Entrainment of high-viscosity magma into low-viscosity magma in the magma pocket: analogue experimental approach

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Magma mixing is an important process in igneous petrogenesis, and mixing both in magma chambers (e.g., Huppert et al., 1984; Campbell and Turner, 1989; Oldenberg et al., 1989) and within conduits (e.g., Blake and Campbell, 1986; Koyaguchi and Blake, 1989; Freundt and Tait, 1986) have been investigated. In this study, we carried out two types of analogue experiments to examine the effects of magma pocket in a conduit on magma mixing processes. The first type of the experiment examined the conditions of mixing in a conduit pipe without magma pocket. In the second type of experiment, we examined the effect of the presence of magma pocket in the conduit. We used water and syrup to conduct the experiments. The density and the viscosity of the syrup range from 1340 to 1480 kg/mˆ3 and from 0.56 to 150.30 Pa sec at 24 degrees C, respectively. The apparatus was made of acrylic plate (0.005 m thick) and pipe. In the case of the first type of experiments, upper vessel (a cubic chamber, 0.06 m on a side) is connected downward to a pipe (0.006 m inner diameter, 0.5 m long). In the second type of experiments, the apparatus consists of an upper vessel and two types of pipes. The vessel is connected downward to the pipe (0.006 m inner diameter, 0.2 m long), pocket (another pipe: 0.025 m inner diameter, 0.05 m long) and subsequently pipe (0.006 m inner diameter, 0.2 m long). At first, we placed less dense and low-viscosity fluid 1 (red colored) over dense and high-viscosity fluid 2 (clear and colorless) in the upper vessel. The lower pipes and pocket were initially filled with fluid 2. The two fluids fell down by gravity. At the beginning of both experiments, fluid 2 flows from the upper vessel into the pipe and subsequently fluid 1 is drawn into the pipe through center of the fluid 2. In the first experiment, initially the central flow (fluid 1) was thin and parallel sided, but as its diameter increased the flow became unstable. The transition from stable to unstable is at Reynolds number = velocity∗diameter of the fluid 1∗density/viscosity =5. In the second type of experiments, when the fluid 1 enters into the magma pocket, the velocity of the fluid 1 decreases and fluid 1 floats in the magma pockets mainly due to buoyancy. This phenomenon occurs also at low Reynolds number (lower than Re=5). At this time mixing may occur between entrained fluid 2 and host fluid 1. It was considered that the two fluids collapse and the mixing occurs when viscosity can not hold the density difference of two fluids for lager diameter of the magma pockets.