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Fault Heterogeneities of Moderately Large Earthquakes at Eastern Tibetan Plateau

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1 Introduction

Coseismic rupture area of a large earthquake is often estimated from aftershock distribution. However, recent studies on the details of moment release distribution show that aftershocks do not always overlap the coseismic rupture area (e.g., Mendoza and Hartzell, 1988).

In this study, we derive the details of the rupture process of three earthquakes using teleseismic waveforms, and examine the relationship between coseismic rupture area and well-located aftershock distribution.

2 Data and Methods

The earthquakes studied here are the 2013 Yaan earthquake ($M_w 6.7$), the 2012 Myanmar earthquake ($M_w 6.8$), and the 2010 Yushu earthquake ($M_w 6.8$) (Fig.1 and Tab.1). These three earthquakes have almost the same magnitude, but with different features regarding their tectonic background and their focal mechanisms. Aftershocks of these earthquakes are widely distributed. We examine the aftershocks with magnitudes down to 2 for the 2013 Yaan and the 2010 Yushu earthquakes because they are recorded by dense local seismic networks (Wang et al., 2010). For the 2012 Myanmar one, we examine aftershocks of larger than 4 which are taken from the USGS PDE catalogue.

To determine the slip distributions, we carry out waveform inversions using teleseismic direct P wave data (Kikuchi and Kanamori, 1982). Waveforms are obtained from the IRIS DMC for stations at distance ranges of 30° and 95° . We calculate synthetic P waveforms using a velocity model comprised of a uniform mantle ($V_p=8.10$ km/s, $V_s=4.68$ km/s) and a two-layer crust ($V_p1=5.57$ km/s, $V_s1=3.36$ km/s; $V_p2=6.50$ km/s, $V_s2=3.74$ km/s) for

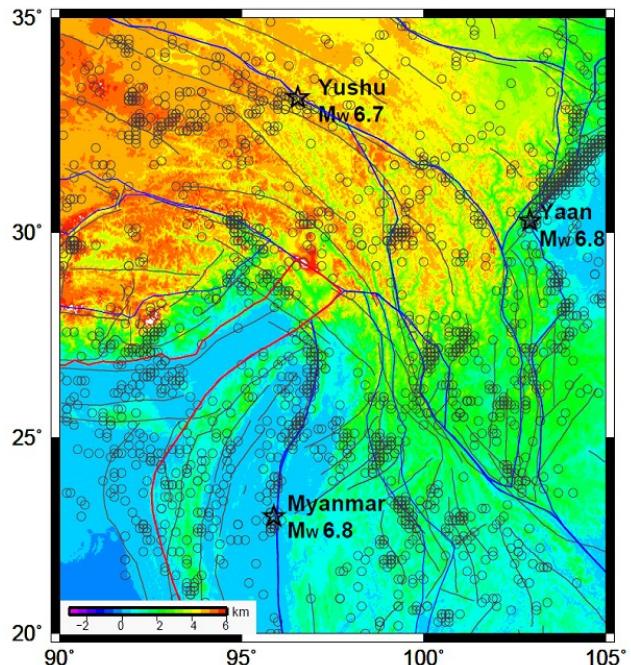


Fig.1. Locations of the three earthquakes studied here (black stars). Gray circles are earthquakes of $M>4.5$ occurred in the past fifty years. Red, blue and gray lines are plate boundary, suture lines and active faults, respectively. The background shows topography.

the source structure (Kennett et al., 1995; Griffin et al., 2011). The depths of the Moho are varied for the various regions using constraints obtained from teleseismic receiver functions and from refraction surveys (Murty et al., 1998).

3 Results

The final results are listed in Tab.1 and also shown in the Fig.2 and Fig.3. Fig.2 shows comparison of vertical-component seismograms with synthetics for the three

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Table 1 Source parameters of three earthquakes obtained from teleseismic waveform inversion

Area	Data	Time, H:M	Lat., °N	Lon., °N	H, km	M _w	Strike/Dip/Rake	Moho, km
Yaan, Sichuan	20 April, 2013	00:02	30.29	102.98	16.5	6.7	34/40/93	50
Myanmar	11 Nov., 2012	01:12	23.01	95.89	10.0	6.8	0/55/-178	40
Yushu, Qinghai	13 April, 2010	23:49	33.19	96.66	5.0	6.8	119/68/0	70

Note: The date and origin time are UTC time.

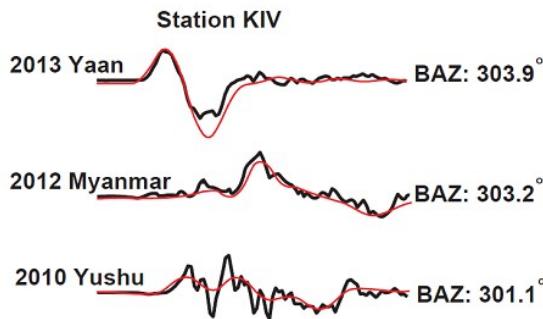


Fig.2. Comparison of recorded waveforms (black) with the synthetics (red) for the three earthquakes recorded at a common station KIV (distance of ~50° and azimuths of ~300°). The time windows are 50 s long and the P waves arrive at ~5 s. Original velocity waveforms are transformed to displacement and band-pass filtered at 0.01 to 1 Hz.

earthquakes. The time windows are 50 s long and the P waves arrive at ~5 s. For the 2013 Yaan earthquake, the P waves have relatively impulsive waveforms with large amplitudes at the beginning. This observation indicates that there is a large slip close to the hypocenter, which is defined as the initial point of rupture. In contrast, for the 2012 Myanmar earthquake, the large amplitudes arrive at ~15 s after the small-amplitude P wave. In this case, the large slip is more distant from the hypocenter. For the 2010 Yushu earthquake, the waveforms are more complicated and have two large amplitudes at the beginning 20 s. The inversion results are able to resolve this difference.

The 2013 Yaan (or Lushan) earthquake (Fig.3(a)) occurred at 00:02 UTC on 20 April 2013 in Yaan city, western Sichuan province, China. This reverse-faulting

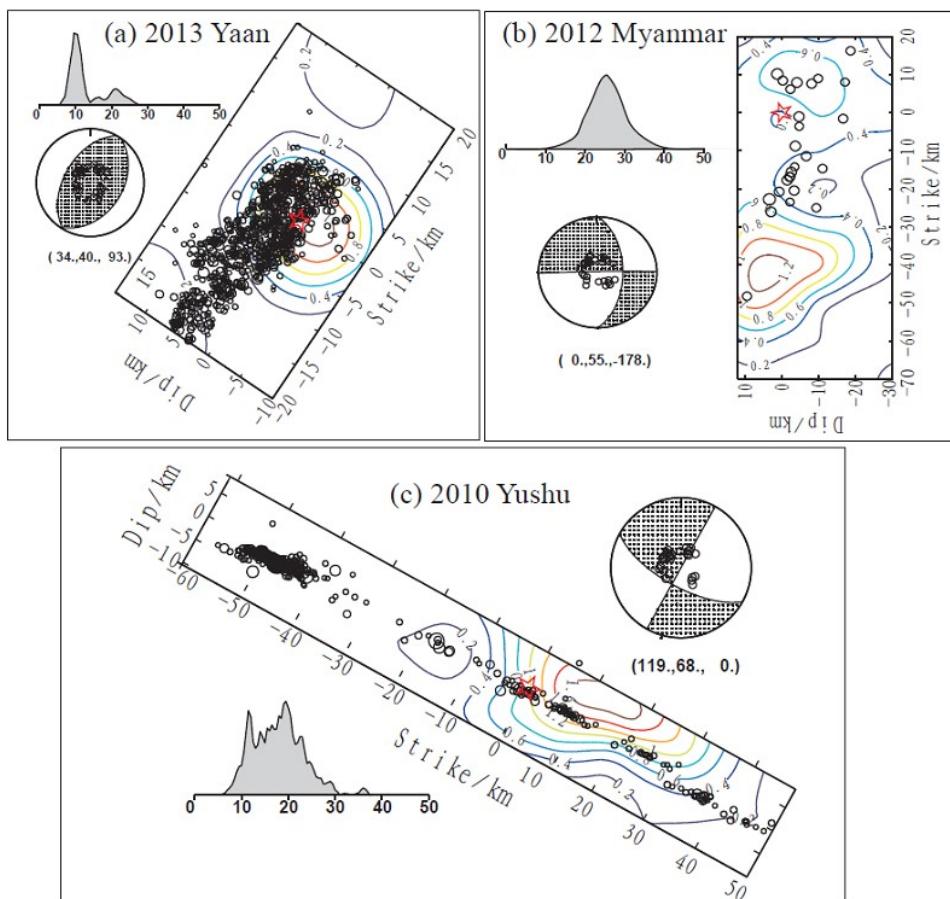


Fig.3. The moment release, focal mechanisms, coseismic slip and aftershock distribution for the three earthquakes. The earthquakes are projected on the fault plane. Contours indicate rupture areas with an interval of 0.2 m.

earthquake is located at the Longmenshan fault, which has been heavily impacted by the 2008 Sichuan earthquake (M_w 7.9). The total seismic moment is 0.12×10^{20} Nm, which equals to a moment magnitude of 6.7. The duration of moment release is ~20 s. There is a significant slip surrounding the hypocenter, consistent with the first big wiggle at the beginning of the waveforms. The aftershock area amounts to ~30*30 km, which is significantly larger than the coseismic rupture area.

The 2012 Myanmar earthquake (Fig.3(b)) occurred at 01:12 UTC on 11 November 2012 in Myanmar. This kind of strike-slip faulting earthquakes predominantly took place along the Sagaing fault, a continental transform fault between the Indian and Sunda plates. The total seismic moment is 0.21×10^{20} Nm, which equals to a moment magnitude of 6.8. The main area of large slip is located ~40 km away from the hypocenter. The directivity caused by this slip distribution can be recognizable from the shorter pulse duration of waveforms to the southern stations. The aftershocks expand on the NS direction around the hypocenter. There is little aftershock activity inside the large slip area.

The 2010 Yushu earthquake (Fig.3(c)) occurred at 23:49 UTC on 13 April 2010 in Yushu city, eastern Qinghai province, China. This earthquake caused extensive damage to the structure, with about 2200 deaths. The total seismic moment is 0.21×10^{20} Nm, which equals to a moment magnitude of 6.8. A major slip took place southeast from the hypocenter. Significant expansion of aftershock activity occurred, with a major subset ~50 km away northeast from the hypocenter.

4 Discussions

When a large earthquake occurs the rupture immediately after the earthquake usually causes strong slips on the fault plane. After the main rupture is completed, the stress change caused by the mainshock gradually propagates outward into the surrounding weak zones. Assuming that

all the earthquakes are occurring on the same fault plane, we can identify the stress change by investigating the relationship between the rupture area and the aftershock distribution.

From the inferred slip distribution and the relocated aftershocks for the three earthquakes, we see that the coseismic rupture areas do not overlap the aftershock area. For the cases of 2013 Yaan and 2011 Yushu earthquakes, the spatial distributions of aftershocks seem to reflect a continuation of the mainshock slip. In contrast, for the 2012 Myanmar earthquake, the large slip seems to take a role of barrier for the aftershock expansion.

Acknowledgements

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Key words: eastern Tibetan plateau, aftershock distribution, source rupture process

References

- Griffin, J.D., Nowack, R.L., Chen, W.-P. and Tseng, T.-L., 2011. Velocity structure of the Tibetan lithosphere: Constraints from P-wave travel times of regional earthquakes. *Bull. Seism. Soc. Am.*, 101: 1938-1947.
- Kikuchi, M. and Kanamori, H., 1982. Inversion of complex body waves. *Bull. Seism. Soc. Am.*, 72: 491-506.
- Kennett, B.L.N., Engdahl, E.R., Buland, R. 1995. Constraints on seismic velocities in the Earth from traveltimes. *Geophys. J. Int.*, 122: 403-416.
- Mendoza, C. and Hartzell, S.H., 1988. Aftershock patterns and main shock faulting. *Bull. Seism. Soc. Am.*, 78: 1438-1449.
- Murty, A.S.N., Mall, D.M., Murty, P.R.K. and Reddy, P.R., 1998. Two-dimensional crustal velocity structure along Hirapur-Mandla profile from seismic refraction and wide-angle reflection data. *Pure Appl. Geophys.*, 152: 247-266.
- Wang Weilai, Wu Jianping, Fang Lihua and Wang Changzai, 2013. Relocation of the Yushu M_s 7.1 earthquake and its aftershocks in 2010 from HypoDD. *Sci. China Earth Sci.*, 56: 182-191.