Two-stage evolution of the Earth's mantle

MASAKI OGAWA

[1]Dept. Earth Sci. & Astronomy, Univ. of Tokyo at Komaba, Meguro, Tokyo. 153-8902, Japan (cmaogawa@mail.ecc.u-tokyo.ac.jp)

I present a two-dimensional self-consistent numerical model of a coupled magmatism-mantle convection system with tectonic plates to discuss the Earth's mantle evolution. Magmatism occurs as a permeable flow of basaltic magma generated by decompression melting through matrix, while a stress-history dependent viscosity of mantle materials induces tectonic plates that rigidly move along the surface boundary. The mantle evolves in two stages owing to decaying heat producing elements (HPEs) in the mantle. On the earlier stage that continues for the first 1-2 Gyr, a thin layer of basaltic materials generated by magmatism develops along the 660 km phase boundary to make upwelling flow from the lower mantle pulsating. The pulses of upwelling flow, or mantle bursts, cause vigorous magmatism owing to a positive feedback between magmatism and mantle upwelling flow. In spite of substantial compositional differentiation of the mantle caused by this magmatism, the mantle remains compositionally rather homogeneous because of a strong convective stirring by mantle bursts. Mantle bursts also make plate motion chaotic. As HPEs decay, however, the mantle evolves into the later stage where mantle bursts subside and tectonic plates move more steadily. The steady plate motion causes ridge volcanism that continuously generates basaltic crusts. After subduction, the crust segregates from the convecting mantle and accumulate on the core mantle boundary to form compositionally dense piles, from which hot plumes occasionally ascend. The mantle becomes more compositionally heterogeneous with time on the later stage.