

## Volcanic activities of Hakkoda volcano after the 2011 Tohoku-Oki earthquake

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The 2011 Tohoku-Oki earthquake of 11 March 2011 is one of the largest earthquakes in recent times, and it generated large displacements and deformation in and around the Japanese islands. Such large crustal deformation, especially the east-west extension exerted on Tohoku area, raises fear of further disasters including triggered volcanic activities as well as triggered seismicity. To assess the potential risks of triggered volcanic activities, understanding of the behavior of volcanic fluids in the crust and volcanic bodies would be a key. In this presentation, as examples of such possibly triggers volcanic activities, we report the recent seismic activities of Hakkoda volcano, and discuss the relation to the movement of volcanic fluids.

Hakkoda volcano is a group of stratovolcanoes at the northern end of Honshu Island, Japan. There are fumaroles and hot springs around the volcano, and phreatic eruptions from Jigoku-numa on the southwestern flank of Odake volcano, which is the highest peak in the main cones of Northern-Hakkoda volcanic group, were documented in its history. Since just after the occurrence of Tohoku-Oki earthquake, the seismicity around the volcano became higher, and the migration of hypocenters of high-frequency volcano-tectonic (VT) earthquake was observed.

In addition to these VT events, long-period (LP) events started occurring beneath Odake at a depth of about 2-3 km from February, 2013, and subtle crustal deformation caused by deep inflation source was also detected by GEONET GNSS network around the same time. The characteristics of LP events are summarized as follows: (1) The spectra of LP events are common between events irrespective of the magnitude of events, and they have spectral peaks at 6-7 sec, 2-3 sec, 1 sec, and so on. (2) The long-period component of LP events appears as a wave packet of a few cycles, and high-frequency ( $>1$  Hz) signals sometimes overlaps it. (3) LP events sometimes occur like a swarm with an interval of several minutes. These characteristics of LP events at Hakkoda volcano are similar to those of LP events at other active volcanoes and hydrothermal area in the world, where abundant fluids exist. Our further analysis using far-field Rayleigh radiation pattern observed by NIED Hi-net stations reveals that the source of LP events is most likely to be a nearly vertical tensile crack whose strike is almost parallel to the direction connecting Odake summit crater and Jigoku-numa. The number of VLPs gradually decreased after September, 2013, and high-frequency VT earthquakes became more dominant in the seismicity around Hakkoda volcano. However, there were a burst of earthquakes beneath Southern-Hakkoda volcanic group, that includes a few low-frequency earthquakes, at the end of December, 2013.

These results suggest that the extensional stress field generated by the 2011 Tohoku-Oki earthquake causes the upward movement of volcanic fluids and heat from the deep, and results in an activation of hydrothermal activities at the pre-existent fracture zone at Hakkoda volcanic group.

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