Impact degassing and atmospheric erosion on early Earth: constraints on the late accretion impactors

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Unveiling the sources of volatiles on Earth is crucial to understand the origins of atmosphere, oceans, and life. The atmospheres on terrestrial planets were significantly modified by the impact degassing and erosion of volatiles during the late accretion (e.g. de Niem et al. 2012). However, the origin of late accretion impactors and their compositions are poorly constrained.

This study focused on the fact that C/H and N/H ratios on Earth' s surface are lower than chondritic values (e.g. Pontoppidan et al. 2014) and explored the conditions to reproduce these ratios by impact erosion during the late accretion. We modeled the atmospheric evolution on Earth using atmospheric & impactor erosion models by Svetsov (2000) and Shuvalov (2009). The atmosphere is assumed to contain three components of volatiles: CO_2, H_2O, and N_2 + non-radiogenic noble gas. The presence of oceans and carbon-silicate cycle on the surface were assumed. We set upper limits to the partial pressures of CO_2 and H_2O, which corresponds to the state of phase equilibrium and carbon-silicate cycle. We treated the abundances of volatiles in impactors as a parameter.

We found that the partial pressures of CO_2 and H_2O reached the upper limits and N_2 partial pressure subsequently reached a steady state. These steady states correspond to the balance between atmospheric supply and loss. The larger volatile abundance in impactors we assumed, the larger the N_2 mass was that we obtained. The final N_2 mass in the case where enstatite chondrite-like composition was assumed as the late accretion impactors is more consistent with the present-day nitrogen budget on Earth than in the case where carbonaceous chondrite-like composition was assumed. We also discuss the dependence of the resulting C/H and N/H ratios in Earth' s surface reservoirs on the composition of the late accretion impactors.

[1] de Niem, D., et al. (2012) Icarus 221, 495.
[2] Pontoppidan, K.M. et al. (2014) Protostars and Planets VI, 363.
[3] Svetsov, V. (2000) Solar Syst. Res. 34, 398.
[4] Shuvalov, V. (2009) Meteoritics & Planetary Science 44, 1095.

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