Collapse and Rifting in the South China Sea*

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Abstract

The South China Sea margin underwent extensional processes for an abnormally long time. For this reason and also because the tectonic events recorded in the sediments are diachronous, the rifting has been much debated. The former margin was situated during Mesozoic times on the upper plate of a subduction zone. It later evolved as a collapsed continental basin on the edge of the Yenshanian Andean-type orogeny, which has been since then considerably eroded, exposing only granites and relicts of Cretaceous molasse basins. The continental crust rifted from the Paleocene to the mid-Oligocene in the eastern part, and the rifting continued until the middle Miocene in the SW, in an environment of marginal basin opened in the midst of the lower plate.

Actually, the former Sundaland promontory, which was surrounded by a large subduction zone, shows early stages of extension marked by the presence of molasses-type deposits, although rifting is clearly documented since the early Eocene only. It suspected that the Molasse deposits have suffered ductile deformation along low- angle faults. During the rifting sensu stricto, the upper crust was extremely stretched for a large time span (early Eocene to middle Miocene) and was sustained near sea level during the entire duration of the rifting process.

The large Jurassic and Cretaceous granitic bodies conditioned the location of the extension via large detachments and normal faults, so that the present-day morphology of the sea floor still reflects the location of the granites on which large reefal platforms developed. In other cases earlier broad folds attributed either to Triassic/Early Jurassic or to Mid-Cretaceous compression condition the detachments and show large roll-over structures. Some of these features, difficult to observe in the field, are preserved in the San Shui (Pearl River) in China.

Some sub-basins of the South China Sea are marked by extremely stretched crust (Phu Khanh, West Natuna, NW Palawan, Tainan) where upper mantle may be in contact with the sediments. Therefore, we distinguish between an early extensional process which started during the Late Cretaceous and possibly Paleocene during which the basement and the Mesozoic granitoids where exhumed, and an early Eocene to middle Miocene rifting, which thinned the crust to 12km-thick over a large area by a boudinage process.

In this system, the reefs are often preserved on top of the boudins. The extension continued long after the beginning of the spreading and continued even after the regional MMU (varying from 15 to 12Ma). Extensional areas are found even in the oceanic crust with low-angle normal faults. This structural configuration, together with the long-lived rifting stage represent an offshore Basin and Range onto which many small basins could develop in a sub-continental/shallow-marine environment. This environment was accessible by quartz-rich clastic input that originated from the erosion of the granitic province formed during the early subduction stage of the South China Sea region.

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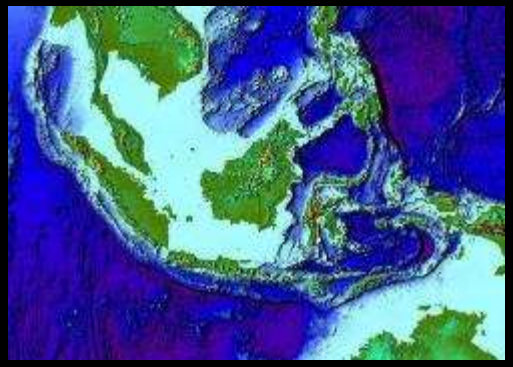
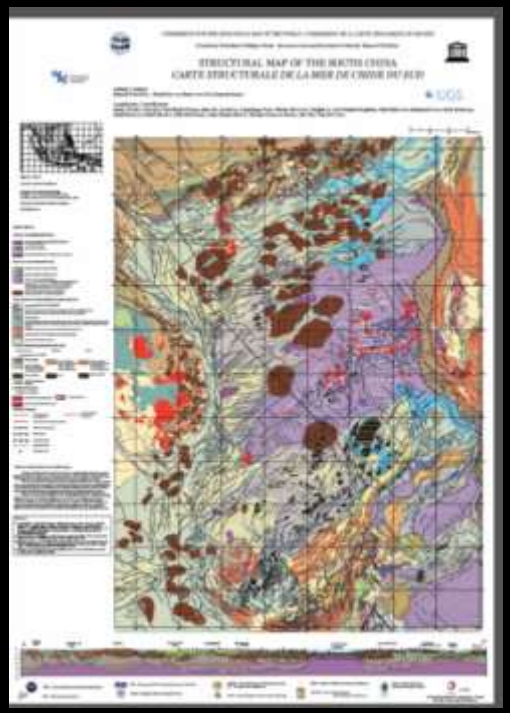
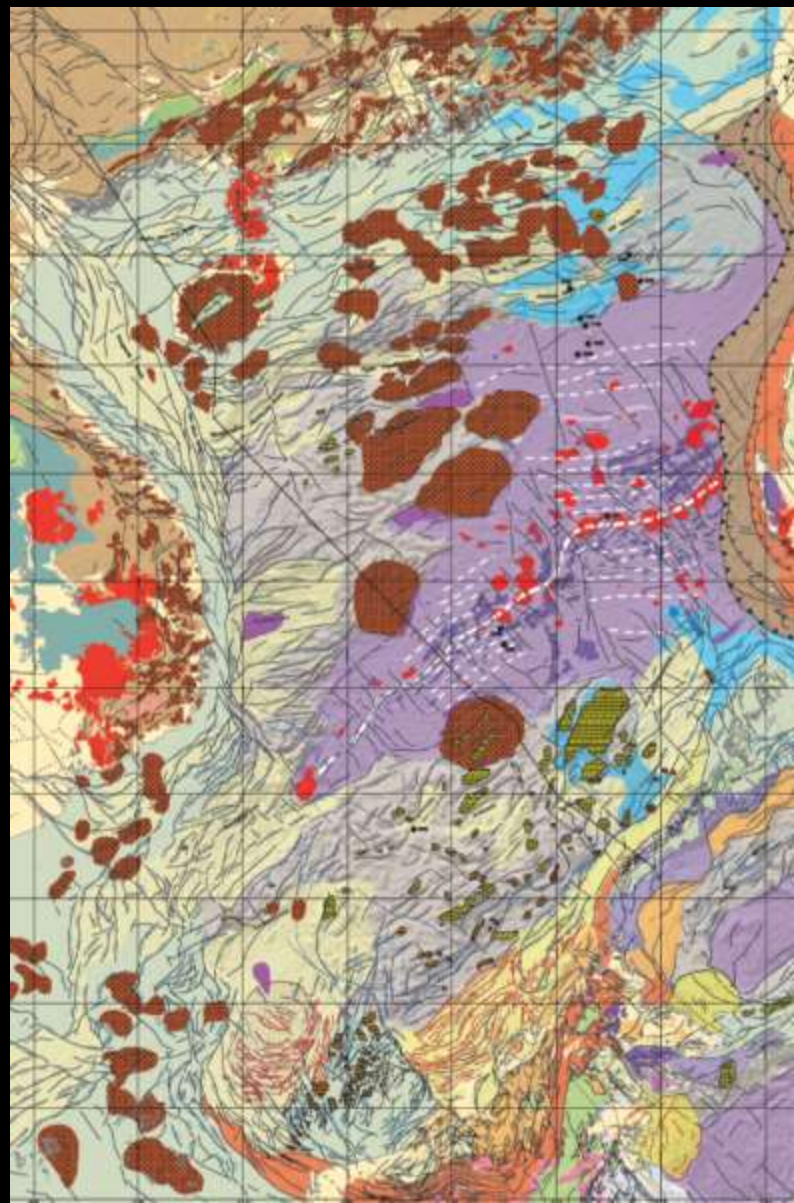






GRI

cnrs Ens TOTAL BGR

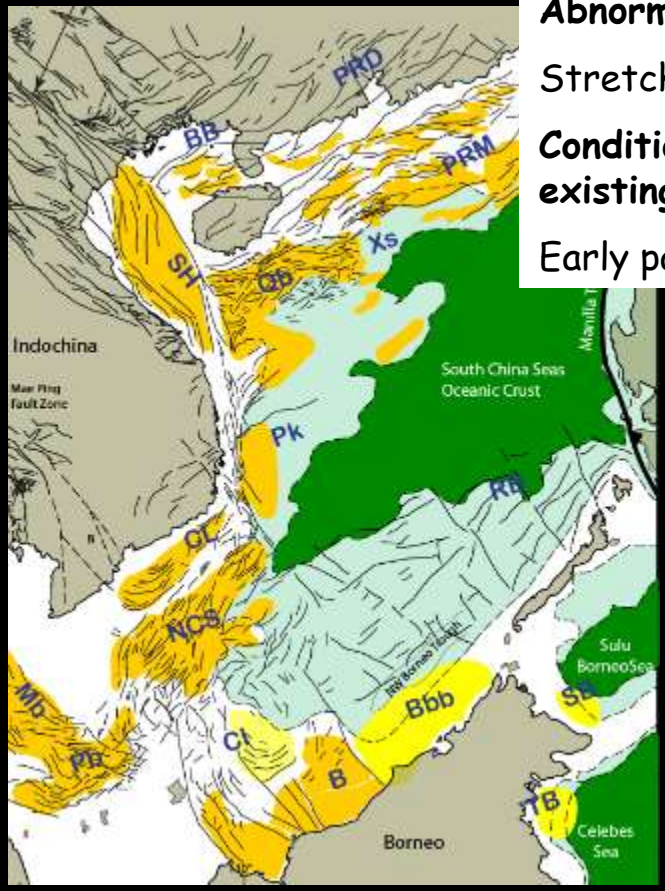
Pubellier et al., CGMW in review

Abnormally long extension,

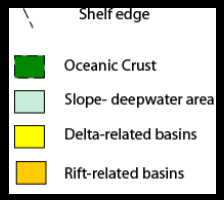
Stretching (B&R)

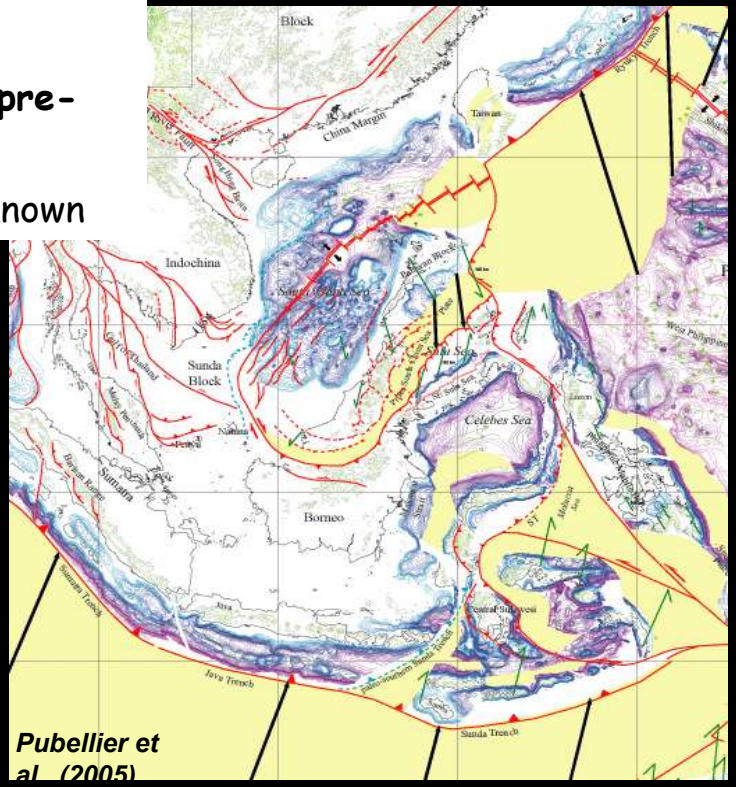
Conditionned by reactivation of pre-existing crustal fabric

Early part of the story is poorly known



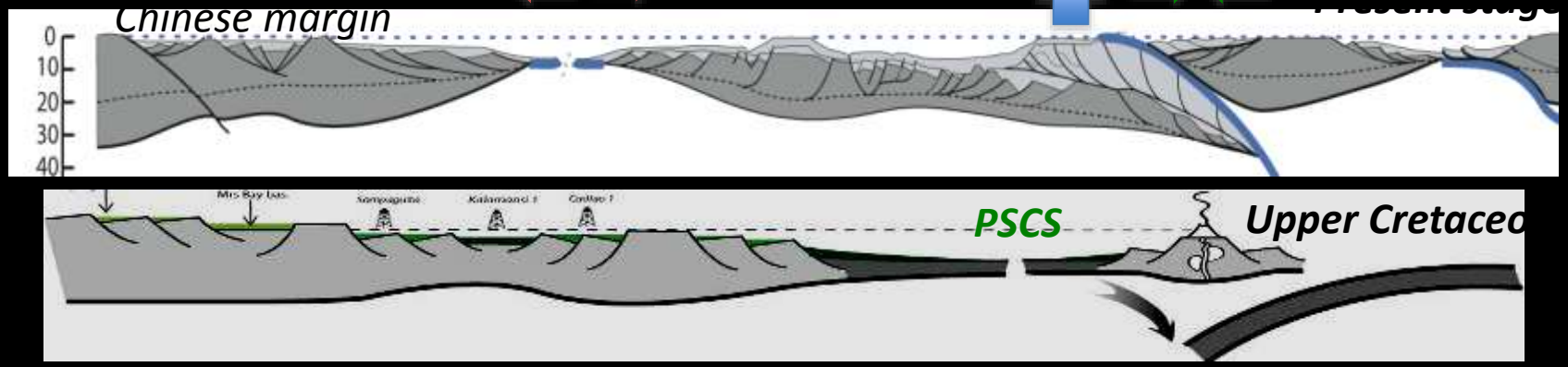
Pubellier et Morley, (2014)





Pubellier et al., (2005)

Pubellier et al., 2005

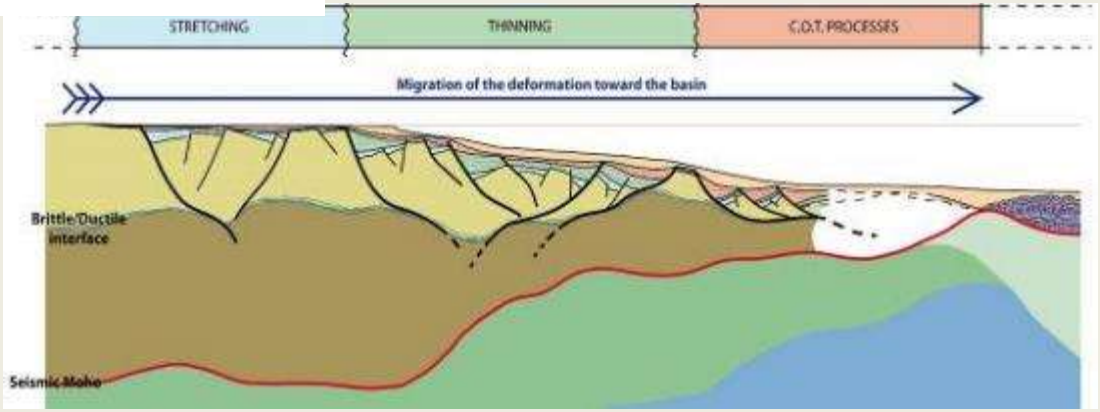


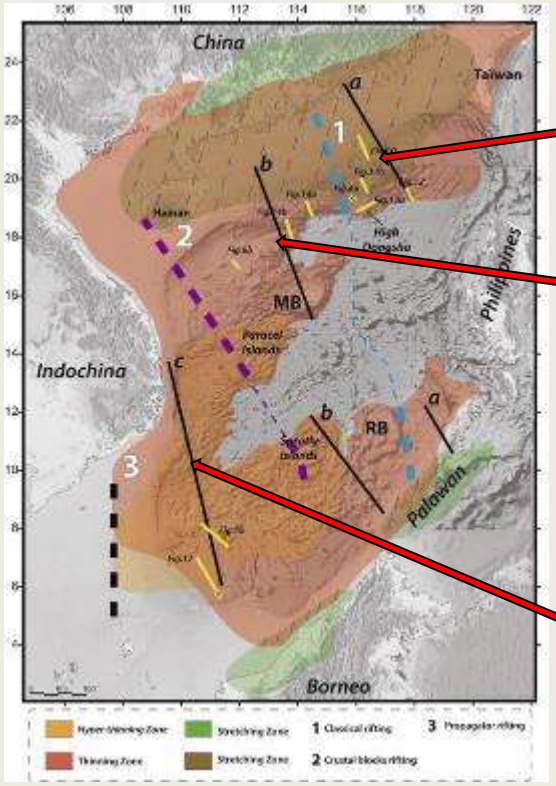
The rifting style is strongly influenced by the initial structure of the margin

Margin « common » with progressive stretching

Strectching with crustal boudinage

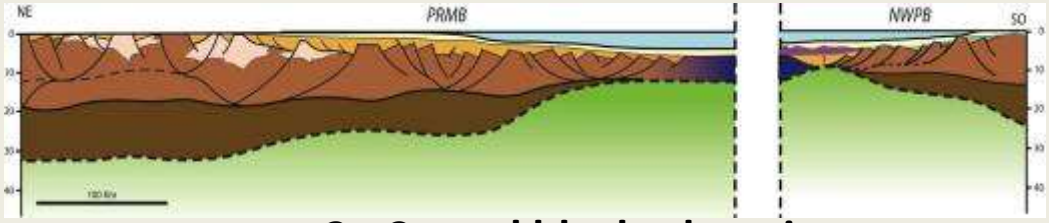
Hyper-extension with exhumation of mantle



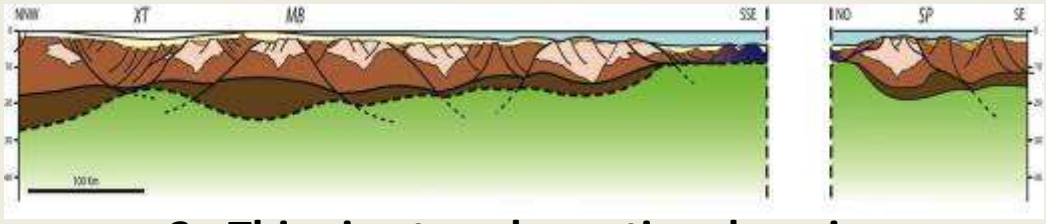


Savva et al., (2014)

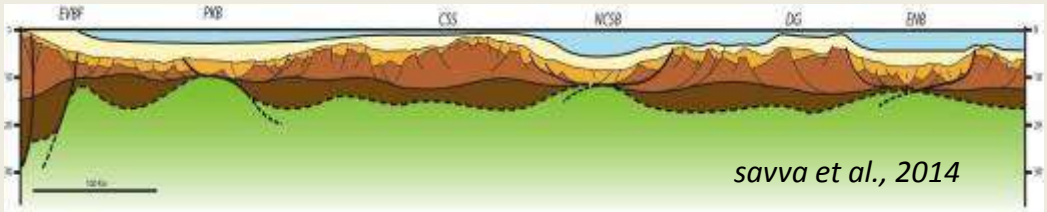
1 : Standard domain



2 : Crustal blocks domain



3 : Thinning to exhumation domain

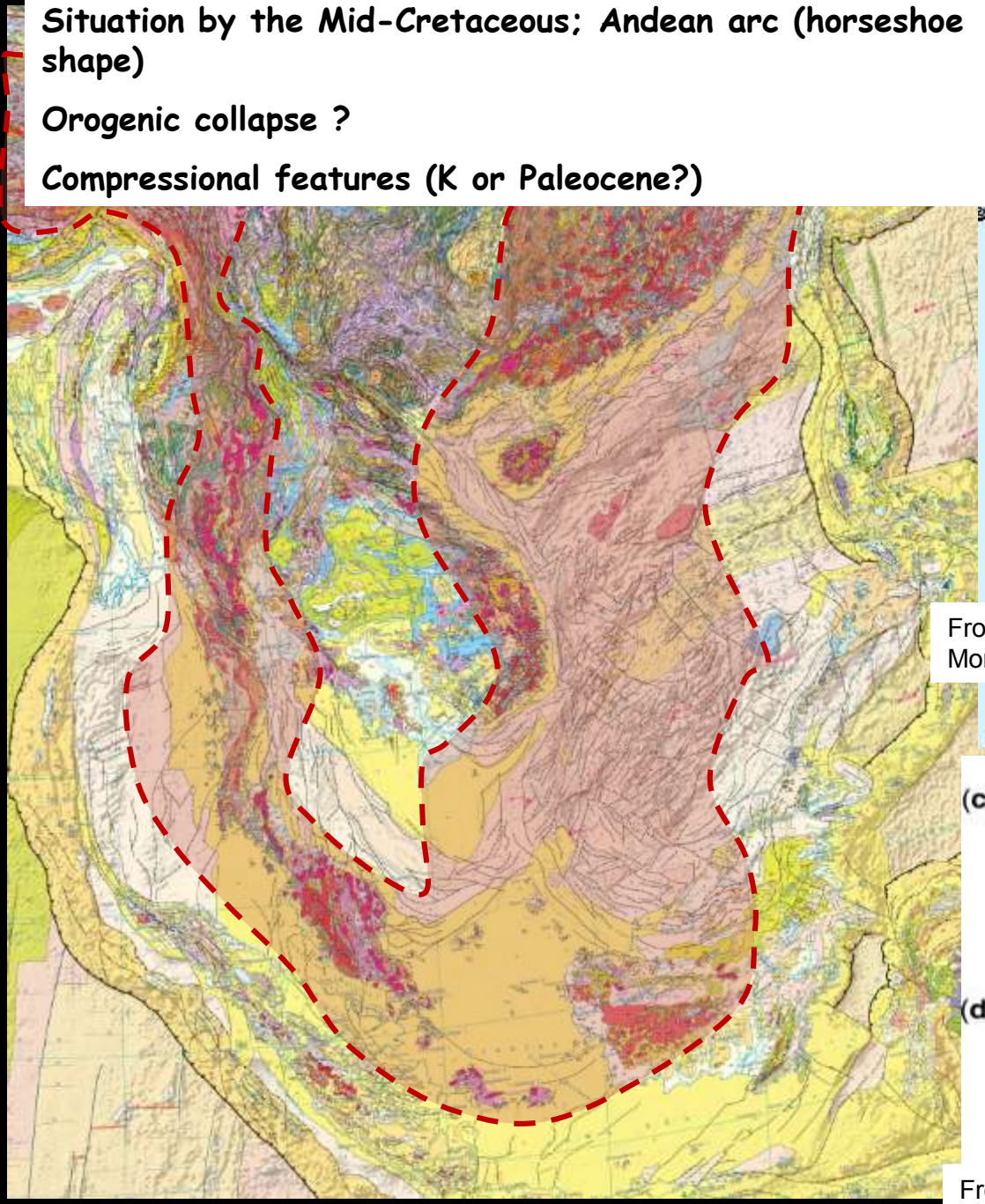


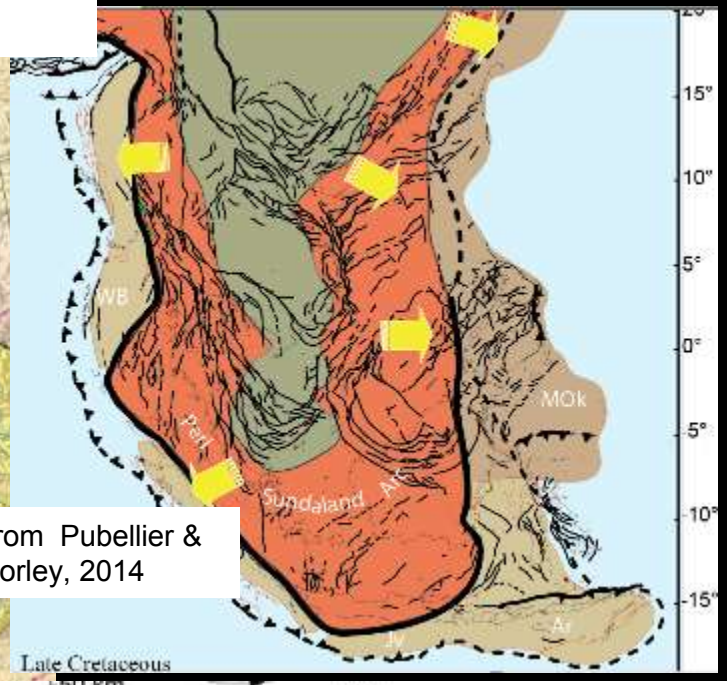
savva et al., 2014

Situation by the Mid-Cretaceous; Andean arc (horseshoe shape)

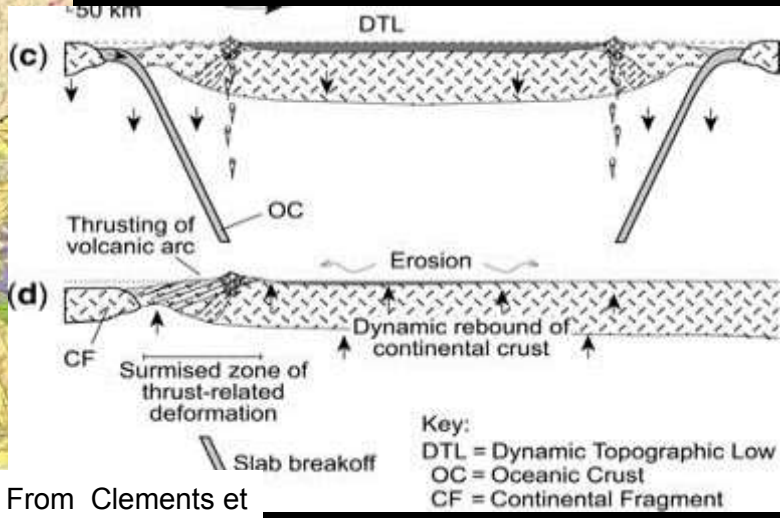
Orogenic collapse ?

Compressional features (K or Paleocene?)





From Pubellier & Morley, 2014

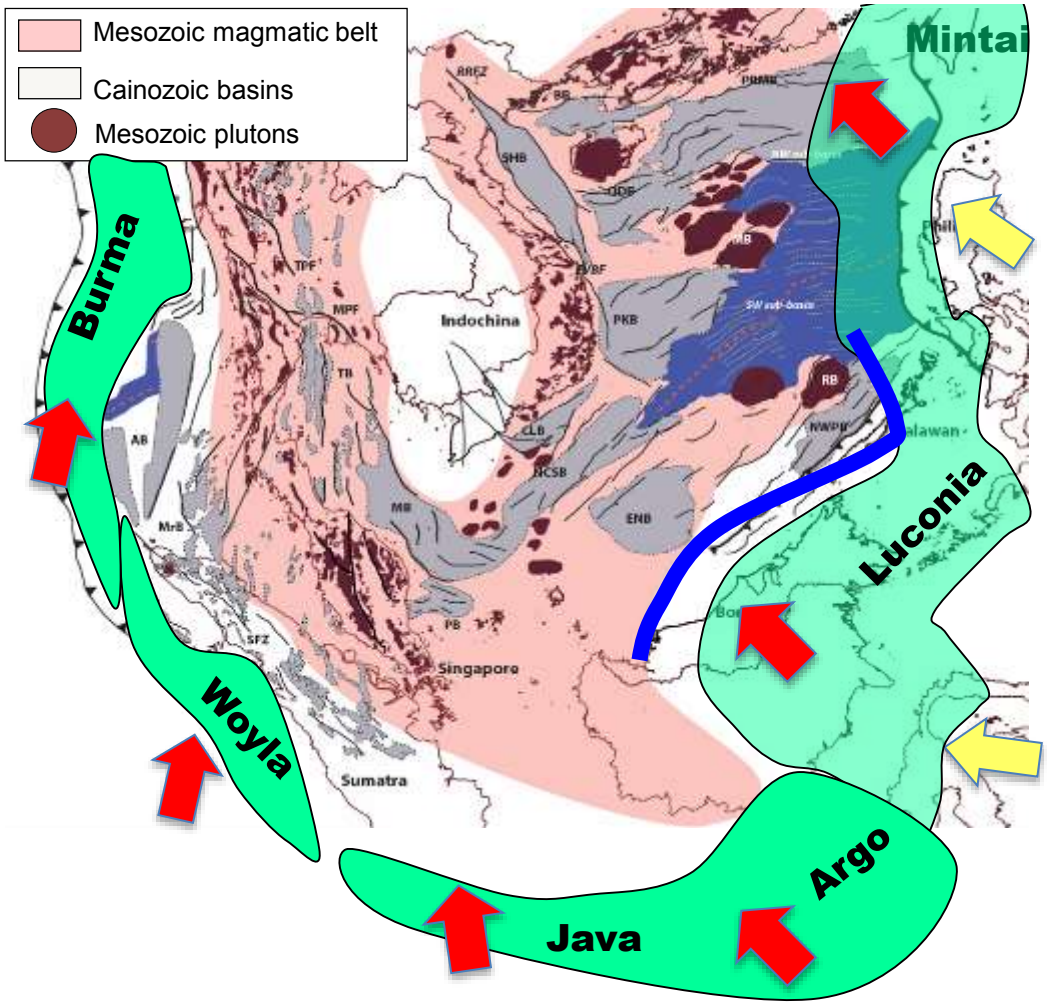


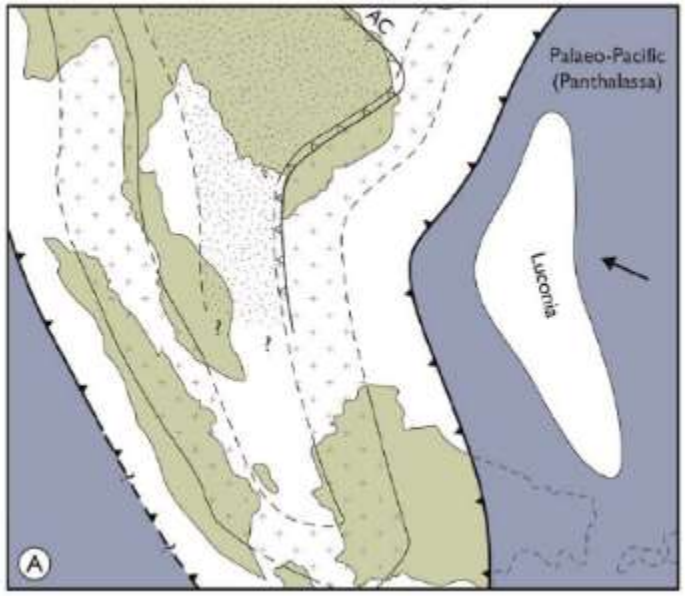
From Clements et al. 2011

Trying to make sense of the ages

Crustal blocks collision terminated the life of the Andean Belt

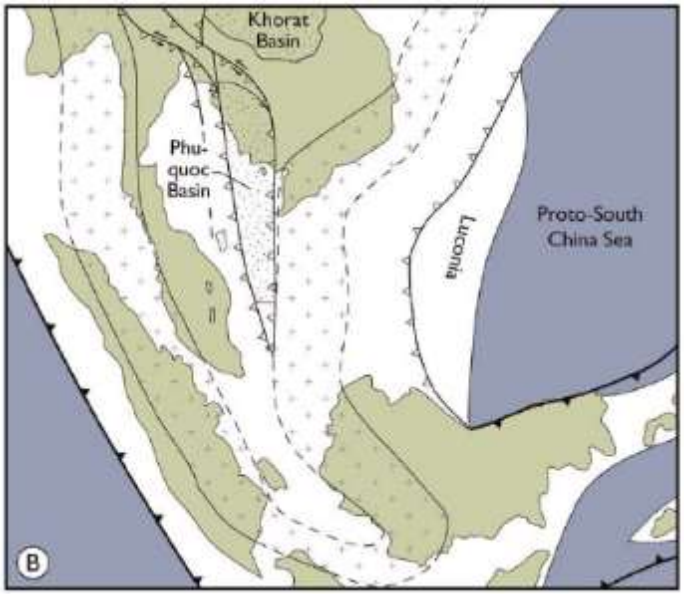
How do we position the PSCS?



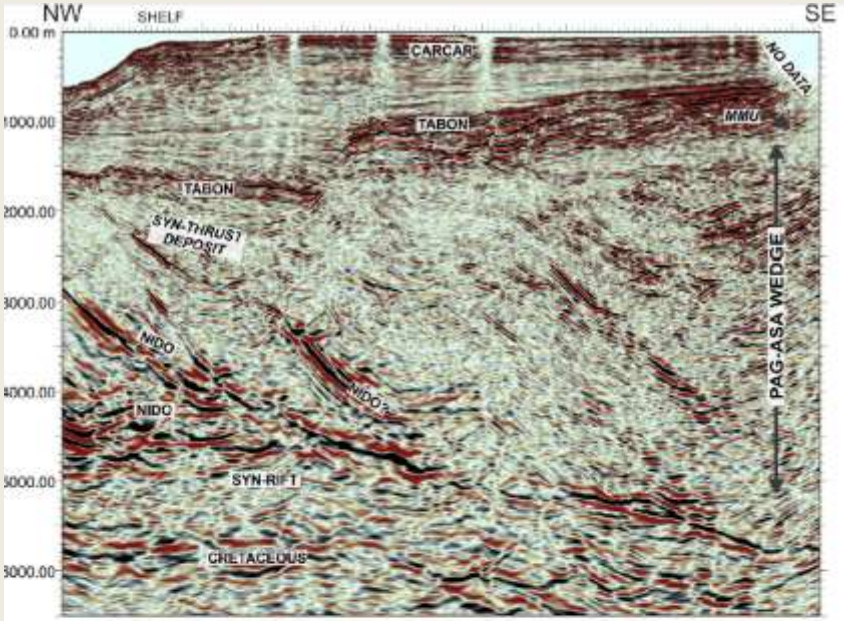


Most of these events are Late Cretaceous. However the PSCS is older (Albian)

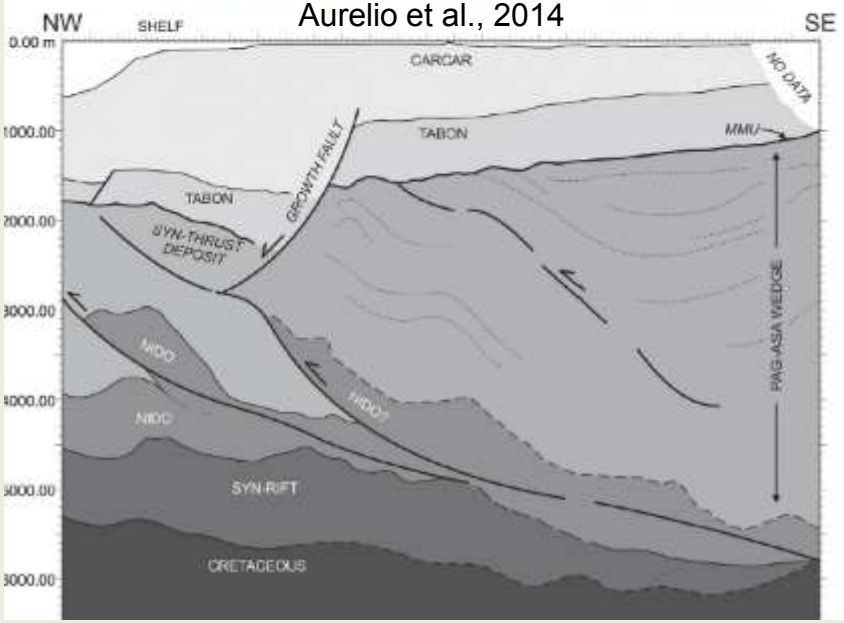
Fyhn, 2010



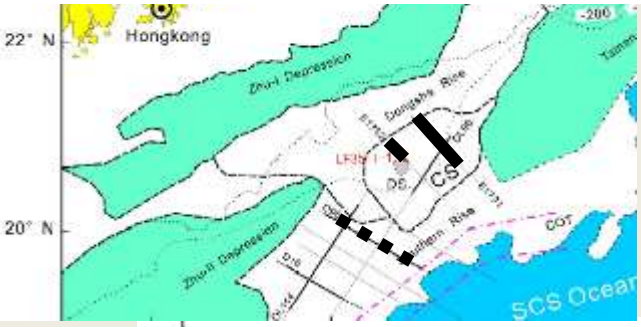
Radialarites in Palawan (Albian age)

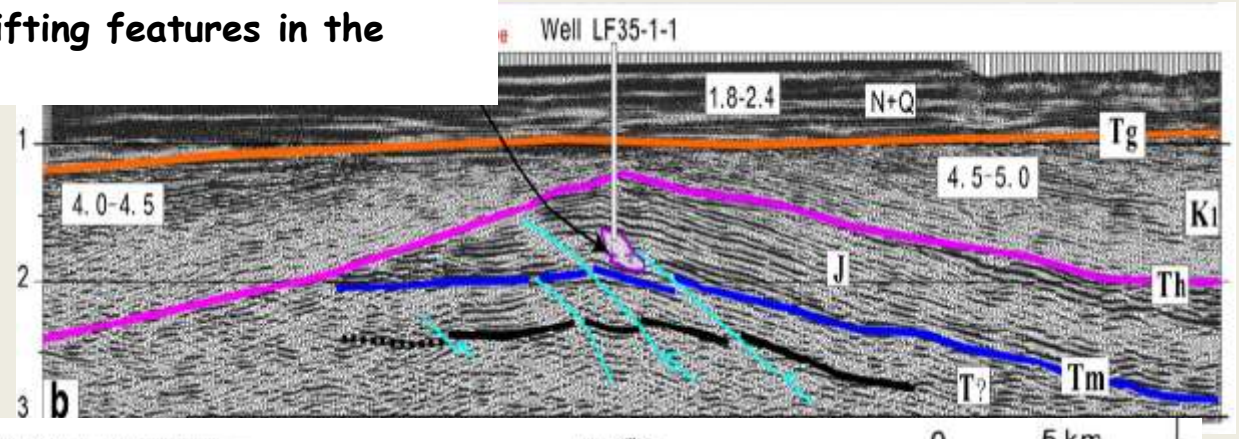


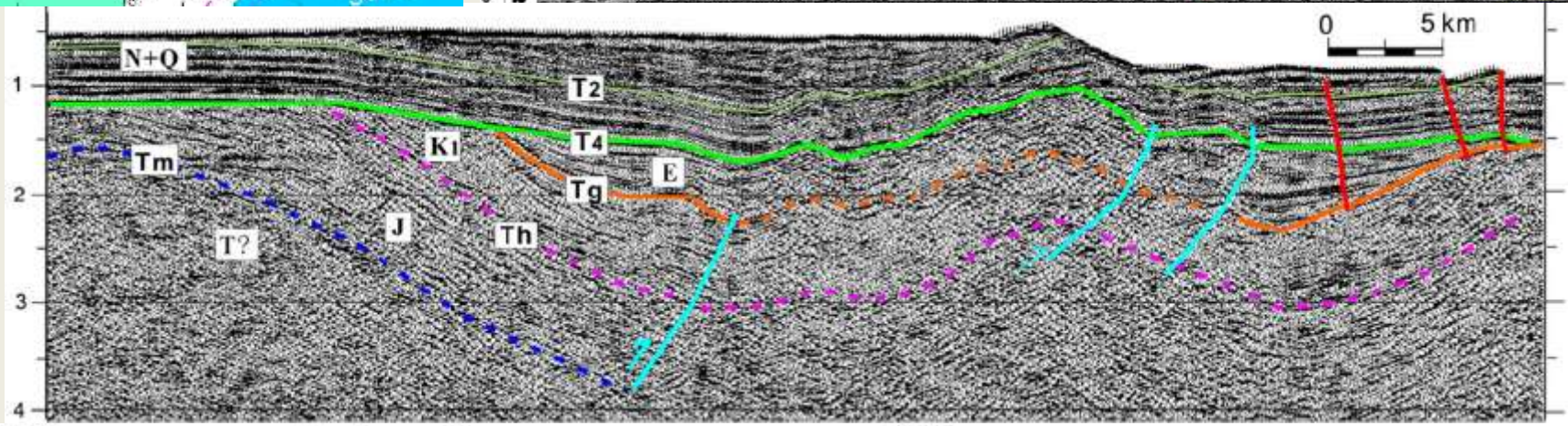
Aurelio et al., 2014

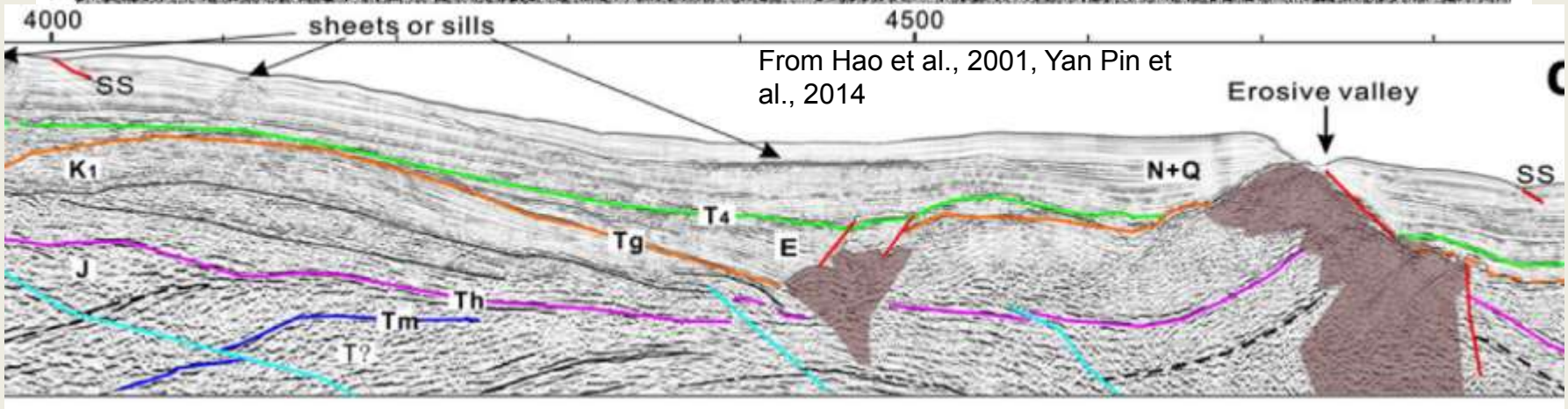


Compression sealed by the Tg. (Paleocene or Late Cretaceous) basin infill. Limited rifting features in the Dongsha region



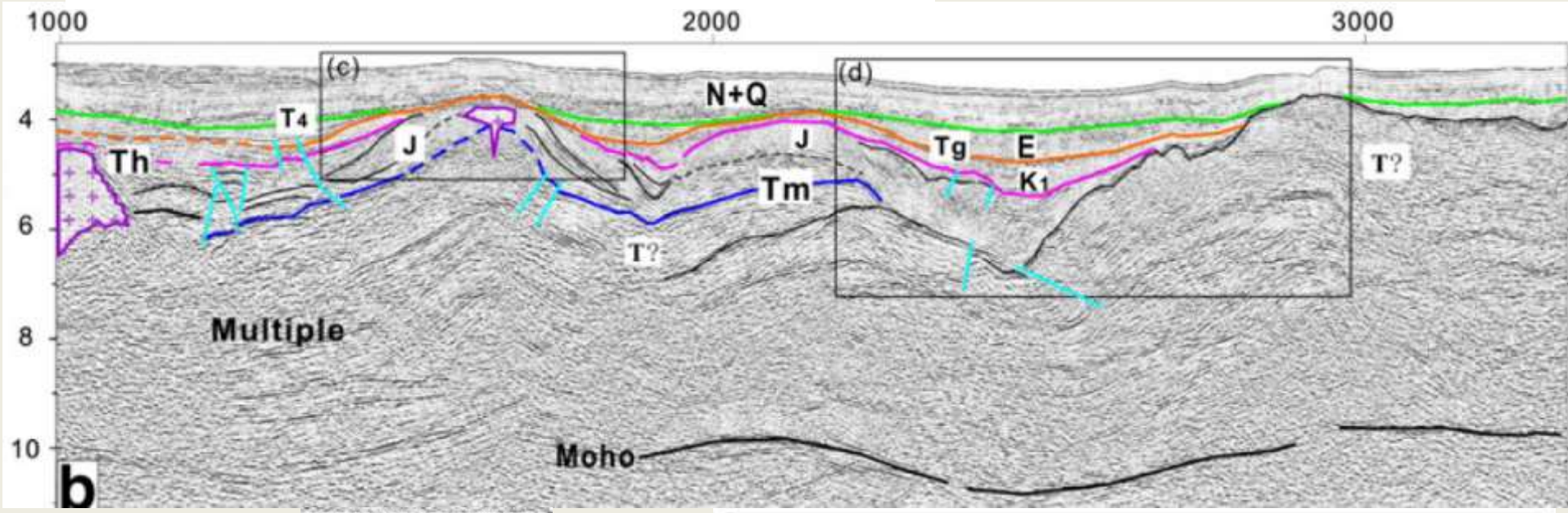


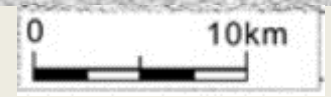




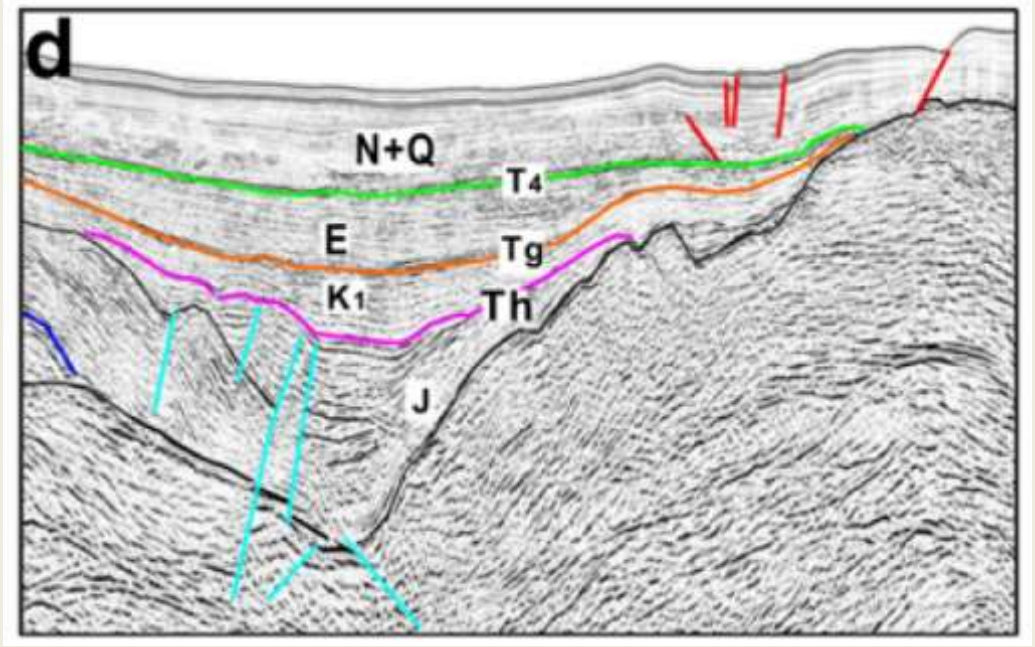
From Hao et al., 2001, Yan Pin et al., 2014

Clear Mesozoic compression post-Early Cretaceous on seismic

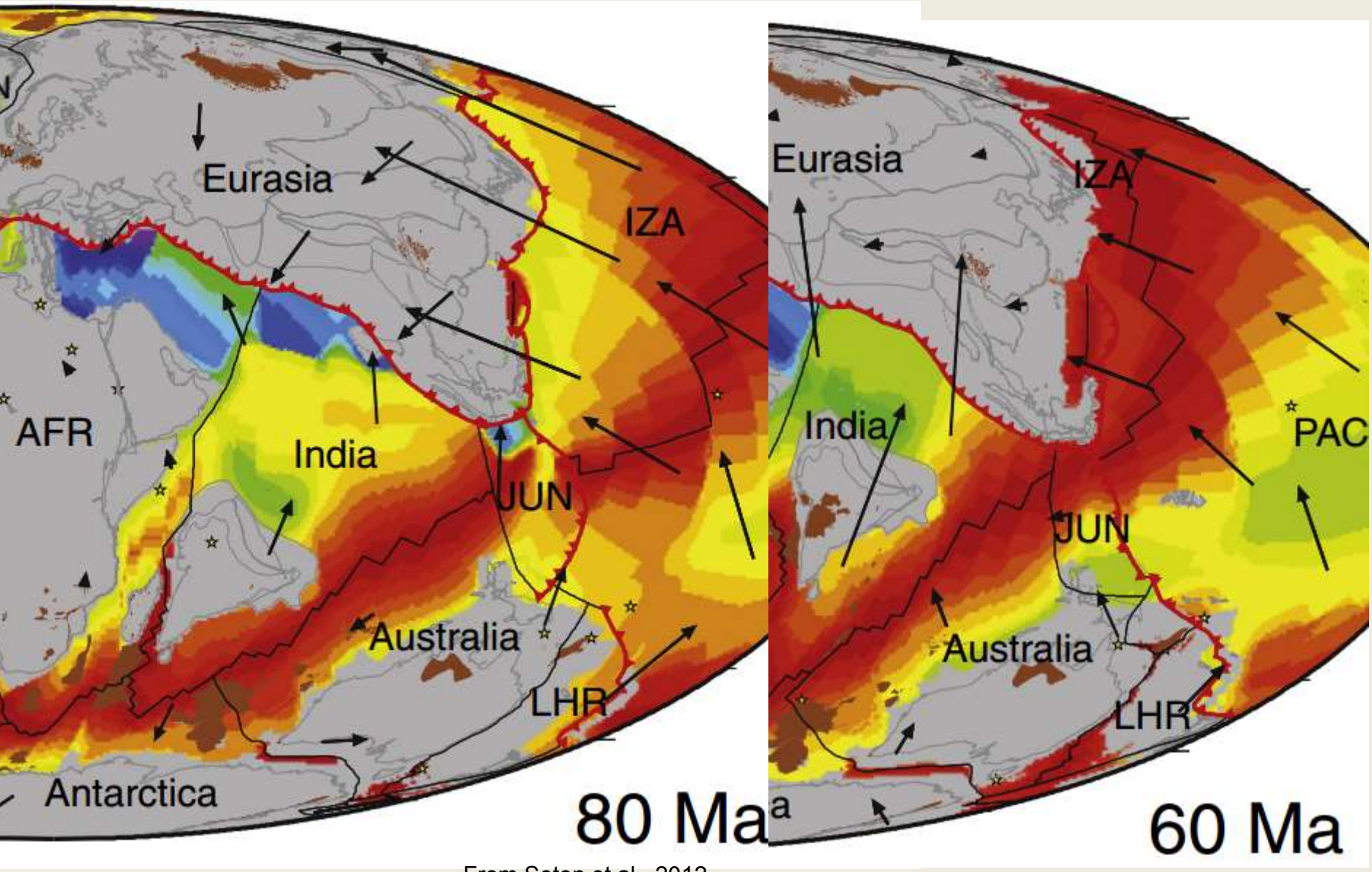




From Hao et al, 2001, Yan Pin et al., 2014



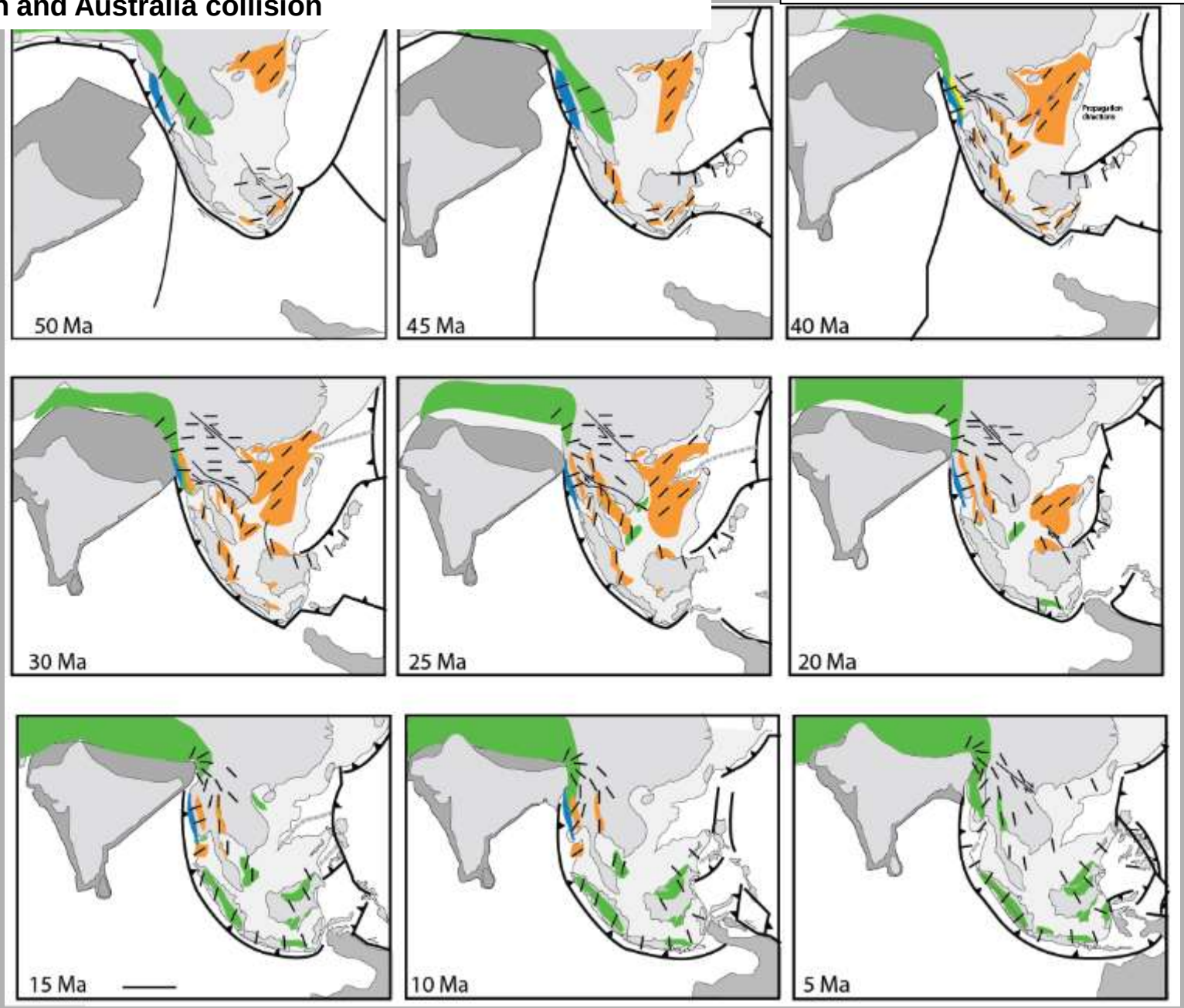
Maybe not only the compression. Should we take into account other factors (ridge subduction?)

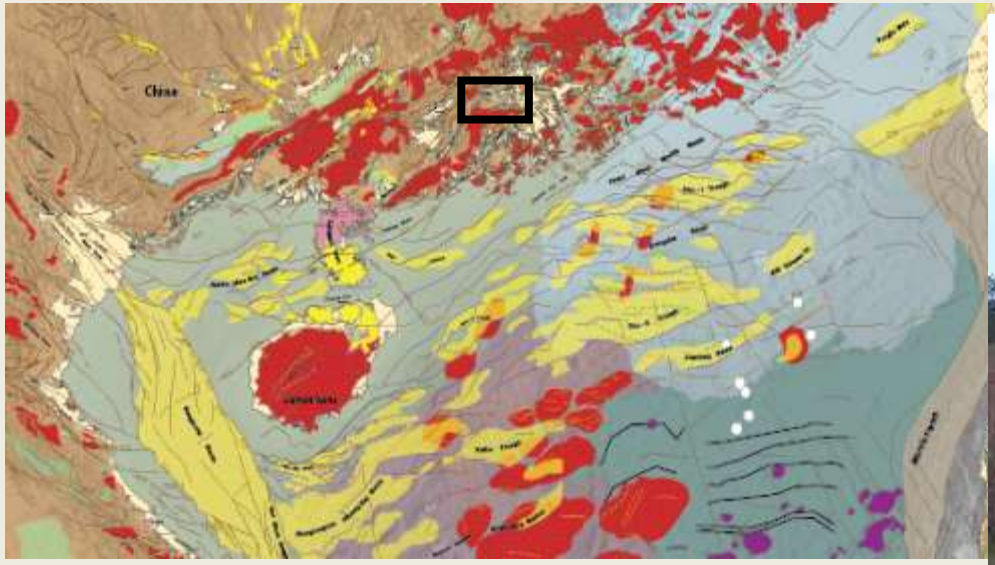


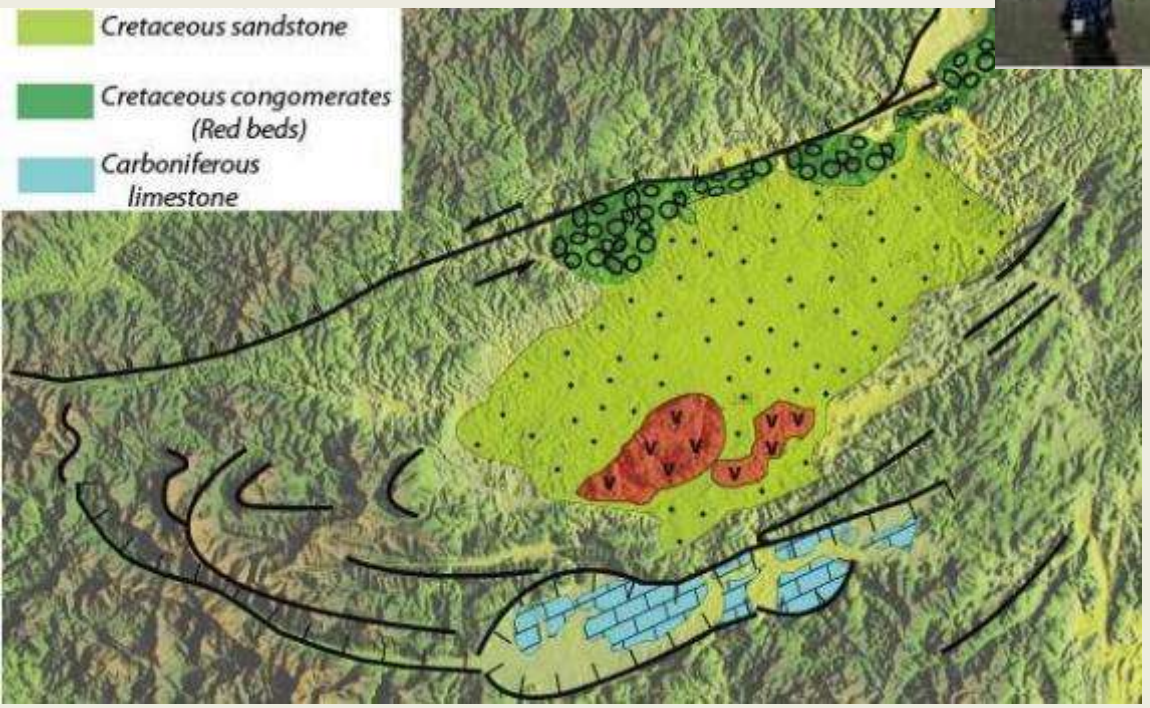
From Seton et al., 2012

The subduction roll-back during the period between India collision and Australia collision

From Pubellier & Morley., 2014

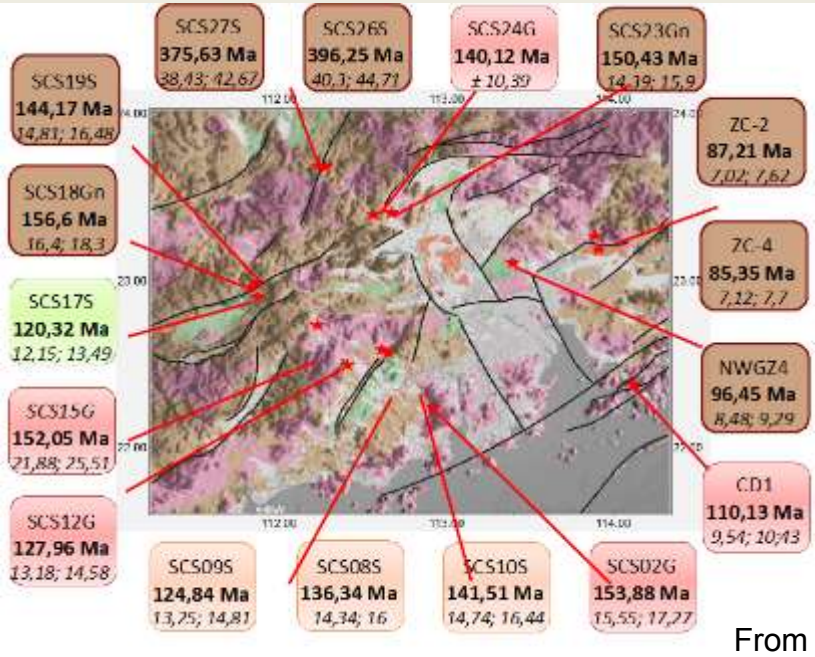




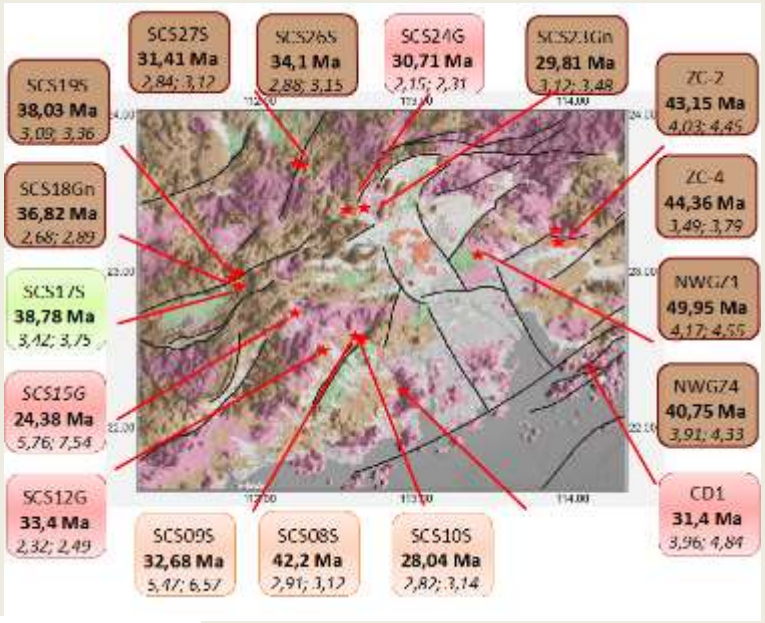


Cretaceous faults bordered most of the main grabens in PRMB

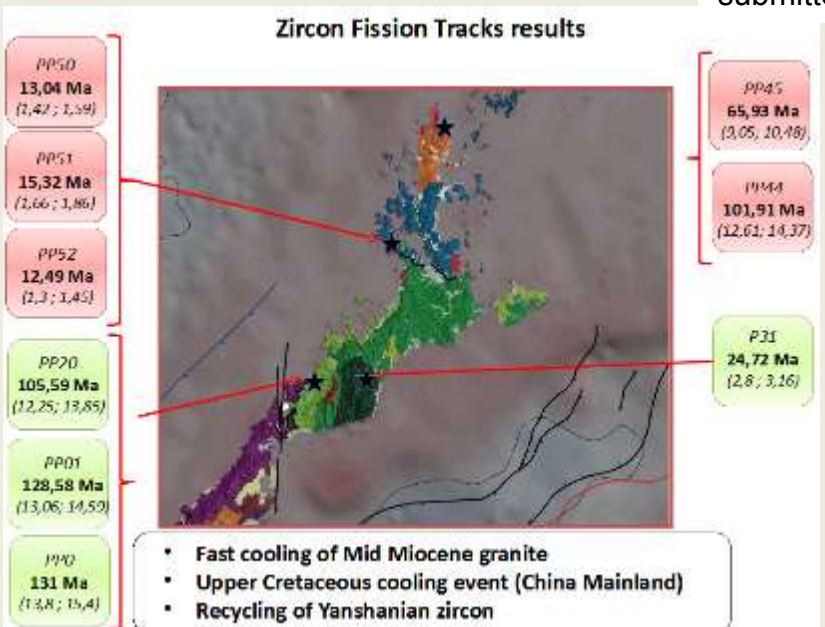
Zircon Fission Tracks: 125-100 Ma

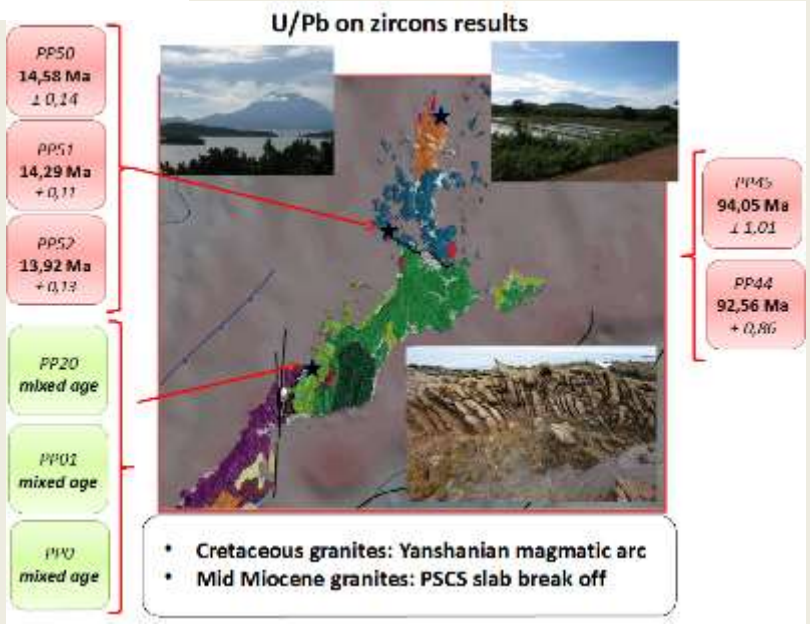


Apatite Fission Tracks : 45 - 20 Ma

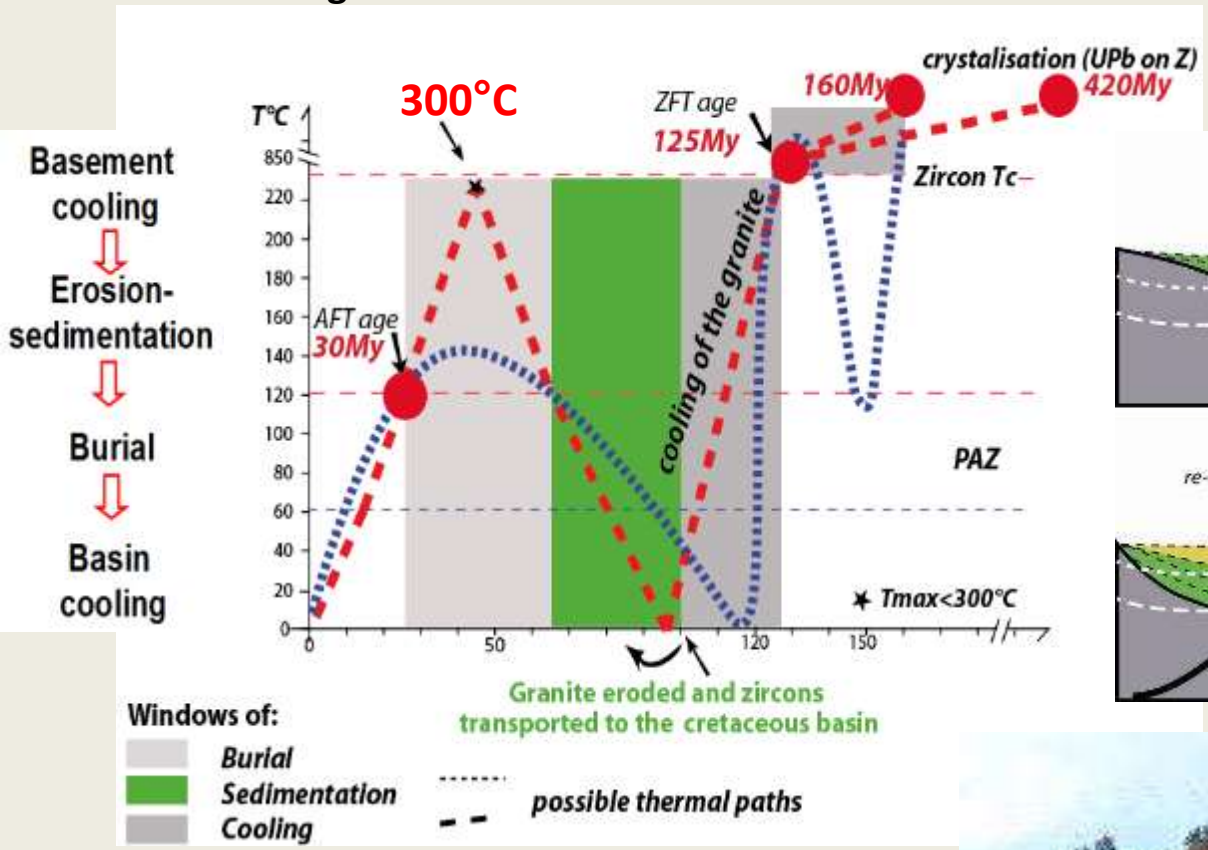


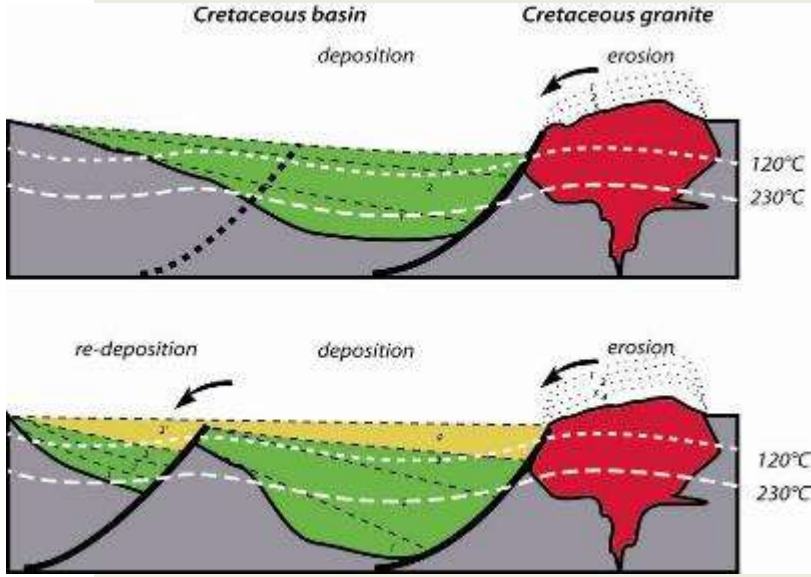
From Pubellier et al., unpublished; Zuo et al., submitted

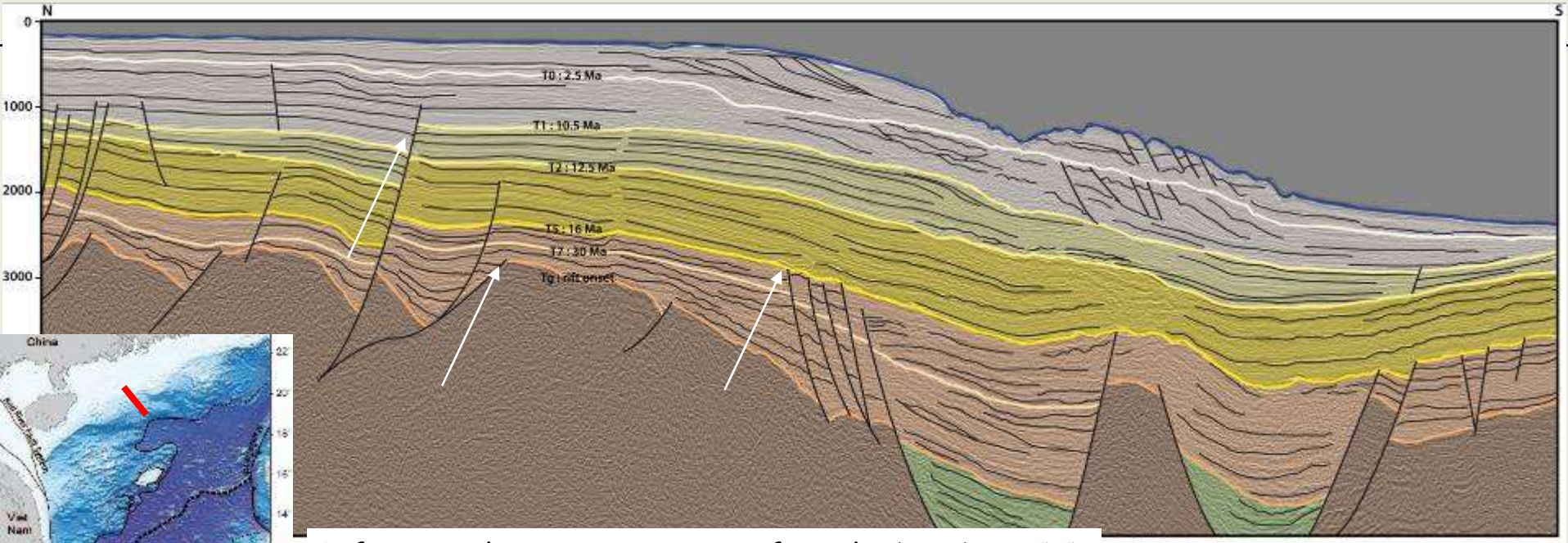




Thermal evolution of the northern margin



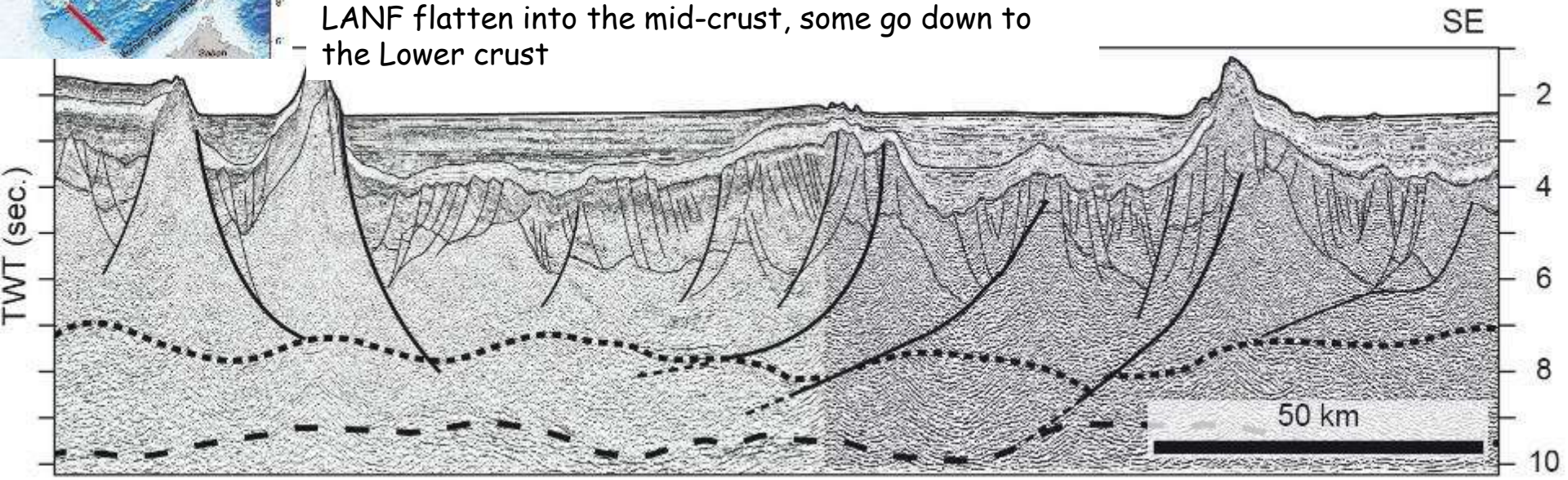




Rifting until 30 Ma, continues after the breakup 15.5 Ma, and extension continues even in the Miocene

LANF flatten into the mid-crust, some go down to the Lower crust

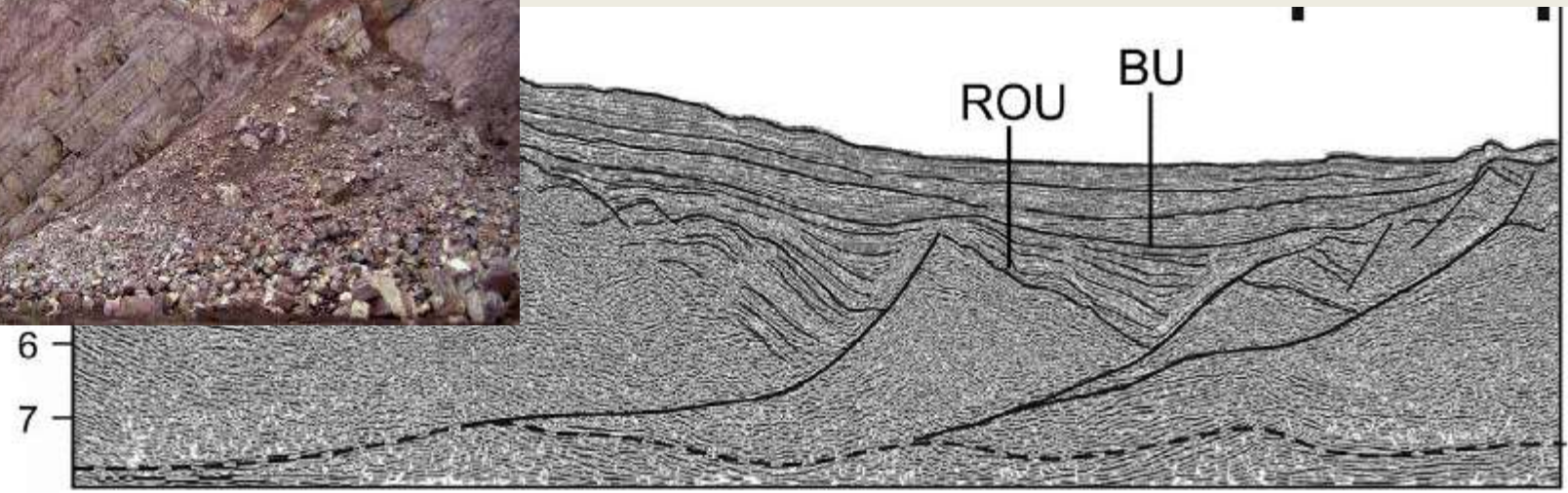
Savva, 2013, Ph.D; Franke et al., 2014.)

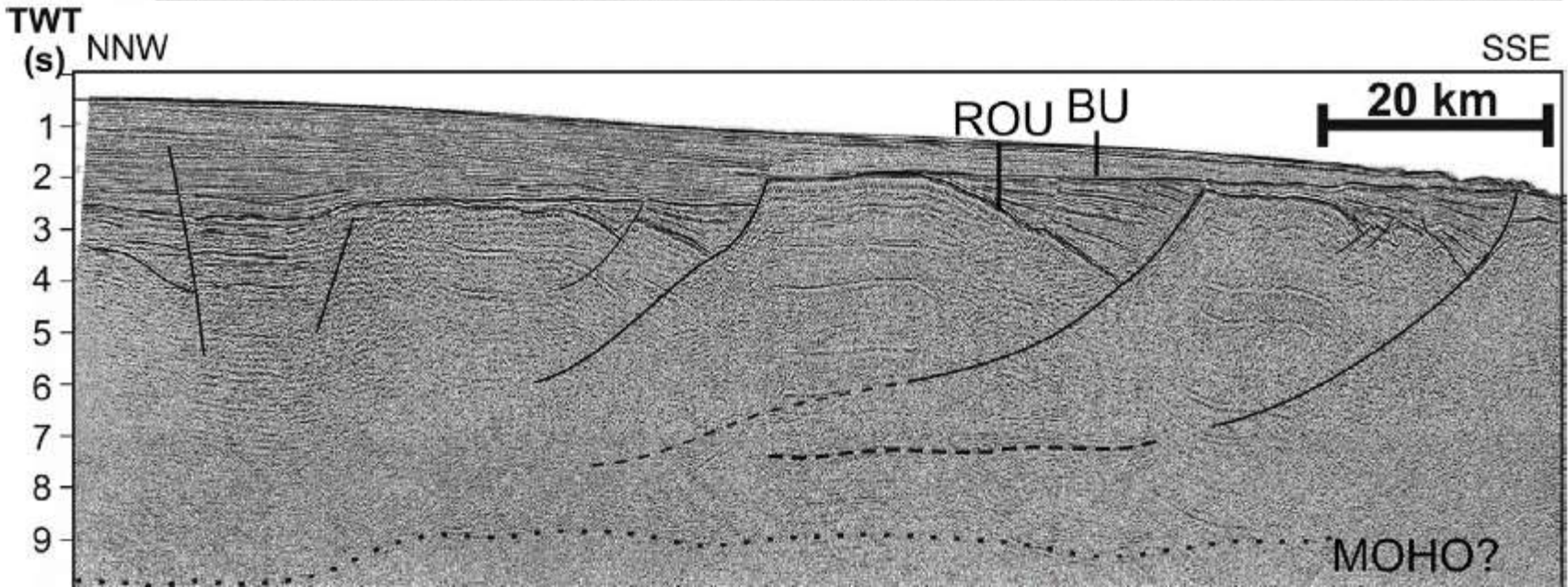


LANF and very tilted blocks (seismic and field)

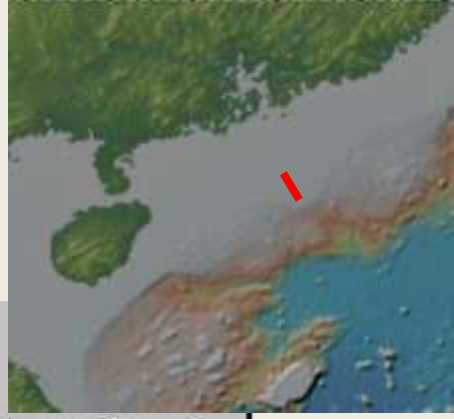
BU Breakup unc, ROU Regional onset unc

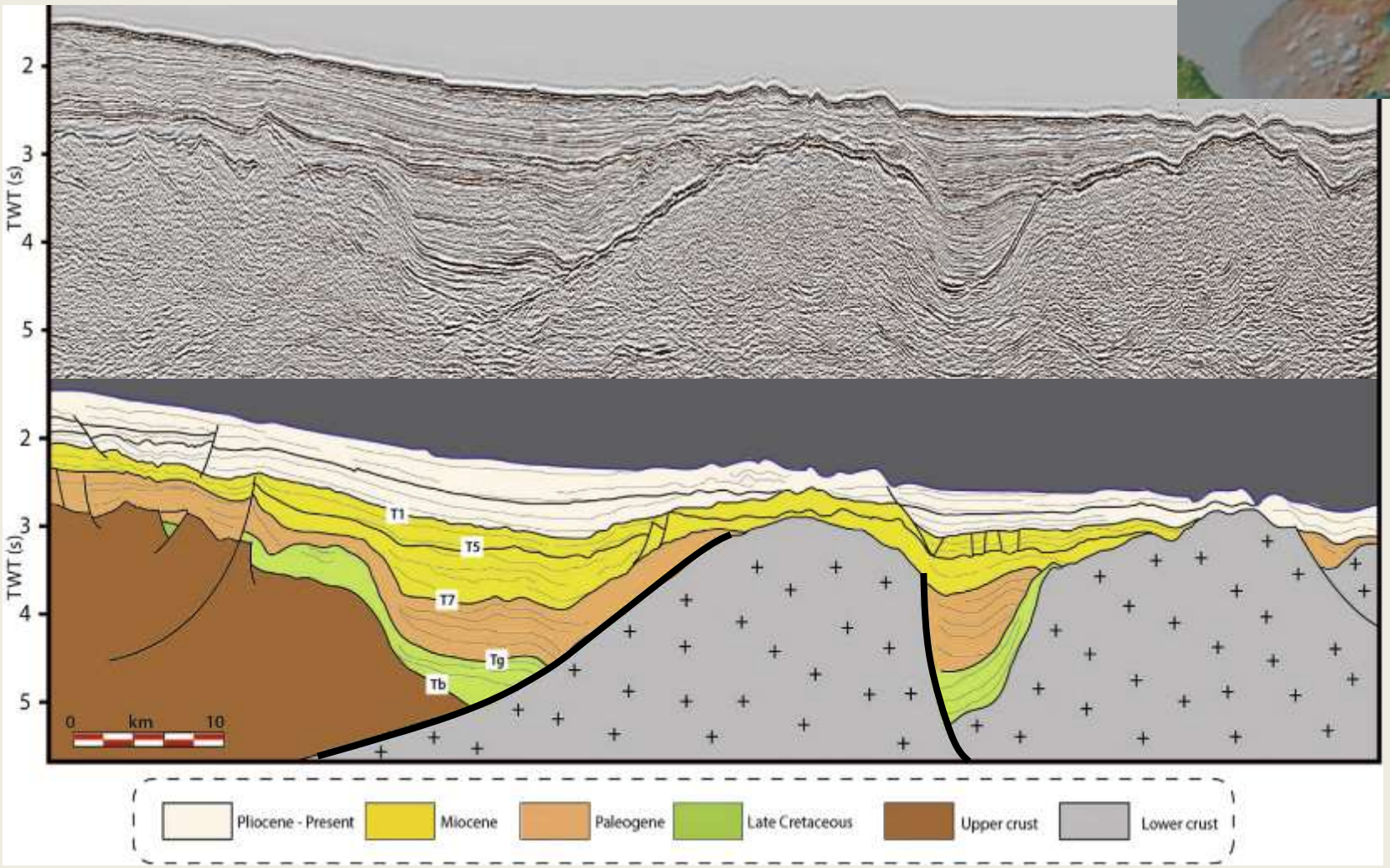
Franke et al., 2014.)

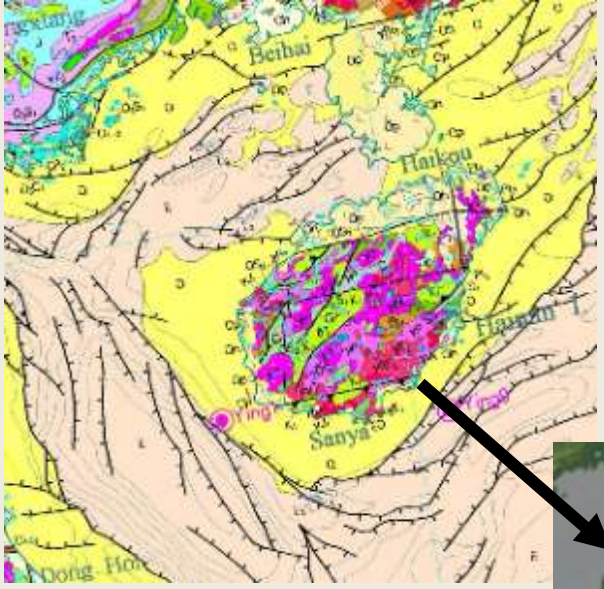


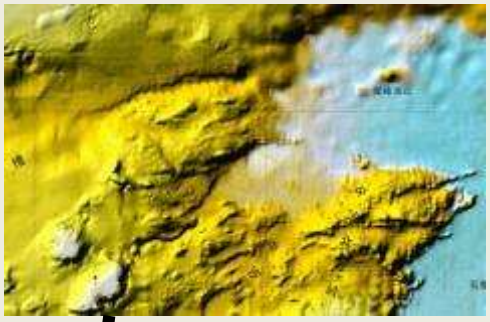


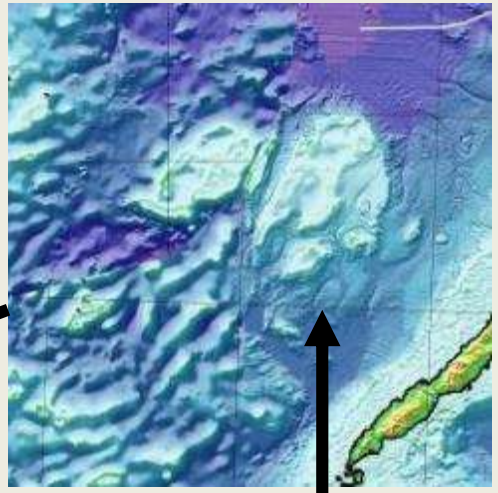
Modified from Savva et al., 2014.)

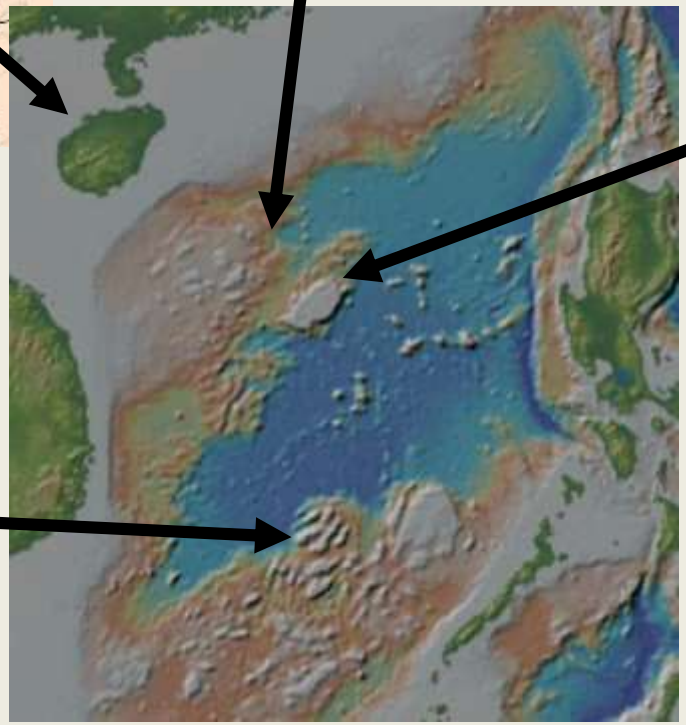


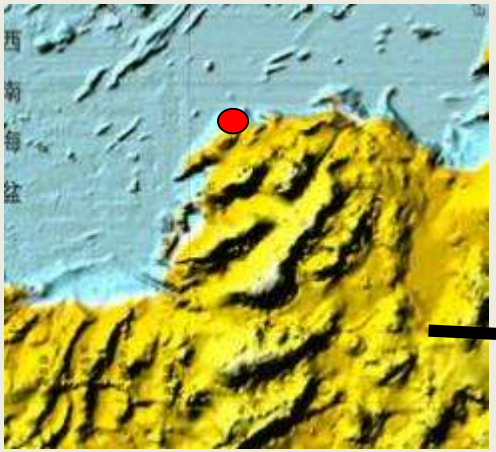


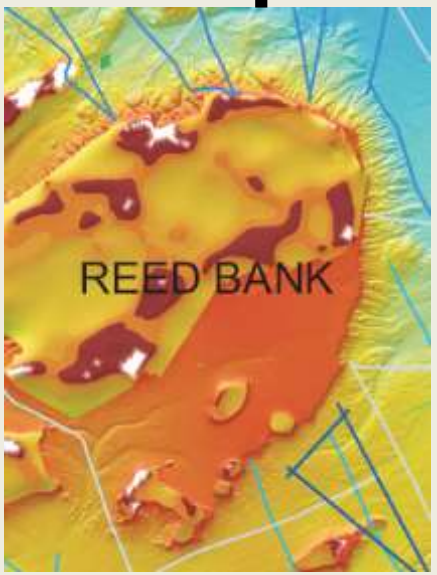






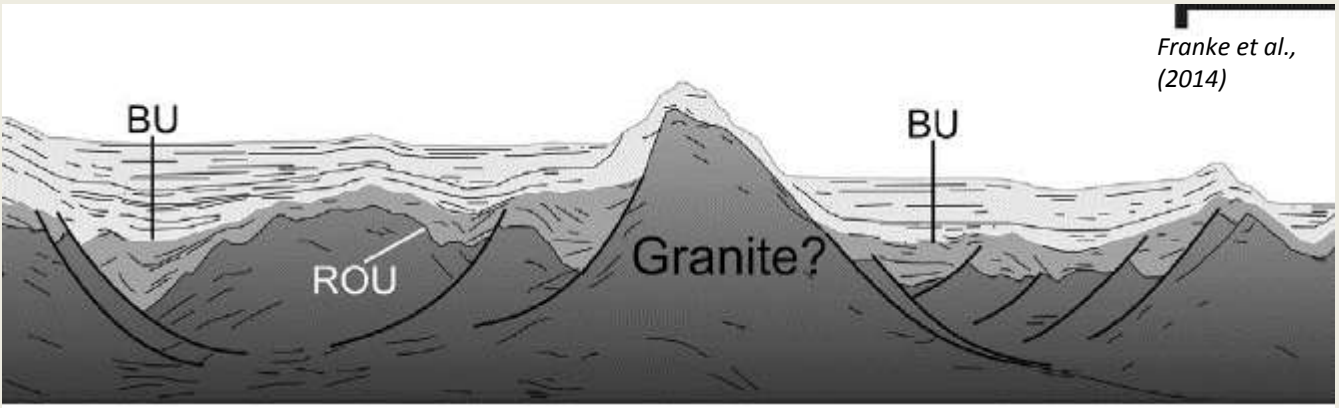






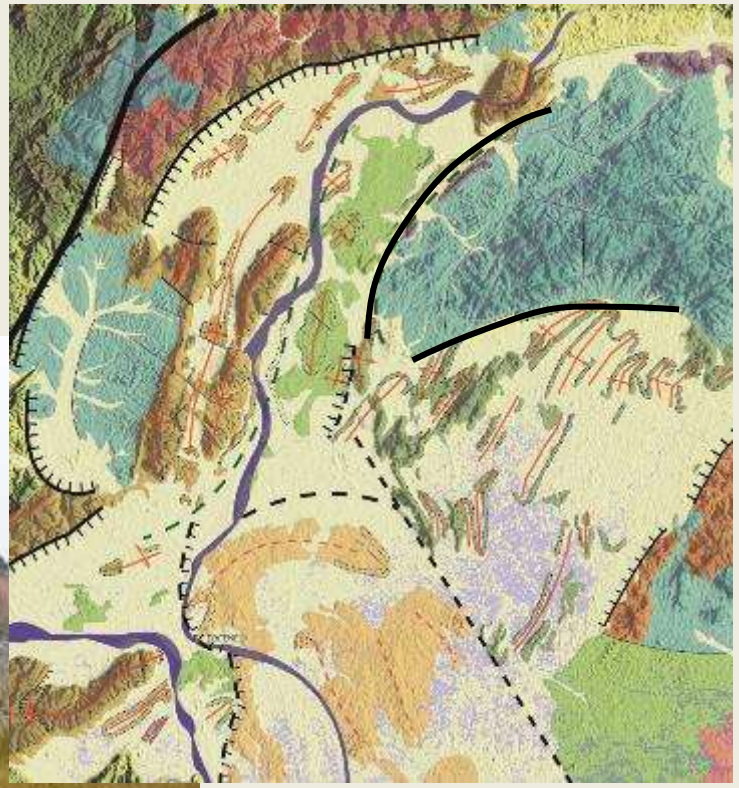
Circular features likely to be all granites; important for behaviour during extension

Detachments on granites

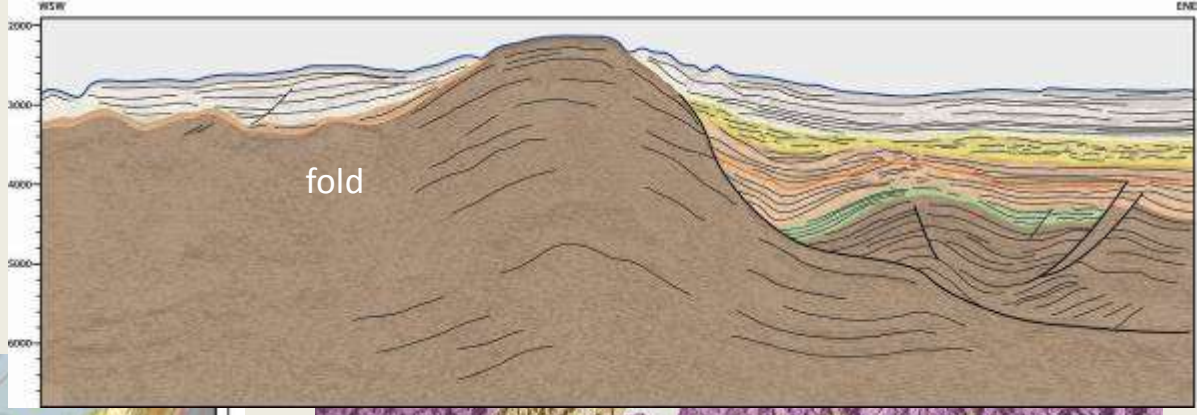


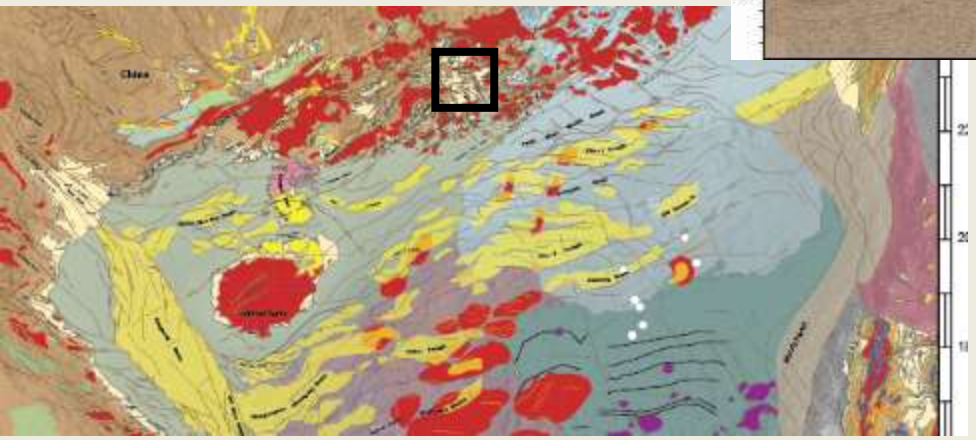
Franke et al., (2014)

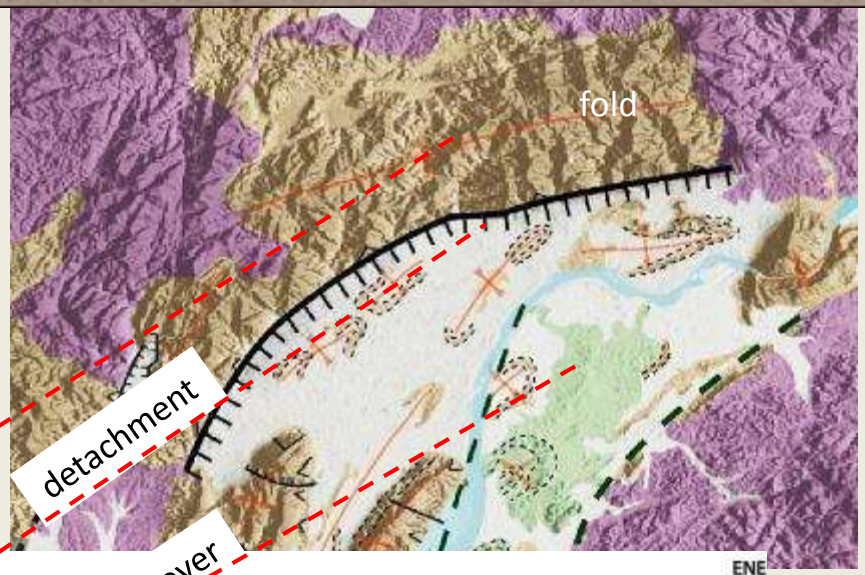
Savva et al., (2014)

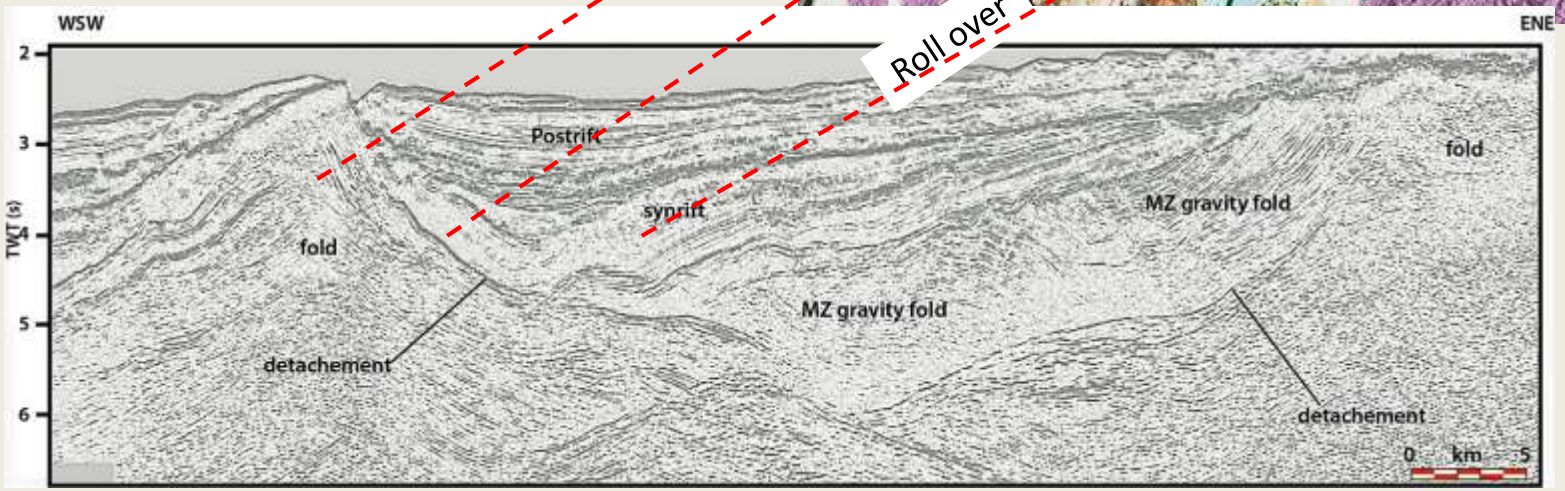


Late K & Paleocne; Extension and detachments (Late K molasse basins



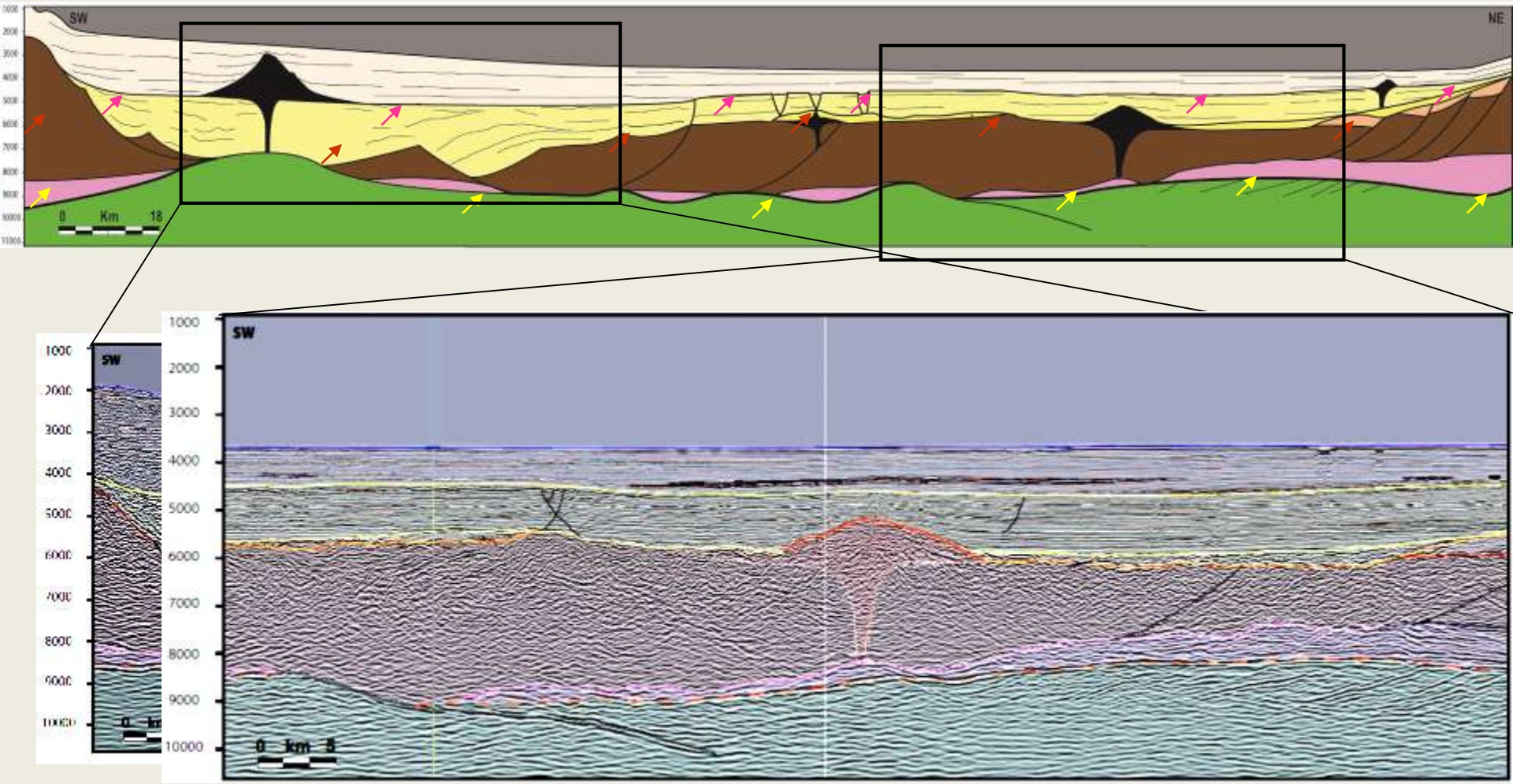


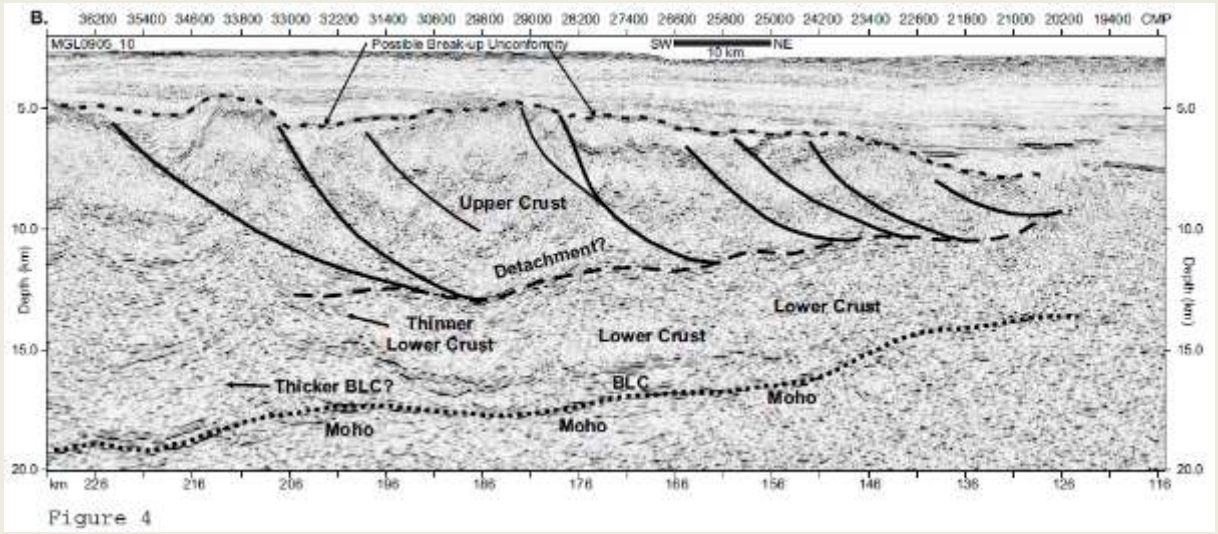


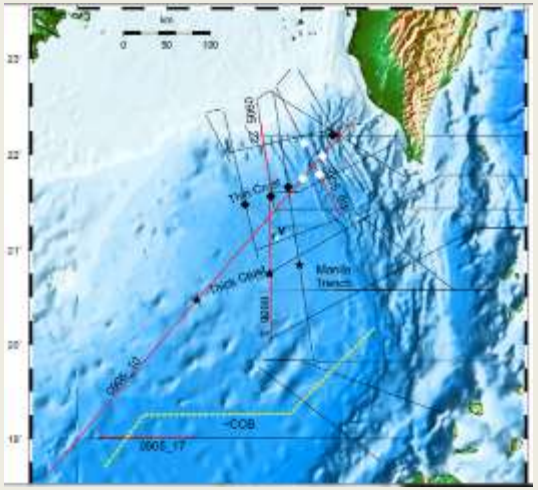


Extreme stretching and Mantle exhumation

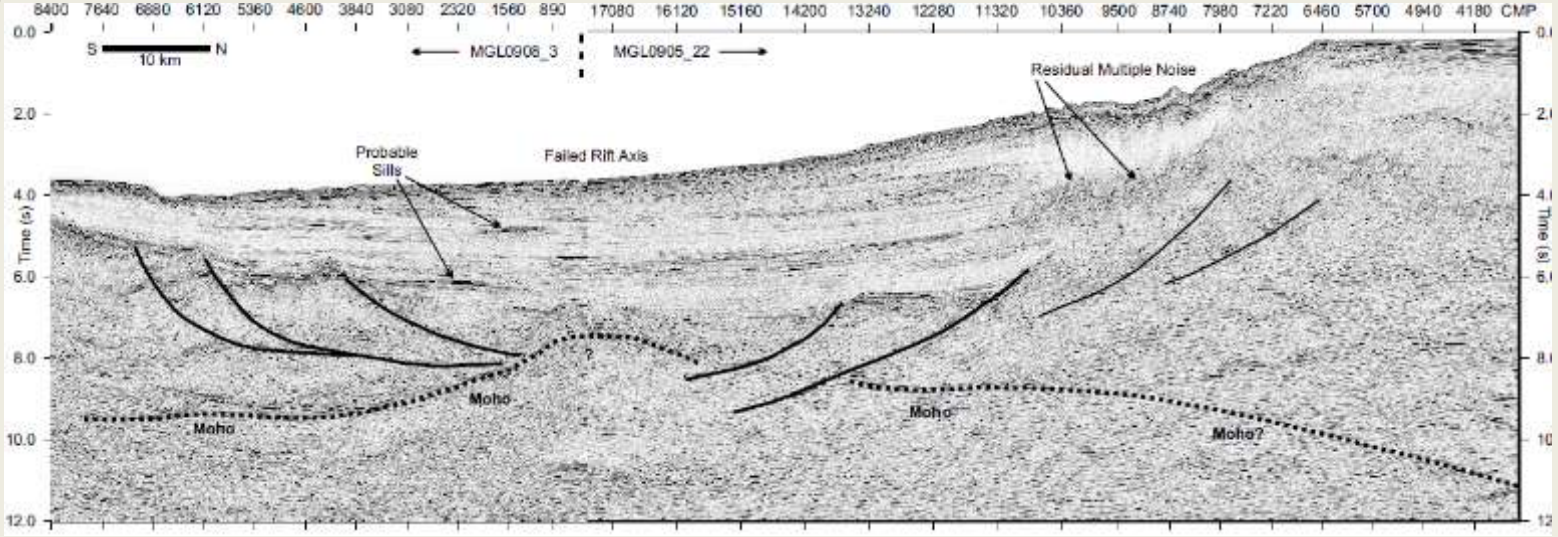
Savva et al. (2012)





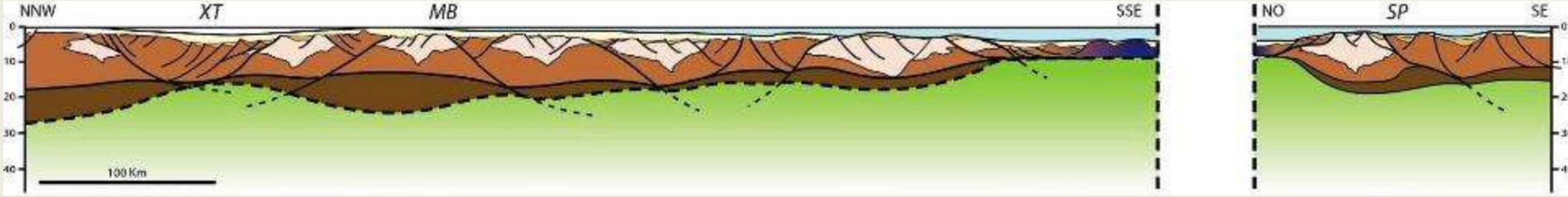


S

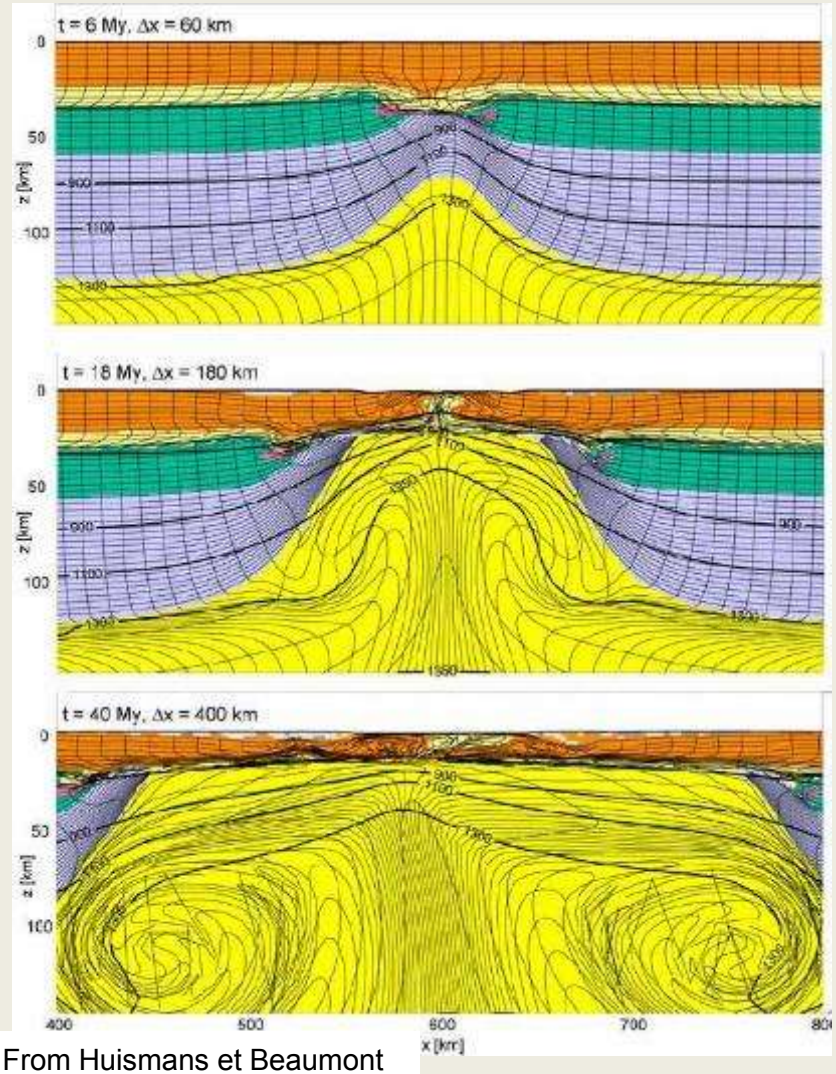


N

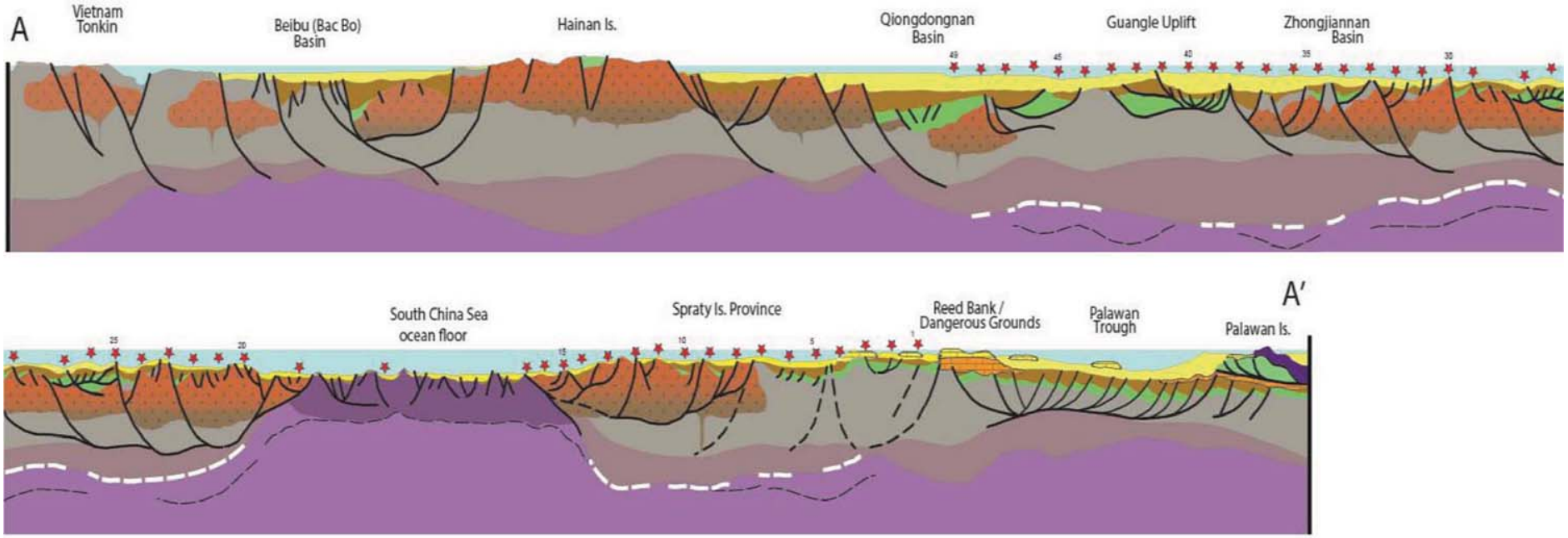
From McIntosh et al., 2014



Long-lasting shallow deposits (during all the duration of the rifting)
Implications



From Huismans et Beaumont



Cross section controlled by seismic, based on the OBS and MCS data

Conclusions;

An event aroud 125 Ma documented by ZFT (Collision of blocks Luconia/Mintai… or rifting of the PSCS)

Opening of the PSCS during Albian times (100 ->?)

Long lasting extension at least since 100 Ma gravity collapse

Extension continues after cessation of rifting during the spreading

Extension continues and is expressed even into the ocenic crust

Extension stops after completion of the subduction of the PSCS

Rheology : Reactivation of morpho-structures with an effect on crustal boudinage. The margin shows various degrees of maturity in the rifting (including mantle exhumation)

Paleogeogrphic/economic interest: the situation with widespread landmasses. Clastics derived from the erosion of the granites by-passed the SCS and were shed to the PSCS

Thermal/depth originality: Facies remain continental (~) until the complete cessasion of extension (rifting & spreading)