The generation process of phreatoplinian eruption seen from 40 ka eruption (Kp I) from Kutcharo volcano, Eastern Hokkaido, Japan: About the contact conditions of magma with external water

*Shohei Shibata¹, Takeshi Hasegawa¹

1. Graduate school of science and technology, Ibaraki University

(Introduction)

Products of phreatoplinian eruptions are dominantly composed of fine-grained ash, which disperses over areas covering tens to several hundred kilometers or more. Phreatoplinian eruptions differ from plinian eruptions in that they contain a considerable amount of pumice (Self and Sparks, 1978). However, the generation process and mechanism of phreatoplinian eruption are still poorly understood because of the absence of direct observations. The phreatoplinian eruption style has been described and defined only by geological evidence, such as widespread pyroclastic deposits consisting of extremely fine-grained ashes and abundant accretionary lapilli (e.g., Self and Sparks, 1978). In this study, we conducted grain size and component analyses of the 40 ka caldera-forming eruption deposits at Kutcharo volcano (Kp I) to reveal the generation processes and fragmentation mechanisms of phreatoplinian eruption.

(Results)

The Kp I eruption deposits are stratigraphically subdivided into 7 units in ascending order (Shibata and Hasegawa, in press). Units 1, 3, 5 are thin pumice falls. The higher the stratigraphic level, the larger in grain size and apparent density of pumice (e.g., for Unit 5, the maximum pumice size is 5 cm and the maximum density is 1.31 g/cm³). Units 2, 4, 6 are relatively thicker, silty ash falls mainly consisting of abundant accretionary lapilli. Stratigraphically higher ash fall units are larger in volume and finer in grain size, with F2 (weight % of particles finer than 1/16 mm) values of > 60% in Unit 6. Microfossils of Dinophyceae (Ceratium hirundinella) are found in Units 1 to 6. This suggests that the units were deposition in a lacustrine environment. Unit 7 is a voluminous and pumiceous ignimbrite. The total volume of the 7 units was estimated to be around 130 km³. Total volumes of pumice fall (units 1, 3, 5) and ash fall (units 2, 4, 6) were approximately 1.6 km³ and 52 km³, respectively. We classified volcanic glass shards (124~63 μm) of Units 1 to 6 into magmatic and phreatomagmatic (quenched) fragmentation types based on Machida and Arai (2003). According to this classification, phreatomagmatic (quenched) type glass shards were commonly recognized through all units. The ratio reaches a maximum (46 %) in Unit 6.

(Discussion)

Pumice falls (Units 1, 3, and 5) got coarser with time, whereas particle sizes of ash fall (Units 2, 4, and 6) became finer towards the deposition of Unit 6. It is suggested that the fragmentation mechanisms were different between pumice fall and ash fall units. Considering the remarkably wide dispersal and high fragmentation, we suggest that Unit 6 was deposited by a “phreatoplinian-style” eruption. It seems that interaction between magma and external water effectively contributed to the fragmentation processes for ash fall units. In addition to glass shards of both bubble wall and pumiceous types, Kp I eruption deposits also commonly contain flake-, and blocky-shaped glass shards produced by phreatomagmatic (quenching) fragmentation. For both types of glass shards to have been generated, part of the ascending magma would have interacted with groundwater before and/or during the magmatic fragmentation (vesiculation) that generally occurs below a depth of approximately 1,000 m in felsic H2O-saturated magma systems (e.g., Zhang, 1999). It can be concluded that a large and deep (~1,000 m) aquifer in the former caldera basin was sustainably supplied with groundwater through the conduit system. The
generation of the phreatoplinian eruption seems to have been controlled by plumbing where conduits penetrated the huge aquifer of pre-existing caldera structures that preserved/hosted a large amount of external water.

Keywords: phreatomagmatic eruption, phreatoplinian eruption, accretionary lapilli, caldera, Kutcharo volcano