Characteristics of pumice texture from the Usu 1977 Plinian eruption, and implications for the magma degassing processes

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The stratigraphic variation of 1977 Usu-Volcano Plinian fall deposits reveals a certain trend in their lithofacies and components, and their pumice displays extremely heterogeneous in its vesicle and groundmass texture. These diversities should indicate the temporal evolution of magma in degassing processes.

The 1977 eruption of Usu-Volcano was characterized by 4 Sub-Plinian eruptions (Suzuki et al., 1982): Big I, II, III, and IV, respectively (Katsui et al., 1978). According to Niida et al. (1982), the Big I eruption column grew up step by step, and then became weak rapidly, after that the small eruption with co-ignimbrite ash occurred.

The 1977 Usu-Volcano Plinian eruption produced various types of pumice in color, vesicularity, bubble number density, and crystallinity of microlite. Based on the color, they are classified into 3 types: white pumice, bright-gray one, and dark-gray one. Although their pumice shows extremely heterogeneity in its color and texture, the bulk chemical compositions are almost identical to each other. It suggests the pumice was produced by the same magma. The whiter pumice is characterized by the higher vesicularity and bubble number density, and the lower crystallinity of microlite. According to numerical and experimental study, the bubble number density of pumice is sensitive to decompression rate of magma: the smaller the decompression rate, the smaller the bubble number density (Mourtada-Bonnefoi and Laporte, 2004). And the crystallization of microlite of skeletal plagioclase may be induced by the devolatilization of magma (Hammer and Rutherford, 2002). So we conclude that the whiter pumice was produced by the magma which was decompressed more rapidly, and which volatile component degassed and escaped less efficiently than darker one. The bubble number densities of their pumice are about 100000-1000000 mm-3, which indicates decompression rate is 100-1000 kPa/s. The values are much higher than the decompression rate of 1.3 kPa/s which estimated from the beginning of the earthquake about 32 hours before Big I eruption. Therefore, we propose that the observed higher bubble number densities are yielded by dramatic increase of decompression rate that simultaneous with fragmentation. The pumice characterized by extremely lower vesicularity and bubble number density, and higher microlite crystallinity was produced by only Big III and IV eruptions, although it didn't by Big I and II eruptions. That results from promoting of degassing and escape of the volatile more efficiently prior to the Big III and IV eruptions than Big I and II eruptions.

The deposit of Big I eruption consists of 4 fall units (I-a, b, c, and d layers) with clear boundaries, and I-a and b layers are inversely graded. The upper half part of I-b layer sediments from the highest eruption column in Big I deposits with maximum clast method by Carey and Sparks (1986). Compared with eruption column behavior, the I-a and I-b layers should sediment from earlier and later growth of eruption column, respectively, and then I-c layer should sediment after the column decreased. After that I-d layer should sediment from small eruption.

We also conducted the component analysis of the deposit in order to see how the proportion of each types of pumice change compared with the eruption sequence. The abundance of white pumice, which is produced by higher decompression rate and less efficiently degassed magma, gradually increases toward the climax of the eruption of Big I at both approximate and distal localities. It is empirically found that the relationship between eruption column height (H) and magma discharge rate (Q) is H = 1.67 Q0.259 (Sparks et al., 1997). And magma discharge rate is proportional to magma ascent rate if the conduit diameter is constant. So, we conclude that the systematic variations of abundance of white pumice in Big I deposit account for the increase of the magma ascent rate, i.e., the eruption column height.