Outgassing dynamics along dikes and fractures

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Two–phase flow dynamics of magmas in volcanic conduits is controlled by several factors, including magma rheology, gas content, flow rate and geometry. Most of the existing models are based on the assumption of a cylindrical conduit, which is realistic only for the very shallow portion of the magmatic system, and never applicable to fissure eruptions, which are very common for basaltic activity in several tectonic settings (Stothers et al., 1986; Wright et al., 2006). It has been proven that magma cooling and solidification along the fissure determines viscosity gradients, which contribute to flow localization and the evolution towards central eruptions (Wylie et al., 1999, Wylie and Lister, 2006). However, even when the effects of magma cooling and solidification are negligible, as in the case of long–lived systems, the elongated geometry of the conduit has primary influence in the distribution of shearing in the flow and can have strong control in the flow pattern and phase distribution. We have investigated the dynamics and flow pattern of the outgassing of basaltic magmas along a dike coupling experimental activity and 2D numerical modeling. Experiments were performed on a 1.5x0.75x0.03 m rectangular bubble column, using glucose syrup at variable concentration (viscosity ranging from 0.1 to 70 Pa s) and compressed air. Gas was inserted through a set of equally spaced nozzles, whose configuration and number was changed to test the effect of the initial gas distribution. The effect of the orientation of the fracture on the flow pattern has also been investigated running experiments with the rig inclined up to 30 degrees. We collected data on the average vesicularity, lateral and vertical gas distribution, pressure gradient and oscillations within the flow. With increasing gas superficial velocities or liquid viscosity, the average properties of the flow varied with trends similar to cylindrical columns, but the geometrical distribution of the phases displayed peculiar features. We observed two main patterns: bubbly flow (for low gas superficial velocities), with non–interacting multiple bubble streets developing form each nozzle, and bubble plume patterns, where all the bubbles were rapidly converging toward the centre of the tank. Plume geometry was controlled by large–scale, gas–driven liquid circulation, developing into circular to elongated patterns. Increasing liquid viscosity increased the size of the gas bubbles, subjected to repeated coalescence and breakup during rise and eventually converging into a single flattened bubble with dm–scale length. Numerical modeling, validated with specific experiments, allowed for the analysis of the time–dependent behavior of the flow and was extended to magmatic conditions to explore the applicability of our experimental results.

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