A mantle evolution model and the Archean-Proterozoic boundary

Masaki Ogawa[1]

[1] Dept. of Earth Sci. & Astronomy, Univ. of Tokyo at Komaba

A numerical model of coupled magmatism-mantle convection system in a two dimensional space has been applied to the study of mantle evolution in the earth. The viscosity of convecting mantle materials is assumed to depend on stress-history as well as temperature to self-consistently reproduce plate tectonics. Magmatism occurs as a permeable flow of basaltic magma formed by pressure release melting through the coexisting mantle materials. The barrier effect of the garnet vs. perovskite transition that occurs at depths around 660 km is also taken into account but the barrier effect of the postspinel transition is neglected. Heat producing elements are incompatible and decay with time. The numerically modeled mantle evolves in two stages. On Stage I, plate tectonics occurs and the moving plates induce ridge volcanism. Besides, hot plumes repeatedly rise up from deep lower mantle to induce vigorous hot spot magmatism and new plate boundaries. The chemical differentiation due to ridge volcanism and hot spot volcanism makes the mantle chemically stratified, and subducting slabs that penetrate deep into the lower mantle induce a broad lateral heterogeneity in the lower mantle. As the heat producing elements decay, the mantle enters into Stage II. The hot spot magmatism due to the plumes from deep lower mantle stops and plate motion and ridge volcanism become more steady. The chemical stratification and lateral heterogeneity that develop on Stage I survive convective stirring induced by moving plates and subducting slabs because of the further chemical differentiation induced by the ridge volcanism. The structure of Archean continents and the shutoff of komatiite at the end of the Archean can be well explained if the Archean-Proterozoic boundary corresponds to the transition from Stage I to Stage II.