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Earthquake cluster activity beneath Tanzawa Mountains in 2012: Migration with a small stress drop

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An earthquake cluster activity took place beneath the Tanzawa Mountains, which is located NE of Mt. Fuji, Japan, with a depth of 20 km at the end of January, 2012. The activity began at 22:39 UT on 27 January and included 78 earthquakes with M $\geq$ 2.0 in the area within 50 hours. Five of them had magnitudes greater than 4.0 and the largest one was M5.4.

First we relocated hypocenters by using the double difference method and found that earthquakes of the cluster activity migrated away from the first earthquake of the activity. The migration was consistent with the fluid diffusion and could be characterized as following two patterns. Earthquakes that occurred within an hour of the first earthquake had a migration speed similar to that of non-volcanic tremors. On the other hand, those occurred between an hour and 50 hours from the first earthquake of the activity showed a migration with a similar speed to the activity of induced earthquakes due to water-injection experiments. These results suggest that the cluster activity would be triggered by a slow slip and fluid diffusion. We confirmed that this migration would not be an apparent one by numerical simulations.

We then analyzed stress drops of 16 earthquakes with M $\geq$ 3.5 that occurred from July, 2003 to June, 2012 in the area of the activity. Earthquakes that occurred before and after the cluster activity had stable values of stress drop with 30 MPa estimated by the equation of Madariaga (1976), or 5 MPa by Brune (1970). On the other hand, earthquakes of the cluster activity included ones with significantly small stress drops. A hypothesis that the cluster activity was associated with fluid explains both the migration of hypocenters and small stress drops of the cluster activity. This is because the shear strength on a fault can be decreased due to the pore pressure of the fluid. This hypothesis is also supported by the fact that earthquakes before and after the cluster activity had similar values of stress drop and that structural studies indicated the existence of little fluid in the region, suggesting that the activity was triggered by a different mechanism from the other earthquakes in the same region. The most plausible explanation is that there is a little fluid in a closed system beneath the Tanzawa Mountains which is undetectable by structural observations.

Acknowledgments: We used waveforms at stations of Hi-net (NIED), Hot Spring Research Institute of Kanagawa Prefecture, Univ. of Tokyo, and JMA, as well as the seismograph network called the MeSO-net, which has been developed under the “Special Project for Earthquake Disaster Mitigation in the Tokyo Metropolitan Area” since 2007. We also used arrival times of P and S waves determined by JMA. Figures were created using Genetic Mapping Tool.

Keywords: Tanzawa Mountains, earthquake cluster activity, migration, stress drop, fluid, pore pressure

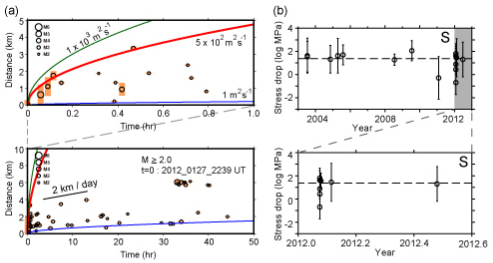

Fig. (a) Hypocentral distances from the first earthquake as a function of elapsed time less than an hour and 50 hours, with scales of source radii. Vertical orange bars indicate source dimensions calculated from estimated stress drops by S waves. Red curve with a diffusivity of 5.0 x 10^{2} m^{2} s^{-1} explains the data better than the other values (green and blue lines) for time < 1 hr. The seismicity for 1 ≤ time ≤ 50 hrs shows a migration with a speed of 2 km a day. (b) Estimated stress drops from S waves as a function of time. Black horizontal broked lines indicate average stress drops of earthquakes that occurred before and after the cluster activity. Results after January 2012 are also shown in the lower panel.