Proto-oceanic and proto-continental lithosphere formation by Archean plume-lid tectonics

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Lithospheric plates growth in modern geodynamics is 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 proto-oceanic spreading. Proto-continental domains were characterized by the 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. Proto-oceanic lithospheric mantle was colder, more depleted and poorer in eclogite inclusions compared to its proto-continental counterpart, due to higher degree of decompression melting within proto-oceanic spreading centers localized atop hot mantle upwellings. Numerical models show feasibility of short-lived deep subduction of such ultra-depleted eclogite-poor proto-oceanic lithosphere. Subsequent rising and accretion of these chemically buoyant ultra-depleted mantle rocks to the bottom of unrelated heterogeneous crustal terrains may offer a feasible way for 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.