A211

Changes in Mass Eruption Rate during 2014-2018 Sinabung's Eruptive Period estimated using Seismic Energy

○Vico L. IPMAWAN, Masato IGUCHI, Taishi YAMADA, Takeshi TAMEGURI

Introduction

Sinabung is a volcano located to the northwest of Lake Toba, Sumatra, Indonesia. This volcano reactivated after a hiatus of 1200 years (Iguchi et al., 2012). The phreatic eruption on September 27, 2010, marked the beginning of pre-magmatic activity, which continued until the end of December 2013. Eruption activity transitioned to fully magmatic in 2014, with high-intensity pyroclastic density currents (PDC) originating from the lava dome that developed in December 2013. PDC activity ceased on January 10, 2014, followed by lava flow until mid-September 2014. The lava dome regrew, and PDC activity resumed until February 2018. However, in August 2014, vulcanian activity occurred, accompanied by a decrease in PDC activity.

The transition from non-Vulcanian to Vulcanian style is important for further study. A change in eruption style implies a shift in disaster eruption mitigation strategies as well. Some researchers reported that change in eruption style can be controlled by Mass Eruption Rate (MER) as a crucial parameter (Melnik and Sparks, 2005) and as an indicator of eruption style changes (Cashman, 2004; Gonnermann and Manga, 2013; Kozono et al., 2013). We estimate the total MER, both from PDC and Vulcanian events, from October 2014 to February 2018. Changes in the total MER over time are discussed in relation to changes in eruption style.

Data and Method

We analyze PDC and Vulcanian events from the farthest seismic station to avoid amplitude saturation. The total MER is obtained from the combination of MER of PDC and MER of Vulcanian events. To calculate the MER of PDC, we assessed the empirical relationship between the seismic energy of PDC and the run-out distance from observer records. Then, separately, we conducted pyroclastic flow simulations (Yamashita and Miyamoto, 1993) by varying the volume to obtain the run-out distance. Using the simulation results, we evaluated the relationship between volume and run-out distance. To obtain the Mass from volume, a density value of ρ = 1400 kg/m^3 was used. To calculate the Mass Eruption Rate, the total mass of each event was divided by the duration of material ejection.

To determine the MER of Vulcanian events, we assessed the empirical relationship between seismic amplitude and plume height. Subsequently, an empirical relationship between mass eruption rate and plume height, based on a theoretical approach, was obtained from Sakurajima (Iguchi et al., 2022)

Results and Discussion

The total MER is obtained by summing the MER of PDC and vulcanian events, as presented in Fig. 1c. The highest MER value is 0.43 megaton/day, which occurred in early October 2014. Then, the MER rate decreased to 0.2 megaton/day in mid-December 2014 to March 2015. As it enters the vulcanian period, MER becomes 0.15 megaton/day. MER remains relatively constant at 0.15 megaton/day until June 2016. Afterward, MER gradually decreases, reaching a value of 0.12 megaton/day at the end of the calculation on February 28, 2018.

We compared the discharge rate of PDC and volcanic ash with calculations from Nakada et al. (2019), CVGHM staff and Kriswati and Solikhin (2020). Nakada et al. (2019) calculations are based on measurements using a Laser Distance Meter and satellite images, while CVGHM staff measures the discharge rate using the growth of lava dome by using Laser Distance Meter. The comparison results are shown in Fig. 1d. Overall, the volume rate trend from this study matches the results of previous studies. Examining the declining trend, the MER graph can be divided into two periods: one with relatively high MER (>0.15 megatons per day) and one with low MER (<0.15 megatons per day). This change corresponds to the boundary between the non-vulcanian and vulcanian periods. This may lead to the interpretation that changes in MER can control the transition in eruption style from lava dome growth with PDC to lava dome growth with PDC and vulcanian eruptions.

A significant difference of discharge rate occurred in October 2015 between the previous and this study. It may be due to the inclusion of vulcanian ashfall in the discharge rate calculation. It is also worth noting that the MER from vulcanian events has been increasing since December 2015. This increasing MER would certainly affect the accuracy of hot spot detection using the MODIS method. Thus, the differences in calculations may be attributed to the increased vulcanian activity, as explained by Kriswati and Solikhin (2020). Another explanation may be attributed to irregularity of lava dome measurement.

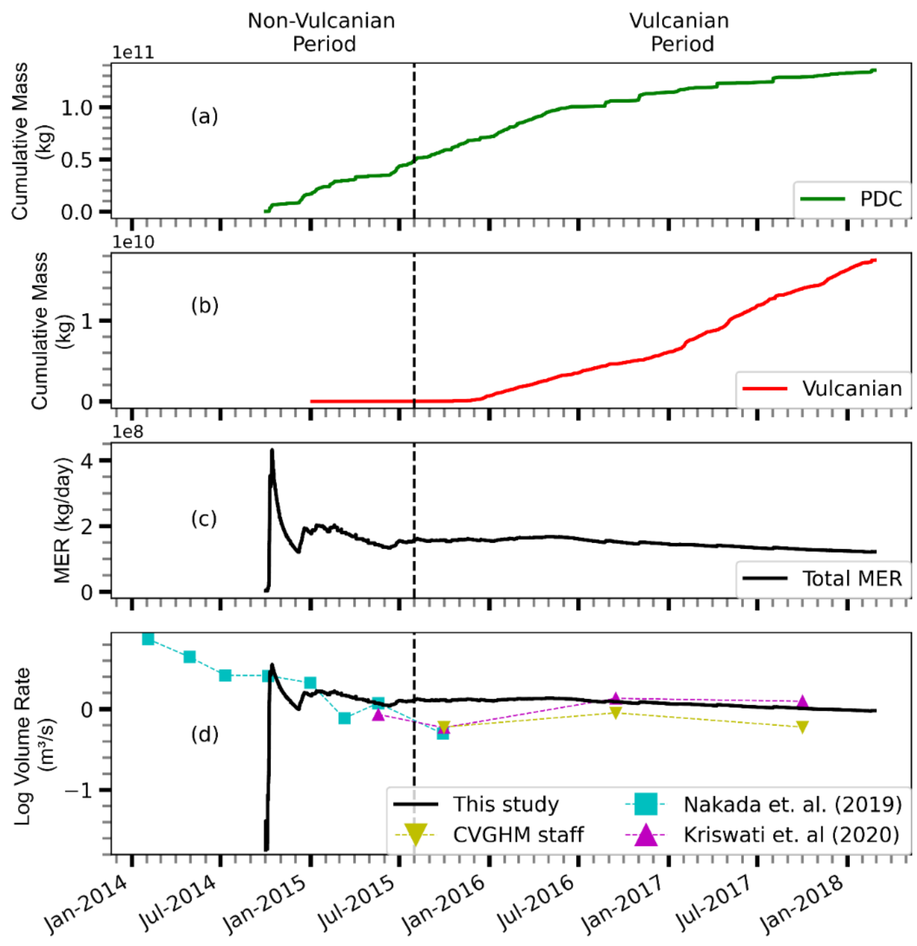

Fig. 1. Cumulative Mass of a) PDC event and b) vulcanian event, c) total MER based on seismic calculation, d) comparison of log discharge rate from this study with the previous studies.