A feedback effect of magma decompression rate on silicic volcanism induced by crystal-rich magmas

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A bifurcation of explosive and effusive volcanism has been thought to be controlled by feedback effects between magma decompression rates and outgassing/crystallization. The feedback effects yield strong nonlinearity between magma decompression rate and eruption explosivity. Here we propose a new feedback effect of the decompression rate of crystal-rich magma based on microstructural observation of natural samples and decompression experiments. Crystal-rich pumices from the Central Andes include broken crystals that form before magma fragmentation, while the same types of crystal are not found in crystal-rich lavas. Rapid decompression can cause the crystal breakage; we infer that the explosive eruption by crystal-rich magma involves the rapid decompression and vesiculation processes before magma fragmentation. In laboratory, crystal-rich magma decompressed at rates corresponding to that during lava effusion shows gas segregation due to the interaction between growing gas bubbles and crystal framework in magma. In contrast, crystal framework collapses under high decompression rates, resulting in magma lubrication. Therefore, when magma decompression rate is high, the crystal-rich magma is lubricated and accelerates toward the surface. This feedback effect would influence other feedback effect and cause strong nonlinearity between magma decompression rate and eruption explosivity.

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