
[EE] Evening Poster | S (Solid Earth Sciences) | S-IT Science of the Earth's Interior & Tectonophysics

[S-IT19] Mineral-melt-fluid interaction and COHN volatile speciation in Earth and planetary

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Sun. May 20, 2018 5:15 PM - 6:30 PM Poster Hall (International Exhibition Hall7, Makuhari Messe)

This session addresses how volatile species in the COHN system affect the geochemistry, mineralogy, and geophysics of the Earth and planetary interior from natural observations, laboratory experiments, and numerical modeling in the temperature, pressure, and oxygen activity range from the early stage of the planet formation to the present.

The COHN volatiles can be critical in zones of mantle upwelling and melting, in the fluid-enriched subduction zones, in the mantle transition zone, in the lower mantle to the core-mantle boundary, and in Earth and planetary cores. However, COHN volatiles affect properties and processes differently depending on their oxidation state, and terrestrial and planetary redox conditions vary in time and space. For example, properties of the upper mantle, which is often oxidizing and comprise CO₂, H₂O, and N₂, will differ from those of the deeper mantle where more reducing conditions may stabilize H₂O, H₂, simple hydrocarbon, ammonia, hydrides, carbides, and nitrides. This difference is because reduced C- and N-bearing species may substitute for oxygen in silicate melts and minerals, whereas C- and N-bearing oxidizing species, such as CO₂, H₂O, and N₂ do not.

This session will address how volatiles control the dynamic processes of Earth and planets, governed by their geophysical and geochemical properties, from geological and laboratory observations coupled with numerical modeling. The topics include (1) Stability relations, chemical and physical properties of crystalline, molten and fluid phases, and partitioning of COHN volatiles among these phases, (2) Stable isotopes, and their fractionation due to pressure and redox conditions, (3) Rheological properties of geomaterials, intergranular fluid, and fluid composition, (4) Seismicity and the influence of volatiles in various tectonic regions including subduction zones. (5) Effects of fluids and melts in numerical simulation of geo-tectonics.

[SIT19-P02] Fast water diffusion in silica glass

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Keywords: water diffusion, silica glass, SIMS, diffusion mechanism

Water diffusion in silicate glass is a fundamental process controlling physical and chemical aspects of magmatism, but fundamental aspects of diffusion in silicate glass are not fully understood. In this study, we report one-order of magnitude faster water diffusion than that reported previously, discovered in diffusion experiments of deuterated water in silica glass, and discuss the water diffusion mechanism by considering diffusion pathways in silica glass.

A SiO₂ glass sample and deuterated water (²H₂O) were enclosed in a silica glass tube and heated in a furnace at 900-750 degree C for 1-20 hours with a water vapor pressure of 50 bar. Deuterated water was used to trace water diffusion at low water-concentration region (<10ppm), where background hydrogen signals obscure a diffusion profile of ¹H₂O. Diffusion profiles of ²H in samples were measured by secondary ion mass spectroscopy (SIMS: Cameca ims-6f) at Hokkaido University.

The ²H intensity rapidly decreases from rim to core of the sample as observed in the diffusion

experiment with $^1\text{H}_2\text{O}$ (Kuroda et al., 2018). This profile shape can be explained by a concentration-dependent water diffusion model in silica glass (Kuroda et al., 2018), where water molecules diffuse through the diffusion pathways formed by breaking Si-O-Si bonds through a hydroxyl formation reaction ($\text{H}_2\text{O} + \text{Si-O-Si} = 2\text{Si-OH}$). In this study, we found that the tail of deuterium profile extends further into the deep region of the sample. This suggests that a small fraction of deuterium-bearing species migrates with a faster diffusion rate and that the diffusion has weak concentration-dependence.

It has been known that noble gas diffusion through “free volume sites” in the dry silica glass structure, and that the activation energy and diffusivity depend on the atomic radius. The fast diffusion coefficient of water in the present study can also be explained by the relation between diffusivity and the size of diffusion species observed for noble gases. Therefore, we conclude that water molecules can diffuse through free volume sites, which provide faster diffusion pathways than those formed through a hydroxyl formation reaction. The concentration of free volume sites, estimated from the solubility of noble gases, is much higher than that observed deuterium concentration in a fast diffusion path in this study. This implies that free volume sites are not fully occupied by water molecules at water vapor pressure of 50 bar. The contribution of fast water diffusion may become larger under higher water vapor pressures, where the concentration of water molecules dissolved into free volume sites may increase as noble gases.