Re-enrichment of cratonic lithospheric mantle beneath an evolving rift: mantle xenoliths from East Antarctica

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Garnet and spinel peridotite xenoliths from the Lambert-Amery Rift in eastern Antarctica indicate four stages in the development of the mantle before entrainment of the xenoliths in the host magma. The last two stages show an intimate relationship between re-enrichment of cratonic lithosphere and its own erosion during the early stages of rift development. Stage I is characterised by low Ca olivine (OL) and orthopyroxene (OPX) in spinel lherzolites derived from harzburgitic protoliths: these yield the lowest temperatures seen in the xenolith suite (830-850°C), and have distinct trace element contents; lower Ti, Cr, V and Zn in OL and OPX, and additionally lower Cu, Ni, Ga and Li in OPX. Stage II is marked by the formation of garnet due to a pressure increase probably related to collision at 1.1 Ga. Some garnets are subcalcic, indicating that the spinel-garnet lherzolites also formed from harzburgitic protoliths. Re-enrichment dominates Stage III, manifested by the growth of clinopyroxene (CPX) in all xenolith groups: although the abundance of CPX attains 15-16% in some samples, chemical equilibrium with OL and OPX was not always reached, so that the non-judicious use of thermobarometers can produce erratic results. Stage IV is an enrichment episode that affected all spinel-garnet peridotites and about half of the spinel peridotites. Reaction rims were produced on CPX that formed during Stage III, the modal content of olivine and Mg/(Mg+Fe) in the rocks was reduced, CaO, Al_2O_3 and trace elements were enriched, and garnets were almost completely transformed to kelyphite. A later stage documented by interstitial glasses and films around spinels is related to infiltration the host magma, demonstrating that all earlier episodes were pre-entrainment events. The pressures indicated by the spinel+garnet lherzolites are at least 200°C higher than the harzburgitic protolith geotherm. Kelyphites contain two pyroxenes and spinel, enabling the temperature during Stage IV to be estimated as 180-200°C hotter than the main xenolith geotherm. The preservation of evidence for three progressively hotter geotherms can be related to the upward movement of isotherms and of the lithosphere-asthenosphere boundary during development of the sub-rift mantle. Episodic re-enrichment may be suceeded by lithosphere erosion during rift development, but may be a widespread effect in the lower cratonic lithosphere where rifting does not develop any further.