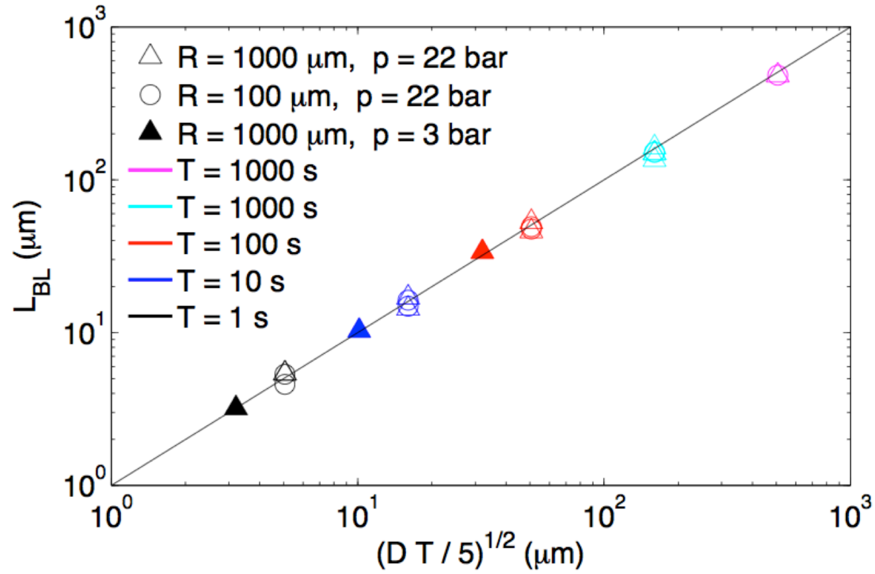

Supplementary Figure 1 (DR1): Results from a model of isothermal diffusive (H_2O) bubble growth where a bubble of initial size, *R*, undergoes sinusoidal changes in pressure with period, *T*, about a pressure of *p*=3 bar and *p*=22 bar with amplitudes of ± 2 and ±20 bar, respectively. The initial dissolved concentration of H_2O represents saturation at pressure *p*. The thickness of the boundary layer, L_{BL}, is defined as the distance in the melt from the melt-vapor interface where the concentration of dissolved H_2O falls to a value of 1/*e* from its maximum value during a sequence of repeated periods of compression and decompression about *p*. The thickness of this boundary layer scales with $\sqrt{DT/5}$, where *D* is the diffusivity at pressure *p* (straight line on the figure). Magma composition is Kilauea basalt (Kushiro et al., 1976) at a temperature of 1140 °Celsius, using the temperature- and H_2O-dependent viscosity formulation of Hui & Zhang (2007), the temperature- and H_2O-dependent diffusivity of Equation 18 in Zhang et al. (2007), the solubility of Dixon (1997) and an equation of state based on Flowers (1979). The bubble growth model is modified after Amon & Denson (1984), Arefmanesh & Advani (1991) and Proussevitch et al. (1993).

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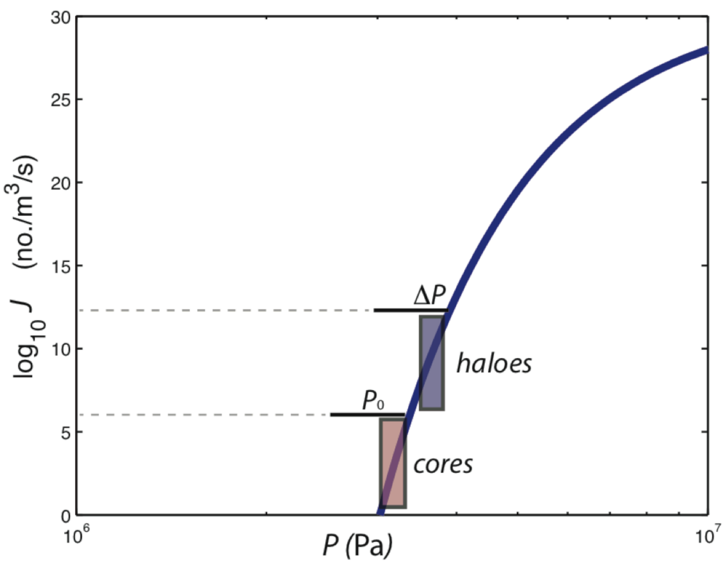

Supplementary Figure 2 (DR2): Nucleation rate (number of bubbles per cubic meter per second) as a function of supersaturation pressure. The observed bubble number densities (bnd) are calculated at $10^6 – 10^{13}$ bubbles/m^3 for the haloes (blue box), and cannot be calculated in cores due to the high variability of bubble number density, but is significantly lower (red box). These bnd values together with decompression timescales of 1 second and nucleation parameters considered in Equation 1 constrain J and hence P_o and ΔP_c to about 3 MPa. The supersaturation accompanying decompression is great enough to nucleate bubbles in the melt shell surrounding larger bubbles (blue box), but not the rest of the melt (red box). Using ρ_m = 1-2x10^3 kg/m^3, these two values imply mean depths of convection of $P_o/\rho_m g \sim \Delta P_c/\rho_m g \sim$ 150-300 meters. We emphasize the uncertainty in this estimate, which is driven by uncertainties in the bnd, decompression timescale and the nucleation parameters.