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InSAR and GPS derived coseismic deformation and fault model of the 2017 Ms7.0 Jiuzhaigou earthquake in the Northeast Bayanhar block

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ABSTRACT

On 8 August 2017, a Ms7.0 earthquake stroke the city of Jiuzhaigou, Sichuan, China. The Jiuzhaigou earthquake occurred on a buried fault in the vicinity of three well-known active faults and this event offers a unique opportunity to study tectonic structures in the epicentral region and stress transferring. Here we present coseismic displacement field maps for this earthquake using descending and ascending Sentinel-1A Interferometric Synthetic Aperture Radar (InSAR) data. Deformation covered an area of approximately 50 × 50 km, with a maximum line-of-sight (LOS) displacement of ~22 cm in ascending and ~14 cm in descending observations on the west side of the source fault. Based on InSAR and Global Positioning System (GPS) measurements, both separately and jointly, we constructed a one-segment model to invert the coseismic slip distribution and dip angle of this event. Our final fault slip model suggests that slip was concentrated at an upper depth of 15 km; there was a maximum slip of ~1.3 m and the rupture was dominated by a left-lateral strike-slip motion. The inverted geodetic moment was approximately 6.75×10^{18} Nm, corresponding to a moment magnitude of Mw6.5, consistent with seismological results. The calculated static Coulomb stress changes indicate that most aftershocks occurred in stress increasing zones caused by the mainshock rupture; the Jiuzhaigou earthquake has brought the western part of the Tazang fault 0.1–0.4 MPa closer to failure, indicating an increasing seismic hazard in this region. The Coulomb stress changes caused by the 2008 Mw7.8 Wenchuan earthquake suggest that stress loading from this event acted as a trigger for the Jiuzhaigou earthquake.

1. Introduction

A moderate earthquake with a magnitude of Ms7.0 struck Jiuzhaigou County, Sichuan, China on 8 August 2017. Its epicentre was located 33.2°N and 103.88°E, and it had a focal depth of 20 km (http://www.csi.ac.cn/). The event, which resulted in 25 casualties and > 250 injuries, represents one in a series of strong intraplate earthquakes that have occurred on the eastern boundary of the Bayanhar block since the 2013 Mw6.6 Lushan earthquake and the 2008 Mw7.8 Wenchuan earthquake (Fig. 1a). According to the aftershock sequence recorded by the Sichuan Seismic Network, 31 M > 3 aftershocks occurred within 10 days of this event, the largest a M4.8 event (http://www.scdzj.gov.cn/dzpd/dzzj/ljysdzzt2775/). Preliminary teleseismic waveform analysis suggested that the rupture process for this event occurred on a left-lateral strike-slip buried fault; the maximum slip was ~0.6 m, occurring at a depth of ~15 km (http://www.cea-igp.ac.cn/). Focal mechanism solutions from different organisations have also indicated coseismic rupture caused by left-lateral strike-slip movement (Table. 1). However, the seismogenic fault responsible for this event has not been identified or studied.

The Ms7.0 Jiuzhaigou earthquake occurred on the northern section of the eastern border of the Bayanhar block, within the Tibetan Plateau (Fig. 1a). Eastward crustal extrusion and the intense deformation of the active Bayanhar block have caused several strong earthquakes (M > 7.0) along the block boundary faults, including the 2008 Mw7.8 Wenchuan, the 2001 Mw7.8 Kokoxili, and the 2013 Mw6.6 Lushan earthquakes (Fig. 1a; Deng et al., 2010; Lasserre et al., 2005; Xie et al., 2013; Xu et al., 2009). This area contains many branch faults and complex structures. The Huya fault, the Tazang fault, and the Minjiang fault are all major active faults in this region (Fig. 1b). Historically, ruptures have occurred on the Huya fault and on the Minjiang fault further to the south, including the 1933 Diexi Ms7.5 earthquake, the 1976 Songpan earthquake swarm (M = 7.2, 6.7, 7.2), and the 1973 Songpan Ms6.5 earthquake (Fig. 1b; Li et al., 1979; Tang and Lu, 1981; Tang et al., 1983a, b). The Tazang fault is a Holocene active fault; its western segment is characterised by strike-slip movement, while the eastern segment demonstrates a thrust mechanism (Ren et al., 2013). It has lower slip rates of ~0.3–1.5 mm/yr along the eastern segment (i.e.,

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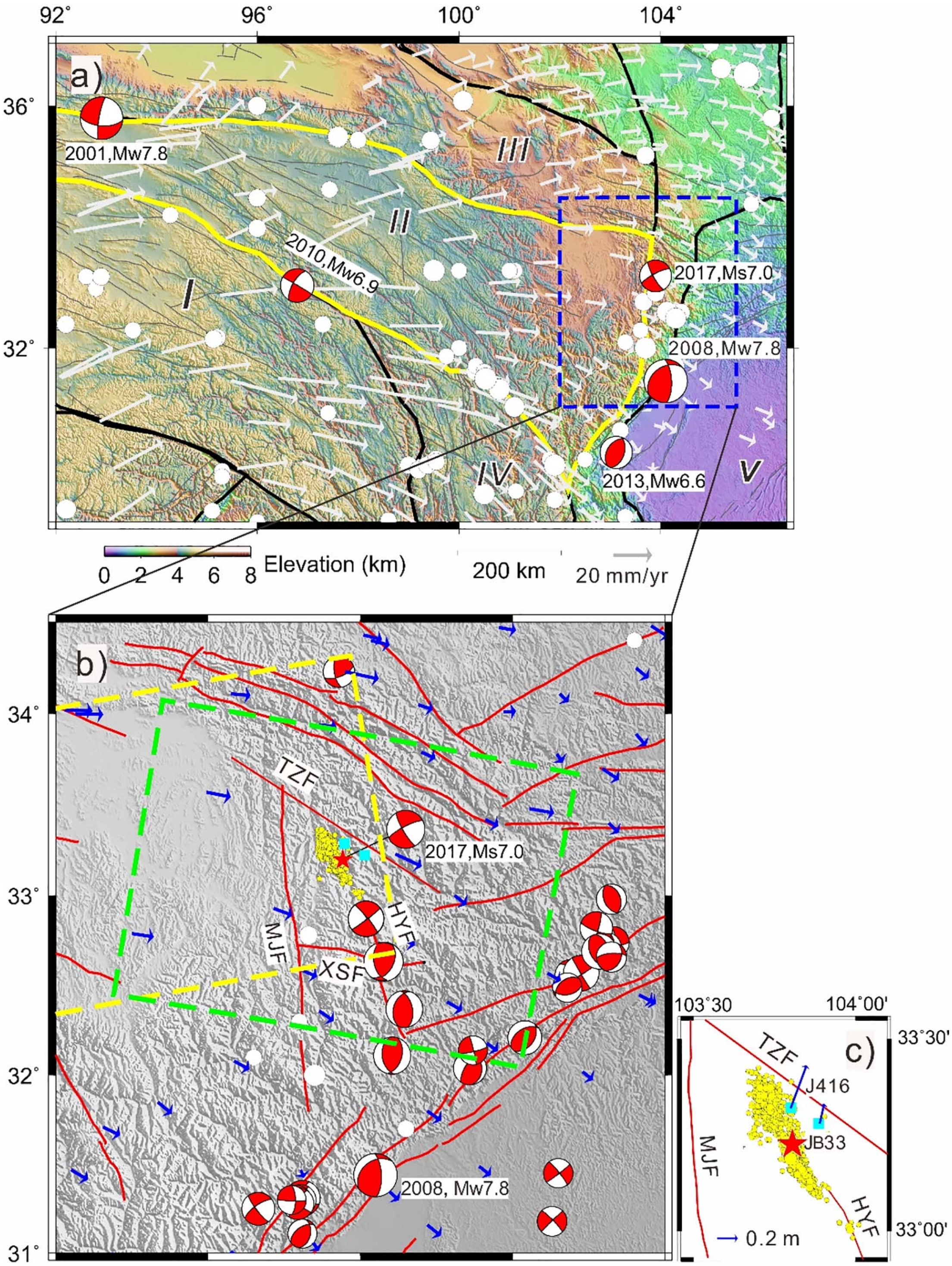

Fig. 1. Study area maps. (a) Tectonic map of the eastern Tibetan Plateau. Beach balls denote Global Centroid Moment Tensors (GCMT, from http://www.globalcmt.org/CMTsearch.html) of four large events (> M6.5) and for the 2017 Jiuzhaigou earthquake. Black and yellow bold lines indicate the boundaries of subblocks, including the Qiangtang (I), Bayanhar (II), Kunlun-Qaidam (III), Chuandian (IV), and Huanan (V) blocks. Grey lines represent active faults. The blue dashed-line rectangle denotes the study area. (b) Enlarged topographic map of the Tazang fault (TZF), the Minjiang fault (MJF), the Huya fault (HYF), and the Xueshan fault (XSF). Yellow and green dashed-line boxes show the coverage of S1A SAR data. Cyan squares denote the locations of *Global Positioning System* (GPS) sites. Yellow circles denote relocated aftershocks following the Jiuzhaigou mainshock (Fang et al., 2017). Beach balls show the moment tensor of the Jiuzhaigou and historical earthquakes. The white dots in (a) and (b) show the locations of historical events. Horizontal component GPS velocity vectors relative to stable Eurasia in (a) and (b) are from Gan et al. (2007). (c) Horizontal coseismic displacements observed by GPS stations J416 and JB33. Epicentres are denoted by red stars. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)