Possibility that the 2007 Chuetsu-oki Earthquake was induced by the 2007 Chuetsu Earthquake

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The 2007 Chuetsu-oki Earthquake (M6.8) occurred only forty kilometers away from the 2004 Chuetsu Earthquake (M6.8). We are aiming physical-model-based forecasts of large earthquakes, and hope to clarify the relation between the occurrences of these earthquakes if any.

The changes in the Coulomb failure function, DCFF, took negative values around the faults of the Chuetsu-oki earthquake (e.g., Headquarters for earthquake research promotion, 2007). It should be noted, however, that a homogeneous half-infinite elastic medium is usually used for the calculation of DCFF, altough these earthquakes were happened in the region that has thick sediments and high temperature gradients. Therefore, we examined whether DCFF still takes negative values or not when visco-elastic, inhomogeneous medium is used for the calculation of DCFF.

We used a three-layered model of an upper crust, a lower crust and an upper mantle. The depths of the boundaries were assumed to be constants 15 and 30 km in one case, and to be smoothly varying according to Zhao et al. (1992) in the other case. The upper crust was assumed elastic, while the deeper layers were assumed viscoelastic. The viscosity coefficients were set to 10**18 or 10**19Pas for both layers in one case, and set to have different values, 10**18 and 10**19, or, 10**19 and 10**20 Pas, for the lower crust and the upper mantle in other case. The elastic constants, P- and S-wave velocities and densities were assumed to be uniform in the whole medium in the first case, to have representative values within each layer in the second case, and spatially varying according to the tomography data of Matsubara et al. (2008) in the third case.

A rectangular fault plane with a size of 25 x 10 km was embedded as the Chuetsu Earthquake after Kato et al. (2006). We calculated the stress field by giving uniform slip of three meters on the fault plane, with a finite element method, using a free software Pylith (Aagaad et al., 2007).

To give the geometry of the receiver fault, we adopted the northern west-dipping segment of the Chuetsu-oki Earthquake after the analysis results and interpretation by Kato et al. (2008). The friction coefficient was set to 0.8. Some calculation results ware validated by an analytical solution of Fukahata and Matsu"ura (2006).

We found that the DCFF can change the sign into positive in and around the region of Chuetsu-oki Earthquake by several years after the Chuetsu Earthquake in many cases where the viscosity coefficient was 10**18Pas in the lower crust. Even the simplest horizontally-layered model, where the elastic constants were set to be uniform in whole medium and the viscosity coefficient to 10**18Pas both for the lower crust and upper mantle, shows the tendency where the sign of DCFF can change near the upper margin of the fault plane by five years.

When we use slightly more complex model, where only the viscosity coefficient in the upper mantle was changed to 10**19Pas, the sign of the DCFF changed into positive within the regions containing the whole fault plane of the Chuetsu-oki Earthquake by five years. The sign of DCFF changed by four years when we changed the shape of the boundary from horizontal one into spatially varying one of Zhao et al. (1992). Further, the sign of DCFF changed by two years when the velocity structure of Matsubara et al. (2008) was used.

Theoretical horizontal displacements at the ground surface that had been calculated using the above models were compared to the observed ones reported by the Geographical Survey Institute. The directionality of the theoretical and observed horizontal displacements matches well and the fit of the amplitudes falls within a range of an order.

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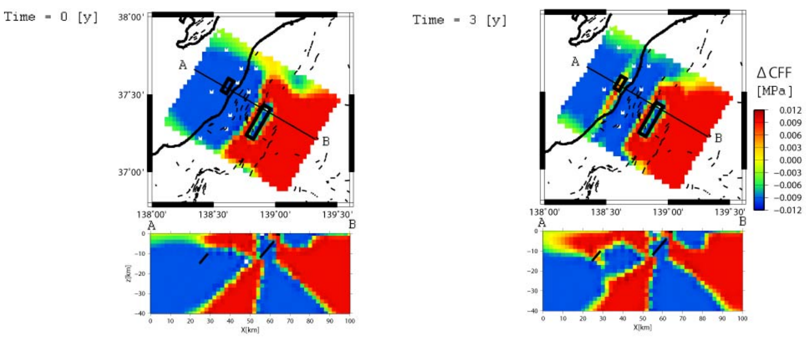

弾性定数は均一、粘性係数は下部地殻とマントルでそれぞれ10**18,10**19とし、層境界深度をZhao et al. (1992)に従って与えた構造モデルを用いた場合のΔCFFの計算結果。上段は深さ14kmの断面、下段は地図中のABに沿う鉛直断面。各地図の北西側、南東側の矩形はそれぞれ中越沖地震、中越地震の断層面を表す。左、右はそれぞれ中越地直後と3年後に対応する。