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Preliminary Results on the Velocity Structure in the Niigata Region, from Regional-scale, Dense Earthquake Observations

Bogdan Enescu[1*], Tetsuya Takeda[1], Kazushige Obara[1], Youichi Asano[1], Ivan Koulakov[2]

[1]NIED, [2]Inst. of Petroleum Geology and Geophys.

The mechanisms that control the occurrence of large intraplate earthquakes are still not well understood. Although physical models to explain their occurrence exist (e.g., Iio et al., 2004), more detailed geophysical observations are necessary to substantiate these models. The dense Global Positioning System (GPS) array developed by the Geographical Survey Institute of Japan (GEONET) has revealed the presence of a high strain rate zone in the central and north-eastern part of Japan (Sagiya et al., 2000). Numerous large intraplate earthquakes have occurred in this broad region, including the recent 2004 mid-Niigata Prefecture (Mw6.6) and the 2007 Niigata Prefecture, Chuetsu offshore (Mw 6.6) earthquakes.

Sato (1994) suggests that in the Niigata region a rift structure, formed as a result of normal faulting when the Sea of Japan opened in the Miocene, is presently reactivated as a reverse fault system by stress field inversion. The tomography results obtained by Kato et al. (2009) revealed the existence of such a structure, beneath a thick sedimentary basin. However, it is still not well understood how the reactivated ancient rift extends spatially since previous studies focused at a more local scale. Moreover, the deeper structure (depth below about 15 km) could not be well resolved.

To have a more detailed understanding of the seismotectonic characteristics in the Niigata region, we have installed a dense temporary network of about 300 seismic stations. The installation was completed in March 2009. This temporary network, with an average spacing between stations of about 10 km, but significantly denser in the aftershock regions of the two large Niigata events (spacing of 3 to 5 km) complements the high-sensitivity seismograph network (Hi-net) of NIED, with a station spacing of about 20 km. We have conducted synthetic tests, using the present temporary and permanent station distribution, to estimate the spatial resolution with which the velocity structure could be resolved in the region. Our results indicate that a resolution of about 10 km is expected from the analysis of real data for a relatively large area and down to a depth of about 20 km. Higher resolutions (of about 5 km) are possible at a more local scale, where the seismic stations are denser.

We have obtained preliminary tomography results using the P- and S-wave arrival times of about 600 events, recorded by both the temporary and permanent stations, occurred from January to May 2009. The software Lotos (Koulakov, 2009) was used for the computations. The horizontal and vertical grid spacing were of 5 km and 3 km, respectively. The starting 1D velocity model is the one used by the Japan Meteorological Agency (JMA). While the number of data is still small for in-depth results, our preliminary findings identify the thick sedimentary layer of the Chuetsu basin and its rough spatial extension. A horizontal cross-section at a depth of 10 km shows a pronounced low-velocity perturbation, located between the source areas of the two Chuetsu earthquakes, and extending from SW to NE. It agrees well with the low-velocity structure identified by Kato et al. (2009), interpreted by the authors as thick sediments filling a deep trough

structure. Compared with the previous results, we can trace the extension of the trough further to the north-east, due to a good spatial resolution.

Keywords: The High Strain Rate Zone of Japan, Niigata region, velocity structure, seismotectonics