Giant Landslides Triggered by the 1718 Tongwei Earthquake in Pan'an, Gansu Province, China

SUN Ping[1,2,*], SHAO Tiequan[3], SHI Jusong[4], ZHANG Shuai[1,2] and MENG Jing[1,2]

1 *Key Laboratory of Neotectonic Movement and Geohazard, Ministry of Land and Resources, Beijing 100081, China*
2 *Institute of Geomechanics, Chinese Academy of Geological Sciences, Beijing 100081, China*
3 *Chang'an University, Xi'an 710054, Shaanxi, China*
4 *China Geological Survey, Beijing 100037, China*

Great earthquakes in mountain areas always trigger severe geologic hazards such as landslides, debris flows and rock falls, thereby causing tremendous property damage and casualties. On 19th June, 1781, a Ms 7.5 earthquake occurred in Tongwei of Pan'an, Gansu Province, west China, and triggered more than 300 landslides near the epicenter (35.08° N, 105.2° E). In particular, in the heaviest damaged area of Pan'an Town, the mountains were moved southward, and a total number of 30,000 deaths were caused (Liu et al., 1984; Chen et al., 2005). This paper presents the research progress of the study on the huge landslides triggered by the 1718 Tongwei earthquake, with the support of China Geological Survey (Project No. 12120114035901) and NSFC (Award No. 41472296 and No. 41372374).

The research area is located about 30 km south of the epicenter, and covers an area of 460 km^2. It is typically dominated by ridges comprised of the Pleistocene loess deposits, represented by tens of meters thick loess deposits overlying the Neocene mudstones. Field investigations revealed 91 landslides in this study area with 4 giant landslides. To explore the internal structure and failure mechanisms of these landslides, five boreholes were drilled along 210° in the movement direction of the major Weijiawan-Lijiaping landslide with a volume of about 2.13×10^8 m^3 at the northern slope of Pan'an Town (Fig.1). It is concluded that:

(1) The area is susceptible to landslide due to its special river valley geometry. It is composed of tens of meters thick Pleistocene loess deposits overlying the basal Neocene mudstone layer, and is dominated by a gently inclined valley with large erosion bank slopes and well-

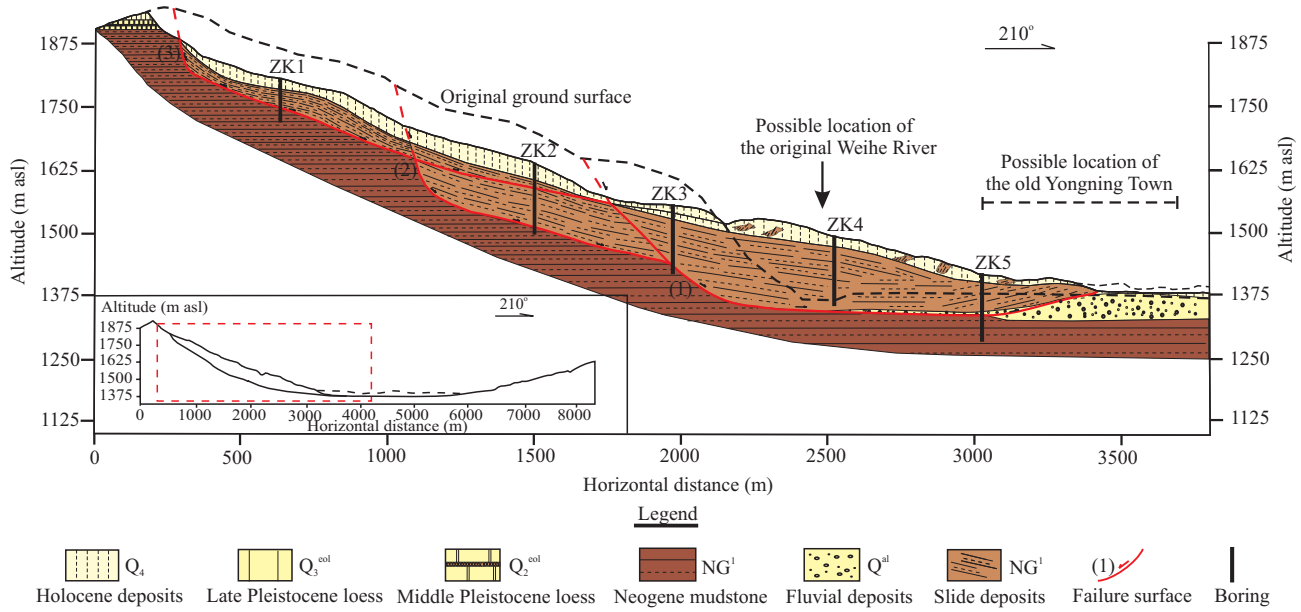

Fig.1. Geological cross section of the typical landslide.

* Corresponding author. E-mail: sunpingcgs@163.com

developed steep mudstone slopes.

(2) Previous studies show that these landslides were defined as loess landslides due to loess sliding along the ancient terrain surface. However, our investigations indicate that the failure surface of the Weijiawan-Lijiaping landslide is located within the deep Neogene mudstone layer (Fig. 1). Therefore, these landslides are classified as loess – mudstone composite landslides. These new findings will be helpful to further unravel the failure mechanisms of these earthquake- triggered landslides recorded in historical documents.

(3) The new results will provide some insights and knowledge for the early recognition of earthquake-triggered landslides in northwest China, especially in the river valley similar to the Weijiawan-Lijiaping landslide.

References

Chen Y.M., Shi Y.C., Liu H.M., and Lu Y.X., 2005. Distribution characteristics and influencing factors analysis of seismic loess landslides, *Earthquake Research in China*, 21(2):235−243.

Harp E.L., and Jibson RW., 1996. Landslides triggered by the 1994 Northridge, California earthquake. *Bulletin of the Seismological Society of America*, 86: 319−332.

Harp E.L., and Jibson R.W., 2002. Anomalous concentrations of seismically triggered rock falls in Pacoima Canyon: are they caused by highly susceptible slopes or local amplification of seismic shaking? *Bulletin of the Seismological Society of America*, 92: 3180−3189.

Huang R.Q., and Li W.L., 2009.Analysis of the geo-hazards triggered by the 12 May 2008 Wenchuan Earthquake, China. *Bulletin of Engineering Geology and the Environment*, 68: 363−371.

Keefer D.K. ,1984. Landslides caused by earthquakes. *Geol Soc Am Bull*, 95: 406−421.

Liu B.C., Zhou J.X., and Li Q.M., 1984. Interpretation on the aerial photograph of 1718 Tongwei earthquake and 1654 Tianshui earthquake, *Seismic Research*, (1):1−7 (in Chinese with English abstract).

Sassa K., 1996. Prediction of earthquake induced landslides. *In: Senneset, K. (Ed.), Landslides. Balkema, Rotterdam*: 115−132.

Sun P., Yin Y.P., Wu S.R., and Chen L.W., 2012. Does vertical seismic force play an important role for the failure mechanism of rock avalanches? A case study of rock avalanches triggered by the Wenchuan earthquake of May 12, 2008, Sichuan, China. *Environmental Earth Sciences*, 66(5): 1285−1293

Yin Y.P., Wang F.W., and Sun P., 2009. Landslide hazards triggered by the 2008 Wenchuan earthquake, Sichuan, China. *Landslides*, 6: 139−152.