Investigation of sub-surface structure and anisotropy in the Himalaya-Karakoram-Tibet collision using Seismic tomography

Naresh Kumar[1,2], Abdelkrim Aoudia[1]

[1] The Internationa Centre for Theoretical Physics (ICTP), Strada Costiera 11, 34151 Trieste, Italy, nkumar_d@ictp.it
[2] Permanent Institute: Wadia Institute of Himalayan Geology, 33 GMS Road, Dehradun – 248001, Uttrakand, India, nkd@wihg.res.in

The 3D variation of the upper lithosphere in the form of seismic shear wave velocities is performed for the western part of the Himalaya and Tibet collision zone. The broadband seismic data of over 200 earthquakes of magnitude range 4.5 to 7.0 is utilized that is recorded at regional distances on broadband seismic stations located in the southern and northern parts of the study region. Dense ray paths between the location of seismic stations and earthquake epicentres enabled us to investigate the sub-surface structures. The data is also divided into different clusters/groups making the ray path of each cluster sampling different structural elements. The seismic wave ray paths between clusters and recording station cover different zones with different orientations respective to the strikes of major structural elements of the Himalaya and Tibet. These paths are perpendicular as well as parallel to the tectonic discontinuities and some paths also cover the western part of Indo-Gangetic plains. The ray paths sample the Himalayan region, the south Tibetan detachment zone, the Indo-Tsangpo suture zone, as well as the Karakoram fault zone and Tibetan plateau regions.

The dispersion curves of both Rayleigh and love waves are obtained from each earthquake event. For both waves, the observations are performed for periods in the range 6-80 sec, and most of the data are within the period range 10 to 50 sec. The data of dispersion curves of different paths is also utilised to obtain 2D tomographic maps, representing the lateral variations of group velocities. These maps suggest changes of shear wave velocities for the study region indicating a high variation at intermediate period ranges for different paths. This variation is for both waves although higher variation is found in case of Rayleigh waves. The average trend is also calculated for one cluster of events that is mainly traversing a single unit of structural element. Weighted averaging of computed dispersion curve for a group of events of a single cluster is obtained based on the fitting of higher order polynomial and also the standard deviation is computed. The variation of fundamental group velocity for the events of single cluster is small however a higher variation is exhibited among different paths. The paths passing through the Indo-Gangetic plains indicates very low velocities for both Rayleigh and Love waves for periods less than 15 sec. It is observed that the waves passing perpendicular to the major structural elements have high variation in velocities in the period range 10 to 30 sec and specifically due to the low velocities of Rayleigh waves. These differences are measured to assess the anisotropic behaviour of the medium for different periods.

The dispersion curves obtained at regular interval through 2D tomography is further inverted to obtain a 3D image of the S-wave velocity structure for the study area. The upper part of the crust has low group/shear velocities corresponding with the Indo-Gangetic plains as the southern part of the study region. In the central part towards south of the Karakoram fault the upper crust is coupled with a very high velocity under thrusting Indian plate. A broad low velocity mid crustal zone is observed along the Indo-Tibetan boundary and Karakoram fault region and north of the Karakoram fault the thick low velocity layer is reported reaching to depths of 45 km with a lateral extent to the north, up to the southern limit of the Tarim basin. Along a profile from NW to SE, the inverted shear wave velocity for the upper part of the lithosphere indicates variable depth of the Moho discontinuity indicating Indian plate Moho dipping towards north and the Eurasian plate dipping towards south. The variation of group velocities and inverted shear wave velocities in different depth sections are weighted to account for the effects of anisotropy, tectonics and partially fluid saturated zones. These results will shed new light on the long-lasting debates regarding processes governing continental deformation of mountain ranges and the formation of the Tibetan plateau.

Cite as: Kumar, N. and Aoudia A., 2014, Investigation of sub-surface structure and anisotropy in the Himalaya-Karakoram-Tibet collision using seismic tomography, in Montomoli C., et al., eds., proceedings for the 29th Himalaya-Karakoram-Tibet Workshop, Lucca, Italy.