Preparation processes leading up to the 2014 phreatic eruption of Mount Ontake, Japan

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On 27 September 2014, at 11:52 a.m. JST (UTC + 9), Mount Ontake produced a phreatic (steam type) eruption, spraying volcanic ash, gas, and debris on surrounding areas. Based on ejecta volume and the maximum ash column height of ~7000 m, the VEI for this eruption was categorized to 2. The 2014 eruption resulted in the deaths of 58 climbers, with a further 5 missing and presumed dead. Before the 2014 eruption, a micro-seismicity just beneath the crater, which might be linked to the eruption, had lasted for around one month. We relocated shallow volcano tectonic (VT) earthquakes and long-period (LP) events from August to September 2014, using differential travel times. Then, we further detected numerous additional micro-earthquakes beneath the craters, by applying a template-matching technique to continuous waveforms using these relocated earthquakes (Kato et al., 2015). The relocated VT earthquakes aligned on a near-vertical plane oriented NNW–SSE, suggesting they occurred around a conduit related to the intrusion of magmatic–hydrothermal fluids into the craters. The frequency of VT earthquakes gradually increased from 6 September 2014 and reached a peak on 11 September 2014. After the peak, seismicity levels remained elevated until the eruption. During the 10-min period immediately preceding the phreatic eruption, VT earthquakes migrated in the up-dip direction as well as laterally along the NNW–SSE feature. The migrating seismicity coincided with an accelerated increase of pre-eruptive tremor amplitude and with an anomalous tiltmeter signal that indicated summit upheaval. Therefore, the migrating seismicity suggests that the vertical conduit was filled with pressurized fluids, which rapidly propagated to the surface during the final 10 min before the eruption.

Maeda et al. (2017) revealed that the tilt change observed immediately (450 s) before the eruption was at first a linear function in time that then switched to exponential growth. The tilt signal can be explained by a vertical tensile crack at a depth of 1100 m from the summit. The linear function was explained by the boiling of underground water controlled by a constant heat supply from a greater depth. The exponential function was explained by the decompression-induced boiling of water and the upward Darcy flow of the water vapor

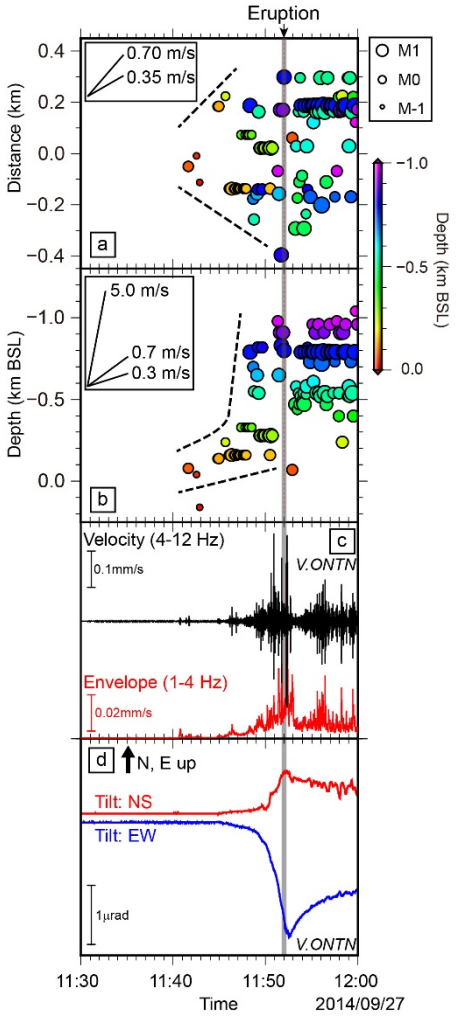

Fig. 1(left) Precursors of the 2014 phreatic eruption (Kato et al., 2015). a) Horizontal distance of detected VT earthquakes from 11:30 to 12:00 JST on 27 September 2014, projected onto the strike of the hypocenter alignments (N15W-S15E). Circles are scaled to magnitude and color-coded to depth. Black dashed lines approximate the locations of the fronts of horizontal earthquake migrations. b) Depth variations in VT earthquakes, colored to depth. Circles are scaled to magnitude. Black dashed lines approximate the locations of the fronts of vertical earthquake migrations. c) Bandpass filtered waveform between 4 and 12 Hz (black curve) and envelope between 1 and 4 Hz (red curve) recorded at the V.ONTN station nearby the summit. d) Time series of tiltmeter records observed at the V.ONTN station. NS and EW components denote the northward and eastward ground-up components, respectively.

through a permeable region of small cracks. This transition can be explained by a breakage of a barrier in the conduit, leading up to the eruption.

To examine temporal change in the long-term seismicity rate beneath the crater, we are now searching for similar events applying template-matching technique to continuous waveform data from 2011 to Sep. 2014. I will show the preliminary result in my talk.

Main References

Kato A, Terakawa T, Yamanaka Y, Maeda Y, Horikawa S, Matsuhiro K and Okuda T (2015) Preparatory and precursory processes leading up to the 2014 phreatic eruption of Mount Ontake, Japan. Earth, Planets Sp 67: 111, doi:10.1186/s40623-015-0288-x.

Maeda Y, Kato A and Yamanaka Y (2017) Modeling the dynamics of a phreatic eruption based on a tilt observation: Barrier breakage leading to the 2014 eruption of Mount Ontake, Japan. J. Geophys. Res. Solid Earth, 122, 1007–1024, doi:10.1002/2016JB013739.