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Two-stage evolution of the Earth's mantle under decaying internal heating

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The Earth's mantle convection with magmatism and tectonic plates are numerically modeled in a two-dimensional rectangular box of aspect ratio 4 to 6 to understand how the mantle evolves owing to decaying internal heating. Both plate tectonics and magmatism as a migration of magma generated by decompression melting are self-consistently modeled. The mantle evolves in two stages. On the earlier stage, the abundant heat producing elements (HPEs) in subducted basaltic crusts strongly heat the deeper part of the lower mantle, and the hot materials enriched in the basaltic components frequently ascend to the surface as bursts to cause vigorous magmatism; the mantle bursts strongly stirs the mantle and split the lithosphere into small fragments that chaotically move. As HPEs decay on the later stage, however, mantle bursts stop, and subducted basaltic crusts formed by ridge volcanism accumulate on the core mantle boundary to form compositionally dense thermo-chemical piles. Hot plumes ascend from the thermo-chemical piles only occasionally to cause mild magmatism, and a limited number of large plates develop to move more steadily. When water injection into the mantle by subducting slabs is taken into account, chemical differentiation of the mantle is promoted to some extent by enhancing magmatism. The overall features, however, do not depend much on whether or not water circulation is implemented within the model. The overall features of mantle evolution do not depend on the choice of the initial temperature, too, provided that the initial temperature is high enough to induce the magma ocean.

Keywords: mantle evolution, mantle convection, magmatism, decaying heat producing elements, water