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Toward a 3D spherical modeling of lunar mantle convection

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Earlier two-dimensional models of coupled magmatism-mantle convection system raise two issues concerning the evolution of the lunar mantle. One is to understand why lunar magmatism continuously occurs with a characteristic time of several hundred million years. When the Rayleigh number of the lunar mantle Ra exceeds the critical value for the onset of thermal convection Rc, earlier two-dimensional models suggest that a positive feedback, called the magmatism-mantle upwelling (MMU) feedback, operates to make magmatism episodic and vigorous; magmatism occurs continuously and mildly as observed on the Moon only when Ra $<$Rc. Another issue is to understand why mare magmatism continued until as recent as about a billion years ago. Magmatism extracts heat producing elements (HPEs) and earlier two-dimensional models predicts that lunar magmatism should have waned much earlier because of this HPEs extraction. A possible solution to this issue is that the lunar mantle contains a reservoir that is enriched in HPEs and compositionally dense at depth. The nature of thermal convection in a basally heated mantle with a small core, however, has not been investigated enough to resolve these issues. To estimate Rc and to understand the nature of thermal convection in the lunar mantle, we are carrying out a linear perturbation analyses and numerical simulation of thermal convection in a spherical shell with a small core.

Keywords: the Moon, mantle evolution, 3D spherical shell, mantle convection, numerical simulation