High Himalayan Discontinuity: a key structure driving the earlier exhumation of the Greater Himalayan Sequence in Central Himalayas

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Studies in the last decades showed that the exhumation Greater Himalayan Sequence (GHS) was driven by the contemporaneous, or alternate activities, of the two main shear zones and faults limiting it to the bottom and to the top: the Main Central Thrust (MCT) and the South Tibetan Detachment (STD) respectively, mainly active between 23 and 17 Ma [1].

Several shear zones and/or faults have been recognized within the GHS, usually regarded as out of sequence thrusts with respect to the MCT [1, with references therein]. However, geological investigations in the GHS of Western Nepal allow the authors to identify different generations of shear zones with different ages.

Moving from the upper part of the GHS to the bottom we can observe the occurrence of two main levels characterized by tectono-metamorphic discontinuities (High Himalayan Discontinuities; HHD) in Central and Western Nepal, well above the MCT zone.

The higher HHD is the contractional top-to-the South Kalopani shear zone [3] localized in Unit III of the GHS in the Kaligandaki valley (Central Nepal). It has been interpreted as an out-of-sequence thrust at 12-16 Ma, by Ar/Ar on white mica [3]. New data have been collected from the Kalopani shear zone. U-Pb ages on monazite along the mylonitic foliation point to a 41-29 Ma age for shearing. Older ages are present as inclusion as inclusions in garnet (48-43 Ma) related to prograde metamorphic conditions. P-T data suggest that the mylonitic foliation developed under decreasing P and T conditions so that the Kalopani shear zone triggered the oldest exhumation of the GHS during the Eocene.

The lower HHD is represented by the Toijem [4] and Mangri [5] shear zones. They separate the upper part of the GHS (with the occurrence of sillimanite along the main foliation) from a lower part mainly made by kyanite-bearing gneiss and micaschist.

The high-temperature top-to-the SW shear zone (Toijem shear zone) has been documented in the core of the GHS in lower Dolpo (western Nepal), whose activity has been constrained at ~ 26 Ma by U-Pb on monazite [4]. To the NW, in the Mugu-Karnali valley a thicker (up to 4 km) shear zone (Mangri shear zone) has been detected in the middle part of the GHS, again pointing to a top-to-the SW sense of shear. The age has been constrained by U-Pb on monazite at ~ 25-17 Ma [5]. The difference in Pressure experienced by the hanging-wall and footwall rock of the two shear zones is at least ~ 2 Kbar.

Considering the metamorphic discontinuitity recently reported in the nearby Karnali area to the NW [6] and the Mangri and Tojiem shear zones it results that the core of the GHS in Western Nepal is affected by a major tectonic and metamorphic discontinuity allowing shearing and exhumation of GHS rocks in a time span from 26 to 17 Ma. In addition, by connecting the tectonic-metamorphic discontinuities in central and eastern Himalaya [7, 8] it is evident the occurrence of a regional-scale feature, nearly at the same level in the GHS, separating the sillimanite-bearing gneiss and schist in upper part of the GHS from the kyanite bearing gneiss and schist in the lower part. This regional tectonic-metamorphic discontinuity (HHD) triggered the earlier exhumation of the GHS, before the classical onset of MCT [4, 5].

Tectonic discontinuities within the GHS have been always regarded as out of sequence thrusts with respect to MCT. Our study demonstrates the limiting occurrence of out of sequence thrusts in central Himalayas and the occurrence of in-sequence ductile shear zones active before MCT in the GHS.

U-Pb-Th ages from zircons and monazites were extracted from a large granitic body intruding both the uppermost portion of the GHS and the lower portion of the Tibetan Sedimentary Sequence [9, 10]. Data from the main granitic body and dykes intruded in the TSS point to an emplacement age at ~ 23-24 Ma [10]. This age constraint is a pin point for the end of the movement of the ductile portion of the STDS in Western Nepal with important consequences for the exhumation history and mechanisms of the GHS. If MCT was active starting from 25 Ma in western Nepal the undeformed granite intruding the STDS at ~ 23-24 Ma strongly limits the timing of contemporaneous activity of MCT and STDS at only 1-2 My.

A number of observations and new data, pointing to a more complex deformation history of the GHS, place a limit to contemporaneous activity of STDS and MCT and consequently to channel flow mechanism as the main mechanism of exhumation of the GHS and even to the timing of extrusion of the GHS in western Nepal: (1) the limited thickness of the GHS (largely below the 20-30 km required for an active channel flow; [10]; (2) the exhumation of the upper portion of the GHS happened before the MCT-STDS activity by activation of a regional-scale tectono-metamorphic discontinuity (High Himalayan Discontinuity); (3) a shear zone activated in the uppermost part of the GHS triggered the earliest exhumation of this tectonic unit during the Eocene; (4) the contemporaneous activity of MCT and STD as well as the extensional decoupling of TSS and GHS happened for a very short time span (1-2 Ma only); and (5) our data point out that exhumation of the GHS was partitioned in space and time and different slices were exhumed in different times, starting from the older in the upper part to the younger in lower one.

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