Attenuation characteristics of P and S waves in the crust of western Tibet

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HIGHLIGHTS

1. First body wave attenuation measurements using local earthquakes in western Tibet.
2. Evidence of high attenuation zone mainly related to both the scattering and intrinsic effects.
3. The study explores the lateral variations of crustal attenuation properties in western Tibet.

STUDY REGION & METHODS

1 Study region

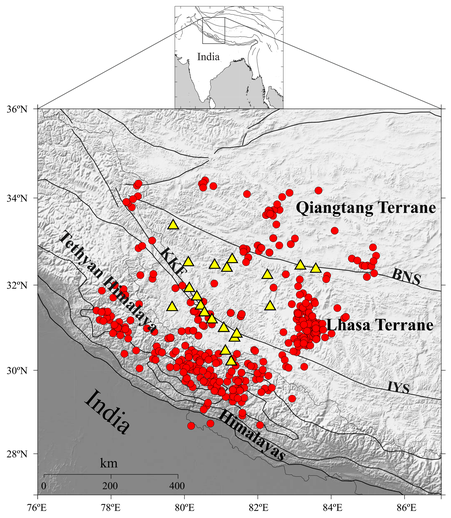

Figure 1: Tectonic map of the study area including locations of the earthquake (red circles) and stations (yellow triangle) used in this study. The upper panel shows the exact location with respect to India. BNS: Bangong-Nujiang suture; IYS: Indus-Yarlung suture; KKF: Karakoram fault.

2 Method

For simultaneous measurements of the body wave attenuation parameters, we have used the extended coda normalization method [1] in this study. The following equations were used to calculate the Q_p^{-1} and Q_s^{-1} values:

$$ln\left[\frac{A_p(f,r)r}{A_c(f,t_c)}\right] = -\left[\frac{\pi f}{Q_p(f)V_p}\right]r + const(f) \quad (1)$$

$$ln\left[\frac{A_s(f,r)r}{A_c(f,t_c)}\right] = -\left[\frac{\pi f}{Q_s(f)V_s}\right]r + const(f) \quad (2)$$

The frequency dependent nature of Q^{-1} is analyzed using a simple power law which can be expressed as,

$$Q^{-1}(f) = Q_0^{-1} f^{-n} \quad (3)$$

DATA ANALYSIS

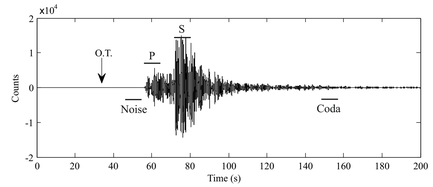

Figure 2: Example of a typical seismogram (N-S component) recorded at station GUGE with M = 3.0 having a hypocentral distance of 131.8 km. the horizontal bar represents 5 s window for P, S, Coda and Noise part respectively. Coda part is started at t_c = 120 s relative to the earthquake origin time. O.T. = origin time.

Low Freq.	Central Freq.	High Freq.
1	1.5	2
2	3	4
4	6	8
8	12	16
12	18	24

Table 1: Different central frequencies with cutoff limits used in this study.

Figure 3: Coda normalized P and S wave amplitudes with hypocentral distance at five different central frequencies for PURG station. The regression lines from the least-squares fit is expressed by solid lines. The error bar shown in each frame represents the standard deviations.

RESULTS 1

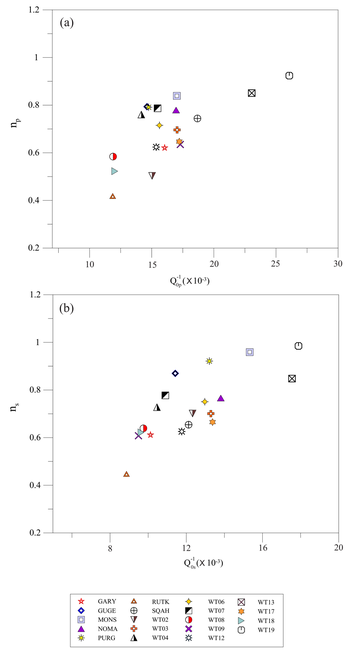

Figure 4: Plot of (a) n_p vs Q_{0p}^{-1} and (b) n_s vs Q_{0s}^{-1} along with their standard deviations.

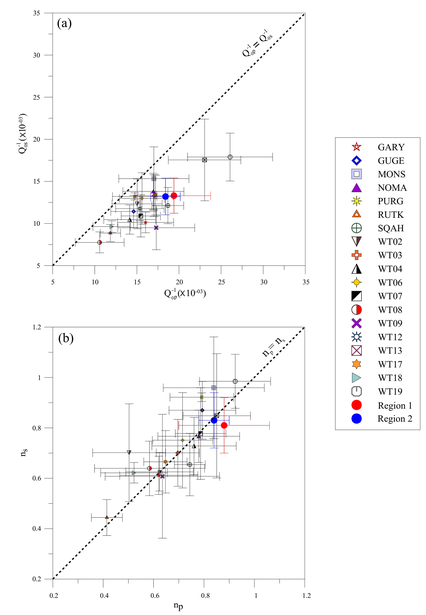

Figure 5: (a) The linear relationship of Q_{0s}^{-1} vs Q_{0p}^{-1} obtained at each station in this study. (b) Plot of n_s vs n_p. Error bars represent the standard deviations in each plot.

RESULTS 2

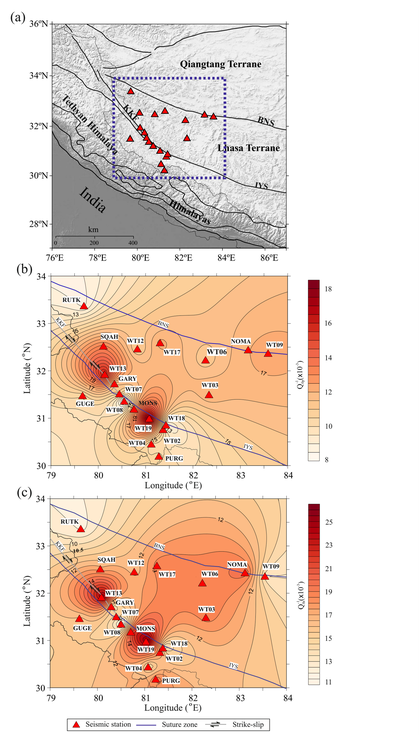

Figure 6: (a) Map of the study region and the dotted rectangle box illustrates the area chosen for the contour plot. (b)-(c) Spatial distributions of estimated Q_{0p}^{-1} and Q_{0s}^{-1} values.

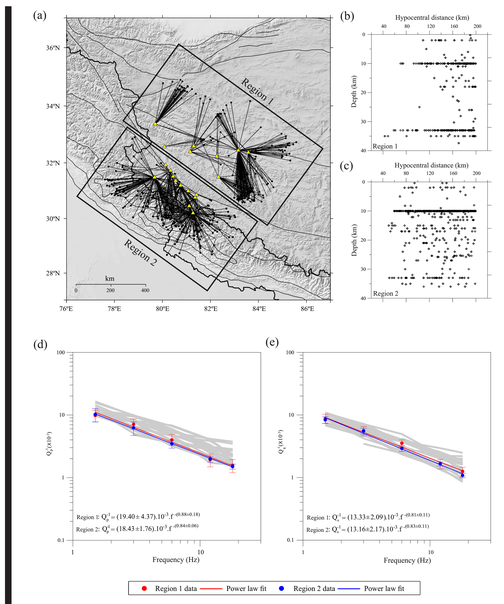

Figure 7: (a) Two ray path distribution used for separate estimation of attenuation properties having an epicentral distance less than 200. The black rectangle box indicates two different regions. (b)-(c) Hypocentral distance and focal depth distributions of data sets used in the analysis. (d)-(e) Estimated mean values of Q_p^{-1} and Q_s^{-1} as a function of frequency for Region 1 and Region 2. Error bars represent the standard deviations of the data. The light grey lines are obtained results at each station in the study area.

CONCLUSIONS

1. In this present study, we have estimated the Q_p^{-1} and Q_s^{-1} values at five different central frequencies for 19 broadband seismological stations. Estimated Q_p^{-1} >Q_s^{-1} values are found to be highly frequency dependent which is mainly associated with the tectonic activity and complexity of the crust.
2. The lose of energy in P wave is found to be more than S wave (Q_p^{-1} >Q_s^{-1}) in the frequency range of 1.5 to 18 Hz at all the stations. Highest attenuation has been observed at WT19 and WT13 stations located near to the KKF and IYS.
3. No significant lateral variation in attenuation characteristics is detected between Region 1 and Region 2 which suggests similar tectonic complexities and heterogeneities present across KKF.
4. The obtained high values of Q_{0p}^{-1} and Q_{0s}^{-1} indicate that the entire western Tibet belong to a high attenuative zone.
5. We found Q_p^{-1}/Q_s^{-1} >1 for the entire frequency range which can be attributed to both intrinsic and scattering phenomena.

ACKNOWLEDGEMENT & REFERENCES

We gratefully acknowledge IRIS Data Management Centre for making data available.

[1] Kazuo Yoshimoto, Haruo Sato, and Masakazu Ohtake. Frequency-dependent attenuation of P and S waves in the kanto area, Japan, based on the coda-normalization method. *Geophys. J. Int.*, 114:165–174, 1993.