Geodetic exploration of the elastic/inelastic behavior of the Earth’s crust: resolution of mechanical response using interseismic, coseismic, and postseismic deformation

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In order to understand dynamic behavior of the Earth’s crust associated with tectonic plate motions, it is indispensable to understand how the crust mechanically respond to applied stresses. It has been well accepted that the Earth’s crust behaves in an elastic manner. But this classical concept has been established based on laboratory rock experiments, propagation of seismic waves, and coseismic deformation, all of which represent a mechanical response to a rapid or instantaneous perturbation. Recently, Meneses-Gutierrez and Sagiya (2016) identified localized inelastic deformation in the Niigata region through a comparison of interseismic and postseismic crustal deformation associated with the 2011 Tohoku-oki earthquake. It should be noted that both interseismic and postseismic patterns reflect cumulative deformation processes, in contrast to the rapid or instantaneous changes that have been used to study elastic response of the crust. The exploration of mechanical behavior of the crust with interseismic and/or postseismic deformation can reveal unknown aspects of the mechanical processes such as inelastic deformation in the Earth’s crust. It is of great importance to understand inelastic deformation processes in the Earth’s crust. Inelastic deformation accumulate elastic strain/stress in the surrounding medium. Inelastic deformation is driven by the absolute stress, not by stress changes. In spite of various implications derived from studies of inelastic deformation, such study has been very difficult since the crust is usually being deformed in the same direction. Under such condition, it is very difficult to distinguish inelastic deformation and elastic heterogeneity effect. Steady crustal movements in an opposite direction from its normal state can be observed only during the postseismic transients. In addition, the area must have a dense enough coverage of precise geodetic observation such as GNSS. Thus the 2011 Tohoku-oki earthquake has provided a precious chance to study inelastic deformation in northeast Japan. We discuss implications and limitations of inelastic deformation analysis associated with the Tohoku-oki earthquake.

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