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Temperature and compositional variations in the Australian cratons

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The upper mantle of the Australian continent has been deeply investigated in the last two decades using a variety of geophysical methods. The resulting models have revealed the robust large-scale features of the continental lithosphere of Australia, i.e. faster seismic velocities in the Archean and Proterozoic cratons in the West, North and South Australia and slower velocities in the eastern Phanerozoic margin. Furthermore, it has been identified a layered velocity structure in central Australia. The zone of low seismic velocities in the uppermost mantle is underlain by the high-velocity zone. This layered structure may have a thermal origin, due to a redistribution of high heat producing elements within the crust or reflect compositional changes, e.g. a presence of amphibole.
To discern temperature and compositional variations in the Australian upper mantle, we apply an iterative technique, which employs a joint inversion of the seismic tomography and gravity data. This technique consists in removing the effect of the crust from the observed gravity field and topography. In the second step, the residual mantle gravity field and residual topography are inverted to obtain a 3-D density model of the upper mantle. The inversion technique accounts for the notion that these fields are controlled by the same factors but in a different way (e.g., depending on depth and horizontal dimension of the heterogeneity.) This enables us to locate the position of principal density anomalies in the upper mantle. Afterwards, the thermal contribution to the density structure is estimated by inverting the seismic tomography model AusREM (http://rses.anu.edu.au/seismology/AuSREM/index.php). Based on the residual fields, we construct an initial compositional model of the upper mantle. In particular, a negative residual density anomaly is interpreted as the material having a larger Mg# and depleted in garnet and CPX Then, the initial thermal model is re-estimated with the new composition and the iterative process continues until the convergence is achieved.
The results show larger iron depletion in the Western Australian craton than in the Proterozoic terranes. Furthermore, at depths larger than 150 km, the depletion becomes negligible beneath the Proterozoic regions, while persists in the Western Australian craton.