Formation of continental crust during ultra-hot Precambrian orogeny: insight from geodynamic modeling

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The restricted geological record on crust-forming processes during Earth's early history provides a controversy on how and when continental crust was formed. Since Precambrian peaks of crustal formation coincide in time with regional high-temperature granulite facies metamorphism and assembly of supercontinents, ultra-hot orogeny associated with proto-continental plates convergence might set up mechanism(s) for efficient magmatic activity necessary for crustal growth.

Using a 2D coupled petrothermomechanical numerical model with mantle temperatures 150ºC higher than the modern temperature we show that convergence of two relatively thin and fertile proto-continental lithospheric plates creates orogenic-scale thick continental crust with temperatures 700-1100ºC at the bottom and with melt-depleted mantle roots in a timescale of tens of millions of years. The model successfully reproduces an ultra-hot accretionary orogen with low to submarin topography. The orogen is underplated by invaded hot asthenospheric mantle and spreads with plate tectonic rates due to the delamination of the lithospheric mantle.The modeled orogeny provides significant net crustal growth and creates new continental crust with a large variety of rock types, including newly formed metabasic and metasedimentary rocks, including disintegrated blocks of earlier crust, and products of partial melting.

The proposed delamination-driven model for a ultra-hot Precambrian orogeny can accurately be applied to explain generation of melt-depleted mantle, thick crust with strong granite-greenstone terranes affinities, ultrahigh temperature granulites and series of TTG-like low and middle pressure granitoids.

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