Contribution of poroelastic rebound to postseismic deformations with special reference to the Western Tottori earthquake

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Introduction

Postseismic deformations following large earthquakes are considered to be caused by the following mechanisms:
(1) stress relaxation due to the viscoelasticity in crust and upper mantle,
(2) afterslip on the source fault and surrounding regions,
(3) coseismic deformation from aftershocks.

Recently, postseismic deformations unexplainable by the above mechanisms were detected by InSAR and GPS observations after the Landers earthquakes and etc. The poroelastic rebound model in which deformation is modeled as the rebound of crust due to coseismic increase of pore pressure and its change due to flow of water is proposed for these postseismic deformations. Here we discuss the contribution of poroelastic rebound to postseismic deformations following the western Tottori earthquake and others.

Poroelastic Rebound Model

Poroelastic rebound model assumes that postseismic deformations are caused by the diffusion of pore pressure change due to the flow of pore fluid. At the coseismic stage, both pore fluid and rock may respond simultaneously. Due to the imcompressiblity of water, Poisson's ratio may be high at this stage (undrained condition). Since pore fluid diffuses as time passes by, only rock may respond to any stress and Poisson's ratio becomes low (drained condition). Difference between responses at these stages can be regarded as postseismic deformation.

In case of strike-slip type earthquake, postseismic deformations are qualitatively similar to coseismic one for the afterslip model. Postseismic uplift (subsidence) is expected in the coseismically uplift (subsided) regions. On the other hand, poroelastic rebound model predicts subsidence in the coseismically uplift region where pore pressure coseismically increases and decreases at the postseismic stage. Thus we can qualitatively distinguish the plausible mechanism by checking vertical deformation.

In this work, I use 0.31 and 0.27 for undrained and drained Poisson's ratio, respectively, referring to Rice and Cleary (1976), and calculate postseismic deformations.

Application to postseismic deformations following the western Tottori earthquake and etc

Left lateral deformations up to 2cm were detected by JUNCO and GSI at the postseismic stage. Large scatter in vertical components, especially in JUNCO's data, has prevented us from modeling of postseismic deformations. However we try to examine vertical deformations incorporating meteorological data in Yonago. Practically, we compare daily temperature, pressure and humidity with time series of vertical component of several sites. We find large shift of vertical component according to high humidity. Therefore we simply discard the data of the day with higher humidity than 80%. Of course, further examination must be made in the future since there are correlations between vertical deformation and other meteorological data.

Since there are still large scatters, it is hard to detect vertical deformations precisely. However, we can recognize possible uplift at Akaya which is located on the NW side of the source fault and subsidence at Kurosaka and Nichinan of GSI on the SW side. Yonago and Mizokuchi of GSI show subsidence in winter and recovery in spring.

We adopt Sagiya et al's(2002) one fault and multi segment fault models for coseismic fault model. Both models can explain left lateral pattern of postseismic displacements. However, it is hard to predict complicated pattern of observed displacements near the source fault. Some sites located relatively far from the source fault cannot be quantitatively explained, neither. Poroelastic rebound model predicts uplift and subsidence on the NW/SE and NE/SW sides, respectively, of the source fault, which might be qualitatively consistent with the observation, although we need further examination of fault model and observed vertical deformations.