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Cratons formation by global plume-lid tectonics in the early Earth

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Modern geodynamics and continental growth are critically driven by subduction and plate tectonics, however how this tectonic regime started and what geodynamic regime was before remains controversial. Based on 2D and 3D magmatic-thermo-mechanical numerical experiments we suggest that a distinct Venus-like plume-lid tectonics regime operated on Earth before plate tectonics, which was associated with widespread tectono-magmatic heat and mass exchange between the crust and the mantle. This regime was characterized by the presence of weak internally deformable highly heterogeneous lithosphere with low topography, massive juvenile crust production from mantle derived melts, mantle-flows-driven crustal deformation, magma-assisted crustal convection and widespread development of lithospheric delamination and eclogitic drips. Both proto-continental and proto-oceanic domains were formed in this regime by a combination of eclogitic drips and ultra-slow spreading. Plume-lid tectonics also resulted in growth of hot internally convecting moderately-depleted chemically buoyant eclogite-rich proto-continental mantle layer. Later, this layer could be rapidly cooled by internal convection and consolidated to form eclogite-rich sub-continental lithospheric mantle (SCLM) domains. Numerical models also show feasibility of short-lived deep subduction of ultra-depleted eclogite-poor proto-oceanic lithosphere formed by ultra-slow spreading. Subsequent rising and accretion of this highly buoyant lithosphere to the bottom of unrelated heterogeneous crustal terrains may offer another way of Archean cratonization associated with eclogite-poor SCLM formation. Numerical models also suggest that plume-induced subduction may likely played a crucial role for making transition from global plume-lid tectonics to global plate tectonics.