

What is “habitable”?: Toward development of aqua planetology

*Yasuhito Sekine¹, Keisuke Fukushi², Takazo Shibuya³, Hidenori Genda⁴, Tomohiro Usui⁴

1. Department of Earth and Planetary Science, University of Tokyo, 2. Institute of Nature and Environmental Technology, Kanazawa University, 3. JAMSTEC, 4. ELSI, Tokyo Institute of Technology

Earth is an aqua planet that holds liquid water on the surface and can support life. On Earth, liquid water has played many essential roles in the biogeochemical cycles and interior evolution, which make our planet to have been habitable during its history. For instance, liquid water causes chemical weathering of lands, which in turn provides nutrients to life and can stabilize climate through the carbon cycle. The presence of water in the interior can also affect mantle convection in association with plate tectonics and continuous degassing. On the other hand, recent theoretical studies of planetary science suggest a possibility that the amount of water on Earth might have been determined stochastically in the planetary formation process. If Earth had possessed greater or less amounts of water on the surface, some of the essential roles that water plays on current Earth would not have worked effectively.

How was the amount of water on Earth determined? How would the biogeochemical cycles have changed if Earth had possessed different amounts of water? To answer these fundamental questions, it is required research at the interactions of geology, geochemistry, biosphere science, planetary science, and solar system exploration. Near-future spacecraft missions for volatile-rich asteroids, Mars, and icy satellites will provide unique observational constraints on water activity on planetary bodies with various amounts of water. Using the observational data, theory based on experiments and modeling could reconstruct water and geochemical cycles occurred on these bodies. Revealing cycles and fixation of water occurred within volatile-rich asteroids are key to determine the amounts of water delivered to Earth during its formation. Knowledge on geochemical cycles on early Mars and icy satellites will also allow to predict possible ecosystems and biomarkers occurred there, which are important for searching for life in future missions. This paper discusses a strategy how to develop the new fields of research, termed “aqua planetology”, at the interdisciplinary interactions. Aqua planetology aims at understanding the roles of liquid water on planetary bodies and tries to make a new definition of habitability on Earth and beyond.

Keywords: aqua planet, terrestrial planet, geochemical cycles