

# **11- Kollision zonen**



# INTERNATIONAL STRATIGRAPHIC CHART

International Commission on Stratigraphy



Eonothem Eon	Erathem Era	System Period	Series Epoch	Stage Age	Age Ma	GSSP
Phanerozoic	Cenozoic	Neogene	Holocene		0.0115	
			Pleistocene	Upper	0.126	
				Middle	0.781	
				Lower	1.806	🚩
			Pliocene	Gelasian	2.588	🚩
				Piacenzian	3.600	🚩
		Zanclean		5.332	🚩	
		Miocene	Messinian	7.246	🚩	
			Tortonian	11.608	🚩	
			Serravallian	13.65	🚩	
			Langhian	15.97	🚩	
			Burdigalian	20.43	🚩	
			Aquitania	23.03	🚩	
			Oligocene	Chattian	28.4 ± 0.1	🚩
	Rupelian			33.9 ± 0.1	🚩	
	Eocene	Priabonian	37.2 ± 0.1	🚩		
		Bartonian	40.4 ± 0.2	🚩		
		Lutetian	48.6 ± 0.2	🚩		
		Ypresian	55.8 ± 0.2	🚩		
	Paleocene	Thanetian	58.7 ± 0.2	🚩		
		Selandian	61.7 ± 0.2	🚩		
		Danian	65.5 ± 0.3	🚩		
	Cretaceous	Upper	Maastrichtian	70.6 ± 0.6	🚩	
			Campanian	83.5 ± 0.7	🚩	
			Santonian	85.8 ± 0.7	🚩	
			Coniacian	89.3 ± 1.0	🚩	
			Turonian	93.5 ± 0.8	🚩	
		Lower	Cenomanian	99.6 ± 0.9	🚩	
			Albian	112.0 ± 1.0	🚩	
			Aptian	125.0 ± 1.0	🚩	
			Barremian	130.0 ± 1.5	🚩	
			Hauterivian	136.4 ± 2.0	🚩	
	Valanginian	140.2 ± 3.0	🚩			
		Berriasian	145.5 ± 4.0	🚩		

Eonothem Eon	Erathem Era	System Period	Series Epoch	Stage Age	Age Ma	GSSP
Phanerozoic	Mesozoic	Jurassic	Upper	Tithonian	145.5 ± 4.0	
				Kimmeridgian	150.8 ± 4.0	
				Oxfordian	155.0 ± 4.0	
			Middle	Callovian	161.2 ± 4.0	
				Bathonian	164.7 ± 4.0	
				Bajocian	167.7 ± 3.5	🚩
		Lower	Aalenian	171.6 ± 3.0	🚩	
			Toarcian	175.6 ± 2.0	🚩	
			Pliensbachian	183.0 ± 1.5	🚩	
			Sinemurian	189.6 ± 1.5	🚩	
			Hettangian	196.5 ± 1.0	🚩	
		Triassic	Upper	Rhaetian	199.6 ± 0.6	🚩
				Norian	203.6 ± 1.5	🚩
				Carnian	216.5 ± 2.0	🚩
	Middle		Ladinian	228.0 ± 2.0	🚩	
			Anisian	237.0 ± 2.0	🚩	
	Lower		Olenekian	245.0 ± 1.5	🚩	
			Induan	249.7 ± 0.7	🚩	
			Changhsingian	251.0 ± 0.4	🚩	
	Permian	Lopingian	Wuchiapingian	253.8 ± 0.7	🚩	
			Capitanian	260.4 ± 0.7	🚩	
			Wordian	265.8 ± 0.7	🚩	
		Guadalupian	Roadian	268.0 ± 0.7	🚩	
			Kungurian	270.6 ± 0.7	🚩	
		Cisuralian	Artinskian	275.6 ± 0.7	🚩	
			Sakmarian	284.4 ± 0.7	🚩	
			Asselian	284.4 ± 0.7	🚩	
			Serpukhovian	294.6 ± 0.8	🚩	
			Gzhelian	299.0 ± 0.8	🚩	
	Carboniferous	Pennsylvanian	Upper	Kasimovian	303.9 ± 0.9	🚩
				Moscovian	306.5 ± 1.0	🚩
			Lower	Bashkirian	311.7 ± 1.1	🚩
				Serpukhovian	318.1 ± 1.3	🚩
		Mississippian	Upper	Visean	326.4 ± 1.6	🚩
Tournaisian				345.3 ± 2.1	🚩	
Lower			Tournaisian	359.2 ± 2.5	🚩	

Eonothem Eon	Erathem Era	System Period	Series Epoch	Stage Age	Age Ma	GSSP
Phanerozoic	Paleozoic	Devonian	Upper	Famennian	359.2 ± 2.5	🚩
				Frasnian	374.5 ± 2.6	🚩
				Givetian	385.3 ± 2.6	🚩
			Middle	Eifelian	391.8 ± 2.7	🚩
				Emsian	397.5 ± 2.7	🚩
				Pragian	407.0 ± 2.8	🚩
		Lower	Lochkovian	411.2 ± 2.8	🚩	
			Pridoli	416.0 ± 2.8	🚩	
			Ludlow	418.7 ± 2.7	🚩	
		Silurian	Wenlock	Gorstian	421.3 ± 2.6	🚩
				Homerian	422.9 ± 2.5	🚩
				Sheinwoodian	426.2 ± 2.4	🚩
	Llandovery		Telychian	428.2 ± 2.3	🚩	
			Aeronian	436.0 ± 1.9	🚩	
			Rhuddanian	439.0 ± 1.8	🚩	
	Ordovician	Upper	Hirnantian	443.7 ± 1.5	🚩	
				445.6 ± 1.5	🚩	
				455.8 ± 1.6	🚩	
		Middle	Darriwilian	460.9 ± 1.6	🚩	
				468.1 ± 1.6	🚩	
				471.8 ± 1.6	🚩	
	Cambrian	Lower	Tremadocian	478.6 ± 1.7	🚩	
				488.3 ± 1.7	🚩	
		Furongian	Paibian	501.0 ± 2.0	🚩	
			513.0 ± 2.0	🚩		
			542.0 ± 1.0	🚩		

Eonothem Eon	Erathem Era	System Period	Age Ma	GSSP GSSA	
Precambrian	Proterozoic	Ediacaran	542	🚩	
			~630	🚩	
		Neo-proterozoic	Cryogenian	850	🚩
			Tonian	1000	🚩
			Stenian	1200	🚩
		Meso-proterozoic	Ectasian	1400	🚩
			Calymmian	1600	🚩
			Statherian	1800	🚩
	Paleo-proterozoic	Orosirian	2050	🚩	
		Rhyacian	2300	🚩	
		Siderian	2500	🚩	
	Archean	Neoarchean		2800	🚩
				3200	🚩
		Mesoarchean		3600	🚩
			Lower limit is not defined		

Subdivisions of the global geologic record are formally defined by their lower boundary. Each unit of the Phanerozoic interval (~542 Ma to Present) and the base of the Ediacaran is defined by a Global Standard Section and Point (GSSP) at its base, whereas the Precambrian Interval is formally subdivided by absolute age, Global Standard Stratigraphic Age (GSSA).

This chart gives an overview of the international chronostratigraphic units, their rank, their names and formal status. These units are approved by the International Commission on Stratigraphy (ICS) and ratified by the International Union of Geological Sciences (IUGS).

The Guidelines of the ICS (Remane et al., 1996, Episodes, 19: 77-81) regulate the selection and

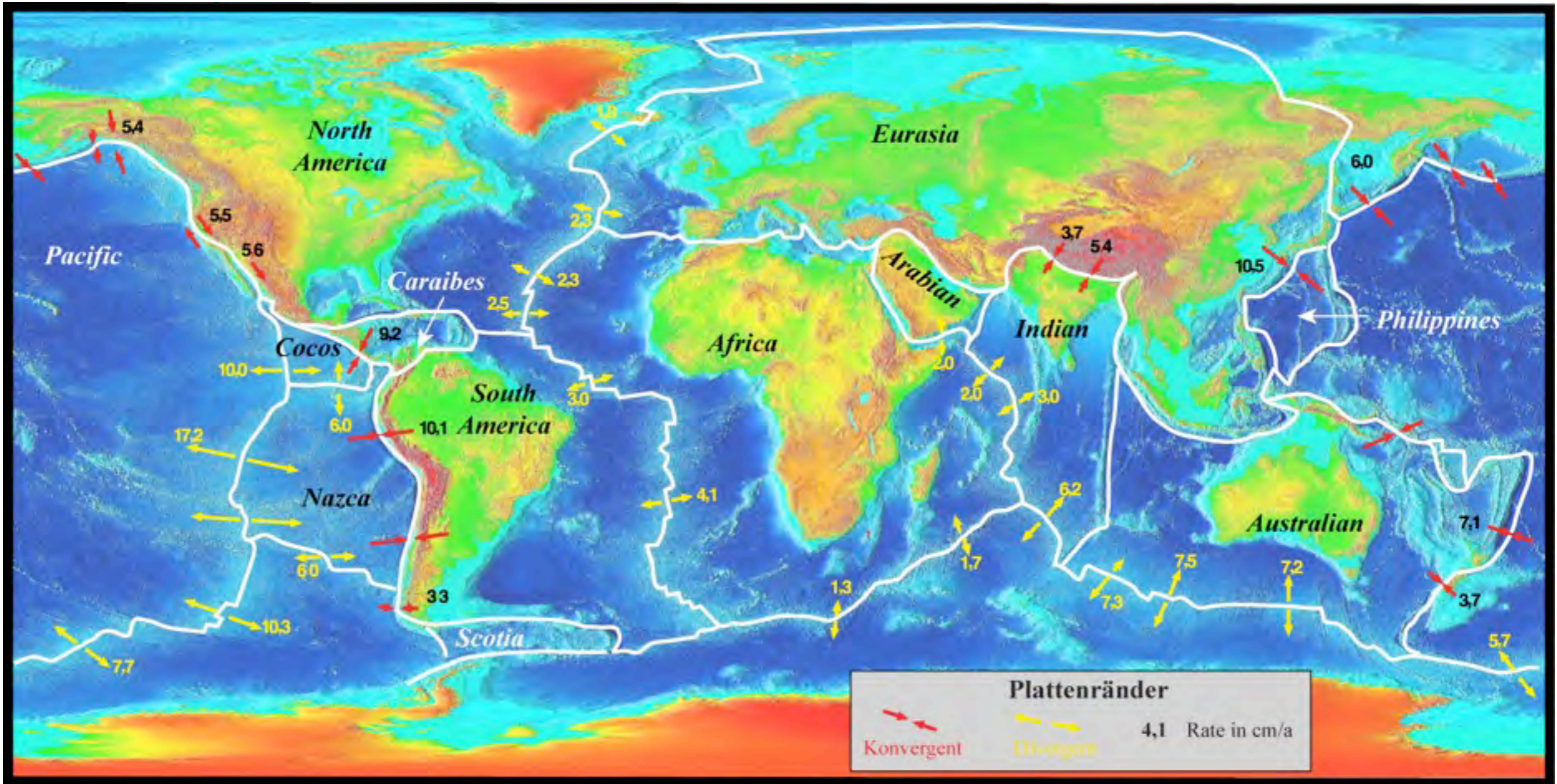
definition of the international units of geologic time. Many GSSP's actually have a 'golden' spike (🚩) and Stage and/or System name plaque mounted at the boundary level in the boundary stratotype section, whereas a GSSA is an abstract age without reference to a specific level in a rock section on Earth. Updated descriptions of each GSSP and GSSA are posted on the ICS website ([www.stratigraphy.org](http://www.stratigraphy.org)).

Some stages within the Ordovician and Cambrian will be formally named upon international agreement on their GSSP limits. Most intra-stage boundaries (e.g., Middle and Upper Aptian) are not formally defined. Numerical ages of the unit boundaries in the Phanerozoic are subject to revision. Colors are according to the Commission for the Geological Map of the World ([www.cgmw.org](http://www.cgmw.org)). The listed numerical ages are from 'A Geologic Time Scale 2004', by F.M. Gradstein, J.G. Ogg, A.G. Smith, et al. (2004; Cambridge University Press).

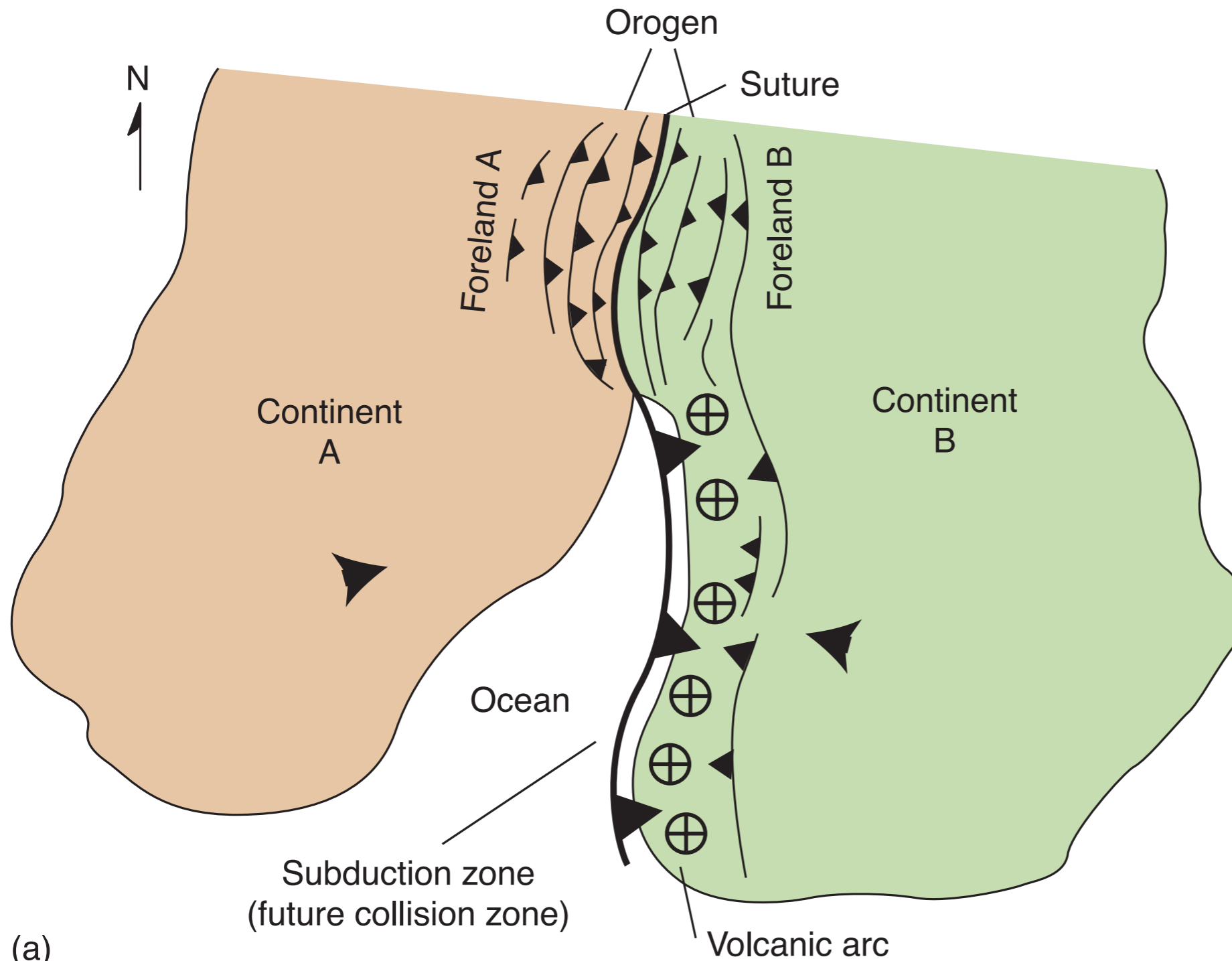
This chart was drafted and printed with funding generously provided for the GTS Project 2004 by ExxonMobil, Statoil Norway, ChevronTexaco and BP. The chart was produced by Gabi Ogg.

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# Konvergente Plattenränder



# From subduction to collision

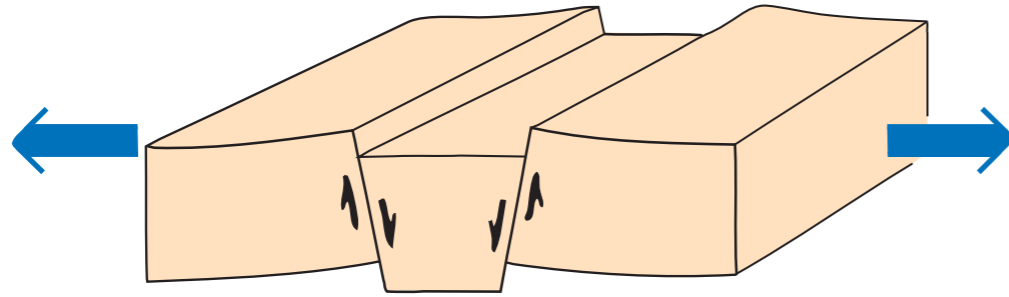


(a)

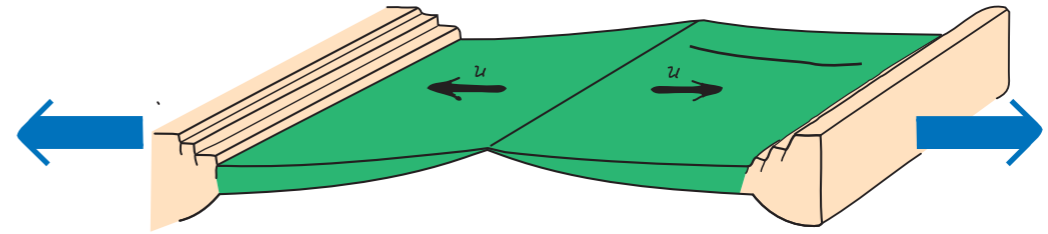
A map showing a zipper-like collision between two continents. Here, the ocean between the two continents is closing progressively from north to south. In the collision zone, the boundary between what had originally been two separate continents.

# Wilson cycle

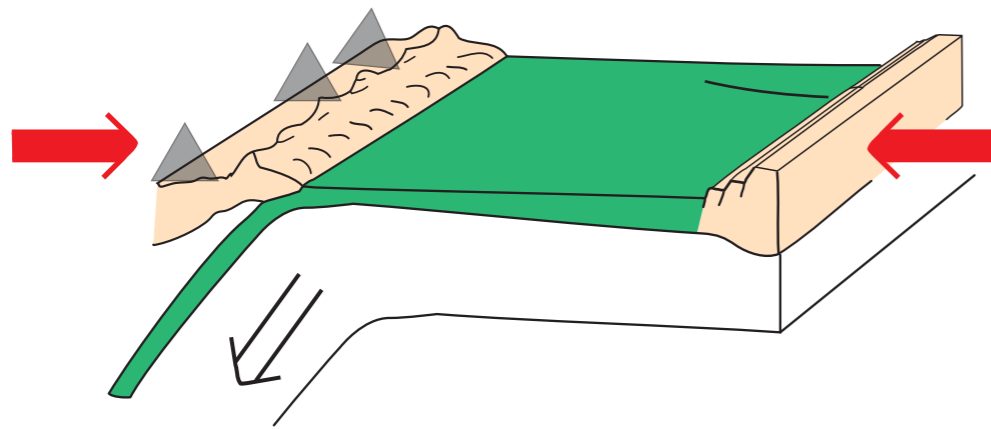
## Rifting



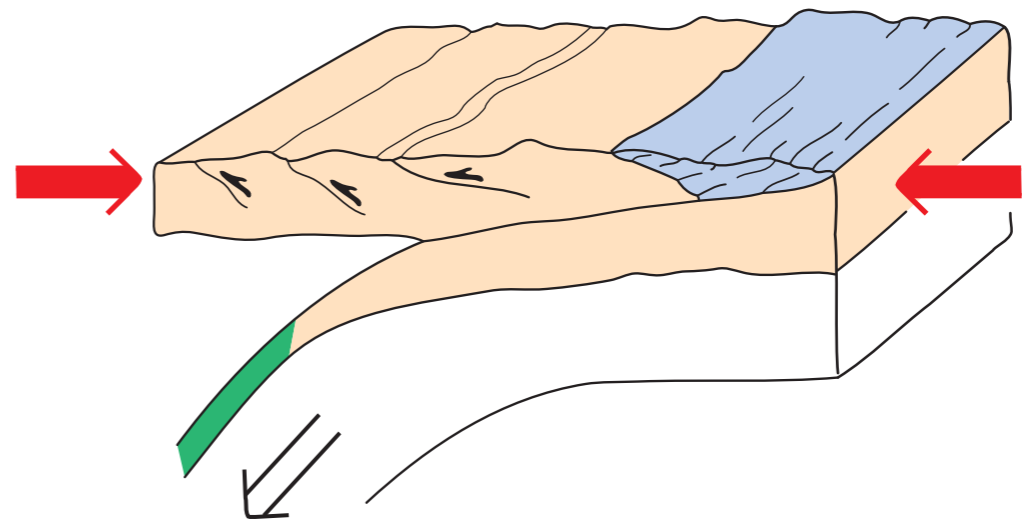
## Ocean formation



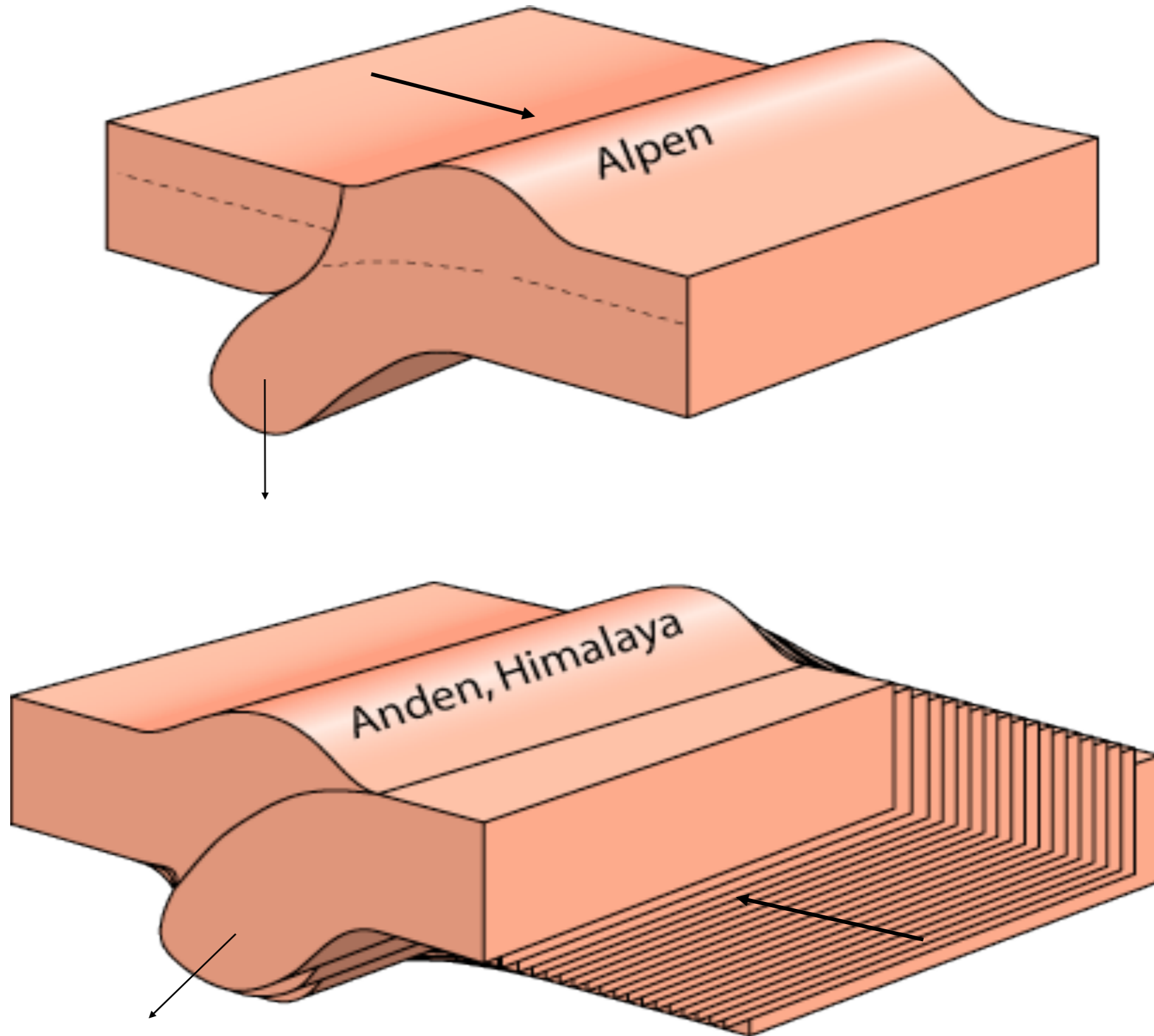
## Subduction



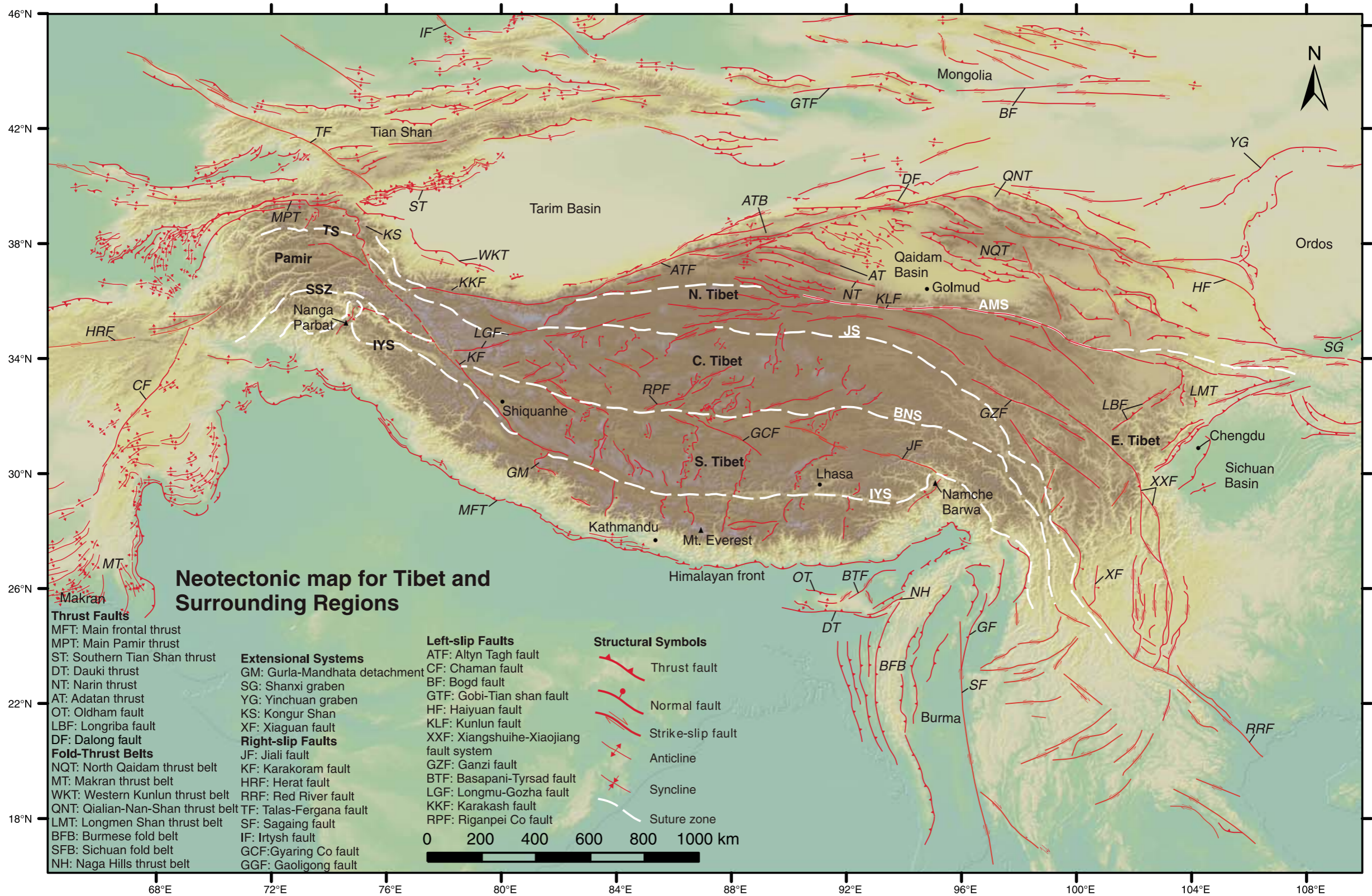
## Collision



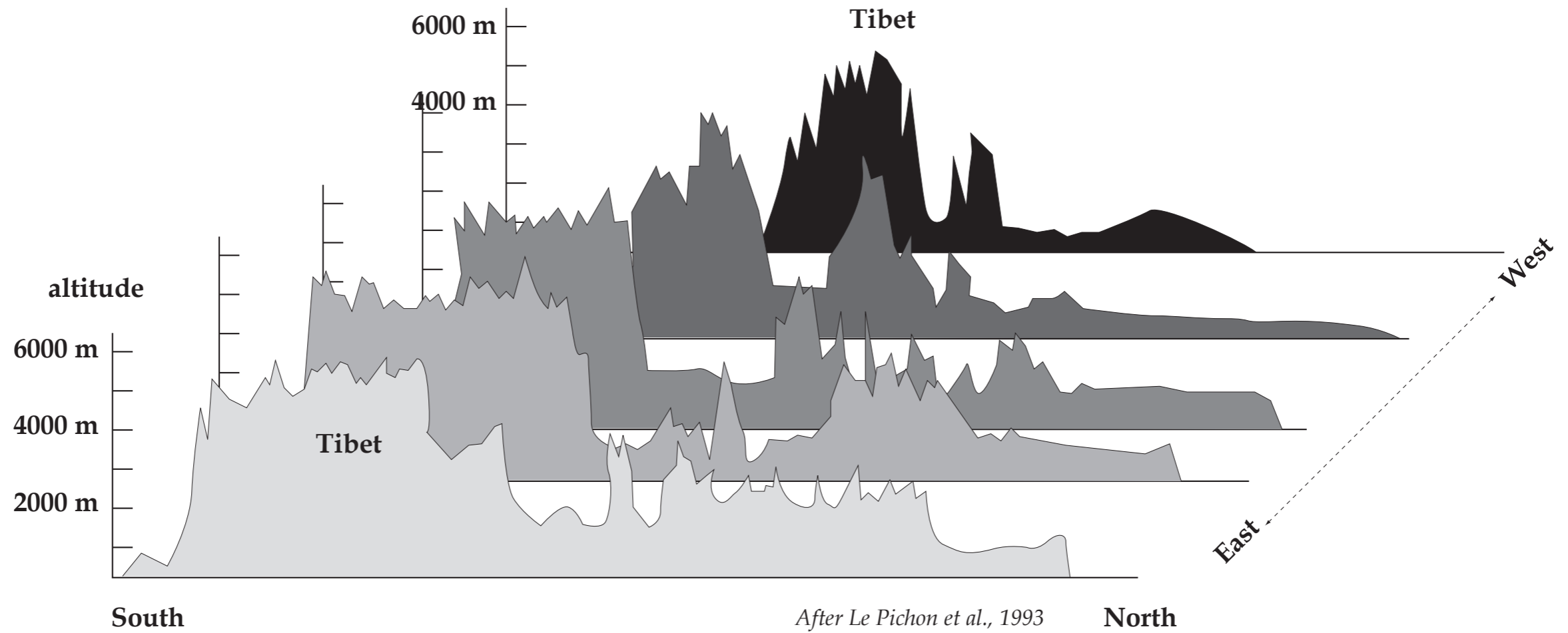
# Topography: Alps vs Himalaya



# Himalaya-Tibet system: topography

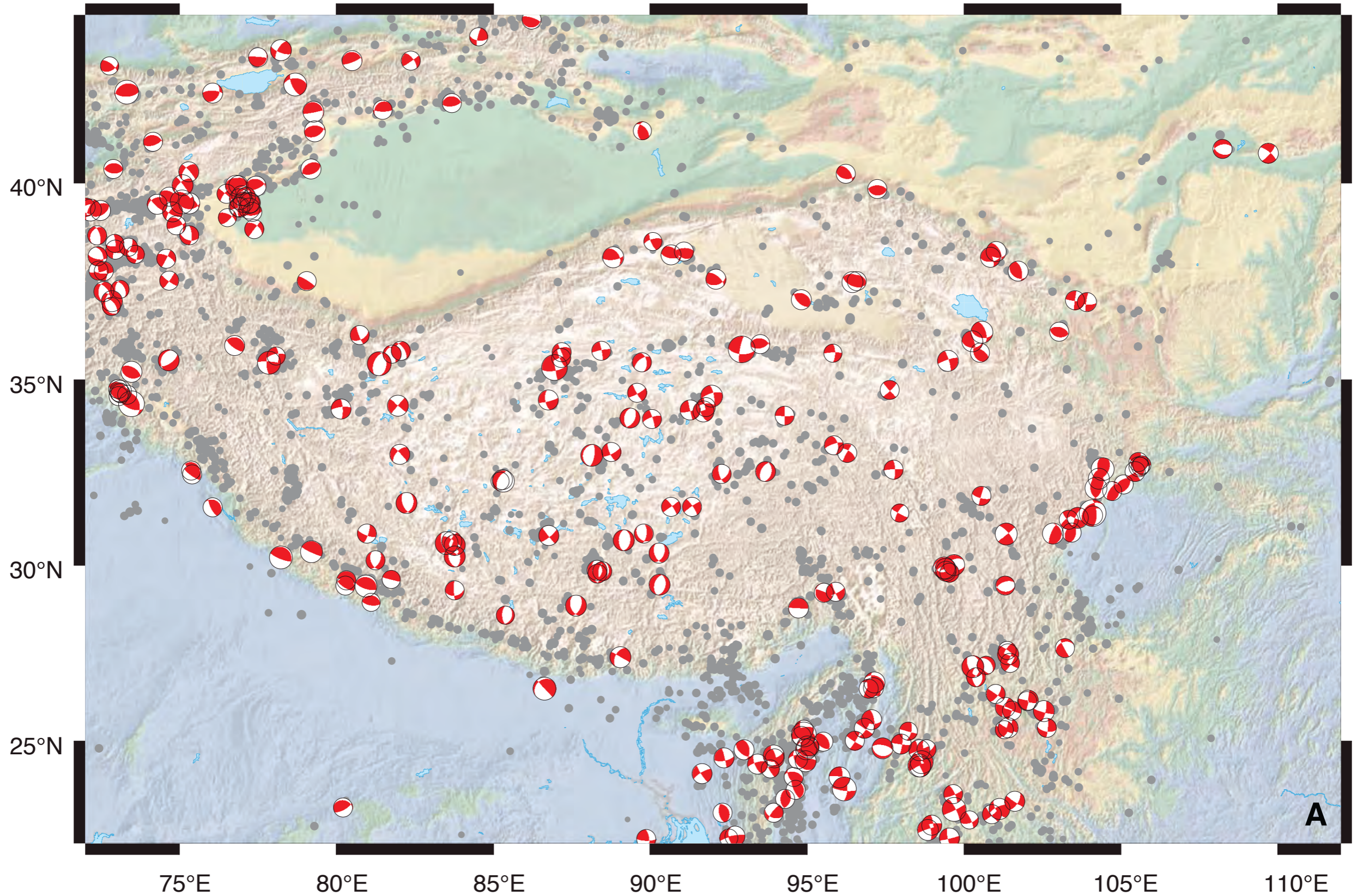


# Himalaya-Tibet system: topography

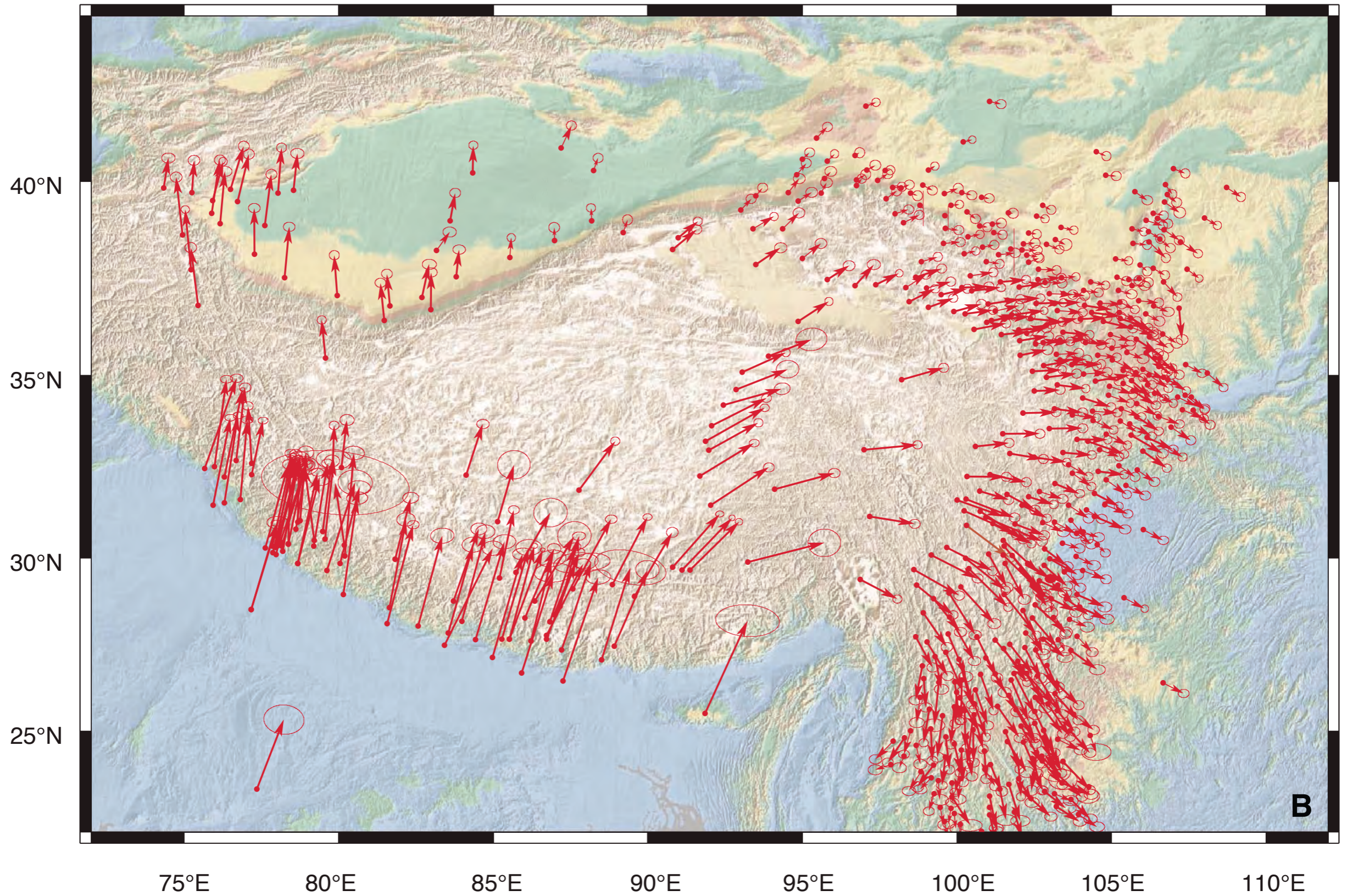




# Himalaya-Tibet system: earthquakes



# Himalaya-Tibet system: GPS



# Himalaya-Tibet system: geology

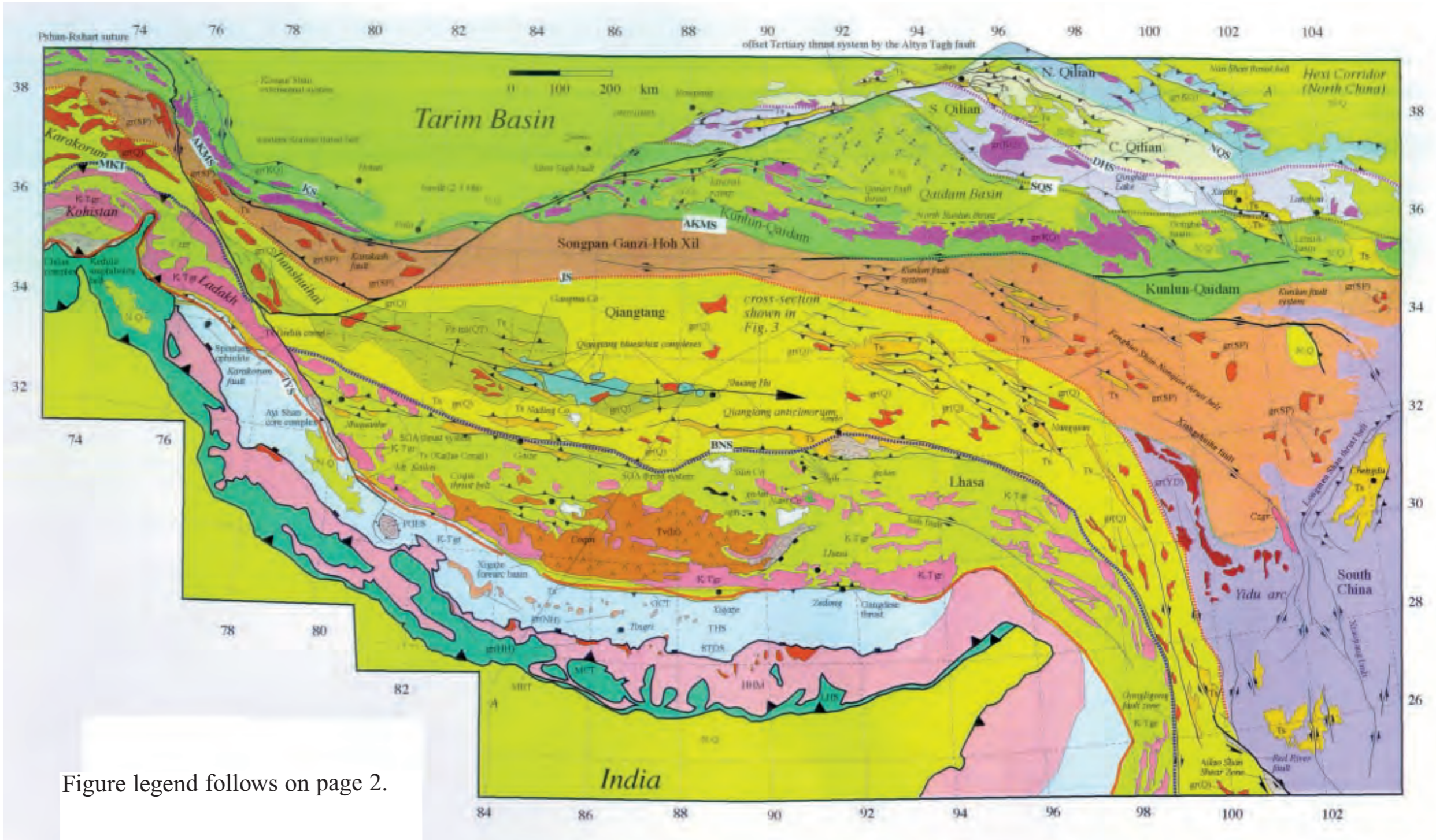
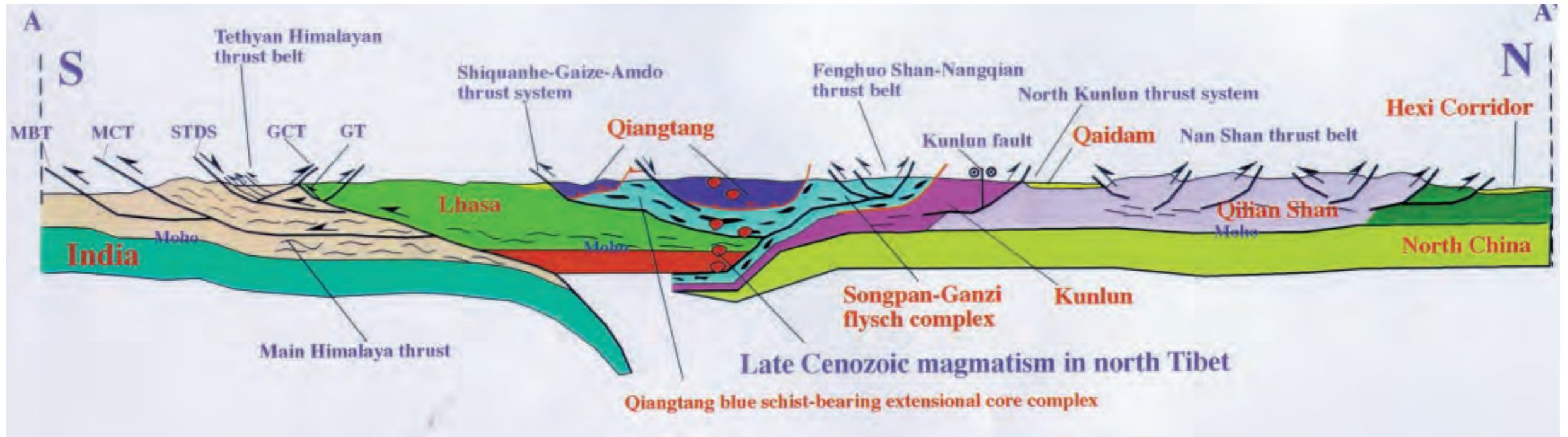
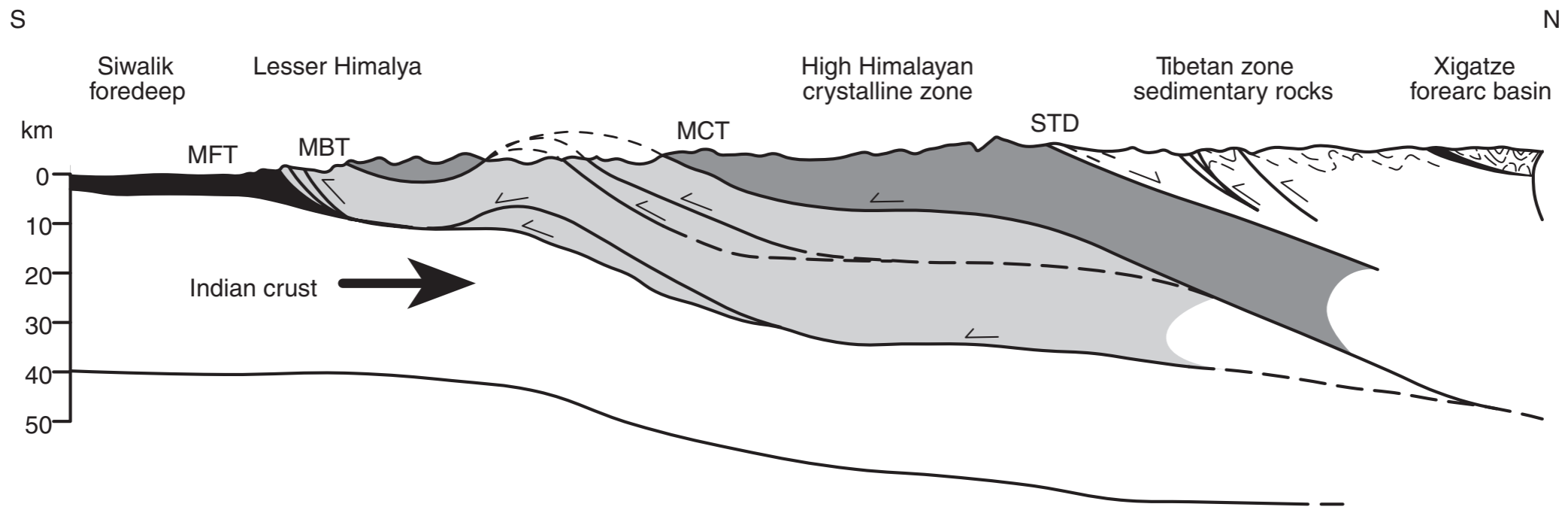


Figure legend follows on page 2.

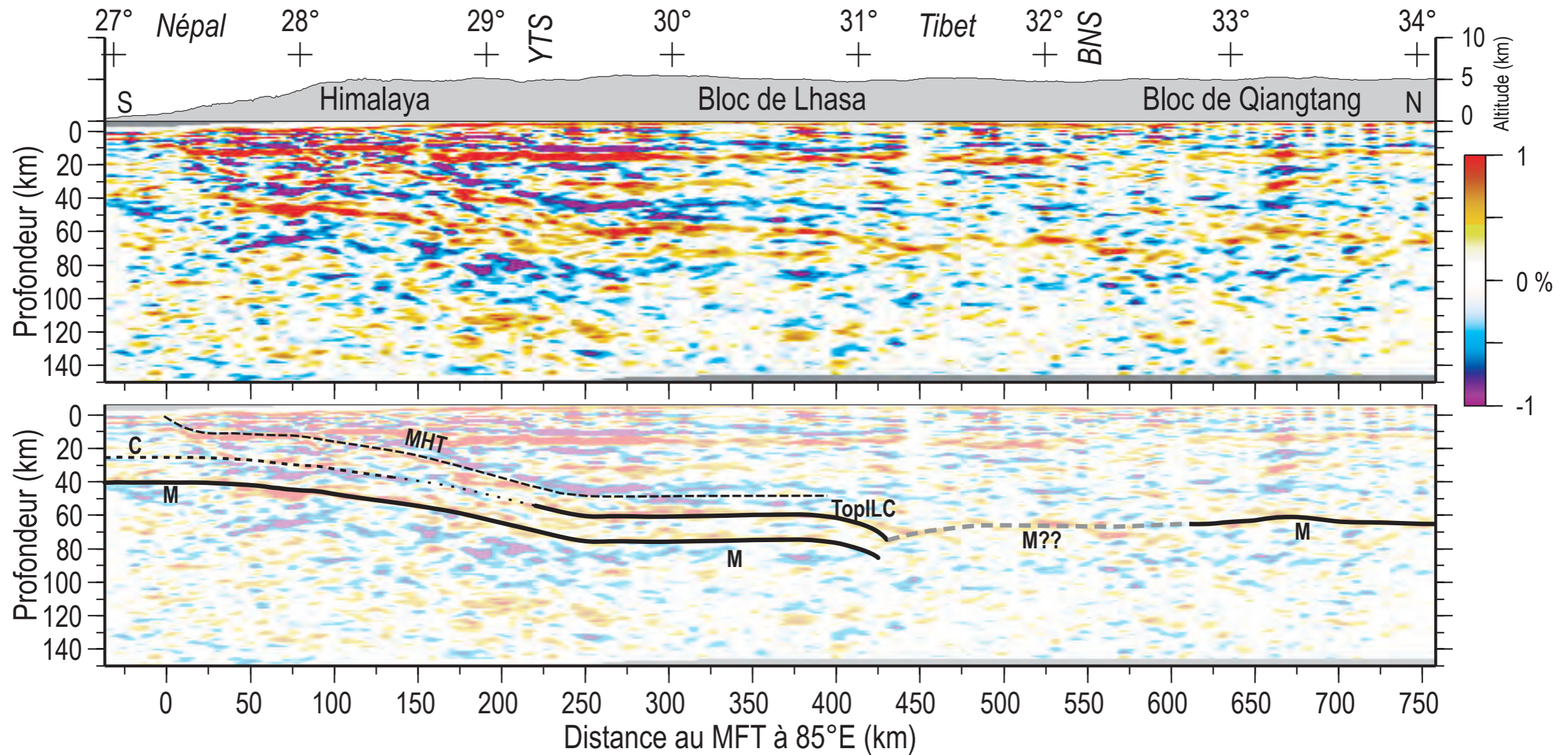
# Himalaya-Tibet system: geology



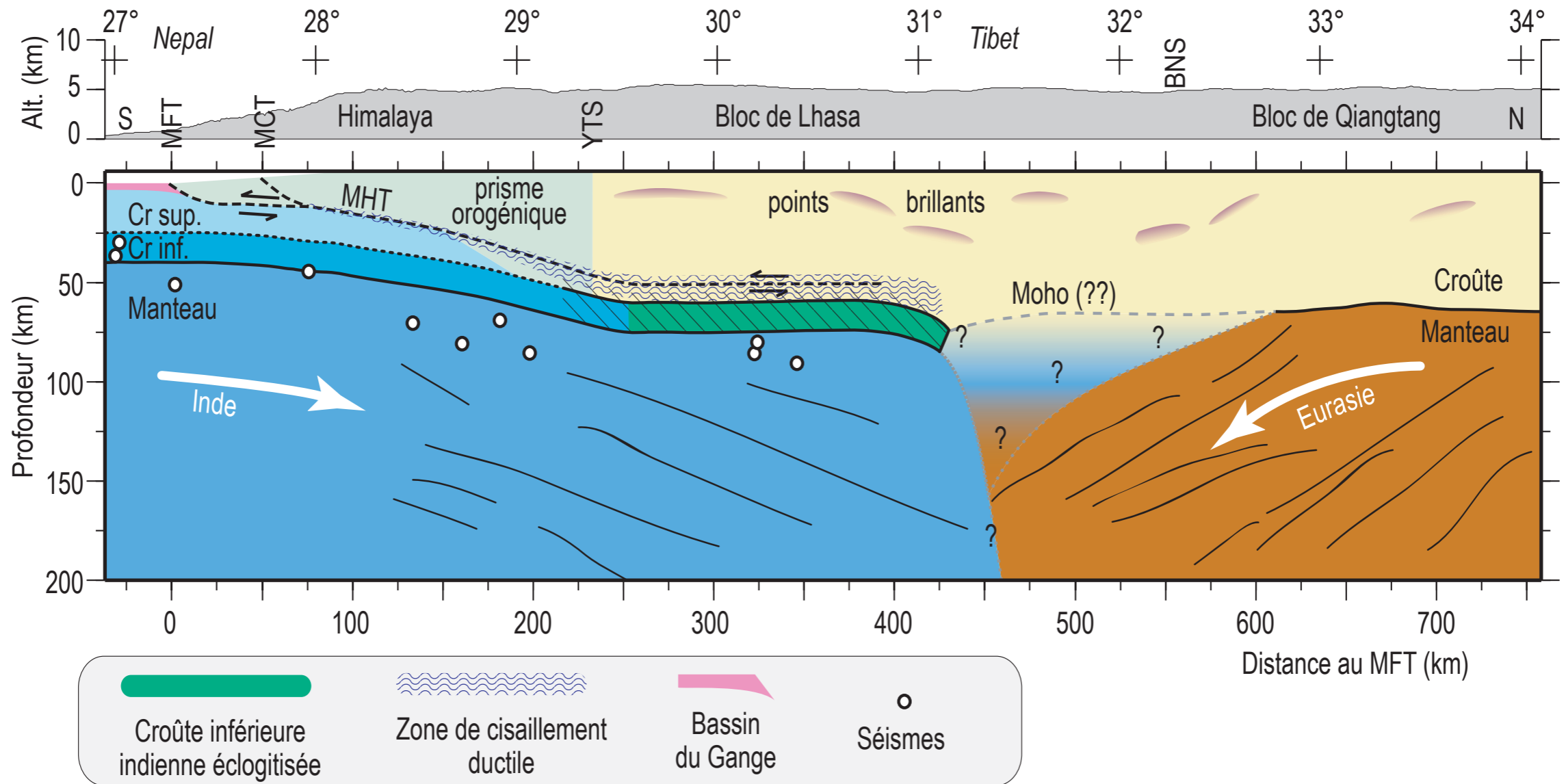
**Figure 3** Schematic geologic cross-section across the Himalayan-Tibetan orogen. See Figure 2 for the location of the cross-section.



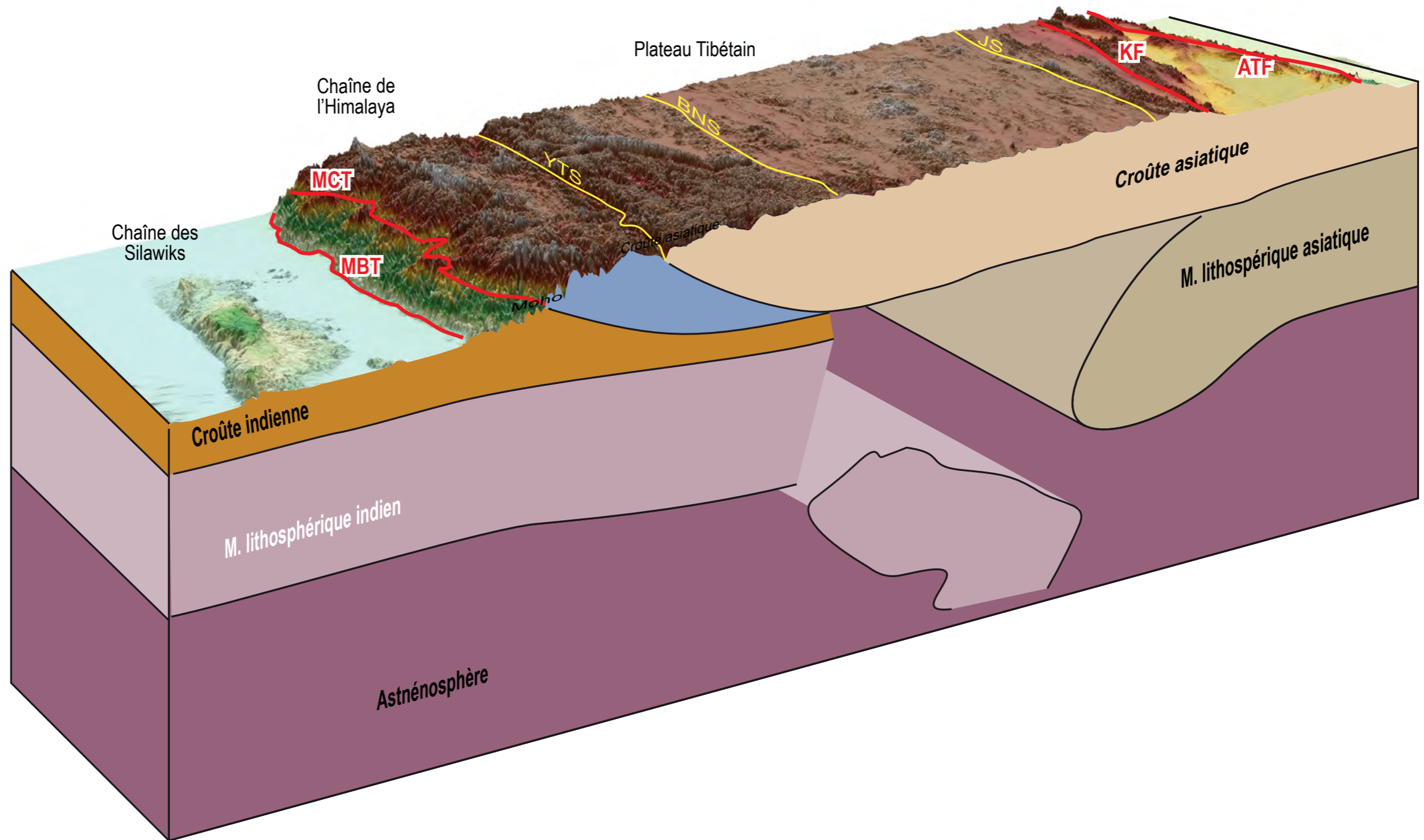
# Himalaya-Tibet system: deep structure



# Himalaya-Tibet system: deep structure



# Himalaya-Tibet system: deep structure



# Himalaya-Tibet system: geology

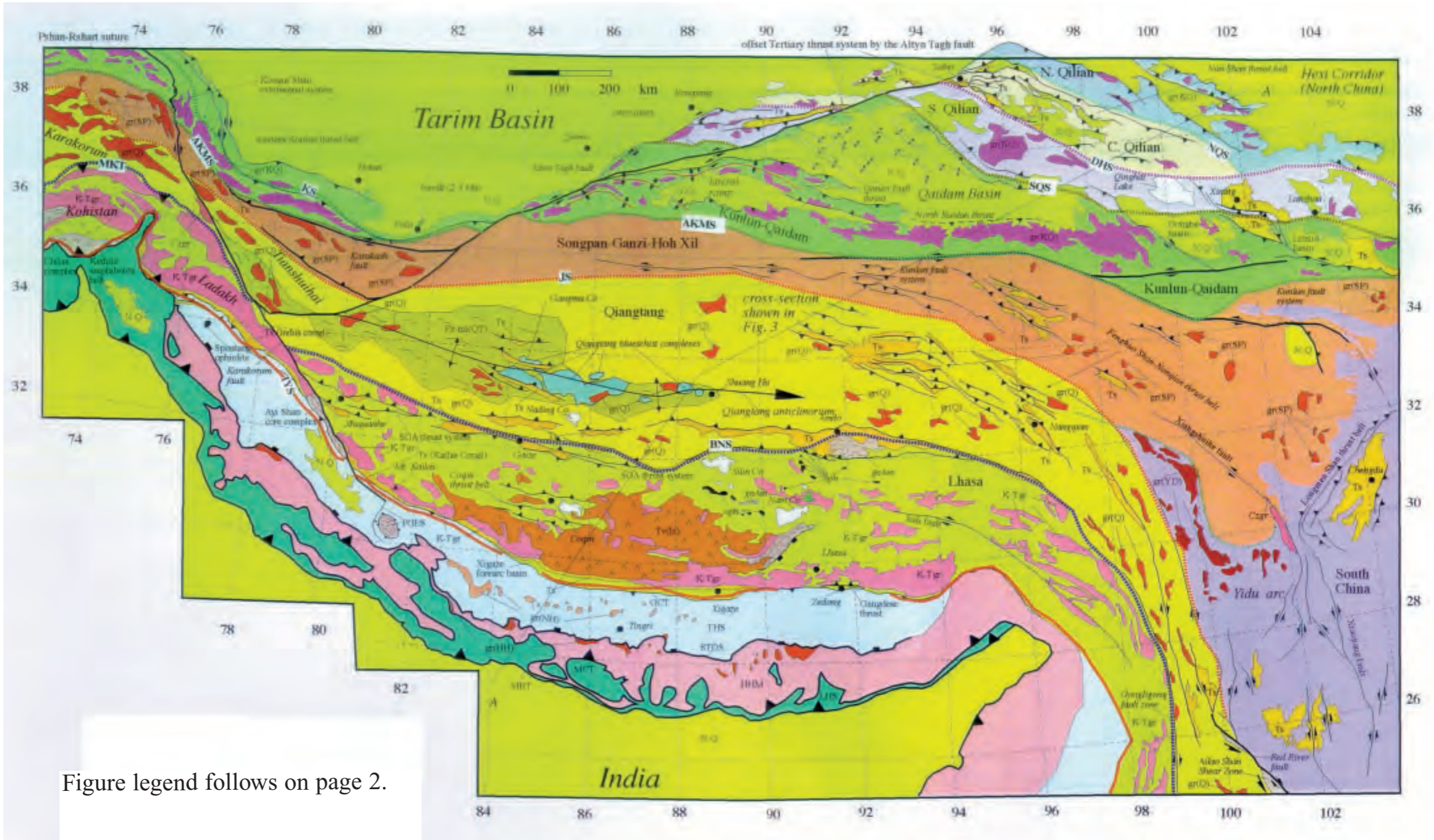
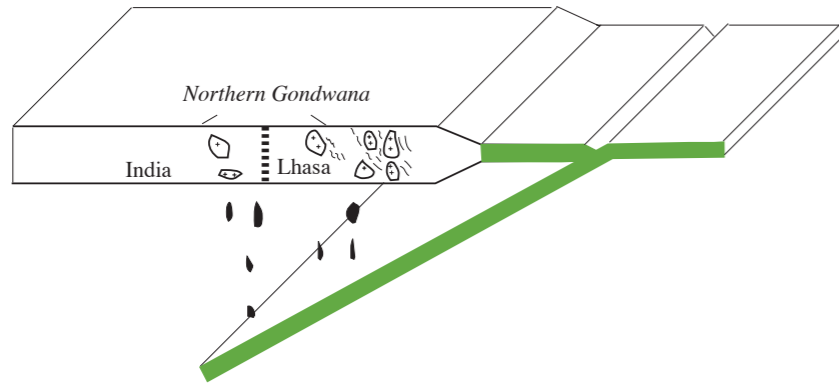


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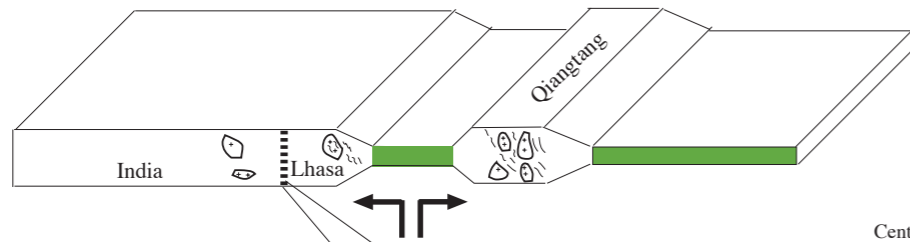


# Himalaya-Tibet system: evolution

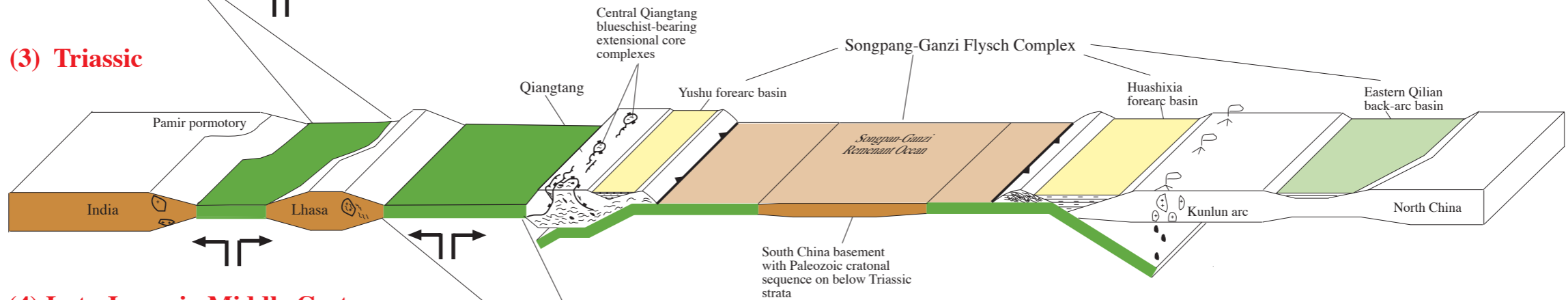
## (1) Cambrian-Early Ordovician



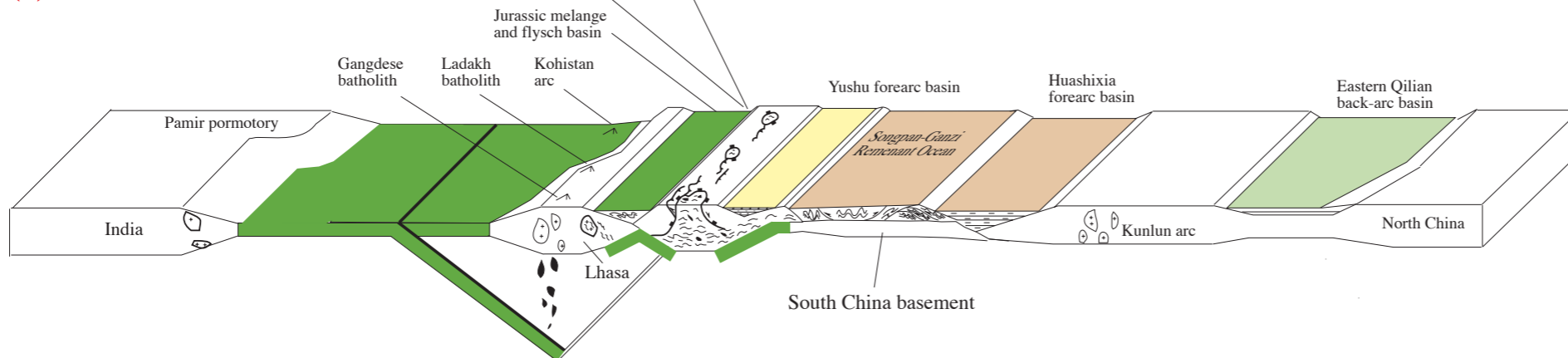
## (2) Early Ordovician-Carboniferous



## (3) Triassic



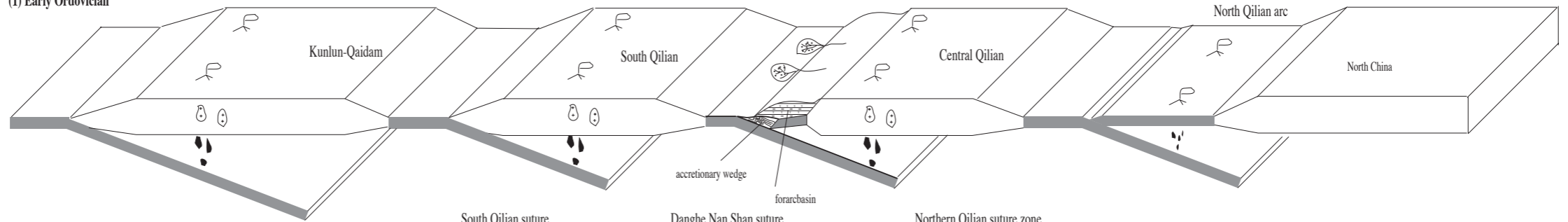
## (4) Late Jurassic-Middle Cretaceous



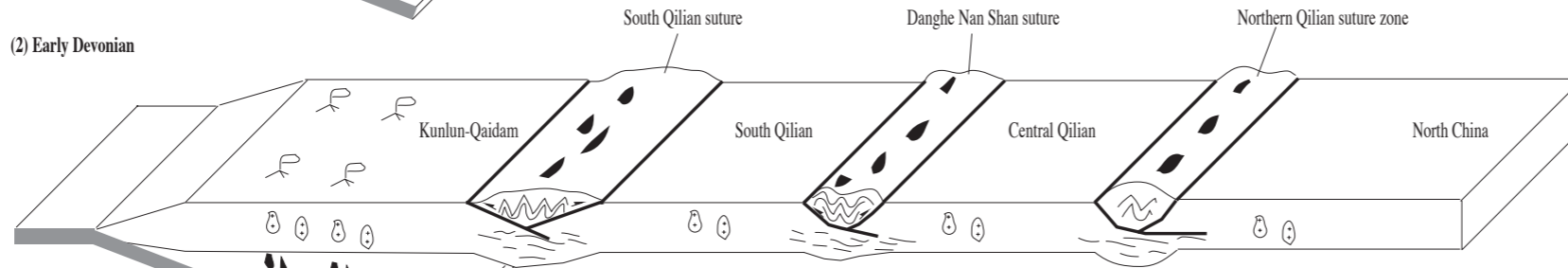
# Himalaya-Tibet system: evolution

## (b) Paleozoic-Mesozoic Evolution of the Kunlun and Qilian Terranes

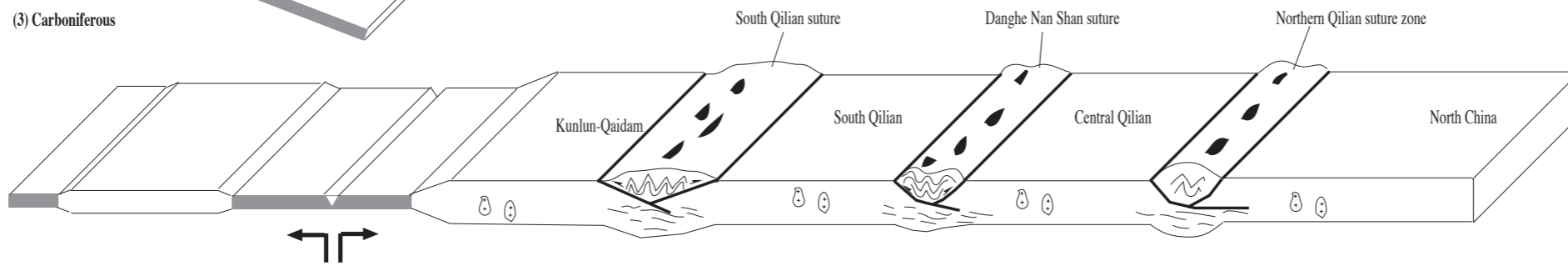
(1) Early Ordovician



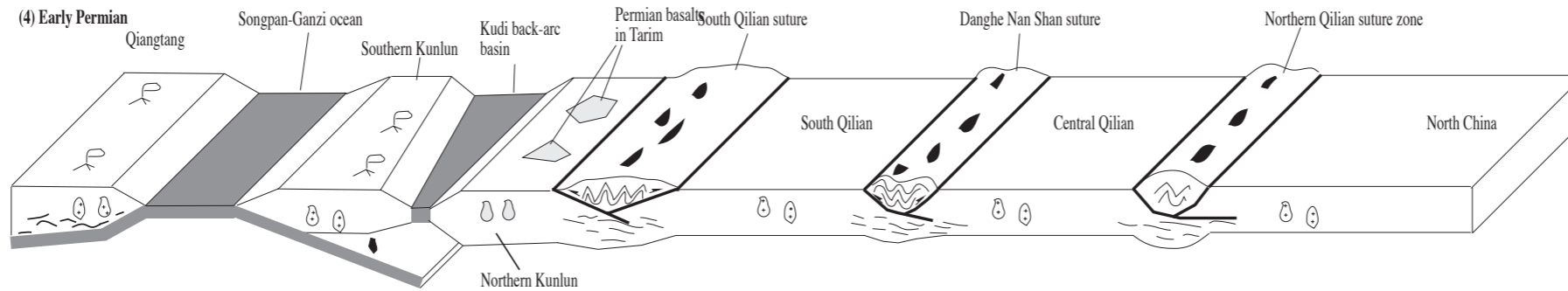
(2) Early Devonian



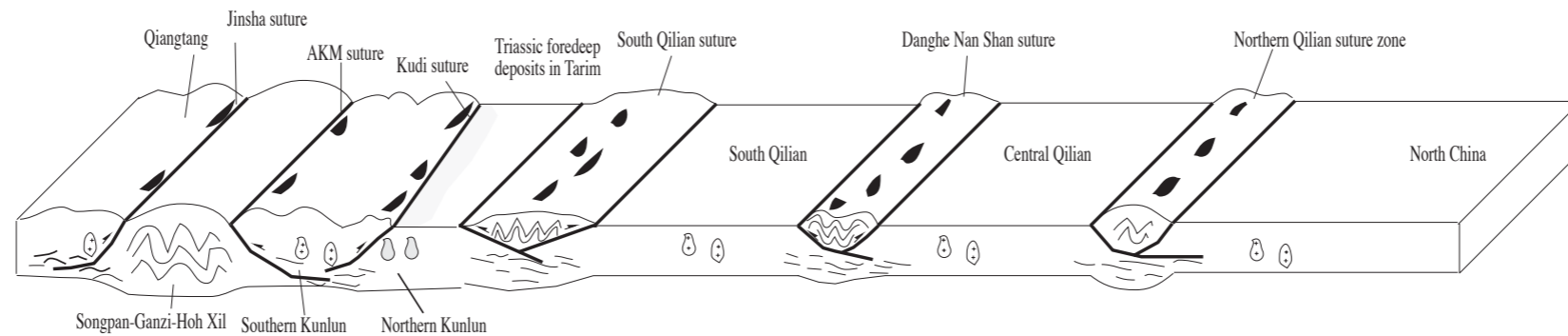
(3) Carboniferous



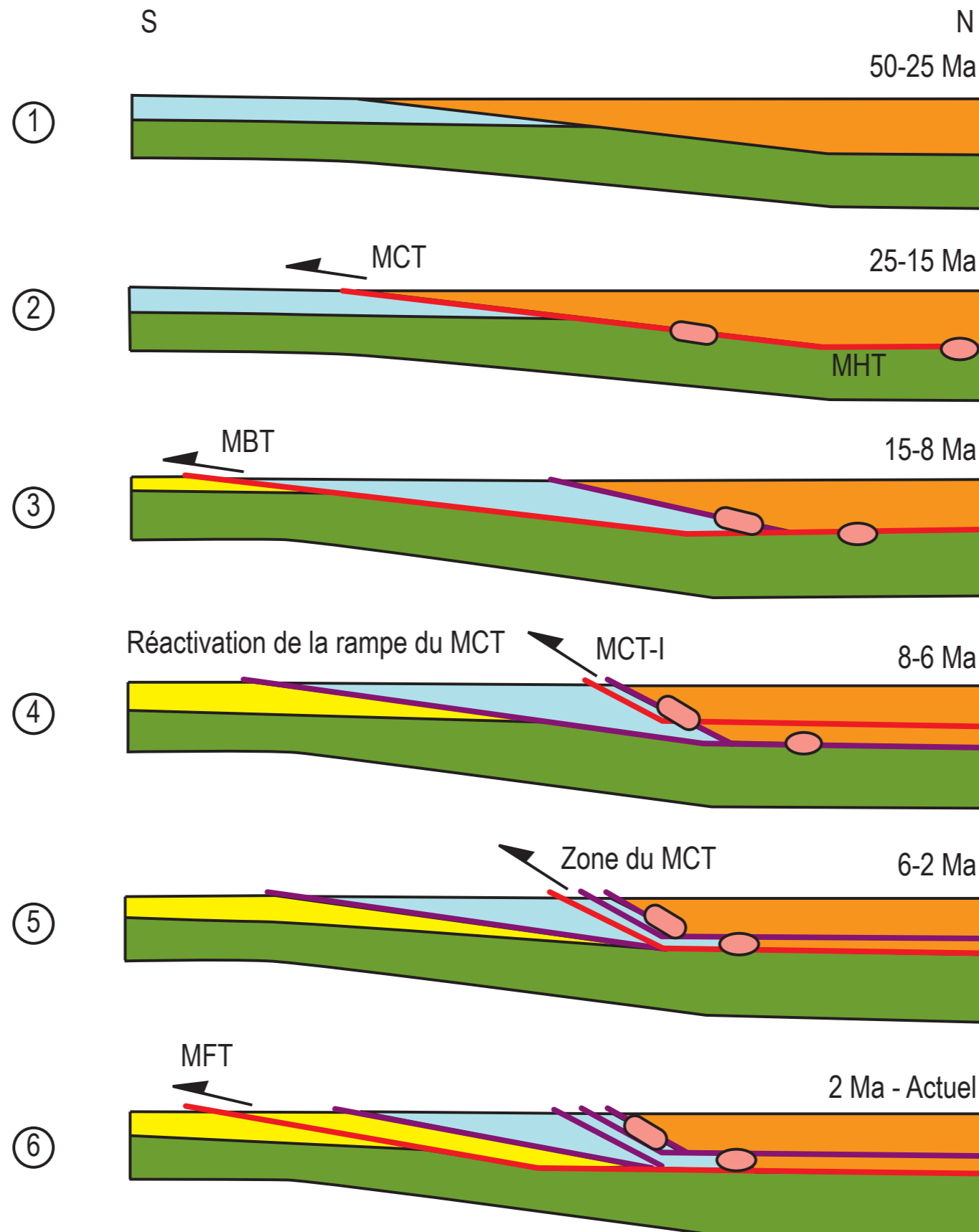
(4) Early Permian



(5) Late Triassic

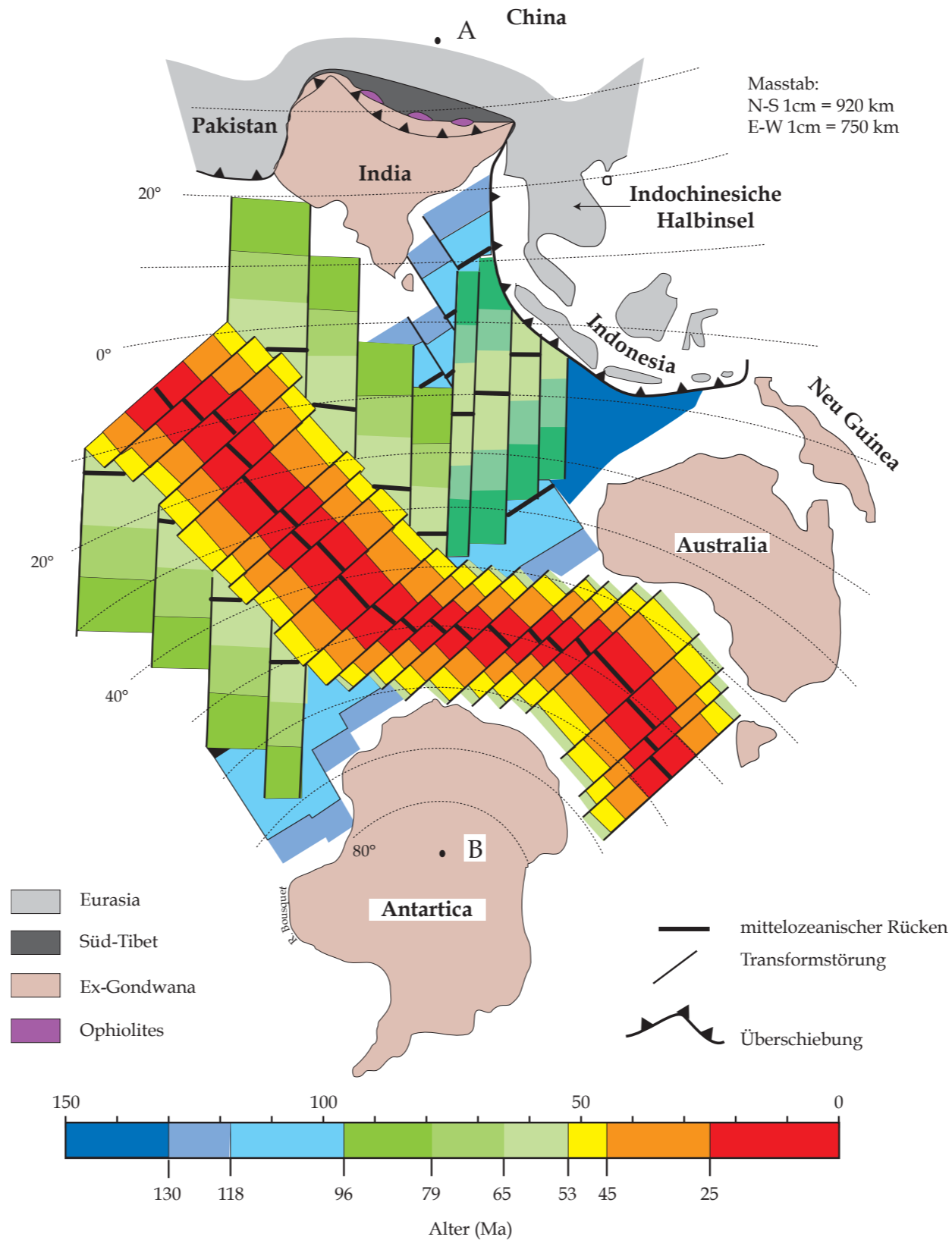


# Himalaya-Tibet system: evolution



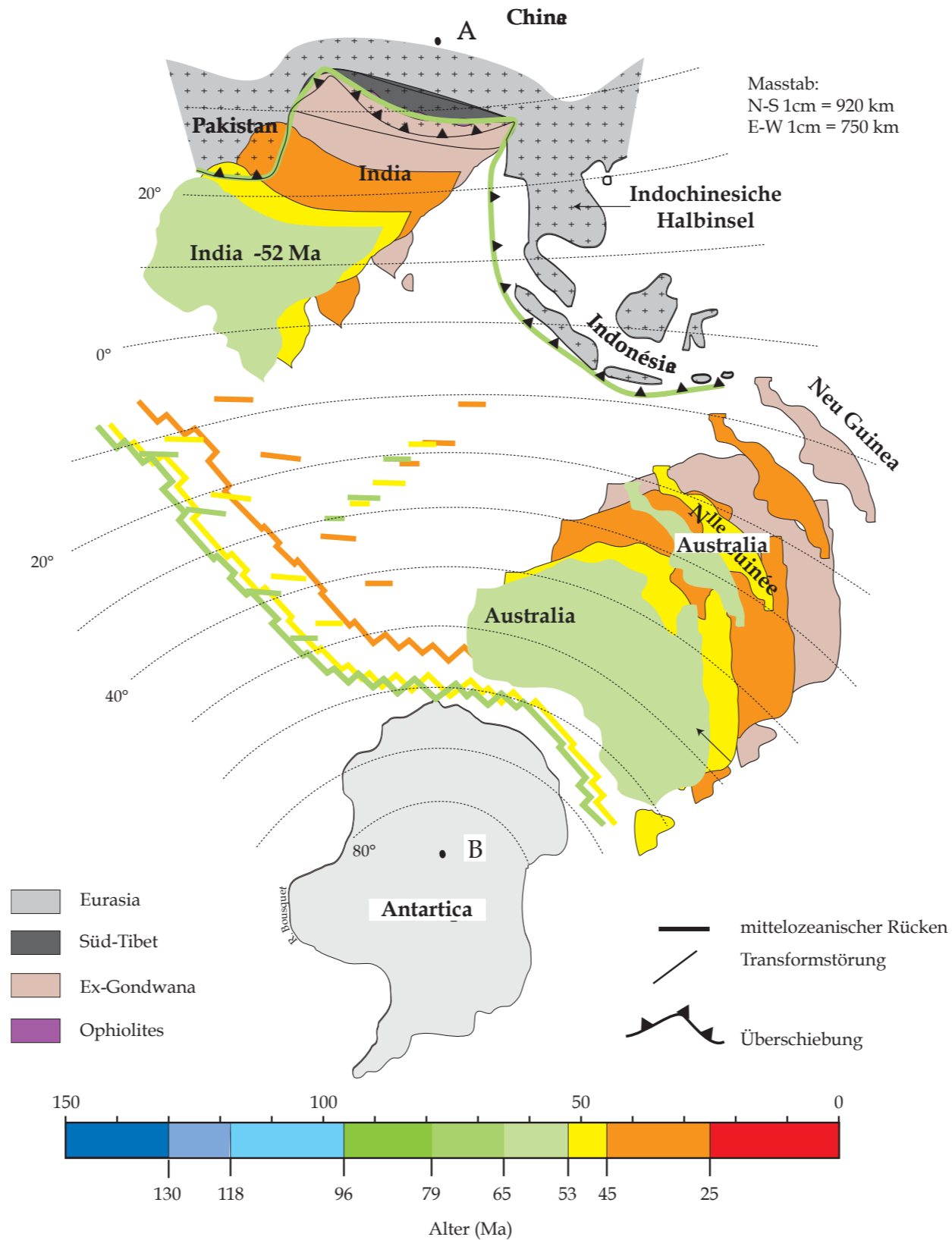
# Himalaya-Tibet system: evolution

Vereinfachte Karte des indische Ozean



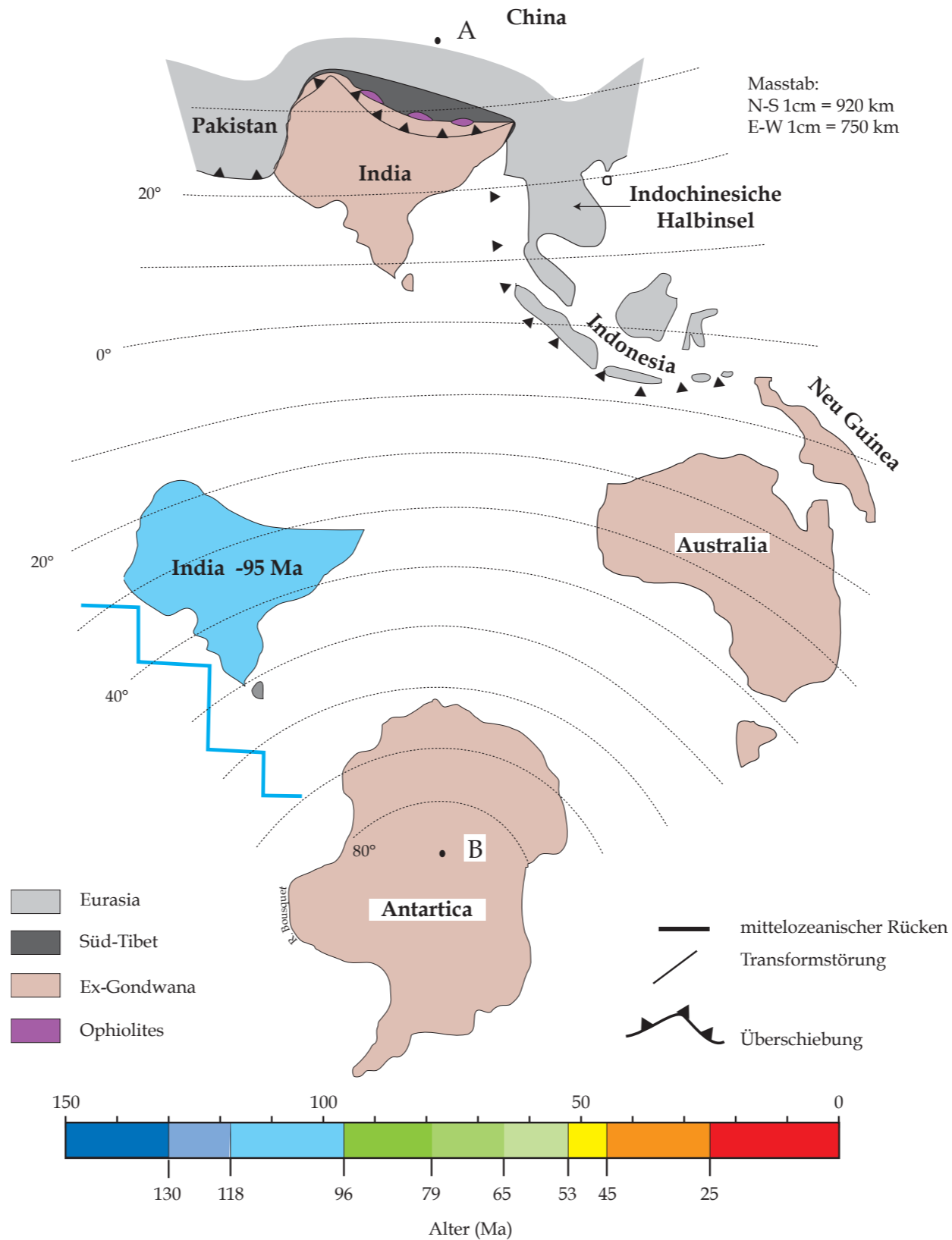
# Himalaya-Tibet system: evolution

Vereinfachte Karte des indische Ozean

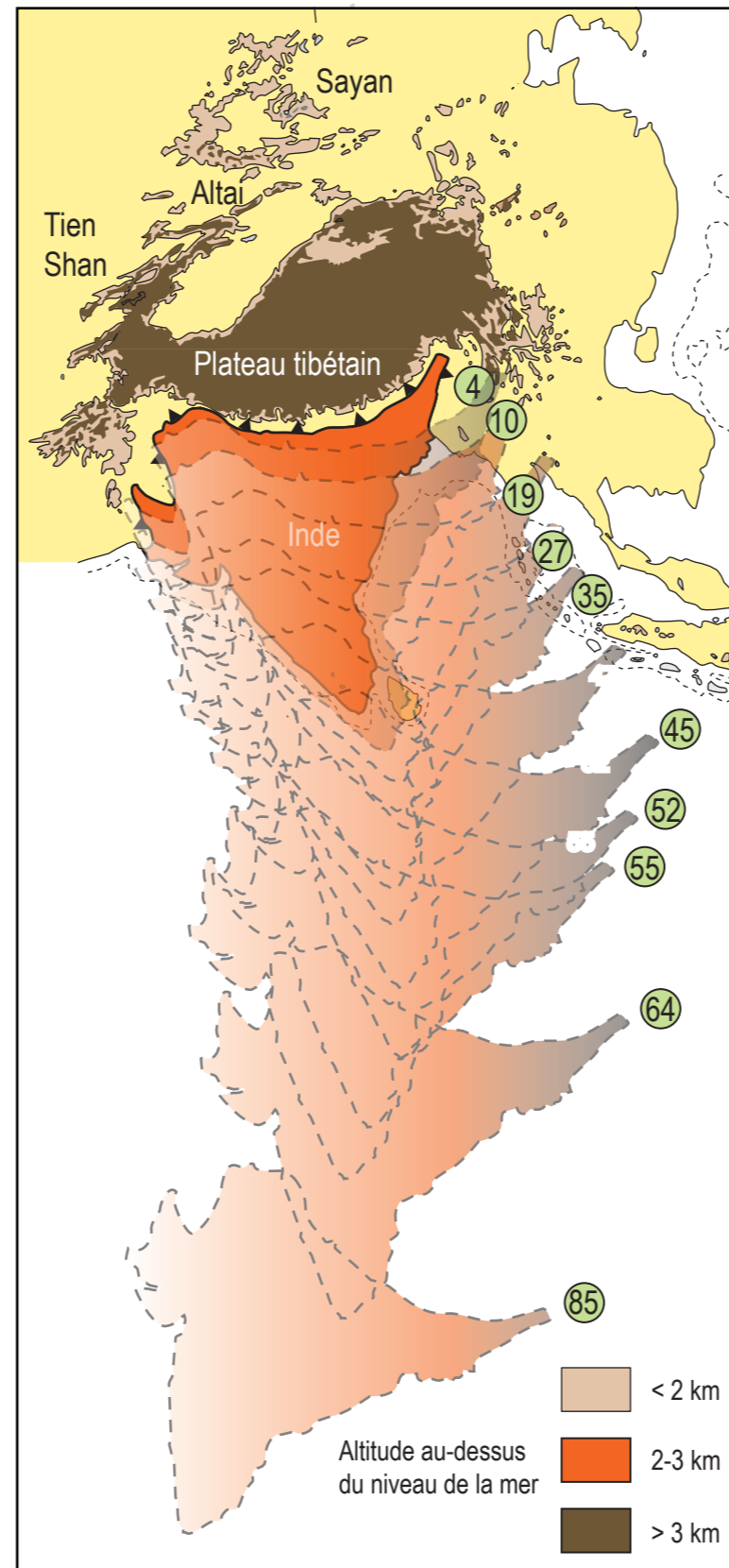


# Himalaya-Tibet system: evolution

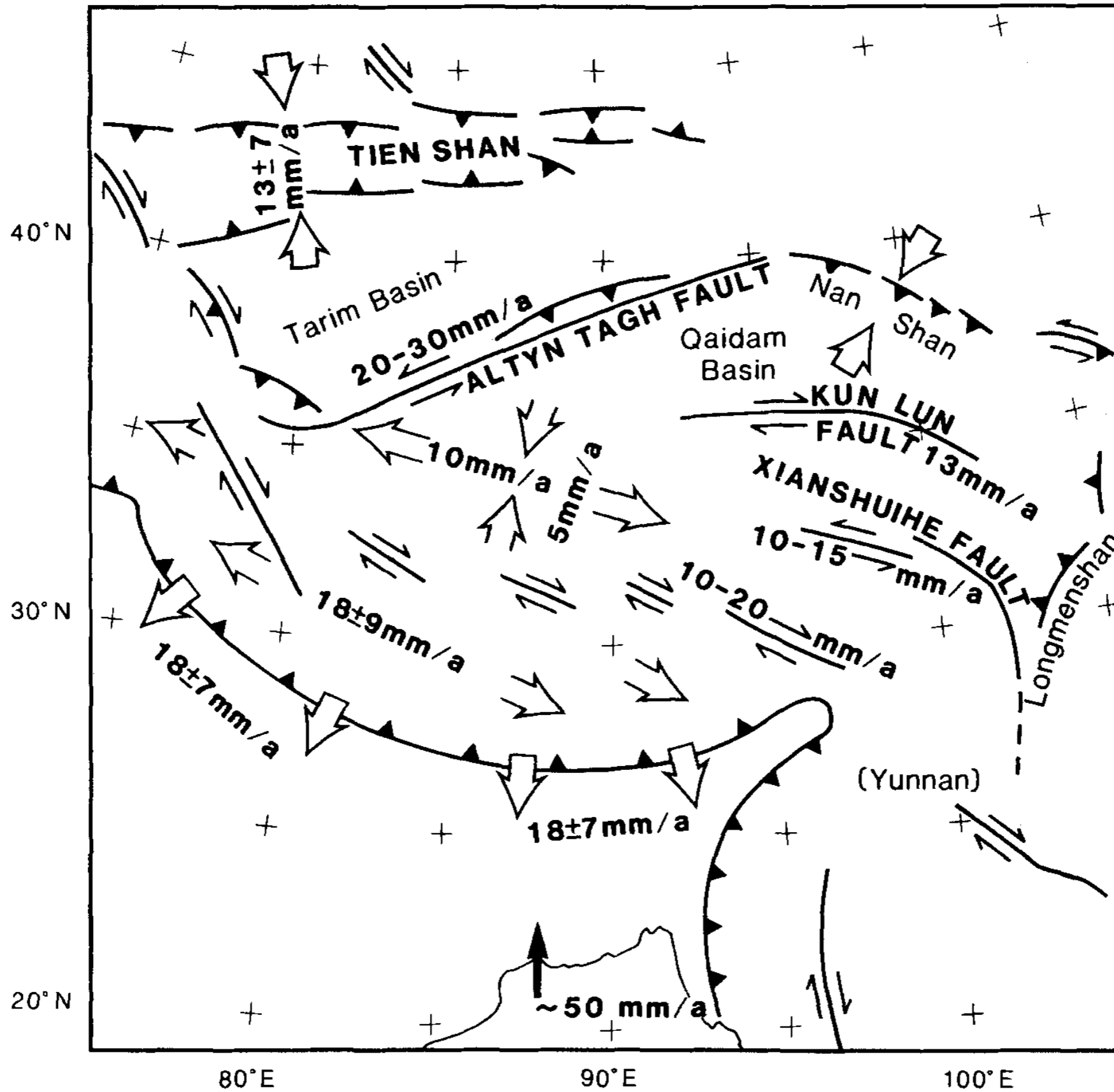
Vereinfachte Karte des indische Ozean



# Himalaya-Tibet system: evolution

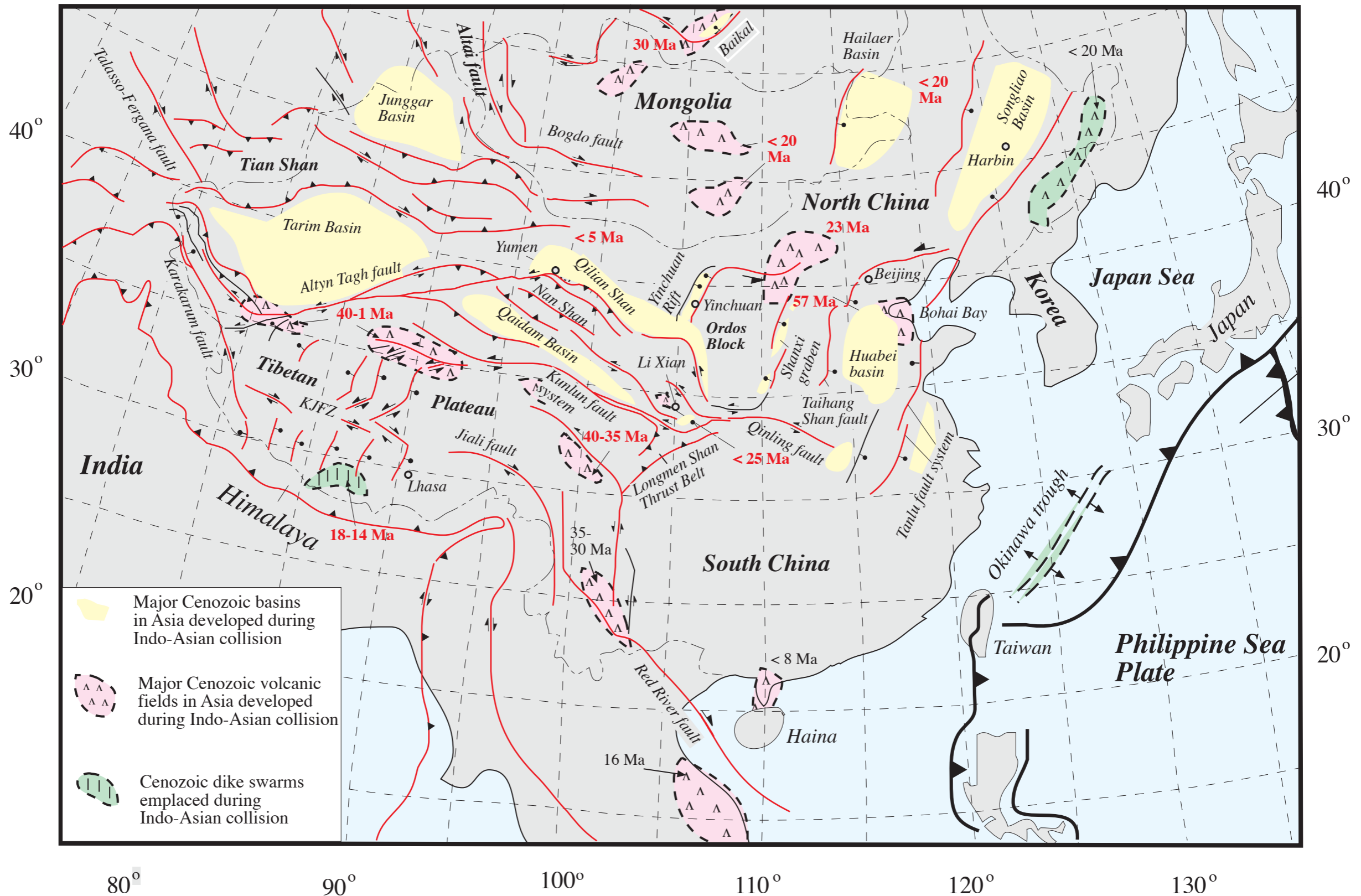


# Himalaya-Tibet system: Neotectonics



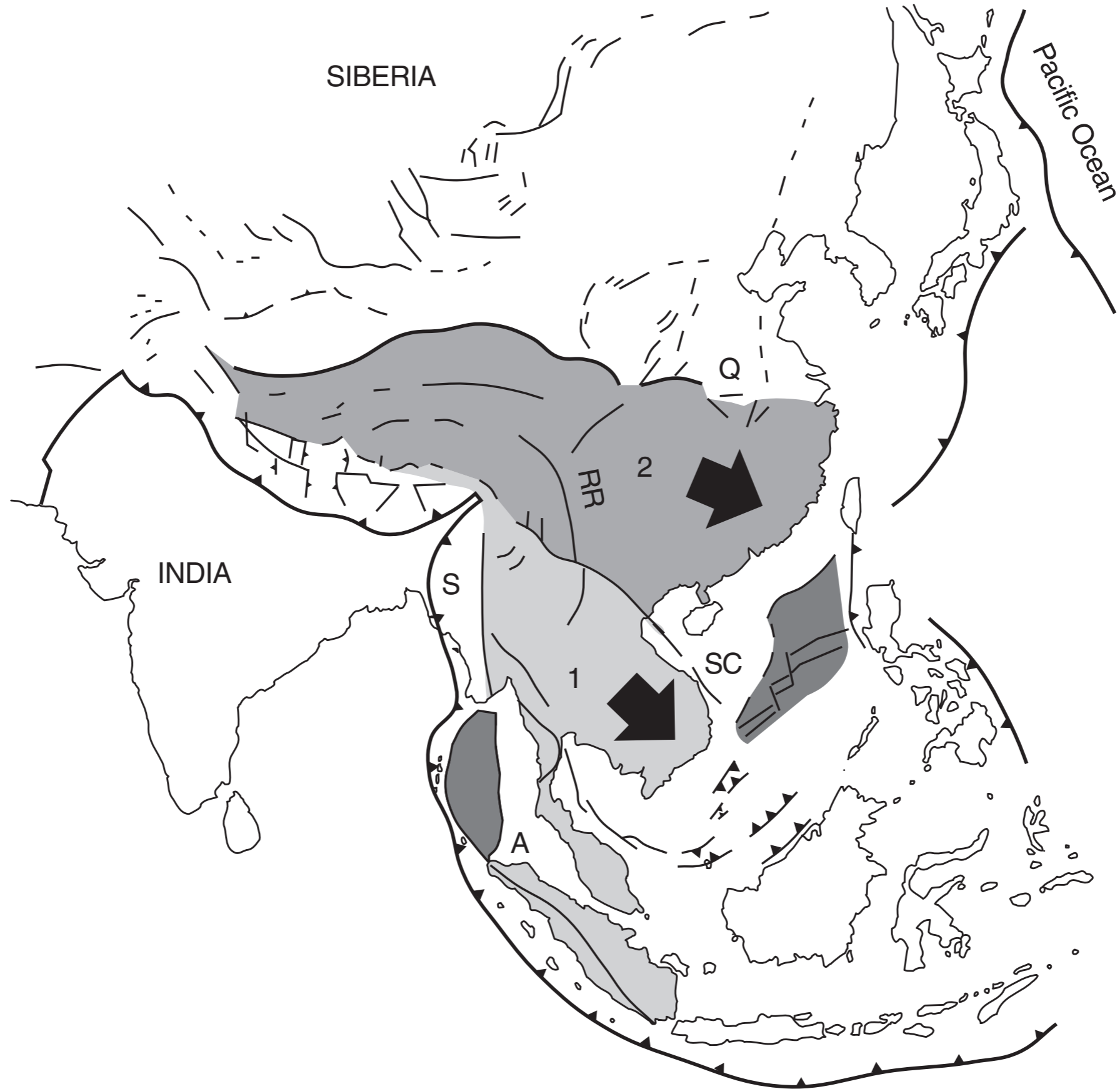


# Himalaya-Tibet system: deformation of Asia

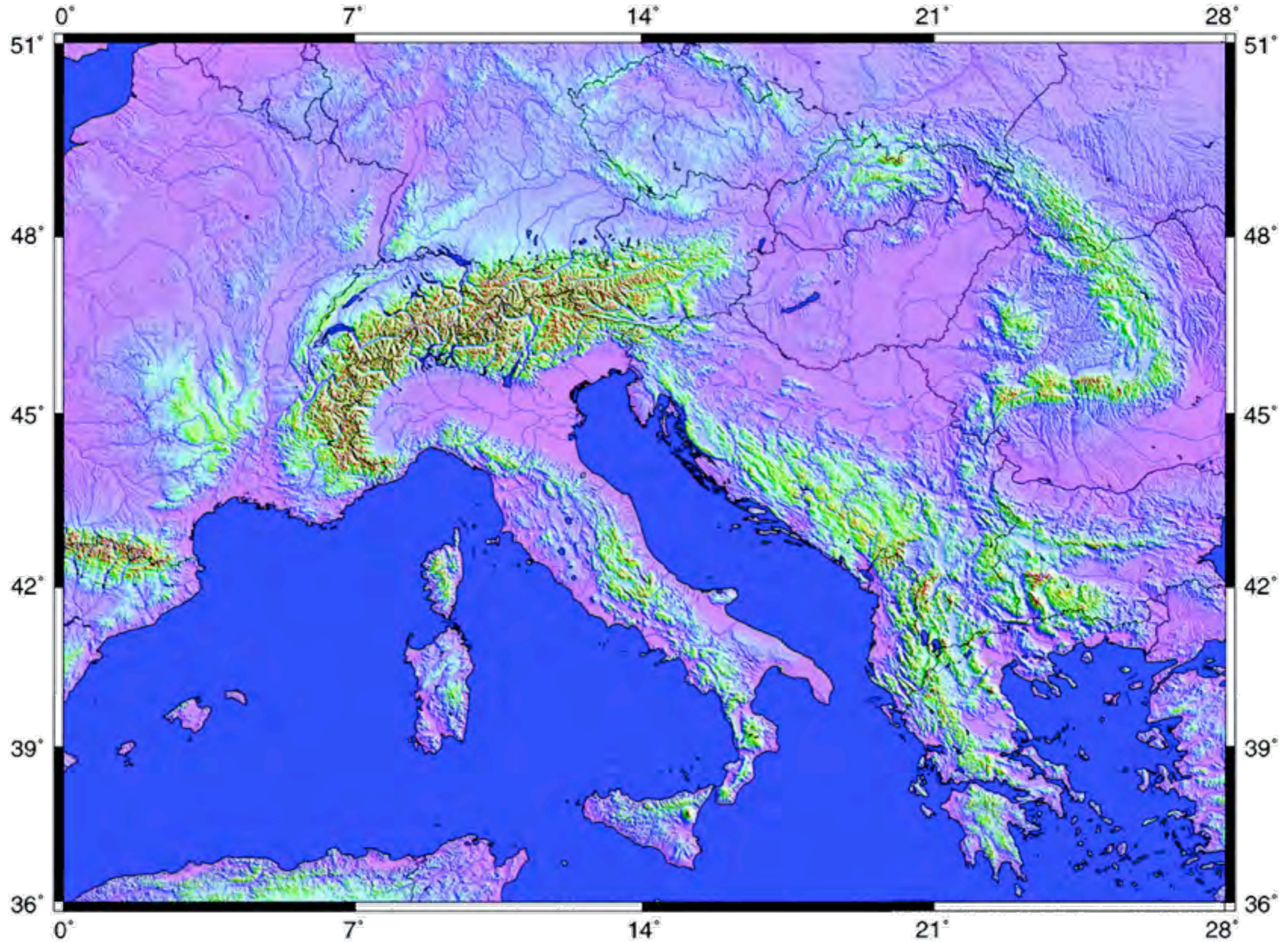


Cenozoic tectonic map of the Indo-Asian collision zone and major active fault systems in Asia.

# Himalaya-Tibet system: deformation of Asia

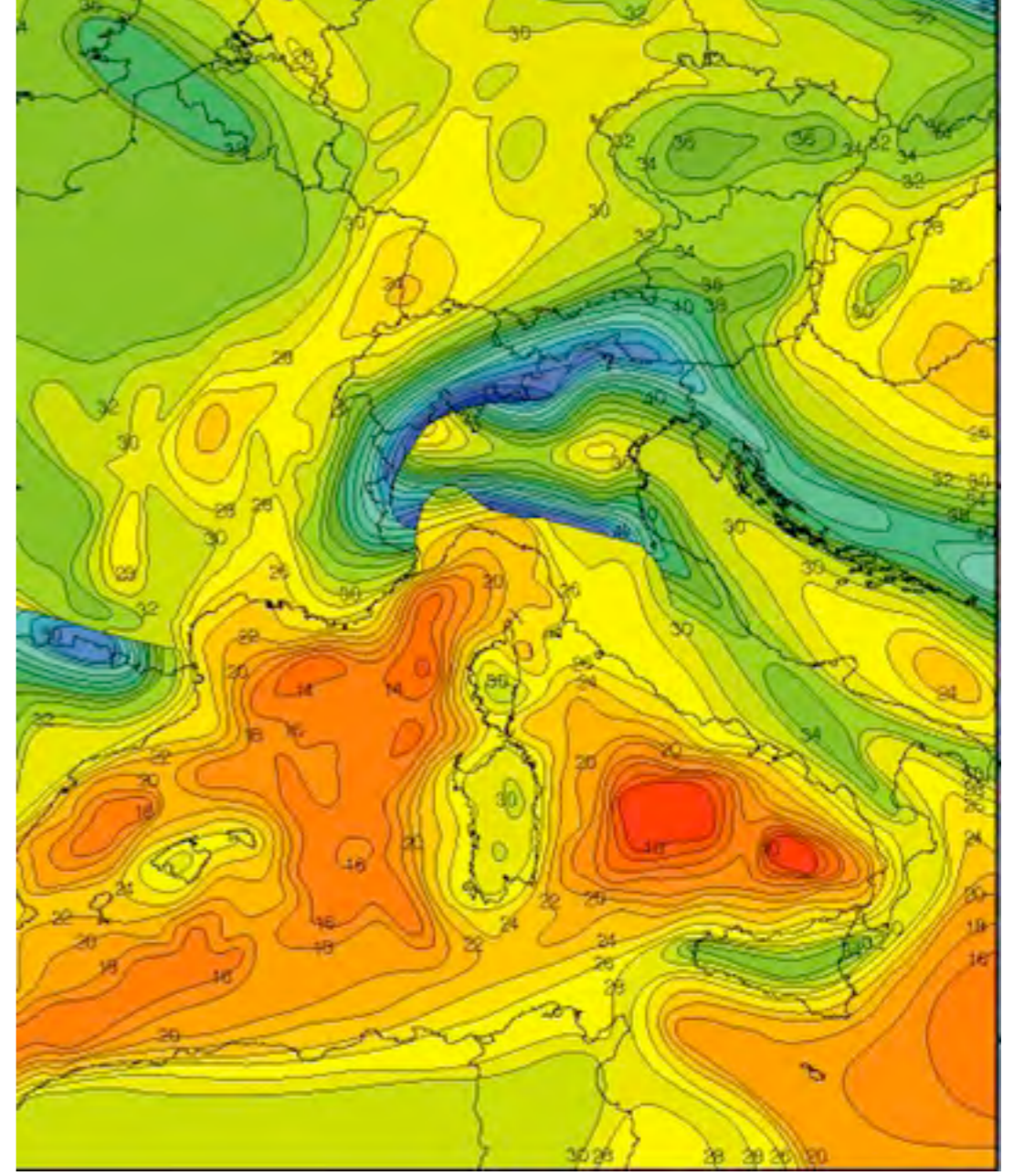


# Around the Alps

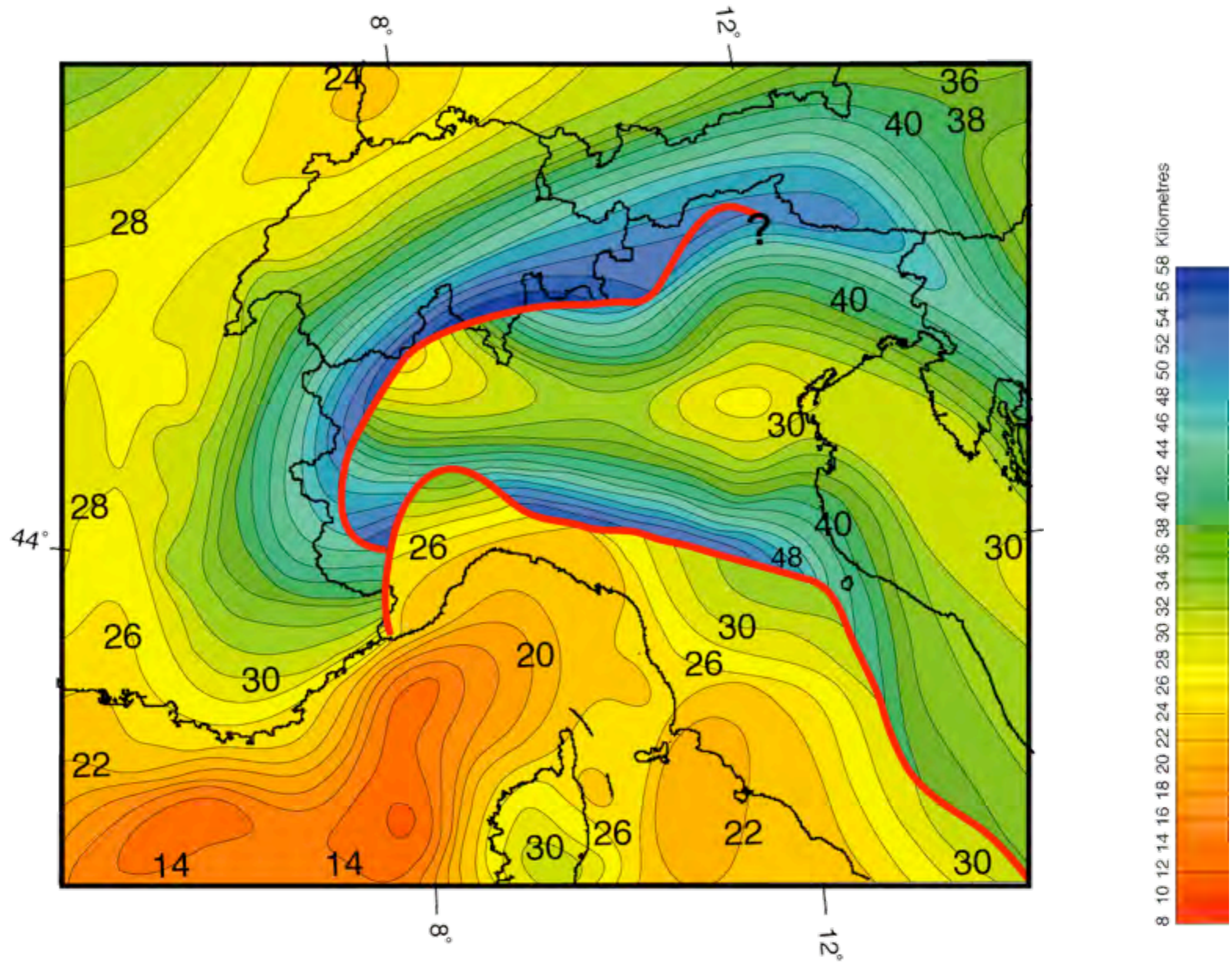


# Topography vs. Moho

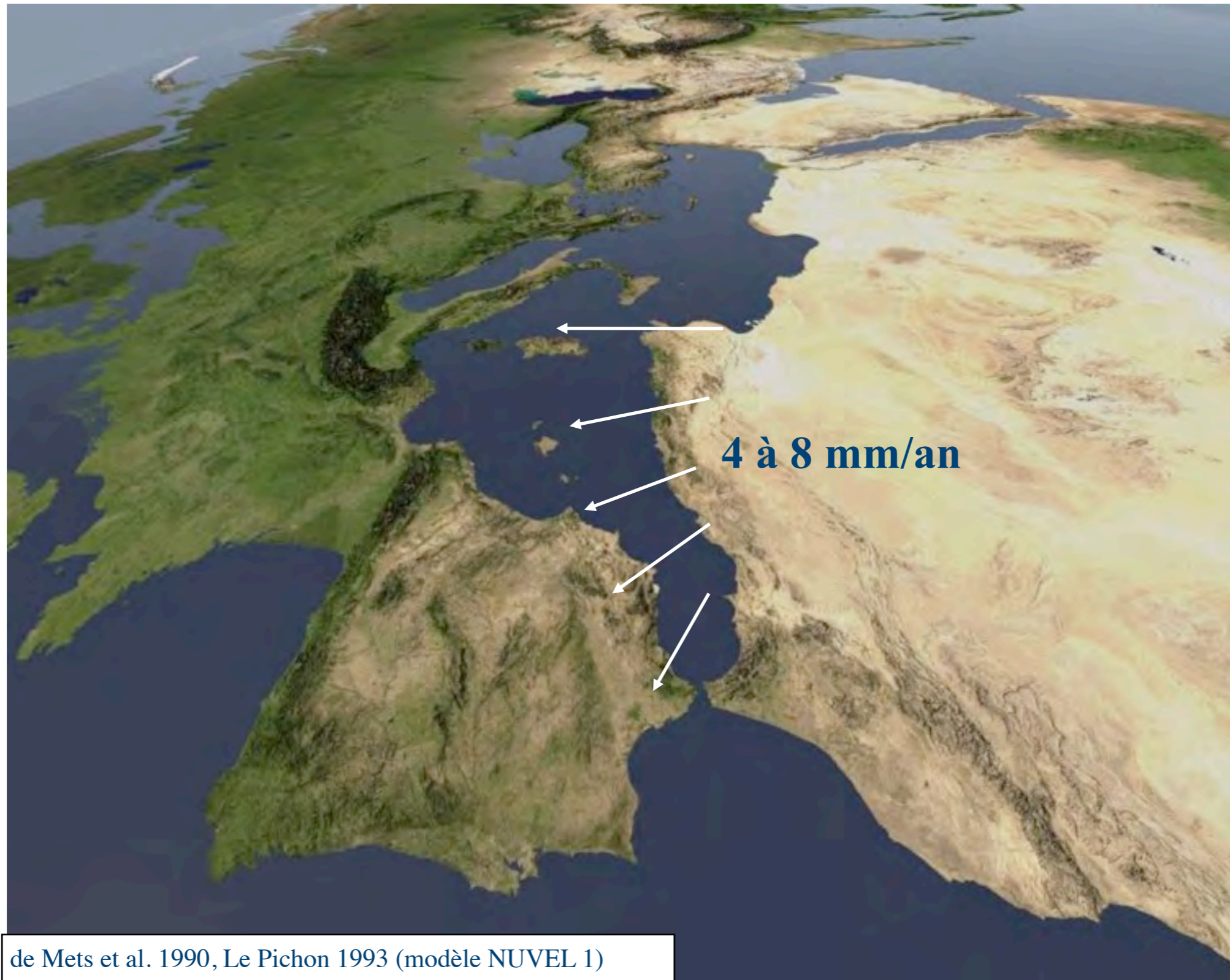
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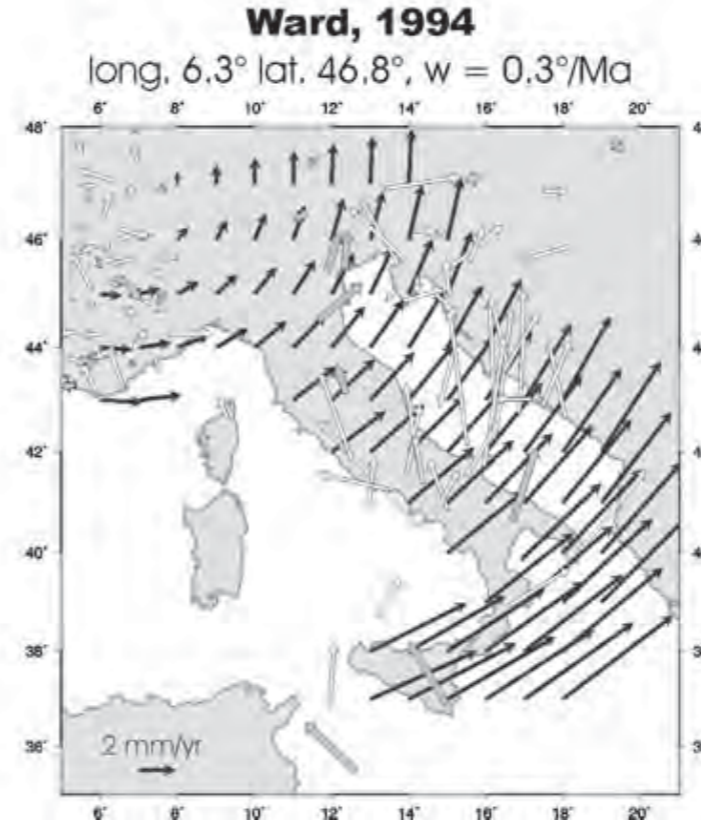
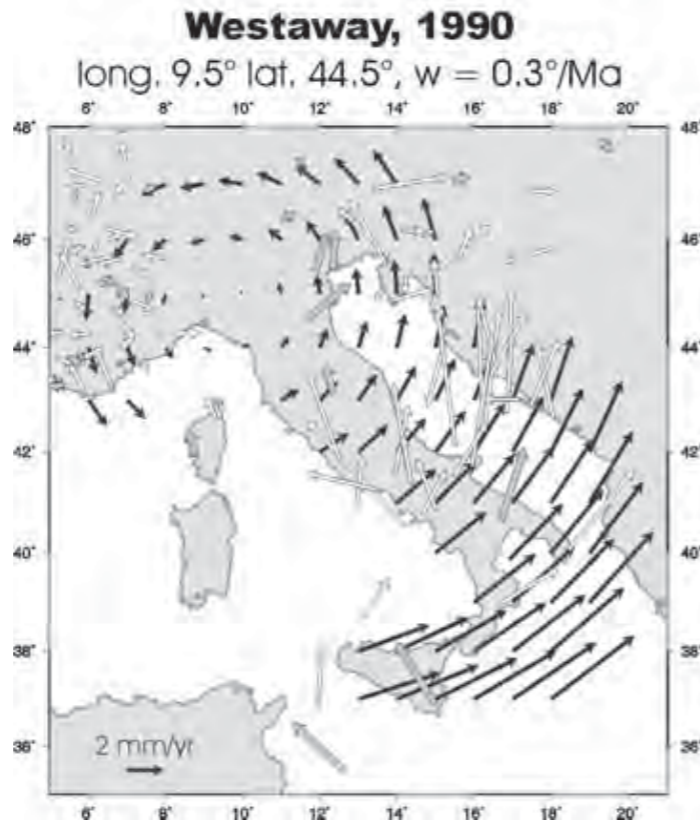
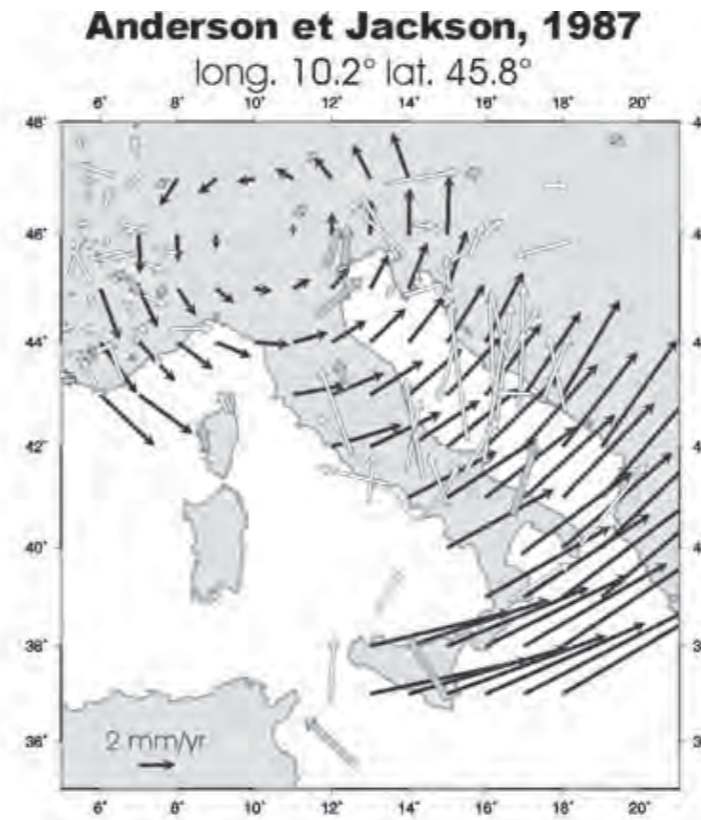
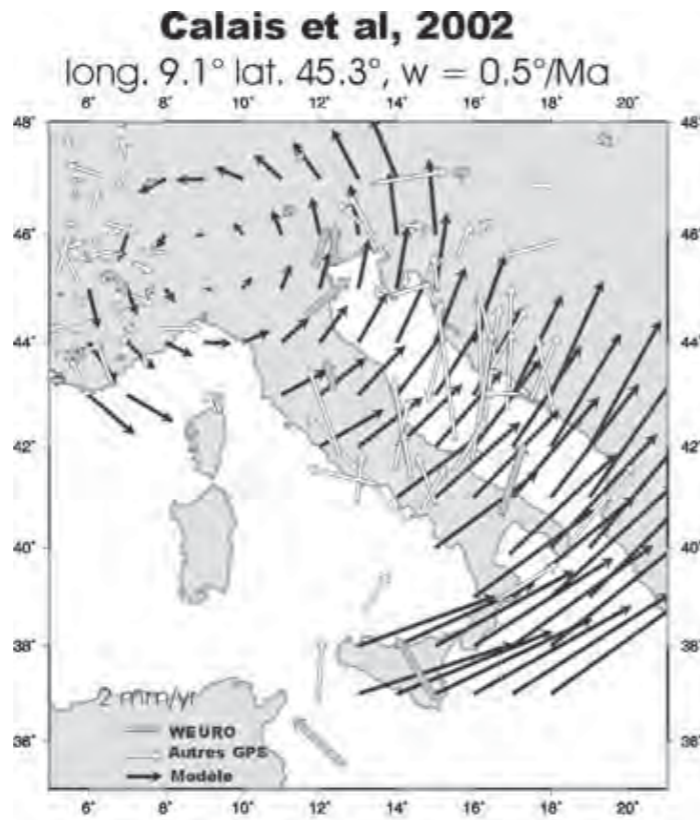
# Moho unten den Alpen



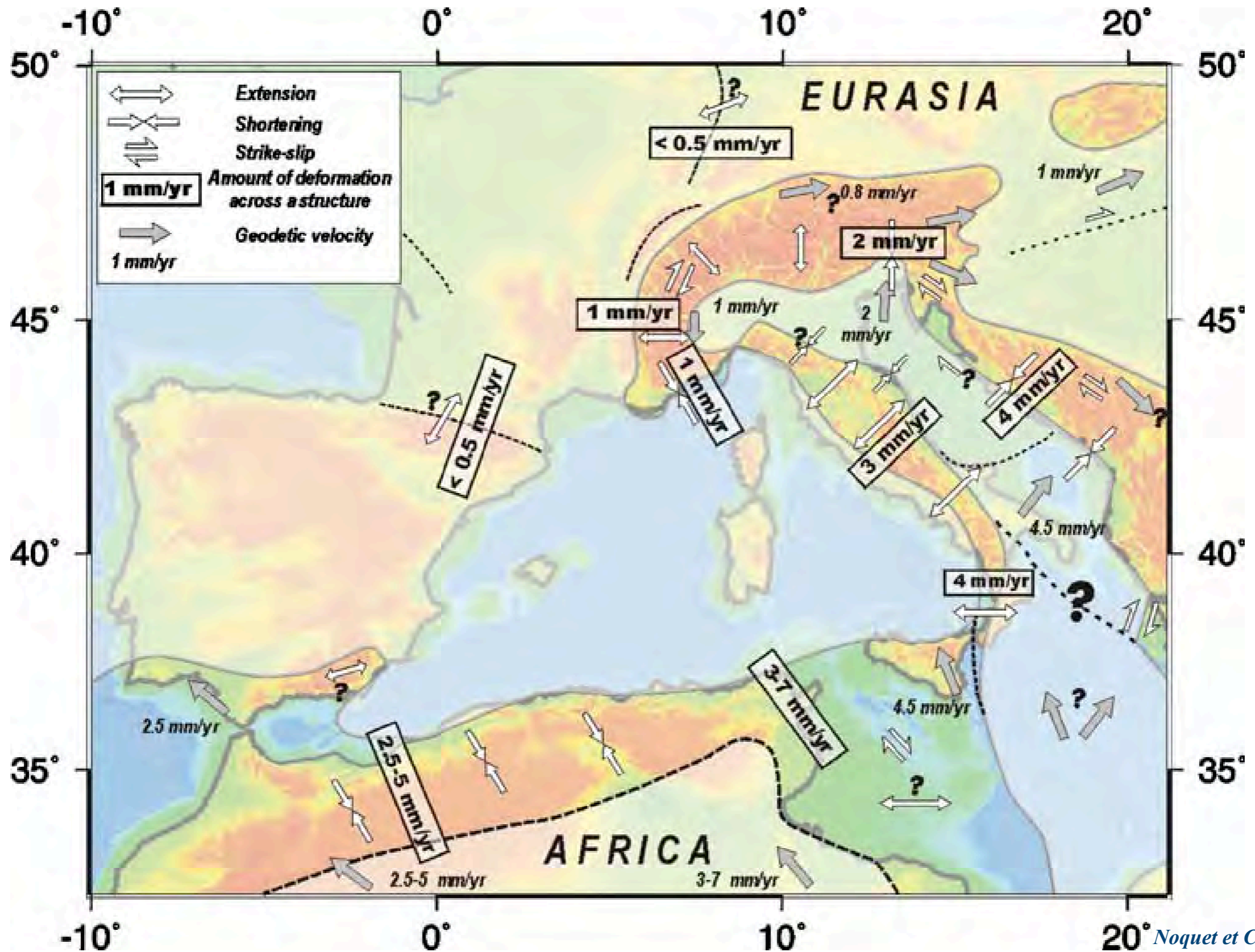
# Plate tectonic: Africa-Europa convergence



# Plate tectonic: Africa-Europa convergence



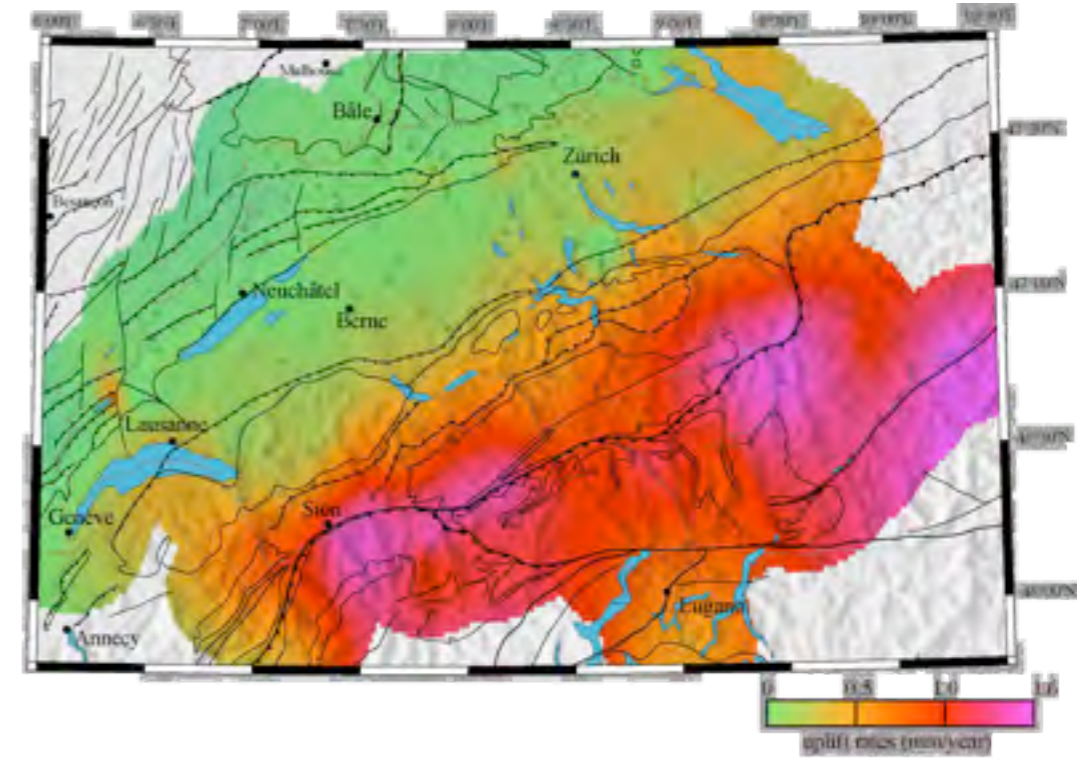
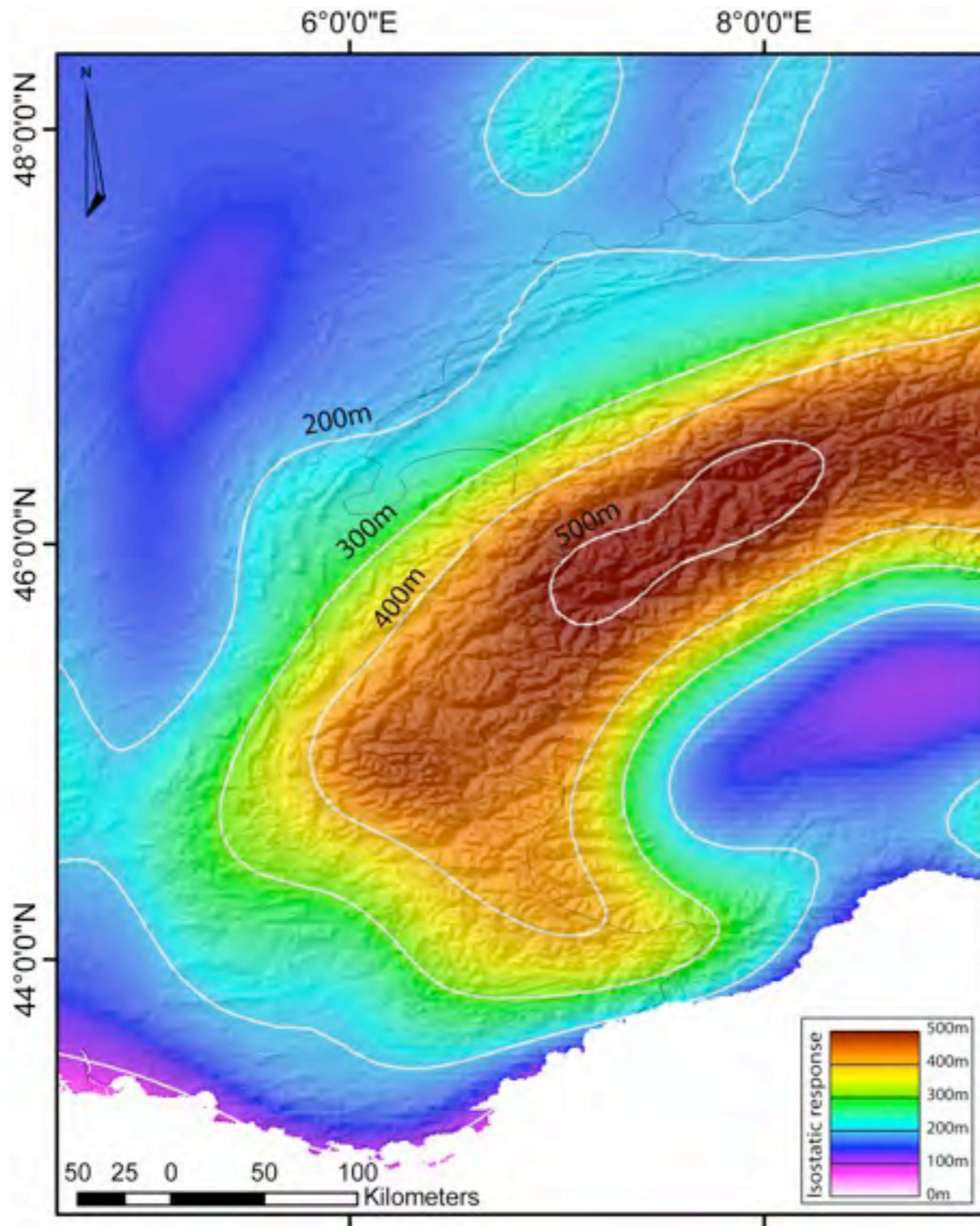
# Plate tectonic: Africa-Europa convergence



Noquet et Calais, 2004



# Today uplift of the Alps

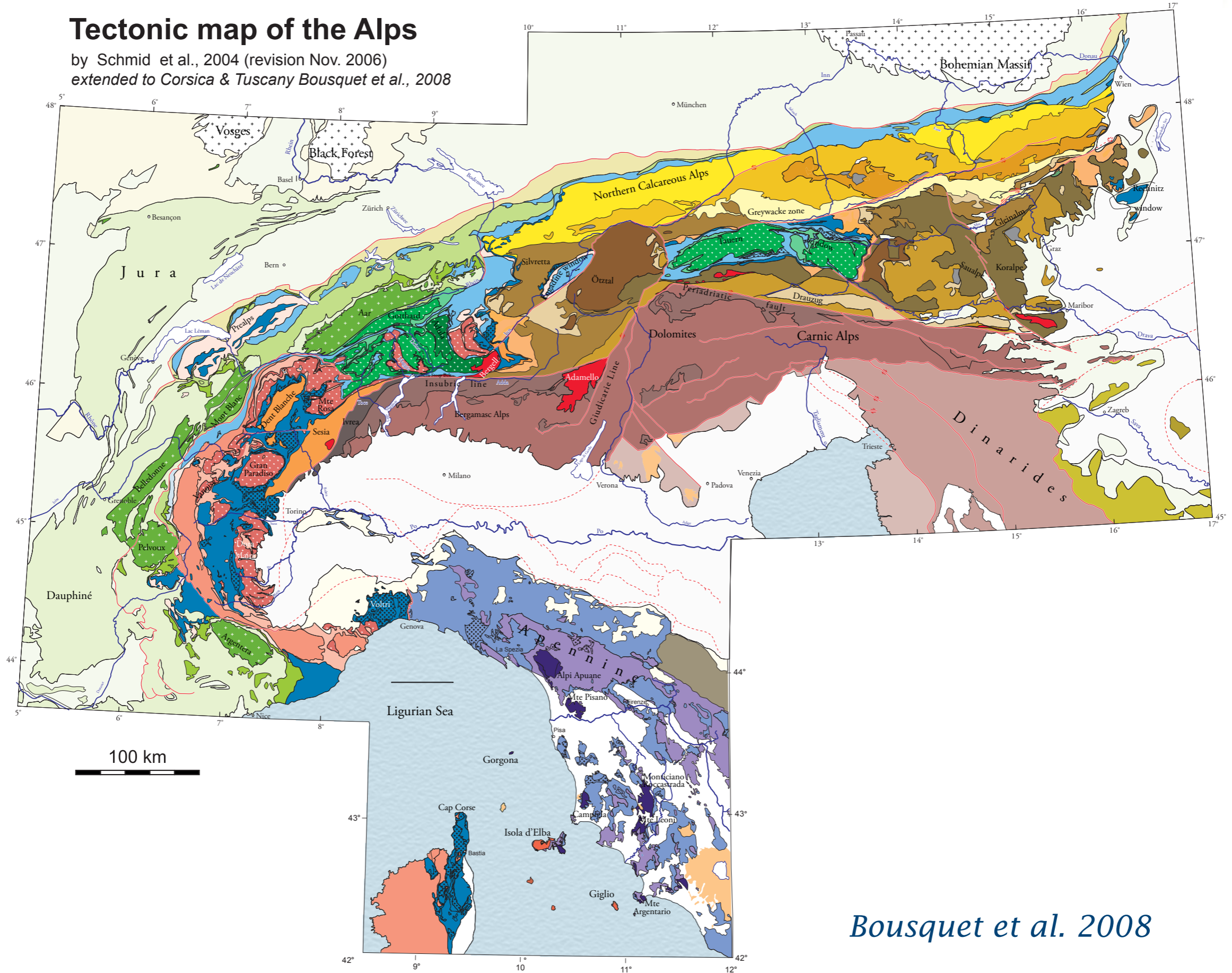


Champagnac et al, 2007

# Tectonic map of the Alps

## Tectonic map of the Alps

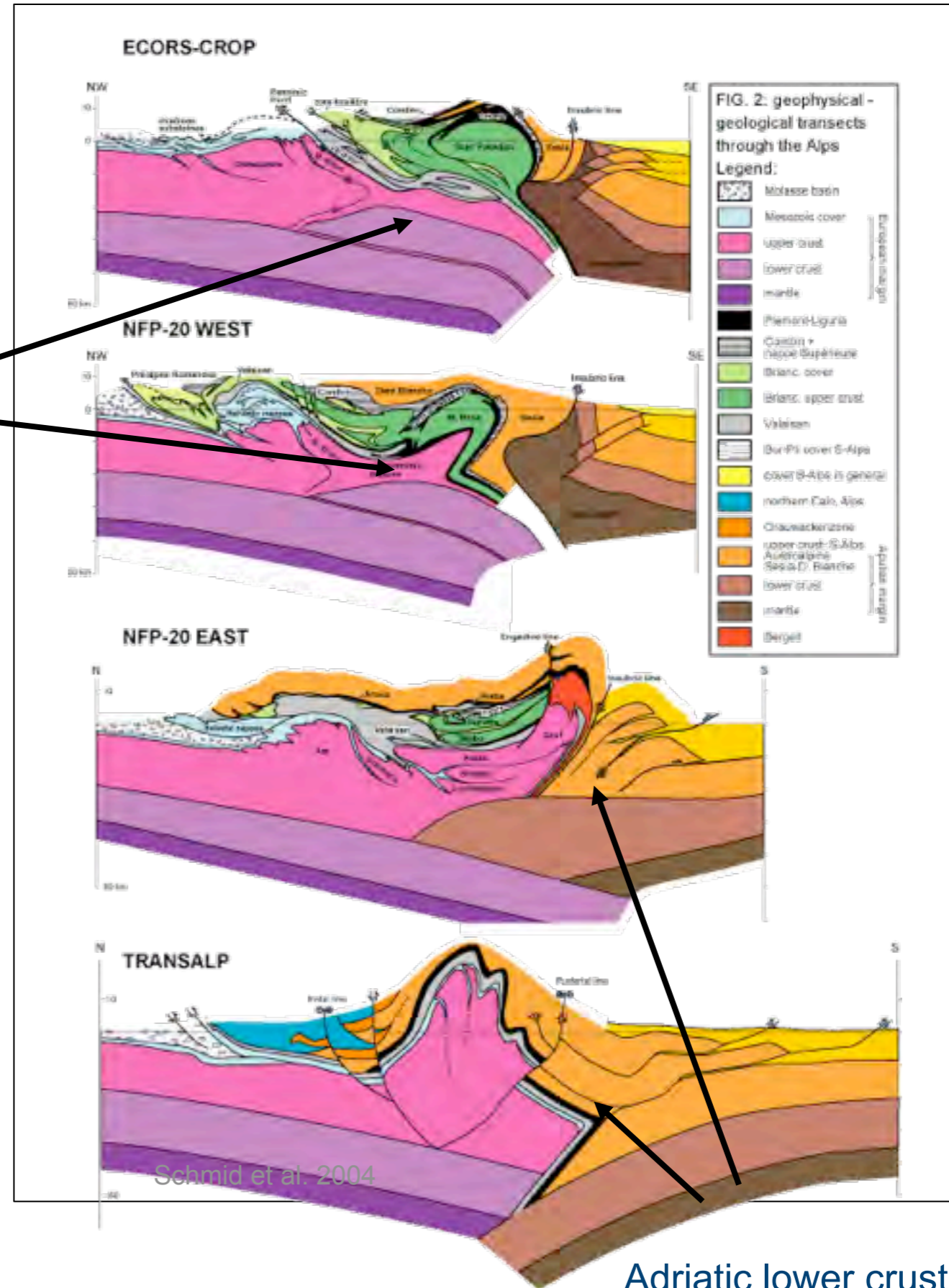
by Schmid et al., 2004 (revision Nov. 2006)  
extended to Corsica & Tuscany Bousquet et al., 2008



Bousquet et al. 2008

# Profiles across the Alps

European lower crust

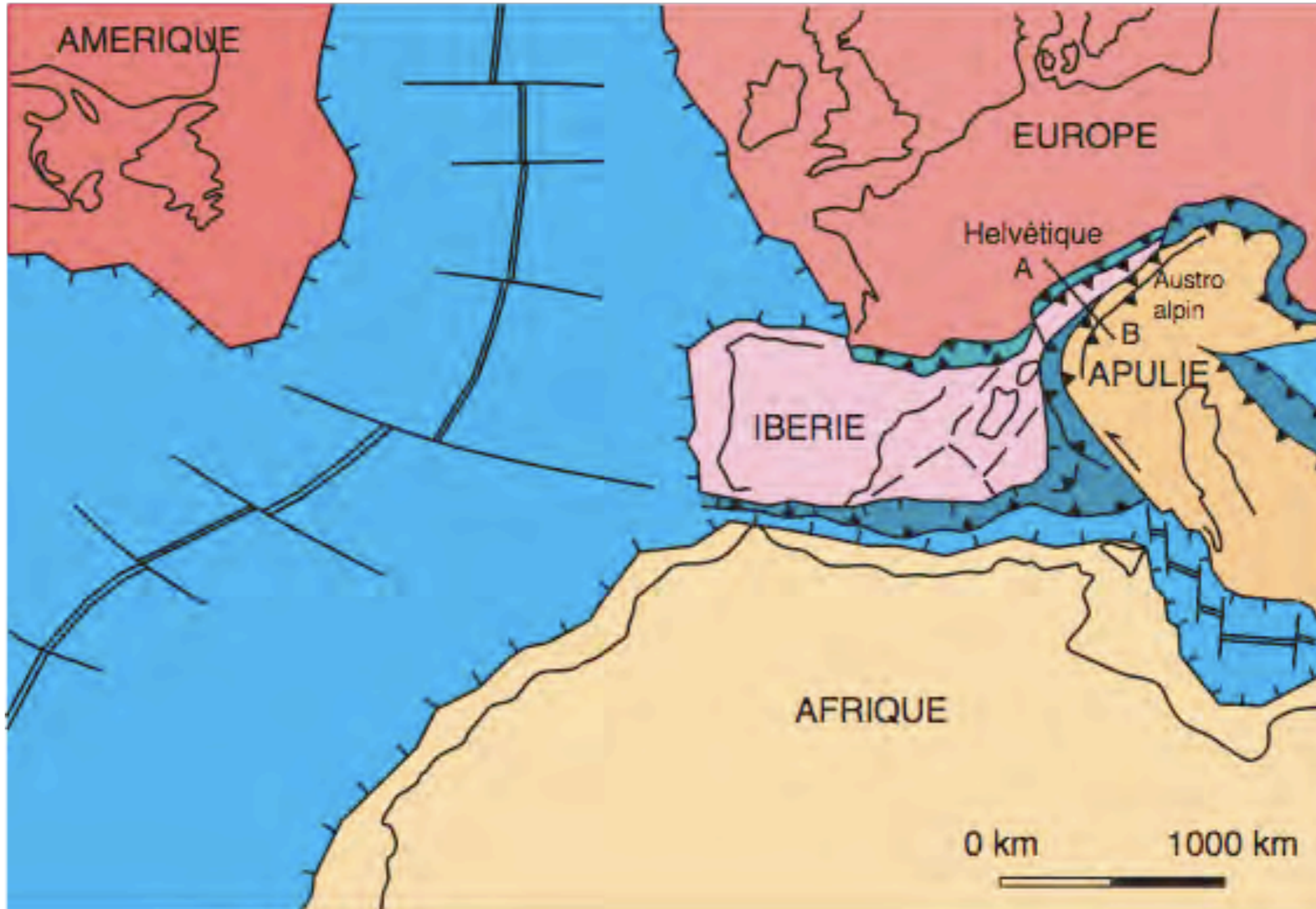


Adriatic lower crust

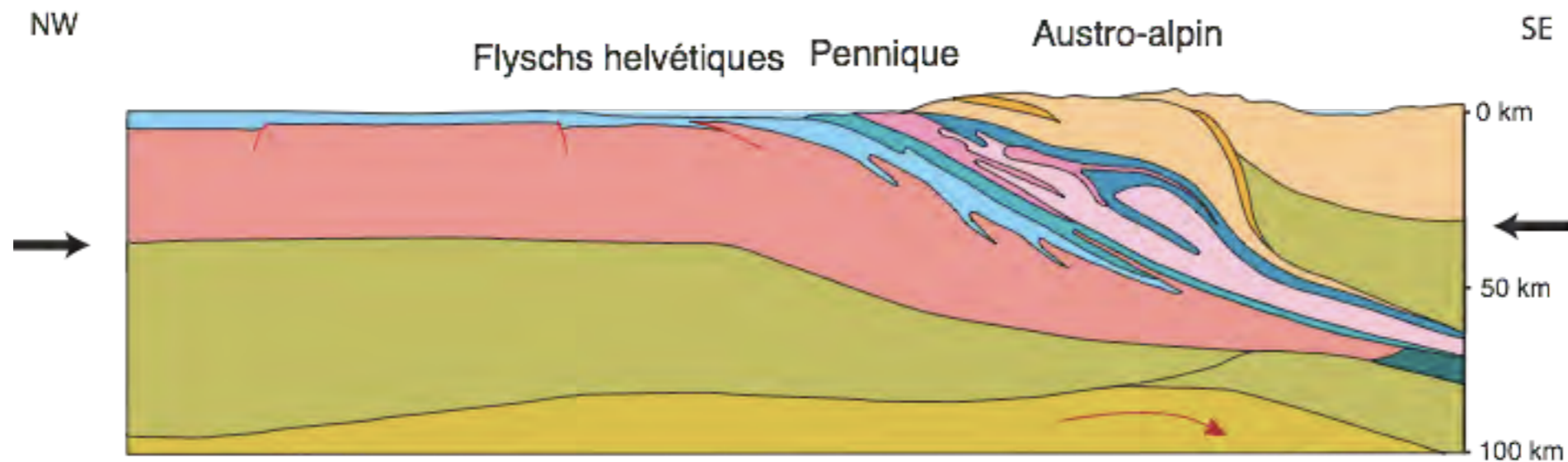
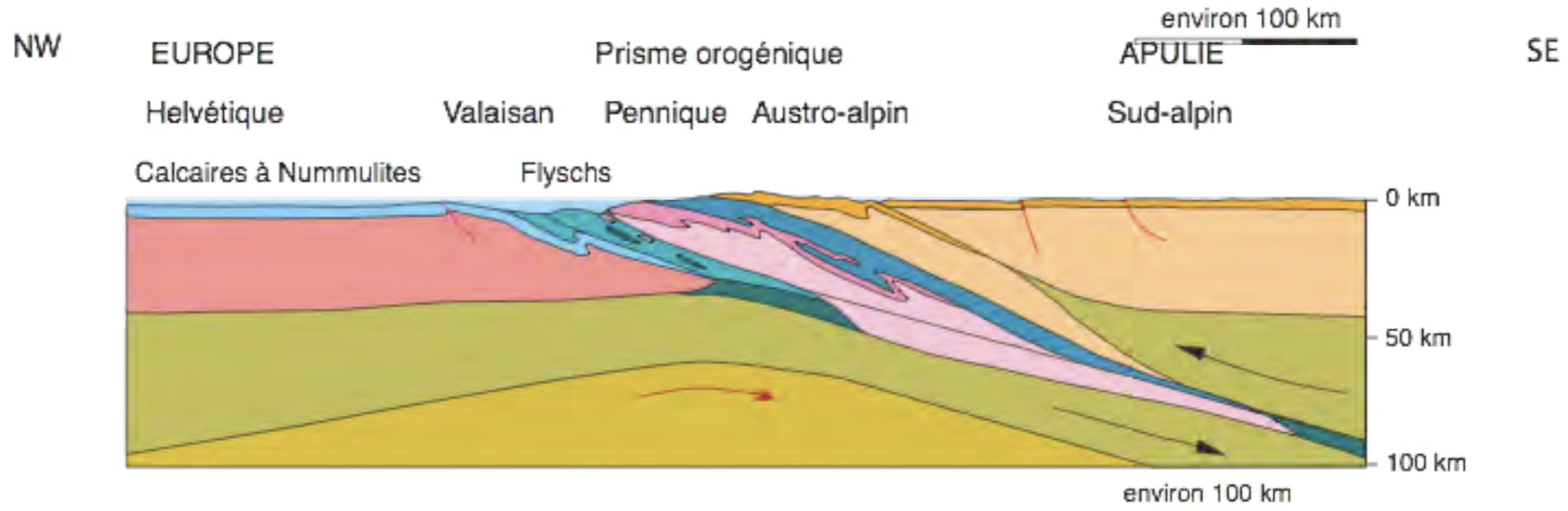
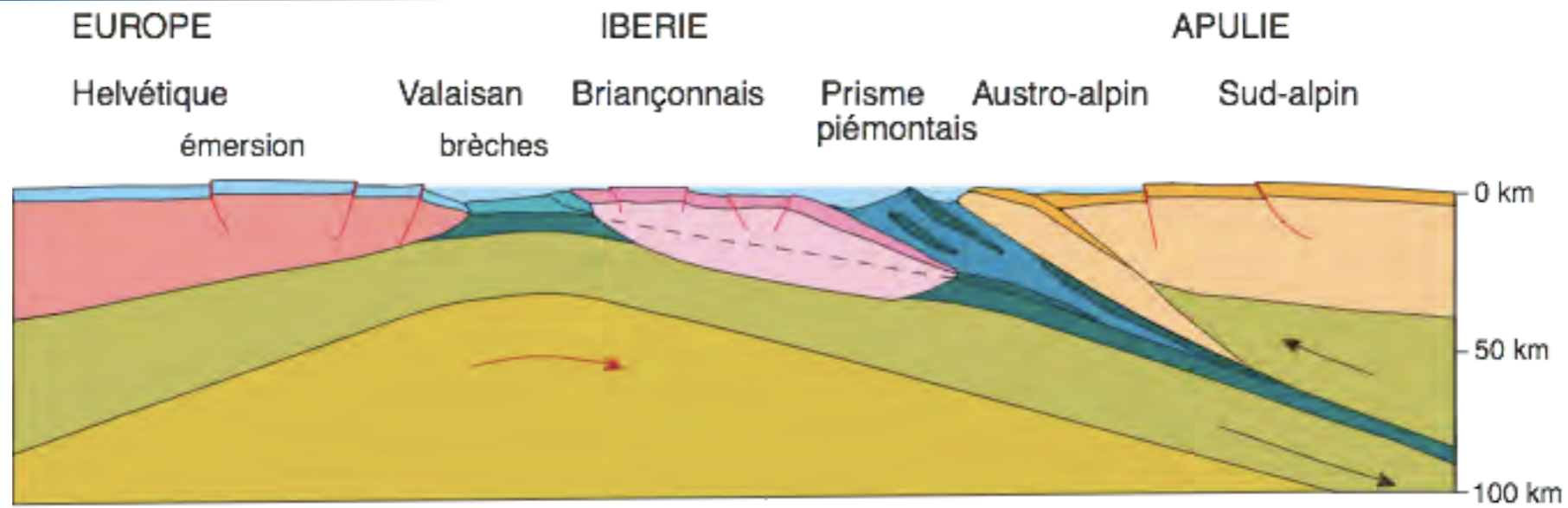
Schmid et al. 2004

# Plate tectonic reconstruction

60 Ma

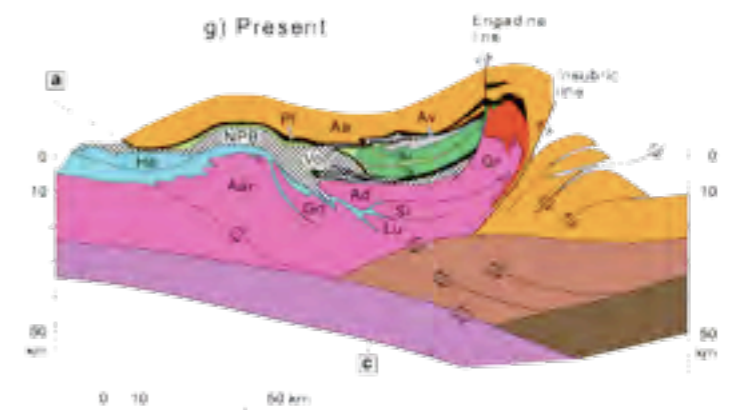
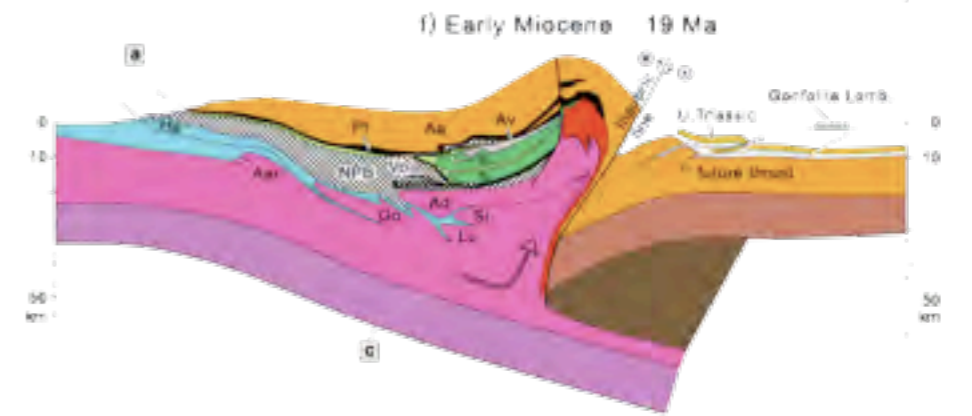
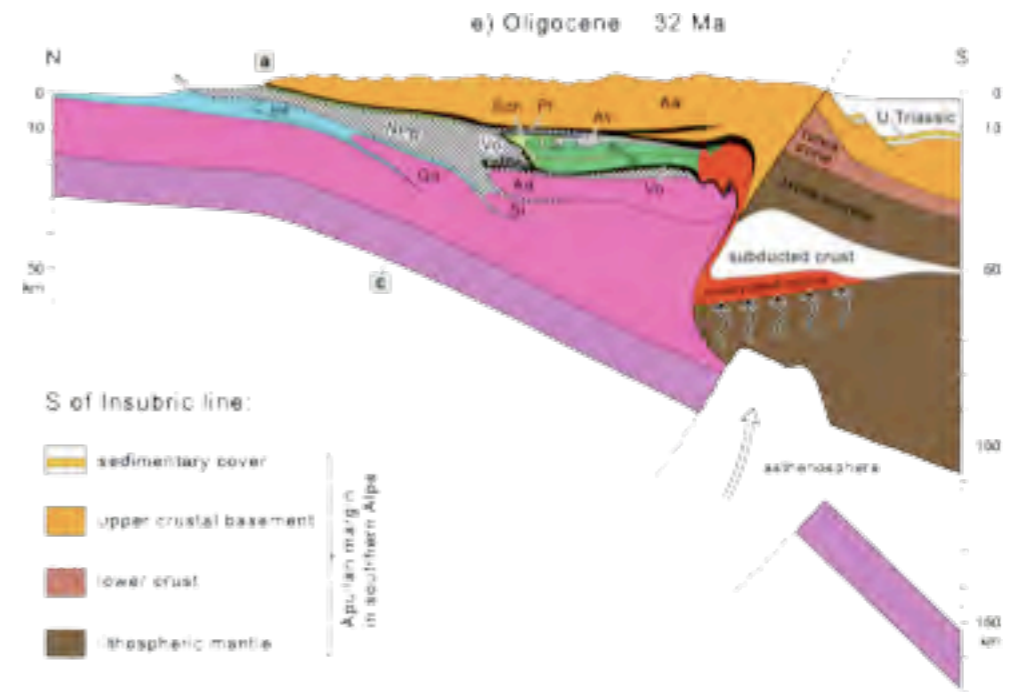
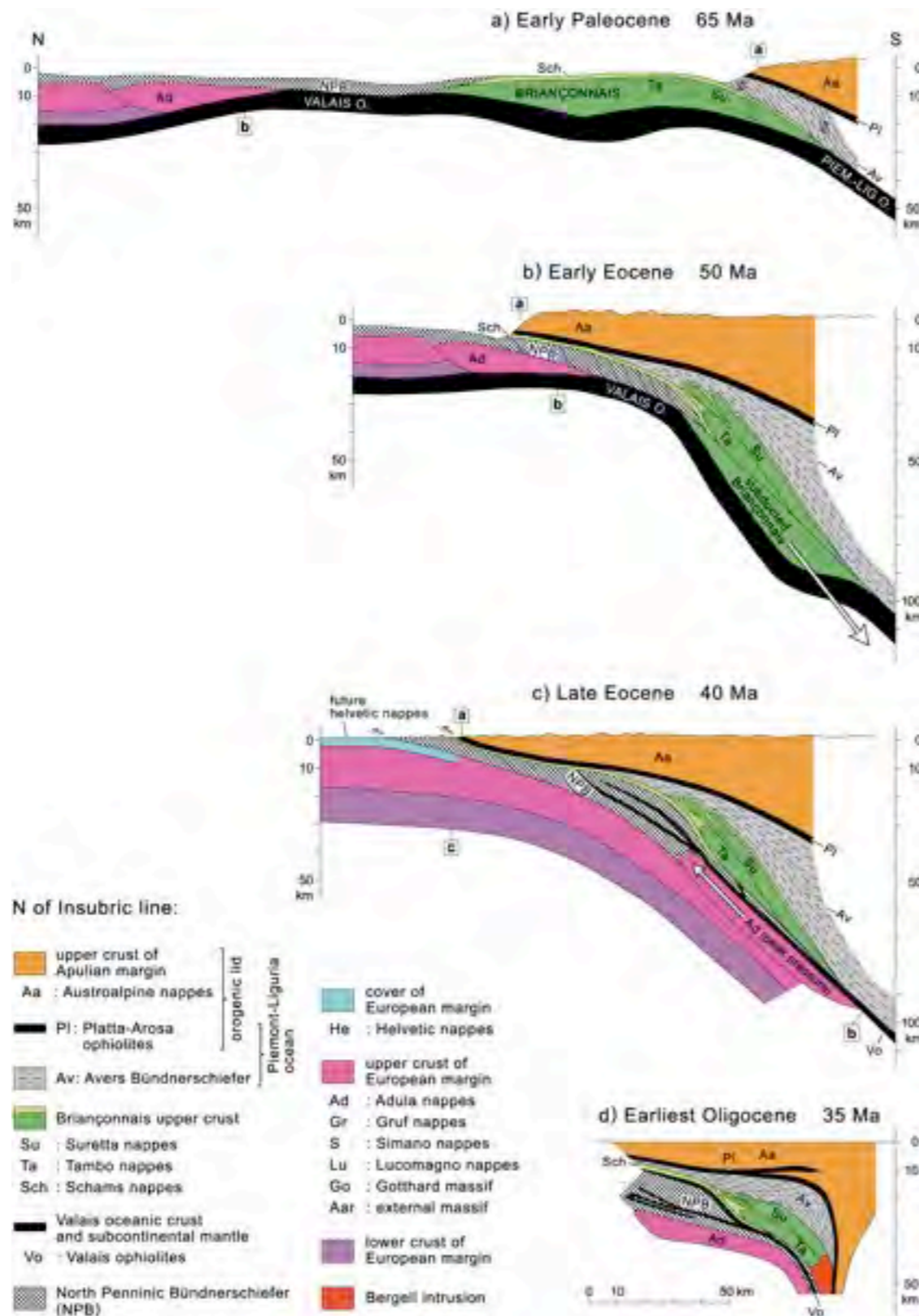


# Schematic cross sections



Marthaler, 2001 environ 100 km

# Schematic cross sections

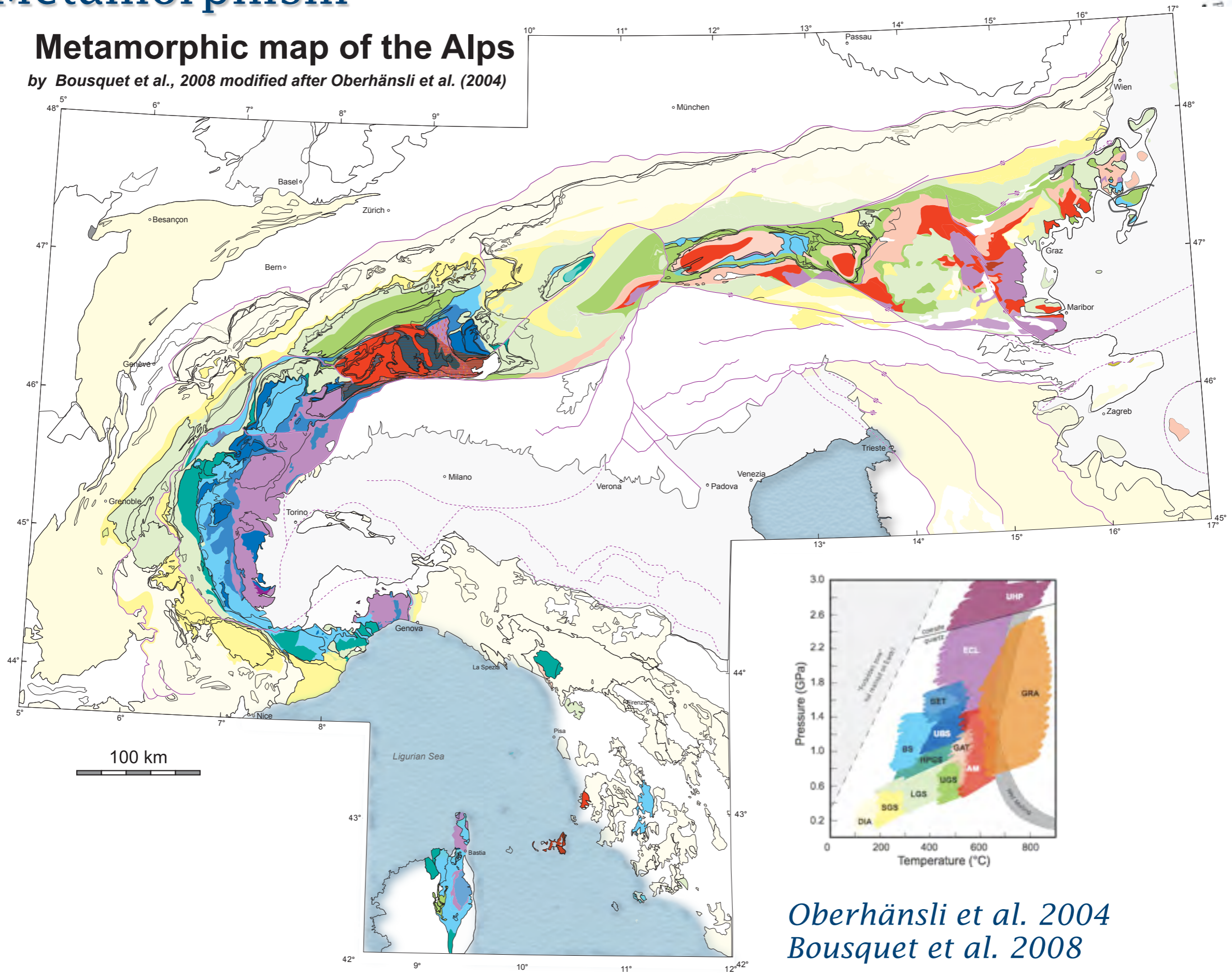


Schmid et al. 2004

# Metamorphism

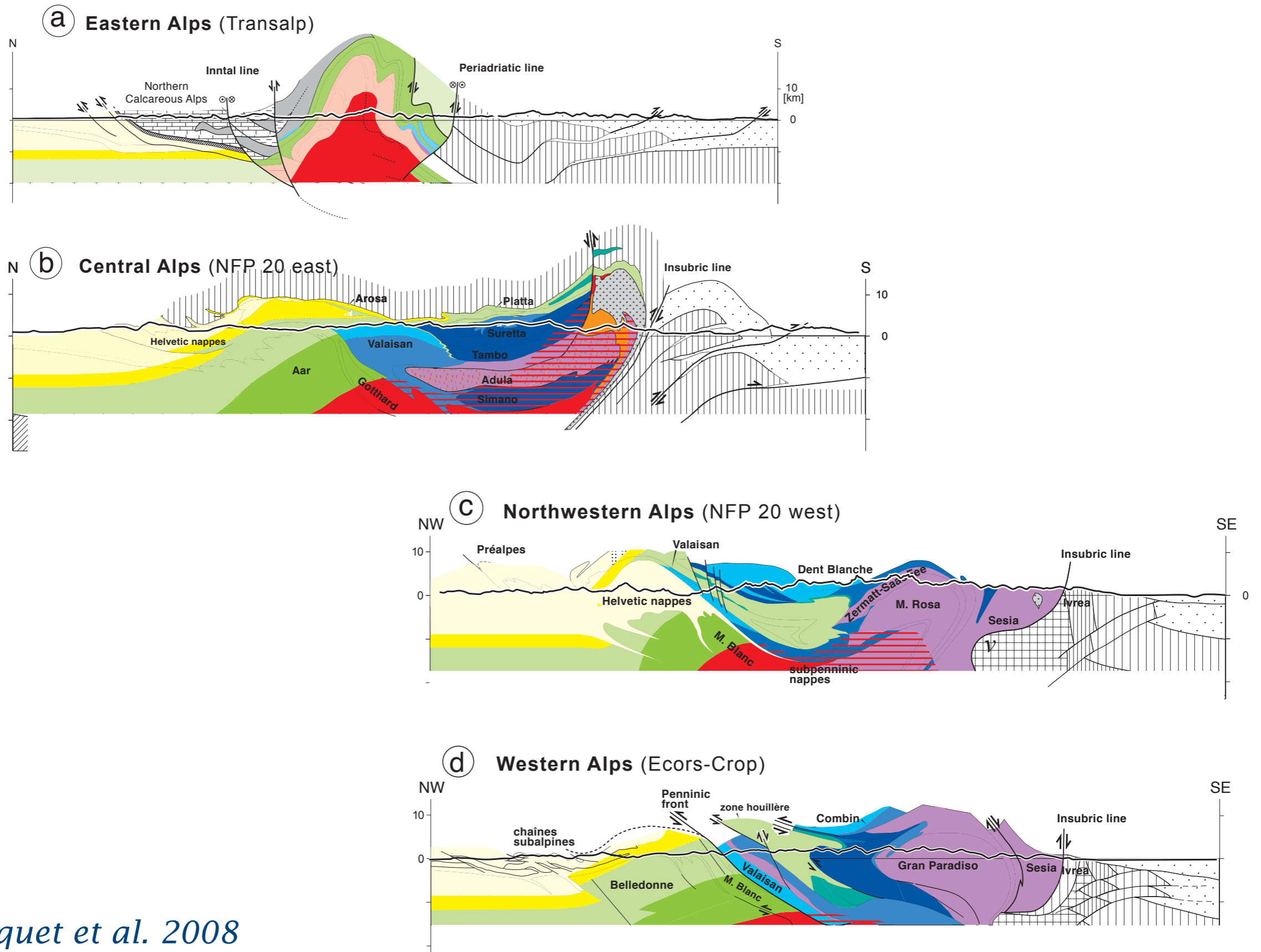
Alpen Vorlesung

## Metamorphic map of the Alps by Bousquet et al., 2008 modified after Oberhänsli et al. (2004)



Oberhänsli et al. 2004  
Bousquet et al. 2008

# Metamorphic cross-sections



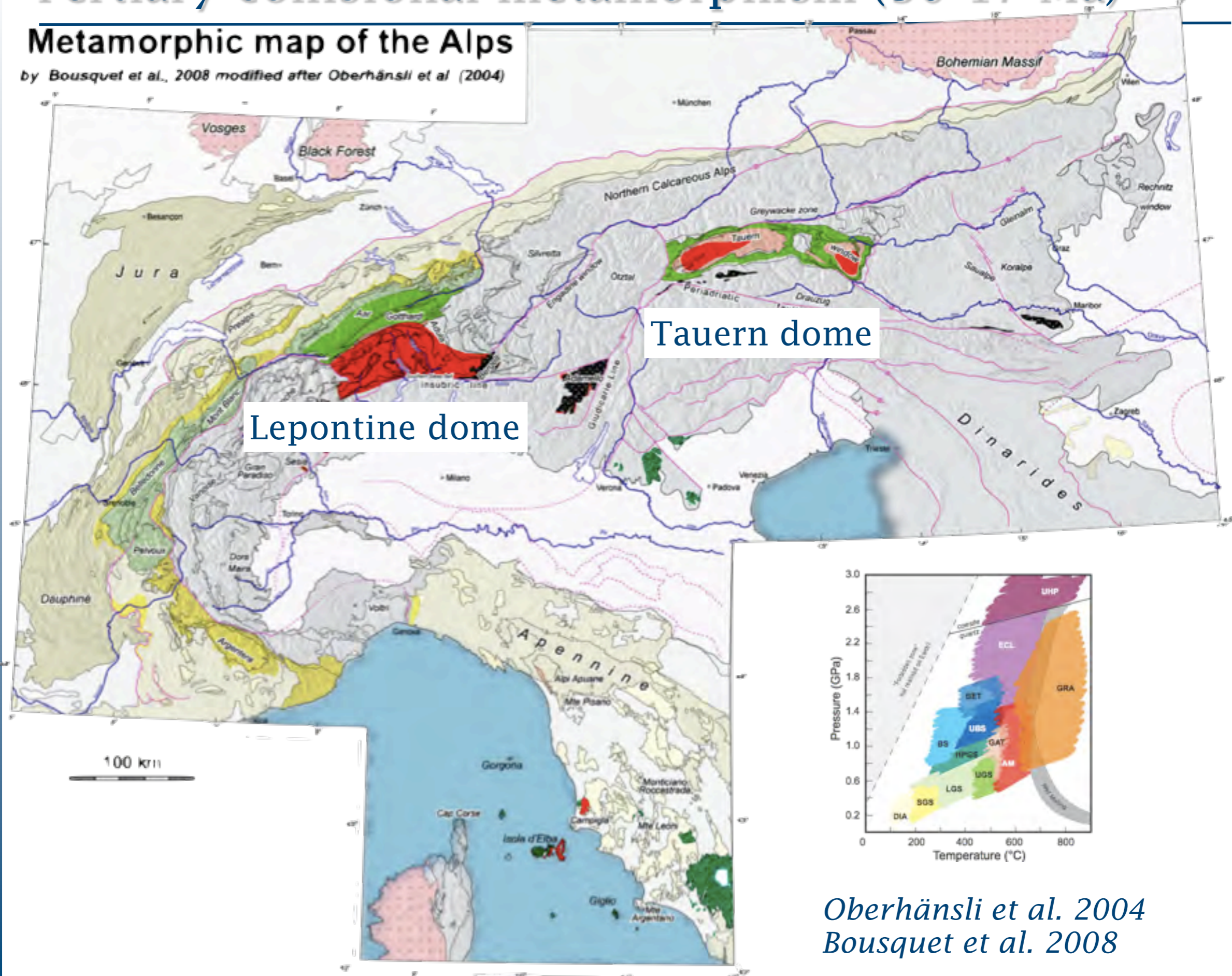
Bousquet et al. 2008



# Tertiary collisional metamorphism (30-17 Ma)

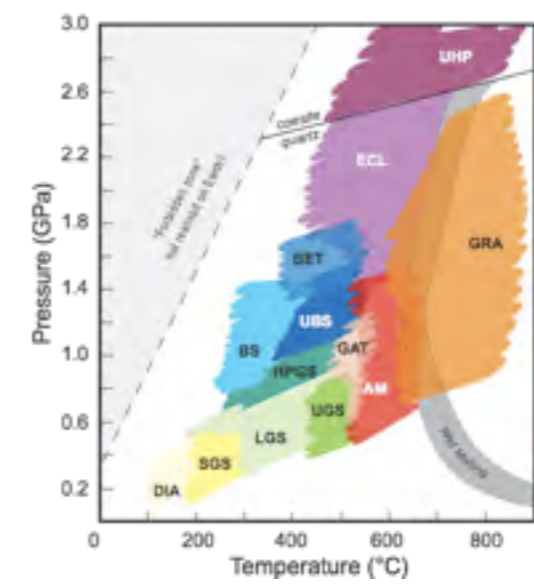
## Metamorphic map of the Alps

by Bousquet et al., 2008 modified after Oberhänsli et al (2004)



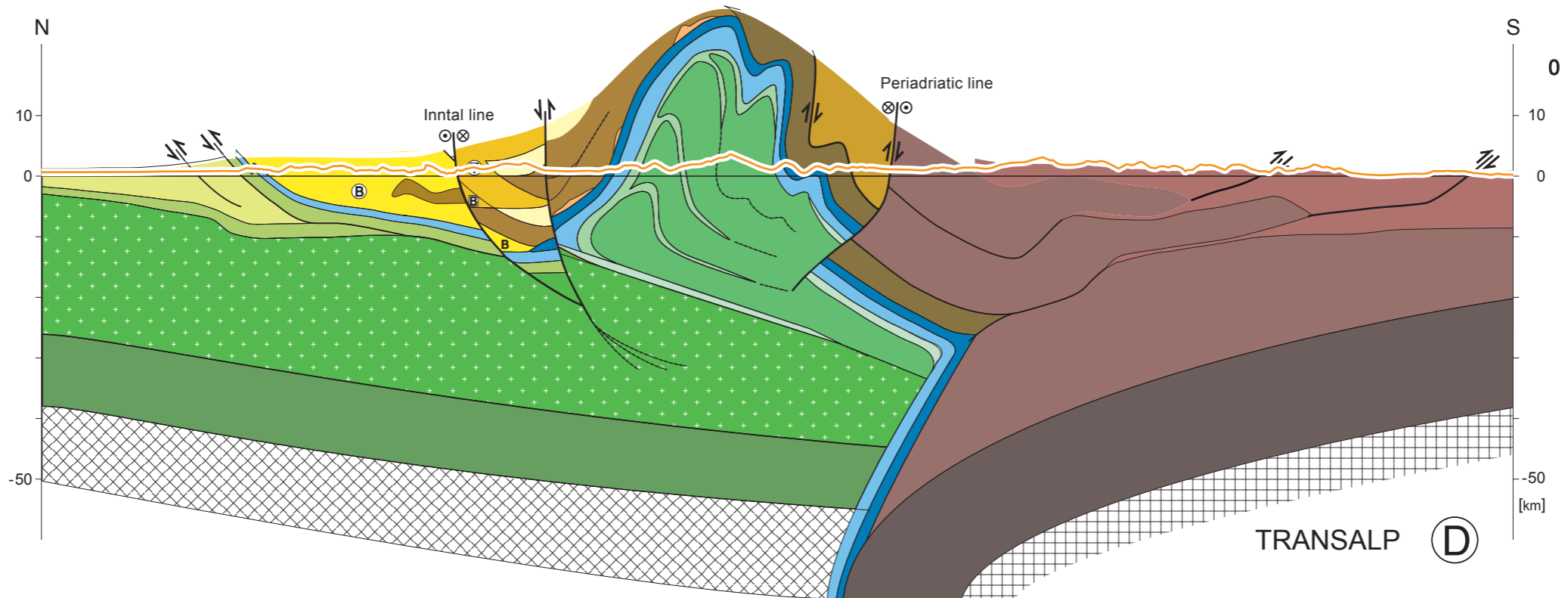
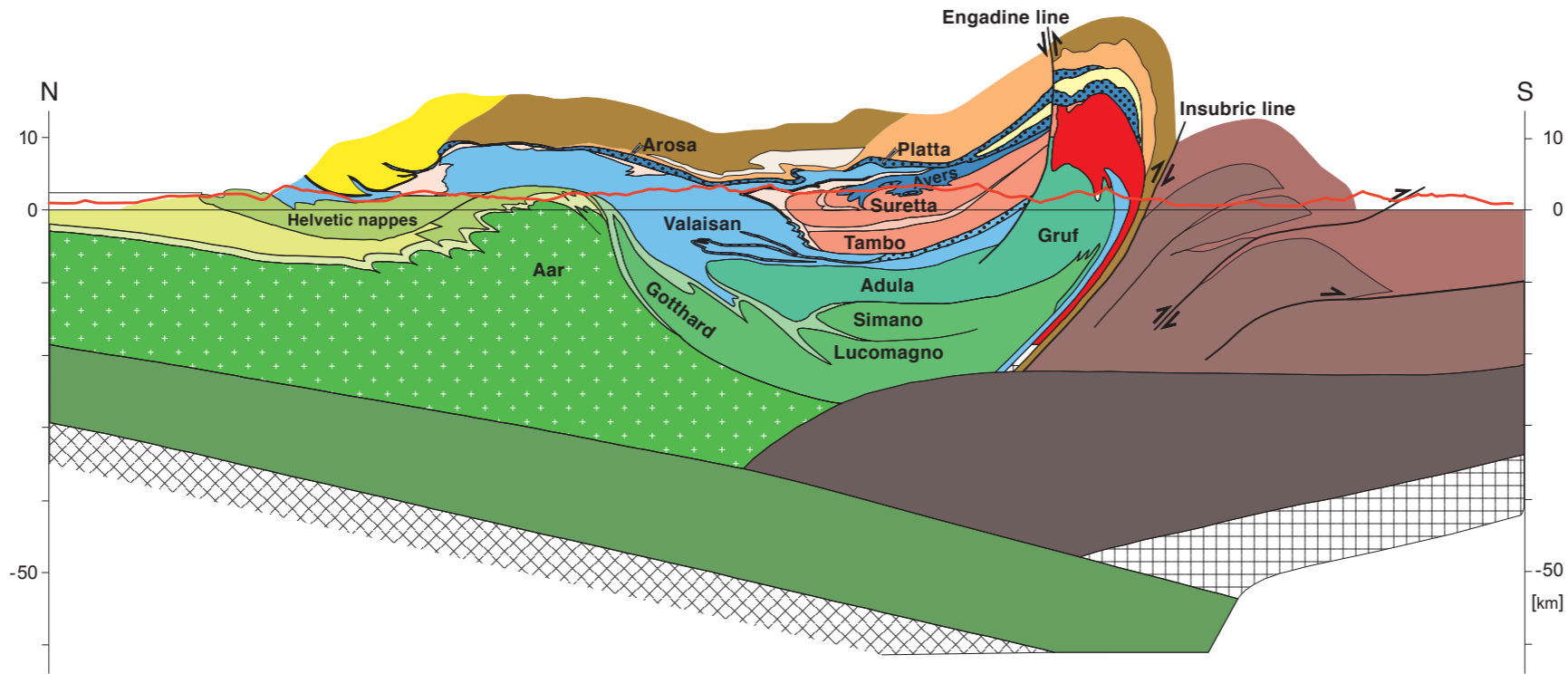
Tauern dome

Leopontine dome



Oberhänsli et al. 2004  
Bousquet et al. 2008

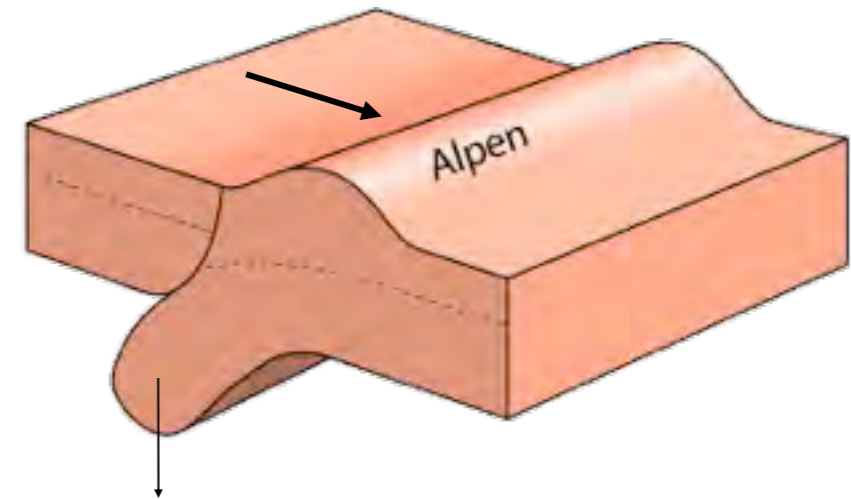
# Relation high T metamorphism & crustal accretion



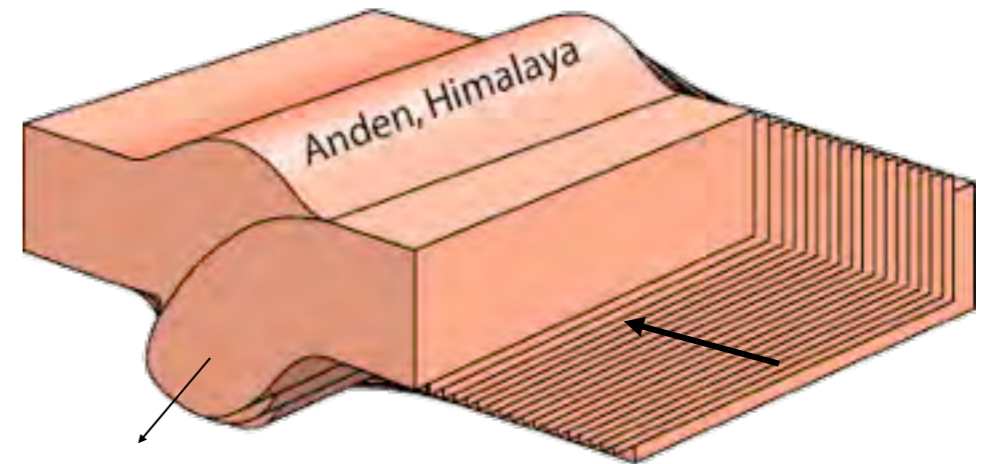
Schmid et al., 2004

# Different types of collision

**Unlike Himalayan type orogens, the Western and Central Alps ride on the subducting plate**



Adria is following rolling back European slab



Europe has not moved S  
=> roll back and slab retreat

