Relation Between Clustering Seismic Activity and Earth Tidal Stress in the Western Shizuoka Prefecture

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Introduction

Swarm like activity was observed in the western Shizuoka prefecture from November 2007 through February 2008 and the activity at a lower level continues until now. This seismicity has the characteristic feature that there are periods when the intensive activity appears periodically. Miyaoka and Kamigaichi (2008) investigated this periodicity in detail and found that the Coulomb stress change on the fault caused by the Earth tide (tidal stress in short here) is closely related to the intensive earthquake occurrence. They also pointed out the phase selectivity, that is, the period the stressing rate is large has good correspondence to the period seismicity is high. On the other hand, there is a physical model (R-S model) that relates the Coulomb stress change with the seismicity rate change based on the rate- and state-dependent friction law (Dieterich, 1994). In this study we try to explain the phase selectivity between the tidal stress and observed seismicity on the basis of the R-S model.

Data and Method

We use the unified JAM hypocenter catalog and selected earthquakes with M larger than or equal to 0.5 from November 2007 through January 2008. The epicenters of the target activity lie on the line of about 3km in length and trending NW-SE direction, and the hypocenters are distributed on an almost vertical plane at depth of 16-18km. The mechanism solution for the largest event (M4.2) represents a good agreement with the hypocenter distribution, so that we suppose every events occur on a left-lateral pure strike slip fault trending N30W. In order to estimate the Coulomb failure stress caused by the Earth tide precisely, we take not only solid Earth tide but also oceanic tide into account using the software Gotic2 (Matsumoto et al., 2001 with modification by Kamigaichi). We assume the value of modified friction coefficient myu' as 0.3 which is necessary for calculating modified Coulomb stress. The reference stressing rate, which is one of the model parameters for the R-S model, is estimated from the observed strain rate (1.2∗10ˆ-7/year) obtained by GPS network data and the assumed rigidity value (30GPa), which results in the value of 1∗10ˆ-5 MPa/day. The parameter value of the reference seismicity rate is set 0.1/day by considering the background seismicity. Another model parameter As, which is the product of friction parameter A and normal stress s, is an unknown parameter that should be determined by fitting the R-S model to the observed seismicity characterized by the phase selectivity described above.

Results and Discussion

As for a periodic loading, the R-S model generally presents the following parameter dependency about the phase difference between stress rate change and seismicity rate change: the phase delay of seismicity rate change from stress rate change becomes smaller when the As becomes smaller, the time cycle becomes longer, or the background stressing rate becomes larger. Therefore, the small phase delay between observed seismicity and theoretical tidal stress suggests the As should be a small value. However, the trial and error procedure to estimate the appropriate value for As reveals that the small As is not enough to explain the small phase delay and additional large background stressing rate is inevitable. Using a trial and error procedure, we estimate the As and background stressing rate as 0.1-1 kPa and 1-10kPa/day, respectively. The estimated value for As is smaller than those of previous studies by the order of one to two. However, Nakata et al. (2008) recently reported that the periodic non-volcanic tremor resulting from the combined effect of the Earth tides and slow slip events can be explained by the R-S model with a small As value (1.3kPa). As the fluid plays an important role to explain a small As, the periodic swarm like activity reported in this study may suggest the fluid intrusion into the studied area.