Geological observations supporting a slip model that stress drop varies with characteristic rupture length

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There are two slip models for slow earthquakes proposed by Ide et al (2007). One is constant stress drop model in which displacement is proportional to rupture area. This model is common for regular earthquakes. The other is diffusional earthquake model with constant displacement. For slow earthquakes, however, both two models can be adoptable because the average slip amounts of smaller events are unknown.
In this study, two geological observations are introduced to discuss how the observations support the diffusional earthquake model.
One is from a relationship between heat generation rate and slip duration estimated from decreasing pattern of vitrinite reflectance with distance from a micro-fault observed in the Shimanto Belt, an exhumed accretionary complex, SW Japan. The micro-fault has shear zones with thickness of up to 3.7 mm. Magnitude of vitrinite reflectance decays with distance from the fault. The distance which vitrinite reflectance attenuates to background level is about 4-10 cm. On the basis of the decreasing pattern, we estimated 2300-8600 $J/m^2/s$ of heat generation rate and 10000-98000 s of slip duration. The relationship between heat generation rate and slip duration from natural faults follows the scaling relationship for slow earthquakes with -1 of scale exponent.
The other is from roughness analyses on surfaces of natural faults, which shows the Hurst exponent is less than 1 in the relationship between power spectrum density and wave number. An example from the micro-faults in the cores from Taiwan Chelung-pu fault Drilling Project (TCDP). The roughness of surfaces of micro-fault was analyzed by 3D topographic micro-analyzer. The Hurst exponent is about 0.7-0.76. This kind of Hurst exponent has been reported for the natural fault normally ranging on 0.6-0.8. So the result from TCDP case is also consistent with the results from previous studies. Assuming the elastic shear deformation, the Hurst exponent less than 1 indicates that the stress drop is not constant but negatively proportional to fault length.
These two examples support the diffusional earthquake model is suitable for slow earthquakes. The -1 of scale exponent between thermal generation rate and slip duration can be achieved when displacement is constant. The thermal generation rate $Q = \mu' * P_{eff} * D/T$ (μ': effective friction coefficient, P_{eff}: effective vertical stress, D: displacement and T is slip duration) is proportional to T^{1}, indicating that the D is constant because μ' and P_{eff} can be constant.
The Hurst exponent less than 1 indicates that stress drop is negatively proportional to fault length as described above when elastic frictional shear was assumed. Because stress drop is expressed as $dS = \mu D/L$ (μ: rigidity, L: dimension of fault plane), when D is constant, stress drop is not constant but negatively proportional to L.
In conclusion, these geological observations support the diffusional earthquake model expected in mechanisms for slow earthquakes, which can not be adopt to the regular earthquake.

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