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Letter Section

On the frequency dependence of Q in the Kalamata (South Greece) region as obtained from the analysis of the coda of the aftershocks of the Kalamata 1986 earthquake

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Of particular importance in understanding the physical laws according to which the elastic energy of an earthquake propagates in the earth's crust, are the results obtained by several investigators which bring out the strong reliance of the attenuation factor (Q) on the frequency (f), indicating a relation of the form:

$$Q(f) = qf^n \tag{1}$$

in the frequency range $f = 0$ to 25 Hz.

Most of the data for crustal attenuation comes from coda waves (Aki and Chouet, 1975; Rautian and Khalturin, 1978; Aki, 1980; Roecker et al., 1982; Del Pezzo et al., 1983; Singh and Hermann, 1983; Pulli, 1984) and indicate a regional variation of the value of n.

An extensive range of results on Q values for various areas and some interesting considerations on the difference between the Q behaviour in tectonically active and stable areas can be found in Aki (1980, 1981).

A confirmation of the frequency dependence for Q in the Kalamata region (South Greece), has been sought using the method of coda analysis developed by Aki and Chouet (1975) and revised by Aki (1980).

Using a set of five mobile stations the Geophysics Department of Athens University recorded a long sequence of local earthquakes, 1 month after the strong shock of 13 September 1986 ($M_s = 6.2$), (see Fig. 1).

Nine well located aftershocks were selected on the basis of the best signal-to-noise ratio and their epicenters are plotted in Fig. 1. The events had focal depths confined within the upper 10Km of the crust with local magnitudes ranging between 1.9 and 2.6.

The following equation was used to predict a time dependence for coda amplitudes (e.g., Roecker et al., 1982):

$$A(r, t/\omega) = C(\omega) \cdot K(r, a) \cdot e^{-bt/2} \tag{2}$$

where $C(\omega)$ is a factor linked to the amplitude at focus, $b = \omega/Q$ and $K(r, a)$ is given by:

$$K(r, a) = \frac{1}{r}\left[\frac{\ln(a+1)/(a-1)}{a}\right]^{1/2} \tag{3}$$

In eqn. (3), r is the source–receiver distance, $a = t/t_s$, t is the time measured from the beginning of the seismic wave propagation from the focus and t_s the S-wave traveltime.

Eqn. (2) can be written as:

$$\log A_c(r, t/\omega) = \log C(\omega) - b(\log e)t/2 \tag{4}$$

where $A_c(r, t/\omega)$ is the corrected amplitude given by

$$A_c(r, t/\omega) = A(r, t/\omega)/K(r, a) \tag{5}$$

A linear relationship versus time is thus obtained for the logarithmic amplitudes of the coda waves and factor b is determined by a least squares fit.

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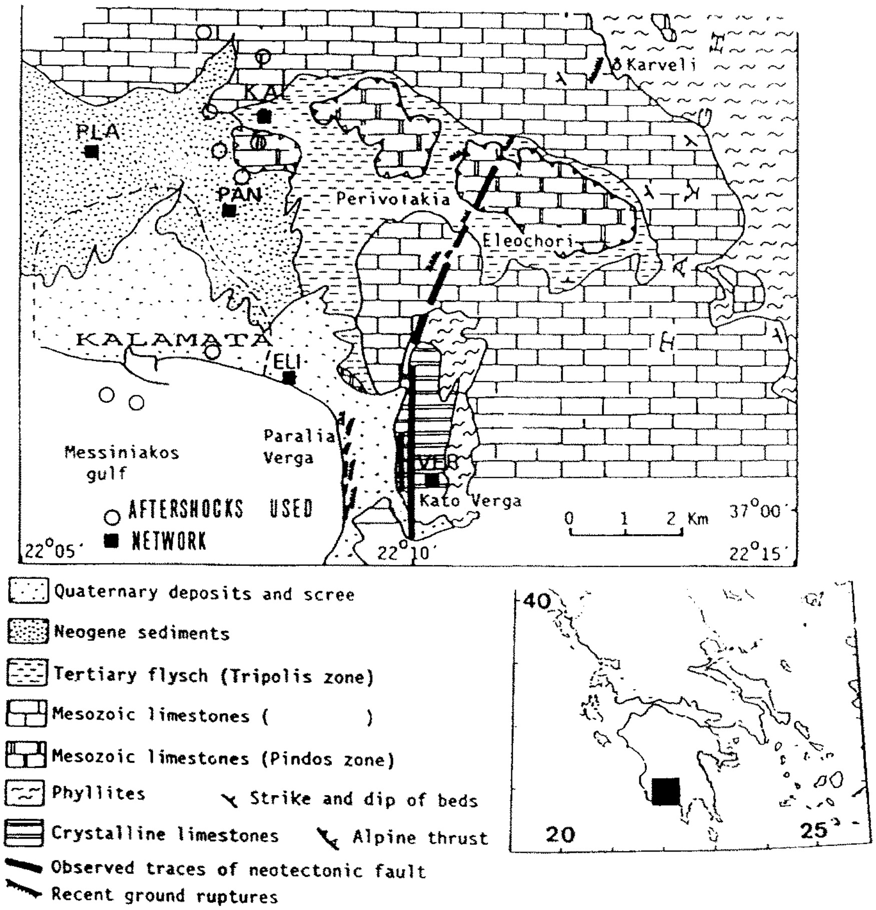

Fig. 1. Tectonic map of the area showing network location and aftershock epicenters used in this study.

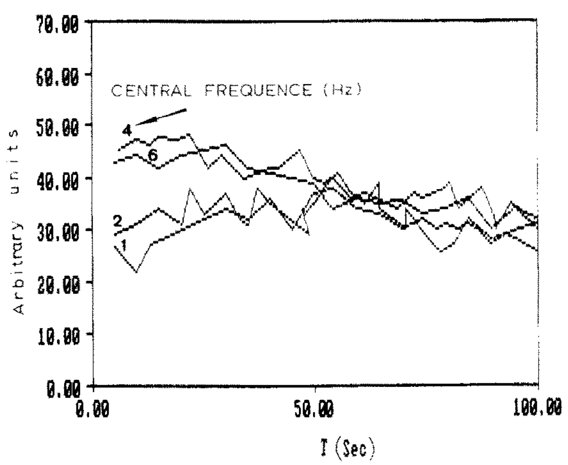

Fig. 2. Seismic spectrum in the time domain for different frequency bands. Note the similar slope of the decay of the curves, implying a linear dependence on frequency of Q.

Beginning at times $t > 2r/B$, where B is the shear wave velocity, values of $A_c(\omega, t)$ were computed using a sliding 2-s window (100 samples) and amplitude decay curves as a function of time were obtained.

An example of the spectra obtained as a function of time is shown in Fig. 2.

The quantity $A_c(\omega, t)$ was estimated by averaging the spectral values corresponding to the running window centered at time t_c in five spectral bands with central frequency $f_c = 1, 2, 4, 8$ and 16 Hz with a width of $0.6 f_c$.

The slope of the quantity log $A_c(\omega, t)$ versus time was calculated for each frequency band and Q least squares fit was applied to the coda decay.

Next, the slopes with correlation coefficients greater than 0.8 were selected and the mean value of attenuation was computed as a function of

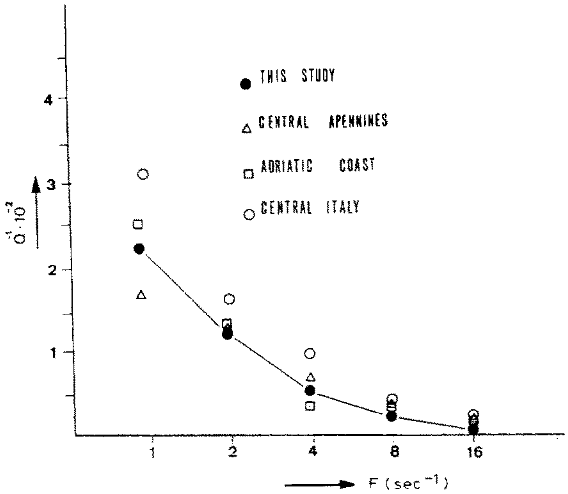

Fig. 3. Coda Q estimates for Kalamata region. Some reported values from other nearby seismotectonic domains are also shown.

frequency, averaging the data from the recording stations.

The obtained trend of variation of Q with frequency was found to fit the empirical relationship:

$$Q = (43 \pm 5) f^{(0.81 \pm 0.17)} \tag{6}$$

This relation is depicted in Fig. 3 in addition to Q estimates obtained from other nearby Mediterranean seismotectonic domains and in particular from the Ancona region (Central Italy) by Del Pezzo et al. (1983), the Adriatic coast (Rovelli, 1984) and Southern Italy (Rovelli, 1983).

From this graph we can conclude that the Q versus frequency relationship obtained for the Kalamata area resembles that of other nearby tectonic regions and supports the correlations found by Aki (1980, 1981) between the level of tectonic activity and the degree of functional dependence on frequency.

Acknowledgments

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