H_2O degassing experiments of the lower Laacher See Phonolite – on the way to eruption

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The Laacher See volcano is one of the youngest volcanoes in Germany with its last eruption 13,006 ± 9 years BP (Reinig et al. 2021). About 6.3 km³ of phonolitic magma was explosively erupted by phreatomagmatic and plinian eruptions in less than 10 days (Wörner and Schmincke 1984). The eruption behavior of such volcanic systems is determined by the phase separation mechanism of H_2O fluid from the supersaturated hydrous silicate melt, caused by the pressure decrease of the magma. The number of fluid vesicles per unit volume of silicate melt (*VND*) is a standard parameter used to quantify the efficiency of fluid-melt separation and thus the acceleration of magma ascent. Two important homogeneous vesicle formation mechanisms are established in the investigation and evaluation of the degassing behavior of silicate melt systems. According to the classical nucleation theory, the *VND* increases strongly with decompression rate (Toramaru 2006) and is therefore a proper parameter for quantifying ascent rate. Recently and specifically for phonolitic melts, the process of spinodal decomposition has been demonstrated, which manifests in the independence of *VND* from the decompression rate (Allabar and Nowak 2018).

To characterize the degassing behavior of the lower Laacher See composition, systematic decompression experiments were conducted in the internally heated pressure vessel. The melts were hydrated with 5.7 or 5.0 wt% H_2O at 200 MPa and 1523 K for 96 h and then continuously decompressed at 1323 K with 0.064 – 1.7 MPa/s to final pressures between 110 MPa and 30 MPa. By reaching the final pressure, the samples were rapidly quenched to room temperature to preserve the vesicle textures and the residual H_2O contents in the melts and to minimize vesicle shrinkage until the glass transition temperature was reached. The *VND*s and the spatial distribution of the vesicles, as well as the H_2O contents in the decompressed melts were analyzed with quantitative image analysis, transmission light microscopy, and FTIR-spectroscopy.

Upon reaching sufficient supersaturation pressure of >100 MPa, all samples exhibit homogeneously dispersed vesicles in the sample center (Fig. 1). Vesicle sizes range from 2 to 13 µm in diameter. Preliminary results indicate that *VND* is independent of decompression rate at all decompression rates. Irrespective of the decompression rate, high log*VND*s of 4.1 to 5.6 mm^{-3} are observed. Further decompression of the degassed melts leads to the formation of coalescence, resulting in a significantly reduced *VND* of the melts.

These observations are consistent with that of Allabar and Nowak (2018), who determined a log*VND* of ~5.2 mm^{-3} for hydrous phonolitic melt of the AD79 Vesuvius white pumice composition. From this, a trend emerges that at least for hydrated phonolitic melt, spinodal decomposition plays a crucial role in the degassing behavior of the melt and thus in the explosive eruption behavior of the volcanic systems.

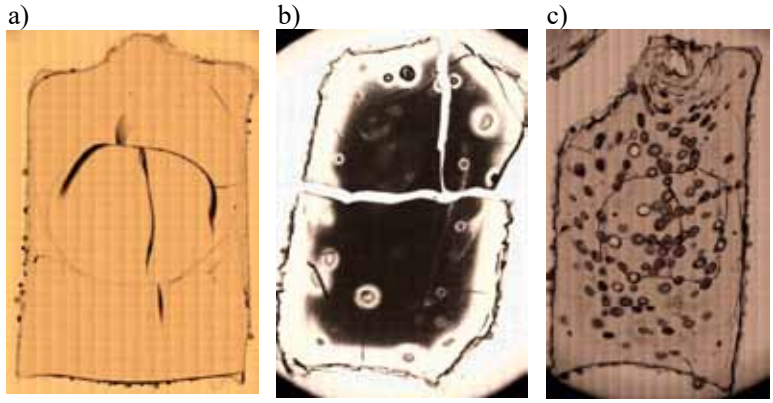

Figure 1. The three degassing steps of an ascending melt. a) No vesicle formation was initiated yet. b) Spontaneous phase separation was triggered by the extreme supersaturation of the melt. c) Further decompression leads to coalescence of the growing vesicles.

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