Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

SIT041-05 Room: 101 Time: May 24 14:45-15:00

Permeability development of volcanic pyroclasts: experimental constraints

Michihiko Nakamura[1*], Satoshi Okumura[1], Shingo Takeuchi[2]

[1]Dept. Earth Sci., Tohoku Univ., [2]Civil Engineering Research Lab., CRIEPI

The permeability of erupted materials has been attracting a considerable amount of attention because it may govern the efficiency of permeable flow degassing, at least at one point in the course of an eruption. Because the vesiculation structure of natural erupted materials is the result of integration of various elementary processes such as bubble growth, coagulation and deformation, and magma fragmentation and welding, it is often difficult to untangle the multiple factors contributing to the permeability. In order to understand the effect of each elementary process on the development of magma permeability during volcanic eruptions, we have started experimental investigation of the synthesized pyroclasts.

The pore microstructure of bubble-bearing magma is principally different from the polycrystalline rocks in a point that fluid flows along the grain edges and corners of the rocks, while along the interconnected bubble networks. Thin melt films between the two contacting bubbles prevent permeable gas flow especially in viscous magmas, making it unsuccessful to describe the interconnection of bubbles with a simple percolation model, in which touching spheres are regarded as connected with each other. The foamed melt produced in an isotropic decompression experiment can be a "reference" material to vesicular magmas. The permeability of the representative rhyolitic run products with isotropic vesicular texture is lower than 10^{-15} m^2at a vesicularity of <70 vol.% and steeply increases at around 70-80% (Takeuchi et al., 2009). This shows that the rhyolitic melt films are stable until vesicularity reaches these high values. The critical vesicularity, at which permeability steeply increases, is strongly dependent on the bubble microstructure. Okumura et al. (2009) performed torsion deformation experiments of vesicular rhyolite melt and demonstrated that shear deformation dramatically increases the magma permeability parallel to the shear direction via the enhancement of bubble coalescence and the networking of tube-like bubbles. The critical vesicularity decreased to 30 % when shear strain is above 8. The experimentally obtained permeability has a range that may control the eruption explosivity($10^{-16\sim-11}$ m^2).

The rapid increase of bubble interconnectivity may lead to production of pumice clasts and volcanic ashes upon the ultimate bulk fragmentation. On the other hand, continuous and local fragmentation may increase permeability and thus promote foam collapse rather than explosion (Nakamura et al., 2008). The permeability of the collapsed and compacted magmas controls the accumulation of gas pressure in the shallow conduit, which induces Vulcanian eruptions and self-explosion of lava domes. To investigate the permeability development in this compaction stage, we have carried out uniaxial compression experiments of synthesized fine (<250 micrometers) volcanic ashes with variable water contents. The compressed run products maintained high permeabilities till porosity decreases very low: 10^{-13} m^2at porosity of 35%, and 10^{-14} m^2at 30% for the compressed products of water-poor (ca. 0.4%) ashes, and 10^{-13} m^2at 20%, 10^{-14} m^2at 10% and $10^{-16\sim-17}$at <5% for the relatively water-rich (0.7%) ashes. The former preserved their original sized shards and fine pores until its porosity decreases to 30%, whereas the latter welded to form coarser grains and thick interspaces. These results show that once magmas are fragmented or the bubbles are extensively interconnected, then interconnection of the pores were maintained during

compaction, and that such a welding and coarsening process may partly explain the variation of permeability-vesicularity relationship in the compaction stage.

Keywords: magma, degassing, permeability, pyroclasts