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Integrating Laboratory and Numerical Decompression Experiments to Investigate Fluid Dynamics into the Conduit

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The study of the fluid dynamics of magmatic melts into the conduit, where direct observations are unattainable, was proven to be strongly enhanced by multiparametric approaches. Among them, the coupling of numerical modeling with laboratory experiments represents a fundamental tool of investigation. Indeed, the experimental approach provide invaluable data to validate complex multiphase codes.

We performed decompression experiments in a shock tube system, using pure silicon oil as a proxy for the basaltic melt. A range of viscosity comprised between 1 and 1000 Pa s was investigated. The samples were saturated with Argon for 72h at 10MPa, before being slowly decompressed to atmospheric pressure. The evolution of the analogue magmatic system was monitored through a high speed camera and pressure sensors, located into the analogue conduit.

The experimental decompressions have then been reproduced numerically using a multiphase solver based on OpenFOAM framework. The original compressible multiphase Openfoam solver twoPhaseEulerFoam was extended to take into account the multicomponent nature of the fluid mixtures (liquid and gas) and the phase transition. According to the experimental conditions, the simulations were run with values of fluid viscosity ranging from 1 to 1000 Pa s. The sensitivity of the model has been tested for different values of the parameters t and D, representing respectively the relaxation time for gas exsolution and the average bubble diameter, required by the Gidaspow drag model. Valuable range of values for both parameters are provided from experimental observations, i.e. bubble nucleation time and bubble size distribution at a given pressure.

The comparison of video images with the outcomes of the numerical models was performed by tracking the evolution of the gas volume fraction through time. Therefore, we were able to calibrate the parameter of the model by laboratory results, and to track the fluid dynamics of experimental decompression.