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Reactive transport modelling of COH fluid fluxing in crustal magmatic systems

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Fluxing of a carbon dioxide-rich fluid in water-rich magmas has been considered to explain carbon dioxide-rich volatile concentrations of melt inclusions and obsidian pyroclasts. It has the potential to cause chemically-driven bubble growth and resorption upon the volatile exchange, which may trigger a volcanic eruption (Yoshimura and Nakamura, submitted). However, actual mechanisms of the fluxing is scarcely understood. In order to grasp an overall image of fluxing, we developed a simple chromatographic model and examined how the chemical compositions of the melt and fluid evolve during the reactive fluid transport. We assumed that a carbon dioxide-rich fluid flows through, and interacts with, a water-rich melt column. Equations of mass conservation and volatile exchange govern this reactive transport model. Two modes of volatile exchange, equilibrium and diffusive modes, were examined in this study. The calculation results showed that the melt column absorbed carbon dioxide (in a few tens-hundred ppm), while discharged a large amount of water (in a few weight percent) to the fluid upon the interaction. The fluid was, on the other hand, diluted with the water, increasing its total mass and H2O/CO2 ratio. The effect of water dilution is more striking during the earlier stage of the interaction. We found that degree of reequilibration of the entire system is controlled by the mass ratio of the totally fluxed fluid to melt in the case of equilibrium exchange mode. If we assume a carbon dioxide-rich vapour composed of 30% water fluxes through a melt column that is degassed in a closed system, reequilibration was accomplished when the total fluid/melt mass ratio exceeds 0.08. In the diffusive exchange case, the melt became undersaturated during the interaction, because water rapidly diffused out of the melt while carbon dioxide infiltrates slowly. When the Damkoehler number (a dimensionless parameter representing timescale ratio of advection to diffusion) is greater than 100, the entire compositional change showed almost the same trends as that in equilibrium case. Applying this result to the data of Mt.Etna's magma erupted in 2006-2007, we calculated the fluid velocity to be 5.1-13 * 10^-4 m/sec.

Keywords: magma, COH fluids, reactive transport, fluxing