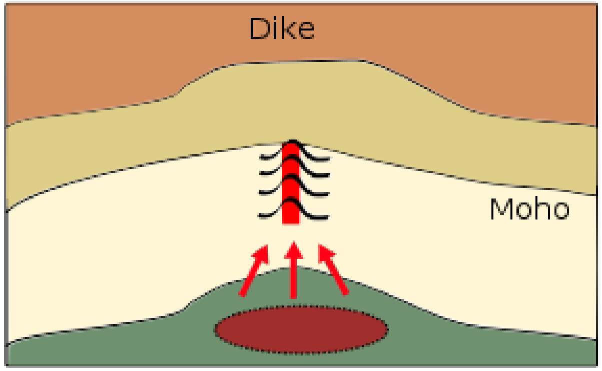
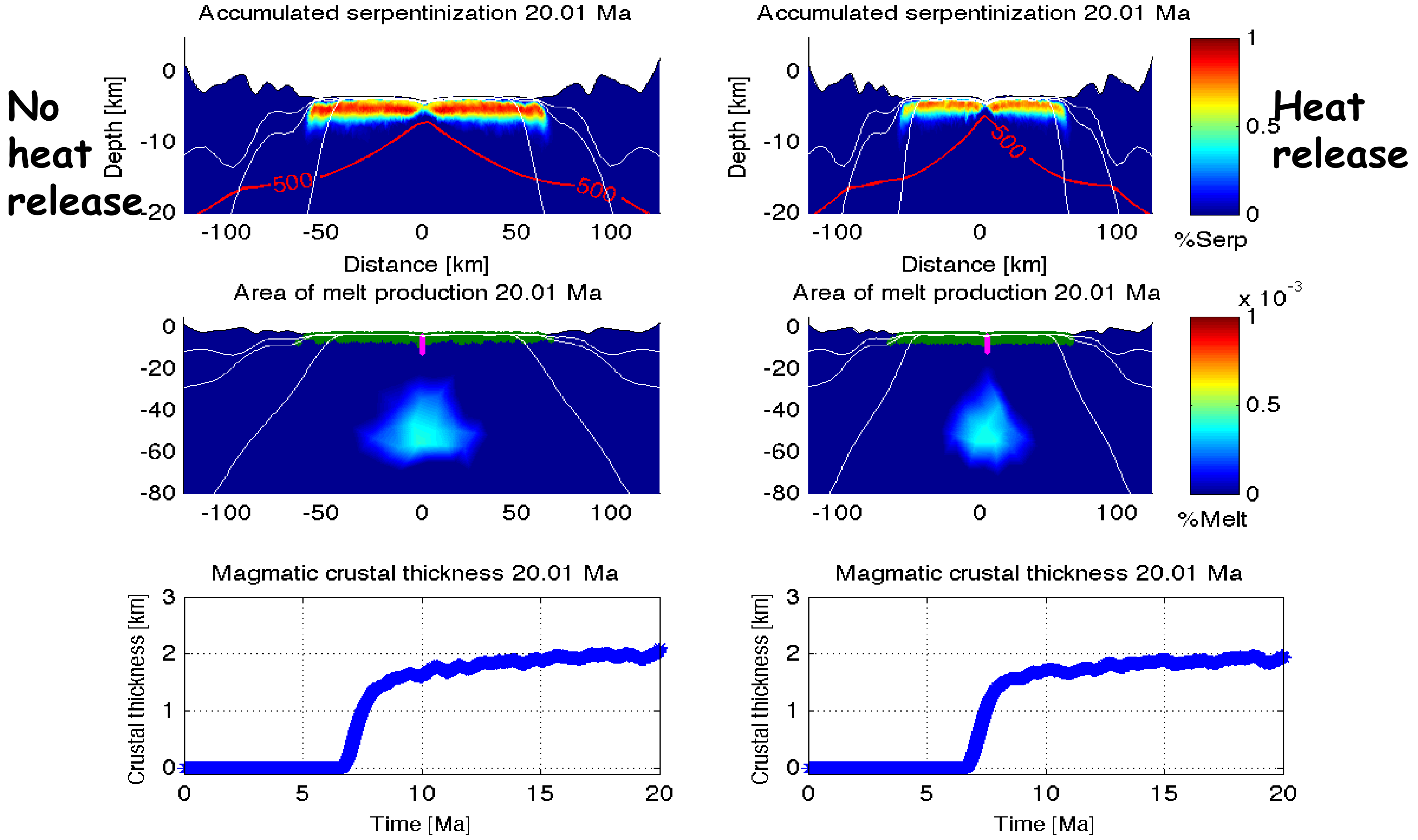
Heat release freezing melt –dike



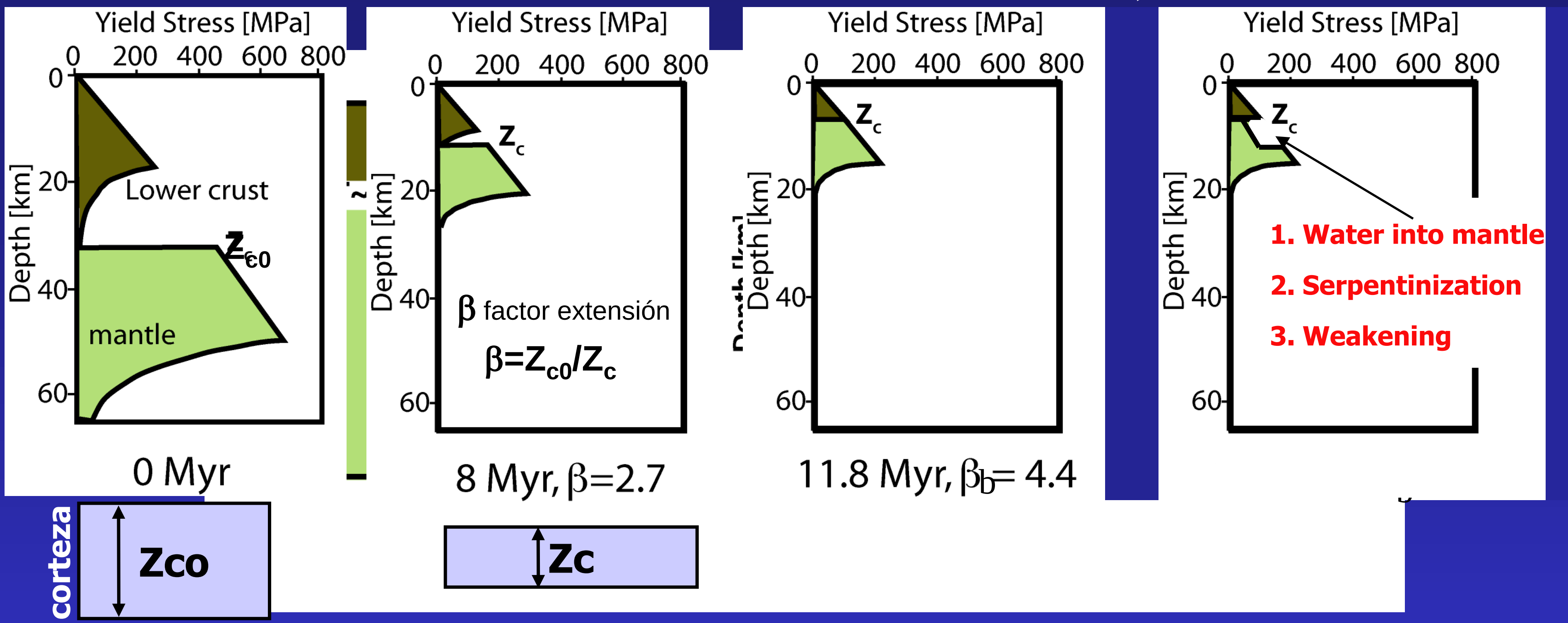
$$T = \frac{1}{2\sqrt{\pi \kappa t}} \int_{-\infty}^{\infty} T'(y') e^{-(y-y')^2/4\kappa t} \, dy'$$

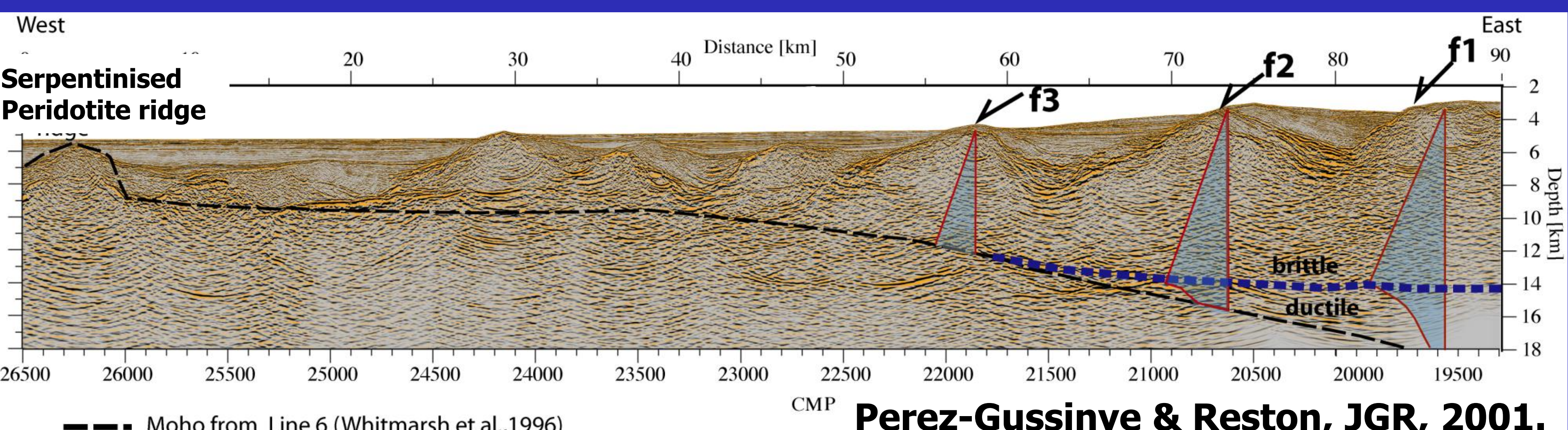
where κ is the thermal diffusivity (m^2/s)
y′ is a dummy variable for integration
t is relaxation time
y is distance from dike or sill center line

Effect on serpentinization



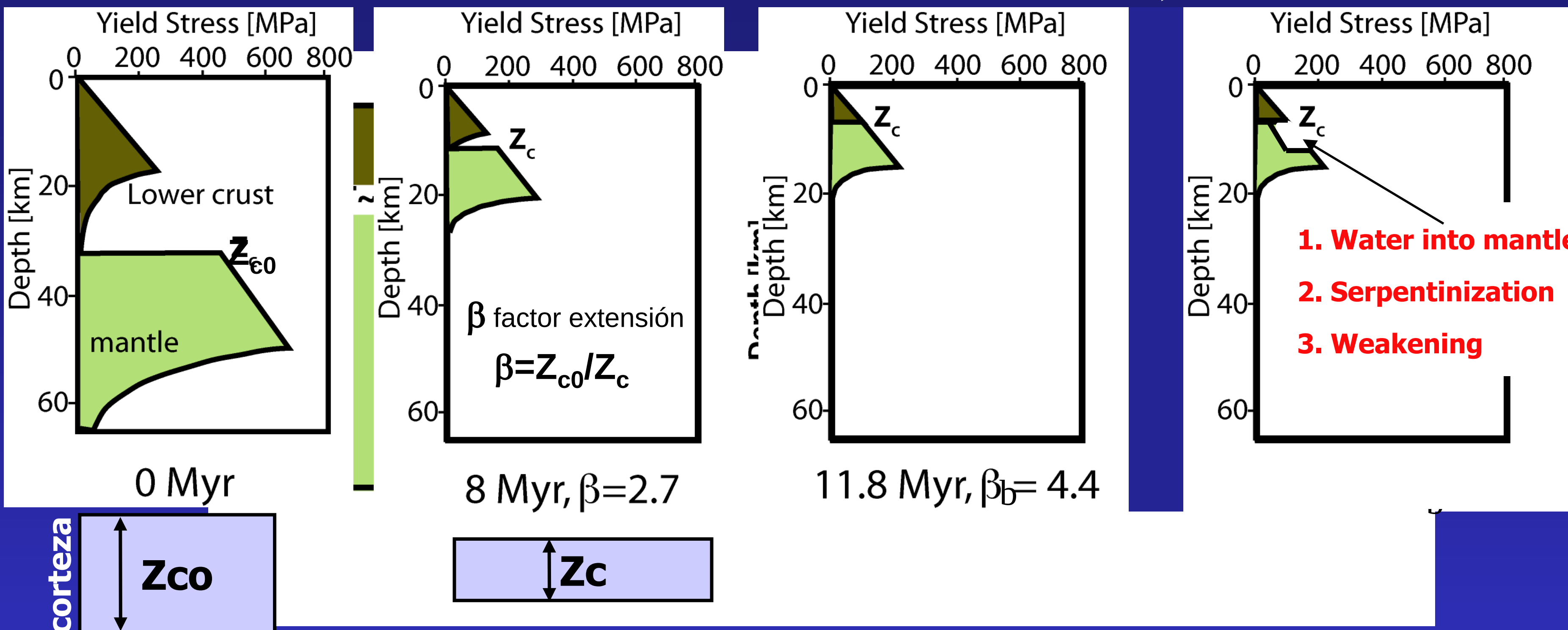
Thermal and rheological model at start of rifting.

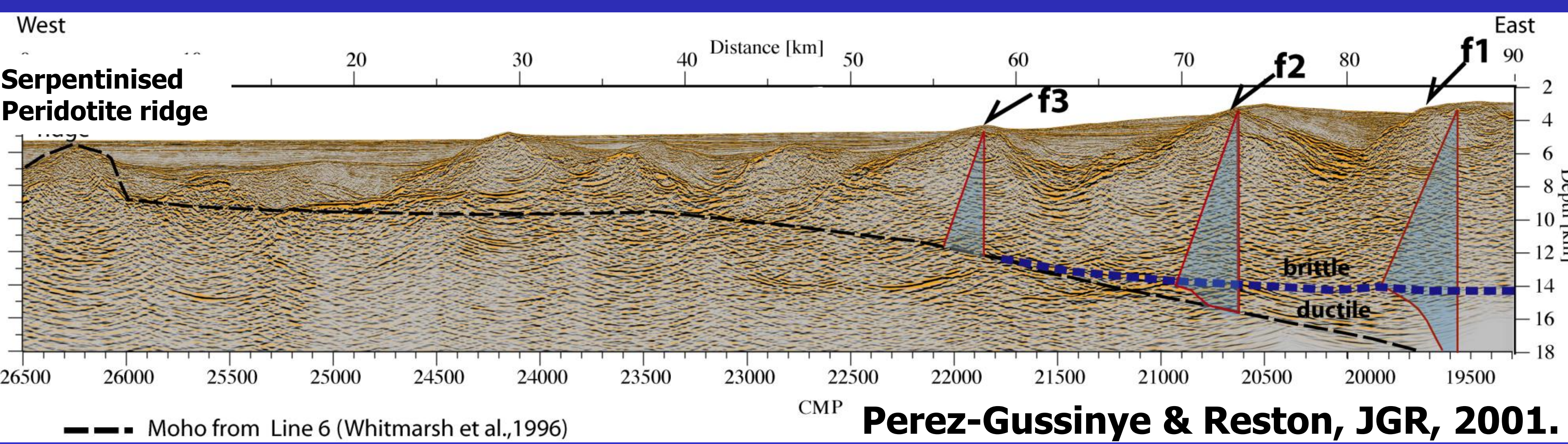




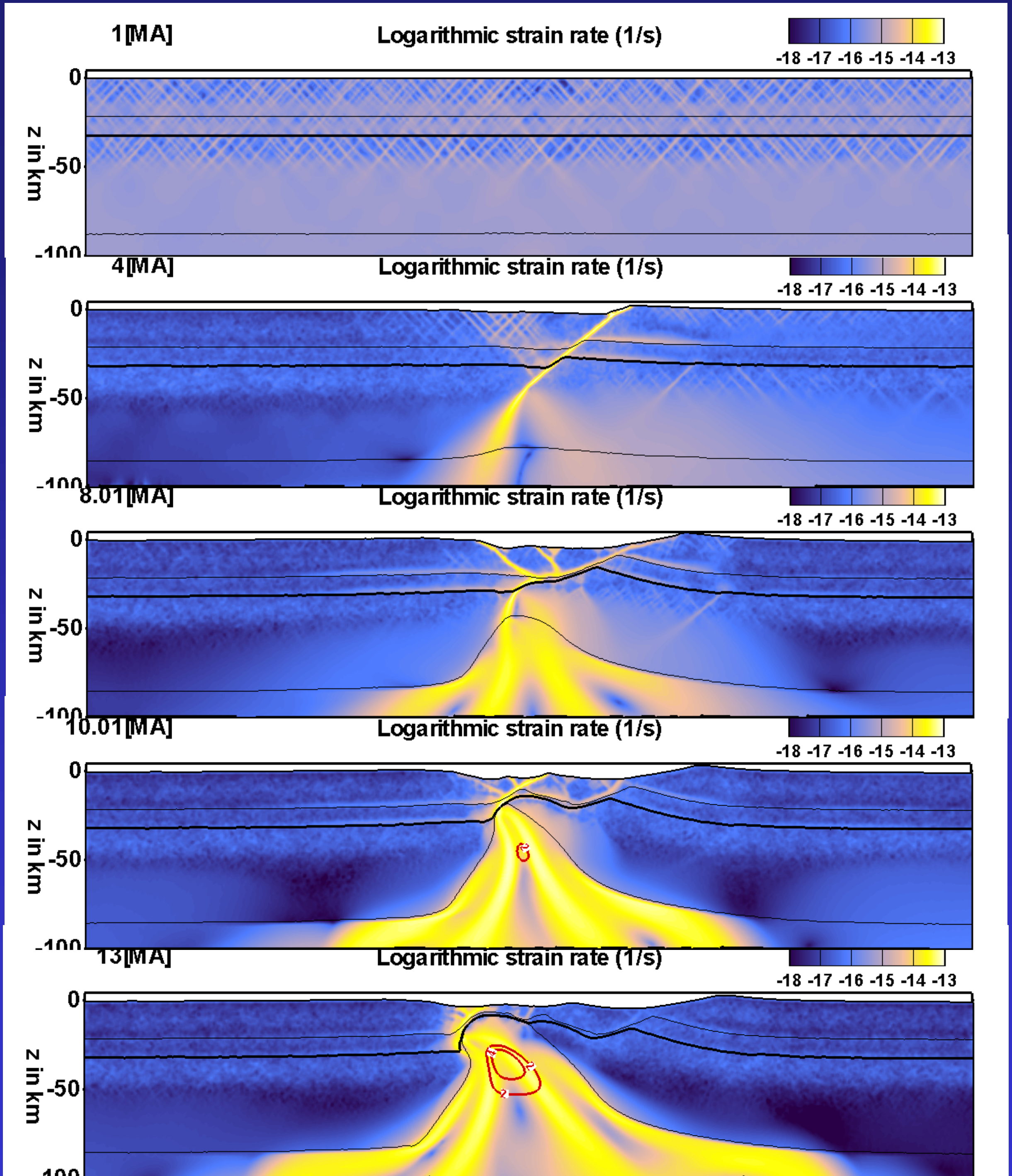
Perez-Gussinye & Reston, JGR, 2001.

TIME DURING EXTENSION





Perez-Gussinye & Reston, JGR, 2001.

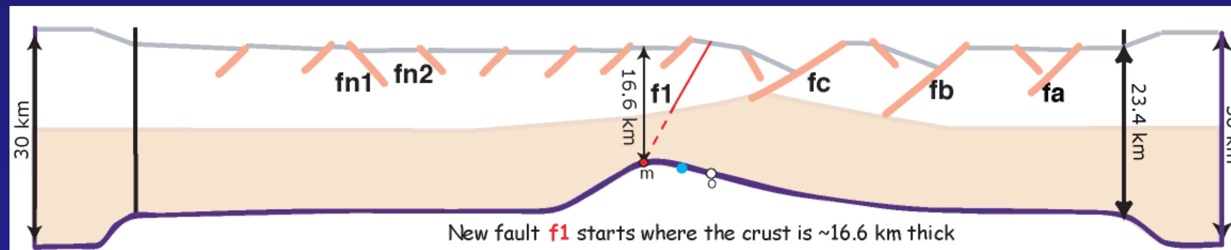


1[MA]
Logarithmic strain rate (1/s)
-18 -17 -16 -15 -14 -13
z in km
0
-50
-100
4[MA]
Logarithmic strain rate (1/s)
-18 -17 -16 -15 -14 -13
z in km
0
-50
-100
8.01[MA]
Logarithmic strain rate (1/s)
-18 -17 -16 -15 -14 -13
z in km
0
-50
-100
10.01[MA]
Logarithmic strain rate (1/s)
-18 -17 -16 -15 -14 -13
z in km
0
-50
-100
13[MA]
Logarithmic strain rate (1/s)
-18 -17 -16 -15 -14 -13
z in km
0
-50

Start of Margin Stage

Most active Faults

Less active Faults



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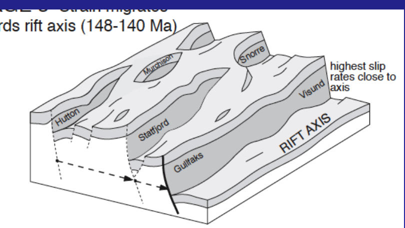

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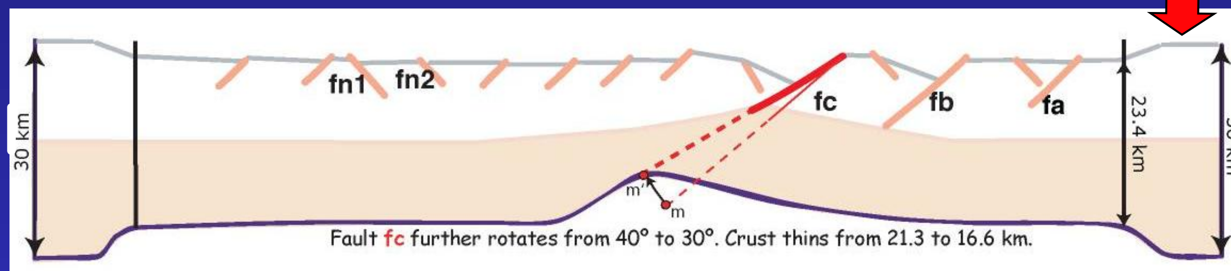

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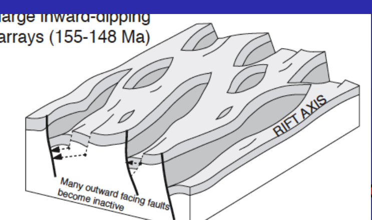

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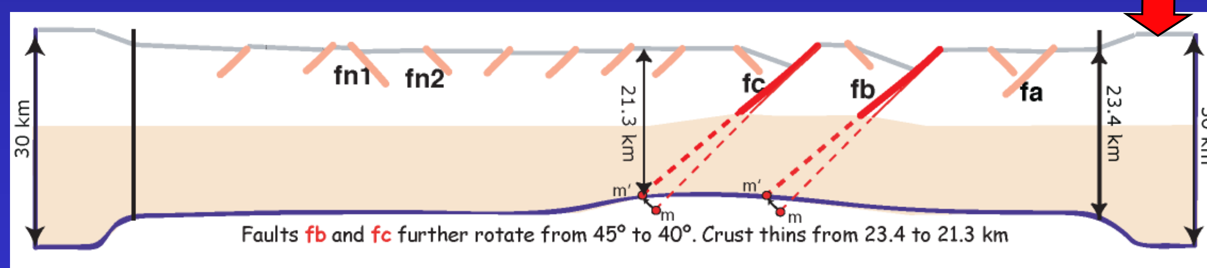

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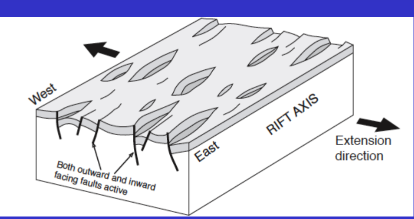

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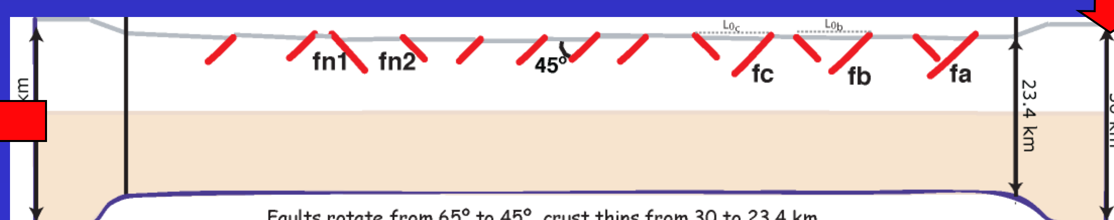
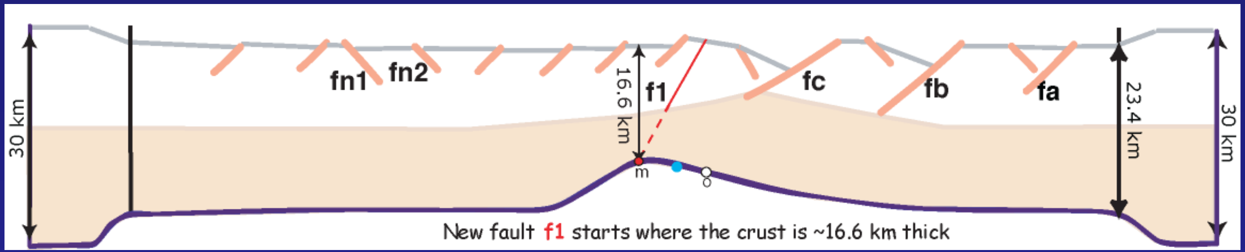


Ranero & Perez-Gussinye, Nature, 2010

Kinematic model: Basin Stage

Most active Faults

Less active Faults



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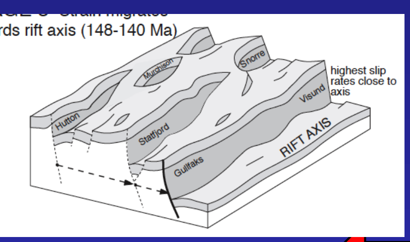

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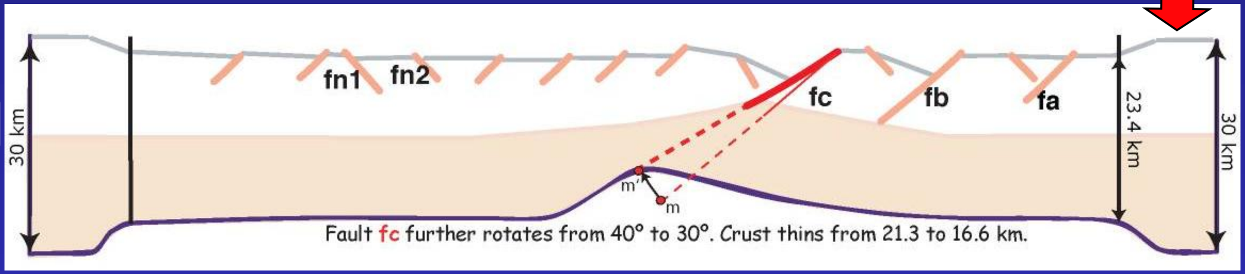

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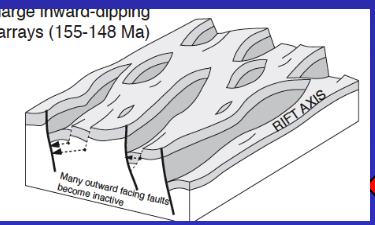

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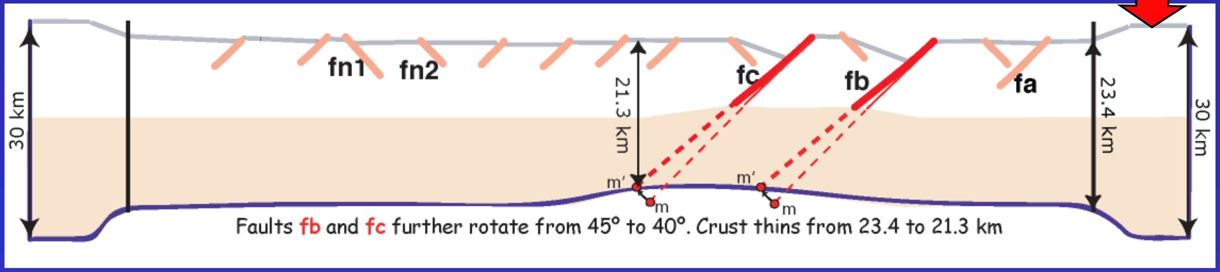

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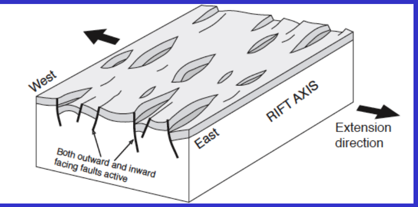

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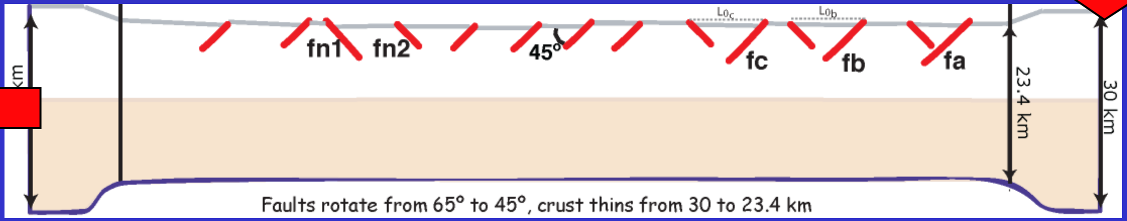
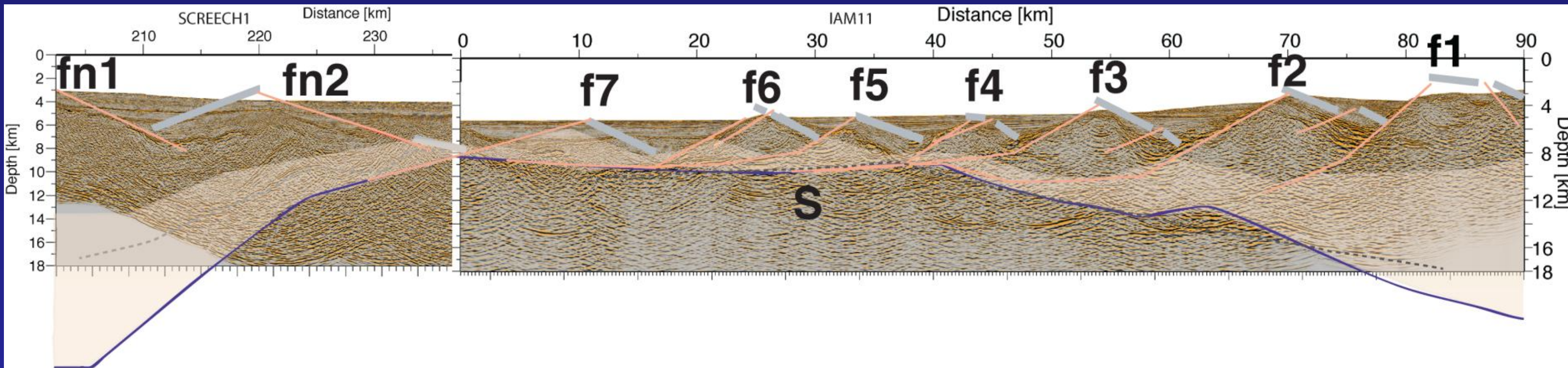
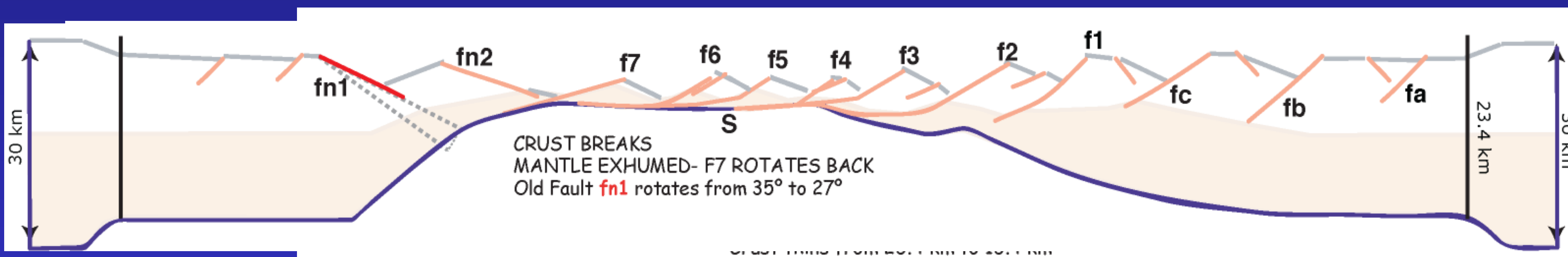
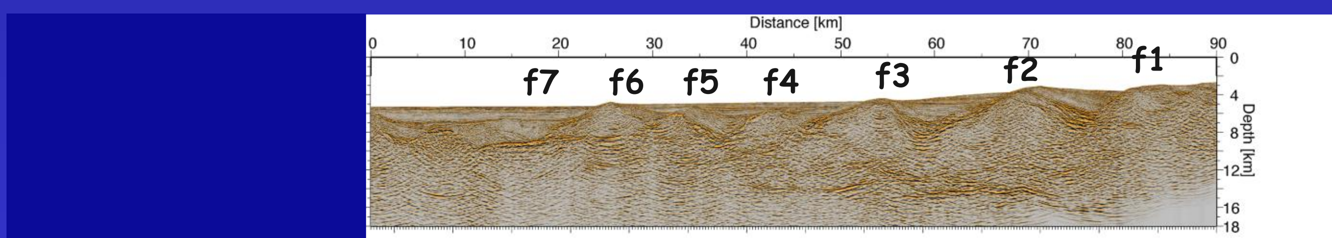


Ranero & Perez-Gussinye, Nature, 2010

Margin stage

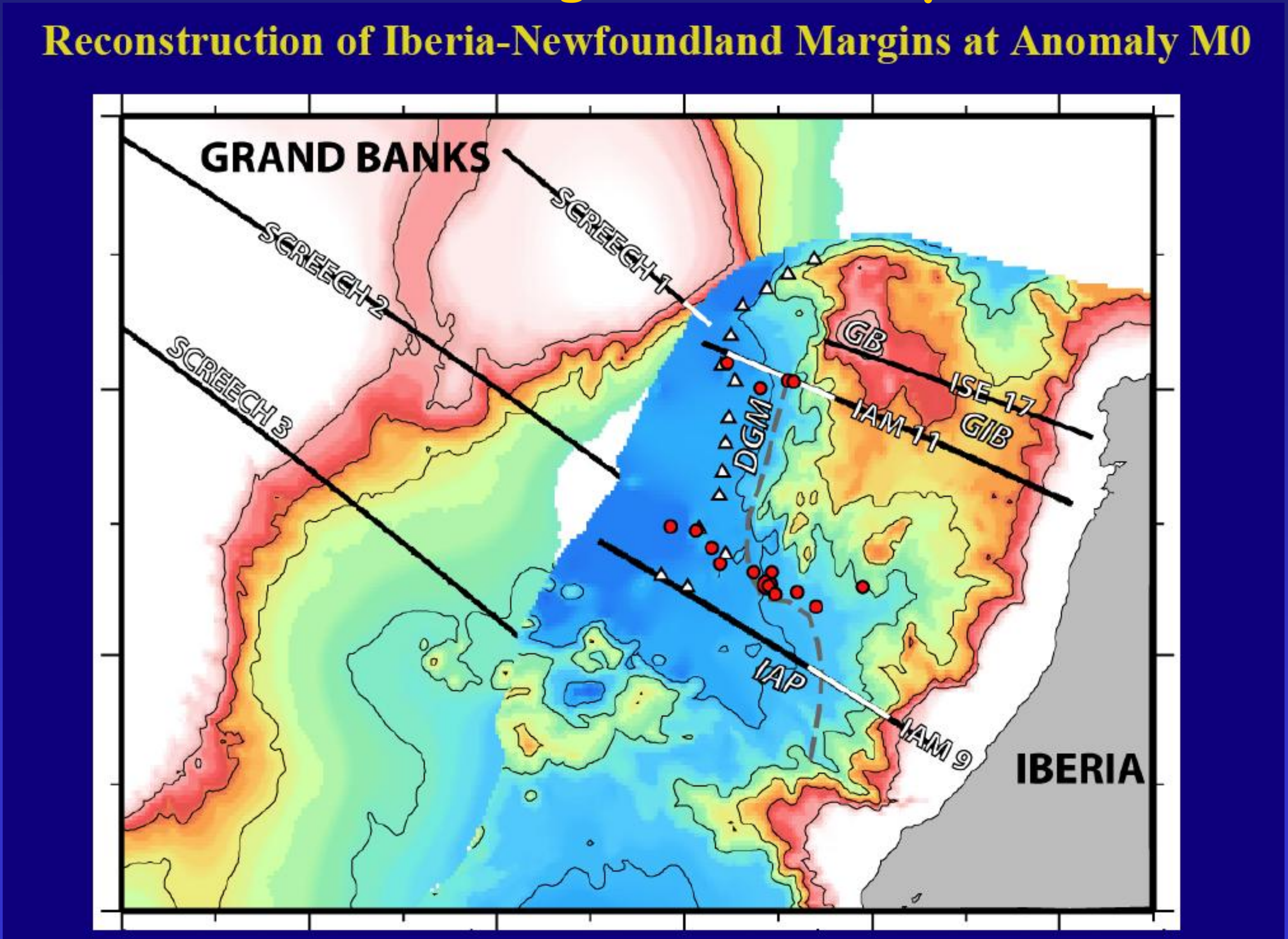


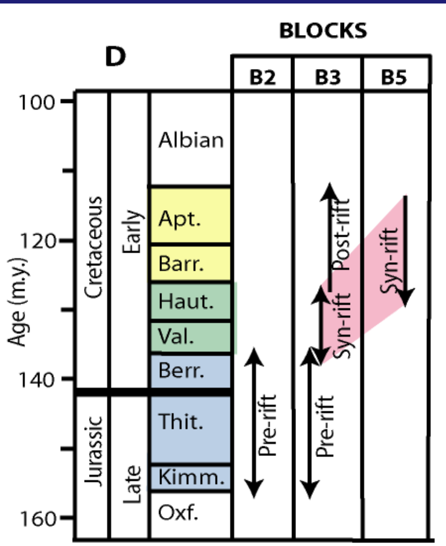




Ranero & Perez-Gussinye, Nature, 2010

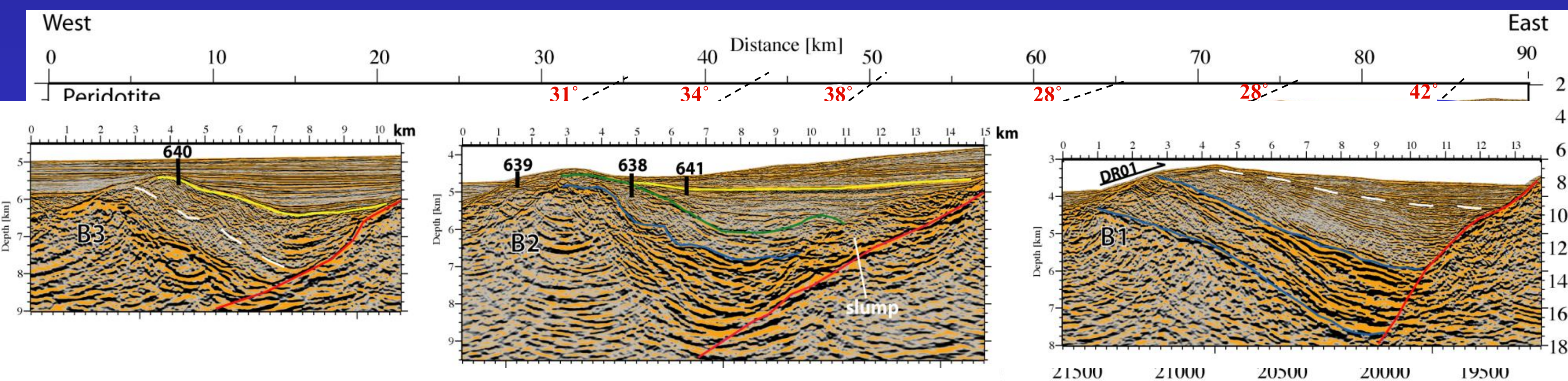
What are fault and crustal thinning kinematics leading to break-up?





BATHYMETRY AND PRE-STACK DEPTH MIGRATION- IAM11

Faulting sequential in time.
Faults cut through progressively thinner crust



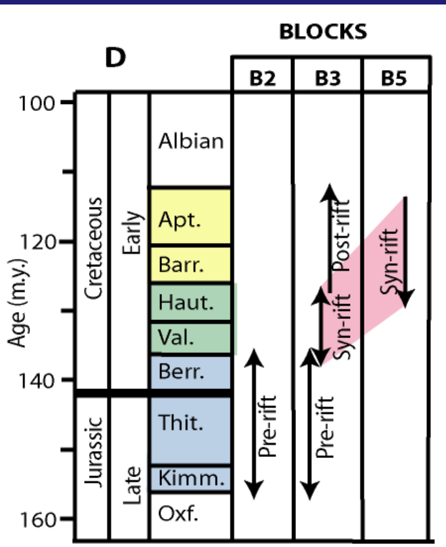
1- Image Pre-Syn rift sediment -> synrift younger basinward

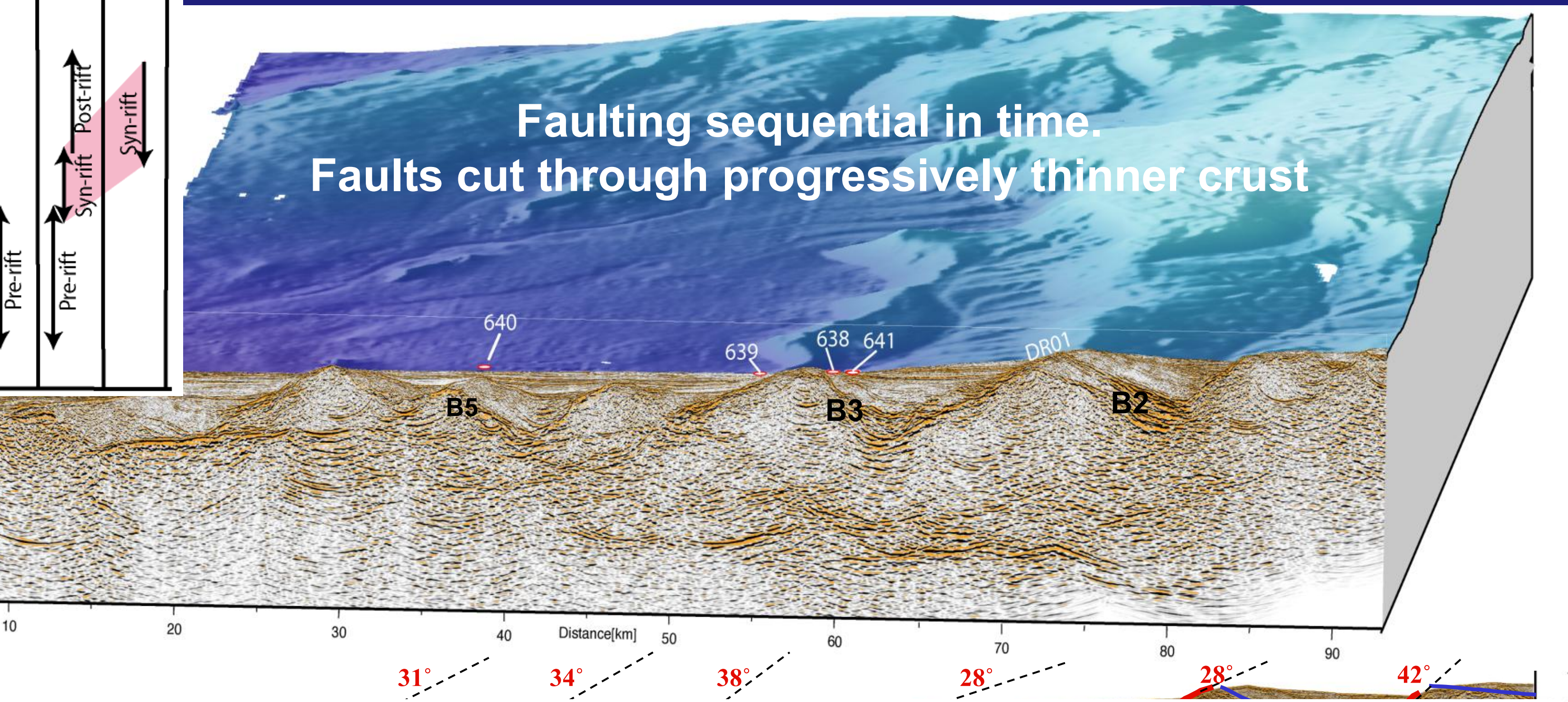
2- Faults start at 65˚-55˚ and rotate to 42˚-28˚.

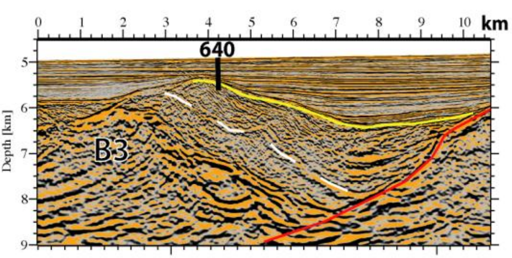
3- Fault block dimensions decrease basinward.

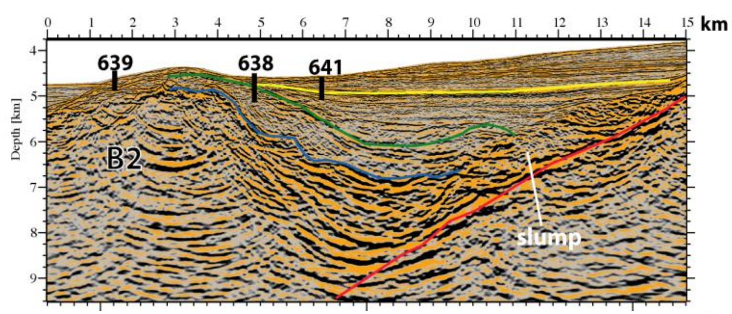
4- Faults cut progressively thinner brittle layer.

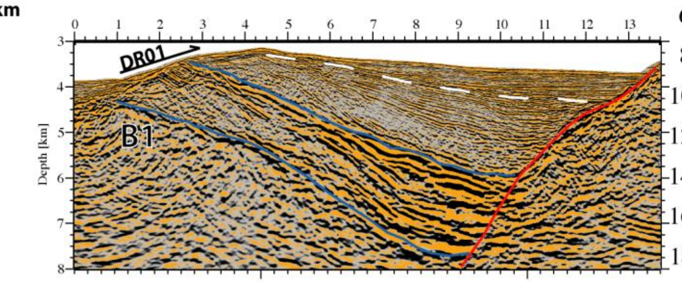
BATHYMETRY AND PRE-STACK DEPTH MIGRATION- IAM11











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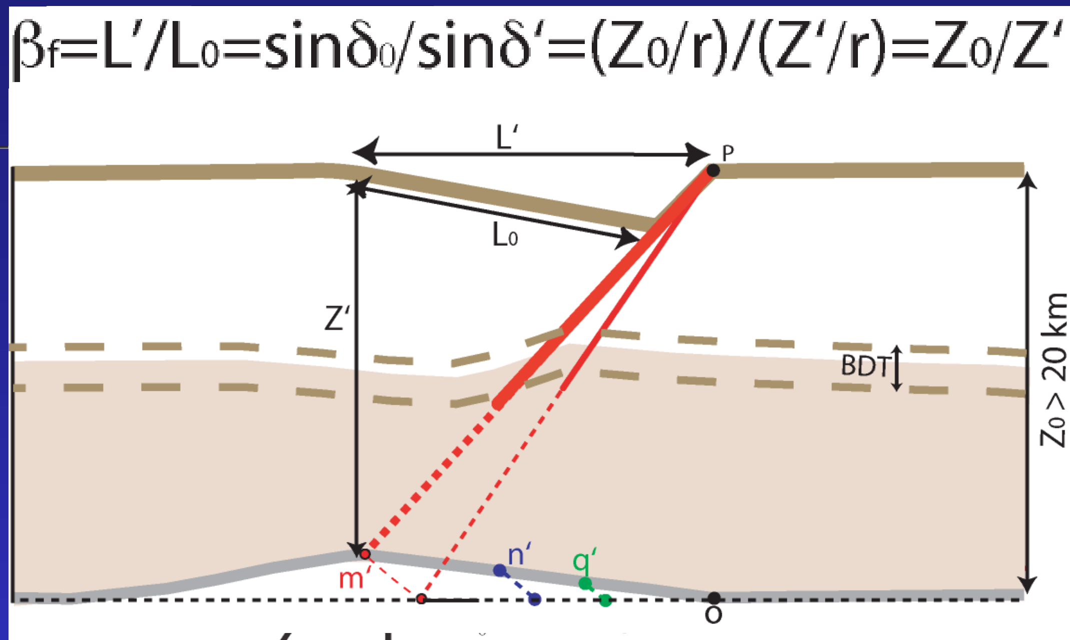
Model rules: Basin stage



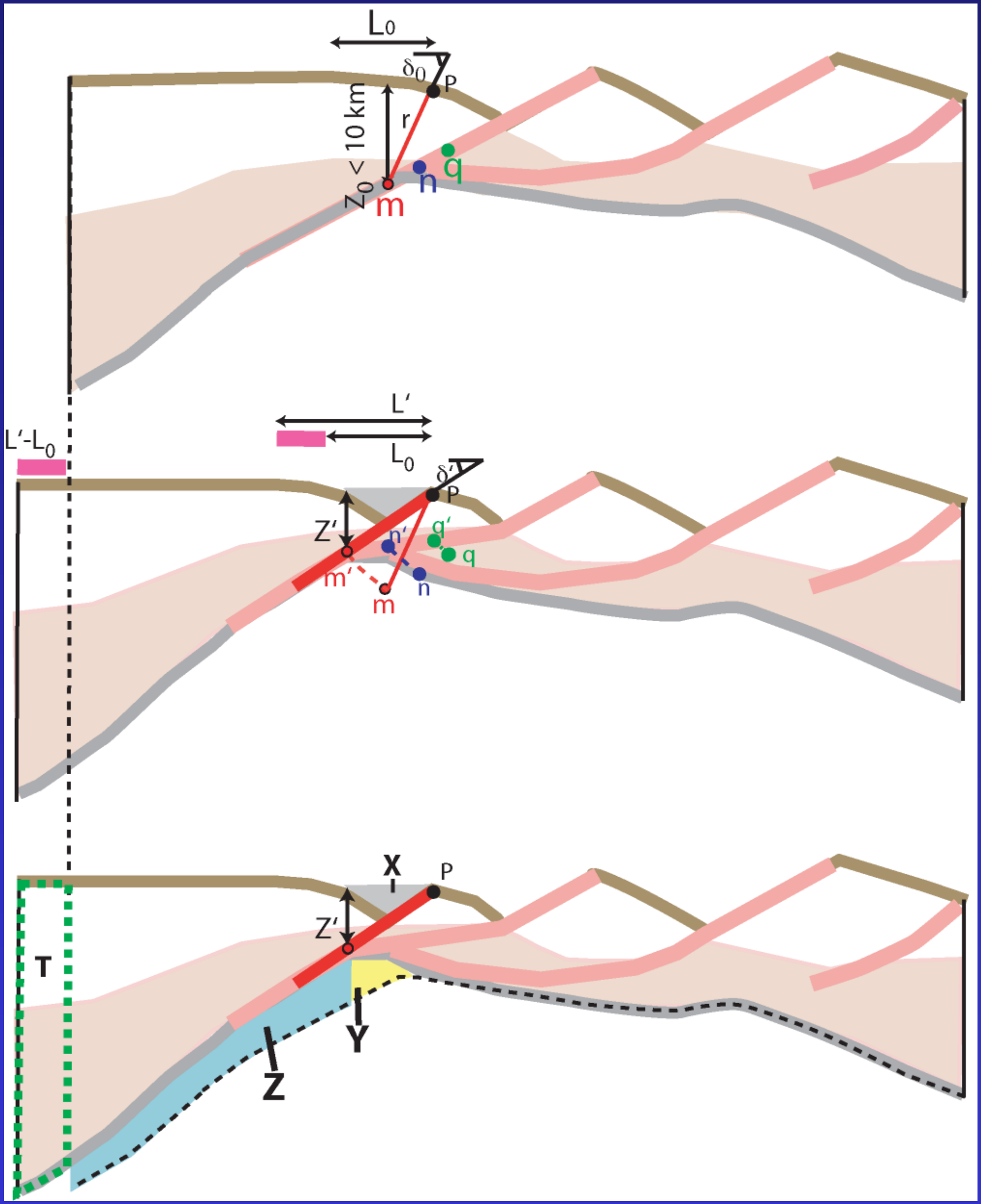
1. Upper crust brittle & lower crust ductile
2. Upper and lower crust extend by the same amount. Lower crust deforms compliant to upper crust.
3. Area conservation: X+Y+Z=T
4. A wide brittle-ductile transition.

Ranero & Perez-Gussinye, Nature, 2011

Model rules

Margin stage:

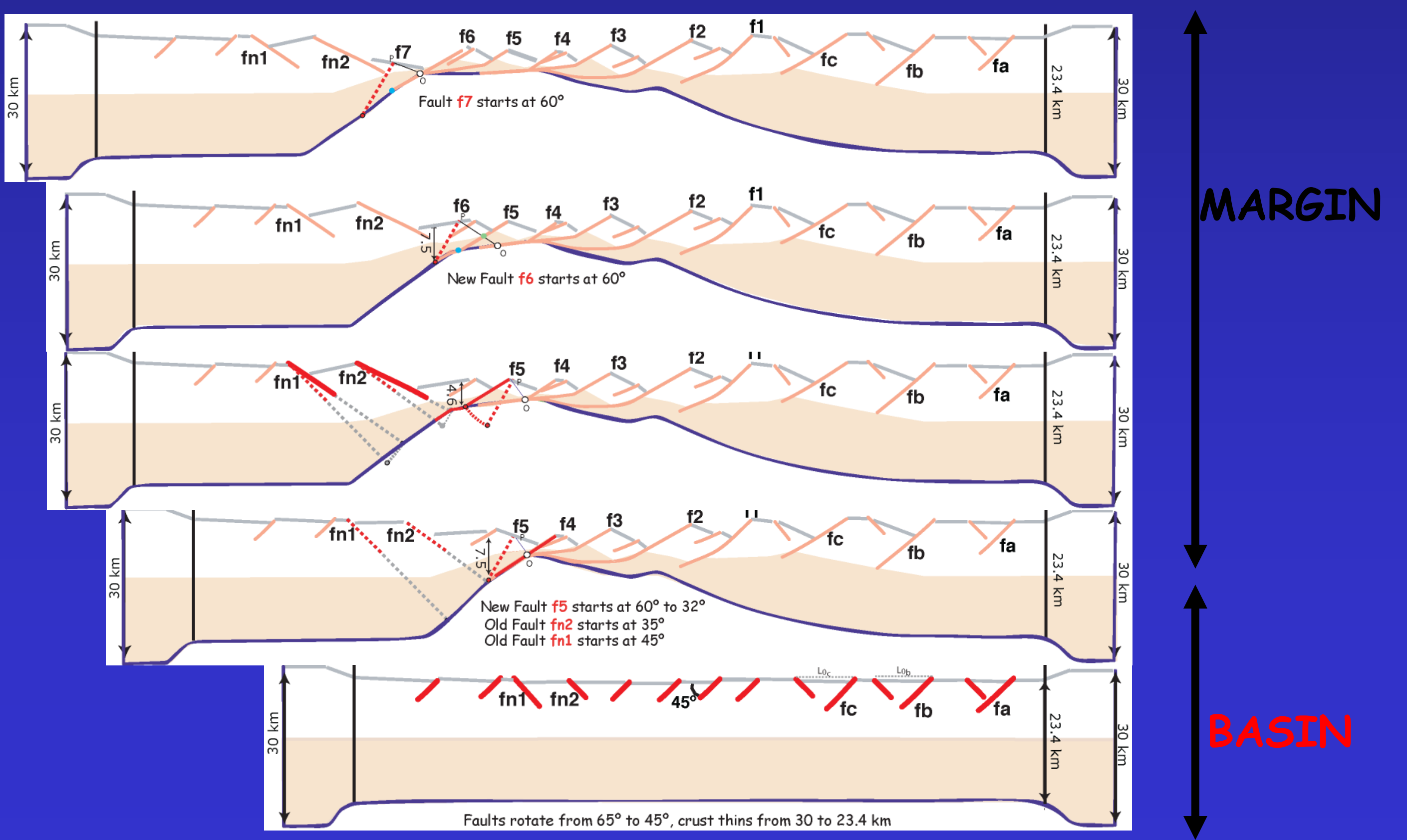
- Lower crust progressively brittle!!
- Upper and lower crust extend by the same amount. Lower crust deforms compliant to upper crust.
- Area conservation: X+Y+Z=T
- Area conservation leads to back-rotation of previous planar faults.



Ranero & Perez-Gussinye, Nature, 2011

Implications

- No active faulting at low angles, just normal Andersonian faulting (normal faults at 60°-30°).



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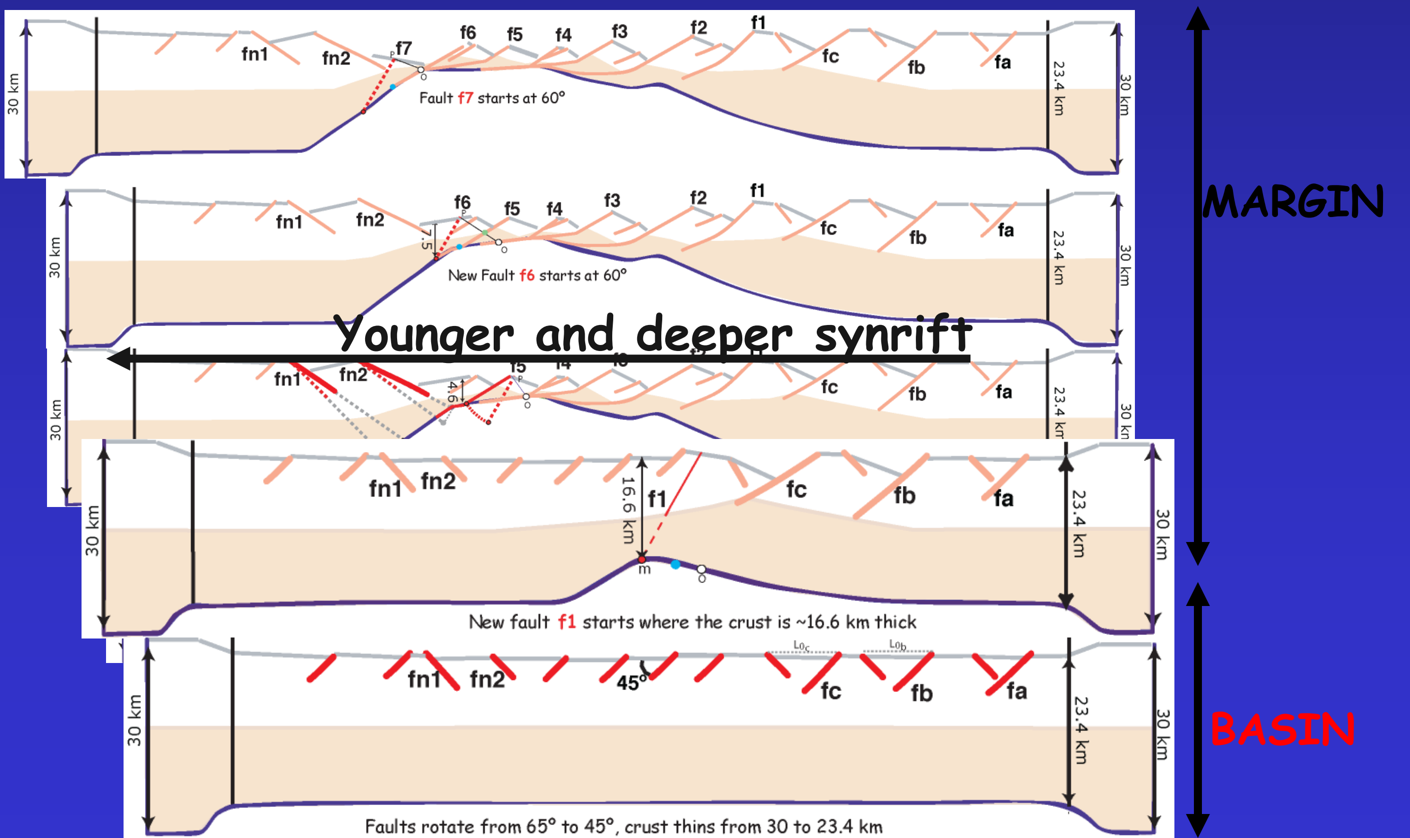

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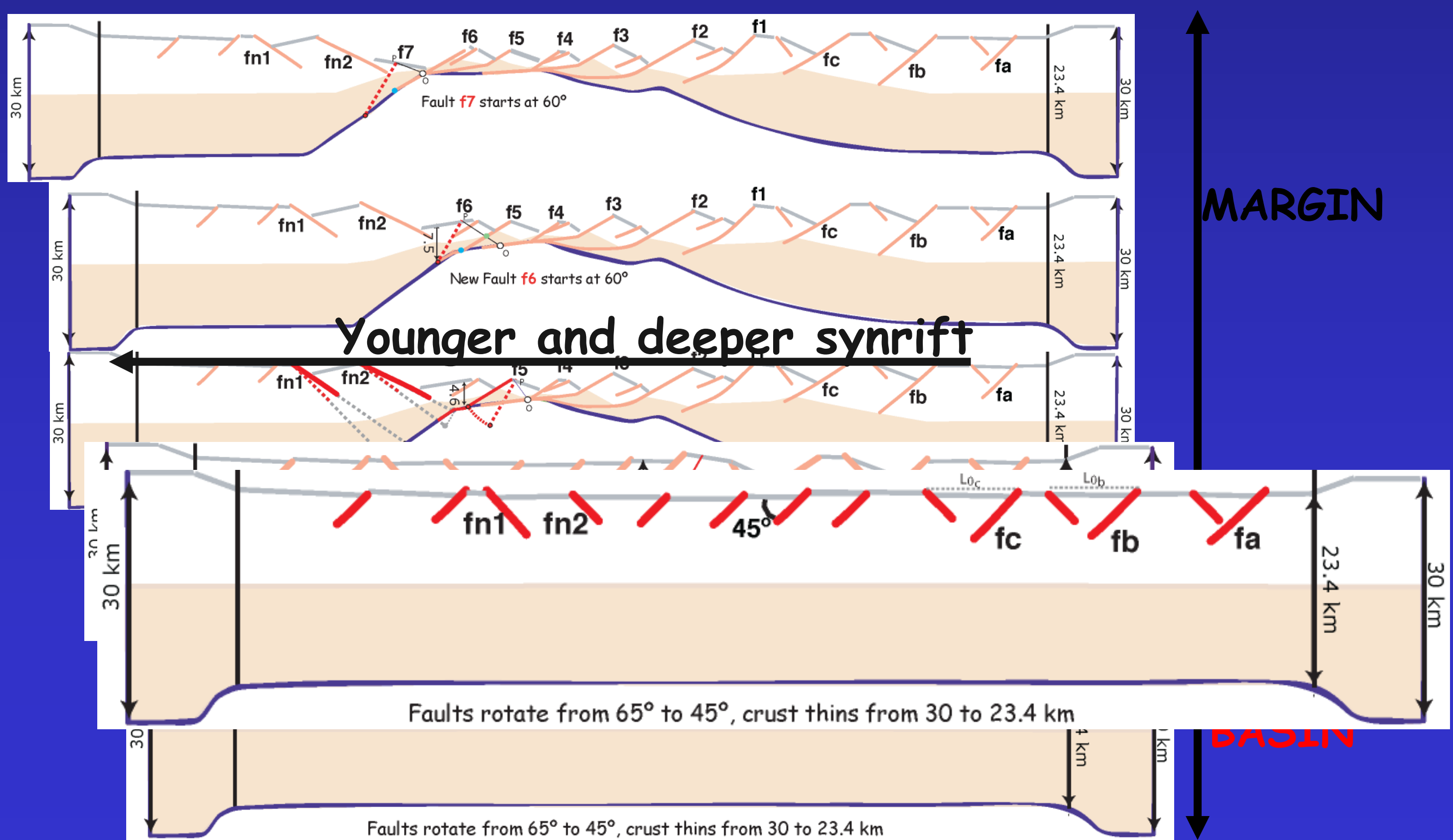

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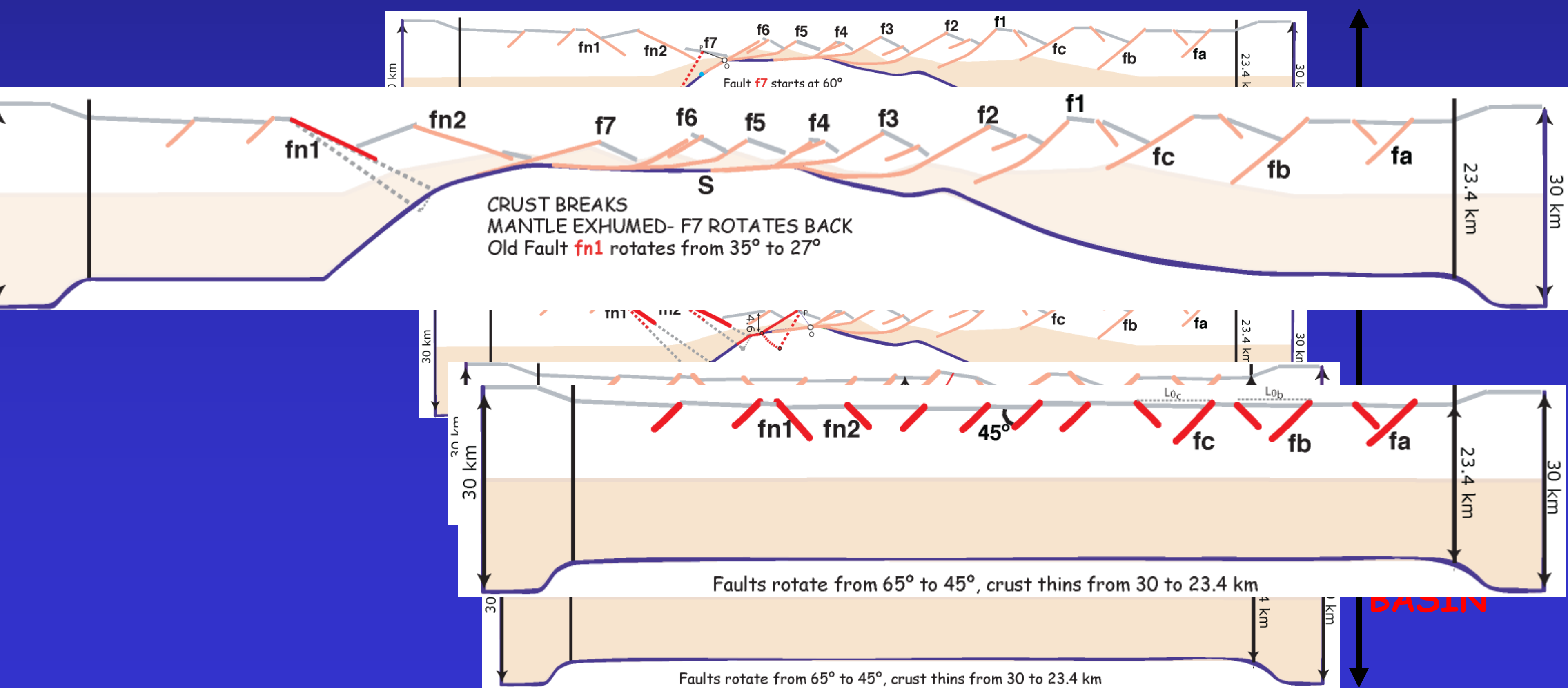

Implications

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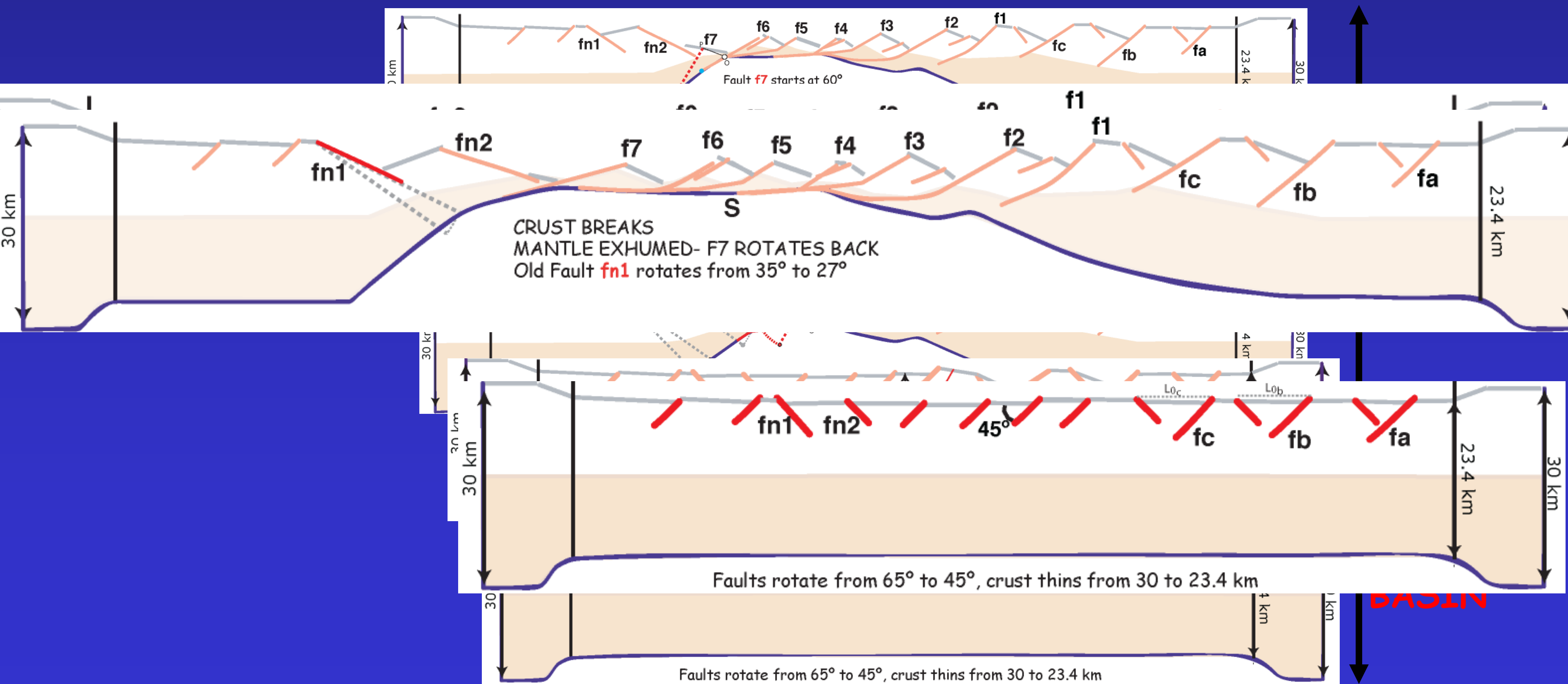
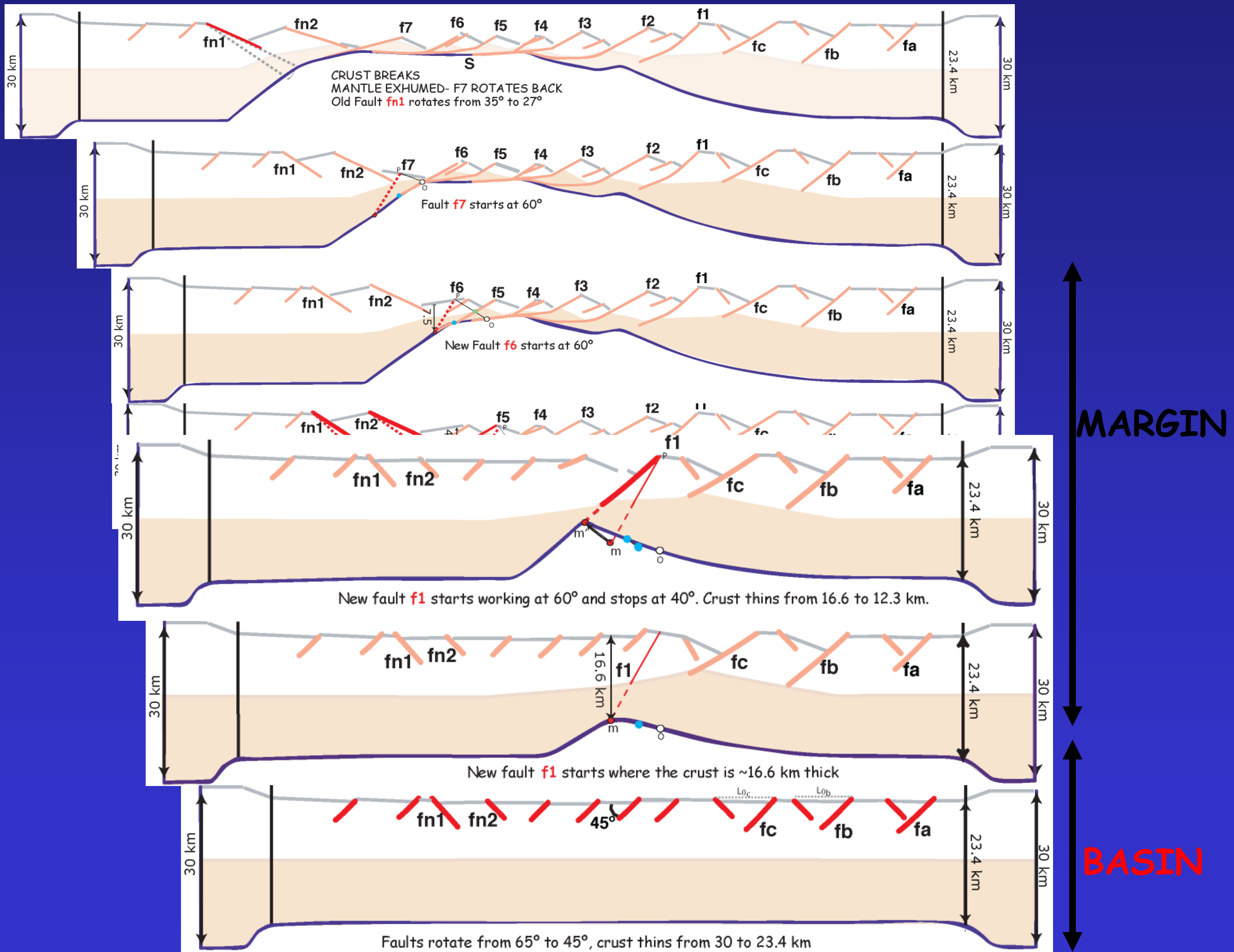


Implications (cont.)

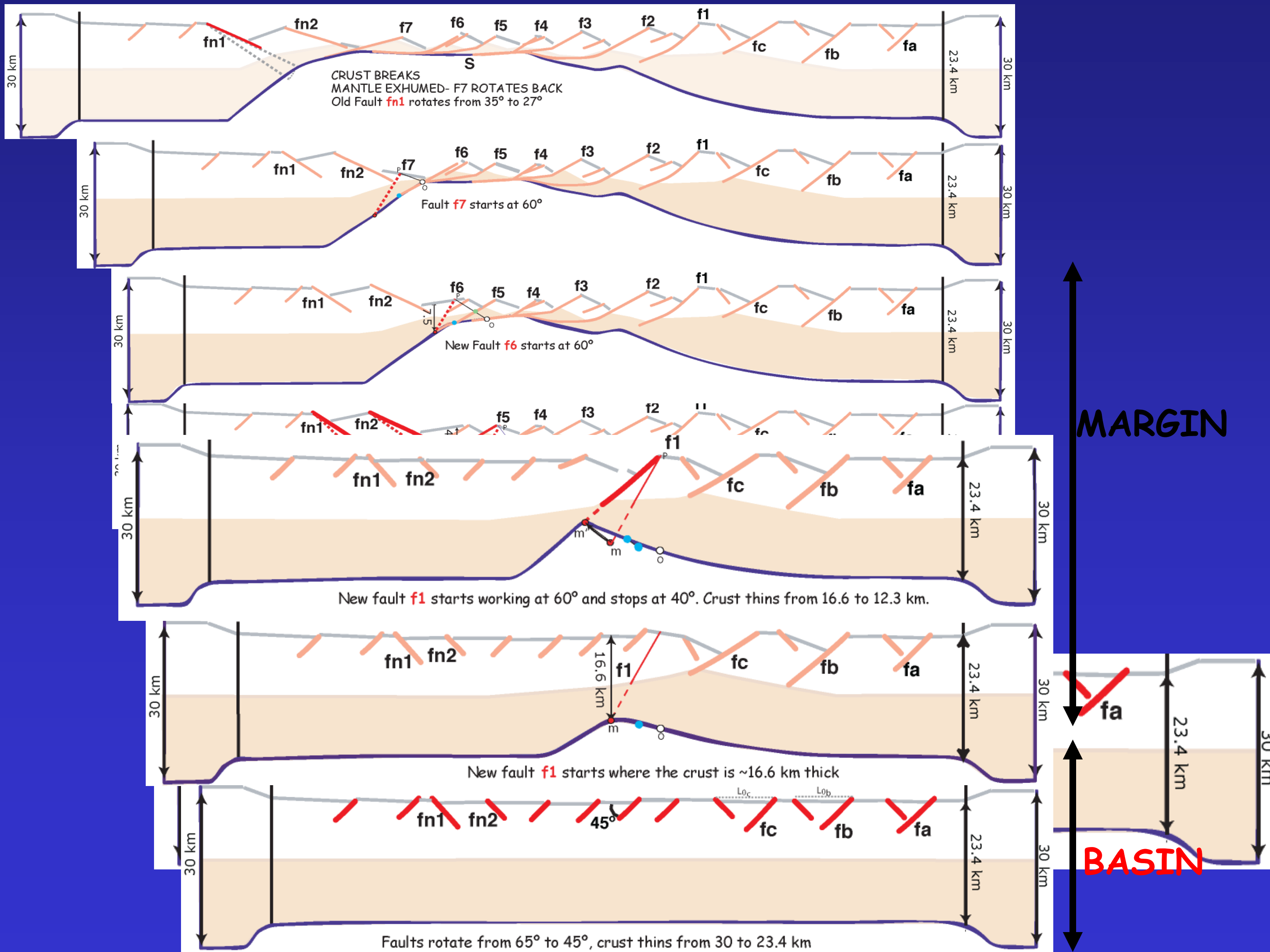
Occurrence of shallow pre-rift and syn-rift over the whole basin, even on top of extremely thinned crust. No need for anomalous subsidence.

Peak heat-flow moves oceanward. Post-rift sediments on continental platform may pre-date continental break-up.

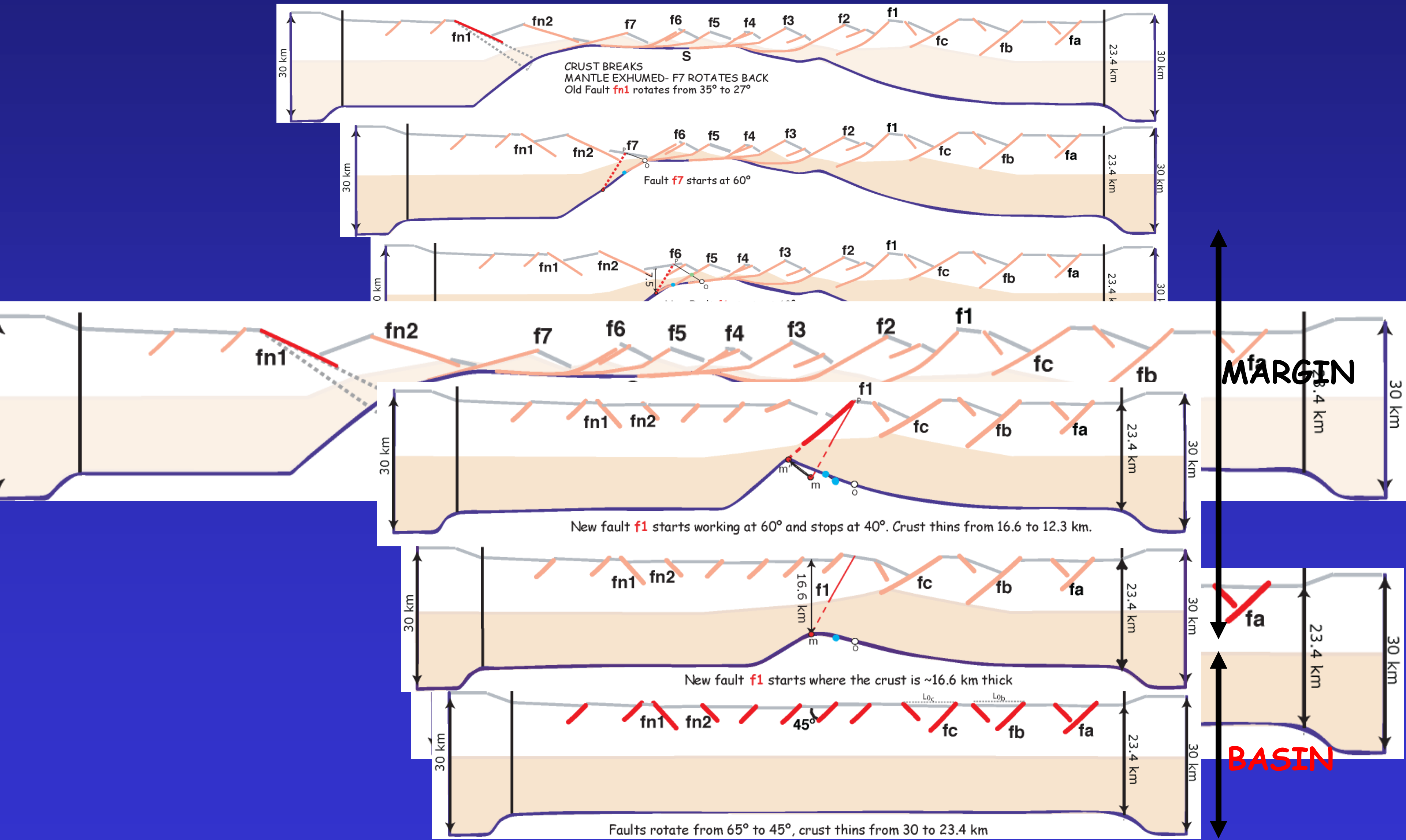
Implications (Illustrated)



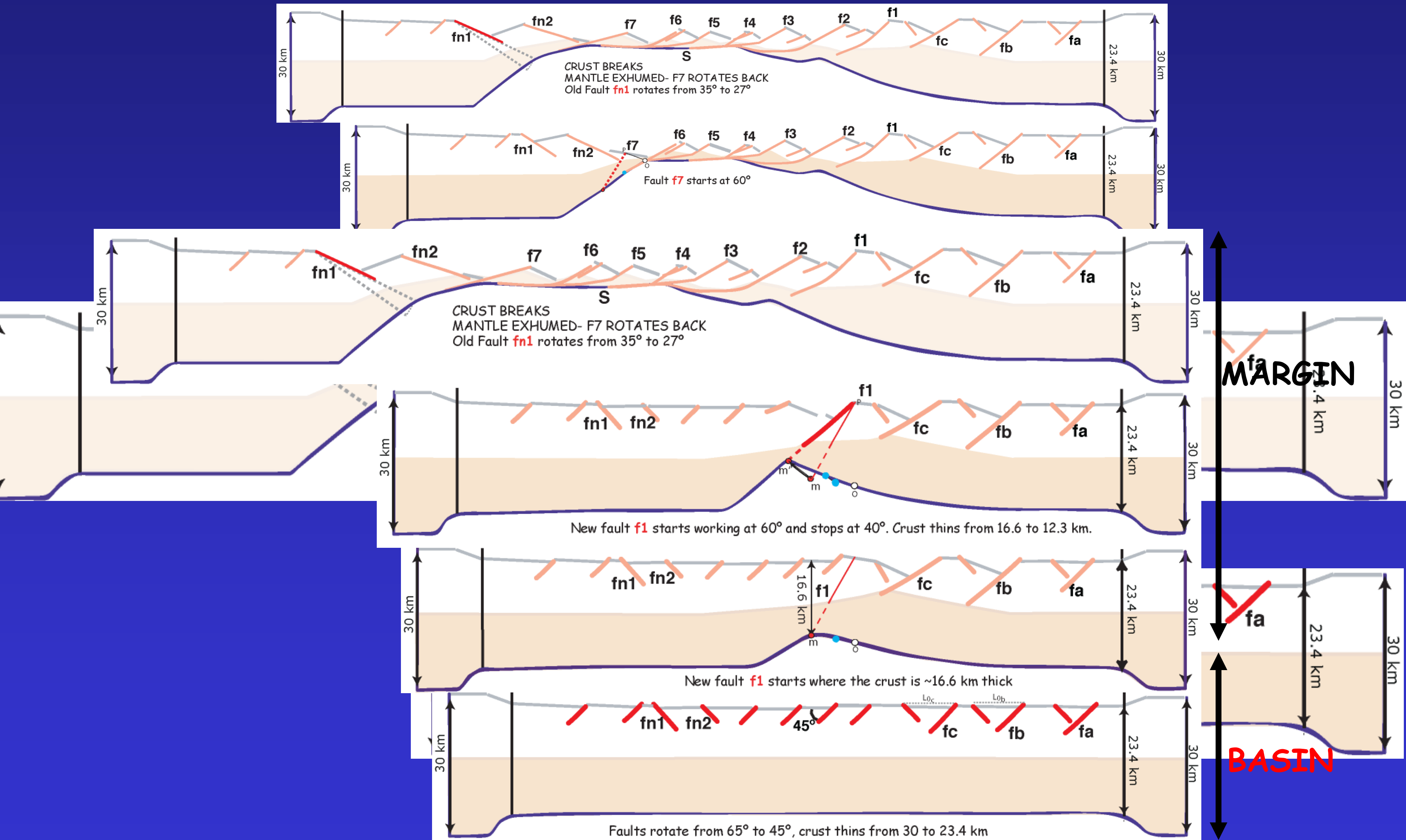
Implications (Illustrated)



Implications (Illustrated)



Implications (Illustrated)

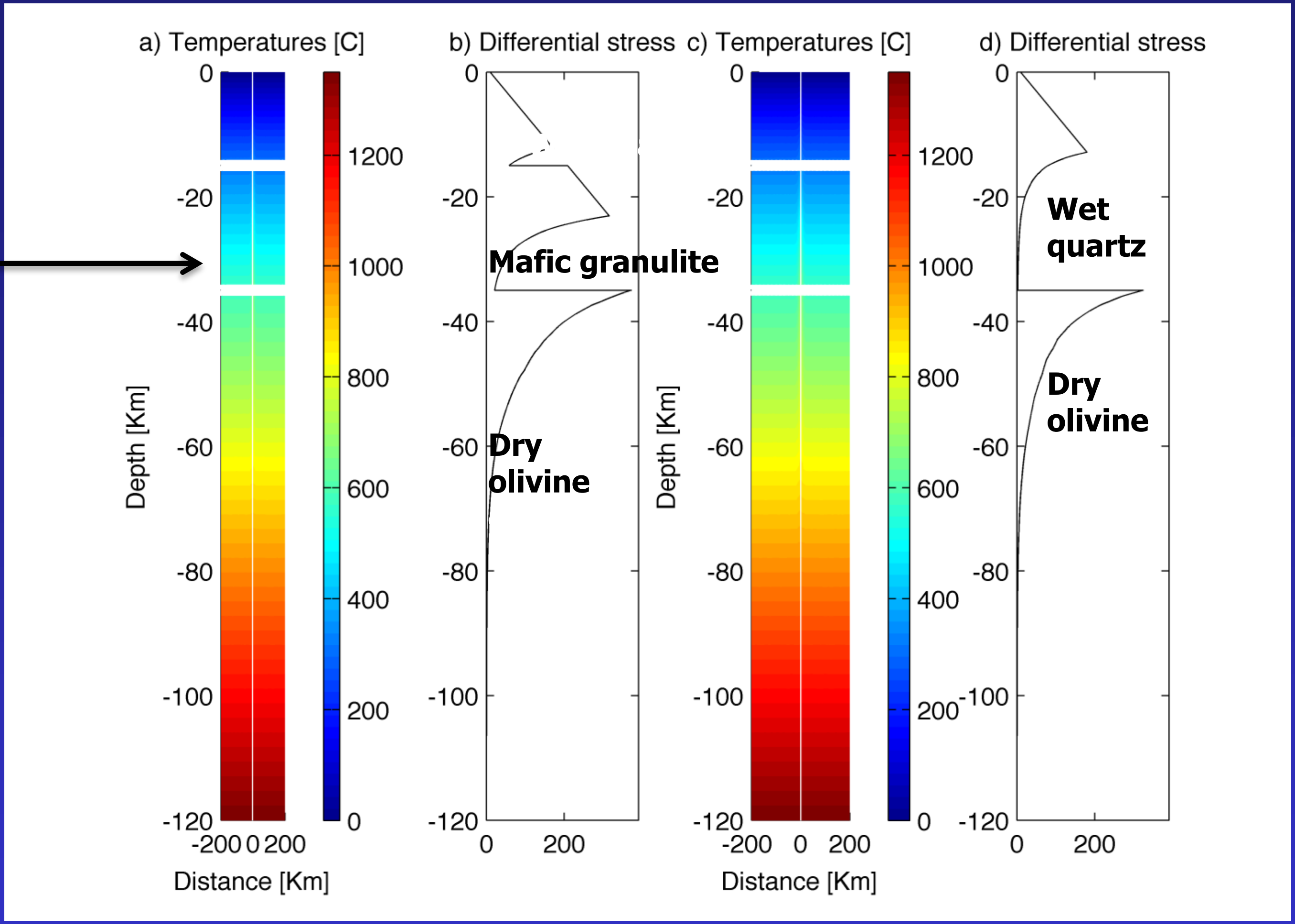


Margin architecture
Melting & Serpentinisation

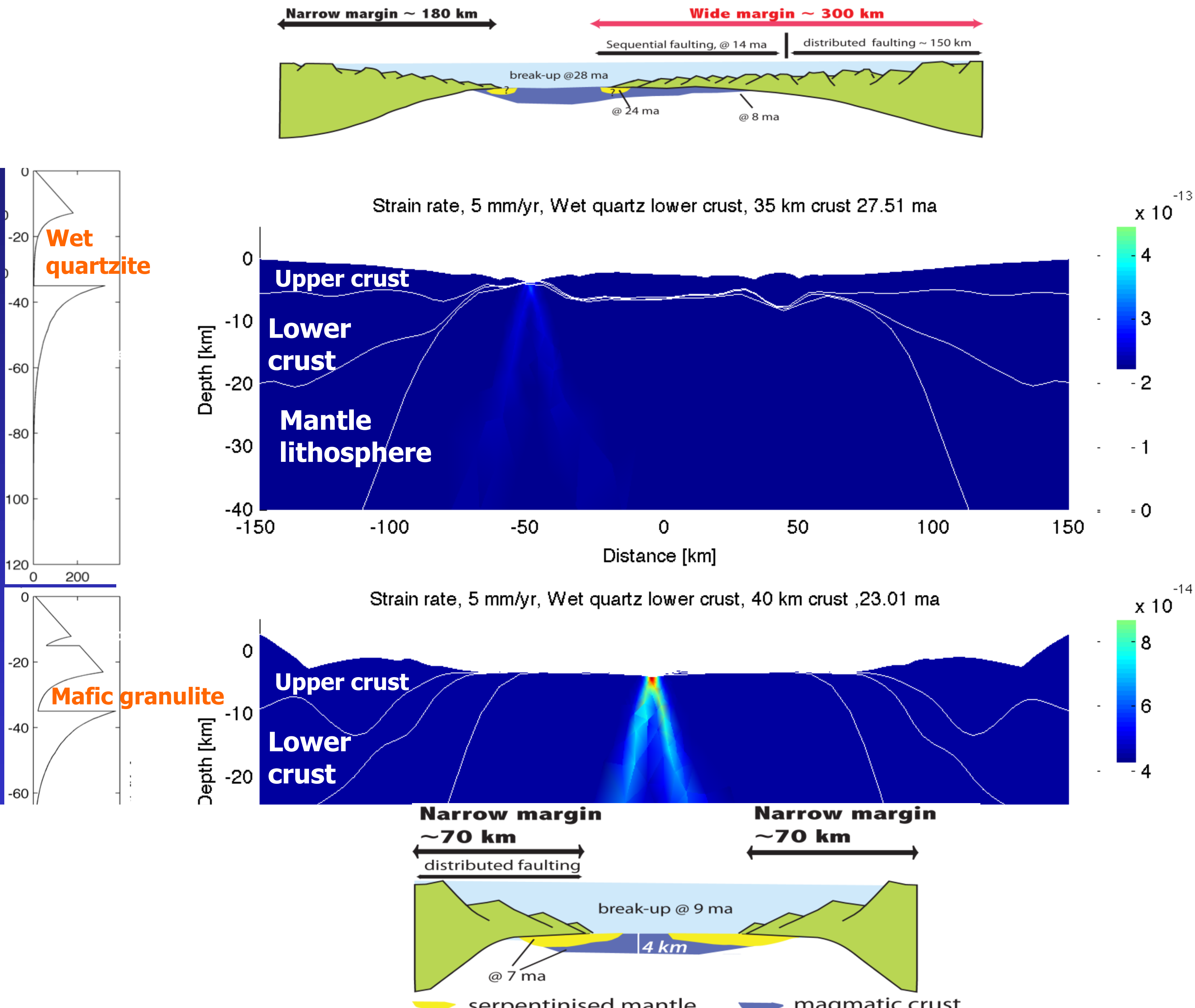
Influence lower crustal rheology:
1- lower crustal composition

Initial configuration - vel. 5 mm/yr - mafic granulite/wet quartz

Local temperature higher by 100 C Close to Moho

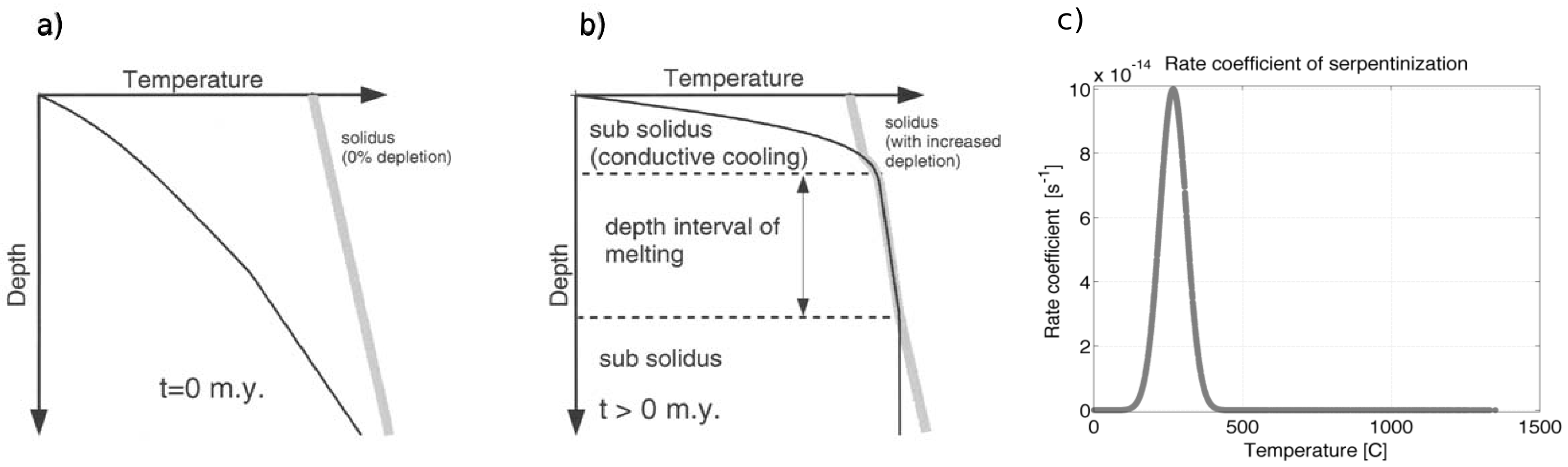


Boundary conditions: constant velocity 5mm/yr at box edges
Brittle and viscous strain softening
Initial weak seed: temperature higher by 100C close to Moho.



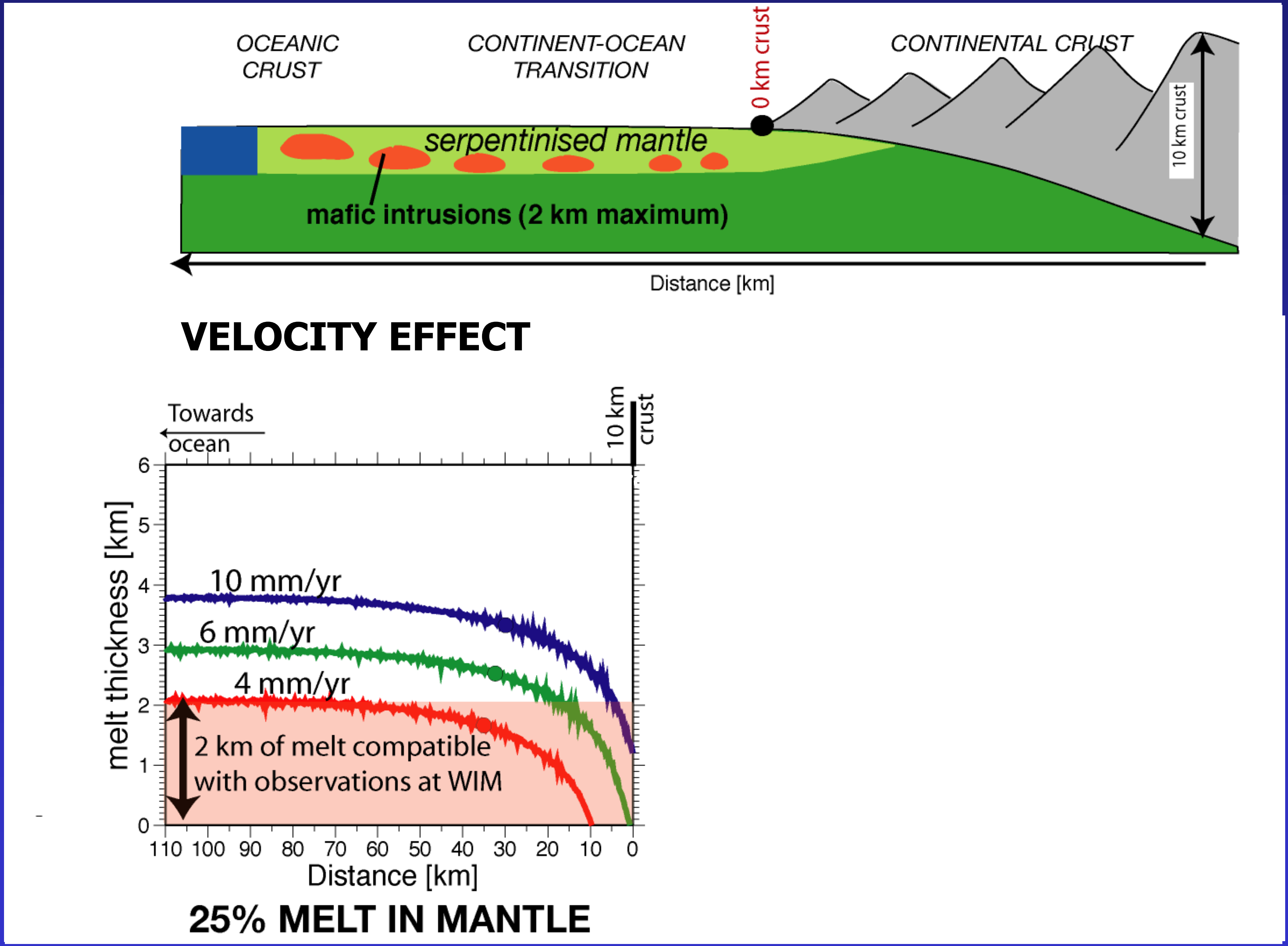
Same velocity = 5 mm/yr

Melting & Serpentinization



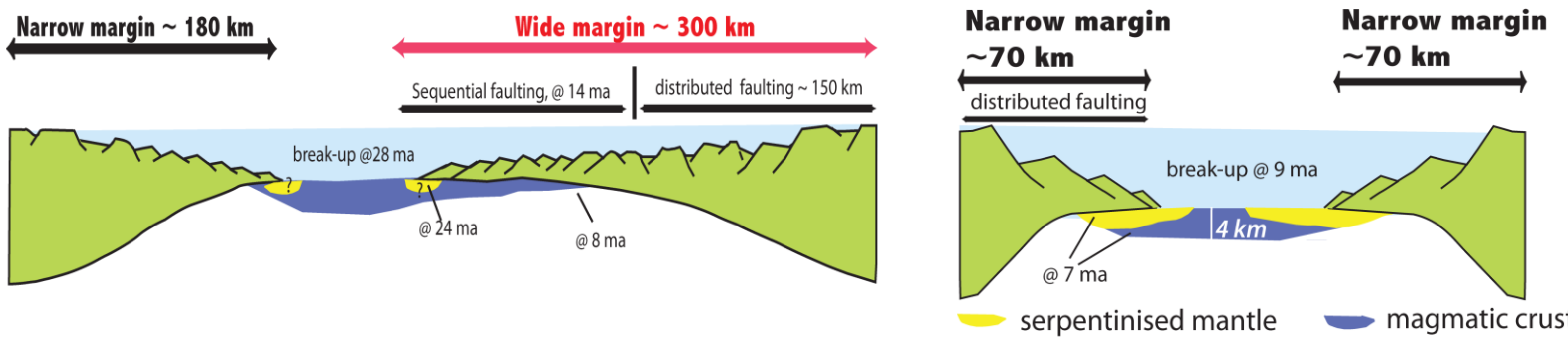
- Dry peridotite solidus melting (parametrization Phipps Morgan, *G-cubed*, 2001).
- Solidus increases with increasing depletion.
- Serpentinization rate dependence on temperature (Emmanuel and Berkowitz, 2006)
- Serpentinization only occurs when the whole crust is brittle.

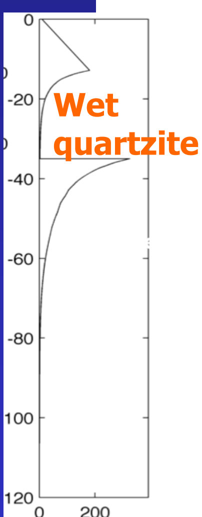
Melting dependency on velocity of extension

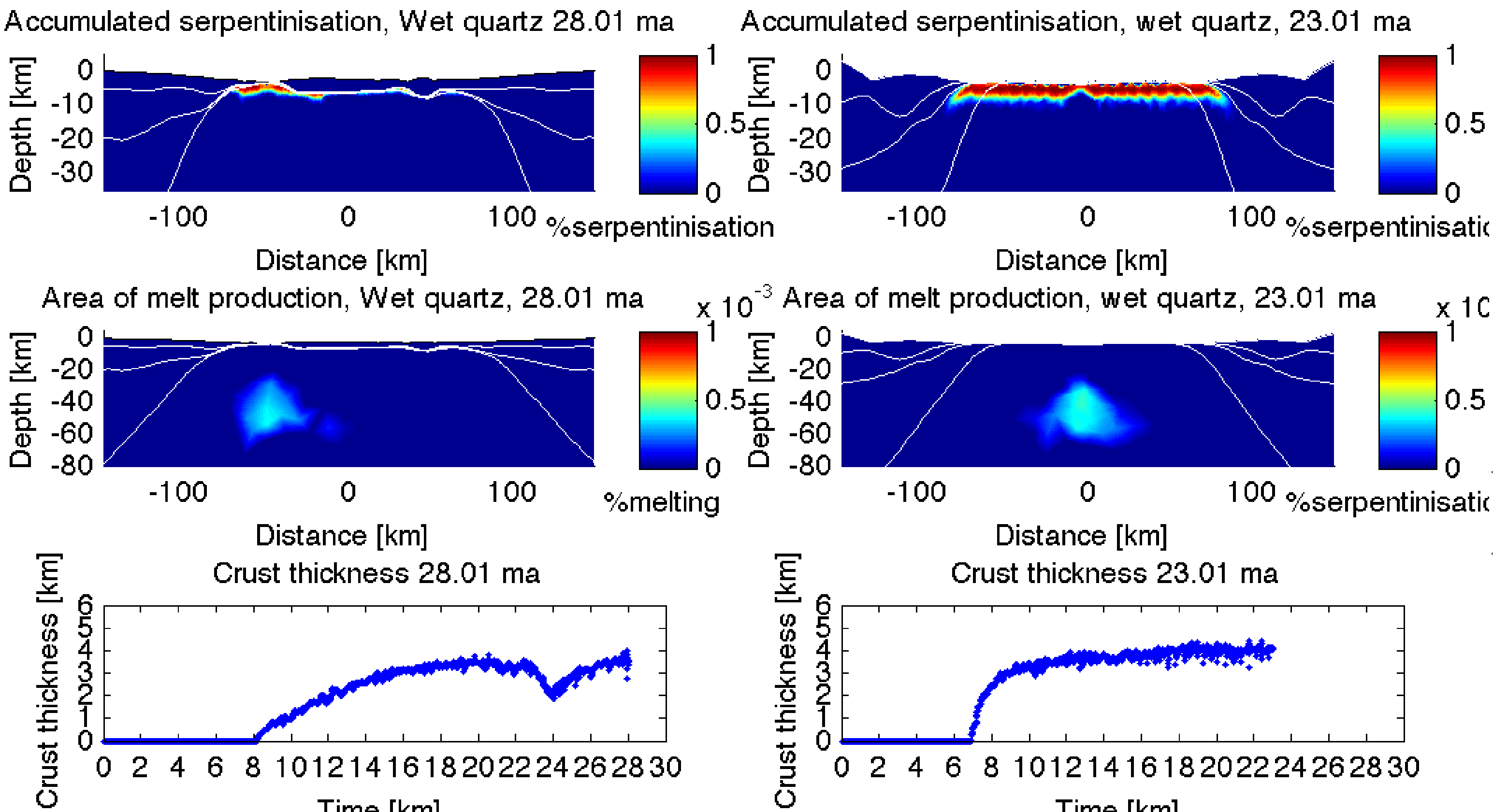


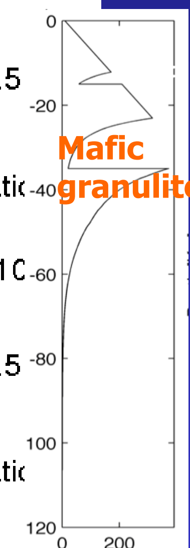
Perez-Gussinye et al., EPSL, 2006.

Effect of lower crustal composition on serpentinisation/melting.









Little serpentinisation, less melting

More serpentinisation & melting

Same velocity = 5 mm/yr

Margin architecture
Melting & Serpentinisation

Influence lower crustal rheology:
2- crustal thickness

Questions

- Formation of asymmetry. ✔
- Degree of asymmetry and margin width.
- Fault geometry with extension ✔ and along margin length.
- Oceanization style (abrupt transition vs exhumed mantle).

Lower crustal rheology: <u>composition</u>, <u>crustal thickness</u>, velocity.

Questions

- Formation of asymmetric conjugate margins.
- Degree of asymmetry.
- Margin width.
- Controls on faulting patterns.
- Oceanization style (abrupt transition vs exhumed mantle). Part 4