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Relative source locations of continuous tremor before and after the subplinian events at Shinmoe-dake

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Shinmoe-dake volcano started its climatic events on January 26, 2011, and three subplinian events occurred in 2 days. Although precursory evidences indicating magma intrusion were found in the time scale of a year, any decisive geophysical signals showing the final stage toward the eruption have not been identified. Volcanic tremor started to be recorded at stations around the summit of Shinmoe-dake at 12:45 on 18 January and had a high intensity after the phreatic eruption at 01:27 on the 19th until Februay 7, If there was any sign indicating rise of new magma to the shallow depth before the phreatic eruption, the tremor could be the candidate. Here we analyze the locations of the continuous tremor before, during, and after the subplinian events.

Seismic stations were sparse especially in the west of Shinmoe-dake before the eruption. A good number of seismic stations were installed after the start of the eruption, which included a dense seismic array operated by Kyushu University. The array was deployed on January 29 about 3 km from the Shinmoe-dake crater in the direction N115^{o}W. Twenty-five 3-component seismometers with a natural frequency of 2 Hz were installed at a sensor interval of 20-40 m.

We first investigated the source location of a long steady tremor on February 2 from 0:00am to 4:05am. Any clear spectral peaks common among the stations were not observed, and the power was broadly distributed in the rages below 2 Hz and 4.5-7 Hz. A MUSIC spectrum analysis was performed for the data from the seismic array using 1.5-2.5 Hz and 3.5-4.5 Hz bands. The results showed that P and S waves constantly came from the direction of the Shinmoe-dake crater. In addition to the array, 16 seismic stations recorded good quality data in this period. The tremor centroids were calculated by simply summing the coordinates of the stations weighted with the route-mean-square amplitudes of the tremor in a 1-7 Hz band. They fell on the center of the Shinmoe-dake crater. When only the stations that were operated before the eruption were used, the centroids were shifted to the northeast because of the biased distribution.

The amplitude distribution of this tremor was used as a reference. The seismic amplitude from January 18 to February 2 at each station was normalized by this reference amplitude. From dependence of the normalized amplitudes on the directions and distances from the Shinmoe-dake crater, the relative source locations of the tremor were estimated. In the afternoon of January 18, when the continuous tremor started, the source moved from the west to the center of the crater and then to the north and the deeper. The tremor source because shallower after the phreatic eruption on the morning of January 19, and a narrow gliding spectral peak appeared around 2 Hz on the night. The tremor declined at 8:00 on January 23 and restarted at 13:15 at a further shallower depth. This shallow source was active until the phreatic eruption on the morning of January 26 before the first subplinian event. The amplitudes at the southern stations were relatively strong during the first and second subplinian events and the same location as the reference event became active after the second subplinian event. It is consistent with the visual observation that the eruption center shifted from the south edge to the center of the crater at the final stage of the second subplinian event.

Keywords: Volcanic tremor, Eruption, Seismic source, Shinmoe-dake