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Reevaluation of the offset of the Great Wall caused by the ca. M 8.0 Pingluo earthquake of 1739, Yinchuan graben, China

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The study of large-magnitude earthquakes that occurred prior to the availability of routine instrumental measurements relies mainly on the analysis of historical documents and field observations. Significant uncertainties often exist in relation to the location of the epicenter, the magnitude, and the actual extent of damage, including the number of fatalities, caused by individual historical earthquakes, because records generally focused on the effects in the restricted regions that were settled. Field observations of the geologic effects of large historical earthquakes provide direct evidence of the coseismic ground deformation and seismic intensity of these large-magnitude events, and can therefore help to improve our understanding of the dynamic mechanisms associated with seismic faulting, and our ability to assess seismic hazards in densely populated epicentral regions.

China is located in one of the most active seismic regions of the world and has experienced numerous destructive earthquakes over its long history. The damage caused by previous large-magnitude earthquakes has been recorded in historical documents, and coseismic ground deformation is locally preserved in ruined ancient buildings such as temples, tombs, and other constructions erected over the past several thousand years (EBASP, 1998; People Network, 2012). Therefore, the ruins of ancient civilizations can sometimes be used to indicate the nature and extent of ground deformation and damage caused by large-magnitude earthquakes.

Previous studies have shown that the Great Wall of China was damaged and offset by the ca. M 8 Pingluo earthquake of 1739 along an active fault zone in the Yinchuan graben, on the western margin of the Ordos Block in northern central China. Based on the apparent displacement, it was concluded that the Great Wall was right laterally offset by 1.45-1.95 m, with a 0.9-2.0 m vertical component, at three locations in this area (He, 1982; Liao and Pan, 1982; Zhang et al., 1986); consequently, the maximum cumulative displacement of the wall was calculated to be 3 m dextral and 2.7 m vertical (Zhang et al., 1986).

However, our recent fieldwork has shown that the Great Wall was probably not affected by the ca. M 8 Pingluo earthquake of 1739, as reported previously. In this study, we reinterprets the offset of the Great Wall on the basis of our new field observations, and attempts to identify the source seismogenic fault that triggered the 1739 M 8 Pingluo earthquake. Our field investigations reveal that (i) the Great Wall was not offset by the ca. M 8 earthquake of 1739, but the wall was, in fact, built on the pre-existing fault scarps; (ii) the Yinchuan-Pingluo fault was most probably the source seismogenic fault of the 1739 earthquake. More work is required if we are to better understand the deformation characteristics of the source seismogenic fault, and also improve our ongoing assessments of the seismic hazard within the densely populated area of the Yinchuan graben.

Keywords: 1739M 8.0 Pingluo (China) earthquake, Great Wall, coseismic surface rupture, active fault, displacement, paleoearthquake