# Lithospheric structure across the Himalayan-Tibetan orogen: a petrological and geophysical study

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**Introduction and objectives**

The Himalaya-Tibetan orogen, resulting from the ongoing convergence between the Indian plate and the southern margin of the Asian plate, represents an excellent natural laboratory to study the continental collision process. Some key-features of the India-Asia convergence are: mountain building, crustal shortening or thickening, widespread deformation 1000-3000 km from the collision zone, presence of a high plateau, low seismic velocity anomalies in the upper mantle, and high-rate tectonic convergence. The average convergence rate is 50–60 mm/yr since 45 Ma, which is accommodated not only in the Himalayan-Tibet belt but also farther north, with nearly 20 mm/yr across the western Tien Shan alone. Different deformation scenarios can be observed at crustal levels. Thrusting and crustal thickening characterise the frontal part of the orogen, also marked by the highest topography of the Himalaya and Karakoram mountains (e.g. Everest Mt. with 8848 m, K2 with 8611 m). In the Tibetan Plateau, N-S grabens and strike-slip faulting suggest crustal extension. However, a thrust regime exists on the margins of the plateau, reflecting crustal thickening and continued mountain building. NW-wards, the Tarim Basin presents an almost completely flat topography, and a strong crust which was not thickened during the northward spreading of the deformation zone ahead the Indian indenter. The rigidity of the Tarim Basin allowed transmitting the stress northwards, resulting in the creation of the Tien Shan Mountains and remaining undeformed.

Several studies have been carried out in the Himalaya-Tibetan area to understand the mechanisms generating the structure of the Himalaya Mountains and the surrounding regions. However, how surface deformation within mountain ranges relates to tectonic processes at depth is not well understood. In a general view, at crustal levels, the spreading or migration of the mountain belts, and hence the diffusion of the deformation, depends on the strength of rocks. At lithospheric levels, the density variations give rise to lithospheric body forces and stresses, which play an important role on the support of the Himalayan-Tibetan orogen, controlling its evolution and mantle dynamics [1].

In this work, we present two 2D crust and upper mantle cross sections down to 400 km depth, along two profiles which cross perpendicularly the Himalaya Mountains and the surrounding areas. The Eastern profile runs from the Indian shield to the Beishan Basin, crossing the eastern Himalaya, Tibetan Plateau, Qaidam Basin and Qilian Mountains. The Western profile crosses the western Himalaya, Tarim Basin, Tien Shan Mountains and Junggar Basin. The goals of this study are to image the crustal and upper mantle structure across the India-Asia collision and to characterize the composition and density inhomogeneities within the lithospheric mantle.

We apply the LitMod-2D code [2] which integrates potential fields (gravity and geoid), isostasy (elevation) and thermal (heat flow and temperature distribution) equations, and mantle petrology. The resulting crust and upper mantle structure is constrained by available data on elevation, Bouguer anomaly, geoid height, surface heat flow and seismic data including P- and S-wave tomography models.

**Data and first results**

Geophysical data were collected from different global datasets: elevation data come from 1-min arc resolution ETOPO1 global elevation model [3]; geoid height data derive from the Earth Geopotential Model EGM2008, filtered to eliminate the contribution of density anomalies deeper than 400 km depth; the Bouguer gravity anomaly was computed applying the complete Bouguer correction to free-air satellite data, using a reduction density of 2670 kg/m3. The mantle composition we used is the NCFMAS system, based on Holland and Powell [4] thermodynamic database reviewed by Afonso & Zlotnik [5].

Our results show the crust and LAB geometries and the compositional variations of the lithospheric mantle along the selected profiles. The resulting models show that the crust-mantle strain partitioning is different from East to West. The units of Lhasa, Qiangtang, Songpan-Ganzi and Kunlun, which form the high Tibetan Plateau, extend for more than 1000 km in the Eastern profile, whereas they are squeezed in less than 600 km between the Himalayan Fold-and-Thrust Belt units (Greater Himalaya, Lesser Himalaya and Tetyan Himalaya) and the Tarim Basin along the Western profile. The Eastern Tibetan Plateau is supported by a thick lithosphere (~280 km) in the South, and a thin and hot lithosphere (~120 km, with 1050ºC at Moho discontinuity) in the North. A more depleted mineral composition is detected in the NE of the plateau. In the Western Himalaya and Tibetan regions, the lithospheric mantle is more homogeneous in thickness and mineral composition, with respect to the Eastern profile. The resulting models are in agreement with seismic tomography, where they observed flat-low angle of the Indian plate beneath Tibet to the West and high angle to the East [6].

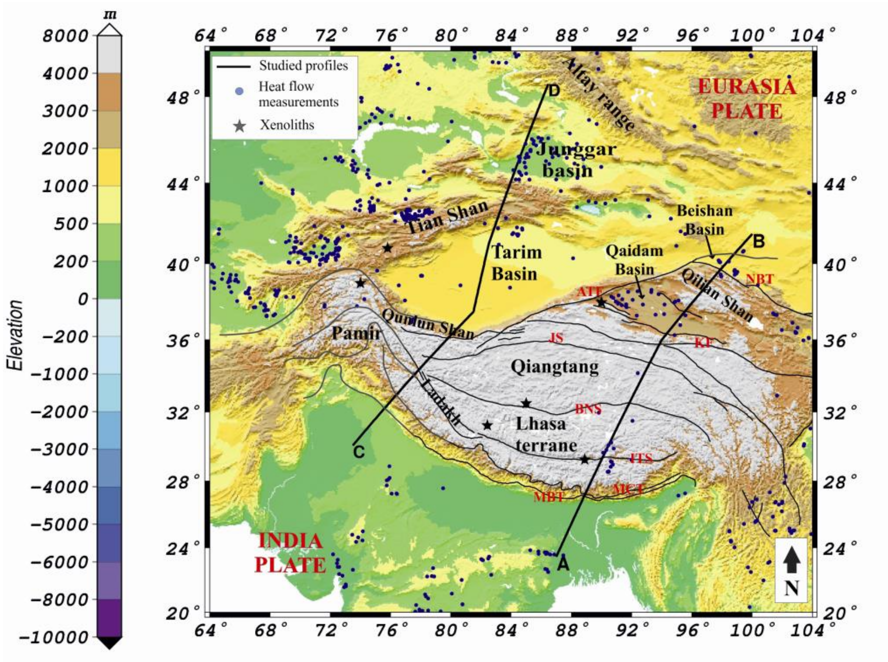


Fig. 1. Map of the study area with the main tectonic units, and localisation of the two modelled profiles. ATF = Altyn Tagh Fault; BNS = Bangong-Nujiang Suture; ITS = Indus-Tsangpo Suture; JS= Jinsha Suture; KF = KunLun Fault; MBT= Main Boundary Thrust; MCT = Main Central Thrust; NBT = North Border Thrust

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Key words: Himalaya-Tibetan orogen; lithospheric structure; LAB; composition of the lithosphere