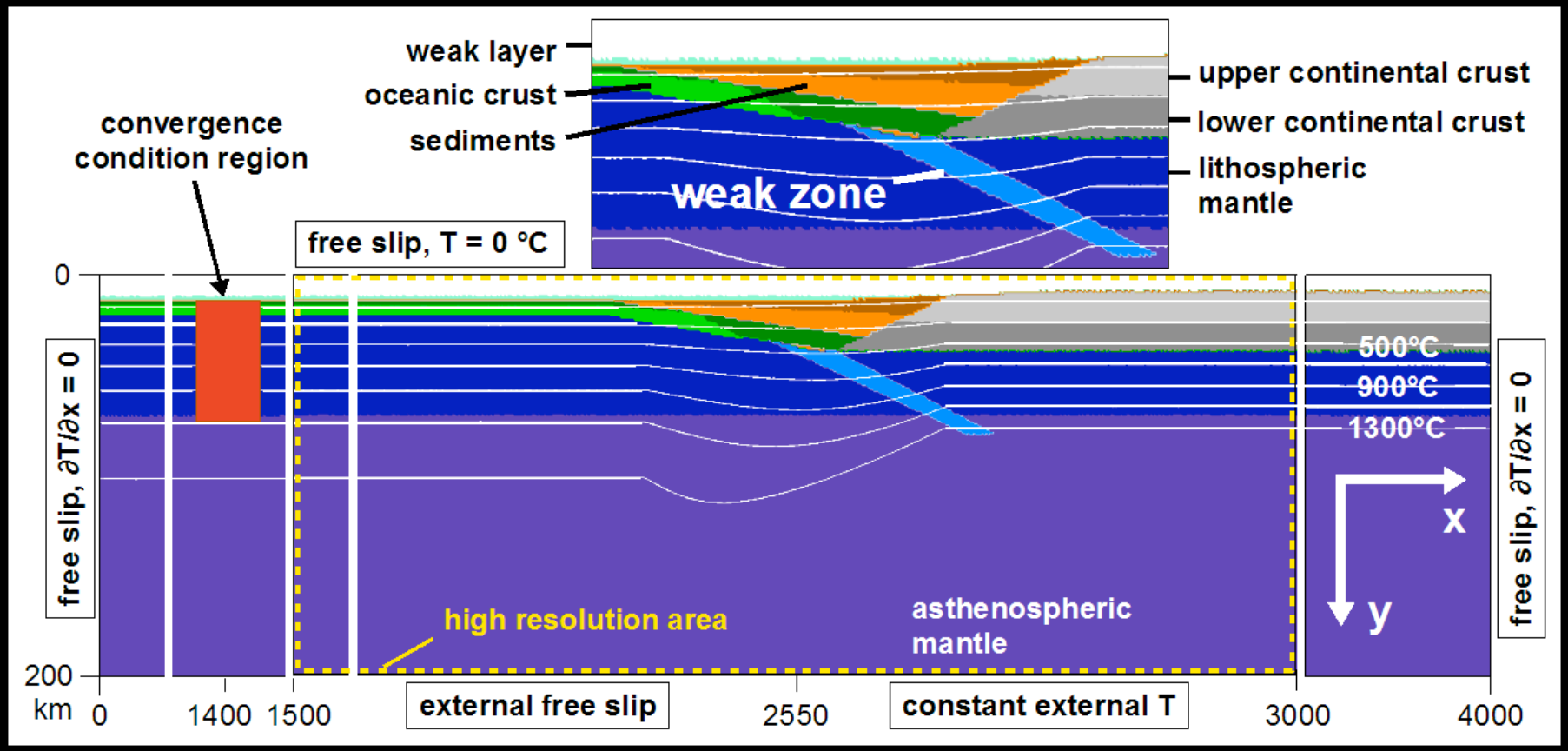
Dynamics of subduction under an active margin:

Effects of rheological weakening by fluids and melts

Numerical Modelling

Irena Löw

THE MODEL



I2VIS code (Gerya and Yuen, 2003)

- 2D coupled petrological-thermomechanical model
- uses FD and non-diffusive marker-in-cell technique
- fully staggered, irregularly spaced grid

THE MODEL

TOPOGRAPHY

transport equation:

$$\frac{\partial y}{\partial t} = v_y - v_x \frac{\partial y}{\partial x} - \boldsymbol{v_s} + \boldsymbol{v_e}$$

$\boldsymbol{v_e}$ = 0.3 mm/a

$\boldsymbol{v_s}$ = 0.03 mm/a (slope instabilities: 1mm/a)

HYDRATION

content of water 0 km: 2 wt%
75 km: 0 wt%

dehydration reactions: released water stored in new markers

percolation of fluids in markers

material in the mantle wedge absorbes up to 2 wt% of water

THE MODEL

MELT EXTRACTION:

- extracted melt is instantaneously transmitted to the surface ➔ volcanic arc
- melt extraction threshold: 4 vol%, non-extractable: 2 vol%

RHEOLOGY

visco-plastic

continental crust sediments upper oceanic crust	wet quartzite
lower oceanic crust	plagioclase (An75)
hydrated / serpentinized mantle	wet olivine
dry mantle	dry olivine

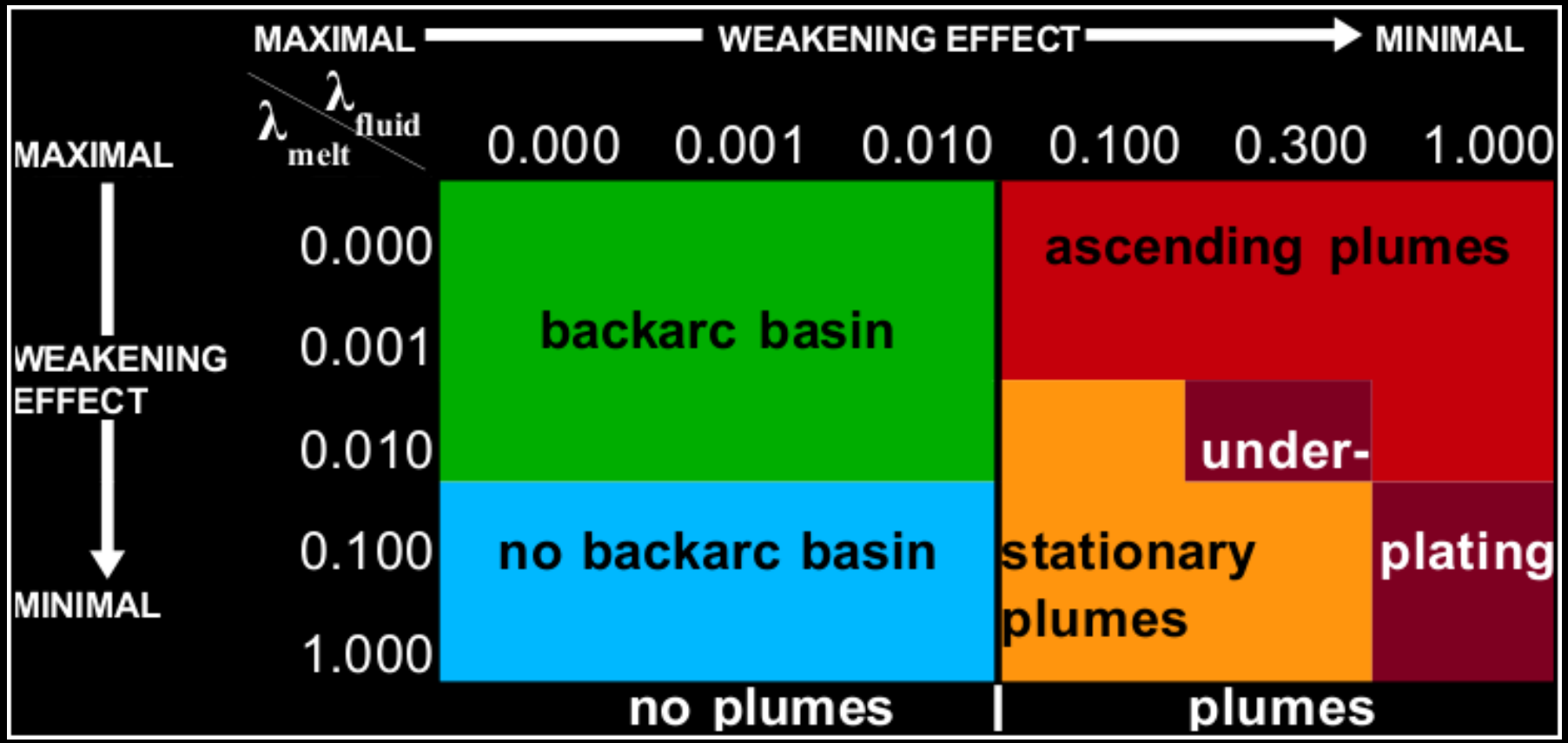
Mohr-Coulomb:

$$\sigma_{yield} = c + p \cdot \sin(\psi_{dry}) \cdot \lambda$$

$$\lambda_{fluid} = 1 - \frac{P_{fluid}}{P_{solid}}$$

$$\lambda_{melt} = 1 - \frac{P_{melt}}{P_{solid}}$$

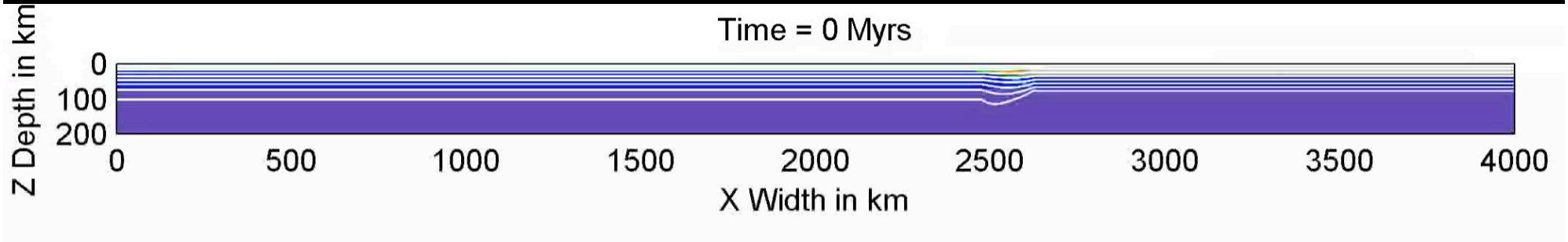
THE EXPERIMENTS

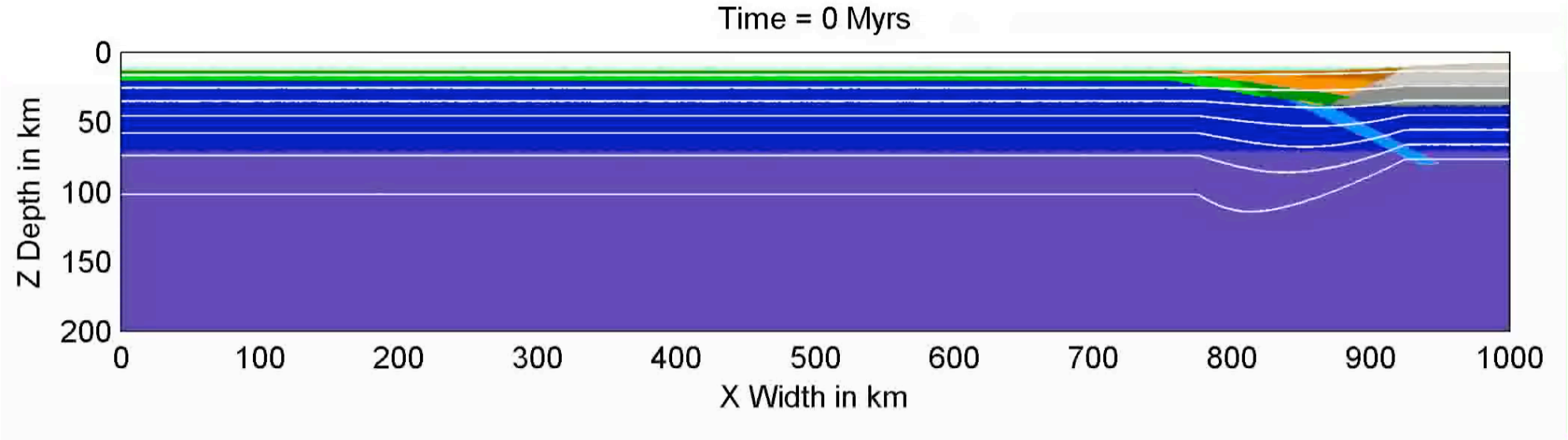


Fluids: weaken forearc region / sediments

Melts: weaken continental lithosphere below the magmatic arc

BACKARC BASINS





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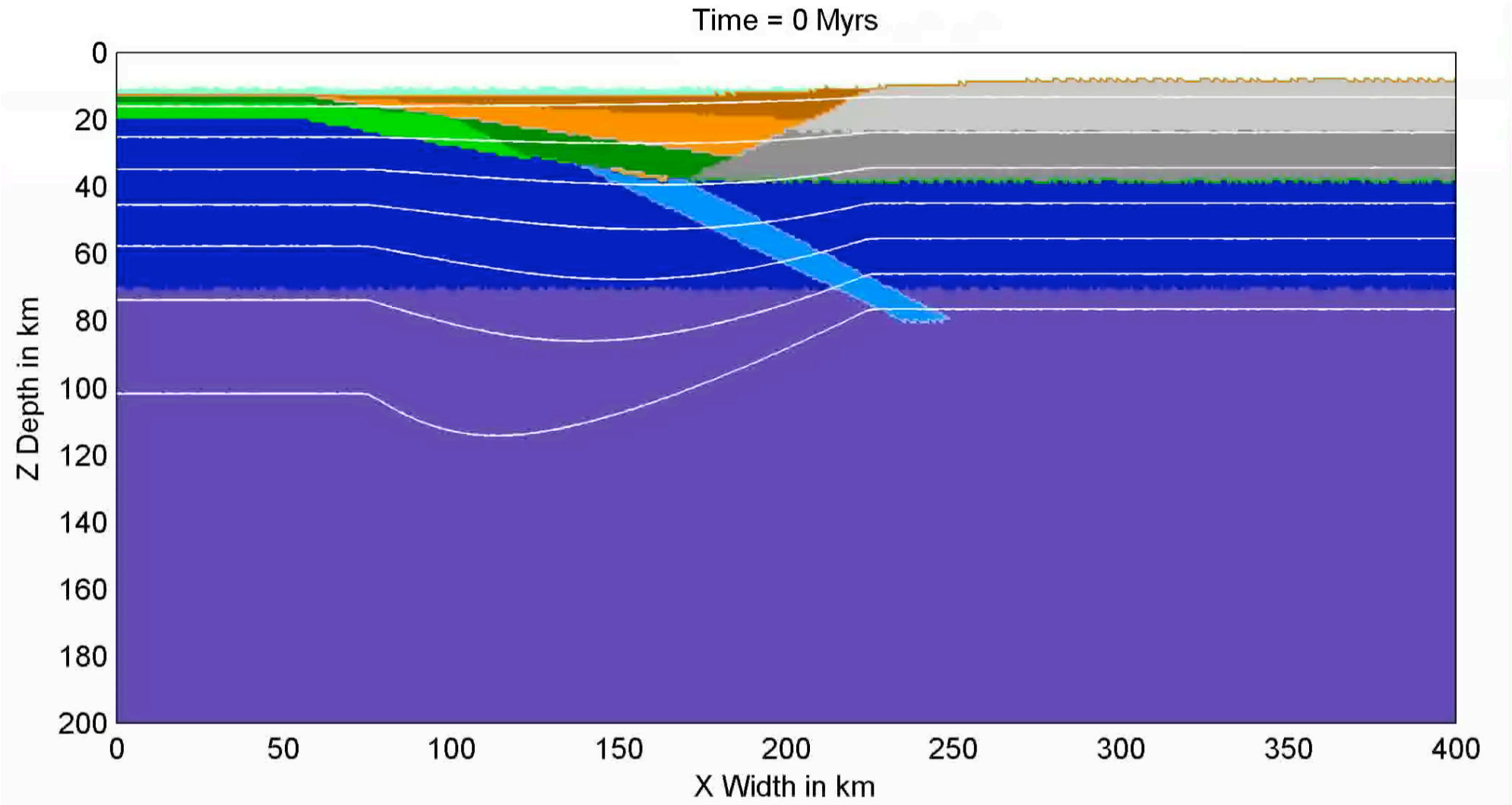

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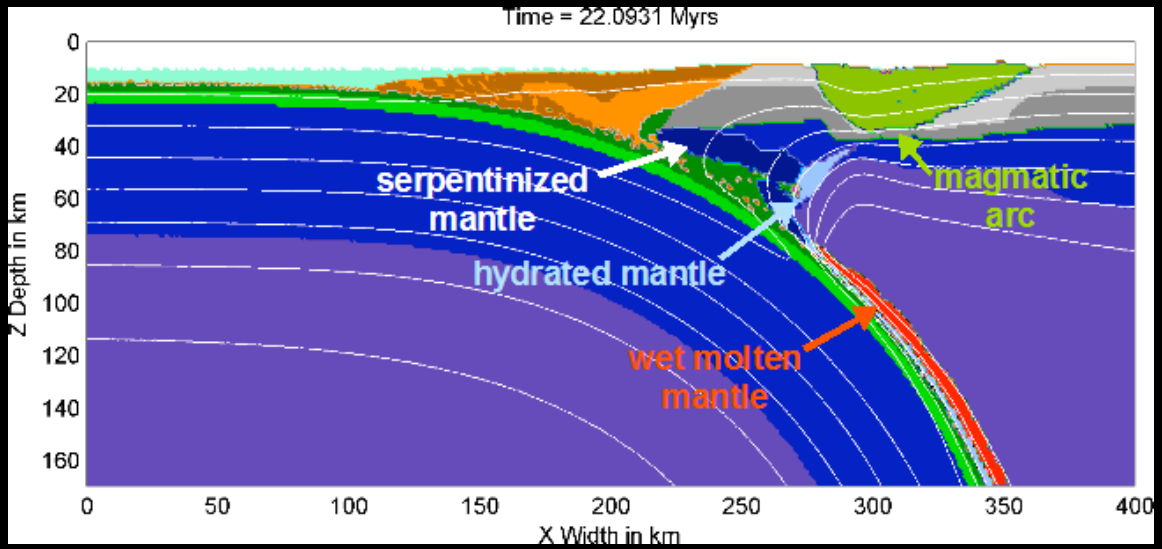
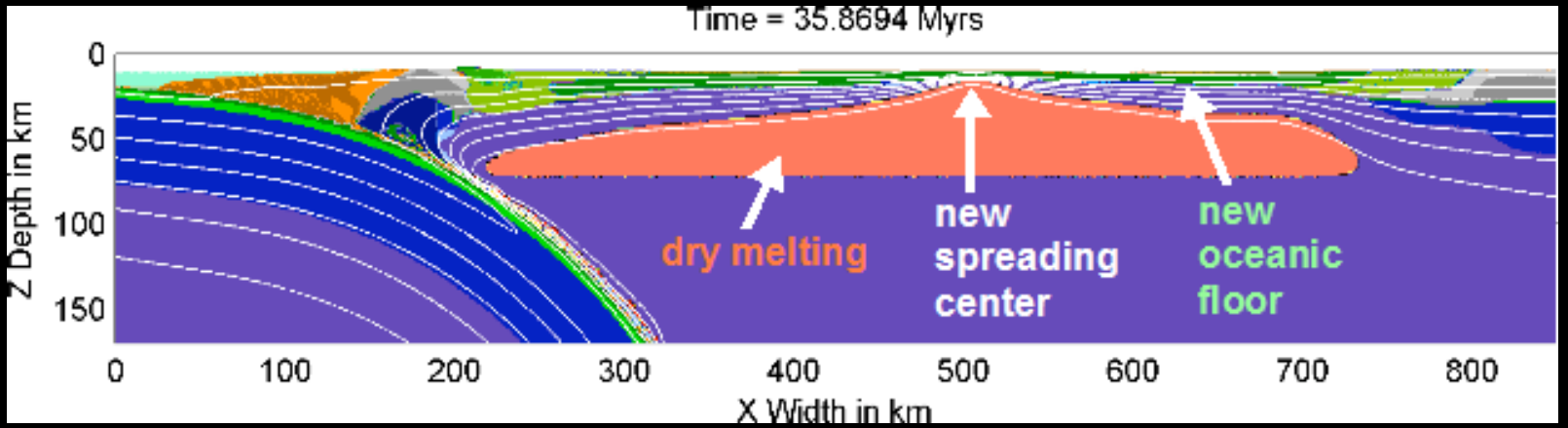
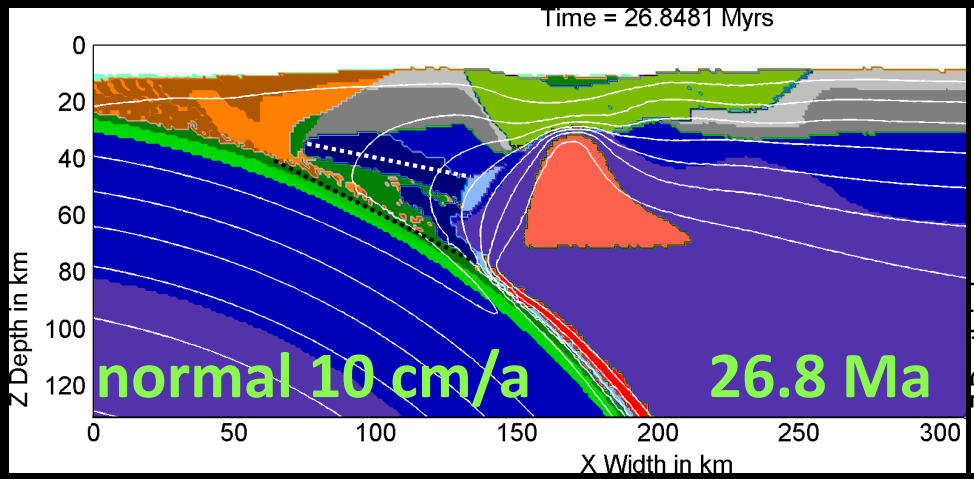
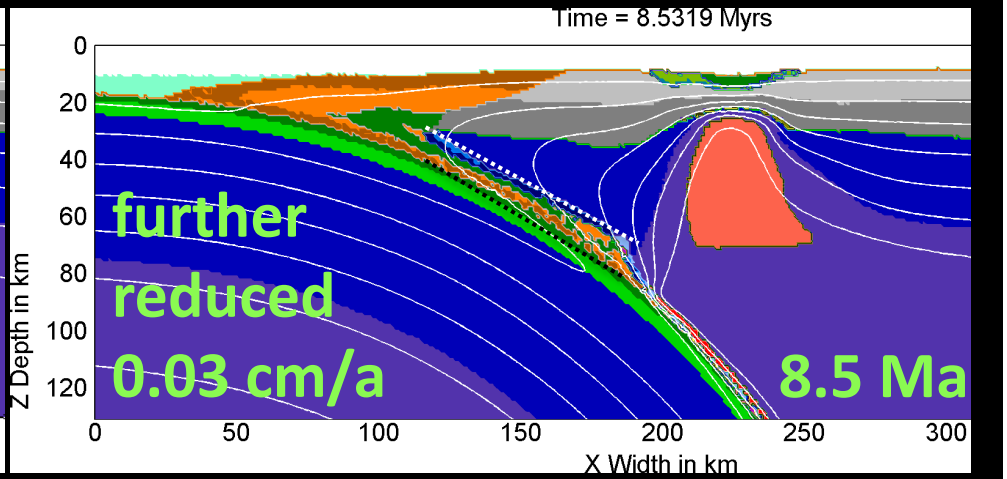


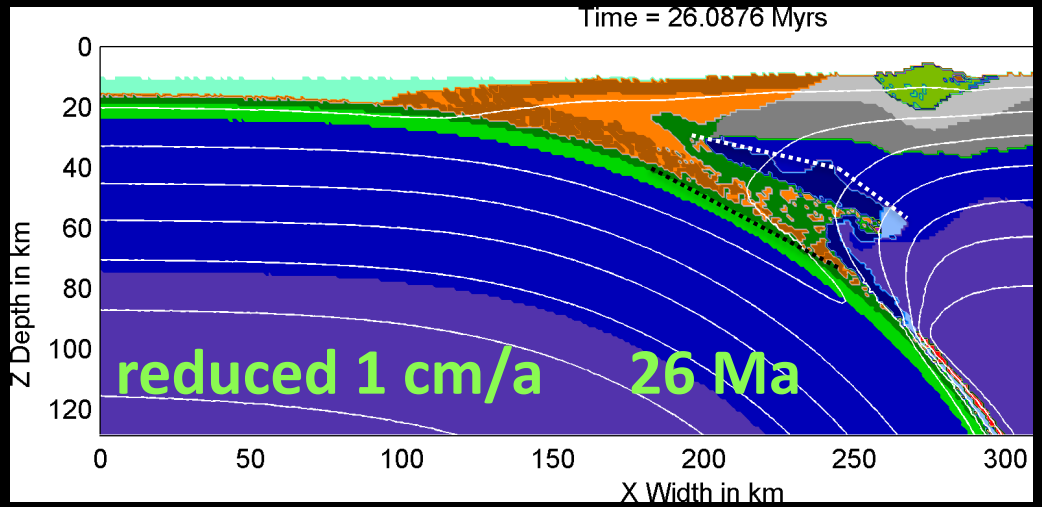


BACKARC BASINS

INFLUENCE OF PERCOLATION VELOCITY

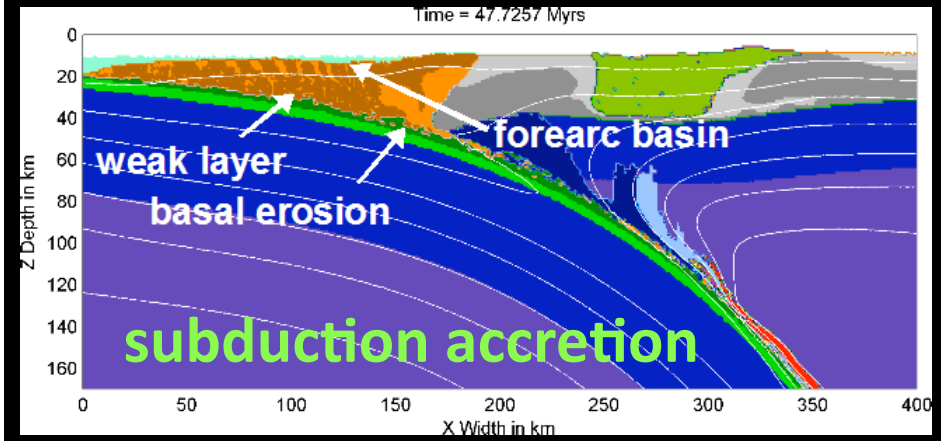


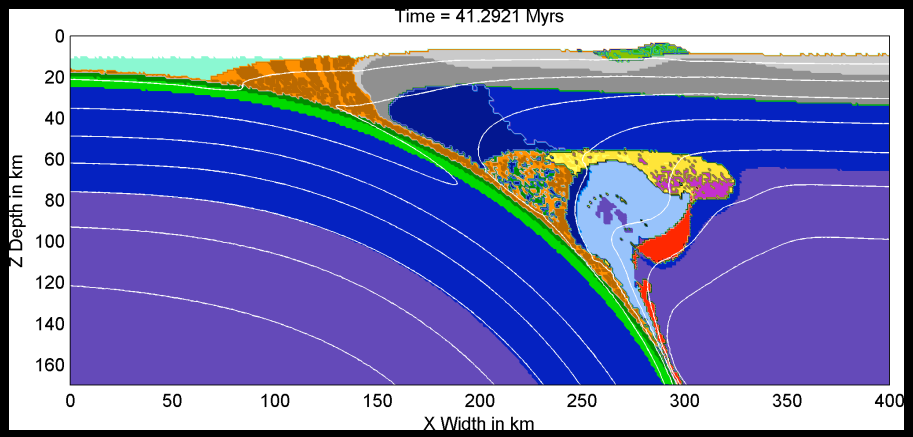


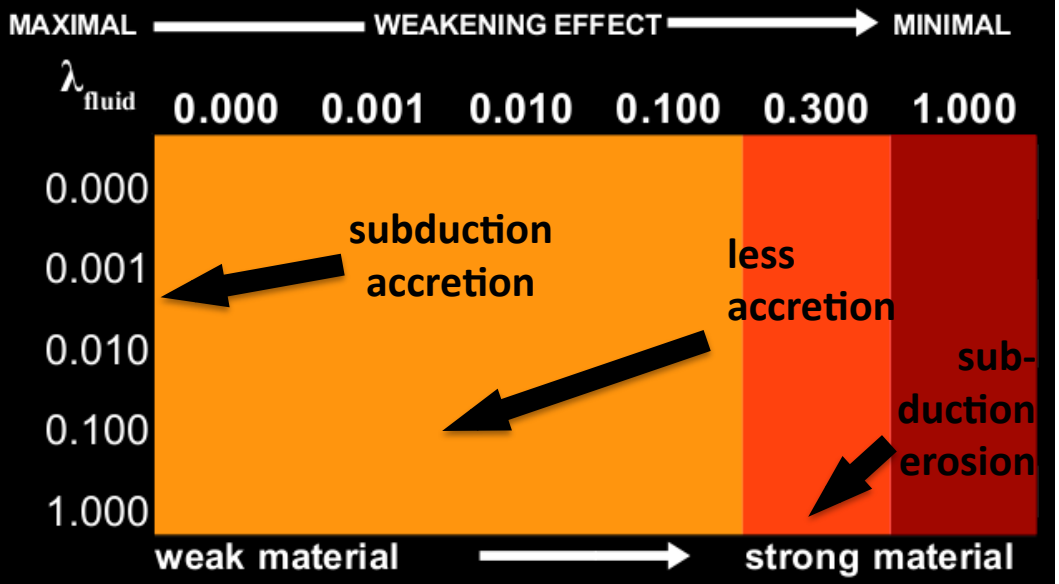


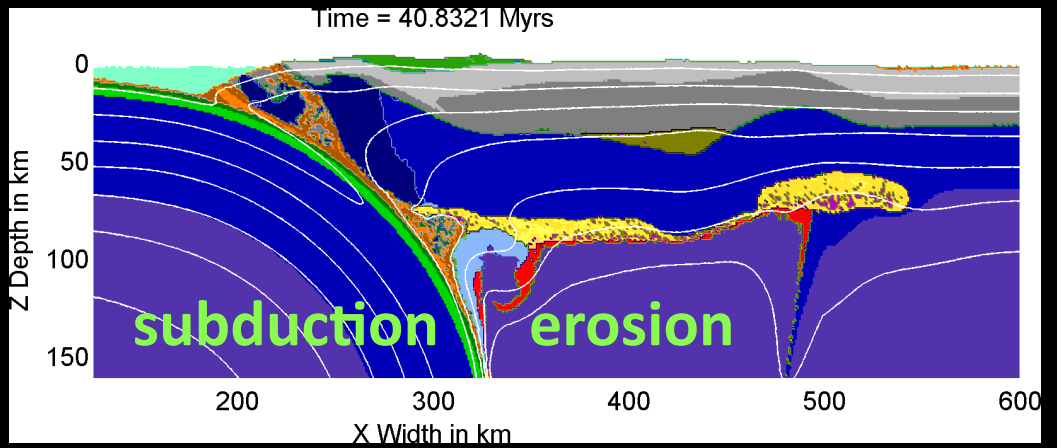
ACCRETION vs. EROSION

COUPLING OF THE PLATES

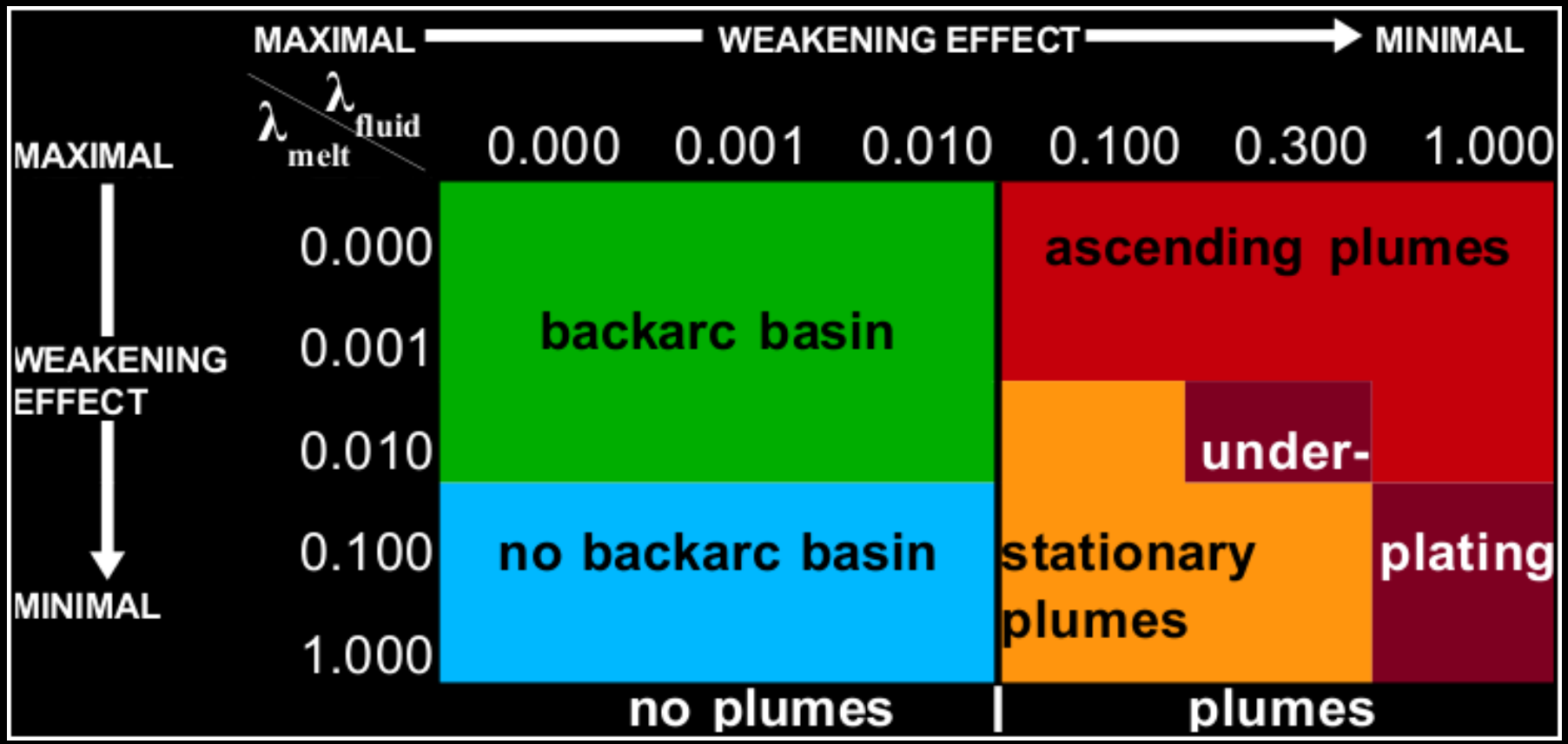








PLUMES


MAXIMAL
WEAKENING EFFECT
MINIMAL
λfluid
λmelt
MAXIMAL
WEAKENING EFFECT
MINIMAL
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0.010
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backarc basin
ascending plumes
under-
plating
no backarc basin
stationary plumes
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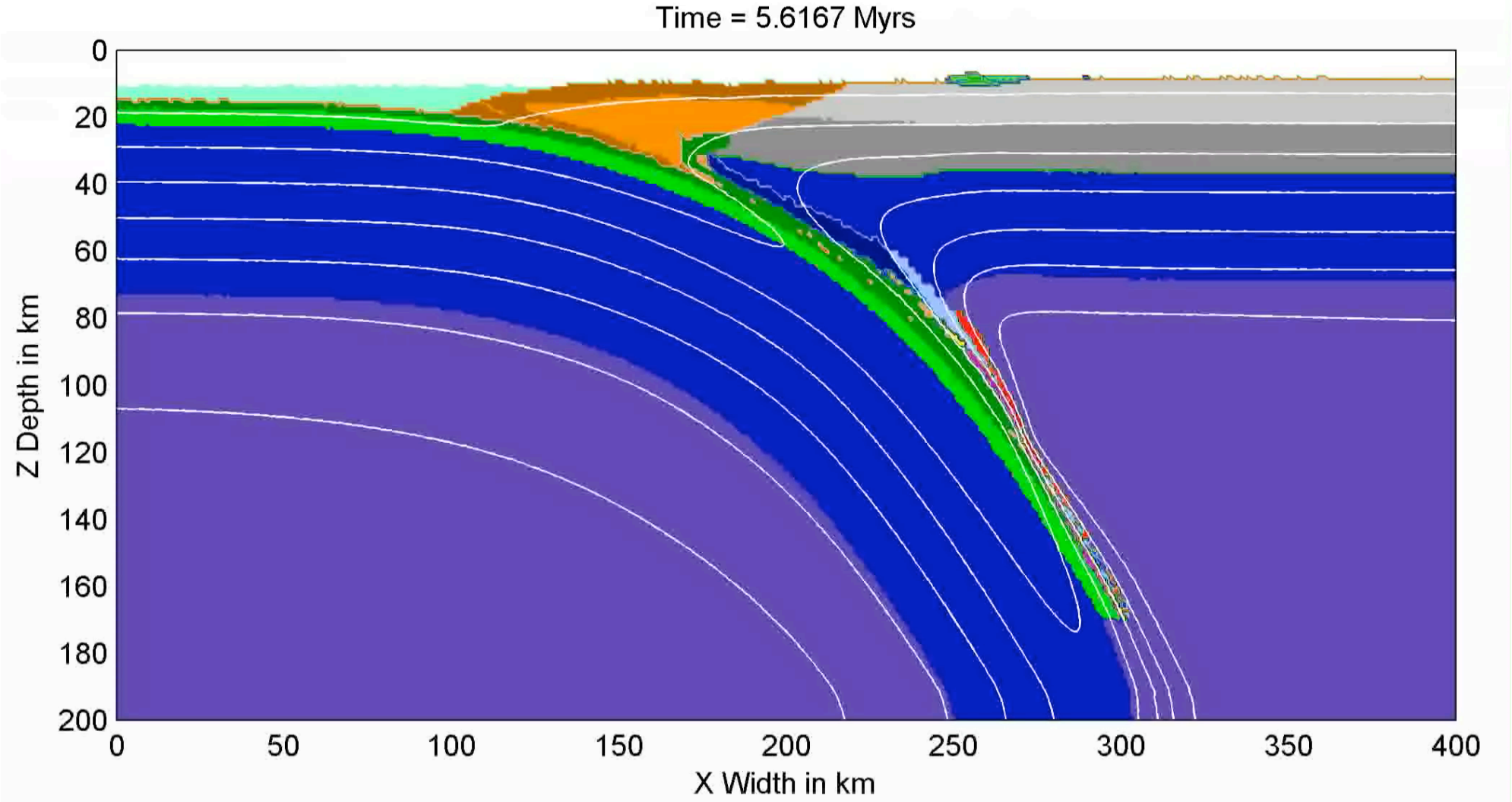
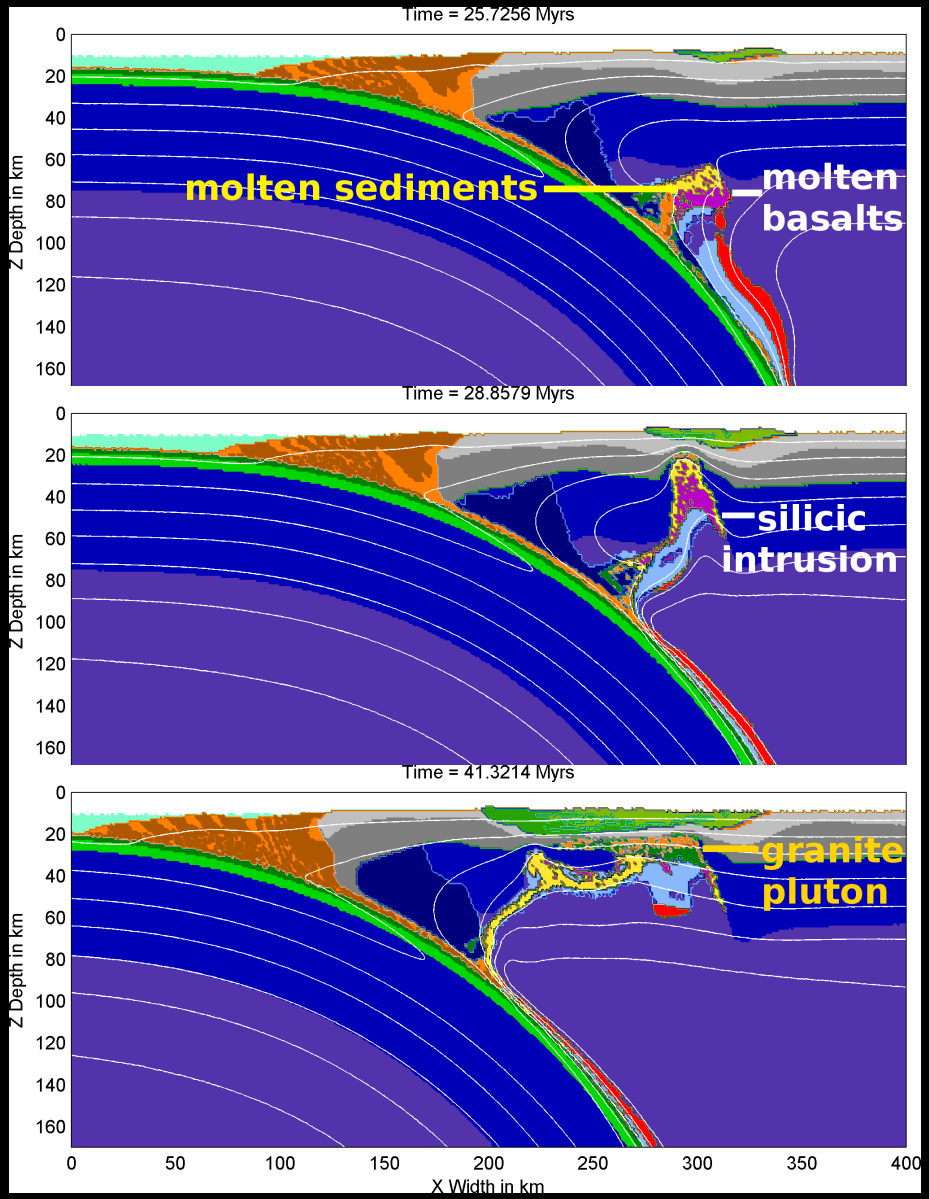
plumes

ASCENDING PLUMES

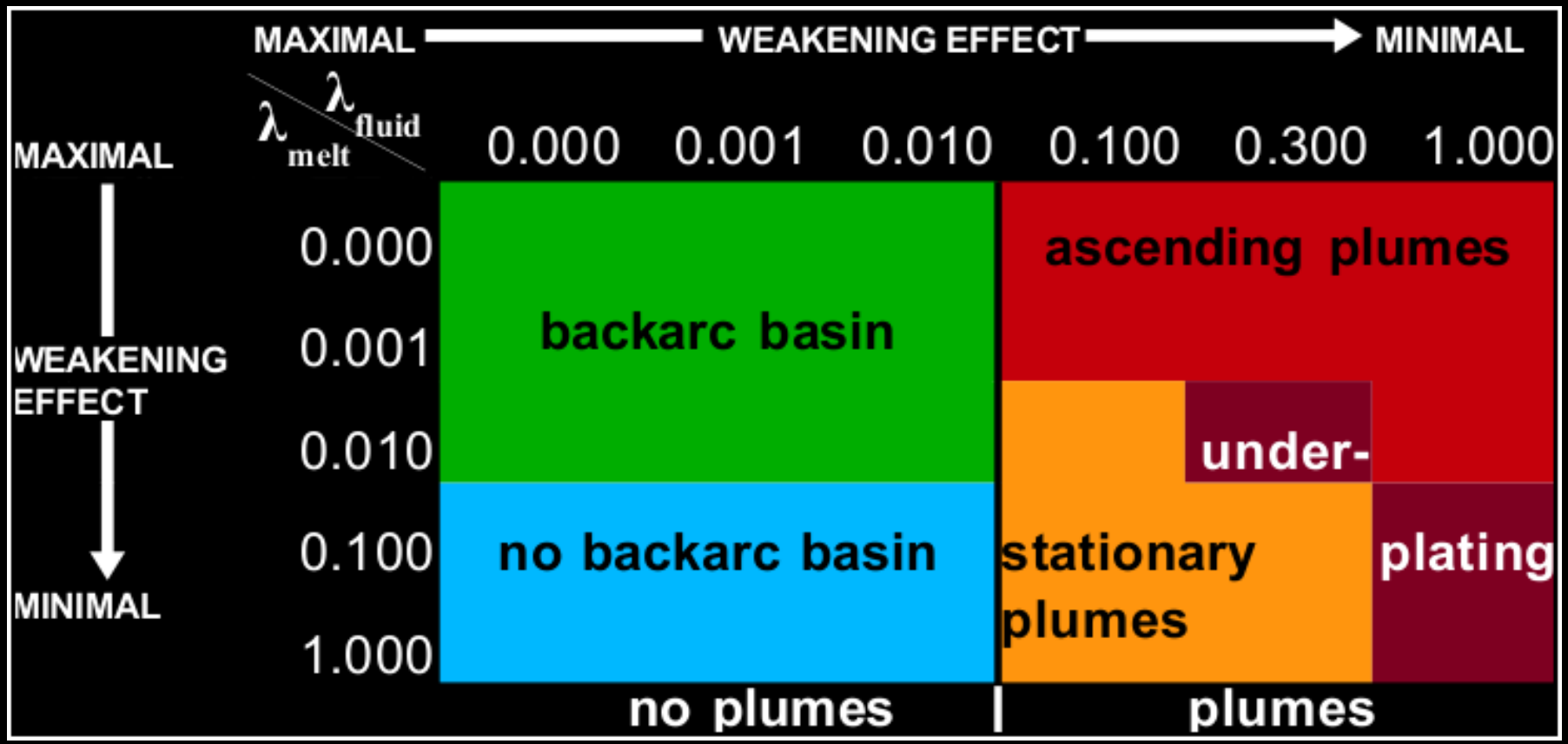


ASCENDING PLUMES



Castro et al. 2008 (submitted)

PLUMES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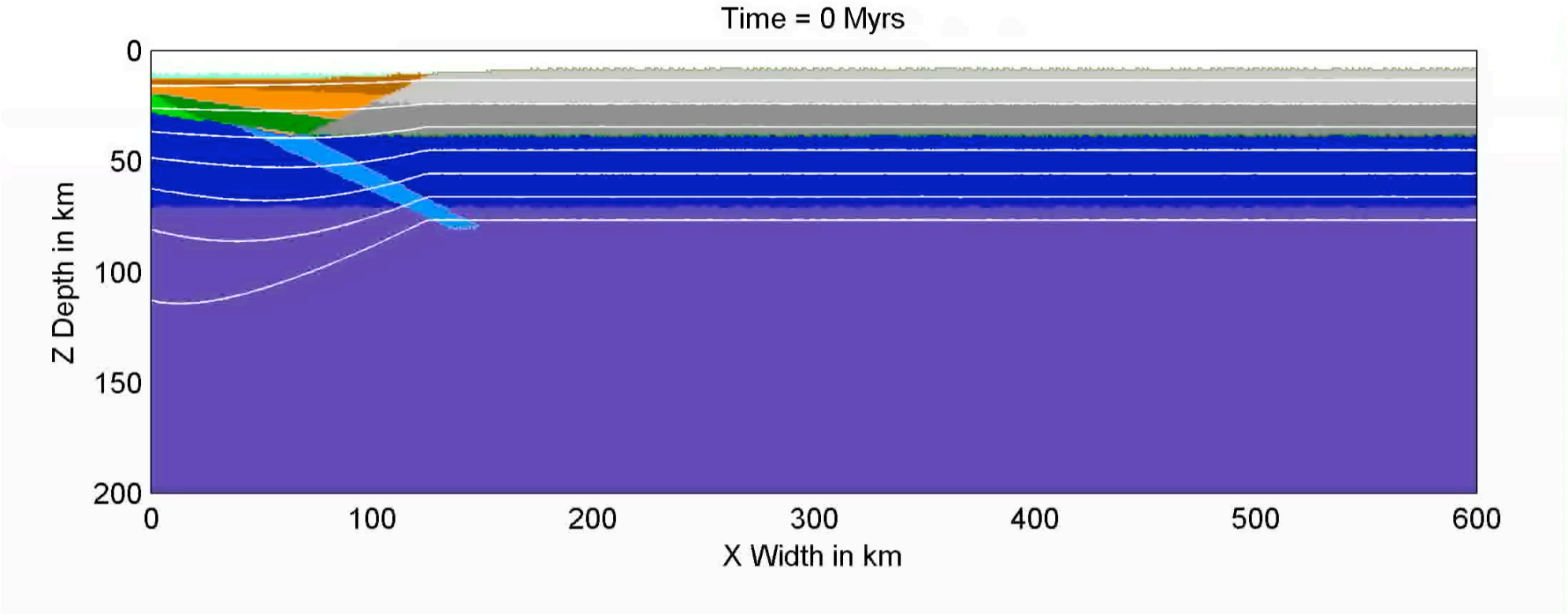
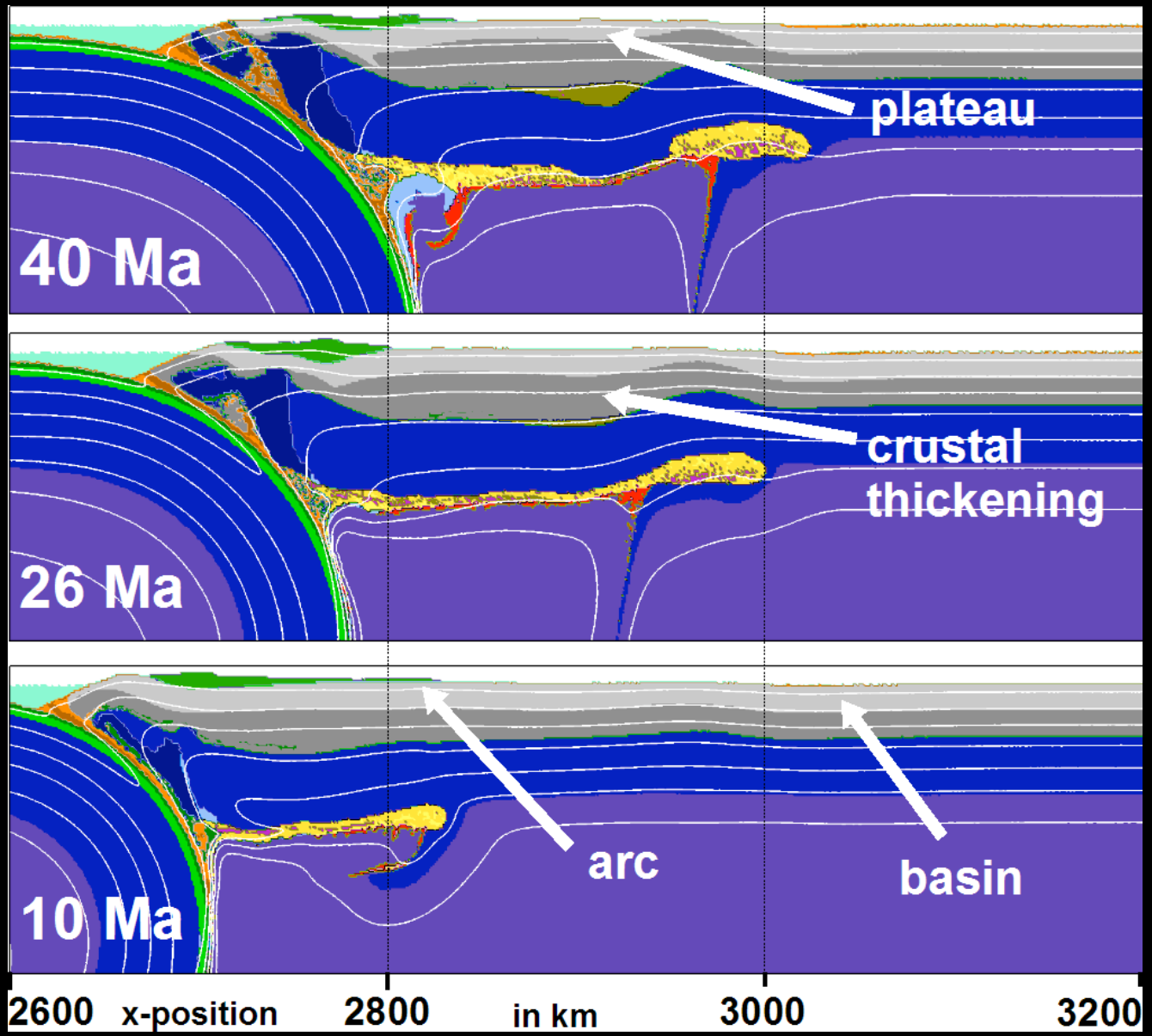
UNDERPLATING



UNDERPLATING



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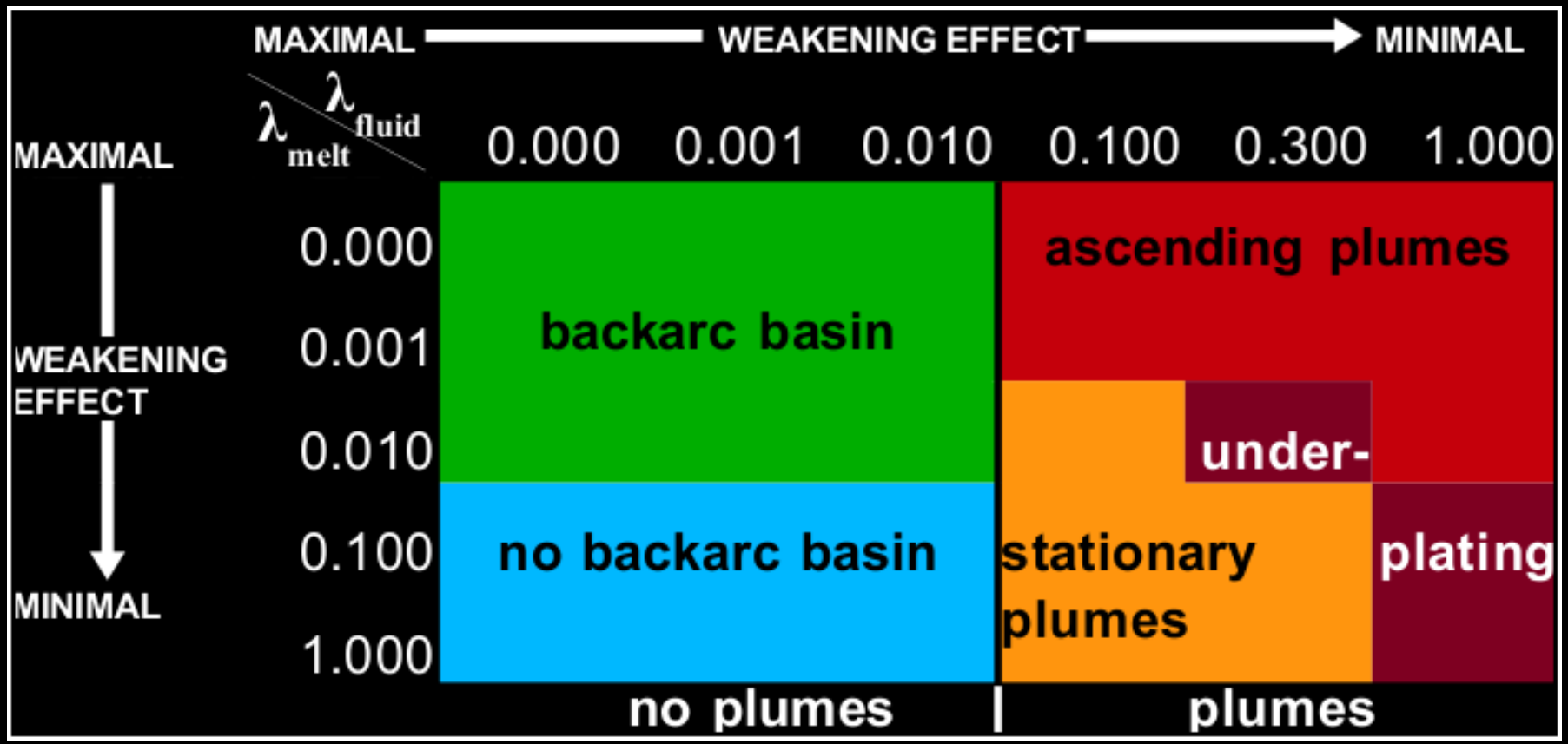
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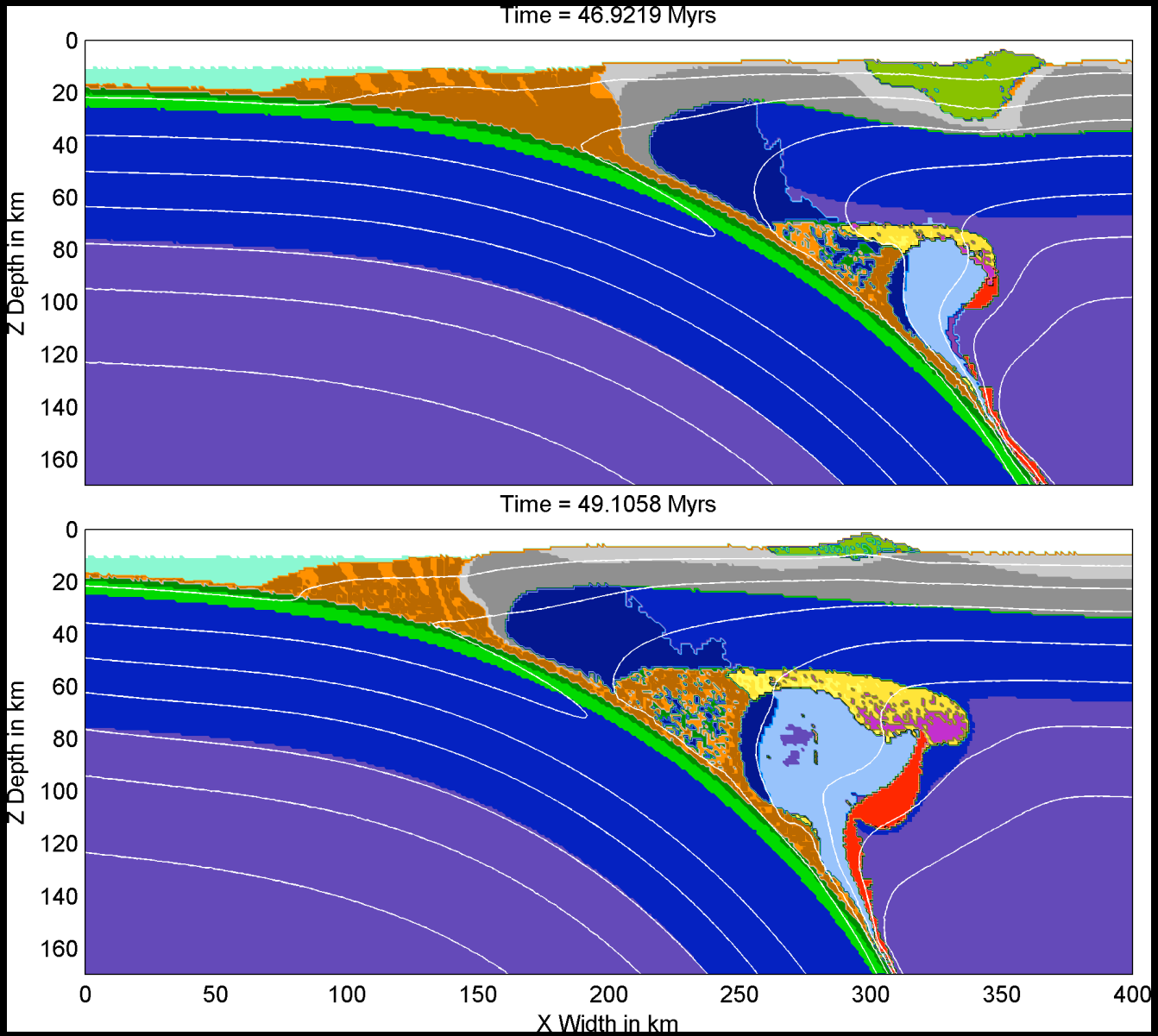
STATIONARY PLUMES



λ_{fluid} = 0.1 more weakening by fluids

λ_{fluid} = 0.3 less weakening by fluids

CONCLUSIONS

- λ_{fluid} / λ_{melt} → different **modes of subduction**
- backarc spreading: **bifurcation of extension**
- λ_{fluid} controlls **coupling of plates**
  →subduction **accretion** or subduction **erosion**
- ascending plumes → **silicic intrusions**