HIMPROBE Deep Seismic Reflection Profiling of the Sub-Himalayan Fold-Thrust Belt, NW India: Images of a Possible "Ulleri-Wangtu" Paleoproterozoic Accretionary Orogenic Event

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NGRI has acquired and processed the first deep seismic reflection study from the Sub-Himalaya (Fig. 1). Previous shallow (4.5 s) oil-industry profiles (e.g. Powers and others, 1998) show complex fold-and-thrust structures within the Tertiary sequence that our HIMPROBE profiles did not target or image. HIMPROBE profiles (Fig. 2) are dominated by a bright reflection band at 3.0–3.5 s two-way-time (TWT) (6–8 km). We follow Powers and others (1998) in interpreting the bright reflections as representing Neoproterozoic (Lesser Himalayan Series-equivalent) Vindhyan strata that have been drilled immediately beneath the décollement. The planar top to the bright reflections is therefore the Main Himalayan Thrust (MHT). Below 3.5 s, reflectivity is far more prominent than above 3 s, and has apparent dips of c. 15° down to c. 12 s TWT on the west-east Profile H2, and (less clearly) as much as 30° on the SW-trending Profile H1 to at least 8 s TWT. These unmigrated dips imply a true dip of the imaged geological fabric of c. 35° WSW. Limited evidence from shallow hydrocarbon-exploration profiles suggest the WSW-dipping reflections exist for at least 150 km NW-SE along strike. The WSW-dipping reflections appear to be truncated upwards by the sub-horizontal bright reflections, so must be older than these interpreted Neoproterozoic strata. We consider the dipping reflections as a single tectonic element forming the major part, 25–30 km, of the Indian basement thickness. The WSW-dipping reflectivity is underlain or overprinted by sub-horizontal reflections, locally bright, that continue to ~16 s TWT ("reflection Moho", c. 51 km), consistent with teleseismic data (Rai and others, 2006). The 42–49 km cratonic basement on our profiles (and at teleseismic stations from CHD to KUL) is 10–30% thicker than directly to the south.

Possible origins for the WSW-dipping reflectivity include: (1) original Archean fabric of the Mewar-Aravalli craton – but this craton has thinner crust and a NE-SW structural trend orthogonal to the reflectivity; (2) a Meso-Neoproterozoic (meta-)sedimentary basin – but the thickness of dipping reflectors is double reported stratigraphic thicknesses in this region, and should not show dips of 35° without subsequent deformation; (3) a "Pan-African" Cambro-Ordovician accretion of the Greater Himalayan terrane to cratonic India or a "Himalayan" Cenozoic tectonic fabric – but Phanerozoic events seem precluded by the apparent truncation of the WSW-dipping reflectivity by overlying Vindhyan strata.

In contrast, a Paleoproterozoic compressional orogeny is consistent with the 35° dip and upward Neoproterozoic truncation of the reflectivity, with 10–30% crustal thickening, and with the widespread occurrence of 1.8–1.9 Ga granitoids in the Lesser Himalaya (Kohn and others, 2010), including Ulleri orthogneisses throughout Nepal. We suggest that an orogenic event thickened the crust between 1.86 Ga deformation of the Wangtu partially-mylonitized augen gneisses and 1.8 Ga eruption of the low-grade Rampur volcanics. The WSW dip of the reflectivity may imply an underthrusting or subduction direction to the (modern) southwest, consistent with an "Andean-type" arc forming along the northern margin of India and the Columbia super-continent (Kohn and others, 2010). The deepest horizontal reflectivity on our profiles and a possible velocity increase above the Moho (Rai and others, 2006) could mark mafic sills related to a rifting episode correlated with the 1.8 Ga Rampur basalt. Crust thickened by the "Ulleri-Wangtu" orogenic event may extend 100–150 km NE of our profiles to the pre-Himalayan location of the Wangtu gneisses, and would first have been subducted beneath the Himalayan thrust front at about 10 Ma, with possible concomitant changes in structural evolution of the Himalayan thrust belt.

References

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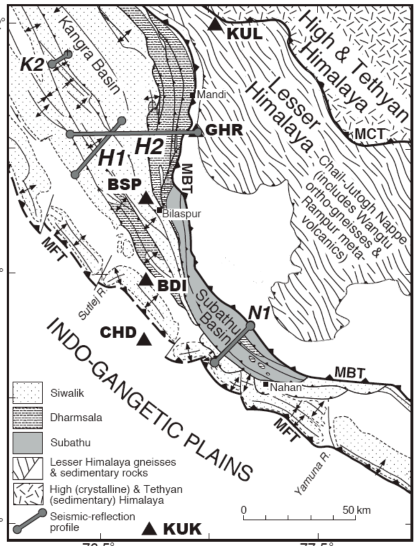
Figure 1. Location of HIMPROBE deep profiles H1 and H2, and shallow exploration profiles (K2–Kangra 2 and N1–Nahan 1) possibly showing WSW-dipping reflectivity. MFT–Main Frontal Thrust; MBT–Main Boundary Thrust; MCT–Main Central Thrust. Broadband seismic stations: black triangles with 3-letter codes (Rai and others, 2006).



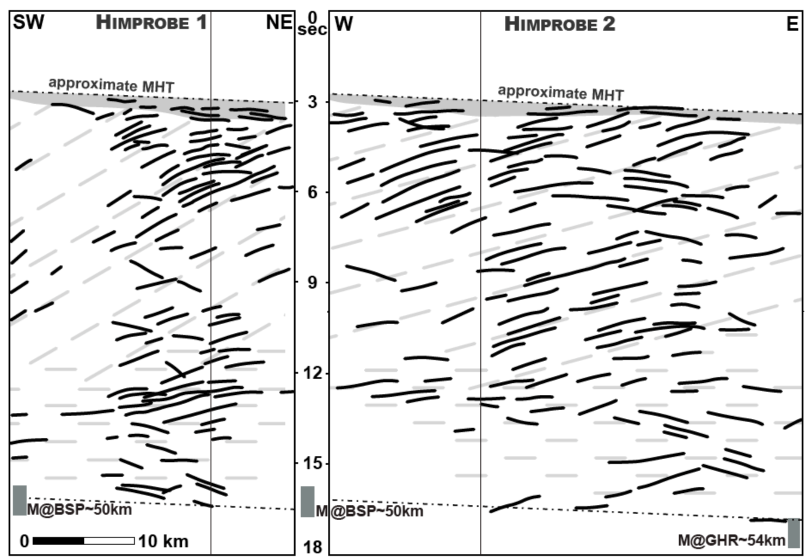
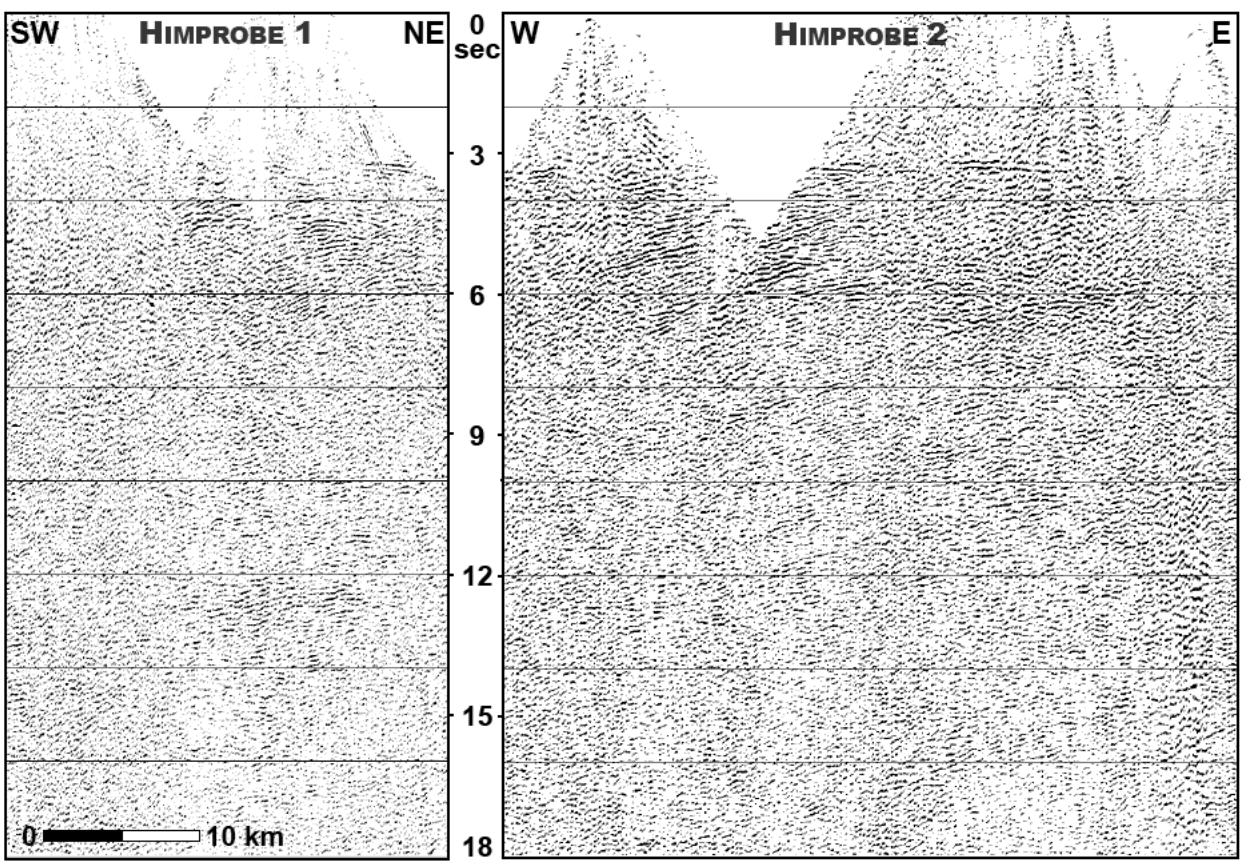


Figure 2. (above right) Line drawings (thick black lines) and interpretive cartoons (grey) of HIMPROBE 1 and 2 stack sections (shown below), all true scale for a velocity of 6 km/s. Thin vertical line: profile intersection. Dot-dash lines at MHT and Moho dip 2.5° (dip of Himalayan décollement, Powers and others, 1998). Grey rectangles: Moho travel-times from teleseismic data (Rai and others, 2006). Grey shading: region of region of bright sub-horizontal reflections inferred to be Proterozoic sedimentary rocks. Dashed grey lines, dipping 30° on H1 and 15° on H2: region of WSW dipping reflectivity. Horizontal dashed grey lines: region of sub-horizontal reflectivity.



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