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Origin of continental lithosphere in off-craton regions: vestiges of cratonic inheritance in Pali-Aike mantle xenoliths (southern Patagonia)

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The off-craton subcontinental lithospheric mantle (SCLM) is thought to have formed by moderate to low degrees (5-20%) of mantle melting during the Proterozoic-Phanerozoic, in contrast with the high melting degrees (> 25%) associated with the accretion of cratonic lithosphere in the Archean. The melting conditions inferred for the off-craton SCLM are rather similar to those for the oceanic lithosphere, thus they are not expected to have produced a low-density LID capable of ensuring a long-term lithospheric support to the overlying continent. Nevertheless, reliable inferences on the original melting environments associated with off-craton lithosphere accretion are difficult to obtain because of the pervasive record of metasomatic refertilization in mantle xenoliths sampled in off-craton settings. Here, we document how co-variation trends of major and trace elements in off-craton mantle xenoliths from Pali-Aike (southern Patagonia) do not reflect melting patterns, in spite of their similarity with "oceanic trend" recorded by abyssal/ophiolitic peridotites. Rather, compositional variations in these xenoliths reflect different refertilization trends that can be back-tracked towards the composition of a high-Mg# (91.7) refractory (Al_2O_3 = 1.0 wt.%, CaO = 0.46 wt.%) spinel-harzburgite, which is interpreted as the original protolith of the off-craton SCLM. Pressure-temperature calculations on this "target protolith" support that the off-craton SCLM beneath southern Patagonia formed by ~30% partial melting at 3.0 GPa and 1550 °C, conditions that are not achieved in the modern ambient mantle and that extrapolate to a paleo-adiabat with a potential temperature T_P of 1540-1570 °C. Thermodynamic modelling with Perple-X yields an extrapolated isentropic melting path for fertile mantle peridotite (KLB-1) that reproduces the P-T-*F* estimates of the Patagonian SCLM protolith. The high T_P in concert with published Re-Os model ages of 2.5-2.7 Ga suggest that the off-craton SCLM beneath Pali-Aike originally formed as cratonic lithosphere in a Paleoproterozoic-Archean thermal regime. High melting degrees in the Late Archean mantle then generate a low-density LID that could survive conductive cooling and stabilize the overlying continent. In contrast, metasomatic refertilization counteracts the chemical buoyancy of the SCLM, leading to its erosion over time and causing the transformation of craton edges into thinner and more fertile off-craton continental lithosphere.