Deep seismic reflection profiling over the Siwalik fold belt of NW Himalaya

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The Himalayan orogeny during the Cenozoic is a product of continent-continent collision between the Indian and Eurasian plates with the formation of a peripheral foreland basin in front of the underthrusted Indian plate. The basin was subsequently folded and uplifted. The foreland basin, located between the Main Frontal Thrust and Main Boundary Thrust, mainly consists of the Siwalik, Dharmasala and Subathu formations deposited during the Cenozoic. It extends almost over the entire length of the Himalayan foothills. The uplifted Siwalik foreland basin rises abruptly by 500-2000 m above the foredeep of the Holocene Indo-Gangetic alluvial plains. To understand the crustal structure of this region a deep seismic reflection study is carried out along 35 km long Barsar-Bhota-Sandhera and 65 km long Farsi-Bhota-Nerchowk profiles across this fold belt. The seismic profiles traverse the Jawalamukhi, Barsar, Gambhar, Palampur and Main Boundary thrusts of the Sub-Himalayan fold belt. The seismic data are acquired with 150-channel RF telemetry system using explosives. Seismic images from the present study indicate a bright reflection band around 3.0-3.5 s and a gently dipping reflection band from 13 s in the western part deepening to 15 s to the east. The present paper discusses about the significance of various reflection bands observed in the region.

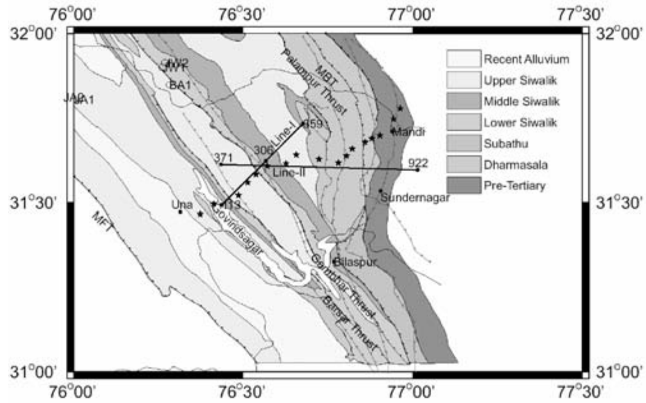

FIGURE 1. Simplified geology and tectonic map of the study region of the NW Himalaya along with seismic profiles and locations of oil wells. The numbers along the profile indicate locations of the pickets. MFT-Main Frontal Thrust; BT-Barsar Thrust; GT-Gambhar Thrust; PT-Palampur Thrust; DT-Drang Thrust, MBT-Main Boundary Thrust

Introduction

The Himalayan mountain belt has evolved through the late Mesozoic subduction of the Indian plate beneath the Eurasian plate with closure of Tethys Ocean and subsequent collision of two plates during the Cenozoic. The NE part of Himalaya is relatively well studied using various geophysical methods by the INDEPTH and other research groups. But, the structure of the NW Himalayan region is mostly determined by the geological mapping and a very few geophysical studies were carried out using gravity and magnetic methods. Shallow seismic studies are being used by the oil industry for exploration of hydrocarbons in the foreland basin. Keeping in view of the geodynamics of the region, a deep crustal seismic reflection study is carried out along 35 km long Barsar-Bhota-Sandhera and 65 km long Nangal-Bhota-Nerchowk profiles (Figure 1) by the National Geophysical Research Institute for the first time covering the NW part of the Cenozoic sub-Himalayan foreland basin to understand the tectonic fabric of the region. The seismic image of the deep crust can unravel the history of basin formation and can provide important constraints to understand the shallow structure in a better way. The present deep crustal reflection study is an attempt to delineate the deep crustal structure and its correlation with the shallow as well as the surface features.

Geology and tectonics

The Himalayan orogenic belt is classified into Sub-, Lesser, Higher and Tethyan Himalaya from south to north. The region south of the MBT consisting of the Tertiary sediments is referred as Sub-Himalaya. On the other hand, the region north of MBT consisting of pre-Tertiary (Mesozoic-Paleoproterozoic) is divided into Lesser, Higher and Tethyan Himalaya. The present study area is mostly located in the Sub-Himalayan Siwalik foreland basin. The basin consists of predominantly fluvial sediments derived from rising Himalayas during the Cenozoic. The Tertiary sediments mainly comprising of the Subathu, Dharmasala and Siwaliks cover the foreland basin. The litho-stratigraphy of the region derived from the well data shows that the Siwalik sequences are underlain by various older sedimentary formations of which the Dharamsala and Subathu are prominent. The foreland basin consists of a number of minor thrusts such as the Barsar, Gambhar, Palampur thrusts located between MFT and MBT. These thrusts separate different geological sequences of the region.

Deep Seismic Reflection Study

Deep seismic reflection study is carried out along 35 km and 65 km long profiles across the Siwalik ranges of the Sub-Himalaya.

Shot holes of 20-25 m depth loaded with 50-70 kg of explosives are used as seismic source. The seismic data are acquired on a 15-18 km long spreads using a high dynamic range Eagle-88, RF-Telemetry seismic equipment. The data are recorded with 4 ms sampling interval to include wide frequency bandwidth of 212 Hz. The data are recorded up to 24 s duration to observe deep crustal and sub-crustal reflections in the region. The topographic variations along the profiles are of the order of 550 to 1600 m (Figures 2 and 3).

The seismic reflection (CMP) data were processed using the ProMax software on a workstation. Bad traces and high amplitude noise bursts are removed and polarity reversals are corrected. Spherical divergence and static corrections are applied. Finally, a stack section is prepared after applying NMO correction using appropriate velocity model. Proper scaling, AGC and bandpass filtering are applied to enhance the data quality.

Seismic data reveal good reflectivity in the region. No prominent reflections are found upto 3.5 s twt, beyond which reflectivity increases. The strong reflection band observed at 3.5 s may represent Tertiary-Pretertiary boundary. Prominent reflectivity is observed from 3.5-12.0 s twt. A gently dipping reflection band observed at 13 s in the western part deepening to 15 s to the east. It may represent Moho.

Acknowledgements
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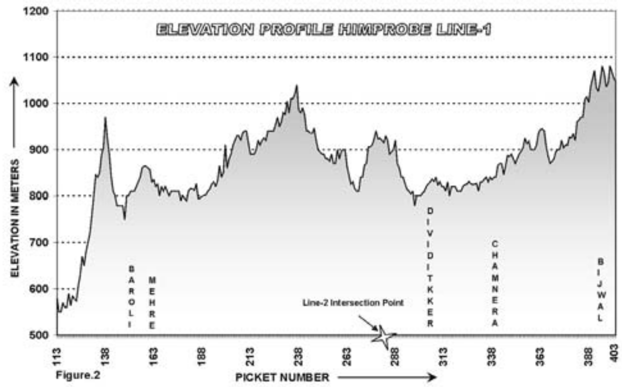

FIGURE 2. Topographic variations along seismic profile-I

FIGURE 3. Topographic variations along seismic profile-II