Formation and early evolution of atmosphere and ocean

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Supply and Loss of Volatiles

The Earth is the only planet to harbor life, as we know so far. The existence of liquid water and atmosphere has been thought to be essential for the emerge and evolution of life. We would like to review mechanisms of supply and loss of volatiles on the terrestrial planets, and discuss the effects of giant impacts on the formation of the ocean and atmosphere.

Planets form in a protoplanetary disk composed of dust and gas. If the main building blocks of the Earth have no volatile, some mechanisms to supply or produce volatiles on the Earth are required to possess the ocean and atmosphere. Supply process of volatile-rich objects from outside the terrestrial planet region is highly related to the planet formation process. Recent planet formation theory suggests that the behavior of forming Jupiter have a great influence on this supply process [1,2].

Loss of volatiles from planets has an influence on the volatile budget on the terrestrial planets. Several volatile loss mechanisms have been discussed, such as hydrodynamic escape [3], loss by giant impact [4], and so on. Loss of water from Venus is important to the habitability of planets.

Cooling of Magma Ocean and Formation of Ocean

It is generally accepted that many giant impacts occur during the last stage of terrestrial planet formation. The energy released by a giant impact is huge, and it can raise the temperature of the whole proto-Earth by about 5000K in average. Therefore, the planet should be wholly molten just after a giant impact. Cooling process from molten Earth is important to formation of the ocean and atmosphere. We have investigated the cooling process using coupled model of magma ocean, atmosphere, and space, and discussed the beheivior of volatiles on the Earth and Venus [5].

Steam atmosphere formed just after the solidification of magma ocean rapidly cools, and the ocean forms in 1000 years through the intense rainfall [6]. The rain drops is very hot (~ 300 ºC) and the rain fall rate is very high (~ 500 cm/yr).

[1] Morbidelli *et al* (2000) *MPS* **35**, 1309–1320 [2] Walsh et al (2011) *Nature* **475**, 206–209 [3] Zahnle and Walker (1982) *RGSP* **20**, 280–292 [4] Genda and Abe (2005) *Nature* **433**, 842–844 [5] Hamano, Abe and Genda (2013) *Nature* **497**, 607–610 [6] Abe (1993) *Lithos* **30**, 223-235