地球の揮発性元素組成の起源：衝突大気剥ぎ取りとコア形成の寄与
The Origin of Earth’s Volatile Composition: Effects of Impact-induced Atmospheric Erosion and Core Formation

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Unveiling the origin of Earth’s volatile composition is crucial for understanding how Earth developed its habitable environment. Carbon (C), nitrogen (N), and hydrogen (H) are the backbone for the chemistry of life and main components of the atmosphere and oceans (e.g., Katling & Casting, 2017). The volatiles in rocky planets are thought to have been delivered by chondritic materials. However, the elemental composition of the bulk silicate Earth (BSE) shows the depletion of C and N relative to H, a high C/N ratio, and a low C/H ratio compared to chondrites (e.g., Hirschmann, 2016; Bergin et al., 2015).

The volatiles delivered to the accreting planet were potentially lost to space by impacts or sequestered in the core. In order to understand how these processes affect the Earth’s volatile composition, we modeled both the main accretion stage and the late accretion stage. The former considered the elemental partitioning between the atmosphere, MO, and metal which segregates into the core (e.g., Hirschmann, 2016; Bergin et al., 2015). The latter considered the partitioning between the atmosphere, oceans, and carbonate (the crust) (e.g., Sakuraba et al., 2019). By calculating the evolution for the range of partitioning coefficient, solubilities, and impactor properties, we evaluated how the resulting volatile composition of BSE depends on these input parameters.

As a result, we succeeded to reproduce the elemental composition of major volatile elements in current BSE from a chondritic source when we chose the appropriate parameter values. While the elemental fractionation during the main accretion ended up with the excess of N/C, the preferential loss of N from the atmosphere during the late accretion reproduced BSE’s volatile pattern. During the main accretion, C was most affected by the core segregation because C is the most siderophile among the volatile elements. During the late accretion, N was most affected by the atmospheric erosion because C and H were trapped in the surface reservoirs. The different BSE’s composition patterns were obtained depending on parameters such as impactor’s composition, impactor’s size-distribution, and element partitioning properties. Our results suggest that the current Earth’s composition can be obtained by the homogeneous accretion of chondritic planetesimals.

[1] Hirschmann, (2016) *American Mineralogist*, 101, 540.
[2] Bergin et al., (2015) *Proceedings of the National Academy of Sciences*, 112, 8965.
[3] Sakuraba et al., (2019) *Icarus*, 317, 48.

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