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Estimation of the frequency-dependent shear wave Quality Factor from acceleration spectra of the Kahak-Qom earthquake 2007

Saman Amiri[1], Meysam Kheyri Moloumeh[2], Kamran Sepanloo[3]

[1]*International Institute of Earthquake Engineering and Seismology, Tehran, I.R.Iran., Samanmiri0@gmail.com*
[2]*Institute For Advanced Studies in Basic Sciences, Zanjan, I.R.Iran., mkheyrim@iasbs.ac.ir*
[3]*Nuclear Science and Technology Research Institute, Tehran, I.R.Iran., Ksepanloo@aeoi.org.ir*

ABSTRACT
In this study high-frequency strong-motion data of Kahak earthquake have been analyzed to determine the $Q_\beta(f)$ and source parameters by inversion of the recorded data. The data represented 21 accelerograms recorded from Kahak-Qom earthquake in the hypocentral distance range from 16 to 160 km. The seismic hazard map for this region illustrates that most of the area in this province is located within high relative risk and characterized by a large number of heterogeneities. For frequency band of 1 to 20 HZ, the frequency-dependent attenuation for this region found to be $Q_\beta = 167f^{0.78}$. Moreover, the source term obtained from inversion was analyzed to estimate various source parameters. Thereby, we estimated seismic moment (3.98×10^{24}dyne-cm), corner frequency (0.17 Hz), source radius (7.2 Km), stress drop (10.23 bars), which are found to be consistent with the corresponding values reported in published studies. The authenticity of achieved $Q_\beta (f)$ relation is checked by comparing the source spectra in various stations with the theoretical spectra. Low values of the coefficient (Q<200) in the $Q_\beta (f)$ relation suggest that the region is seismically and tectonically active.

Keywords: (Kahak Earthquake, Source parameters, $Q_\beta (f)$, inversion)

INTRODUCTION
On 18 June 2007 an earthquake of Ml=5.7 vibrated the capital of Iran, Tehran. The epicenter of the event was located at the east western flank of Tehran, around 100 km from Qom city. This earthquake is important not only because it vibrated the capital of Iran, with almost 12 million inhabitants, but also because no big earthquake at a distance of less than 200 km has affected so far Tehran according to instrumental records (Hamzehloo et al.2007). An acceleration spectrum contains valuable information regarding the source and medium characteristics. The source spectrum of an earthquake can be approximated by the omega-square model (Brune, 1970), which has ω^2 decay of high frequencies above the corner frequency. The source acceleration spectrum can be estimated from a accelerate record after correcting with diminution function, which accounts for the geometrical spreading and inelastic attenuation. The work presented here is approximately based on the technique of (Fletcher, 1995) and (Joshi 2006a, 2006b) that used inversion methods. In this paper, the Brune's source model (Brune, 1970) is used together with the propagation filter. As it can be seen from Table (1) (Bindi et al., 2006) studied low value of Q_0 (Q_0<200) in North-West of Turkey illustrates tectonically and seismically active while the NE-US (Benz et al., 1997) with high Q_0 are representative for stable regions.

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$$r_0 = 2.34\, \beta / 2\pi f_c \qquad (1)$$

Where $\rho = 2.8\ g/cm^3$ and $\beta = 3.4$ km/s are the mass density and the shear-wave velocity in the vicinity of the earthquake source. For computing the seismic moment of these aftershocks, the following expression given by (Kanamori,.1977) has been used:

$$Log10\ M_0 = 1.5\ M_L + 16.05 \qquad (2)$$

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$$A\ (f) = C.\ S(f).D(f) \qquad (4)$$

Where C is constant at a particular station for a given earthquake, S(f) represents the source acceleration spectra, and D(f) denotes a frequency-dependent diminution function that modifies the spectral shape and is given as (Boore and Atkinson,. 1987):

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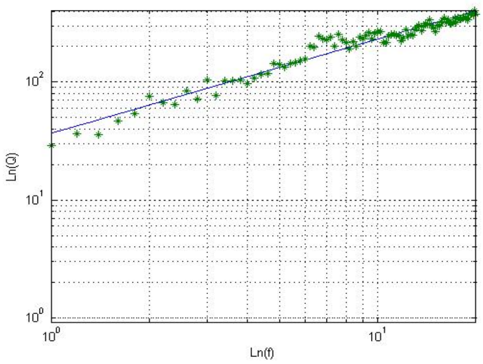
Where $R_{\theta\varphi}$ is the average shear-wave radiation pattern, FS is the free surface amplification; PRTITN is the reduction factor that accounts for partitioning of energy into two horizontal components and is fixed value 0.707 and ρ and β are density, and the shear wave velocity, respectively.



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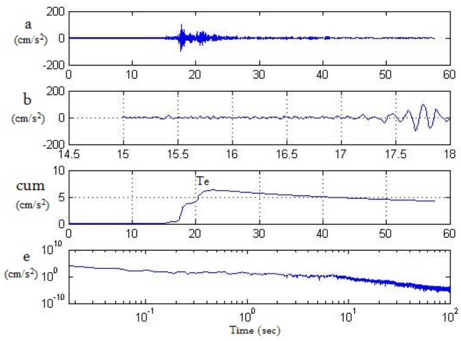

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Inversion matrix can be represented in the following form:

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Model parameters are contained in the model matrix m, and the spectral component is in the data matrix d. Inversion of the G matrix using Newton's method gives the model matrix m as:

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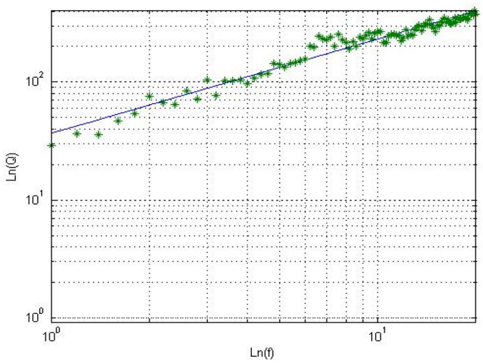

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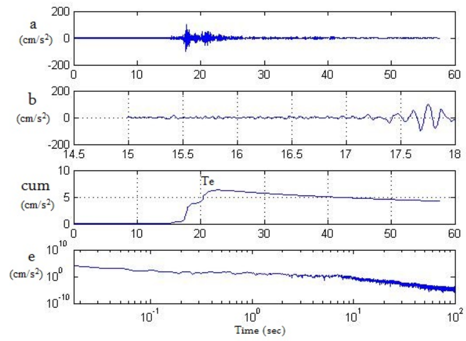

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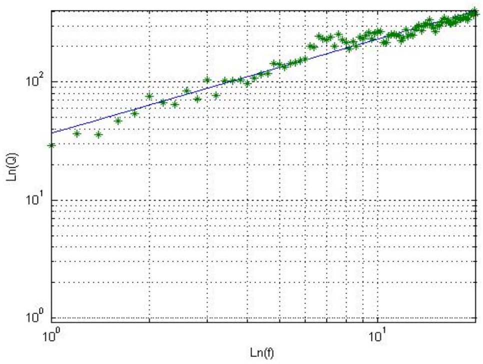

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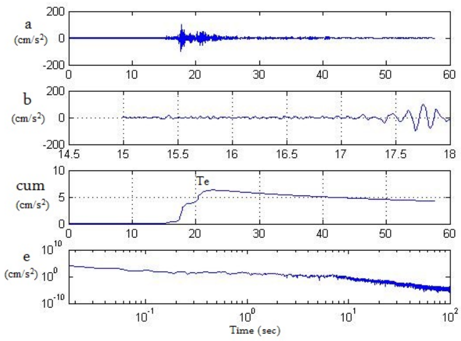

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Estimation of the frequency-dependent shear wave Quality Factor from acceleration spectra of the Kahak-Qom earthquake 2007

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[1]International Institute of Earthquake Engineering and Seismology, Tehran, I.R.Iran., Samanmiri0@gmail.com
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ABSTRACT
In this study high-frequency strong-motion data of Kahak earthquake have been analyzed to determine the $Q_\beta(f)$ and source parameters by inversion of the recorded data. The data represented 21 accelerograms recorded from Kahak-Qom earthquake in the hypocentral distance range from 16 to 160 km. The seismic hazard map for this region illustrates that most of the area in this province is located within high relative risk and characterized by a large number of heterogeneities. For frequency band of 1 to 20 HZ, the frequency-dependent attenuation for this region found to be $Q_\beta = 167f^{0.78}$. Moreover, the source term obtained from inversion was analyzed to estimate various source parameters. Thereby, we estimated seismic moment (3.98×10^{24}dyne-cm), corner frequency (0.17 Hz), source radius (7.2 Km), stress drop (10.23 bars), which are found to be consistent with the corresponding values reported in published studies. The authenticity of achieved Q_β *(f)* relation is checked by comparing the source spectra in various stations with the theoretical spectra. Low values of the coefficient (Q<200) in the Q_β *(f)* relation suggest that the region is seismically and tectonically active.

Keywords: (Kahak Earthquake, Source parameters, Q_β *(f)*, inversion)

INTRODUCTION
On 18 June 2007 an earthquake of Ml=5.7 vibrated the capital of Iran, Tehran. The epicenter of the event was located at the east western flank of Tehran, around 100 km from Qom city. This earthquake is important not only because it vibrated the capital of Iran, with almost 12 million inhabitants, but also because no big earthquake at a distance of less than 200 km has affected so far Tehran according to instrumental records (Hamzehloo et al.2007). An acceleration spectrum contains valuable information regarding the source and medium characteristics. The source spectrum of an earthquake can be approximated by the omega-square model (Brune, 1970), which has ω^2 decay of high frequencies above the corner frequency. The source acceleration spectrum can be estimated from a accelerate record after correcting with diminution function, which accounts for the geometrical spreading and inelastic attenuation. The work presented here is approximately based on the technique of (Fletcher, 1995) and (Joshi 2006a, 2006b) that used inversion methods. In this paper, the Brune's source model (Brune, 1970) is used together with the propagation filter. As it can be seen from Table (1) (Bindi et al., 2006) studied low value of Q_0 (Q_0<200) in North-West of Turkey illustrates tectonically and seismically active while the NE-US (Benz et al., 1997) with high Q_0 are representative for stable regions.

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The main shock have 21 accelerogram of BHRC (Building and Housing Research Center), respectively. All instruments were composed of SSA-2 digital accelerographs with a 10-Gal (0.1 m/s^2) threshold, sampling rate of 200 samples/s, and natural frequency of 50 Hz. This configuration yields a flat acceleration response between the frequencies of 0.01 to 20.

In the first step of estimation, two horizontal components of acceleration were low-pass filtered, with cutoff frequency at 20 Hz, and then vectorized. Inversion analysis is based on detection of S-wave window and the S-wave analysis was based on the SH-waves synthesized from horizontal components, because SH-waves are not affected by other seismic phases. The resulting component, *a(t)*, is transverse to the direction of propagation of the earthquake waves and a time window containing the direct SH wave, was selected from the accelerograms by using Kinoshita algorithm (1994). The second step, (Kinoshita,.1994) method is used for determining the end of *S*-wave time window analysis, in this research. Also, take start of energy descent in diagram by using

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In continue, by applying (Andrews,.1986) formula Equation corner frequency of the SH-waves has been calculated as the first source parameter for each station.

Then, by using corner frequency, M_0, the radius of circular rupture (r_0) and stress drop for events are calculated which are cited in table (2).

One of the significant parameter representing the source is its size, which is defined by the radius for circular rupture. The corner frequency f_c of the source spectra is related to the radius r_0 of the equivalent circular crack, which is used to model the earthquake. Such relations have been given by (Brune., 1970, 1971) as

$$r_0 = 2.34\, \beta / 2\pi f_c \qquad (1)$$

Where $\rho=2.8\ g/cm^3$ and $\beta=3.4$ km/s are the mass density and the shear-wave velocity in the vicinity of the earthquake source. For computing the seismic moment of these aftershocks, the following expression given by (Kanamori,.1977) has been used:

$$Log10\ M_0 = 1.5\ M_L + 16.05 \qquad (2)$$

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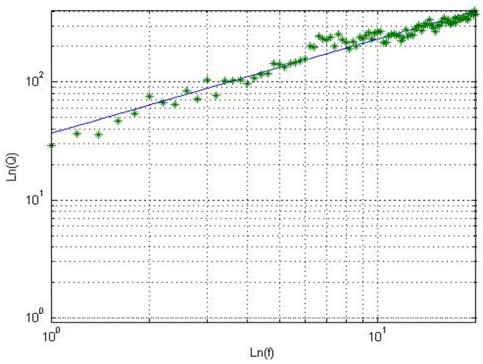

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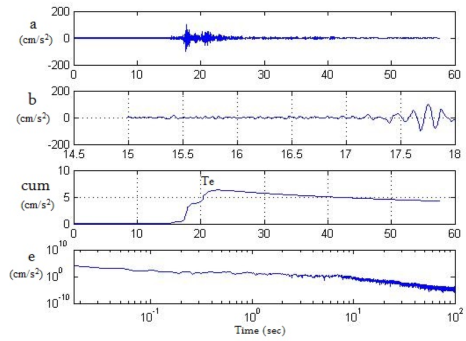

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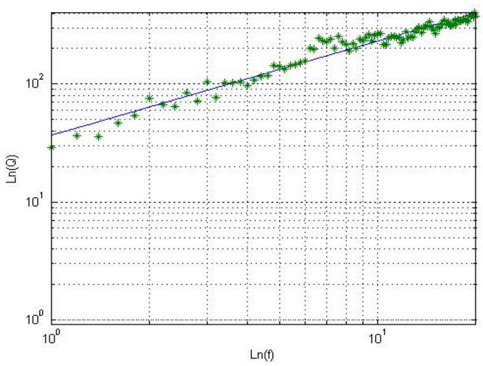

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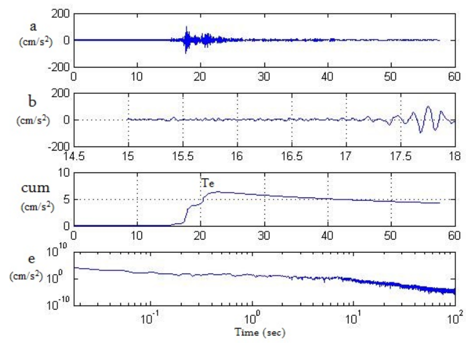

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Estimation of the frequency-dependent shear wave Quality Factor from acceleration spectra of the Kahak-Qom earthquake 2007

Saman Amiri[1], Meysam Kheyri Moloumeh[2], Kamran Sepanloo[3]

[1]*International Institute of Earthquake Engineering and Seismology, Tehran, I.R.Iran.*, Samanmiri0@gmail.com
[2]*Institute For Advanced Studies in Basic Sciences, Zanjan, I.R.Iran.*, mkheyrim@iasbs.ac.ir
[3]*Nuclear Science and Technology Research Institute, Tehran, I.R.Iran.*, Ksepanloo@aeoi.org.ir

ABSTRACT
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Keywords: (Kahak Earthquake, Source parameters, Q_β *(f)*, inversion)

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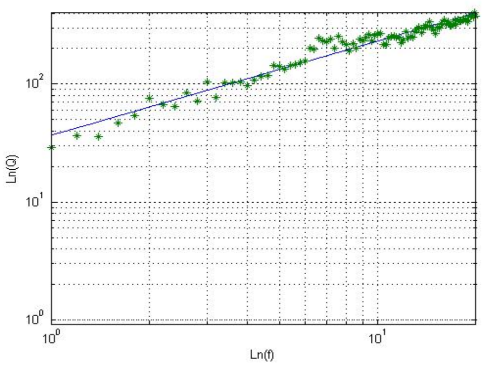

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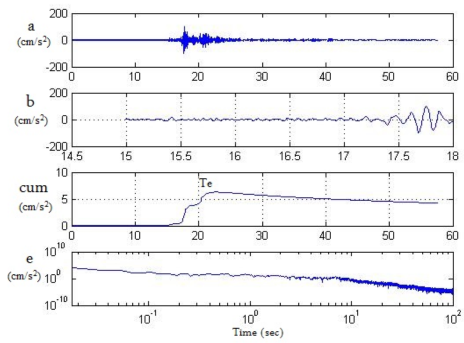

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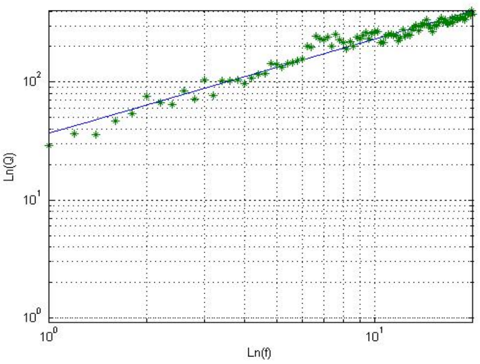

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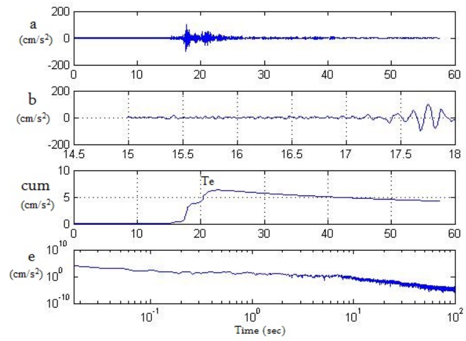

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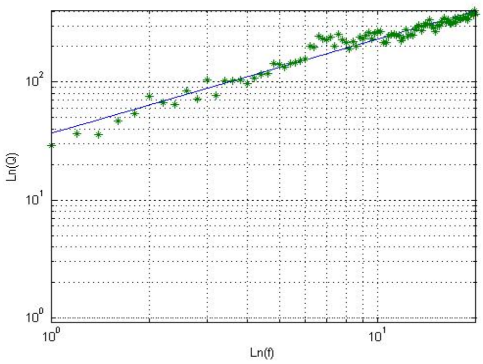

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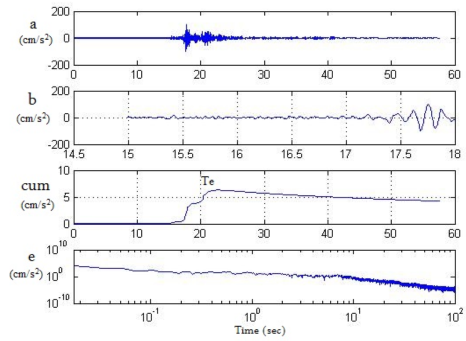

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Estimation of the frequency-dependent shear wave Quality Factor from acceleration spectra of the Kahak-Qom earthquake 2007

Saman Amiri[1], Meysam Kheyri Moloumeh[2], Kamran Sepanloo[3]

[1]International Institute of Earthquake Engineering and Seismology, Tehran, I.R.Iran., Samanmiri0@gmail.com
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ABSTRACT

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Keywords: (Kahak Earthquake, Source parameters, Q_β *(f)*, inversion)

INTRODUCTION

On 18 June 2007 an earthquake of Ml=5.7 vibrated the capital of Iran, Tehran. The epicenter of the event was located at the east western flank of Tehran, around 100 km from Qom city. This earthquake is important not only because it vibrated the capital of Iran, with almost 12 million inhabitants, but also because no big earthquake at a distance of less than 200 km has affected so far Tehran according to instrumental records (Hamzehloo et al.2007). An acceleration spectrum contains valuable information regarding the source and medium characteristics. The source spectrum of an earthquake can be approximated by the omega-square model (Brune, 1970), which has ω^2 decay of high frequencies above the corner frequency. The source acceleration spectrum can be estimated from a accelerate record after correcting with diminution function, which accounts for the geometrical spreading and inelastic attenuation. The work presented here is approximately based on the technique of (Fletcher, 1995) and (Joshi 2006a, 2006b) that used inversion methods. In this paper, the Brune's source model (Brune, 1970) is used together with the propagation filter. As it can be seen from Table (1) (Bindi et al., 2006) studied low value of Q_0 (Q_0<200) in North-West of Turkey illustrates tectonically and seismically active while the NE-US (Benz et al., 1997) with high Q_0 are representative for stable regions.

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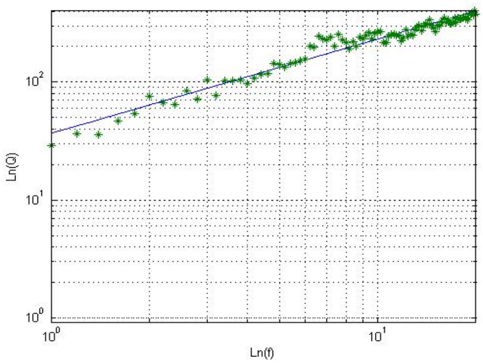

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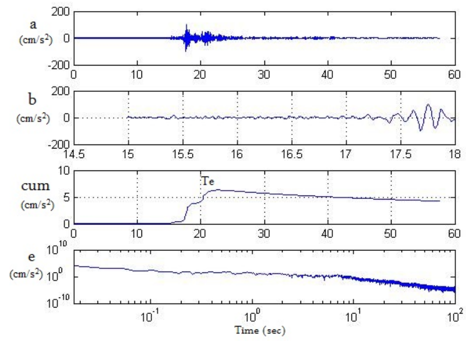

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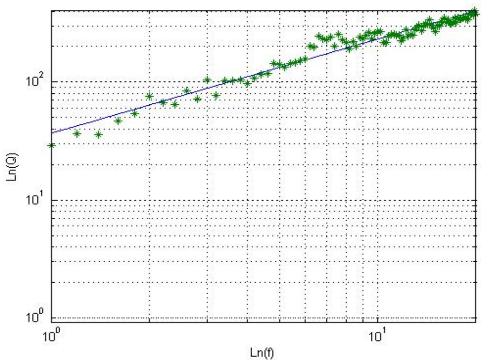

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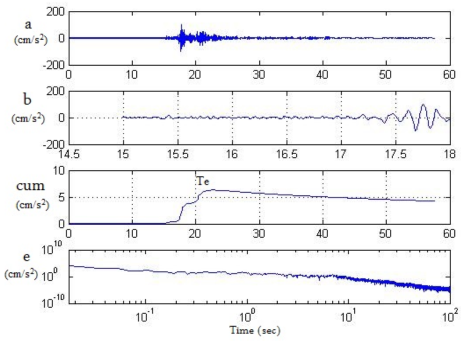

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Estimation of the frequency-dependent shear wave Quality Factor from acceleration spectra of the Kahak-Qom earthquake 2007

Saman Amiri[1], Meysam Kheyri Moloumeh[2], Kamran Sepanloo[3]

[1]International Institute of Earthquake Engineering and Seismology, Tehran, I.R.Iran., Samanmiri0@gmail.com
[2]Institute For Advanced Studies in Basic Sciences, Zanjan, I.R.Iran., mkheyrim@iasbs.ac.ir
[3]Nuclear Science and Technology Research Institute, Tehran, I.R.Iran., Ksepanloo@aeoi.org.ir

ABSTRACT

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Then, by using corner frequency, M_0, the radius of circular rupture (r_0) and stress drop for events are calculated which are cited in table (2).
One of the significant parameter representing the source is its size, which is defined by the radius for circular rupture. The corner frequency f_c of the source spectra is related to the radius r_0 of the equivalent circular crack, which is used to model the earthquake. Such relations have been given by (Brune., 1970, 1971) as

$$r_0 = 2.34\, \beta / 2\pi f_c \qquad (1)$$

Where $\rho=2.8\ g/cm^3$ and $\beta=3.4$ km/s are the mass density and the shear-wave velocity in the vicinity of the earthquake source. For computing the seismic moment of these aftershocks, the following expression given by (Kanamori,.1977) has been used:

$$Log10\ M_0 = 1.5\ M_L + 16.05 \qquad (2)$$

The other important parameter of an earthquake source is the stress drop, $\Delta\sigma$, which is defined as the difference of pre-existing tectonic stress and the dynamical frictional stress. For a circular crack of radius r_0, the stress drop $\Delta\sigma$ is given as (Papageorgiou and Aki., 1983):

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$$A(f) = C.\ S(f).D(f) \qquad (4)$$

Where C is constant at a particular station for a given earthquake, S(f) represents the source acceleration spectra, and D(f) denotes a frequency-dependent diminution function that modifies the spectral shape and is given as (Boore and Atkinson,. 1987):

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In the bracket parameter show propagation filter and In the preceding equation $P(f,f_m)$ is high-cut filter. In this paper, we have used f_m as 20 Hz. This expression serves as the basis for our inversion. C is constant at a particular station for a given earthquake. For a Double-couple seismic source embedded in an elastic medium, considering only S-waves, C is given as:

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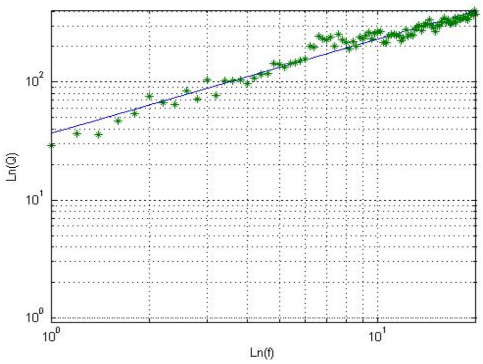

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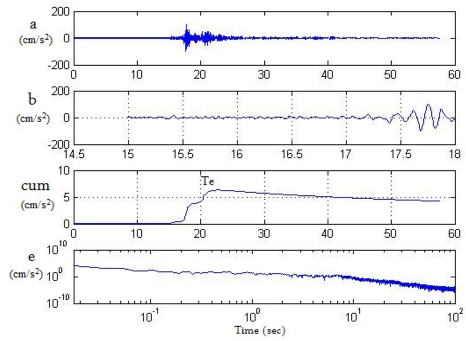

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In equation (8), the term f_c represents the corner frequency. The equation (4) serves as a foundation of the present inversion algorithm.

Inversion matrix can be represented in the following form:

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Model parameters are contained in the model matrix m, and the spectral component is in the data matrix d. Inversion of the G matrix using Newton's method gives the model matrix m as:

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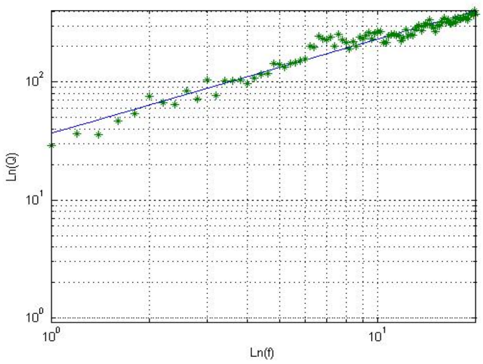

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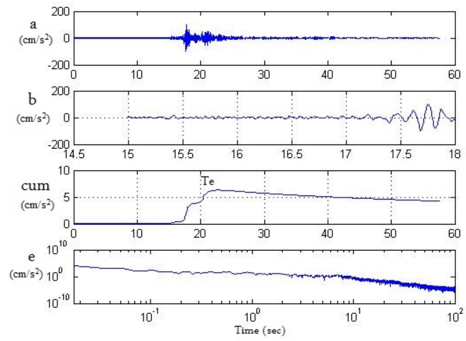

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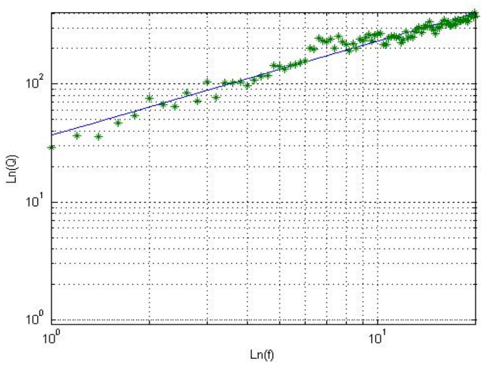

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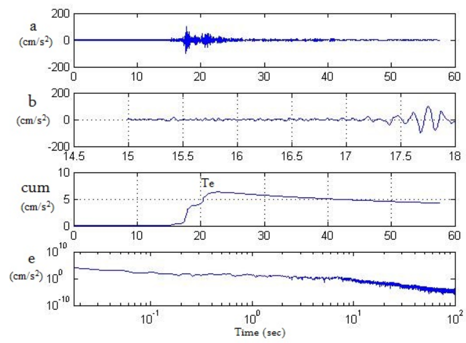

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Estimation of the frequency-dependent shear wave Quality Factor from acceleration spectra of the Kahak-Qom earthquake 2007

Saman Amiri[1], Meysam Kheyri Moloumeh[2], Kamran Sepanloo[3]

[1]*International Institute of Earthquake Engineering and Seismology, Tehran, I.R.Iran., Samanmiri0@gmail.com*
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ABSTRACT

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Keywords: (Kahak Earthquake, Source parameters, $Q_\beta (f)$, inversion)

INTRODUCTION

On 18 June 2007 an earthquake of Ml=5.7 vibrated the capital of Iran, Tehran. The epicenter of the event was located at the east western flank of Tehran, around 100 km from Qom city. This earthquake is important not only because it vibrated the capital of Iran, with almost 12 million inhabitants, but also because no big earthquake at a distance of less than 200 km has affected so far Tehran according to instrumental records (Hamzehloo et al.2007). An acceleration spectrum contains valuable information regarding the source and medium characteristics. The source spectrum of an earthquake can be approximated by the omega-square model (Brune, 1970), which has ω^2 decay of high frequencies above the corner frequency. The source acceleration spectrum can be estimated from a accelerate record after correcting with diminution function, which accounts for the geometrical spreading and inelastic attenuation. The work presented here is approximately based on the technique of (Fletcher, 1995) and (Joshi 2006a, 2006b) that used inversion methods. In this paper, the Brune's source model (Brune, 1970) is used together with the propagation filter. As it can be seen from Table (1) (Bindi et al., 2006) studied low value of Q_0 (Q_0<200) in North-West of Turkey illustrates tectonically and seismically active while the NE-US (Benz et al., 1997) with high Q_0 are representative for stable regions.

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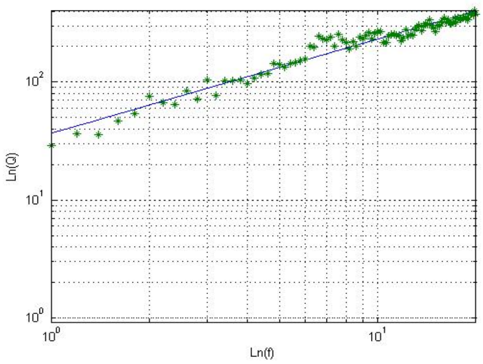

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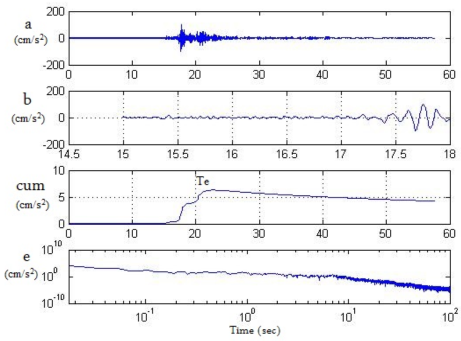

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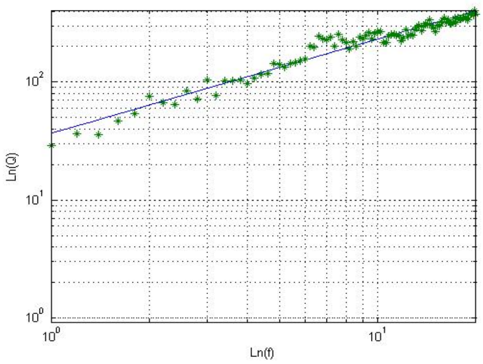

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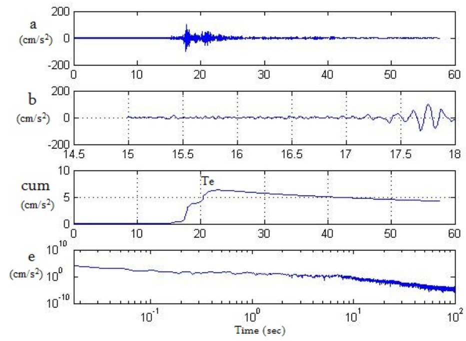

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Estimation of the frequency-dependent shear wave Quality Factor from acceleration spectra of the Kahak-Qom earthquake 2007

Saman Amiri[1], Meysam Kheyri Moloumeh[2], Kamran Sepanloo[3]

[1]*International Institute of Earthquake Engineering and Seismology, Tehran, I.R.Iran.,* Samanmiri0@gmail.com
[2]*Institute For Advanced Studies in Basic Sciences, Zanjan, I.R.Iran.,* mkheyrim@iasbs.ac.ir
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ABSTRACT
In this study high-frequency strong-motion data of Kahak earthquake have been analyzed to determine the $Q_\beta(f)$ and source parameters by inversion of the recorded data. The data represented 21 accelerograms recorded from Kahak-Qom earthquake in the hypocentral distance range from 16 to 160 km. The seismic hazard map for this region illustrates that most of the area in this province is located within high relative risk and characterized by a large number of heterogeneities. For frequency band of 1 to 20 HZ, the frequency-dependent attenuation for this region found to be $Q_\beta = 167f^{0.78}$. Moreover, the source term obtained from inversion was analyzed to estimate various source parameters. Thereby, we estimated seismic moment (3.98×10^{24}dyne-cm), corner frequency (0.17 Hz), source radius (7.2 Km), stress drop (10.23 bars), which are found to be consistent with the corresponding values reported in published studies. The authenticity of achieved Q_β *(f)* relation is checked by comparing the source spectra in various stations with the theoretical spectra. Low values of the coefficient (Q<200) in the Q_β *(f)* relation suggest that the region is seismically and tectonically active.

Keywords: (Kahak Earthquake, Source parameters, Q_β *(f)*, inversion)

INTRODUCTION
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The main shock have 21 accelerogram of BHRC (Building and Housing Research Center), respectively. All instruments were composed of SSA-2 digital accelerographs with a 10-Gal (0.1 m/s^2) threshold, sampling rate of 200 samples/s, and natural frequency of 50 Hz. This configuration yields a flat acceleration response between the frequencies of 0.01 to 20.

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Then, by using corner frequency, M_0, the radius of circular rupture (r_0) and stress drop for events are calculated which are cited in table (2).
One of the significant parameter representing the source is its size, which is defined by the radius for circular rupture. The corner frequency f_c of the source spectra is related to the radius r_0 of the equivalent circular crack, which is used to model the earthquake. Such relations have been given by (Brune., 1970, 1971) as

$$r_0 = 2.34\, \beta / 2\pi f_c \qquad (1)$$

Where $\rho = 2.8\ g/cm^3$ and $\beta = 3.4$ km/s are the mass density and the shear-wave velocity in the vicinity of the earthquake source. For computing the seismic moment of these aftershocks, the following expression given by (Kanamori,.1977) has been used:

$$Log10\ M_0 = 1.5\ M_L + 16.05 \qquad (2)$$

The other important parameter of an earthquake source is the stress drop, $\Delta\sigma$, which is defined as the difference of pre-existing tectonic stress and the dynamical frictional stress. For a circular crack of radius r_0, the stress drop $\Delta\sigma$ is given as (Papageorgiou and Aki., 1983):

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$$A(f) = C.\ S(f).D(f) \qquad (4)$$

Where C is constant at a particular station for a given earthquake, S(f) represents the source acceleration spectra, and D(f) denotes a frequency-dependent diminution function that modifies the spectral shape and is given as (Boore and Atkinson,. 1987):

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In the bracket parameter show propagation filter and In the preceding equation $P(f,f_m)$ is high-cut filter. In this paper, we have used f_m as 20 Hz. This expression serves as the basis for our inversion. *C* is constant at a particular station for a given earthquake. For a Double-couple seismic source embedded in an elastic medium, considering only S-waves, C is given as:

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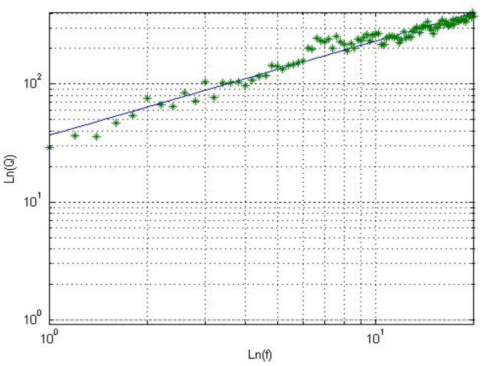

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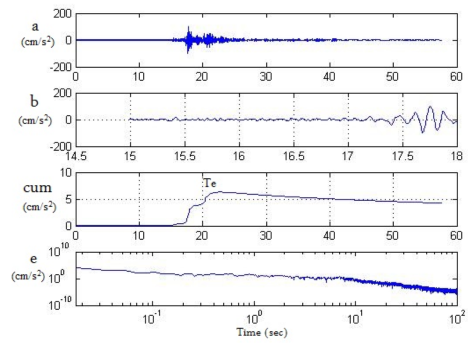

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The source spectrum of event is represented by the term, $S(f,f_c)$. Following equation given by Aki (1967) and Brune (1970) is employed in this work:

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In equation (8), the term f_c represents the corner frequency. The equation (4) serves as a foundation of the present inversion algorithm.

Inversion matrix can be represented in the following form:

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Model parameters are contained in the model matrix m, and the spectral component is in the data matrix d. Inversion of the G matrix using Newton's method gives the model matrix m as:

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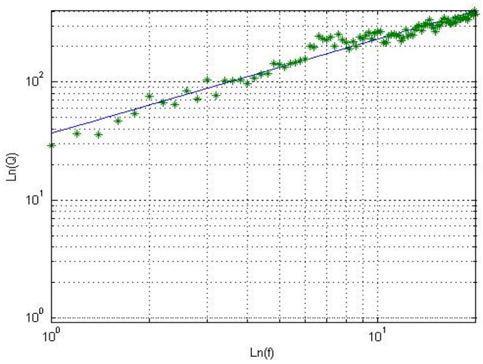

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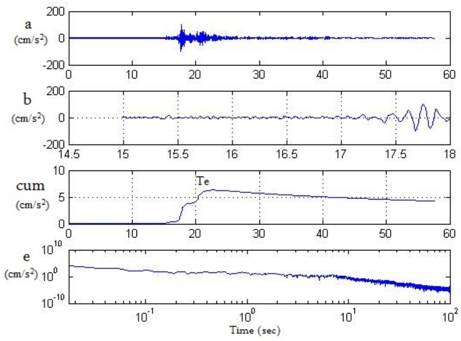

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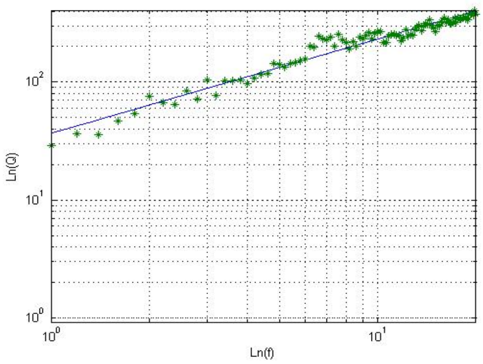

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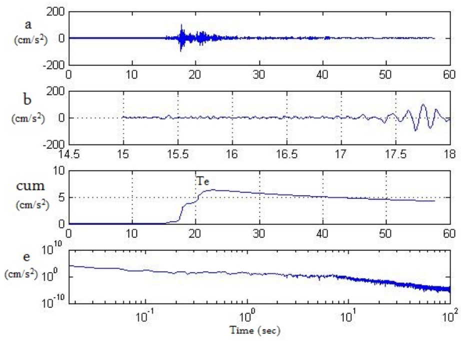

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Estimation of the frequency-dependent shear wave Quality Factor from acceleration spectra of the Kahak-Qom earthquake 2007

Saman Amiri[1], Meysam Kheyri Moloumeh[2], Kamran Sepanloo[3]

[1]International Institute of Earthquake Engineering and Seismology, Tehran, I.R.Iran., Samanmiri0@gmail.com
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ABSTRACT

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Keywords: (Kahak Earthquake, Source parameters, Q_β *(f)*, inversion)

INTRODUCTION

On 18 June 2007 an earthquake of Ml=5.7 vibrated the capital of Iran, Tehran. The epicenter of the event was located at the east western flank of Tehran, around 100 km from Qom city. This earthquake is important not only because it vibrated the capital of Iran, with almost 12 million inhabitants, but also because no big earthquake at a distance of less than 200 km has affected so far Tehran according to instrumental records (Hamzehloo et al.2007). An acceleration spectrum contains valuable information regarding the source and medium characteristics. The source spectrum of an earthquake can be approximated by the omega-square model (Brune, 1970), which has ω^2 decay of high frequencies above the corner frequency. The source acceleration spectrum can be estimated from a accelerate record after correcting with diminution function, which accounts for the geometrical spreading and inelastic attenuation. The work presented here is approximately based on the technique of (Fletcher, 1995) and (Joshi 2006a, 2006b) that used inversion methods. In this paper, the Brune's source model (Brune, 1970) is used together with the propagation filter. As it can be seen from Table (1) (Bindi et al., 2006) studied low value of Q_0 (Q_0<200) in North-West of Turkey illustrates tectonically and seismically active while the NE-US (Benz et al., 1997) with high Q_0 are representative for stable regions.

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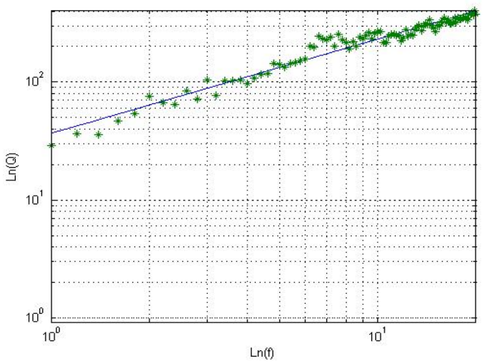

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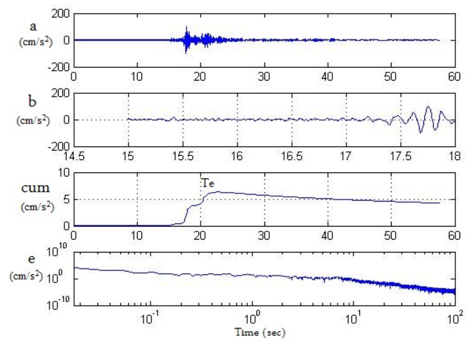

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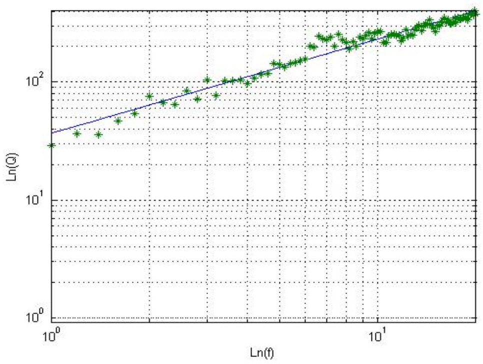

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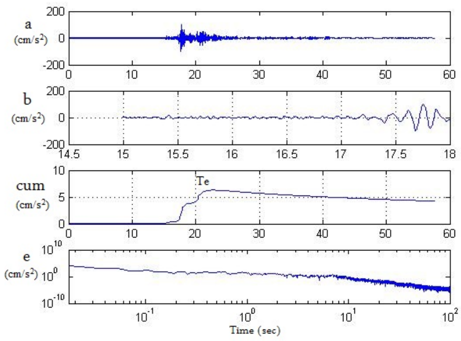

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In this study, the minimum error is obtained in the inversion scheme for a relation which gives $Q_\beta = 167f^{0.78}$. Low values of the coefficient (Q < 200) in the Q_β *(f)* relation suggest that the region is seismically and tectonically active. Furthermore, the inversion scheme also gives the estimate of the corner frequencies for the earthquakes, which gives stress-drop values for this earthquake at 10.23 bars, respectively, which very well matches with other observations.

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Estimation of the frequency-dependent shear wave Quality Factor from acceleration spectra of the Kahak-Qom earthquake 2007

Saman Amiri[1], Meysam Kheyri Moloumeh[2], Kamran Sepanloo[3]

[1]*International Institute of Earthquake Engineering and Seismology, Tehran, I.R.Iran.,* Samanmiri0@gmail.com
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ABSTRACT

In this study high-frequency strong-motion data of Kahak earthquake have been analyzed to determine the $Q_\beta(f)$ and source parameters by inversion of the recorded data. The data represented 21 accelerograms recorded from Kahak-Qom earthquake in the hypocentral distance range from 16 to 160 km. The seismic hazard map for this region illustrates that most of the area in this province is located within high relative risk and characterized by a large number of heterogeneities. For frequency band of 1 to 20 HZ, the frequency-dependent attenuation for this region found to be $Q_\beta = 167f^{0.78}$. Moreover, the source term obtained from inversion was analyzed to estimate various source parameters. Thereby, we estimated seismic moment (3.98×10^{24}dyne-cm), corner frequency (0.17 Hz), source radius (7.2 Km), stress drop (10.23 bars), which are found to be consistent with the corresponding values reported in published studies. The authenticity of achieved Q_β *(f)* relation is checked by comparing the source spectra in various stations with the theoretical spectra. Low values of the coefficient (Q<200) in the Q_β *(f)* relation suggest that the region is seismically and tectonically active.

Keywords: (Kahak Earthquake, Source parameters, Q_β *(f)*, inversion)

INTRODUCTION

On 18 June 2007 an earthquake of Ml=5.7 vibrated the capital of Iran, Tehran. The epicenter of the event was located at the east western flank of Tehran, around 100 km from Qom city. This earthquake is important not only because it vibrated the capital of Iran, with almost 12 million inhabitants, but also because no big earthquake at a distance of less than 200 km has affected so far Tehran according to instrumental records (Hamzehloo et al.2007). An acceleration spectrum contains valuable information regarding the source and medium characteristics. The source spectrum of an earthquake can be approximated by the omega-square model (Brune, 1970), which has ω^2 decay of high frequencies above the corner frequency. The source acceleration spectrum can be estimated from a accelerate record after correcting with diminution function, which accounts for the geometrical spreading and inelastic attenuation. The work presented here is approximately based on the technique of (Fletcher, 1995) and (Joshi 2006a, 2006b) that used inversion methods. In this paper, the Brune's source model (Brune, 1970) is used together with the propagation filter. As it can be seen from Table (1) (Bindi et al., 2006) studied low value of Q_0 (Q_0<200) in North-West of Turkey illustrates tectonically and seismically active while the NE-US (Benz et al., 1997) with high Q_0 are representative for stable regions.

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The main shock have 21 accelerogram of BHRC (Building and Housing Research Center), respectively. All instruments were composed of SSA-2 digital accelerographs with a 10-Gal (0.1 m/s^2) threshold, sampling rate of 200 samples/s, and natural frequency of 50 Hz. This configuration yields a flat acceleration response between the frequencies of 0.01 to 20.

In the first step of estimation, two horizontal components of acceleration were low-pass filtered, with cutoff frequency at 20 Hz, and then vectorized. Inversion analysis is based on detection of S-wave window and the S-wave analysis was based on the SH-waves synthesized from horizontal components, because SH-waves are not affected by other seismic phases. The resulting component, *a(t)*, is transverse to the direction of propagation of the earthquake waves and a time window containing the direct SH wave, was selected from the accelerograms by using Kinoshita algorithm (1994). The second step, (Kinoshita,.1994) method is used for determining the end of *S*-wave time window analysis, in this research. Also, take start of energy descent in diagram by using

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In continue, by applying (Andrews,.1986) formula Equation corner frequency of the SH-waves has been calculated as the first source parameter for each station.

Then, by using corner frequency, M_0, the radius of circular rupture (r_0) and stress drop for events are calculated which are cited in table (2).

One of the significant parameter representing the source is its size, which is defined by the radius for circular rupture. The corner frequency f_c of the source spectra is related to the radius r_0 of the equivalent circular crack, which is used to model the earthquake. Such relations have been given by (Brune., 1970, 1971) as

$$r_0 = 2.34\ \beta / 2\pi f_c \qquad (1)$$

Where $\rho=2.8\ g/cm^3$ and $\beta=3.4$ km/s are the mass density and the shear-wave velocity in the vicinity of the earthquake source. For computing the seismic moment of these aftershocks, the following expression given by (Kanamori,.1977) has been used:

$$Log10\ M_0 = 1.5\ M_L + 16.05 \qquad (2)$$

The other important parameter of an earthquake source is the stress drop, $\Delta\sigma$, which is defined as the difference of pre-existing tectonic stress and the dynamical frictional stress. For a circular crack of radius r_0, the stress drop $\Delta\sigma$ is given as (Papageorgiou and Aki., 1983):

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In the next step, we obtained frequency-dependent Q from generalized inversion method for each accelerogram, recorded from Kahak-Qom earthquake. The displacement spectrum of shear waves at distance R due to an earthquake of seismic moment M0 can be described by (Boore, 1983; Atkinson and Boore, 1998):

$$A(f) = C.\ S(f).D(f) \qquad (4)$$

Where C is constant at a particular station for a given earthquake, S(f) represents the source acceleration spectra, and D(f) denotes a frequency-dependent diminution function that modifies the spectral shape and is given as (Boore and Atkinson,. 1987):

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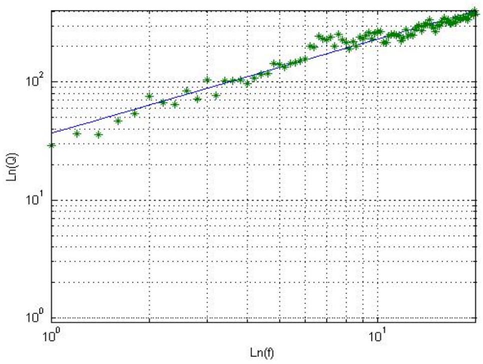
Where $R_{\theta\varphi}$ is the average shear-wave radiation pattern, FS is the free surface amplification; PRTITN is the reduction factor that accounts for partitioning of energy into two horizontal components and is fixed value 0.707 and ρ and β are density, and the shear wave velocity, respectively.



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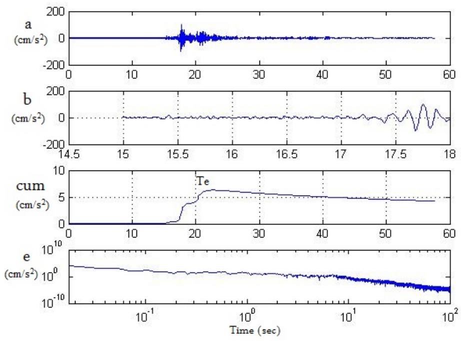

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The source spectrum of event is represented by the term, $S(f,f_c)$. Following equation given by Aki (1967) and Brune (1970) is employed in this work:

$$S(f,f_c) = (2\pi f)^2 / (1+(f/f_c)^2) \qquad (7)$$

In equation (8), the term f_c represents the corner frequency. The equation (4) serves as a foundation of the present inversion algorithm.
Inversion matrix can be represented in the following form:

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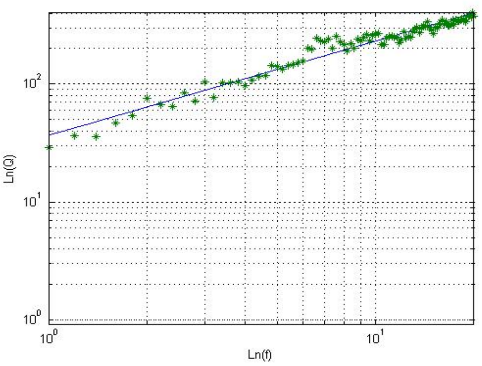

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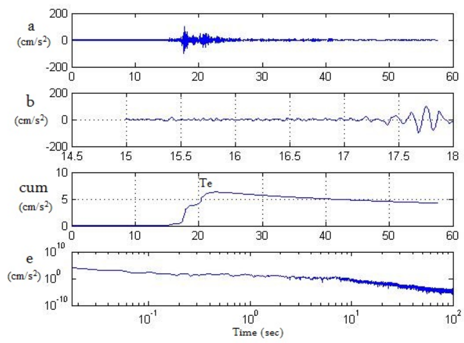

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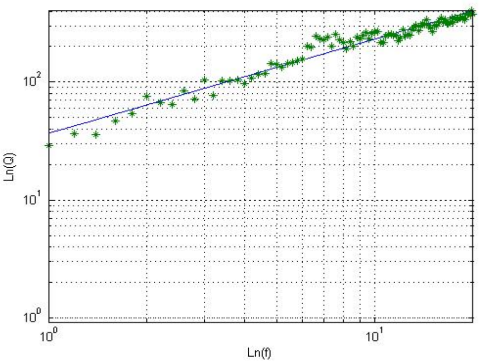

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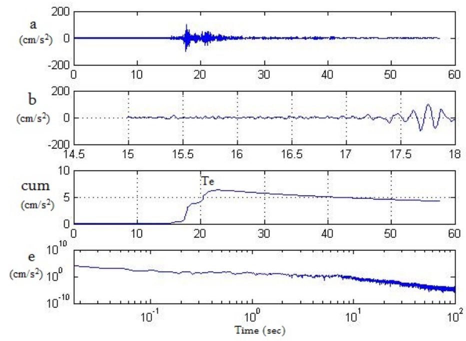

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In this study, the minimum error is obtained in the inversion scheme for a relation which gives $Q_\beta = 167f^{0.78}$. Low values of the coefficient (Q < 200) in the Q_β *(f)* relation suggest that the region is seismically and tectonically active. Furthermore, the inversion scheme also gives the estimate of the corner frequencies for the earthquakes, which gives stress-drop values for this earthquake at 10.23 bars, respectively, which very well matches with other observations.

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Estimation of the frequency-dependent shear wave Quality Factor from acceleration spectra of the Kahak-Qom earthquake 2007

Saman Amiri[1], Meysam Kheyri Moloumeh[2], Kamran Sepanloo[3]

[1]*International Institute of Earthquake Engineering and Seismology, Tehran, I.R.Iran., Samanmiri0@gmail.com*
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ABSTRACT
In this study high-frequency strong-motion data of Kahak earthquake have been analyzed to determine the $Q_\beta(f)$ and source parameters by inversion of the recorded data. The data represented 21 accelerograms recorded from Kahak-Qom earthquake in the hypocentral distance range from 16 to 160 km. The seismic hazard map for this region illustrates that most of the area in this province is located within high relative risk and characterized by a large number of heterogeneities. For frequency band of 1 to 20 HZ, the frequency-dependent attenuation for this region found to be $Q_\beta = 167f^{0.78}$. Moreover, the source term obtained from inversion was analyzed to estimate various source parameters. Thereby, we estimated seismic moment (3.98×10^{24}dyne-cm), corner frequency (0.17 Hz), source radius (7.2 Km), stress drop (10.23 bars), which are found to be consistent with the corresponding values reported in published studies. The authenticity of achieved $Q_\beta (f)$ relation is checked by comparing the source spectra in various stations with the theoretical spectra. Low values of the coefficient (Q<200) in the $Q_\beta (f)$ relation suggest that the region is seismically and tectonically active.

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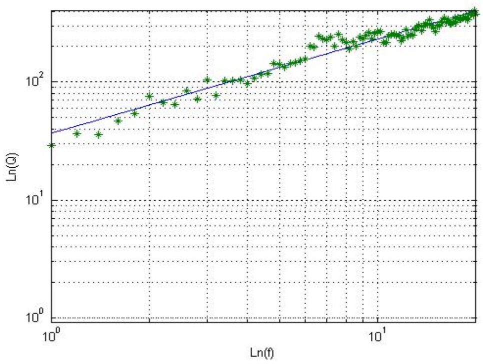

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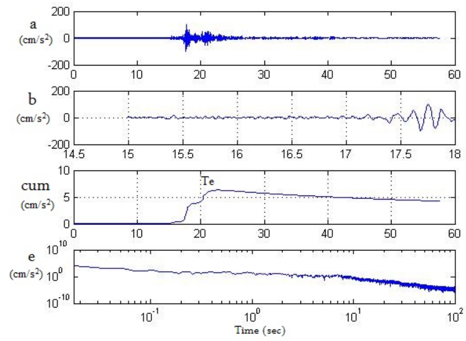

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Where $R_{\theta\varphi}$ is the average shear-wave radiation pattern, FS is the free surface amplification; PRTITN is the reduction factor that accounts for partitioning of energy into two horizontal components and is fixed value 0.707 and ρ and β are density, and the shear wave velocity, respectively.

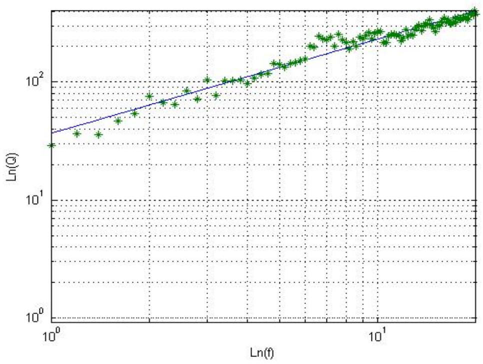

Figure 2. Estimated Quality Factor for Kahak Station $Q_\beta(f) = 36f^{0.79}$

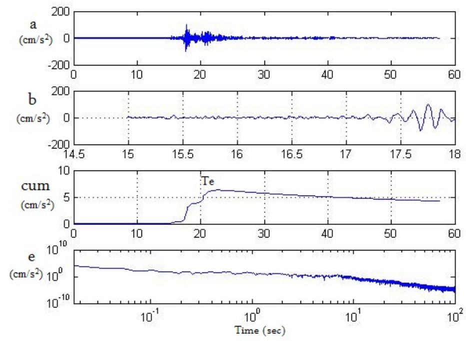

Figure 1. Separation S wave by using Kinoshita (1994) in Kahak station. The ending time, T_e, of the S-wave window is assigned to (a) point on the time axis where $c(k)$ starts to decrease.

The source spectrum of event is represented by the term, $S(f,f_c)$. Following equation given by Aki (1967) and Brune (1970) is employed in this work:

$$S(f,f_c) = (2\pi f)^2 / (1+(f/f_c)^2) \qquad (7)$$

In equation (8), the term f_c represents the corner frequency. The equation (4) serves as a foundation of the present inversion algorithm.

Inversion matrix can be represented in the following form:

$$Gm=d \qquad (8)$$

Model parameters are contained in the model matrix m, and the spectral component is in the data matrix d. Inversion of the G matrix using Newton's method gives the model matrix m as:

$$M^{est} = (G^T G)^{-1} G^T d \qquad (9)$$

The corner frequency is treated as the input parameter in the inversion algorithm Matrix (M^{est}) illustrate for every frequency, in this study used frequency band between 1 to 20 HZ , 0.2 steps so we have 96 frequency with 96 values of Q for each station. Matrix (M^{est}) illustrate for every frequency.

Table 2. Estimated source parameters of the Kahak earthquake.

Earthquake	M_l	M_w	M_0 (dyne-cm)	r_0(km)	$\Delta\sigma$(bar)	f_c(HZ)
Kahak Eq	*5.7*	*5.5*	3.98×10^{24}	*7.20*	*10.23*	*0.17*

CONCLUSION(S)

In this study, the minimum error is obtained in the inversion scheme for a relation which gives $Q_\beta = 167f^{0.78}$. Low values of the coefficient (Q < 200) in the Q_β *(f)* relation suggest that the region is seismically and tectonically active. Furthermore, the inversion scheme also gives the estimate of the corner frequencies for the earthquakes, which gives stress-drop values for this earthquake at 10.23 bars, respectively, which very well matches with other observations.

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