Studies of Earthquake Rupture Complexities with Applications to the Emergency Response in the Recent Significant Intraplate Earthquakes in the Eastern Tibetan Plateau

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During the last decade several significant intraplate earthquakes occurred in the eastern Tibetan Plateau. These include the Kunlun Mountain Pass earthquake (M_W7.8) of 2001 November 14, the Wenchuan, Sichuan, earthquake (M_W7.9) of 2008 May 12, and the Yushu, Qinhai, earthquake (M_W6.9) of 2010 April 14. The spatiotemporal rupture complexities of these earthquakes were determined using the fast and robust inversion methods we developed in the last two decades, and the inverted results obtained within a few hours after the occurrence of the earthquake were reported immediately to the authorities and released to the public, and were proved to be very useful in the earthquake disaster emergency response.

The M_w7.8 Kunlun Mountain Pass earthquake (KMPE) occurred on the northern margin of the Bayan Har Block of the eastern Tibetan Plateau. The epicenter of this earthquake was located in the Kunlun Mountain Fault (KMF). Despite its large magnitude of M_W7.8 the 2001 KMPE caused no casualty or major damage, because it occurred in a non-habitant mountainous area with elevation ranging from 4500m to 6860m. This earthquake was followed by a large number of aftershocks, which mainly distributed about 200km away eastern to the epicenter of the main shock along the KMF. The inversion results indicate that this event was caused by a left-lateral strike-slip faulting on a nearly vertical fault, being consistent with the southeastward movement of the Bayan Har Block relative to South China Block. The source process of the KMPE had spatiotemporal complexity but overall was characterized by unilateral rupture from west to east. The whole event can be divided into three sub-events in terms of the characteristics of spatiotemporal distribution of slip and slip-rate. The three sub-events started at different locations in the strike direction and at different times, and afterwards fused into a single one of the KMPE.

The M_W 7.9 Wenchuan earthquake occurred on the eastern margin of the Bayan Har Block of the eastern Tibetan Plateau. This earthquake ruptured an area 350 km in length by 50 km in width, of the 470 km-long northeast-southwest striking Longmenshan Fault Zone (LFZ) of northeast Sichuan. Unlike the KMPE about 89 thousand people were confirmed killed or missing. Soon after the occurrence of the earthquake, we started to analyze available seismic recordings to retrieve information describing the earthquake source mechanism, and released the preliminary results of the determination of the focal mechanism and the source rupture mechanics from the inversion to the authorities and to the public within five hours for earthquake disaster emergency response. The M_W 7.9 Wenchuan earthquake had a predominantly thrust

focal mechanism with a small right-lateral strike-slip component and was produced by the ruptures of four asperities with varying focal mechanisms. Two of the more substantial concentrated-slip patches breached the surface, with calculated peak slips of 7.5 m and 6.7 m at the surface, in the two cases, which match the observed displacements closely. The extensive huge thrusting which breached the surface, the asymmetry in irregular rupture propagation between the northeast and the southwest segments, and the long duration for the ruptures to the northeast of the epicenter are all responsible for the heavy destruction in the northeastward elongated meizoseismal areas as well as the asymmetric distribution of numbers of aftershocks between the areas to the northeast and southwest of the epicenter. There were evident hanging-wall/foot-wall effect which accounts for the significant difference in the damage between the northwestern and the southeastern sides of the causative fault.

The M_W 6.9 Yushu earthquake occurred on the southern margin of the Bayan Har Block of the eastern Tibetan Plateau. This event is mainly a left-lateral strike-slip event with a minor normal component, and is consistent with the southeastward movement of the Bayan Har Block relative to South China Block to the east and the Sichuan-Yunnan Block to the south. It caused about 3,000 people death or missing. Two and half hours after the occurrence of the earthquake, we released the preliminary results of the determination of the focal mechanism and the source rupture mechanics from the inversion to the authorities and to the public. It was pointed out that the Yushu earthquake has several distinct characteristics. There exist two principal sub-events which correspond two slip-concentrated patches locating near the hypocenter and to the southeast of the epicenter. The rupturing of the slip-concentrated patch to the southeast of the epicenter breached the ground surface. The large peak-slip and large peak slip-rate about 2.1m and 1.1m/s, respectively, indicate that the Yushu earthquake is an event with large slip-velocity on the fault plane. Overall the Yushu earthquake is a unilateral rupture event with the rupture mainly propagating southeastward. It was suggested that the Yushu city, located 44 km to the southeast of the epicenter, would be heavily destroyed due to the facts that the slip-concentrated patch to the southeast of the epicenter breached the ground surface, and that the strong focusing of the seismic energy to the southeast of the epicenter caused by the seismic Doppler effect. These have been confirmed later by the tremendous damage in the Yushu city and proved to be very informative in the Yushu earthquake relief work.