On spatio-temporal variation of seismic velocity change associated with large earthquakes

*Kaoru Sawazaki[1]

1.National Research Institute for Earth Science and Disaster Prevention

Seismic velocity of the Earth’s subsurface varies not only with nonstationary phenomena such as earthquakes and volcanic activities, but also with stationary phenomena such as groundwater movement and plate motion. Seismic interferometry is an effective technique that can detect subtle velocity changes caused by these geophysical phenomena, and has been widely applied to dense continuous seismograph networks like Hi-net and F-net that have been prepared in recent decades. The studies so far have revealed that the velocity reduction up to a few percent is commonly observed after large earthquakes, and the velocity recovery continuing over a few months follows after that. The main causes of the velocity reduction due to large earthquakes are considered to be the fracturing of fault zone, the static strain change due to coseismic deformation, and the damage in the shallow ground due to strong ground motion. In the early studies, the observed velocity change had often been interpreted as change of the frictional strength on the fault plane. Recently, however, studies which relate the change to strong ground motion and the damage in the shallow ground are increasing in combination with similar phenomena such as nonlinear ground response and liquefaction. On the other hand, some studies reported velocity reduction associated with slow-slip, postseismic deformation, and earthquake swarm, which are not accompany with strong ground motion. Thus discussions on the main cause of the velocity change are still continuing. In this presentation, I introduce recent studies on the spatio-temporal distribution of seismic velocity change, and discuss on causes of the velocity change due to large earthquakes. On the spatial distribution, I introduce an example that effectively used sensitivity of seismic wavefield to detect velocity changes at different depths, and interpreted the observed depth-dependence by the weighted sum of the contributions of crustal deformation and strong ground motion. On the temporal scale of the velocity recovery, I discuss on the observed recovery process in relation to “slow dynamics”, the log-linear recovery behavior recognized in rock experiments, and to the time-constant of postseismic deformation and groundwater diffusion processes. Because the temporal change is usually observed as combination of background changes and nonstationary changes, I also examine such cases that include multiple time-varying factors.

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