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Fully self-consistent modelling of the southern African lithospheric/sublithospheric mantle using elevation, surface heat flow, magnetotelluric, surface wave, and petrological data.

Javier Fullea, Mark R. Muller, Alan G. Jones, and David Khoza
Dublin Institute for Advanced Studies, Geophysics Section, Dublin, Ireland (jfullea@cp.dias.ie)

The determination of the present-day thermal and compositional structure of the lithospheric and sub-lithospheric upper mantle is one of the fundamental goals in modern lithospheric modelling. In this context, a detailed knowledge of the thermophysical properties of mantle minerals, their temperature and pressure dependence, and their equilibrium assemblages within the lithospheric mantle is crucial. Realistic thermal and compositional models of the lithosphere and sublithospheric upper mantle are therefore essential for understanding i) the origin and evolution of the lithosphere, ii) the nature of the lithospheric/sublithospheric mantle coupling, iii) the relationship between surface features and deep seated processes, and iv) the emplacement of major ore deposits, amongst others. In one case-study from southern Africa we examine the Proterozoic Rehoboth Terrane, accreted to the western boundary of the Archaean Kaapvaal Craton. In contrast to the relatively well studied Kaapvaal Craton, the deep lithospheric structure, temperature distribution, and diamondiferous potential of the Rehoboth Terrane remain poorly known, mainly due to the scarcity of data. Although the presence of several kimberlite pipes distributed across the Rehoboth Terrane has been reported, none of them has yet proved to be diamondiferous, suggesting variations in the lithosphere-asthenosphere boundary depth and/or mantle composition between the two lithospheric domains. In this work we generate self-consistent lithospheric/sublithospheric mantle models of the Rehoboth Terrane and the Kaapvaal Craton that simultaneously fit geophysical and petrological observables (elevation, surface heat flow, magnetotelluric, surface wave and xenolith data), consequently reducing the uncertainties associated with the modelling of these observables alone, or in pairs, as commonly done in the literature. Our approach is built within a self-consistent thermodynamic/geophysical framework, where all thermophysical properties in the mantle are functions of the Gibbs free energy of the stable mineral assemblages. The main advantage of this approach is that essential parameters describing the mantle structure (e.g. density, seismic velocity and electrical conductivity) are obtained consistently as a function of temperature, pressure and composition, rather than being imposed independently or on an ad hoc basis.