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Xenolith Constraints on the Lithospheric Architecture and Mantle Geochemistry of the South Australian Craton

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The lithology, geochemistry, and architecture of the sub-continental lithospheric mantle (SCLM) underlying the South Australia Craton has been constrained using pressure (P) and temperature (T) estimates and mineral compositions for >4,000 garnet and diopside mantle xenocrysts from >10 Jurassic kimberlites. We show that lithospheric thickness is greatest (>200 km) beneath the central Gawler Craton, whereas thinner lithosphere occurs beneath the eastern Nackara Arc (Adelaide Fold Belt). Xenocryst compositions of define two litho-chemical domains within the shallow and deep SCLM that are separated by a mid-lithosphere discontinuity (MLD). The shallow SCLM (60–130 km) comprises low Cr_2O_3 lherzolite and wehrlite, with depleted and refertilized compositions enriched in light rare earth elements. The mid-lithosphere (130–160 km) is depleted in garnet and Cr diopside, and has strong- negative seismic receiver functions calculated from nearby permanent seismic stations. We interpret these properties to reflect minor amounts of pargasitic amphibole in highly refertilized lherzolite. The deep SCLM (>160 km) comprises high Cr_2O_3 lherzolite with elevated TiO_2 and FeO, and depleted OlvMg (0.91-0.93), which relate to previous melt extraction events and prolonged high-T melt metasomatism along the lithosphere base. We interpret the litho-chemical stratification of the SCLM to reflect a multi-stage top-down growth (Figure 1). The shallow SCLM reflects an amalgamation of Precambrian cratonic nuclei characterized by heterogeneity in geochemical enrichment and depletion. Interaction of the shallow SCLM with mantle plumes accreted melts along the paleo-lithosphere-asthenosphere boundary, which now occurs as a MLD. The deep SCLM represents depleted mantle residue formed during mantle plume impingement and thickened during orogenesis.