Consequence of Hydrocarbon Haze Formation on Global Carbon Cycle under Anoxic and Mildly Oxidized Environment

YASUTO WATANABE[1*], EIICHI TAJIKA[1], KAZUMI OZAKI[2], PENG K. HONG[3]

[1] Department of Earth and Planetary Science, the University of Tokyo, Japan (*correspondence: yasuto@eps.s.u-tokyo.ac.jp)

[2] Department of Environmental Science, Toho University, Japan

[3] Planetary Exploration Research Center, Chiba Institute of Technology, Japan

The atmospheric oxygen level (pO_2) in the Archean (4.0–2.5 Ga) is suggested to have been much lower than 10^{-5} PAL (present atmospheric level) [1]. In sufficiently reducing atmosphere (CH_4/CO_2 > ~0.2), hydrocarbon haze may be formed [2]. In the Late Archean, while some geological records suggest temporal increase of pO_2 [3], another suggests a transient haze formation [4]. However, influence of the haze formation on the global carbon cycle has not been fully investigated. Here we used a coupled model of atmospheric photochemistry–marine microbial ecosystem–global carbon cycle, including a photochemical model *"Atmos"* [2], to investigate the effects of hydrocarbon haze formation on global carbon cycle under completely anoxic condition in the Middle Archean (pO_2 < 10^{-10} PAL) and mildly oxidized condition in the Late Archean (pO_2 ~ 10^{-6} PAL). We found that, removal of haze particles due to rainout from the atmpshere works as an effective CO_2 consumption pathway in completely anoxic atmosphere, which makes the climate unstable. In the mildly oxidized world, however, the haze formation rate was not affected significantly by the change in pCO_2, suggesting that there is a negative feedback mechanism concerning the haze formation rate through changes in the UV flux in the atmosphere and atmospheric redox condition. As a result, the hazy climate state could be stable under such a mildly oxidized condition. Our result is consistent with the geological record that suggests a transient formation of hydrocarbon haze in the Late Archean.

[1] Pavlov and Kasting (2002), *Astrobiology 2*(1), 27-41.
[2] Arney et al. (2016), *Astrobiology 16*(11), 873-899.
[3] Anbar et al. (2007), *Science 317*(5846), 1903-1906.
[4] Izon et al. (2017), *PNAS 114*(13), E2571-E2579.