Lithospheric-scale experiments of continental rifting monitored in an X-Ray CT scanner

Frank Zwaan & Guido Schreurs – University of Bern – frank.zwaan@geo.unibe.ch

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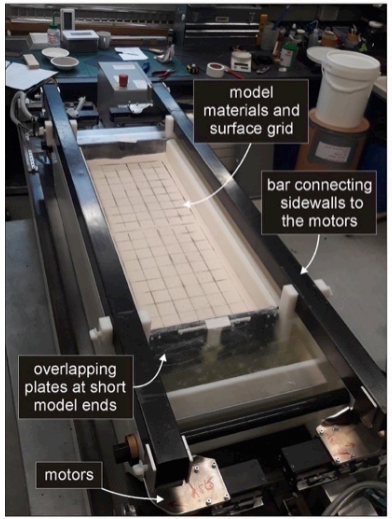

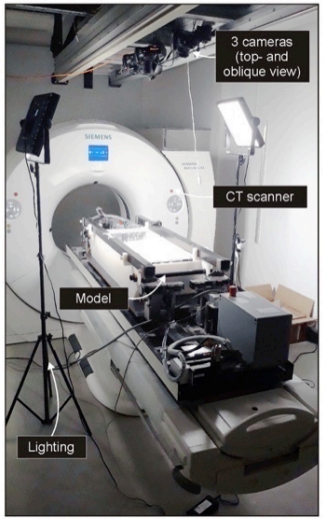

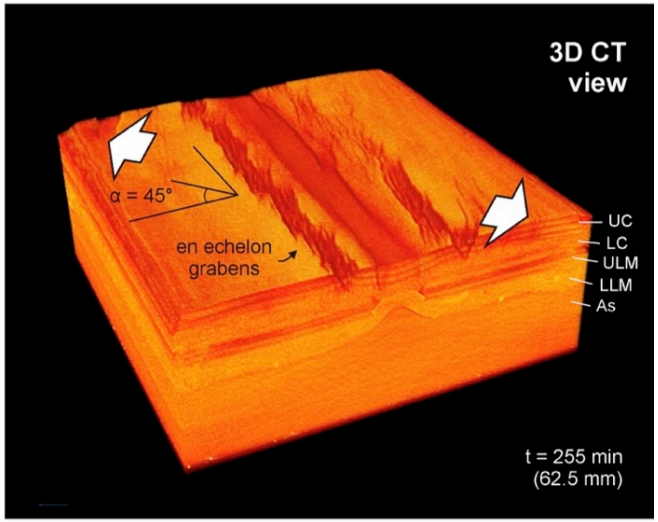

EGU General Assembly 2022

Swiss National Science Foundation

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Background: we do analogue tectonic modelling

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- Aim: Reproducing tectonic processes in the laboratory

Nature: many km's, millions of years

Image: Patagonia (Pinterest)

Lab: cm to m scale, minutes-hours

Image: Cadell (1888)

Motivation: crustal-scale models are cool but a bit limited

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- **What is the influence of deeper layers during tectonic deformation?**

Motivation: lithospheric-scale modelling is better!

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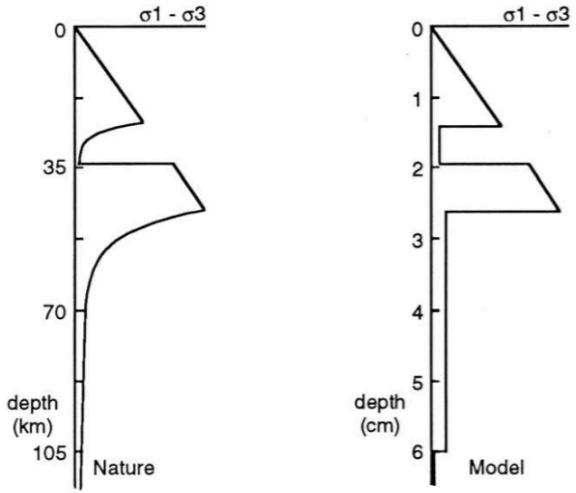

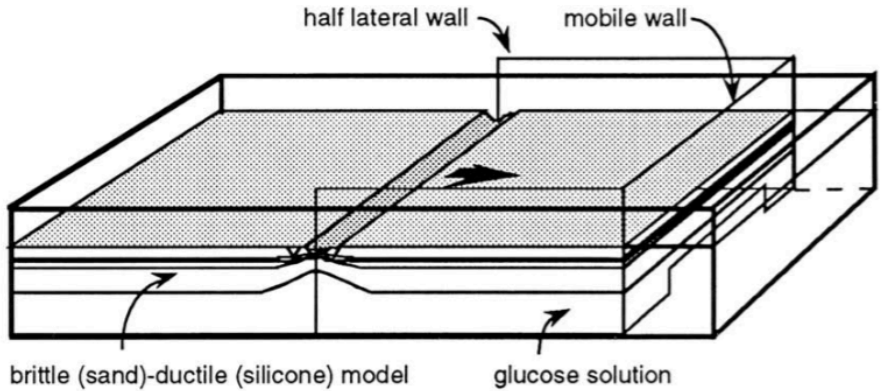

- **Dense fluid bottom layer representing the asthenosphere allows for isostacy**
- **Multilayer model lithosphere is more realistic**

Brun & Beslier 1996

Motivation: however, model-internal visualization is poor…

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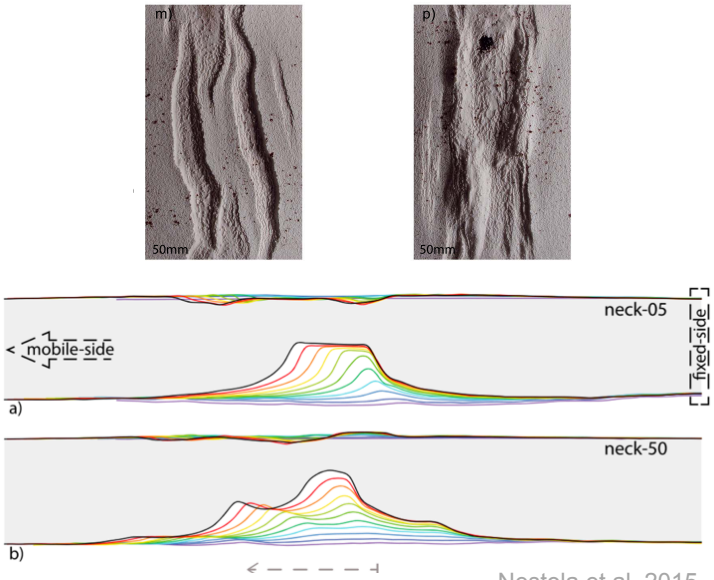
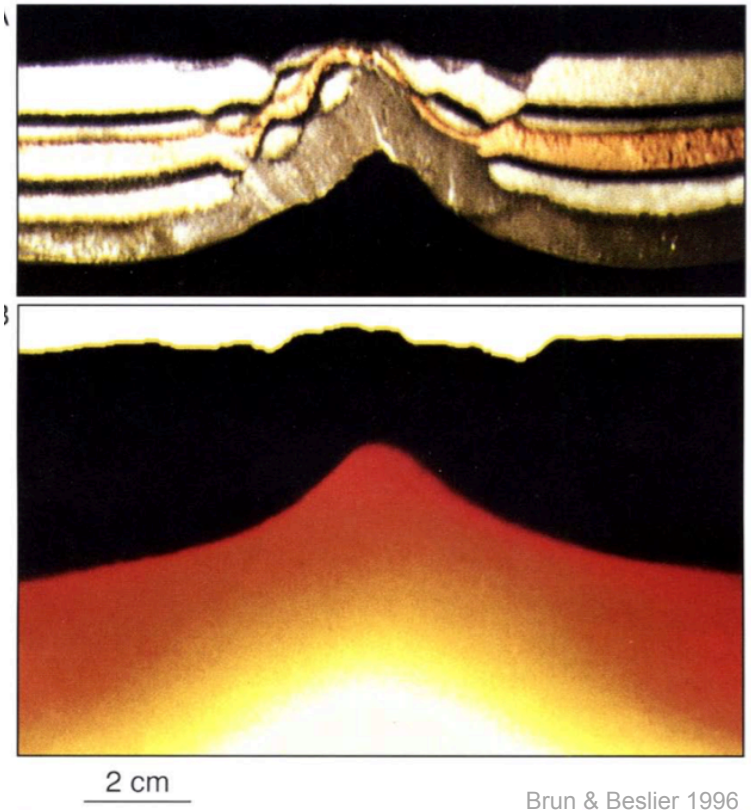
- **Some internal deformation visible when cutting open and destroying the model…**



Nestola et al. 2015



Brun & Beslier 1996

Motivation: we need to find a way to look inside the model

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- **Problem:** no direct visualization of internal deformation

Motivation: we need to find a way to look inside the model

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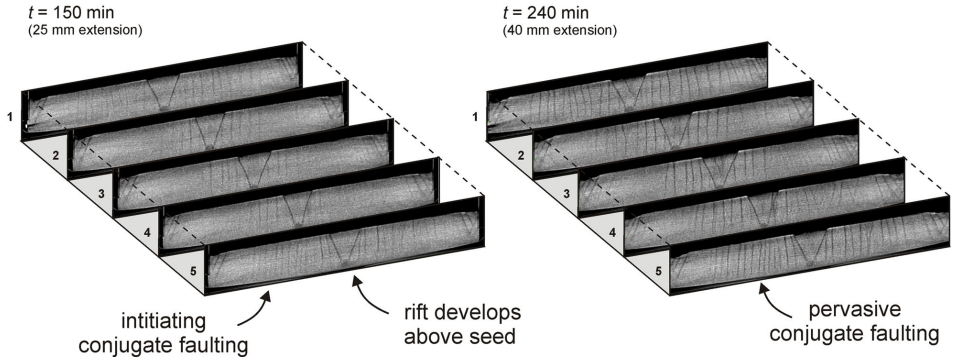
- **Problem:** poor visualization of internal deformation
- **Solution:** CT-scanning?



Zwaan et al. 2019

Motivation: we need to find a way to look inside the model

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- **Problem:** poor visualization of internal deformation
- **Solution:** CT-scanning?
- **Challenge:** building a new machine for lithospheric-scale modelling in a CT-scanner

Model design: we built a new lithospheric-scale set-up

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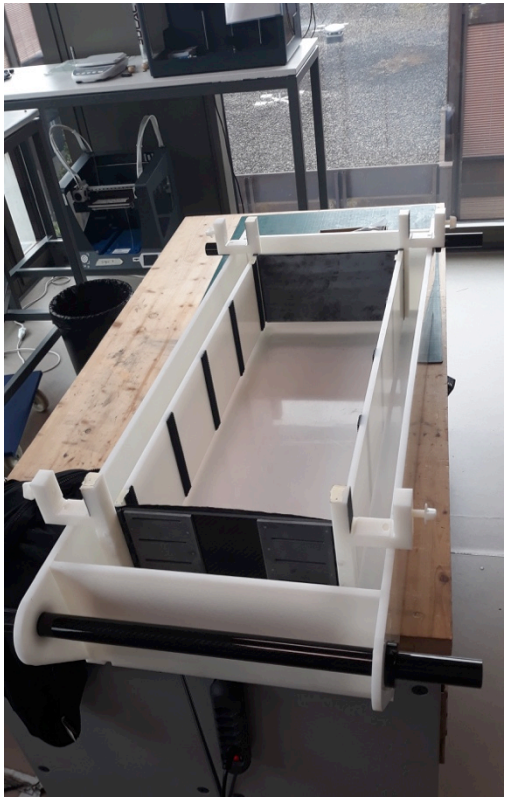

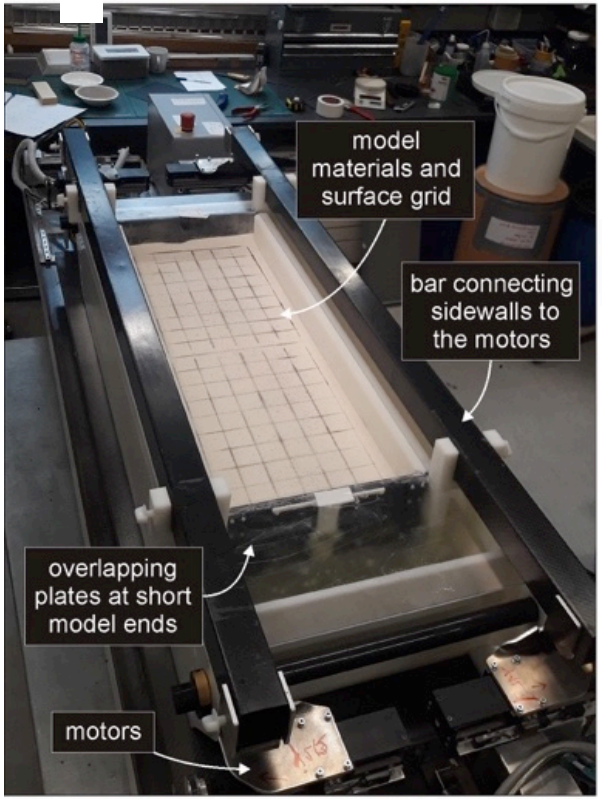

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Model design: how it works

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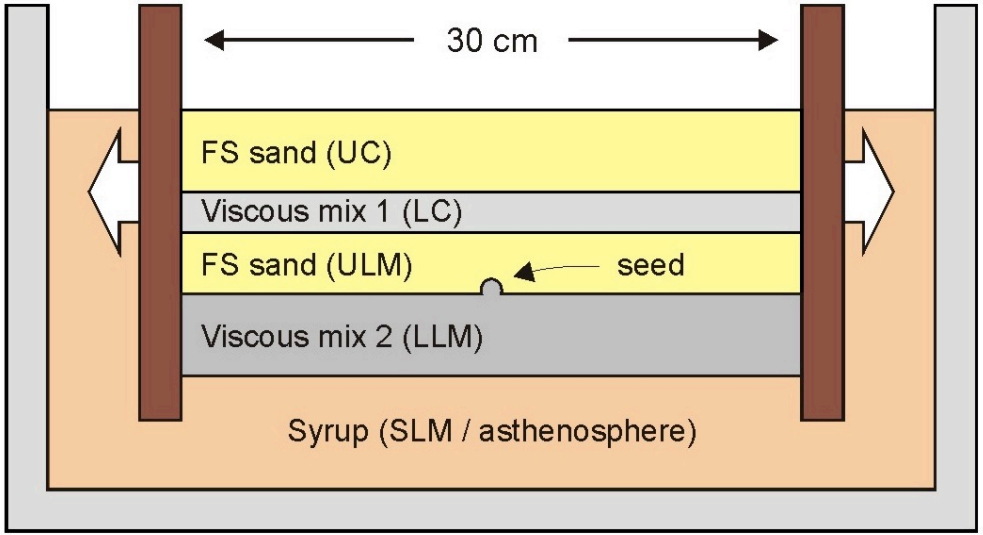

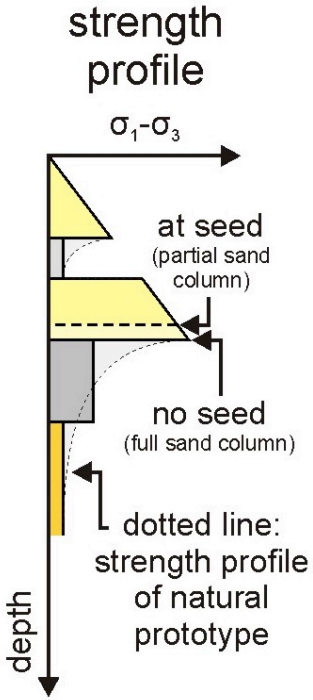

- **Multilayer model lithosphere on top of a heavy fluid (glucose syrup, see slide 4)**

Model design: how it works → rifting models

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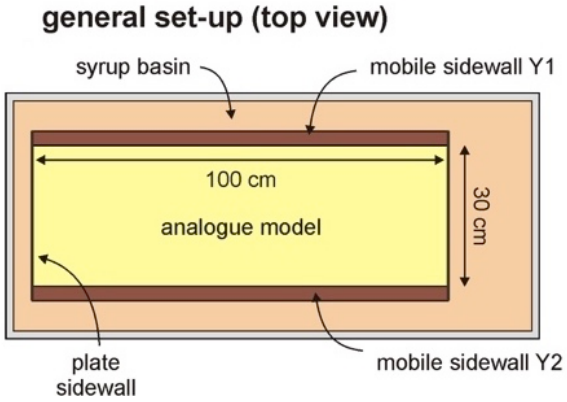

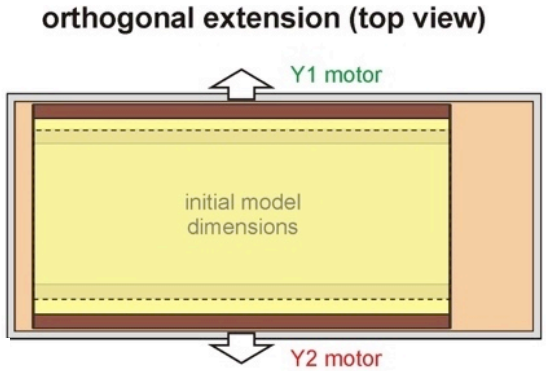

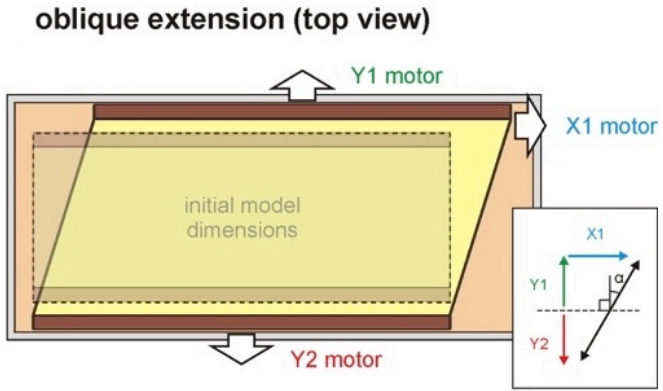

- **Various sidewall motions possible**

Model analysis: we use different monitoring techniques

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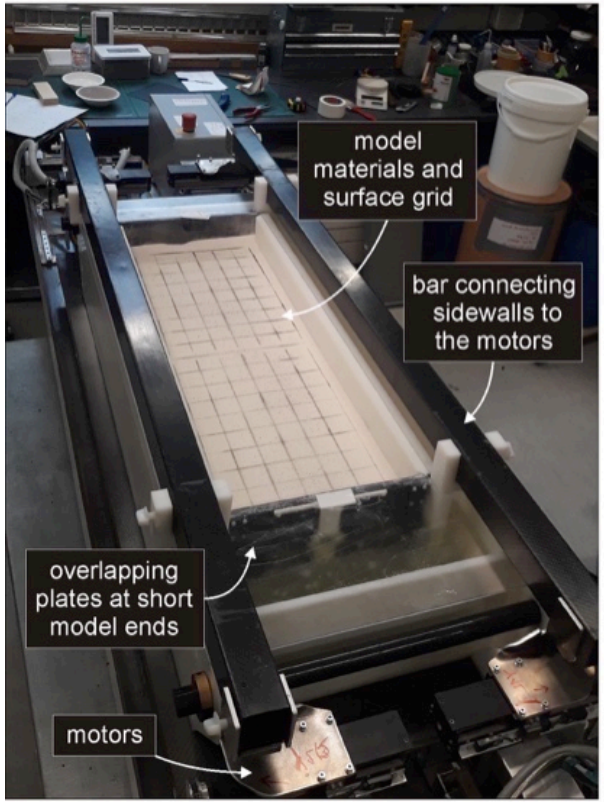
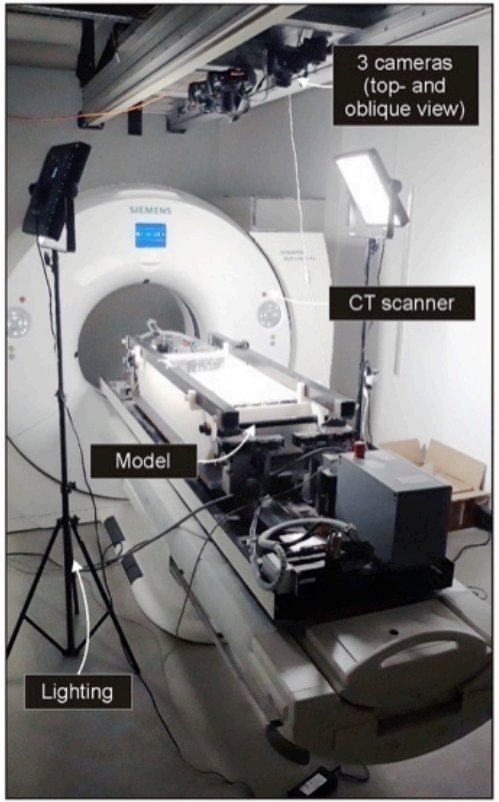
- **Three camera rigs for surface observations:**
  - **Top views**
  - **Oblique views for topography reconstruction**
- **X-ray CT-scanning for unique model-internal monitoring**





Results: a little time lapse image shows model evolution

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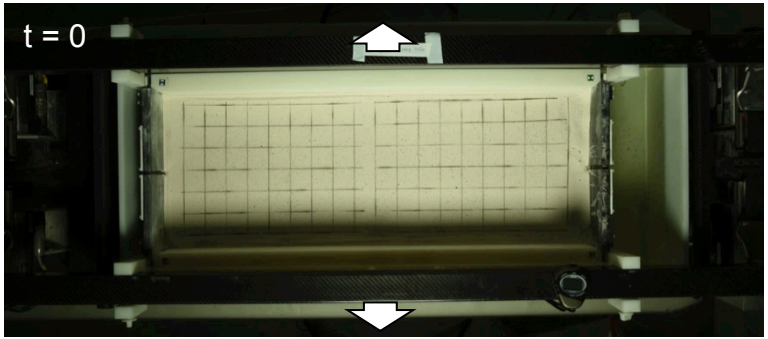

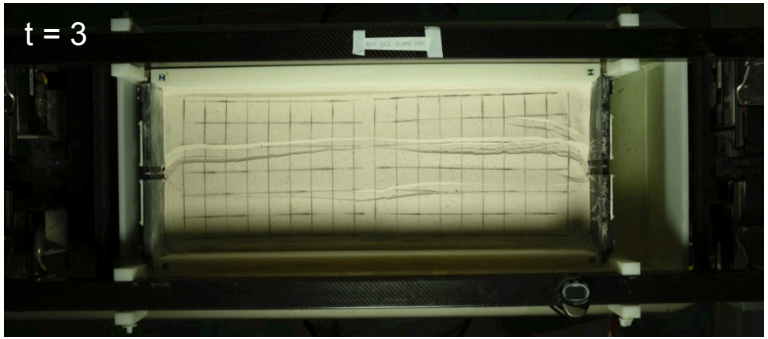

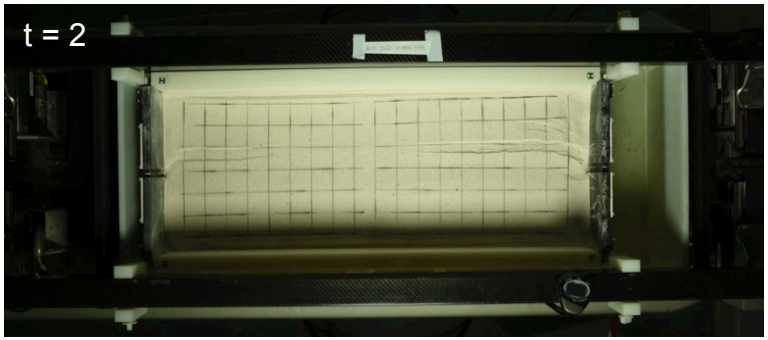

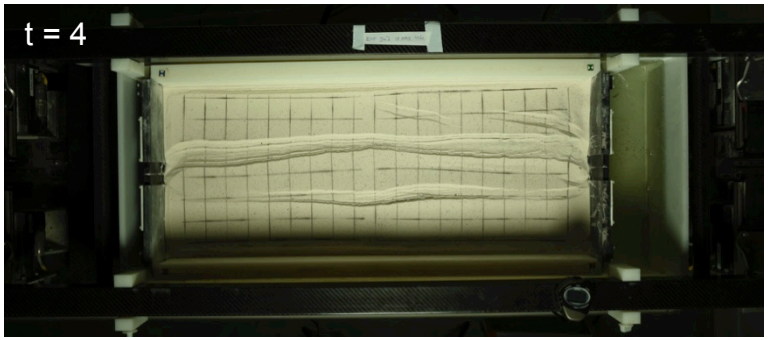

Results: extracting topography + surface strain evolution

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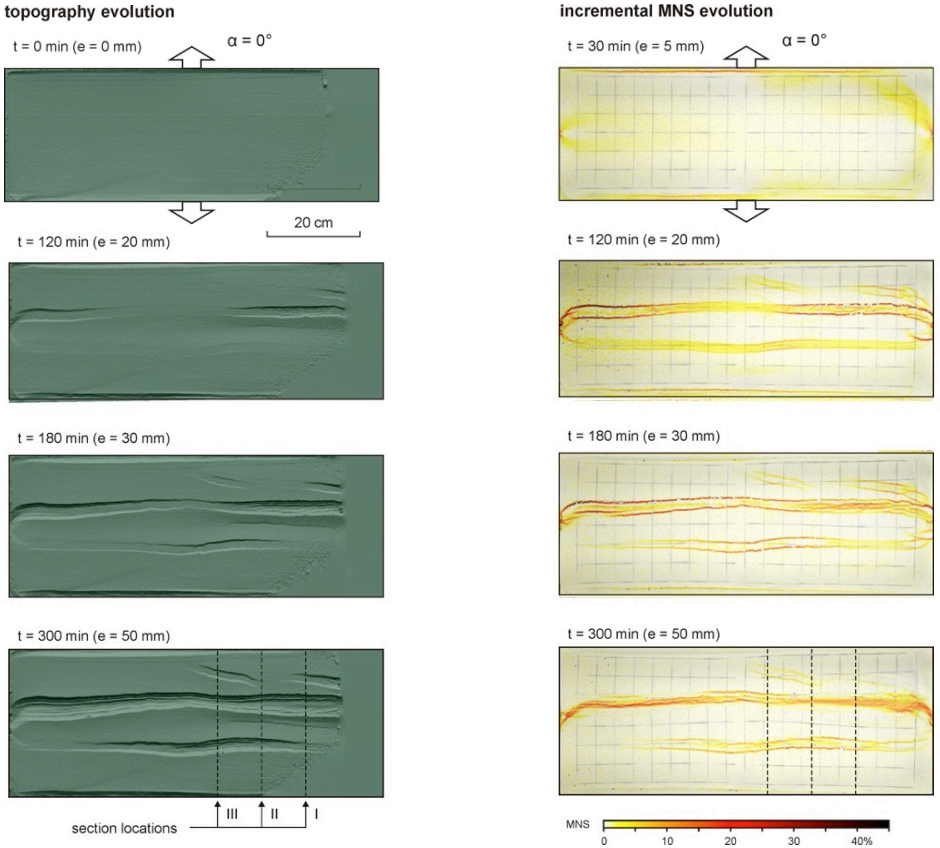

- **Incremental train maps show active normal faults**

Results: CT-scanning allows for model-internal analysis

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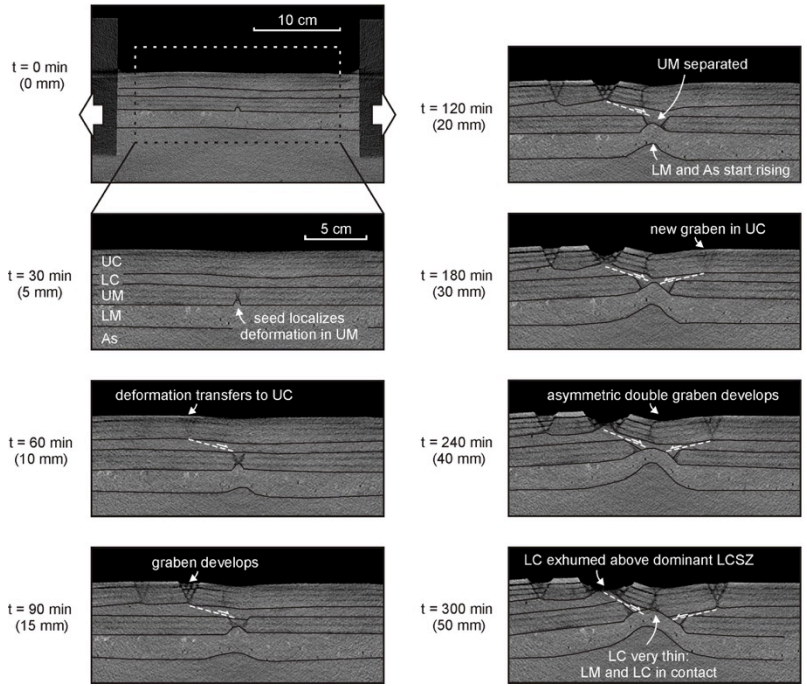
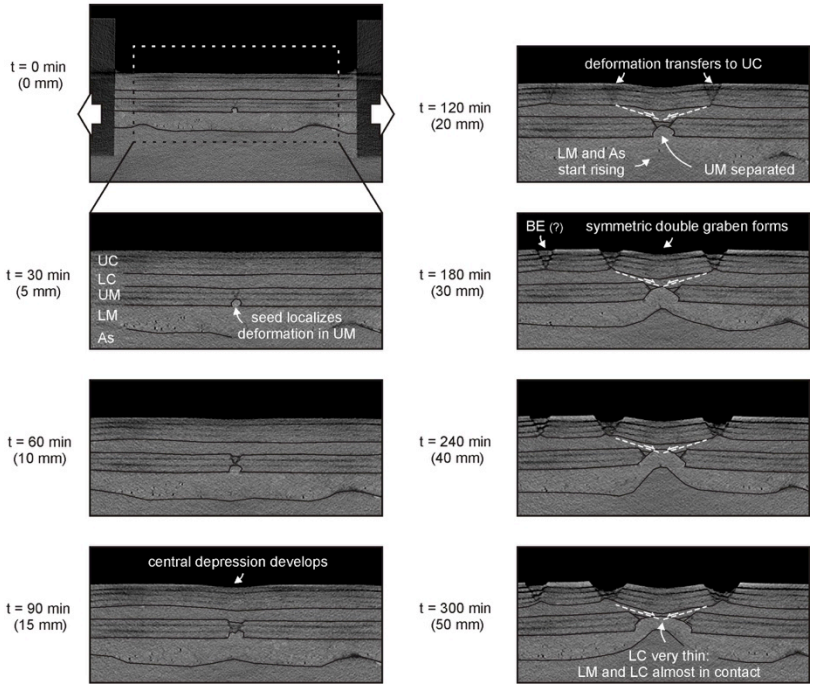
Section I: asymmetric double rift



Section III: symmetric double rift



- **Section locations on slide 14**

Results: and we can compare the evolution of both sections

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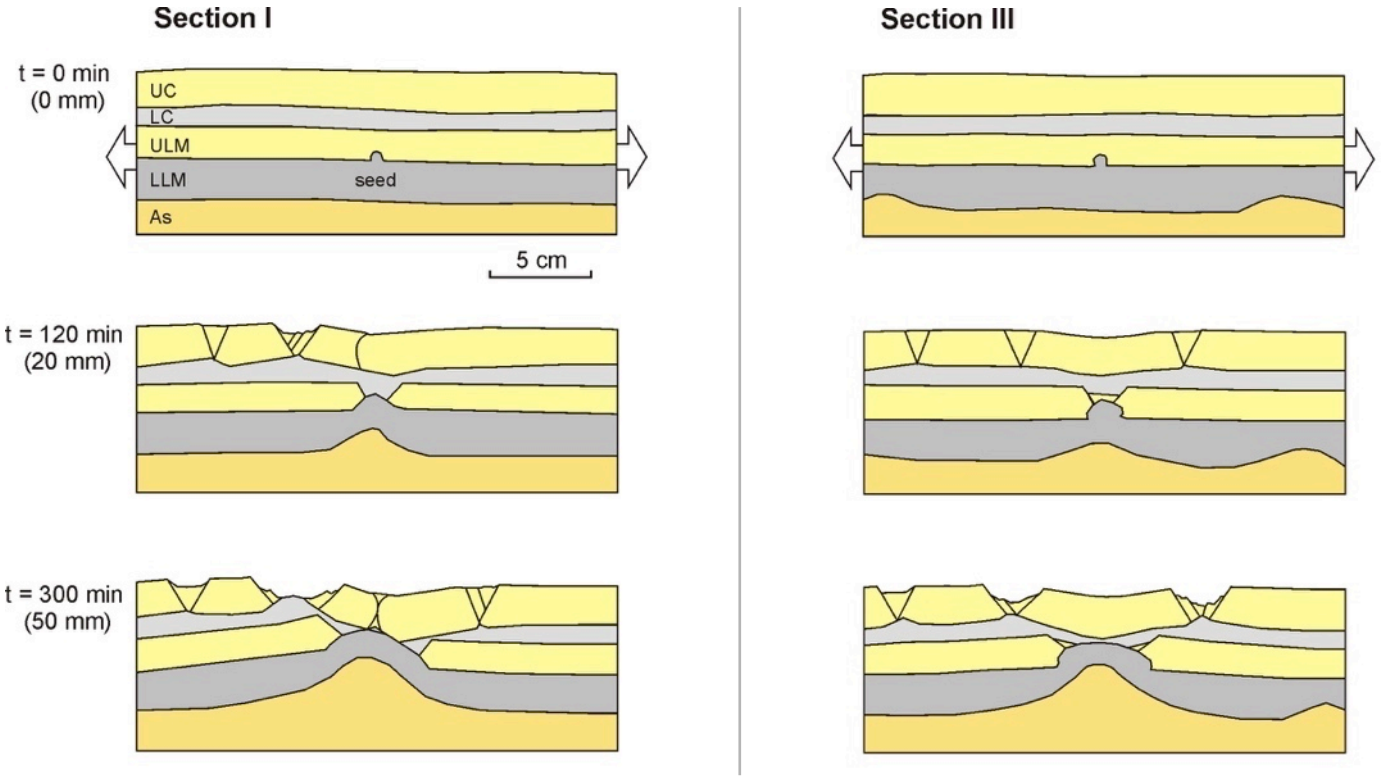

Results: we also mapped horizons over time

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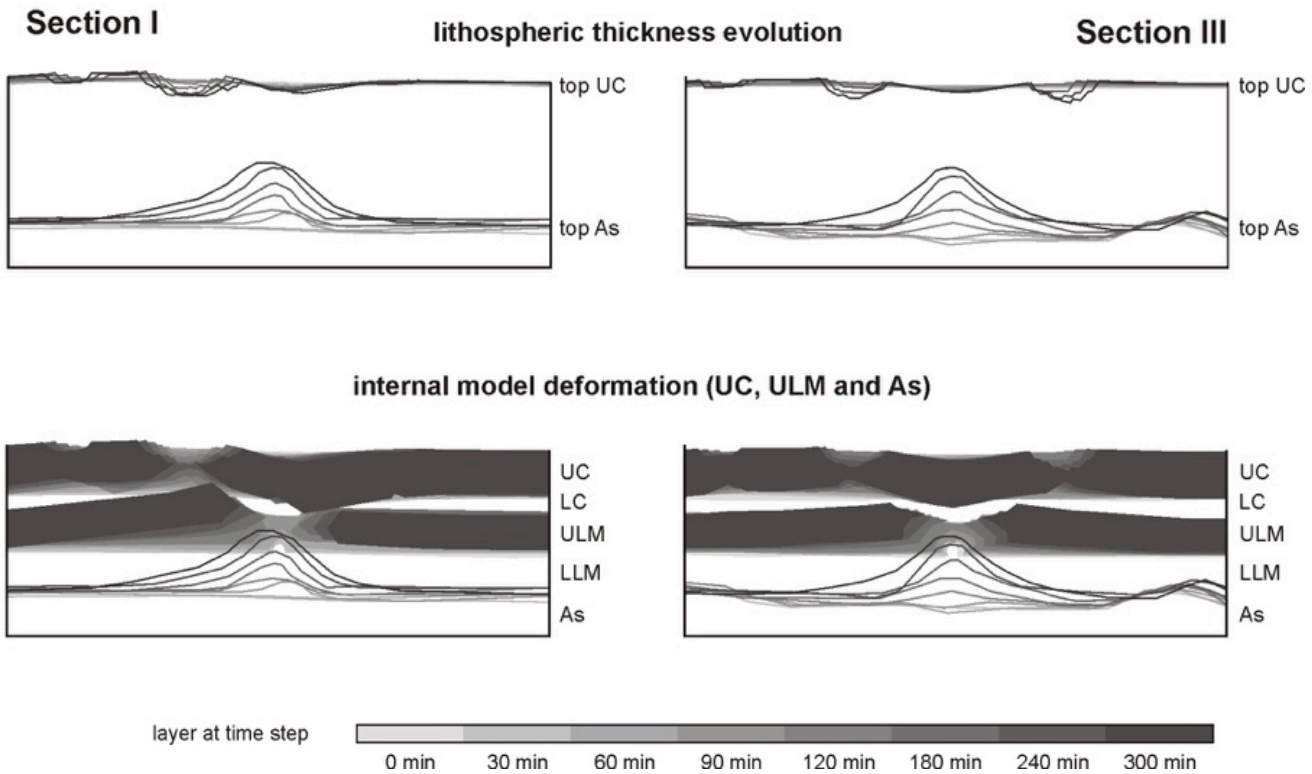

Results: and we quantified in-section deformation too

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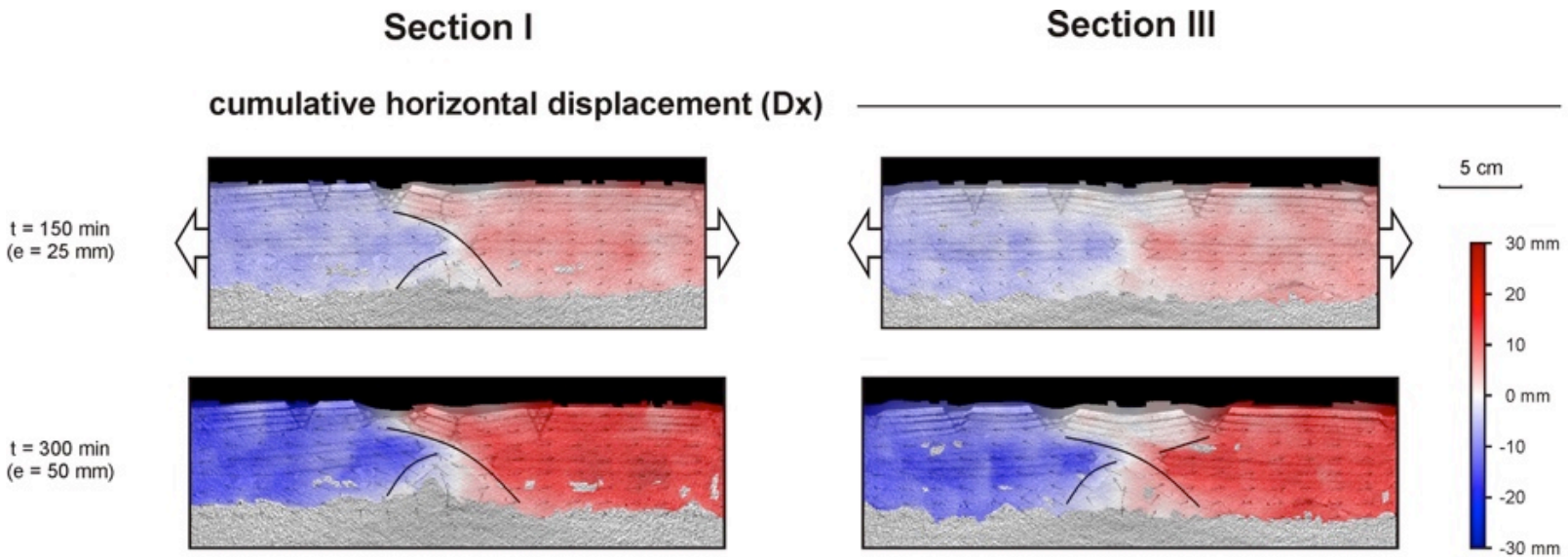

Results: we did some oblique extension modelling as well

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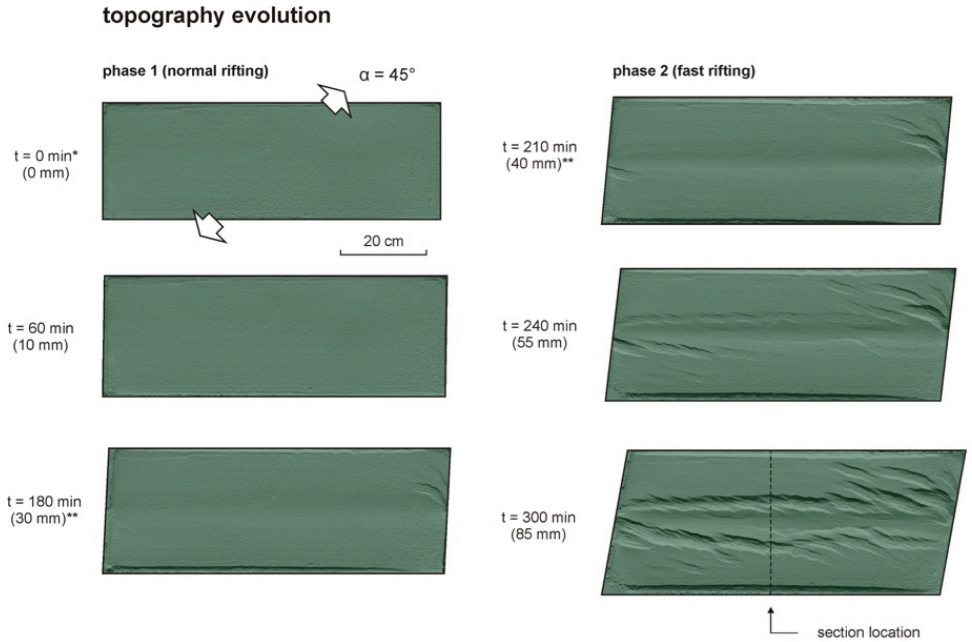

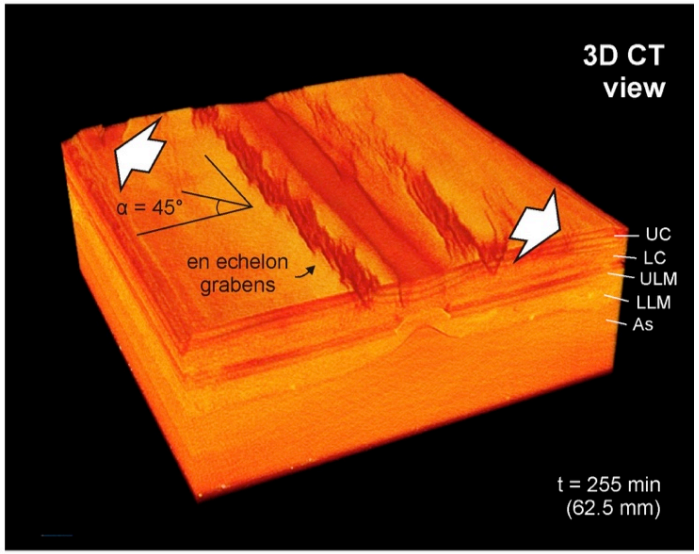

- **En echelon graben structures!**

Interpretation: can we compare with nature?

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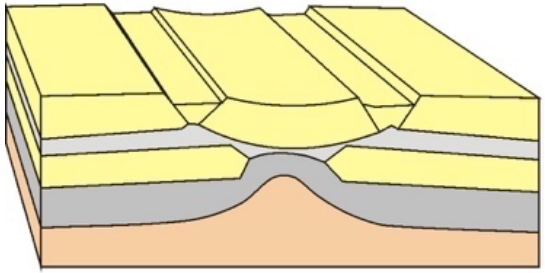
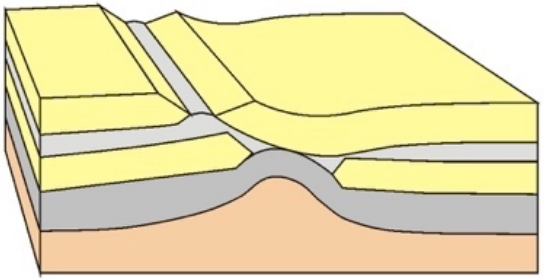
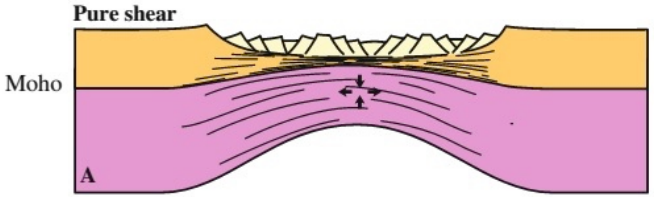
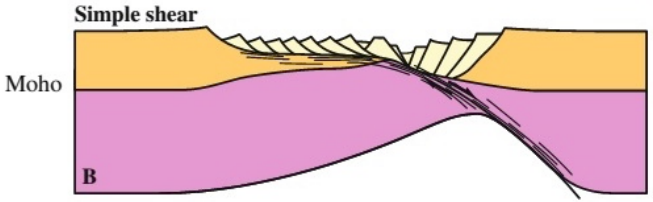
symmetric orthogonal extension



asymmetric orthogonal extension







Gabrielsen 2010

Interpretation: oblique extension may complicate things!

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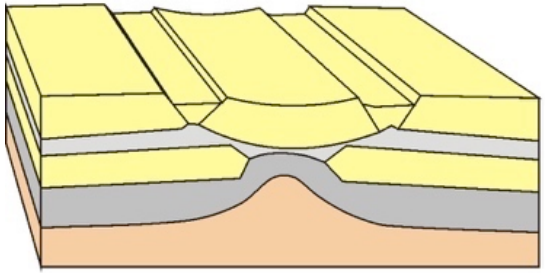
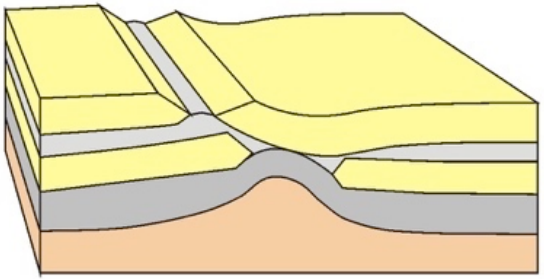
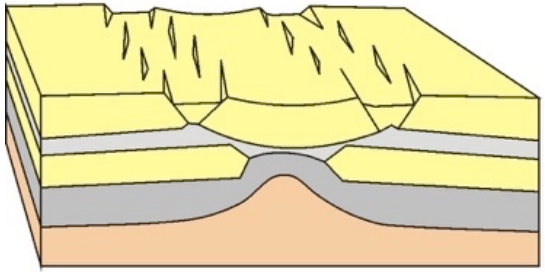
symmetric orthogonal extension



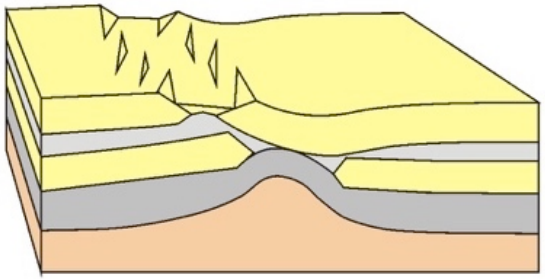
asymmetric orthogonal extension



(fast) symmetric oblique extension



(fast) asymmetric oblique extension (?)



Conclusion: success and new opportunities!

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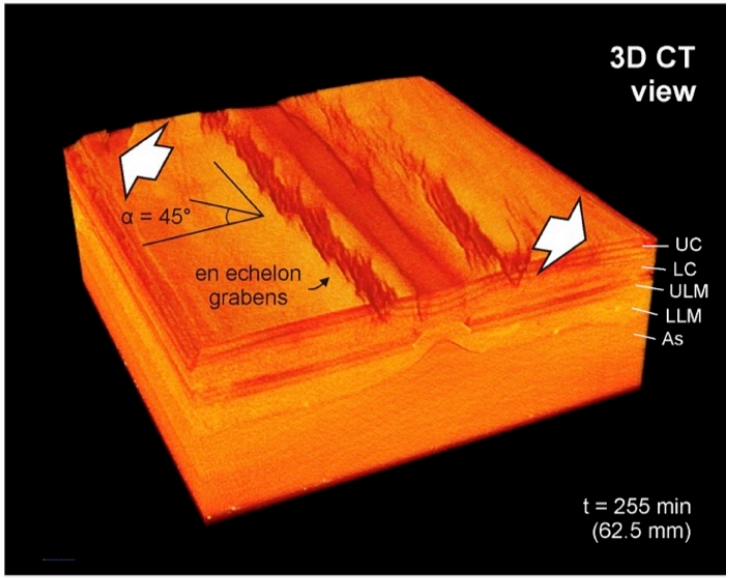
- New machine for lithospheric-scale modelling in a CT-scanner ☺
- Lots of interesting results so far, and lots of options for the future!
- Paper in review with Tectonics (preprint already available online!)
  Link: https://doi.org/10.1002/essoar.10510709.1
- Questions? frank.zwaan@geo.unibe.ch