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# Reexamination of eruptive sequence of Heian eruption in Towada volcano, northeast Japan

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1. Introduction
Towada-a tephra(To-a: Machida et al.,1981) is the latest deposit at Towada volcano, in Heian period. In this episode some transitions from magmatic to phreatomagmatic activities have occurred within a short period, approximately a half days. So it is a good instance to explore the mechanism of phreatomagmatic eruption. Although previous studies have investigated this eruption, the details about eruptive sequence are problematic. The purpose of this study is to show in detail the geological features of this eruption based on the field survey and laboratory works, focusing especially on the eruptive sequence of Heian eruption.

2. The newly eruptive sequence of Heian eruption
In distal area (Ochiai-bashi at 10.5km SSE from vent), To-a eruptive products are composed of plinian pumice fall deposit(OYU-1), fine ash deposit(OYU-2), plinian pumice fall deposit(OYU-3) and pyroclastic flow deposit(Kemanai pyroclastic flow:KPf) in ascending order (Takahashi,1999). In proximal area (Shimeitei and Karatama-sawa at 6km SW and SSE from vent respectively), To-a are composed of OYU-1, surge deposit (OYU-S) and KPf. OYU-S has often interpreted as a part of KPf (i.e. pyroclastic veneer deposit or basal layer). While KPf has a large amount of pyroclastic obsidian fragments, they are not almost observed in OYU-S. This feature of constituent in each unit implies that OYU-S is another unit unlike KPf.
OYU-S within 8km from source vent is rich in finer particles with the distance. The other features such as the thickness and the number of coarse pumice layer intercalated in OYU-S change with flow distance, and the faces resemble to OYU-2 in far place. Although OYU-2 has regarded as a fall deposit, the eroded unit boundary between OYU-1 and OYU-2 suggest that OYU-2 was flow deposit. Consideration to the distribution of OYU-S limited within proximal area, OYU-2 is the marginal faces of OYU-S.
At Hiyakawa path (6.5km SE from vent) the surge deposit (OYU-4) were newly found between OYU-3 and KPf. OYU-4 resembles to Oyu-2 rich in fine particles and it is possible to distinguish with KPf from the component feature without obsidian fragments. OYU-4 could regard as the base-surge deposit by phreatomagmatic eruption like OYU-2.
Matsu'ura et al. (2007) recognized that magma of Heian eruption were divided into high-Na and low-Na group as the border between OYU-2 and OYU-3 from the differences of glass and mineral compositions. Because the magma transition in OYU-S was only uppermost part, they concluded that the latest phase of OYU-S corresponded to OYU-3. But we found the surge deposit (OYU-4) overlying OYU-3 pumice fall, it indicates that the mostupper part of OYU-S was not OYU-3 but OYU-4. This new stratigraphy might imply the interruption of phreatomagmatic eruption among OYU-2 and OYU-4.

3. conclusions
The sequence of Heian eruption is summarized as five units (OYU-1, -2(=OYU-S), -3, -4, KPf) in ascending order. It proved that the transition of magmatic and phreatomagmatic eruption has

repeatedly occurred in this episode. The repetition of transitions in eruption style might be caused by the fluctuations of magma discharge rate, accompanying with the destruction of conduit wall during magma ascent and an explosion by hydrovolcanism.