Imaging of the crust by aftershocks of the 2000 Western Tottori prefecture earthquake

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On October 6, 2000, a large earthquake with a JMA magnitude of 7.3 occurred in the western Tottori prefecture of Japan. Although the earthquake is a large intra-island-arc type event, a surface rupture is not clearly observed. The generation mechanism of such an intra-island-arc earthquake is not clarified yet. The heterogeneous crustal structure is one of the key points to understand these earthquakes. To reveal the heterogeneous crustal structure in the fault area of this earthquake, many seismic observations and experiments were carried out.

Aftershock observations were conducted in the source region of the 2000 western Tottori prefecture earthquake. A multi-channel seismic array was deployed along and across the main fault area. The multi-channel seismic array was operated for 85 hours to obtain quasi-continuous records of aftershocks. Two hundred and ninety-six events were recorded by the multi-channel array. To exclude noisy events, we manually checked all the traces of recorded events. We selected 81 events among them as good for analyzing.

The common midpoint (CMP) reflection method is widely used to image heterogeneous crustal structures. The sources and receivers are located at or near by the surface in the CMP method. Since the natural earthquakes are not located on the surface of the earth, we cannot use the usual CMP method. Therefore, we proposed a new method, the natural earthquake reflection profiling (NERP) method, to image the crust using natural earthquakes. By the NERP method, we calculate a common reflection point (CRP) for sources in the subsurface and receivers on the surface to transform original data into zero-offset depth section. This method strongly depends on the hypocentral location and origin time of earthquakes and the background velocity structure. To estimate these parameters accurate enough, the Joint Hypocenter Determination (JHD) method was applied.

We applied the NERP method to the multi-channel seismic data by assuming both PP and SS reflections. Since both PP and SS profiles image the reflectors at the same depth, we can interpret that the reflectors are not ghost reflection images but real reflectors. The results are follows: Above a depth of 5 km, no image is found because of few aftershocks in shallow depth. Between depths of 5 and 9 km are several reflectors. Between depths of 9 and 14 km, the reflectors are not clearly found. Below a depth of 14 km are many clear reflectors.

Between depths of 5 and 9 km the aftershock distribution is diffused three dimensionally. Between depths of 9 and 14 km, however, the aftershocks are concentrated around the fault plane. The area, in which the aftershocks diffused three dimensionally, is reflective, and vice versa.

In the depth range between 5 and 9 km, some less-reflective zones are found. Compared with the aftershock distribution, no aftershocks occurred in these less-reflective zones. A very small slip occurred on the fault plane during the main shock in these less-reflective zones. Compared with recent swarm-like seismic activities in 1989, 1990 and 1997, no earthquake occurred in these less-reflective zones. The P wave velocity in these less-reflective zones is slightly slower than that in the neighbor area. Those characteristics of the less-reflective zones indicate that brittle fracture does not occur in the less-reflective zone but stably slip deformation is dominant there. It is possible that the stably slip areas are distributed in the upper crust, which may contribute the major characteristics of the 2000 western Tottori prefecture earthquakes.