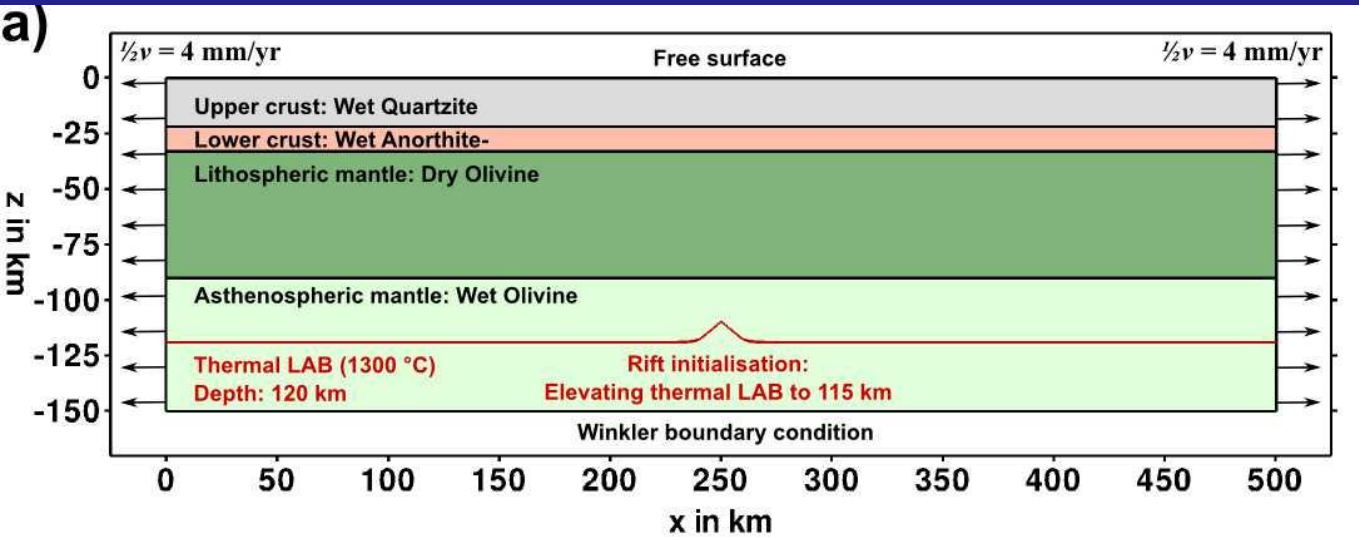
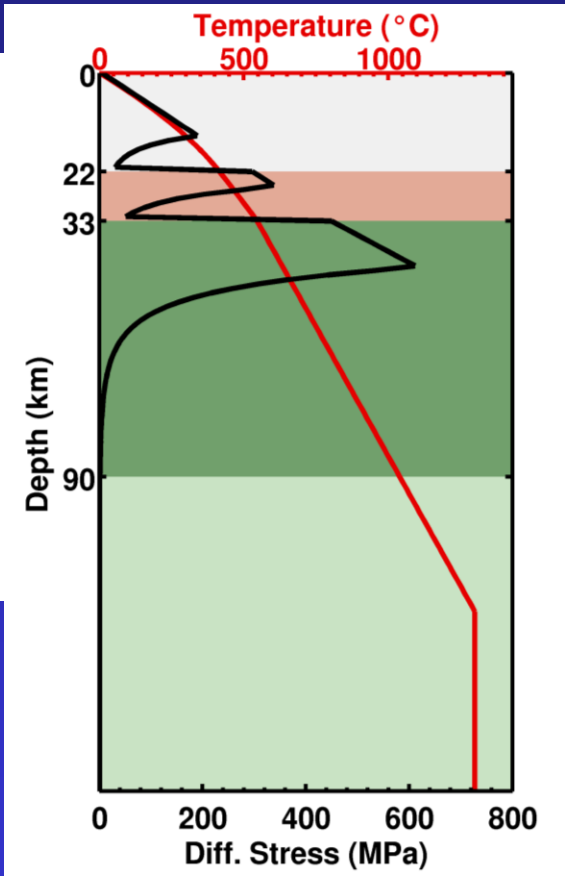
Asymmetry by sequential faulting - Dynamics of the system



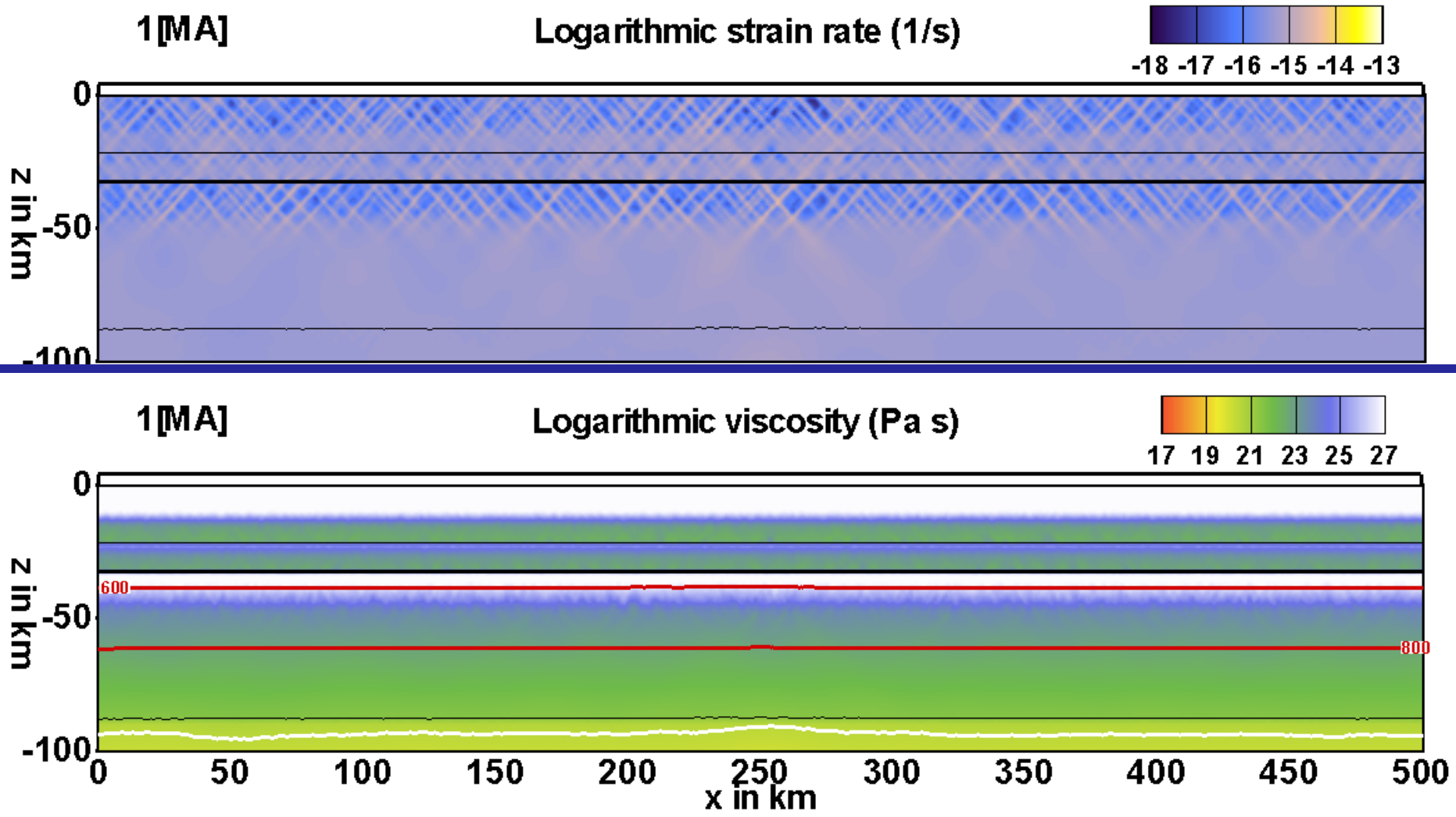


2D version of SLIM3D

$$\dot{\varepsilon}_{ij} = \dot{\varepsilon}_{ij}^{el} + \dot{\varepsilon}_{ij}^{vs} + \dot{\varepsilon}_{ij}^{pl}$$

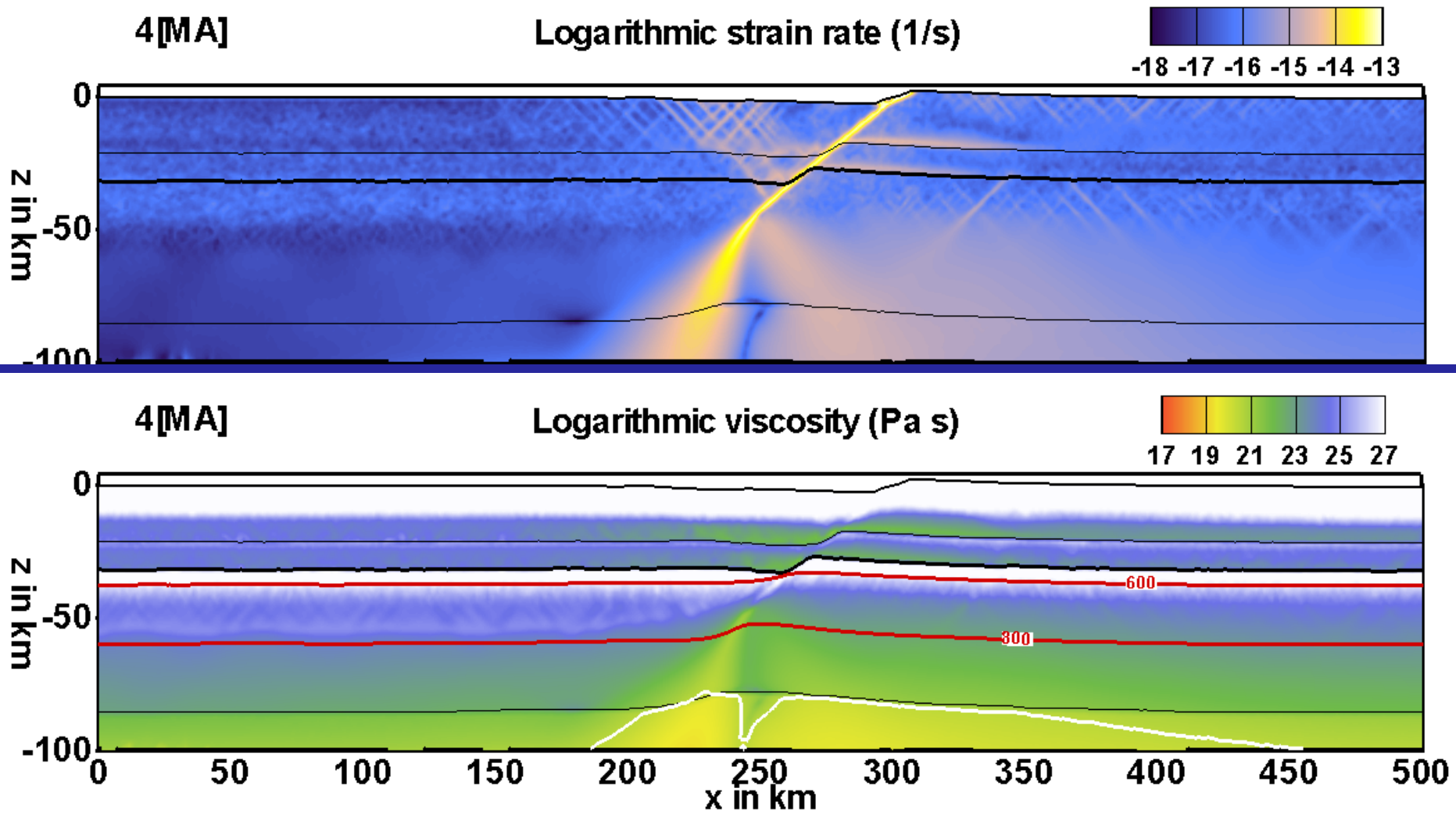
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr



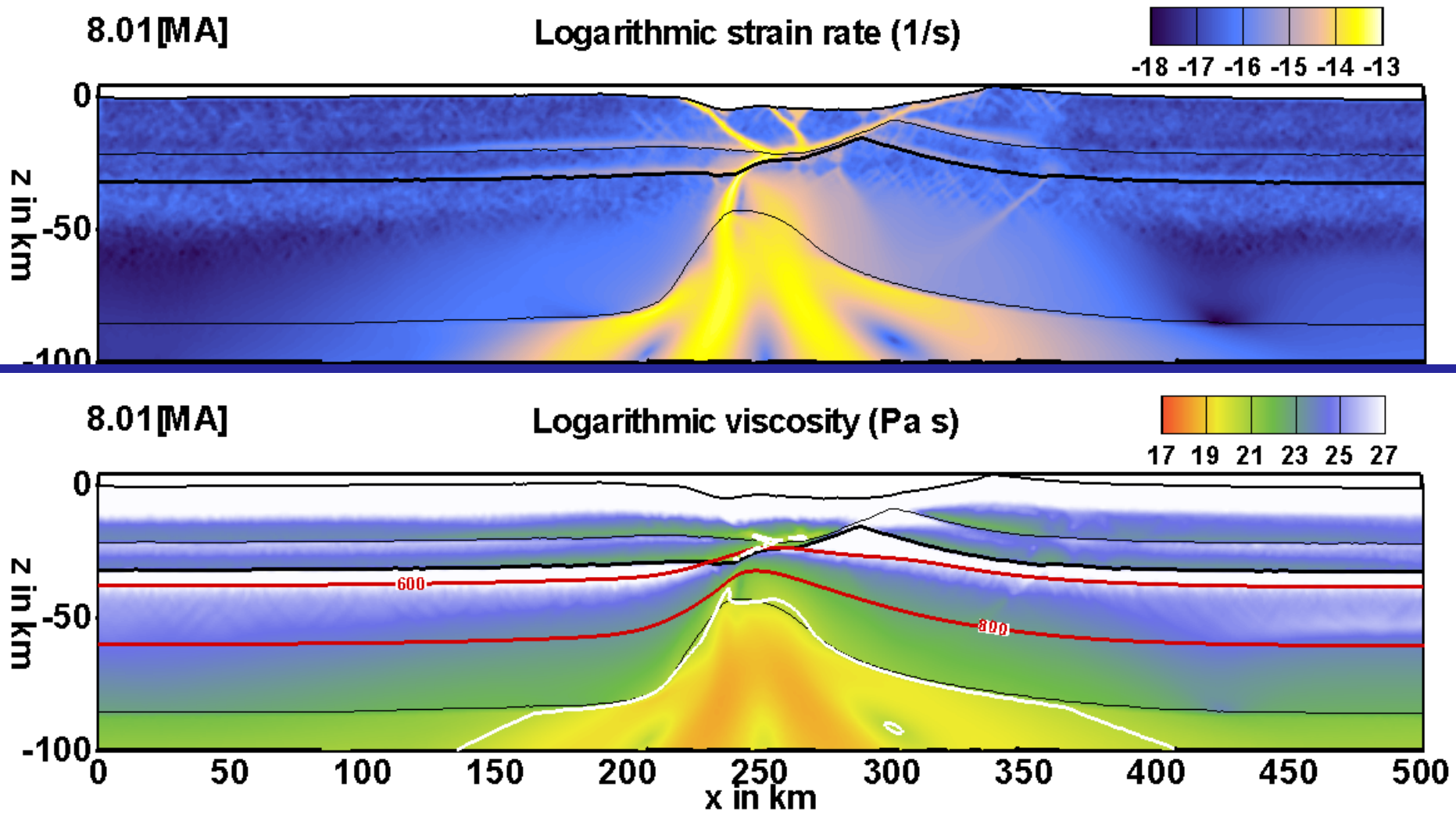
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr



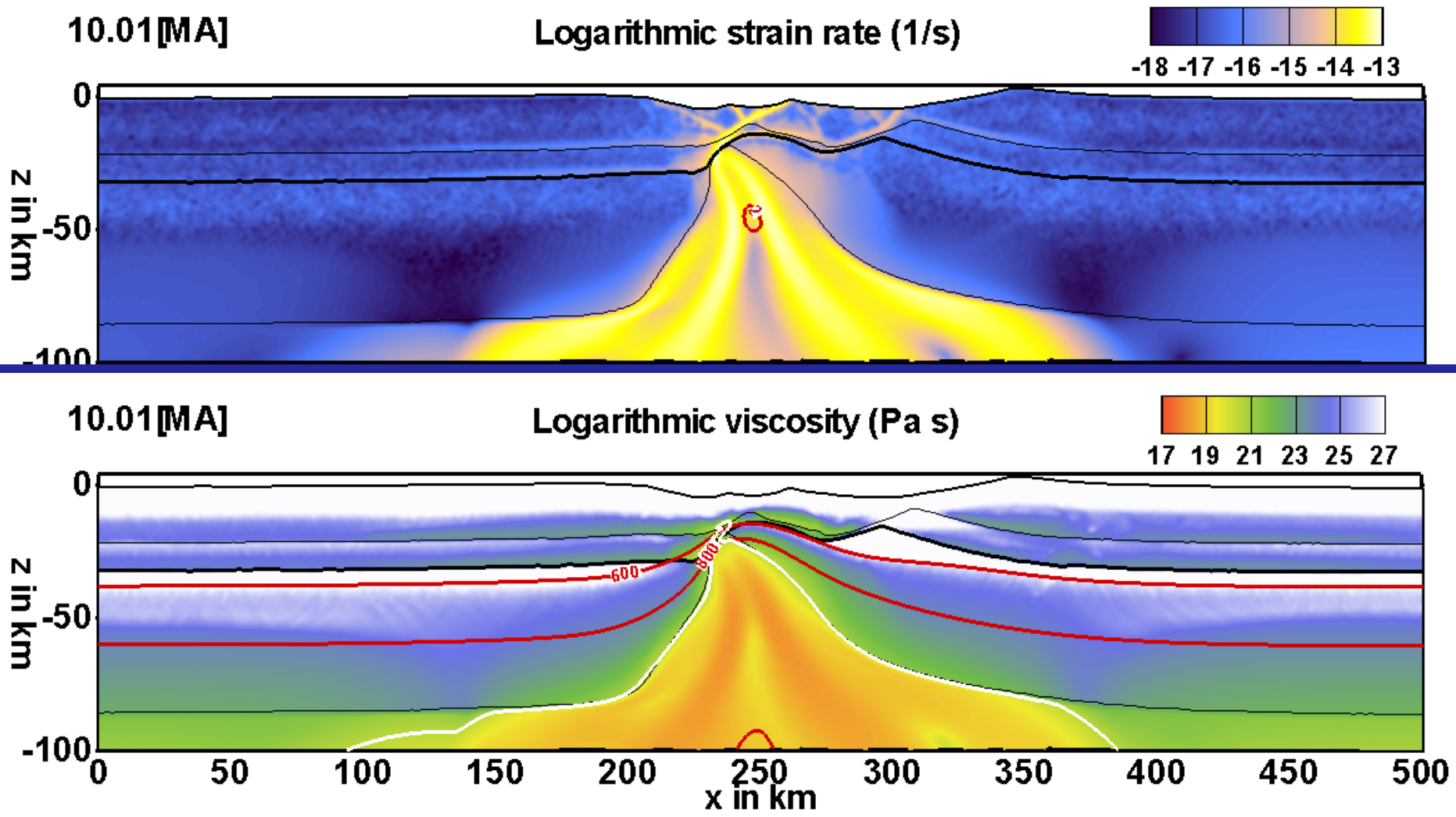
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr



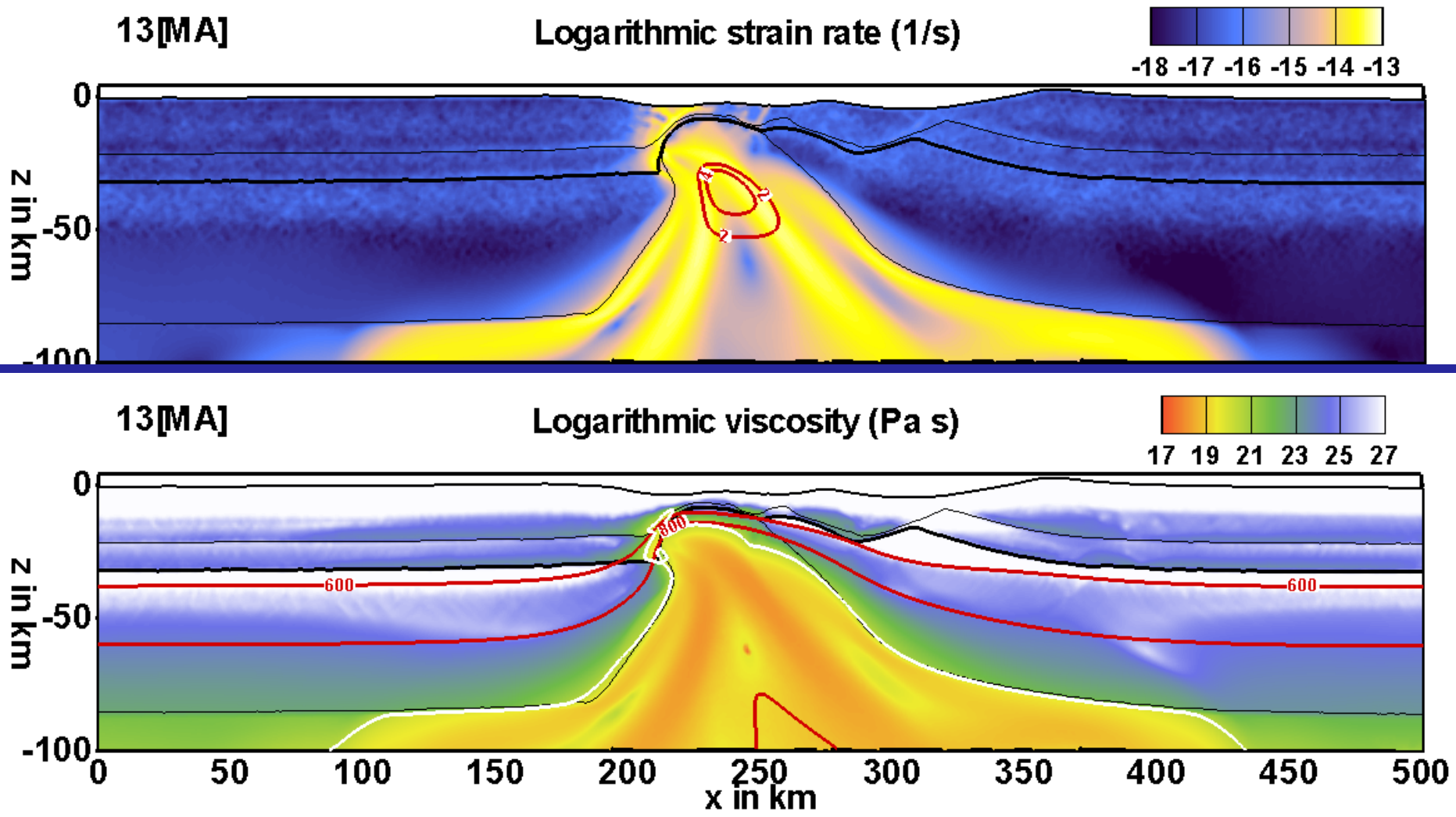
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr



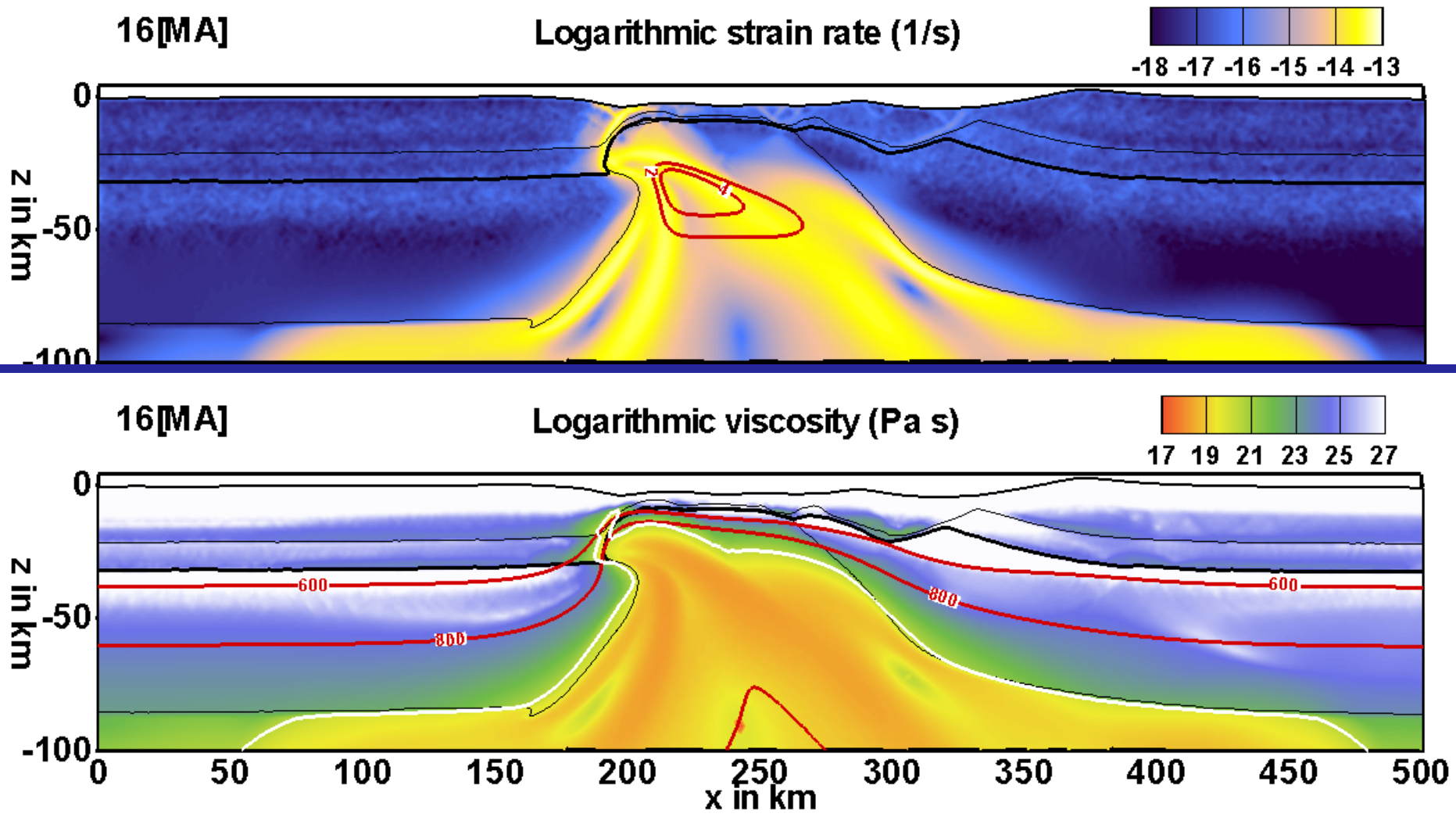
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr

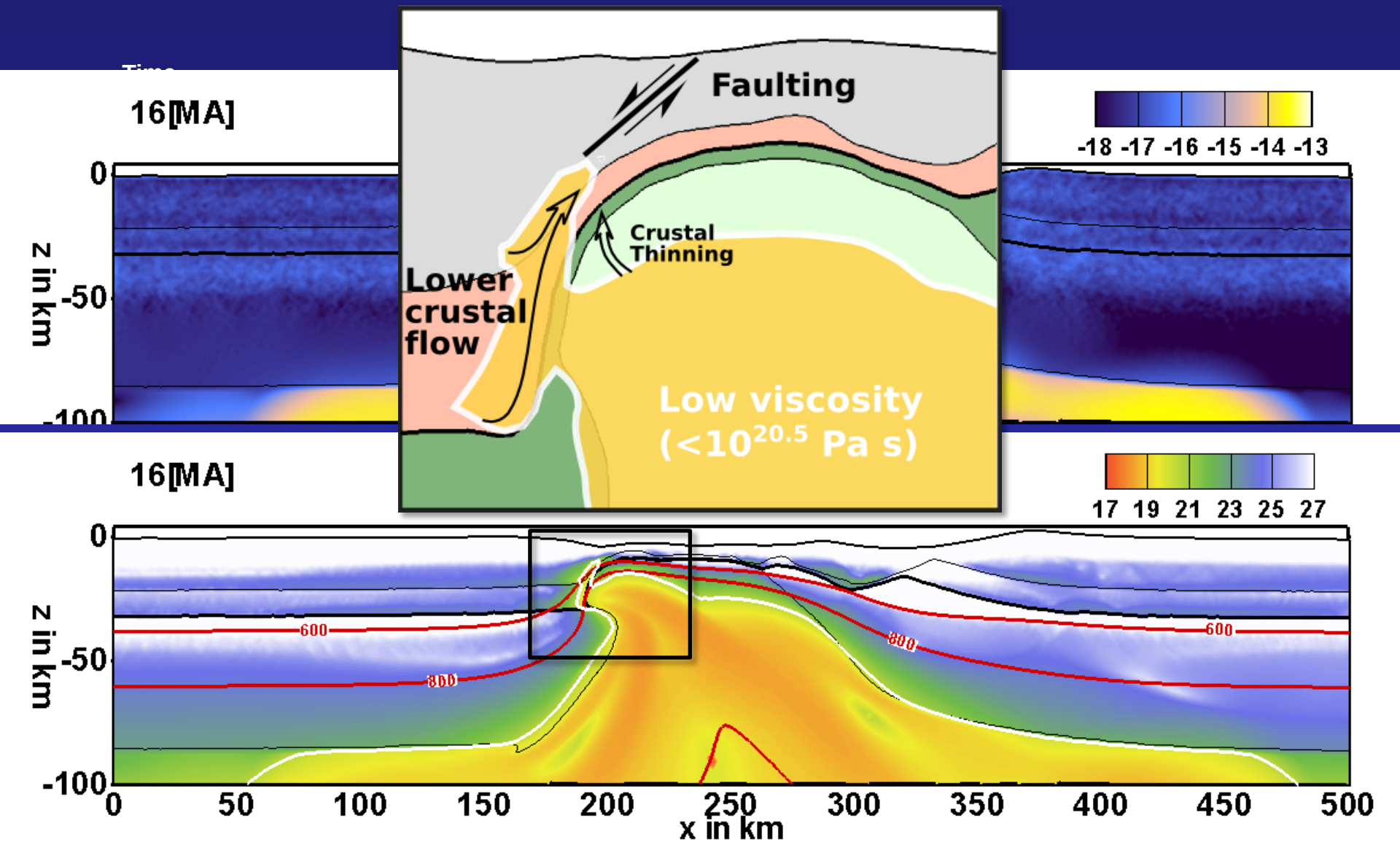


Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr

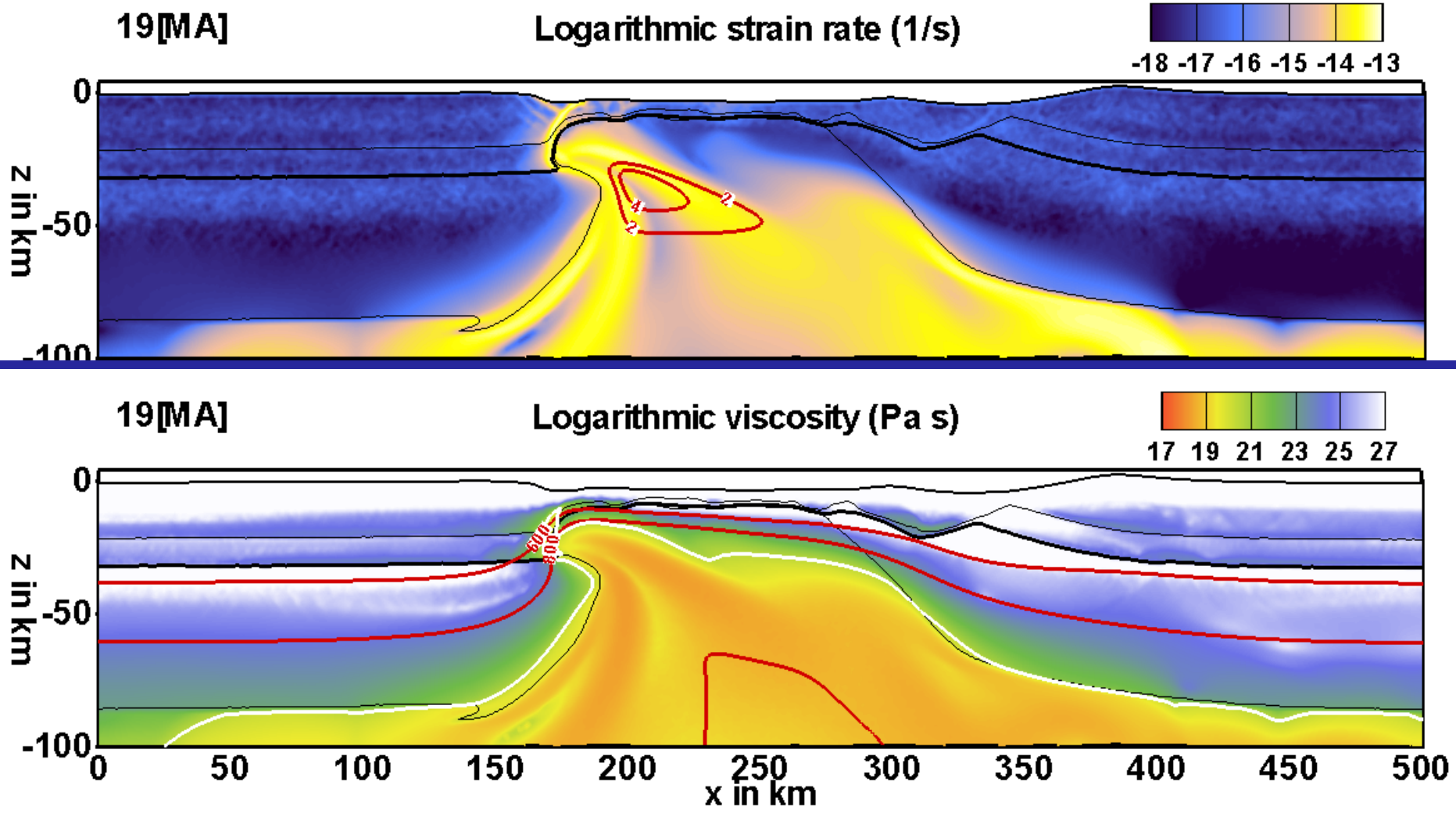


Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014



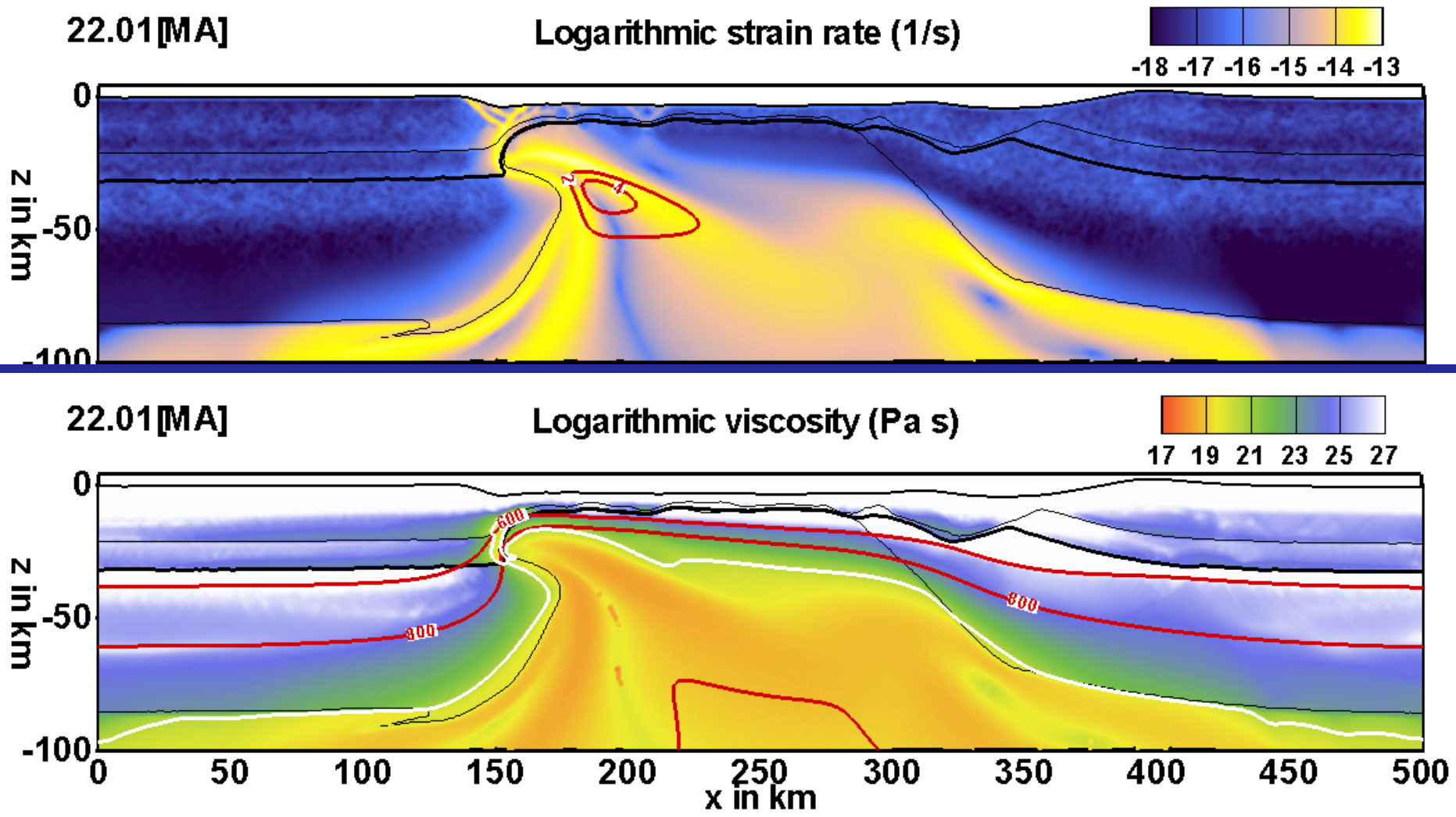
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr



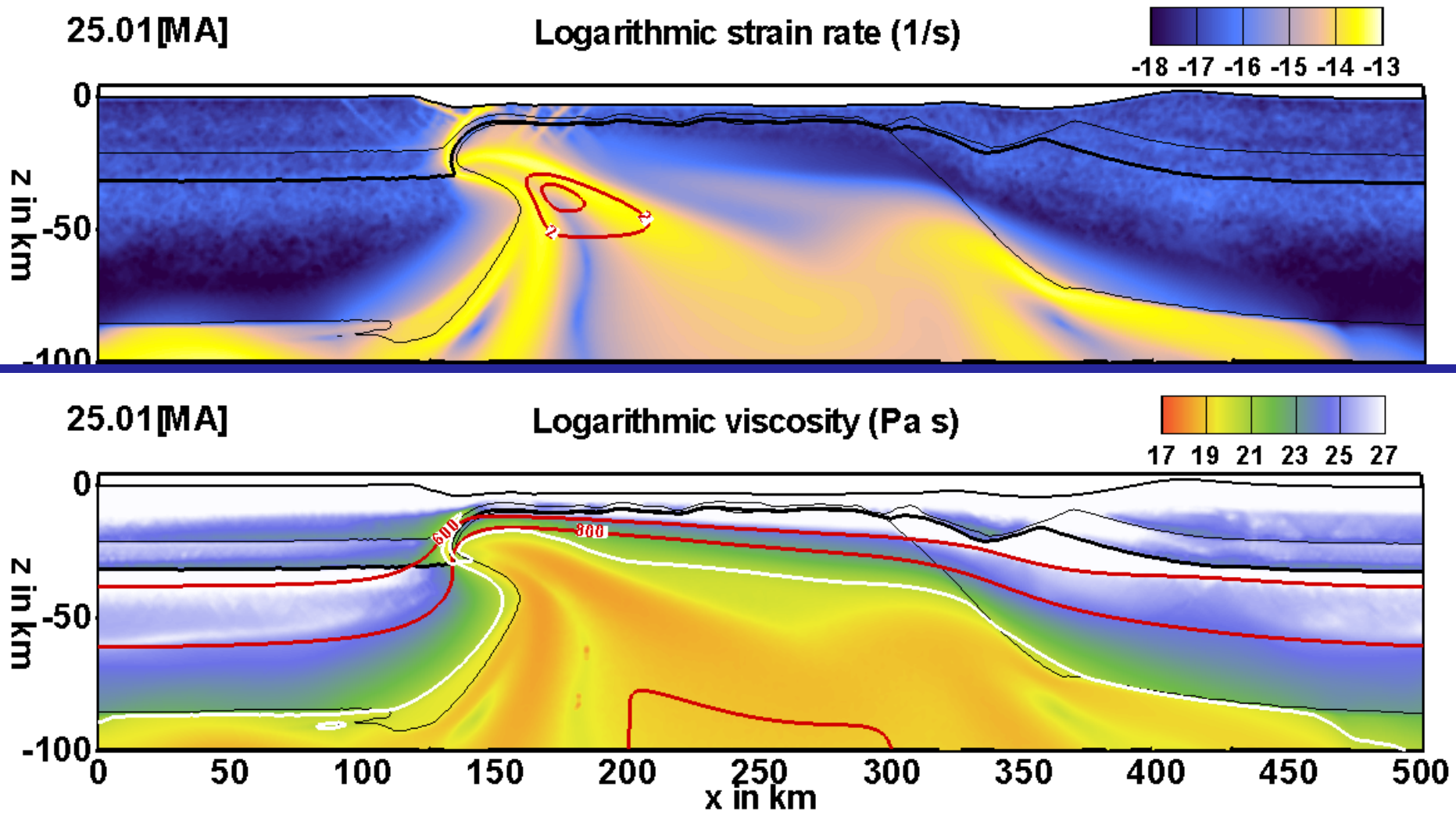
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr

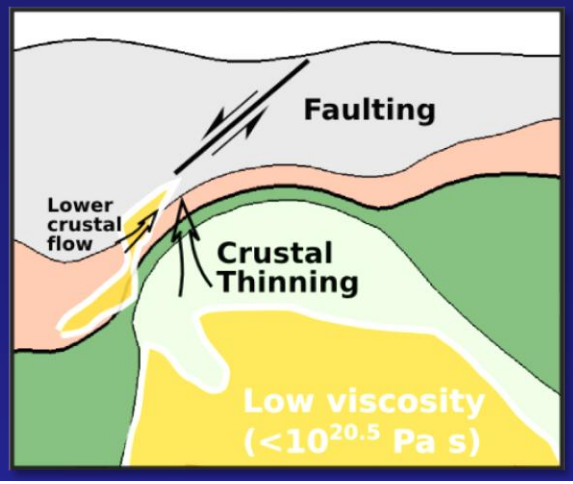


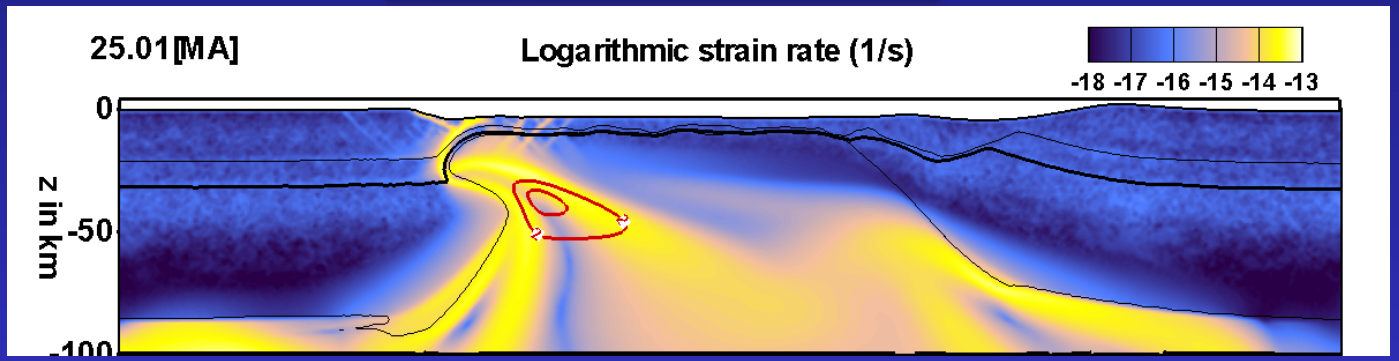
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

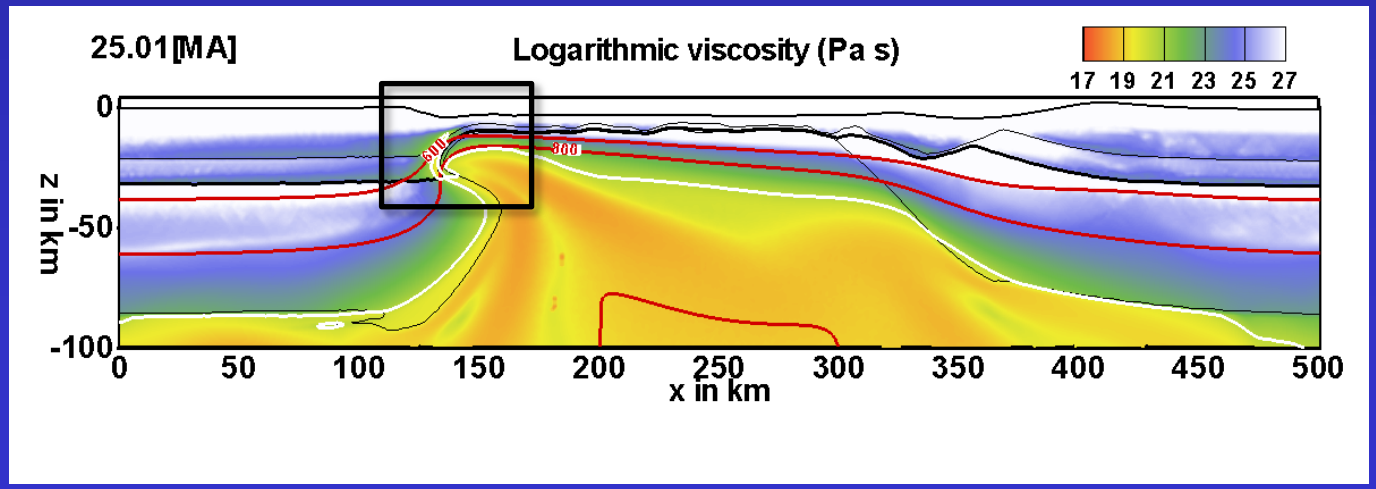
Full extension velocity 8 mm/yr



Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

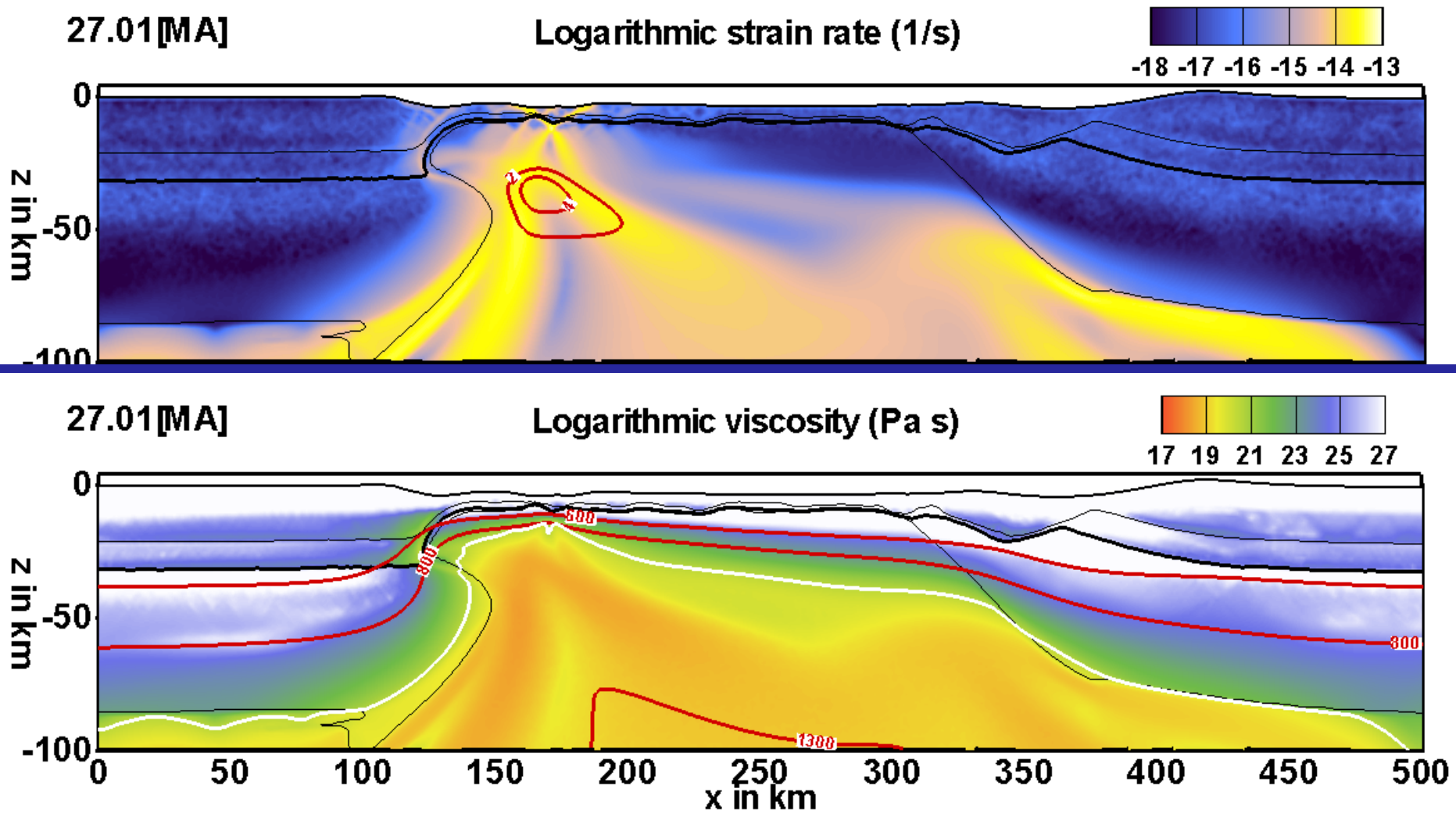






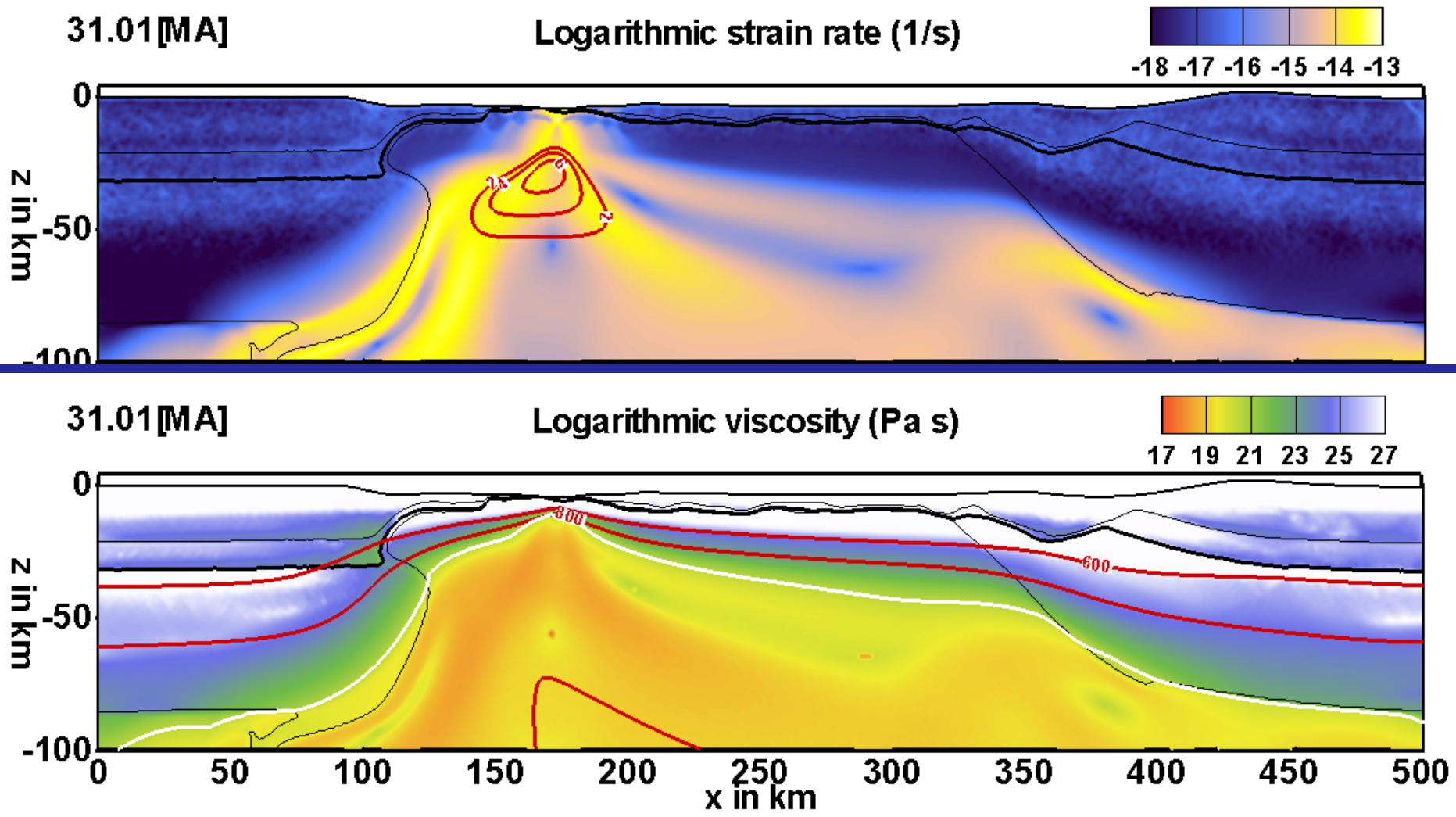
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr



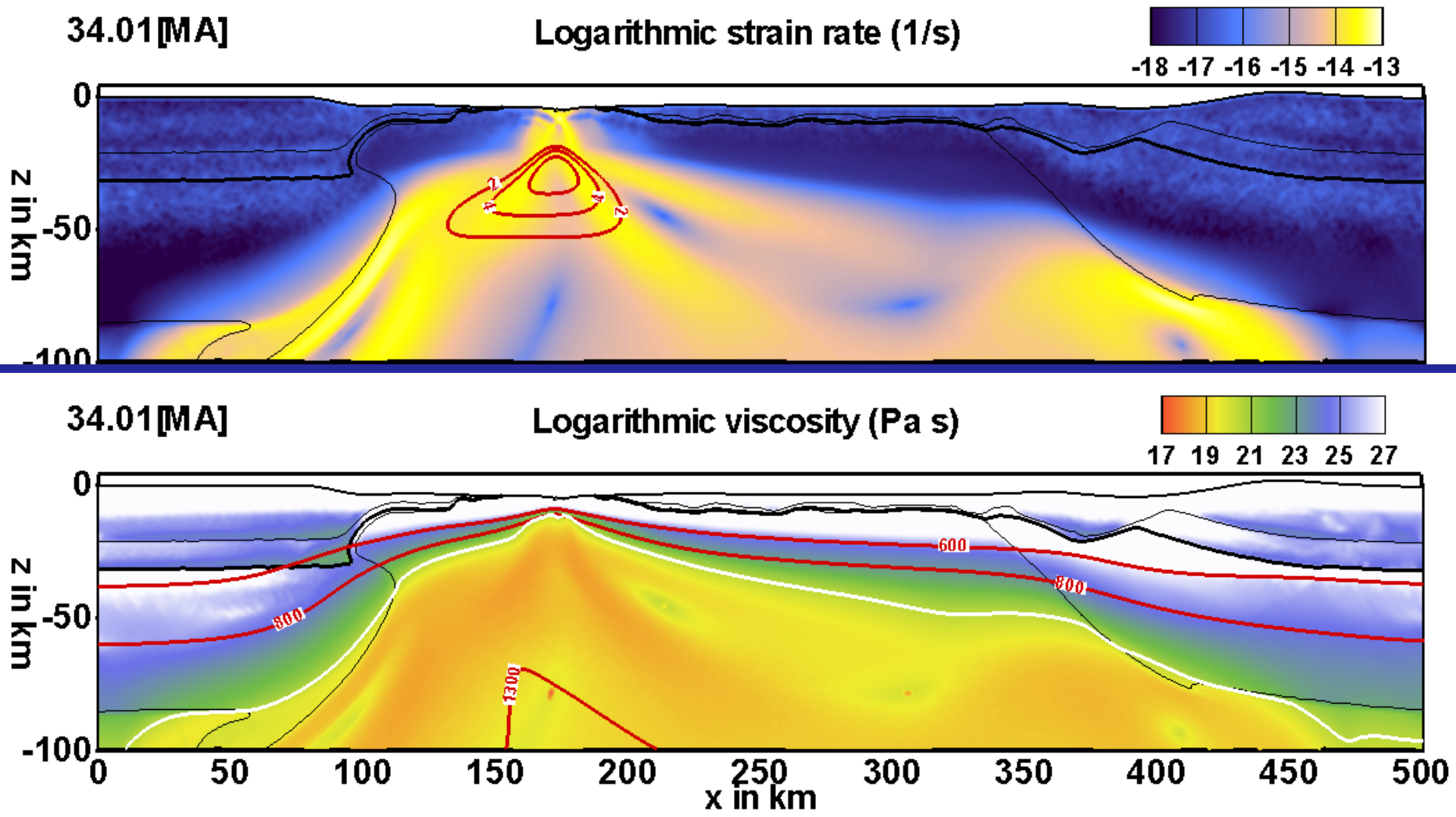
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr



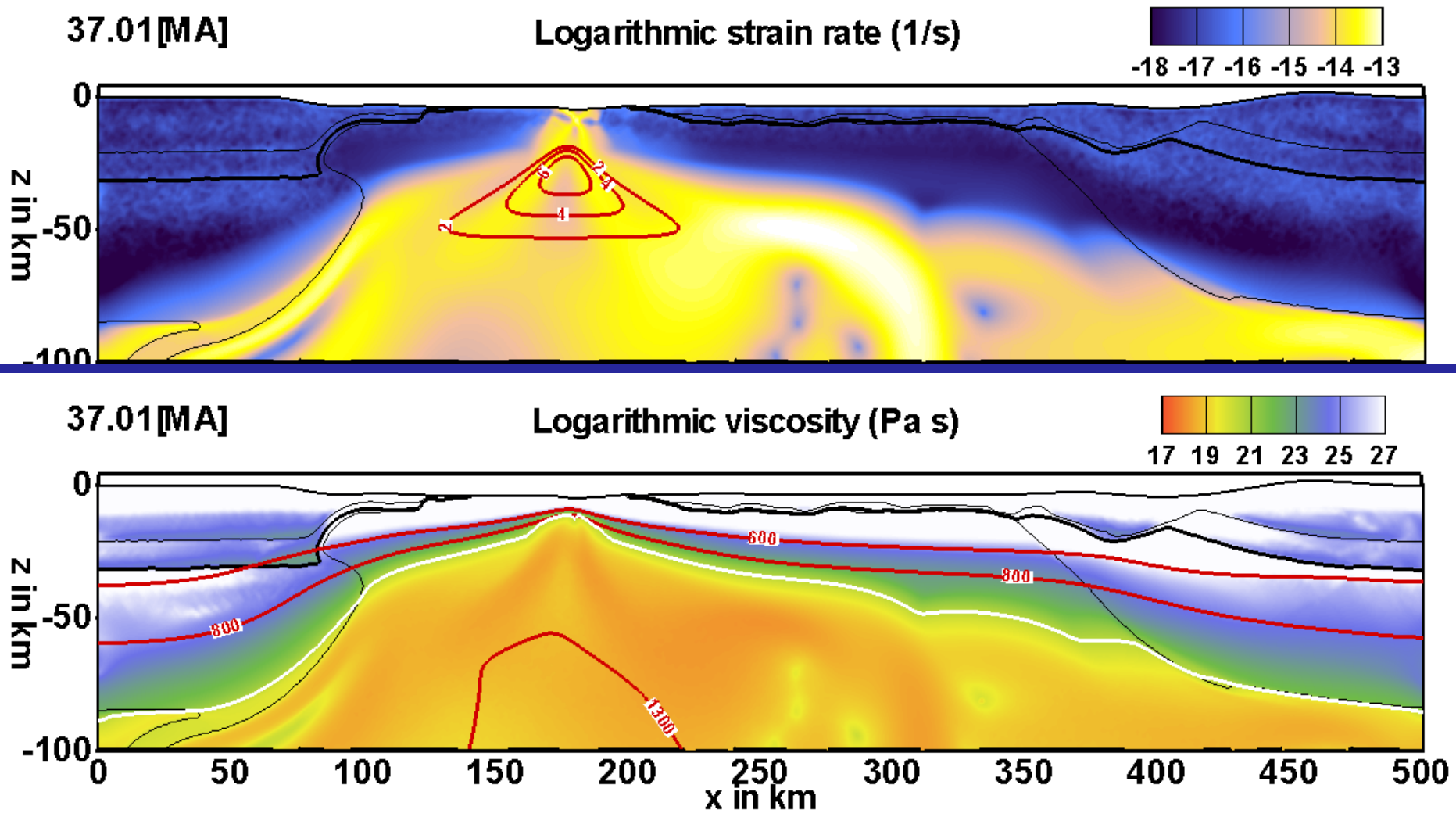
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr



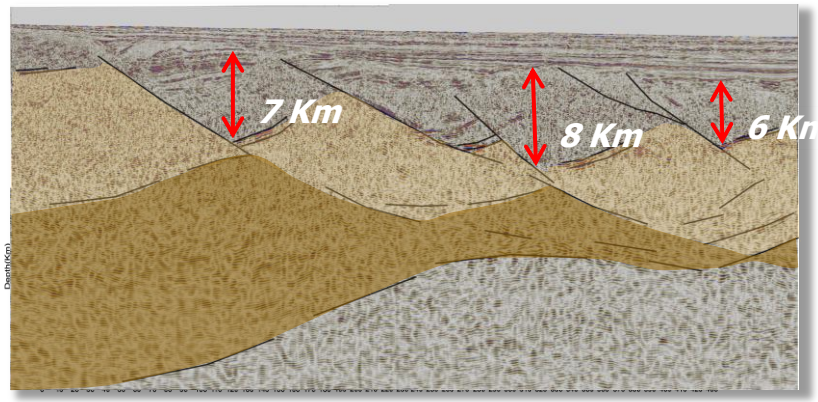
Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

Full extension velocity 8 mm/yr

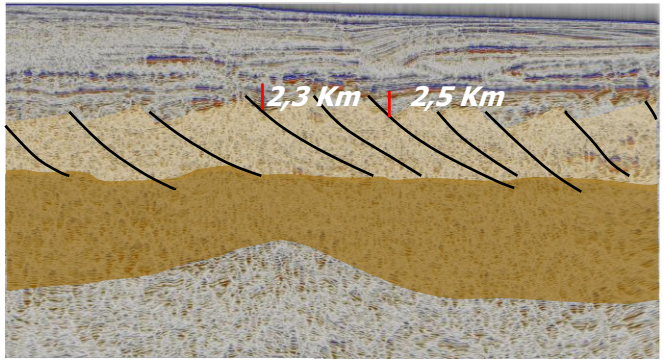


Brune, Heine, Perez-Gussinye & Sobolev, Nature comm., 2014

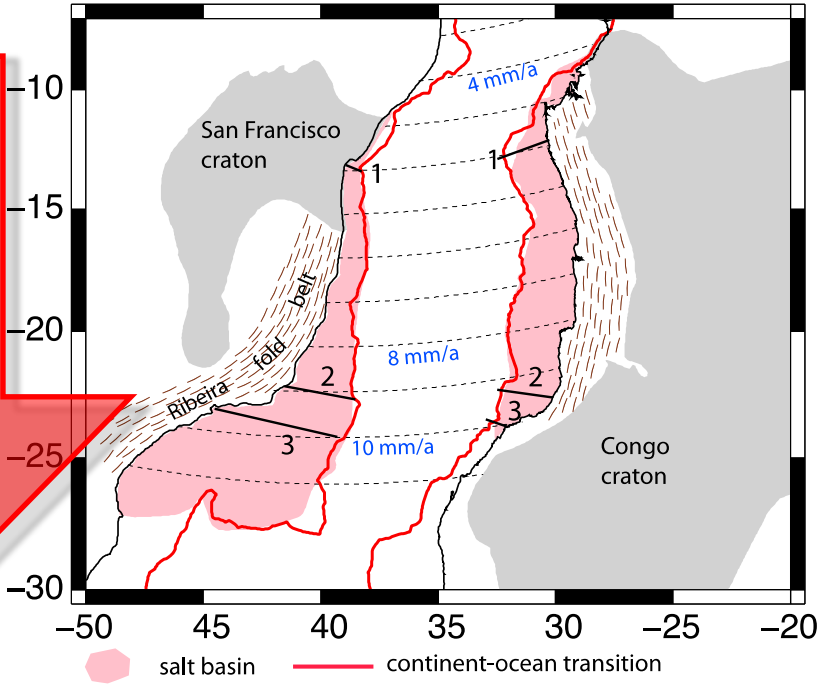
Changing fault patterns



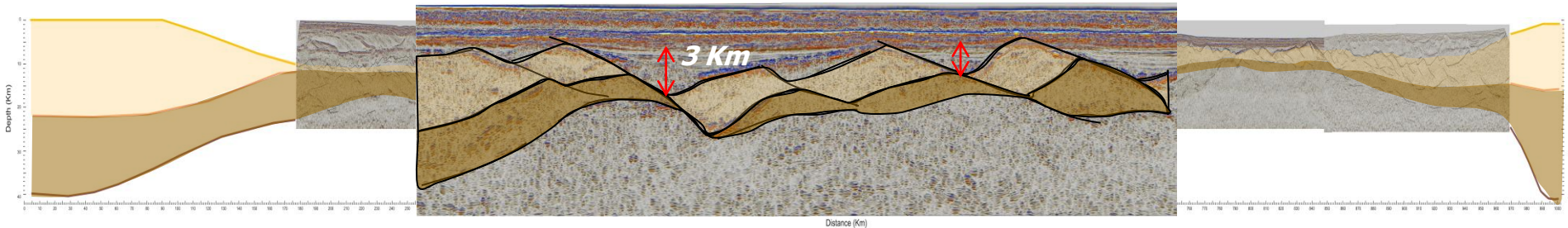
2- CAMPOS - KWANZA



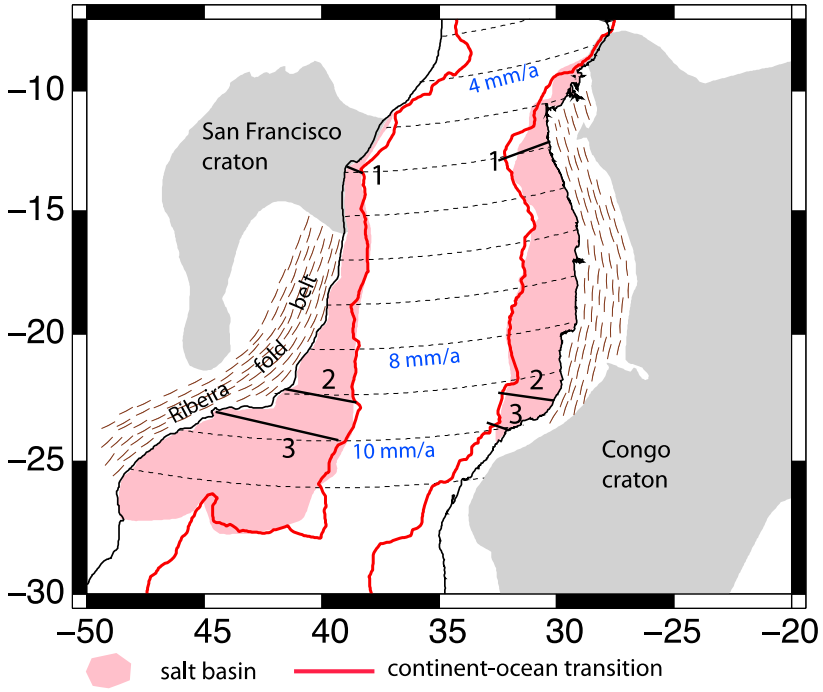
Increasing importance of ductile flow



3- NORTH SANTOS- SOUTH KWANZA



Modes of extension and oceanization along the Brazilian/African margins



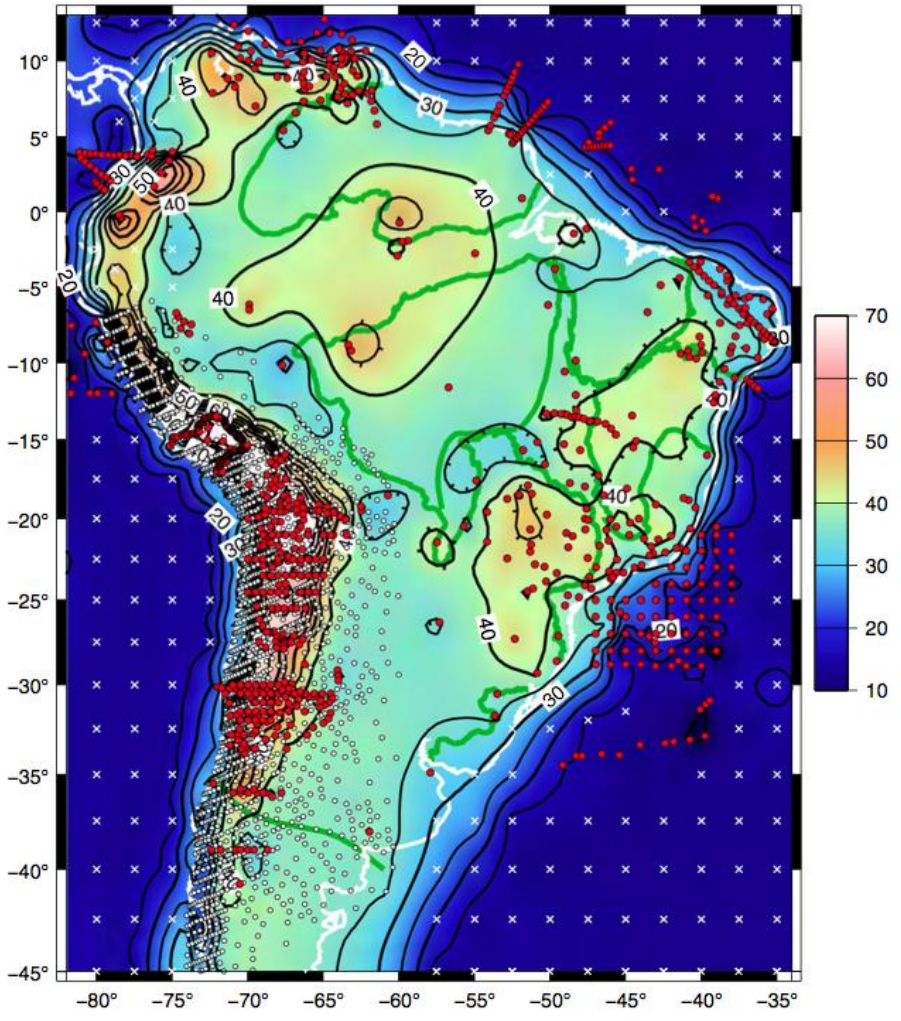
South Atlantic margins

1- Camamu - South Gabon
2- Campos - Kwanza
3- North Santos – S. Kwanza

From North to South:

- Basin width increases
- Initial lithospheric configuration changes from craton to mobile belt
- Degree of asymmetry varies.
- Extension velocity increases, from 2.5 km/Myr- 5km/Myr (half).
- Crust is 37- 40 km in Camamu and Santos and 35 – 40 km in Campos.

Crustal thickness from reciever functions (Assumpaco)



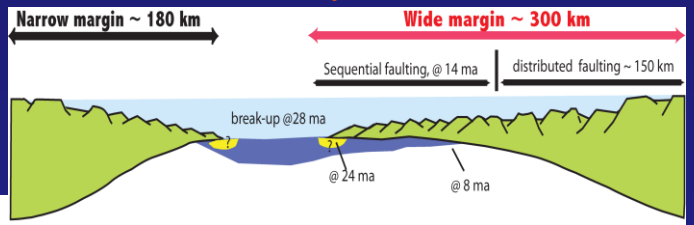
Perez-Gussinye, Araujo, et al., in prep.

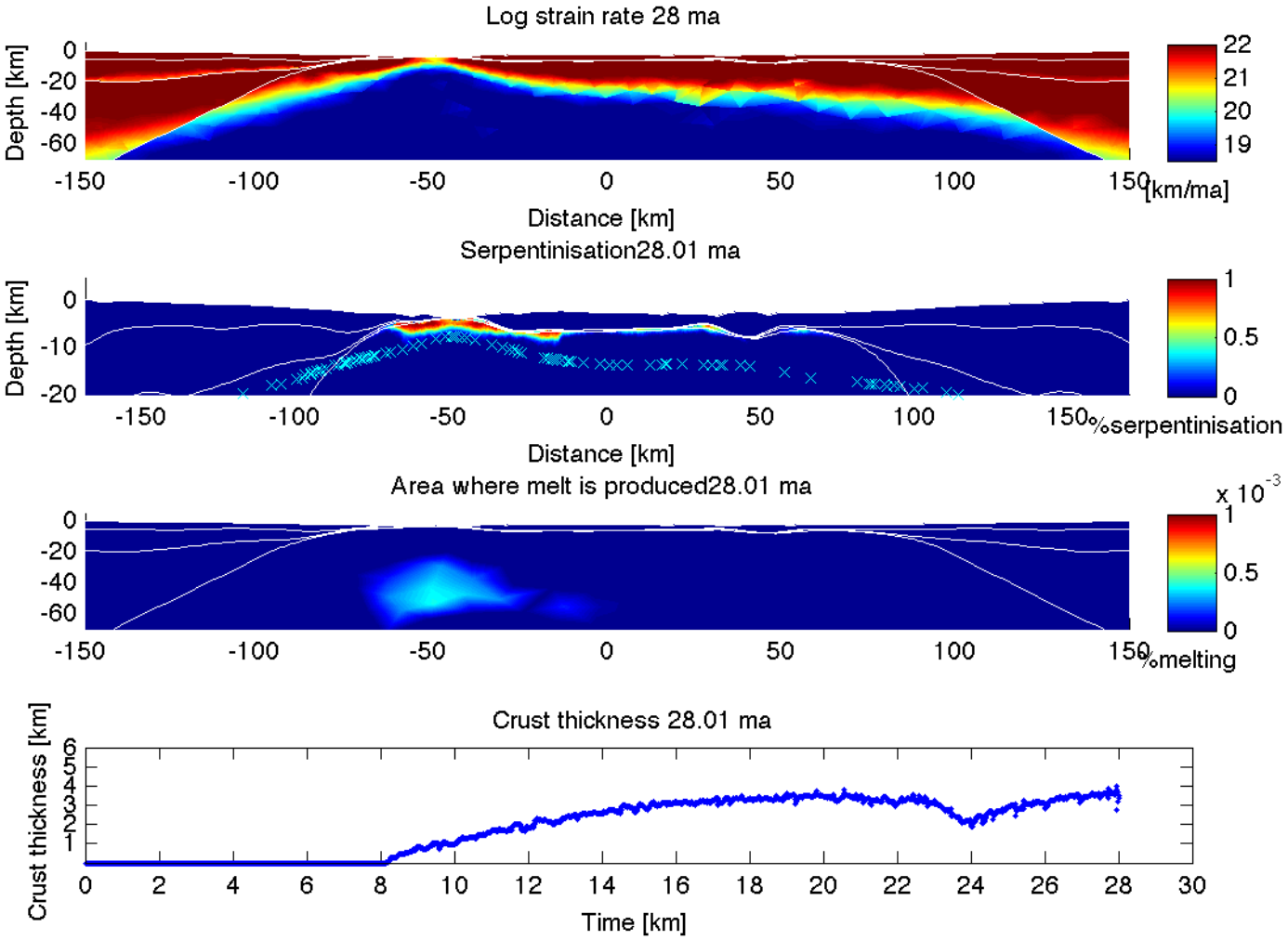
Questions

- What controls the formation of asymmetry ✔ and its degree?
- What controls margin width and faulting pattern?
- Which oceanization styles can we expect (exhumed mantle/abrupt transition to magmatic crust)?

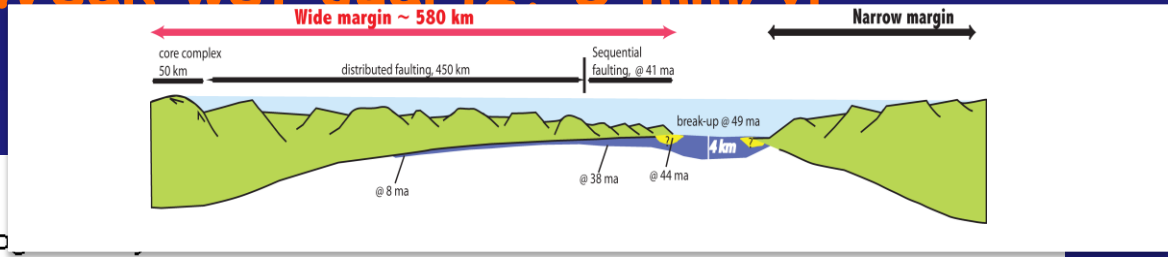
Lower crustal rheology: composition, crustal thickness, velocity.

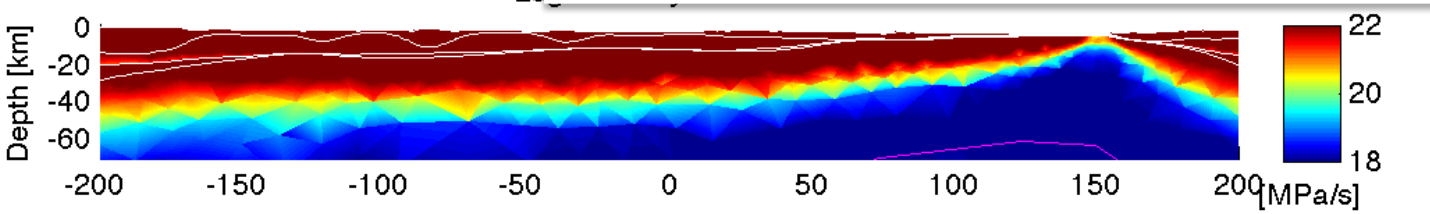
35 km crust, Weak wet quartz, 5 mm/yr

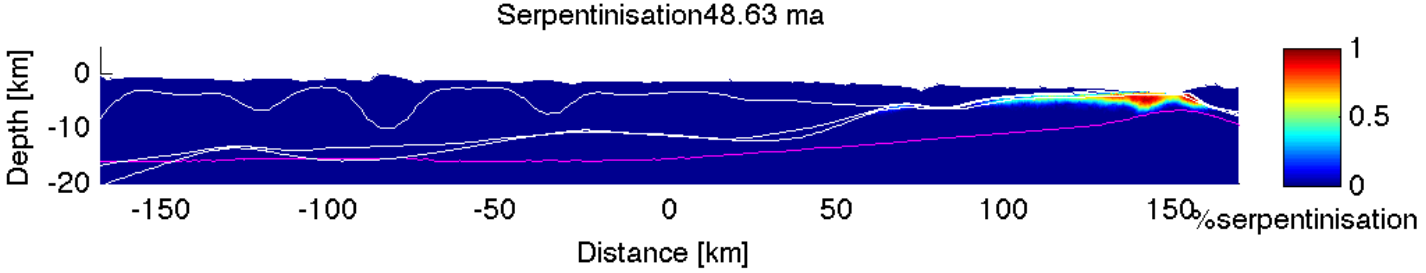


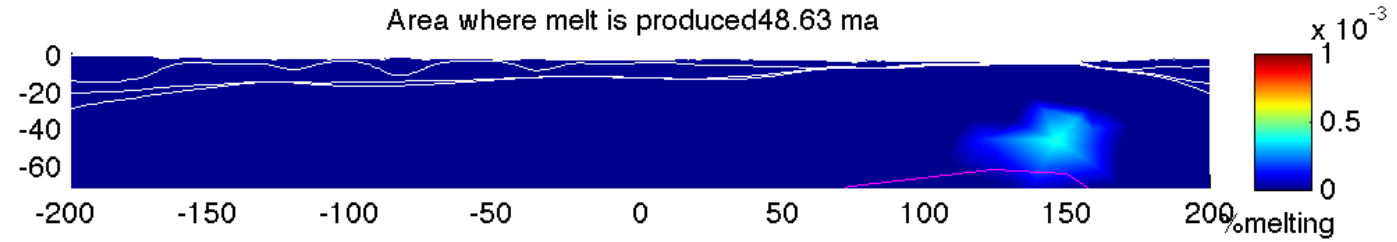


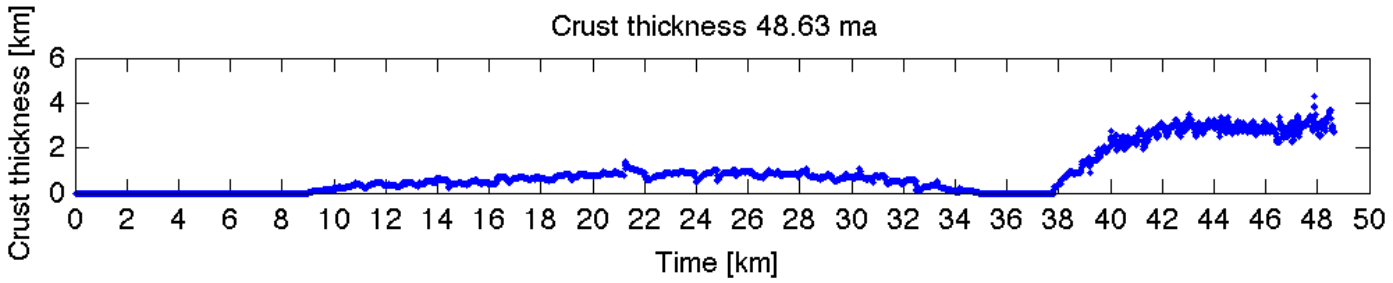
40km crust, Weak wet quartz, 5 mm/yr



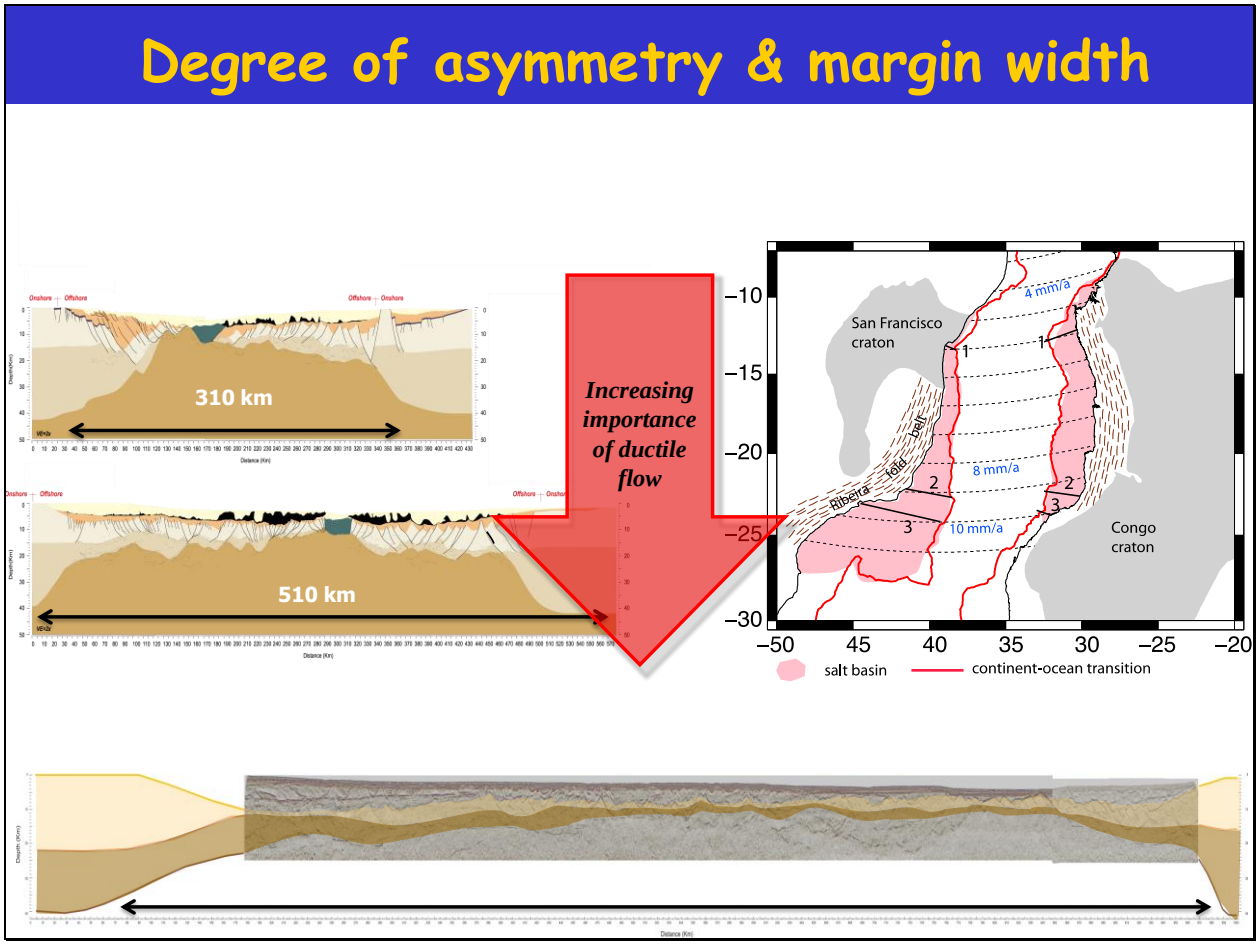






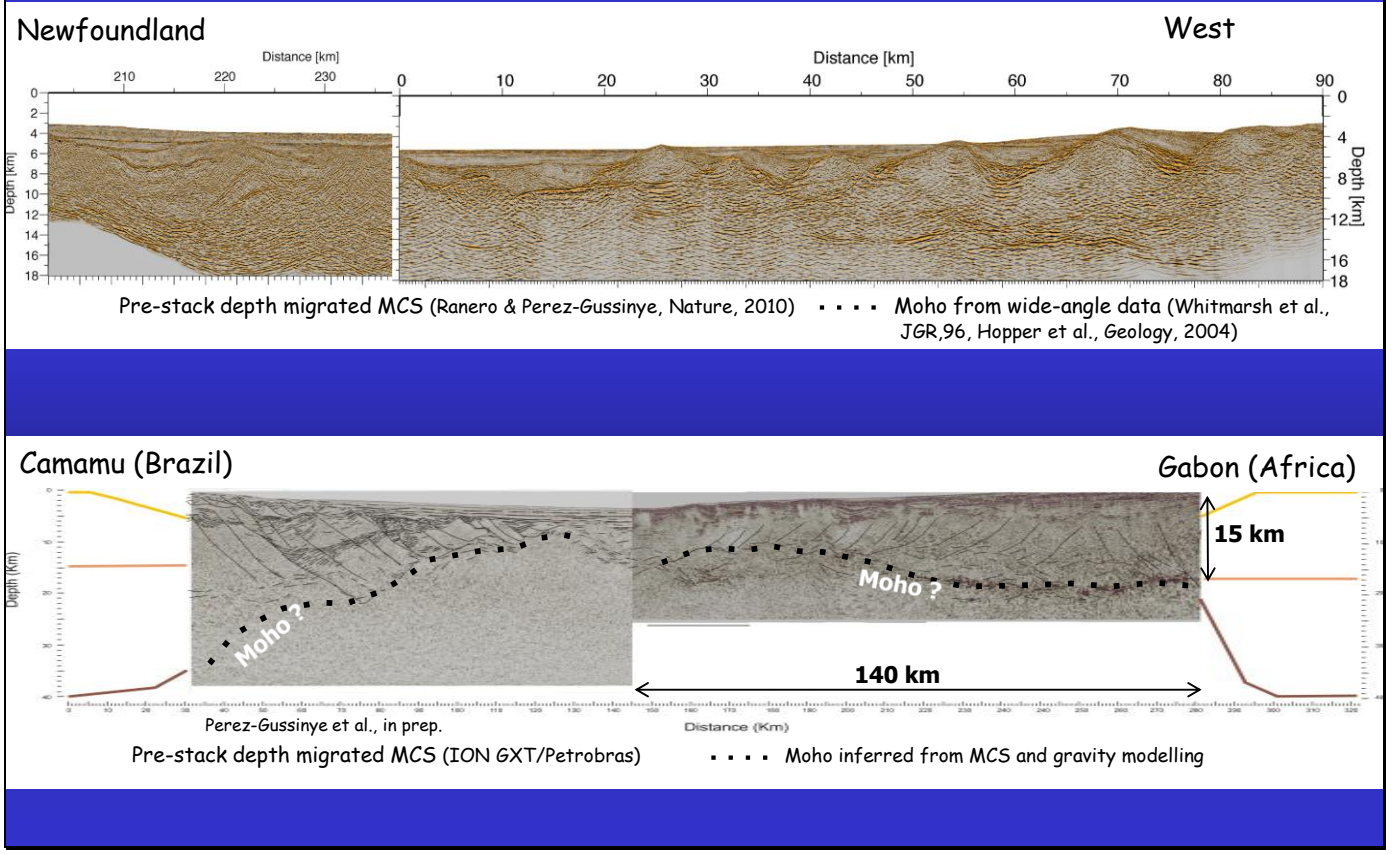


Degree of asymmetry & margin width



Presenter's notes: These are interpretations of 3 seismic sections representative for the tectonic architecture along the margin. From North to South the combined conjugate margin width dramatically increases. To the north the asymmetry is very marked and observed from the necking zone. Fault offsets are very large, indicating large synrift subsidence. The asymmetry of Campos-Kwanza is observed in the larger width of the Campos but archectural styles of both margins are similar, with faults dipping both inward and outward of the basins and having small fault offset. The North Santos is extremely wide. Here faults have also small offsets and dip in both directions. The conjugate margin is much narrower, producing a larger asymmetry in terms of conjugate margin width.

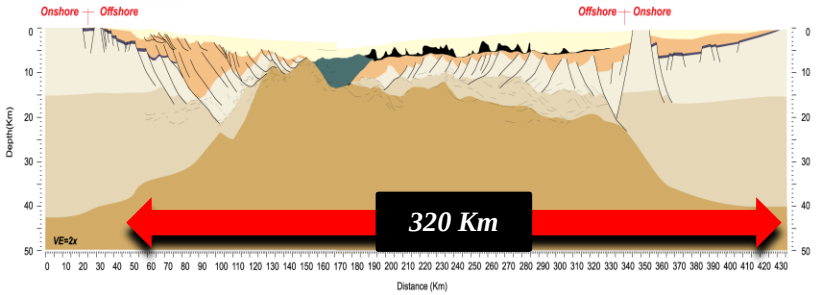
1. Conjugate margin degree of asymmetry and width



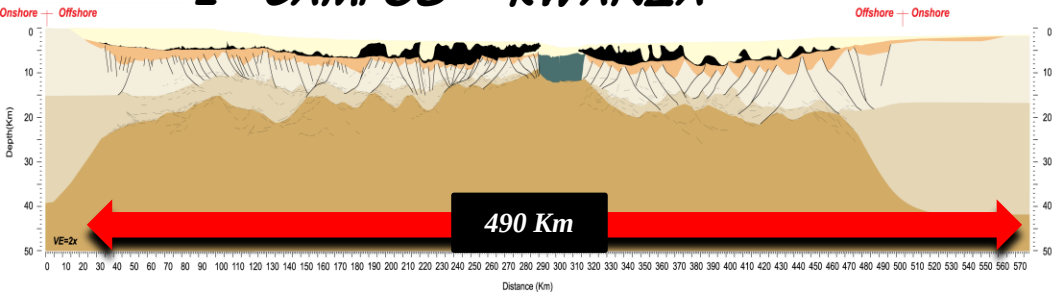
Presenter's notes: I have been focusing in answering the following questions: The evolution in which extension is small and there is no marked asymmetry; the basin stage, to a stage in which break-up has occurred and what remains are two asymmetric margins on both sides of the new ocean. Seismic data also show that these last stages of rifting are associated with the occurrence of detachment-like faults and we want to understand what is their role in generating the asymmetry and in break-up.

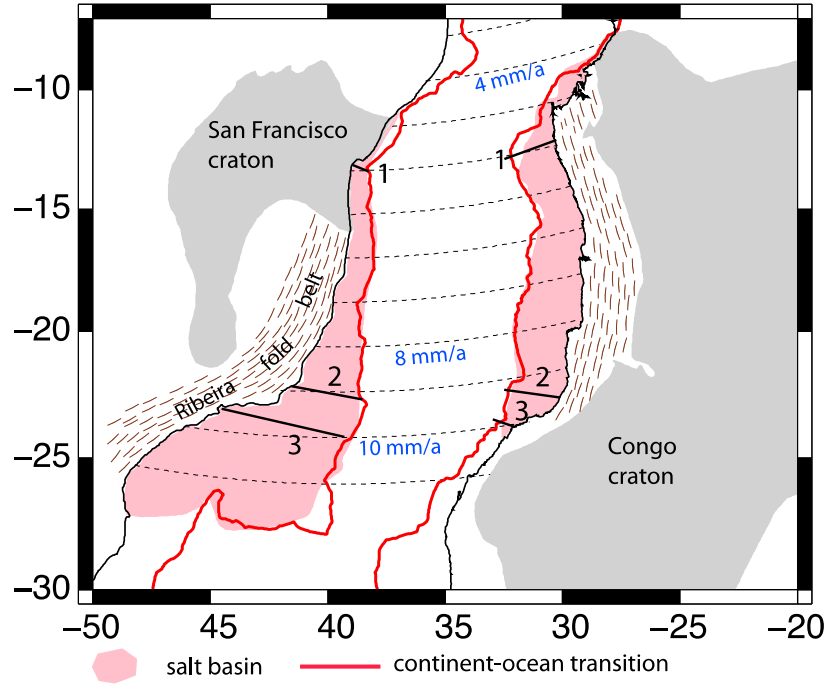
1. Conjugate margin degree of asymmetry and width

1- CAMAMU-GABON

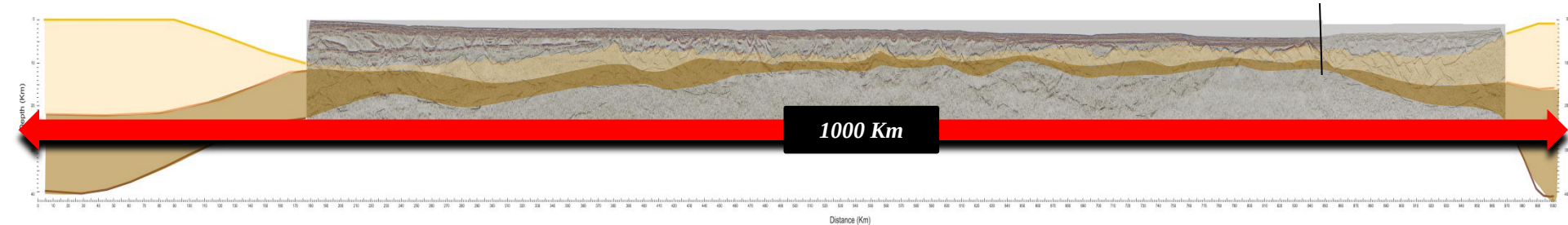


2- CAMPOS - KWANZA

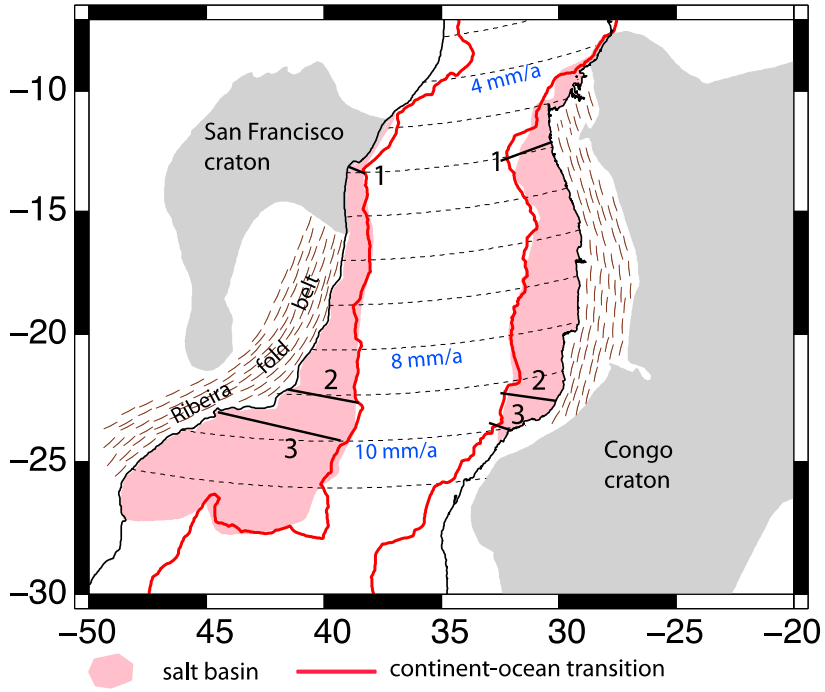




3- NORTH SANTOS- SOUTH KWANZA



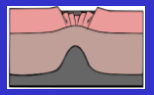
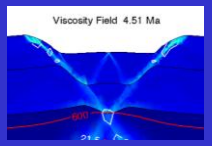
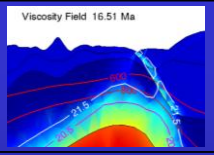
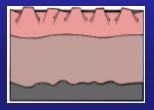
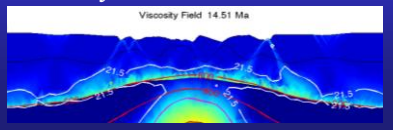
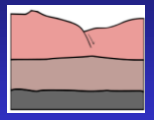
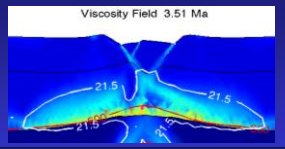
3. Transition to oceanic spreading



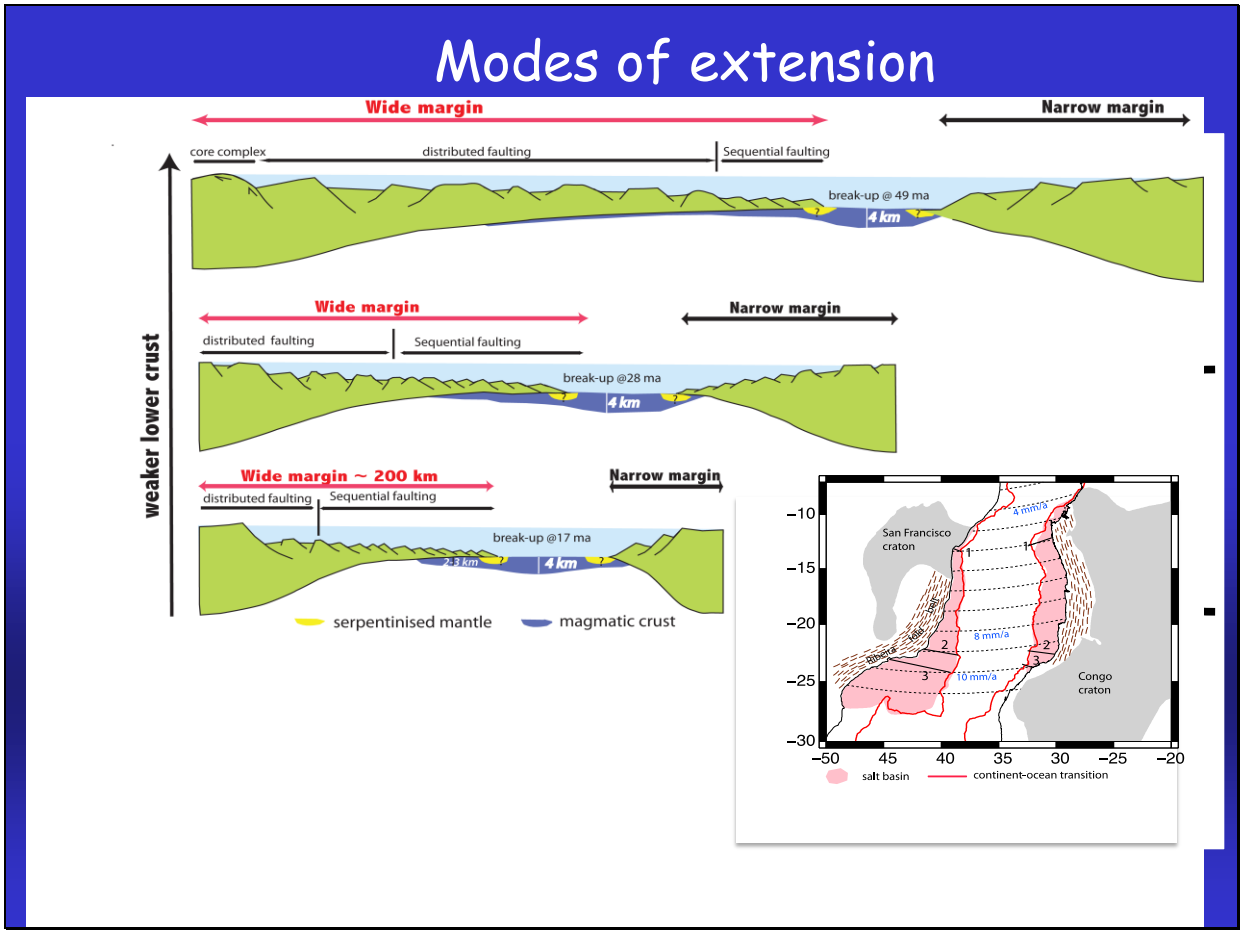
Nature and extent of COT: unknown.

- **West Iberia: wide COT consisting of exhumed and serpentinised mantle.**
- **Slow extension (ultra-slow end-member).**

Preliminary results- Low viscosity channel

Mode of extension	Minimum viscosity in lower crust	Region
Narrow 	$\log(\mu_{min}) \geq 21.5$	Small area 
Seq. faulting 	$20.5 \leq \log(\mu_{min}) \leq 21.5$	Pocket 
Wide 	$20.5 \leq \log(\mu_{min}) \leq 21$	Area broadly extended 
Core complex 	$\log(\mu_{min}) = 20.5$	Area less extended than wide case 

Presenter's notes: 26In summary, our preliminary results show the following: A narrow rift occurs when there is no channel of low viscosity in the lower crust. Most of the lower crust has a viscosity of $10^{21.5}$ Pascals/second or more. Sequential faulting mode occurs when there is a localized pocket of low viscosity that connects the crust with the mantle. For wide rift mode to occur, there needs to be an extended and thin low-viscosity channel in the lower crust. Finally the core complex mode occurs when a less extended and thicker low viscosity region takes place in the lower crust. We observe that the viscosity values for core complex mode are lower than in the wide mode. What we shall investigate in the near future: If for other velocities and crustal thicknesses, do these modes occur for the same viscosity values and spatial viscosity distribution?



Presenter's notes: 1. There are many parameters that have an impact on the final architecture and symmetry of the margins. 2. Rheology of the lower crust seems to play a very important role. 3. For strong crust margins developed symmetrically and narrow (type 1). 4. For intermediate strength crust asymmetry is favoured. 5. For a very weak crust the conjugated margins are symmetric and wide (type 2). 6. However, the degree of asymmetry changes regionally in areas of similar lower crustal rheology, for example in the South Atlantic where we observe: 7. Narrow asymmetric margins for Camumu-Gabon, 8. Wider symmetric for Campos Kwanza, 9. And very wide asymmetric for North Santos-South Kwanza. 10. Also note that the polarity of the asymmetry changes from North (African margin is the widest) to South (Brazilian margin is the widest). 11. Looking at this map we can note that the narrowest margins developed close to a craton while the widest developed where the craton is far away from the margin edge.

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: composition, crustal thickness, velocity.

Questions

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

Part 3