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Seismogenesis and earthquake triggering during the 2010–2011 Rigan (Iran) earthquake sequence

Hiwa Mohammadi [a, *], Thomas J. Bayliss [b], Esmaeil Nekouei Ghachkanlu [a]

[a] Department of Earth Sciences, College of Sciences, Shiraz University, Shiraz, Iran
[b] Seismic Risk Group, School of Environmental Sciences, University of East Anglia, Norwich, Norfolk NR4 7TJ, United Kingdom

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ABSTRACT

This study assesses the aftershock activity of two earthquakes that occurred on December 20, 2010 with magnitude of M_N 6.5 (Global CMT M_w 6.5) and January 27, 2011 with magnitude of M_N 6.0 (Global CMT M_w 6.2) in the Rigan region of southeastern Iran. This study has been done by assessing the statistical properties of the aftershock sequences associated with each of these earthquakes, namely *b*-value of Gutenberg–Richter relation, partitioning of radiated seismic energy, *p*-value of modified Omori law and the D_C-value associated with the fractal dimension. The *b*-values of $b = 0.89 \pm 0.08$ and $b = 0.88 \pm 0.08$ were calculated for first main shock and second main shock sequence respectively. This suggests that this region is characterized by large differential stress; the genesis of large aftershock activity in a short time interval gives power this. Further, 2.2% of the whole energy is related with the aftershocks activity for first main shock sequence while 97.8% is associated with main shock; for second sequence, 20% of the total energy is associated with the aftershocks activity while 80% is associated with main shock. The *p*-values of 1.1 ± 0.12 and 1.1 ± 0.1 were calculated for first and second main shocks sequence respectively, which imply fast decay rate of aftershocks and high surface heat flux. A value of the spatial fractal dimension (D_c) equal to 2.34 ± 0.03 and 2.54 ± 0.02 for first and second main shocks sequence respectively, which reveals random spatial distribution and source in a two-dimensional plane that is being filled-up by fractures. Moreover, we then use the models to calculate the Coulomb stress change to appraise coming seismic hazard by inspecting the static Coulomb stress field due to these two main shocks for the recognition of the conceivable regions of aftershocks activity. The first main shock increased stress by more than 0.866 bars at the hypocenter of the second main shock, thus promoting the failure. In addition, the cumulative coseismic Coulomb stress changes due to the reveals that most of the aftershocks happened in the region of increased Coulomb stress.

1. Introduction

On December 20, 2010 at 22:12 local time, a moderately-sized earthquake of M_N 6.5 (Global CMT M_w 6.5) took place near Rigan in southeastern Iran. Thirty-eight days later, another moderately-sized earthquake M_N 6.0 (Global CMT M_w 6.2) occurred nearby on January 27, 2011 at 12:09 local time on January 27, 2011. The Rigan area is located in southeastern Iran, at the southern segment of the Lut block and the northern border of the Jazmourian depression (Fig. 1). The first main shock resulted in four deaths, all in the low settlement of Chah Qanbar; no casualties were narrated from the 2011 event (Walker et al., 2013). The historical seismicity (Fig. 1) of this area is limited to the earthquakes reported after 1800 A.D. (Ambraseys and Melville, 1982; Berberian, 1995). Berberian (1995) suggests evidence may be present for historical earthquakes around Koohbanan, Zarand, Kerman, Bam and Mahan caused by active faults near them. Important historical earthquakes are the Nosrat-Abad (1838), Hoorjand (November 1854), Chatrood (January 17, 1864), Chatrood (August 4, 1871) and Sirch (1877). The $M_S = 7.0$ Nosrat-Abad earthquake was a shock followed by two years of aftershocks. The $M_S = 5.8$ (MMI = VII+) Hoorjand earthquake destroyed some villages located northeast of Kerman. More recently Iranian seismic activity has been documented on in-situ recording equipment, notably during the 2003 Bam (M_w=6.6) and 1998 (M_S=5.3) earthquakes with known mechanisms and the 1923 (M_S=5.6) with unknown focal mechanism which related to

* Corresponding author.
E-mail address: Hiwa.2006.waran@gmail.com (H. Mohammadi).

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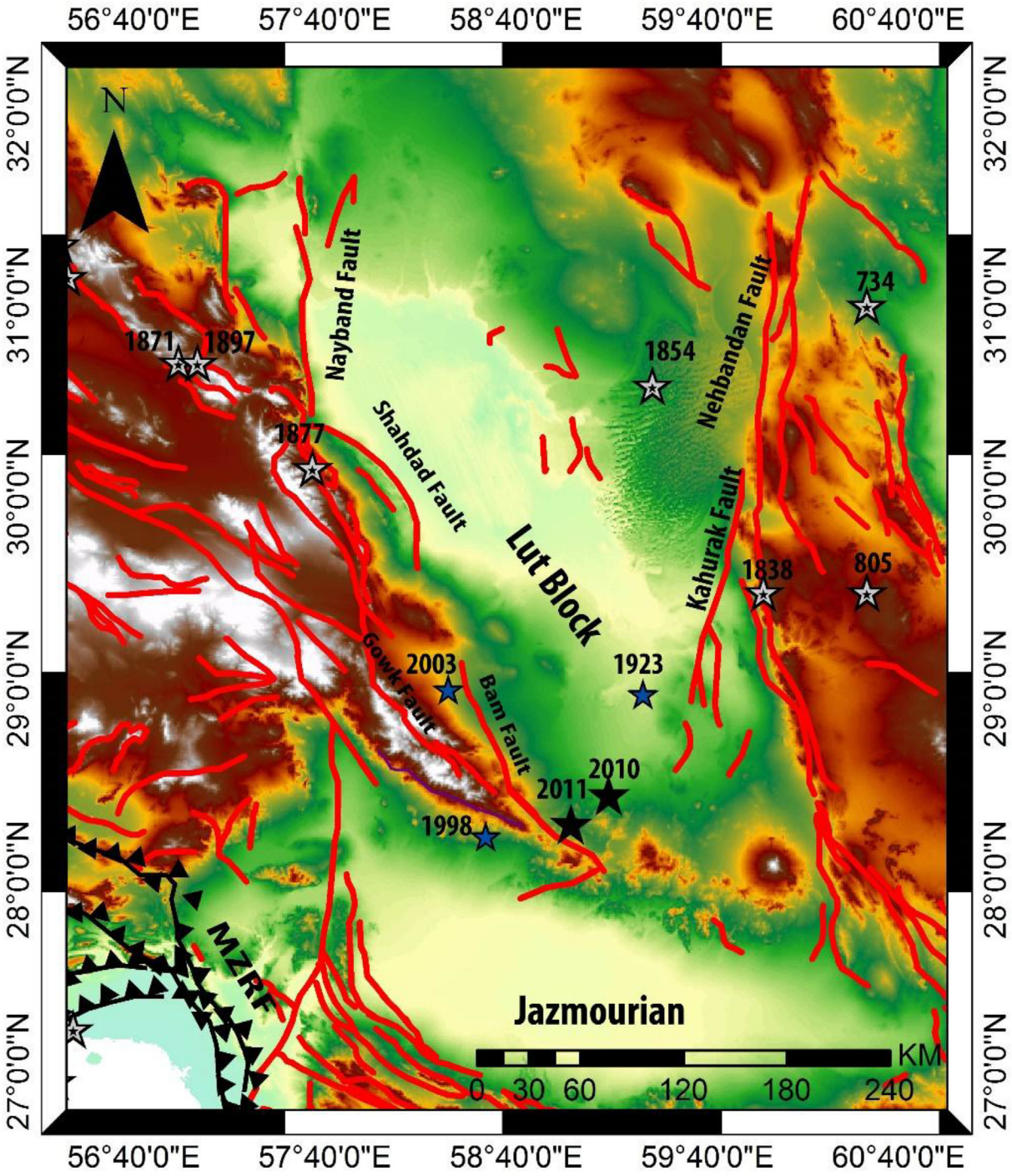

Fig. 1. Simplified tectonic map of SW Iran (Black Stars show epicenter of main shock which occurred December 20, 2010 and January 27, 2011, Blue Stars show instrumental event and Gray Stars show Historical event and major faults adopted from Ashtari-Jafari (2011)). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

the Kahourak fault.

The Lut block is placed in southeastern Iran and expands approximately 200 km east to west and almost 900 km north to south, and is commonly regarded as a non-deforming tectonic structure. It is bordered to the south by the Jazmourian depression, to the north by the Doruneh fault, to the west by the Nayband fault and the Gowk fault system and the Nehbandan fault system in the east (Hessami and Jamali, 2006). The Gowk, Sabzevaran, Bam, Jiroft and the Nehbandan (including Kahurak F., southwest termination) fault zones are the seismically active fault systems close to the epicentral area considered in this study. Rezapour and Mohsenpur (2013) state that December 20, 2010 Rigan earthquake started by enactment of a dextral fault in the upper crust. They also state that the geometries of the conceivable activated fault planes match the Kahurak and Bam faults in the area, while a clear alignment of the epicentral distribution of the aftershocks recorded by the temporary seismic network are consistent with the Kahurak fault trend. However, Ashtari-Jafari (2011) determined that the first main shock