Tectonic discontinuities within the Greater Himalayan Sequence in Western Nepal: insights on exhumation mechanisms

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The Greater Himalayan Sequence (GHS), one of the main tectonic units of the Himalayan range, shows an impressive continuity running from east to west for more than 2000 kilometers. However, the thickness of the crystalline rocks decreases from 20-30 Km in the eastern Himalayas up to nearly 2 km in western Nepal (Carosi et al., 2007; 2010). Large volumes of granites were intruded in its upper portion, below the South Tibetan Detachment System (STDS; Burchfield et al., 1992; Searle, 1999; Beaumont et al., 2001; Carosi et al., 2002; Grujic, 2006; Godin et al., 2006 with references) but moving westward, toward Dolpo and Mugu- Karnali regions (Nepal) granites became scarcer (Leech, 2008). The ductile fabric within the GHS is due by a general shear as a consequence of the contemporaneous motion of the STDS and Main Central Thrust (MCT) at nearly 23-17 Ma (Grujic et al., 1996; Carosi et al., 2006; Larson & Godin, 2009). However, the deformation within the crystalline rocks is not only referable to a simple fabric related to a top-to-the south sense of shear developed in the time span of activity of the STDS and MCT.

Several shear zones and/or thrusts have been recognized within the GHS. Most of them have been regarded as out of sequence thrusts with respect to the MCT (Mukherjee et al., 2011 with references therein). However, geological investigations in the GHS of Western Nepal allow the authors to identify different generations of shear zones with different kinematics and different ages.

A high-temperature top-to-the SW shear zone (Toijem shear zone) has been recently documented in the core of the GHS in lower Dolpo (western Nepal), whose activity has been constrained at circa 26 Ma (Carosi et al., 2010) before the onset of shearing of the MCT. The Toijem shear zone is responsible for the exhumation of the hanging wall rocks before the well-known period of exhumation by extrusion or channel flow of the GHS by the contemporaneous activity of the Main Central Thrust and South Tibetan Detachment System.

Going to the west, in the Mugu-Karnali valley a km-thick shear zone with a top-to the SW sense of shear is again located in the middle part of the GHS nearly separating the upper part of the GHS (with the occurrence of sillimanite along the foliation) from a lower part mainly made by kyanite-bearing gneiss and micaschist. Its preliminary U-Th-Pb age brackets its activity in the STDS-MCT time span. This shear zone is similar to the one described by Yakymchuck (2010) in the Karnali valley few dozen kilometres to the west of Mugu-Karnali.

However, in Western Nepal, shear zones within the GHS are not all related to top-to-the South shearing: in the uppermost part of the GHS, north of Jumla village a ductile shear zone, involving tourmaline-bearing leucogranites shows a top-to-the SE sense of shear and stretching lineation pointing to an orogen-parallel extension. U-Pb age on zircons constrains its activity $<$ 20 Ma.
A cross-cutting undeformed dyke in the GHS of lower Dolpo, emplaced at nearly 17 Ma point to the end of ductile deformation in the GHS at that time.

Recent field and satellite-image investigations documented a large granitic body (nearly 110 km^2) intruding both the uppermost portion of the GHS and the lower portion of the Tibetan Sedimentary Sequence (Bertoldi et al., 2011). U-Pb-Th ages from zircons and monazites extracted from the main granitic body and dykes intruded in the TSS point to an emplacement age at ~ 22-24 Ma. This age constraint represents a pin point for the upper limit of the movement of the STDS (or at least of the lower ductile shear zone) in western Nepal with important consequences for the exhumation history and mechanisms of the GHS.

A number of observations, pointing to a more complex deformation history of the GHS, could place a possible limit of channel flow exhumation and even to extrusion of the crystalline unit in western Nepal: (1) The limited thickness of the GHS (largely below the 20-30 km required for an active channel flow; Godin et al., 2006); (2) the exhumation of the upper portion of the GHS happened before the MCT-STDS activity (e.g. Tojiem shear zone); and (3) the extensional decoupling of TSS and GHS for a very short time span (1-2 Ma only); (4) the occurrence of ductile shear zones at the top of GHS with an age < 20 Ma with orogen-parallel displacement and top-to-the South-East sense of shear.

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