Improving seismic hazard assessment in China and the United States based on lessons learned from the 2008 Wenchuan (M7.9) earthquake

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Proposal Summary: On May 12th, 2008, a massive earthquake struck the Longmenshan mountain belt on the western margin of the Sichuan Province of central China. The earthquake, named for the town of Wenchuan, caused nearly 70,000 fatalities, left more than 5 million people homeless, and led to enormous economic losses (AAAS, 2008). The Wenchuan rupture occurred in a region with no prior, historic earthquakes of comparable size, and in an area with only modest amounts of crustal deformation measured by satellite geodesy prior to the earthquake. Thus, the event occurred with little prior warning based on existing methods of seismic hazards assessment. Moreover, the Wenchuan earthquake ruptured a specific type of fault, known as a thrust, that has recently triggered several other highly destructive earthquakes (1994 M6.7 Northridge, California; 1999 M7.6 Chi-Chi, Taiwan; 2004 M9.0 Sumatra; and 2005 M7.6 Kashmir, Pakistan events). Thrust fault earthquakes are characterized by severe levels of damage and significant geologic and seismologic complexity. In the case of the Wenchuan earthquake, this complexity was manifest by the simultaneous rupture of two northwest-dipping faults that extended laterally across a major structural boundary. This ability to breach barriers and involve multiple faults splays enabled the Wenchuan earthquake to be very large, thereby increasing the magnitude and duration of the hazardous ground shaking. Finally, the faults that ruptured were located more than 200 km into the interior of the mountain belt, in an area that was not traditionally considered to be tectonically active. This location presumably spared the large population centers, such as the city of Chengdu, that occur at lower elevations from major damage, yet suggests that other faults in the region might be capable of even more catastrophic earthquakes in the future (Hubbard and Shaw, 2009).

The goal of our proposed research is to understand how the structural architecture of the Longmenshan thrust systems influenced the Wenchuan rupture, such that we may improve our abilities to assess earthquake hazards in the Sichuan basin, as well as in other mountainous terrains of western China and the U.S. Indeed, many of the greatest earthquake hazards in the U.S. occur in similar tectonic environments in southern California, the Pacific Northwest, and Alaska. Our research will integrate geological and seismologic data from the Wenchuan earthquake and neighboring areas of the mountain belt to characterize the three-dimensional geometry of the fault system in the Longmenshan. This effort builds on our experience at Harvard in developing community fault models that are now used by the U.S. Geological Survey as the basis for regional earthquake hazards assessment in southern California (Plesch et al., 2007). Based on these results, we will work collaboratively with our Chinese colleagues to develop state-of-the-art community fault and velocity models for the Sichuan area that will serve as the basis for an improved understanding of the regional earthquake hazards. Lessons learned from the Wenchuan earthquake will also be applied to improve the way in which seismic hazards are assessed in the U.S.

The proposed research targets a collaboration between academic and industry groups in China (Professor Jia Dong & students, Nanjing University; L. Benliang, PetroChina) and researchers at Harvard. Resources from the Harvard China Fund will enable a genuine collaboration in this study, augmenting other funding that is generally restricted to domestic studies. Thus, the proposed budget targets participation by Harvard personnel in collaborative field work and research in China, as well as the hosting of Chinese graduate students here at Harvard. Results of the study will include joint publications in peer-reviewed scientific journals, and the development of technical products that will improve seismic hazards assessment in both countries. During the second year of the collaboration, we also plan to develop a course at Harvard on the active tectonics of China, which will be attended by both U.S. and visiting Chinese students.