R004-08
C 会場 ：11/6　AM2 （10:45-12:30）
11:00〜11:15

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A long-term evolution of a compositionally-driven dynamo: implications for a sudden decline in lunar paleointensity

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At present, the Moon does not possess its own magnetic field by a dynamo action, which worked in the ancient era [e.g., Garrick-Bethell et al., 2009]. It is thought that the lunar dynamo had a long lifetime (hundreds of millions of years) from the lunar paleointensity records. A long-lived dynamo hypothesis is also supported by a study of the magnetic anomalies on the Moon [Takahashi et al., 2014]. On the other hand, a recent study suggests that the lunar dynamo was shut down by 4.19 Ga and supports a short-lived dynamo hypothesis [Tarduno et al., 2021]. A sudden decline in lunar paleointensity by at least an order of magnitude by 3.3 Ga is an important issue to understand the evolution history of the Moon. This sudden paleointensity variation may corresponds to either the cessation of the lunar dynamo or a shift to a different dynamo mechanism [Tikoo et al. 2014]. Here we examine a long-term lunar dynamo evolution focusing on sudden decline in paleointensity. In order to elucidate the issue, we perform numerical dynamo simulations combined with thermal history calculations.

Among various lunar dynamo mechanisms proposed so far, we adopt a compositionally-driven dynamo because it is believed to be long-lived [Laneuville et al., 2014 ; Scheinberg et al., 2015]. We made thermal history calculations to obtain the inner core size as well as its growth rate as a function of time. Guided by the information, core geometry and compositional buoyancy source (i.e. Rayleigh number, Ra) are consistently determined as input parameters for dynamo runs. The inner to outer core radius ratio, χ, is varied discretely. Individual simulation results at each χ are connected to trace an evolution curve in the χ-Ra space.

We found two cases consistent with the decline in lunar paleointensity, where the dynamos are maintained in a range of χ=0.2 - 0.5 corresponding to 4.25 - 3.81 Ga. Afterward, they terminate in different fashions. Two ways of interpretation for the drop in lunar paleointensity are suggested: dynamo shutdown or a transition to a different dynamo regime. Our results demonstrate that a long-lived lunar dynamo with a sudden intensity drop is reproduced by a single mechanism of compositionally-driven dynamo.

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