

Structural geology and metamorphism of the Spiti valley-eastern Lahul-Parvati valley area, Himachal Himalaya (India)

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The Himalayan orogen is the result of the continental collision between the Indian and Asian plates that began 55-50 Ma ago and that was associated with intracontinental thrusting and nappe formation. The oldest tectonometamorphic phase is revealed by relics of isoclinal folds, related to metamorphic peak conditions at the amphibolite facies-granulite facies boundary ($P \sim 1000$ MPa, $T \sim 700^\circ\text{C}$). Consequently, this phase caused considerable crustal thickening that most probably occurred during an early stage of continental collision. The first event clearly attributed to the continental collision between India and Asia is documented by two converging structures, the NE-verging Shikar Beh Nappe and the SW-verging north Himalayan Nappe system. The Shikar Beh Nappe is documented by isoclinal folding and top-to-the NE shearing, related to upper amphibolite facies peak conditions ($P \sim 650-850$ MPa, $T \sim 700^\circ\text{C}$). The Shikar Beh Nappe structures were overprinted by the SW-verging folds of the Main Fold Zone that formed at the front of the north Himalayan Nappe system. These nappes were thrust from the northern edge of the subducted continent towards SW during incipient subduction of India below Asia. Subsequently, the subduction zone stepped from the base of the north Himalayan nappes to the Main Central Thrust zone. SW-directed thrusting at the Main Central Thrust zone and contemporaneous NE-directed normal movement in higher crustal levels indicate that the Crystalline Nappe was extruded towards SW between the Lesser Himalayan Sequence and the north Himalayan Nappe system. Simultaneously with extrusion of the Crystalline Nappe, dextral strike-slip movement occurred. Thermobarometry indicates that the isogrades related to the Shikar Beh Nappe were passively deformed during the extrusion of the Crystalline Nappe and that normal- and dextral strike-slip shearing was associated with considerable decompression. Extrusion of the Crystalline Nappe was followed by large-scale, upright or steeply inclined, NE-verging folds and then by another phase of normal movement.

The pre-Himalayan tectonic evolution is documented by olivine gabbros and garnet amphibolites that originated from tholeiitic melts and that are interpreted to be of a Upper Precambrian to Cambrian age. Bulk rock major- and trace element analyses as well as the mineral compositions indicate that this mafic magmatism was most probably related to large-scale extension and to significant magmatic underplating. It is proposed that magmatic underplating caused partial melting of the crust from which Cambro-Ordovician granitic intrusions originated that occur all along the Himalayan chain within the High Himalayan Crystalline.