

# Geology of the **Himalayan Mountain Range**, with special reference to the western Himalaya

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**H**imalaya – (Him+Alya) means “abodes of snow” – is one of the youngest and highest mountain ranges on the globe with many peaks as high as 7000 meters and above. It is about 2400 km in length from Afghanistan-Pakistan in the west and Namcha Barwa in the east. It varies in width between 250 to 300 km along its length. The mountain range is arc-shaped, convex southwards with syntaxial

bends at the western and eastern ends (Wadia 1931; Valdiya 1980). The syntaxial bends are parallel to continental scale deep fault known as Chaman Fault and Sagaing Fault in the western and eastern end respectively. The Himalayan mountain Range controls the monsoon climate of the Indian subcontinent which is the life line for country particularly along the Indo-Gangatic plains. Its snow and ice laden peaks above 4300–5800 metre

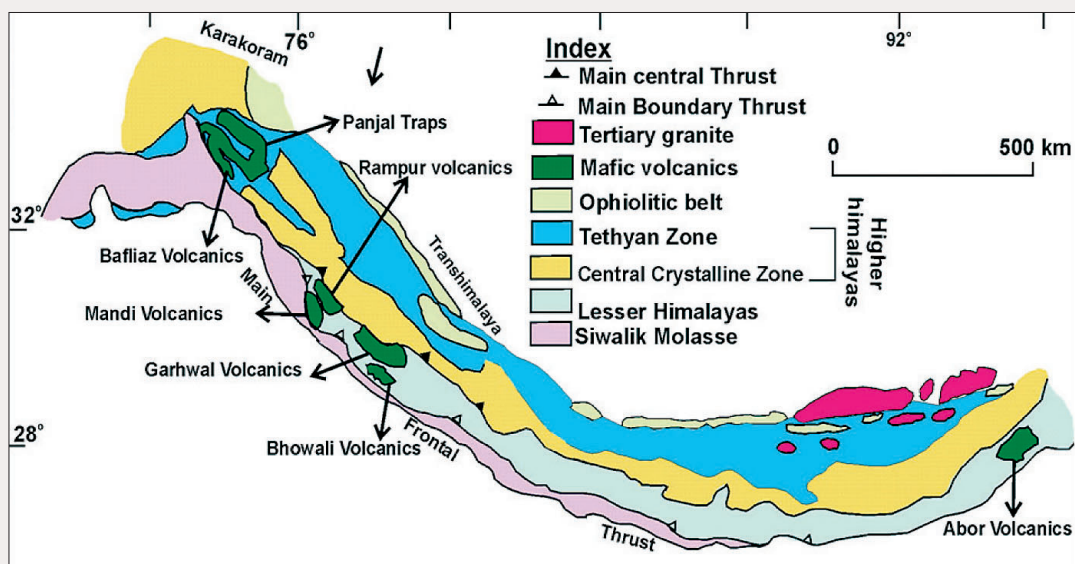
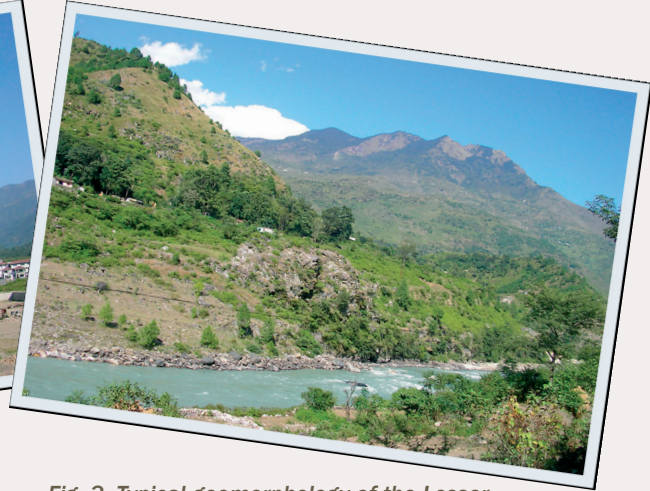


Fig. 1. Outline geological map of the Himalayan Mountain Belt showing its major tectonic subdivisions across the range.



**Fig. 2.** Transition from the Indo-Gangatic Plains to the Sub-Himalaya in front and Lesser Himalaya at rear.



**Fig. 3.** Typical geomorphology of the Lesser Himalaya with mature topography.

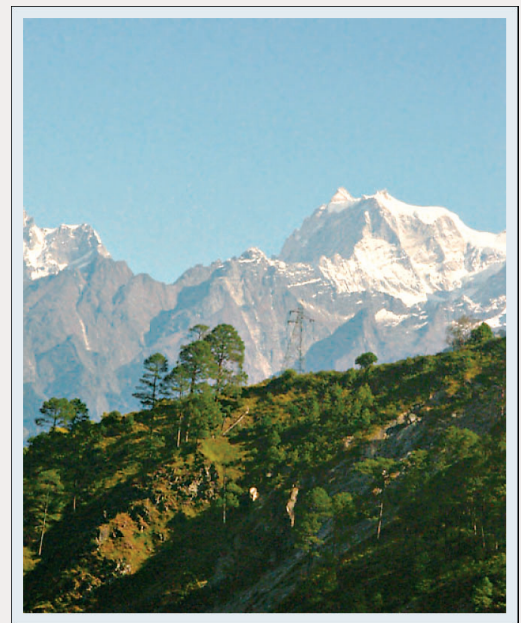
snowline including 15000 glaciers feed major rivers of the world including the Brahmaputra, Ganges and the Indus.

The Himalayan mountain range is subdivided into four principal tectonic zones, from south to north these are: the Sub-Himalaya, the Lesser Himalaya, the Higher Himalayan Crystallines and the Tethyan Himalaya (Fig. 1).

The Sub-Himalaya, also known as the Siwalik Range (250–800 m high), rises above the Indo-Gangatic Plains along the Main Frontal Thrust (Fig. 2). The Sub-Himalaya consists predominantly of Tertiary and Quaternary sediments and is bounded to the north by northward dipping Main Boundary Thrust, separating it from the overlying Lesser Himalaya (Fig. 3).

The Lesser Himalayan Range in general is quite rugged and higher than 2500 m, however, in the Kashmir Valley (North Western Himalaya) the Pir Panjal Range rises to heights greater than 3500 m (Valdiya 1998). The Lesser Himalaya consists of Precambrian and Cambrian sequences of the Damtha, Tejam, Jaunsar-Garhwal and Mussoorie Group in Garhwal region of the western Himalaya (Valdiya 1980). The lowermost Damtha Group consists of turbiditic flysch that passes into slates, quartzites, volcanic rocks and

intrusive doleritic dykes and sills. Tejam Group conformably overlies the Damtha Group, it comprises predominantly dolomites, pyritous–carbonaceous slates, marls and interbedded calcitic marbles. The Jaunsar-Garhwal Group consists of a thick sequence of alternating assemblages of psammities, mafic rocks volcanic flows, dykes and pelites (Srivastava

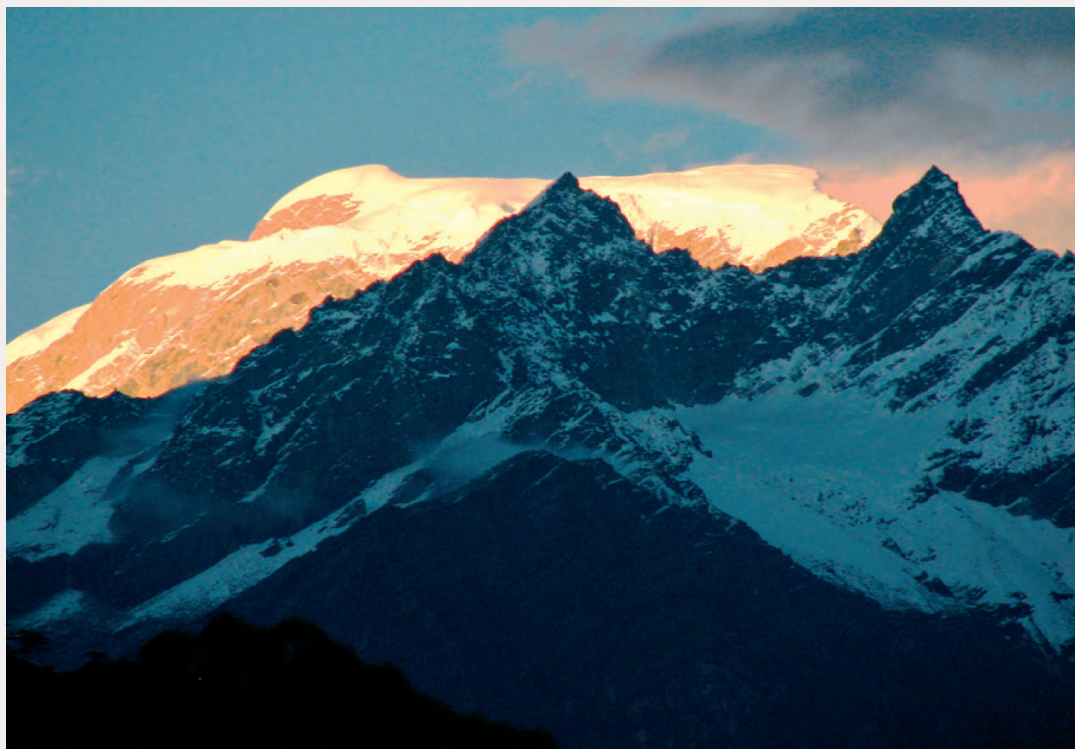


**Fig. 4.** Transition from the Lesser Himalaya (with vegetation cover) to the Higher Himalayan Crystalline with high peaks laden with snow and glaciers.

and Ahmad 1979; Ahmad and Tarney 1991). The Mussoorie Group is represented by a persistent horizon of conglomerate intercalated with greywackes and siltstones at the base, which pass into carbonaceous slates and varicoloured limestone. This succession is followed stratigraphically up section by carbonate-limestone, marl, slate, dolomite horizon in the middle and shale, conglomerate interbedded with phosphatic carbonaceous-pyritous slates, black limestone and pyritous and/or felspathic quartzite in the upper portion.

The Higher Himalayan Crystallines is separated from the Lesser Himalaya along the Main Central Thrust. The Higher Himalayan crystalline is extremely rugged with perennial snow and glacier capped peaks with elevation of 3000 m to more than 8000 m (e.g. Mount

Everest 8848 m and Mount Kanchanjanga 8598 m; Figs. 4 and 5). The Higher Himalayan Crystallines in the western Himalaya is represented by the Chail, Jutogh and Vaikrita Groups of rocks. The rocks of the Chail Group are thrust over the weakly metamorphosed Lesser Himalayan sediments towards the south along the northward dipping Chail Thrust. In turn it is overthrust in the north by the rocks of the Jutogh Group. It is equivalent of the Munsiri and Almora Groups in Garhwal and Kumaun, along the northward dipping Jutogh or Munsiri Thrust. Rocks of the Jutogh Group are overthrust in the north by the rocks of the Vaikrita Group along the northward-dipping Vaikrita Thrust or the Main Central Thrust (Ahmad et al. 2000; Fig. 1). Thus the Higher Himalayan Crystalline rocks represent imbricated thrust sheets, with the grade of



*Fig. 5. Typical topography of the Higher Himalayan Crystalline with no vegetation and high peaks (5000 m to >8000 m).*



metamorphism increasing from the Chail Group to the Vaikrita Group (Thakur 1992). The Chail Group consists of a metamorphosed sequence of greenschist facies including phyllites, phyllitic quartzite, psammitic schists, orthoquartzites, arkose, chlorite schist limestones and meta-basic rocks amphibolites. Foliated granitic rocks, which at times become augen gneisses, also occur in the Chail Group. The Jutogh Group is represented by higher grade metamorphic rocks consisting of garnet, staurolite and kyanite bearing schists, quartzites, marbles, granitoids, gneisses, amphibolites and graphitic schists. The Vaikrita Group is an approximately 5–7 km thick thrust sheet composed of high-grade metamorphic rocks which includes banded gneisses, amphibolitic bands, calc-silicate gneisses and migmatites (Thakur 1992; Valdiya 1998, 2010).

These rocks have been intruded by late Tertiary post-tectonic granite.  $P$ – $T$  estimates for the rocks of the Jutogh and Vaikrita Group by Hodges and Silverberg (1988) and Metcalfe (1993) indicate that while pressure varies between 5–6 kbar for the Jutogh Group and between 6–6.9 kbar for the Vaikrita Group, the temperature remained relatively uniform at about 600° C.

The Higher Himalayan Crystallines passes into the Tethyan Himalayan sequences towards north along the South Tibetan Detachment System (Richards et al. 2005). The Tethyan Himalaya is a rugged terrain with beautifully sculptured landscape developed in sedimentary sequences that range in age from Late Precambrian (>600 My old) to Cretaceous and Eocene (95–45 My old; Valdiya 1998). As the high ranges of the Higher Himalayan Crystalline act a barrier for the wet Monsoon cloud to go further north, the Tethyan Himalayan Range has developed into a cold and dry desert, with sparse vegetation and naked rocks

(good for the geologists). The Puga formation of the Tethyan Himalayan sequence has recorded presence of coesite within the eclogites, indicating that these rocks have experienced ultra high pressure metamorphism (Fig. 6, Mukherjee and Sachan 2003).



*Fig. 6. Tethyan Himalayan topography showing coesite bearing eclogite lens enclosed in the granitic gneiss.*



*Fig. 7. View of the Ladakh batholiths in front and Karakoram Range with snow bound peaks at rear (seen from the Tethyan sedimentary sequence in the south).*

As the area is dry and cold, the rocks are weathered mechanically with little effects on chemical weathering.

The Himalayan Province ends along the Indus-Tsangpo Suture zone of Ladakh-Kohistan range where the Indian plate collided with the Asian (Tibetan) plate at about 55 My ago. The Indus-Tsangpo Suture Zone is represented by remnants of the Neo-Tethyan

ocean, major part of which was subducted as India moved north with respect to Asia. During the process oceanic and continental arcs developed between the Indian and the



**Fig. 8.** Green patches within the Indus suture zone along the Indus River, Ladakh batholiths in front in the north.



**Fig. 9.** Khardung La (the highest motorable pass on the earth – 18380 Feet) occasionally covered with snow.



**Fig. 10.** Pangon Tso Lake (one of the highest altitude brackish lakes on the earth – 4350 m) just north of the Karakoram batholiths.

Eurasian plate, these are represented by the Kohistan-Ladakh Arc with sequences of rocks ranging in composition from ultramafic (melange rocks) through mafic (gabbro, basalt) to acidic (granite-granodiorite-diorite: Figs. 7 to 10) and their volcanic equivalents (Ahmad et al. 1998).

We propose to arrange a field excursion in the Kashmir-Ladakh region of the north western Himalaya to show the spectacular Permian Panjal traps and the arc magmatic rocks of Indus Suture zone in Ladakh region for geologists/earth scientists in the summer of 2012 in collaboration with the Geological Society of Finland and the University of Helsinki. During this field trip you will experience working in a high altitude terrain (average height 3500 m, but many parts as high as >6000 m) with beautifully preserved rock exposure and fantastic structures. You will cross Khardung La (Fig. 9) and the Pangang Tso high altitude brackish water lake, probably remnant of the Neo-Tethyan Ocean as many believe (Fig. 10). You will also frequently meet curiously looking friendly visitors at your exposures (Fig. 11).

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*Fig. 11. Curious and friendly on lookers while doing field work in Ladakh.*

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