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Unpublished K-Ar dates measured in the geochronology laboratory of Yamagata University – Rocks from Myojinyama in the Mukaimachi caldera, northeastern Yamagata Prefecture

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Abstract

This report presents K-Ar dating results of volcanic rocks from Myojinyama in the Mukaimachi caldera, northeastern Yamagata Prefecture, as measured at the geochronology laboratory of Yamagata University. Four andesitic rocks of Myojinyama yielded K-Ar dates of 0.83 ± 0.08, 0.69 ± 0.05, 0.67 ± 0.08, and 0.61 ± 0.05 Ma. A pumice sample shows a K-Ar date of 0.47 ± 0.05 Ma. These results support the former suggestion: post-caldera volcanic activity of Mukaimachi caldera took place during 1.0 to 0.6 Ma.

Introduction

The geochronology laboratory of the Yamagata University continued K-Ar dating for rocks from Quaternary volcanoes in northeastern Japan to ascertain the spatiotemporal distribution of volcanic activities in this region. These projects were performed earlier by faculty members: Prof. Nobuo Takaoka, Prof. Kazuo Saito, and the late Dr. Kazuya Fukunaga with their graduate and undergraduate students. Measured K-Ar dates were presented in their respective theses. Although some were published (e.g. Zaosan by Takaoka et al., 1989; Murayama-Hayama by Saito and Kamei, 1995; Shiratakayama by Ishii and Saito, 1997), many K-Ar dates have not been reported.

This report presents K-Ar dates from Myojinyama in the Mukaimachi caldera, northeastern side of Yamagata Prefecture, as measured by Yamagata University. The K-Ar dating experiment for the Myojinyama samples is a part of the undergraduate research project (Konno, 1985MS) supervised by NT. Compilation and comparison of K-Ar dates among Konno

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(1985MS) and other documents (NEDO, 1990; Toshida et al. 1999; Kondo et al. 2004) were performed by NI. Quoted dates are valuable for elucidation of the volcanic history in the Mukaimachi caldera, and adjacent Akakura and neighboring Onikobe calderas.

K-Ar dating

Myojinyama and Nukazukayama Andesite (Taguchi, 1975) are distributed around Myojinyama and Nukazukayama north of the Akakura Hot Spring. Actually, Myojinyama and Nukazukayama Andesite are regarded as lava domes formed by post-caldera volcanism of the Mukaimachi caldera (Sato, 1986). A simplified geological map of the Mukaimachi caldera is shown in Figure 1. Geological features of the Mukaimachi caldera and adjacent Akakura caldera were described by Otake (2000). Taguchi (1975) demonstrated the stratigraphic relation as explained below. The Myojinyama and Nukazukayama Andesite erupted after deposition of the Ohayama Formation and Kan-nodai Formation. The Myojinyama and Nukazukayama Andesite are covered by the Hitohane Formation with unconformity. The Hitohane Formation is overlain by the Mitsuzawa Formation with unconformity.

Four andesite samples for K-Ar dating were collected from Myojinyama. Sampling locations and altitudes of andesites are N 38° 44′ 16.02″, E 140° 34′ 3.13″, 388 m for Myojin 6-50, N 38° 43′ 59.93″, E 140° 33′ 44.05″, 330 m for Myojin 7-54, N 38° 43′ 57.04″, E 140° 33′ 42.81″, 342 m for Myojin 7-56 and N 38° 43′ 55.83″, E 140° 33′ 37.56″, 382 m for Myojin 7-63. A pumice sample was collected from the southeastern flank of Myojinyama. The sampling location and altitude of Myojin pumice were N 38° 44′ 6.08″, E 140° 33′ 58.57″, 337 m. The locate is in the Hitohane Formation distribution area of the geological map (Figure 1). Longitude and latitude are in Japan Geodetic Datum 2000 (JGD2000).

The rock types of the andesites are two-pyroxene andesite with hyalopilitic texture. The pumice rock type was not described in Konno (1985MS). The pumice contains abundant plagioclase and subordinate hypersthene phenocrysts. The groundmass portion of the pumice is composed mainly of glass.

Fresh rock tips of a sample were crushed and sieved into a 0.15–0.25 mm size fraction. These grain samples were washed in water and dried. Phenocryst fragments were separated magnetically from the matrix fraction. To avoid the influence of excess argon in phenocryst, the matrix concentration was used for K-Ar dating.

Potassium contents of samples were measured using flame photometry with a Hitachi 208 type atomic absorption photometer with a flame

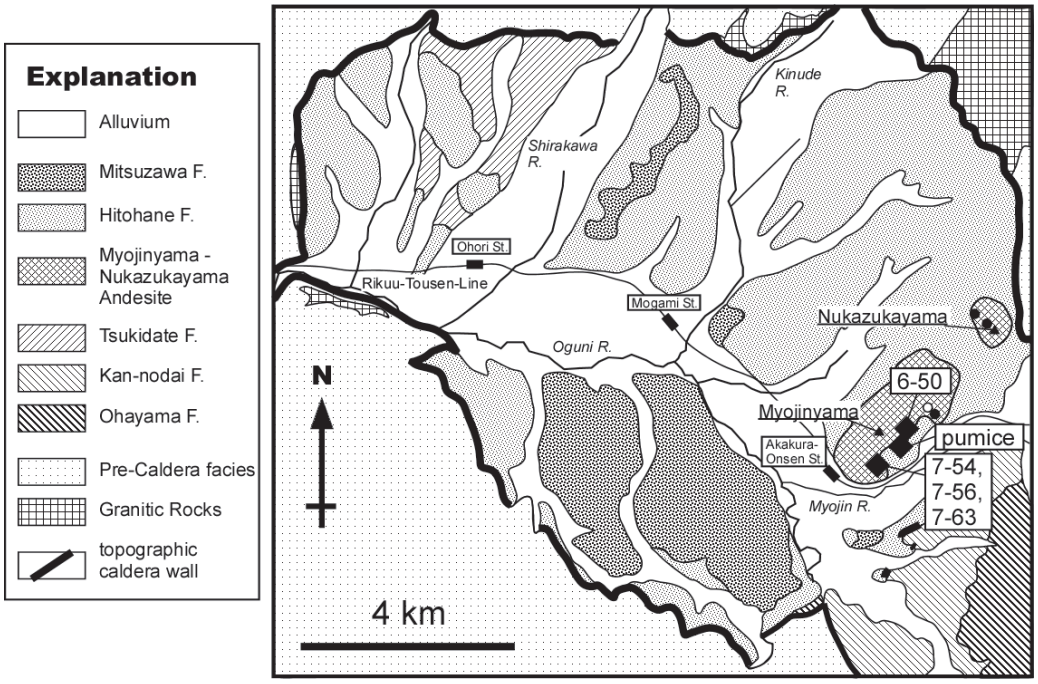

Figure 1. Simplified geological map of the Mukaimachi caldera and sampling locations. The geological map is modified after "1:100,000 geological map of Yamagata Prefecture (sheet of Mogami area)" from the Applied Geological Society of Yamagata (2016). Solid diamonds denote sample positions used for data collection in the study described herein. Small open circles show sample positions of NEDO (1990) on Myojinyama. Small solid circles show sample positions reported by Toshida et al. (1999) and Kondo et al. (2004).

photometer mode. Measured potassium contents of the reference samples (JB-1, Geological Survey of Japan Geochemical Reference samples, igneous rock series) are consistent with the reference value of JB-1. The relative uncertainty of the potassium content analyses was estimated as 5%.

Abundances of radiogenic ^{40}Ar were measured using peak comparison method without ^{38}Ar spike following the procedure described by Takaoka et al. (1989). Samples were degassed at 1550℃ in a Mo crucible using a resistance furnace. Extracted gases were purified using two Ti getters and were then introduced into the mass spectrometer. Argon isotopes were analyzed with a single focus sector type mass spectrometer for a 20 cm radius and 90° deflection (Takaoka, 1976). To calculate the amount of radiogenic ^{40}Ar, mass discrimination and hot blank corrections were conducted during the argon isotope analyses.

For K-Ar age calculation, the following constants were used: $\lambda_e = 0.581 \times 10^{-10}$, $\lambda_\beta = 4.962 \times 10^{-10}$, $^{40}K/K = 0.0001167$ (Steiger and Jäger, 1977).

Uncertainty about the K-Ar age was calculated from the propagation of analytical errors in potassium and radiogenic ^{40}Ar contents (1 sigma level).

Results and Discussion

Results of K-Ar dating of Myojinyama samples are presented in Table 1. The K-Ar dates of Myojin 6-50, Myojin 7-54, Myojin 7-56, Myojin 7-63, and Myojin pumice are, respectively, 0.61 ± 0.05, 0.67 ± 0.08, 0.83 ± 0.08, 0.69 ± 0.05, and 0.47 ± 0.05 Ma.

Table 1 K-Ar dating results of Myojinyama samples

Sample No.	K content (wt.%)	Radiogenic ^{40}Ar (10^{-8} cm^3STP/g)	A.C. (%)	Age (Ma)
Myojin 6-50	0.62 ± 0.03	1.47 ± 0.10	69.3	0.61 ± 0.05
Myojin 7-54	0.23 ± 0.01	0.60 ± 0.07	86.4	0.67 ± 0.08
Myojin 7-56	0.61 ± 0.03	1.95 ± 0.17	81.3	0.83 ± 0.08
Myojin 7-63	0.57 ± 0.03	1.53 ± 0.09	77.0	0.69 ± 0.05
Myojin pumice	1.05 ± 0.05	1.94 ± 0.20	95.3	0.47 ± 0.05

N.B.

A.C. represents the air contamination ratio (non-radiogenic ^{40}Ar / total ^{40}Ar).

K-Ar dates of volcanic materials from the inner part of the Mukaimachi caldera are summarized below. NEDO (1990) reported 0.98 ± 0.10 Ma of a rock from the Sasamori Quarry in Myojinyama, and 0.62 ± 0.14 Ma, 0.69 ± 0.04 Ma, and 0.80 ± 0.32 Ma of Myojinyama Andesite samples from the boring core in the Mukaimachi caldera. Toshida et al. (1999) reported K-Ar dates of Myojinyama - Nukazukayama Andesites, 0.83 ±0.05 Ma from a rock from the Sasamori Quarry in Myojinyama and 0.61 ± 0.02 and 0.63 ± 0.02 Ma for rocks from Nukazukayama. Detailed K-Ar dating results reported by Toshida et al. (1999) were described by Kondo et al. (2004). A K-Ar date of 0.39 ± 0.03 Ma from pumice of the Mitsuzawa Formation has been reported by NEDO (1990).

K-Ar dates of Myojinyama Andesites measured in Yamagata University are consistent with K-Ar dates described in earlier reports. This coincidence strongly supports an earlier inference: Post-caldera volcanic

activity of Mukaimachi caldera occurred during 1.0–0.6 Ma. The K-Ar date of 0.47 ± 0.05 Ma from the Myojin pumice is slightly younger than the dates of Myojinyama - Nukazukayama Andesite samples and older than the date of Mitsuzawa Formation (0.39 ± 0.03 Ma; NEDO, 1990). The K-Ar date of the Myojin pumice measured at Yamagata University is consistent with the stratigraphic relation. The Hitohane Formation, which covered the Myojinyama and Nukazukayama Andesite, is overlain by the Mitsuzawa Formation as described by Taguchi (1975).

Summary

K-Ar dating results of the Myojinyama – Nukazukayama Andesite by Konno (1985MS) strengthen the inference of post-caldera volcanic activity of Mukaimachi caldera occurring during 1.0–0.6 Ma. Additionally, a K-Ar date from Myojin pumice shows consistency of the stratigraphic relation between Myojinyama – Nukazukayama Andesite and the Hitohane Formation.

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