# Occurrence of a low-temperature dilute pyroclastic density current just before the caldera-forming eruption in a water-rich environment : a case study of Hachinohe ash, Towada volcano, NE Japan

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Hachinohe ash and Hachinohe ignimbrite are volcanic products of Episode L of eruption (13,000 b.p.y.) in the Towada volcano. Towada volcano has a caldera lake that was formed by three such episodes accompanying a large-scale pyroclastic flow. Episode L is the latest and most voluminous of the caldera-forming eruptions in Towada. Hachinohe ash consists of alternating fine ash and ash-coated pumice clast layers. Both ash and pumice are widely dispersed. The ash layers contain accretionary lapilli, which indicates the involvement of external water. Hayakawa (1983) concluded that these ash layers were derived from a phreatoplinian eruption, formed by the interaction between fragmented magma and lake water.

Most phreatoplinian deposits are interpreted as fallout deposits from wet eruption columns. Ash layers in Hachinohe ash are inferred as fallout deposits from their distribution and grain size characteristics. However, in fine ash deposits affected by large quantities of water, it is difficult to determine the mode of emplacement from grain-size features alone. In addition, the simulation of the behavior of the eruption column following the mixing of magma and external water indicates the development of a wet eruption column and the occurrence of cold, wet ashflow derived from wet column collapse (Koyaguchi and Woods, 1996). Thus, the purpose of this study is to re-examine the emplacement process of Hachinohe ash, based on field surveys.

We mainly surveyed the eastern area, within 45 km from the Towada caldera. As a result, Hachinohe ash consists of 6 units (HP1- 6 in ascending order) same as previous studies, but the further complexity of each unit is recognized. In particular, it was found that HP1, which mainly consists of fine ash, can be divided into two parts, a lower part (HP1a) and an upper part (HP1b). Although the grain size characteristics make the emplacement process ambiguous due to the presence of ash aggregates, their sedimentary structures indicate that there are significant differences between HP1a and HP1b. HP1b is composed of fine ash with accretionary lapilli and uniformly mantles the ground surface just before the eruption. These features indicate that HP1b is a phreatoplinian fallout deposit. On the other hand, HP1a is characterized by a weakly cross-stratified lithofacies, and is mainly composed of thin, coarse ash layers. HP1a forms an infill at a topographical low, and is, thus, affected by topographical obstacles. These features indicate that HP1a is a dilute flow deposit. Although HP1a is deposited as far as 45 km from the vent, it includes some chips of wood with charred surfaces 25 km away from the caldera, which implies that HP1a was emplaced at a relatively low temperature (but >100°C) at this distance. Thus, HP1a is a low-temperature dilute pyroclastic density current (PDC) depositing at large distances from the source due to a phreatoplinian eruption, and not a fallout deposit as suggested in previous studies.

Although the occurrence of base-surges as dilute PDCs is often observed in phreatomagmatic explosions, the surge deposits are limited to within several kilometers from the vent. While these deposits form at scales much smaller than that of HP1a, some examples of distant emplacement of dilute PDC, similar to HP1a have been documented, such as: 7.3 ka Kikai caldera eruption Unit $B_l$, 12 ka Neapolitan Yellow Tuff eruption LM1, 160 ka Kos Plateau Tuff eruption Unit B, 7.6 Ma Akdag-Zelve ignimbrite eruption Upper/Lower surge series. All of these PDC deposits were formed during silicic caldera-forming eruptions in a shallow sea or lacustrine basin. Moreover, these

 

dilute PDCs are products just before the caldera collapse accompanying an ignimbrite, and the contribution of external water in the source vent generates the dilute PDC. Therefore, the occurrence of dilute PDCs might be a universal phenomenon during such huge eruptions in a water-rich environment.

Keywords: Towada volcano, Hachinohe ash, phreatoplinian eruption, caldera-forming eruption, dilute pyroclastic density current

 