Attenuation of coda waves in the Rif area.

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Abstract

We present in this work the attenuation scattering of coda waves in the northern part of Morocco precisely in the RIF region. In this study we used 15 broadband seismometers widespread between the latitude of 34.00 and 35.50 and the longitude of -5.30 and -3.20. To analyze coda waves in this region, we collect 70 local and regional earthquakes during 2014 for five laps time 20,30,40,50 and 60s. To estimate seismic attenuation of coda waves we used the back-skattering model. The quality factor which is inversely proportional to the seismic attenuation were computed at diverse central frequencies 1.5, 3.0, 6.0, 9.0, 12.0, 18.0 and 24.0 Hz. For the lapse time of 60s, the estimated quality factor gives Qc average value from 149.86 at 1.5 Hz and 491,66 at 18,0 Hz central band frequencies. We noticed that the quality factor gets bigger when the central frequency band is higher, which show an obvious dependence between the quality factor and frequency.

Study Site

The Rif region surrounded to the north by the Alboran sea and to the south by the midle-Atlas Range (Fig. 1). This region is characterized by the complexities of the seismotectonic pattern and moderate seismic activity associated to the presence of a complex actives faults, which start from Tanger to the East.

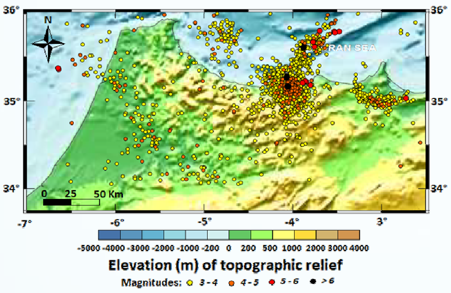

Fig 1 Topographic map shows the seismicity of the Rif region during 1994 -2019 period, the black circles show Al Hoceima earthquakes of 2016, 1994 and 2004 from north to south respectively,

Historical seismicity data shows that the Rif region was hit by three destructive earthquakes, the first was on 1994 may 26th (Mw 6.0), the second was on 2004 February 24th (Mw 6.4) and the last was on 2016 January 25th (Mw 6.3). The two earlier earthquakes were the most damaging earthquakes in the Rif zone.

Data

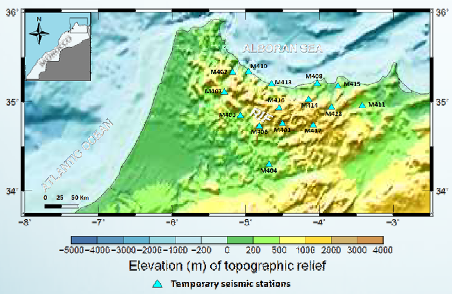

Fig 2 : Topographic map showing the temporary broadband stations deployed in the location of the study, The elevations (m) of the topographic relief are indicated on the colour scale,

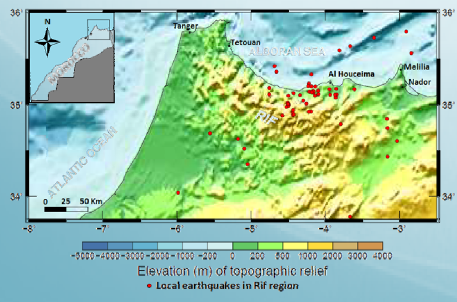

Fig 3: Data: The illustrated case in this work implies 70 seismic events recorded during the 2014 year, the depths are spaning between 0 and 47.8km and magnitudes ranging from 2 to 5 (ML).

Methods

Method of measuring Qc

1. The seismograms are filtered in 6 frequency bands: 1-2 Hz, 2-4 Hz, 5-7Hz, 8-10Hz, 11-13Hz, 17-19Hz.
2. Signal is selected from coda arrival (tc=2*ts) to coda duration , (ts : travel time for S-wave) and (tc: coda arrival time).
3. Considered part of coda waves is corrected for geometrical spreading. Then amplitudes has been multiplied by $t^{-\beta}$to account for geometrical spreading (β=1 considered for local earthquakes).
4. The coda window was selected in 20s, 30s, 40s, 50s and 60 s).
5. A linear regression of $ln(A(f,t)t)$ versus t.
6. Seismic attenuation is related to frequency according to the following power-law found by Mitchell (1981):

$$Q_c(f) = Q_0 . f^n \quad [1]$$

Q_0 is the reference quality factor value of Q_c at frequency f_0 (generally 1 Hz).
n is the frequency parameter that covariates heterogeneities.

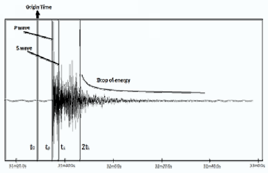

Fig 4: Example of seismogram for the earthquake recorded on the April 7th 2014 at the station M418 showing the origin time, arrivals of P and S and the Coda.

What's is seismic coda ?

Seismic coda waves results mainly from the scattering and diffraction of S waves .
the single scattering method is used to compute the coda-Q the coda waves amplitude at frequency f, and elapsed time t can be expressed by Aki and Chouet (1975) as :

$$A(f,t) = S(f) t^{-\beta} e^{-\pi . f . t / Q_c} \quad [2]$$

Q_c: Quality factor of coda waves
β: the geometrical spreading parameter
S(f): the source function at frequency f

Results

We got through the single backscattering model to demonstrate the frequency dependence of Q relationship $Q_c(f) = Q_0 . f^n$ in the frequency band (1.5-18)Hz , as follows:

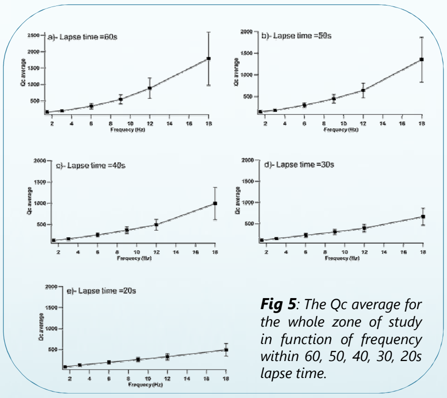

Fig 5: The Qc average for the whole zone of study in function of frequency within 60, 50, 40, 30, 20s lapse time.

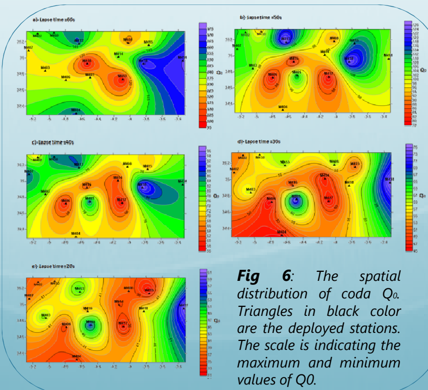

Fig 6: The spatial distribution of coda Q₀. Triangles in black color are the deployed stations. The scale is indicating the maximum and minimum values of Q0.

Discussion

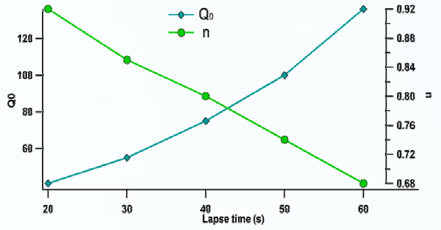

Fig 7: Plot of the average of Q0 and n in function of lapse time.

The frequency-dependency in seismic attenuation : We confirm then that the Q_c value increases with an increase of frequency (fig 5).
The heterogeneity dependency with depth : The deep layers of the earth are less heterogenous than the shallow parts (Fig 6).
The lapse time dependency in seismic attenuation : An increase in $Q_0$and a decrease in frequency parameter n (Fig 7).

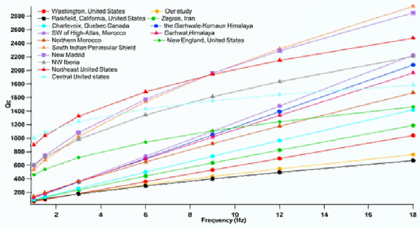

Fig 8: Comparison of quality factor values of the Rif region with other regions around the world.

Comparison between our study and other results around the world

The comparison of the Coda Q results of our study with other regions around the world shows that the lowest values of Q_0 and the highest values of n were related to the Rif region and Parkfield California, these results suggest that the crust in this area appears to be more 'attenuating' and heterogeneous.

Conclusions

- The comparison of estimated Q_0 for regions around the world indicates that the attenuation in Rif region is higher than most regions in the world.
- The attenuation of seismic waves at high frequencies (1 to 30 Hz) in the lithosphere must be known for the deconvolution of the effects of the seismic source seismograms.
- A temporary network has supported regional seismology and has formed the backbone of knowledge and support for scientists. This work should be relevant to forecast the soil movements from theoretical sources models.
- The frequency-dependent attenuation relations developed in the present study would be useful in various scientific and engineering applications,

Acknowledgement

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