Degassing process of rhyolitic magma inferred from heating experiments

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The degree of degassing of volatile elements of magma controls the mode of volcanic eruption. We have performed heating experiments of rhyolitic glasses to quantify the flux of H2O, which is major volatile element in magma, through melt film. In-situ observations of vesiculation of obsisidian samples containing about 0.7 wt% H2O were performed using our heating stage device. The experimental temperature was 960 C, and the vapor H2O fugacity was controlled by using Ar or H2 -CO2 mixed gases. The vesiculation and degassing processes of samples at 960 C were summarized into six stages as follows. The first stage is an preparation stage, where no bubble is observed. The second stage is a small bubble growth stage. This stage is suitable for the observation of the growth process of independent bubbles. Next is the bubble contact stage. The bubbles begins to come in contact mutually. At the fourth stage, a group of bubbles continues to grow keeping a globular shape of the cluster. Then the growth speed slows down, and the cluster of bubbles reach the maximum size. Finally at sixth stage, the cluster starts shrinking. We noticed that the shape of the cluster had no longer been spherical at this contraction stage. We made a model of the degassing process at the contraction stage. At the contraction stage, gas pressure in the bubble is assumed to be kept almost the ambient pressure because the bubble cluster deflate without keeping spherical shape which can increase the internal pressure by surface tension of melt film. Moreover, H2O partial pressure outside of the bubble is controlled to be constant. Therefore,in this case,the gas flow from inside to outside the bubble is thought to be a steady-state flow with constant flux calculated by Fick's first law ;J=D x dC/dx(J: flux D: diffusion coefficient C: concentration).The volume of the deflated bubble cluster was estimated to be the two-thirds power of measured area of the digitized image of the cluster. The 15 minutes' volume change at the contraction stage was measured every minute, and the fluxes of the water molecules that flowed through the bubble boundary film were estimated from the state equation of the ideal gas for three cases; 0 bar ,0.05 bar, and 0.1 bar of H2O partial pressure outside of the bubble. When the concentration of H2O at the boundary of melt film follows Henry's Law (C proportional to $P_{1/2}$), the ratio of flux will be 1:0.78:0.68 for 0 bar ,0.05 bar, and 0.1 bar of H2O partial pressure. It is confirmed that H2O partial pressure outside the bubble cluster controls the amount of flux. Scanning electron microscope observation of the experiment samples indicates that the thickness of the bubble wall is about 50. The diffusion coefficient of water in the obsidian melt film calculated from approximate value of the measured flux; $1x10^{20}$ molecule/m^2/min is $7x10^{-9}cm^2$/s. This value is the same by order as the diffusion coefficient of water in the rhyolite melt. This means that the amount of flux passing through the bubble film is determined by the solubility of the volatile element to the melt film and its diffusion speed in the melt film, and gives the following suggestions for the degassing process from the vent. When bubbles are connected like a chain without tearing their boundary melt films, there is no flux between bubbles because there is no partial pressure difference of the volatile element between the bubble. When this bubble chain contacts the wall of volcanic conduit of low partial pressure of volatile element, flux occurs only from the bubble contacting the wall with the partial pressure difference. The deflated bubble gains higher internal pressure of volatile element because of surface tension of bubble wall with increasing curvature, and produces the flux to inner side of bubble chain. Destruction of bubble walls or some special mechanism suspending bubble diameter during degassing are necessary to degass efficiently through bubble chain.