Geological Evaluation of Frequency and Process of Caldera-forming Eruption: A compiled study of Indonesian caldera volcanoes

Akira Takada, Ryuta Furukawa[a], Kiyoshi Toshida[b], Supriyati Andreastuti, Nugraha Kartadinata[c]

[a] Geological Survey of Japan, AIST

[b] Geosphere Science Sector, Civil Engineering Research Laboratory, CRIEP

[c] Center for Volcanology and Geological Hazard Mitigation, Indonesia

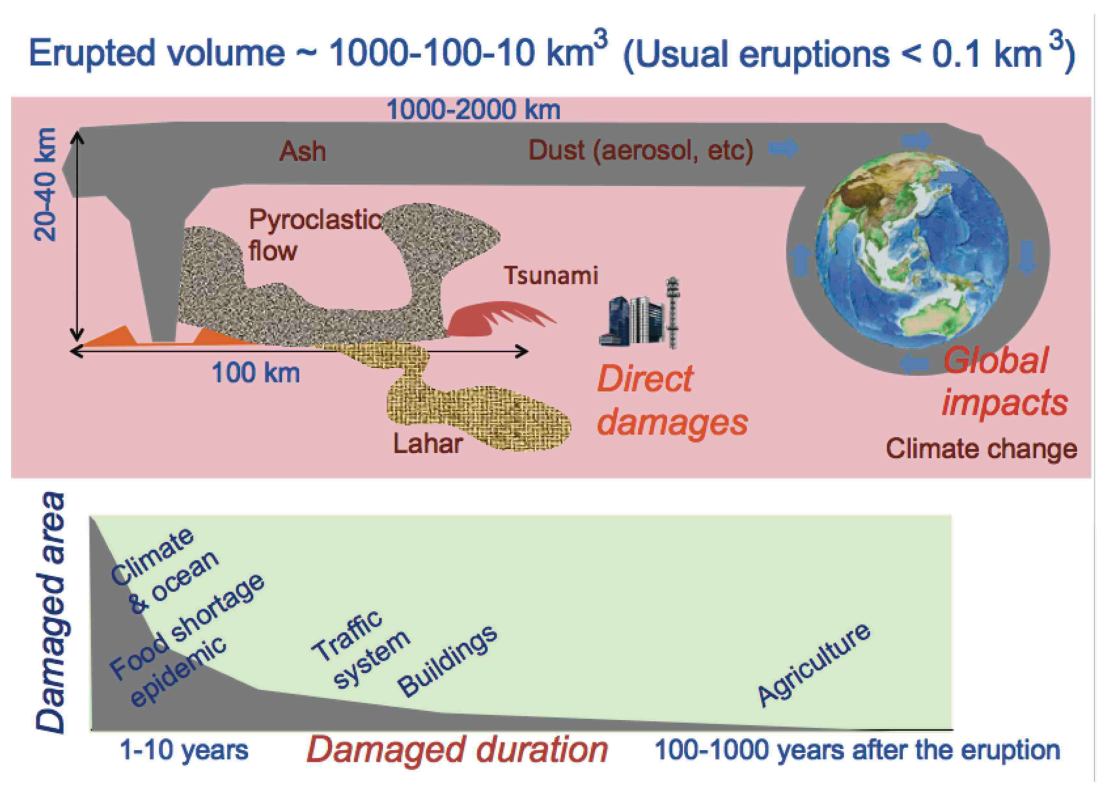

Fig. 1. Caldera-forming eruption

Why the caldera-forming eruption is important ?

There are various volcanoes in the world. Almost volcanoes erupted frequently. However, some volcanoes seem to be quite for preparing a large-volume eruption with caldera formation. What is a caldera-forming eruption? Compared with usual eruptions, a caldera-forming eruption, erupted volume~ 10-1000 km3, causes huge direct damages, wide-spread pyroclastic flow, air fall, lahar, tsunami, and global impacts such as climate change; The recovering time is more than 10 years for climate, ocean, food, human health, traffic, buildings, and 100-1000 years for land use (Fig. 1). Japanese have forgotten a caldera-forming eruption, because the last one occurred 7,000 years ago. Indonesia was suffered twice for the last 200 years, and three times within 1000 years. The total victims amount to 130,000, which is 55 % of the total ones from eruptions in the world during the last 200 years.

We have questions on the caldera-forming eruption.

(Q1) Can we get a precursor sign for the eruption (where, when, what volume)?

(Q2) Is not the eruption infrequent (< once / 100 years)?

(Q3) Can we evaluate the next candidate for hazard mitigation?

We carried out the JST-JICA project as follows.

(1) The first is to study the process to the caldera forming eruption, that is, the quantitative eruptive history of target volcano to caldera-forming eruption, especially, multi-caldera volcanoes in Bali (**Furukawa et al., G-EVER1 poster**).

(2) The second is to clear the frequency of the caldera-forming eruption, that is, the temporal and spatial distribution of the eruption in East Java and Bali (**Toshida et al., G-EVER1 poster**).

(3) The third (this paper) is to evaluate volcanoes base on the obtained geological data, in order to answer (Q1) and (Q2). The results will contribute to the answer of (Q3).

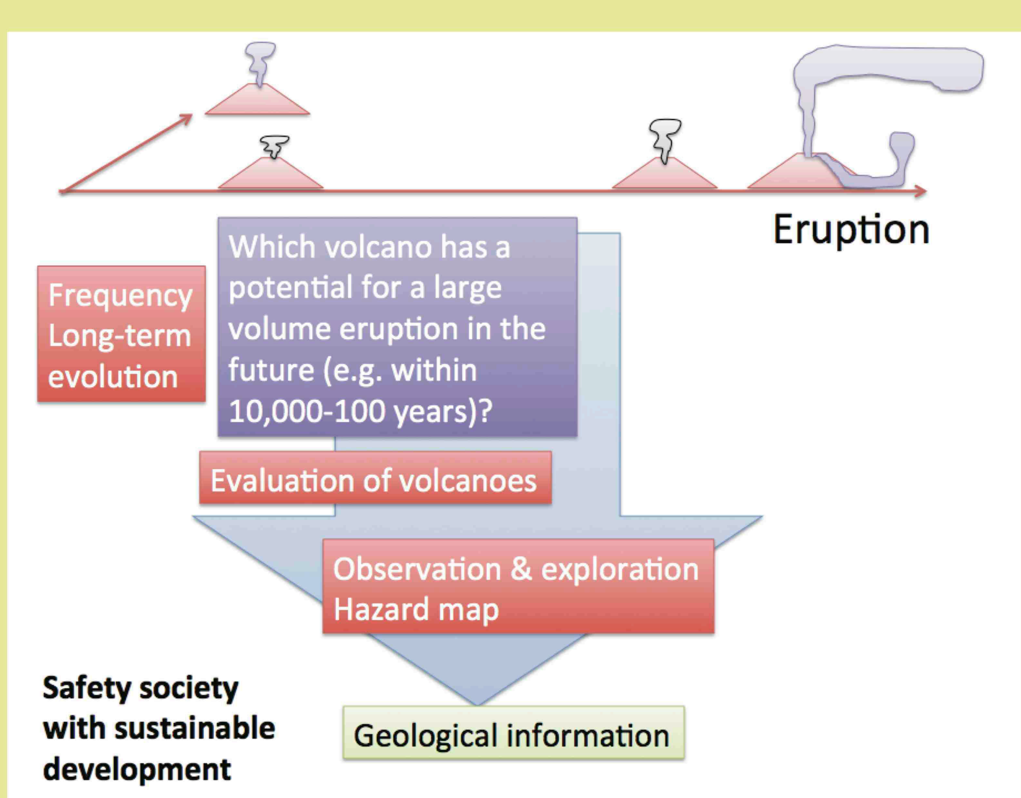

Fig. 3. Long-term evaluation

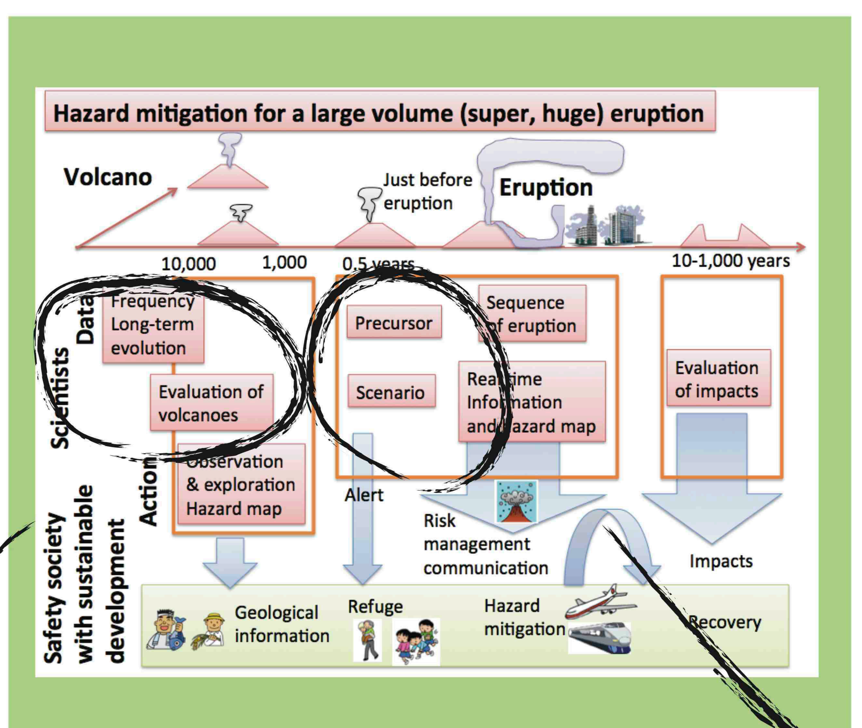

Fig. 2. Process of hazard mitigation for a caldera-forming eruption

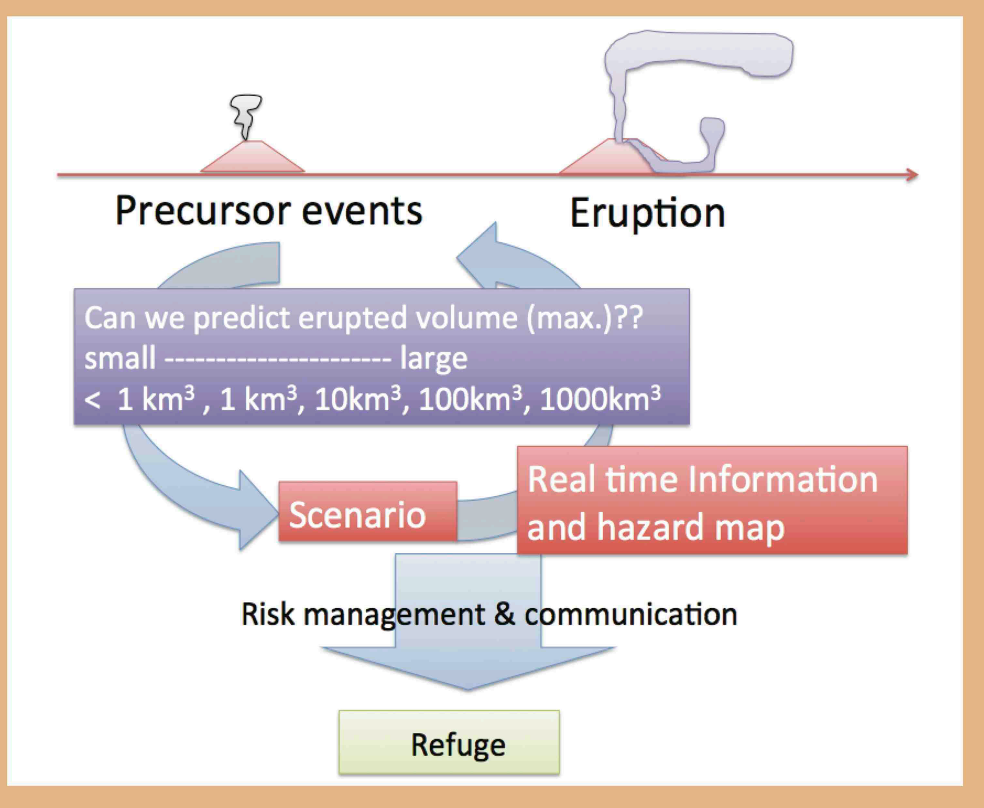

Fig. 7. short-term evaluation

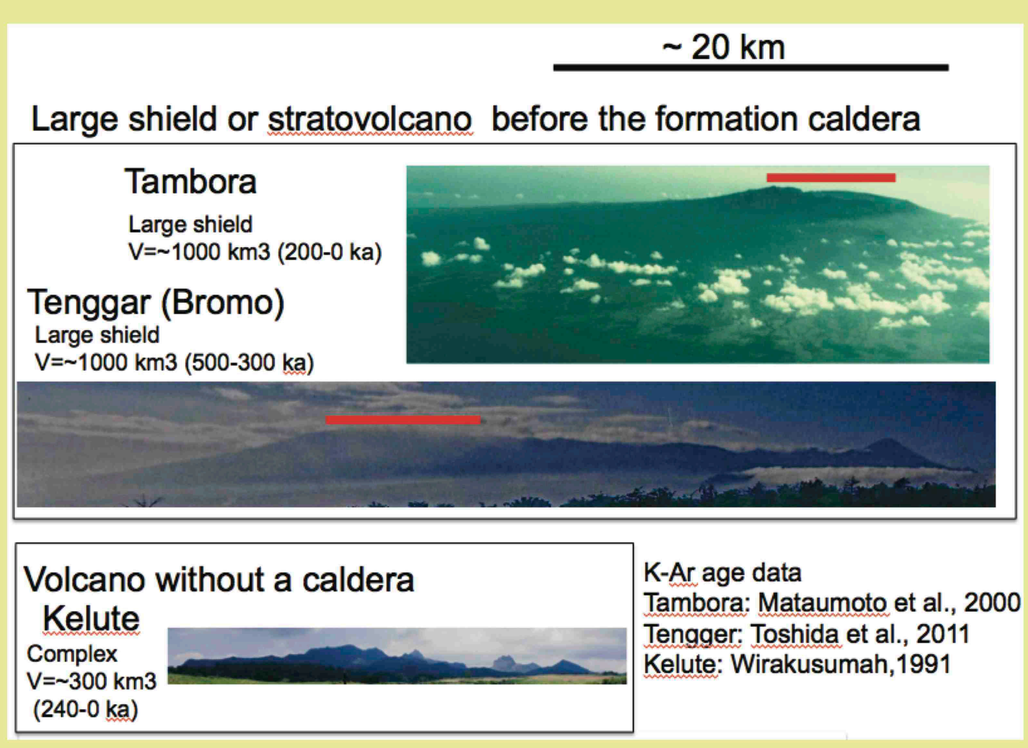

Fig. 4. Photographs of volcanoes with caldera (Tambora, Tenggar), and a volcano without caldera (Kelute).

Can we evaluate a volcano evolving into caldera-forming eruption in the long-term?

There was a large shield or stratovolcano constructed with a large eruption rate before the caldera forming eruption, for example, Tambora, and Tenggar. In contrast with those volcanoes, Kelute has never cause the caldera-forming eruption (Fig. 4). The eruption rate is far smaller than those of volcanoes with caldera.

For example, we compiled the eruptive history of caldera volcano, Tambora (Takada et al., 2000; Matsumoto et al., 2000), and Rinjani (Takada et al., 2003; Nasution et al., 2003; Furukawa et al., 2004; Furukawa et al., 2005). The corporation project between GSJ and VSI got the scenario that, during the last 10,000 years, the eruption rate decreased, eruption style changed to more explosive, and chemical composition changed (Fig. 5).

The cluster of volcano complex is composed of several volcanoes with repose periods. If the magma flux increases, the volcano can evolve into the caldera-forming stage. The schematic diagram of the cumulative eruptive volume with time shows the evolution process of the ideal volcanoes with caldera-forming eruption (Fig. 6).

In the future, we may be able to evaluate a volcano evolving to the caldera-forming eruption, based on the basic data on the process and frequency of the caldera-forming eruption.

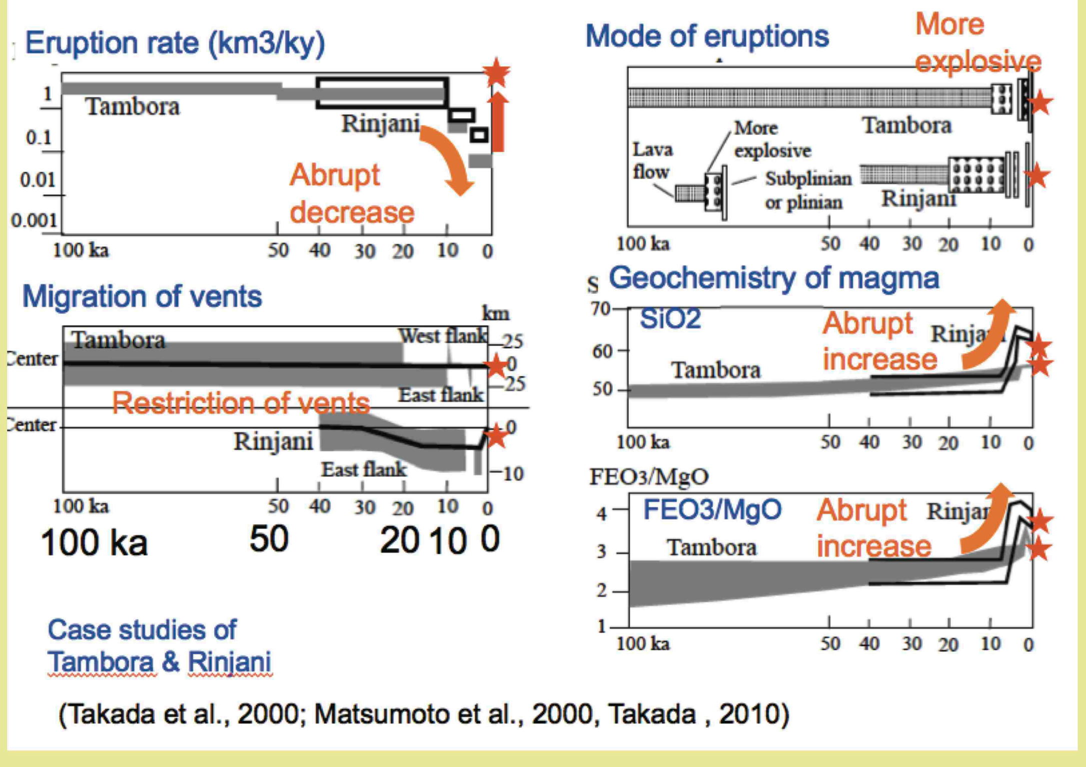

Fig. 5. Long-term evolution of the caldera volcano.

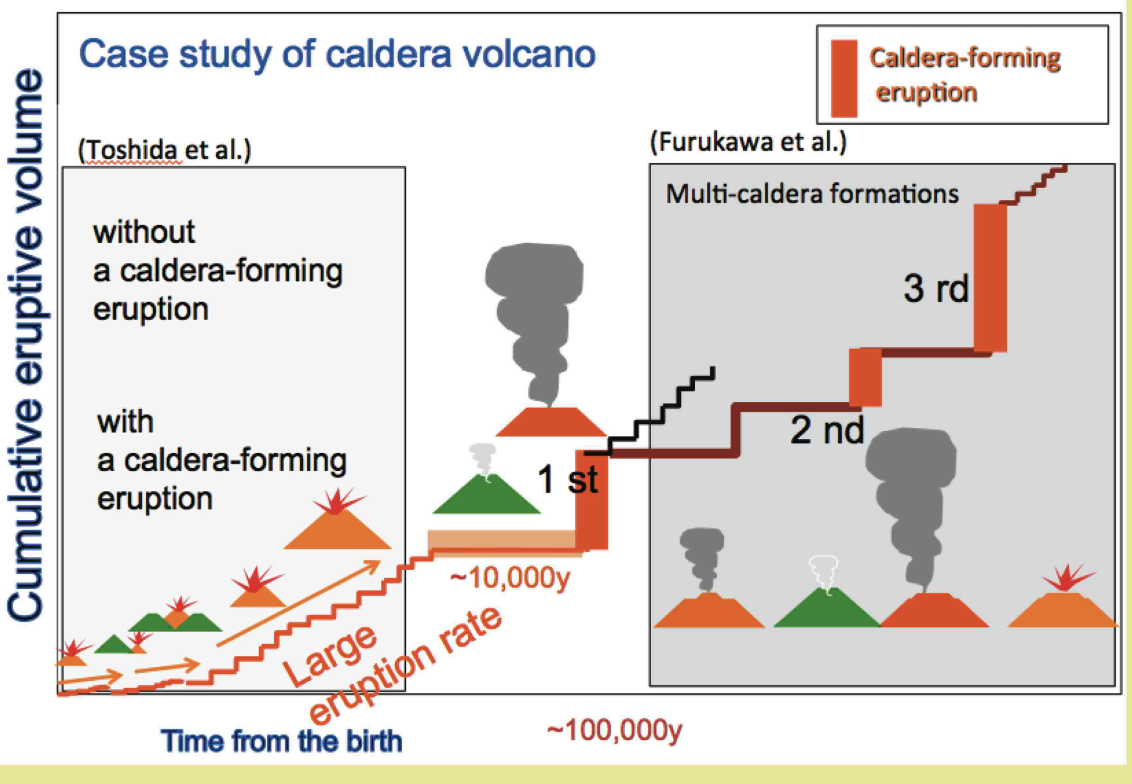

Fig. 6. Schematic diagram for eruptive history before the caldera-forming eruption. Data of Tambora and Rinjani are compiled from Takada et al.(2000a), and Takada et al.(2003), respectively.

Can we catch a sign of caldera-forming eruption in the short-term?

During the last a few months, we may catch the short-term process as the progressive activity to the climax eruption (Fig. 7).

The upper of Fig,8 is the example of Pinatubo 1991 eruption, Philippine (Harlow et al., 1996; Hoblitt ea al., 1996; White et al., 1996; Wolfe and Hoblitt, 1996).

The second is that of Krakatau 1883 (Rampino and Self, 1982).

The lower is that of Tambora 1815 (Junghuhn, 1854; Self et al., 1984, Stothers, 1984; Yamamoto et al., 2000; Takada and Yamamoto, 2008).

There occurred a lot of small eruptions and hydrothermal explosions during the last a few months just before the climax. Moreover, there occurred unusual wide-range hydrothermal activity, 2-5 km-wide, before the climax, suggesting the existence of an active large volume magma beneath the summit (Fig. 9).

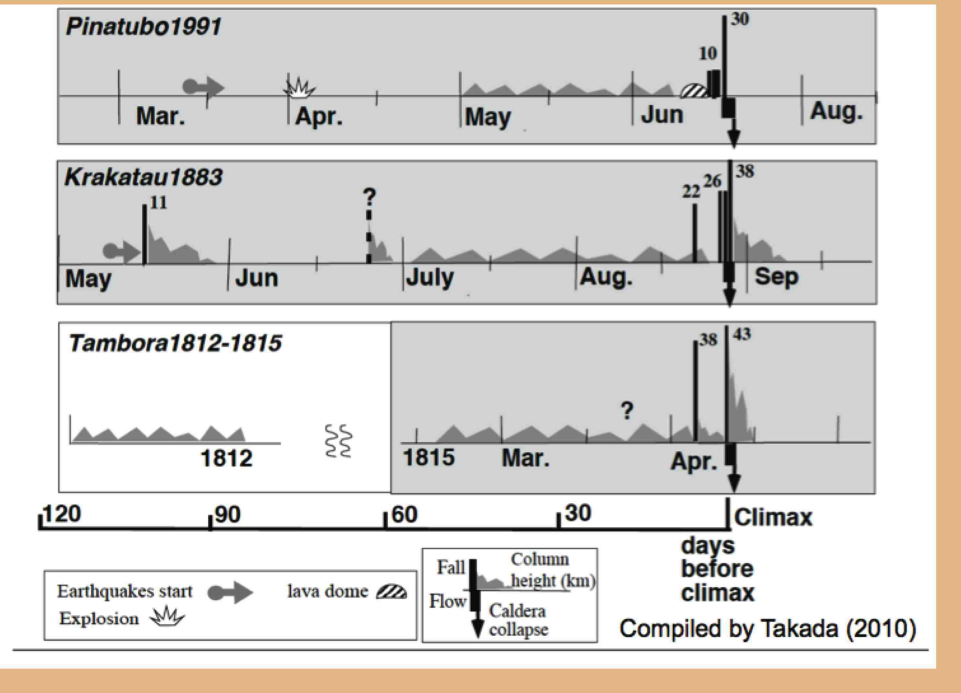

Fig. 8. Eruptive sequences of the caldera-forming eruption on Pinatubo 1991 eruption (Wolfe and Hoblitt, 1996; Harlow et al.,1996; White, 1996; Hoblitt et al.,1996), Krakatau 1883 eruption (Rampino and Self, 1982), and Tambora 1815 eruption (Junghuhn, 1854; Stothers.1984; Self et al.,1984; Yamamoto et al.,2000; Takada and Yamamoto,2008).

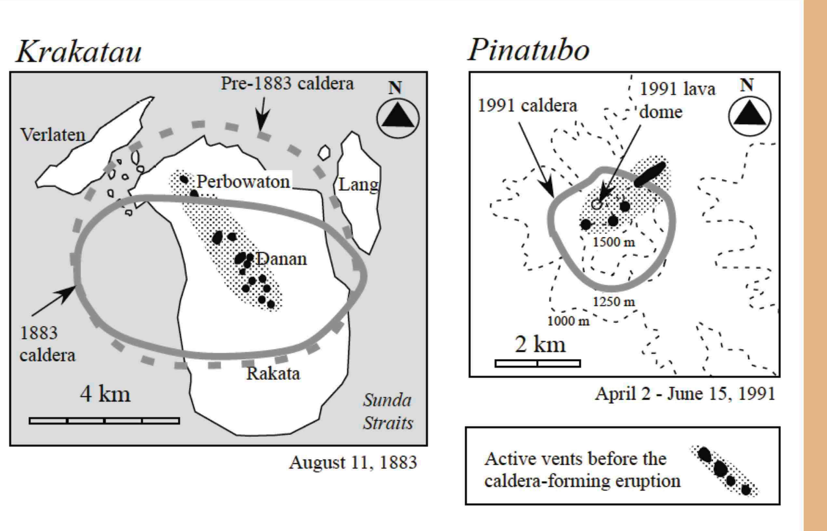

Fig. 9. The distribution of active vents with magmatic or phreatic eruption just before the caldera-forming eruption. The left is an example of Krakatau 1883 eruption after the sketch map of Captain H. J. G. Ferzenaar on Aug. 11, 1883 (Simkin and Fiske, 1983). The right is that of Pinatubo 1991 eruption after Wolfe and Hoblitt(1996).