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Fast diffusion path for water in silica glass

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Abstract

Diffusion experiments of ^2H_2O at 900–750 °C and water vapor pressure of 50 bar found diffusion of water in SiO_2 glass more than one order of magnitude faster than that reported previously. The fast diffusion profile of water was observed as an extended tail of the normal water diffusion profile by a line scan analysis with SIMS, and it can be fitted with a diffusion model with a constant diffusivity. The obtained fast diffusion coefficient suggests that the diffusion species responsible for the fast diffusion is not molecular hydrogen but molecular water. The diffusivity and activation energy for the fast water diffusion can be explained by the correlation between diffusivities of noble gases in silica glass and their sizes. Because noble gases diffuse through free volume in the glass structure, we conclude that molecular water can also diffuse through the free volume. The abundance of free volume in the silica glass structure estimated previously is higher than that of ^2H observed in the fast diffusion in this study, suggesting that the free volume was not fully occupied by ^2H_2O under the present experimental condition. This implies that the contribution of the fast water diffusion to the total water transport in volcanic glass becomes larger under higher water vapor pressure conditions.

Keywords: Water, silica glass, SIMS, diffusion pathway, free volume