

# The Tectonics of the Tso Morari Ultra High Pressure Nappe in Ladakh, NW Indian Himalaya

Albrecht Steck<sup>1\*</sup> and Jean-Luc Epard<sup>2</sup>

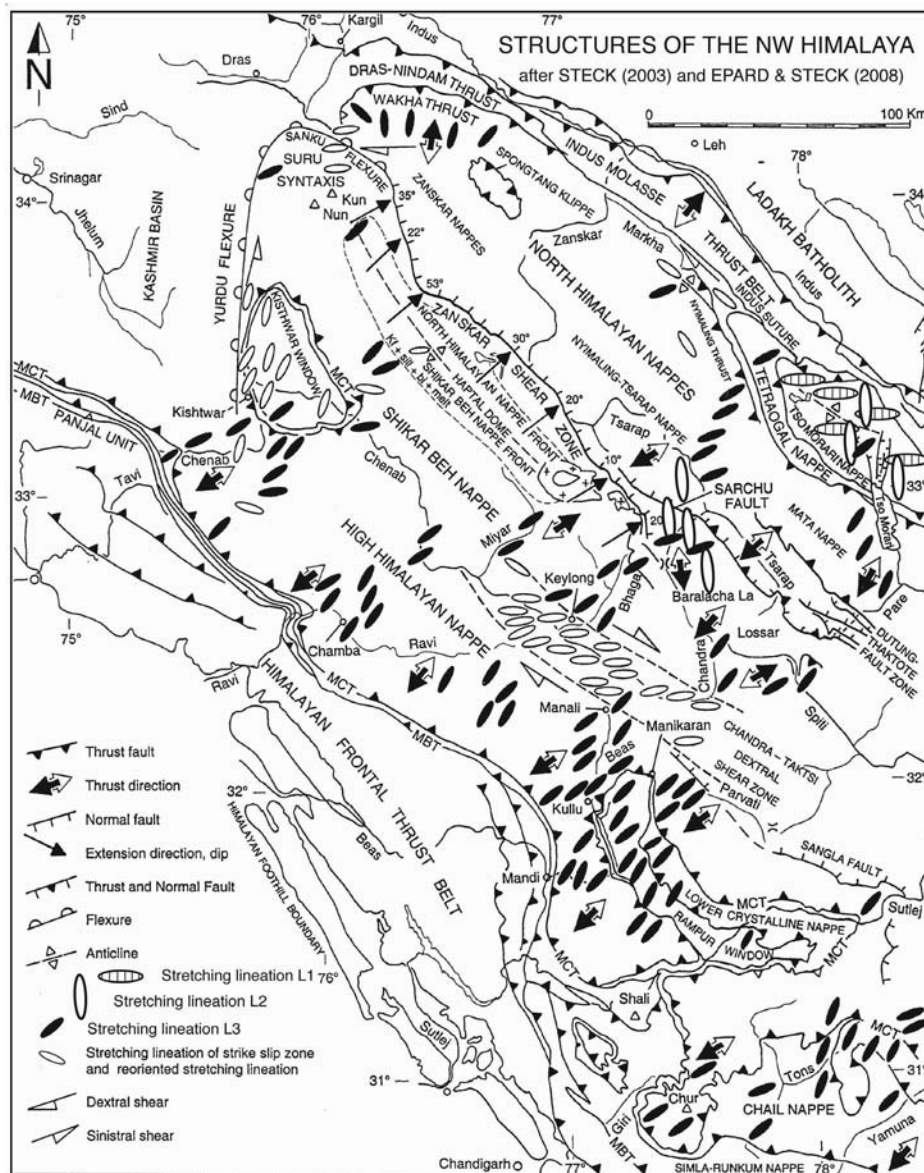
<sup>1</sup> Institut de Minéralogie et Géochimie, Université de Lausanne, Anthropole, CH-1015 Lausanne, SWITZERLAND

<sup>2</sup> Institut de Géologie et Paléontologie, Université de Lausanne, Anthropole, CH-1015 Lausanne, SWITZERLAND

\* For correspondence, email: albrecht.steck@unil.ch

A tectonic model for the structural development of the Tso Morari ultra-high pressure nappe is proposed. It is integrated into the context of the formation of the North Himalayan nappes of the Ladakh Himalaya. In the area, this stack of nappes is composed by, from base to top, the Tso Morari, Tetraogal, Karzok ophiolite, Nyimaling-Tsarap and Mata nappes (Steck et al. 1998, Steck 2003). Four stretching lineations, L1 – L4, are successively developed on

the main schistosity in the North Himalayan nappes (Epard and Steck 2008). L1, with its top-to-the E shear indicators, was formed during the W-directed high temperature extrusion of the ultra high pressure Tso Morari nappe. L2, with its top-to-the S shear indicators, was formed during an early N-directed underthrusting of India below Asia. It is developed in the roof of the Tso Morari nappe as well as at the base and frontal part of the Nyimaling-



Tsarap nappe in the area of Sarchu and Baralacha La. L3, with top-to-the SE shear indicators, was developed in the whole North Himalayan nappe stack during a NE-directed underthrusting of India below Asia. The same NE-directed L3-stretching lineation was also developed in the younger High Himalayan nappes during their SW-directed extrusion and emplacement between about 40 and 18 Ma. L4 is related to active NW-directed low temperature, dextral strike-slip movements. The observed change of underthrusting direction showed by the orientation of L2 and L3 is compatible with paleomagnetic models suggesting an anticlockwise rotation of the Indian continent between 52 Ma and 35 Ma. These two time-constraints are given by the age of the ultra high pressure metamorphism and the Tso Morari dome uplift to a depth of 10 km respectively. The warping of the Tso Morari dome started already some 48 Ma ago with the formation of an extruding nappe at depth. The Tso Morari dome reached a depth of 15 km about 40 Ma ago in the eastern Kiagar La region and 30 Ma ago in the western Nuruchan region (Schlup et al. 2003). The extrusion rate was of about 3 cm/yr between 53 and

48 Ma, then 1.2 mm/yr between 48 and 30 Ma and 0.5 mm/yr after 30 Ma. The Tso Morari dome is still affected by faults, open regional dome, basin and pull-apart structures, coeval with a zone of dextral transpression parallel to the Indus Suture zone (Epard and Steck 2008).

#### References

- Epard JL and A Steck. 2008. Structural development of the Tso Morari ultra-high pressure nappe of the Ladakh Himalaya. *Tectonophysics*: (in press)
- Schlup M, A Carter, M Cosca and A Steck. 2003. Exhumation history of eastern Ladakh revealed by  $^{40}\text{Ar}/^{39}\text{Ar}$  and fission track ages: The Indus river-Tso Morari transect, NW Himalaya. *Journal of the Geological Society of London* 160: 385-399
- Steck A, JL Epard, JC Vannay, J Hunziker, M Girard, A Morard and M Robyr. 1998. Geological transect across the Tso Morari and Spiti areas: the nappe structures of the Tethys Himalaya. *Eclogae Geologicae Helveticae* 91: 103-121
- Steck A. 2003. Geology of the NW Indian Himalaya. *Eclogae Geologicae Helveticae* 96: 147-196