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A quantitative expression for the local slip model of seismic quiescence

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In ASC meeting of 2008, I have presented a result of comparison of various theories about the physical background of seismic quiescence. To generate unstable sliding which leads to a large earthquake, reduction of the contact area between fault surfaces is necessary. Considering this necessary condition and reproducibility of the phenomenon, I have concluded that the model of ' local slip' is convinced to be a principal mechanism, in which aseismic local slip slowly grows in the circumstances of asperity between fault surfaces and seismic activity is reduced by local release of shear stress (Wyss et al,1981).
Yoshikawa(2008) reported that quiescence can be recognized in at least 8 cases among 10 events (0.80 in ratio) for the interplate repeated earthquakes in the pacific side of Hokkaido - Tohoku Japan, with the magnitude 7.0 and larger since 1948 in JMA catalog. And he has pointed that there is a scaling relationship of the quiescence period (Tq) and region(Lq) with the magnitudes of the earthquakes in the above 8 cases. If the relationship is generally true, it is necessary for the physical model of seismic quiescence to explain the reason of the scaling relationship at the same time. On the other hand, another model of 'frictional restriction' is applicable to the case of the 198 3 Japan Sea Earthquake(M7.7), in which seismic activity is considered to become quiet as a result that sliding is restricted by increase of frictional force acting on a fault plane in a wide area. However, since there are no sclale factors which constrain the fault size, the model of the ' frictional restriction' cannot explain the scaling relationship.
We propose here a quantitative explanation for the 'local slip' model. As for appearance of the local slip, it is natural to consider it as a process appearing on the way to reach macroscopic faulting from local stable sliding. As the normal stress and shear stress (or rate) is decreased by local slip in some low strength portion, seismic quiescence is observed. This process is described by the slip dependent constitutive law (Ohnaka, 1992). The growth (X) of local slipping is supposed to be characterized by the critical length of the nucleation (Lc). While X is shorter than Lc the stable slipping continues, acceleration of the slipping starts as the growth exceeds the critical length(Lc). As for the critical length (Lc), it is closely related with the roughness of the fault plane (Rc), represented by a linear relationship between them (Ohnaka&Shen,1999). The critical length (Lc) and the fault size (S) are related through seismic moment (Mo). That is, Mo=a (Lc)**3=GDS, (a:a constant, G:rigidity, D:total slippage along fault) (Ohnaka,2000). And the seismic moment can be written as Mo=GDWL, (W:a fault width to be supposed constant). It is important here that a scaling relationship holds among Lc, Rc and L.
We assume that the local slipping length (Lq) is controlled by the roughness of the fault plane (Rc). Since the roughnes (Rc) can be related to the fault length (L), we can suppose between the fault length (L) and the slipping length (Lq) as Lq=b*L . Then clearly 'b' will be larger than 0 and smaller than 1. When 'b' equals to zero, the quiescence will not occur. 'b' generally will not take a same value for different faults. However, it is not natural to consider that there is a large difference between the repeating earthquakes. In those cases as in the pacific side of Hokkaido - Tohoku Japan, as mentioned above, 'b' will become a not so small and be keeping a nearly constant value. Then the period of the quiescence (Tq) can be obtained by considering the repeating period (T), as Tq=(Lq/L)T.

Keywords: seismic activity, quiescence, physical model, constitutive law