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Evolution of Venusian mantle with magmatism and compositional differentiation in a numerical modeling

Takatoshi Yanagisawa[1*], Masaki Ogawa[2]

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

The surface age of Venus is estimated to be 300-600 Myr on average, and is young in contrast to Mars, where magmatism has mostly subsided on the early stage of its history. Detailed surface observations suggest that magmatism is still ongoing on Venus, at least locally. On the other hand, Venus is a planet where the lithosphere is stagnant and plate tectonics does not operate, which is similar to Mars. When the lithosphere is stagnant, the solid-state mantle convection is unlikely to cool the mantle so efficiently as to extract all the heat internally generated by heat producing elements. In such a situation, it is crucial to take account of melting of mantle materials in the modeling of thermal history, as we suggested for the evolution of Martian mantle (Ogawa and Yanagiawa, 2011, 2012). Here, we apply our numerical model of mantle evolution with coupled magmatism for Venus to understand its thermal history, the history of magmatism, and structural evolution of the mantle. In the numerical experiments, we discuss how the crust enriched in heat producing elements develops, how the crust recycles back into the mantle, and how the mantle evolves to affect the history of magmatism and the lithosphere in accordance with the crustal evolution. We take account of the barrier effect of the phase transitions at the top of the lower mantle, and our model allows compositional differentiation of the mantle by magmatism. Based on the numerical results, we discuss the difference of evolution between Venus and Mars.

Keywords: Venus, evolution of mantle, magmatism, numerical simulation