Very fine fault structure of the 2000 western Tottori, Japan, earthquake

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We investigate the faulting process of the Western Tottori earthquake by combining aftershock hypocenters and moment tensor solutions. Aftershock locations were determined by the double difference method using P- and S- phase arrival data from the JMA unified catalog. Moment tensors are estimated by inversion of FREESIA broadband waveforms. The complex aftershock zone contains numerous discrete faults whose orientations agree with their moment tensor solutions. Some of these faults are nearly orthogonal to the mainshock. Source models of the mainshock indicate that it ruptured only the southern half of the aftershock zone. The rapid appearance of aftershocks in the northern part of the zone requires a near instantaneous response to the mainshock stress redistribution.

We investigate the detailed fault structure of the 2000 western Tottori earthquake by relocating aftershocks and by estimating moment tensors of the mainshock and aftershocks. For the relocation we used the P- and S- phase data in the JMA unified hypocenter catalog that will appear in the Seismological and Volcanological Bulletin of Japan. We applied the double difference (DD) algorithm (Waldhauser and Ellsworth, 2000, BSSA). The DD method minimize the difference between the observed and computed traveltime for one earthquake with the same quantity at a nearby neighbor. As a consequence, most of the raypath to the station is common to both sources and errors in the computed traveltimes there by are largely of common mode and cancel in the double difference subtraction. As a result the DD method produces robust locations in the presence of unknown heterogeneous velocity structure. We used stations within 120 km epicentral distance and earthquakes with phase data from at least 8 stations. We analyzed about 40 days of data from October 6 to November 17. The total number of detected earthquakes was about 9200 in the JMA unified catalog and we successfully relocated about 8500 earthquakes. We missed less than 10 M 3-4 earthquakes just after the mainshock because of the insufficient phase readings, however, other missed earthquakes are all less than M 2. Using the relocated hypocenters we modeled the aftershock area as a sum of at least 15 small subfaults, most of which were appear shortly after the mainshock. Aftershocks lie between 5 and 15 km in depth in the mainshock slip region (consists of 3 subfaults) and between 8km and 12 km in other regions. In 15 minutes after the mainshock, aftershock occurred in the mainshock slip region. After one hour, however, the aftershocks expanded to the whole area. We also found that the width of the fault became thick as time passed. This suggests the expansion of aftershocks off the fault. On the other hand, we estimated about 80 moment tensors whose magnitudes are above 3.3. Most mechanisms are strike-slip type and their P- axis directions directed to northwest - southeast, which is consistent to the tectonic loading direction in this region. However, if we look at them closely, we find that there are two main groups of strike direction, N145E and N170E. We recognized that these directions of fault strikes obtained by the moment tensor analysis and those by the relocation are consistent with each other. We also observe faults in the aftershock sequence that are nearly orthogonal to the mainshock fault plane and that have the conjugate sense of motion. Thus this variation in the direction of P- axes and fault planes appears to be due to existing fault structure in this region.