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# Effects of water on Martian mantle evolution induced by magmatism and solid-state convection

YANAGISAWA, Takatoshi[1*], OGAWA, Masaki[2]

[1]IFREE, JAMSTEC, [2]Graduate School of Arts & Sciences, Univ. Tokyo

To consider the thermo-chemical evolution of Martian mantle, we present numerical models of mantle evolution including magmatism in two-dimensional box geometry. By including magmatism, our models can reproduce compositionally layered mantle structure and surface crust spontaneously, and can treat the whole evolution process consistently. The viscosity is strongly temperature-dependent, and the lithosphere is stagnant. The effect of water is included in two aspects depending on its content; decreasing the melting temperature of mantle materials, and decreasing the viscosity of the solid mantle. At the first stage of evolution, a magma ocean develops and generates a basaltic crust, a layer of compositionally buoyant residue of the crust in the uppermost mantle, and a deep-mantle compositionally denser layer, which has a higher content of the basaltic component. The magma ocean extracts most of the water initially contained in the upper layer, but some water remains in the lower layer of the mantle. Subsequently, hot plumes ascend from the lower layer to induce magmatism. The water allows plume magmatism to continue for a long duration, up to 5 Gyr depending on the initial water content and the detail of the initial temperature distribution in the mantle, provided that the mantle is initially not too hot just after planetary formation. The plume magmatism is sufficiently active to cause significant crustal growth and dehydration of the crust and mantle in the early evolutionary stage when the internal heating is strong; the amount of extracted water is equivalent to a water layer of up to several hundred meters in depth. Water can also enhance the extraction of heat producing elements from the mantle, which makes the lithosphere thicker. Both crustal growth and dehydration eventually subside as the heat producing elements decay. By comparing these results with recent studies on crustal evolution, we gain a deeper understanding of the tectonic history of Mars.

Keywords: Martian mantle, structural evolution, magmatism, water