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Investigating degassing dynamics into the shallow conduit through decompression experiments

Laura Spina, Bettina Scheu, Corrado Cimarelli, and Donald Dingwell
Ludwig Maximilians University, Department of Earth and Environmental Sciences, München, Germany
(laura.spina@min.uni-muenchen.de)

The history of bubbles' growth and interaction, as well as their spatial distribution in the shallow conduit, is deeply interconnected with the style of the eruptions. According to the fundamental role played by volatiles in the eruptive process, more effort is required in determining how the key factors of volcanic systems (i.e. magma properties, decompression rate) influence the dynamics of degassing. Therefore, our aim is to provide, through the analysis of decompression experiments on analogue materials, insights on such relations.

We performed several decompression experiments with a shock-tube apparatus, and using silicon oil as laboratory-analogue for the magmatic melt.

The sample was placed in a transparent autoclave, saturated with Argon for an established amount of time under a fixed pressure (up to a maximum of 10 MPa). Successively it was decompressed to atmospheric conditions, by releasing gas through a control valve. The dynamics of gas exsolution processes were recorded by using pressure sensors and a high speed camera. A range of viscosity values (1, 10, 100, 1000 Pa s) was investigated, for the same decompression path. Furthermore, some experiments were carried out with the addition of glass beads, as analogue to crystals, to the pure liquid.

The height of the expanding column was monitored, in conjunction with images recorded during the experiments, and the growth rate of bubbles was measured at different times and depth. Finally, bubble size distribution has been evaluated at various stages for some experiments, in order to achieve a spatial map of the ongoing degassing phenomena.

Results allowed us to define different regimes occurring during the decompression, whose features and characteristics are strongly affected by fluid viscosity. Indeed, several degassing phases were observed, from bubbly fluid to the eventual buildup of a more or less "foamy" phase, which ultimately experiences periodical oscillations around an average equilibrium level. Such periodic fluctuations, whose intensity and frequency depend on the experimental conditions, are triggered by bubbles bursting at the surface and mostly promoted by coalescence. Furthermore, an order of magnitude increase in the radial expansion velocity has been observed, as the nucleation front moves downward, during the experiment.