

Seismic images of the source area of the 2004 Chuetsu, Niigata earthquake

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In order to better understand the generating mechanism of the 23 October 2004 Chuetsu earthquake (M 6.8), we adopted 110,352 P- and 75,391 S-wave high-quality arrival times from 5013 earthquakes to determine three-dimensional (3-D) seismic velocity (V_p , V_s) and Poisson's ratio structures in the epicentral area. We used two groups of earthquakes. One group includes 3305 aftershocks shallower than 30 km recorded by the dense High-Sensitivity Seismic Network (Hi-net) between the time 23 October and 5 November 2004. The other group includes 1708 earthquakes (magnitude larger than 2.5; depths shallower than 200 km) recorded by Hi-net and J-Arrey during the period from June 1991 to September 2004. We used both absolute travel times and relative travel times (double-difference) to accurately relocate the hypocenters of the aftershocks, which enable us to determine the seismic velocity (V_p , V_s) and Poisson's ratio structures accurately in the study area. The earthquakes shallower than 200km provide information of the upper mantle, which enable us to investigate the deep structure beneath the mainshock and aftershocks. Anomalies of seismic velocity (V_p , V_s) and Poisson's ratio of up to 6% and 10% are revealed in the aftershock area. The hypocenter of the mainshock is located in a distinct zone where V_p , V_s is high while Poisson's ratio is low. However, a strong low velocity (V_p , V_s) and high Poisson's ratio zone is imaged clearly right under the mainshock hypocenter, which may reflect fluids released from pore fluids and mineral dehydration in the crust or by the dehydration process associated with the subducting Pacific slab. The existed fluids may weaken the mechanic strength and fracture rock matrix of the crust, which may have triggered the Chuetsu earthquake. The mainshock and aftershocks occurred in a fault system that locates along a concentrated deformation zone along the Niigata-Kobe tectonic zone (NKTZ). The seismic velocity (V_p , V_s) and Poisson's ratio change dramatically along this fault system. Most of the ruptures at depth 10-15 km are not located in the low velocity zones but between the low velocity and high velocity zones. The structure images obtained indicate that an obvious boundary of seismic velocity (V_p , V_s) and Poisson's ratio with a depth of 10-15 km exists along the fault from southwest to northeast with a length over 30 km, which is well consistent with the spatial distribution of the ruptures. Our results also show that most of the larger historic intra-plate earthquakes occurred in this area are located in or around the high seismic velocity (V_p , V_s) zones, which is well similar to the epicentral distribution of the larger interplate earthquakes occurred along the upper boundary of the subducting Pacific plate beneath the Pacific Ocean off Northeast Japan.