Bubble number density of pumice and ash of Aira eruption products: estimate from bubble wall thickness

Yoshie Oki[1]; Tatsuyuki Ueno[2]; Hiroaki Sato[3]; Keiko Suzuki-Kamata[4]

[1] Earth and Planetary Sci., Kobe Univ; [2] Earth Sciences, Kobe Univ.; [3] Earth and Planetary Sci, Kobe Univ; [4] Earth and Planetary Sci, Kobe Univ.

http://www.kobe-u.ac.jp/volcano/hsato.html

Cursory examination of vesicle textures of pumice and ash of large scale eruption products often shows that bubble wall thicknesses of pumice and ash are much different (e.g. Machida and Arai, 1992). We describe here the vesicle textures in terms of grain size of pyroclasts of a caldera-forming pyroclastic eruption of Aira caldera 25000 ybp. We focused on the bubble-wall thickness for the comparison of vesicle textures of pumice and ash, which reflect the bubble size and number density of the pyroclasts. Assuming a bubble cell model of Sahagian and Proussevitch (1993), the bubble wall thickness (d) is proportional to vesicle size for constant vesicularity (p) and also is related to the number density of vesicles (N), as N = 6*(1-p^(1/3))^3 /[pai*(1-p)*d^3]. For the measurement of bubble wall thickness, we arbitrarily drew straight lines in a back-scattered electron image of a section of pyroclasts, and measured the apparent thickness of bubble wall where the lines meet the center line of a bubble wall. More than 300 bubble wall thicknesses are counted for each sample, and the number of walls in each class with 2^n microns is obtained. We assumed random 3D orientation of bubble walls, and corrected for the effect of measuring apparent thickness by reducing the number of walls for larger class from the number of walls for smaller class. The number density of bubble is obtained by summing the N for each class from the above equation assuming the vesicularity of 0.8 for ash fragments. This method is calibrated against the measurement by other methods of Toramaru (1990), and showed good correspondence.

We selected three samples of the Aira pyroclastic eruption products; i.e., Osumi pyroclastic fall deposit; Ito pyroclastic flow deposit, and AT co-ignimbrite deposit. These samples were sieved to obtained grain size distributions. We then made polished thin sections for different grain size from -3 phai to 4 phai, for which back scattered electron images were obtained for bubble wall thickness measurement. The average bubble wall thickness varies by more than 1 order of magnitude according to the grain size of the pyroclasts, ranging from less than 3 microns thick for pumices of Osumi pumice fall deposit (-1-0 phai) up to 30 microns thick for bubble wall ash of AT co-ignimbrite ash (1-4 phai), corresponding to bubble number densities of 5-12*10^14 and 3-5*10^12 m^-3, respectively (we assumed p=0.80). Although we have no data on the vesicularity of pyroclasts in the formation of the bubble-wall glass ash, its width/length ratio suggests high vesicularity similar to the pumice components. Difference in bubble number density between pumice and bubble-wall glass ash indicates that the mode of vesiculation during the eruption are different for pumice-forming magma and ash-forming magma. The low number density of vesicles of the bubble-wall glass ash suggests that the decompression rate of the corresponding magma would be small (Toramaru, 1995; Mourtada-Bonnefoi and Laporte, 2004), which is somewhat odd to the presumed rapid magma ascent during caldera-forming eruptions. Three possible causes of the low number density of vesicles for the bubble-wall glass ash are suggested; i.e., (1) large oversaturation of water due to rapid decompression suppressed the bubble nucleation, (2) vesiculation occurred under small water-oversaturation due to slow decompression in the conduit during the caldera-forming pyroclastic flow eruption, (3) vesicle nucleation started in the magma chamber, where low oversaturation caused low number density of vesicles, and subsequent expansion of vesicles during rapid ascent in the conduit. At present, we have no conclusive evidence for determining the absolute cause of the low number density of bubble-wall glass ash.