Distribution and physical properties of volcanic ash on the northern flank of Mount Sakurajima

Original Article

Distribution and physical properties of volcanic ash on the northern flank of Mount Sakurajima

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Summary

Based on field investigation and soil test, we investigated the distribution and physical characteristics of volcanic ash caused by the ebb and flow of volcanic activity in the northern flank of Mount Sakurajima. The results were as follows:

(1) The annual average thickness of the volcanic ash layer during heightened volcanic activities (1972 to 1993) was 4.4 and 6.5 times greater than that measured during low activities (1994 to 2006) at distances of 2.5 km and 3.8 km, respectively, from the Minamidake crater of Mount Sakurajima.

(2) The dry density of the volcanic ash layer was 1.29 g/cm^3 and 1.49 g/cm^3 during the period of heightened volcanic activities (1972 to 1993) and it was 1.18 g/cm^3 and 1.43 g/cm^3 during the period of low activities (1994 to 2006) at distances of 2.5 km and 3.8 km, respectively, from the Minamidake crater of Mount Sakurajima. The void ratio of the volcanic ash layer during the period of low activities was greater than that during the period of heightened activities.

(3) The median diameter of solid particles in the volcanic ash layer was 0.15 mm and 0.26 mm during the period of heightened volcanic activities (1972 to 1993) and it was 0.13 mm and 0.21 mm during the period of low activities (1994 to 2006) at distances of 2.5 km and 3.8 km, respectively, from the Minamidake crater of Mount Sakurajima. The median diameter of solid particles in the volcanic ash layer during the period of low activities was smaller than that during the period of heightened activities.

Key Words: Mount Sakurajima, volcanic ash, volcanic activity

1. Introduction

The ebb and flow of volcanic activity has a great effect on the hydrologic and erosion regime of the surrounding areas. The erosion rate, sediment yield and discharge on the flank of Mount Sakurajima during low volcanic activity were found to be much smaller than during heightened activity (Teramoto et al., 2005, 2006b). The reason for the large decrease of erosion rate, sediment yield and discharge during low volcanic activity is considered to be related to the decrease of supplied volcanic ash volume, the changes in deposition conditions and physical properties of volcanic ash following the ebb of volcanic activity.

The purpose of this research is to study the distribution, deposition conditions and physical properties of volcanic ash based on field investigation and soil test, as well as the effect of the ebb and flow of volcanic activity on them in the northern flank of Mount Sakurajima.

2. Study area and methods

The study area is the middle reach of the northern flank of Mount Sakurajima, as shown in **Fig. 1**. The topography lower than 300 m above the mean sea level in the study area is hill slope and plateau. The topography from 300 m to 500 m above the mean sea level consists of a mixture of hill slope and steep slope. The topography at 500 m above the mean sea level or more is steep slope. The vegetation at less than about 600 m above the mean sea level consists of broad-leafed trees and

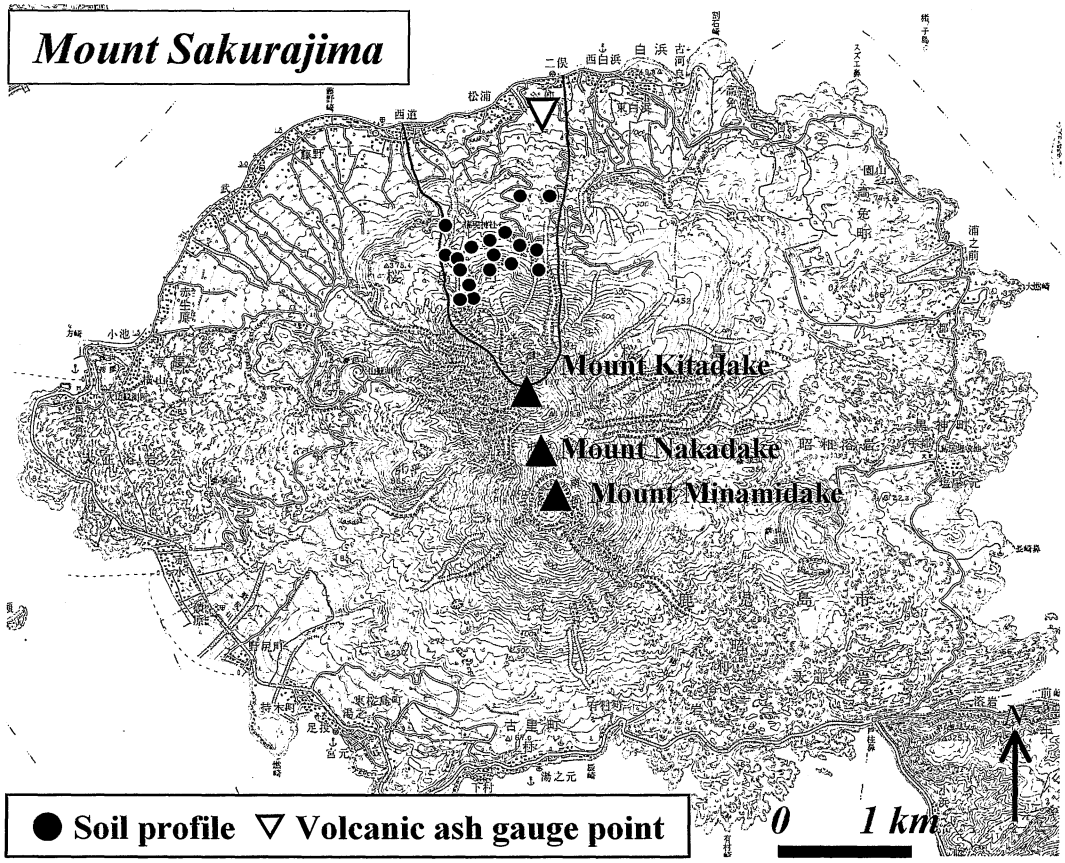

Fig. 1 Location of study area.

Japanese cedar of artificial tree. The vegetation at 600 m above the mean sea level or more consists of herbs and shrubs. The summit of Mount Sakurajima is bare land slope. The geological composition of the study area consists of a 1914 Taisho pumice layer covered with a soil layer and a volcanic ash layer.

Moreover, from 1978 onward, Kagoshima Prefecture measured the amount of volcanic ash in the lower reach of the study area (Fig. 1).

The methods consist of field investigation and soil tests on samples collected from the volcanic ash layer. The investigation of the distribution and deposition condition of volcanic ash was conducted through the observation of soil profile. Nineteen soil profiles were investigated (Fig. 1). Investigation was conducted in December 2006. The soil profile was established on the slope that was near to flatness limited to sheet erosion. The soil test of volcanic ash determined the specific gravity of grains, bulk density, grain size distributions and dry density. To measure the dry density, an undisturbed sample was collected in metallic cylinders 55 mm in diameter and 60 mm in height.

3. Temporal change of annual amount of volcanic ash

Mount Sakurajima has been continuously in action with frequent and lively small-scale ash eruptions from Minamidake crater since 1972. **Fig. 2** shows the change in the annual amount of volcanic ash in the lower reach of the study area as measured by Kagoshima Prefecture from 1978 to 2006 on a yearly basis (Kagoshima Prefecture, 1978-2006). The annual amount of volcanic ash during 1978 and 1993 was large. Moreover, the amount of volcanic ash in 1985 was approximately 65 kg/m^2, the largest annual value for the period from 1978 to 2006. Since 1994, the annual amount of volcanic ash fall has been decreasing remarkably.

4. Distribution and physical properties of volcanic ash

According to volcanic ash deposition conditions such as tone, density, hardness and humus content based on the observation of the soil profile, the volcanic ash deposition since 1972 was divided into two layers. Since the upper layer of volcanic ash

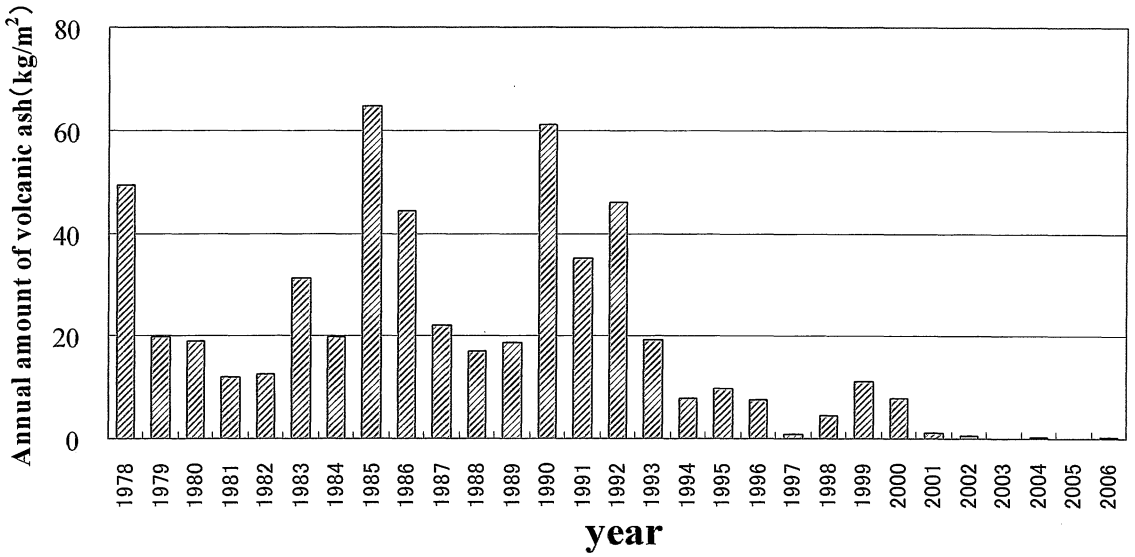

Fig. 2 Change in the annual amount of volcanic ash in the lower reach of the study area from 1978 to 2006.

contained much humus, it seems that the upper layer was accumulated during the period of low volcanic activities from 1994 to 2006. It seems that the lower layer was accumulated during the period of heightened volcanic activities. Thus, changes of volcanic activities influence the characteristics of volcanic ash considerably.

Fig. 3 shows the annual average thickness of volcanic ash layer during periods of both heightened (1972 to 1993) and low volcanic activities (1994 to 2006) according to distance from the Minamidake crater of Mount Sakurajima. The annual average thickness of volcanic ash layer during the two periods became smaller with increased distance from the Minamidake crater. The annual average thickness of volcanic ash layer during the period of heightened volcanic activities was greater than that during the period of low activities. The annual average thickness of the volcanic ash layer during the period of heightened volcanic activities was between 4.4 and 6.5 times greater than in the period of low activities.

Fig. 4 shows the dry density of volcanic ash layer during periods of both heightened (1972 to 1993) and low volcanic activi-

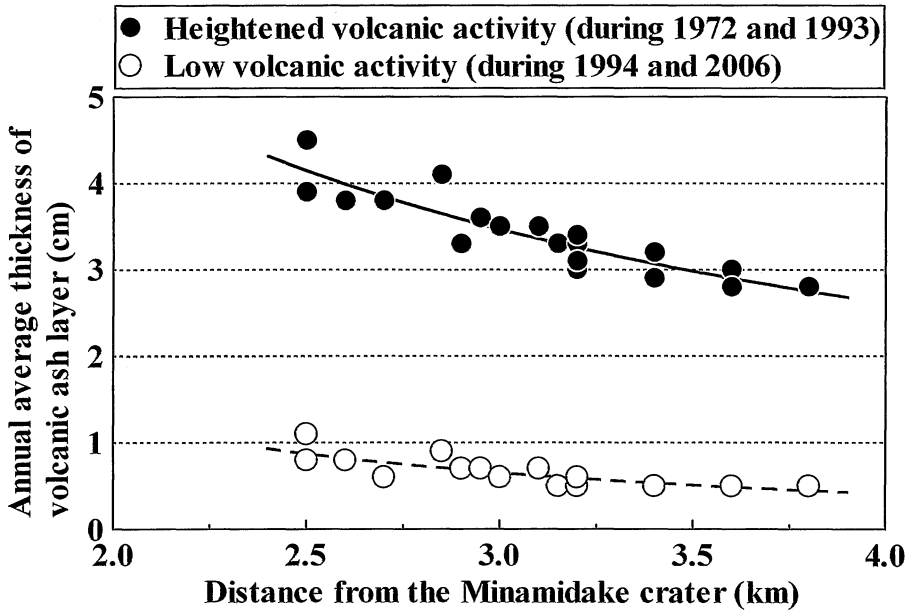

Fig. 3 Annual average thickness of volcanic ash layer during periods of both heightened and low volcanic activity in relationship to the distance from the Minamidake crater of Mount Sakurajima in the study area.

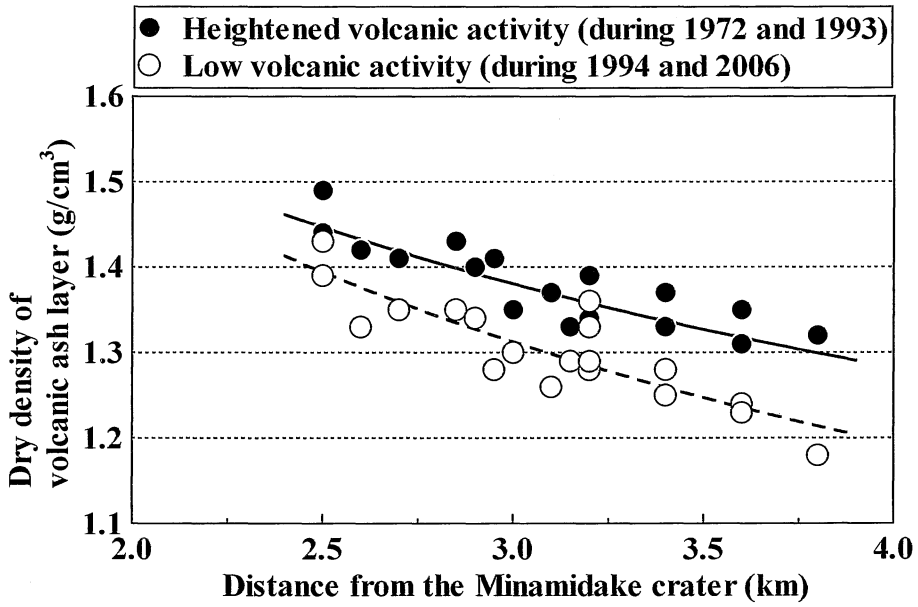

Fig. 4 Dry density of volcanic ash layer during periods of both heightened and low volcanic activity according to distance from the Minamidake crater of Mount Sakurajima in the study area.

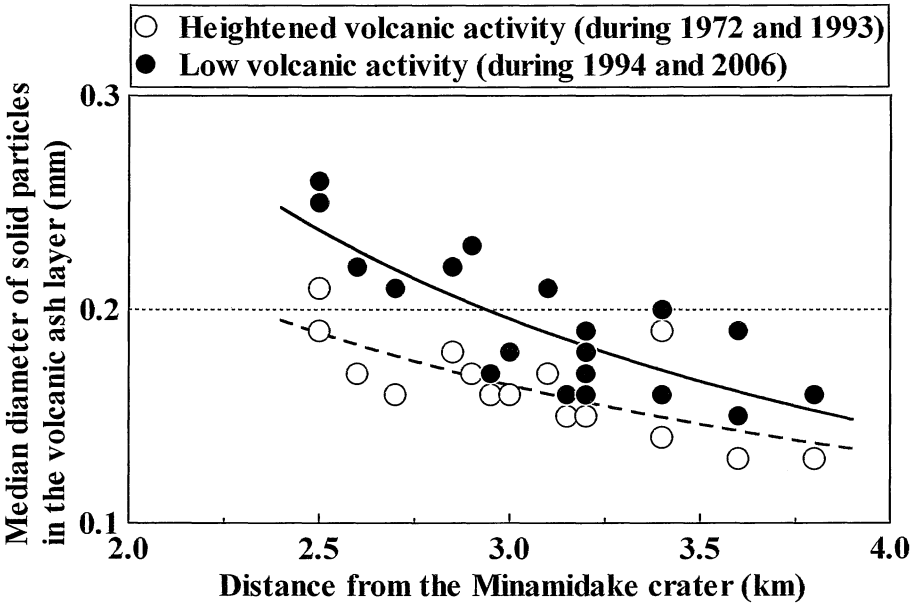

Fig. 5 Median diameter of solid particles in the volcanic ash layer during periods of both heightened and low volcanic activity according to distance from the Minamidake crater of Mount Sakurajima in the study area.

ties (1994 to 2006) according to distance from the Minamidake crater of Mount Sakurajima in the study area. The dry density during two periods became smaller with increased distance from the Minamidake crater. The dry density during the period of heightened volcanic activities was greater than that during the period of low activities. The dry density of the volcanic ash layer was between 1.29 g/cm^3 and 1.49 g/cm^3 during the period of heightened volcanic activities, and was between 1.18 g/cm^3 and 1.43 g/cm^3 during the period of low activities. The void ratio of the volcanic ash layer during the period of low volcanic activities was greater than that during the period of heightened activities. The reason for the increase of void in the volcanic ash layer is thought to be a result of root growth by recovering vegetation following the ebb of volcanic activity.

Fig. 5 shows the median diameter of solid particles in the volcanic ash layer during periods of both heightened (1972 to 1993) and low volcanic activities (1994 to 2006) according to distance from the Minamidake crater of Mount Sakurajima in the study

area. The median diameter of solid particles during the two periods became smaller with increased distance from the Minamidake crater. The median diameter of solid particles during the period of heightened volcanic activities was greater than that during the period of low activities. The median diameters of solid particles were between 0.15 mm and 0.26 mm during the period of heightened volcanic activities and were between 0.13 mm and 0.21 mm during the period of low activities.

Shimokawa & Jitousono (1987) showed the thickness of volcanic ash layer, the dry density of volcanic ash layer and the median diameter of solid particles in the volcanic ash layer during the period of heightened volcanic activities (between 1972 and 1983) tended to decrease with increased distance from the Minamidake crater. These results are similar to the results of the current study.

The ebb of volcanic activity causes the decrease of volcanic ash deposition and volcanic gas in the surrounding watershed of Mount Sakurajima. As a result, it brings the recovery of the vegetation (Teramoto et al., 2006c), the increase of void and infiltration capacity in the volcanic ash layer caused by growth of roots (Teramoto et al., 2004, 2005), the armoring of the surface volcanic ash layer (Teramoto et al., 2006a) and the decrease of erosion rate, sediment yield and discharge (Teramoto et al., 2004, 2005, 2006b).

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桜島の北側斜面における火山灰の分布とその物理的性質

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要　旨

本論では，桜島の北側斜面で実施した現地調査および土質試験の結果に基づき，噴火活動の盛衰に伴って，火山灰の分布，火山灰の堆積状況ならびに火山灰の物理的性質がどのように変化しているのかを検討した。得られた結果は次の通りである。

(1) 南岳火口から約2.5～3.8kmの範囲で比較すると，噴火活動が活発な期間（1972～1993年）における年平均での火山灰層厚は，穏やかな期間（1994～2006年）におけるそれの約4.4～6.5倍であった。

(2) 南岳火口から約2.5～3.8kmの範囲で比較すると，噴火活動が活発な期間（1972～1993年）における火山灰層の乾燥密度は1.29～1.49g/cm^3，穏やかな期間（1994～2006年）におけるそれは1.18～1.43g/cm^{3}であり，活動が穏やかな時期における火山灰層の空隙率が大きかった。

(3) 南岳火口から約2.5～3.8kmの範囲で比較すると，噴火活動が活発な期間（1972～1993年）における火山灰層の中央粒径は0.15～0.26mm，穏やかな期間（1994～2006年）におけるそれは0.13～0.21mmであり，活動が穏やかな時期の方が小さかった。

キーワード：桜島火山，火山灰，噴火活動