

# Earth as an open system to the Universe, and five multi-layered spheres to produce a habitable planet

\*Shigenori Maruyama<sup>1</sup>

1. Earth-Life Science Institute, Tokyo Institute of Technology

## <Purpose>

To understand the Earth's history including life, we need to treat the Earth as an open system within the Universe. Such an approach has not yet fully considered. Here, I demonstrate it for the first time.

## <Method>

Utilizing data set derived from geological evidences that have been collected through systematic rock sampling from all the continents over 30 years, we consider the Earth system as five multi-layered spheres, 1) atmosphere-ocean, 2) biosphere, 3) crust and upper mantle in the framework of plate tectonics, 4) lower mantle driven by plume and superplume, and 5) metallic core to cause magnetosphere which protect the life on the surface. And this Earth system is driven by the internal heat of the solid Earth and/or the solar energy for the surface. Mutual interaction between these five spheres produce the Earth's history including life.

## <Result>

The most important key factor to keep mutual interactions between spheres is the function of plate tectonics continuing over 4.4 Gyr, which has been maintaining the Earth system as the robust systematic and dynamic equilibria. Specifically, plate tectonics has circulated carbon between atmosphere-ocean, biosphere, and crust and upper mantle through carbon fixation within sediments to produce a habitable planet. Biosphere plays another significant role as a buffer of CO<sub>2</sub> to stabilize atmospheric temperature within habitable status (not to evolve into Venus-like planet). However, biosphere has been critically influenced by galaxy-galaxy collisions happened at 4.5-4.0 Ga (birth of Earth and Prokaryote), 2.5-2.2Ga (birth of Eukarya), 0.8-0.5 Ga (plants and metazoans) appeared in association with frequent mass extinctions.

## <Discussion>

Based on the understanding of Earth's system and its history, we are able to extend it to our future, and predict the Earth's history including final event of disappearance of the Earth in 8 billion years. I propose the biggest 20 events of Earth's history including future Earth.

Keywords: Earth system, Habitable planet, The biggest 20 Earth's events