THE GEODYNAMICS SEMINAR №594

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Science Research Bldg. 1, 4th floor.
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Experimental constraints on the distribution of Fe^{2+} and Fe^{3+} in the crystallizing Earth's magma ocean

The distribution of Fe^{2+} and Fe^{3+} in the mantle of terrestrial planets affects the oxygen fugacity of the mantle. Given that volcanic gas composition is mainly controlled by the oxygen fugacity of the mantle, constraining the distribution of Fe^{2+} and Fe^{3+} in the mantle provides a key insight into the chemical link between planetary surface and interior. Previous our experiments have suggested a possible formation of Fe^{3+}-rich highly oxidizing Earth's magma ocean ($Fe^{3+}/\Sigma Fe$ ($\Sigma Fe = Fe^{2+}$ and Fe^{3+}) > 0.2) (Kuwahara et al., 2023, Nat. Geosci.), but this is inconsistent with the $Fe^{3+}/\Sigma Fe$ ratio of the present upper mantle ($Fe^{3+}/\Sigma Fe = 0.03$). A possible solution to this problem is preferential incorporation of Fe^{3+} into lower mantle minerals during the crystallization of the Earth's magma ocean. However, solid-liquid partitioning of Fe^{2+} and Fe^{3+} has never been reported. Here I report first experimental constraints on partitioning of Fe^{2+} and Fe^{3+} between silicate melt and bridgmanite, the most dominant lower mantle mineral of the Earth (Kuwahara and Nakada, 2023, EPSL). The results show a limited fractionation of Fe^{2+} and Fe^{3+} between bridgmanite and silicate melt at 23-27 GPa. The effects of oxygen fugacity and Al content of bridgmanite are not significant to change the solid-liquid partitioning behavior of Fe^{2+} and Fe^{3+}, suggesting that the crystallization of the lower mantle cannot fractionate Fe^{2+} and Fe^{3+} in the magma ocean. If the Earth's magma ocean has higher $Fe^{3+}/\Sigma Fe$ ratio than the present upper mantle as we previously argued, another mechanism is necessary to explain the present upper mantle's $Fe^{3+}/\Sigma Fe$ ratio. In this seminar, I discuss implications of our recent experimental results for the redox evolution of the Earth's mantle in Hadean and Archean eons.

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