Sm-Nd isotope characteristics of the Pilbara and Yilgarn Cratons, Western Australia: implications for crustal growth in the Archean

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The timing and mechanisms of crustal growth, the role (if any) of modern-style plate tectonics and potential secular changes, during the Archean are poorly understood. To provide constraints on these questions, we present isotopic and geochemical data for the well exposed, classic, Paleoarchean to Mesoarchean Pilbara Craton (>3.5 to <2.8 Ga), and the large, but poorly outcropping, largely Neoarchean Yilgarn Craton (>3.0 to 2.6 Ga), both in Western Australia. Both are dominated by typical Archean granite-greenstone geology.

Regional Sm-Nd data from felsic magmatic rocks indicates both cratons comprise large proto-cratonic cores with relatively uniform Nd T_{DM} model ages – c. 3.6-3.5 Ga for the eastern Pilbara, and c. 3.3-3.1 Ga for the western Yilgarn. Distinct isotopic breaks separate these cratonic nucleii from marginal Archean terranes with significantly younger, but also more domainally-variable, T_{DM} model ages.

The cratonic nucleii are characterised by episodic felsic magmatism spanning 650 m.y. (from >3.47 Ga to 2.85 Ga) for the Pilbara Craton and 350 m.y. years (3.0 Ga to 2.63 Ga) for the Yilgarn Craton. In both, this magmatism was dominated by transitional TTG-type compositions, and shows secular variations to more potassic, siliceous compositions, consistent with an increasing component of crustal reworking. Definitive arc-related magmatism, e.g., boninites, calc-alkaline andesites, sanukitoids, are largely absent.

The surrounding marginal terranes are characterised by isotopically younger domains that broadly correspond to geological domains. Importantly, these domains are either characterised by primitive isotopic signatures (i.e., Nd T_{DM} ages close to crystallisation ages), and/or contain evidence for arc-related magmatism, i.e., boninites, sanukitoids (Pilbara), and calc-alkaline andesites (Yilgarn).

The Pilbara cratonic nucleus is best interpreted to have formed as a result of vertical crustal growth in an episodic plume-environment. The Yilgarn cratonic nucleus possibly formed in a similar manner, although the evidence is not as clear. Subsequent marginal arc-related magmatism affected both cratons and the marginal terranes in both are interpreted as representing lateral crustal growth and terrane accretion, not dissimilar to modern style plate tectonics. Evidence from the Pilbara suggests such accretionary processes were operative as early as the Mesoarchean.