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Thermal History of Earth: Archean to present

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Possible geodynamic regimes have may have prevailed in Earth's history are discussed on the basis of the theory of plate-tectonic convection as well as the recently-revised chemical composition of the bulk silicate Earth. Plate-tectonic convection, modulated by strong depleted lithosphere created at mid-ocean ridges, demands more sluggish plate tectonics when the mantle was hotter, contrary to the traditional view of more rapid tectonics in the past. This notion of sluggish plate tectonics can simultaneously satisfy geochemical constraints on the abundance of heat-producing elements and petrological constraints on the degree of secular cooling, in the framework of simple whole-mantle convection. As a consequence of reduced secular cooling, mantle plumes were most likely weaker in the past. The chemical evolution of Earth's mantle may have been encumbered considerably by sluggish plate tectonics and weak mantle plumes, maintaining its compositional heterogeneity at various spatial scales to the present day. The new evolution model of plate tectonics may also provide a constraint on the long-term net water flux from the hydrosphere to the solid Earth. Internal heat production probably played an important role in controlling plate dynamics in the early Archean, for which a different mode of mantle convection is suggested.