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Melt degassing triggered by magma injection?

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Explosive eruptions of silicic magmas depend mainly on the amount and the degassing behavior of soluble volatile components like H_2O and CO_2. The injection of a hot mafic magma into a cooler volatile-rich rhyolitic magma chamber might initiate mingling and mixing processes at the interface of the two melt reservoirs (Paredes-Marino et al. 2017). An accompanying increase in temperature and a buoyant ascent of the H_2O-saturated rhyolitic melt may cause a sufficiently high decrease in solubility at pressures < 300 MPa (e.g. Holtz et al. 1995) to trigger vesicle formation. Furthermore, the interface between different melt compositions might act as a site for enhanced vesicle formation. To test this hypothesis, bimodal decompression experiments were conducted. Basaltic and rhyolitic compositions similar to the Askja eruption 1875 in Iceland (Sparks and Sigurdsson 1977) were used for this purpose. For the preparation of the experiments, rhyolitic and basaltic glass cylinders were molten and hydrated separately in an internally heated argon pressure vessel with H_2O excess at 200 MPa and 1523 K for 96–168 h and then isobarically quenched with 16 $K\cdot s^{-1}$. The hydrated glass samples were cut perpendicular to the cylinder axis. The cylinder faces were polished to enable a perfect contact of the rhyolite cylinder with the basalt cylinder. An additional decompression experiment with two contacted hydrated rhyolite cylinders was conducted as a reference to test the experimental setup.

Each pair of cylinders was heated isobarically with 25 $K\cdot s^{-1}$ to 1348 K at 210 MPa and equilibrated for 10 min. To simulate the magma ascent, three bimodal samples and the reference sample were decompressed with rates of 0.17 $MPa\cdot s^{-1}$ or 1.7 $MPa\cdot s^{-1}$ to the final pressure of 100 MPa and then quenched with 44 $K\cdot s^{-1}$. H_2O vesicle number and spatial distribution as well as the H_2O contents in the decompressed samples were analysed by microscope, quantitative BSE image analysis, and FTIR-spectroscopy, respectively.

All decompression experiments resulted in vesiculated samples. In the rhyolite reference experiment, the H_2O vesicles are homogeneously distributed within the whole sample. The former interface of the cylinders is no longer visible. This confirms that the former contact plane of the cylinders does not influence the degassing behaviour during decompression.

Optical examination and electron microprobe analysis of oxide diffusion profiles of the decompressed bimodal samples expose the development of a hybrid melt zone between the rhyolite and the partially crystallized basalt, documenting mixing processes during the decompression experiments (Petri 2020). The hybrid zone in the rhyolitic compositional dominated region is decorated with an enhanced number of H_2O vesicles compared to the rhyolitic and basaltic glass volumes. This suggests that the injection of a basaltic melt into a rhyolitic melt reservoir may lead to significantly enhanced homogeneous H_2O vesicle formation in the hybrid zone and, therefore, enhanced degassing with the concomitant triggering of explosive eruptions.

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