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Himalayan Cenozoic Exhumation: Erosion vs. Tectonics

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Exhumation is a general term involving the processes like normal faulting, ductile thinning and erosion, which are responsible for unroofing of the deep-seated rocks to the surface. Though it can occur in any kind of geological setting i.e. at oceanic rifts and transform faults, continental rifts, subduction zones but has maximum potential in the continent-continent collision zones e.g. like the Himalayan orogenic belt. The Cenozoic Himalayan foreland sedimentary basin and offshore Bengal and Indus fans are the important evidences of tectonic and erosional exhumation of the Himalaya. The dominance of erosion or tectonics in exhumation of Himalayan metamorphic rocks has generated an interesting debate among the present day earth scientists. Interplay between tectonism and erosion in their dominant roles in exhuming the orogen is such a complex phenomenon that the same thermochronological data, e.g. differential fission track apatite and zircon ages for measuring the exhumation rates from a section of the NW Himalaya, have been recently interpreted, differently, either due to tectonic extrusion of overthrust crustal wedges[1] or selective erosional-controlled high exhumation by removal of detritus from provenance[2-3].

With examples of various fold-controlled structures in the Himalayas like the Kulu – Rampur (KR) Window and KR Antiform, the Suru Antiform, the Chisoti Dome, the Tso Morari Dome, the Kishtwar Window, and the Western and Eastern Himalayan Syntaxial zones, we postulate crustal-scale folds and domes in young orogenic belts and core complexes as effective additional mechanism for fast exhumation of deep-seated rocks, in addition to the fault-controlled tectonic exhumation. Existing and newly generated thermochronological (Fission track, Rb-Sr and Ar-Ar) data used to quantify the exhumation pattern around these structures provide evidence that these have experienced fastest exhumations during Pliocene – Pleistocene and, being the fold controlled structures, these signify of folding as an additional very efficient mechanism of tectonic exhumation of deeply buried sequences in the Himalaya, irrespective of the climatic factors like heavy monsoon precipitation and consequential accelerated erosion. These Himalayan antiforms and windows appear to have started growing since 7.5 Ma from deep interior of the orogen and have migrated southward sequentially as a fault – bent fold system at an interval of 2.5 to 2.0 Ma due to ramping on mid-crustal Main Himalayan Thrust (MHT). It appears that the MHT undergoes sequential interlocking, thereby, enhancing exhumation as a result of development of dome over ramp. In the Marsyandi River catchment in the Annapurna Himalaya also the dominance of tectonically – controlled erosion in the High Himalaya over crustal ramp and independent of the spatial variations in precipitation, has been reported[4]. This scenario of dominant tectonically driven exhumation in the Himalaya, including the mechanism of crustal – and small – scale folding is different from erosional controlled exhumation of certain orogenic belts like Southern Alps[5] (New Zealand), Taiwan[6] and Pamir – Tien Shan[7], where climatic factors, erosional patterns and efficient denudation of detritus are the dominant factors.

Thus, we conclude that though erosional – controlled mechanism may be considered as an efficient exhumation process, this mechanism, as an alternative to tectonic exhumation, can not bring deeply-buried rocks in orogenic belts on to the surface, but may be supportive to various tectonic processes like crustal overthickening and thinning due to faulting etc., and, additionally folding.

Keywords: Exhumation; Erosion, Tectonics, Fission Track Dating (FTD); Himalaya; Kulu – Rampur (KR) Window; Tso Morari Dome; Kishtwar Window; Western and Eastern Himalayan Syntaxial zones

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