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Q Anisotropy in the Region of Garhwal Himalaya

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ABSTRACT

Empirical relations have been found out to describe the decay in amplitude with distance of s-waves in the region of Garhwal Himalaya. These functions results from the analysis of spectral amplitudes of three component digital records from 19 local earthquakes obtained from 12-station seismological network deployed in the Garhwal lesser Himalaya. The events lie in a magnitude range from ML 2 to ML 4.5, epi-central distance 5 km to 120 km and focal depth from 5 km to 50 km.

To determine the variations of the quality factor Qin the direction of wave propagation (Q anisotropy), independent estimates have been made of the attenuation of SV- and SH-waves using vertically polarized and transversely polarized components, respectively. Frequency analyzed (1-12 Hz) and in the whole distance range, the frequency dependence of Q can be approximated as Qsh = 74.3 f 1.0 for the SH-wave and Qsv = 81.5 f 0.95 for the SV-waves. The small difference between SH and SV spectral decay, suggests that Q anisotropy is negligible. However, In the distance range of 5-50 km, Qsv tends to be significantly greater than Qsh at frequency > 8 Hz. So in this distance range we observed Q anisotropy in the studied region. The dependence of Q value with frequency in this range is Qsh = 110 f 0.94 for SH- wave and Qsv = 134 f1.0 for SV-waves.

Keywords: *Velocity; Anisotropy; Frequency; S-Wave.*

1.0 Introduction

Due to devastating effect of earthquake, its prediction and estimation is a matter of great interest for the safety of humans. Earthquake prediction should be reliable on the basis of the natural processes and its derivation in such a way that any other 'researcher' would obtain the same result using the derived methodology. There are numerous earthquake precursors 'exists' now a days but they are having their own advantages and limitations. It has been observed that when events have occurred, the properties of medium at that location get changed. The change in properties of medium is expressed in terms of Quality factor that is measure of attenuation.

Attenuation is one of the basic properties of seismic waves from which physical properties of earth's interior and its state can be known. The quality factor Q of shear wave is consider as an important input parameter for the assessment of seismic hazard in earthquake prone areas by studying dependency of attenuation on frequency of seismic waves and also the effect on the nearby areas as the distance increases from the source. It is also necessary to give seismic estimation of soil.

Many studies related to S-wave attenuation have been carried out by various researchers in world (e.g.; Tsukuba (1979) (Japan), Marmara (2004) (turkey)) as well in India (Garhwal Himalaya (Sharma et al, (2004)) with the varying focal depth and interpret the dependency of attenuation on frequency.Many Recent studies have been carried out on P-wave (Mele et al., 1996) and S-
wave attenuation (Mele et al., 1997)'gives the idea about the presence of a strong attenuation zone beneath the Italian Apennines. They interpreted that these observations are due to advection of asthenospheric material in the uppermost crust mantle. The area of northern Alpine is characterized as the area of high heat flow (Ponziani et al., 1995). They had estimated that beneath the anisotropic region in Apennines, it is

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having thickness of 160 km based on the observed delay time between split shear-wave phases. Another study has been carried out across Tuscan-Umbro-Marchesan region situated in Italy, Ponziani et al. (1995) found that the structure is crustal structure. In another study in Marche region they found that the lower crust which consists of 15-km-thick layer having velocity of P-wave of 6.5-6.7 km/s.

The velocity of upper crust is low 6.0 km/s topped by one of 6.3 km/s in the upper region. They conclusion was thatthe crustal structure of Tuscan-Umbro-Marche strip as a product of Moho doubling and crustal shortening, Minelli et al. (1991) proposed the modal.

In our present Study, we analyze S-waves from the events that were recorded locally in the Garhwal Himalaya to estimate the quality factor. The main focus of our study is to evaluate Q anisotropy using SV- and SH- waves separately.

2.0 Region Studied

In the present study Quality factor is determined for the seismic regions of Garhwal Himalaya. The region is located between two major boundary thrusts (i.e., The MBT and The MCT) and is seismically' active.

The department of Earthquake Engineering, IIT Roorkee has deployed a 12 station seismological networks in the region around Tehri Dam in the Garhwal Lesser Himalaya for the monitoring of seismic activities of the region. Tehri Hydro Development Co-operation India Ltd. (THDCIL) has sponsored the project.

3.0 Method and Data

Generally, geometrical spreading, scattering of energy and intrinsic absorption controlled the decay of body-wave amplitude with distance. The mechanism of attenuation makes amplitude decay approximately as 1/R at short distances (R is hypocentral distance),

where most of the direct waves arrives. Scattering of energy and intrinsic absorption mechanisms produce an exponential decay of the amplitudes which is related to the quality factor Q or proportional to Q. Thus, total attenuation, for a particular given frequency can be approximated from the following function:

$$A(f,R) = G(R) \times e^{\frac{-\pi f t}{Q}} \qquad (1)$$

Where, t is lapse time measured from earthquake origin time, f is frequency and (R) is known as geometrical spreading function. We have used the following functional form:

$$G(R) = \frac{c}{R^n} \qquad (2)$$

Taking the natural log above equation can be written as,

$$\ln A(f, R) = \ln(c) - \ln(R) - \frac{\pi f R}{vQ} \ln(e) \qquad (3)$$

Velocity of S-wave is taken as 3.14 km/s as an average velocity. After solving Eq.(7) c and Q values are estimated when A (f, R) is specified.

The attenuation functions, A(f, R) is obtained empirically in the frequency band between'1 and 12 Hz, by fitting the spectral amplitude decay of the records using a nonparametric approach'(e.g. Anderson and Quaas, 1988; Castro et al., 1990, 1997; Anderson and Lei,1994). In this method the observed spectral amplitudes Ui (f, R) from the earthquake are modeled as'

$$\bar{U}i(f, R) = Si(f, R) \times A(f, R) \qquad (4)$$

Where, Si (f, R) is scalar that depends on the size of event i. We determined A (f, R) from Eq (8) by forming a set of linear equations for each frequency considered and constraining the attenuation function to be smooth decreasing function of distance with a value of one at R = 0 (e.g. Castro et al., 1990, 1996, 1997).

We used 19 events with clear S-wave arrivals to calculate the displacement spectra. Fig. 4.3 shows the distribution of events and stations used respectively. The earthquakes have magnitude between 2 and 4.5 and were recorded in the distance range of 5 and 125 km.

Base line correction is applied to the components of motion of the events by subtracting the mean. Then, the records were rotated into longitudinal, transversely polarized and vertically polarized component to select time windows for SV- and SH- waves. On an average, the window length selected for S-waves vary between

3 and 7 s is selected the average window length for S-waves, we have used 5.14 s. The time windows were tapered with 5% cosine taper before the calculation of Fourier Transform. After that instrument magnification correction has applied on the calculated acceleration spectra

In our calculation we used the following equation:

$$\ln(A \times R) = \ln(c) - \frac{\pi f R}{v Q}$$

From the above equation we plot graph between ln (A×*R*)on Y-axis and hypocentral distance (R) on X-axis and find out the slope of straight line, from that slope we can calculate the Quality factor (Q). This is repeated in our frequency range considered (1 -12 Hz) to get the value of Quality factor at each frequency. The above study is carried out for both SH- and SV-wave and finally the variation is compared.

Now taking frequency dependent relation, Q = m fn, we calculated the values of m and n from the regression analysis for both SH- and SV-waves. This relation gives the approximate relation between frequency and Quality factor of a particular area.

Table 1: Seismological Network Stations Used for Recording

S.N.	Station	Code	Lat. (N)	Long. (E)	Rock Type	Elevation
1	Vinakkhal	VIN	30-33.99	78-39.32	Phyllites	1640
2	Chandrabadhni	CHN	30-18.31	78-37.14	Quartzite with Phyllites	2244
3	Rajgadi	RAJ	30-50.64	78-14.39	Quartzite with Phyllites	1908

Table 2: List of the Events Used in the Study

Event No	Date	Origin Time			Lattitude(N)	Longitude(E)	Depth	Magnitude
	Y-M-D	Hrs	Mins	Sec	Degrees	Degrees	Km	Ml
1	120103	16	18	7.20	30.67	78.18	15.63	2.64
2	120106	23	13	20.56	30.42	79.18	10.97	2.25
3	120209	19	17	32.00	30.86	78.29	14.09	3.89
4	120302	22	37	13.45	30.06	78.35	24.16	2.25
5	120302	23	2	2.19	30.91	78.25	13.29	2.63
6	120315	15	17	7.28	30.74	78.43	12.2	2.24
7	120326	23	48	22.84	29.98	78.43	31.12	2.57
8	120410	18	59	25.96	30.64	78.68	16.75	2.3
9	120125	18	36	38.71	30.84	78.31	8.5	2.89
10	121029	7	38	47.87	30.5	78.11	9.7	2.6
11	121127	12	15	14.72	30.87	78.44	16.23	4.5
12	130211	10	48	52.66	30.87	78.33	36.66	4
13	130218	15	7	23.6	30.85	78.76	45.34	2
14	130430	6	52	41.19	30.8	78.19	4.53	2.12
15	131113	23	33	42.53	30.13	78.97	24.99	3.4
16	131120	0	20	57.33	30.7	78.58	16.57	2
17	140224	14	15	5.63	30.47	79.10	14.34	3
18	140310	23	23	51.16	30.3	78.53	8.56	2.6
19	140326	19	4	2.98	30.79	78.40	7.37	2.3

Fig 1: Map Showing Events Considered In the Study

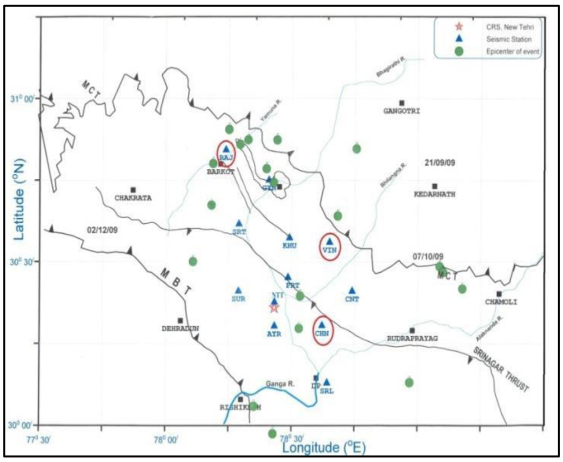
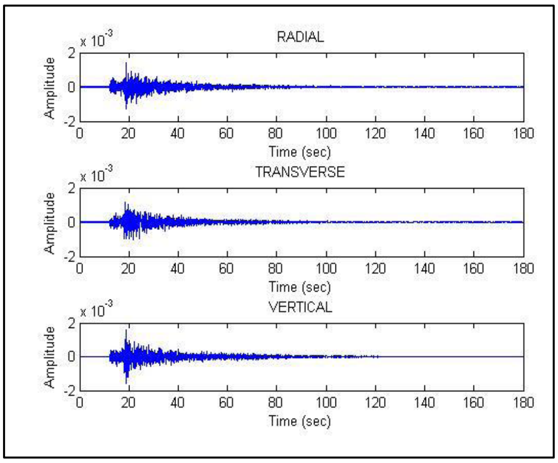


Fig 2: Radial, Transverse and Vertical Three Components Seismograms Of 09/02/2012 at Vin Station



4.0 Results

The S-wave of 150 seismograms from nineteen local earthquakes recorded in the hypocentral distance range from 5 km to 120 km and focal depth range from 9 km to 50 km and magnitude M 2 to 4.5 have been analyzed in the frequency range from 1 Hz to 12 Hz for estimating the amplitude.

Fig 3: Plot of Qsh Vs F (Frequency) for SH Wave (5-120 km)

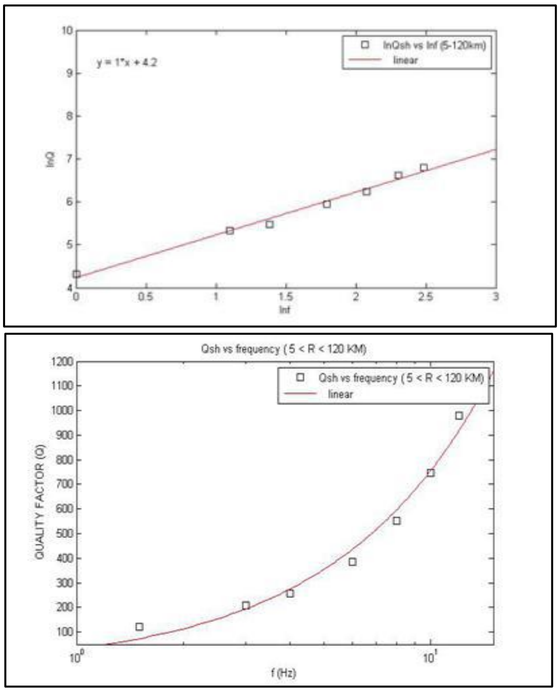


Fig 4: Plot of Qsv Vs F (Frequency) for SH wave (5-120 km)

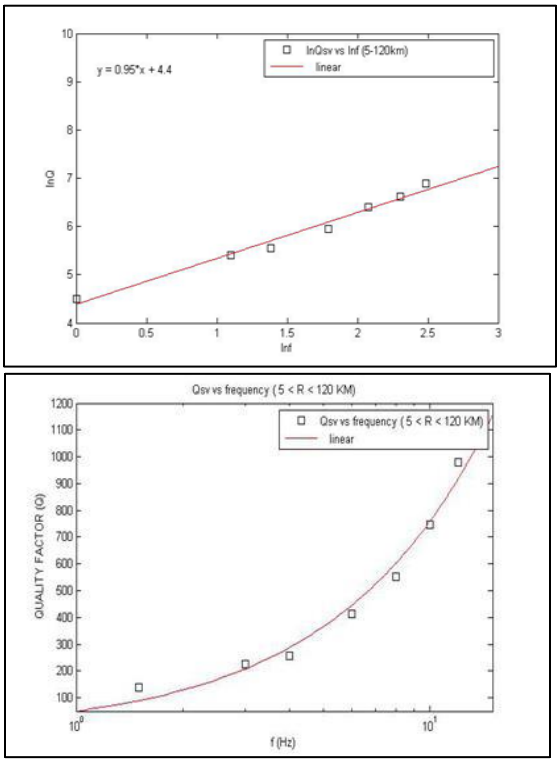


Fig 5: Plot of Qsh Vs F (Frequency) for SH Wave (5-50 km)

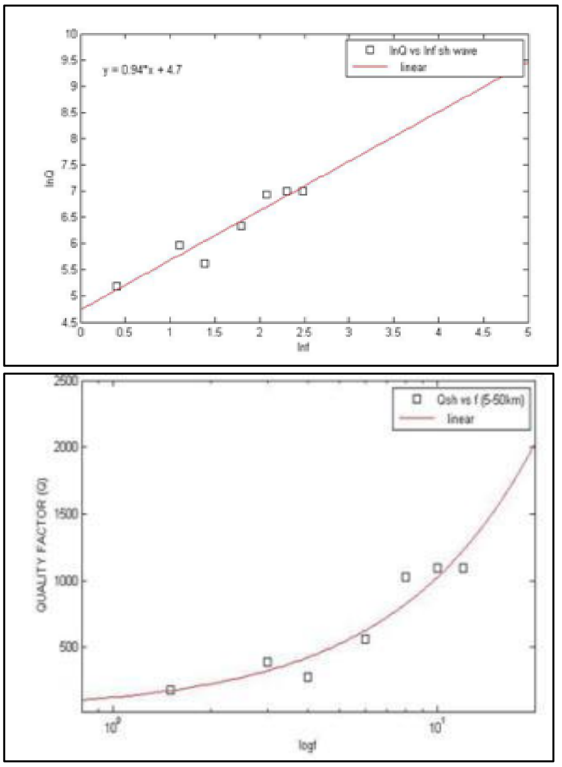


Fig 6: Plot of Qsv Vs F (Frequency) for SV Wave (5-50 km)

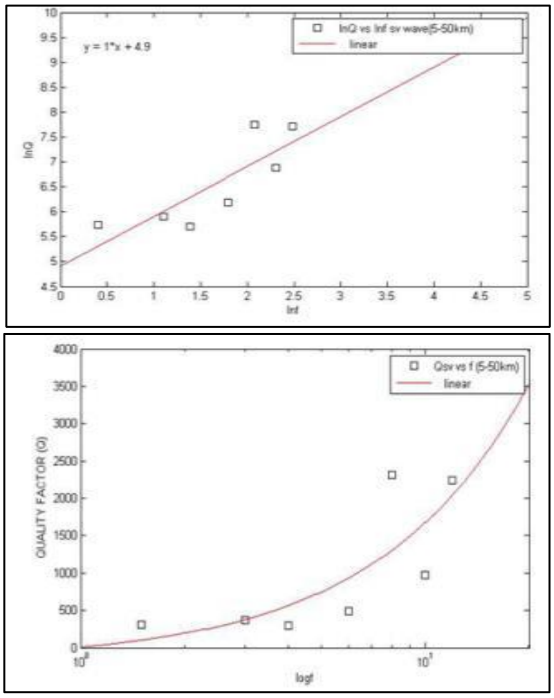


Fig 7: Plot of Qsh Vs f (Frequency) for SH wave (50-120 km)

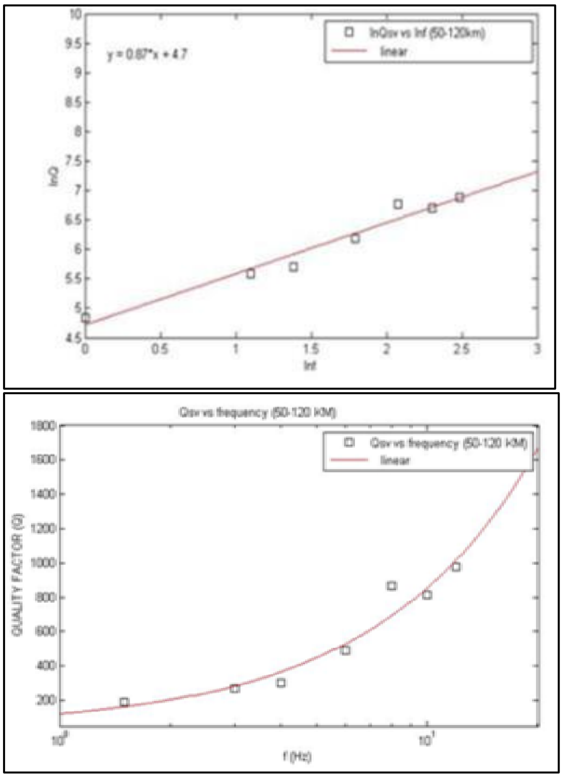
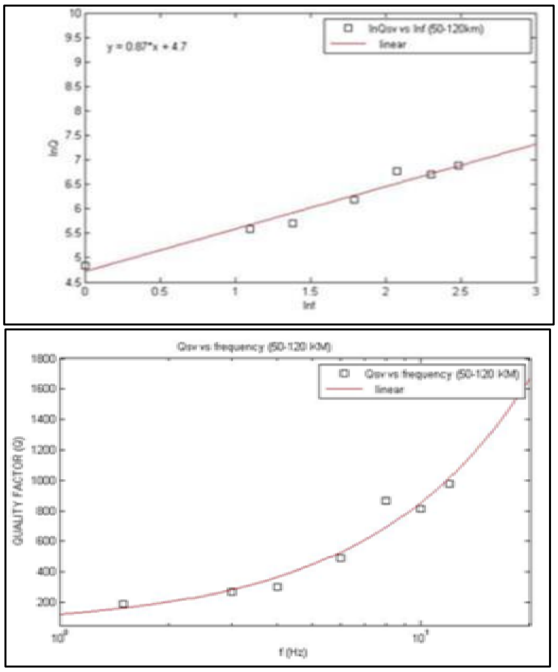


Fig 8: Plot of Qsv Vs F (Frequency) for SV Wave (50-120 km)



4.0 Conclusions

The Attenuation functions for the SH-and SV-wave do not show much difference in amplitude decay for the distance range between 5 and 120 km. From this we can conclude that Q anisotropy is negligible. We also found that Q is frequency dependent for S- wave. This dependence can be approximated by Qsh = 74.3 f 1.0 for SH-wave and Qsv = 81.5 f 0.95 for SV-waves.

In the distance range of 5-50 km, Qsv tends to be significantly greater than Qshat frequency > 8 Hz. So in this distance range we observed Q anisotropy in the studied region. The dependence of Q value with frequency in this range is Qsh = 110 f 0.94 for SH- wave and Qsv = 134 f 1.0 for SV-waves.

Qsh and Qsv values are not showing any significance difference in the range of 50-120 km at lower frequencies but at frequencies greater than 8 Hz there is slight variation in the values of Quality factor. So we concluded that Q anisotropy is not that significant in the range of 50-120 km. The dependence of Q value with frequency in this range is Qsh = 81.5 f 1.1 for SH- wave and Qsv = 110 f 0.87 for SV-waves.

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