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Long-term eruption rate in step diagram for forecasting caldera volcanism

Daisuke MIURA[1*], Hisashi Sasaki[2], Hiroko Makita[2], Setsuya Nakada[3], Makoto Murakami[4], Eisuke Fujita[5], Sakae Mukoyama[2]

[1]CRIEPI, [2]Kokusai Kogyo Co., Ltd., [3]ERI, Univ. Tokyo, [4]Hokkaido Univ., [5]NIED

1. Introduction

Large explosive volcanism has often been dormant longer than ten thousand years but is a potential threat to give a severe damage into modern social community. Due to this hazardous reason, an adequate and systematic tool is needed to assess a potential of volcanic hazard from future large explosive eruption. Changes of style, magnitude, timing and location at past eruption play an important role to give a plausible scenario of future eruption and its hazard. Precise measurements in eruption age and volume of ejecta are essential to analyze long-term eruption rate and its change, drawn as "step diagram." This geologic tool is a realistic approach to assess the potential threat of large explosive eruption.

2. Long-term eruption rate

The step diagram indicates cumulative discharge (eruption) rate of erupted magma in a volcano or a volcanic field. It is ideally grouped into three patterns of discharge rate curve (Koyama and Yoshida, 1994). The discharge rate curve at an actual volcano, however, shows diverse patterns outside the ideal three curves, and the curve gradient often changes in stage of volcano evolution. In order to assess accurately the potential of large eruption, careful observations in the change of discharge rate linked with change of magma property and evolution stage are essential. Because precise data set of volume and eruption age was fulfilled, three examples of domestic caldera volcanoes have been employed to discuss the change of discharge rate curves, are the followings.
(1) Kuttara volcano: The Kuttara volcano has been diverse in styles of eruptions during a hundred thousand years. There are three stages divided by major change of magma composition, i.e., Aroyo, Takeura and Kuttara stages. Long-term discharge rate of Kuttara volcano are 3.5 km^3 (DRE)/ky for 95-83 ky ago (Kt-8 to Kt- 5 events) and 2.7 km^3(DRE)/ky for 62-42 ky ago (Kt- 4 to Kt-1 events). These are almost similar gradient of discharge curve, each other. The long dormancy for ca. 20 ky occurred from 83 to 62 ky ago.
(2) Towada volcano: The Towada volcano has produced multiple units of plinian eruptions after forty three thousand years ago. Long-term discharge rate of Towada volcano is 1.4 km^3(DRE)/ky after 43 ky ago. These are gentle gradient ranging 0.15-0.21 km^3(DRE)/ky after each major plinian eruption (To-Q, To-N and To-L). Average recurrence interval of caldera-forming eruptions is approximately fifteen thousand years.
(3) Aira volcano: The Aira volcano had first produced major plinian eruption after ninety thousand years ago. Long-term discharge rate is 2.5 km^3(DRE)/ky and post-caldera Sakurajima volcano shows 1.5 km^3(DRE)/ky. Nevertheless, long-term discharge rate before 29 ka great Aira eruption is 0.36 km^3(DRE)/ky and this is smaller order than those of total discharge rate.

3. Discussion

The average of long-term discharge rate in each caldera volcano is of a few km^3(DRE)/ky. A number and amount of eruption event, magma property and a total duration of volcanism are distinct in those calderas. Nevertheless, the similarity observed in discharge rate is fruitful to discuss the process of large eruption. Duration of smaller amount of discharge rate than total rate also occurs at them between each large explosive eruption. The duration of low magma discharge is in the range of ca. 15,000 years in Towada, ca. 20,000 years in the Kuttara and ca. 60,000 years in the Aira. It could correspond to the period for accumulating a sufficient amount of magma in the magma chamber. Rock samples of small eruption in this low discharge duration can involve magma property changing toward the large explosive eruption.

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