

Co- and post-seismic vertical displacements of Wenchuan M_s 8.0 earthquake near Beichuan

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Abstract: Co- and post-seismic vertical displacements of the Wenchuan earthquake derived from two measurements in 2008 and 2010 along two partly-damaged leveling lines near the epicenter show the following features: Co-seismic displacement at Beichuan-Yingxiu fault was as large as 4.711 m near Beichuan, where the maximum observed fault offset was 5.1 m. In contrast, the observed co-seismic offset of the Qingchuan fault in Pingwu County was only 0.064 m. During 2008–2010, the post-seismic displacement rate was 5–27 mm/a near Beichuan-Yingxiu fault in Beichuan area, 20.6 mm/a at Jiangyou-Guangyuan fault near Dakang, and only 0.2–1.3 mm/a at Qingchuan fault near Gucheng.

Key words: Wenchuan M_s 8.0 earthquake; post-seismic vertical displacement; leveling; Beichuan area

1 Introduction

Large horizontal and vertical displacements were observed after the Wenchuan M_s 8.0 earthquake, which occurred on a 300 km segment of Longmenshan faults. The maximum displacement occurred near the southern and northern ends of the earthquake fracture, near Yingxiu and Leigu, respectively, where serious destructions were also encountered^[1]. After the earthquake, China Earthquake Administration organized an investigation of the earthquake from August to September 2010, and the bench marks of Dujiangyan-Wenchuan leveling line were found mostly destroyed and unusable. However measurements were made along two partly-damaged first-order leveling lines by teams from First and Second Crust Monitoring and Application Centers of CEA. In this paper, we present some of the leveling data obtained in the investigation and another in 2010.

2 Longmenshan fault

The Longmenshan fault is a major fault in the South-North seismic belt, which is a boundary between the Tibet Plateau and the South-China block. The fault extends from Luding and Tianquan in Sichuan province in the south to Baoxing, Dujiangyan in the north, and then to Mianxian in Shanxi province in the northeast. It has a total length of about 500 km, and a width of about 40–50 km, and consists of three faults, which are from west to east Maowen-Wenchuan, Beichuan-Yingxiu, and Jiangyou-Guanxian faults. It has a strike of $N45^\circ E$, a slip direction of NW, and an inclination angle of about $50^\circ - 70^\circ$ (Fig. 1)^[2–6]. The Wenchuan earthquake occurred in the central section of Longmenshan fault (in Yingxiu town of Wenchuan county).

3 Data and processing

The bench marks of Dujiangyan-Wenchuan leveling line were massively damaged by the earthquake, and became unusable. During the investigation from August

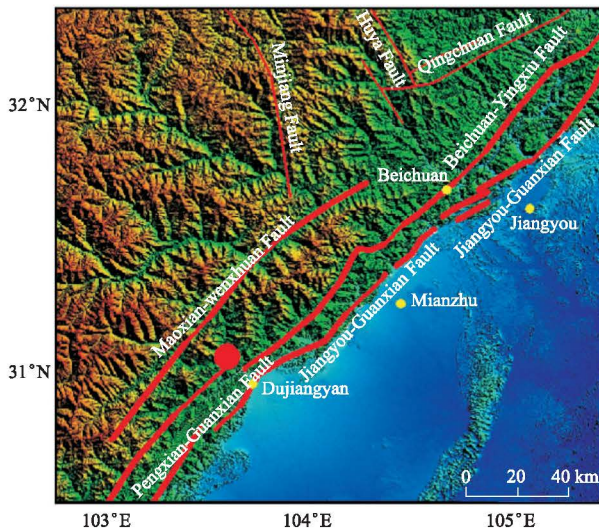


Figure 1 Distribution of regional faults and epicenter location of Wenchuan M_s 8.0 earthquake

to September in 2008, two first order leveling lines were measured, one is 201.8 km long from Pingwu, Beichuan to Mianzhu, and the other is 35.6 km long from Guixi to Jiangyou (Fig. 2). About 50% of the bench marks of these lines were destroyed in the earthquake. The equipment used include an electronic level meter (Ni002A), an invariable level staff, and an iron foot-plate. The leveling measurement was made strictly according to China's first, second order leveling specifications. The root-mean-squares error is ± 0.385 mm/km for the line from Pingwu, Beichuan to Mianzhu, and ± 0.385 mm/km for the line from Guixi to Jiangyou.

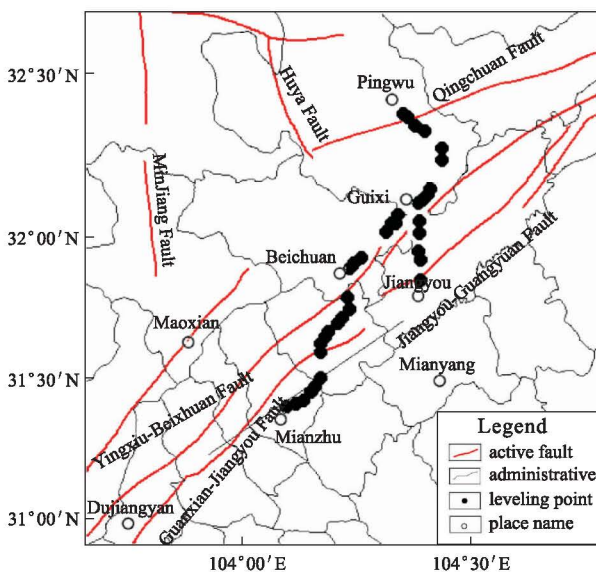


Figure 2 Location of the leveling lines used in this investigation (2008)

A team from First Crust Monitoring and Application Center (CEA) measured the two remaining leveling lines in Sichuan in June, 2010. The root-mean-squares error is ± 0.333 mm/km for the line from Pingwu, Beichuan to Mianzhu, and ± 0.376 mm/km for the line from Guixi to Jiangyou.

Figure 2 shows the leveling line from Pingwu-Beichuan to Mianzhu across Qingshan, Beichuan-Yingxiu and Guanxian-Jiangyou faults and the line from Guixi to Jiangyou across Jiangyou-Guanxian fault. The former line passes through the Beichuan area from NE to SW, thus providing the best data to analyze the vertical displacement of the earthquake fracture near this worst-damage area. However, due to transportation paralysis and bench marks loss, leveling work was not done very close to Beichuan. By calculating and processing the leveling data in 2008 and 2010, the post-seismic vertical displacement was analyzed near Beichuan. The bench mark (II Pingbai 7) in Gucheng town of Pingwu county was used as the datum reference point, because its elevation did not change significantly during this period.

4 Vertical displacements

In the following, the measured pre-earthquake, co-seismic and post-seismic vertical displacements are presented and discussed.

4.1 Pre-earthquake vertical displacement

The vertical deformation in the area of Longmenshan fault before the earthquake was presented in a previous paper^[7], and is shown in figure 3. It may be seen that during 1975 – 1997 the bench marks in the Anxian-Mianzhu area showed subsidence, while those in other areas showed uplift. The deformation rates were entirely different between the mountainous area on the west side of Longmenshan fault and the Sichuan basin on the east side. The former area showed an uplift rate several times larger than the subsidence rate shown in the latter area. If taking Sichuan basin as the frame of reference, Sichuan plateau west of Longmenshan showed an uplift rate of 3.5 mm/a, and Longmenshan showed an uplift rate of less than 0.5 mm/a to 1.5 mm/a; the rate gradually increased from east to west.

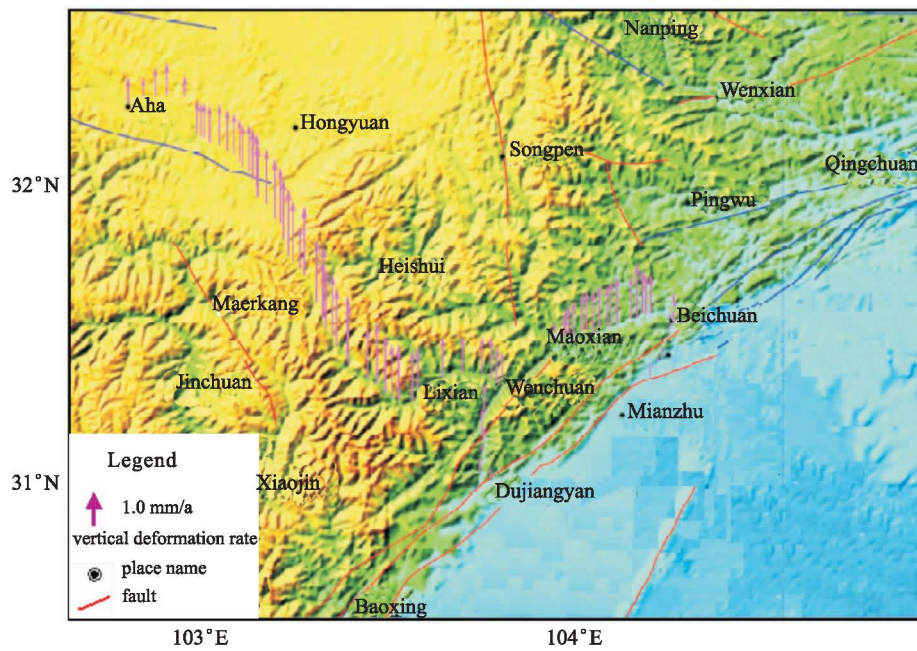


Figure 3 Pre-earthquake vertical deformation rate in Longmenshan fault during 1975 – 1997^[7]

4.2 Co-seismic vertical displacement

The observed co-seismic vertical displacements are shown in figures 4 and 5^[2], and they have the following features :

(1) They are closely correlated with distance from the fault; larger amplitude, if closer.

(2) The relative displacement between the hanging and foot walls of the Qingchuan fault in Pingwu county was only 0.064 m, indicating little relative movement; no fracture was observed on the surface either.

(3) The displacement at Beichuan-Yingxiu fault was as large as 4.711 m near Beichuan, about 2.440 m near Guixi, and 1.003 m near Nanba town in Pingwu county.

(4) The relative displacement between the hanging and foot walls of Beichuan-Yingxiu fault near Beichuan was 5.100 m.

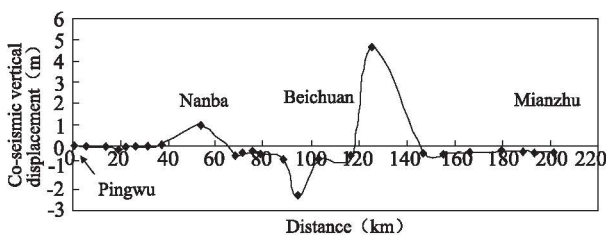


Figure 4 Co-seismic vertical displacements of Wenchuan earthquake in Pingwu-Beichuan-Mianzhu area^[2]

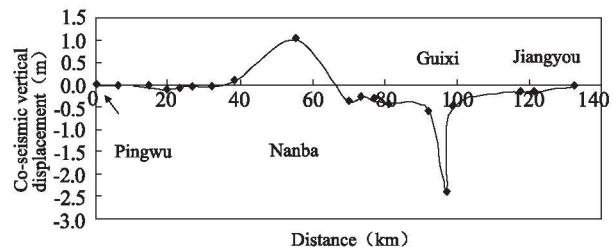


Figure 5 Co-seismic vertical displacement of Wenchuan earthquake in Pingwu-Guixi-Jiangyou area^[2]

4.3 Post-seismic vertical displacement

Post-seismic vertical displacements calculated from the leveling data observed in 2008 and 2010 show the following features (Figs. 6 and 7) :

(1) They showed mainly uplift, with an amplitude of 10 – 53 millimeters and a yearly rate of 5 – 27 mm/a near Beichuan.

(2) They were large near the Beichuan-Yingxiu fault, with a maximum of 54.4 millimeters in Beichuan.

(3) They were large near Jiangyou-Guangyuan fault, with a maximum of 41.2 millimeters near Dakang town in Jiangyou.

(4) They were small near Gucheng town of Pingwu county, with a yearly rate of 0.2 – 1.3 mm/a, indicating little activity of Qingchuan fault.

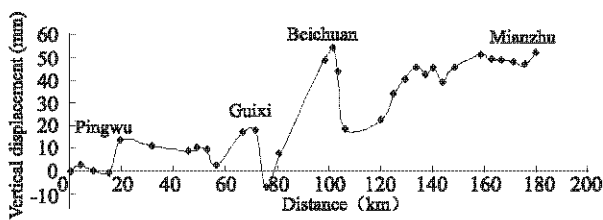


Figure 6 Post-seismic vertical displacement in Pingwu-Beichuan-Mianzhu area(2008 – 2010)

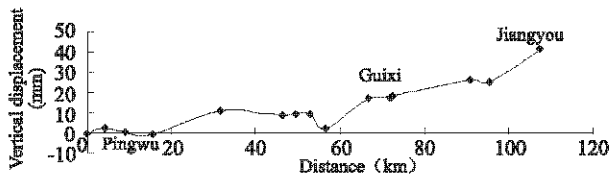


Figure 7 Post-seismic vertical displacement in Pingwu-Guixi-Jiangyou area(2008 – 2010)

5 Conclusions and discussion

Although, due to earthquake damage, only two partly damaged leveling lines of the leveling network were left for measurement, the results from the investigations in 2008 and 2010 did provide the following preliminary information:

(1) The post-seismic vertical displacements were mainly uplift near Beichuan, with an amplitude of 10 – 53 mm and a yearly rate of 5 – 27 mm/a, which was 10 – 50 times of the normal rate.

(2) The post-seismic vertical displacement was larger for sites closer to the Beichuan-Yingxiu fault, showing that the fault was active from 2008 to 2010.

(3) The region from Beichuan to Mianzhu in Bei

-chuan-Yingxiu fault was active from 2008 to 2010, with a yearly uplift rate of 20 mm/a.

(4) The maximum co-seismic vertical displacement was 4.711 m at Beichuan-Yingxiu fault near Beichuan, and the post-seismic vertical displacement there was 10 – 53 mm from 2008 to 2010. These two features suggest that this fault will be active for a long time to come.

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