Excavation of an overlooked active volcano II: Large Holocene phreatic eruptions at Washibaike volcano and its surrounding area

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The aim of this study is to elucidate the Holocene phreatic eruption history of Washibaike volcano and its vicinity. Washibaike is a Quaternary volcano with a distinct crater (Washibaike crater), located in the deepest part of the Northern Alps (central Japan). Large-scale fumarolic activity occurred in 2020 and 2021 at Iwozawa at the southern foot of the volcano (Oikawa et al., 2021). Recent studies (Ishizaki et al., 2021) have revealed that the clayey tephra widely distributed around the volcano is the product of one of the largest phreatic eruptions in Japan. However, several problems remain: the 14C age of the tephra suggests that the eruption may have occurred more than once, and the distribution of the tephra has not been well traced, which may over/underestimate the volume of the ejecta. We conducted additional field surveys around Washibaike, in its vicinity (around Mt. Mitsumatarenge and Kumonodaira), to the west (towards Mt. Yakushi), to the east (towards Mt. Yari), to the south (towards Mt. Kasa), and to the north (towards Mt. Suisho), and analyzed 14 additional ^{14}C dates.
In the study area, two light-colored clayey tephras are identified. The lower tephra (hereafter referred to as the Washiba A tephra) is characterized by the absence of lapilli-sized granite fragments. On the other hand, the upper tephra (hereafter referred to as the Washiba B tephra) is characterized by the abundance of lapilli-sized granite fragments. In several outcrops around Mt. Mitsumatarenge, pyroclastic surge deposits with accretionary lapilli are found directly beneath the Washiba A and B tephras. The calibrated calendar years of each tephra, inferred from the ^{14}C age of the soil immediately below the tephra, are 4250 cal BP for the Washiba A tephra and 1950 cal BP for the Washiba B tephra. The age obtained is consistent stratigraphically, since K-Ah tephra (7300 cal. BP; Fukusawa, 1991) can be seen in many outcrops below the Washiba A tephra.
The absence of juvenile materials in both tephras indicates that phreatic eruptions formed the tephras. Clays extracted from tephra samples by elutriation were analyzed by XRD and hydrothermally altered minerals such as silica minerals (quartz, cristobalite), kaolin minerals, and alunite were identified. Based on these mineral species and assemblages, it is likely that a hydrothermal system with an acidic hydrothermal alteration zone existed beneath the volcano, which was the source of the eruptions that formed both tephras.
Based on the tephra thickness data obtained in this study and the data obtained in previous years, isopach maps of the Washiba A and B tephras were constructed. The main axes of distribution of each tephra are northwest for the Washiba A tephra and southwest for the Washiba B tephra. The locations of the eruption sources (craters) inferred from the isopach map are around the Iwosawa area for the Washiba A tephra and around the Washibaike crater for the Washiba B tephra. The eruptive volumes calculated from isopach diagrams using the empirical formula of Hayakawa (1985) are 1.8×10^7 m^3 for the Washiba A tephra and about 2.0×10^7 m^3 for the Washiba B tephra, both of which are the largest phreatic eruptions that occurred during the Holocene in Japan.

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