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Hadean geodynamics: Constraints from the physics of magma ocean and the growth of continental crust

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The geodynamic regime of the Hadean Earth has long remained elusive, primarily owing to the severe paucity of geological records. In recent years, however, notable progress has been made on a few relevant fronts, such as continental growth, magma ocean solidification, and the onset of plate tectonics, and it is now possible to depict a rough sketch for the likely evolutionary path of the early Earth. My reconstruction of the Hadean Earth is based on the following two pillars: Earth system dynamics and temporal continuity. No component in the Earth system exists in isolation. The beginning of the early Earth is constrained by the formation history of Earth, and the early Earth has to evolve into the familiar modern Earth. For example, a Venus-like massive CO2-rich atmosphere, which must have existed as a result of magma ocean solidification, has to be removed efficiently during the Hadean to match a relatively low pCO2 in the early Archean, and the popular notion of stagnant lid convection in the early Earth is in direct conflict with this atmospheric constraint. A recent study suggests that such an efficient removal of atmospheric carbon is impossible even with the modern version of plate tectonics, but that a particular kind of mantle expected from magma ocean solidification could allow rapid plate tectonics, facilitating efficient carbon sequestration. In this contribution, I will review these theoretical and observational constraints on Hadean geodynamics.