Research Interests – Anja Allabar

My primary research involves the investigation of degassing mechanisms of magmas that drive explosive volcanic eruptions. H_2O is the main dissolved volatile component in magmas, and is soluble to several weight percent at crustal depths (i. e. high pressure). The ascent and decompression of a hydrous melt decreases water solubility and the melt becomes supersaturated. At a certain supersaturation, water starts to exsolve by forming fluid bubbles. This vesiculation significantly decreases magma density and increases buoyancy, thus accelerating magma ascent. The positive feedback between rapid magma ascent and bubble growth by diffusion and decompression can result in magmatic foam fragmentation near the volcanic vent and thus lead to explosive volcanic eruptions.

The dynamic processes within a volcanic system are not accessible for direct observation. To help understand how water exsolves from magma to drive eruptions, it is thus necessary to conduct laboratory decompression experiments at high pressure and temperature to simulate magmatic conditions. In this way, pressure induced melt degassing can be triggered in millimetre-sized samples. At any point during a decompression experiment, the samples can be rapidly cooled to room temperature to capture the conditions during vesiculation. The resulting glassy and partially degassed samples enable analytical access to different stages of melt degassing, and thus investigation of processes deep within a volcanic system.

My current work mainly focuses on formation of H_2O-bubbles at the very beginning of degassing in crystal-free melts. For highly viscous rhyolitic melt, bubble formation can be adequately described by the generally accepted theory of homogeneous nucleation. However, I found that nucleation theory fails to describe the initial degassing behaviour of phonolitic melts such as that of the 79 AD Mount Vesuvius eruption. Rather, this low-viscosity magma may have reached a chemically unstable state that led to spinodal decomposition, in which spontaneous phase separation of water and melt involves uphill diffusion in order to reduce the free energy of the system. This new finding has important consequences for the understanding and modelling of volcanic eruptions as well as for the interpretation of explosively ejected phonolitic pumice and ash. Based on the discrepancy of bubble formation between hydrous rhyolitic and phonolitic melts, I am presently extending my initial work to conduct decompression experiments using rhyolitic and peralkaline melt compositions, and thus explore the reasons for the different degassing behaviour.

Once I produce suitable samples in the laboratory, they can be analysed for, e. g., size and space distribution of bubbles and H_2O concentration gradients in the glass. However, it has to be accounted for the protocol of the laboratory experiments. For example, both sample size, and the capsule walls that surround the melts during experiments, can have a significant effect on degassing. This must be avoided in order to obtain results that can be upscaled and be comparable to natural magmatic processes. Another example with respect to decompression experiments is that bubbles can shrink significantly due to decreasing molar volume of water in the bubbles and increasing solubility of water in the melt during cooling before the samples can be analysed at ambient temperature. This process leads to an underestimation of melt porosity when bubble textures are examined in rapidly cooled glassy samples. Improperly accounting for this bubble shrinkage effect would undermine the interpretation of the experimental results and their applicability to natural volcanic systems. Consequently, I developed novel methods to enable determination of the temperature at which bubble shrinkage during cooling stops. This helps to correct porosity data with respect to cooling induced bubble shrinkage.

Within the framework of an international research team, we currently study the phase separation of supersaturated hydrous silicate melts during differential heating. This is an alternative promising approach to decipher phase separation mechanisms of hydrous magma. In addition, in peripheral support of my PhD work, I attended synchrotron campaigns where volcanic glasses were heated to magmatic temperatures at ambient pressure. Temperature induced vesiculation processes are traced in-situ using synchrotron X-ray tomography.

In my future work, I plan to build on my experience with decompression experiments of homogeneous melts to systematically investigate phase separation of partially crystallised melts. Such a multiphase system is comparable to most magmas in nature that commonly contain crystals prior to magma ascent. I aspire to further expand my analytical and experimental capabilities by performing in-situ decompression experiments at both high pressure and high temperature to directly investigate phase separation of hydrous silicate melts. Such direct observation at high pressure and temperature should circumvent the problems that arise during cooling of samples in conventional experiments. I expect that future experimental results will be important steps towards better understanding the dynamic magmatic processes involved in explosive volcanic eruptions.