# Shear heating and subduction initiation


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## Shear Heating ?

$$\rho c_p \frac{DT}{Dt} = \nabla \cdot (k \nabla T) + \rho H_r + H_a + H_s$$

$$\eta \sim \exp \frac{Q}{RT} \Rightarrow \tau = 2\eta\dot{\varepsilon} \Rightarrow H_s = \tau : \dot{\varepsilon}$$

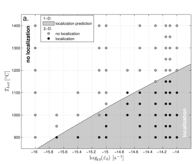
## Methodology

- numerical modelling (using the FE-Code MILAMIN_VEP)
- visco-elasto-plastic rheology
- quadratic elements ($Q_2P_{-1}$)
- regular remeshing
- irregular grid to allow for a high resolution

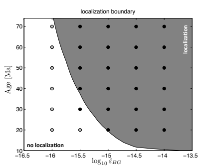
## Goals of this study

- Predict the localization behaviour of the models -> Does shear heating result in localization for Earth-like parameters ?
- Predict the post-localization behaviour -> Is localization always followed by subduction ?

## Localization prediction

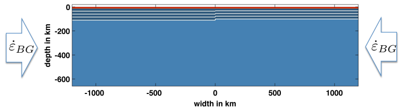



continental lithosphere (Crameri & Kaus (2010))




oceanic lithosphere (this study)

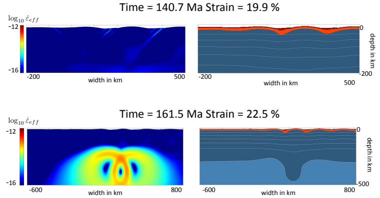
## Model Setup




- oceanic lithosphere with upper and lower crust
- model compressed with constant strainrate
- thermal heterogeneity at 0 km

## No Localization

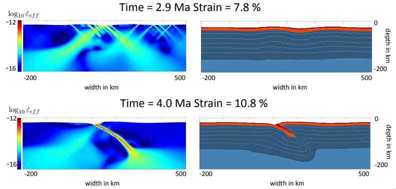
$\dot{\varepsilon}_{BG} = 10^{-17}$




No Subduction

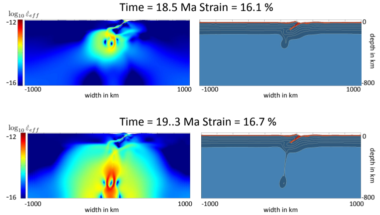
## Localization

$\dot{\varepsilon}_{BG} = 9 \cdot 10^{-16}$




## Drip-off

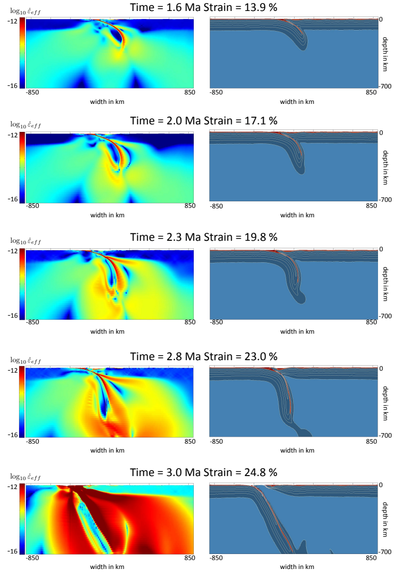
$\dot{\varepsilon}_{BG} = 3 \cdot 10^{-16}$




No Subduction

## Subduction initiation

$\dot{\varepsilon}_{BG} = 3 \cdot 10^{-15}$




Subduction

## Drip-off prediction (work in progress)

- growth rate of drip is predictable (Conrad & Molnar (1999))

$$w_{drip} = \left[C' \frac{n-1}{n} \frac{\rho_m g \alpha \Delta T}{B_m} (hF_n)^{-1/n} (t_b - t)\right]^{\frac{n}{1-n}}$$

- C' and $t_b$ still have to be determined from the numerical results
- C' depends on initial perturbation size → Scaling ?

## Conclusions

- localization does not always result in subduction
- it is possible to predict the onset of localization for arbitrary lithospheric rheologies and temperature structures with a simple semi-analytical model
- drip-off can prevent subduction by removing negatively buoyant material

## References


Conrad, C. and Molnar, P. (1999). Convective instability of a boundary layer with temperature- and strain-rate-dependent viscosity in terms of 'available buoyancy'. Geophysical Journal International.

Crameri, F. and Kaus, B. (2010). Parameters that control lithospheric-scale thermal localization on terrestrial planets. Geophysical Research Letters.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