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Relationship between hypocentral distributions and seismic heterogeneous structures inferred from dense array data

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At present, we have not fully understood how earthquakes, especially crustal ones, are generated. However, elucidating generation process of earthquakes is very important for long-term forecasting and disaster reduction. To investigate the generation process of the mainshock and the swarm activity near the source, we conducted a three-dimensional travel time tomography in and around the source region of the 1984 western Nagano Prefecture earthquake, central Japan.

In western Nagano Prefecture, Ooida et al. (1989) pointed out that there was a high seismic activity in the hypocentral region of this earthquake even before the mainshock (at least from May, 1978, when Mt. Ontake erupted) and the activity is still high even now. We can also observe the swarm seismicity in the eastern part of the source region in recent years. In this region, Iio et al. (1999) have been conducting a dense seismic observation with 57 stations separating 1-4 km from each other. We used as much as about 215,096 P-wave and 183,917 S-wave travel time data from this network. The travel time errors were a few ms and a few decade ms for P and S arrival times, respectively.

In the tomographic inversion, we had three stages mentioned below. First, we determined the initial hypocenter locations and origin times with a fixed initial velocity structure. Next, we estimated the one-dimensional velocity profile as well as recalculated hypocenters and station corrections through a one-dimensional inversion. Lastly, we performed a three-dimensional seismic tomography to obtain three-dimensional velocity perturbations together with recalculated hypocenters and station corrections. Considering the errors of the estimated arrival times, horizontal grids were set with the interval of 1.5 km in the central part of the analysis area where many used hypocenters are distributed, and 3 km outside there. Vertical grids were designated with the interval of 1 km above the depth of 4 km and as 2 km below. We used pseudo bending (Um and Thurber, 1987) and LSQR method (Paige and Saunders, 1982) for ray tracing and matrix inversion, respectively.

As a result, we obtained detailed hypocenter distributions and velocity structure at depths of 2-6 km in the mainshock and swarm source regions. Hypocenters in the swarm region are located in the region with low Vp/Vs ratios, while few earthquakes occur in the region with high Vp/Vs ratios. We suggest that the difference in amount of cracks and fluids contained in them controls the seismic activity. The rupture propagation associated with the mainshock is considered to be confined under the ground by a low-velocity region and horizontally by a high Vp/Vs region.