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Magmatic-phreatomagmatic transition and vesicularity change in Heian eruption of Towada Volcano

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1. Introduction

The occurrence of phreatomagmatic eruption is considered to be controled by external water and magma ratio (Wohletz and McQueen, 1984). However, this criterion holds true for only mafic magma (Kato et al., 1997). On felsic explosive eruptions, magma is vesiculated and fragmented before contacting with water, and degree of fragmentation seems to be one of the controlling factors through the difference of contact surface (Yamamoto, 1989). This study examines the factor for magmatic-phreatomagmatic transition other than magma-water ratio.

2. Magmatic-phreatomagmatic transition in the Heian eruption of Towada Volcano

Heian eruption, the latest silicic volcanism at Towada volcano, began with magmatic eruption, thereafter repeated magmatic and phreatomagmatic eruptions alternately (Hiroi and Miyamoto, 2010). Through the activity the vent was in Nakanoumi caldera lake (Kudo, 2010) and the magma contacted with lake water inferred from the existence of cauliflower pumice (Heiken, 2006).

From the steadiness of grain size distribution with time, the first magmatic eruption (plinian pumice fall deposit: unit OYU-1) kept constant magma discharge rate. And from the steadiness of grain size distribution in the deposit that depends on column height, which is controlled by magma-water ratio (Koyaguchi and Woods, 1996), magma-water ratio can be regarded as constant at OYU-1 stage. Following few hours OYU-1 activity, the eruption proceeded to phreatomagmatic one rapidly (base surge deposit: unit OYU-2).

3.Vesicularity change in pyroclastics during the transition

Phreatoplinian eruption, the typical felsic phreatomagmatic eruption, produces extremely fine-grained ash deposit (Self and Sparks, 1978) mostly consisting of plate-like shards originated from large expanded bubble wall (Heiken and Wohletz, 1985). Because external water hinderes bubble growth by cooling, bubbles should grow before contacting with external water. Hiroi and Miyamoto (2011) classified shards into large expanded bubble group and small bubble group, and proved successive bubble growth through OYU-1 and OYU-2 stages.

Past studies demonstrated that pumice from magmatic eruption has low density than that from phreatomagmatic one (e.g., Walker, 1980), that is in harmony with the density measurements for pumices of Heian eruption, but seems to be in conflict with vesicularity expected from glass shards analysis.

It is inferred that pumices by magmatic eruption still vesiculate even after their ejection. To the contrary pumices by phreatomagmatic eruption freeze their vesicularity at contact with water. This implies vesicularity difference occurrs after the magma-water contact. Since the surface of pumice should hold their texture at fragmentation, we focused on their bubbly and foamy portions ratio to investigate the difference of bubble growth estimations from shards and pumice density, and confirmed the similar increase of bubbly portion on pumice surface with time (25 - 58 % and 53 - 62 % from bottom to top in OYU-1 OYU-2 deposits, respectively). Contrary to the shards, however, their increase is not successive throughout but decreased temporarily at the transition from OYU-1 to OYU-2. It may be the result of superposition of additional vesiculation on inherent vesicularity increase with time on OYU-1 pumice to acquire higher bubbly portion in its late stage than that of the beginning of OYU-2.

4. Conclusions

Fine-grained shards on magmatic and phreatomagmatic eruptions hold the information at fragmentation, but pumice on phreatomagmatic eruption freezes its texture immediately before magma-water contact rather than at fragmentation, and pumice on magmatic eruption may loose both of them to some degree by further vesiculation after the ejection.

The increase of large expanded bubble, suggested by fine-grained shards analysis, is an important factor for the transition from magmatic to phreatomagmatic eruptions through the efficient heat transfer from magma to water.

Keywords: magma eruption, phreatomagmatic eruption, vesicularity, fine-grained shards, coarse-grained pumice, felsic eruption