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Research Article

Attenuation of P and S Waves in the Javakheti Plateau, Georgia (Sakartvelo)

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The frequency-dependent parameters of attenuation of P and S waves in one of the most seismically active regions, of the Javakheti plateau, have been estimated using digital data for the first time. We have analyzed and processed hundred and fifty local shallow earthquakes that occurred from 2006 to 2018 and were recorded by five seismic stations. The quality factors for P waves (Q_p) and for S waves (Q_s) were evaluated by means of the extended coda normalization method. The obtained Q_p and Q_s are strongly frequency dependent in the frequency range of 1.5 to 24 Hz, and increase with frequency according to the following power laws: $Q_P = (17.4 \pm 2.3)f^{1.100 \pm 0.033}$ and $Q_S = (28.8 \pm 3.3)f^{1.048 \pm 0.039}$. The observed Q_s/Q_p ratio was found to be greater than unity over the entire frequency range, suggesting that scattering may play the main role in the attenuation of body waves on the Javakheti plateau. The frequency dependence of the S wave is very similar to the frequency dependence of the shear wave for another seismically active region of Georgia, the Racha area. A comparison of our results to those other regions of the world shows that among the seismically active areas, the Javakheti plateau is characterized by relatively low values of Q_p and Q_s, but they are more than volcanic regions such as Etna and Qeshm Island, Iran. The observed results characterize the entire earth's crust in the study area and will be useful for source parameter estimation, ground motion prediction, and hazard assessment of the Javakheti plateau.

1. Introduction

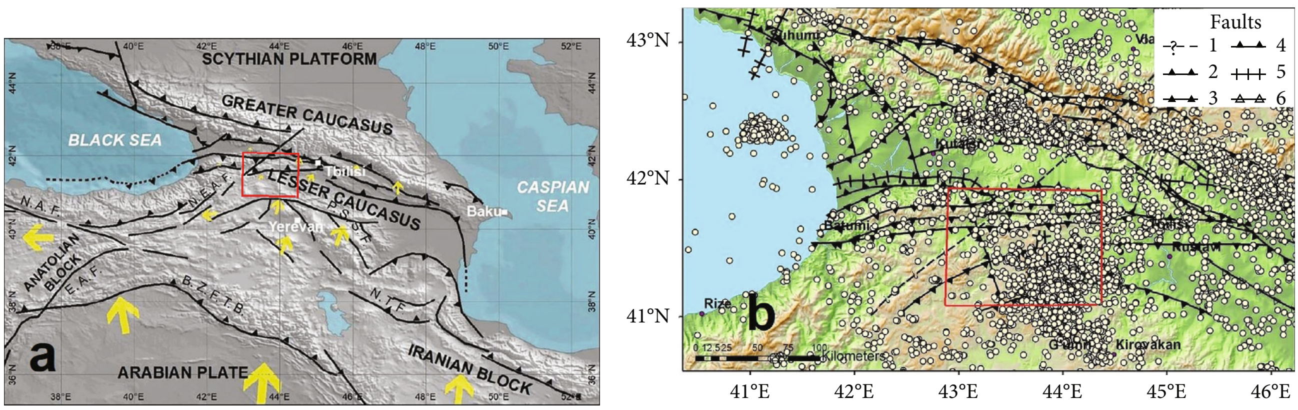
The study of numerous tasks of seismology and engineering seismology is impossible without assessing the properties of attenuation of seismic waves. Namely, the attenuation properties of seismic waves are important for studying earthquake source physics, earth structure, and simulation of strong ground motion. Especially, the spectral content and attenuation of transverse S waves are essential for engineering seismology as they are the main parameters for seismic hazard assessment, and 0.8-10 Hz waves are the most interesting for engineering structures. Therefore, the attenuation of S waves has been studied more intensively than that of P waves. Generally, the quality factor Q (inverse of attenuation), which is the measure of the decay rate of a seismic wave's amplitude at a narrow frequency range, is used to characterize the attenuation of seismic waves. It is a nondimensional parameter and is determined as the ratio of wave energy to the energy dissipated per cycle of oscillation [1, 2]. When seismic waves travel through the Earth, their amplitudes decrease and the seismic waves attenuate. Attenuation of seismic energy depends on geometric spreading (due to the wave field extension), scattering (due to different scale heterogeneities randomly distributed in the lithosphere), and intrinsic absorption (due to the inelasticity of the medium, mainly by converting seismic waves' energy into heat). Thus, total attenuation is the sum of scattering and intrinsic attenuation and provides information about the composition and geological structure of the Earth. Numerous works in the world show that Q values can characterize the seismic activity and geological environment of the region. Namely, it is lower in tectonically active areas and higher in stable regions, e.g. [3].

Since the early 1970s, evaluating attenuation by coda waves has become a widely used method due to the properties of coda waves [2–9]. According to Aki and Chouet [2] coda waves are formed by the superposition of scattering S waves from heterogeneities of different scales. They introduced the seismic attenuation parameter coda Q_C and developed the single backscattering model for Q_C estimation. The coda waves at the short distance are caused mainly to single scattering and the decay rate (envelope) of coda amplitudes of local earthquakes at distances up to 100 km, in a narrow frequency range is independent of site effect, hypocentral distance, and magnitude. Consequently, coda waves characterize the average properties of the medium. Besides coda waves, the quality factor Q can also be estimated using body waves Q_P, and Q_S, Lg wave—Q_{Lg} [2, 10–14]. The attenuation of seismic waves in the Caucasus until the 21st century was mainly estimated from analog data (their frequency range is limited). Development of the net of digital seismographs in Georgia began in 2003 and it becomes possible to use modern methods in solving various problems of seismology. In recent years, the number of digital records has increased intensively: and currently, there are 47 seismometers and 6 accelerometers. Seismic hazard assessment is one of the main tasks in our country and the probabilistic seismic hazard maps need to be updated continuously. Georgian scientists try to improve studies related to seismic hazards according to European, American, and Japanese building codes in order to improve the Georgian because, recently, the number of construction and various engineering projects significantly has increased in Georgia including the Javakheti area, and they need proper seismic design of high standards. Seismic wave propagation in the earth's crust and its attenuation is one of the important issues for seismic hazard analysis. Thus, we need to study it carefully, especially when we are not spoiled by a similar type of research in Georgia. Since the postcollision volcanic plateau of the Javakheti is one of the most hazardous regions of Georgia and is interesting from both seismic and tectonic points of view, we have estimated the attenuation properties of P and S waves by applying the extended coda normalization method [11, 15] using the data of the local earthquakes at different frequencies. There are various methods to evaluate attenuation parameters of seismic waves, but we chose coda normalization methods because Q_C estimates for the Javakheti were made earlier [16] using the single backscattering model [2] in the frequency range 1.5-24 Hz and for four lapse time windows (20, 30, 40, 50 s). Observed Q_C values were low and increased both with an increase of frequency and lapse time. Q_C estimates and their frequency-dependent relationships were in a range of values of tectonically active and highly heterogeneous regions. The decrease of coda attenuation with lapse time was explained due to decreasing homogeneities with depth, since the lapse time increased, the coda waves were generated in larger and deeper volumes of the earth, which became more homogeneous than the upper layers of the Earth's crust.

The Caucasus region is considered to be well-studied from a geological and geophysical point of view [17]. There is a sufficient number of articles about the attenuation of seismic waves (body and surface waves) for the Caucasus (e.g., [18–21]), but only a few papers in which the attenuation properties of the lithosphere under the Javakheti plateau have been evaluated, and they were done mainly by means of analog records [22–24]. As it was noted [25], Georgia was the first country in the Caucasus where the attenuation properties of the earth's crust were investigated using the coda waves. In the early eighties of the last century, Q_p and Q_s were estimated by the coda normalization method on the basis of analog data for the entire territory of Georgia (but the attenuation was not estimated for the Javakheti area separately) in epicentral distances from 50 to 300 km [26]. Though in 1984, coda Q_C was estimated in the frequency range of 0.6 to 42 Hz using the ChISS apparatus, which was installed in Akhalkalaki and was designed by Zapolskii [27]. This record was similar to instruments used by Aki and Chouet [2]. The coda was analyzed in a time window of 20-120 s. The dependence of Q_C on frequency was expressed by the following equation $Q_C = 48f^{0.98}$. Then Q_C values were determined for the Javakheti plateau using only one digital seismic station AKH and only one coda window equal to 40 s and established the relationship $Q_C = 41f^{1.052}$ [24]. Finally, the coda Q_C was estimated in different coda windows using five digital stations [16]. Thus, in particular, the attenuation properties of the lithosphere under the Javakheti plateau have not been previously estimated from digital data. Therefore, in the future, the estimates of Q_p and Q_s will be used to solve various problems of seismology and engineering seismology in the study area.

2. The Study Region

Georgia belongs to the Mediterranean belt and is located in the western part of the South Caucasus within the convergent boundary between the Arabian and Eurasian plates, where the relative motion is mainly carried out by the fold and thrust belts within the Greater and Lesser Caucasus [28–31], (Figure 1(a)). Therefore, the active tectonics of Georgia and the Javakheti plateau (which is located in the south of Georgia in the central Caucasus) is determined by the collision of the Arabian and the Eurasian plates in the Miocene-Pleistocene. The study region—the Javakheti plateau—is a unique region of Georgia due to its geographical location and geological complexity. Throughout the region, the Baku-Tbilisi-Ceyhan oil pipeline and the South Caucasus gas pipeline are passing. Also, highways connecting Georgia with Turkey and Armenia and other communications of international importance are being built. Along with natural disasters typical for mountainous areas—floods, landslides, erosion of river banks, etc.—the entire territory of the region is the most seismically active region of Georgia with a maximum magnitude of 7.2 and the reoccurrence period of such events is of order $10^3 - 10^4$ years [31]. Thus, it is important to investigate and assess the damage from natural disasters in this area and to solve those problems knowledge of the



(a) (b)

Figure 1: (a) Tectonic setting of the Caucasus region. N.A.F.: North Anatolian Fault, E.A.F.: East Anatolian Fault, N.E.A.F.: Northeast Anatolian Fault, B.Z.F.T.B.: Bitlis-Zagros Fold and Thrust Belt, N.T.F.: North Tebriz Fault, and P.S.S.F.: Pambak-Sevan-Sunik Fault. The fastest velocity vector is the northward movement of the Arabian Plate at 25 mm/yr [31]. (b) Epicenters of earthquakes ($M_L \geq 2.0$) occurred in Georgia from 2003 to 2019 (grey circles), the active faults are also shown, 1 refers to the strike-slip, 2 refers to the reverse, 3 refers to the left reverse, 4 refers to the right reverse, 5 refers to the normal fault, and 6 refers to the nappe. The Javakheti plateau is marked with a red frame.

attenuation of seismic waves versus distance is one of the main issues.

The Javakheti highland is a young tectonic unit formed during Neogene–Quaternary era and is a classic example of continental collision volcanism [32]. The territory is a rather complex orographic system of high mountain ranges and deep tectonic troughs. The Javakheti plateau contains several dozen volcanic centers of the Late Neogene and Eopleistocene, most of which correspond to fault zones [33]. In the central part of the study area in the meridional direction, the high mountain ranges Samsari and Kechuti are stretched (Figure 2) which are part of the biggest stratovolcano of the Javakheti highland. The high seismicity of this plateau is caused by the activity of these deep faults. They are the main source of both weak and large earthquakes. As a rule, volcanic environments are highly heterogeneous, the unconsolidated volcanic rock may increase the effect of scattering [34] and intrinsic attenuation [35], and accordingly, Q values are relatively low in such regions.

In general, Georgia is characterized by moderate seismicity (Figure 1(b)). The number of earthquakes and the maximum intensity in Georgia are less than in neighboring Turkey and Iran, but strong earthquakes have often been observed in its territory. Javakheti is distinguished by a large number of small earthquakes from other regions of Georgia, as well as from the Caucasus. Large earthquakes are located along the main tectonic faults. The specificity of the seismicity of the region is due to the high degree of fragmentation of active faults into separate small crustal blocks. Because of the small blocks of the earth's crust, they cannot accumulate large seismic energy, so small earthquakes occur there almost every day [36]. According to [37], since Javakheti is an area of young volcanism, a large number of weak earthquakes could have a volcanic origin. Large earthquakes also occurred in this territory. The three largest earthquakes occurred during the instrumental period: Tabatsquri (1940, M6), Paravani (1986, M5.9), and Spitak (1988, M7). Three historical earthquakes ($M \geq 6.5$) are also known from ancient Georgian annals in 1088, 1283, and 1899. Earthquakes on the Javakheti plateau are characterized by different types of focal mechanisms such as strike-slip, normal, and thrust The region is experiencing N-S compression and W-E extension [36]. The GPS data also confirms this fact [38].

3. Data and Methods

We have analyzed the data of 150 earthquakes recorded by the National Seismic Monitoring Centre Network of Ilia State University from 2006 to 2018. Records have been obtained from five seismic stations AKH, ABS, BGD, BRNG, and DMN equipped with broadband Guralp CMG40T, CMG-3ESPC, and Trillium 40 seismometers at a sampling rate of 100 samples per second were used (Figure 2). All stations are located on volcanic rock. To evaluate Q_P and Q_S values, we have chosen most of those earthquakes and stations that were previously used to estimate the quality factor of coda waves Q_C [16]. Selected earthquakes have the following features: the epicentral distances and focal depths are less than 65 km and 18 km, respectively. The range of local magnitudes is 1.8-4.4. Figures 3 and 4 show the frequency distribution of earthquakes versus local magnitudes and the number of earthquake records versus hypocentral distance used in the study to estimate Q_p and Q_s at different central frequencies, respectively. More than 500 seismograms with a signal-to-noise (S/N) ratio equal to or more than three were processed to assess the quality factors of body waves—Q_P and Q_S.

The quality factors Q_P and Q_S were estimated with the help of the coda normalization method (CNM), worked out by Aki [15] for estimating attenuation by normalizing the direct S wave amplitude by S coda amplitude. Later this method, Yoshimoto et al.[11] extended for the P wave, and it is now possible to measure simultaneously the Q_p and Q_s

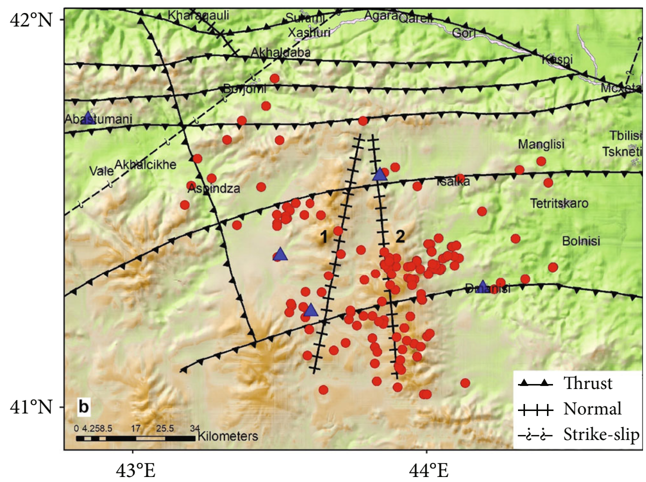


Figure 2: Map of epicenters of earthquakes (solid circles) and seismic stations (triangles) used in the present study. Types of faults are also shown. 1-Samsari, 2-Kechuti.

values. This method relies on the assumption that the energy of coda waves is uniformly distributed in space and for local earthquakes, P and S wave radiations have the same spectrum ratio in a specific frequency range. In turn, at a small distance (less than 100 km), coda spectral amplitude waves change proportionally to S wave spectral amplitudes. Therefore, the spectral amplitudes of coda, P, and S waves vary proportionally, and the division of P and S wave amplitudes by coda amplitudes at a fixed lapse time (greater than twice the direct S wave travel time) removes the source and site effects that are common for direct and coda waves. Especially, CNM can be used when an earthquake occurs in a hard-to-reach place, for example, in the mountains or in a water area.

Thus, according to the works [11, 15], the quality factors of P wave (Q_p) and S wave (Q_s), using the normalization of P and S wave spectra amplitudes by the coda wave, can be estimated from the seismogram observed at a different frequency range and at a different hypocentral distance by the following equations:

$$\ln \left[\frac{A_S(f,r)r}{A_C(f,t_C)}\right] = -\frac{\pi f r}{Q_S(f)V_S} + \text{const}(f), \tag{1}$$

$$\ln \left[\frac{A_P(f,r)r}{A_C(f,t_C)}\right] = -\frac{\pi f r}{Q_P(f)V_P} + \text{const}(f), \tag{2}$$

where $A_P(f,r)$, $A_S(f,r)$, and $A_C(f,t_C)$ are the direct P and S wave maximum amplitude and coda wave spectral amplitude at a distance r, respectively; f is the frequency; and t_C is a fixed time from the origin. V_P and V_S are the average velocities of P and S waves. $V_P = 5.9$ km/s and $V_S = 3.1$ km/s [39]. The geometrical spreading factor for body waves is taken as r^{-1}. The constant terms denote the scattering characteristics of the Earth medium of a given region. The Q_P and Q_S can be obtained from the slope of the linear regression equations (1) and (2) expressing the relationships between the normalization amplitudes of direct and coda waves—A_P/A_C, A_S/A_C—with hypocentral distance.

To process the data, we used the software Seismic Analysis Code (SAC) [40]. From each seismogram, a trend and mean value was removed, the baseline was corrected, and a cosine taper was applied. Then, seismograms were filtered by using a Butterworth bandpass filter at five frequency ranges of 1-3 Hz, 2-4 Hz, 4-8 Hz, 8-16 Hz, and 16-32 Hz with central frequencies at 1.5, 3, 6, 12, and 24 Hz. Figure 5 shows the original and band pass-filtered seismograms of the vertical Z component for the 24/07/2007 earthquake M4.4 recorded at the station AKHA.

For each frequency band, we measured the maximum peak-to-peak amplitudes of P and S waves in a 5 s time window starting from the onset of each wave on the vertical Z and horizontal NS components, respectively. Half the value of the peak-to-peak amplitude is $A_P(f,r)$ and $A_S(f,r)$. Differences in the maximum amplitude of S waves between the horizontal components generally do not exceed 6%. Coda spectral amplitudes $A_C(f,t_C)$ were derived from the root mean squares of the coda amplitudes of the same component of the seismogram. $A_C(f,t_C)$ was estimated for the time window of 5 s centered at $t_C = 50$ s measured from the earthquake origin time for each central frequency. All data from various stations were combined in a single plot since the coda wave amplitude decay rates with time (envelope) for the lithosphere under the Javakheti plateau at a specific frequency range among the five different stations used for assessing the attenuation of coda waves are the same due to properties of coda waves [16]. It is independent of the hypocentral distance (at least up to 70 km), local magnitude, and the azimuth of the station. We have observed the same trend for the normalized amplitudes of A_P/A_C and A_S/A_C at different stations. Therefore, it was possible to combine data from different stations in a single graph and to evaluate the average values of Q_P and Q_S from the slope of Equations (1) and (2) (Figure 6). In 18 cases, it was impossible to measure the A_C at $t_c = 50\,s$, due to high noise, then we used a master curve obtained from the average decay rate of coda waves in the different frequency ranges constrained for the Javakheti region at different frequency bands using local earthquakes. It should be noted that the use of the reference curve to estimate A_C values at a fixed time does not affect its value, since the envelope of coda amplitudes is the same in a narrow frequency band for different stations of the studied region [16].

4. Results and Discussion

Quality factors of P and S waves Q_P and Q_S were estimated for the Javakheti plateau by applying the extended coda normalization method [11] according to Equations (1) and (2) at five frequency bands. Obtained values of Q_P and Q_S estimated from the data of all stations are given in Figure 6.

Mean values of Q_P and Q_S show a strong frequency dependence character in the frequency range of 1.5-24 Hz. Namely, they increase with increasing frequency. The observed Q_P and Q_S values were fitted to the power-law function of form $Q(f) = Q_0(f)^n$ at all central frequencies,

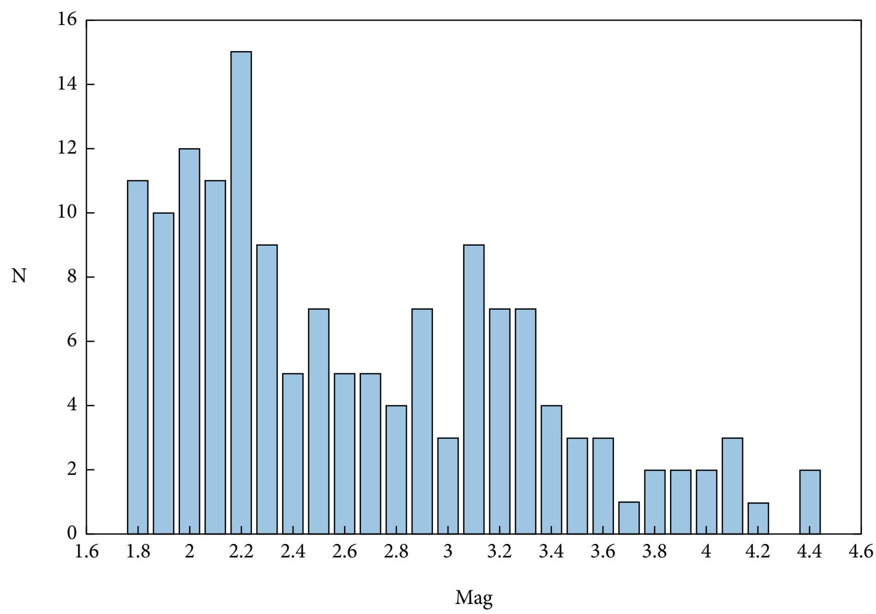


Figure 3: Frequency distribution of earthquakes versus local magnitudes.

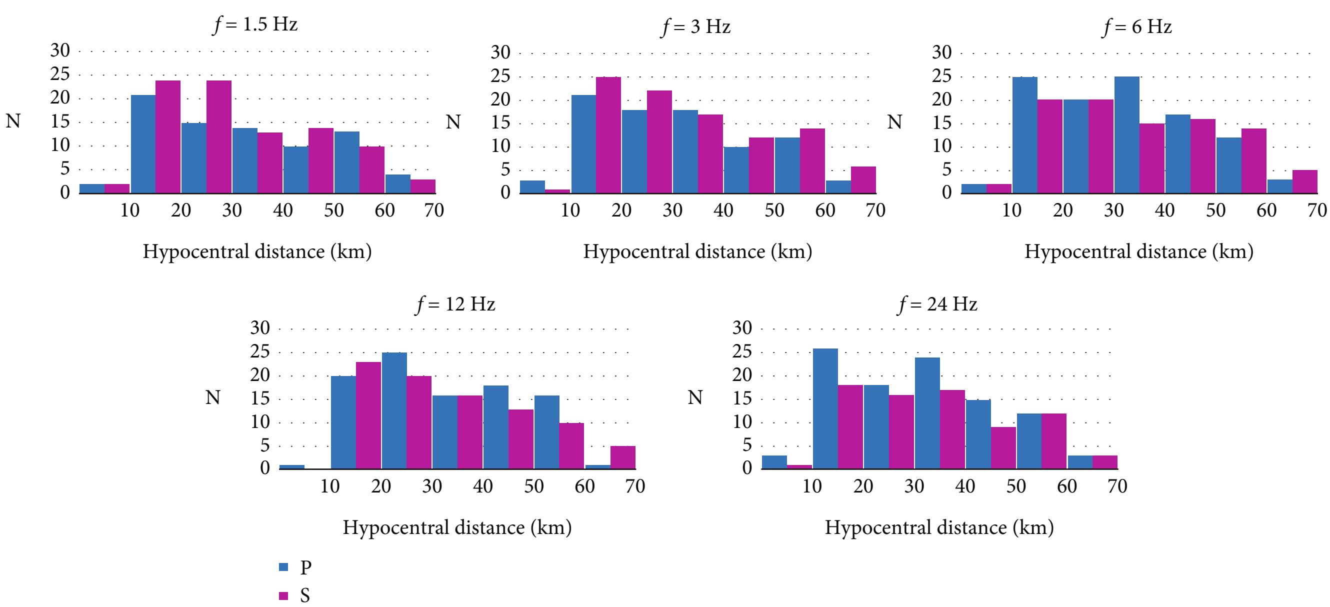


Figure 4: The number of earthquake records versus hypocentral distance used to estimate Q_p and Q_s at different central frequencies.

where Q_0 is the quality factor at 1 Hz and n is the frequency relation parameter [41]. The frequency-dependent quality factors for P and S waves are expressed by the power law as:

$$Q_P = (17.4 \pm 2.3) f^{1.100 \pm 0.033},$$
$$Q_S = (28.8 \pm 3.3) f^{1.048 \pm 0.039}. \tag{3}$$

The obtained values of quality factors are low and the values of frequency relation parameter n are more than unity. This means that the region is highly heterogeneous and seismically active. The relatively high values of attenuation (low Q) and of n frequency exponents correspond to the seismically active areas in the world [11, 25, 42–45]. We have found that P waves attenuate slightly more rapidly than the S waves and the ratio of Q_S to Q_P is more than unity ($Q_S/Q_P > 1$) in all frequency bands and varies from 1.4 to 1.6 (Figure 7(a)). According to Aki [46], when a wave propagates in heterogeneous media the conversion of a P wave to an S wave is larger than the conversion of an S wave to P. Thus, the attenuation of a P wave is greater than that of an S wave, and as a result, Q_P becomes less than Q_s. It was shown in other works in the world that $Q_S/Q_P > 1$ for regions with complex tectonics [3, 12, 47–49].

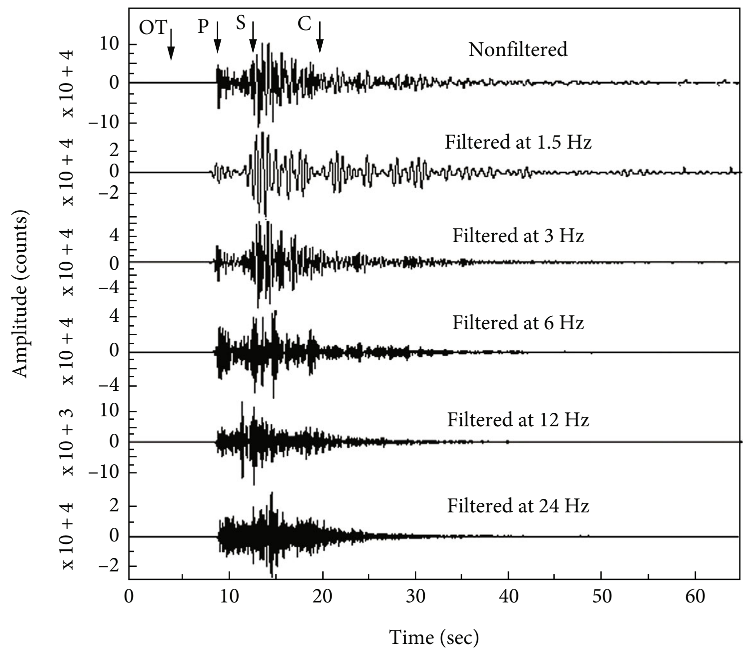


Figure 5: Example of original and band pass-filtered seismograms (Z component) for central frequencies at 1.5, 3, 6, 12, and 24 Hz, respectively, for the local earthquake (2007/07/24) with M4.4 and epicentral distance of 30 km recorded at station AKHA. Arrows indicate origin time, P, S, and coda waves' arrivals.

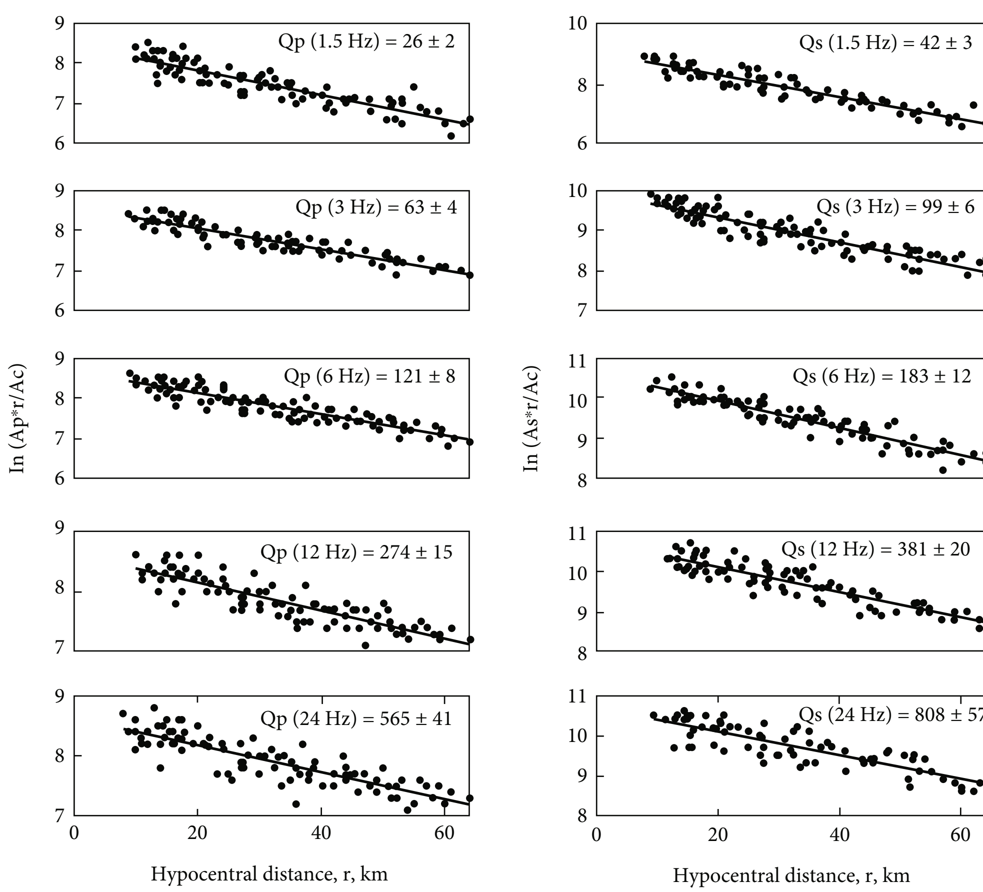


Figure 6: Plots of normalized P and S wave amplitudes with hypocentral distance at different frequencies and for all seismic stations. The regression lines and estimated Q_P and Q_S are also shown.

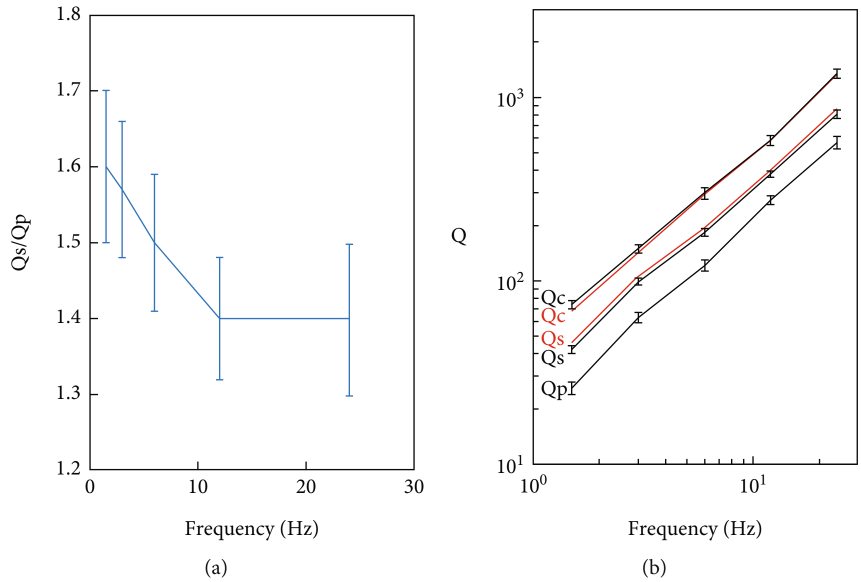


Figure 7: (a) Q_s/Q_p ratio as a function of frequencies for study region. (b) Mean values of Q_S, Q_P, and Q_C versus the central frequency for the Javakheti plateau (black lines) and the Racha (red lines) region.

As it was noted above, the values of Q_C for the Javakheti region were estimated at different lapse times [16]. To compare Q_S and Q_C values, it is needed that the coda and S waves sample a comparable volume of the Earth. Therefore, we have selected Q_C values estimated in the 30 s coda window and Q_S values for earthquakes with travel times less than about 15 s recorded at hypocentral distances up to 65 km. Frequency dependence of Q_C at lapse time 30 sec was expressed by:

$$Q_C = (47.6 \pm 3.8) f^{1.034 \pm 0.048}. \tag{4}$$

Thus, the frequency exponents (n) are almost equal for Q_C and Q_S. It means that the attenuation mechanisms for coda and S waves are similar and the coda waves are composed of S waves [5, 15]. According to Aki and Chouet [2], coda waves at a lapse time of 30 s sample a spherical volume with a radius of about $v_s t/2 = 47$ km, and because the depth of the crust under the Javakheti is about 48 km [39], the obtained values of attenuation are average in the crust. However, $Q_C > Q_S$. Values of Q_C and Q_S vary from 74 to 1334 and from 42 to 808, respectively, within the frequency range of 1.5-24 Hz. It can be explained by possible predominance scattering effects beneath the study region, i.e., when the seismic waves propagate in the medium, more seismic energy is distributed in the coda waves from the direct body waves. This should be investigated in the future by separating the total attenuation into intrinsic and scattering attenuations. Figure 7(b) shows the frequency dependence of the average values of Q_S, Q_P, and Q_C.

It is interesting to compare our results with those obtained for another seismically active region of Georgia such as Racha area (Figure 7(b)), where intense volcanism occurred until the end of the Bajocian age [50]. This region is located in the Northwest of Georgia at the joint of the Greater Caucasus and the Transcaucasian middle massif. The seismic activity of the Racha sharply increased after the strong earthquake in 1991 M7. We have found that the effect of intrinsic attenuation is dominated over scattering attenuation for this region and is a strong function of frequency. Unfortunately, we can only compare Q_S values, since Q_P values for the Racha region have not been estimated until now. The Q_S values are also low for Racha, they increase with increasing frequency and are expressed according to power-law as $(31 \pm 2) f^{1.038 \pm 0.037}$ [51]. Thus, the attenuation parameters are similar for these two regions of Georgia, Q_S values change at 1-24 Hz frequency band from 42 to 808 and 46 to 863 for Javakheti and Racha regions, respectively. Low values of quality factors of direct S waves are also reported for the North Caucasus [21].

We compared the Q_P and Q_S parameters obtained in this study with other tectonically and seismically active regions of the world. It is shown from Figure 8 that among the seismically active areas, the Javakheti plateau is characterized by low values of Q_P and Q_S and the relatively high-frequency exponent n. Only the Q_S for the volcanic area of Etna [52] and the Q_P in Qeshm Island, Iran [53], are much lower than those obtained for the Javakheti plateau. The high values of Q_P and Q_S were observed for South Korea [47], which is the most stable region among the considered areas. This figure shows that Q values and the rate of their increase in the Javakheti area are comparable to other seismically active regions like the Umbria-Marche, Italy [54]; Bhuj, India [48]; Kanto, Japan [11]; Kinnaur Himalaya [49]; Cairo, Egypt [55];and Baoshan, China [56].

As was noted in [51], generally the lithosphere of the Caucasus is characterized by high attenuation. The Caucasus belongs to a relatively young tectonic structure and the attenuation of seismic waves in the lithosphere of the Caucasus is large; and, accordingly, the Q values are lower than in

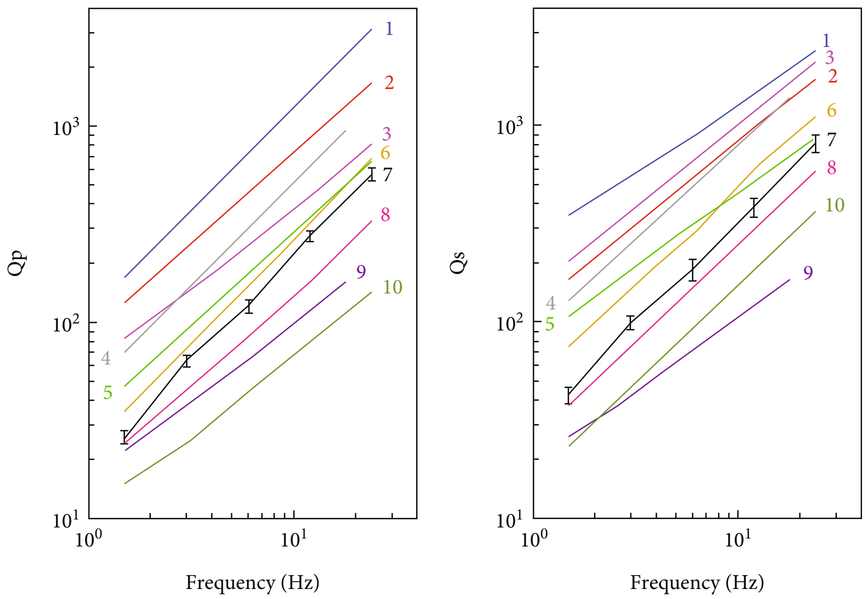


Figure 8: Comparison of Q_P and Q_S values for different regions. Line 1: South Eastern Korea [47]; line 2: Baoshan, China [56]; line 3: Cairo, Egypt [55]; line 4: Kinnaur Himalaya [49]; line 5: Kanto, Japan [11]; line 6: Bhuj, India [48]; line 7: this study; line 8: Umbria-Marche, Italy [54]; line 9: Etna, Italy [52, 59]; and line 10: Qeshm Island, Iran [53].

those regions where the age of folding is older. The geological age of folding in the Lesser Caucasus, where Javakheti is located, is younger. In such a tectonic structure, the deformations are complex; the earth's crust below the study area consists of numerous faults and cracks; and, therefore, the attenuation is large [50]. The high attenuation in the study area can also be caused by low-velocity anomalies of P and S waves found in the Earth's crust and upper mantle under the Javakheti plateau [57]. As a rule, a highly fractured medium is mainly related to low-velocity regions and, accordingly, to large attenuation. In addition, a high temperature of up to 750°C revealed at the Moho depths beneath the Lesser Caucasus might cause high attenuation in the study region [58].

5. Conclusion

In the present study, we estimated Q_P and Q_s values in the frequency range of 1-24 Hz and established their frequency dependence. It was found that Q_P and Q_s increased from 26 and 42 at 1.5 Hz to 565 and 808 at 24 Hz, respectively. We have selected the Javakheti plateau due to seismic activity reasons because, recently, it is one of the most active regions in Georgia in terms of seismicity. When we study seismic hazard in Georgia, ground motion prediction models are one of the significant stages of the analysis. Thus, we have paid attention to this stage of the probabilistic seismic hazard analysis. Quality factor analysis plays an important role to understand attenuation features of the region at different frequency bands. Especially, geometrical spreading varies slightly for different regions in Georgia. Thus, each seismic active region needs to be analyzed separately as we did in the study for the Javakheti plateau. We have analyzed seismic attenuation variations for ground motion studies. This variation can be due to material properties or physical states of a medium (such as temperature, stress, and water consistency). For example, the existence of cracks or seismic fault zones or seismogenic zones may change the attenuation properties of the region. However, studying physical properties was not the scope of our studies. In the near future, we also plan to study attenuation properties based on the increased number of records (which will be available due to the increased number of new seismic stations), compare them with the study presented in the manuscript, analyze how it changes at different frequency band, and what is the reason of it from possible reasons mentioned above.

Data Availability

The detailed data about all earthquakes are collected by a team of the Institute of Earth Sciences and National Seismic Monitoring Centre (http://ies.iliauni.edu.ge) under the Ilia State University and access can be done upon the special request to the institute. Requests for access to these data should be done via e-mail: earthscience@iliauni.edu.ge.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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