

Figure S1. The distribution of geothermal anomaly area over 50 °C in Ioyama fumarole area: (1) January 16, 2016; (b) February 2, 2016; (c) February 9, 2016; (d) February 21, 2016; (e) March 12 and April 29, 2016. Light red shows the same area in d. The spot H appeared on March 12. The spots G and I appeared on April 29; (f) August 20, 2016; (g) December 10, 2016; (h) February 4, 2017. Areas horizontal lines are below 50 °C; (i) March 19, 2017; (j) June 3, 2017; (k) September 25, 2017; (l) February 3, 2018. The base maps in (a) to (f) by GSI (Geospatial Information Authority of Japan) map (<https://maps.gsi.go.jp/>).

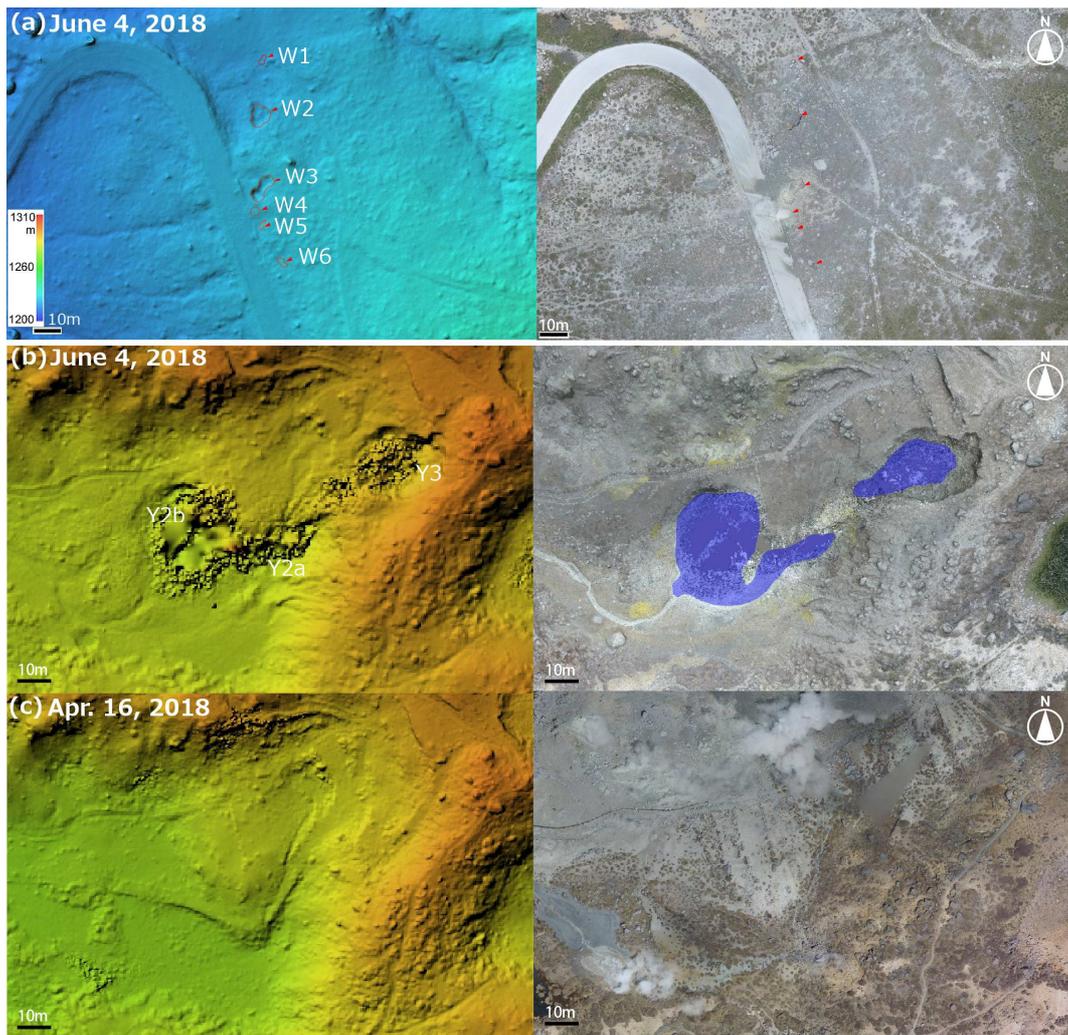


Figure S2. Digital elevation models and photographs: (a) Around the Ioyama-west crater on June 4, 2018; (b) Around the Ioyama-south craters on June 4, 2018; (c) Around the Ioyama-south craters on April 16, 2018.

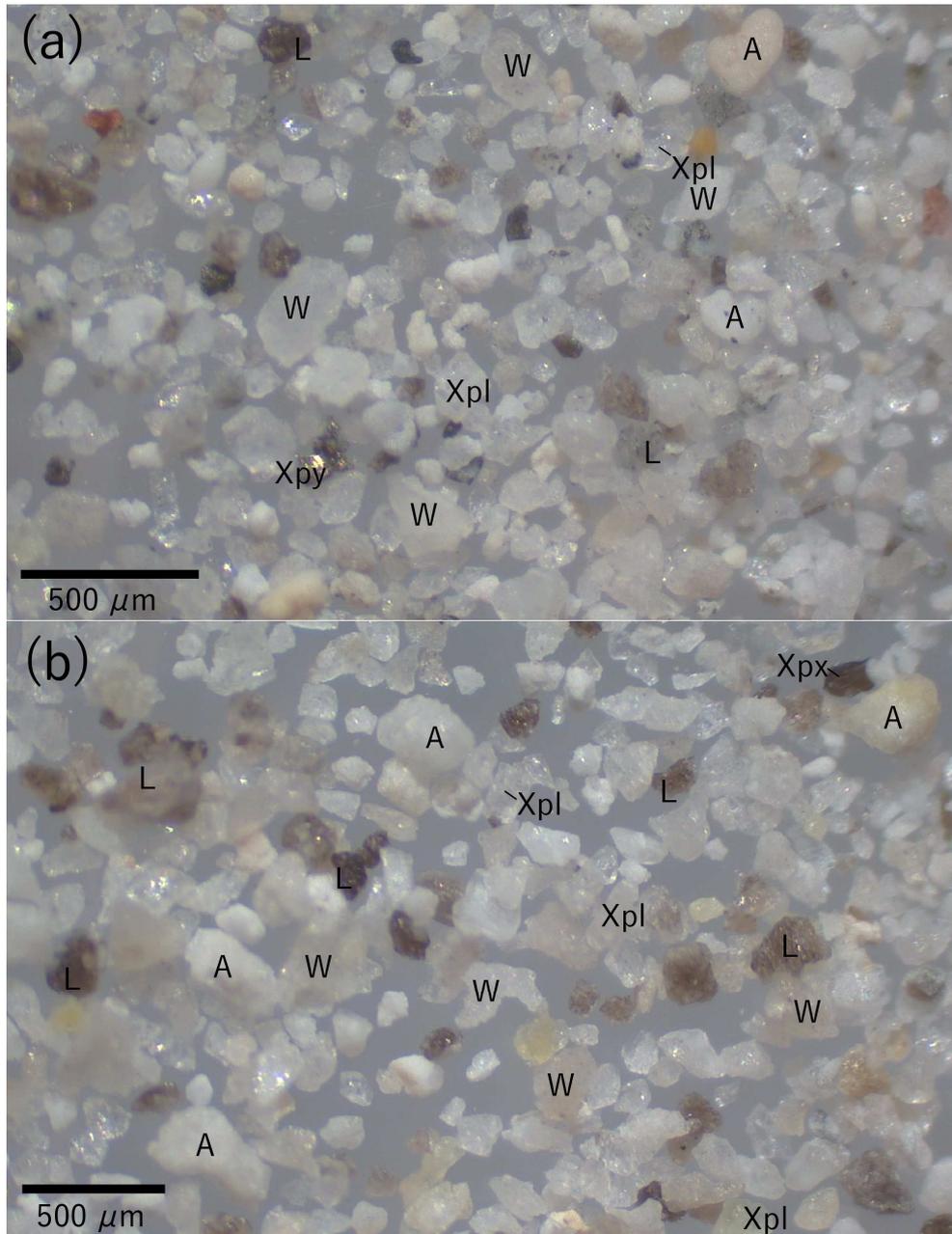


Figure S3. Photomicrographs of ashy deposit grains: (a) 20180419-ash sample collected from the Ioyama-south craters. ; (b) 20170426-ash sample collected from the jet fumarole vent A. L: lithic fragment, W: white-colored fragment, A: strongly altered fragment, Xpl: plagioclase, Xpy: pyrite, Xpx: pyroxenes.

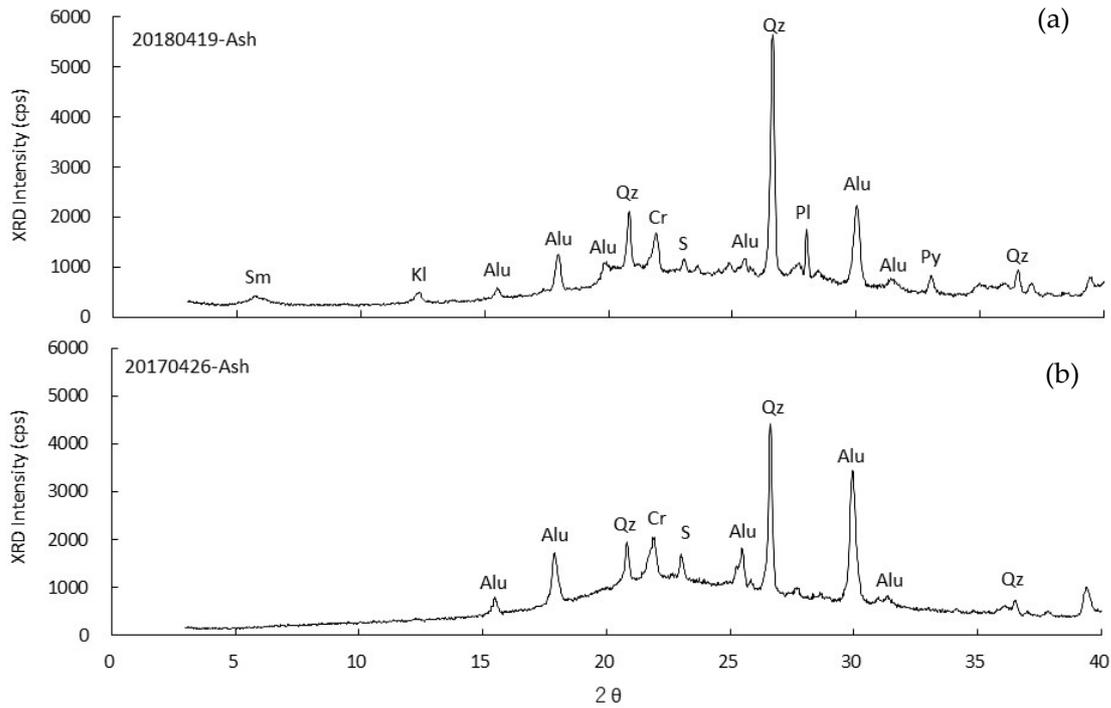


Figure S4. XRD analyses: (a) 20180419-ash sample collected from the Ioyama-south craters. ; (b) 20170426-ash sample collected from jet fumarole vent A. Alu: alunite (soda), Kl: kaolinite, Cr: cristobalite, Qz: quartz, Py: pyrite-, Sm: smectite, S: sulfur, Pl: plagioclase.

Table S1. The oxygen and hydrogen isotope analyses of hydrothermal water from the Ioyama.

Sample No.	Day	pH	δD (‰)	$\delta^{18}\text{O}$ (‰)
K3-1	Feb. 16, 2016	2.1	-53.1	-8.3
K3-2	Feb. 21, 2016	1.9	-53.1	-8.1
K3-3	Mar. 12, 2016	2.0	-53.9	-8.2
K3-4	Mar. 30, 2016	2.0	-54.0	-8.0
Y1	Apr. 16, 2018	1.6	-31.3	0.0