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Numerical models of mantle evolution in the moon

OGAWA, Masaki[1*]

[1]Graduate School of Arts and Sciences, Univ. of Tokyo

Numerical models of magmatism in convecting mantle are presented to understand the lunar magmatism that was active for the first 1 Gyr but rapidly declined after that. In the model, the characteristic time of magmatism is on the order of several hundred million years, much longer than that of the model of magmatism on larger planets like Mars, because a positive feedback between magmatism and mantle convection does not work: Upwelling flow of mantle convection induces magma by decompression melting. The buoyancy of the magma enhances the upwelling flow itself, and hence makes magmatism vigorous in a large planet. This positive feedback, however, does not work in the moon because of its low Rayleigh number. The long characteristic time of magmatism in the model is consistent with observations. The suggested mild magmatism implies that the heat extraction by magmatism is inefficient in the moon. Since the convective heat extraction is also inefficient in the moon because of its low Rayleigh number, this inefficient heat extraction by magmatism suggests that the most important mechanism of mantle cooling in the moon is thermal diffusion. Indeed, the thickening of the lithosphere with time by thermal diffusion makes the activity of magmatism decline within the first 1 Gyr of its history regardless of the initial content of heat producing elements in the mantle and other parameters that controls magmatism and mantle convection in the models. It may be necessary to carry out further numerical studies that include the early chemical differentiation of the mantle by magma-ocean to understand the magmatism that remained active till 2 Ga locally in some areas of the moon.

Keywords: mantle evolution, mantle convection, magmatism, the moon