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The thickness of diversely constructed lithosphere controls the ages of isotopic reset in Archean cratons

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Cratons, the oldest blocks of stable lithosphere on Earth, contain the earliest portions of the geological record. The resistance of their underlying thick, strong, buoyant melt-depleted mantle keels to subsequent reworking and tectonism is necessary for long-term cratonic survival. However, cratonic keels show substantial geographical variations in thickness, and the effect of this variation on craton stability and preservation remains unknown.

Here, we investigate the low-temperature evolution (ca. <400° C) of the Archean (4.0-2.5 Ga) Pilbara Craton in Western Australia through a craton-wide, *in-situ* Rb-Sr geochronology survey (n=81) of plagioclase and biotite from all major granitoid units. The spatial distribution of ages remarkably correlates with regional isotropic V_s seismic tomography-derived lithosphere-asthenosphere boundary (LAB) depth models [1, 2]. Without plausible craton-wide heating events and associated magmatic activity, these Rb-Sr ages must reflect metamorphic reset events linked to fluid mobilization and infiltration of larger plutons, manifested as macroscopically-invisible cryptic metasomatism. These crustal fluid-flow-triggered overprints reflect extra-cratonic Neoarchean (2.8-2.5 Ga) and Paleo-Mesoproterozoic (2.5-1.0 Ga) tectonic events and are a function of variations in lithospheric strength and thickness. Two-thirds of the Pilbara Craton consists of areas of younger metamorphic overprint ages, which are generally underlain by thinner lithosphere than areas of older overprints. These spatial variations may be imparted by pre-cratonization tectonomagmatic regime heterogeneities or variations in shortening rates during amalgamation. Importantly, our results suggest that the contribution of early subduction-like processes to the production of thick lithosphere may be overstated. We conclude that cratonic lithospheric thickness controls fluid-borne metamorphism in Archean blocks. Thus, it is at least partly responsible for mass movement within cratons long after tectonic stabilization, linking large-scale lithospheric architecture with fluid movements over billions of years.

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