GSA Data Repository 2017249

Pioli et al., 2017, Outgassing and eruption of basaltic magmas: The effect of conduit geometry: Geology, doi:10.1130/G38787.1

ITEM DR1: EXPERIMENTAL TECHNIQUES AND FLOW FACILITY

Experiments were performed in a 1.5x0.75x0.03 m rectangular bubble column, made with transparent acrylic resin walls and an aluminum frame (fig. 1). The gas was injected at the bottom of the column through a set of 12 equally spaced nozzles. Nozzles were connected to valves in groups of three to ensure uniform gas supply.

Air was provided from the laboratory compressed air main system. It was metered by one of a number of flow meters mounted in parallel. These had different sensitivity and provided a digital output which was fed into the data logger. Gas flow rates from 2 to 80 L/min were employed. This corresponded to superficial gas velocities (u_{sg}) of 1 x10^{-3} to 6 x 10^{-1} m/s. The initial heights of the liquid in the column, before the onset of gas flow, varied between 0.98 and 1.2 m.

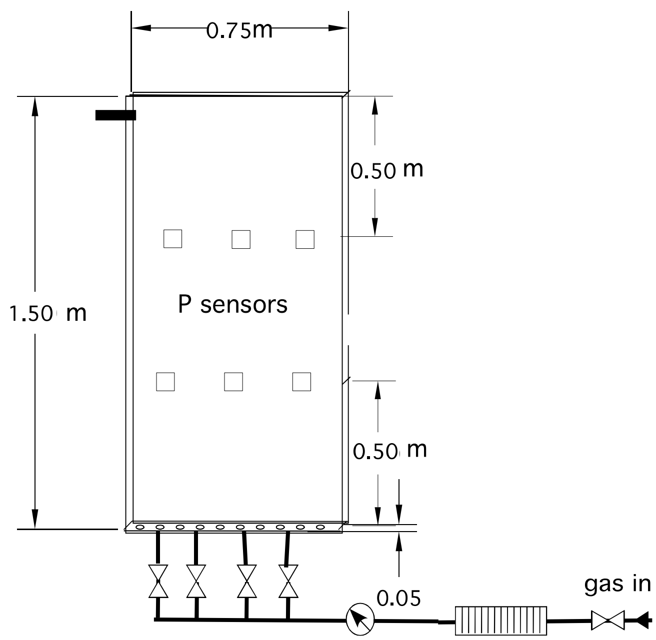


Fig. 1. Experimental apparatus.

Experiments were carried out with either water or aqueous solutions of glucose syrup at different concentrations, with viscosities ranging from 10^{-1} to 70 Pa s. The densities and viscosities employed are shown in Figure 2. The specific gravity of each solution was measured by weighing known volumes of liquid and the viscosity was measured using a

rotational viscometer. Measurements were made when a new liquid was introduced into the flow facility. The physical properties of the liquids used are provided in table 1.
For any given condition (i.e. liquid properties and gas flow rates), the initial gas inlet configuration did not affect the average properties of the flow (i.e. gas fraction, average P drop) but, especially at low gas flow rates, could affect the flow configuration (i.e. flow patterns). For this reason, experiments to investigate the average properties were conducted either by using all the 12 gas inlets or just the three central ones.

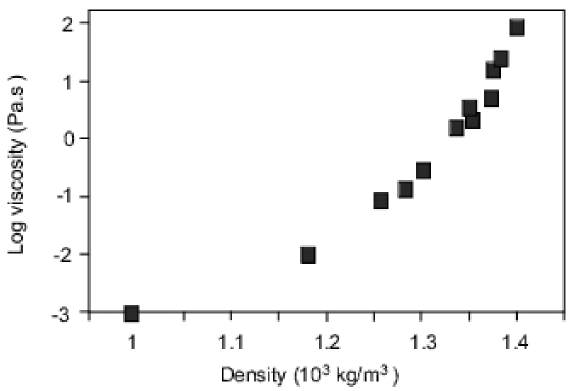


Fig. 2 Variation of physical properties of glucose mixtures used in the experiments after progressive dilution with water. Errors are smaller than symbol size.

Liquid	**Density (Kg/m^3)**	**Rheology**	**Viscosity (Pa s)**	**Surface tension (N/m)**
Water ⁺	1000	Newtonian	$8.9x10^{-4}$	$7\ x10^{-2}$
Undiluted glucose syrup	1400	Newtonian	$8.0x10^{1}$	$8\ x10^{-2}$
Basaltic magma	~2800	Variable	10^{0}-10^{3}	$8x10^{-2}$

Table 1. Main properties of the liquid used and of basaltic magmas

Instrumentation

Pressure was measured with a system of 6 transducers mounted in rows of threes at 0.5 and 1 m from the base of the column. The transducers had a resolution of 0.1 and 0.05 bar/volt, respectively. All the signals were collected by a digital acquisition card and recorded simultaneously at frequencies of 100 Hz. Each run was recorded for 8 min. The recording was started a few tens of seconds after having set the run conditions to ensure steady state and avoid transient effects.

Selected experiments, covering the entire range of flow rates and liquid viscosities were monitored using a Phantom v10 high-speed camera synchronized with the acquisition system. Movies where taken at 200 fps time resolution. The camera resolution is 528 x 1000 pixels which convert in 6.7 pixel/cm in the collected frames. Image analysis was used to assess the size of the largest bubble in the flow and the average height of the flow mixtures during the experimental runs. The volume gas fraction in the mixture (i.e vesicularity) was assessed by comparing the height reached by unaerated liquid and the mixture during the runs. Visual observations of the flow were aimed at evaluating the bubble distribution in the flow and to discriminate between flow regimes and assess transitions.

Scaling details

The experiments were scaled based on different dimensionless parameters (table 2), such as:

Eo= Eotvos number, $g(\rho_l-\rho_g)d_b/\sigma$, quantifying the ratio between buoyancy and surface tension forces,

Re= Gas Reynolds number, $\rho_l\, d_b u_{gs}/\eta$, quantifying the ratio between inertial and viscous forces,

We note that Ka= $Mo^{0.25}$ where Mo is the Morton Number quantifying the ratio between viscous and surface tension forces,

Oh is the Onhesorge number, $\eta\, /(D\, \rho_l\, \sigma)^{0.5}$, relating viscous forces to inertial and surface tension forces.

Fr is the Froude number, as defined in the paper.

Where g is the acceleration of gravity, ρ_l and ρ_g are the liquid and gas density, d_b is the bubble diameter , σ is the surface tension of the liquid, η is the viscosity of the liquid. Usg is the gas superficial velocity, D is the hydraulic diameter of the column. For a comprehensive discussion on the scaling parameters, see Pioli et al. (2012).

	Eo	*Mo*	*Fr*	*Oh*	Re_{max}
Basaltic eruptions	10^0-10^4	10^5-10^{10}	10^{-3}-10^{-1}	10^{-4}-10^{-1}	10-10^4
Experiments- water/air	10^2-10^3	10^{-11}	10^{-3}-10^{-1}	10^{-4}	10^2-10^4
Experiments- undiluted syrup/air	10^{-1}-10^5	10^8	10^{-3}-10^{-1}	10^2	10^{-4}-10^{-2}

Table 2. Scaling parameters of the experiments and basaltic eruptions.

Given the relationship:

$$\varepsilon_g = \frac{u_{sg}}{C_0\, u_{sg} + v_{gd}} \ .$$

that can be transformed in:

$$\frac{1}{\varepsilon_g} = C_0 + v_{gd} \frac{1}{u_{sg}} \ .$$

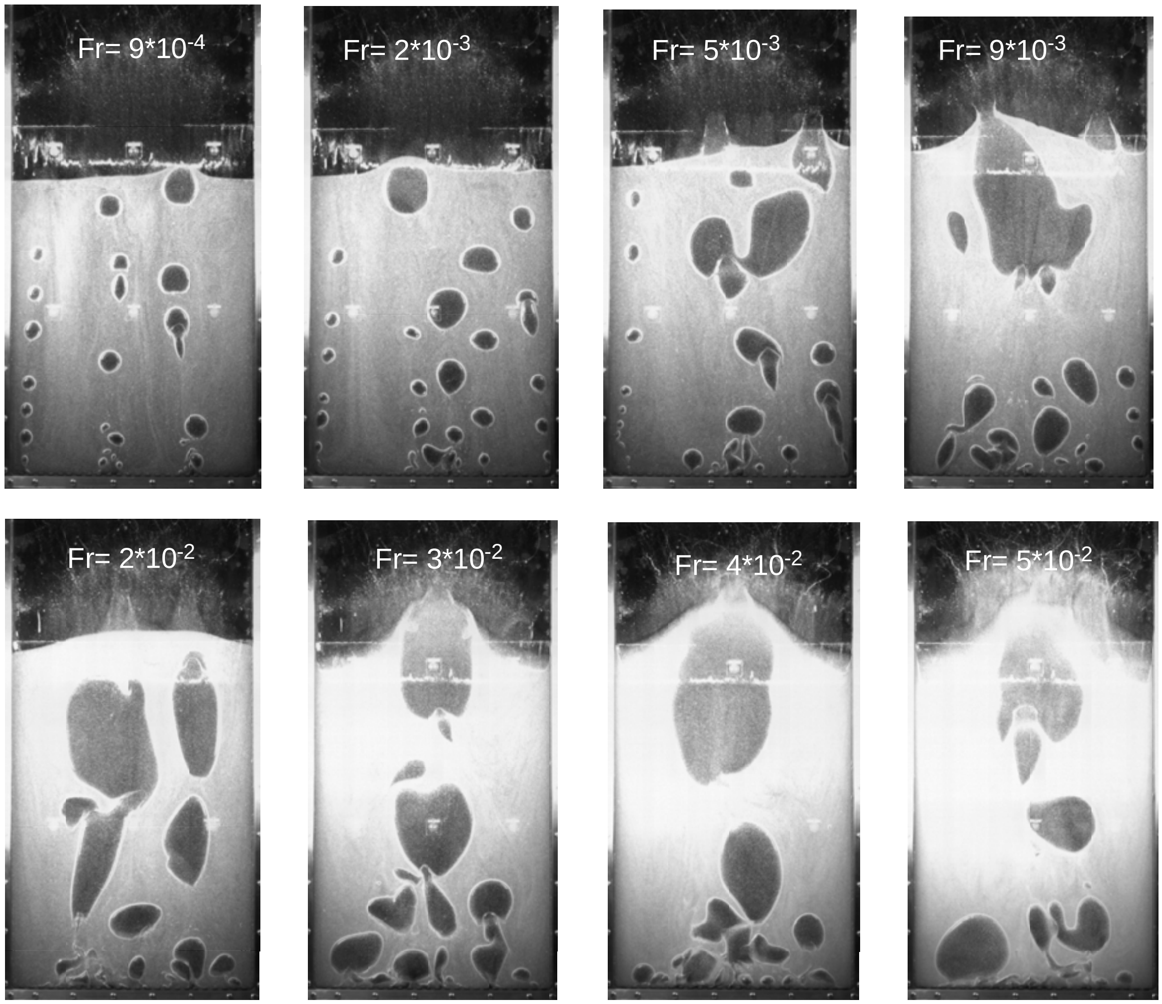
C_0 can be obtained by fitting experimental results in terms of ε_g^{-1} and u_{sg}^{-1}

Linear fitting done on 3 series of experiments resulted in an average C_0 of 6.9 with standard deviation of 0.7. Goodness of linear fit was quantified with the R^2 coefficient of determination, ranging from 0.90 to 0.99.

REFERENCES

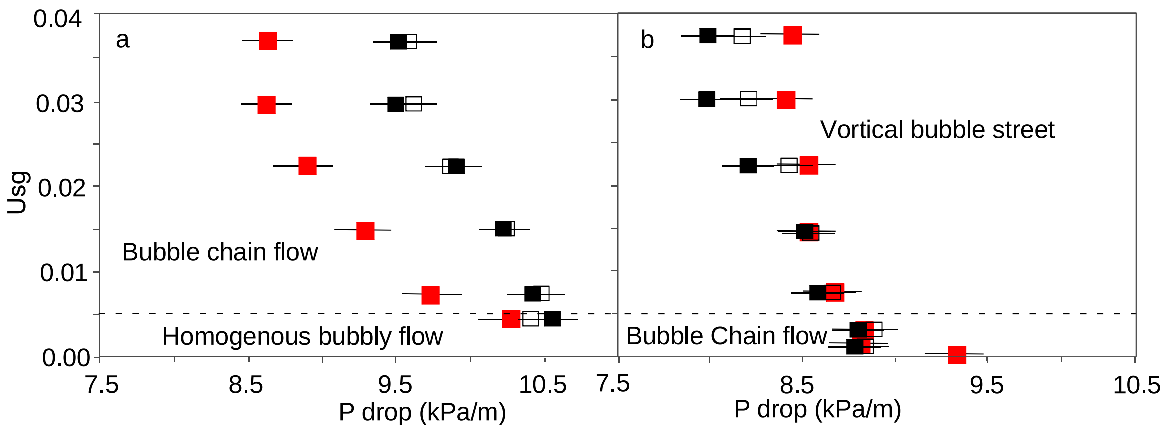
Pioli, L., Bonadonna, C., Azzopardi, B. J., Phillips, J. C., & Ripepe, M. (2012). Experimental constraints on the outgassing dynamics of basaltic magmas. Journal of Geophysical Research, v. 117, B03204. http://doi.org/10.1029/2011JB008392

ITEM DR2: EXPERIMENTAL REGIMES AT Ka=169



Representative snapshots of experimental runs for Ka=169 (i.e. liquid viscosity of 70 Pa s and density of 1405 kg/m^3). The rig is 1.5 m tall and 0.75 m wide.

ITEM DR3: EXPERIMENTAL PRESSURE GRADIENTS FOR SELECTED EXPERIMENTS



Variation of vertical P drop as measured at central (red symbols) and lateral (black and white symbols) with superficial gas velocity u_{sg} a) Ka=167 (undiluted glucose syrup) b) Ka=0.002 (pure water experiments)