

Supplementary Material: Appendix B

We attribute the measured mass loss in our samples to the integration of two signals: (1) mass loss due to diffusion of H₂O out of the sample over the experimental timescale, and (2) mass loss due to H₂O leaking out of the sample through cracks formed during quenching.

We have modelled the magnitude of mass loss in our experimental cores that can be ascribed to H₂O diffusion (and escape) through the cylinder walls over the time of the experiment (Crank, 1975, pg. 74). The dimensionless concentration (x/x_0) of the diffusing agent (i.e. H₂O) can be mapped as a function of dimensionless radius (r/r_0) from the exterior wall of the cylinder inwards for the parameter α where:

$$\alpha = \frac{D \cdot t}{r_0^2} \quad . \quad (B1)$$

We have used Zhang et al. (2007) to select the appropriate diffusion rates (D ; m²/s) for our experiments (1.7E-12 to 4.5E-13 m²s⁻¹) and used the maximum times of each experiment for t (s). For our 1 cm diameter experimental cores and their maximum dwell times we obtain α values between 10⁻⁵ to 10⁻³. These calculations indicate that for a *maximum* time and temperature, H₂O loss due to diffusion through the cylinder walls will never affect a thickness greater the exterior 1 mm of the core. This is substantially thicker than the maximum "bubble depleted" margin (0.4 mm) observed in any of our run products. Furthermore, the maximum drop in concentration is to 50% of the original H₂O content. This partial diffusion-controlled degassing would correspond to a mass loss of 0.37 mg if we accept the modelling limits (0.5 mm rinds depleted of H₂O) and 0.16 mg if we use the observed rinds (0.2 mm). As these values are well below the observed mass loss (Figure B1) we again assert that diffusion is not the primary mechanism for mass loss.

We believe mass loss due to H₂O leaking through cracks formed during quenching is the dominant mechanism. Though we don't have images to confirm the presence of microfractures in our samples we have several observations that give us confidence in this interpretation: (1) if H₂O mass loss were occurring during the high-T experiments a majority of the H₂O vapor filling bubbles would be lost and bubbles would collapse as the melt around them relaxes. However as these experimental products have measured final porosities up to 70% we are confident that at the time of quenching H₂O vapor must still be present within bubbles; (2) the very systematic positive relationship between volume change and mass loss for all experiments (including those before the plateaus) suggests the mechanism responsible of mass loss is related to the volume of bubbles at the time of quenching rather than the time or temperature of an experiment; (3) because samples are quenched below T_g within 10-15 seconds of removal from the furnace it's likely that the quenched glass surrounding bubbles is extremely fragile and potentially unstable. Romano et al. (1996) noted microfractures developing around isolated H₂O-filled vesicles in quenched glasses due to contraction of the glass around the vesicles during quenching. In these experiments escape of H₂O along microfractures after quenching caused a decrease in glass density, which was most pronounced in the time between quenching and the post-experiment physical property measurements. We believe a similar mechanism is responsible for mass loss in our samples, though it may be amplified by the close proximity of bubbles (and thus thin glass walls) in our higher porosity samples.

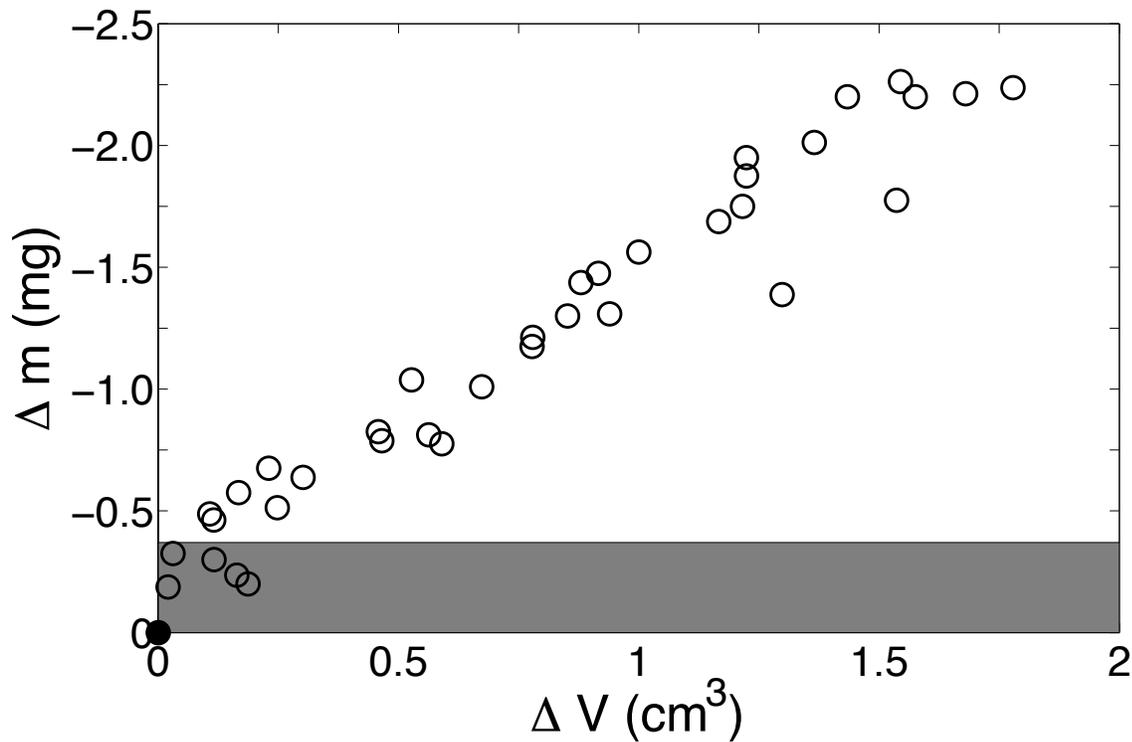


Figure B1. Change in sample mass (Δm) vs. change in sample volume (ΔV) for all experiments at all temperatures (900-1100°C). The maximum mass loss that can be ascribed to diffusion out of the cores is shown as a grey box. The strong positive correlation between the measured mass loss and volume gain is ascribed to post-experiment leakage of exsolved H₂O during quenching. There is no correlation to experimental temperature, indicating that mass loss depends only on the magnitude of volume increase (i.e. vesiculation) and that the core can effectively be viewed as a closed-system during the high-*T* experiment.

References

- Crank, J. (1975) *The Mathematics of Diffusion*, 414 p. Clarendon Press, Oxford.
- Romano, C., Mungall, J.E., Sharp, T., and Dingwell, D.B. (1996) Tensile strengths of hydrous vesicular glasses: An experimental study. *American Mineralogist*, 81, 1148-1154.
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