ANALYSIES OF THE BAM EARTHQUAKE, SE IRAN, ON 26 DECEMBER 2003

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ABSTRACT :

On 26 December 2003 at 1:26 utc a large earthquake Mw 6.6, (seismic moment 6-9×10 ^{18} Nm) struck the city of Bam in the Kerman province, southeast Iran. USGS reported that its hypocenter was located at 29.004°N, 58.337°E (IIEES was located at 29.08°N, 58.38°E) and depth 10 km. Teleseismic focal mechanism from several groups show a steeply – dipping right lateral strike-slip fault. This earthquake caused catastrophic damage to Bam city and neighboring villages about 40000 people were killed and about 30000 people injured .The historical citadel “Arg-e-Bam” which is the biggest adobe complex in the world and the world heritage site by UNESCO, was damaged by this earthquake. We investigate the hypocenter of aftershocks of the Bam earthquake by using a temporal seismic network around the city of Bam. A seismic network consisting of 7 temporal stations was installed on 12/28/2003 by a team of geophysics institute of the University of Tehran, and continued until 2/26/2004. Each station was equipped with digital PDAS seismometer. In this study, we obtained the distributions of aftershocks by Hypo71 software. The hypocenters have distributed linearly over about 18-20 Km in parallel with a line 3- 4 km west of the geological Bam fault and extend from the south of Bam city(southeast railway station) to the heavily damaged area in the eastern part of the city including the historical mud brick citadel “Arg-e-Bam”. The aftershocks show that the Bam earthquake occurred not in the Bam fault, but in the new fault parallel geological Bam fault with distance 3- 4 km at west. The relation of the active fault plane to the surface features is still a matter of debate. Some authors suggest the Bam-Baravat scarp is the only active fault. Other authors suggest the co-seismic slip occurred on 2 different faults, a vertical strike-slip fault located west, beneath the co-seismic surface breaks, and a reverse fault dipping 60° westward that reaches the surface 4 km to the east, beneath the Bam-Baravat escarpment. In this study the aftershocks distribution don't confirm the evidence of two distinct faults.

KEYWORDS: Distribution of aftershocks; Strike-slip faulting; Bam earthquake; Iran.

INTRODUCTION

The Bam earthquake of 2003 December 26, occurred in southern termination of Nayband- Gowk-Sabzavaran (N-G-S) system fault, which is located on the west side of the Lut block with the length about 600 Km, en echelon and N-S trending (Fig.1). This system fault accommodates part of the 2.5 $cmyr^{-1}$ northward motion of Arabia relative to Eurasia (Berberian et al.1984; Jackson &McKenzie 1984; Walker & Jackson 2002; Vernant et al. 2004). There are no recorded historical earthquakes at Bam. Most of the citadel of Arg-e-Bam, one of world heritage sites inscribed by UNESCO, which was constructed by mud brick about 2000 years ago destroyed in this earthquake. The historical and instrumental seismic activity associated with the Bam- Baravat Escarpment itself is rather low and most earthquakes are related to the N-G-S system fault, and has also been associated with several large historical earthquakes (Ambraseys & Melville 1982; Berberian & Yeats 1999), (Engdahl et al.1998). Four large earthquakes (M>6) since 1981 have occurred near the Gowk fault zone (Berberian et al., 1984, 2001). The Gowk fault zone, a predominantly right–lateral strike–slip zone that extend from 50 km west of Bam northward (Walker and Jackson, 2002).The Bam- Baravat escarpment, located 2 Km east of the city of Bam, is made of three major segment s, probably active during the Pleistocene time, trending approximately N-S and ranging from 10-30 Km long (Berberian 1976; Hessami et al. 2004).

STATION AND AFTERSHOCK DISTRIBUTION

A seismic network consisting of 7 temporal stations (fig. 2) was installed around Bam city on December 28, 2003 (2 days after mainshock) and monitoring continued February 26, 2004. Each station was equipped with digital seismometer PDAS and L4CD (three components) by institute of Geophysics, University of Tehran. In figure 2 the yellow triangles show the stations location. The aftershocks was recorded, are 1083 events above M 2.7 (fig.2). We selected 243 events that recorded by five upto seven stations; After processing of Data by using Hypo71 software, we used from 3-D velocity model (Tatar et al, 2004) that obtained V_p/V_s ratio from Bam earthquake. Figure3 shows 243 epicenter distributions of aftershocks overlapping on a satellite taken by NASA satellite. Most of epicenters are not on the geological Bam fault (Bam- Baravat fault), but are distributed along a line parallel about 3-4 Km west of the Bam- Baravat fault. The epicenter distribution is nearly linear in the direction of N-S. The dip angle of hypocenter distribution is about 90˚. The trend of aftershocks indicates the new fault begin from south of Bam city toward the north of Bam, 18-20 Km length, and most of aftershocks was occurred in 5-15 Km depth (fig. 4). We suggest a fault model to explain complex geometric pattern of surface ruptures, no two distinct faults (fig.5). This model provides a reasonable tectonic for explaining the relationship between the new rupture and the geological fault (Bam-Baravat fault). The ruptures are produced by a secondary fault, which is connected to the Bam-Baravat fault at depth as shown in fig.5. Analysis of aftershocks indicates that the rupture was located on the Bam-Baravat fault at depth, and main rupture in south of Bam city toward the center of city, west of the Bam-Baravat fault, as suggested by InSAR imagery at surface (Funing et al, 2005) and distribution of aftershocks along this new blind fault (Nakamura et al., 2005; Tatar et al., 2005).

Conclusion

1. *The trend of the epicenter distribution is linear about 18-20 Km axis in the N-W direction, parallel to a line about 3-4 Km west of Bam-Baravat fault on the ground surface.*
2. *The hypocenter distribution shows a nearly vertical trend to lie farther west with depth 5-20 Km for most of aftershocks.*
3. *We suggest a fault model to explain complex geometric pattern of surface ruptures, no two distinct faults. The ruptures are produced by a secondary fault, which is connected to the Bam-Baravat fault at depth about 15 Km.*

PHOTOGRAPHS

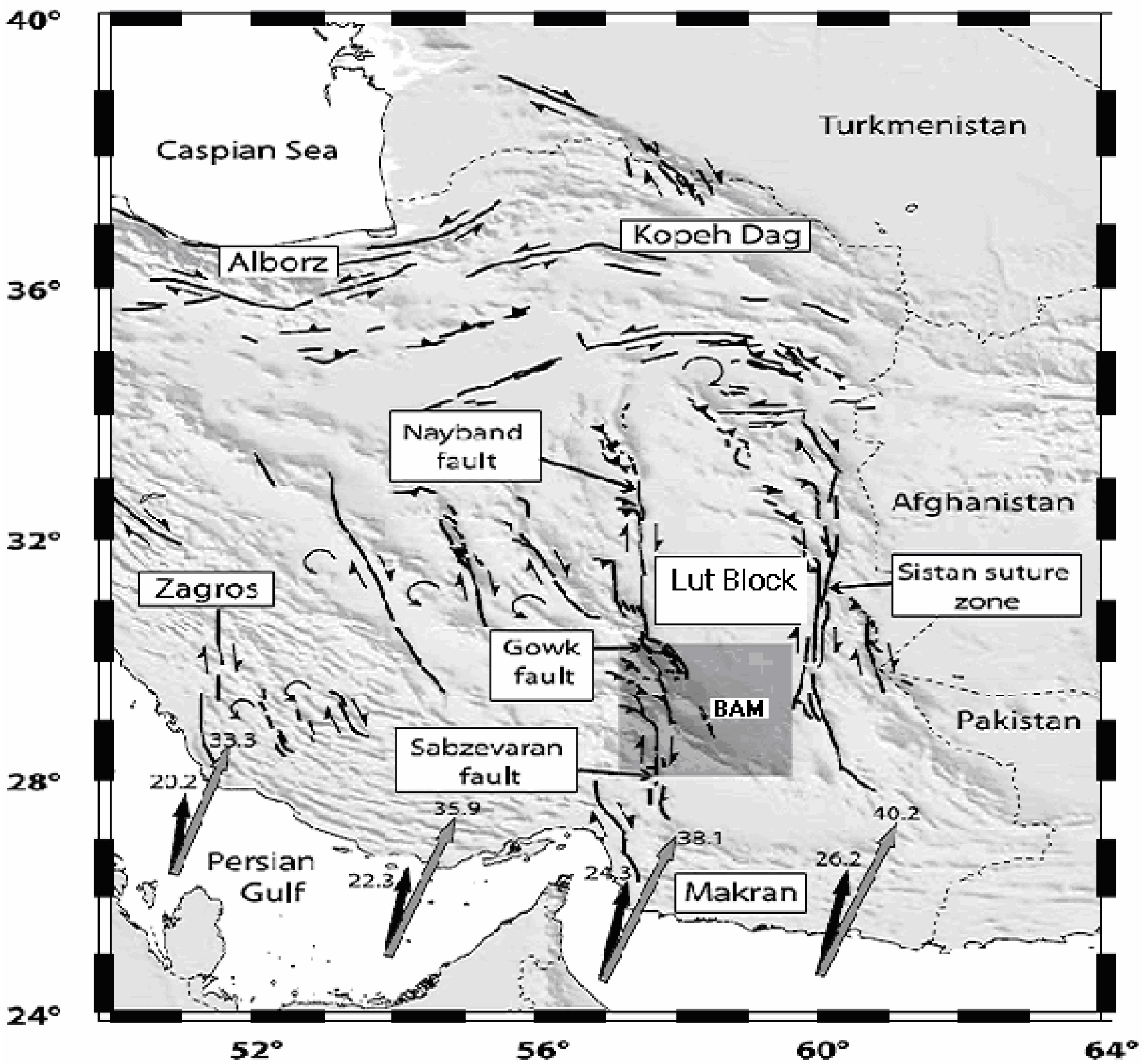

Figure 1. Shaded relief map of central and eastern Iran showing major faults. Arabia-Eurasia relative plate motions are shown as the black and gray arrows, with rates in mmyr^{-1}. Black arrows are GPS estimates (Sella et al.,2002), and gray arrows are 3 Ma average rates based on sea floor magnetic anomalies estimated using Africa-Eurasia (Chu and Gordon, 1998) and Arabia-Africa (Demets et al., 1994) motions. Shaded area shows the location of Bam.

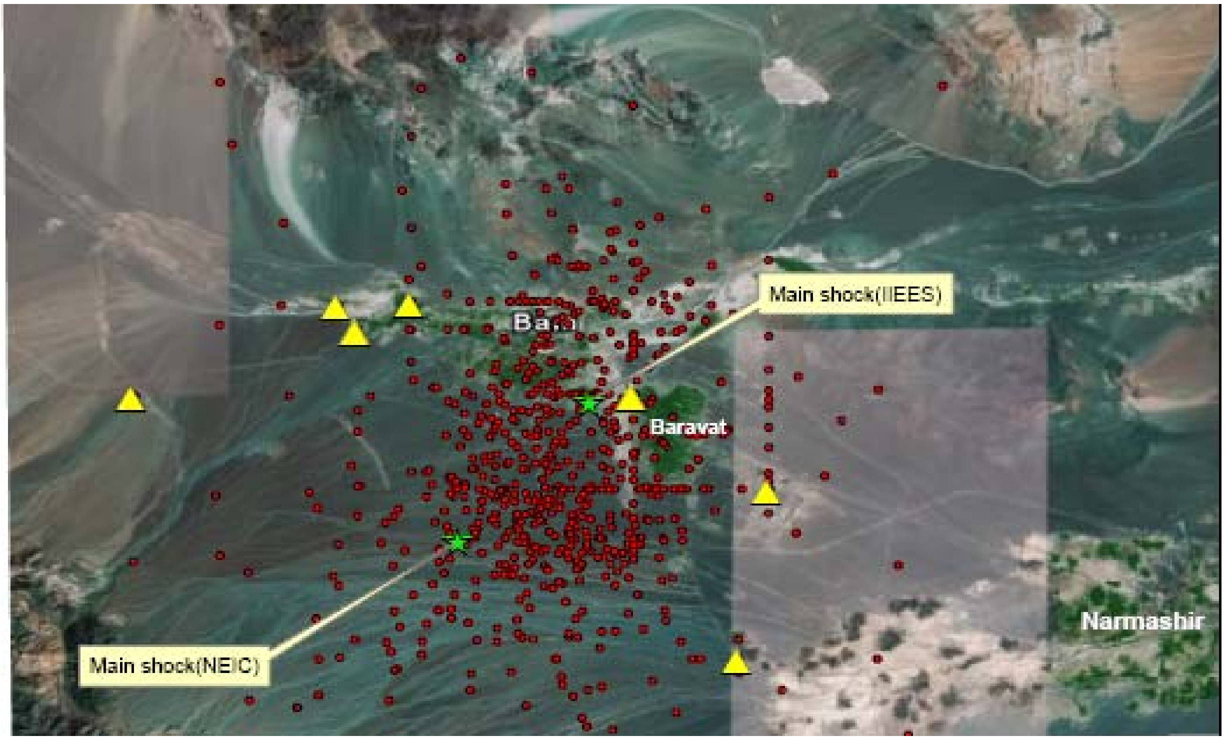

Figure 2. Epicenter distribution (red dots) of 1083 aftershocks, which recorded all of the 7 stations, as shown on the satellite map. Yellow triangle indicates stations of the temporal seismic network, which are installed by a group of Institute of Geophysics, University of Tehran. The green stars indicate the mainshock location by NEIC and IIEES.

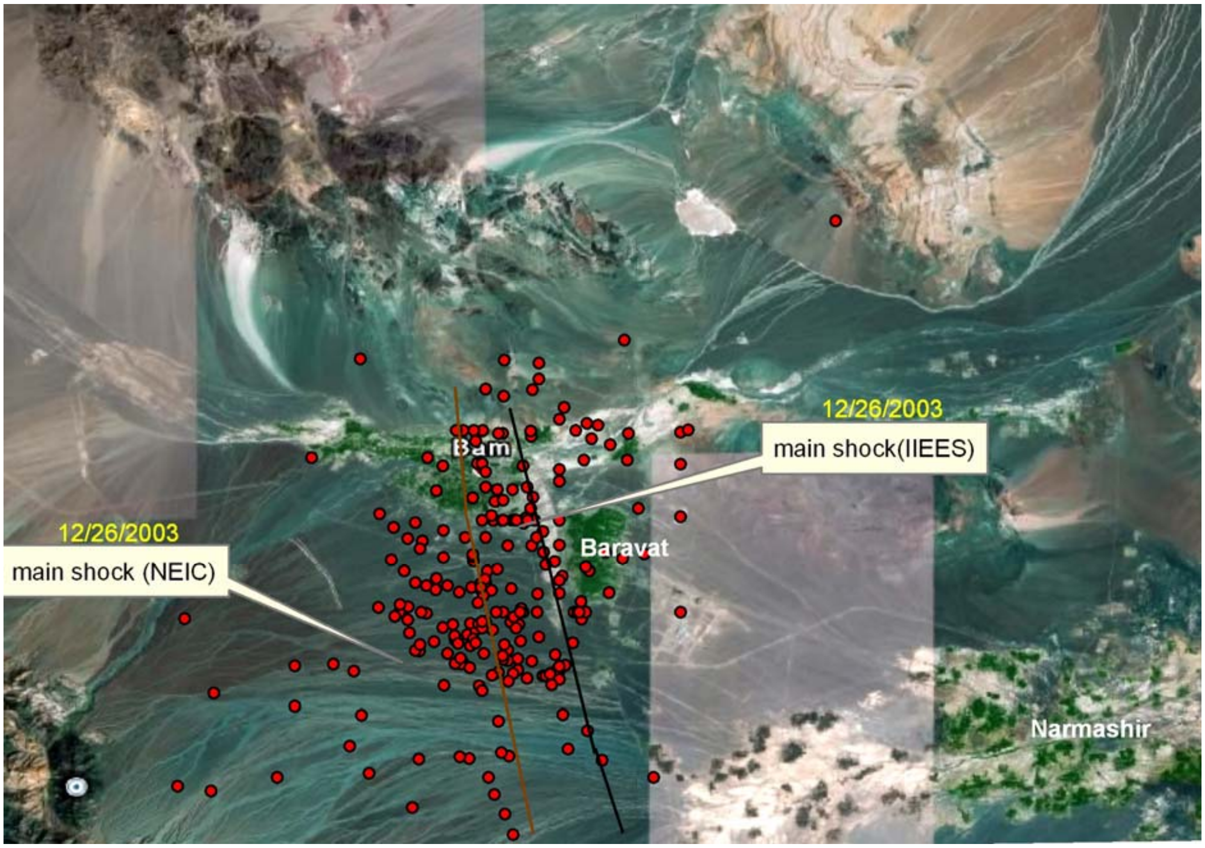

Figure 3. Epicenter distribution (red dots) of 243 aftershocks, which recorded 5 upto7 stations, as shown on the satellite map. Yellow triangle indicates stations of the temporal seismic network. The green stars indicate the mainshock location by NEIC and IIEES. Black line and brown line indicate Bam-Baravat escarpment (geological fault), and blind strike-slip fault (new fault), respectively. The blind strike-slip fault passes the center of Bam city, and the escarpment lied between Bam city and Baravat town.

Figure 4. E-W trending section across the 243 aftershocks showing a vertical plane located beneath the co-seismic surface cracks. Aftershocks are concentrated between 5 and 15 Km depth.

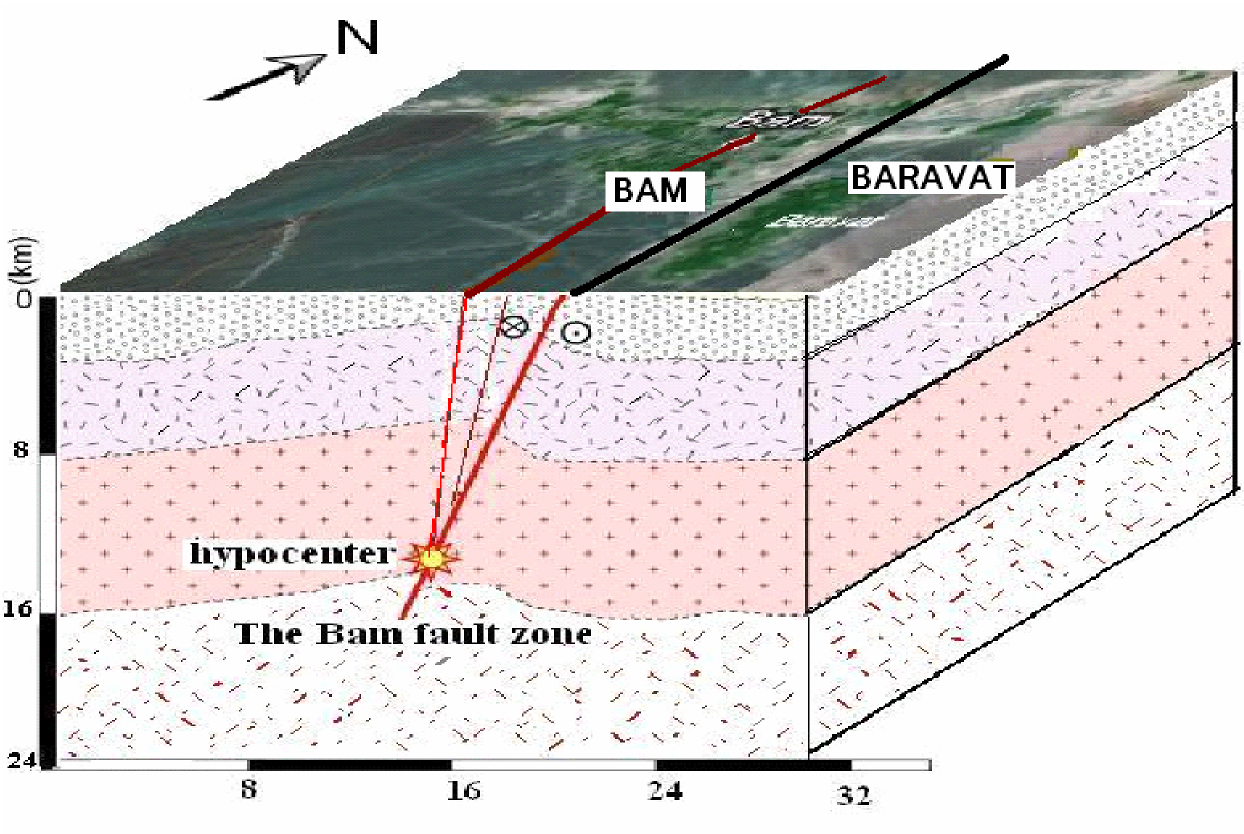

Figure 5. 3-D diagram of fault model for the 2003 Mw6.6 Bam earthquake. Black line and brown line indicate Bam-Baravat escarpment (geological fault), and blind strike-slip fault (new fault), respectively. The blind strike-slip fault passes the center of Bam city, and the escarpment lied between Bam city and Baravat town.

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