The evolution of the Hadean Earth

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Within the first several hundred years of Earth's history, Earth had progressed from an initial global magma ocean, into a habitable planet. The dynamics of the planet during this period are poorly known, largely due to the lack of a geological record for the first 500 million years of Earth's history. Yet many of the first order characteristics of the Earth, such as silicic crust, and liquid water on the surface, arose under a planetary regime that may have been profoundly different from that today. Recent investigations into geochemical and geodynamic constraints on the Hadean suggest the planet was largely stagnant - more akin to Io, or Venus, than the Earth today. Investigations into the dynamics of this period are strongly contingent on both the initial conditions – which are poorly understood for the post-magma ocean Earth, and the drastic evolution of the planet's thermal state over the Hadean, which depends not just on the evolution of heat production, but the loss of initial heat, and the coupled evolution of the core and atmosphere. Concurrent to these processes, enormous impact events affected atmospheric evolution, plate strength, and the mantle state. Giant impacts can both aid plate tectonics by weakening plates, or hinder it by further raising mantle temperatures, and it is not clear a priori how they affect tectonic systems. Here I present numerical simulations of mantle convection within an evolving planet, which incorporate a coupled, evolving core, evolving heat sources, and giant impacts. I assess the importance of large-scale planetary processes, such as impacting, atmospheric loss, and tectonic regime, on the early Earth, using a combination of numerical approaches, and summarise recent advances in implementing this important process in models of the evolution of the Earth.