

## The Himalayas Seen from Bhutan

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Most of the publications on the wider Himalayas deal with the western and central part with easier access, better exposures, climate and lesser political restrictions. This changes drastically from Sikkim to the east with difficult field conditions, over 10 m rain in Assam and restrictions for foreign investigators. It is the domain of the geologists of the Geological Survey of India, their excellent work only partly published and without regional maps. My own experience in this area, apart of an investigation of satellite photos covering the wider Himalayas, are expeditions into the Bhutan Himalayas from 1963 to 1977.

The geology of Bhutan represents the eastern Himalayas and differs in many aspects from the more western regions. The over 17 km thick central crystalline thrustsheet is more widespread and exposes throughout a remarkable reversed metamorphism, increasing northwards with large intrusions of leucogranites. It decreases suddenly towards the Tibetan border with the transgressive tethyan sediments, which also occur in some isolated basins on top of the crystallines. No tethyan faultzone exists in the north and the earliest fossils, after decreasing metamorphism, suggest an Ordovician age. The Lesser Himalaya forms a narrow band but opens eastwards into a large, northwards directed spur with complicated internal tectonics, emphasized by slices of over 1000 my old granitoids in late Precambrian sediments, dominated by 5000 m thick quartzites. From this spur all along the eastern Lesser Himalayas outcrops a steep narrow band of Permo-Carboniferous, coal-bearing Damudas, bordering along the MBT the constant belt of Siwaliks, interrupted only along the western Bhutan foothills, overthrust by the Lesser Himalaya. This coincides with a remarkable shallowing of the Brahmaputra basin with Shillong elements outcropping only 35 km to the south of the MBT, the narrowest spot of the whole Himalayan foreland.

All the elements from Bhutan can be followed through the eastern Himalayas until the East Himalayan "syntaxis". The narrow Damuda belt opens along the Siang river (NS directed Brahmaputra), with the incoming Permian Abor volcanics, the equivalent of the West Himalayan Panjal traps, both volcanics restricted to the west and east end of the Himalayas. The Abor volcanics form a complicated north plunging antiformal window of marine Eocene in the Siang gorge, its size similar to the Hazara-Kashmir "syntaxis" in the west. The equivalent of the Nanga Parbat uplift in the east Himalayas could be the Namche

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Barwa high, though the structural connections with the Abor spur are still vague. The Himalayas do not end with the respective syntaxis but with remarkable fault and thrust zones, the Sarobi and Chaman faults in the west, the Mishmi thrust in the east. Both Himalayan ends and the respective continuations along the west and east border of the Indian shield are strikingly different. The west is characterised by widespread evaporites, outcropping in the salt range, forming an important decollement horizon. They are responsible for the discrepancies between surface and subsurface structures. Evaporites are so far unknown in the eastern Himalayas except for some late Precambrian-Cambrian gypsum horizons in the Shumar spur of the Lesser Himalaya in southeast Bhutan. A 6000 m thick Eocene flysch belt grading into a younger molasse follows the allochthonous Quetta and Las Bela ophiolites, thrust on the west border of the Indian shield. A similar flysch zone, here with exotic blocks, is related to the allochthonous Naga ophiolites of the Indo-Burman ranges. They are thrust towards the Shillong and Mikir massives of the eastern Indian shield. No similar flysch development is known from the main Himalayan range. The outstanding, southeast striking Mishmi thrust which overrides even Quaternary sediments, cuts all the main Himalayan elements as well as all the Indo-Burman ranges. The complete tethyan Himalaya has disappeared between a thin crystalline belt and the still enigmatic Tidding ophiolite zone, which continues into the western border of the Burmese Shan plateau. The Tidding zone is southwestwards overthrust by granites reminiscent of the Transhimalaya.

THE WIDER EASTERN HIMALAYAS



- A Amdo, D Darjeeling, L Lhasa,
- T Timphu (Bhutan), S Shumar
- NB Namche Barwa,
- NT Nienchen Tangla
- LH Lower Himalayas
- HH Higher Himalayas
- TH Tibetan (Tethys) Himalayas
- Molasse
- Flysch
- Eocene windows
- Ophiolites i.g.
- Abor volcanics with Damusa
- Tibetan granitoids
- Transhimalayan Gr.
- Tibetan basement
- Indian Shield and Shan Plateau (Burma)
- strike lines
- faults, fractures
- thrusts

It is most conspicuous how the eastern Himalayas, the Mishmi hills as well as the Indo-Burman ranges encroached for hundreds of kilometers from the north, the northeast and the southeast on the Shillong shield and its northeastern continuation under the Assam basin, with several thousand meters of Neogene and Quaternary sediments. In spite of recent seismicity, trending north-south in the middle of the basement, this northeastern continuation of the Indian shield has remained fixed.