Elastic and Inelastic behavior in the Mid-Niigata area as observed by a dense GNSS network through the preseismic, coseismic and postseismic deformation of the 2011 Tohoku-oki earthquake

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The Niigata-Kobe Tectonic Zone (NKTZ) had been identified as a deformation zone in Central Japan, where localized geodetic E-W contraction (10^{-7}/yr, Sagiya et al. 2000), one order of magnitude larger than the geological strain rate in the area (10^{-8} /yr, e.g. Wesnousky et al., 1982) is observed. Origin of such discrepancy had been the subject of much debate. By comparing the mechanical responses of NKTZ to enforced deformation before and after the 2011 Mw 9.0 Tohoku-oki earthquake, Meneses-Gutierrez and Sagiya (2016) identified inelastic deformation in northern NKTZ, proving significance of inelastic processes in crustal deformation of inland Japan, and providing a solution to the long-lasting controversy between geodetic and geological strain rates in the area. However, detailed strain distribution and their mechanical characteristics were not fully resolved with the available dataset at this stage.

In 2010, the Association for the Development of Earthquake Prediction (ADEP), in collaboration with Nagoya University, constructed 20 continuous GPS sites in the Mid-Niigata area, for the purpose of monitoring crustal activity around the Western Nagaoka Basin fault, one of major active faults in this area where disastrous earthquakes, such as the 2004 Chuetsu (Mw 6.6) and the 2007 Chuetsu-oki (Mw 6.6) earthquakes, have occurred recently. Analysis of this network with GEONET allows a better description of the crustal deformation in the Mid-Niigata area.

We evaluate the response of Mid-Niigata during the preseismic, coseismic and postseismic periods of the 2011 Mw9.0 Tohoku-oki earthquake by analyzing strain distributions based on the dense GPS network available. Wavelength decomposition of the strain distributions showed that while localized extension was observed during the coseismic period related to the presence of a weak sedimentary layer in the area, localized contraction in the preseismic and the postseismic periods was found. Differences in the amplitude and horizontal location of such localized deformation suggested that in addition to a persistent inelastic process, elastic heterogeneities within the crust might be embedded in the geodetic data in the preseismic and postseismic period as well. We modeled deformation in the Mid-Niigata region considering contributions from both elastic and inelastic sources. Our model showed that both elastic and inelastic sources are necessary to explain crustal deformation in Mid-Niigata. We also found evidence of mechanically vertical decoupling between the weak sedimentary layer and the basement rock. Our results imply that the preseismic and postseismic strain rate patterns represent direct effects of the shallow portion of the crust in Mid-Niigata area.

Keywords: Global Positioning System, The Niigata-Kobe Tectonic Zone, Inelastic deformation, The 2011 Tohoku-oki earthquake, Mechanical response of the crust

