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A new density model of the upper mantle of North America

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We investigate the density structure of the North America upper mantle based on the integrative analysis of the gravity field and seismic data. The basis of our study is the removal of the gravitational effect of the crust from the observed field to determine the mantle gravity anomalies. We use a new crustal model, which is based on nearly all existing seismic determinations including the most recent. The resultant mantle gravity anomaly map shows a pronounced negative anomaly (-50 to –400 mgal) beneath western NA and the adjacent oceanic region, and positive anomalies (+50 to +350 mgal) east of the NA Cordillera. This pattern reflects the well-known division of NA into the stable eastern region and the tectonically active western region. In the same way we estimate the residual topography, which represents the part of the surface topography not- (or over-) compensated by the crustal structure. We invert these fields jointly with seismic tomography data to image density distribution within the crust and upper mantle. The inversion technique accounts for the fact that the residual gravity and residual topography are controlled by the same factors but in a different way, e.g. depending on depth. In the final stage we separate the effect of mantle temperature variations, which is estimated from seismic tomography models constrained by geothermal modelling. Some features of the composition density distribution, which are invisible in the seismic tomography data, are for the first time detected in the upper mantle. The strongest positive anomaly is co-incident with the Gulf of Mexico, and indicates possibly a high-density eclogite layer that has caused subsidence in the Gulf. Two linear positive anomalies are also seen: one with a NE-SW trend in the eastern USA roughly coincident with the Appalachians, and a second with a NW-SE trend beneath the states of Texas, New Mexico, and Colorado. These anomalies are interpreted as due either to: (1) the presence of remnants of the Farallon slab in the upper mantle; or (2) mantle density anomalies associated with westward directed subduction during the Laramie orogeny. The upper mantle beneath the Canadian shield exhibits a pronounced negative anomaly (-50 to –200 mgal) that is consistent with chemical depletion. Based on these geophysical results, we discuss the primary processes that have formed and modified the crust and lithospheric upper mantle.