Why Archaean cratons differ from younger continental lithosphere

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The most outstanding features of Archaean cratons are their extraordinary thickness and enduring longevity. Seismically, Archaean cratonic fragments are sharply-bounded deep roots of buoyant cold lithospheric mantle, clearly distinguishable from non-cratonic lithosphere. The age of diamond inclusions and the Os-isotope composition of deep cratonic xenoliths support a model of coeval formation of the crustal and residual mantle portions.

Archaean and post-Archaean crust also differ, not in bulk composition, but in crustal architecture. Key drivers of crustal rearrangment were the radioactive heat-producers U, Th and K. In the early Earth, high radioactive heat production led to self-organisation into evolved, potassic upper and refractory lower crust. The lag time between crust formation and re-organisation was much shorter than today. An additional factor contributing to cratonic restructuring was the emplacement of dense supracrustal rocks in ensialic greenstone belts, leading to gravitational inversion. The dome and keel architecture of Archaean cratons was thus driven by crustal radioactive heat and high temperature mantle melting, yielding dense, low viscosity lavas piling up at surface.

A pleasing complementary observation from cratonic mantle roots is that refractory mantle nodules also suggest very high degrees of melting and extraction. Thus, the most logical conclusion seems that the komatiite mantle source was up to 500ºC hotter than modern asthenosphere. With higher degree and depth of melting, a thicker and severely depleted bouyant cratonic residue was formed, perfectly equipped to preserve the Archaean crustal record.

However, there are significant inconsistencies in this otherwise convincing line of reasoning. They include: Archaean crust is not especially thick, the dunites expected after very high degree melting are rare, many cratonic harzburgites are much richer in orthopyroxene than predicted [1], and cratonic harzburgites often contain garnet. Finding a solution to these issues has important ramifications for secular evolution of the continents and thermal evolution of the mantle. In this presentation, I will contrast the various proposed solutions, including purging of surprisingly carbonated ancient mantle [e.g. 2], onset of plate tectonics, a Neoarchaean superplume event and collapse of Hadean cumulate barriers.

[1] Boyd (1989) *EPSL* 89, 15-26

[2] Herzberg (2016) *J. Petrol.* 57, 2271-2288