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Superplumes in Evolving Mantle

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A self-consistent numerical model is presented for magmatism in a convecting mantle with plate tectonics. Superplumes as broad and hot regions enriched in basaltic component and heat producing elements develop at depth in the lower mantle owing to the segregation of subducted oceanic crusts from convecting mantle and the sedimentation of segregated crustal materials on the core mantle boundary. The superplumes are thermally buoyant but compositionally dense and are neutrally buoyant as a whole. In the mantle of early Earth where the internal heating is strong, however, the thermal buoyancy often overcomes the compositional buoyancy in some parts of the superplumes and the thermally buoyant parts are detached from the superplumes to uprise to the surface as hot plumes. The hot plumes induce frequent and vigorous hot spot magmatism, which, in turn, induces new plate boundaries. The frequent developments of new plate boundaries keep the activity of plate tectonics rather steady. In the mantle of the later stage of the Earth& #39;s history, where the internal heating is not so strong, in contrast, this type of hot plumes from superplumes become rare and, instead, the mantle materials above the superplume heads sometimes uprise as hot plumes owing to the basal heating from the superplume heads. The change in the formation process of hot uprising plumes make the plume temperature significantly drop at some time in the Earth& #39;s history. Furthermore, the decline in plume activity makes the development of new plate boundaries less frequent and makes the activities of plate tectonics and superplumes themselves fluctuate much with time. These changes in plume temperature and plume activity mesh with the tectonic evolution of the Earth from the Archean to the present inferred from the recent observations of old continents and komatiite.