EGU21-7852, updated on 27 Apr 2021
https://doi.org/10.5194/egusphere-egu21-7852
EGU General Assembly 2021

A model for multicomponent diffusive bubble growth in magmas

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Bubble growth is one of the key processes that govern the degassing of magmatic systems and drive volcanic eruptions. Typically, the gas exsolution process begins with the nucleation of bubbles in an oversaturated melt and continues with bubble growth. Bubbles grow by mass diffusion, when the silicate melt is oversaturated in volatiles, and by mechanical expansion as a response to pressure decrease. The viscosity of the surrounding melt and the surface tension oppose a resistance to bubble growth and control the mechanical disequilibrium between the bubbles and the melt itself. The combination of the Rayleigh-Plesset equation with a diffusion equation represents a common approach to describe diffusive bubble growth. A number of models have been developed for describing bubble growth dynamics in magmas, most of them accounting for a single volatile specie. Nevertheless, the multicomponent nature of magmatic volatiles has long been recognised to play a major role in controlling magmatic exsolution process. Here we present a model describing bubble growth in magmas in the presence of multiple volatile species through a fully non-ideal multicomponent saturation model. Numerical simulations show the role of the different species (e.g., water and carbon dioxide) in the dynamics of diffusive bubble growth for different melt compositions. The new model is implemented in the MagmaFOAM library, a dedicated computational tool to solve multiphase flows characterizing magmatic systems that extends the open-source library OpenFOAM. Within the MagmaFOAM framework it is possible to combine the bubble growth model with fluid solvers in order to fully capture the multi-scale nature of liquid and gas phases in magmatic systems.