Seismotectonics of the 2008 and 2009 Qaidam earthquakes and its implication for regional tectonics

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Introduction

Three magnitude >6 earthquakes struck Qaidam, Qinghai province, China, in November 10th 2008, August 28th and 31st 2009 respectively. Some researchers proposed that seismogenic fault was the steep Zongwulongshan thrust based on co-seismic deformation from InSAR data during the 2008 earthquake (Elliott et al, 2011; Wen et al, 2012) and the 2009 earthquakes (Elliott et al, 2011). Their conclusions for the Zongwulongshan thrust is not compatible with field documents and regional tectonic stess (Ye et al, 1996; Wu et al, 2009; Li et al, 2010). We used our local GPS data and focal mechanisms to locate the seismogenic faults. The most recent surface faulting and folding were discussed with geological and geomorphological data.

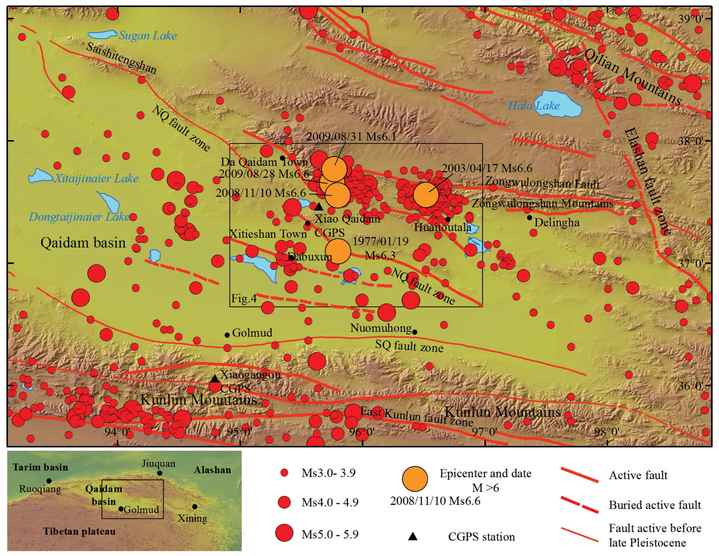

Fig.1 Regional active faults and seismicity around the north margin of Qaidam basin

GPS data

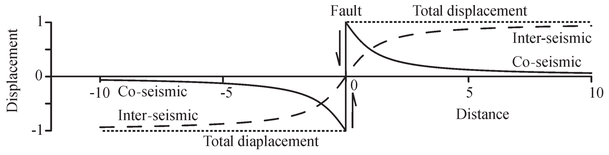

Fig.2 fault dislocation and elastic-rebound model

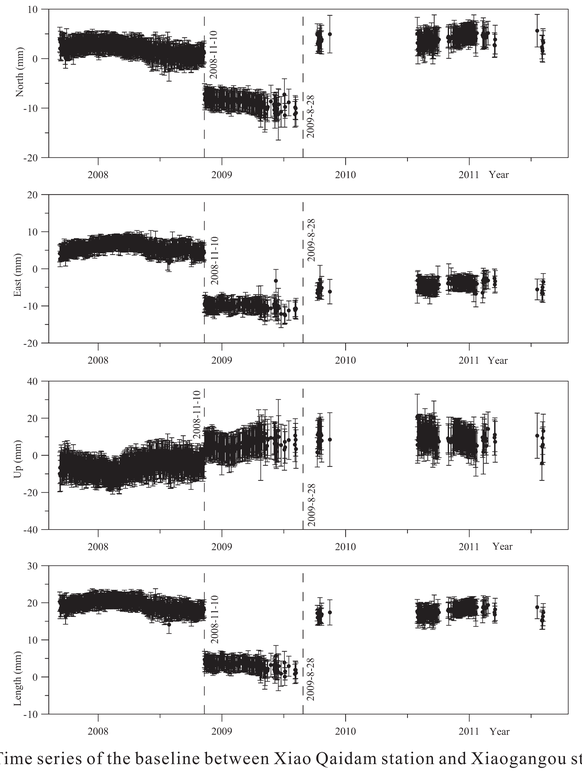

Fig.3. Time series of the baseline between Xiao Qaidam station and Xiaogangou station

We can determine the location of the GPS stations with respect to the faulting block by interseismic and co-seismic motion of these GPS stations as show in dislocation model.

For the 2008 earthquake, Xiao Qaidam station and Xiaogangou Station are located in different wall of the seismogenic fault.

GPS data indicate that the seismogenic fault of the 2009 earthquakes are located on the north of the Xiao Qaidam CGPS station.

GlobalCMT solutions

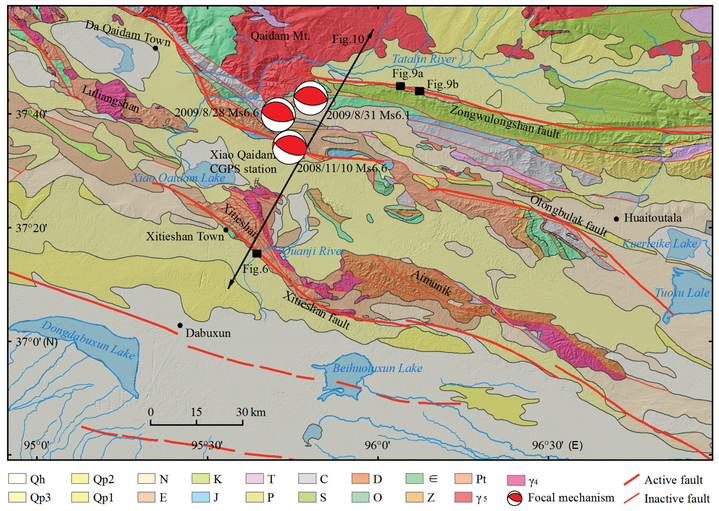

Fig.4. Simplified Geological map shaded with relief and globalCMT solutions

	strike	dip	slip	Strike sense	regional
2008.11.10	252	28	57	left-lateral	√
	108	67	106	right-lateral	
2009.08.28	295	31	102	right-lateral	
	101	60	83	left-lateral	√
2009.08.31	277	33	90		
	98	57	90		

The NWW and E-W trending faults are reverse with left lateral on the northern margin of the Qaidam basin and Qilianshan - Hexi Corridor area according to GPS geodesy and geologial data.

The seismogenic fault of 2008 Ms6.6 earthquake is located about 50km on the south of the epicenter according to the focal mechanism solution and source location.

The seismogenic fault of 2009 Ms 6.6 earthquake is located on the north of the epicenter.

Seismicity

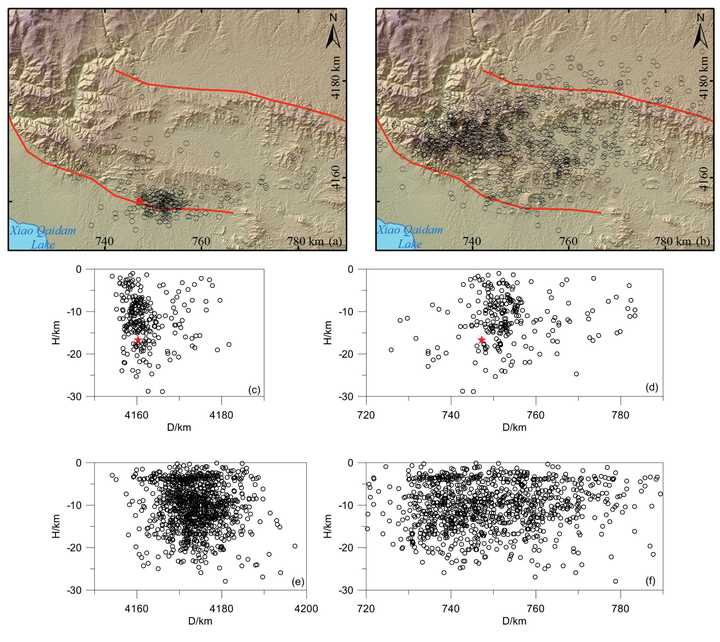

Fig.5. Relocated aftershocks around the 2008 and 2009 earthquakes
Aftershocks during Nov. 10th 2008 to Aug. 18th 2009: map view (a); N-S profile (c); E-W profile (d);
Aftershocks during Aug. 28th 2009 to Dec. 31st 2009: map view (b); N-S profile (e); E-W profile (f);
Red star shows the epicenter of Nov. 10th 2008 Ms6.6 earthquake as the reference for the relocation.

The aftershocks of the 2008 earthquake are mainly clustered on the south of the aftershocks of the 2009 earthquakes with similar depth of 5-20 km. The horizontal migration of aftershocks in the cross section may indicates different seismogenic faults rather than different segments of the same fault for these two main shocks.

Active faulting and folding

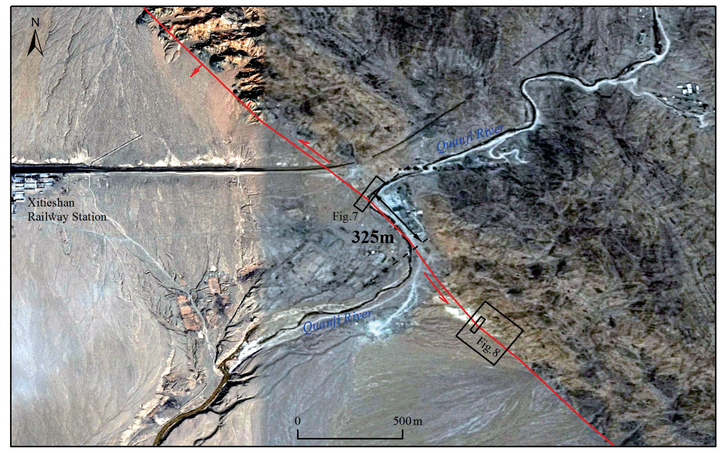

Fig.6. Offset and image of the piedmont of Quanji River near Xitieshan Railway Station

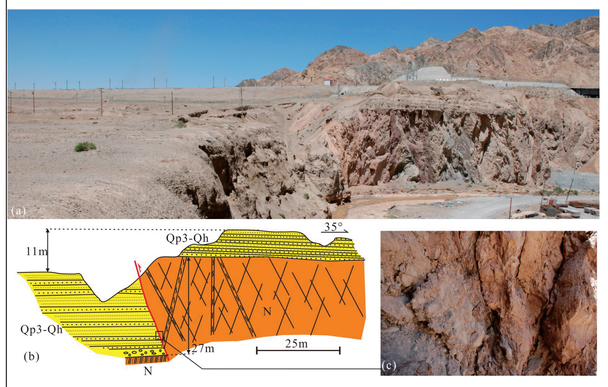

Fig.7. Field photo (a), profile (b) of the Xitieshan fault excavated by the Quanji River, and foliations along the fault plane(c)

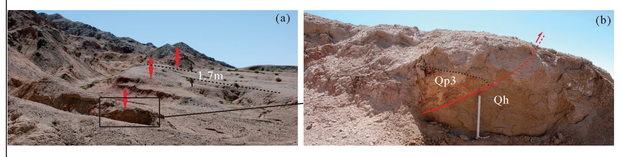

Fig.8. Offset alluvial fans (a) and fault profile (b) of the Xitieshan fault

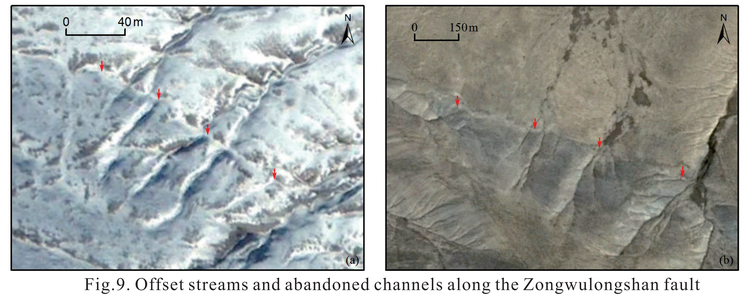

Fig.9. Offset streams and abandoned channels along the Zongwulongshan fault

The offset landforms show that the Xitieshan fault and Zongwulongshan fault were quite active in the past several thousand years.

The Tatalin River incised deeply into the Qaidam Mountains in the hanging wall of the Zongwulongshan fault, and the Quanji River incised deeply into the Xitieshan Mountains in the hanging wall of the Xitieshan fault. These uplifting and incising landforms indicate significant deformation in the hanging wall of the thrust during the late Quaternary. The uplift and folding may have absorbed a large part of shortening across the northern margin of the Qaidam basin.

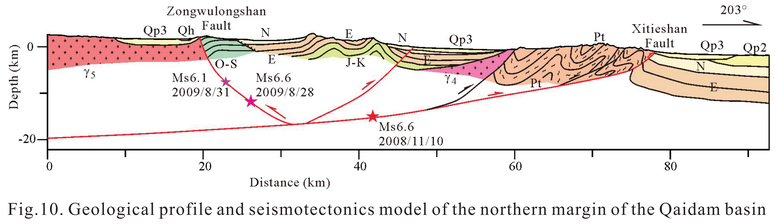

Fig.10. Geological profile and seismotectonics model of the northern margin of the Qaidam basin

Conclusions

We analyzed the co-seismic displacement recorded by our continuous GPS, the focal mechanism, relocated aftershocks and field geological and geomorphological investigation on the Xitieshan fault and Zongwulongshan fault. The Xitieshan fault is the seismogenic fault of the 2008 Qaidam earthquake, which is located on the south of the epicenter and the Xiao Qaidam CGPS station. The Xitieshan fault is a southward thrusting fault with low dip angle and active folding in the hanging wall. The Zongwulongshan fault is the seismogenic fault of the 2009 Qaidam earthquakes, which is a south-dipping back thrust of the northern margin thrust system of the Qaidam basin.

The Xitieshan fault and Zongwulongshan fault are fold-related faults, and the shortening and uplift of folding in the hanging wall is a large part of deformation across the northern marginal thrust of the Qaidam basin. Faulting and its related folding dominate the contemporary structure style of the northern margin of the Qaidam basin and Qilianshan tectonic system. This kind of fault and fold system determines that the earthquake activity in such a region is characterized with small magnitude and high frequency.

(References Omitted)