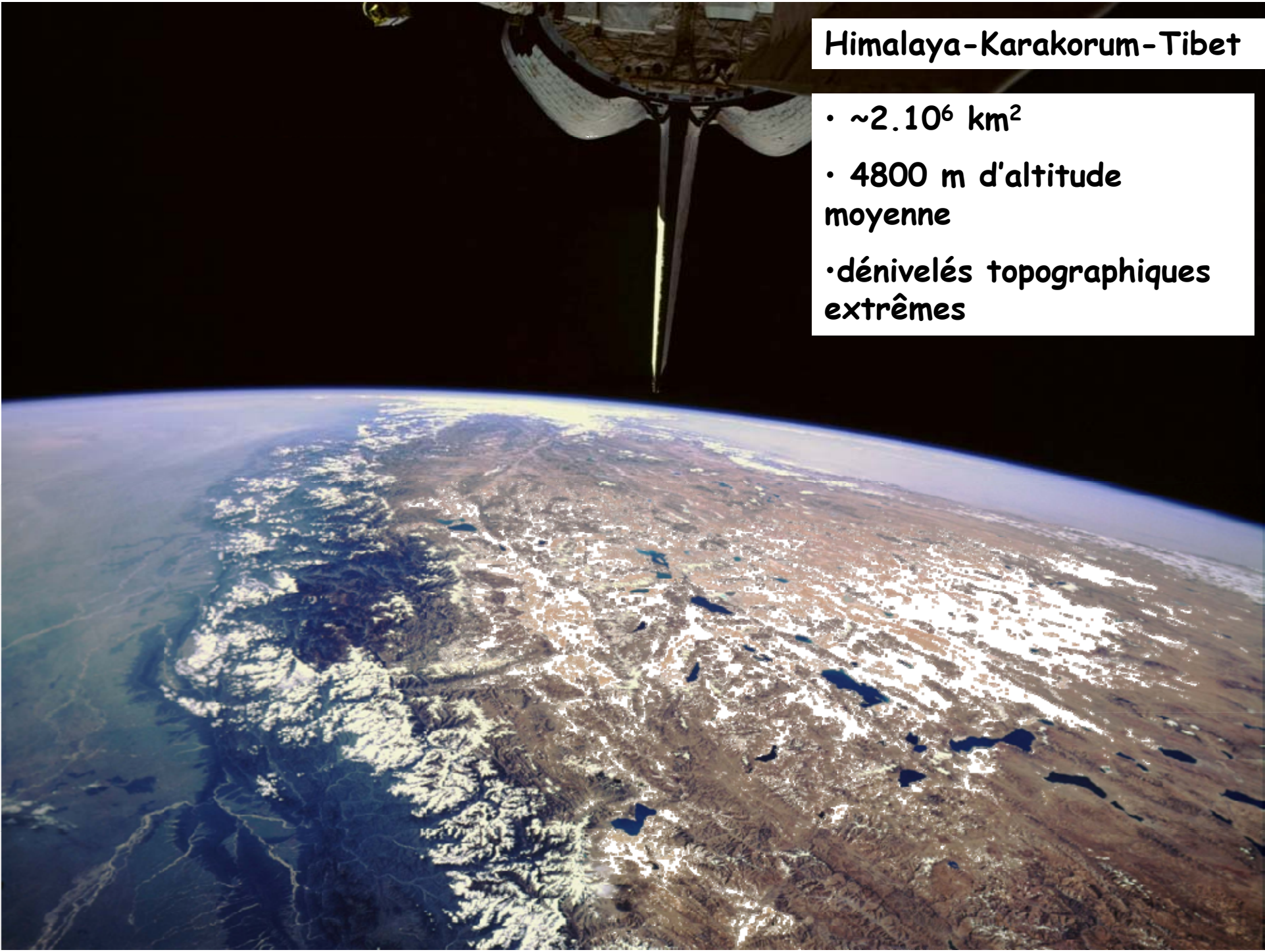


Eocene Tibetan plateau remnants and Quaternary high reliefs in the northwest Himalaya

Stéphane Guillot,
Peter van der Beek,
Gweltaz Mahéo,
Arnaud Pêcher
Anne Replumaz
Martin Roddaz



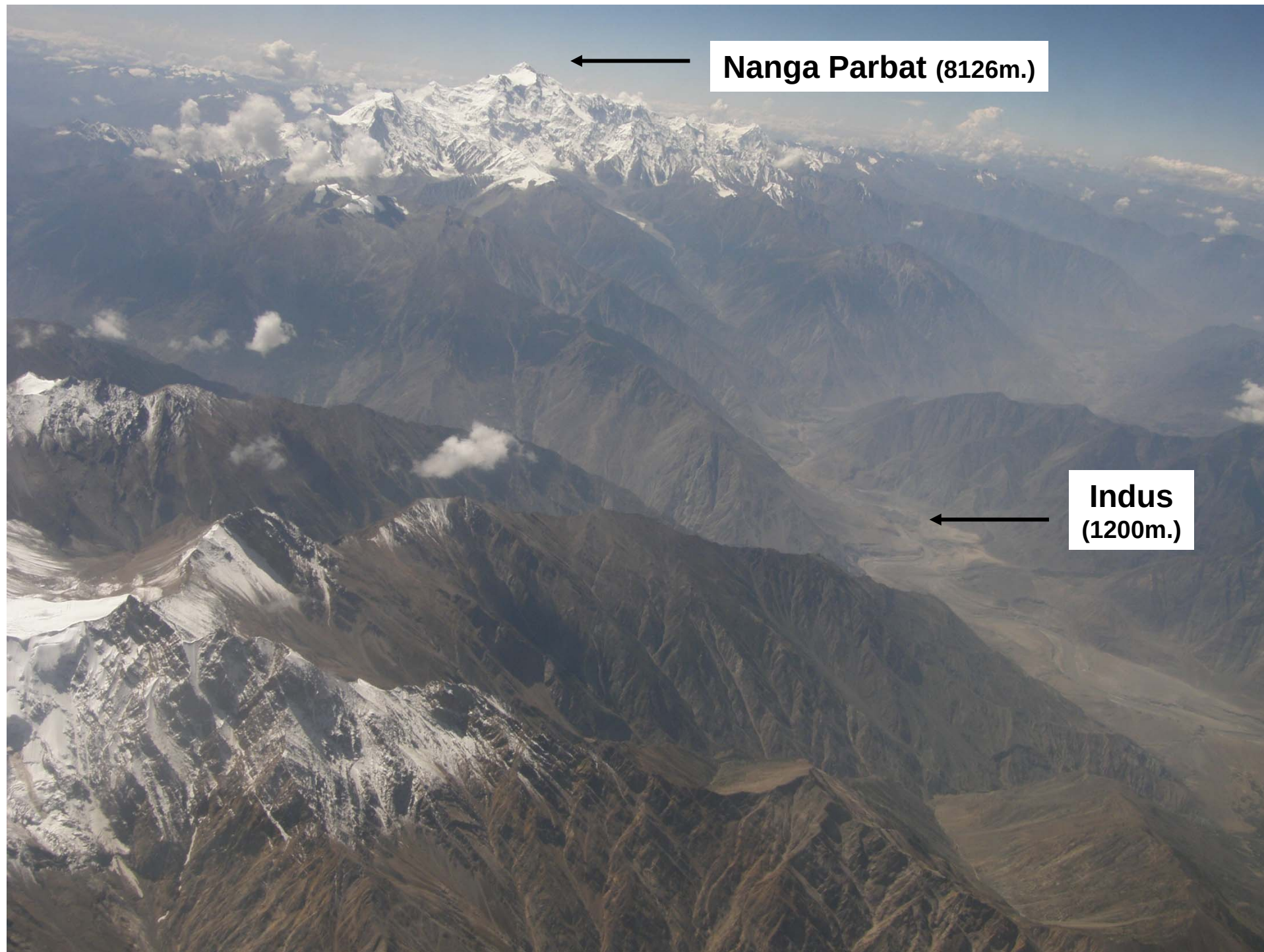


Himalaya-Karakorum-Tibet

- $\sim 2.10^6 \text{ km}^2$
- 4800 m d'altitude moyenne
- dénivelés topographiques extrêmes







Nanga Parbat (8126m.)

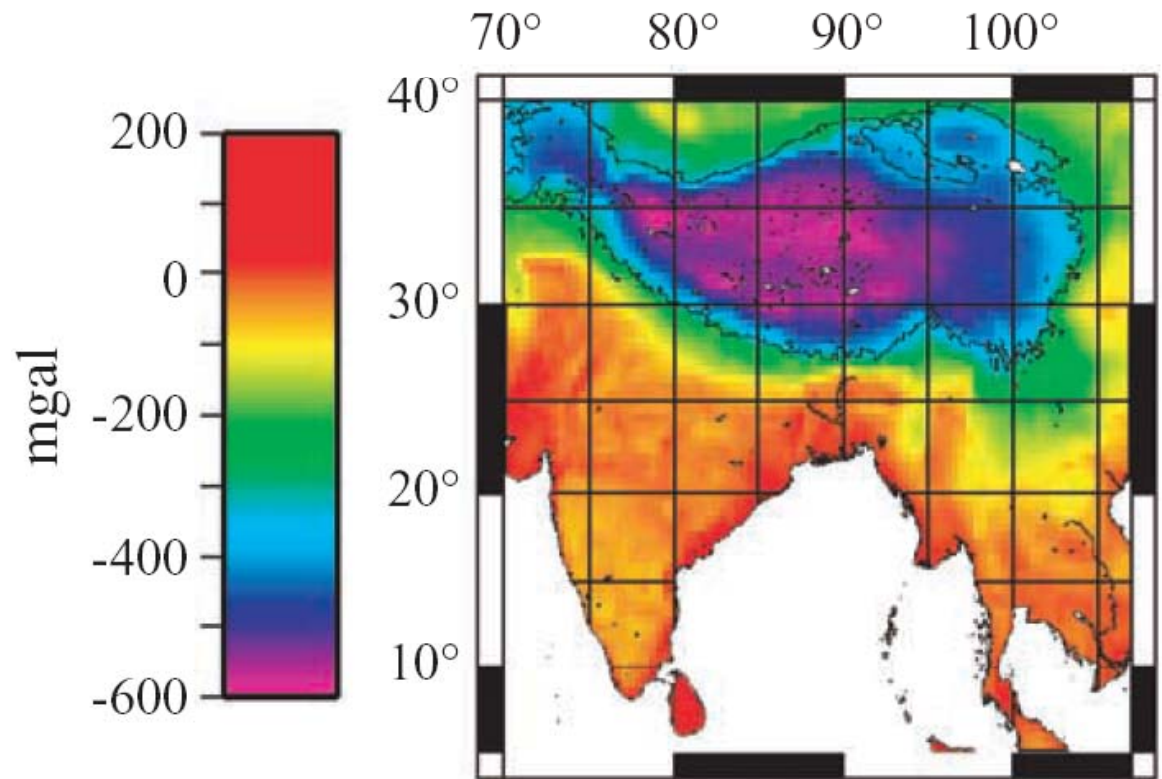
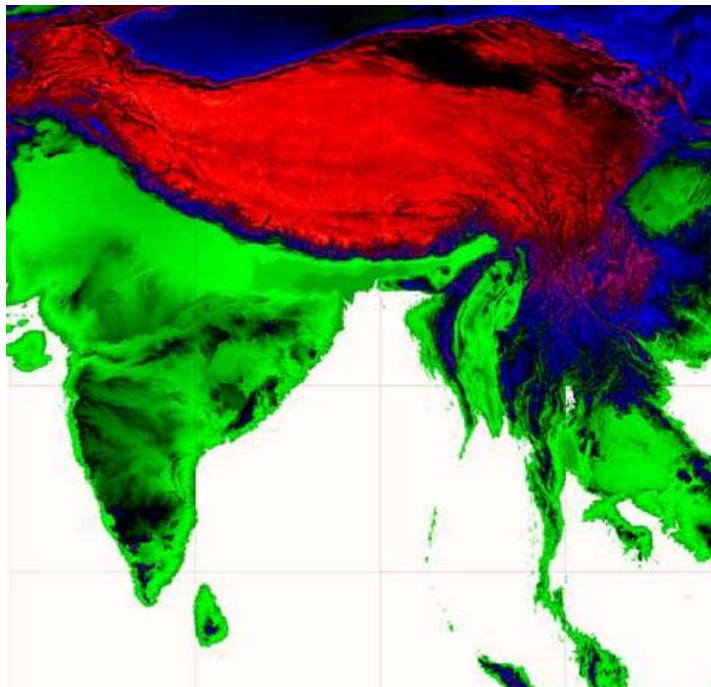
**Indus
(1200m.)**

How to built the Tibetan Plateau ?

Since when ?

Why the Himalaya-Karakorum so high?

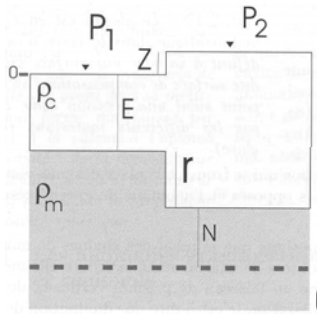
Since when ?



Bouguer anomaly
(Jordan & Watts, 2005)

=> A major thickened area

Crustal thickness estimation



Local d'Alembert isostatic compensation:

$$P_1 = P_2 \Rightarrow r(\rho_m - \rho_c) = z \rho_c$$

At the first order

$$\rho_c = 2,8 \cdot 10^3 \text{ kg/m}^3, \rho_m = 3,3 \cdot 10^3 \text{ kg/m}^3, E = 40 \text{ km}$$

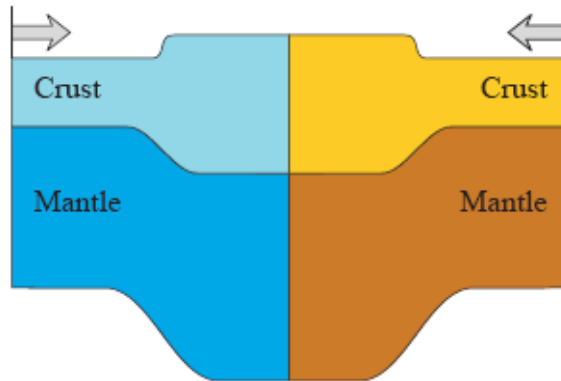
➤ South Tibet: $z = 5000\text{m} \Rightarrow r = 28 \text{ km} \Rightarrow H_c = r + E + z = \mathbf{73 \text{ km}}$

$\Rightarrow \sim \text{OK}$

➤ the relief is isostically equilibrated by the crustal root

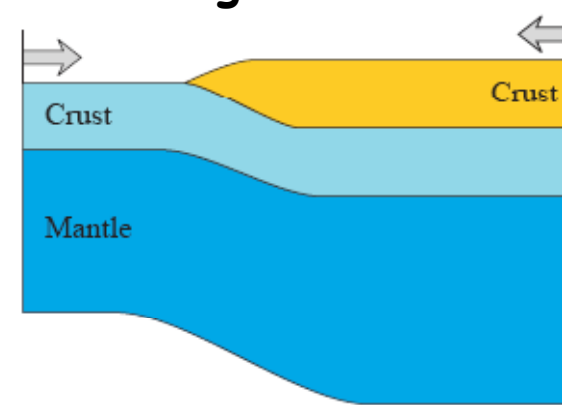
What happen in depth ? Models of plateau formation

Homogeneous thickening



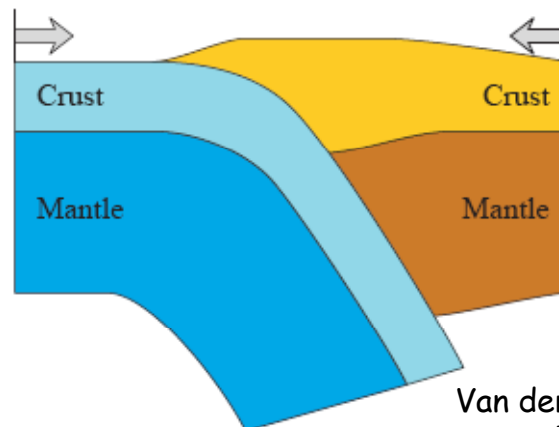
England & Houseman, 1986, 1989
Holt et al., 1995, 2000

underthrusting

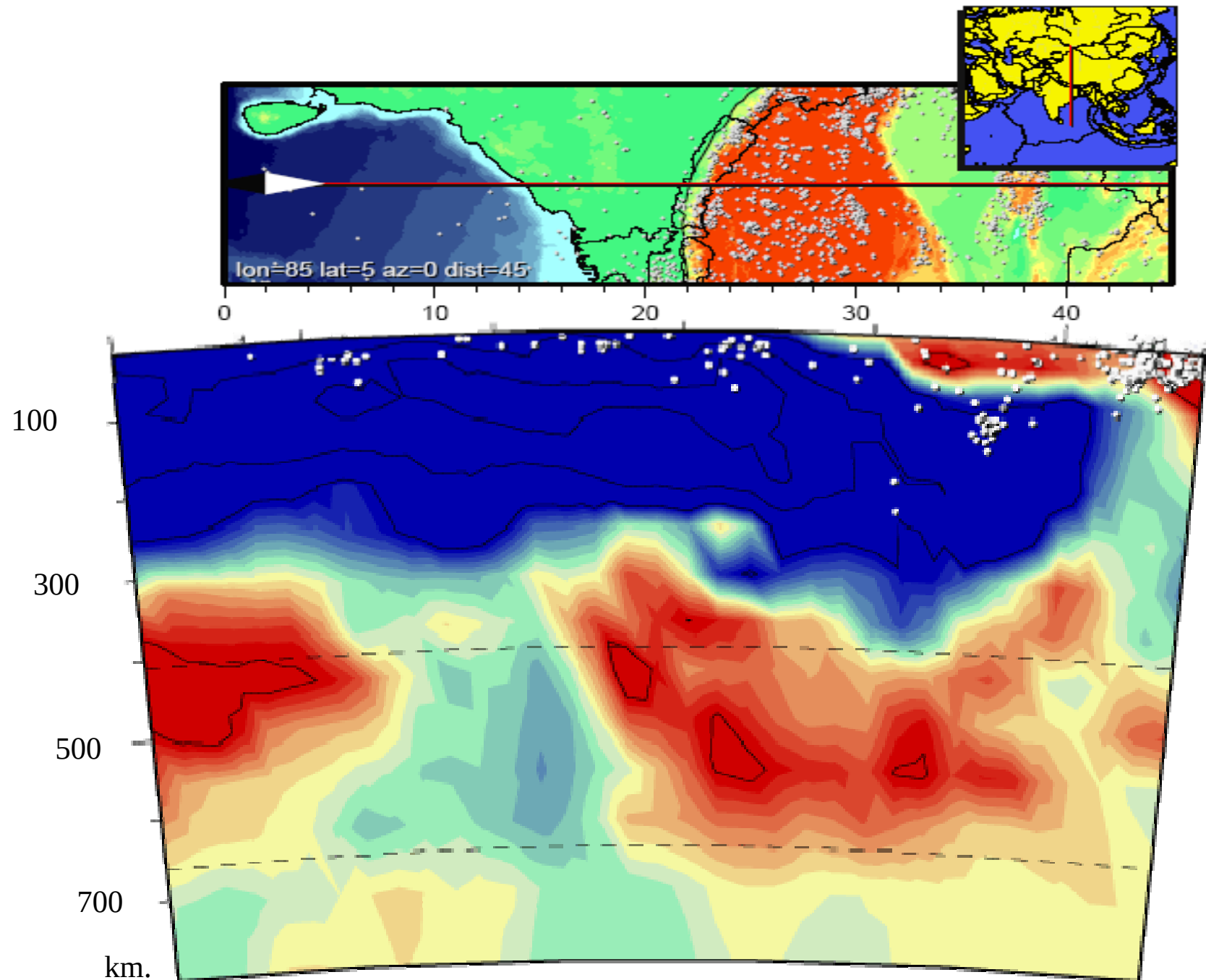


Argand, 1924
Gansser, 1964
Powell & Conaghan, 1973

Subduction

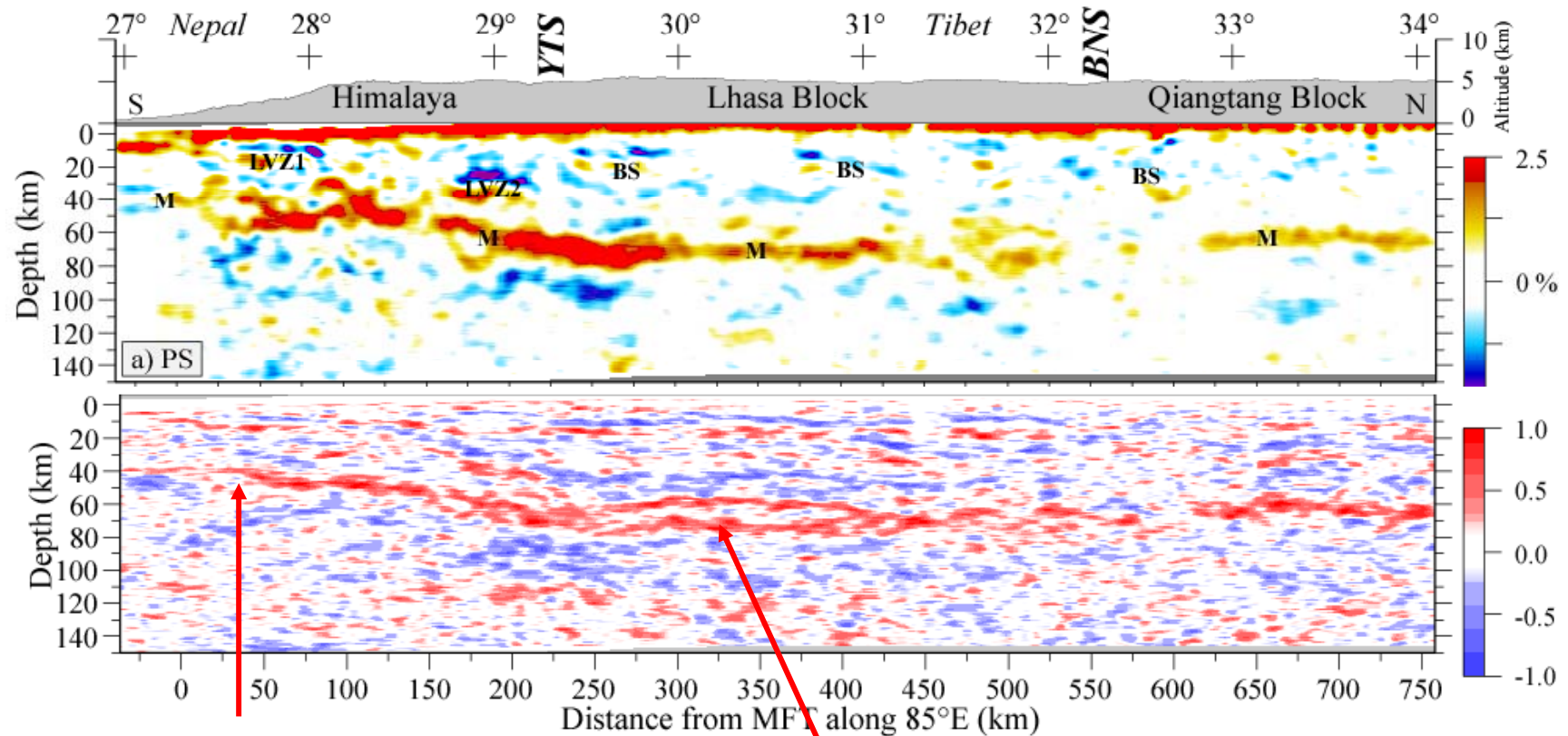


Miyashiro, 1982
Van der Voo et al., 1999
Tapponnier, 2001



(Replumaz et al., Tectonophy 2009, 2010)

Hi-Climb profile (migrated receiver functions)

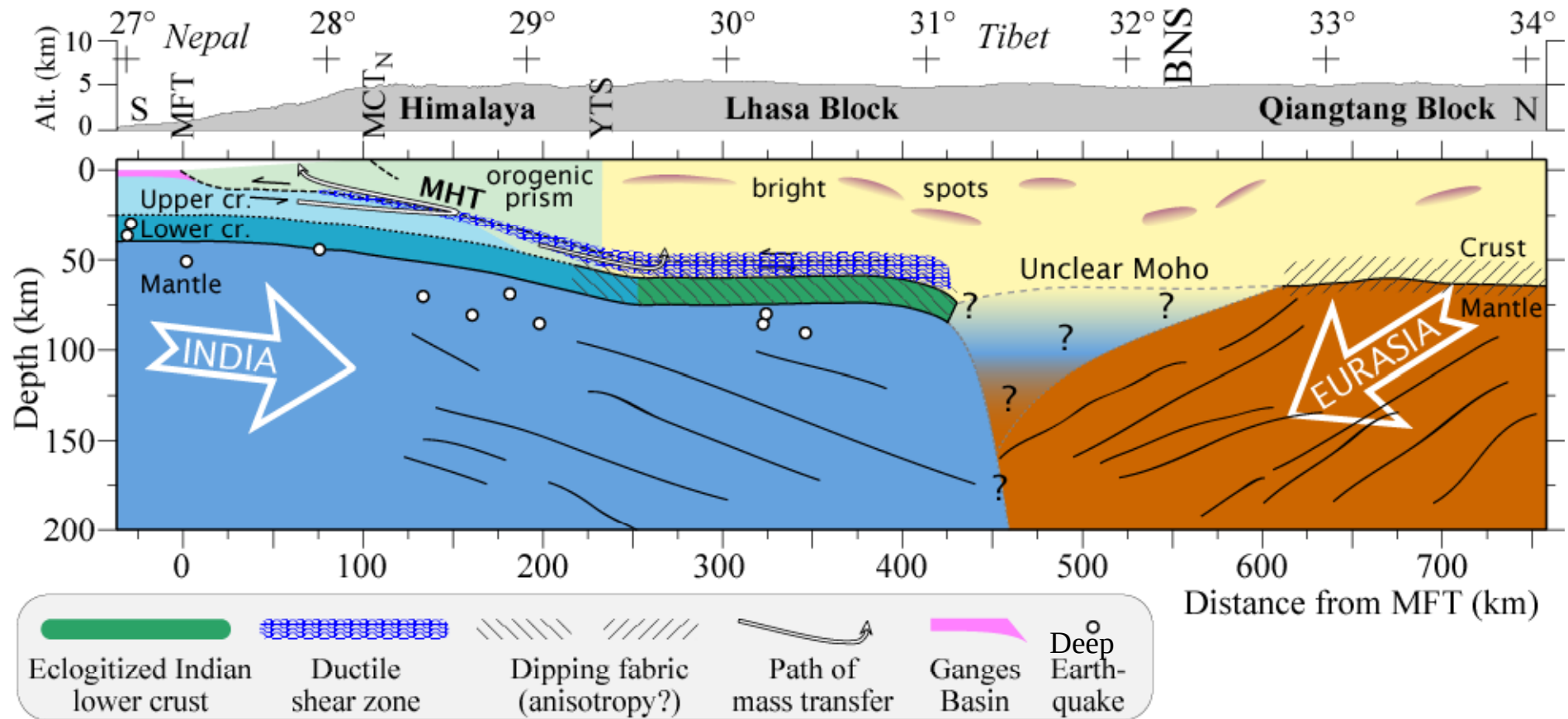


Nabelek et al., Science 2009

- Moho beneath Nepal at 40 km

Moho gently dip northward beneath the High Himalaya and South Tibet till ~75 km depth

Interpretation



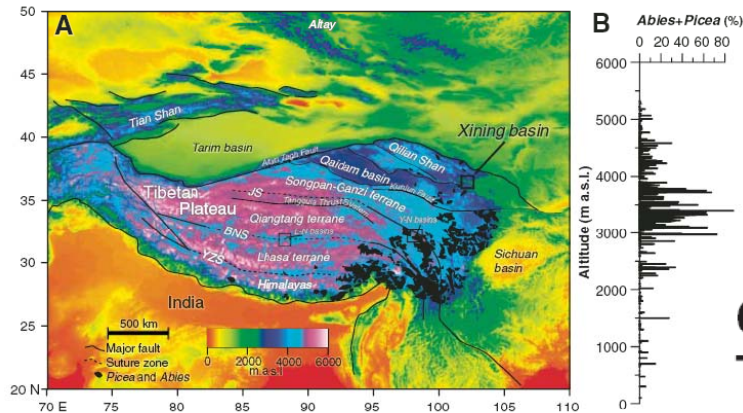
(Chen & Yang, 2004)

Nabelek et al., 2009
Hetenyi et al., 2010

Tibetan uplift prior to the Eocene-Oligocene climate transition: Evidence from pollen analysis of the Xining Basin

G. Dupont-Nivet^{1*}, C. Hoorn², M. Konert³

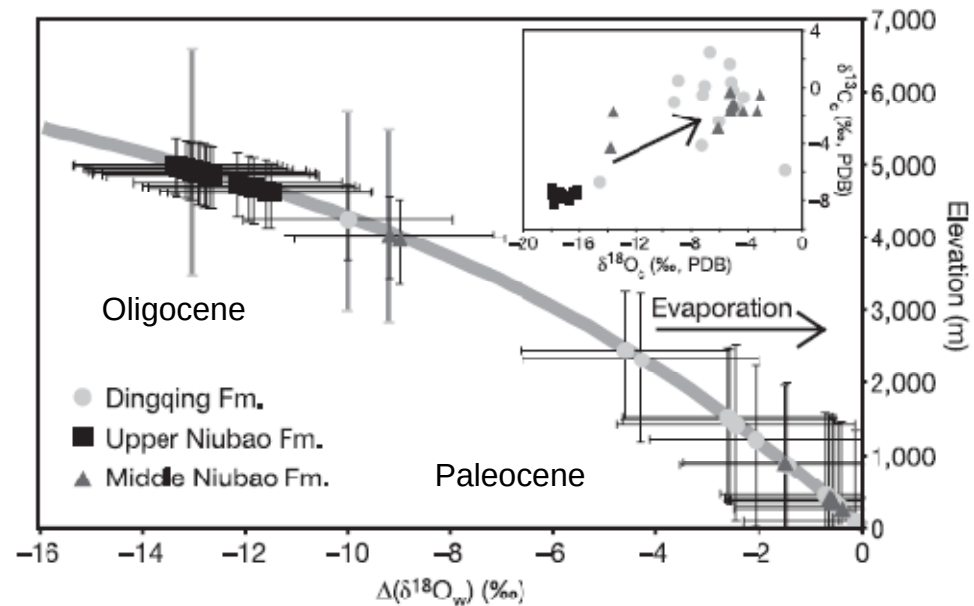
Geology, 2008



Constraints on the early uplift history of the Tibetan Plateau

Chengshan Wang^{*,†}, Xixi Zhao^{†,‡}, Zhifei Liu[§], Peter C. Lippert[†], Stephan A. Graham[¶], Robert S. Coe[‡], Haisheng Yi^{||}, Lidong Zhu^{||}, Shun Liu^{||}, and Yalin Li^{*}

PNAS, 2008

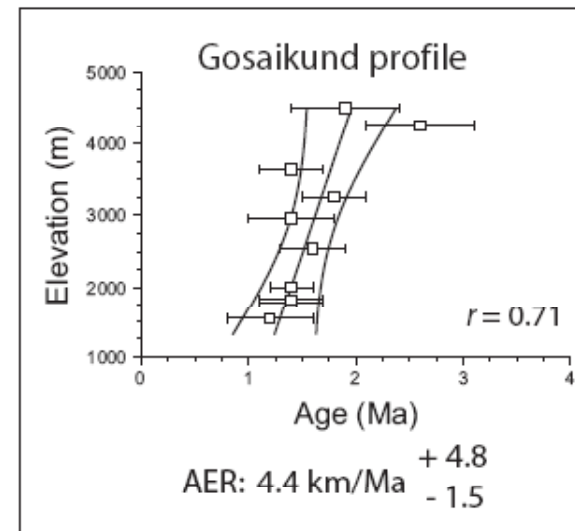
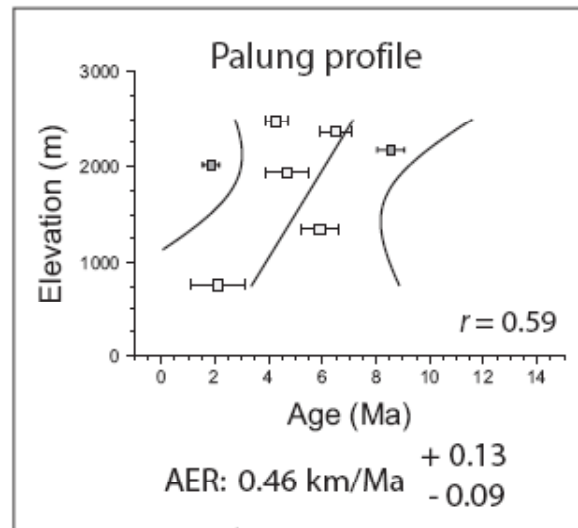


What about Himalayan reliefs ?

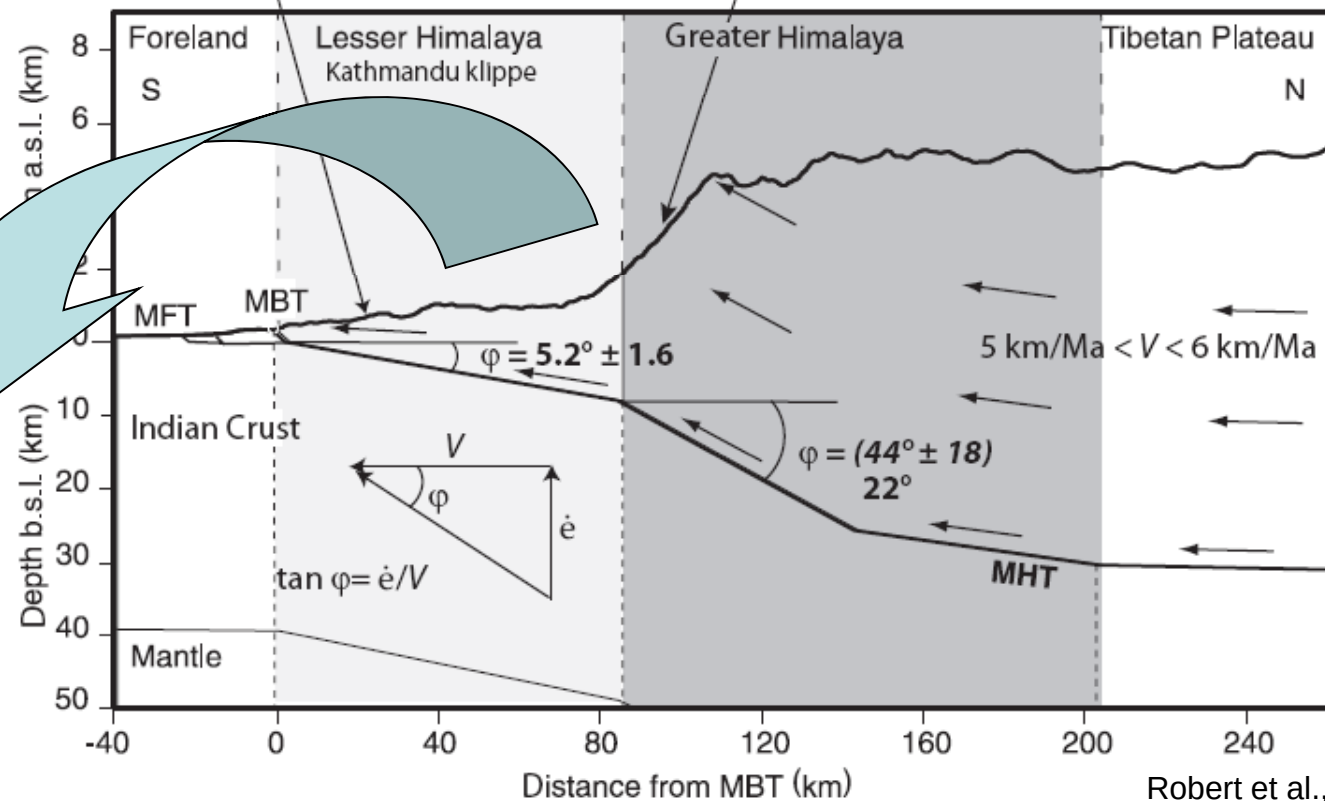
Himalaya : orogenic prism

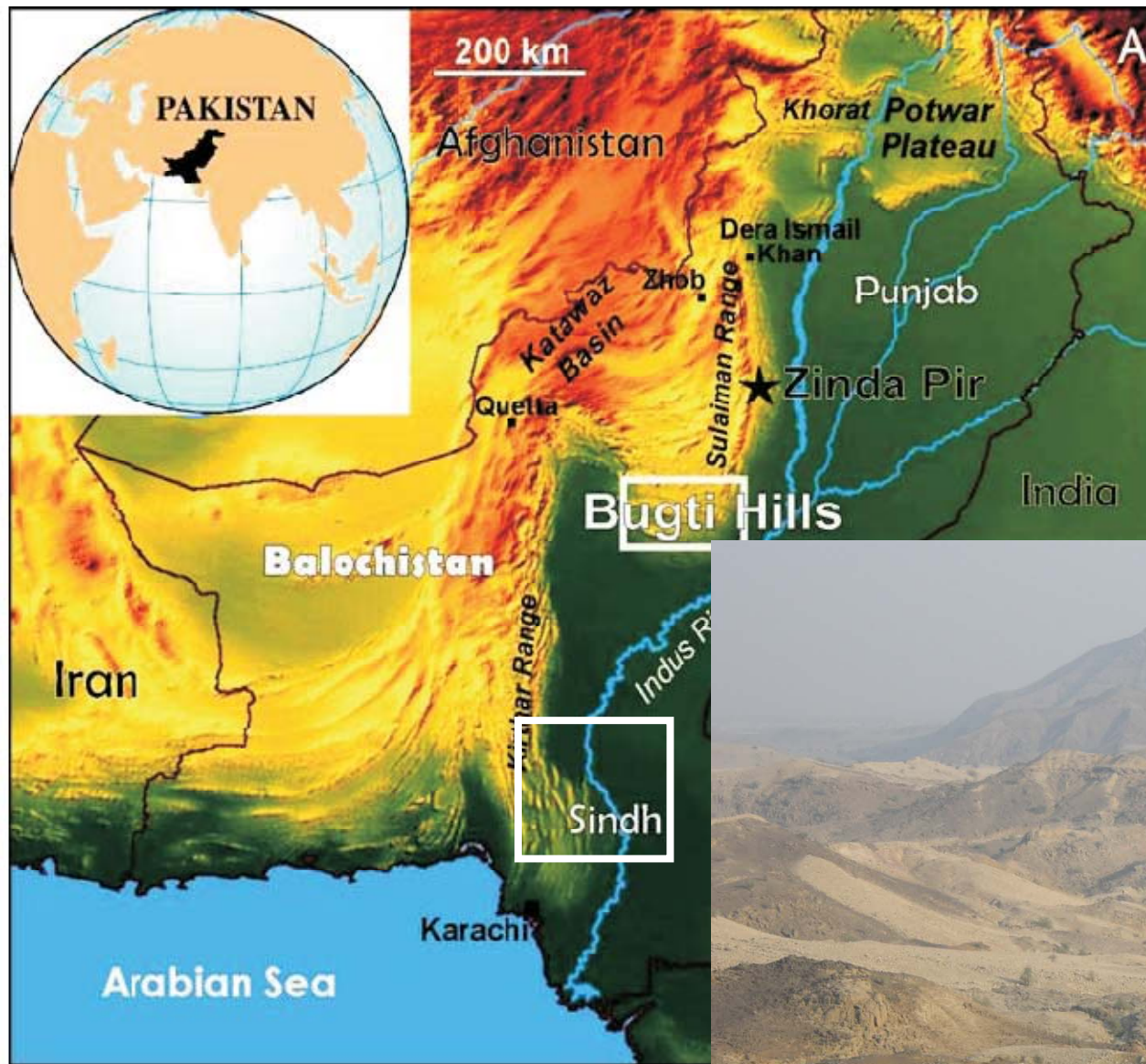
=> progressive growing of the reliefs?

or incised plateau?



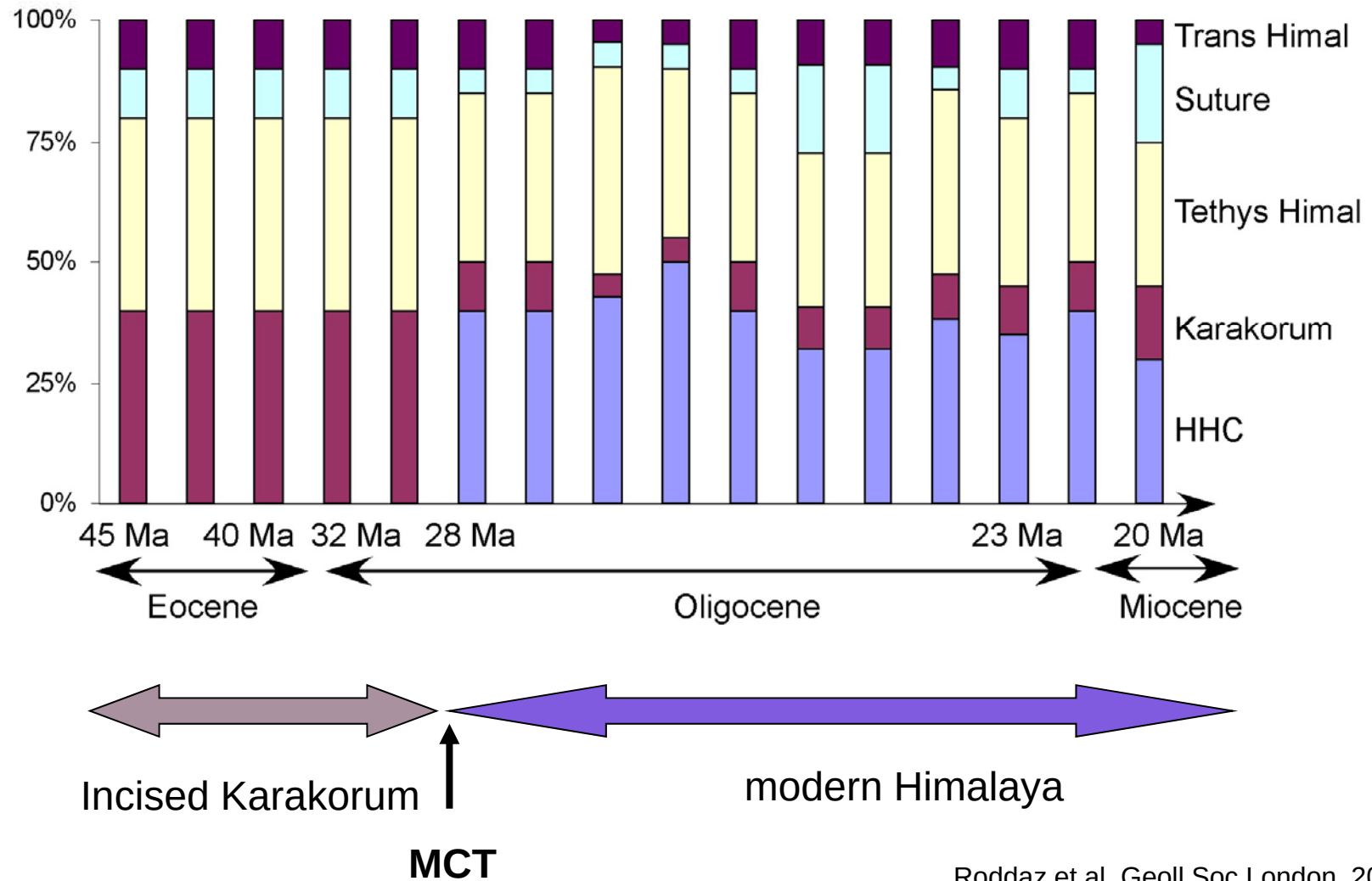
Erosion
5 mm/yer



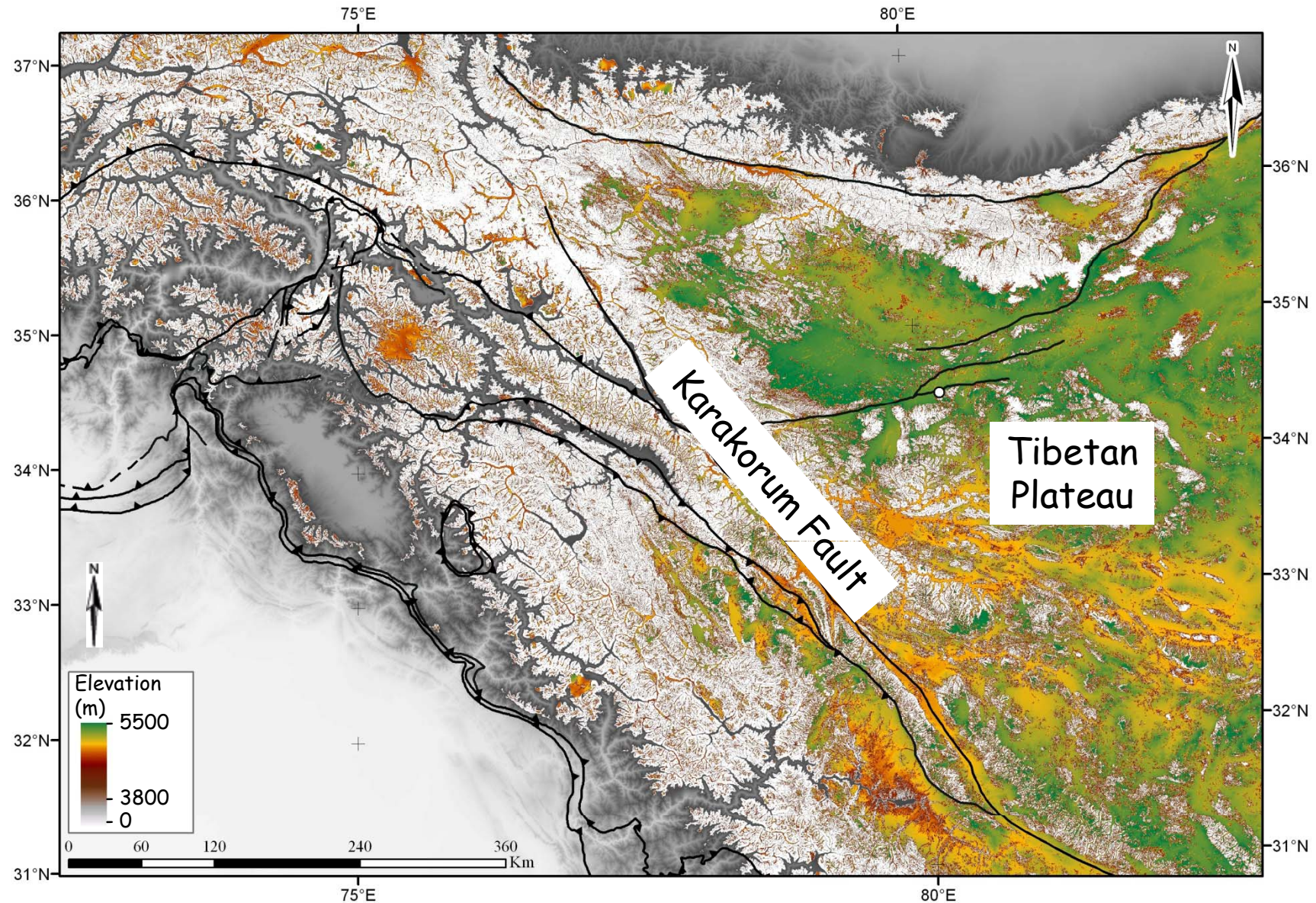


Roddaz et al. Geoll Soc London, 2011

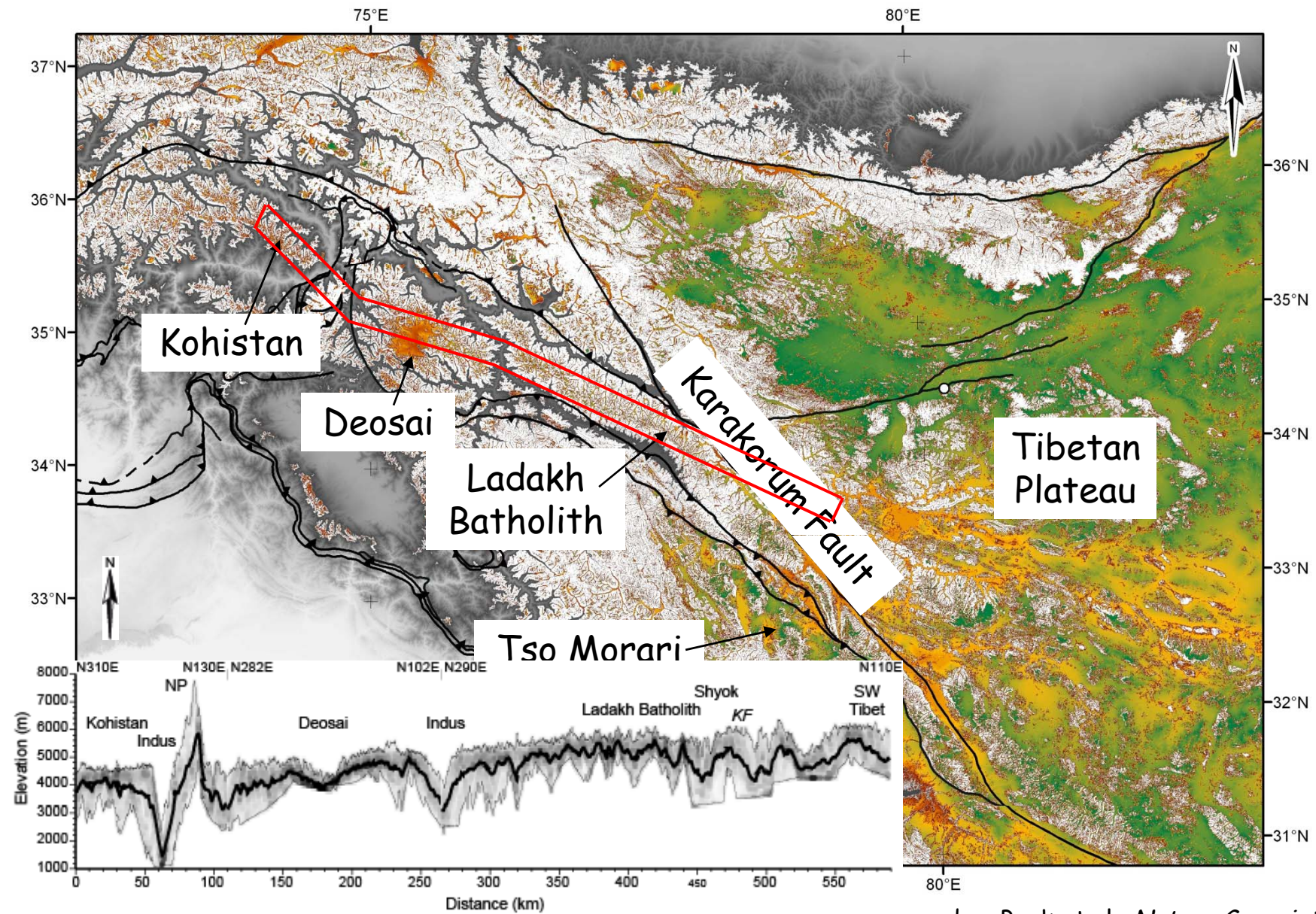
Provenance variations through time (Paleo Indus, Pakistan)



High altitude plateau surfaces

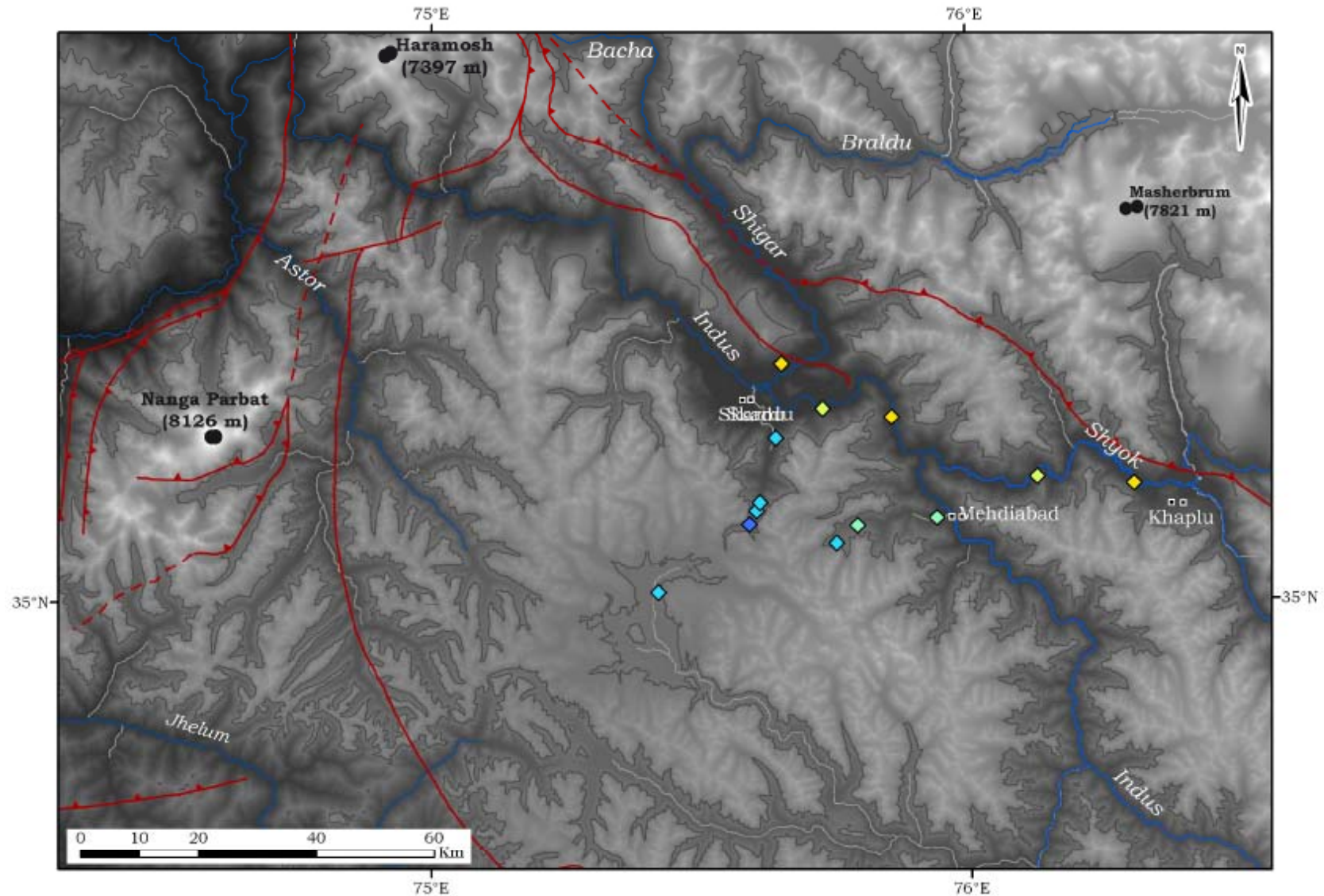


High altitude plateau surfaces

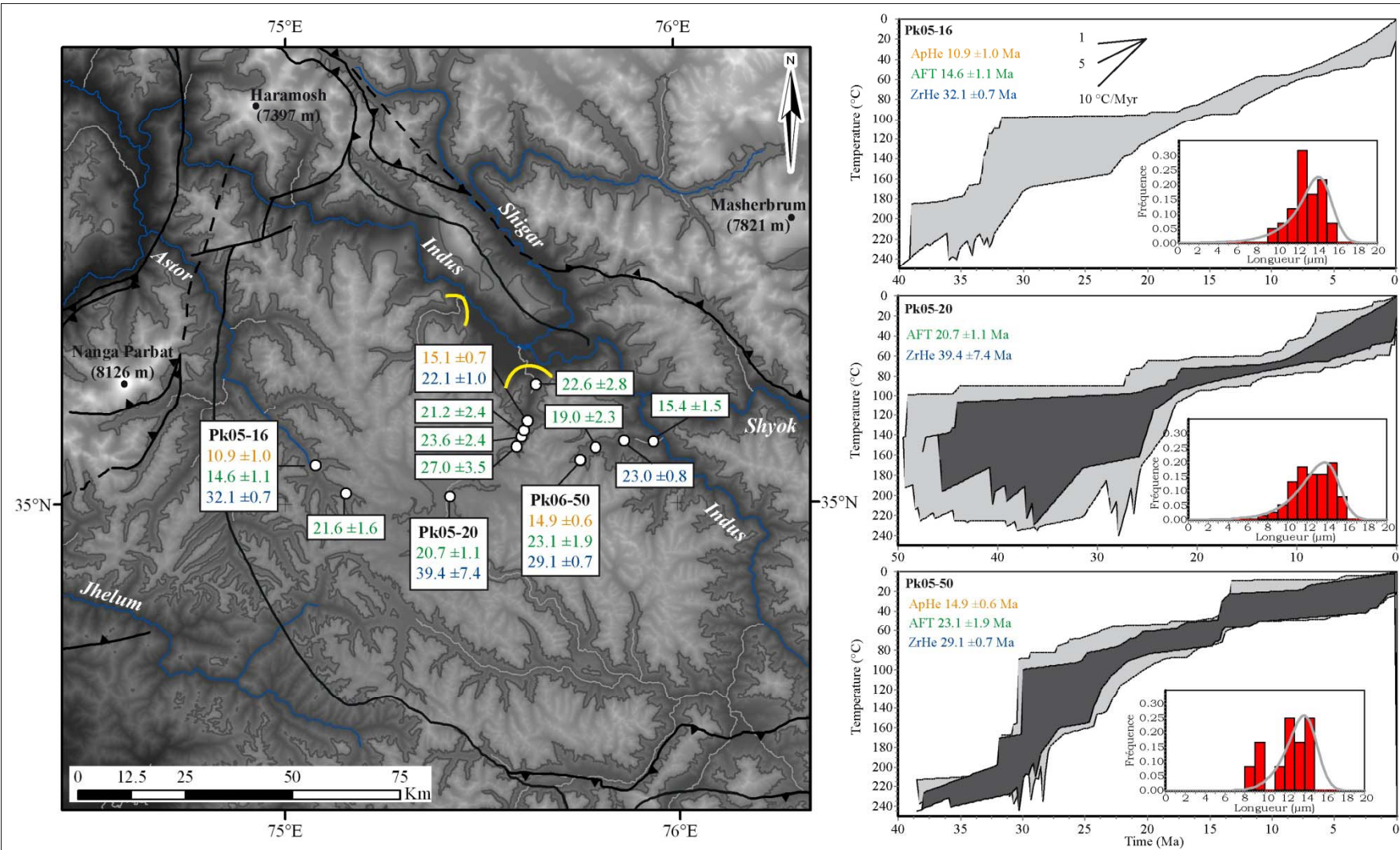


van der Beek et al., *Nature Geosci.*, 2009

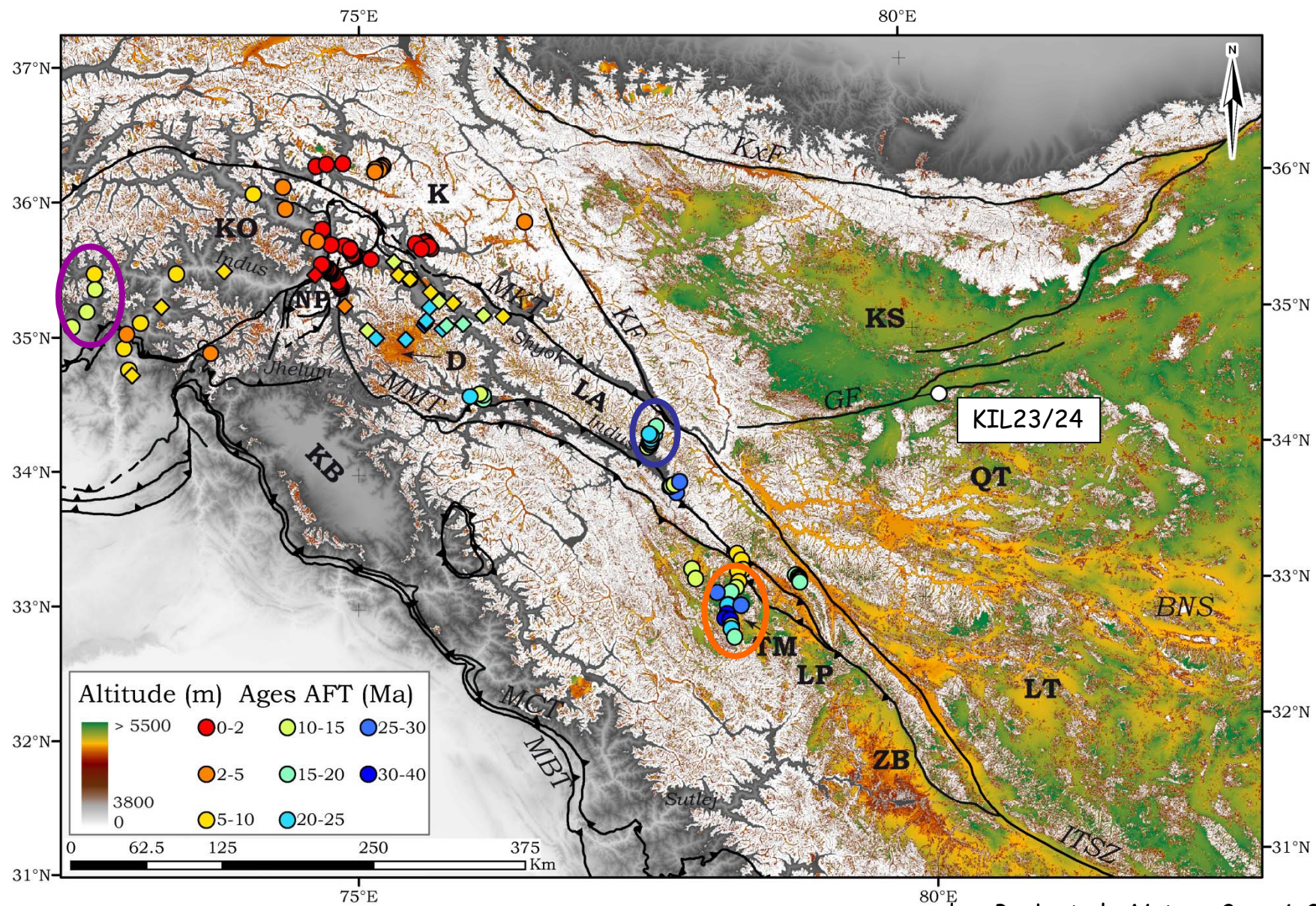
Deosai Plateau - thermochronology data



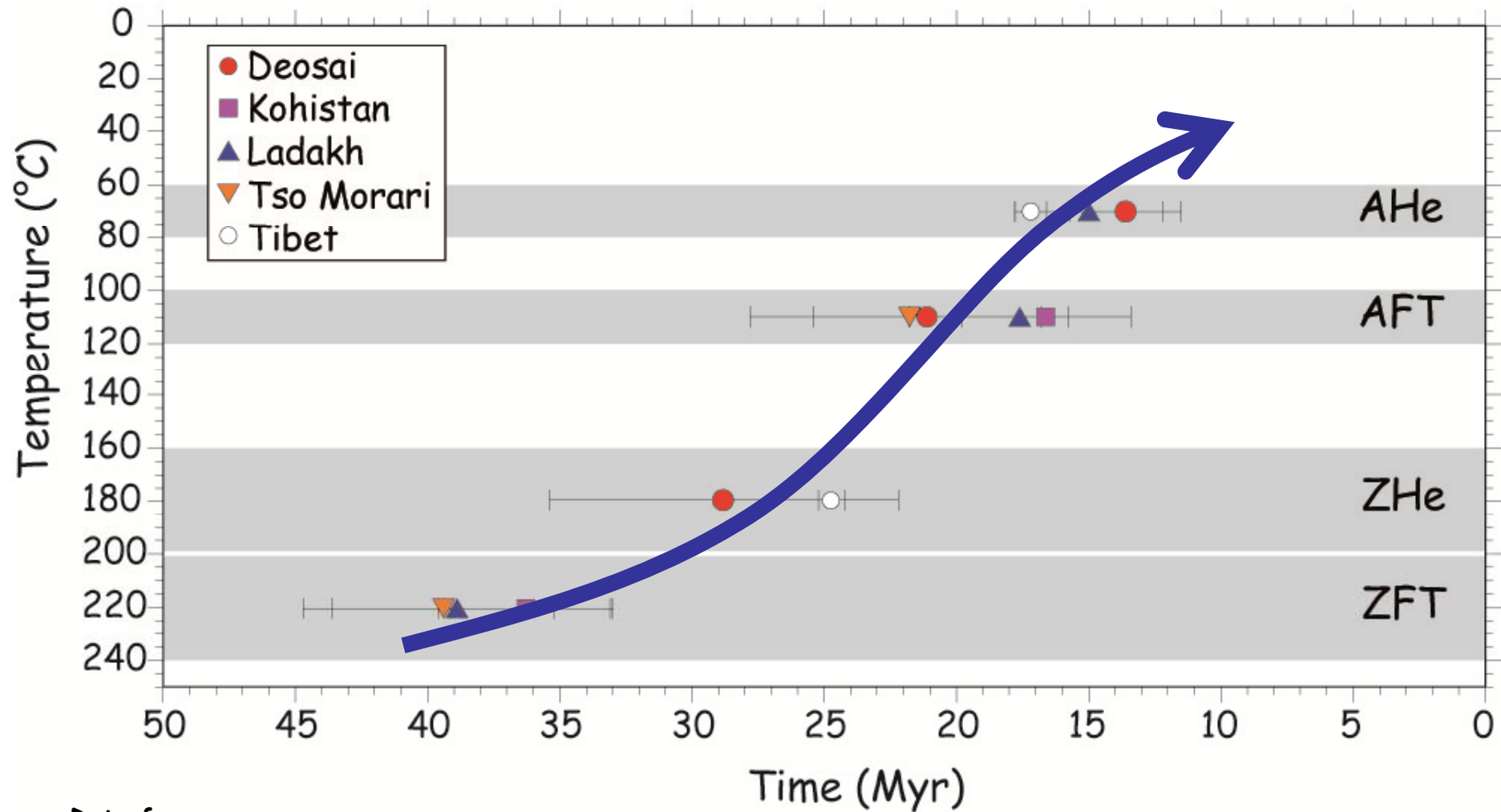
Deosai Plateau - thermochronology data



=> Denudation rate < 0.25 mm/an



Comparison with other high altitude surface



Data from:

Zeitler, *Tectonics*, 1985

Kumar et al., *Curr. Sci.*, 2007

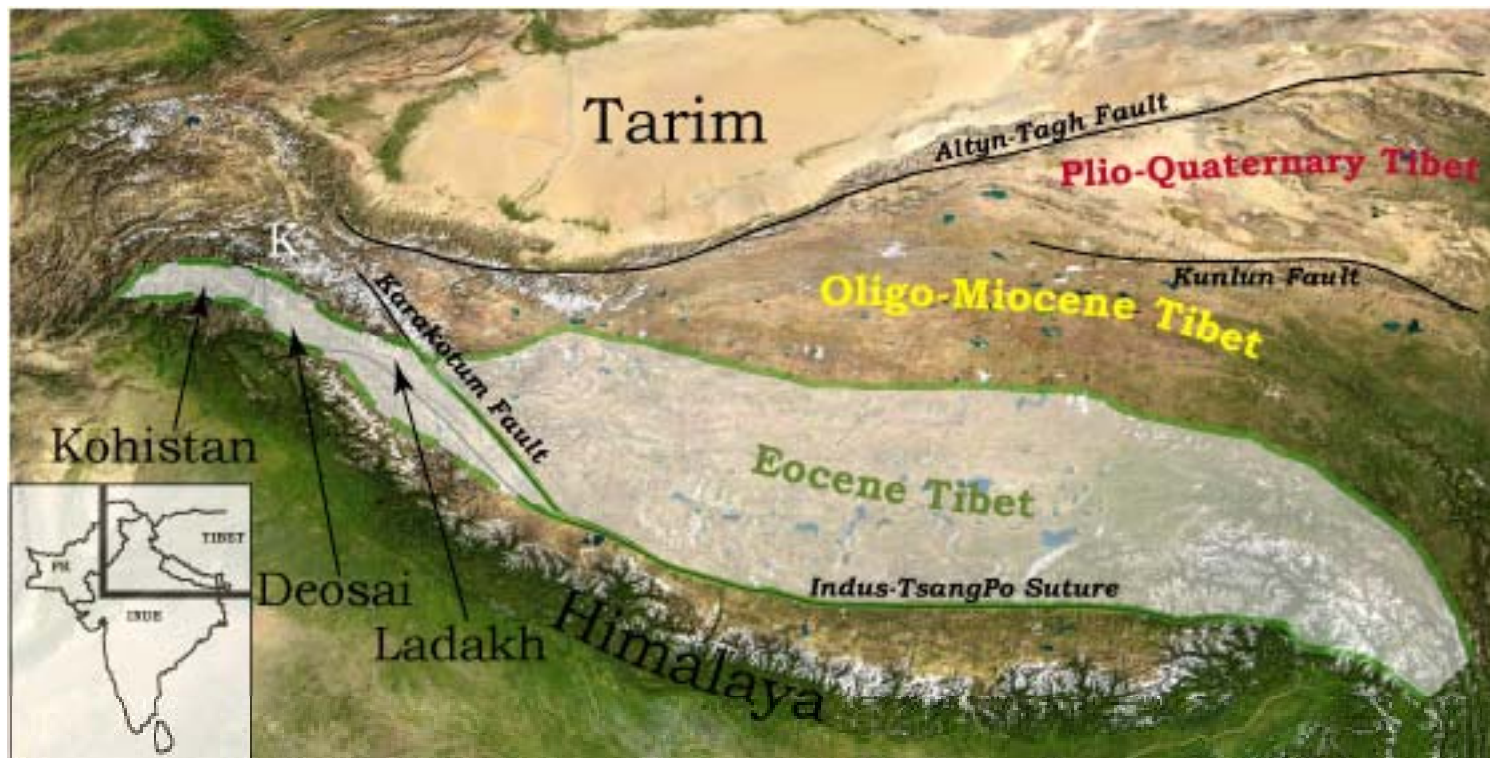
Kirstein et al., *J. Geol. Soc.*, 2011

Schlup et al., *J. Geol. Soc.*, 2003

van der Beek et al.,
Nature Geosci., 2009

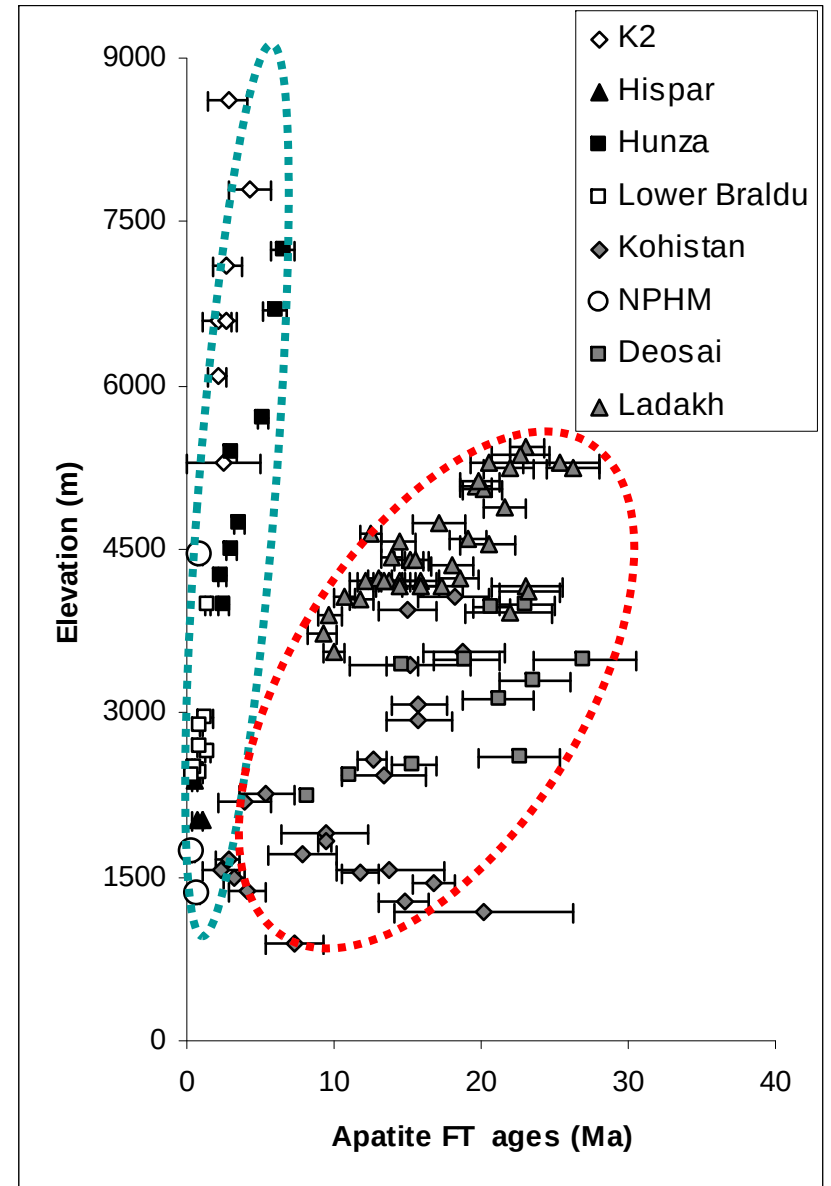
Implications

- Morphological continuity and similar exhumation history between NW Himalayan high altitude surface and Eocene Tibet



After Tapponnier et al., *Science*, 2001

NW Himalaya : two contrasted patterns



Conclusions

Tibetan plateau : old (40 Ma) formed by underthrusting of continental lithosphere

Tibetan plateau : not influenced by external forcing

NW Himalaya : old plateau, strongly incised by the Indus river system

+ thrust activity since 30 Ma

recent Uplift (5 Ma ?) built the high reliefs