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Long-term distribution of volcanic activity around calderas in Bali and East Java, Indonesia, determined by K-Ar dating

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Long-term history of active calderas in Indonesia have not been well constrained due to the lack of chronological data. The ages of pre-caldera activities are mostly unknown. We therefore conduct comprehensive sample collection, K-Ar dating and topography analysis of volcanic rocks in Bali and East Java.

We have found three periods of volcanic activity in Bali. They are 1.6 m.y. BP, 0.7-0.5 m.y. BP, and 0.2 m.y. to present. The number of new volcanoes formed increased with successive active periods. Somma of both Batur and Bratan caldera volcanoes consist of multiple volcanoes that were formed at 0.5 Ma and 0.2-0.1 Ma. The calderas have been formed between the edifices.

(a) The ages of lavas from both the bottom and the upper part of Penulisan agree each other at 0.5 Ma. Penulisan is therefore formed at 0.5 m.y. BP.
(b) The age of lava from Tapis is also 0.5 Ma, and agrees with ages of Penulisan lavas.
(c) The ages of lavas at the base of Abang and the northern apron of Batur somma in Les waterfall area are 0.15-0.2 Ma. They are significantly younger than Penulisan.
(d) The age of lava from the small 706 m peak volcano between Batur and Bratan is also 0.2 Ma, and agrees with the age of lava from northern apron of Batur somma.
(e) The ages of lavas consisting the dissected ridges in the northern apron of Bratan are 0.5 Ma.
(f) The age of aphyric lava that forms plateau in the north apron of Bratan (Old Buyan Bratan) is 0.2 Ma.
(g) The age of lava in SW apron of Batukau volcano is also 0.2 Ma.
(h) The age of lava near Asah is 1.6 Ma. The unit belongs to Tertiary Djembrana volcanics, but the age is found to be Quaternary.

At Tengger caldera, East Java, the age of the two caldera-forming eruptions are found to be older than 0.3 Ma., based on dating and stratigraphy of the different parts of somma edifice. The ages are found to be much older than previous studies.

(i) Caldera-forming eruption deposit of Tengger caldera at NW part of the caldera wall consists of alternating layers of pyroclastic fall and pyroclastic surge deposits as well as lava flow layer. The age of the lava is 0.3 Ma. Therefore, Tengger caldera was formed at 0.3 m.y. BP, which is much older than in previous study.
(j) At the NW wall of Tengger caldera, ages of lavas at the caldera rim and the bottom of the caldera wall agree at 0.45 Ma. The age of lava at the bottom of the SE wall and the age of lava from NW apron agree at 0.3 Ma. They are younger than age of NW wall lavas. It seems that Old Tengger (sensu stricto) consists of multiple stratovolcanoes.
(k) Based on the ages from (i)(j), we can estimate that Ngadisari caldera and the intra-caldera units were formed between 0.3-0.45 m.y. BP, which is 2-3 times older than in previous study.
(l) The age of lava from the dissected Kukusan volcano is 1.7 Ma. Kukusan is much older than Tengger. The volcanic activity in the Tengger-Bromo region has started by 1.7 m.y. BP.
(m) The age of lava that fill the depression of the Kukusan is 0.08 Ma. Parasite vent in the northwestern apron has therefore formed during post-caldera stage.
(n) The age of pyroclastic bomb from G. Garu is 0.25 Ma and is younger than Tengger caldera.
(o) The ages from Ayekayek-Ranu Pane area are 0.02-0.04 Ma, which are consistent with previous 14C age.
(p) The age of lowermost unit of Semeru in the southern apron is 0.5 Ma. Activity of Semeru dates back to 0.5 m.y. BP.

These results enable us to define long-term distribution of volcanoes leading up to caldera-forming activity in the range of 100 thousand to one million-year time scale.

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Keywords: caldera, volcano, K-Ar dating, Quaternary, Indonesia