomography model of Bedle and Van der Lee (2009) using mineral physics equations. For the first iteration a uniform composition and anelasticity model is applied for entire North America. The obtained temperature distribution is used to estimate the gravity effect and to remove it from the total mantle gravity anomalies, which are controlled by both temperature and compositional variations. The residual field to a large extent depends on compositional variations but still biased by errors in the initial temperature model. However, experimental data give us every reason to believe that the latter effect is less important. Therefore, we can predict compositional variations using the residual gravity anomalies and use them to correct the initial temperature field. The loop should be repeated until convergence is reached. In the last iteration we modify composition by introducing lateral and vertical variations of Mg# (the molar ratio Mg/(Mg+Fe)). Depth distribution of the compositional variations is taken in agreement with xenoliths studies (e.g. Griffin et al., 2004). The latter predict a strong Fe depletion in the shallow part of the upper mantle (<150 km) beneath the North American cratons. The re-estimated mantle temperatures, which correspond to the predicted composition, show much more variability compared to the initial ones and are consistent with the studies based on independent methods.