Difficulties in constraining crustal displacement paths at Nanga Parbat, Western Himalayan Syntaxis

Poster no. 246-2

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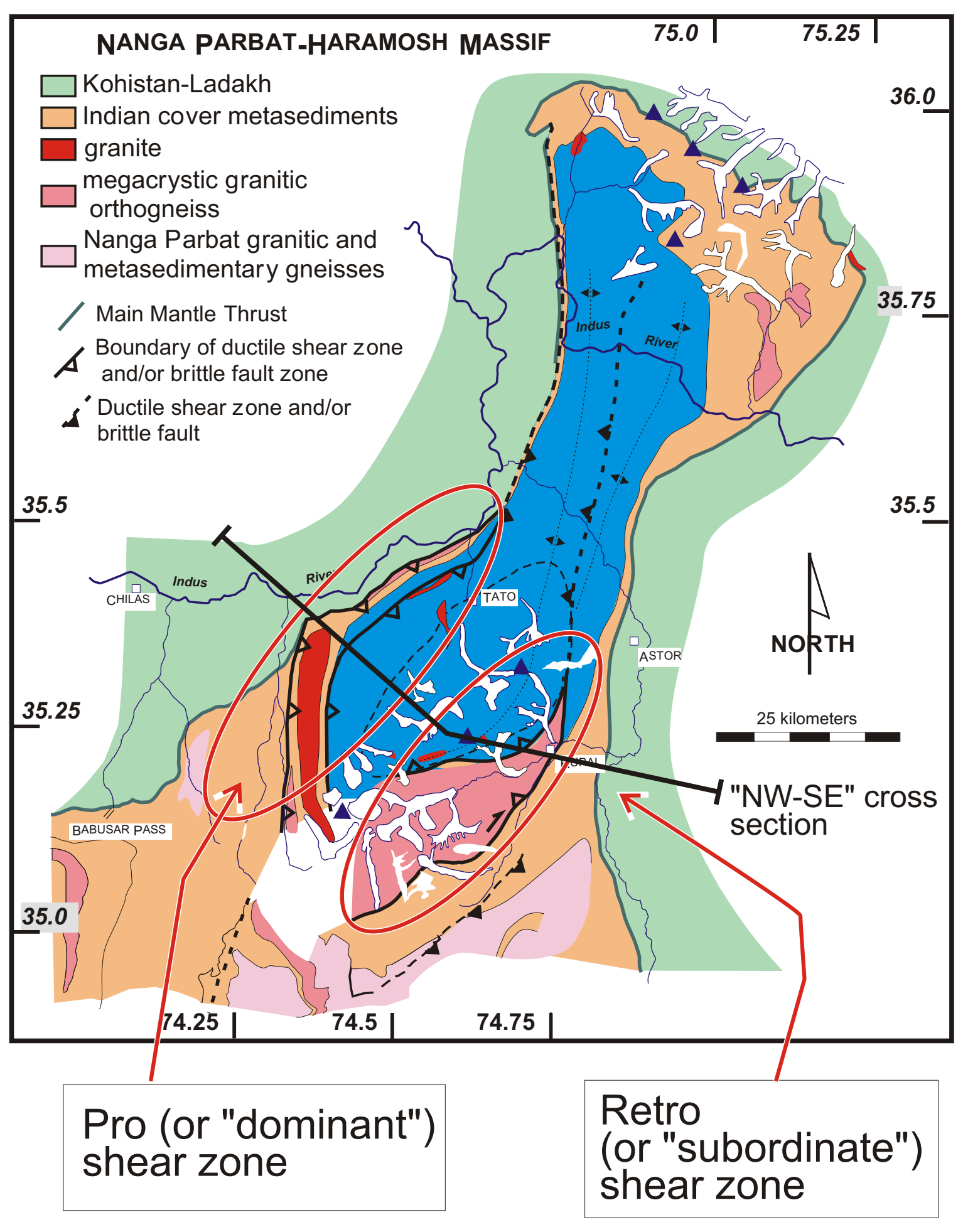
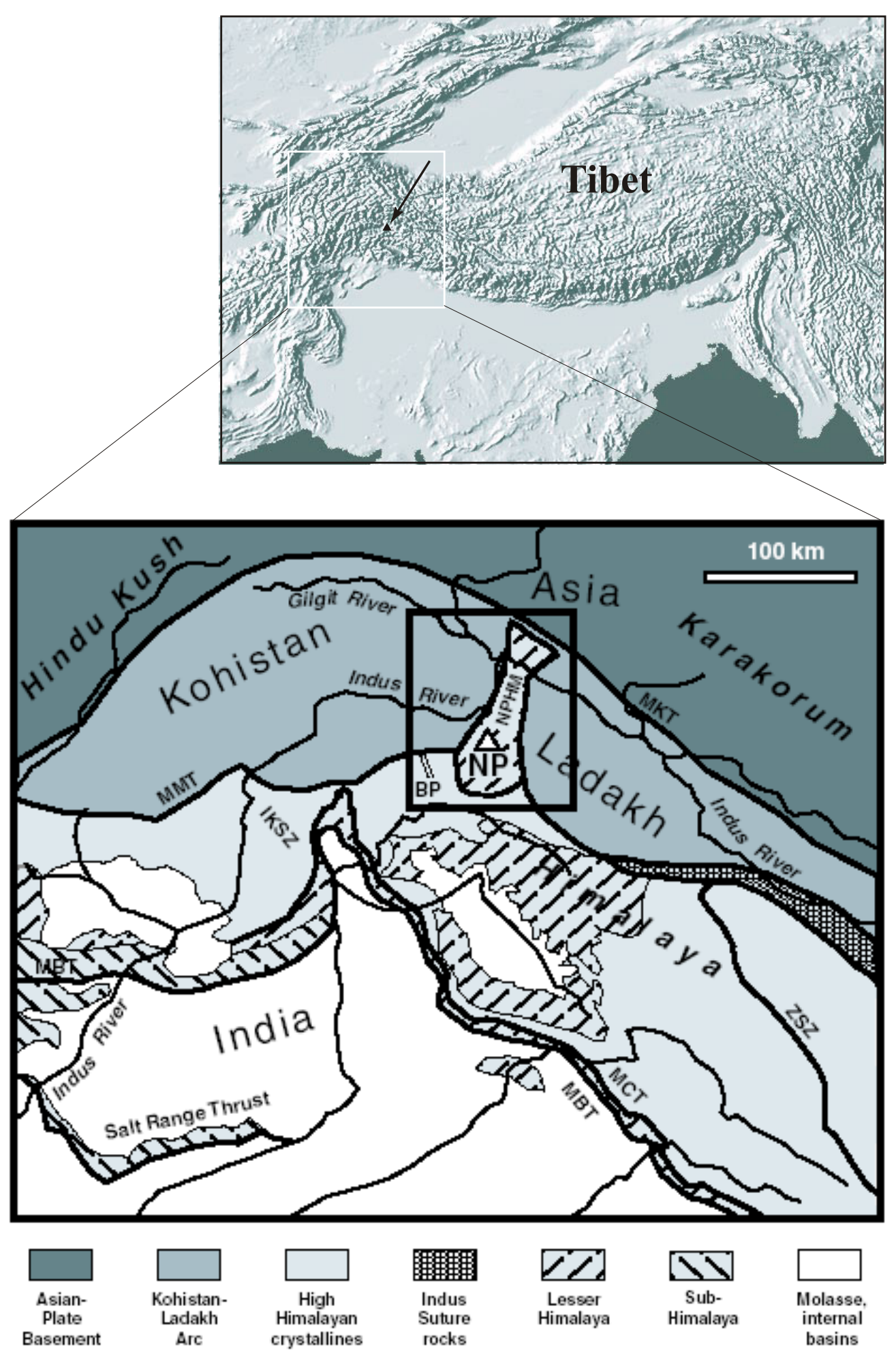
Figure 2 after Schneider et al. 1999



Introduction

The Nanga Parbat - Haramosh Massif (NPHM) in Pakistan lies in the western Himalaya and marks the tip of the Himalaya arc, termed the "syntaxis" (Fig. 1 ***to right***). In this region, crustal displacements are complicated by the interplay of the "normal" convergence of the Indian plate (~north) with the accumulation of strain from the expanding arc; the arc continues to expand as collision progresses, causing a strong partitioning of strain to the arc- parallel direction. At NPHM this results in very young plutonism, metamorphism and exhumation. NPHM has a general dome form whose exhumation and relative uplift has been accommodated by two steep, ~NNE trending, 30-50 km long, approx. conjugate orientation, crustal-scale shear zones (Figures 2 & 3 - map & cross section of NPHM). As seen in the cross section, the shear zones have pro- & retro- (or dominant and subordinate) geometries. These thrust-displacement shear zones have allowed the ~25 km wide core of the massif to be uplifted in a pop-up mechanism.

Figure 1
Regional Overview



More introduction

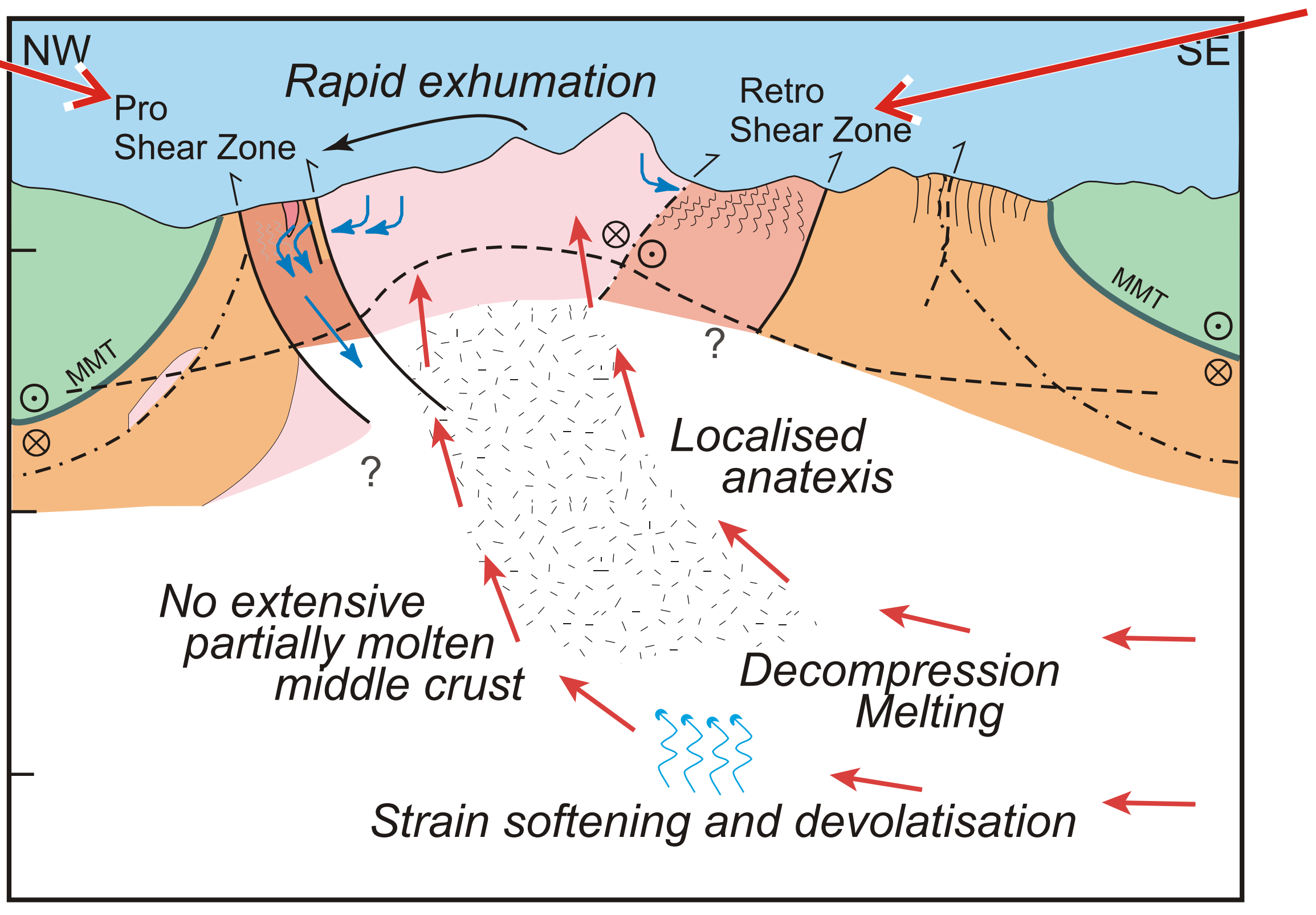
Both shear zones are accompanied by very large age gradients in cooling & plutonism that young inwards (i.e. towards the core), as well as hydrothermal activity, seismicity and conductivity that is focussed along the surface traces of the shear zones or their respective projections at depth.

The host rock in which both shear zones are found contains a pre-existing high strain fabric related to the earlier main Himalayan N-S convergence. It comprises mainly of a 5-15 km thick shear zone whose fabric is now steeply dipping, approx. N-S trending with ~N- plunging to sub-horizontal mineral, fold hinge & intersection lineations. This package of rock records a broader range of deformation conditions than that subsequently preserved in the conjugate shear zones, creating difficulties in separating deformation events.

The Pro- Shear Zone is clear

The dominant s.z. (i.e. on the NW side) is narrower and better defined than the subordinate s.z. It is a series of granitic orthogneiss layers (or lenses) 10's - 100's m wide that are intercalated with (originally intruded into?) layered meta-sedimentary & granitic gneisses. Mineral stretching lineations are at high angles to those in the host rock; differentiation of the s.z. boundaries is straightforward. Sense of shear indicators on numerous scales indicate reverse displacement thrust sense; SE over NW.

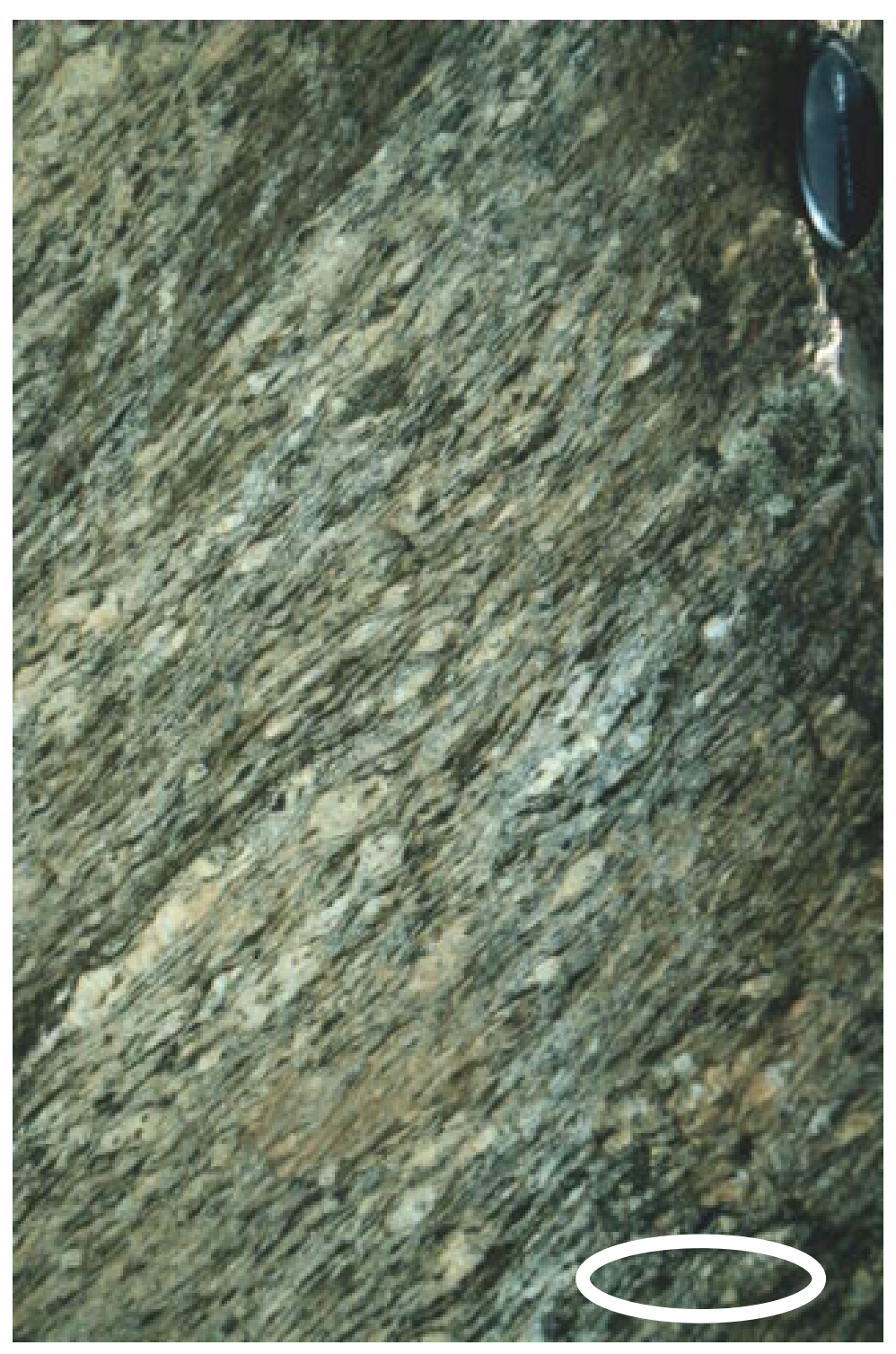
Figure 3 after Schneider et al., 1999; Zeitler et al. 2001



The Retro- Shear Zone is less clear

The retro shear zone is a several km wide, ~NNE trending belt of homogeneous granitic orthogneiss showing a pervasive C/S fabric and augen asymmetry that mostly indicates NW side up with dextral shear. Accompanying asymmetric (kinematic) fabric is marked (e.g.) by biotite planes clearly forming S and C surfaces, and 0.5-2 mm feldspar porphyroclasts that define augen with asymmetric tails. The shear zone broadens from a couple to >5 km to the south (away from the core of the massif), accompanied by a gradual 90° change in fabric orientation (which the sense-of-shear indicators track!).

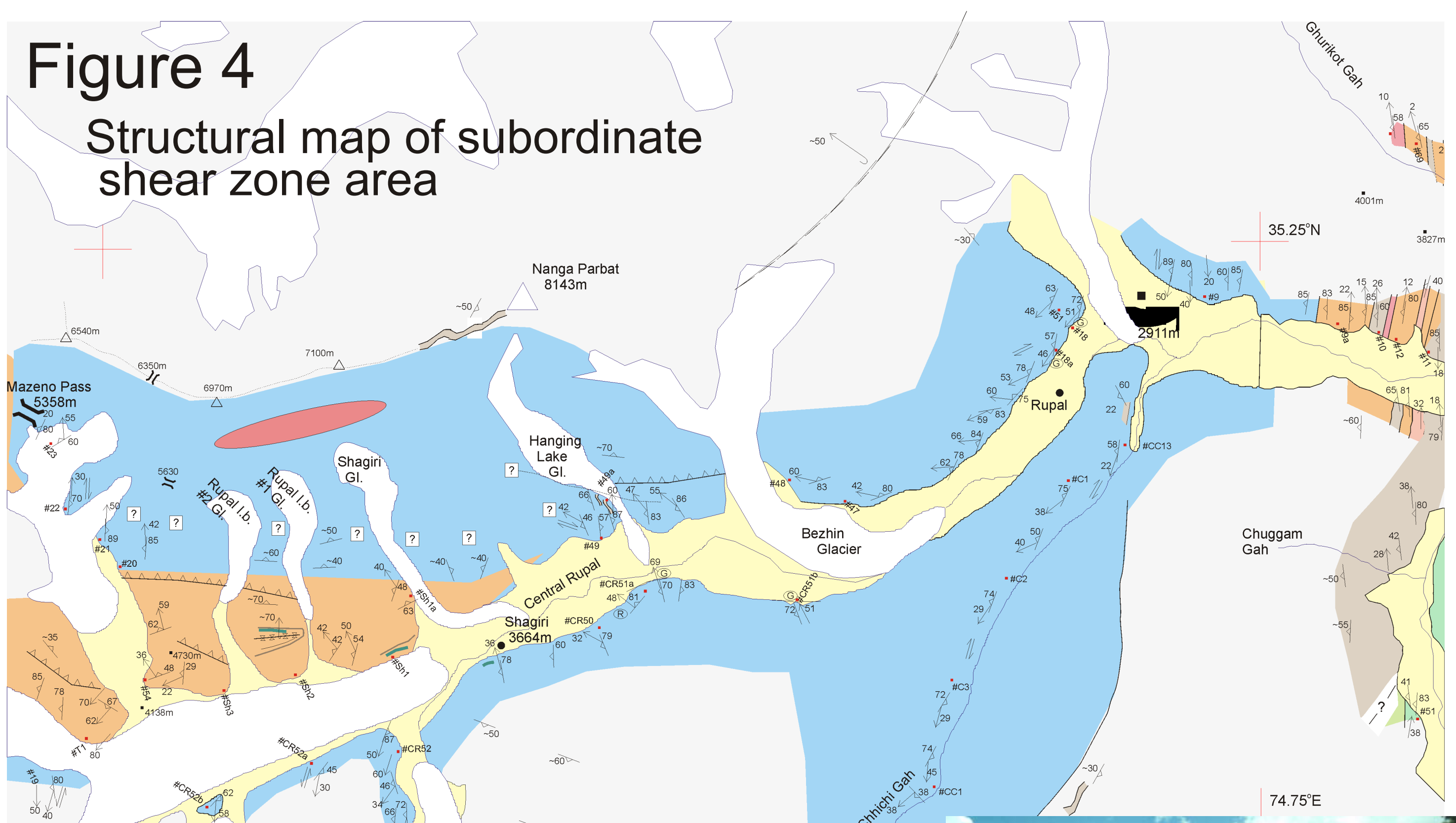
The retro shear zone outcrops across much of eastern Rupal and Chichi valleys but does not, however, have clear, sharp shear zone margins; neither classic ductile strain gradient margins (i.e., Ramsay and Graham, 1970) nor margins marked by significant brittle discontinuity. Consequently, the true extent of the retro shear zone is hard to define, most notably to the west and south.



C/S fabric of Retro-Shear Zone showing dominantly west up & over east thrust-sense. This ~5km-wide shear zone forms the southeastern margin of the central Nanga Parbat massif and is the eastern fault of the proposed pop-up structure.

The shear zone fabric is very well developed and highly consistent both along and across strike, on the scale of several 10's km. It is likely that the protolith was a granitic rock with large feldspars that was deformed during or directly after emplacement. Monazite grains from the s.z. show complex growth imagery and Th-Pb spot analyses give ages from 20-10 Ma (Schneider et al. 1999). Likely, there was localised synkinematic plutonism that recurred throughout the shear zone evolution, providing local foci into which strain was preferentially partitioned thereby further obscuring the finite deformation history.

Figure 4
Structural map of subordinate shear zone area



Legend

0 — 5 km

North

Himalayan Rocks

▨	Metapelitic schists and gneisses (typically garntiferous) interlayered with marbles and amphibolites. Part of NW Himalayan cover rocks
▨	Metapelitic schists and gneisses (typically non-garnetierous). Probably not part of NW Himalayan cover rocks.
🟧	Undifferentiated interlayered gneisses and schists.
🟥	Migmatitic garnetiferous (pelitic) gneisses
▨	Streaked quartzofeldspathic ("Angel Hair") unit
⬜	Lath unit (including highly strained portions)
🟦	Iskere Gneiss
🟦	Monotonous granitic orthogneiss (including Rupal Chhichi S.Z.)

Kohistan-Ladakh Series Rocks

🟩	General amphibolite, metabasite, metadiorite, etc.
🟩	Actinolite schist
▨	Volcanosedimentary origin (volcanic sands, pillow basalts, etc)

Other

🟨	Unconsolidated sediment (outwith main glacier bodies)
🟥	Granite
⬜	Glacier

Symbols

50 Local foliation mesurement
~50 Remote foliation mesurement
50 Local lineation mesurement
Antiform
Synform
Over turned antiform
General direction of wrench component of local displacement

View to SSW up Chhichi Nullah from pass over Rupal-Chhichi ridge. S/C mylonitic granitoid rocks of the Rupal-Chhichi (i.e. *Retro*) Shear Zone form most of the western wall; the eastern wall has abundant metasedimentary schists probable Indian cover). The contact crosses into the western side of the valley just north of the dark and snow-covered ridge in the far distance.

Can YOU help???

1. Why does the fabric in the "shear zone" swing around by at least 90 degrees yet remain consistent with lithology and sense of shear?

2. Can stretching lineation be used to "track" displacement paths and be used as a reference for sense of shear indicators?

3. Why is stretching lineation parallel with fold hinges in the shear zone orthogneiss AND in the adjacent country rocks (quartzites, marbles, etc) to the SE that do NOT show good sense of shear indicators (and is not thought to be part of the shear zone)?

Poster presented at:
Geological Society of America
Annual Meeting, Denver, 2002
(30 October 2002)