Experimental deformation of viscous fluid with gas bubbles: Microstructure and permeability, and implication for volcanic eruption

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The open-system magma degassing controls the explosivity and eruption styles of volcanic eruptions through reducing the amount of gas phase in magmas and thus driving force of magma ascent and expansion. A mechanism of the open-system degassing in highly-viscous silicic magmas is thought to have been a permeable gas flow through connected bubbles. However, recent decompression experiments under isostatic condition showed the increase of magma permeability around 70 vol% vesicularity, which implies the occurrence of the permeable degassing only at shallow volcanic conduits, and even at this high vesicularity the experimentally obtained permeability is too low to degas magmas effectively during ascent. Hence, non-explosive eruption requires other mechanism that increases magma permeability. Here, we experimentally show for the first time that shear deformation dramatically increases the magma permeability parallel to the shear direction via enhancement of bubble coalescence and formation of tube-like structure. A conduit flow model shows that magma deformation results in large permeability even at deep conduits, and the permeable degassing through deformed magmas toward earth surface may control the eruption explosivity. This model also explains the observation of volcanic gases that the degassing from deep conduit occurs in effusive eruptions.