

The link between oxygen fugacity and water content of Earth and Moon

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Both post-Giant Impact accretion and inheritance from planetesimal building blocks have been proposed as the the volation source for the Earth and Moon. Long-term heterogeneous models have been constructed where continuous addition of volatiles from planetary building blocks ultimately sources the Earth-Moon volatile inventory [1]. Alternatively, late accretion scenarios are supported by isotopic similarities between Earth and chondrites [2] [3]. Why the Earth and Moon have such different volatile contents is difficult to explain, although stochastic models have been proposed [4].

The process of H₂ loss explains many of the volatile-related observations. Water has long been known to be an oxidizing agent in early nebular processes. The $f(\text{O}_2)$ of the Earth-Moon system was low immediately following the Giant Impact. At IW-1, hydroxyl (OH⁻) is stable in basalt melt at high pressure, but at low pressures, H₂ becomes stable and degassing occurs as H₂ gas [5]. The combination of low H₂ solubility and rapid diffusion rates explains the near ubiquitous anhydrous character of the Moon. Only rapidly quenched melts sourced from depth retain high H₂ contents, as seen in orange glass beads. On Earth, the loss of one ocean's worth of H₂ by hydrodynamic escape would raise the $f(\text{O}_2)$ of Earth's mantle from *IW* to *FMQ*. At that point H₂O rather than H₂ becomes stable and H₂ loss becomes self-arresting. This model explains the dichotomy between Earth and Moon. Rapid, early hydrodynamic escape of H₂ also explains many of the isotopic 'anomalies' observed in other elemental systems. The Cl isotope systematics of Mars, Earth and Moon are explained by this process.

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