Introduction to the Special Issue on the 2008 Wenchuan, China, Earthquake

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The M_w 7.9 Wenchuan earthquake occurred on 12 May 2008 at 14:28 China standard time (06:28 UTC) in the middle of the day. People were caught by surprise because this region, along the edge of the Tibetan plateau, was not listed as a place with a high seismic hazard. Destruction was huge. More than four million inhabitants were left homeless. Casualties numbered more than 80,000 people, and there were major economic losses. This event was one of the deadliest earthquakes in China during the last few centuries, after the Haiyuan earthquake in 1920 and the Tangshan earthquake in 1976, which claimed 200,000 and 250,000 lives, respectively. The Wenchuan earthquake occurred a few months before the beginning of the 2008 Olympic games, held in Beijing, China, and the emergency response from the government of the Republic of China was massive. In part, for efficiency during this tremendous rescue effort, scientists had difficulty gaining access to the field for the first several months. Such difficulties have partly hampered deployment of temporary networks of survey equipment, such as GPS or seismic stations by international teams, as is often the case after a major earthquake.

Along with the M_w 7.7 Chi-Chi, Taiwan, earthquake in 1999 and the M_w 7.6 Kashmir earthquake in 2005, the 2008 Wenchuan earthquake is one of the largest continental thrust earthquakes with excellent field observations that was well recorded by a variety of geophysical networks. Hence, it remains a primary target for understanding strain-accommodation processes in a compressive environment. In addition, the Wenchuan earthquake, which occurred in the Longmen Shan range at the edge of the Tibetan plateau, has called into question certain viewpoints held by the scientific community. GPS results have repeatedly shown almost no signal across the Longmen Shan fault system, and for decades, many scientists have considered that only minor deformation could take place in the area. The Wenchuan earthquake has considerably challenged this belief.

Despite all the difficulties of access, the scientific community has put a considerable effort into understanding this event, which is in part reflected in the 34 papers presented in this special volume. It should be stressed that this earthquake has been a unique opportunity for the Chinese earth-sciences community to show the quality and the diversity of the teams active in China, and about 60% of the papers in this volume have a lead author who is Chinese.

This special issue of *BSSA* illustrates the wide scope of the community interested in earthquakes. Two topics dominate this volume: strong-motion studies (nine papers) and surface-rupture studies (six papers). The other 19 papers address various aspects related to the earthquake, from structural geology to engineering aspects or gravity field measurements, among other topics. A large number of strong-motion records (> 60) are available at a considerable range of distances (a few to several hundred kilometers) for the Wenchuan event. These data were used by Bjerrum *et al.* (2010), Lu *et al.* (2010a), Wang *et al.* (2010), and Wen *et al.* (2010) to test several aspects of ground-motion prediction equations. Simulating ground-motion records that were compared to actual data, these authors have tested the recent Next Generation Attenuation ground-motion models, and they discuss the ability of models to predict data in different frequency domains. Li *et al.* (2010) used a dataset of strong-motion records located within 400 km from the epicenter to specifically study the effect of hanging-wall versus footwall location and the directivity effect of rupture propagation. They show that the hanging-wall/footwall effect is significant only in the first 40 km and for periods below 1 s but that the directivity effect is observable at all distances and frequencies. Ghasemi *et al.* (2010) and Kurahashi and Irikura (2010) simulated strong-motion records to constrain the finite seismic-source model. Both studies show that the source is divided into subevents that generate separated pulses in the records. Tests were also performed to check which finite source models better reproduce the spectral characteristics of the strong-motion records. Lu *et al.* (2010b) examined the characteristics of the finite source from the strong-motion records. They compared the spectral response of the Wenchuan earthquake to records available for other large earthquakes and to spectra of the Chinese design code, which they found to be lower than the observed data at short and intermediate periods but comparable at long periods. Xu, Herrmann, Wang, and Cai (2010) used records from 474 small regional earthquakes to derive an absolute ground-motion scaling model, including geometrical spreading function, attenuation, and a spectral decay parameter.

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In addition to the large number of strong-motion studies, other seismological studies are presented in this volume. Xu, Hermann, and Koper (2010) used a dataset of small-to-moderate earthquakes recorded by temporary networks between 2000 and 2004 to compute moment-tensor solutions for 79 events, which are compatible with the rotation of the eastern Himalayan syntaxe. Smyth *et al.* (2010) focused on forecasting the number of large aftershocks for specific time windows after the Wenchuan earthquake. They show that for aftershocks with a magnitude greater than or equal to 5, the Gutenberg–Richter model based on the most recent part of the sequence predicts the number of aftershocks for a given time window as efficiently as the more classic aftershock forecasting methods based on the modified-Omori law. Cheng *et al.* (2010) investigated velocity and structural changes along the Longmen Shan fault using ambient seismic noise. They show that they are able to detect a distinct region with a 0.4% velocity decrease, which matches the deep rupture area of the earthquake. Hence, they suggest that this method could be used to probe temporal structural changes at seismogenic depth. Zhang and Ge (2010) derived the source parameters of the Wenchuan earthquake, including identification of the two main patches of energy release, using a back-projection method applied to broadband data from the Australian seismic network. Chavez *et al.* (2010) computed synthetic low-frequency seismograms using a newly developed 3D seismic wave propagation parallel finite difference code. They also computed the displacement and maximum velocity pattern. These simulations compare well with actual data from the Chinese network, with ground deformation derived from Differential Interferometric Synthetic Aperture Radar (DInSAR) measurements, and with modified Mercalli isoseisms for the Wenchuan earthquake. Jiang *et al.* (2010) investigated the effect of the Wenchuan earthquake as a possible source of dynamic triggering for earthquakes on other faults in China. They find that the effect is more pronounced when faults have already been activated in recent time (historical) and when faults are located in the forward direction of propagation of the rupture. These two conditions, however, do not seem to be sufficient to ensure seismic triggering. Lin (2010) also investigated the triggering effect of the Wenchuan event, but in the very specific case of dynamic stress caused by the *ScS* wave bouncing back to the epicenter region. He shows that the level of dynamic stress would be large enough to trigger earthquakes and that the timing of the arrival of the *ScS* wave is in good agreement with the timing of the M_w 6 aftershock that occurred about 15 min after the mainshock.

The surface ruptures associated with the Wenchuan earthquake have been documented extensively, and papers in this volume will be a valuable source of information for anyone interested in earthquake surface-rupture properties. Liu-Zeng *et al.* (2010), Ren *et al.* (2010), Yu *et al.* (2010), and Zhou *et al.* (2010) investigated different parts of the rupture, illustrating the complexity of the ground rupture's expression, including specific studies in stepover zones. They also provide offset measurements at different places. The paper by Zhou *et al.* (2010) takes one more step because they investigated what would be a safe distance to rebuild, according to ground rupture that was observed in the field. Wei *et al.* (2010) examined another aspect of the surface rupture, the morphology of the seismic scarp, through measurements of the roughness of the scarp surface. They find evidence of large differences in the main direction of the roughness depending on the sites and style of deformation. Liu *et al.* (2010) provide information about past earthquakes along the fault that ruptured during the Wenchuan earthquake. Using ^{14}C dates and optically stimulated luminescence dates, they propose that the last event, with a similar magnitude to the Wenchuan event, occurred between 2.1 and 1.1 ka. The paper by Yuan *et al.* (2010) is also related to the surface expression of the earthquake because it deals with a very large landslide located at the northern end of the rupture. The specific morphology of the landslide is described to demonstrate that a high level of both vertical and horizontal acceleration was needed to trigger this event. Densmore *et al.* (2010) and Hubbard *et al.* (2010) bring the Wenchuan earthquake into a larger perspective in their discussion of the kinematics of the Longmen Shan fault system. Densmore *et al.* (2010) emphasize the connection of the earthquake with the structures already mapped and the difficulty of pointing to which fault is actually active. Hubbard *et al.* (2010) propose a structural scheme to understand the Longmen Shan fault system, based on the taper wedge theory.

Furuya *et al.* (2010) and Xu, Liu, *et al.* (2010) derived the slip distribution associated with the Wenchuan rupture from geodetic studies including Synthetic Aperture Radar (SAR) data and Global Positioning System (GPS) data. Both studies lead to the same maximum slip of about 10 m and to the observation that the rupture started with a dominant thrust mechanism that changed to a more strike-slip mechanism as the rupture propagated northward.

Verberne *et al.* (2010) performed friction experiments in the laboratory on rock samples collected in the area of the Wenchuan event. They prepared and tested simulated gouges under various temperatures and shear velocities. They argue that the clay-rich sediments of the region may have a damping effect upon rupture propagating from depth, whereas the limestone may accelerate propagation, producing significant stress drops.

Lekkas (2010) completed a macroseismic study, comparing two intensity scales, the EMS1998 and the ESI2007 scales. A correlation of the intensities measured in the field with the geological structures is also proposed.

Deng *et al.* (2010) examined the Coulomb stress variations associated with the filling of the Zipingpu reservoir. They show that the filling of the reservoir indeed increased the level of the shallow seismicity but that the change in stress is too small to cause any significant effect at the depth of the Wenchuan earthquake hypocenter.

Zhu *et al.* (2010) investigated change in the gravity field as a possible precursory signal to large earthquakes.

They report that anomalies in the gravity field had been reported before the event and were interpreted as a precursory signal. Starting from this observation, the paper focuses on the uncertainties of the data and possible improvements in the data collection that would reinforce the dataset for further testing of the precursory assumption.

Zhu and Zhang (2010) propose a mechanical model of the Longmen Shan fault system based on a viscoelastic finite element description of the fault. Modeling 300,000 yr of seismic activity, they show that small events occurring below 15 km on a low-angle fault plane would obey a time-predictable model, whereas larger events would only occur when the level of stress reached a critical level on the upper steeper part of the fault.

Zheng *et al.* (2010) take the opportunity of this earthquake to provide a state-of-the-art report on the Data Management Center of the China Earthquake Network Center of the China Earthquake Administration.

Chen and Wang (2010) bring an interesting perspective on the difficult question of the prediction of earthquakes. They discuss historical milestones for earthquake prediction in China to show that up to now the most efficient way to mitigate risk remains an honest assessment of the seismic hazard paired with an appropriate building code.

Indeed, the 2008 Wenchuan earthquake has been a disaster for the Chinese population. This earthquake, however, was the opportunity for the Chinese earth-science community to come forward, to take its place in the international scientific community, and through the many studies partly presented in this volume, to foster new collaboration with foreign colleagues. The Wenchuan earthquake will remain a landmark in the earthquake history of China. It has brought a wealth of important data that will hopefully help to increase the understanding of earthquake processes, particularly those at continental compressional regions, and improve awareness about seismic risk in areas with long earthquake return times.

Data and Resources

No data were used in this paper.

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