Deep mantle volatile cycle and plate tectonics: Impact to the climate evolution

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We investigate the deep mantle volatile (water and carbon) cycle and its impact to plate tectonics and climate evolution in the numerical mantle convection simulations couping with the energy balance model of the surface climate model. To calculate the mantle water cycle, the storage capacity model of water in each mantle minerals as functions of temperature and pressure is incorporated into numerical mantle convection simulations so that the dehydration process can be included in the numerical model of mantle water cycling as well as the regassing and degassing processes. However, the decarbonation process cannot be included because the storage capacity model of carbon is not well-established. In three migration processes of mantle volatiles, the volcanic degassing plays a significant role because the volatile composition of the atmosphere-ocean system can be described as a balance between degassing flux and silicate weathering effects as uptake of the volatile components. As a result, the optical properties of the atmosphere-ocean system such as the Albedo and planetary radiation are changed with the volcanic degassing. Other two migration processes may be worked for regulating the volatile content stored in the deep planetary interior and inventory of surface volatile reservoir. The style of plate tectonics driven by mantle convection may strongly affect the style of climate evolution and inventory of surface volatile reservoir. In the stagnant lid mode of mantle convection, the snowball climate is dominated for over a few billion years because the strong radiative cooling is controlled due to less amount of volcanic degassing associated with the stagnant lid convection. Whereas, the continuous carbon degassing is expected in the continuous surface plate motions so that the mild climate can be found, which allows having the liquid water over a few billion years on the planetary surface. In order to preserve the amount of surface seawater on the planetary surface as the present-day amount of surface seawater on the Earth, the required amount of the water in the entire planetary system may be around 10 to 12 Ocean Masses of present-day Earth's water ocean. Therefore, the mantle volatile cycle concerning with the plate tectonics driven by mantle convection may control the habitability of the rocky planets such as the Earth.

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