Mantle convection mode controls warm and moist environment

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'Are there any life except livings on our Earth in open universe?' We searched for the condition of sustaining warm and moist environment to answer the question. The reason is that life live confortable with warm and moist environment. If sea does exist and does not evaporate or freeze, then the warm and moist environment may be accomplished. We defined the 'Lifetime' of the warm and moist environment as the term while the surface temperature exceed the reference temperature. We adopted the global average temperature of the present Earth as the reference temperature. Nemely, it is fixed at 15 degree Celcius. We investigated the controlling factors of the lifetime with particular reference to the planetary radius and convective the mode of mantle convection.

The balance of incident and emited energy flux determine the surface temperature of a planet. The incident flux increases with time, because the solar luminosity increases owing to its evolution. The emited energy flux depends on the planetary surface temperature and the greenhouse effect. We considered carbon dioxide and water vapor as the greenhouse gases. A carbon cycle controls the amount of carbon dioxide in the atmosphere. This means a balance between the supply by degassing from the planetary interior and the removal through carbonate formation determines the amount of carbon in the atmosphere. The increase of degassing carbon dioxide results in enhancement of greenhouse effect. The degassing depend on the thermal history of the planet. The cooling of the planetary interior results in decrease of the degassing, and thus, the decrease of the greenhouse effect. If such cooling effect gets stronger than the effect of increasing solra luminosity , then the surface temperature decreases. Thus the planetary thermal history strongly affects the duration of the warm and moist environment. The planetary thermal history depends on parameters such as the planetary size, the properties of the mantle material and the mode of mantle convection. So, we investigated the dependence of lifetime on these parameters by using a numerical model. We used a mixinglength theory for calculation of the thermal history. This study, we searched for the upper bound of the lifetime by assuming the maximum degassing. Neverthless, we believe it would be sufficient to clarify the effect of the convection mode on the surface environment. We considered two convective modes: the Earth-like Plate Tectonics Mode and the Venus or the Mars-like Stagnant Lid Mode.

Lifetime increases with planetary size. The lifetime of a planet with the Stagnat Lid Mode is longer than that with the Plate Tectonics Mode, while the planetary size is smaller than Mars size. When the planetary size exceeds Mars size, however, the lifetime with the Plate Tectonics Mode is longer than on with the Stagnant Lid Mode. Thus, the dependence of the life time on the planetary size is stronger on a planet with the Plate Tectonics Mode than that with the Stagnant Lid Mode. The reason is that degassing is controlled by temperature at main convection region with the Plate Tectonics Mode and this temperature change drastic with planetary size. On the other hand, degassing is controlled by temperature profile near the surface with the Stagnant Lid Mode, but temperture profile near the surface changes a little. The main differnce between two convective modes is existence of Mid Ocean Ridge and this led the difference result. Since the life time on a Mars sized planet is less than two billion years, planets with the Plate Tectonics seems to have advantage for sustaining warm and moist environment over billions of years time scale than the planets with the Stagnant Lid tectonics.