Bubble nucleation in H2O-CO2 bearing basaltic melts: results of high temperature decompression experiments

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Previous experiments have shown that mechanisms of basalt degassing are strongly contrasted when gas bubbles are present or when they are absent. Thus, experimental information on the kinetics of bubble nucleation in basaltic melts is needed, and high temperature decompression experiments have been investigated.

All experiments used PST-9 basaltic pumice from Stromboli as starting material. The sample was fused in air at 1400°C for 3h and then cylinders (l up to 10mm, d 2.5 and 5mm) were cored. Synthesis experiments were performed to produce the volatile-bearing melts to be used in the decompression experiments. Glass cores, distilled H2O and Ag2C2O4 were loaded in AuPd capsules. Three different H2O/CO2 were introduced, corresponding to XH2Oin=1 (#1: only H2O dissolved in glass), 0.55 (#2: high dissolved H2O/CO2), 0 (#3: low dissolved H2O/CO2). The synthesis experiments were ran at 1200°C during about 40h in an internally heated vessel pressurized with Ar-H2. The synthesized crystal- and bubble-free glasses were cut in 2 parts: one for the decompression experiments and the other for the analysis. Decompression experiments were conducted at a fast rate of 39kPa/s, exceptionally of 77.8kPa/s, at 1200°C from an initial pressure (Pin) of 200MPa and to final pressures (Pf) of 200, 150, 100 and 50MPa. Experiments to 25MPa are in progress. Each run included 3 capsules, corresponding to the 3 XH2Oin conditions of glass synthesis, allowing results for the 3 H2O/CO2 to be directly compared. Charges were rapid-quenched immediately after attainment of Pf. Textures were analyzed by X-ray microtomography, and volatile concentrations and spatial distributions in pre- and post-decompression glasses were determined by FTIR.

Pre-decompression glasses have homogeneous volatile contents and distributions. They divide into 3 compositional groups consistent with their XH2Oin conditions of synthesis: group #1 (average H2O content = 4.82 wt.%, average CO2 content = 0 ppm), group #2 (2.15 wt.%, 883 ppm), group #3 (0.82 wt.%, 849 ppm). These values are in agreement with recent solubility data but appear significantly different from solubility models. Glasses decompressed to Pf>50 MPa are relatively bubble-poor with vesicularities up to 0.2vol% and bubble number densities between 1 to 100mm-3. Bubble size ranges from 0 to 100µm. These characteristics suggest that homogeneous bubble nucleation begins at Pf<50Mpa. Critical bubble supersaturation pressures (difference between Pin and the nucleation pressure) are therefore of a minimum of 150MPa for the 3 groups of glasses; a same range has been found for rhyolitic melts. H2O contents of group #1 post-decompression glasses decreasing with Pf. In contrast, group #3 glasses have CO2 contents progressively decreasing with Pf at approximately constant melt H2O contents. Group #2 glasses are intermediate: both their H2O and CO2 contents decrease with Pf. Decompression paths for group #3 are nearly vertical in a H2O/CO2 diagram, a trend similar to theoretical decompression paths calculated assuming closed-system equilibrium degassing. However, final glass CO2 contents exceed the equilibrium concentrations for the different Pf. For the group #2 glasses, decompression paths differ from theoretical decompression paths, and final CO2 contents are also much higher than expected in the case of equilibrium degassing.