ABSTRACT

The NW Himalaya is one of the most complex and heterogeneous seismotectonic unit of the Alpide-Himalaya seismic belt. The substantial release of accumulated strain energy of India-Eurasia collision in the form of micro-earthquakes in the recent past makes the region vulnerable to future seismic hazards. The purpose of present investigations is to understand the seismotectonic architecture beneath the study area bounded by 29°- 33°N and 76°-81°E, which includes the two highly seismically active zone of NW Himalaya i.e. Himachal Himalaya and Kumaon-Garhwal Himalaya. The present work includes; Investigation of seismic anisotropy beneath the western segment, NW Indian Himalaya using shear wave splitting; Seismic attenuation characteristics of coda waves in the Northwestern Himalayan (India) region; Spatio-temporal analysis of seismicity; Three-dimensional crustal velocity structure estimation for the study area.

Seismic anisotropy beneath the Indo-Eurasia collision zone utilizing the core-refracted (S(K)KS) phases from 167 earthquakes recorded by 20 broadband seismic stations deployed in the western Himalaya has been investigated. The 76 new shear-wave splitting measurements reveal that the fast polarization azimuths (FPA) are mainly oriented in the ENE-WSW direction, with the delay times varying between 0.2 and 1.7s. The FPAs at most of the stations tend to be orthogonal to the major geological boundaries in the western Himalaya. The average trend of the FPAs at each station indicates that the seismic anisotropy is primarily due to the strain-induced deformation in the uppermost 400 km of the Earth by the ongoing Indo-Eurasian collision. One possibility may be the contribution from the mantle flow in the direction of the Indian plate motion. The findings of the study highlight the fact that lithospheric deformation due to ongoing convergence between India and Eurasian plate, and the absolute plate motion related strain are the two possible causes for the azimuthal anisotropy in the western sector of the Himalaya region. The mantle strain revealed in the present study may be due to a combination of basal shear resulting from plate motion and ductile flow along the collision front due to compression.

Digital seismogram data of 82 earthquakes from the Northwestern Himalayan (India) region recorded at different stations during 2004–2006 were analysed to study the seismic coda wave attenuation characteristics in this region. We used 132 seismic observations from local earthquakes with a hypocentral distance < 240 km and a magnitude range of 1.2–4.9 to study the coda Qc using the single isotropic scattering model. The Qc values were estimated at 10

central frequencies: 1.5, 3, 5, 7, 9, 12, 16, 20, 24, and 28 Hz using starting lapse-times of 10, 20, 30, 40, 50, and 60 s and coda window-lengths of 10, 20, 30, 40, and 50 s. The Qc fits the frequency dependent power-law, Qc= Q0f n. For a 10 s lapse time with a 10-s coda window length Qc = 47.42f 1.012 and for a 50 s lapse time with a 50 s coda window length, Qc = 204.1f 0.934. Q0 (Qc at 1 Hz) varied from ~ 47 for a 10 s lapse time and a 10 s window length, to ~ 204 for a 50 s lapse time and a 50 s window length. An average frequency dependent power law fit for the study region may be given as QC = 116.716f 0.9943. The exponent of the frequency dependence law n ranged from 1.08 to 0.9, which correlates well with values obtained in other seismically and tectonically active and heterogeneous regions of the world. In our study region, Qc increases both with respect to lapse time and frequency. The low Qc values or high attenuation at lower frequencies and high Qc values or low attenuation at higher frequencies suggests that the heterogeneity decreases with increasing depth in the study domain.

The study describes a 1D velocity model for the Kinnaur-NW Himalaya, based on comprehensive analysis of ∼3000 seismograms from 11 digital broadband stations, deployed in this highly seismically active region of Himalayan arc during 2008 and 2013. Each event from 356 local earthquakes clustered in the Higher Himalaya seismic belt, have a minimum of 5 P- and 5 S-phase readings. These well-constrained crustal earthquakes have been selected, out of 518 events that occurred in this domain with magnitudes 1.8 < M < 5.6, after the relocation performed by HypoDD. The relocated seismicity highlighted the active deformation persisting underneath the NW-SE striking features incorporating the Main Central Thrust (MCT), the South Tibetan Detachment (STD) and the N-S striking rift, the Kaurik-Chango fault (KCF). The observed seismicity beneath the MCT exhibits strong association with the actively deforming mid-crustal ramp (MCR) present in the study area. We report lower crustal earthquakes in the region, which exhibits a great correlation with the seismic activity noticed at southern Tibet. This may be critically due to the presence of dry granulites within the lower crust, which have larger effective elastic thickness (Te) to support its occurrence. The recent seismic performance along the KCF accounts for strain portioning, which accommodates about 20% of the convergence on the Karakoram fault and act as a stress barrier to the nearby southwestern element of the Himalayan Seismic Belt (HSB).

3D velocity inversion has been performed to investigate subsurface structure and seismogenic layers in and around the source zone of 1975 Kinnaur earthquake (M6.8) in the northwestern Himalaya. The study region exhibits low P-wave velocity (Vp) and low Vp /Vs including a

lower velocity zone (LVZ) at middle crust. The existence of LVZ indicates presence of fluid or any partial melting strata in the upper crust of the lithosphere. This may be a consequence of underthrusting of the Indian crust, which produces a frictional heat and cause metamorphic dehydration reaction. This reaction causes the released fluid to percolate upwards into the brittle portion of the crust that manifests the leucogranites, which marks the low velocity layer.

The major findings in the thesis provide constraint to the lithospheric structure of the NW Himalaya, India region with special emphasis to its observed seismic anisotropy, attenuation characteristics and refined minimum 3-D tomographic crustal structure.

Key words: NW Himalaya, Seismic Anisotropy, Coda Wave Attenuation, Crustal Velocity Structure, HypoDD, Seismicity, 3D tomography.