YIN Zhiqiang, ZHAO Wuji, 2013. Some giant landslides from Sigouxia gorge to Laganxia gorge in NE Tibet Plateau since the Late Glacial. *Acta Geologica Sinica* (English Edition), 87(supp.): 413-417.

Some Giant Landslides from Sigouxia Gorge to Laganxia Gorge in NE Tibet Plateau since the Late Glacial

YIN Zhiqiang[1,2,*], ZHAO Wuji[3]

1 *Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029,China*
2 *China Institute of Geo-environment Monitoring, Beijing 100081,China*
3 *China University of Geosciences(Beijing),Beijing 100083,China*

The upper reaches of Yellow River NE Tibet Plateau (TP) is a high prone zone of geological disasters in western part of China, which lied in the first slope-descending zone along the eastern margin of Tibet Plateau, where is tectonically very active. In the region, some large-scale and giant landslides are notable for their scale, complex formation mechanism, and serious destruction (Yan et al.,2000; Huang,2007). In this paper, some ancient and old typical giant landslides characteristics that occurred in the southwest of China since the late Glacial has been summarized, then analyzed the geological conditions, different triggering factors, mechanisms and considered that these giant landslides were triggered by strong earthquakes and high rainfall.

1 Geomorphological setting in the study area

The study area is located in the upper reaches of Yellow River of the north-eastern Tibet Plateau, where is the transition zone between the Tibet Plateau and the Loess Plateau. There falls inside the geographic region of the Animaqing mountainous and Guanting basin, which is dominated by mountain ridges rising of 6282 m and flat land of 1750m, the Yellow River winds in from west to east between the mountains and canyons since Quaternary middle Pleistocene to Late Pleistocene, and is consisted of some basins and valleys, i.e., Gonghe, Guide, Qunke-Jianzha, Xunhua and Guanting basins and Longyangxia, Laxiwaxia, Lijiaxia, Gongboxia and Jishixia gorges from Laganxia Gorge to Shigouxia Gorge, these basins and mountainous gorges interval development. In the region, the altitude difference of many mountain slopes is larger than 900 m by the role of the internal and external geological forces. The extensive development of these high and steep mountainous slopes favored terrain conditions and invading the basis for large-scale landslides development since late Pleistocene, so landslides and debris flows develop widely in the region and transform into a geological disaster-prone area(Shang et al.,2003). At least 21 giant landslides have been identified from remotely sensed images and field survey by authors.

* Corresponding author. E-mail: yinzq@mail.cigem.gov.cn

2 Giant landslide developmental characteristics

Over 21 giant landslides differing in type, size and degree of activity were identified and mapped in the upper reaches of Yellow River (Yin et al., 2010, 2013). Because of influence by topography, lithology, active tectonics, climate change and other environmental factors, the landslide distribution displayed imbalance in the region. For example, landslides mainly located in the two sides of main stream of Gonghe basin, Guide basin, Qunke - JianZha basin, Xunhua basin and Guanting basin, and the south bank of the landslides are more than the north.

Field surveys found that landslides extremely developed on both sides of the Yellow River, and the number of super-large landslides (the mass residual volume is greater than$1*10^8 m^3$) is 11, which landslide mass residual volume is 60.96*108m3. And the number of giant landslides is (the mass residual volume is between $1*10^7 m^3$ and $1*10^8 m^3$) is 10. Of these basins, the most numbers, the amount of residual mass and the largest density strength is Qunke-Jianzha basin, which substance composed mainly of Tertiary mudstone.

The high and steep slopes are very abundant developed under several large-scale uplifts of Tibet Plateau and erosion and cutting activity of the Yellow River, which provides plenty of free space for landslides formation by

topography in the region. Regard as the lithology, the red clay of Paleogene and Neogene rift basin sedimentary affords a wealth of material conditions for landslides developing.

Our analysis show that the spatial distribution morphological of landslides can be divided into eight categories, they are round-backed armchair-like and semi-elliptical shapes，dustpan shape，dumbbell shape，tongue shape (including long tongue, rectangular, mat, stepped shape and etc), saddle shape，long-arc shape，triangular shape. Such as the the flat pattern of Xiazangtan landslide Ⅰ and Kangyang landslide that look like armchair and semi-elliptical shapes. The length and width of landslides are mainly concentrated on the 1500-2500m; the length and width of landslides mass were extended direction by different polarization. The thicknesses of landslides were commonly more than 25m. The average elevation value of the landslides are mainly between 2400 and 2800m and the relative elevation differences between the front sheer opening and back trailing edge are concentrated on the 300-700m and the peak is 875m. The highest concentration of the average slopes angle are 15-25°, while a good linear relationship between the average slope angle, relative elevation differences and the length of landslides mass(Qin et al.,2012).

Another characteristic is the most of ancient and old landslides, and the sliding distance is far away and belonging to types of high-speed remote landslides, which had blocked the Yellow River, leaving a large number of landslide residual mass across the other side. Such as the Gelongbu landslide that located in Jishixia valley and Suozi landslides that located in Qunke-Jianzha basin.

Table 1 presents some of the giant landslides with their volume greater than $1\times10^9 m^3$ that occurred since late Glacial in NE Tibet Plateau. For a better understanding of these giant landslides, some typical ones are introduced, and their formation processes are briefly analyzed in this abstract. The locations of these landslides are shown in Fig. 1.

3 Three typical giant landslides Xiazangtan giant landslide

Several typical landslides developed along the banks of the Yellow River. For example, the Xiazangtan landslide that occurred on the south bank of the Yellow River

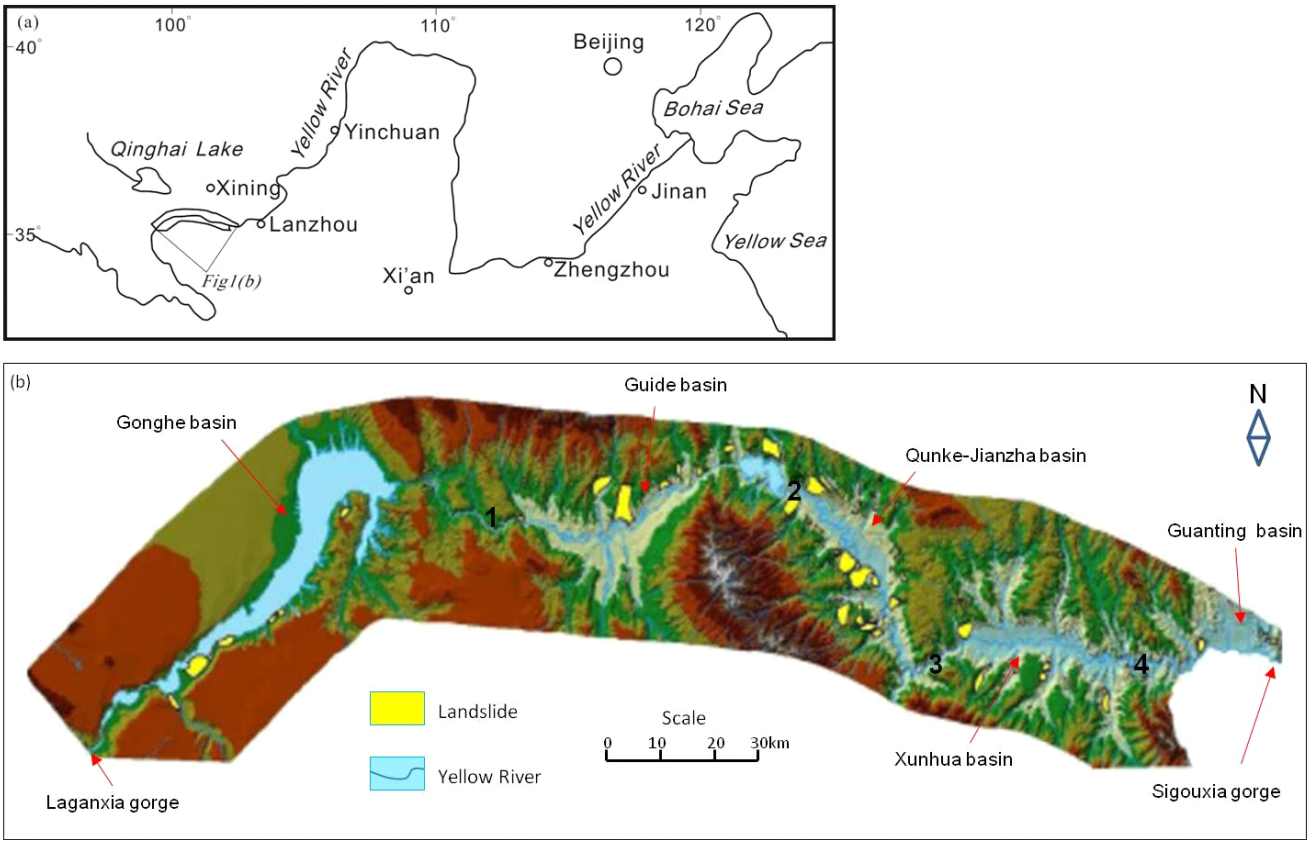

Fig.1 Location and geomorphological sketch of the study area
(a. Location of the study area of Yellow River, b. map of geomorphology and landslides distribution, 1.Laxiwa gorge, 2. Lijiaxia gorge, 3.Gongboxia gorge, 4.Jishixia gorge

affected an area of ~4.5 km×~2.5 km and mobilized a volume of $14.18\times10^8m^3$ and consisted of Tertiary red clay and sand sediments. It was reported as the one of largest one to occur in China (Yin et al., 2010). In its front sheer opening edge, there are two sub-scale landslides that were occurred later. the landslide can be divided into two phases, the forming age are 49000 ± 5000a(Optically Stimulated Luminescence) and 28000 ± 2000a (Electron Spin Resonance), the early periods of landslides mass had across the Yellow River and blocked it, till recently, there are some landslide masses on the opposite the Yellow River. On the top of the landslide mass in reverse topography, on its southern side, there was a depth of 26.3m ancient lake sediments deposits that had disappeared before the Holocene, because a deep ditch had cut throughout the landslide mass from south to north at the west. The Xiazangtan village that immigrant resettlement area in 2005, which directly locates on the landslide mass, thus, the landslide seriously threaten these people-lived. Field survey shows that the overall of the landslide is stability and does not occur in the short-term.

3.1 Gelongbu giant landslide

Gelongbu landslide located in the Jishixia gorge where is very narrow, and belonging to the Cretaceous glutenite bedrock landslide. The front sheer opening elevation of landslide is 1860-1865m, 45-50m above the modern river level was the equivalent to the terrace Ⅳ of Yellow River. The back trailing edge elevation is 2100m and the main sliding direction is 51 °. The length and width of landslide mass are 1100m and 1200m, average depth is 90m, so the volume is about $2\times10^8m^3$ that belongs to the super-large landslide, the mass is Cretaceous sediments. After the occurrence of the landslide, the landslide mass severely blocked the Yellow River and to form dammed lake in the upstream, the other side of the river has left a lot of the landslide mass and upstream several kilometers long lake facies. The ^{14}C age of organic matter from bottom samples of the dammed lake sediment is 9100±40yrBP (cal) (measured by Beta Laboratory, USA), implying that the dammed lake was formed in the early Holocene.

3.2 Suozi giant landslide

Suozi landslide located in the left bank of Yellow River in Qunke-Jianzha basin and the residual mass was divided into two parts, the length, width and depth of left and right bank are 2150m,800m; 5250m, 4000m and approximately 120m, 25m respectively. The whole residual mass volume

Table 1 Some giant landslides since late Glacial from Sigouxia gorge to Laganxia gorge

Name of landslide	Location	Longitude	Latitude	Relative elevation	Residual mass volume /$\times10^8m^3$	Average angel of slope
Mangla river	Gonghe basin	100°26′18″	35°43′56″	418	1.20	42
Baicitan		100°30′07″	35°49′11″	538	2.84	40
Chana		100°48′49″	36°05′38″	350	1.27	35
Ashigong	Guide basin	101°34′01″	36°09′07″	556	1.60	40
Xijitan		101°27′06″	36°03′44″	240	8.40	30
Tangsecun	Qunke-Jianzha basin	101°48′55″	36°05′27″	790	1.20	35
Quhetankou		101°56′12″	36°00′28″	700	0.17	51
Kangyang		101°57′20″	36°00′05″	715	10.60	42
Xiazangtan		101°58′51″	36°08′51″	300	15.05	30
Zhihuqiedong		102°03′45″	35°54′36″	608	0.10	20
Shengguotan		101°53′12″	36°06′32″	730	0.48	30
Xiaqiongsi		101°53′46″	36°06′04″	300	0.35	30
Lannitan		101°58′58″	35°59′55″	372	0.86	20
Suozi		102°03′41″	35°54′40″	250	13.55	48
Shange	Xunhua basin	102°32′53″	35°46′43″	400	1.08	25
Chaligang		102°21′12″	35°53′57″	500	0.39	25
Tangjiakatan		102°14′20″	35°14′20″	305	2.40	30
Mengda	Jishixia gorge	102°38′19″	35°49′48″	250	0.16	18
Gelongbu		102°35′18″	36°49′31″	350	0.42	50
Gelongbu		102°36′45″	35°49′46″	875	1.19	51
Badashan	Guanting basin	102°55′03″	35°22′05″	350	0.66	35

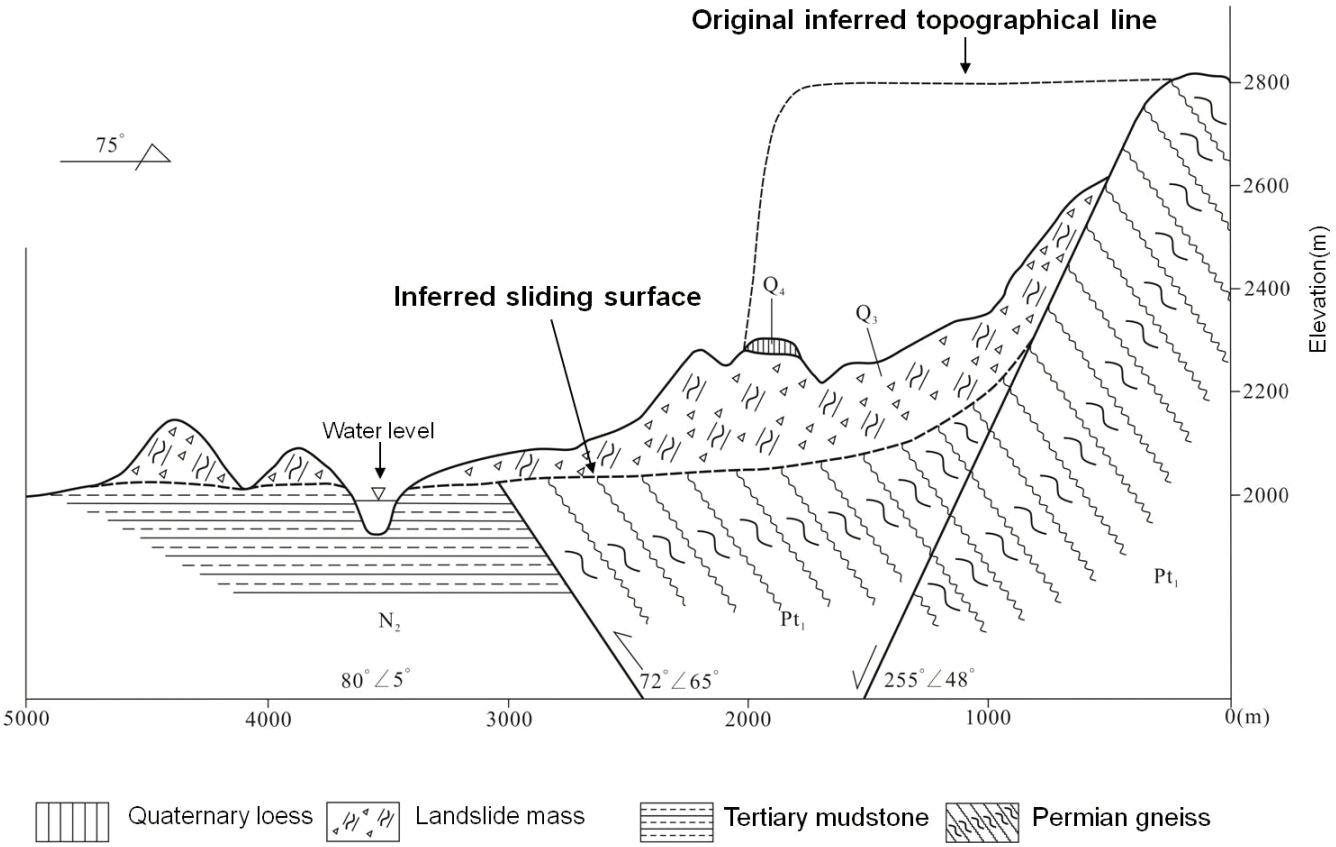

Fig. 2 The profile view of Suozi giant landslide

is $14.35\times10^8 m^3$, the horizontal sliding distance is 5700m and vertical height difference is 875m. The back trailing edge of the sliding mass is to maintain more completely and the central completeness poor, the front sheer opening was chunky disorder and the rock is relatively smaller than 10cm. The trailing edge of the sliding bed are controlled by two active deep fault belts, Xiqinling-Jishishan fault belt and the Lajishan fault belt, the occurrence are 255°∠48° and 72°∠65° (Fig.2), they all have some branch faults, e.g. the east of Jianzha fault that is the important thrust fault belt in north of Tibetan plateau and extend hundreds of kilometers (Li et al., 2011). Therefore, we can speculate that the occurrence of Suozi high-speed remote landslide may be related to the east of Jianzha fault activity, filed survey found on the hillside of the landslides upstream 11km developed massive lacustrine that may be the product of the Yellow River dammed lake sediments.

The Yellow River was dammed after occurrence of landslide and the Permian Gneiss strata overlaying the Tertiary mudstone on the right bank of Yellow River.

Keywords: Giant landslides; Case study; Late Glacial; NE Tibet Plateau

Acknowledgements

The research work described herein were funded by the National Nature Science Foundation of China under Grant No. 40802089, 41172158 and funded by the China Geological Survey under Grant No. 1212011220123. The financial supports are gratefully acknowledged.

References

Huang, Runqiu, 2007. Large-scale landslides and their sliding mechanisms in China since the 20th century. Chinese Journal of Rock Mechanics and Engineering 26(3), 433-445 (in Chinese with English Abstract).

Li Xiaolin, Guo, Xiaohua and Li Wanhua, 2011. Mechanism of giant landslides from Longyangxia valley to Liujiaxia valley along upper Yellow River. Journal of Engineering Geology 19 (4),516-530 (in Chinese with English Abstract).

Qin Xiaoguang, Yin, Zhiqiang, 2012. Earthquake and Local Rainfall Triggered Giant Landslides in the Unconsolidated Sediment Distribution Region along the Upper Yellow River-Remote Sense Analysis of Geological Disasters. J Geophys Remote Sensing 1:e105. doi:10.4172/2169-0049.1000e105

Shang, Yanjun, Yang Zhifa and Li Liao, 2003. A super-large landslide in Tibet in 2000: background, occurrence, disaster, and origin. Geomorphology 54,225–243.

Yan Chunjie, Sun Yunzhi, Tang Huiming,2000.Surface Micro

textures of Slipping Zone Soil of Some Landslides in the Three Gorges Reservoir District and Their Significance .Acta Geologica Sinica,74(2):349-352.

Yin Zhiqiang, Cheng Guoming, Hu Guishou and Wei Gang, 2010. Preliminary study on characteristic and mechanism of super large landslides in the upper Yellow River since late Pleistocene. Journal of Engineering Geology 18(1), 41-52 (in Chinese with English Abstract).

Yin Zhiqiang,Wei Gang, Qi Xiaobo and Zhou Cuiqiong. 2013. Study on the spatial and temporal characteristics of landslides and their response to climatic change from Sigouxia gorge to Lagan gorge in the upper reaches of Yellow River. Journal of Engineering Geology 21(1),129-138 (in Chinese with English Abstract).

About the first author

Yin Zhiqiang Male; born in 1980; PhD of institute of Geology and Geophysics, Chinese Academy of Sciences, engineer of China Institute of Geo-Environmental Monitoring. He is now responsible for the project "Geological hazard survey in the upper reaches of Yellow River" and has investigated landslides, debris flows and collapses in western China for several years.