Survey of Guoxia-Silaotou fault

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Abstract. Guoxia-silaotou fault is a part of Longxian-Baoji fault zone. In previous studies, people only inferred the spatial distribution of the fault from the indirect evidences of geomorphology and geophysics. In this paper, through the detailed investigation of the fault, the outcrop of the fault plane is found; the trenching method is used to investigate the fault, and the activity scale of the fault is revealed. It is found that in the late Pleistocene, the activity intensity of the fault is relatively high.

1. Introduction

As shown in Figure 1, the Longxian-Baoji fault zone is a part of the compression boundary structural zone between the northeastern margin of the Qinghai-Tibet Plateau and the southwestern margin of the Ordos block. The active faults in the fault zone play an important role in the tectonic evolution of the Western Weihe basin. Longxian- Qishan- Mazhao fault is the largest and most active fault in Longxian-Baoji fault zone. It starts from xinjichuan in Longxian County in the north, passes through Longxian County, Qianyang County, Fengxiang County, Qishan County and Fufeng County, and inserts into the northern foot of Qinling Mountains, with a total length of nearly 200km (Figure 1). Many scholars have studied the fault [1-6]. The Longxian- Qishan -Mazhao fault is divided into six segments in Microzonation of Ground Motion in Baoji City, which are Xinjichuan segment, Dongfeng segment, Shuigou segment, Yidian segment, Gushuicun segment and Yabai segment from north to south.

Xinjichuan segment dips to northeast, dip angle 50 ~ 80 °; the hanging wall is Zhidan group, and the footwall is pre Cretaceous. Along the fault, the fault triangle planes are well-preserved. Dongfeng section starts from Dongfeng Town in the northwest, extends southeast to the north of Zhangjiadian, and the strike angle is 310°  and the dip angle is 50-70°  and the length is about 40km. Both sides of the fault are hills covered by loess. The Jurassic sandstone, Neogene glutenite and Middle Pleistocene loess are faulted, and some lower strata of Upper Pleistocene are faulted. In the north of Guancun, Shibiétan fault dislocated the Middle Pleistocene gravel layer, and the overlying first terrace strata were continuous and complete. Several sections show that the activity of this section was strong before the late Pleistocene, and it was mainly activity of normal fault. There was still obvious activity in the early and middle of Late Pleistocene, but the activity became weak in the late Pleistocene, and the activity was not obvious in the Holocene. Shuigou section is from the north of Zhangjiadian to the southeast, through Fanjiazhai, Shuigou and Zhougongmiao, to Xujiayao in the north of Qishan County, with a strike angle of 310° and a dip angle of 50 ~ 70° and a length of about 32km. In this section, the landform is clear. The footwall of the fault is covered by low mountains and hills, and the lithology is Sinian and Paleozoic siliceous limestone and limestone. The hanging wall is alluvial and proluvial plain. In Shuiguosi and Liujiuzhuang area, faults were very developed, and 6 new and old faults are found, mainly normal faults, with straight section and fault distance ranging from tens of centimeters to several meters. On the section, stepped faults or small grabens and horsts are often formed, and the
shape is complex. In Shuigousi, faults generally intersect the first paleosol layer of late Pleistocene. The top boundary of the first paleosol layer in several fault sections has a fault displacement of 0.5 ~ 2.5m. In some sections, the fault plane goes straight to the surface. In the areas of Zhouchongmiao, Fenghuangshan and Lingqiancun, there are also sections of the first paleosol layer, with the bottom boundary of the first paleosol layer staggered by 0.70m. Because there is no Holocene strata at the top of the fault plane in the above section, it is impossible to judge whether the fault is active in Holocene. Yidian section is from Xujiahe to Southeast via Lubanqiao, Xiyuanshang and Yidian. Its strike is 300° and its dip angle is 45~80° and its length is about 11km. Geomorphologically, both sides of the fault are loess tableland. There is no obvious landform in Xujiahe Yidian section, but fault section is found in Lubanqiao and Xiyuan, which is 2~3m away from the first paleosol layer. This segment is at least an active fault of late Pleistocene. Gushui section is from Taipingzhuang in the south of Yidian to Gushui reservoir, it is about 20km long and 300~330° in the northwest direction. There is a loess slope in the northwest direction, which is high in the West and low in the East. The maximum height difference is about 80m. The scarp is a right step oblique combination on the north and south sides of Weihe River. The scarp in the southeast of Guoqiaxiyao to Xiya turns north-south, and protrudes eastward from Xiya to Nanyao, forming two-level loess tableland. Although the landform of this section is clear, no typical fault section is found in Tanjiahe, Xicun, Xujiahe, Xianguan, Luojia, Xidatong, Nandatong, Zhangjiayao, BeiYao, Xiya and Nanyao brick along the line. The Gushui fault section discovered by predecessors has not been found. There is a fault section near Xujiahe in Fufeng. The paleosol layer is discontinuous, but there is no obvious fault plane. The southernmost segment is the Yabai segment, where a fault section with fault Q_p^{1-2} is found beside the Heihe reservoir.

Figure 1 Outline of regional structure

Guoxia-Silaotou fault is a part of Longxian-Baoji fault zone. In the past work, the spatial distribution of Guoxia-Silaotou fault was inferred only from the indirect evidences of geomorphology and geophysics. There is a lack of direct evidence. This work tries to obtain detailed direct evidence through detailed field investigation.

2. Research history of Guoxia-Silaotou fault

2.1 Shallow seismic exploration

On the basis of field investigation, a shallow seismic profile was set up in Tianjiahe village, Fufeng County, in the project Microzonation of Ground Motion in Baoji City (Figure 2). The survey line is perpendicular to the strike of Guoxia-Silaotou fault and is located in the Weihe River Valley in the south of Fufeng County, with an overall strike of NE. The geographical location of the survey line
starts from the north of Jiajiapo in the northeast and ends in the gully in the north of Dongjiawan village through Yijiapu and Sanrenzhuang in the southeast along the Weihe river.

As shown in Figure 3, the time profile of data interpretation shows that the occurrence of seismic wave group has little change in general, and there are four strong reflection interfaces (T1, T2, T3, T4) in wave group division. According to the geological interpretation, there is a fault (DFb7) at stake 1321, which is a normal fault with a NS dip angle of about 73 degrees. Wave group and T1, T2, T3 strong reflection interface show that the footwall of the fault is horizontal far away from the fault and bends downward near the fault. The hanging wall strata (T1, T2, T3) is nearly horizontal and shows anticline near the fault. There are secondary small reverse faults with different inclinations at stake 972, 1084, 1194 and 1262, indicating that they have been subjected to obvious compression. In addition, the hanging wall T4 is anticlinal near the fault, supporting the shallow T1, T2 and T3, while the footwall T4 is synclinal near the fault. The buried depth of the upper breakpoint of the fault is about 50m.

2.2 Combined borehole profile
On the basis of shallow seismic exploration, the results of shallow seismic are verified by using borehole joint section in in the project Microzonation of Ground Motion in Baoji City. Tianjiahe borehole joint profile (Figure 4) is arranged at the location of shallow seismic anomaly. The total length of borehole section is 510m, the maximum depth of the borehole is 60m, the minimum hole spacing among the boreholes is 13.5m, and the total footage is 386m. The anomaly determined by the Shallow seismic exploration is located between ZK1 and ZK2. The middle layer ① and layer ② of the borehole profile are loess-like soil, cobble and gravel sand, which are deposited by Weihe River. The layer ③ to the west of borehole ZK3 is loess-paleosoil sequence, and the bottom boundary is relatively stable. The lower layer ⑤ is calcareous tuberculosis layer, which has become calcium plate. The thickness of ZK3 borehole to the west is relatively stable, which is 2.3~3.3m, and the thickness to the east gradually thinned, and disappears in ZK5 borehole. Layer ⑦ is brown-red silty clay with stable thickness. The layer ④ to the east of ZK3 borehole is silty clay with loess characteristics. The upper part of the calcareous nodule layer of ZK7 borehole is medium sand and silt, which indicates that there is an erosion surface near ZK3 hole. According to the comprehensive judgment, no evidence of fault activity can be found in the abnormal location and the boreholes profile nearby it. There are two possibilities that one is that the abnormal position t is not accurate, and the other is that the depth of borehole profile does not reach the upper breakpoint of fault.

3. Detailed field exploration of Guoxia-Silaotou fault

In the historical work, direct evidence of the activity of the Guoxia-Silaotou has never been obtained, so we conducted a long-time detailed field investigation on the fault. In a much hidden small corner of Guoxia village, traces of the suspected fault were found (before, many units of several related projects had carried out the investigation of Qishan mazhao fault nearby, and no outcrop of the fault profile was found). Through the verification of trenching engineering, it is proved that this is the profile of Qishan mazhao fault (Figure 1, Figure 2).

Figure 6 shows the outcrop of the original section of the fault. It can be seen from the figure that the dark paleosol layer of late Pleistocene is very stable and primitive. In the lateral extension direction of the paleosol, the paleosol suddenly disappeared and was replaced by the late Pleistocene loess. The boundary between the two sets of strata is a steeply dipping boundary. In order to verify whether the boundary is the location of fault plane, trenching is carried out. According to the topography, profile and other surrounding conditions, we excavated a trench about 10m long, 1m wide and 2m deep (Figure 6). The paleosol in the footwall was penetrated by the trench, and that in the hanging wall was
revealed. As a marker layer, the paleosol on both sides of the fault clearly reflects the nature of the fault.

![Figure 5 Original section outcrop of the fault](image)

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![Figure 6 Fault profile revealed by trenching](image)

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![Figure 7 Section of Guoxia sidaoren fault](image)

Figure 7 Section of Guoxia sidaoren fault

As shown in Figure 7, the fault passed through the late Pleistocene paleosol, but did not completely break through the overlying late Pleistocene loess. It shows that the fault is in the early stage of late Pleistocene and has not been active at the end of late Pleistocene.

Judging from the measured data, the vertical fault displacement of the fault is about 2m. The strike of the fault is 300° with NE dip and 67° dip.

4. Conclusion

Guoxia-Silaotou fault is a part of Longxian Baoji fault zone. In previous studies, people only inferred the spatial distribution of the fault from the indirect evidences of geomorphology and geophysics. In this paper, through the detailed investigation of the fault, the outcrop of the fault plane is found; by means of trenching, the fault is investigated and the active scale of the fault is revealed. It is found that in the late Pleistocene, the activity intensity of the fault is relatively high. Judging from the measured data, the vertical fault displacement of the fault is about 2m. The strike of the fault is 300° with NE dip
and 67° dip. Since only one section is found in this work, there are some limitations in the inference of fault strike, and more work is expected in the future.

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