Abstract

The attenuation characteristics of seismic waves in the lithosphere at high frequencies are extremely important parameters which are used for the determination of seismic source properties and earthquakes produced strong ground motion characteristics; thus, being imperative for seismic hazards assessment of a region. Seismic wave energy is attenuated with propagation distance mainly due to geometrical spreading and two loss mechanisms, namely, intrinsic absorption and scattering attenuation. The intrinsic absorption is the irreversible loss of energy due to inelasticity of the medium; however, scattering attenuation is the redistribution of the seismic energy that occurs when seismic waves interact with the medium heterogeneities. The attenuation of seismic waves in the lithosphere, particularly, decay rate of coda amplitudes, $Q^{-1}_C$, its regional values and spatial variation has been useful to quantify the tectonics and seismicity of the area. Coda waves are considered to be a superposition of backscattered body waves due to randomly but uniformly distributed small-scale heterogeneities in the lithosphere. The single scattering model was extended to non-coincident source and receiver by, thus enabling one to analyze the coda waves just after the S-wave arrival.

The aim of the present research work is to add the understanding of the attenuation properties of the Garhwal Himalayas, by analyzing coda waves from local earthquakes recorded during November 2003 to June 2004. The attenuation characteristics are estimated as, coda wave attenuation, $Q^{-1}_C$, P-wave coda attenuation, $Q^{-1}_a$, and S-wave coda $Q^{-1}_β$. An attempt has also been made to quantify the relative contribution of scattering $Q^{-1}_S$ and intrinsic attenuation, $Q_i^{-1}$ for the study area. Knowledge of the relative contribution of intrinsic and scattering attenuation is important for identification of subsurface material, interpretation of tectonic setup and quantification of the ground motion.
Seismic coda wave attenuation ($Q^{-1}_C$) characteristics in the Garhwal region, northwestern Himalaya is studied using 113 short-period, vertical component seismic observations from local events with hypocentral distance less than 250km and magnitude range between 1.0 to 4.0. Coda wave attenuation ($Q^{-1}_C$) is estimated using the single isotropic scattering method at several starting lapse times and coda window lengths. Results show that the ($Q^{-1}_C$) values are frequency dependent in the considered frequency range, and they fit the frequency power law ($Q^{-1}_C(f) = (Q_0^{-1} f^{-n})$). The $Q_0$ ($Q_C$ at 1 Hz) estimates vary from about 50 for a 10 s lapse time and 10 s window length, to about 350 for a 60 s lapse time and 60 s window length combination. The exponent of the frequency dependence law, n is greater than 0.8, in general, which correlates well with the values obtained in other seismically and tectonically active and highly heterogeneous regions. The spatial variation of coda attenuation indicates that the level of heterogeneity decreases with increasing depth. The variation of coda attenuation has been estimated for different lapse time and window length combinations to observe the effect with depth and it indicates that the upper lithosphere is more active seismically as compared to the lower lithosphere and the heterogeneity decreases with increasing depth.

In 1980, Aki firstly obtained the frequency dependent S-wave attenuation $Q^{-1}_S$, in Kanto area of Japan by coda normalization method. Based on the Coda Normalization method, A new method was proposed known as extended coda normalization method, for the simultaneous measurement to P-wave and S-wave attenuation by extending the conventional coda normalization method to P-wave. The P-wave attenuation ($Q^{-1}_P$) and S-wave attenuation ($Q^{-1}_S$) were estimated by applying the extended coda normalization method for the frequency range from 1.5 to 24 Hz. Estimates of $Q^{-1}_P$ and $Q^{-1}_S$ decrease with the increase in the frequency. The values of $Q^{-1}_P$ and $Q^{-1}_S$ show strong frequency dependence and fit the power-law relation. Obtained results are in the range of those reported for $Q^{-1}_P$ and $Q^{-1}_S$ of the other seismically active regions. The ratio of $Q^{-1}_P/Q^{-1}_S$
is larger than unity in the entire analyzed frequency range and may suggest high degree of heterogeneity in the region.

It is observed that both intrinsic and scattering attenuation contribute almost equally for coda attenuation at lower frequencies and window length 60s. At higher frequencies for all lapse times intrinsic attenuation controls coda attenuation. This shows that the attenuation characteristics changes with depth.