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Eruptive History of Tangkuban Perahu Volcano, West Java, Indonesia: A Preliminary Report

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I. Introduction

Tangkuban Perahu volcano, which is located in West Java, is one of the active volcanoes in Indonesia (Fig. 1). Tangkuban Perahu is a post-caldera volcano situated on the eastern rim of Sunda caldera. Some previous workers conducted research on Tangkuban Perahu volcano, *e.g.*, Van Bemmelen (1949), Silitonga (1973), Kusumadinata (1979), Koesoemadinata (1992), Soetoyo and Hadisantono (1992), and Sunardi and Kimura (1998). However, they only explained the simple geologic condition of the volcano. The eruptive history, therefore, still remains unclear.

To reconstruct the precise eruptive history of Tangkuban Perahu volcano, we established the tephra stratigraphy and performed AMS radiocarbon dating. In this paper, we discuss the eruptive history and the characteristics of Tangkuban Perahu volcano.

II. Tephra Stratigraphy

Stratigraphy of Tangkuban Perahu tephra group has been established from detail observations of each tephra layer at various sections.

Tangkuban Perahu tephra group stratigraphically overlies the large-scale ignimbrite erupted during the formation of Sunda caldera. This tephra group can be simply divided into two sub-groups (Fig. 2), *i.e.*, the Old Tangkuban Perahu (OT) and the Young Tangkuban Perahu (YT).

Here we define that one eruptive episode is equivalent to one tephra formation intercalated with underlying and overlying soil layers. One tephra formation, therefore, reflects one eruptive episode, which could be single or multiple eruptive phases without a significant time gap.

1) The Old Tangkuban Perahu tephra sub-group (OT)

The Old Tangkuban Perahu tephra subgroup (OT) is composed of thirty tephra formations. Nine tephra formations have been considered the results of major eruptions (Fig. 3). Those formations in ascending order are OT4, OT5, OT6, OT7, OT9, OT18, OT21, OT22, and OT23. The remaining twenty-one formations were produced by several small-scale eruptions and they can be recognized only at the type section. They consist of small amounts of subordinate scoria embedded

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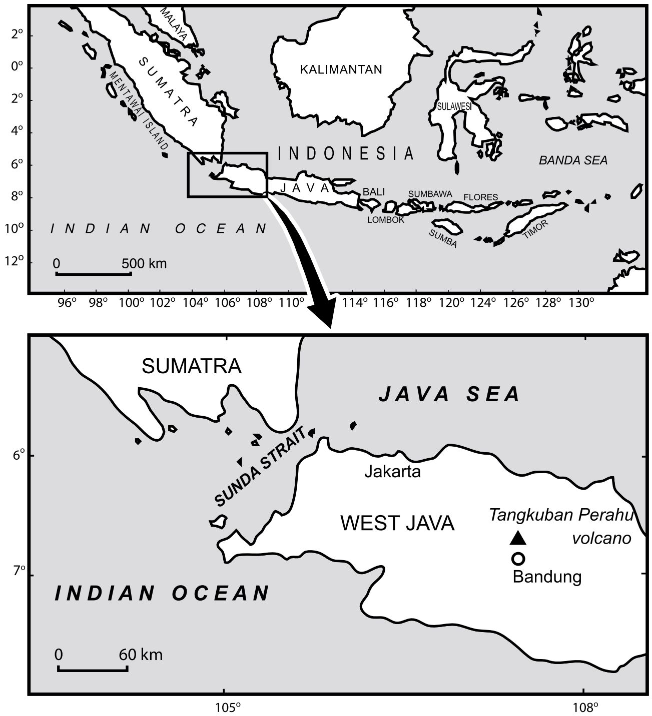

Fig. 1 Location map of Tangkuban Perahu volcano.

within the soil matrix or occur as a very thin ash layer.

Two units of pyroclastic flow deposits are found only at the type locality. Both are strongly weathered and are grouped into OT19 and OT26, having thicknesses of 20 cm and 15 cm, respectively. They show scattered scoria embedded in ash matrix that contains a large volume of charcoal. Considering the thickness and the distance from the vent (3.5 km), both pyroclastic flow deposits were assumed to have been produced by small-scale eruptions.

Some outcrops of fresh basaltic lava flows can be traced mainly in the east and at some quarries northeast of the volcano. The lava flows are composed of massive and vesicular basaltic andesite. Aphanitic texture can be easily recognized on a hand specimen. However, under a polarizing microscope it sometimes shows a pilotaxitic texture and displays the existence of small phenocrysts of olivine, clinopyroxene, and plagioclase.

Tephra layers of the OT sub-group have a prominent characteristic commonly showing intercalation of magmatic and phreatomagmatic origins. They are sometimes observed to contain subordinate scoria embedded sporadically within the phreatomagmatic ash.

Phreatomagmatic ash deposits exhibit dark gray to whitish gray color. Well defined beddings having thicknesses ranging from less than 1 cm to 20 cm are also observed. Some outcrops show a total thickness exceeding one meter. At a type section (3.5 km away from the vent), the thickest phreatomagmatic beds reach 120 cm for OT21. Each layer is generally hard, fresh, and very often shows the

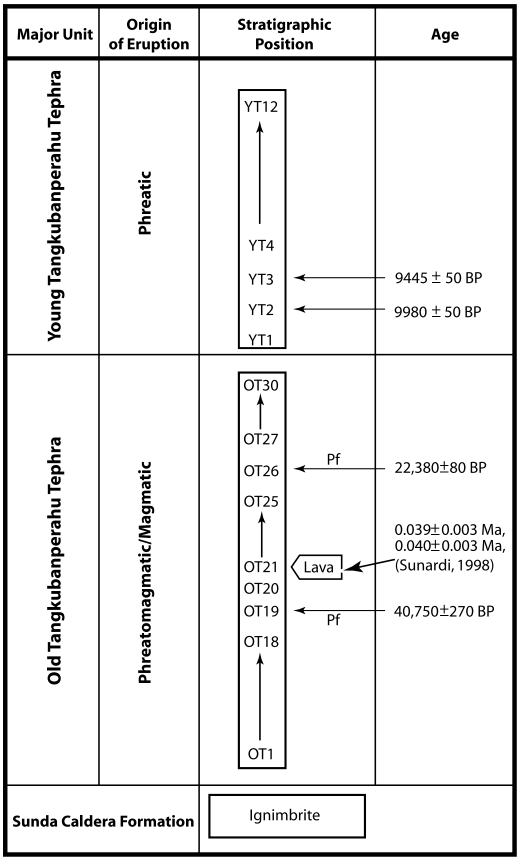

Fig. 2 Generalized stratigraphic column of the Tangkuban Perahu tephra group.

presence of vesicles. The accretionarry lapilli are sometimes included.

Magmatic deposits comprise scoria and ash layers. Scoria is well sorted, poorly to well vesiculated and predominantly of sub-angular to angular clasts-shape. Maximum diameter of scoria fragments found just in the crater rim was 20 cm. The thickness of scoria layers ranges from 1 to 60 cm.

2) The Young Tangkuban Perahu tephra sub-group (YT)

The YT sub-group is composed of twelve tephra formations (Figs. 4 and 5). This sub-group was emplaced only at the upper part of

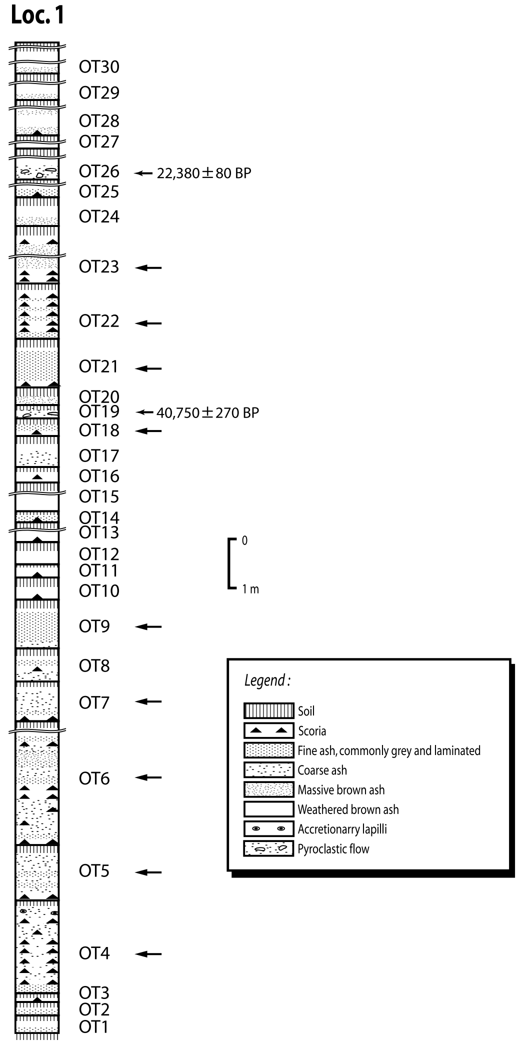

Fig. 3 Detailed stratigraphic column of the Old Tangkuban Perahu tephra group.
The section is taken at Loc. 1 (3.5 km away from the vent). Arrow indicates major eruption.

the volcano. Near the crater rim the deposits are very thick and can be recognized easily, however, they rapidly become thinner outward. For instance, one of the base surge deposits stacked just at the crater rim has a thickness of more than 2 m. However, the thickness abruptly decreases to 60 cm at 300

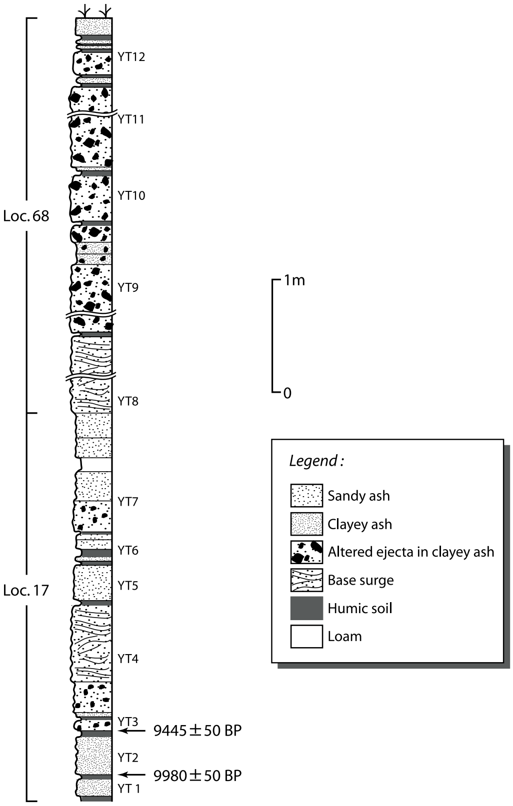

Fig. 4 Detailed stratigraphic column of the Young Tangkuban Perahu tephra group.
Locs. 17 and 68 are type sections for the sub-group.

m from the crater. At the distance of 3.5 km from the crater (Loc. 1: type section for the OT sub-group), the thickness is even less at only 12 cm. These suggest that the volume of the YT sub-group is not significant in amount compared to that of the OT sub-group.

Although each tephra formation is separated by soil layers, YT5 and YT12 are exceptions. YT12 is considered as the youngest product of Tangkuban Perahu volcano, consisting of five layers of tephra each separated by soil. However, the soil layers were quite thin, averaging less than 1 cm. This suggests that intervals between eruption were very short. For simplification, we grouped those tephra layers into one tephra formation.

The tephra layers in the YT sub-group have a prominent characteristic and are quite distinguishable from the OT sub-group. All deposits are predominated by phreatic deposits; base surge, clayey ash, sandy to ash layers, and altered ejecta embedded in ash matrix.

Clayey ash layers are light gray to white, and are commonly exposed as a pile of thin ash layers. The thickness varies between less than 1 cm and about 40 cm. Silty to sandy ash layers are gray to light gray and often contain subordinate lithics.

Altered ejecta are dominated by sub-angular to angular blocks of basaltic lithic, set in clayey ash matrix. Near the crater rim, the ejecta are loose, and have a thickness of more than two meters. The maximum diameter of lithic fragments observed just in the crater rim reached 20 cm. Two distinctive base surge deposits can be easily found mainly in the crater area. The deposits comprise stacking ash layers and they abruptly become thinner outward the crater rim.

III. AMS Radiocarbon Dating

A total of five charcoal fragments were ^{14}C-dated (Figs. 3 and 5). These samples were washed with distilled water and then cleaned chemically by acid-alkali-acid (AAA) treatments. The treated samples were sealed in an evacuated Vycor® tube with CuO, and combusted at 850 ℃ in an electronic furnace. The resulting CO_2 was purified cryogenically in a vacuum line and then reduced catalytically to graphite on Fe-powder with H_2 in a sealed Vycor tube (Kitagawa *et al.*, 1993). Graphite was pressed into targets for AMS-^{14}C

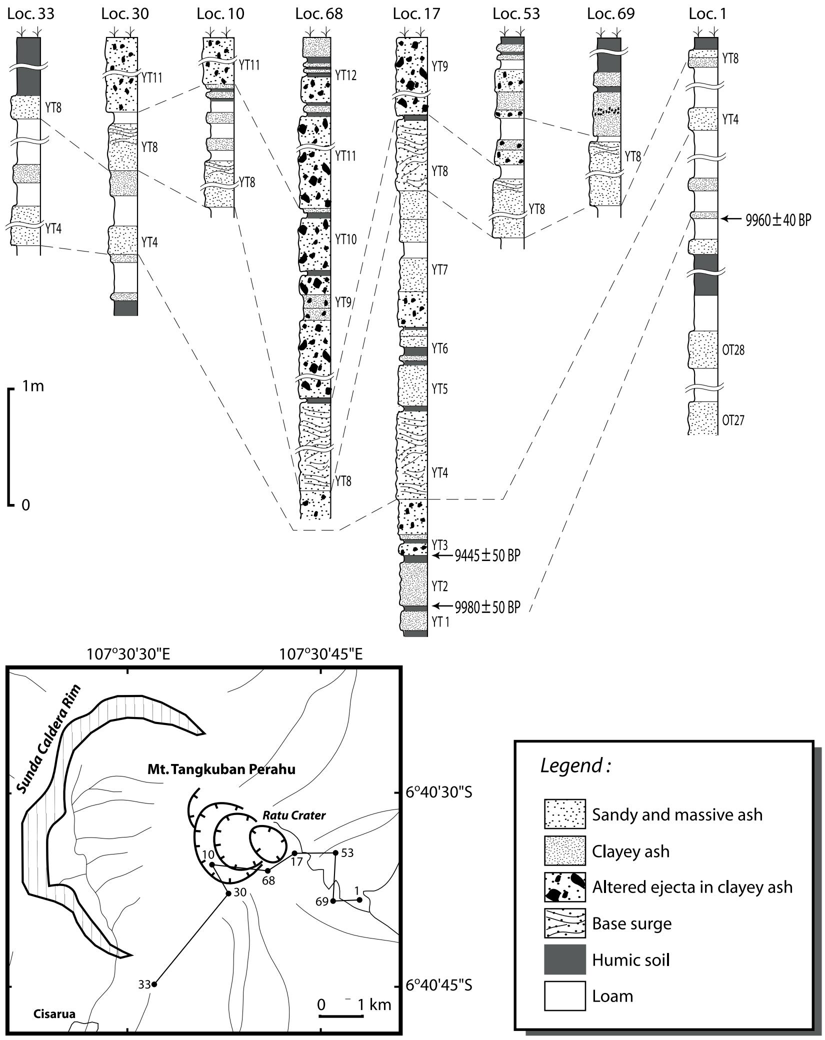

Fig. 5 Stratigraphic correlation of the Young Tangkuban Perahu tephra group.

measurements. The $^{14}C/^{12}C$ ratios of the sample were measured by a HVEE Tandetron AMS at Nagoya University (Nakamura *et al.*, 2000), using a NIST oxalic acid (HoxII) as standard.

IV. Results and Discussion

The ^{14}C dates of 40,750 ± 270 BP (NUTA2-2239) and 22,380 ± 80 BP (NUTA2-2238) are obtained from charcoal samples beneath the OT19 and OT26 at Loc. 1, respectively (Fig. 3). The contact between lava flow and tephra layer is found at Locs. 24 and 25. It is clearly discerned that the lava underlies exactly the OT21 scoria fall without a separating soil layer. This suggests that the effusion of lava corresponded to the deposition of OT21. The K-Ar ages of the lava are 0.039 ± 0.003 Ma and 0.040 ± 0.003 Ma (Sunardi and Kimura, 1998), indicating it is slightly younger than OT19. Referring to these K-Ar ages and tephra stratigraphy, it may be concluded that the radiocarbon date (40,750 ± 270 BP) for OT19 is acceptable.

Locs. 17 and 68 have been determined to be type sections due to the presence of the most complete tephra succession among others (Figs. 4 and 5). The ^{14}C dates of 9445 ± 50 BP (NUTA2-2515) and 9,980 ± 50 BP (NUTA2-2513) are yielded for charcoal samples from Loc. 17 just below YT3 and YT2, respectively. The ^{14}C date of 9,960 ± 40 BP (NUTA2-2237) is also obtained for charcoal sample from soil layer beneath YT2 at Loc.1. These dates are consistent with tephra stratigraphy (Fig. 5). Unfortunately, the radiocarbon age for YT1 has not yet been obtained; nevertheless, the stratigraphic position of YT2 is near the boundary between the YT and the OT sub-groups. This suggests that the style of eruption changed from magmatic/phreatomagmatic to phreatic at about 10,000 BP.

V. Conclusion

We studied the eruptive history and characteristics of Tangkuban Perahu volcano, West Java, Indonesia.

On the basis of tephra stratigraphy and AMS ^{14}C dating, the Tangkuban Perahu tephra group can be divided into two sub-groups, *i.e.*, the Old Tangkuban Perahu (OT) and the Young Tangkuban Perahu (YT). The Old Tangkuban Perahu tephra sub-group(OT) consists predominantly of alternations of scoria fall and thinly bedded phreatomagmatic ash. On the other hand, the Young Tangkuban Perahu tephra sub-group (YT) predominantly consists of ash fall deposit, altered ejecta embedded in ash matrix and two distinctive base surges. The activity of the YT sub-group started at about 10,000 BP.

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