Geophysical Research Abstracts
Vol. 18, EGU2016-18112, 2016
EGU General Assembly 2016

The numerical simulation study of the dynamic evolutionary processes in an earthquake cycle on the Longmen Shan Fault

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The Longmen Shan, located in the conjunction of the eastern margin the Tibet plateau and Sichuan basin, is a typical area for studying the deformation pattern of the Tibet plateau. Following the 2008 Mw 7.9 Wenchuan earthquake (WE) rupturing the Longmen Shan Fault (LSF), a great deal of observations and studies on geology, geophysics, and geodesy have been carried out for this region, with results published successively in recent years. Using the 2D viscoelastic finite element model, introducing the rate-state friction law to the fault, this thesis makes modeling of the earthquake recurrence process and the dynamic evolutionary processes in an earthquake cycle of 10 thousand years. By analyzing the displacement, velocity, stresses, strain energy and strain energy increment fields, this work obtains the following conclusions: (1) The maximum coseismic displacement on the fault is on the surface, and the damage on the hanging wall is much more serious than that on the foot wall of the fault. If the detachment layer is absent, the coseismic displacement would be smaller and the relative displacement between the hanging wall and foot wall would also be smaller. (2) In every stage of the earthquake cycle, the velocities (especially the vertical velocities) on the hanging wall of the fault are larger than that on the food wall, and the values and the distribution patterns of the velocity fields are similar. While in the locking stage prior to the earthquake, the velocities in crust and the relative velocities between hanging wall and foot wall decrease. For the model without the detachment layer, the velocities in crust in the post-seismic stage is much larger than those in other stages. (3) The maximum principle stress and the maximum shear stress concentrate around the joint of the fault and detachment layer, therefore the earthquake would nucleate and start here. (4) The strain density distribution patterns in stages of the earthquake cycle are similar. There are two concentration areas in the model, one is located in the mid and upper crust on the hanging wall where the strain energy could be released by permanent deformation like folding, and the other lies in the deep part of the fault where the strain energy could be released by earthquakes. (5) The whole earthquake dynamic process could be clearly reflected by the evolutions of the strain energy increments on the stages of the earthquake cycle. In the inter-seismic period, the strain energy accumulates relatively slowly; prior to the earthquake, the fault is locking and the strain energy accumulates fast, and some of the strain energy is released on the upper crust on the hanging wall of the fault. In coseismic stage, the strain energy is released fast along the fault. In the poseismic stage, the slow accumulation process of strain recovers rapidly as that in the inerseismic period in around one hundred years. The simulation study in this thesis would help better understand the earthquake dynamic process.