Transform versus non-transform offsets are controlled by the variation of magmatic accretion in the offset zone as well as by the offset distance

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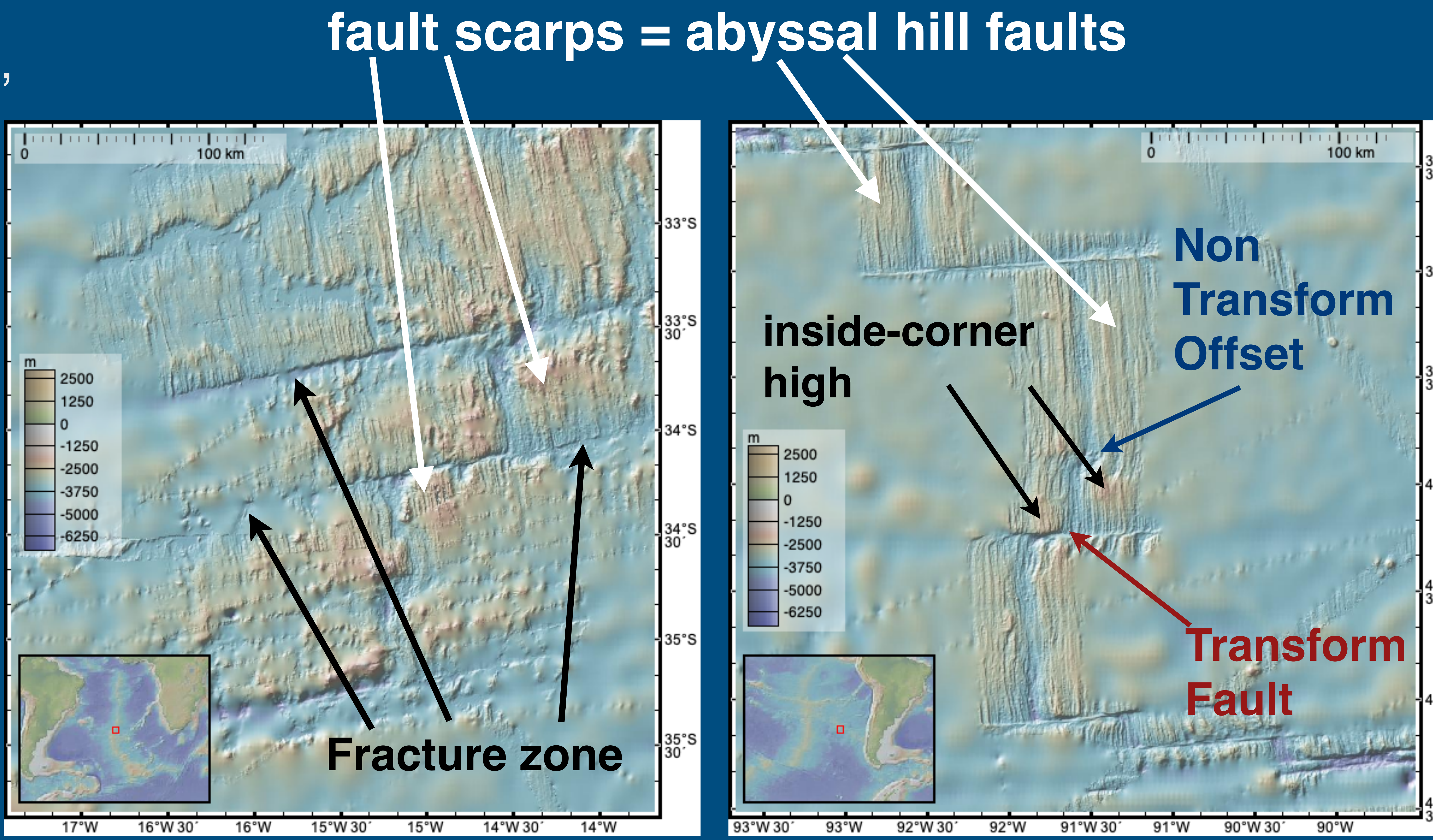
TS 9.1 Analogue and numerical modelling of tectonic processes

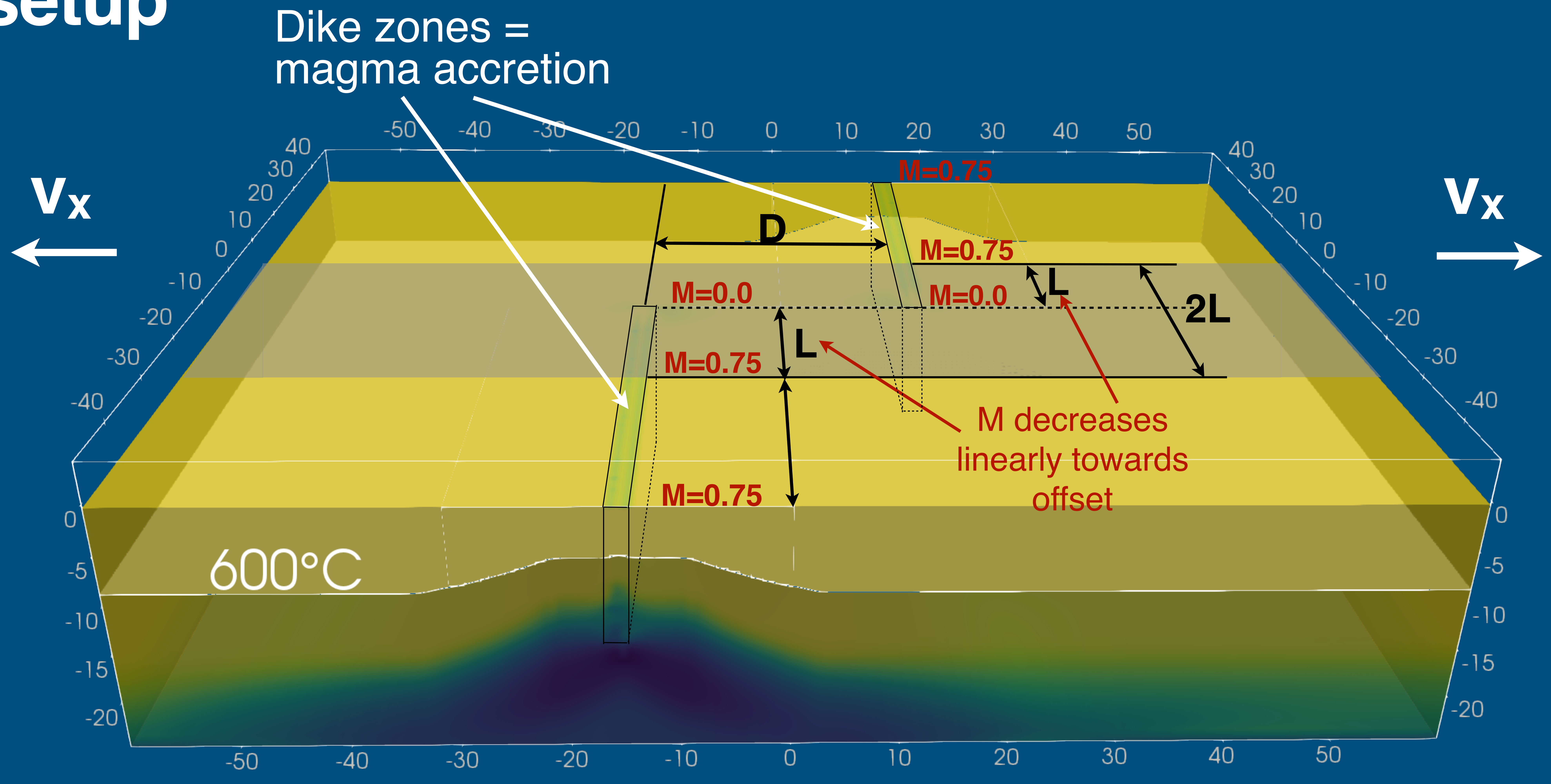
Introduction

- Transform faults (TF) or non-transform offsets (NTO) separate mid-ocean ridges (MOR)
- Segment offsets can evolve from TFs to NTOs or the other way around (e.g. Hey et al., 2015)
- Fraction of spreading accommodated magmatically (M) influences fault spacing, axial topography and ridge morphology
  (e.g. Buck et al. 2005, Ito & Behn 2008, Howell et al. 2016)

What controls the formation of transform faults (TF) versus non-transform offsets (NTO) ?



Model setup



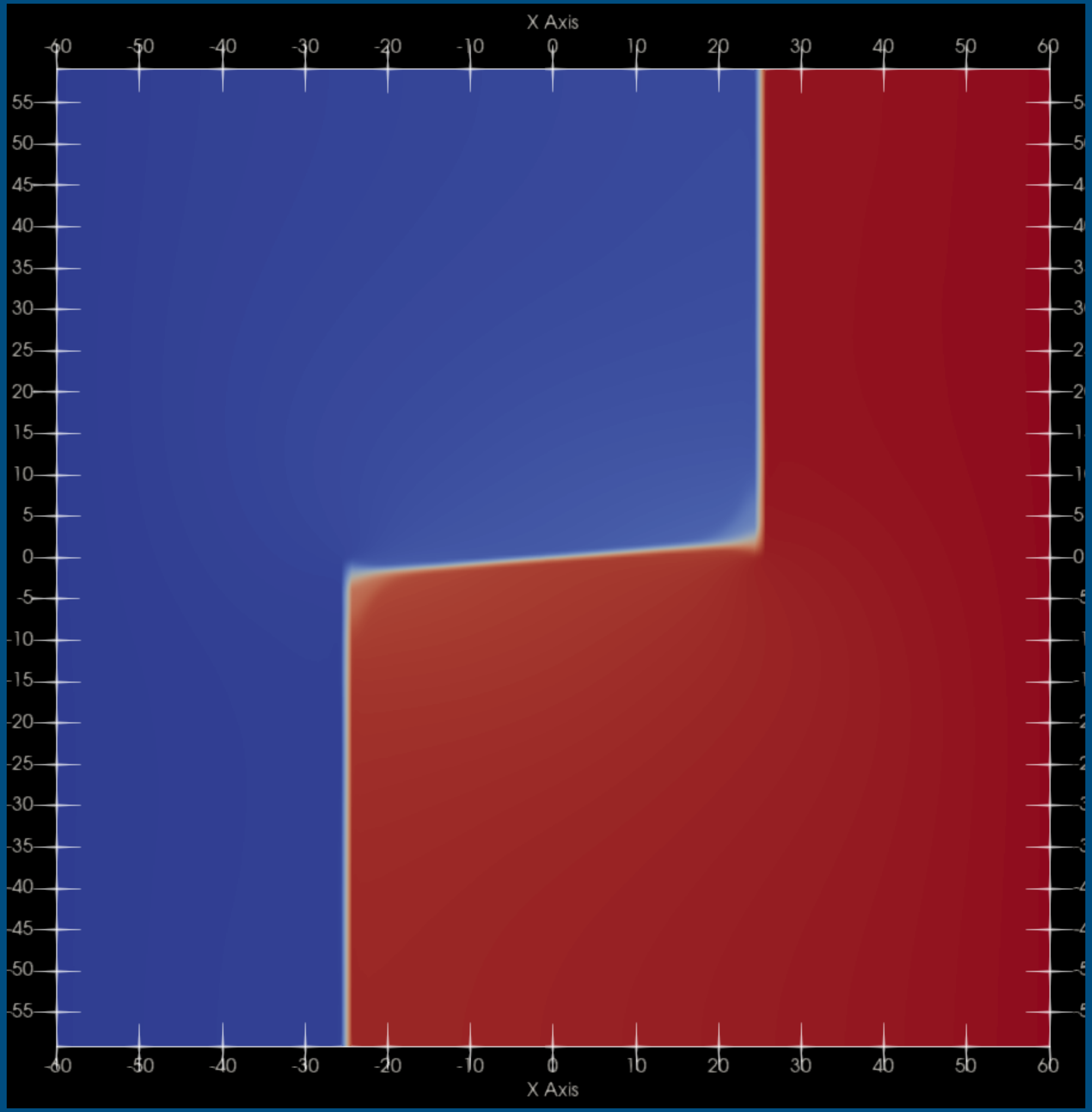
- 3D finite difference code LaMEM: solves for momentum, mass and heat conservation
- visco-elasto-plastic model allows spontaneous fault formation and evolution
- “dike zone”: imposed divergence to simulate magmatic accretion along one ridge segment

Numerical results and natural observations

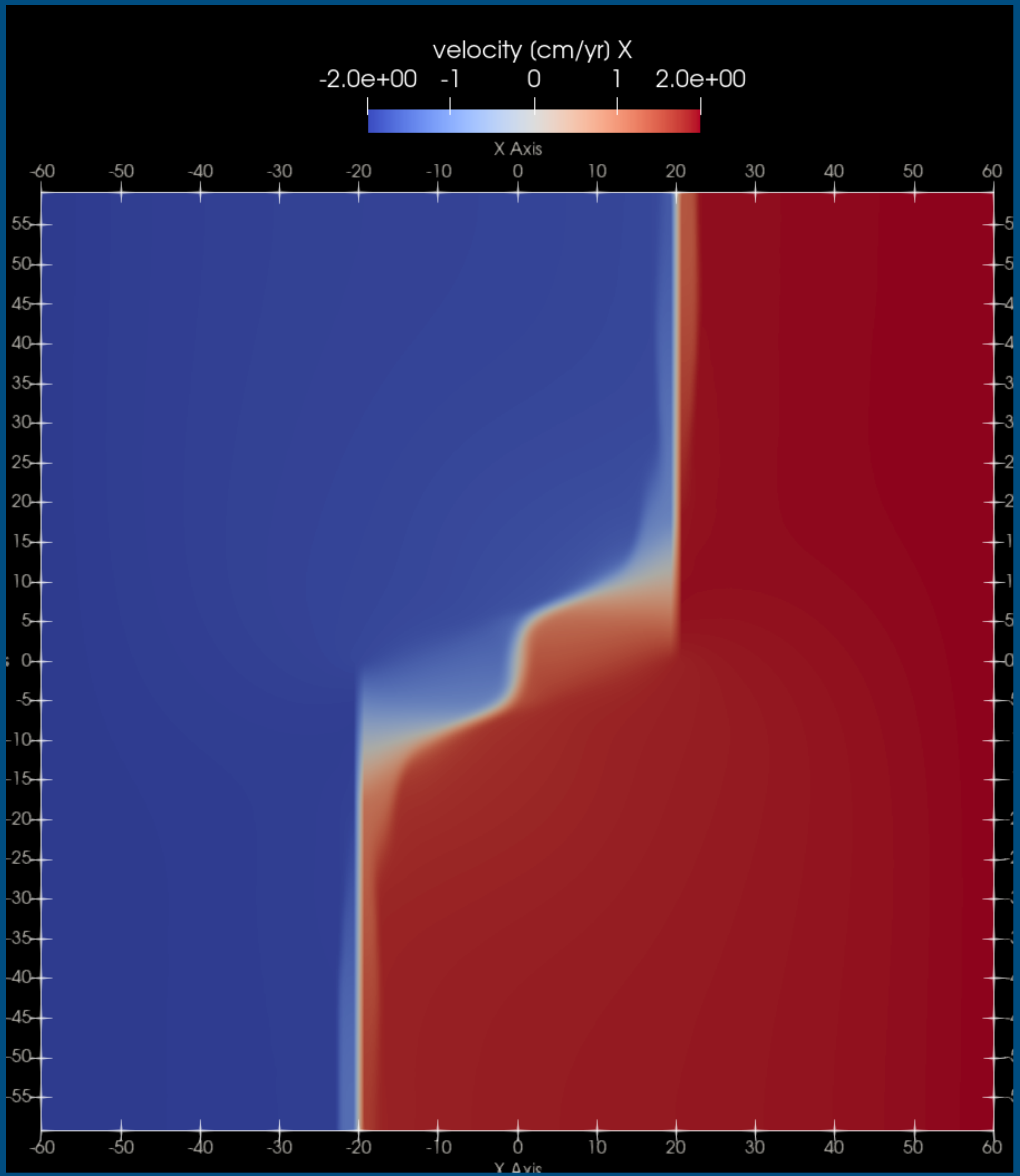
Velocity field to define regime (backup)

Transform Fault
(TF)

< 8°

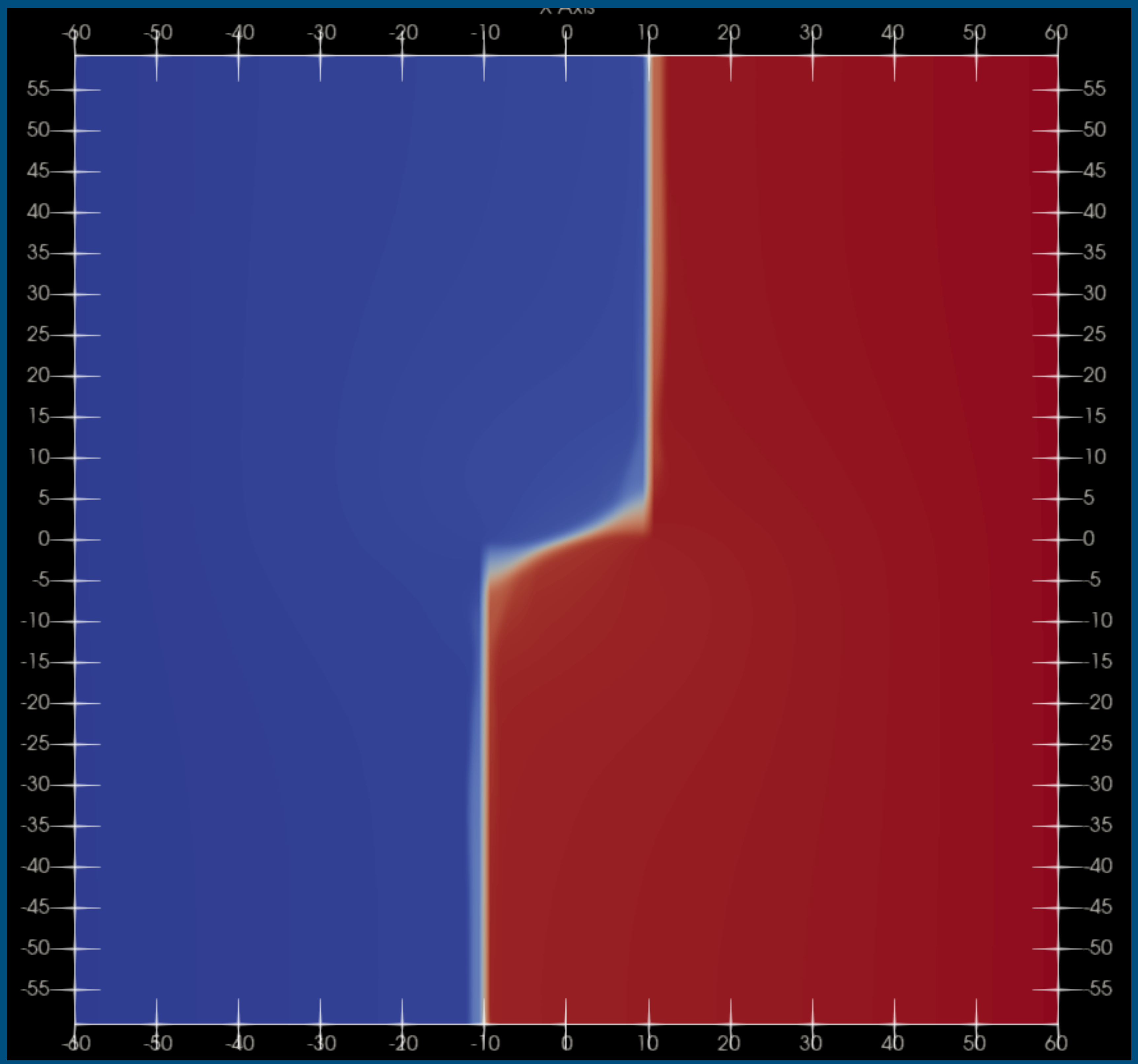


Intra Transform Spreading Center
(ITSC)



Non Transform Offset
(NTO)

> 8°



Overview on numerical model results

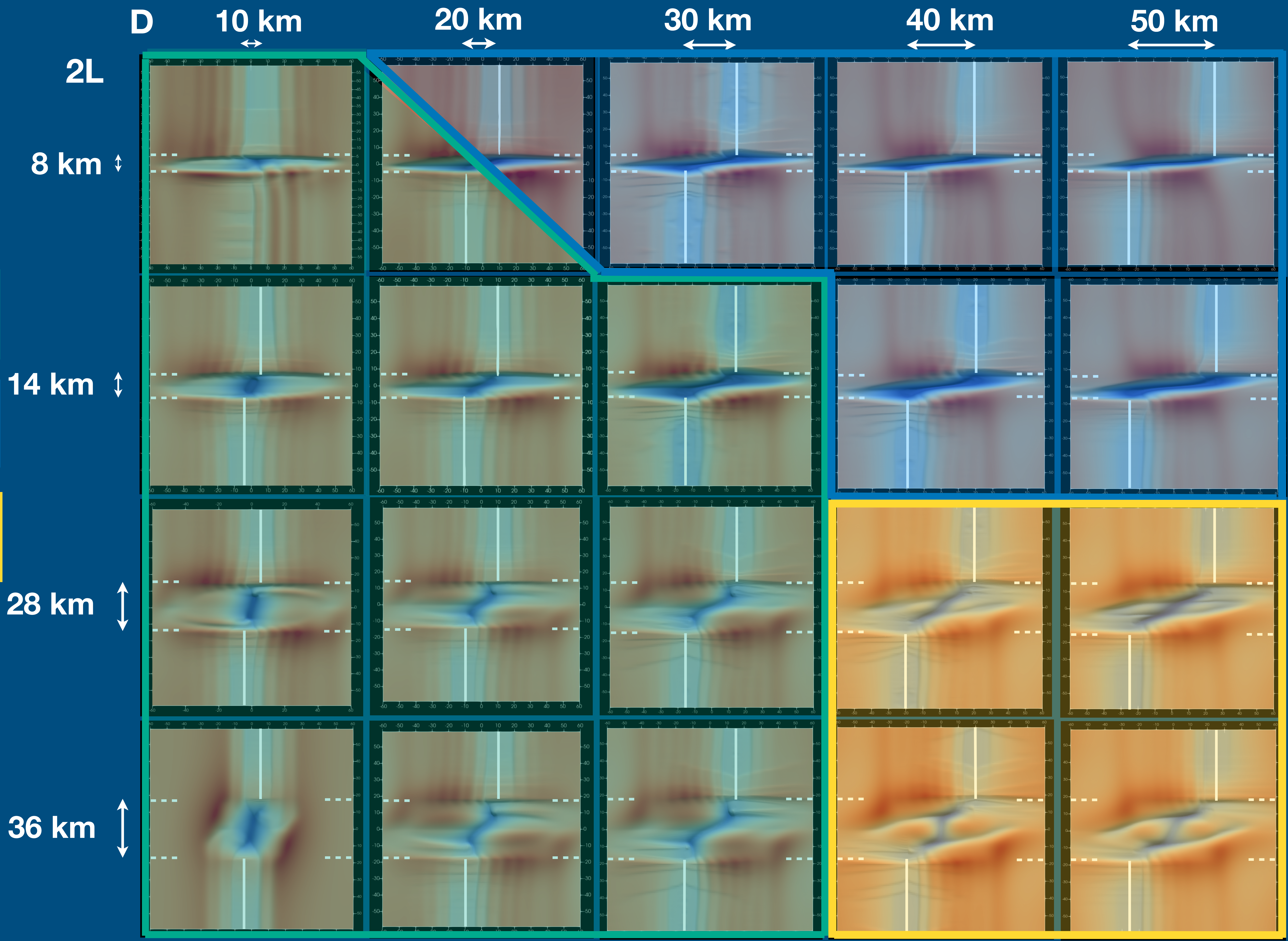
all models at t = 2 Myr

Overview on numerical model results

1) Small-medium offset, any underlap: NTO

2) medium-large offset, small underlap: TF

3) Large offset, large underlap: ITSC



Overview on numerical model results

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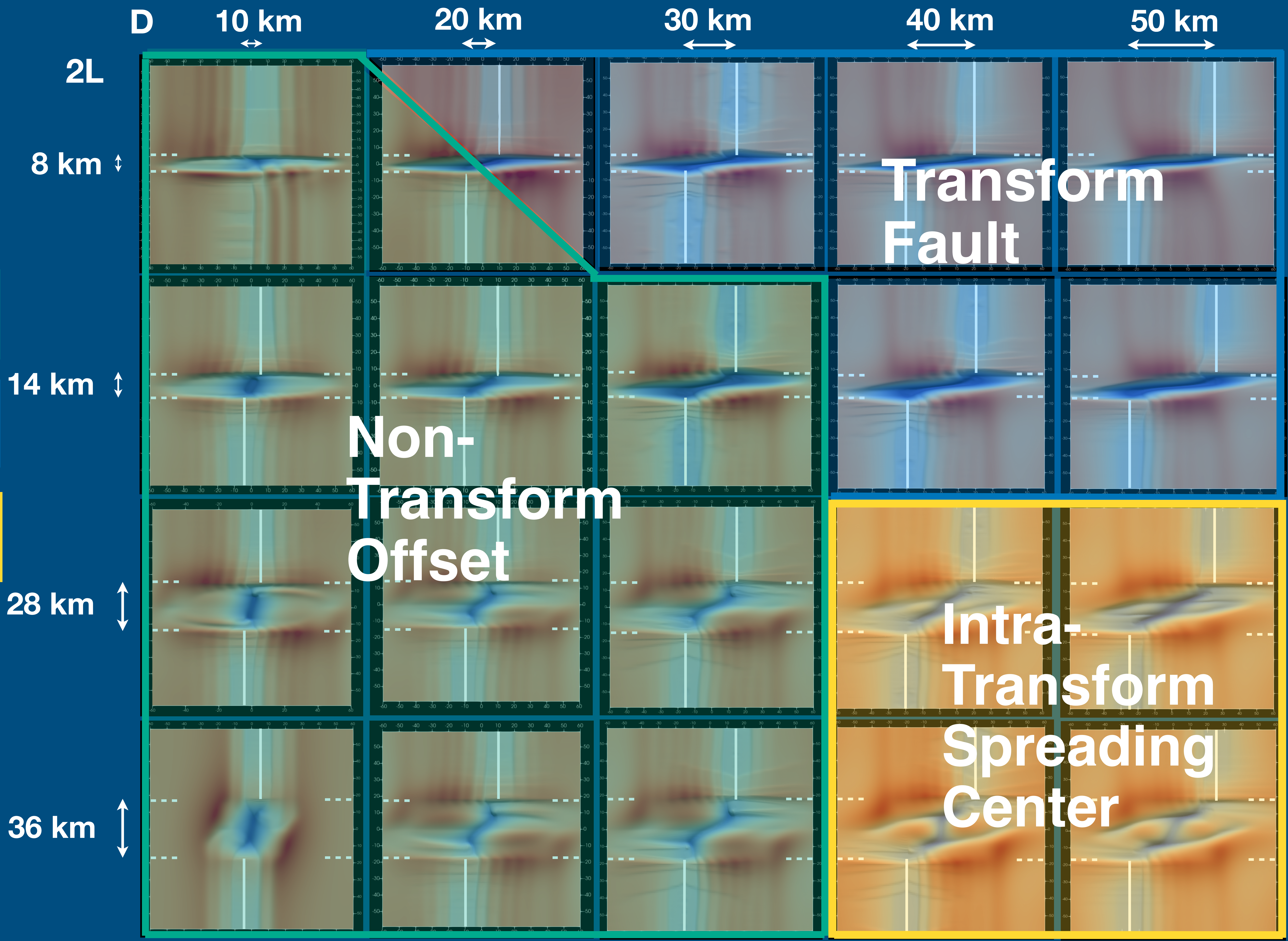


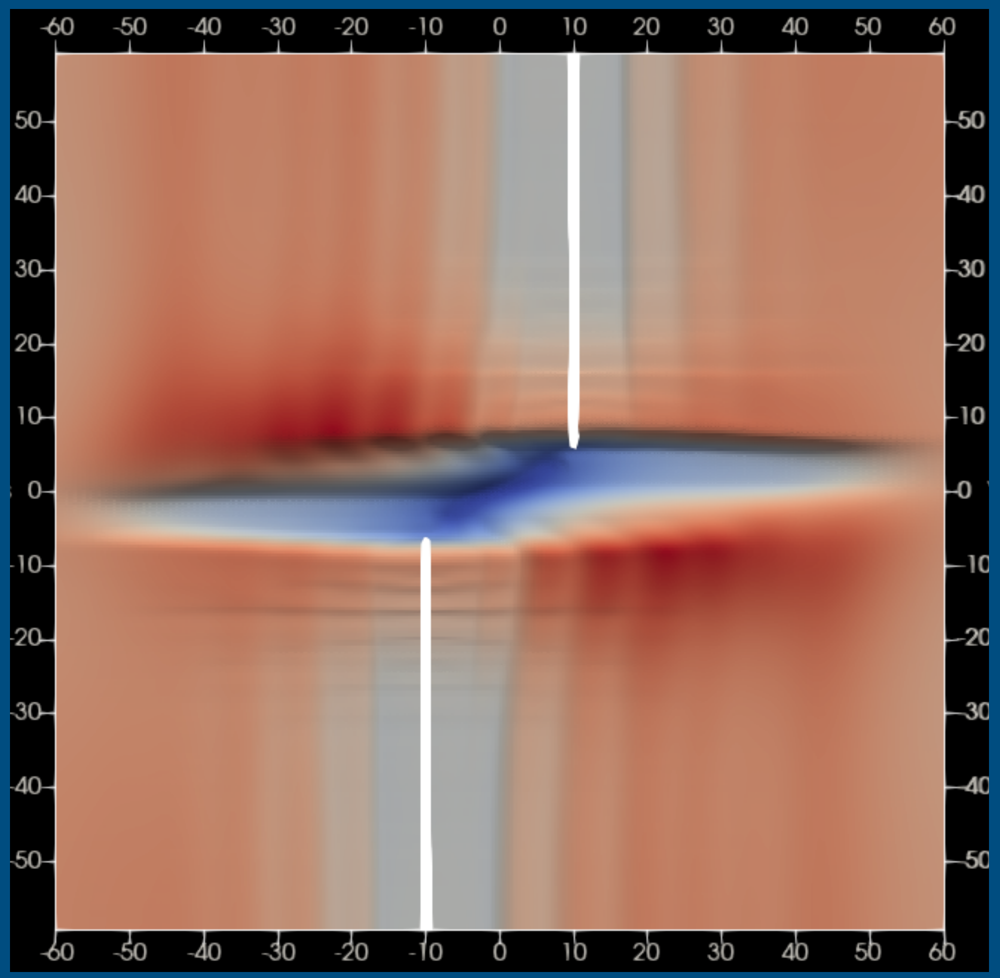
Summary Part I

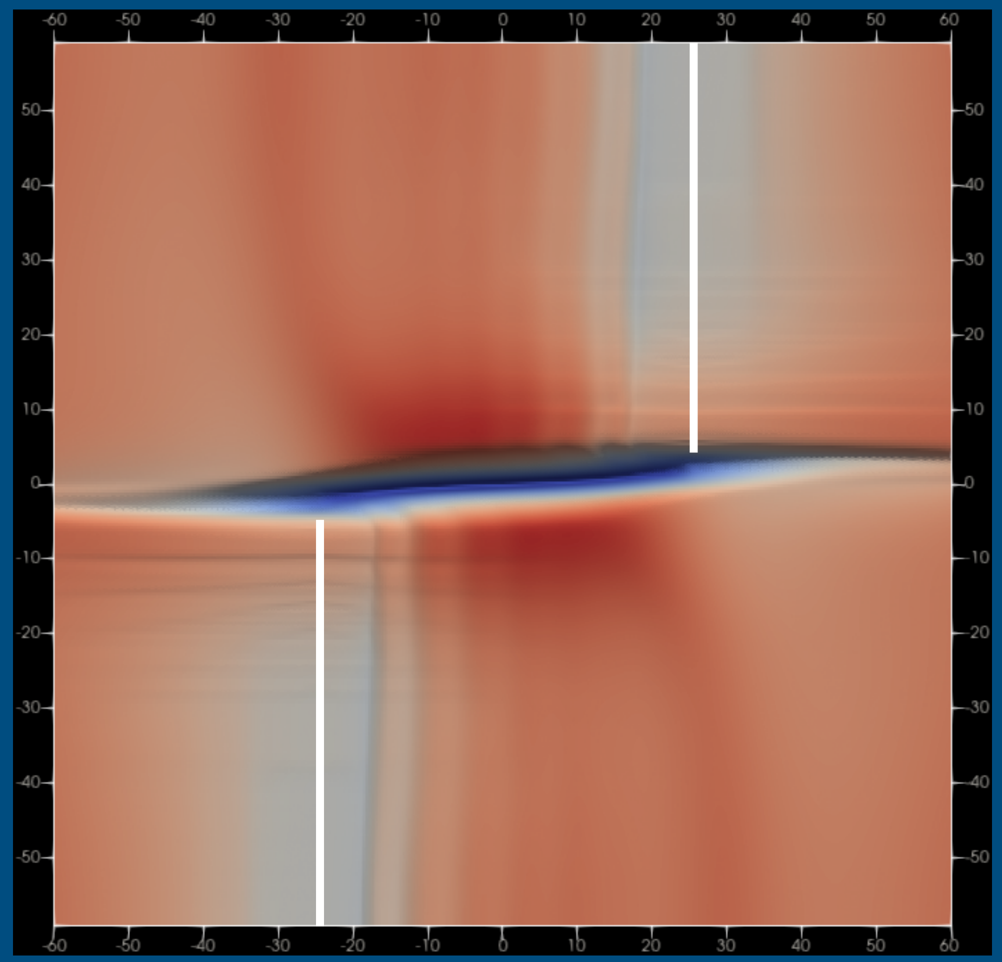
- Models can reproduce a variety of offset-types between ridges
- Depending on offset D and underlap distance L,
  3 different regimes can be identified:

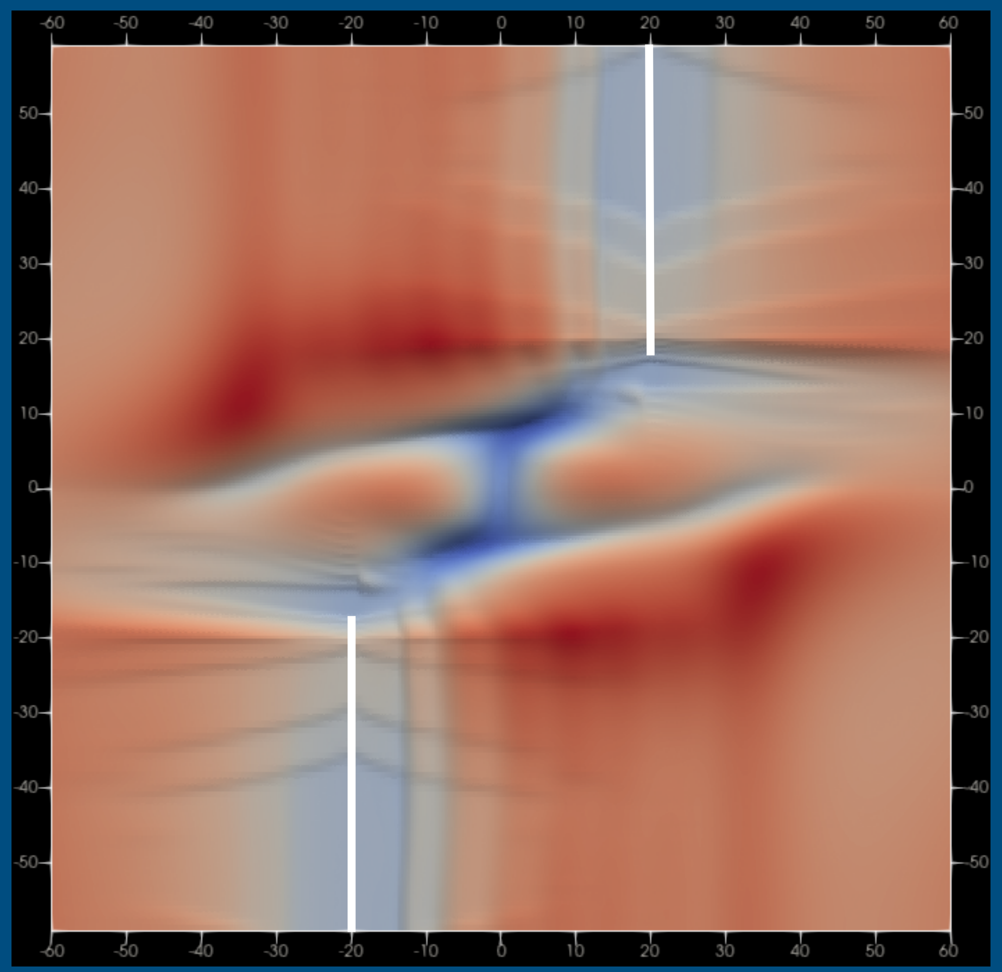
■ NTO
small-medium offset,
all distances of underlap

TF
medium-large offset
small underlap

ITSC
large offset,
large underlap





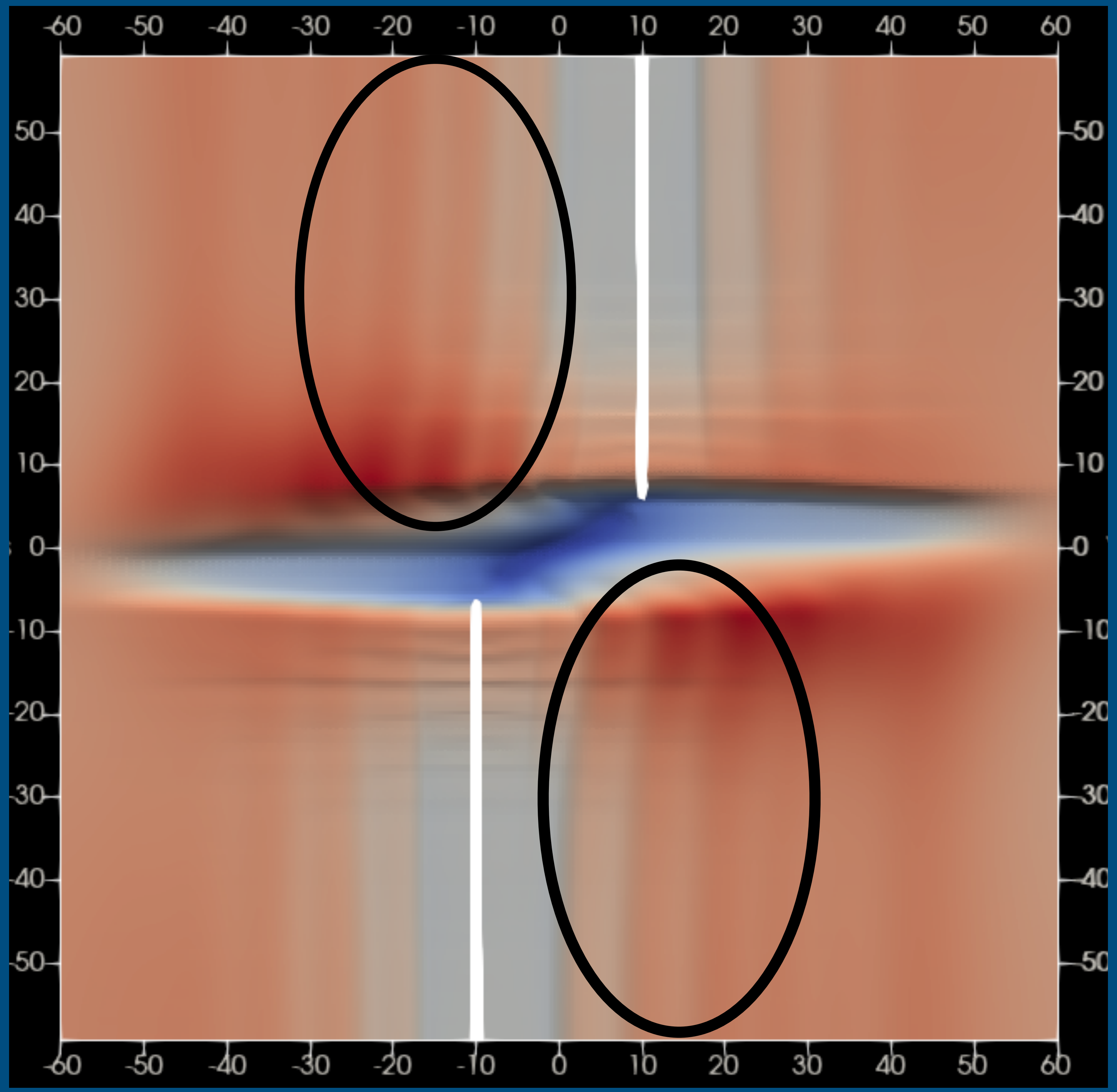


Part II: Development of abyssal hills

Observation: faulting preferably on the inside where transform fault is located

Investigate the importance of relative weakness of TF and FZ for fault development

20km offset, 2L = 14km



Part II: Development of abyssal hills

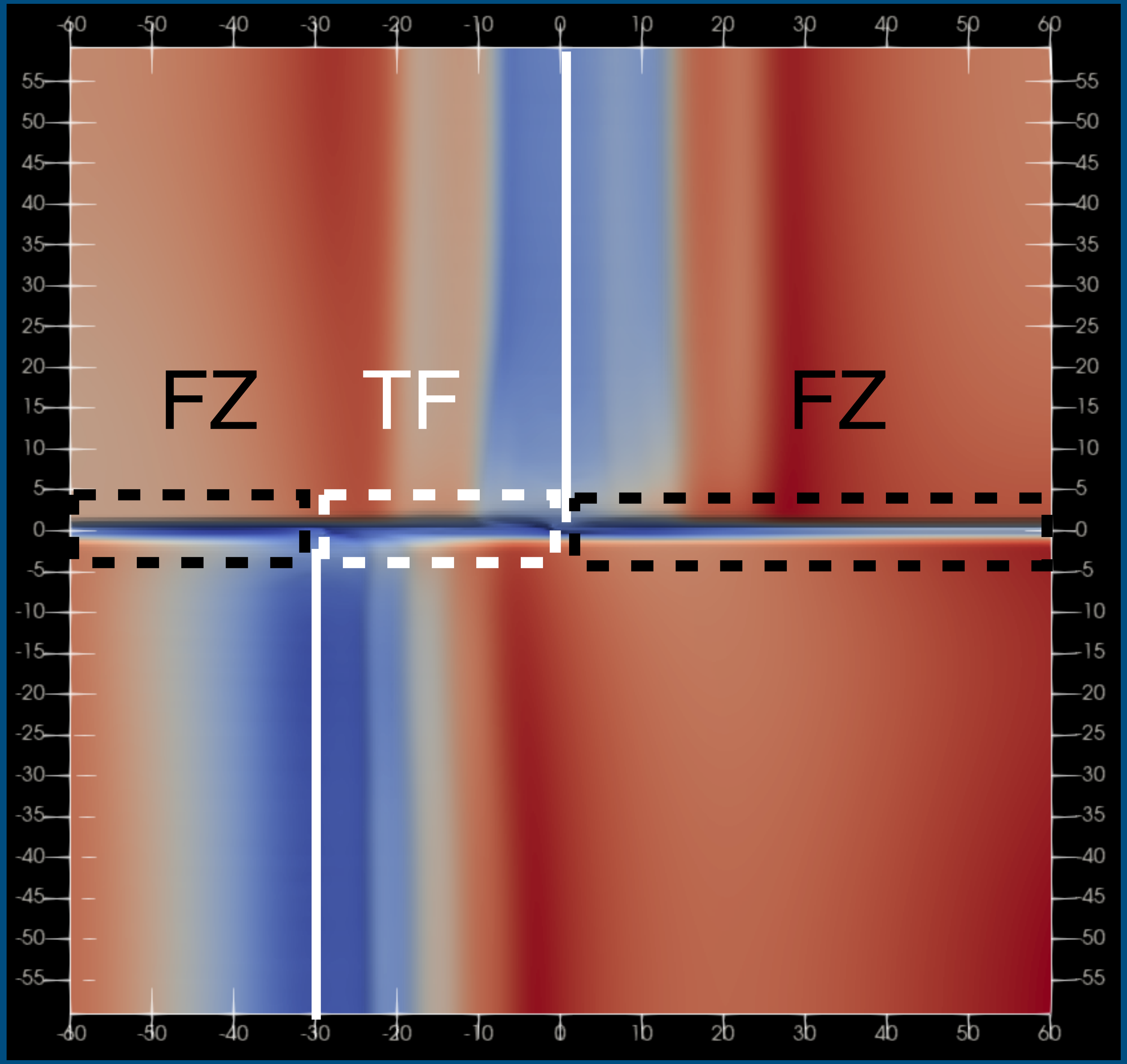
Observation: faulting preferably on the inside where transform fault is located

Investigate the importance of relative weakness of TF and FZ for fault development

Isolate behavior of faulting: constant M=0.75

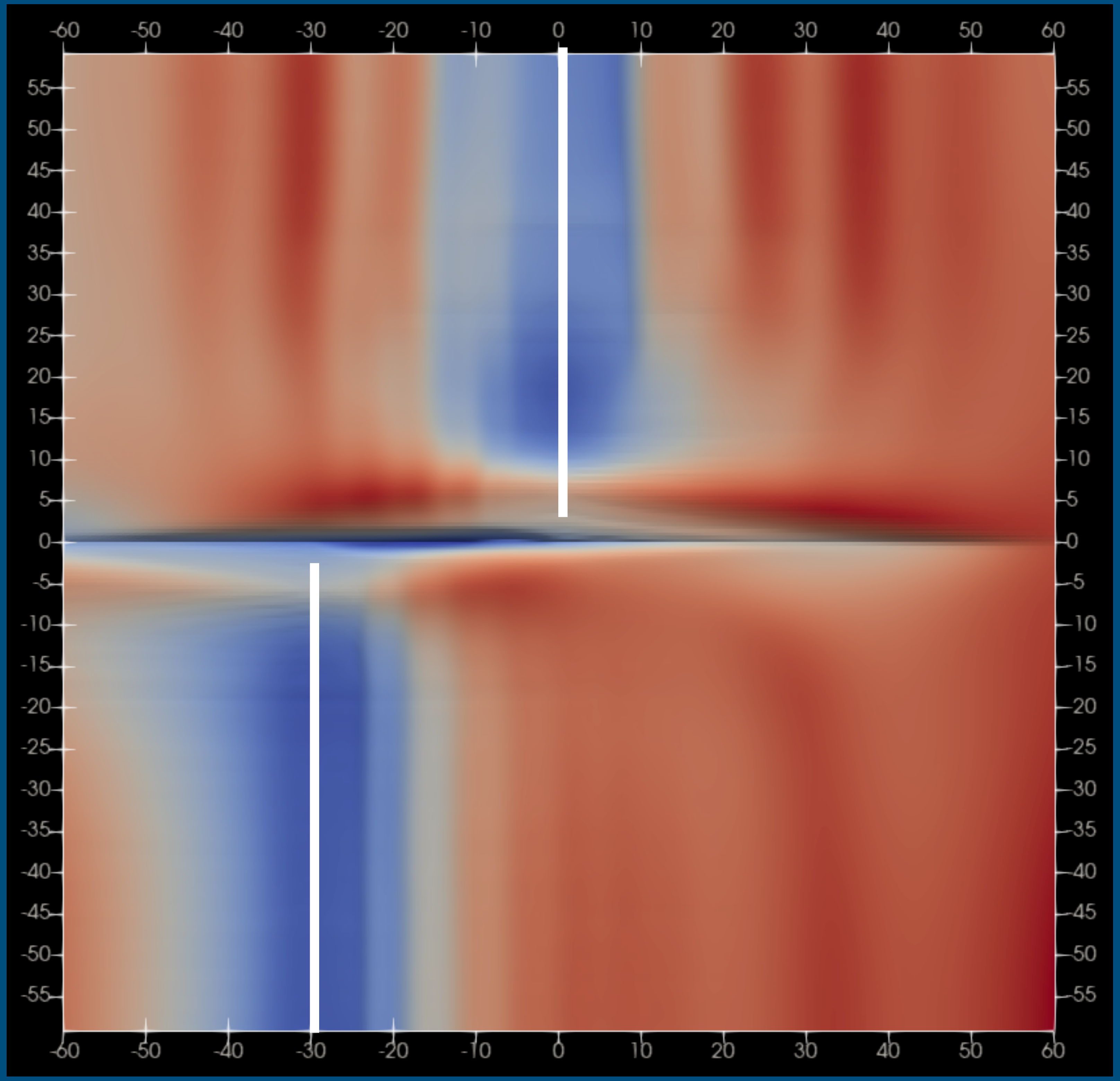
Impose lower initial friction angle and low cohesion in transform fault (TF) and/or fracture zone (FZ)

30km offset, 2L = 0km



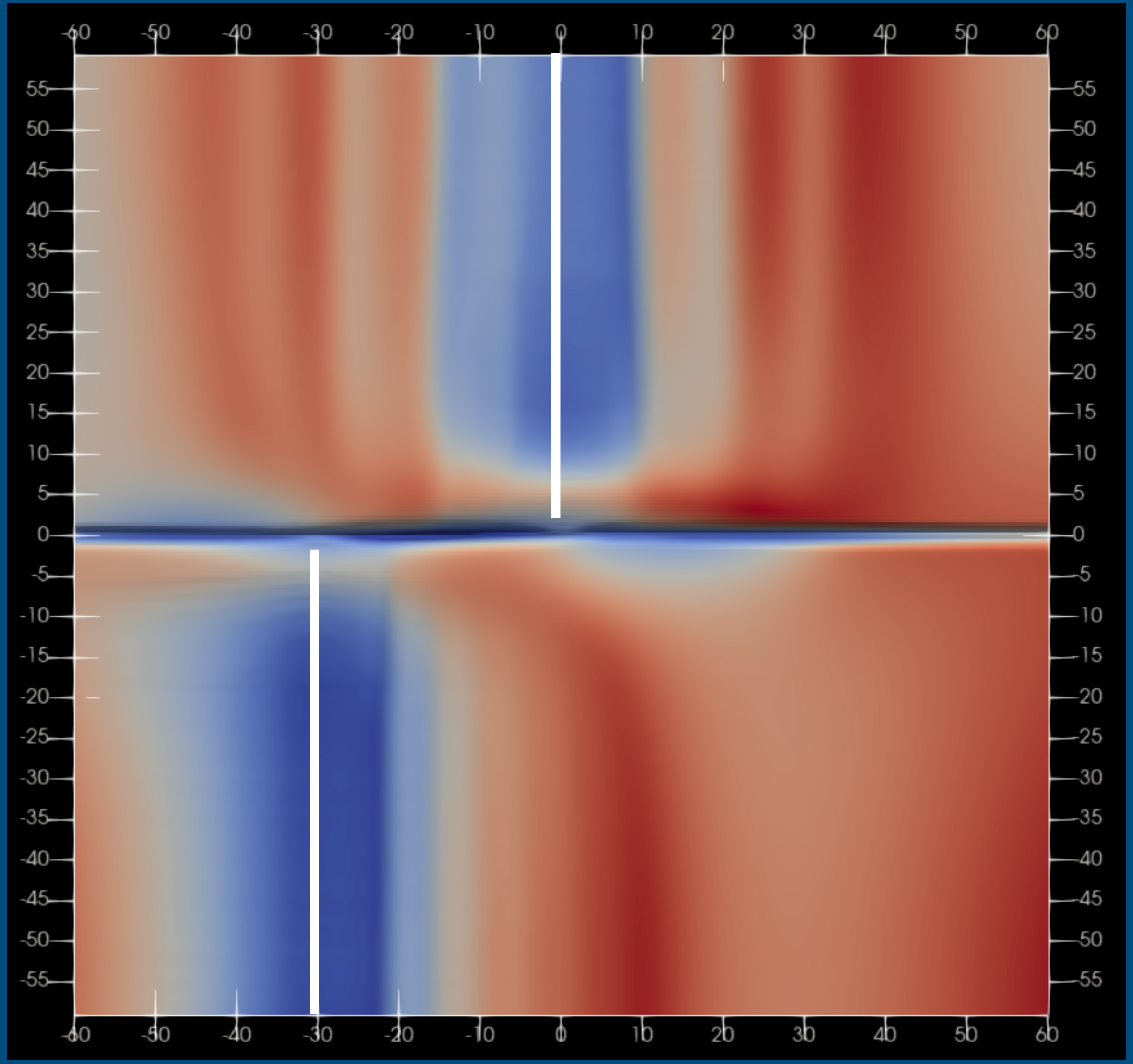
Results with different imposed weakening

No initial imposed weakening



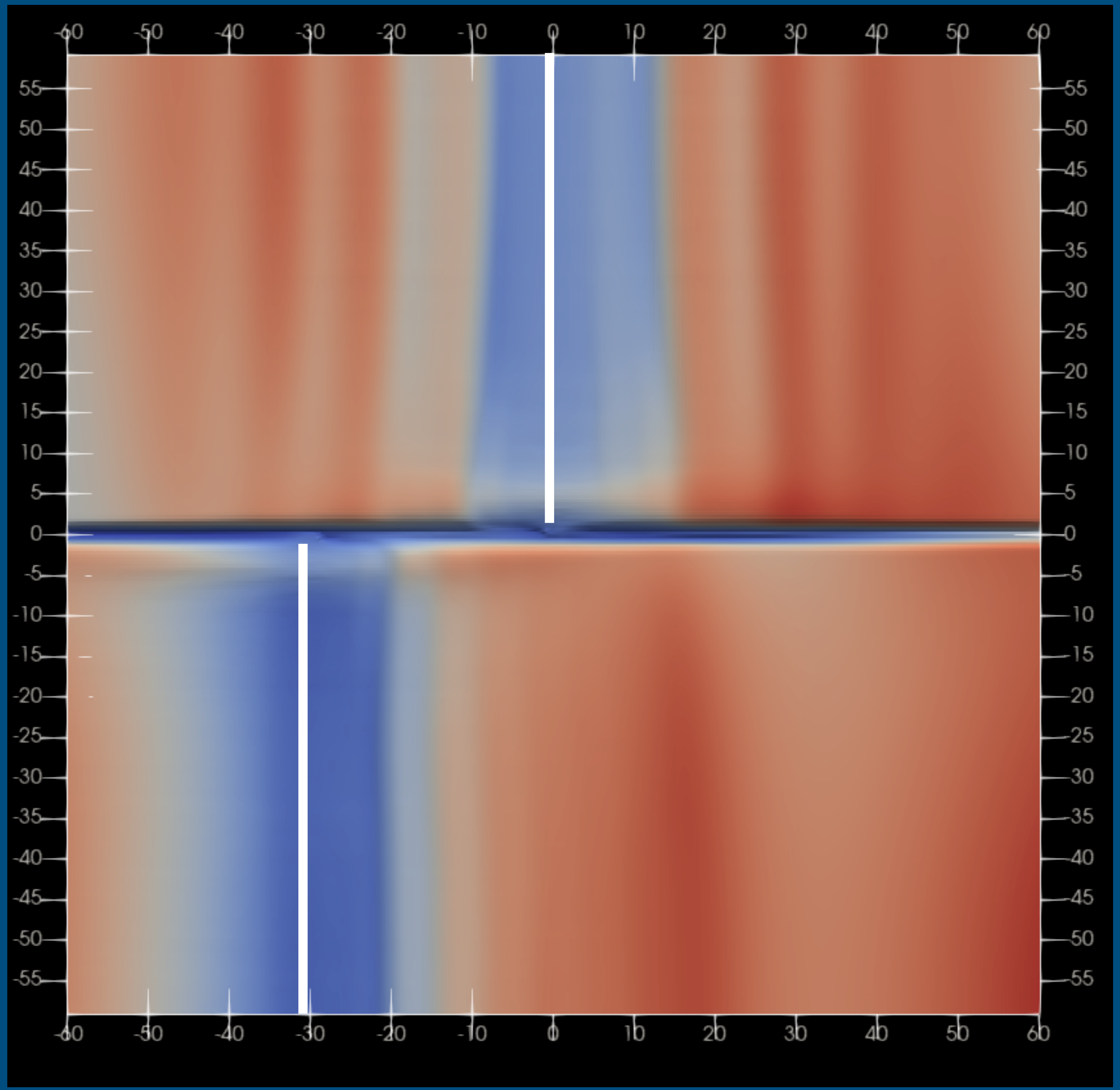
Only imposed on Fracture zone:

initial friction angle: 10°
initial cohesion: 10 Pa



Imposed on FZ and TF:

initial friction angle: 10°
initial cohesion: 10 Pa



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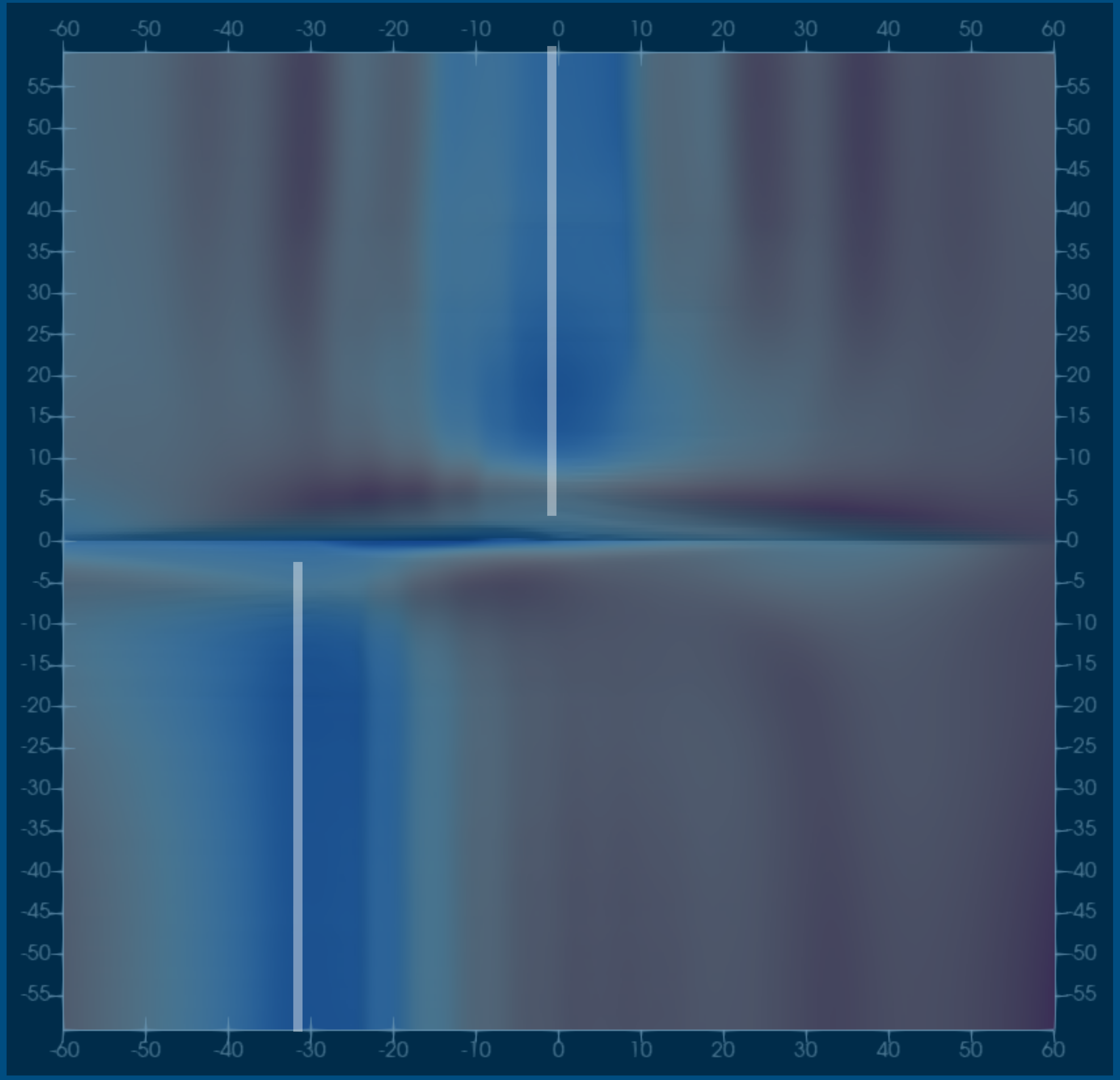

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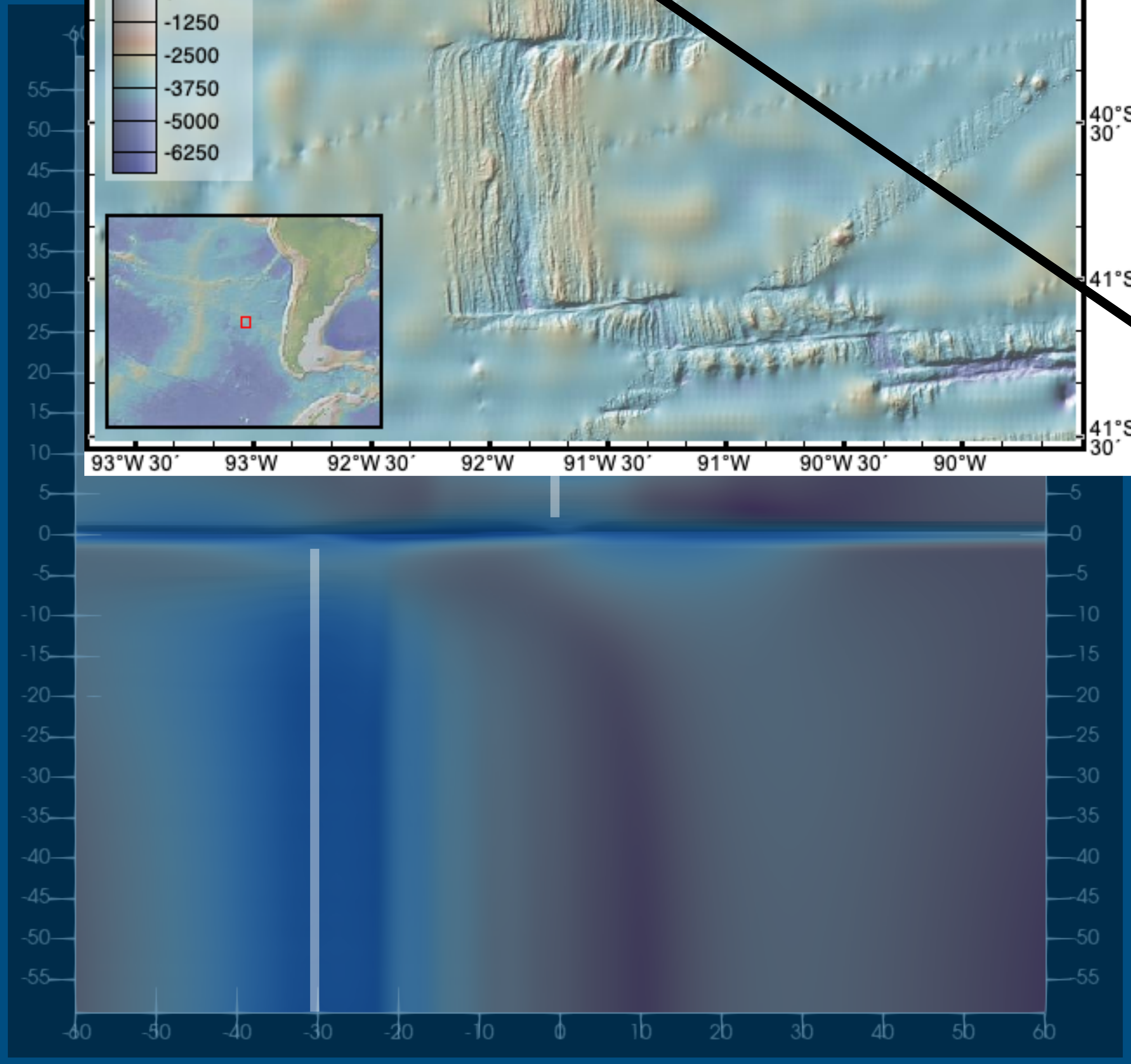

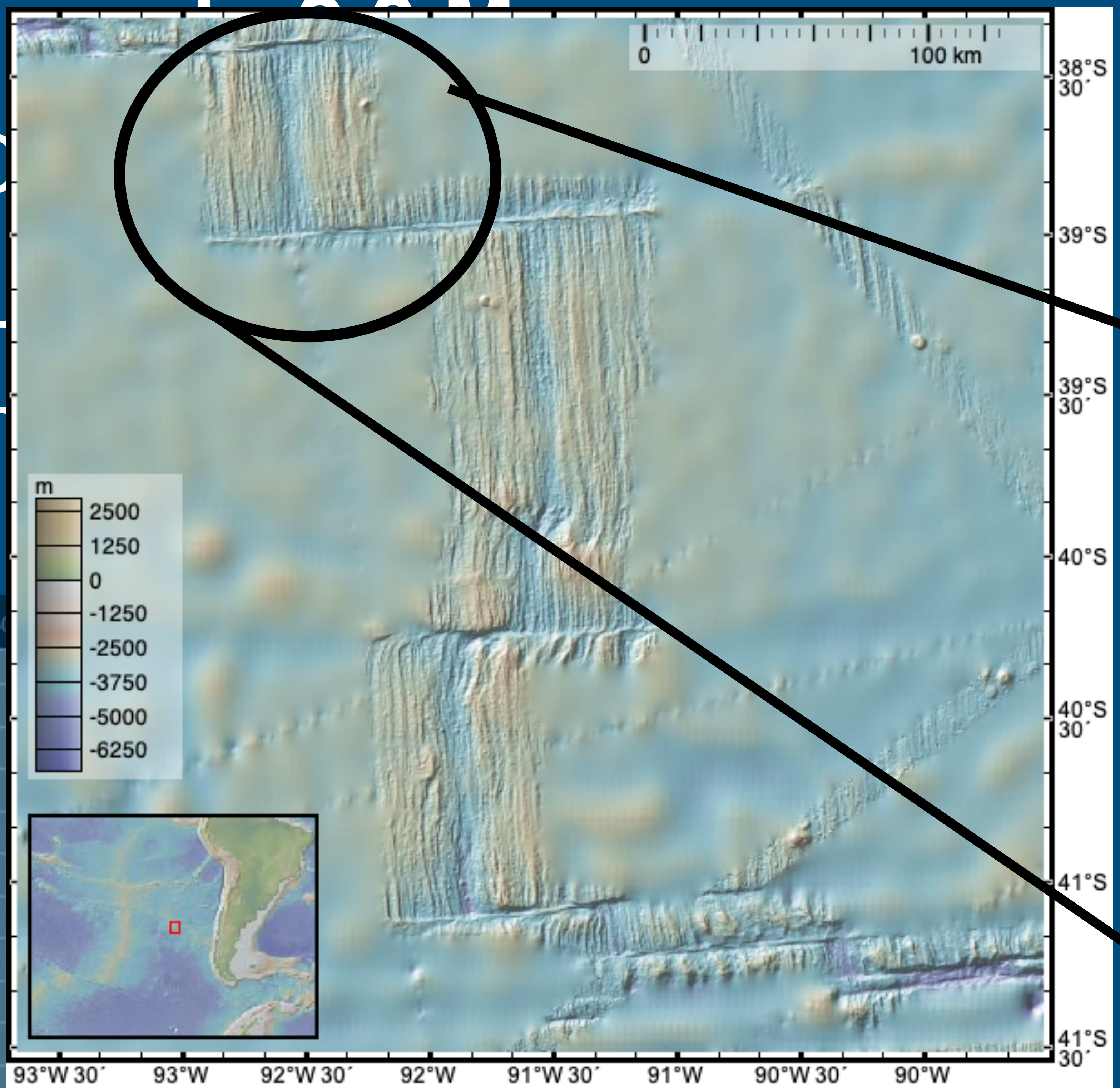

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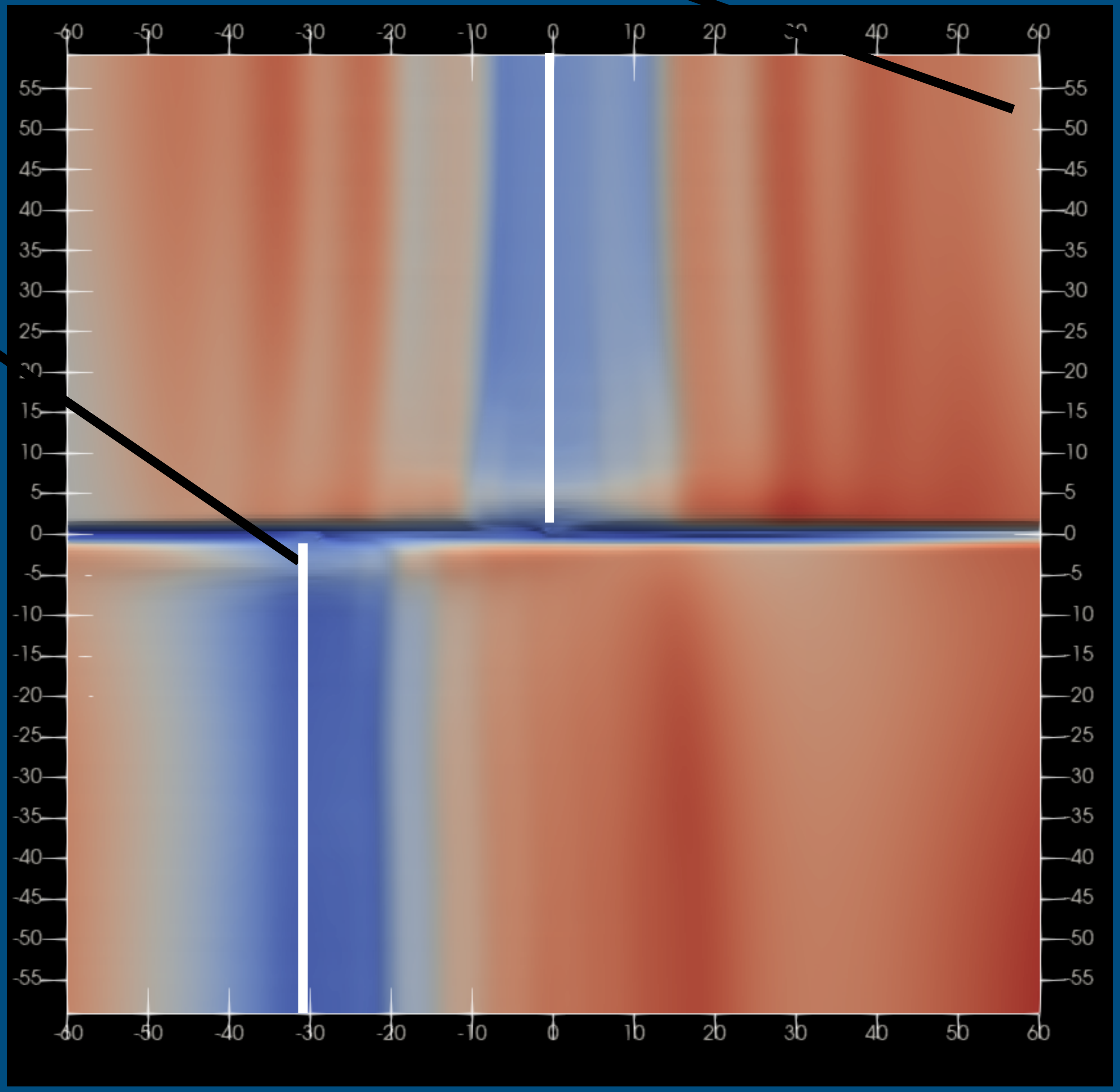

Take home messages & Outlook

- ***NTOs, TFs and ITSC*** develop depending on the ***size of offset*** between ridges and the ***distance over which magmatic extension decreases***

- a relatively ***weak fracture zone*** is necessary to ***promote faulting on the inside and outside*** of MORs (in our models) and lead to a more natural-looking TF

Next steps:
- define a clear boundary between TF and NTO (new?)
- relate relative weakness of FZ vs TF to fault spacing and occurrence in nature