

SUPPLEMENTAL MATERIAL

Correction for diffusion profiles

As stated in the main text, the measured H₂O concentrations reflect the values dissolved in the glass after peak vesiculation had occurred during bomb expansion. Assuming that observed plate offset is representative of volumetric expansion, and that during vesiculation the bomb was a symmetrically expanding sphere, we can extend the linear tensile strain $\gamma = 1 - L/(L + \Delta L)$ into volumetric strain, equivalent to bomb porosity change. Porosity change $\delta\phi = 1 - [R(1 - \gamma)^3/R^3] \sim 0.6$ for $\gamma = 0.25$. Density measurement of the entire bomb indicates a bulk porosity of $\phi \sim 0.6$, thus we can infer that the bomb comprised a fully dense melt prior to expansion (i.e. $\phi = \delta\phi$) and that the vesiculation event has reduced the far-field glass H₂O concentration by mass transfer into the bubbles from the measured bubble walls. Additionally, the vesiculation has dilated the spatial coordinates in the observed gradient of H₂O toward the dense obsidian edge. To correct for this, we apply two corrections: first for the absolute H₂O concentrations, and second, for the spatial dilation. In both corrections, we use the observation from **Fig. 3D** that the dense obsidian rind is approximately 100 μm thick (less wide than the total diffusion gradients; **Fig. 3B**), in order to define a step function in groundmass porosity such that $\phi = 0$ at spatial position $x < 100 \mu\text{m}$, and $\phi = 0.6$ at spatial position $x > 100 \mu\text{m}$. This approximates what is in reality a smooth, albeit steep, gradient in porosity (**Fig. 3D**).

To correct for the absolute H₂O concentrations at all points in the profiles, we apply the mass balance (Wadsworth et al. 2020) $c' = c + 100\phi\rho_g/(\rho - \rho\phi)$, where c' is the pre-vesiculation local H₂O concentration, c is the observed local H₂O concentration, ρ_g is the gas density (here taken to be 0.2 kg m^{-3}), and ρ is the melt density (taken here to be 2280 kg m^{-3}). The average of the far-field c_1 measurements is $c_0 = 0.68 \pm 0.04 \text{ wt.}\%$, which means that $c_2 \approx 0.69 \pm 0.04 \text{ wt.}\%$, a minor deviation from the observed value. To correct the spatial axis in the transects we take the observed distance x and relate it to the pre-vesiculation distance x' such that $x' = [(x - x^*)(1 - \phi) + x^*]$ if $x > x^*$, otherwise $x' = x$. Taken together, these two spatial corrections result in the transects presented in **Fig. 3B**, which are used to model the pre-vesiculation diffusion process. These corrections ultimately lead to model timescales that are around a factor of ~ 2 lower than those that would have resulted if these corrections had not been performed, demonstrating that such corrections are necessary when modelling diffusion processes in volcanic glass that has undergone secondary post-diffusion vesiculation.