

## Dichotomy of the Deep Earth Carbon and Water Cycle – A review

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The Earth is unique among the terrestrial planets in our solar system in having a fluid envelope that fosters life. The key behind Earth's habitable climate is well-tuned cycles of water (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), and other volatile species. While on ten to thousands of year time-scales the budget of fluids in the atmosphere, hydrosphere, and biosphere is dictated by fluxes between near surface reservoirs, over million to billion years this is maintained by exchange of volatiles and fluids between the Earth's interior and the exosphere. This is owing to the fact that the total mass of H<sub>2</sub>O and carbon in the interior is likely greater than that observed in the exosphere. The Earth inhales surface fluids (primarily in the form of carbonate and hydrate minerals) through recycling of crustal materials (sinking of Earth's crust into the interior) into the mantle while the deep Earth exhales volatiles back to the Earth's surface by volcanism. However, the deep Earth processes (e.g., melting) and material properties (compositional diversity and their influence on physical and dynamical properties) that allow such interior-exosphere exchange are still incompletely known.

While both water and carbon affect the dynamics of the deep interior, their geochemical behaviors and the effects on melting and dynamical properties are distinctly different. This chiefly owes to the fact that while water in most of the Earth's mantle is held in nominally anhydrous silicates, carbon is stored in accessory phases. Consequently, carbon does not have direct effects on the bulk physical properties of the mantle, whereas dissolved water greatly affects mantle viscosity. On the other hand while carbon in the form of carbonates deepens the mantle solidus, beneath ocean ridges, by more than 250 kilometers, trace water causes the solidus depression by only a few kilometers. In this talk I will highlight the dichotomy of deep Earth carbon and water cycle. I'll review the deep Earth carbon and water cycle as currently constrained by natural observations and laboratory experiments. The topics of interest will include volatile concentrations of the interior reservoirs, the mode of storage, the effect of carbon and water on mantle melting, the present-day fluxes and geochemical pathways of the respective volatile species between the exosphere and the interior. The discussion will also cover how the global carbon and water cycle may have evolved through time and how the ancient Earth may have experienced very different exosphere-interior exchanges than that observed in the modern Earth.