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Water-induced mantle overturns leading to the origination of Archean continents and sub continental lithospheric mantle

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The originations of the Archean continents and sub continental lithospheric mantle (SCLM) were most important events in the early Earth and crucial for understanding how the early Earth worked. The mechanisms for the originations of the Archean continents and SCLM remain unclear. It is widely accepted that Archean tonalite-trondhjemite-granodiorite (TTG) plutons were derived from hydrous mafic magmas in the garnet/ amphibole stability field. Although the subduction can bring water to the mantle to produce granitic magma, the island Arc Model for the origin of continents meets fundamental challenges. The growing evidences support the plume-driven oceanic plateau models for the origin of continents. However, the lower parts of the oceanic plateau have been thought to be dry. How to generate the hydrous meta-basalt at the base of the oceanic plateau remain an open question.

This study suggests that the Archean continents and sub continental lithospheric mantle (SCLM) resulted from the evolution of the hydrous magma ocean (MO). The whole-mantle magma ocean (MO) created by the moon-forming giant impact likely evolved into an outer MO and a basal MO since the MO would crystallize initially in the mid mantle. The basal MO can be stable because the density difference between silicate liquid and solid phase reduces dramatically at such high pressure and the silicate liquid is enriched in iron relative to the solid. The basal MO at the beginning should contain a certain amount of water since extensive studies suggest substantial accretion of water-rich bodies during core formation. With the solidification, the basal MO eventually became gravity unstable because of the enrichment of water. The triggered massive mantle overturns resulted in the major pulses of the crust and thick SCLM generations. The model avoids a fatal drawback of the oceanic plateau model for the origin of continents: the source of H_2O needed for the formation of TTG. The model can also account for why the TTG and thick SCLM basically occurred in the Archean and why only the Earth among inner planets was covered with the continental crust.