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NUMERICAL MODELLING OF SALT DIAPIRISM DURING THIN-SKINNED EXTENSION

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1 - INTRODUCTION

The occurrence of salt diapirs is strongly associated with potential geothermal and hydrocarbon energy sources. One occurence of salt diapirism is commonly seen in areas undergoing thin skinned extension (e.g. North Angolan passive margin). Although this feature has been the subject of a few structural geological and analogue studies, research into the dynamics of such a system is scarce. Therefore we applied two-dimensional numerical modelling to address the following question:

Which geological/geometrical or material parameters affect the growth rate and shape of the diapir and how?

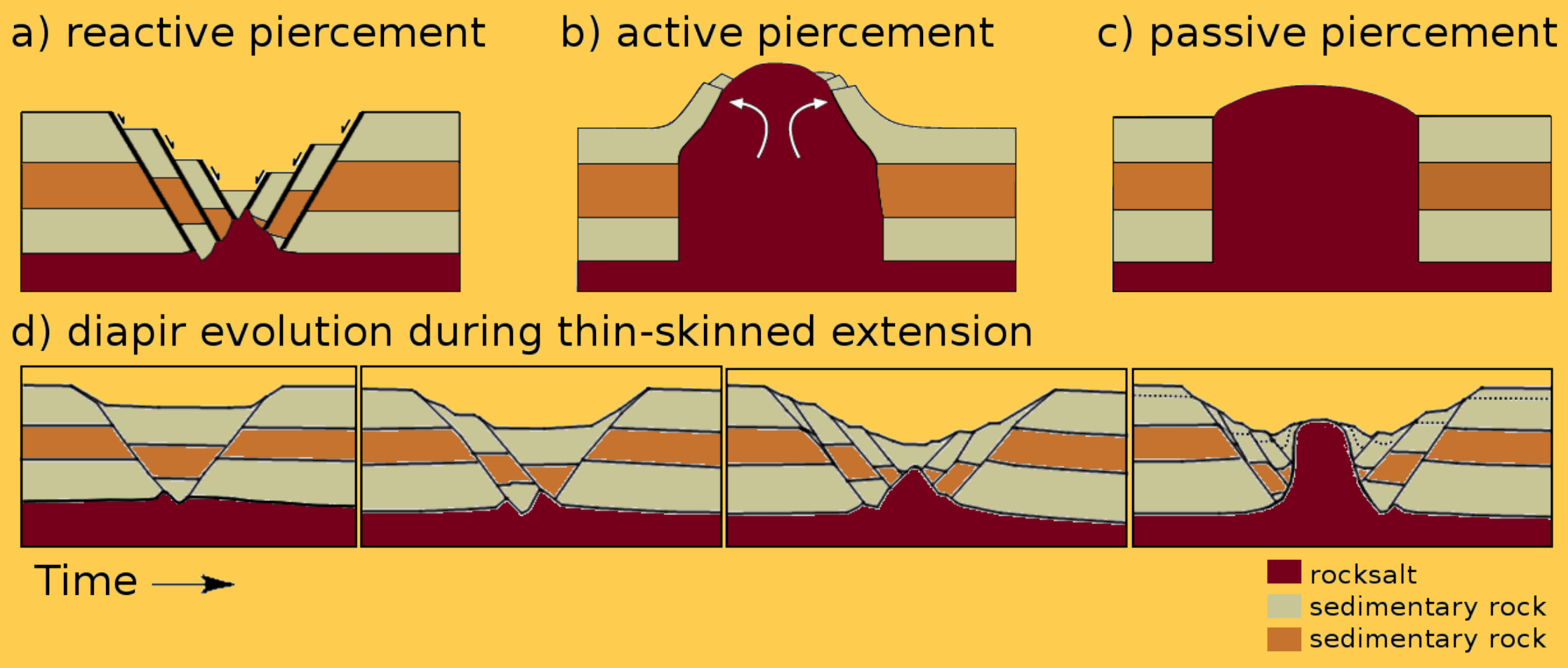
2 - METHODOLOGY

We assume that materials in the Earth's crust behave like incompressible visco-plastic fluids. Their flow is then best described by the Stokes equations:

$$\begin{aligned} \boldsymbol{\nabla}(\mu(\boldsymbol{\nabla} v + \boldsymbol{\nabla} v^T)) - \boldsymbol{\nabla} p + \rho \boldsymbol{g} &= \mathbf{0} \quad (1) \\ \boldsymbol{\nabla} \cdot \boldsymbol{v} &= 0 \quad (2) \end{aligned}$$

Equation (2) is the mass conservation equation for incompressible fluids and equation (1) is the momentum conservation equation. This set of equations is solved by means of a Finite Element code similar to the one presented in [1].

3 - STRUCTURAL GEOLOGY



Different modes of diapirims (a,b,c), after [2] and the evolution of a diapir as results from analogue experiment (d), after [3].

7 - OUTLOOK

Points considered for future research:

- Nonlinear viscous rheology for salt
- Expand to 3D
- Inclined basement (often the drive behind thin-skinned extension)

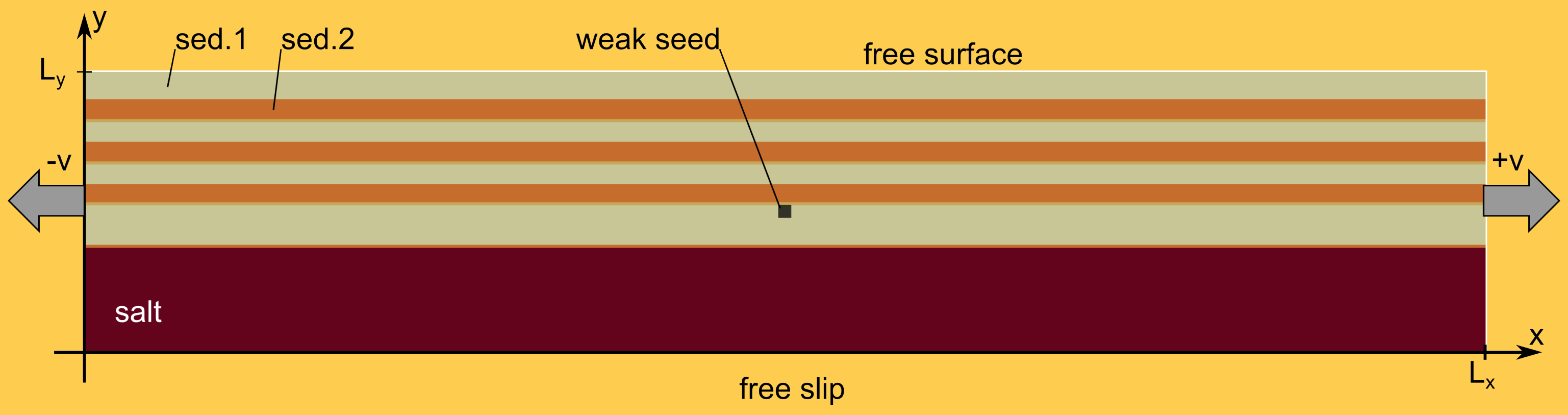
REFERENCES

[1] C. Thieulot, 2011. FANTOM: Two- and three-dimensional numerical modelling of creeping flows for the solution of geological problems In *Phys. Earth Planet. Inter.*

[2] M. R. Hudec, M. P. A. Jackson, 2007. Terra infirma: Understanding salt tectonics In *Earth-Sci. Rev.*

[3] B. C. Vendeville, M. P. A. Jackson, 1992. The rise of diapirs during thin-skinned extension In *Mar Pet Geol.*

4 - SETUP

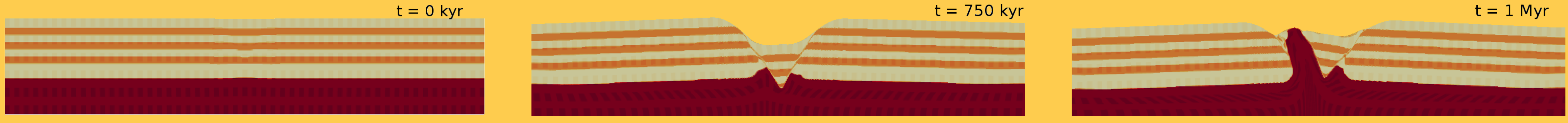


L_x= 20km, L_y= 4km.
Salt: linear viscous rheology, density ρ_0 = 2100 kg·m^3, viscosity μ = 1 x 10^{18} Pa·s.

Sedimentary rocks: nonlinear plastic rheology, ρ_0 = 2500kg·m^3 (type 1) or 2400kg.m^3 (type 2), $\mu_0 \approx$ 1 x 10^{24}Pa·s, cohesion c = 55 MPa (1) or 62 MPa (2), angle of friction $\phi = 32^o$ (1) or 30^o (2).

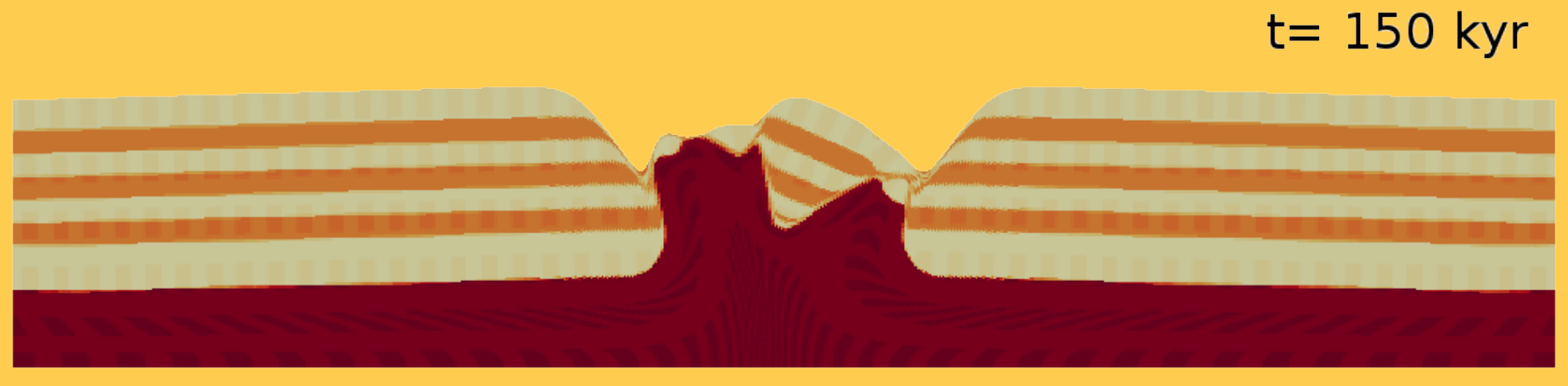
5 - RESULTS

Evolution of reference model (v = 0.1 cm·year^{-1}, ρ_{salt}/ρ_{sed} = 0.86, t_{final} = 1 Myr):



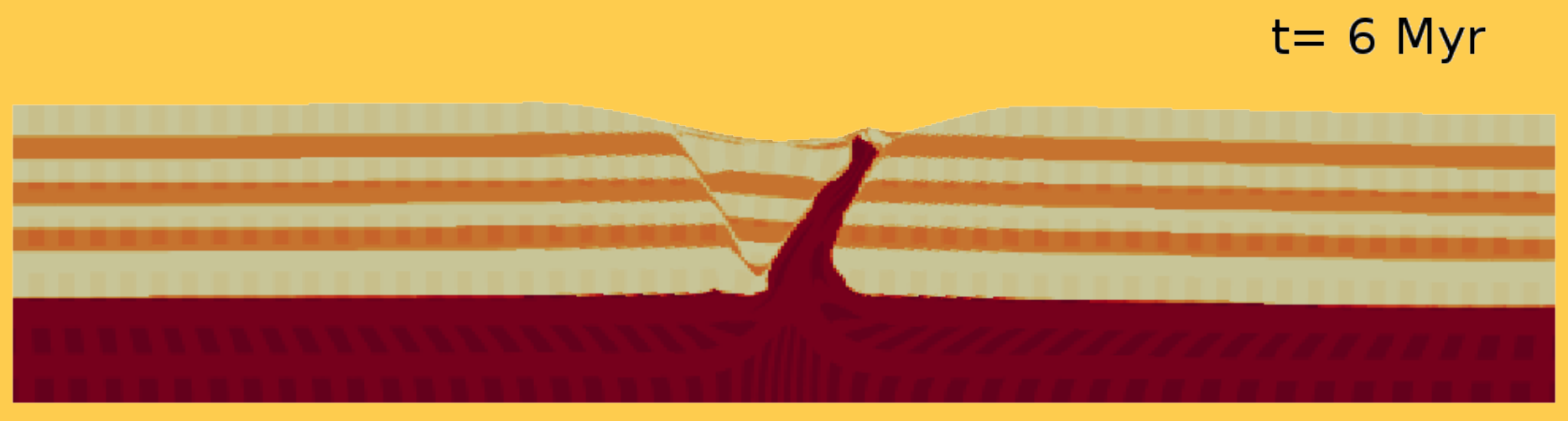
Differences in spreading rate:

Higher spreading rate:



v = 1 cm·year^{-1}
t_{final} = 250 kyr

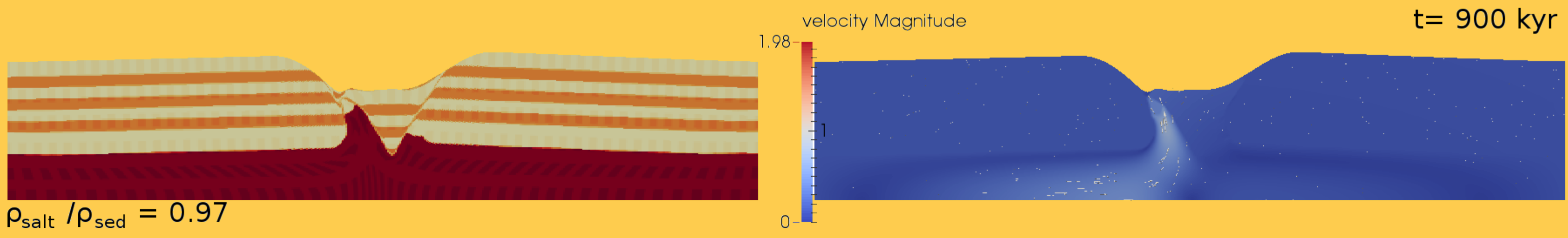
Lower spreading rate:



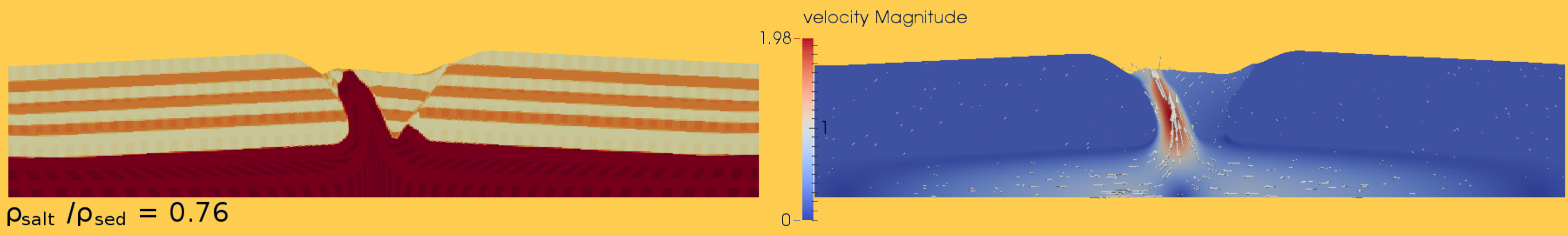
v = 0.01 cm·year^{-1}
t_{final} = 6 Myr

Differences salt/sediment density contrast:

Lower contrast:

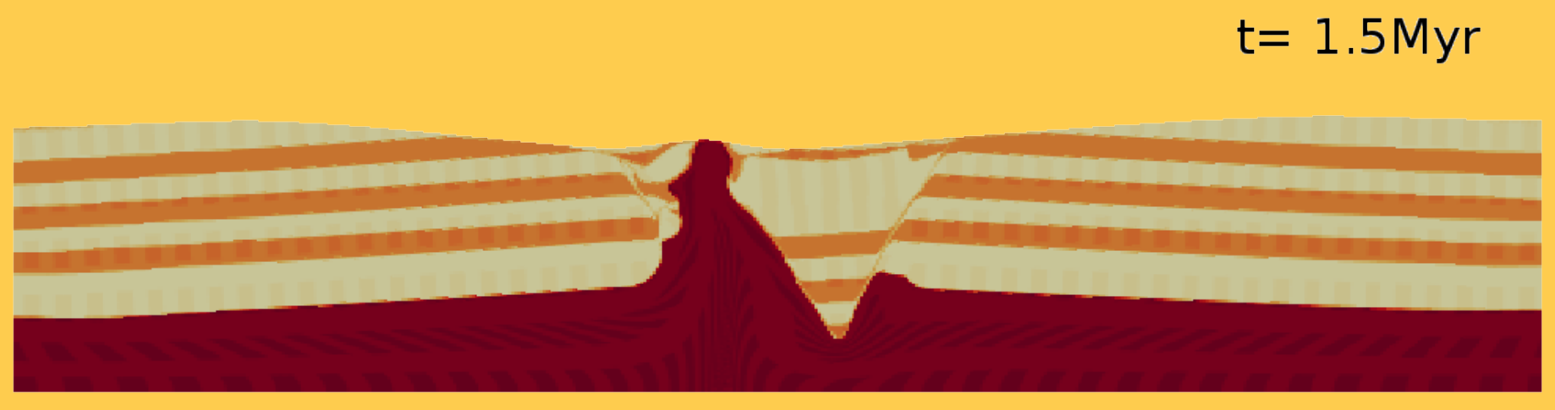


Higher contrast:



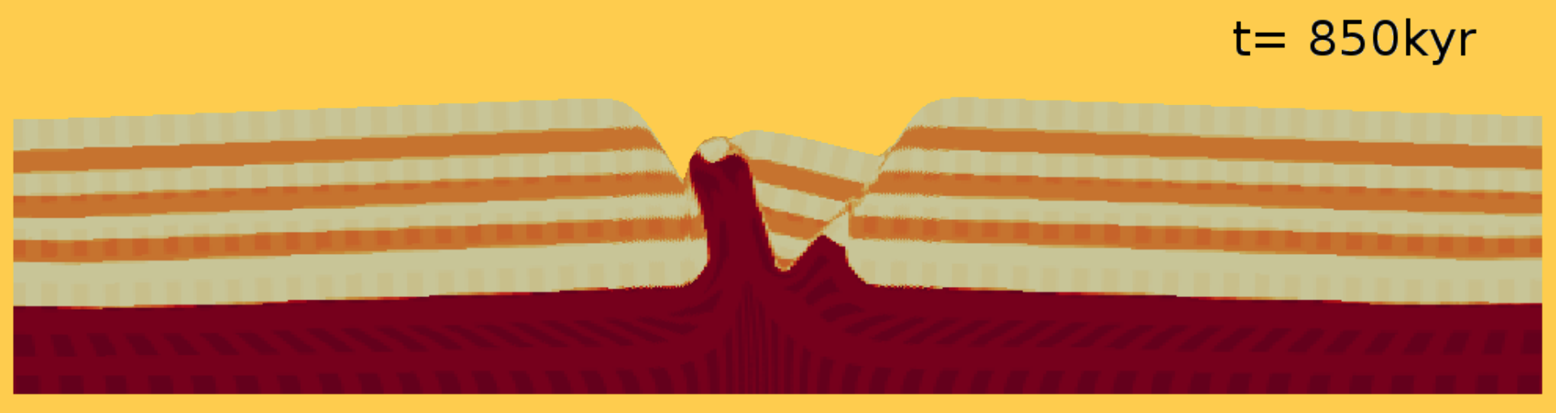
Differences in local surface processes vigour:

More vigorous:



t_{final} = 1.5 Myr

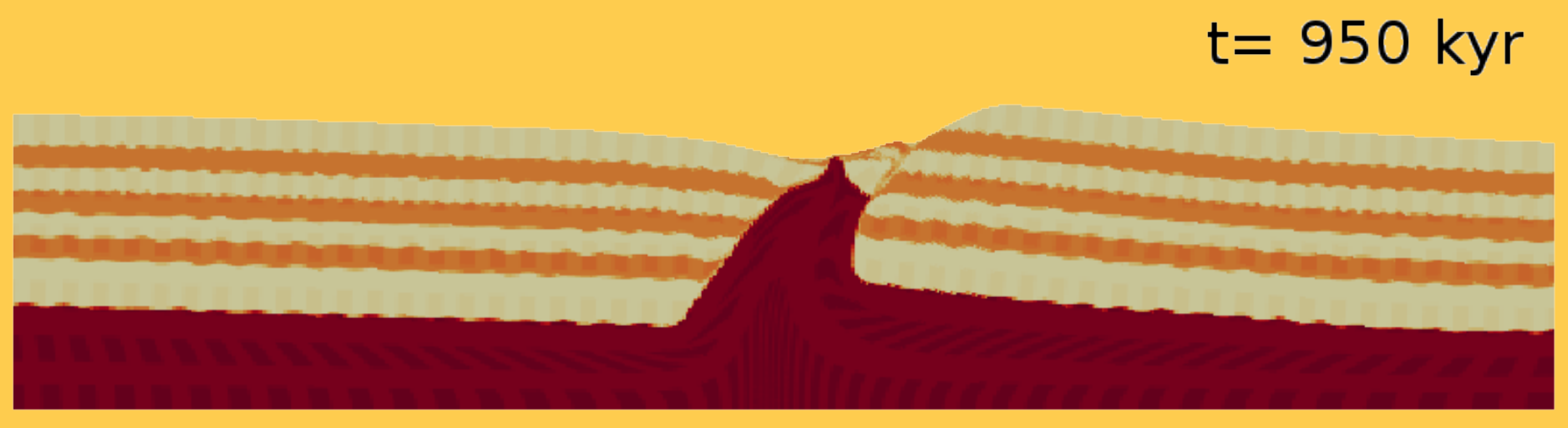
Less vigorous:



t_{final} = 850 kyr

Perturbations on salt-sediment interface:

Larger perturbations



Half-graben

6 - CONCLUSIONS

Increased extension rates result in:

- Shorter surfacing time
- Relatively longer reactional phase
- Overall thicker diapir

Increased density contrast results in:

- Shorter surfacing time
- Increased growth rate during active piercement

Increased surface processes vigour results in:

- Longer surfacing time
- Decreased growth rate during active piercement
- Enhanced cone-shape

Enhanced salt-sediment interface perturbations results in:

- Enhanced asymmetry; half-grabens

Overall there is a good correlation with other structural-geological, analogue and numerical studies, as well as natural phenomena.