Plume origin for onset of early plate tectonics and its influence to core-mantle evolution with high core thermal conductivity

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We investigate the cause for onset of early plate tectonics and its influence on the thermo-chemical evolution of simulated mantle convection coupled to a parameterized core cooling model that can include effects of high core thermal conductivity. Three tectonic modes are found, which can be controlled by varying the friction coefficient for brittle behavior (modes mobile lid, stagnant lid and episodic lid). The tectonic mode is established early on, with subduction initiating at around 60 Myr from the initial state in mobile and episodic cases, triggered by the arrival of plumes at the base of the lithosphere. Crustal production assists subduction initiation, increasing the critical friction coefficient. The tectonic mode has a strong effect on core evolution via its influence on deep mantle structure; episodic cases in which a thick layer of basalt builds up experience less core heat flow and cooling and a failed geodynamo. Thus, a continuous mobile lid mode existing from early times matches Earth's mantle structure and core evolution better than an episodic mode characterized by large-scale flushing (overturn) events. The heat flow across the core-mantle boundary (CMB) that is one strong constraint for core-mantle thermal evolution is obtained as ~ 20 TW for the successful core-mantle evolution model with the continuous mobile lid mode, which is a factor of three higher CMB heat flow than the previous study[1]. This may be also consistent with the recent core evolution theory [2]. As a result of getting such a high CMB heat flow, the possible magnetic evolution of Earth's core could be obtained with high core thermal conductivity constrained by high P-T physics [3].

Referernces. [1] Nakagawa, T., and P. J. Tackley, G-cubed, 2015; [2] Labrosse, S., PEPI, 2015; [2] Gomi , H. et al., PEPI, 2013.