Stratigraphy and eruption styles of 40 ka Kp I eruption, Kutcharo Volcano, Eastern Hokkaido, Japan

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Kutcharo volcano is located in eastern Hokkaido and is the location of the largest caldera in Japan (26×20 km). The first eruption associated with the formation of Kutcharo caldera produced the Furuume welded tuff (FWT) at 400 ka. Subsequent caldera-forming eruptions generated Kutcharo pumice flows Ⅷ to Ⅰ (KpⅧ to Kp Ⅰ in ascending order; Katsui and Satoh,1963 : Hasegawa et al.,2011). The shape of the present (26 x 20 km) caldera was mostly defined by the largest Kp IV eruption (175km$^{3:}$ Hasegawa et al.,2016). The Kp Ⅰ eruption (40 ka) is the second largest (125km^3) with its activity caused by large-scale phreatomagmatic explosion (Okumura, 1991,1996). However, detailed eruption stratigraphy, eruption styles and sequences are unknown.

We conducted geological survey to reveal the eruption sequence of Kp Ⅰ. In this study, we provide description of the tephra layers and subdivided stratigraphy. In addition, we performed grain size analysis and component analysis based on the subdivided stratigraphy and examined the evolution of the eruption styles. Grain size analysis was done using an electromagnetic sieve shaker for -5ϕ to 4ϕ. For finer particles (< 4ϕ), the particle size frequency was calculated using laser scattering particle size analyzer and converted to weight percentages. Further, the percentages of various component for 1 mm to 32 mm grains in the samples were determined by visual classification and weight scale.

As a result of the geological survey, Kp Ⅰ deposits are subdivided into Unit 1 to Unit 9 in ascending order. Units 1 and 2 are distributed within 30 km northeast of the caldera. Unit 1 is a yellowish white to white, clast-supported pumice layer, mainly composed of lapilli-sized pumice and lithic fragments with small amounts of isolated crystals and cohesive silty ash. Unit 2 is a white silty ash layer and rich in accretionary lapilli and isolated crystals. Units 3 and 4 are yellowish white to white pumice layer and white silty ash layer, respectively, showing similar facies as Unit 1 and 2. However, the distributions of Units 3 and 4 are wider than those of Units 1 and 2. Unit 5 is a white, clast-supported pumice layer. The pumice in Unit 5 is coarser and highly vesicular compared to those of Units 1 and 3. Unit 5 also rarely includes cauliflower surface pumice. Unit 6 is a white, silty ash layer containing accretionary lapilli with maximum thickness > 2 m and widely spread in eastern Hokkaido, and it can be correlated with Kutcharo-Shoro tephra (Kc-Sr: Machida and Arai, 2003). Unit 7 is a white, non-welded pumice flow deposit, covering aa wide area from northeast to west of the Kutcharo caldera. Unit 7 is the largest in Kp Ⅰ deposits with 2-30 m in thickness, and contains variously vesiculated pumices and cauliflower surface pumice. A heavier components (lithic fragments and crystals) concentration layer, observed at the base of Unit 7, is interpreted as the Ground layer (Walker et al.,1981). The Ground layer includes fresh andesite that is lacking in Unit 6 or lower. Unit 8 is a white silty ash layer with minor lapilli-sized pumices. Unit 9 is a white, non-welded pumice flow deposit. Distribution of Unit 8 and Unit 9 is limited in northern part of the caldera. Mineral assemblages of isolated crystals are plagioclase, pyroxene and olivine are common. On the other hand, few olivine phenocrysts can be recognized in pumice samples.

Grain size distributions of Unit 1 to 3 indicate bimodal distributions. The coarser and finer peaks are around -1 to 0ϕ and 5ϕ, respectively. On the other hand, Units 4 to 6 show unimodal distributions.

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Sorting is more uniform in the upper units. Although the percentages of fine particles (≦4ϕ) are commonly 20~45 wt.%, Unit 5 is characteristically poor (4 wt%) in fine particles. Lithic componentry of Units 1, 2 and 3 are 26 wt%, 36 wt%, 37 wt%, respectively. While, those of Unit 4, 5 and 6 are 13 wt%, 3 wt%, 11 wt%, respectively.

It seems that the peaks of very fine particles (5ϕ) commonly recognized in Units 1 to 3 were generated by phreatomagmatic fragmentation. Furthermore, the poorly sorted and lithic rich characters of these units suggest vent-opening processes through an unstable conduit with wet conditions. Wider distribution areas and decreasing the proportions of lithic fragments for Units 4 to 6, indicate the vent system became more stable to form a higher eruption column. Units 6 and 7, account for the majority of the volume of the Kp I , ejected at climax phase. Vent widening and/or sifting resulting in caldera-formation occurred in Unit 7 because lithic types clearly changes from this phase. After the relatively small phases of Units 8 and 9, the explosive activity of KpI eruption terminated.

Keywords: Kutcharo caldera, Large scale pyroclastic flow, Tephra stratigraphy, Phreatomagmatic eruption

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