

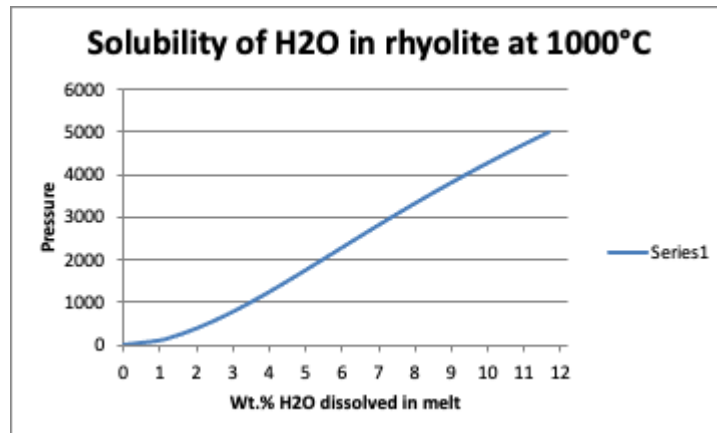
Problem 3: Will it ooze or will it solidify.

Why is the volatile phase taken to be the driver of eruptions?

The volatile phase is taken to be a driver of eruptions to the solubility of the volatiles in the magma. For rhyolitic magma we know that it erupts at relatively lower temperature (compared to basaltic magmas) ranges of 800-1000 celsius and due its high silicate composition it also has high viscosity. Volatiles have high vapor pressures so they will form a gaseous phase as pressure decreases. This of course will depend on the solubility of the water present. If it were to dissolve into the melt then gas will not form. For water to dissolve the following must be true: $\text{H}_2\text{O}(\text{melt}) + \text{O}^{2-}(\text{melt}) \rightleftharpoons 2\text{OH}^-(\text{melt})$, which will also reduce viscosity. This indicates that the proportion of water in silicate melts is $K = (X_{\text{OH}})^2 / (X_{\text{H}_2\text{O}})(X_{\text{O}})$. This can hold for ideal mixtures and small wt%. If we consider solubility as a function of pressure, temperature and composition than an empirical expression exist to obtain measurements of water solubility. Using the software program VolatileCalc (from USGS) we can determine this measurement. The equation used to model is

$$2 \ln X_{\text{H}_2\text{O}}[\text{melt}] = \frac{a}{T} + \sum b_i X_i \left(\frac{P}{T} \right) + c \ln f_{\text{H}_2\text{O}} + d$$

In this equation $a = 2565$, b_i = molar volume of H_2O in the melt (dependent on composition), $c = 1.171$ (modifies linear dependence of X on effective partial pressure), $d = -14.21$ (entropy change). Using VolatileCalc I get graph below of wt% H_2O vs pressure at 1000°C with 100 bar (10Mpa) increments.



Fig(1)

We can see that for smaller pressures solubility will be low and 5.45%Wt H_2O is at 200 MPa.

Since at lower pressure water is not dissolving as much as it could be at higher pressures it is therefore exsolving. Gas bubbles form and rise. Volume will increase as a result of the ideal gas law equation.

$$V = \frac{nRT}{P}$$

We can assume a water amount of 5.55 moles, $T = 1000^{\circ}\text{C}$, and R is the ideal gas constant in SI units ($\text{m}^3\text{PaK}^{-1}\text{mol}^{-1}$). If we vary the pressure we can determine the pressure gradient related to the change in volume. Doing this we see for $\Delta P = 100\text{MPa}$ the volume increases from $2.30\text{e-}4$ to $46.20\text{e-}4$. Below are various plots of pressure vs volume.

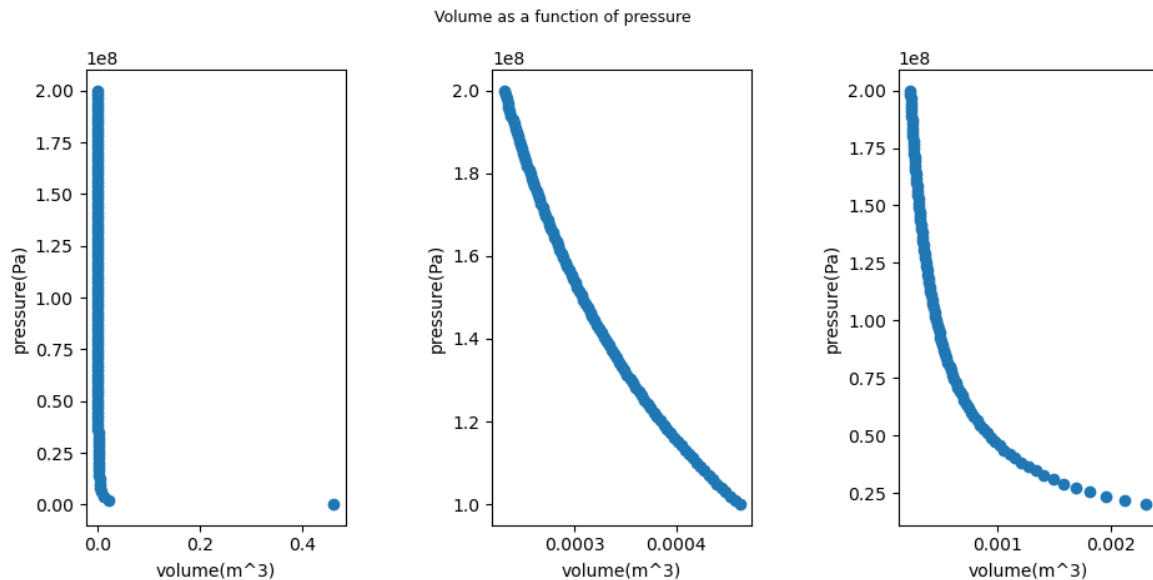


Fig2

The first plot shows the change in volume from 200MPa to atmospheric pressure. The plot in the middle shows the change in volume from 200MPa to 100MPa. The leftmost plot tracks the volume as the pressure is reduced 10 fold. All plots show increments of 100 evenly spaced values from starting pressure to minimum pressure.

We can see that once the bubble reaches atmospheric pressure it “erupts”.

The presence of water favors the formation of granites rather than the eruption to the surface due to water decreasing the melting temperature of the magma. Therefore there will be partial melting in the crust and eventually fractional crystallization.

Obsidian bypasses explosive eruption because of rhyolitic melt with low wt%H₂O. If this were the case then most of the volatiles would have had to leave the melt. Since we know obsidian is glassy, this indicates a lack of crystals that formed.

200Mpa-same magma body can form three types

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