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Sediment thickness beneath the Indo-Gangetic Plain and Siwalik Himalaya inferred from receiver function modelling

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ABSTRACT

The Indo-Gangetic Plain and the adjoining Siwalik Himalaya are the seismically most vulnerable regions due to high density of human population and presence of thick sediments that amplify the seismic waves due to an earthquake in the region. We investigate the sedimentary structure and crustal thickness of the region through joint inversion of the receiver function time series at 14 broadband seismograph locations and the available Rayleigh velocity data for the region. Results show significant variability of sedimentary layer thicknesses from 1.0 to 2.0 km beneath the Delhi region to 2.0–5.0 km beneath the Indo-Gangetic Plain and the Siwalik Himalaya. As we progress from the Delhi to the Indo-Gangetic Plain, we observe a decrease in the shear velocity in sedimentary layer from ~2.0 km/s to ~1.3 km/s while the layer thickness increases progressively from ~1.0 km in south to 2.0–5.0 km in the north. Average *S*-velocity in the sedimentary layer beneath the Siwalik Himalaya is ~2.1 km/s. Crustal thicknesses varies from ~42 in the Delhi region, ~48 km in the Indo-Gangetic Plain, ~50 km in the western part of Siwalik Himalaya to ~60 km in the Kumaon region of Siwalik Himalaya.

1. Introduction

The Indo-Gangetic Plain and the adjoining Siwalik Himalaya, with a human population of over 500 million, are the seismically most vulnerable regions due its proximity to the Himalayan seismic zone and the presence of thick sediments that amplify the seismic waves generated even from small-magnitude earthquakes. The neighboring Himalaya region has experienced several moderate sized earthquakes, and the great 1803 Kumaon earthquake, which cause severe damage and took a heavy toll of life. Recent space geodetic measurement by Bilham et al. (2001) suggests a significant slip deficit in this segment of the Himalaya, capable of generating a great earthquake in the near future. It is, therefore, important to minimize the loss, by appropriately designing man-made structures. This necessitates detail knowledge of sedimentary structure is required to synthesize ground motion for possible earthquake scenario to quantify seismic hazard in the region.

The sedimentary structure beneath the Siwalik Himalaya and the Indo-Gangetic Plain was inferred from gravity, seismology (both earthquake and explosion) and drilling data from the Oil and Natural Gas Commission (ONGC). Based on modelling of Rayleigh and Love wave group and phase velocity dispersion measurements between Delhi and Shillong (north-east India), Tandon and Chaudhury (1964) and Chaudhury (1966, 1969) suggested an average ~3 km of the sediment beneath the Ganga plain. Using the short period surface wave phase velocity data along paths parallel to the northern edge of the Ganga plain and western Himalayan foothills, Tandon and Chaudhury (1968) estimated 5–6 km thickness of sedimentary column. Mitra et al. (2011) estimated ~2.5 km thick sediments with Vs ~2.0 km/s beneath the Ganga Plain based on modelling multimode Rayleigh and Love wave group velocity data from 4 stations (green triangle in Fig. 1). Recent receiver function (RF) study (Srinivas et al., 2013) over the Indo-Gangetic Plain (between 79–81°E and 26–29°N) shows sediments with Vs of 0.72–2.5 km/s and thicknesses varying from 0.7 to 3.7 km (magenta triangle in Fig. 1). Hetenyi et al. (2006), using RF data from 10 broadband stations (black triangles in Fig. 1, along 85°E) of the Hi-CLIMB seismological experiment, produced a high resolution image of the base of the Himalayan foreland basin at ~5 km depth. Previous data from ONGC drilling in the Indo-Gangetic Plain show the basement depth variation of 1–6 km from south to north (for east of 79°E) and 0–4 km from south to north (for west of 79°E) (Sastri et al., 1971; Rao, 1973; Karunakaran and Ranga Rao, 1979; Singh, 1996). Two exploration

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