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Cyclic activity of earthqaukes and ground deformation observed during the 1991-1995 dome growth at Unzen Volcano, Japan

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Unzen Volcano in SW Japan began to erupt on November 17, 1990, and growth of an associated dacite lava dome occurred from May 20, 1991 to early February 1995. The volume of extruded lava is estimated to be about 0.21km^3 (Nakada et al., 1999). Pyroclastic flows occurred frequently during the dome growth.

Just before the dome emergence and during the dome growth, cyclic tilt oscillation within a period of 1 to 3 h was observed in the EW component at the FG1 station located about 680m west from the crater. Yamashina et al. (1994) assumed that the oscillation presented the repetition of inflation and deflation at the uppermost part of the active vent, suggesting a cyclic upward flow of lava with high viscosity. They made a formula to successfully estimate the daily supply rate of lava using the magnitude of tilt oscillation. Umakoshi et al. (2011) revealed that the HF seismicity in the crater area around the dome emergence of May 20, 1991, increased and decreased repeatedly within a period of 1 to 2 h, which correlated with tilt cycles in such a way that the seismicity increased during uplifting on the side facing the crater. In contrast, when the craterward ground was subsiding, the seismicity rate was much lower. However, it has yet to be investigated whether such synchronization emerged in other periods of dome growth or not except for the period from October 1994, when a lava spine was growing (Yamashina et al., 1999). In this study, therefore, we investigated the relationship between tilt oscillation and temporal changes of seismicity level during the entire period of dome growth.

We used the tilt data at FG1, which were telemetered to the Shimabara Observatory of Kyushu University, and the earthquake list created by Umakoshi et al. (2008). Using earthquake counts in 10-min intervals and the tile data, we calculated cross-correlation coefficients in the time window of 12 h. As a result, we found three periods in which the temporal changes of the seismicity level correlated with the tilt oscillation. These were after November 1993, when the HF seismicity level was high. However, the manner of synchronization was different from that found in May 1991, that is, the seismicity rate increased gradually during the uplifting on the craterward side, and then decreased gradually during subsidence on the craterward side. This suggests that the source process of HF earthquakes is different between the cases in May 1991 and those after November 1993. No clear correlation with tilt oscillation was found in the period from June 1991 to October 1993, when the LF seismicity level was high. Also, there are some cases in which the temporal changes of HF seismicity did not correlate with the tilt oscillation. These indicate that the synchronization between tilt oscillation and seismicity level emerged only in parts of the periods when the HF seismicity level was high.

In other cases of cyclic activity of earthquakes, we found the temporal changes of the seismicity level related to the occurrences of pyroclastic flows. Also, we investigated the relation between tilt oscillation and seismicity level during the growth of a lava spine in detail.

Keywords: lava dome, tilt oscillation, cyclic activity, seismicity, high-frequency earthquake