SCG65-01 Room:201A Time:May 19 11:00-11:15

Relation between stress field around active fault and fault activity

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In order to evaluate potential of fault activity, it is important to estimate effect of stress acting on active faults. We analyzed 'slip-tendency' that defined as the ratio of shear stress to normal stress acting on the surface of fault plane (Morris et al., 1996). The stress field is obtained based on the focal mechanisms data in intra-plate region, central Japan, estimated by Yukutake et al., (2012). Applying the stress inversion method (Hardebeck and Michael, 2006) to the focal mechanisms data, we estimated the stress state around active faults. Parameters about the position, strike and dip angle of active faults are taken from 'Active fault database of Japan' by The National Institute of Advanced Industrial Science and Technology (http://riodb02.ibase.aist.go.jp/activefault/). We found that most of active faults with large average slip rate (more than or equal to 1m/year) are likely to have large slip-tendency.

Keywords: Stress field, Active fault, Slip tendency

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SCG65-02 Room:201A Time:May 19 11:15-11:30

Determination of effective friction coefficient by optimizing slip tendencies on fault plane orientation distribution

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Friction coefficient (mu) on fault is one of the most crucial parameters to evaluate the risk of faulting and to modeling tectonic phenomena. It is difficult to estimate the coefficient especially of underground faults and of ancient geological faults. This paper proposes a stochastic method to determine the effective friction coefficient from a distribution of fault surface orientations.

The geological faults and observed seismicities are definite proofs of (ancient) slippage. They are expected to provide information on frictional properties in the earth's crust. Stress tensor inversion techniques applied to such meso-scale faults and seismic focal mechanisms usually determine a reduced stress tensor composed of three principal stress orientations and a stress ratio. Angelier (1989) tried to determine all six independent components of stress tensor including magnitudes of principal stresses, assuming that the normal stress (Sn) and shear stress (Ss) on observed fault surfaces satisfies Ss/Sn >= mu. In his analysis, the friction coefficient can be determined graphically on Mohr's diagram, although there remains an ambiguity to recognize the straight line Ss/Sn = mu that bounds the distribution of points showing stresses on faults. The purpose of this study is to remove this ambiguity during the determination of friction coefficient.

The new method proposed by this study utilizes the slip tendency (Morris et al., 1996), which was introduced to quantify the tendencies of reactivations of faults in fractured rock masses. This parameter is strongly related to the friction coefficient since it is defined as the simple ratio between normal and shear stresses (Ss/Sn) on a fault surface. Slip tendency calculation has been applied to both geological faults and present seismicities (e.g., Collettini and Trippetta, 2007; McFarland et al., 2012), and it was confirmed that the natural frequency of fault orientations appears to obey the slip tendency (Lisle and Srivastava, 2004). This study presumes that the frequency of fault orientations is a monotonously-decreasing function of the reciprocal of slip tendency (Sn/Ss). Then we can compose an inversion method for fitting the shape of the function to observed distribution of fault orientations. If the optimized frequency distribution function has a sudden decrease to zero at a certain value of slip tendency, the value can be interpreted as the desired friction coefficient. Note that what can be determined is an effective friction coefficient under the influence of pore fluid pressure.

The new method was applied to 122 meso-scale fault-slip data gathered from the Pleistocene Kazusa Group, eastern Boso peninsula. N-S striking normal faults dominate the data set, and a single-phase E-W tensional stress was detected by a stress inversion analysis. As the result, the internal friction coefficient was determined to be 0.45 +0.34/-0.09. The precision estimated by bootstrap analysis was large because the shape of the optimized frequency distribution function was unfortunately convex. The friction coefficient around 0.45 is slightly small but appears to be reasonable for a young sedimentary rock.

References
Angelier, J., 1989, Jour. Struct. Geol., 11, 37-50.
Collettini, C. and Trippetta, F. 2007, Earth Planet. Sci. Lett., 255, 402-413.
McFarland, J.M., Morris, A.P., Ferrill, D.A., 2012, Comp. Geosci., 41, 40-46.
Morris, A., Ferrill, D.A. and Henderson, D.B., 1996, Geology, 24, 275-278.
Lisle, R.J. and Srivastava, D.C., 2004, Geology, 32, 569-572.

Keywords: stress tensor inversion, effective friction coefficient, slip tendency, orientation distribution, fault-slip analysis

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SCG65-03 Room:201A Time:May 19 11:30-11:45

Crustal stress field formed by plate convergence and topography in northeastern Japan

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We estimated the crustal stress field in northeastern Japan prior to the 2011 Mw9.0 Tohoku-Oki earthquake based on earthquake focal mechanisms determined using seismograms from temporary and permanent seismic networks deployed in this area. Results show that the arc and back-arc are characterized by spatially uniform margin normal compression. However, the fore-arc has different stress orientations. The Kitakami and Abukuma mountain ranges in the north and south have s1 axis oriented nearly N-S and vertical, respectively, and the region in between without mountain range has a similar stress field to the arc and back-arc. This indicates that the margin normal compression in the arc and back-arc is not caused mainly by the coupling with the Pacific plate but perhaps by the convergence of the Eurasia plate from the back-arc side. Anomalous stress fields in the mountain ranges of the fore-arc are probably due to gravitational force.

Spatially homogeneous margin normal compression is observed throughout the arc and back-arc as already mentioned, but the stress field even in those regions might also be influenced by the topography. Using the distribution of the generalized stress ratio (Simpson, 1997), we found a clear spatial correlation between strike-slip fault stress regime (i.e. higher sv) and high mountain ranges in those regions, which again suggests that the prevailing stress field has been influenced by topographic loading, though the s1 orientation is constant.

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SCG65-04 Room:201A Time:May 19 11:45-12:00

Temporal stress change around the Iwaki-city in northeast Japan before the 2011 Tohoku earthquake

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We present the temporal heterogeneities of the crustal stress before the 2011 Tohoku earthquake around the Iwaki-city using the small magnitude earthquakes. Otsubo et al. (2008; Tectonophysics, 457, 150-160) proposed a stress tensor inversion method to separate stresses from earthquake focal mechanism data from spatially and temporary varying state of stress. The method is applied to focal mechanisms of the earthquakes collected by Imanishi et al. (2012; Geophys. Res. Lett., 39, L09306).

The inversion method revealed two normal-faulting stress states, corresponding to two stress periods and the transition between the two stress periods corresponds to the period between 2005 and 2008. In the stress period I from 2003 to 2005, a WNW-ESE trending tri-axial extensional stress is dominant. The stress ratio increases from the stress periods I (Phi = 0.5) to II (Phi = 0.8) in this area. The temporal changes of S3-axis orientation and stress ratio of stress state had induced by the event that occurred during 2005 and 2008. We interpret that the changes of the stress period from I to II are induced by the extension during the post-seismic deformation of the M 7-class earthquake. We estimate the magnitude of the change of differential stress from the Stress B to A. The differential stress of the Stress A is estimated at ~3 times as large as at the differential stress of the Stress B under these assumptions.

We revealed that the pre-shock normal-faulting stress regime had been built up by 2003, furthermore the differential stress of the pre-shock normal-faulting stress was increased by the post-seismic deformations of the M 7-class earthquake before the 2011 Tohoku earthquake. The increase of the differential stress has contributed to the stress accumulation that can be sufficient to cause an inland earthquake by amount of stress change of the 2011 Tohoku earthquake around the Iwaki-city.

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Keywords: multiple inverse method, focal mechanism, large trench type earthquake, post-seismic deformations, active fault, 2011 Iwaki earthquake

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SCG65-05 Room:201A Time:May 19 12:00-12:15

Stress drops of induced earthquakes associated with the 2011 Tohoku-oki earthquake

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After the occurrence of the 2011 Mw 9.0 Off the Pacific Coast of Tohoku Earthquake (Tohoku-oki earthquake), induced earthquakes are actively occurring at several inland areas, including Fukushima Hamadori region and the middle part of the Akita prefecture. Focal mechanisms of these induced earthquakes are inconsistent with the present-day stress field in overall northeast Japan that is characterized by a reverse-faulting regime with E-W compression. One possible mechanism is that the stress field in those areas abruptly changed from horizontal compression to extension because trench-normal compressive stress within the overlying plate was reduced after the Tohoku-oki earthquake (Kato et al., 2011; Yoshida et al., 2011). If so, the differential stress magnitudes in those areas before the Tohoku-oki earthquake should be smaller than the static stress changes associated with the Tohoku-oki earthquake (1 MPa or less). Moreover, it is expected that stress drops of these induced earthquakes is less than 1 MPa. In this study, we determined stress drops of these induced earthquakes by using the Multi-Window Spectral Ratio method (Imanishi & Ellsworth, 2006). The estimated stress drop values are approximately 10 MPa, which is inconsistent with the hypothesis of a drastic change in stress state. The present result rather favors the conclusion of Imanishi et al. (2012) that the Tohoku-oki earthquake could trigger those earthquakes in a limited area combined with a locally formed pre-shock stress regime that is different from a reverse-faulting one with E-W compression. Terakawa et al. (2013) indicate that the increase in fault-confined fluid pressure would have played a critical rule in the occurrence of these induced earthquakes. This mechanism and the combination with the locally formed pre-shock stress heterogeneity are also enabled if the fault strength was still in excess of approximately 10 MPa (the stress drops of induced earthquakes).

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Keywords: induced earthquake, the 2011 Mw 9.0 Off the Pacific Coast of Tohoku Earthquake, stress drop, stress field, MWSR method