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Ellipse-approximated Isopach Maps for Estimating Ashfall Volume at Sakurajima Volcano

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In studies of volcanic tephra, it is usual that the overall volume of tephra is estimated ashfall volumes based on representative locations within the ashfall area. The precision of the volume estimation largely depends on the number of the locations. However, in the case of ongoing eruptions on island volcanoes, such as Sakurajima volcano, the observation locations are usually limited. We therefore have developed a practical method for estimating ashfall volume and distribution in such case. The method approximates the distribution of ashfall as ellipses, with the distribution area (A) and thickness or weight of deposit (T) determined by $A = \alpha T^{-1}$. The ellipse-approximated isopachs can be determined by using the direction of the ellipse axis and ashfall data at two points. In determing the ellipse axis exactly, we usually need additional ashfall amounts from the other locations. We set 37 samplers around Sakurajima volcano, and retrieved the samplers 15 times, from April to December, 2008. Using the propose method, we are able to determine the volume of ash produced by small, continuous eruptions.

Key words: ashfall distribution; isopach; ellipse approximation; volume estimation; Sakurajima volcano

1. Introduction

The difficulty of ashfall volume estimation for small islands or short intermittent eruptions in Japan is a major issue, when forecasting the progress of volcanic eruptions. Hence, we propose a tool for estimating ashfall volume using limited ashfall observation locations as inputs. Such tool is useful in the case of ongoing eruptions when observation locations are usually limited.

Many authors have proposed methods to calculate the distribution or volume of pyroclastic falls. The most advanced method is to produce an isopach map (lines of equal thickness) of tephra deposits, based on many points determined by geological surveys. Other approaches to volumetric calculations include simulation models based on the dynamics of the eruption column and existing models or codes (Ishimine, 2007). An isopach is a contour line that shows the same thickness of tephra for a given area. Whole ashfall volume can be estimated using isopach map by applying integral calculus. Many studies have shown that tephra thickness decreases exponentially with distance from the vent. Thorarinsson (1954) showed important results related to the exponential decrease in tephra thickness with increasing distance from the source. Porter (1973) considered that the correlation of thickness and distance followed a power relationship for Hawaiian tephra. Suzuki (1981) presented a logarithm approximation method that explained these correlations.

If the area and tephra thickness are correlated, then the volume of tephra can be deduced. Rose *et al*. (1973) estimated ashfall volume by integrating the plot of log (T) against log(A) with distribution area (A) and thickness or weight of deposit (T). Recently, ashfall deposits were shown to follow exponential decreases of log(T) against log ($\sqrt{A}$) for plinian tephra (Pyle, 1989). Fierstein and Nathenson (1992) used two proximal and distal exponential rates (κ) of the plot of log(T) against log ($\sqrt{A}$), which changed at the break in slope, in order to calculate the volume. Bonadonna and Houghton (2005) used a power method to estimate the volume of Plinian tephra deposits. When using the exponential method or the power formula, many isopachs are required to estimate the ashfall volume over large areas accurately.

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