Coseismic Rupture along the Double-layered Dipping Fault of the 2008 Wenchuan Earthquake

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The southwestern part of the 2008 Wenchuan earthquake fault consists of double-layered dipping faults with a joint vertical left-lateral fault perpendicular to the dipping faults from the investigation of surface fault scarps. We investigated how these coseismic fault slips were created along such complicated fault geometry based on kinematic and dynamic rupture modeling.

We first constructed a fault model based on the surface fault traces and InSAR fault models. It consists of three planar faults, F1 (SW Beichuan Fault), F2 (Xiaoyudon Fault) and F3 (Pengguan Fault +NE Beichuan Fault). Strike dip and rake angles, length, width and the location of upper western corner are as follows: F1: (N223E, 50, 135), (130km, 45km), and (30.82N, 103.28E). F2: (N131E, 90, -28), (10km 19km), and (31.23N, 103.72E). F3: (N222E, 37, 90), (206km, 35km), (31.01N and 103.28E). It should be noted that we only focus on the southwestern part of the fault in the present study, so that northeastern fault segments are omitted in this modeling.

Based on the above fault model, we computed near-fault ground motions assuming the hypocenter location of (31.061N, 103.333E, 17.3km) using the discrete wavenumber simulation code (AXITRA). Because we are interested in the rupture evolution on the fault system, we assumed a static slip distribution estimated by InSAR analysis and try to investigate the rupture propagation pattern by a trial and error way.

From the kinematic rupture modeling using two near-fault accelerograms observed at Wolong (WCWL) and Bajiao (SFBJ) stations, we found that the rupture initiated on F1 and propagated until the joint of F2, then it simultaneously along both dipping faults (F1 and F3) triggered by F2. During the transition of the rupture from F1 and F3, the rupture on both F1 and F3 delayed about 6 seconds. The average rupture velocity was 2.2 km/s.

To explain the above complicated rupture history, we constructed a spontaneous rupture model. We assume a uniform tri-axial stress field with the maximum principal stress (compression is taken positive) directing to N350E. We found that different coefficient of friction is required between F1 and F3 to make rupture transfer at the joint of F2. Then, we could obtain qualitatively consistent spontaneous rupture model. In this model the delay of the rupture is achieved by the interactions between F1 and F2 and F2 and F3.

From the kinematic - dynamic rupture modeling of the 2008 Wenchuan earthquake, we found that the two parallel dipping faults ruptured simultaneously during the main shock. Under the uniform stress field assumption around the fault system, the coefficient of friction is smaller on F1 than that on F3. F2 plays an important role to trigger the rupture on F3.

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