Local earthquake Tomography: velocities and Vp/Vs beneath the Garhwal Himalaya, N-India

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In this study we have determined P-wave velocity structure of the crust (consisting of two layers) and upper mantle (half space) beneath the Garhwal Himalaya, N-India by inverting the arrival times of 1405 and 1109 P type and S type waves respectively. Values of 5.42 km/s and 3.12 km/s are obtained for P and S-wave velocities respectively in the upper crustal layer (0-17 km); and 6.03 km/s and 3.47 km/s for the second crustal layer (17-50 km). In the upper mantle (half space) P and S-wave velocities are estimated to be 8.12 km/s and 4.72 km/s.

We determined P and S-wave velocities for the Garhwal Himalaya. This is the first attempt of estimating crustal and upper mantle P and S-wave velocities in the Garhwal region using arrival time data from local earthquakes. The data were obtained from a programme of microearthquakes investigations undertaken by the University of Roorkee, Roorkee, India during 1979-80 and 1984-85-86 with the aim of building up a detailed picture of seismicity in the region. For this purpose five to seven portable seismographs were operated in the Yamuna and Bhagirathi valleys in the vicinity of the Main Central Thrust (MCT).

In the 1-D inversion we considered 10 different sets of initial velocity models. These initial models were created by adding Gaussian noise with a standard deviation of 0.1 km/s to a start-up model which is from the previous results obtained by Chander et al. (1986) and Sushil et al.(1987). Thus a priori uncertainties for the initial velocities were assumed to be 0.1 km/s. The hypocenter parameters determined for the start-up model were used as the initial parameters in the 1-D inversion. A priori uncertainties of the initial hypocenter parameters were given by the standard deviations of hypocenter parameters determined for the 10 different sets of initial velocity models. The a priori uncertainties are 0.6s for the origin time, 0.02deg for the latitude, 0.02deg for the longitude, and 3.0 km for the focal depth. The initial station corrections were assumed to be zeros for all the stations. The linearized inversion was iterated until the standard deviation of travel time residuals (SDTR) varied by less than 0.001s. Although initial SDTR varied from 0.19 to 0.28s for different initial velocity models, they all reduced to a value of about 0.18s after the convergence.

The P velocity of the upper crustal layer is 5.42 km/s, which is 0.22 km/s higher than that estimated by Chander et al. (1986). The value estimated presently is considered more accurate for the area of the sedimentary wedge of the central Himalaya. The P-wave velocity 6.03 km/s of second crustal layer estimated in this study is almost the same as the velocity of 6.0 km/s previously estimated by Sushil et al. (1987).

Gabriel and Kuo (1966) also proposed a crustal model for New Delhi-Lahore region, some distance to the south of the Himalaya using surface wave dispersion data. They characterized this region as a shield region. The value of Poisson's ratio 0.25 was obtained by them for the second layer which presumably corresponds to the basement beneath the Indo-Gangetic alluvium. In this study the estimated P-wave velocity 6.03 km/s and S-wave velocity 3.47 km/s for this layer gives a Poisson's ratio of 0.25. Thus we infer that the basement layer in the south of Himalaya extends towards north and lies also beneath the sedimentary wedge of the lesser Himalaya. On this basis we believe that the P-wave speed determined by us offer a seismological evidence for the presence of Indian shield rocks beneath the lesser Himalaya. Ni and Barazangi (1983) studied body wave propagation in the India, Tibet and Afghanistan using WWSSN data. They estimated a value of 8.45 0.08 km/s for Pn velocity in the Himalaya. Compared with our value of 8.12 km/s the value is significantly large. The discrepancy is considered to have resulted from the difference in the ray coverage of the two datasets. Ni and Barazangi (1983) had to use data in which the ray paths between earthquakes and recording stations were not strictly confined in the Himalaya whereas the ray paths of our dataset travel only inside the Himalayan region.