Time scale of the separation of molten metal droplets in the magma ocean: implications to metal-metal differentiation during core-mantle segregation

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Highly siderophile elements (HSE) in the Earth's interior are thought to have been partitioned into Fe-Ni metal phases in the magma ocean and have segregated into the core during Earth's formation, because high-pressure silicate-metal partitioning experiments have demonstrated that HSE are strongly partitioned into silicate melt when metal and silicate phases are in equilibrium in the magma ocean. On the other hand, recent studies report the existence of HSE-bearing small phases in CAI, chondrules, and matrices in chondrites, suggesting that HSE had been partly included in small HSE phases distinct from Fe-Ni metal phases in the magma ocean. If so, HSE had not fully been partitioned into Fe-Ni metals in the magma ocean. In this study, we have calculated the time scale of separation of metallic droplets in silicate melt of a convecting magma ocean, and examined the condition under which HSE behave separately from Fe-Ni in the magma ocean. We compared the time scale of separation in silicate melt between molten Pt and molten Fe metal droplets, and found that Pt metal droplets can be suspended in silicate melts more likely than Fe metal droplets under a wide range of conditions. This means that HSE discrete phases could have stayed behind after Fe-Ni phases had been separated from silicate melt in the magma ocean. Therefore, the HSE excess in the modern mantle compared with the expectation from high-pressure partitioning would be the result of incomplete separation of HSE phases in the magma ocean.

Keywords: magma ocean, highly siderophile element, core-mantle segregation

