Interaction between cover deformation and pre-salt seamounts in passive margins:

Physical models applied to the Northwest and Eastern Mediterranean basins

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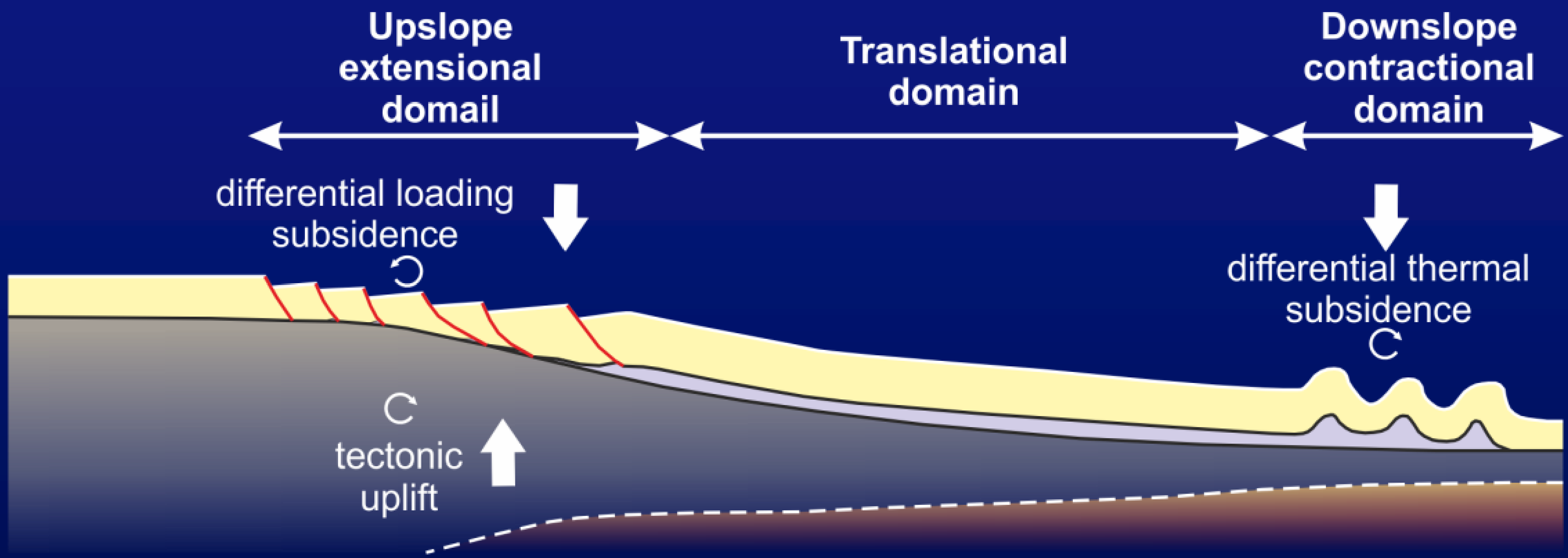
Overview A

Passive margins with post-rift salt



Modified from Rowan et al., 2004

- ***Broad zones of deformation with horizontal translation of the cover by gravitational failure***
- ***Linked system of thin-skinned updip extension and downdip contraction***
- ***Third intermediate domain where the cover is passively translated downdip above the salt***

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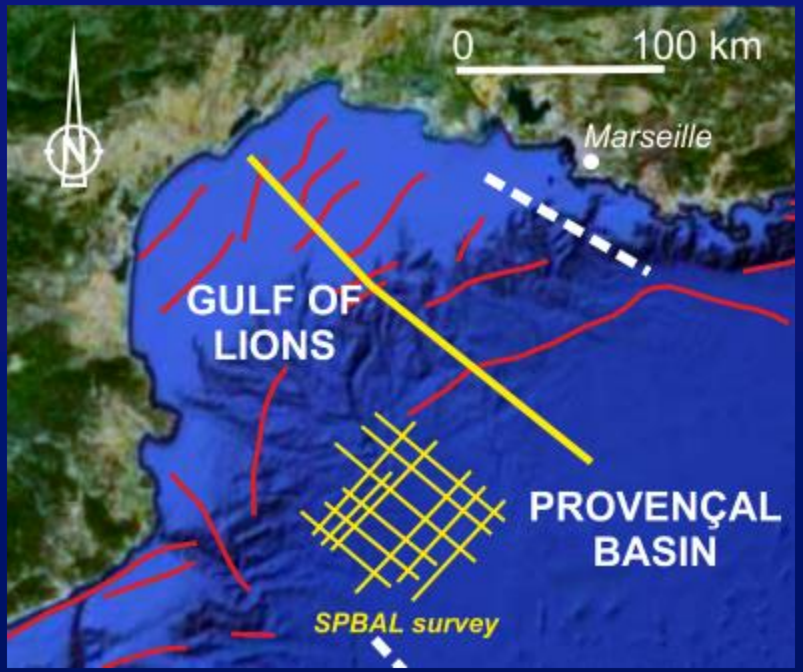
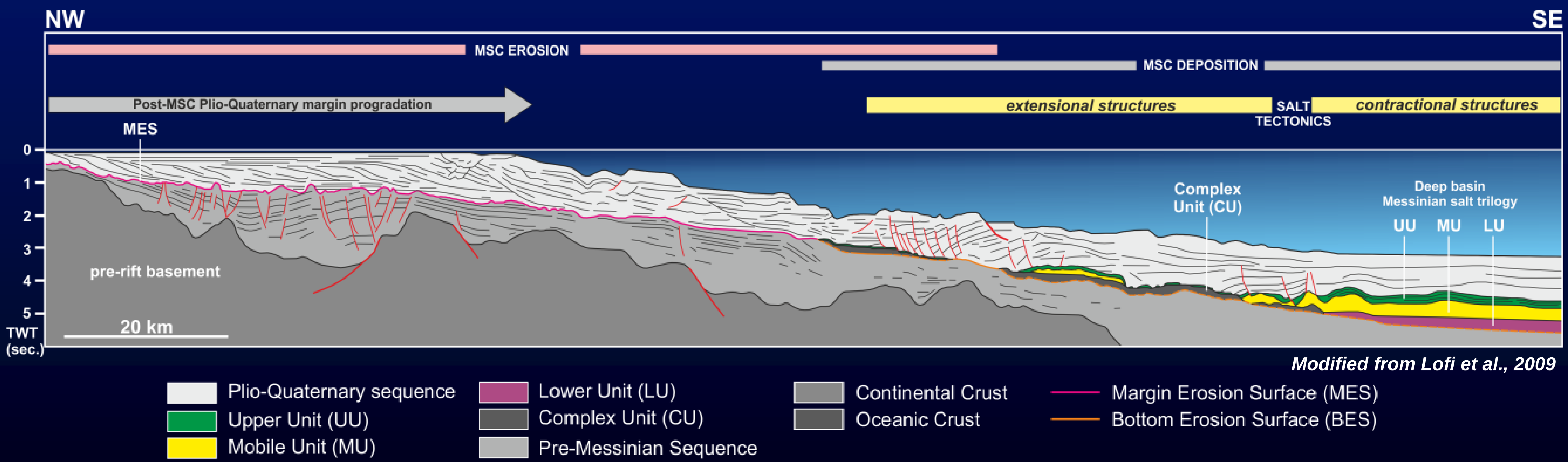
Overview A

Regional structure (Gulf of Lions, Western Mediterranean)

- ***Present day margin architecture reflect the post-MSC evolution (progradation, subsidence, compactation & salt tectonics)***
- ***Upper part deeply eroded during MSC (Margin Erosion Surface)***
- ***Three-phased evaporite sedimentation on the deep basin (LU, MU & UU + CU) during the MSC***





Modified from Lofi et al., 2009

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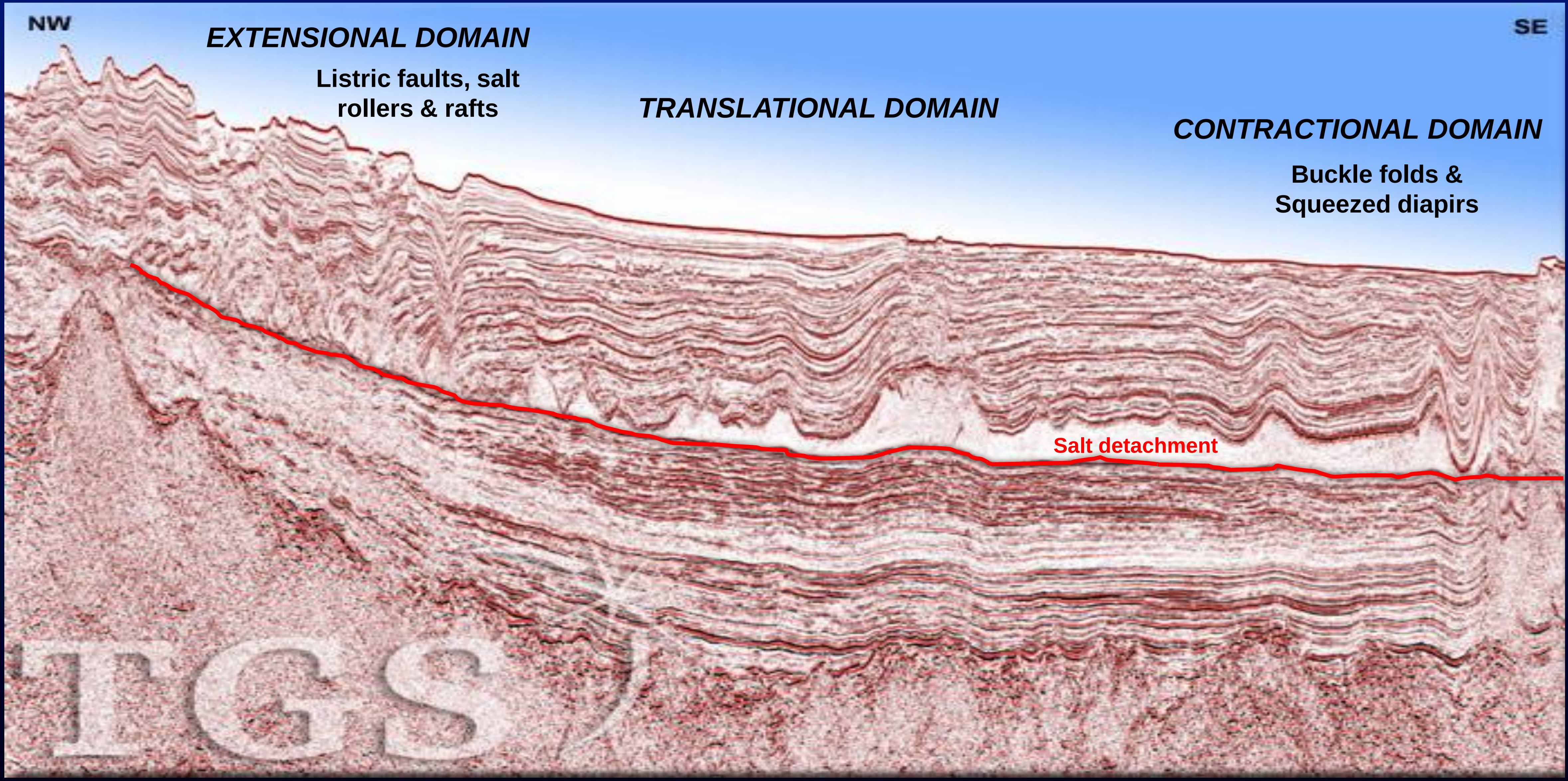
Overview A

Deep basin structure (Western Mediterranean)

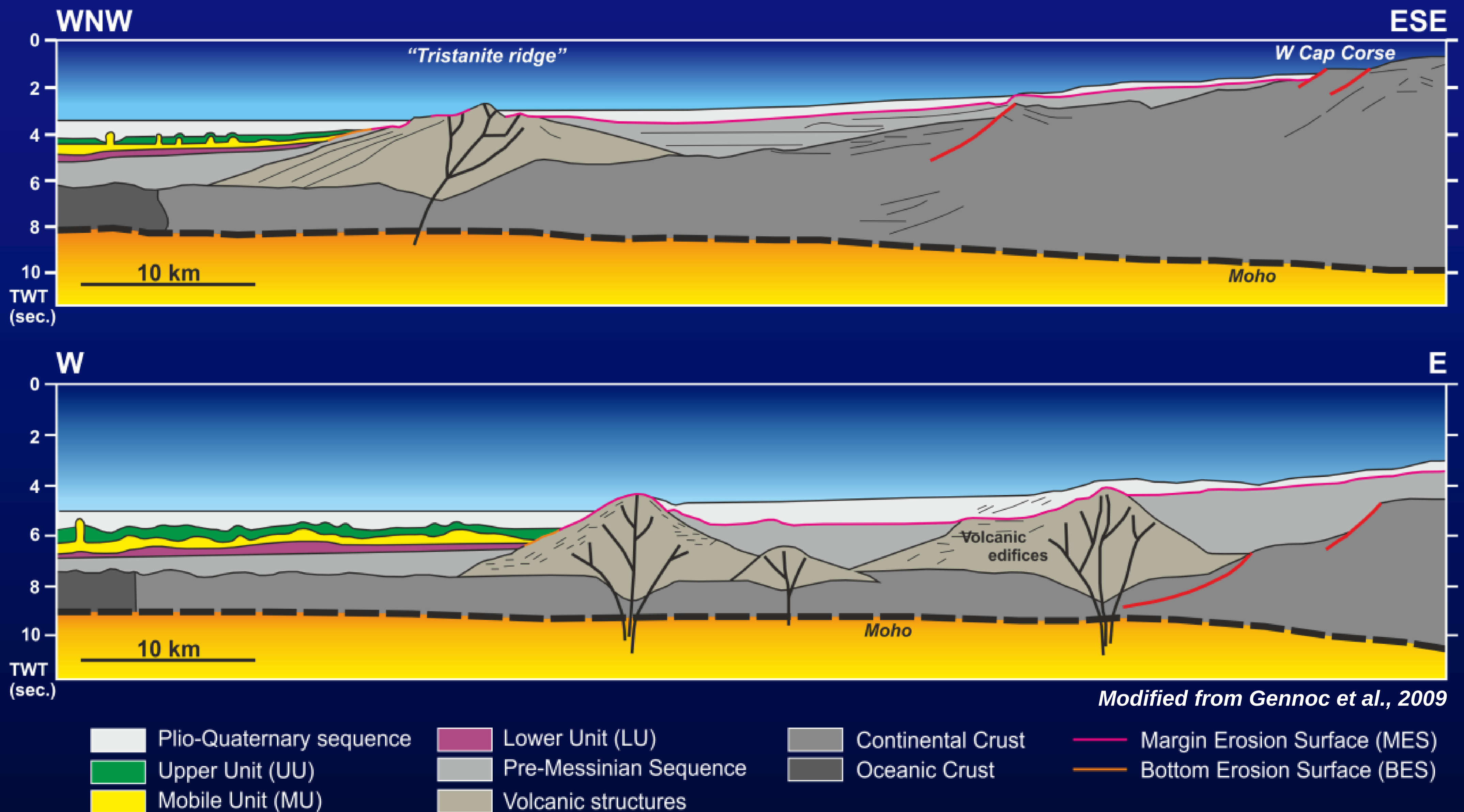
- ***Post-rift Messinian salt acts as a regional dêcollement along the Western Mediterranean***
- ***Upslope extension (listric growth faults) accommodated by downslope shortening (pillows & diapirs).***



Virtual Seismic Atlas, Rhone Fan Profile RM01

Overview A

West Corsica margin (Western Mediterranean)



Modified from Gennoc et al., 2009

- ***Lower to Mid Miocene volcanic edifices limiting the evaporitic basin***
- ***No critical control on the evaporites deformation***

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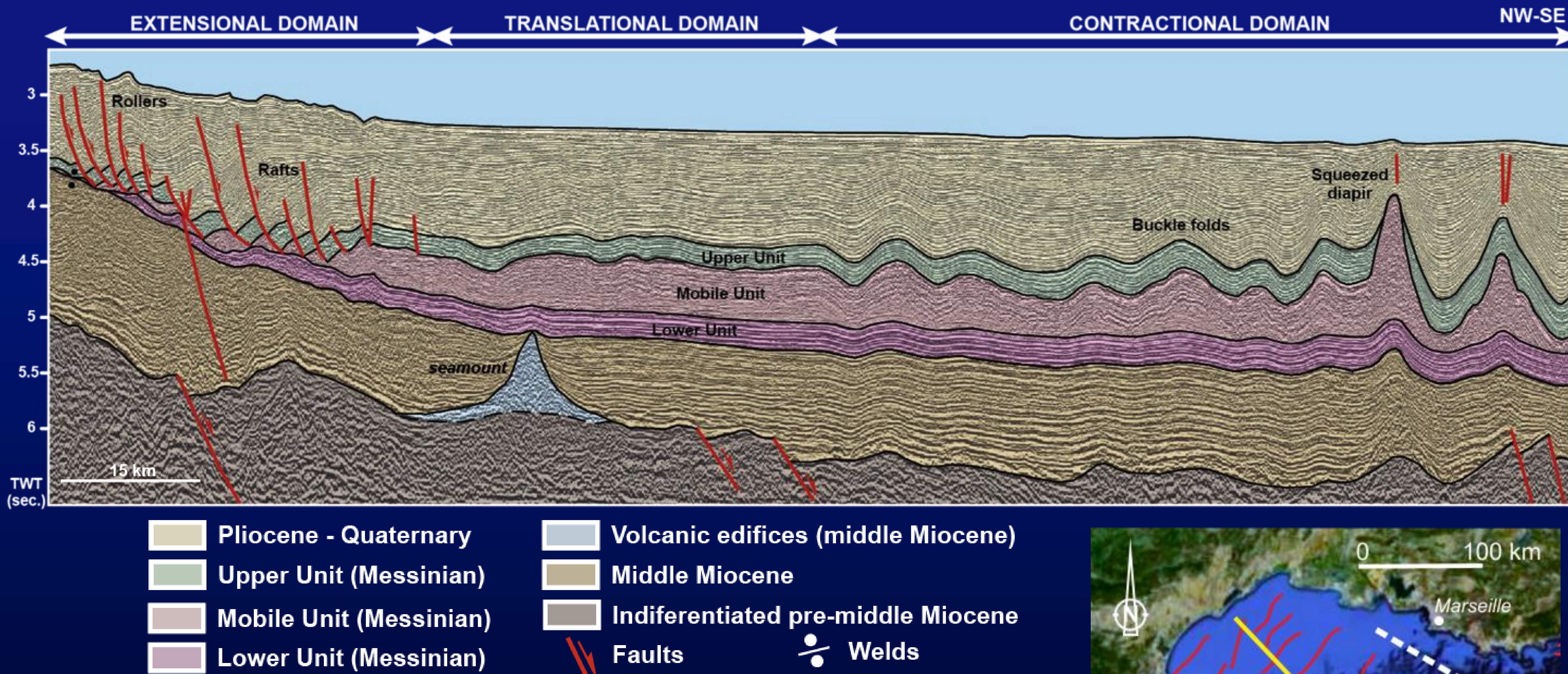
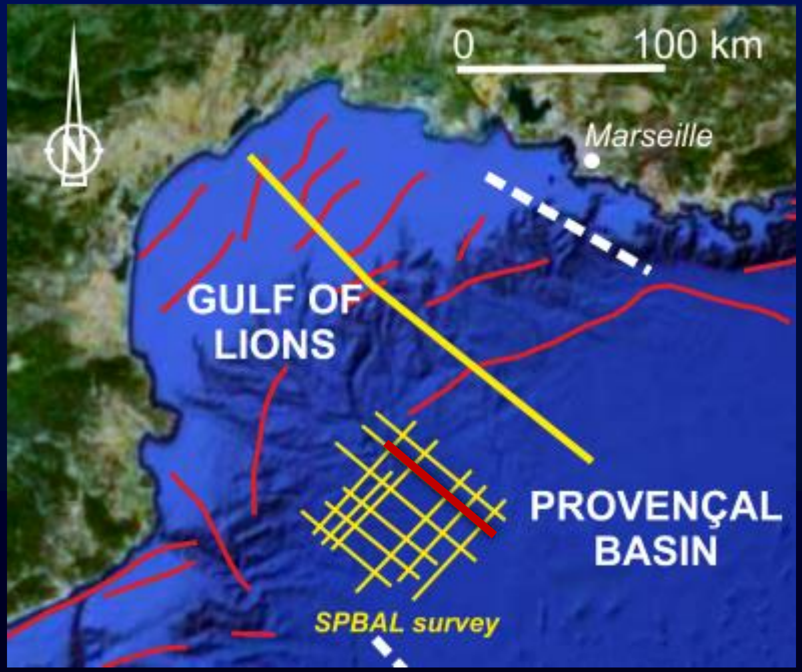
Overview A

Provençal basin (Western Mediterranean)





- ***Post-rift Messinian salt acts as a regional dêcollement along the Provençal Basin but....***
- ***… Lower to Mid Miocene volcanic edifices with a NNE-SSW trend located on the upper extensional domain of the salt-bearing passive margin***

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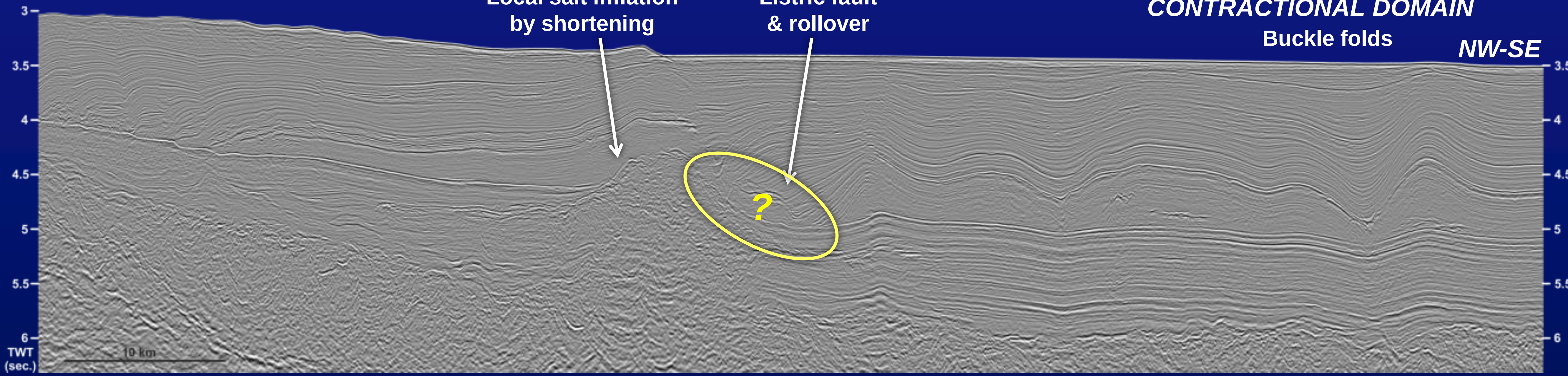
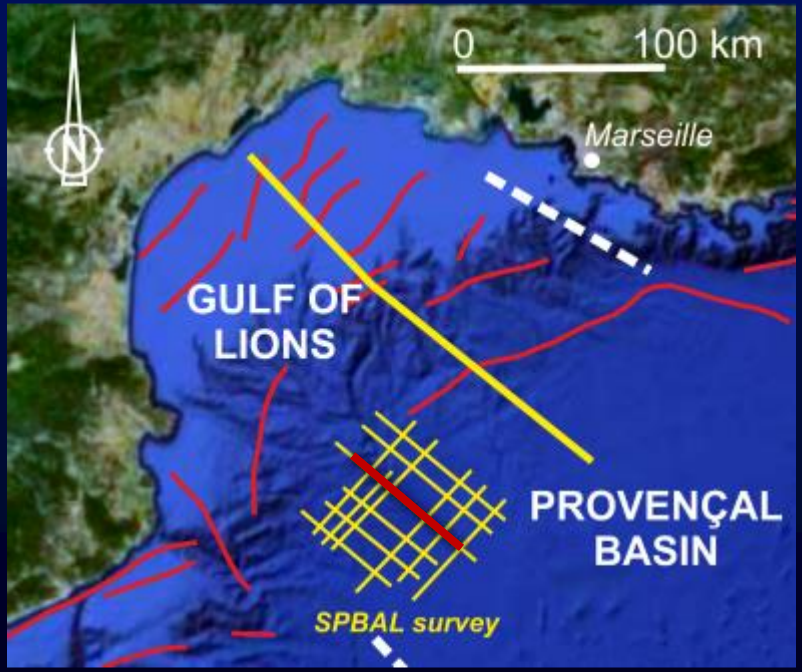
Overview A

Provençal basin (Western Mediterranean)



- ***The apex of these reliefs can be located below, inside or above the salt units***
- ***These reliefs strongly controls the gravitational failure of the margin, developing secondary structures superimposed to the lower part of the extensional & the translational domain***
- ***Unfortunately 2D seismic coverage & quality is not enough to recognize the 3D geometry of the secondary structures controlled by these reliefs***



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Rationale

- ***Thin-skinned gravitational gliding & spreading drive deformation on salt-bearing passive margins developing a characteristic structural zonation with three major domains (extensional, translational & contractional), but…***
    - ***What happens during gravitational failure when the margin includes pre-salt "reliefs"?***
    - ***Can these "reliefs" modify the architecture of the margin?***
    - ***In that case, what are the main factors intrinsic to the "reliefs" that control the kinematic evolution of the margin?***
    - ***How the rheology of the salt layers controls the style and distribution of intrasalt strain?***

↓

ANALOG MODELING APPROACH

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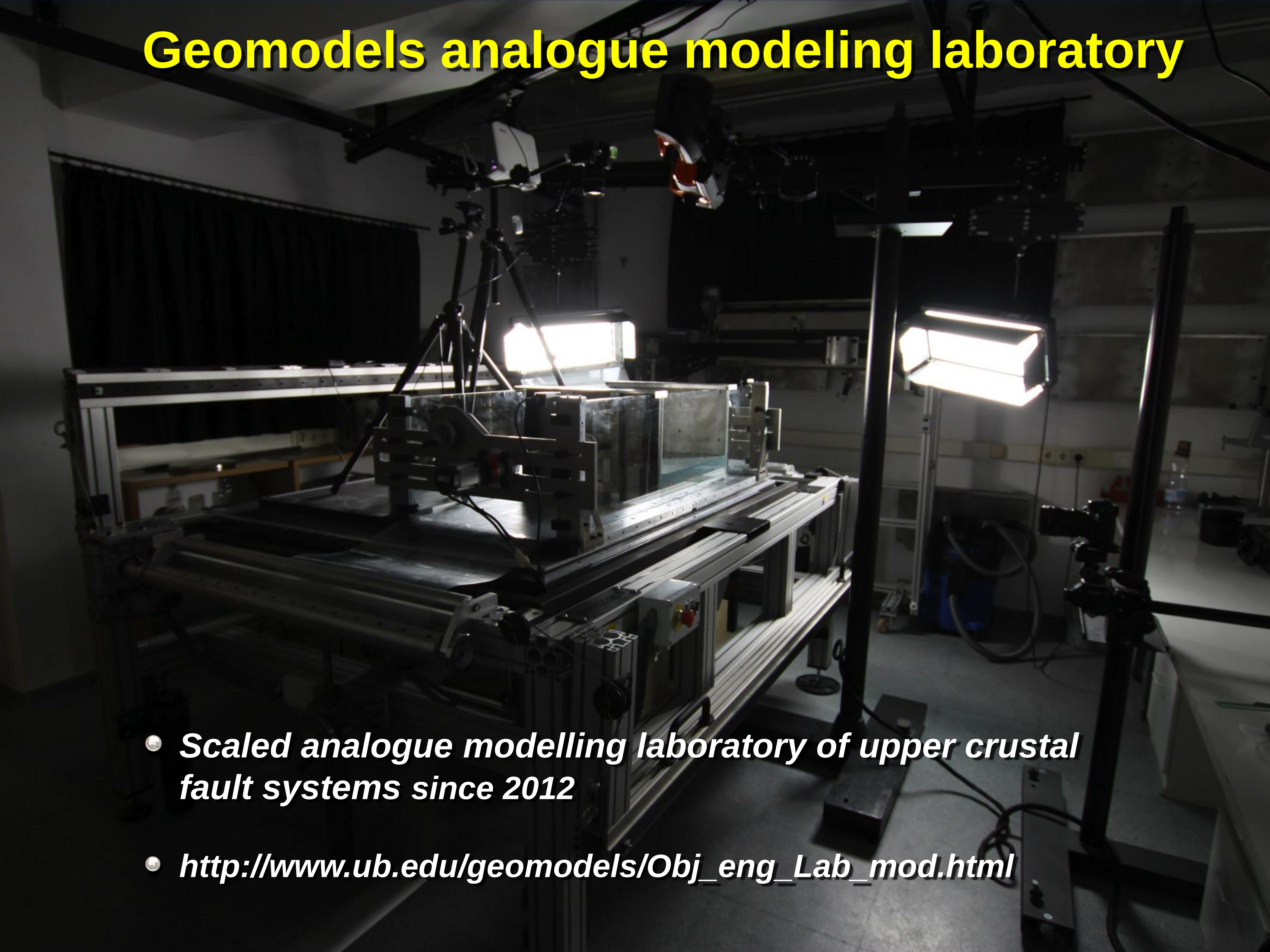
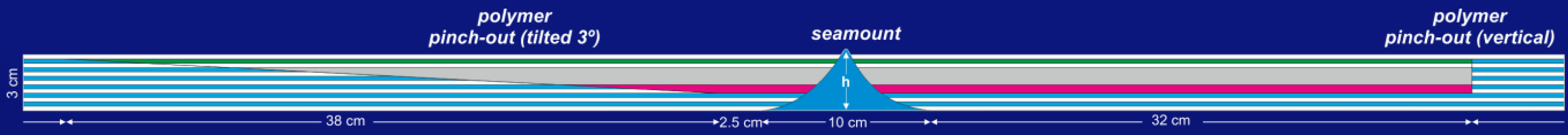
Geomodels analogue modeling laboratory



- *Scaled analogue modelling laboratory of upper crustal fault systems since 2012*
- *http://www.ub.edu/geomodels/Obj_eng_Lab_mod.html*

Experimental setup

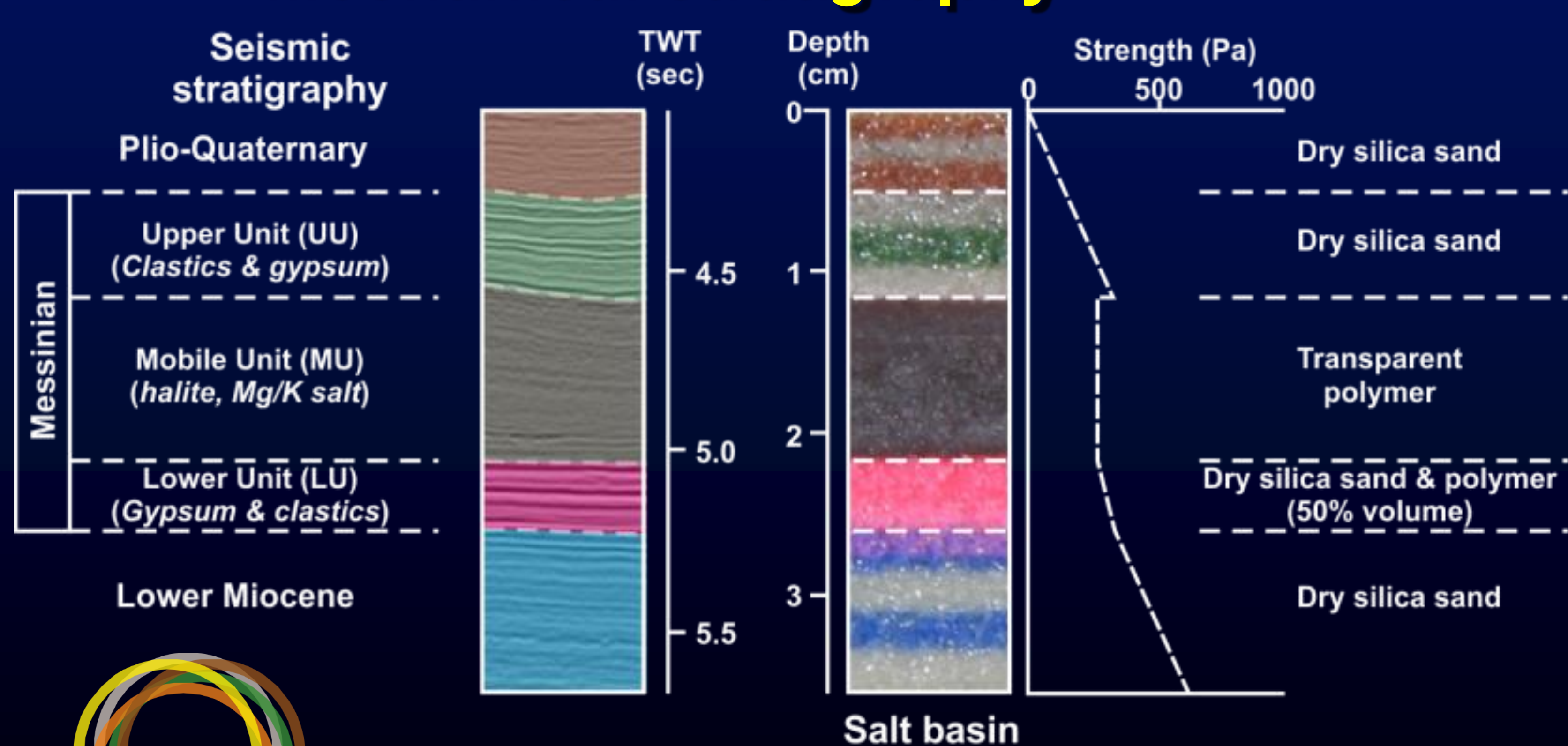
Experimental approach



Tested parameters

- ***Position of the seamount apex vs. salt units***
- ***Seamount height (2.1; 2.8; 3,5; 4,2; 5.5 cm)***
- ***Different degrees of gravitational gliding (6 & 18 hours)***
- ***Orientation of the seamount vs. the margin dip***

Mechanical stratigraphy



Colored passive markers to test salt flow & intrasalt strain around the seamounts

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Experimental setup

Experimental approach

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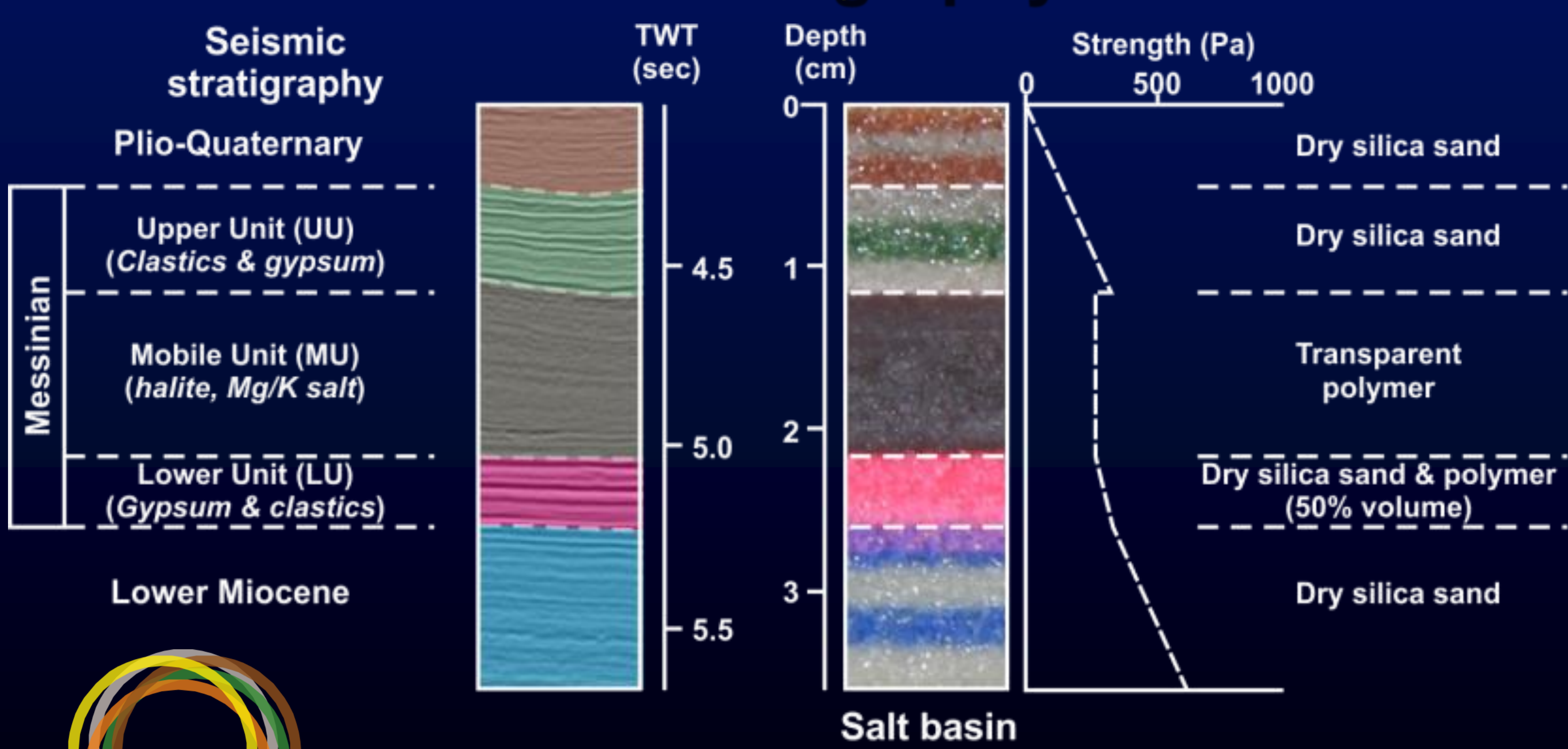

Colored passive markers to test salt flow & intrasalt strain around the seamounts

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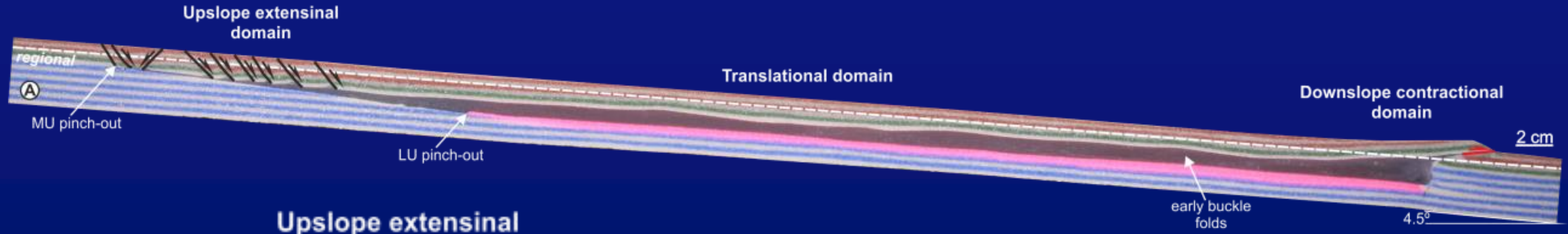
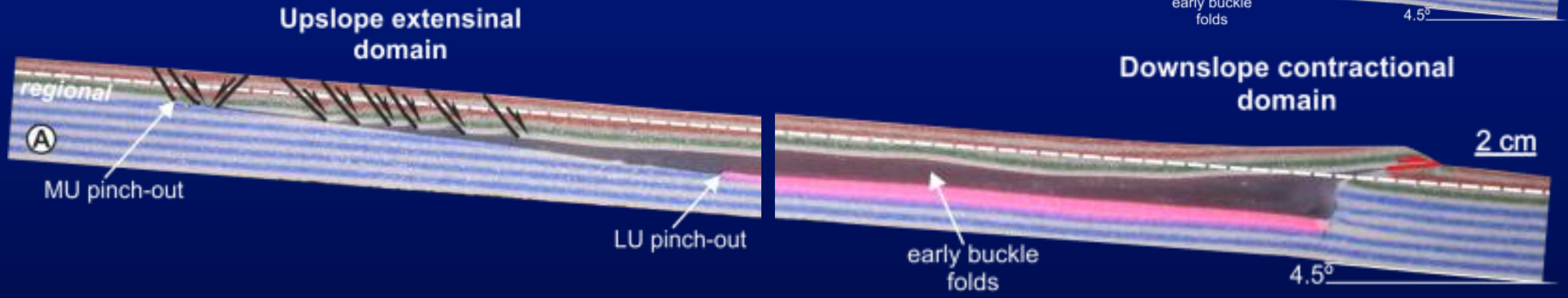
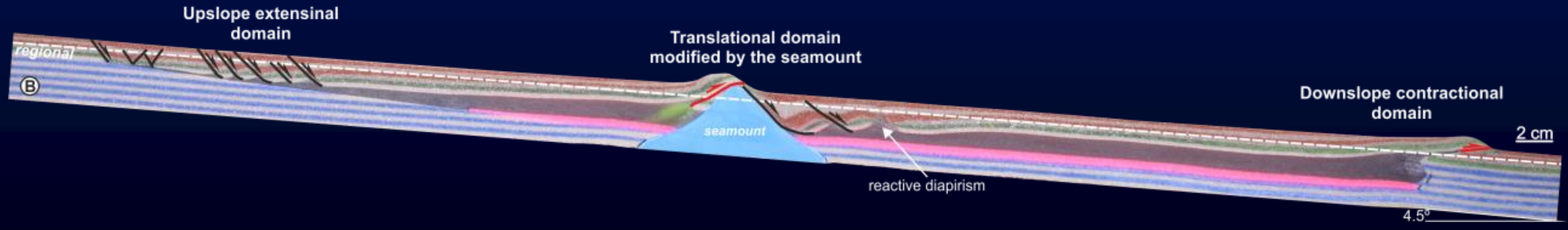
Experimental results

Baseline model (without seamount) – (Exp. 0)





Model with seamount (3.5 cm height) – (Exp. 4)



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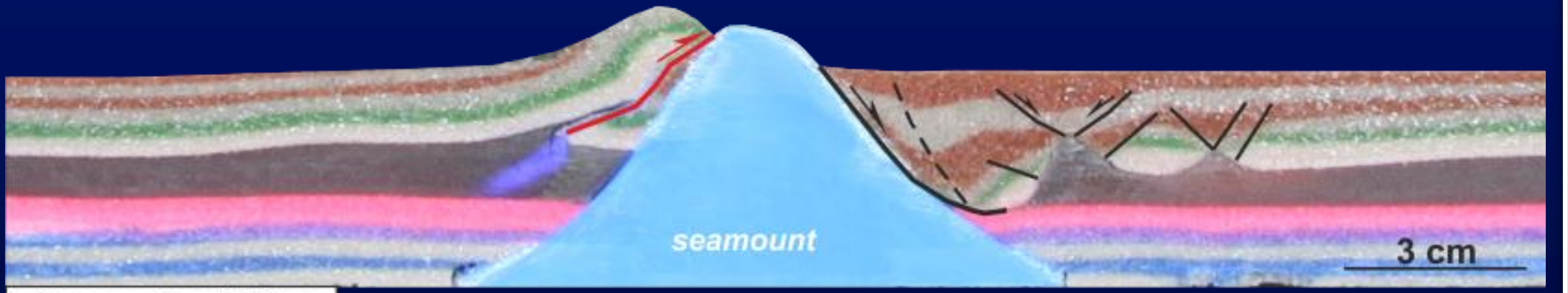
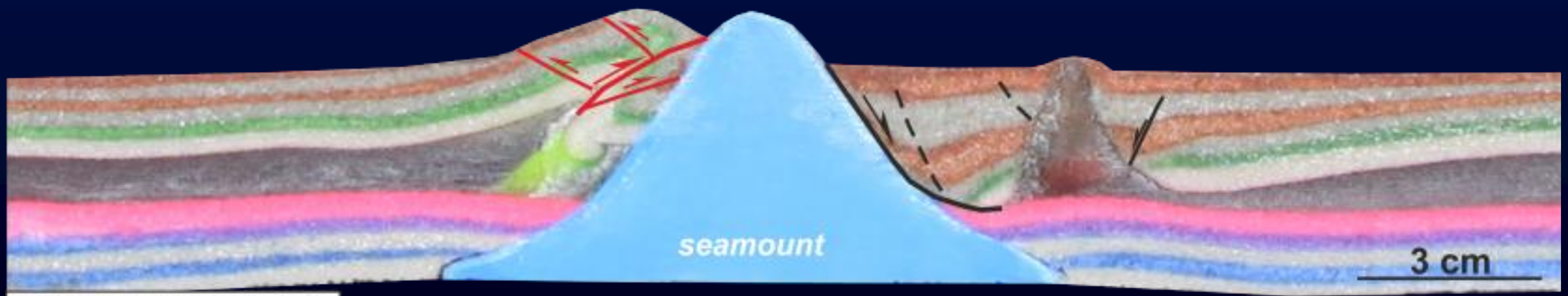
Experimental results (Exp. 5 – after 6 hours)

- *Apex of the seamount located above the salt units*
- *Thrusting updip & growth listric faults with rollovers & diapirism downdip*

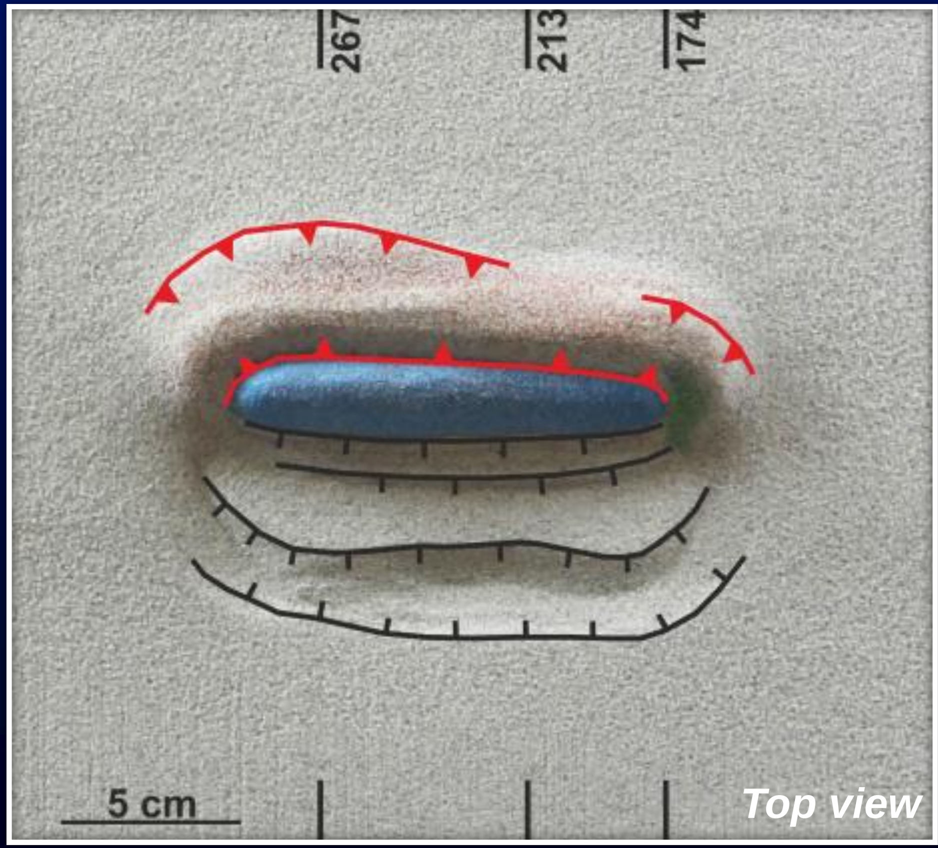
Cross-section 174mm



Cross-section 213mm

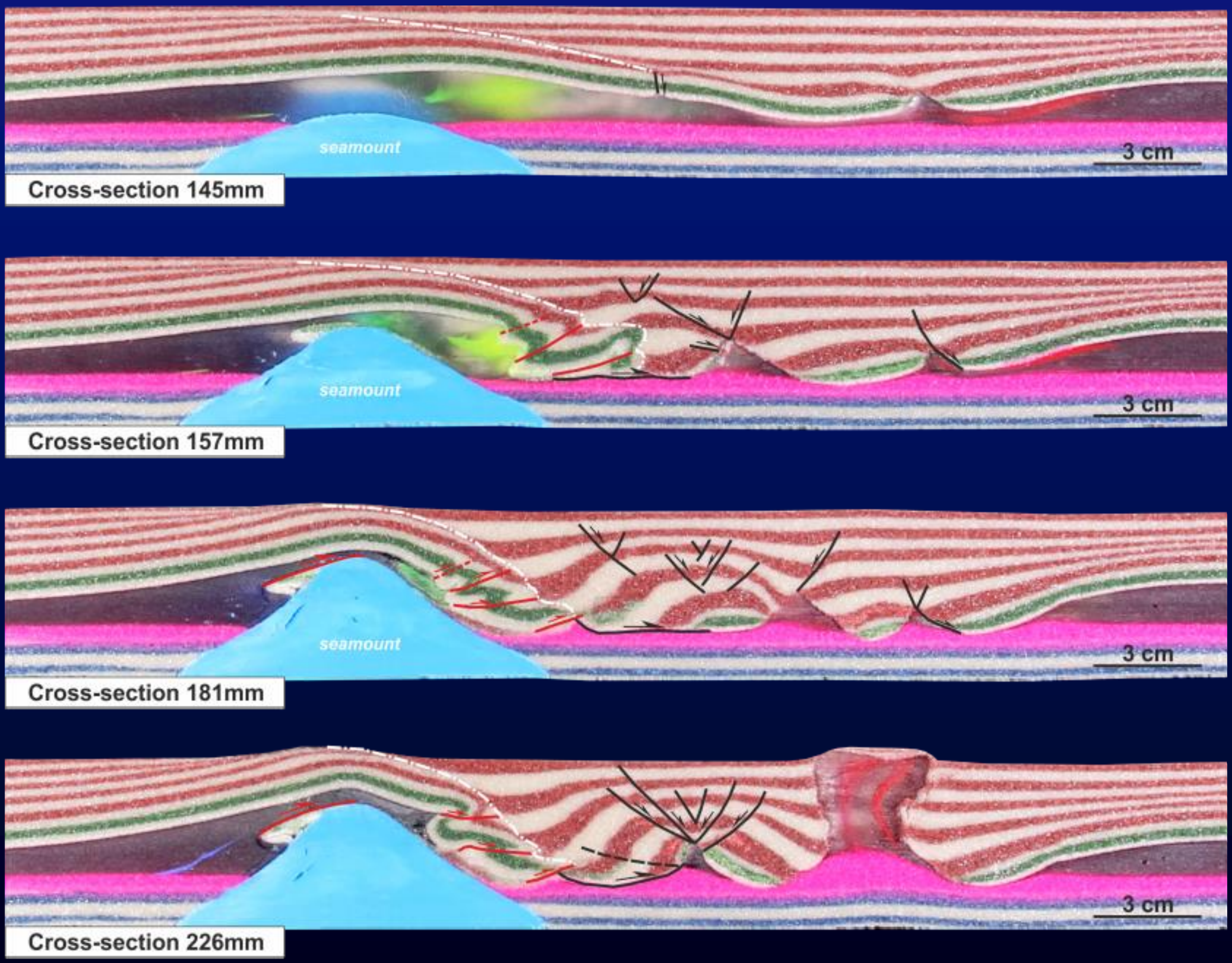


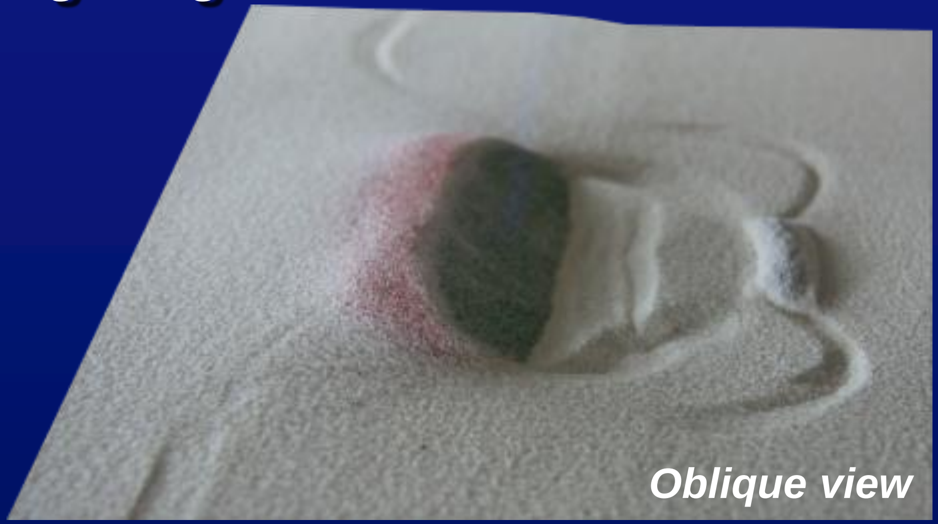
Cross-section 267mm

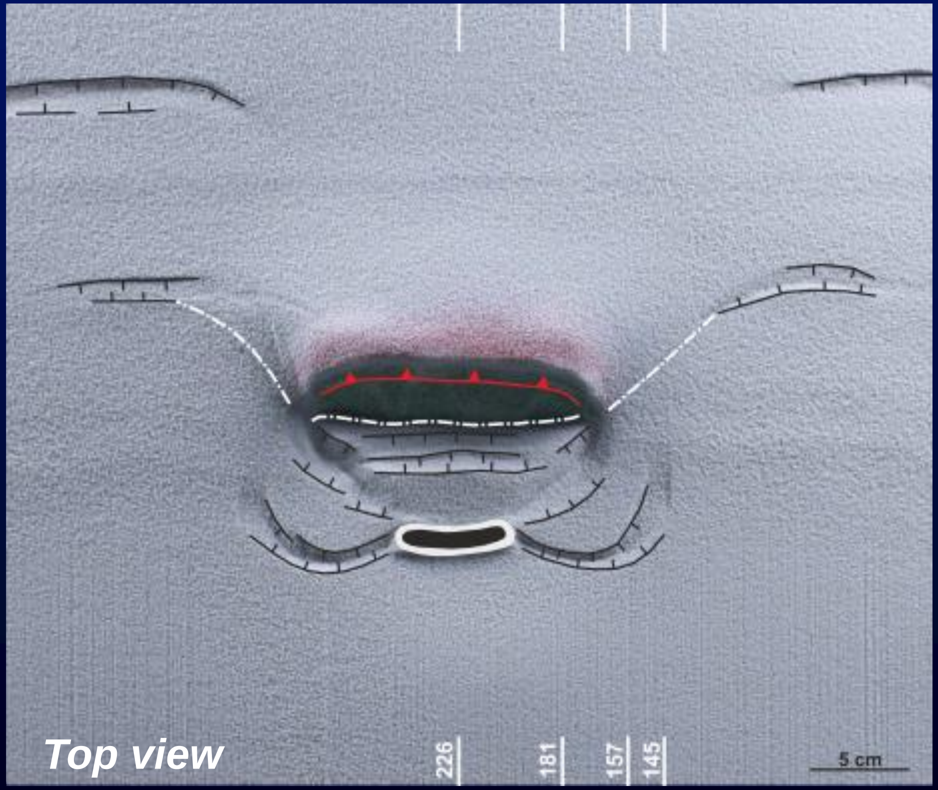


Experimental results (Exp. 3 – after 18 hours)

- ***First stage similar to the previous model***
- ***Second stage with cover overthrusting & basinwards gliding***







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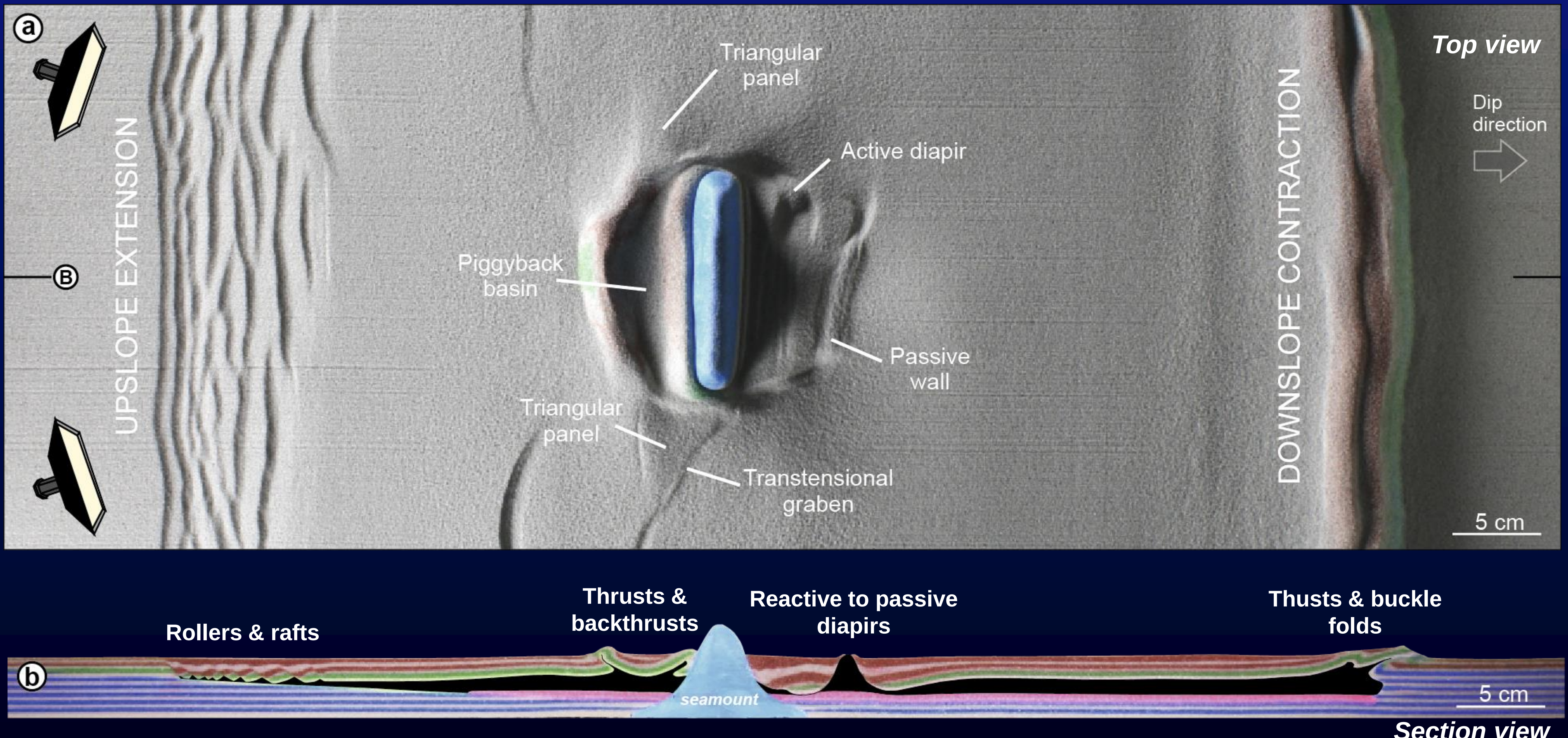
Experimental results (Exp. 6 – after 6 hours)

- ***Seamount apex above the regional at the beginning of the gliding***
- ***Buttressing more effective → thrust, backthrust & piggyback basin***
- ***Early basinwards diapirism***



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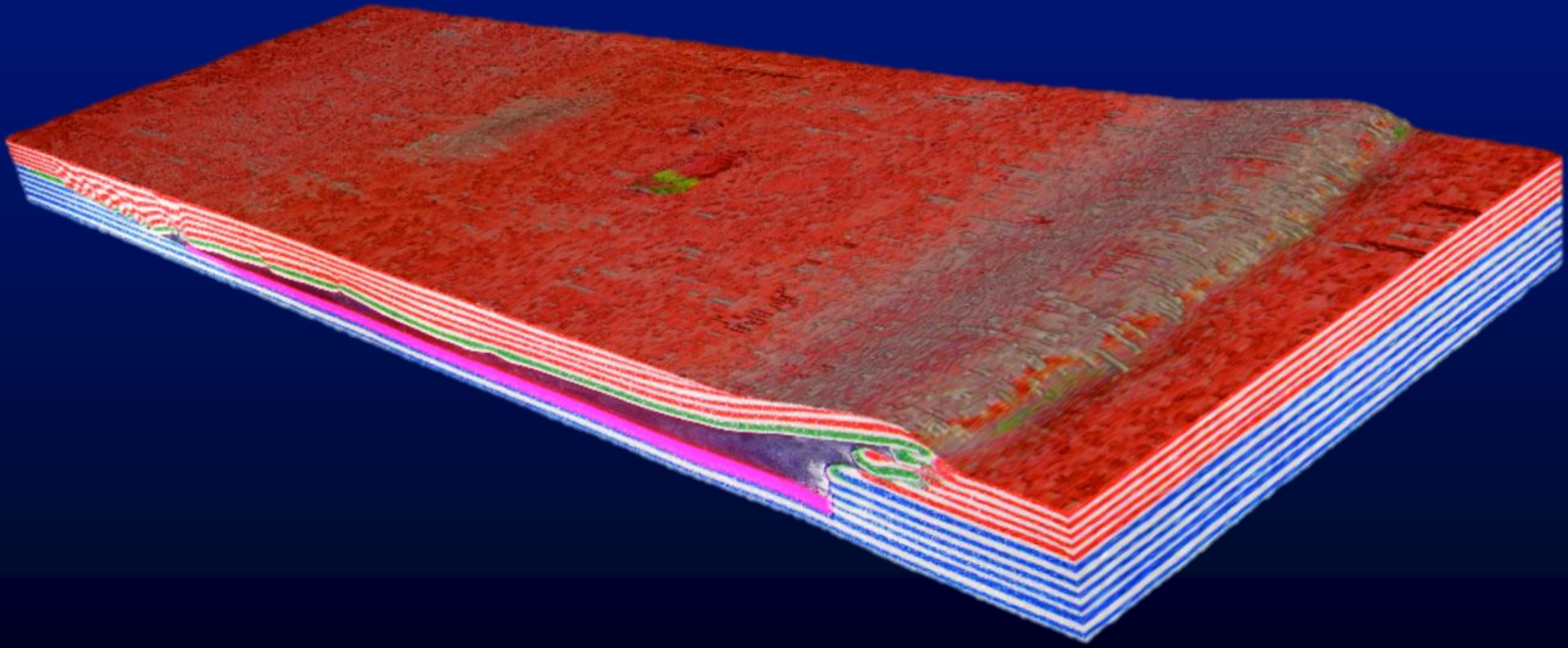
Experimental results (Exp. 3)

3D voxel reconstruction from vertical cross-sections

- *Upslope extension: listric faults, rollovers & polymer rollers*
- *Downslope contraction: imbricate thrust system detached on the polymer in the lower pinchout*



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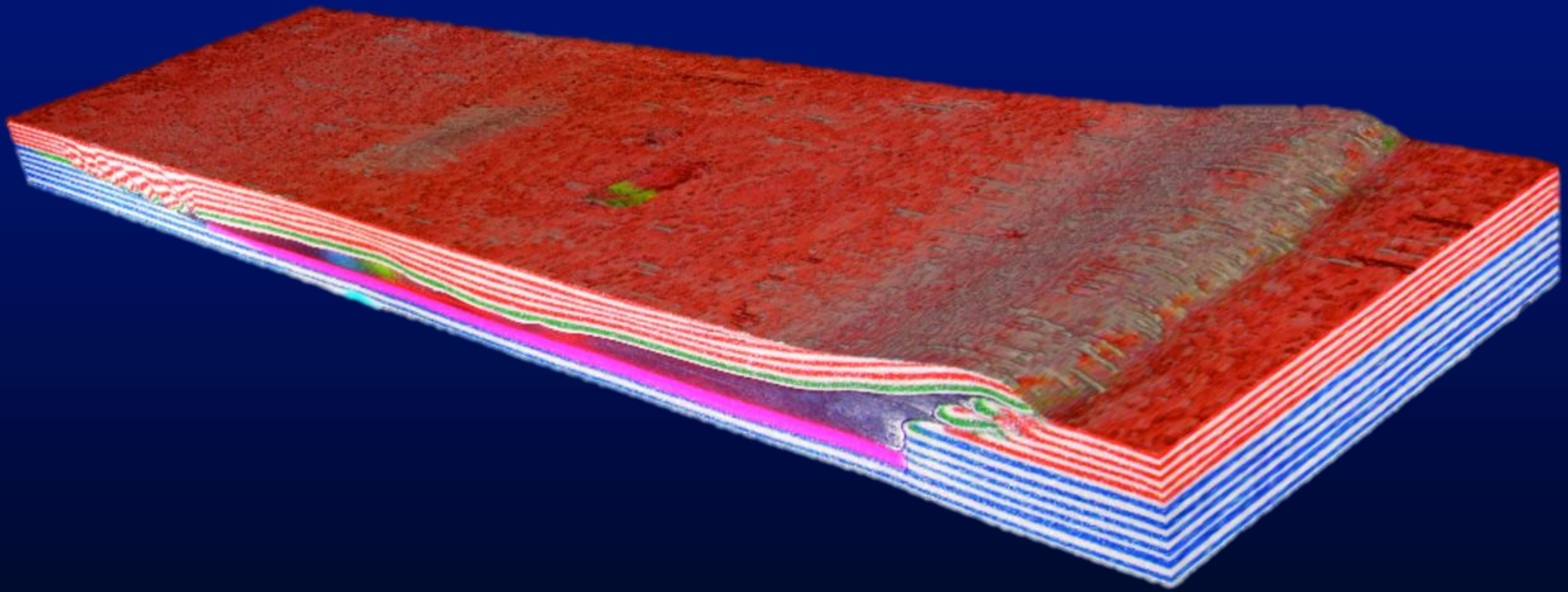

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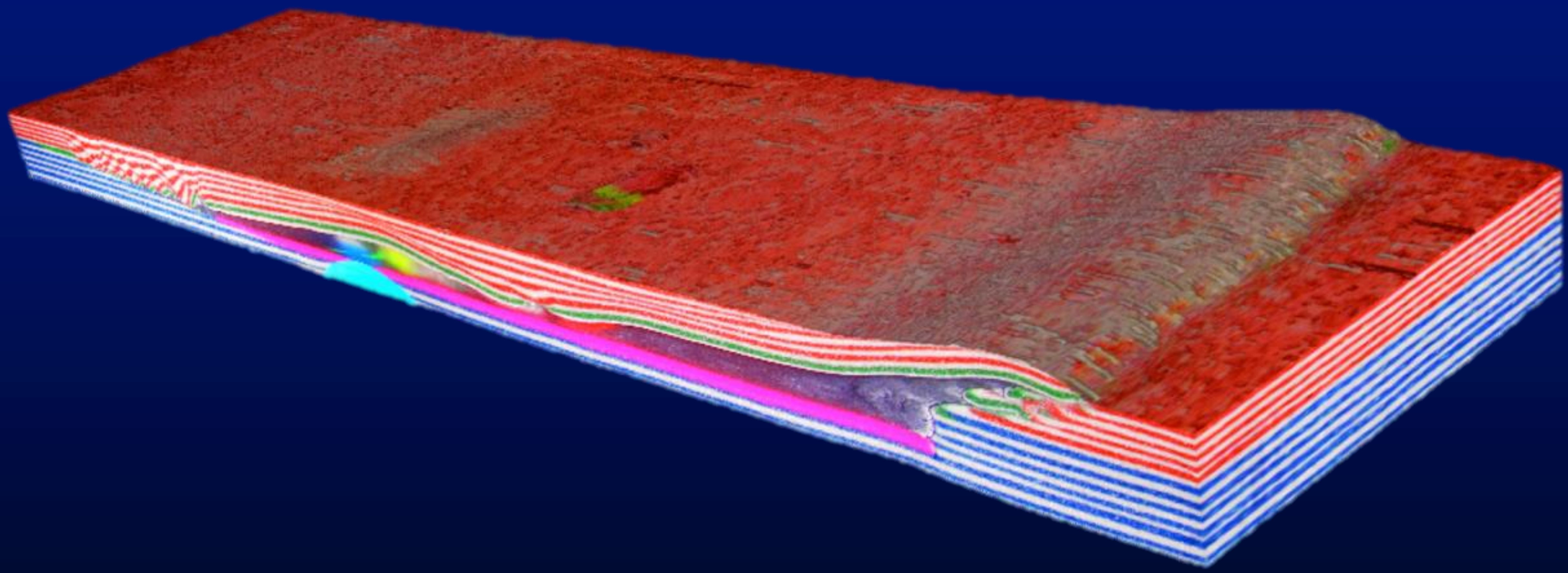

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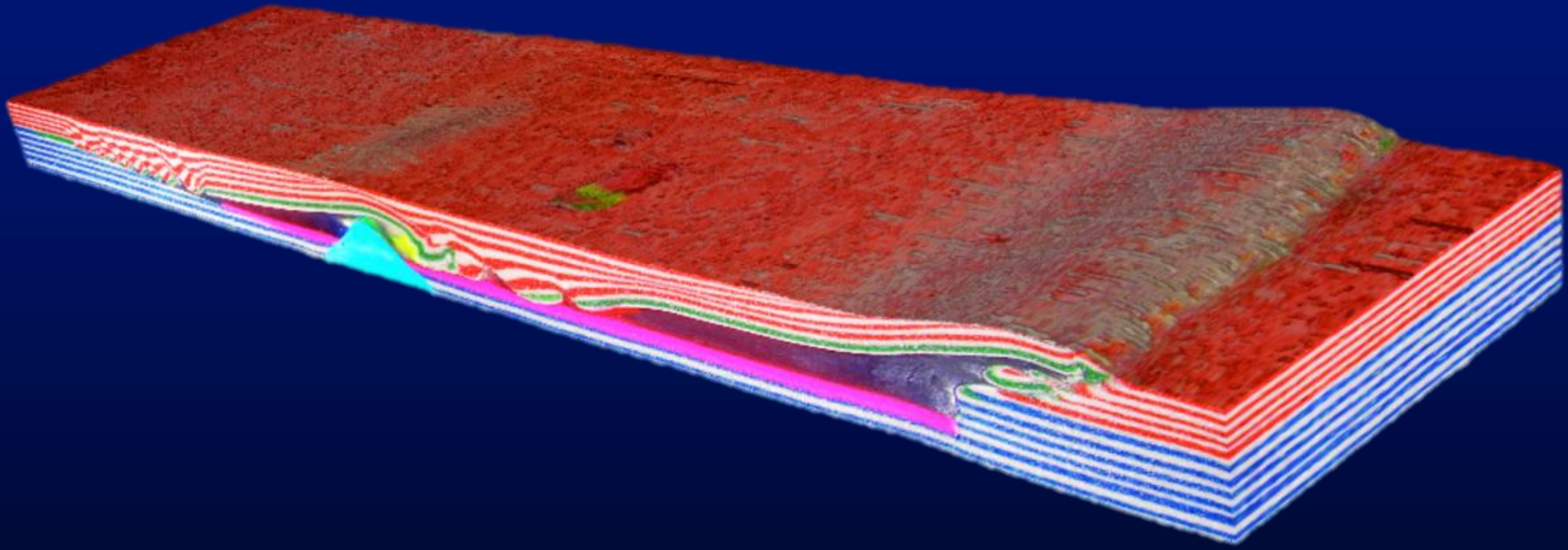

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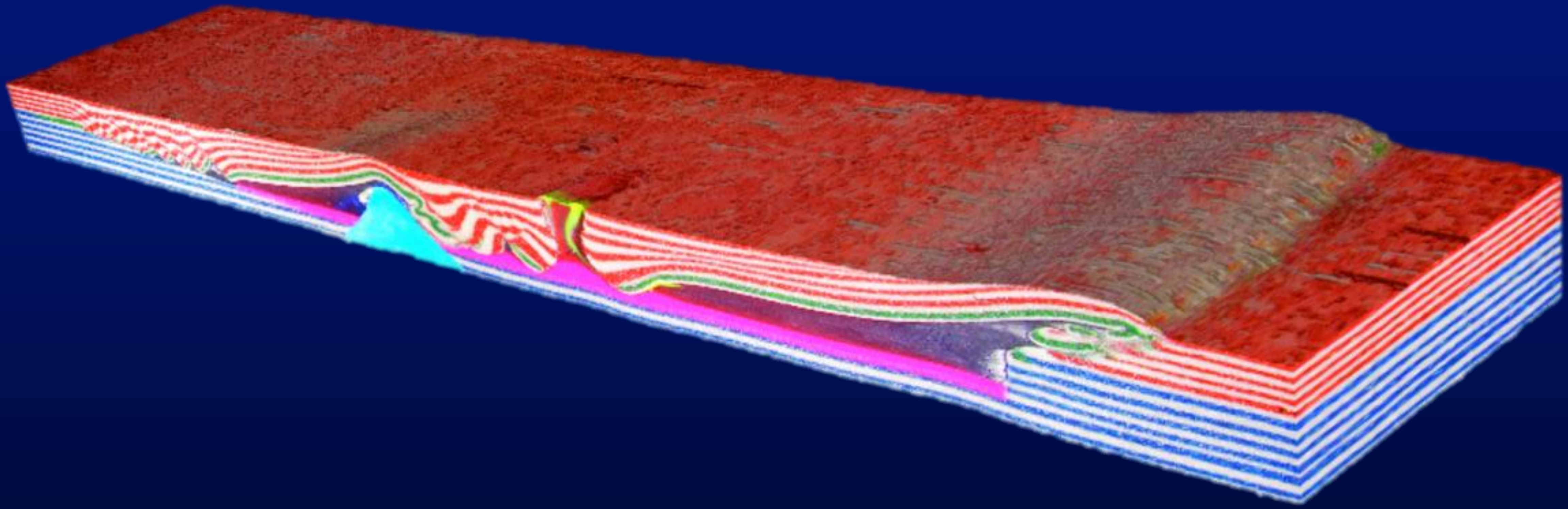

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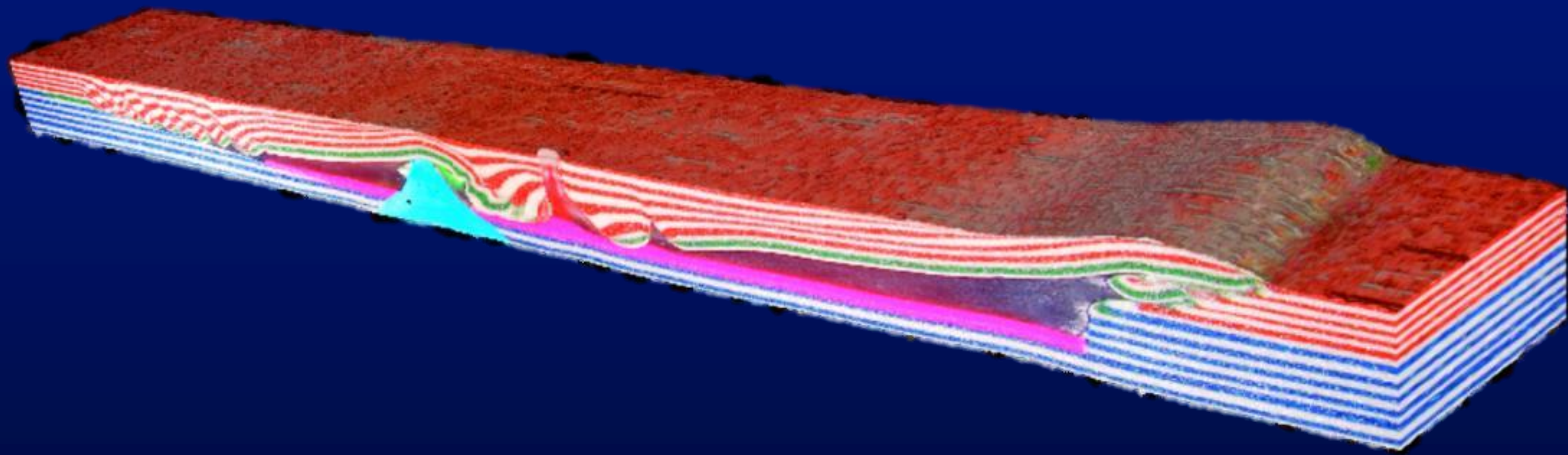

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Experimental results (Exp. 3)

3D voxel reconstruction from vertical cross-sections

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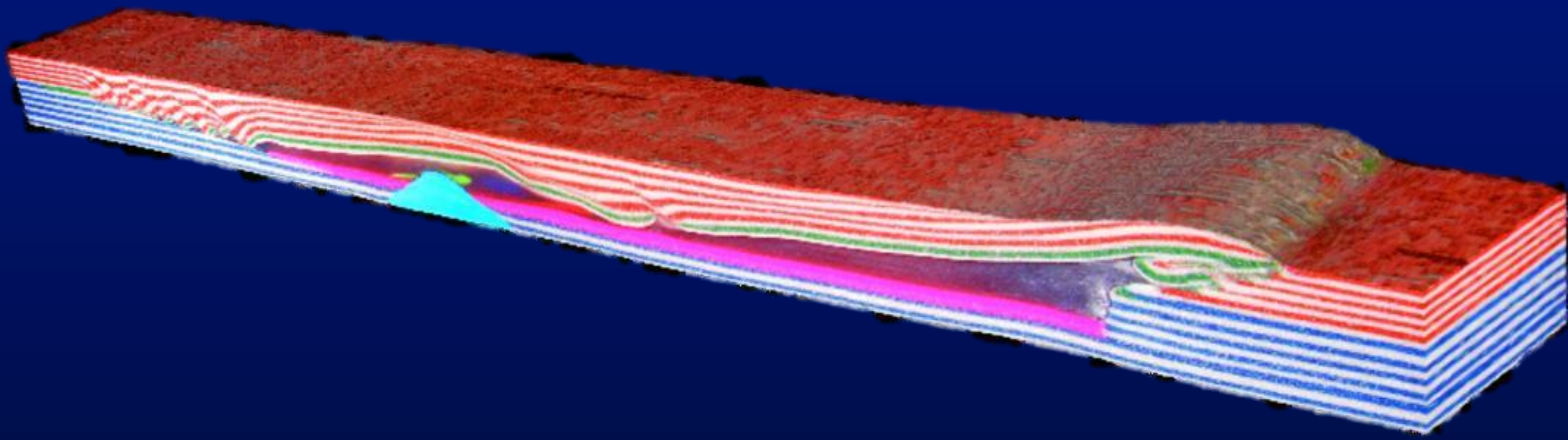

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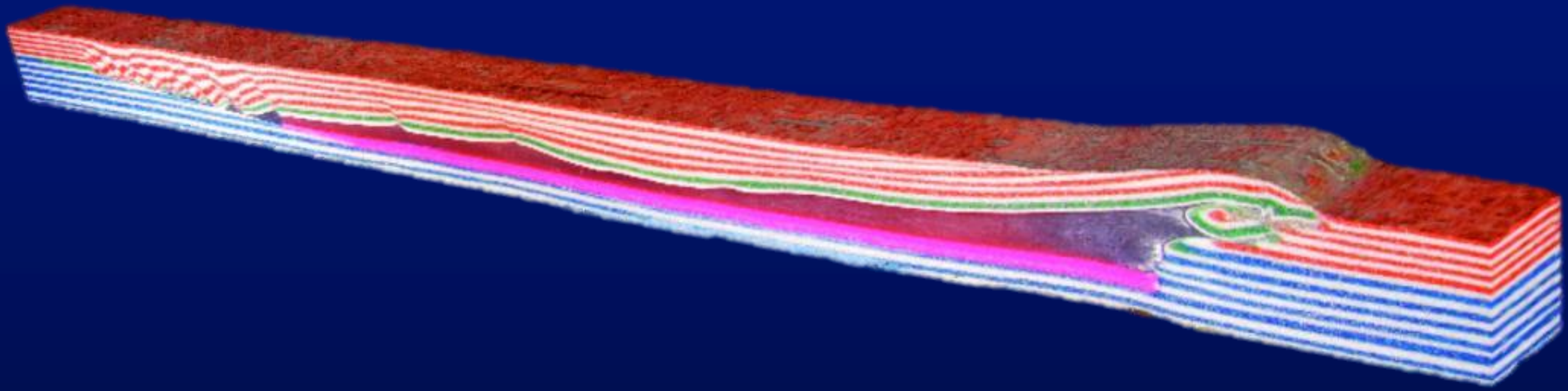

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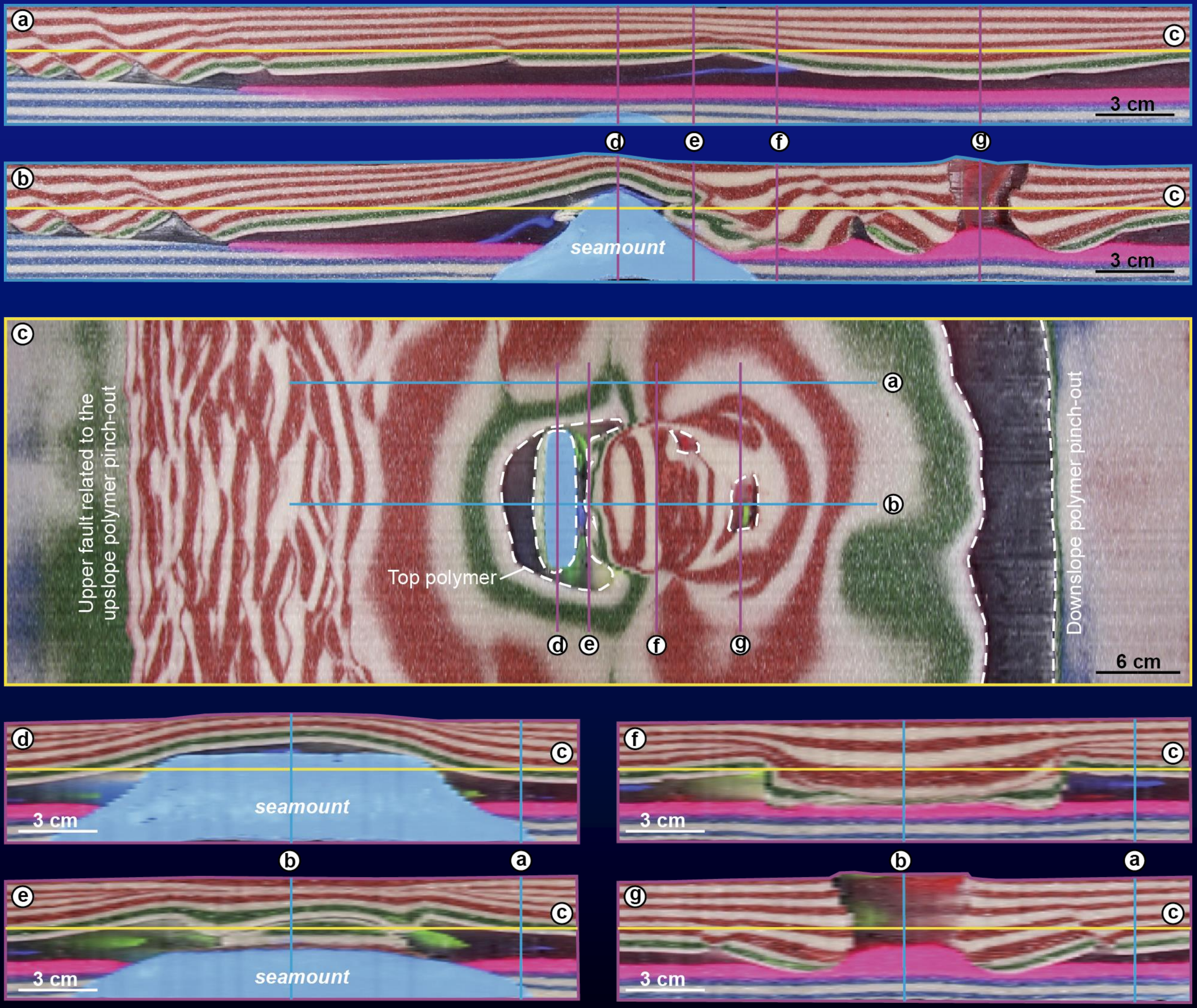
Experimental results (Exp. 3)

3D structure & architecture



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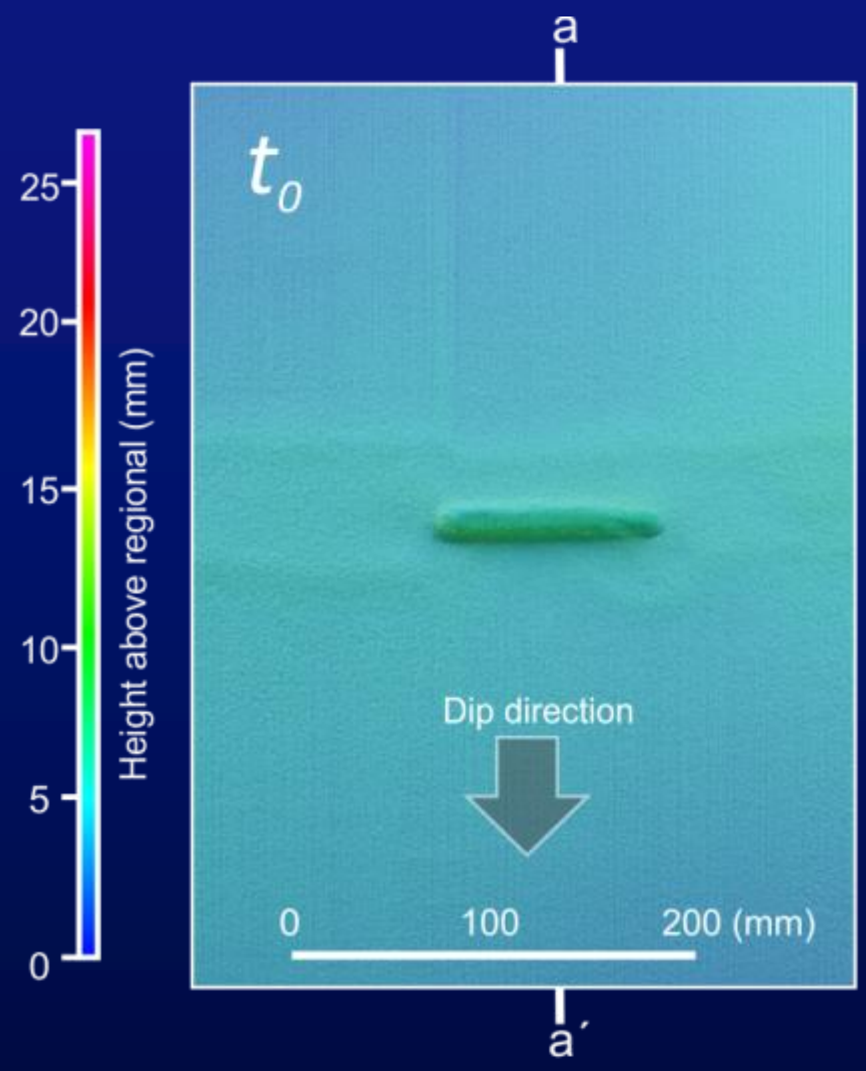
Experimental results (Volc05)

Kinematic evolution of the structures associated to the seamount



Initial setup (t_0)

- ***Flat topography***
- ***Seamount higher than the regional***
- ***Rig tilting 4,5º basinwards***
- ***Gravitational failure***

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Experimental results (Volc05)

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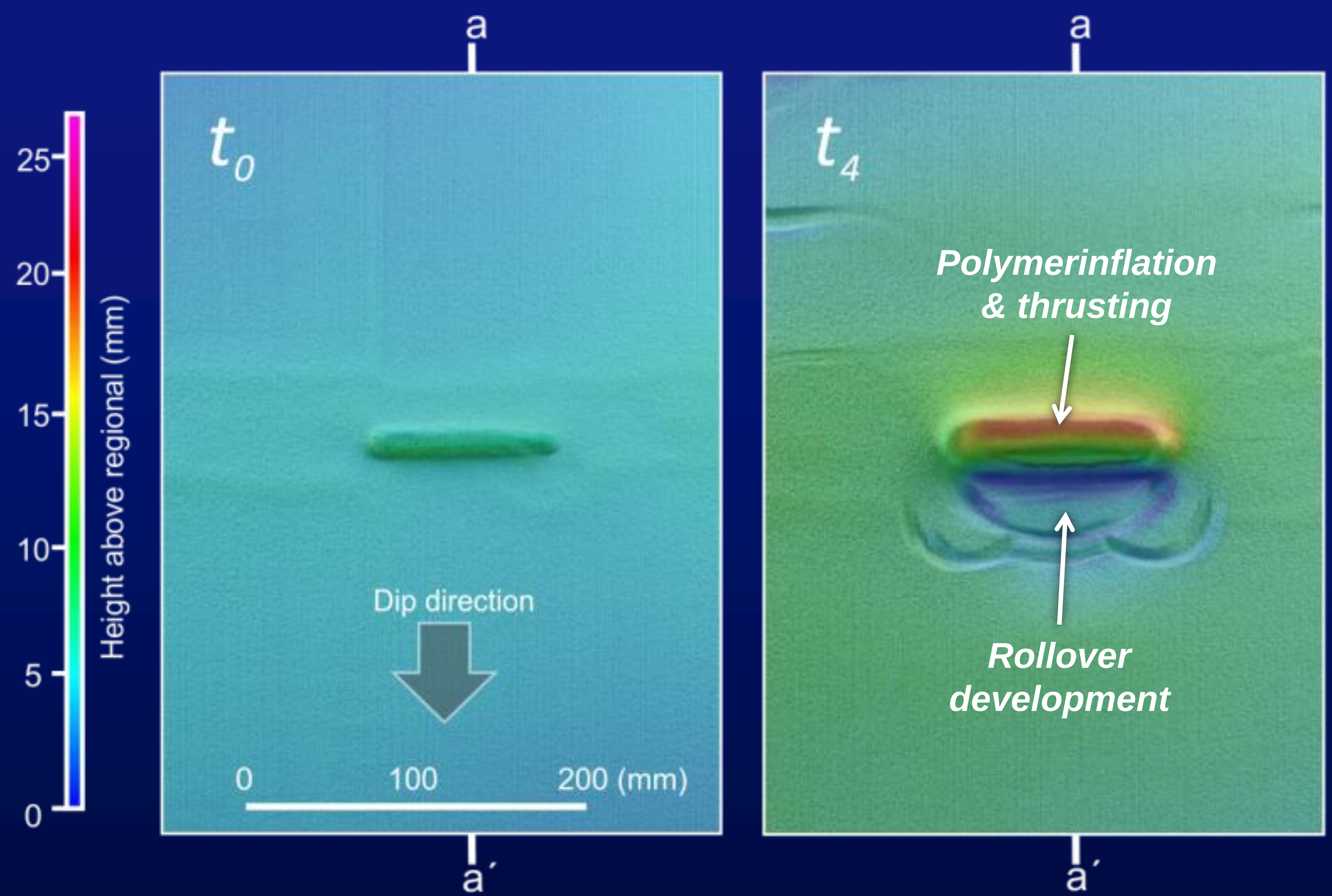
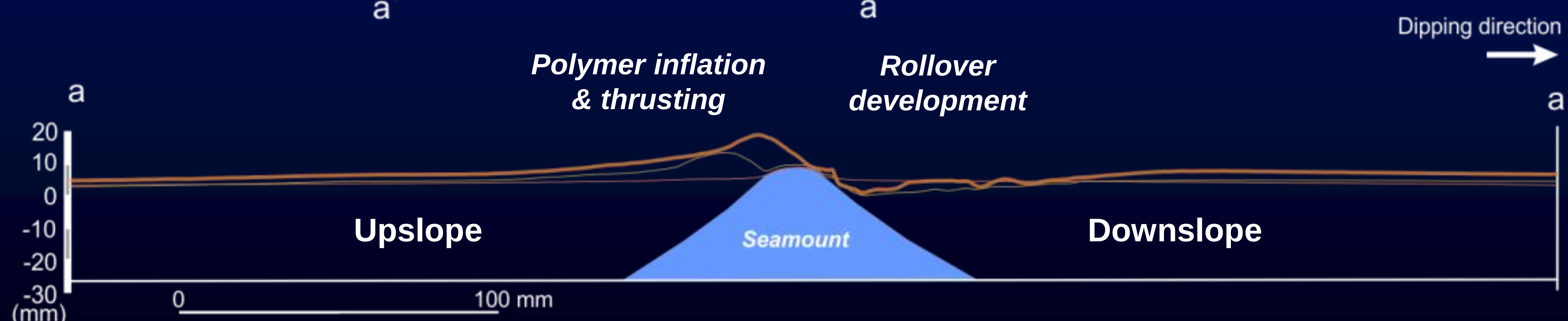


Gravitational failure (t_4)

- ***Upslope polymer inflation & thrusting***
- ***Basinward extension (rollover)***



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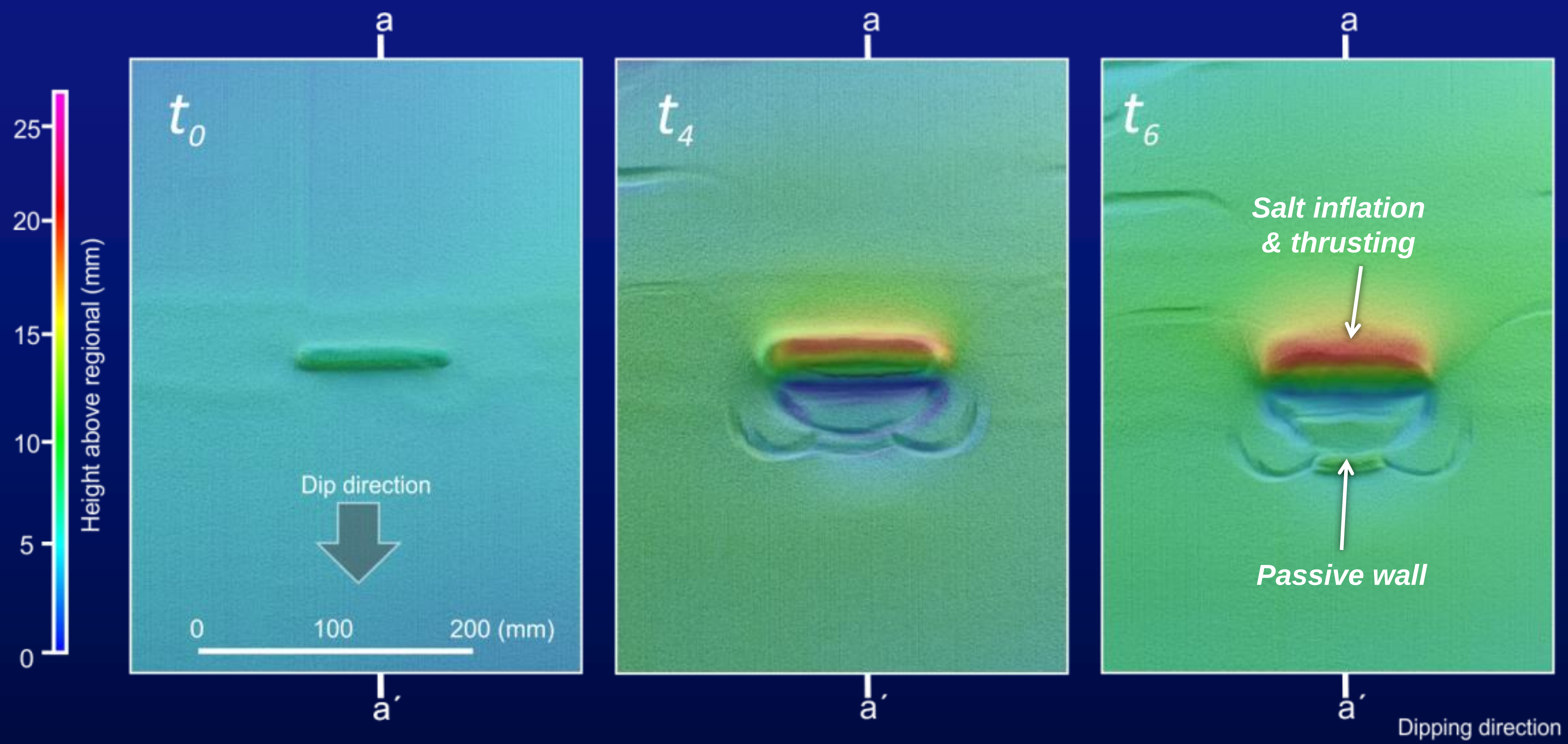
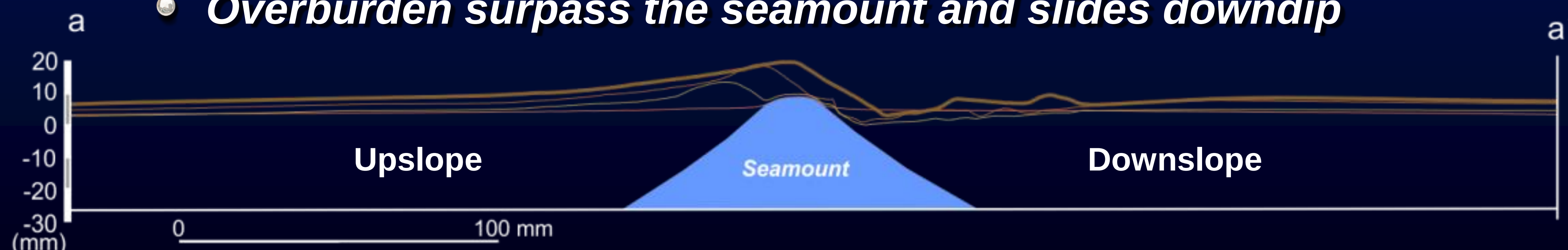


- ***Overburden surpass the seamount and slides downdip***



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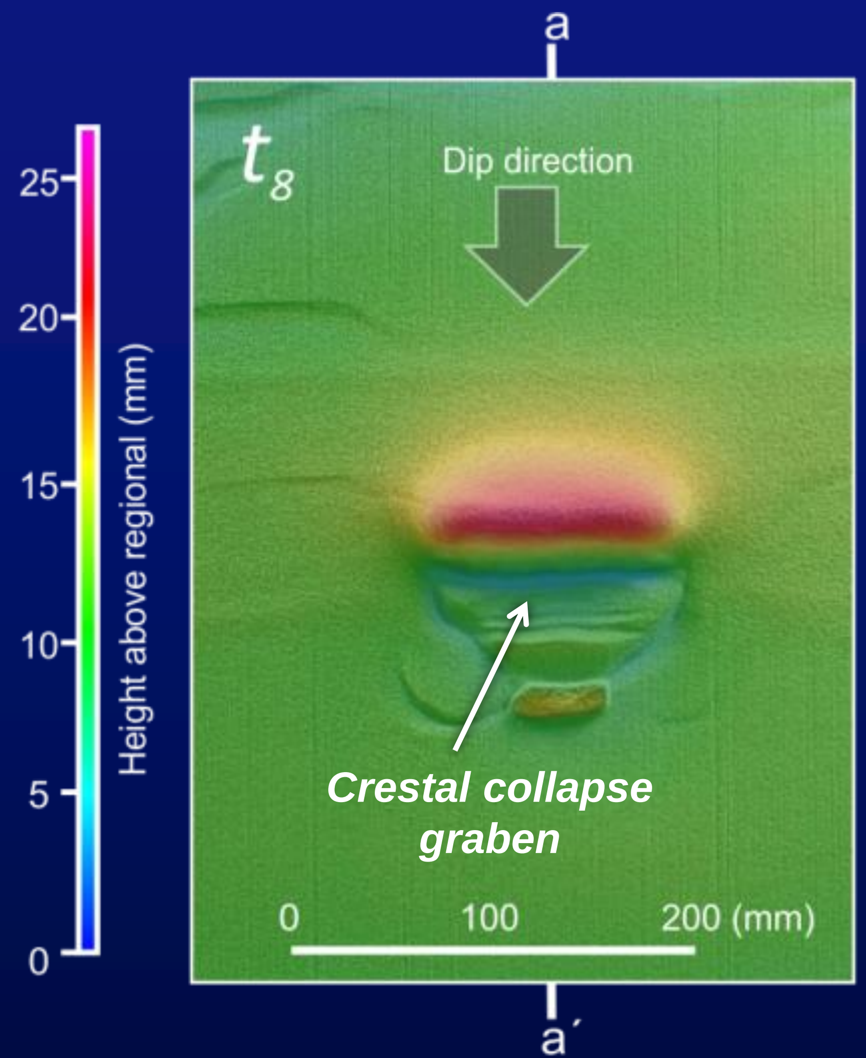

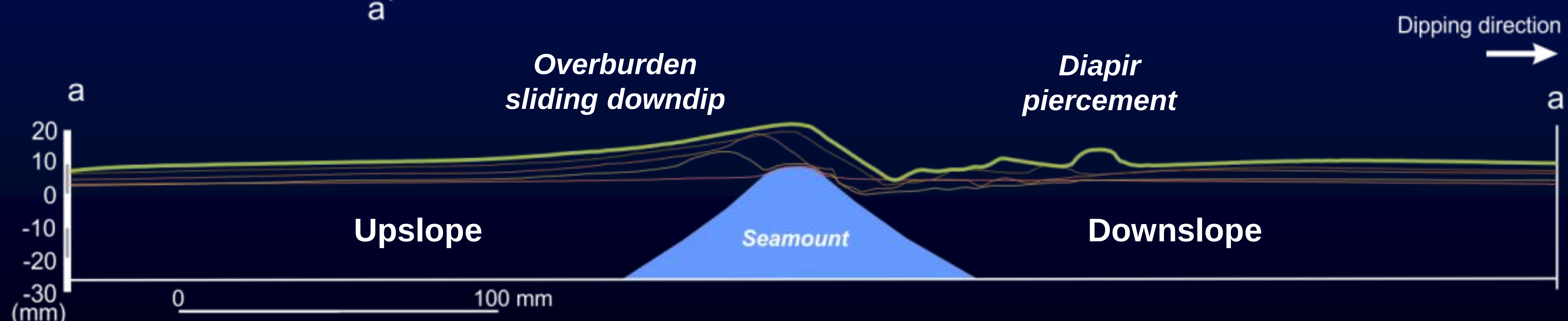

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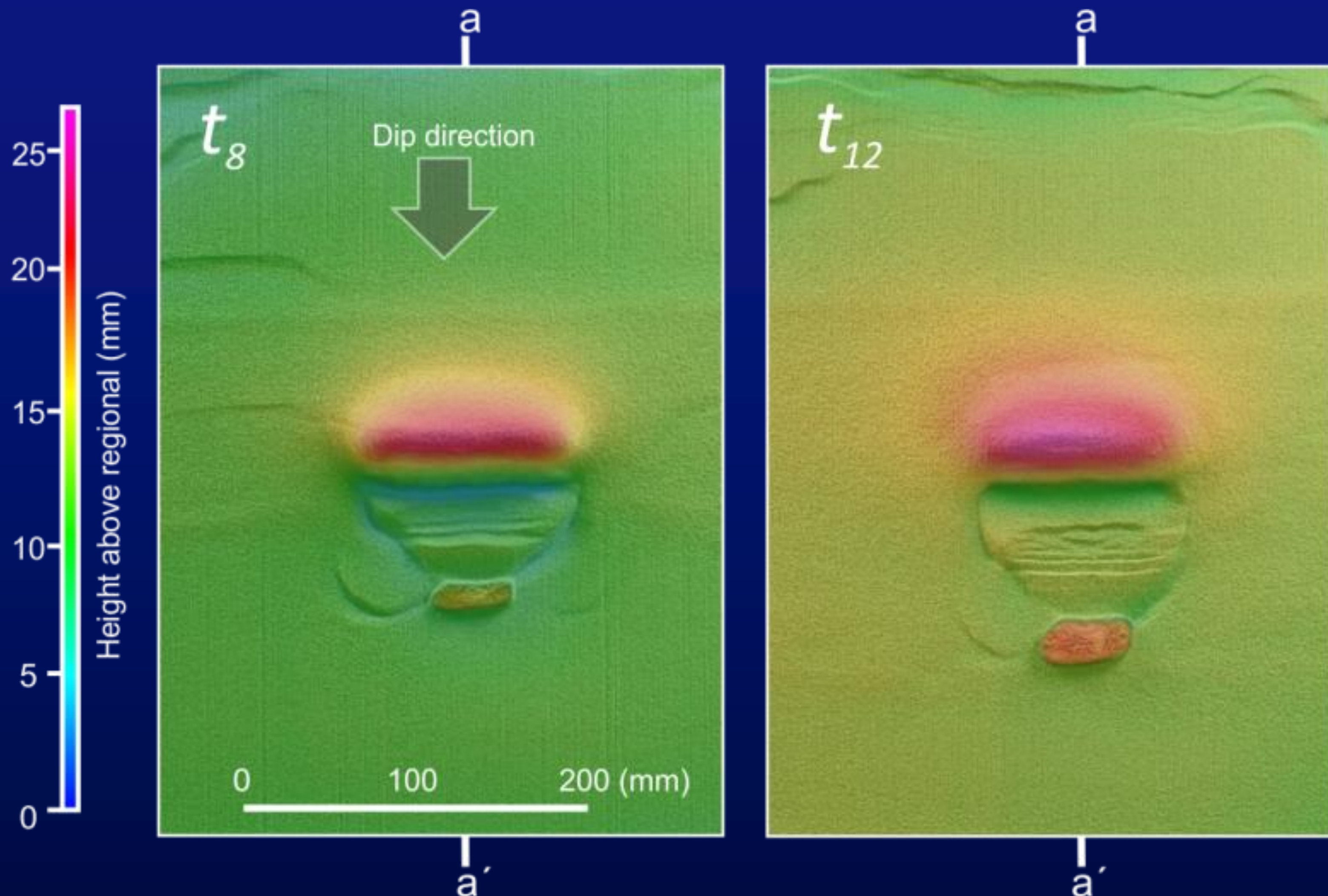
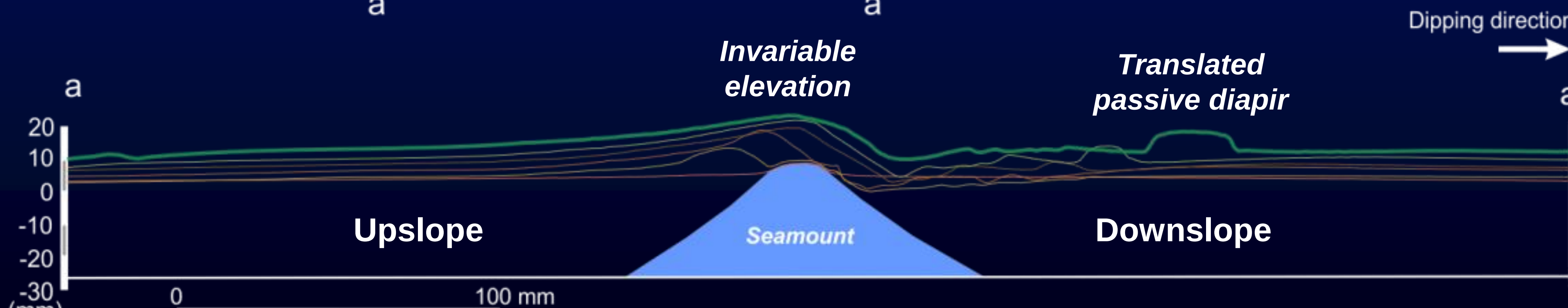
Experimental results (Volc05)

Kinematic evolution of the structures associated to the seamount



Gravitational failure (t_{12})

- ***No polymer inflation***
- ***Passive diapir of the rollover hinge translated basinwards***
- ***Development of a***
- ***crestal-collapse graben***



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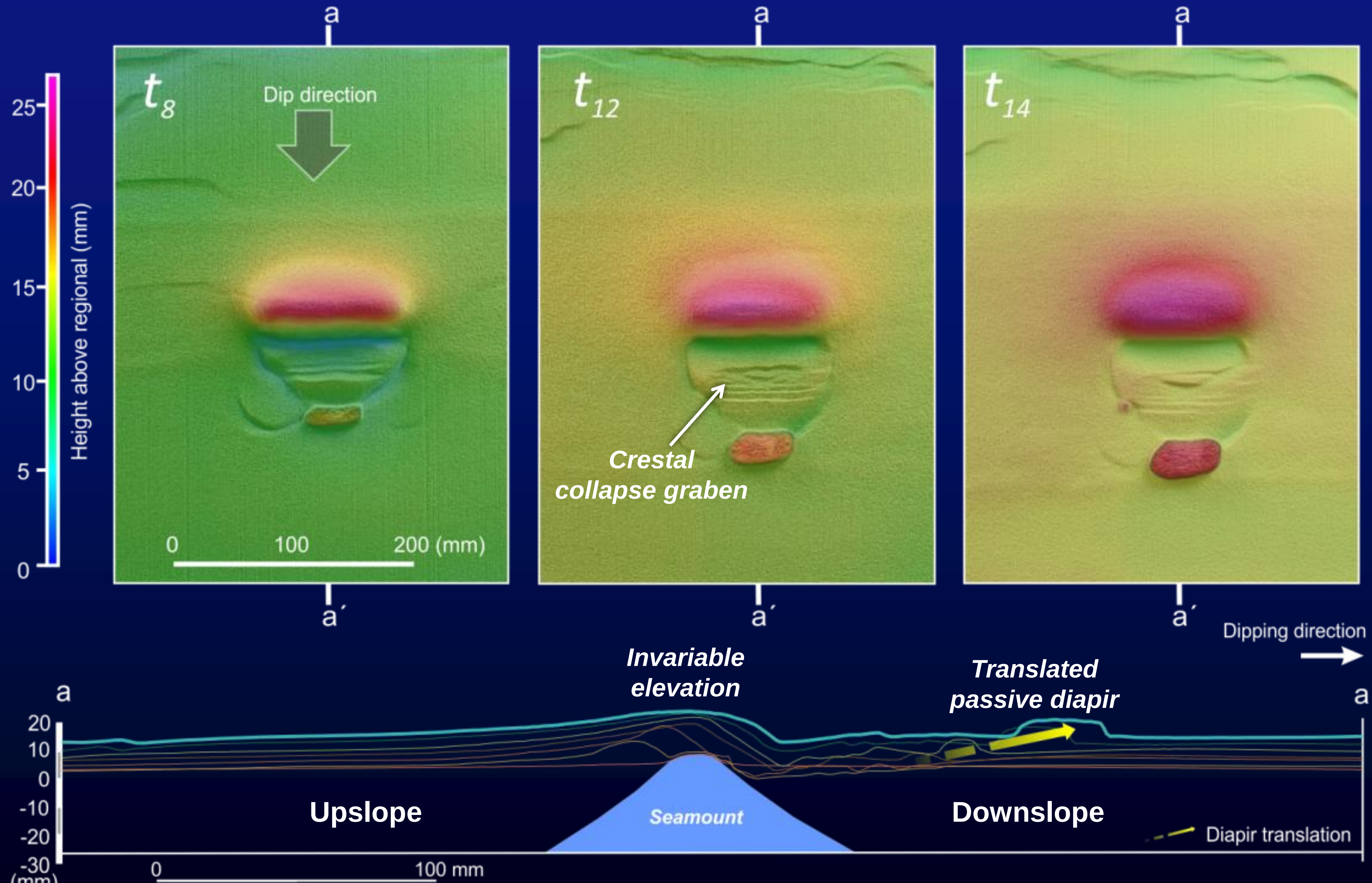

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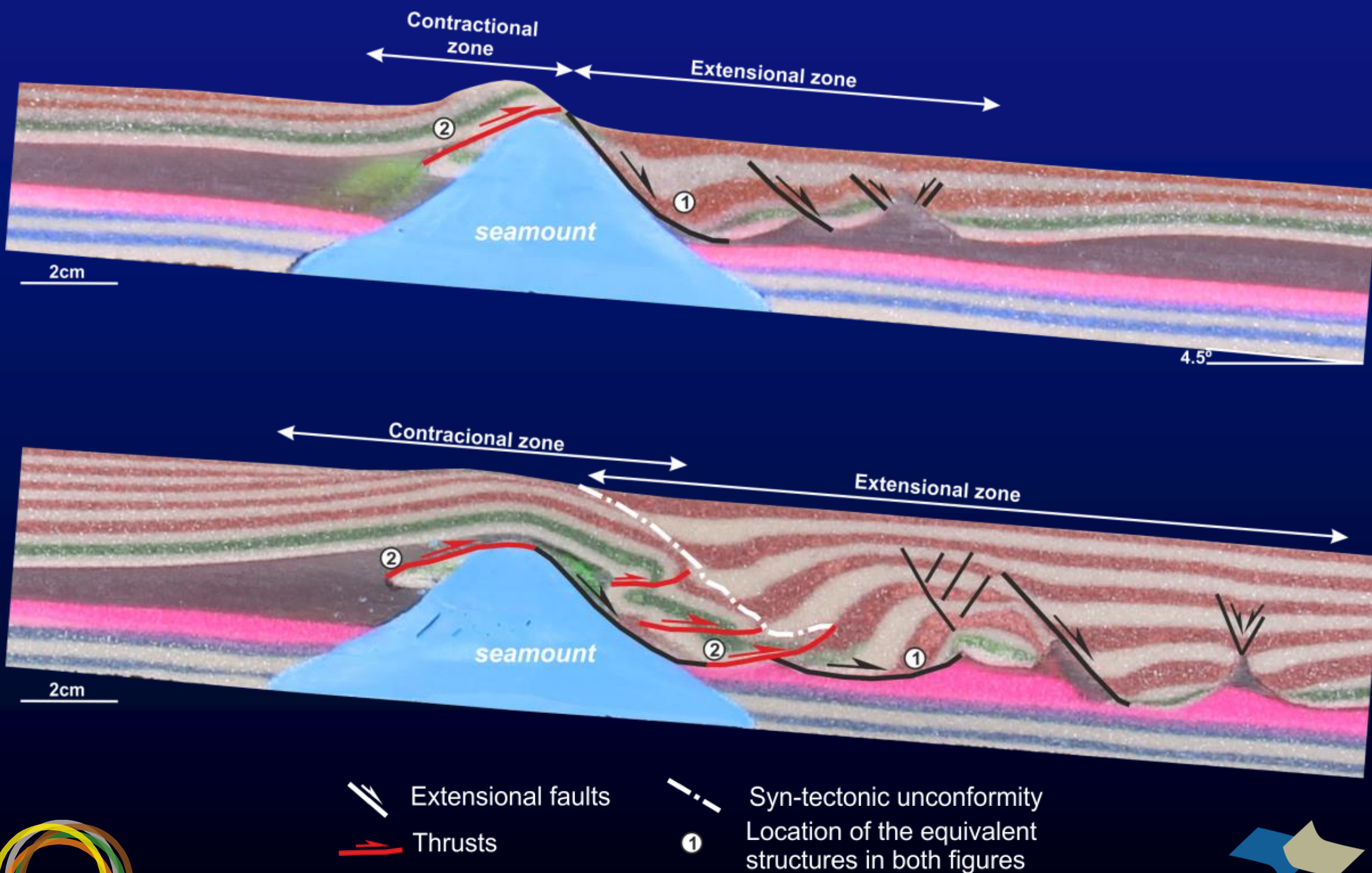
Experiments comparison

Kinematic evolution of the structures associated to the seamount



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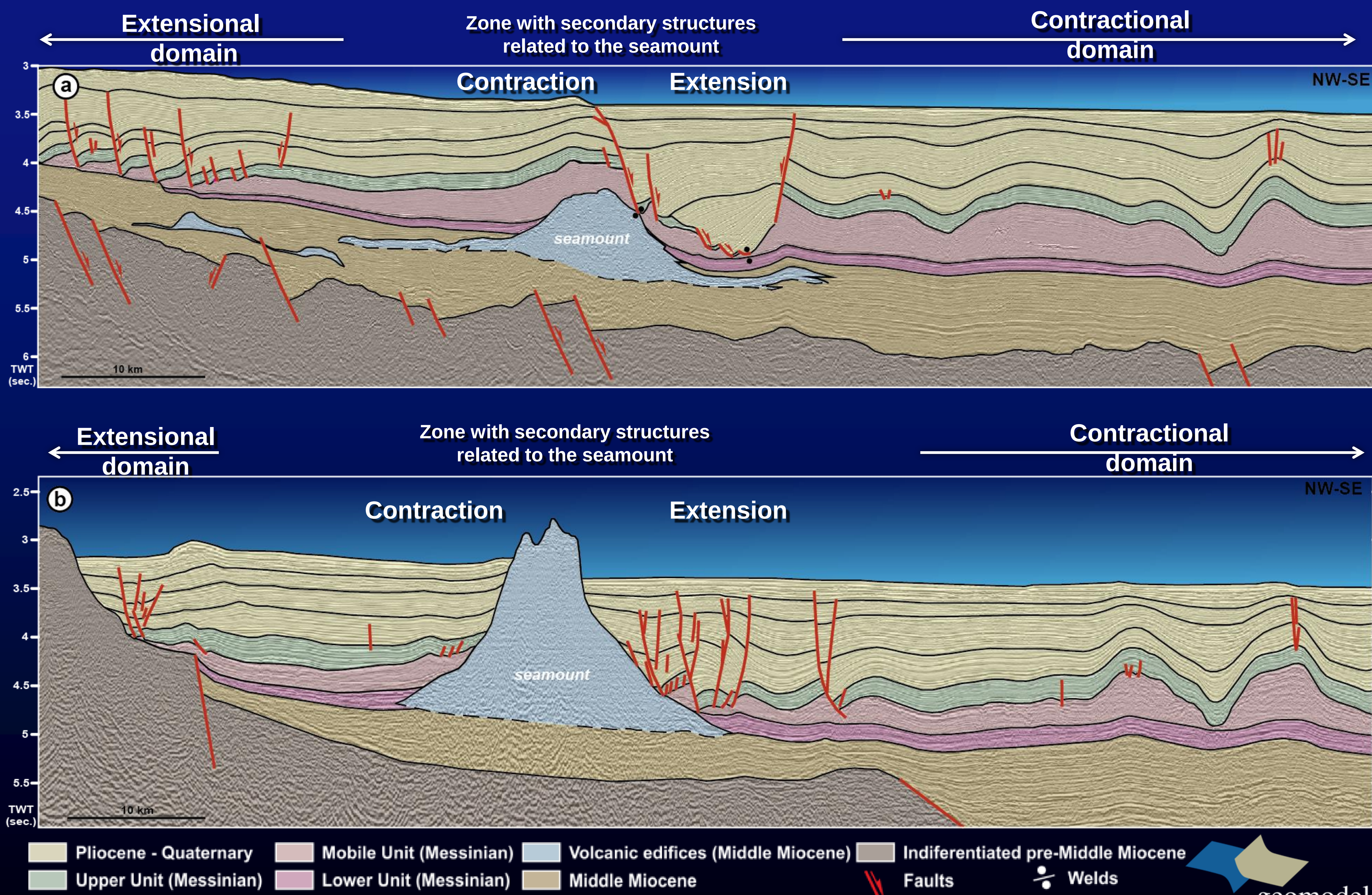
Comparison with seismic examples



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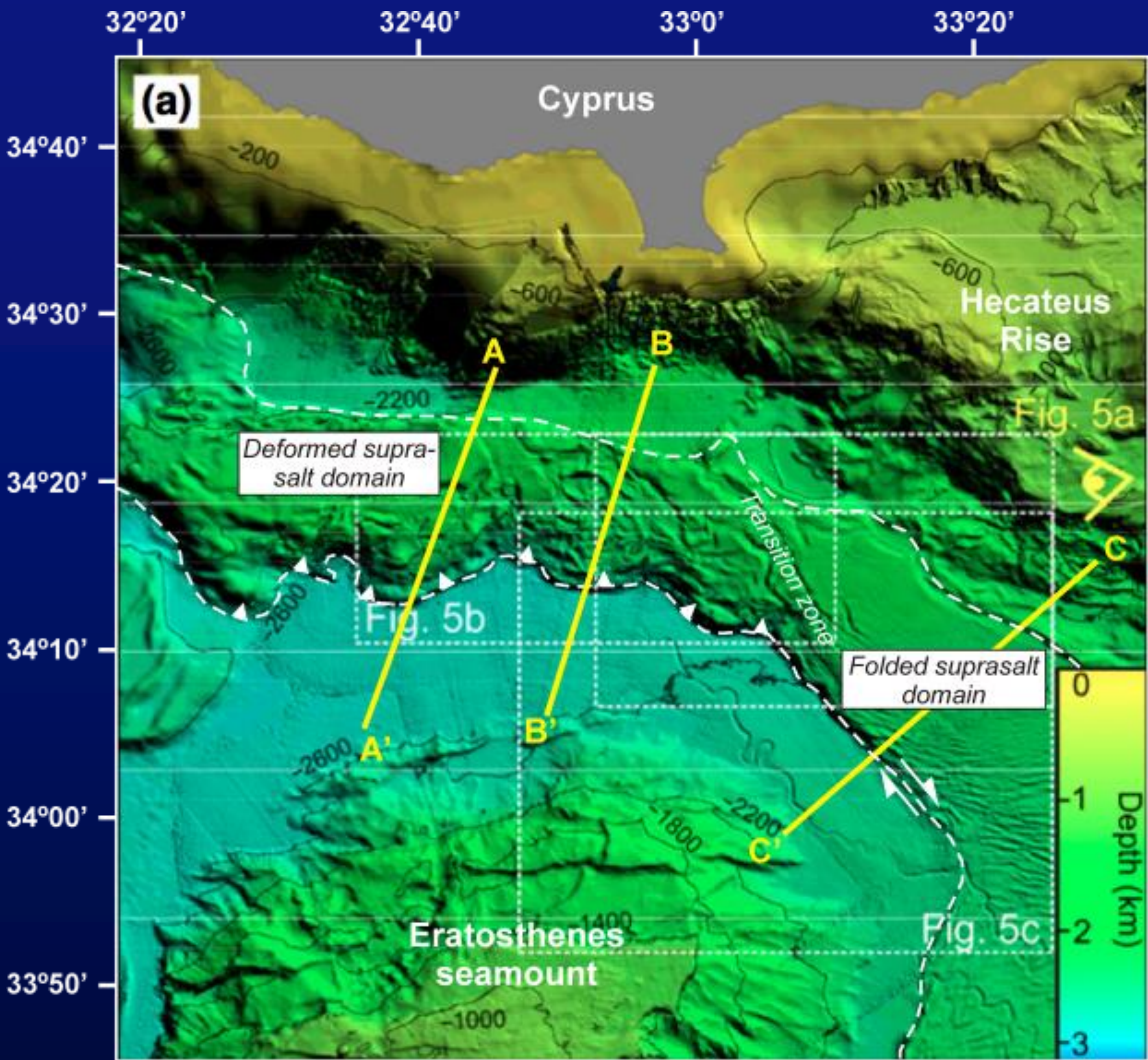
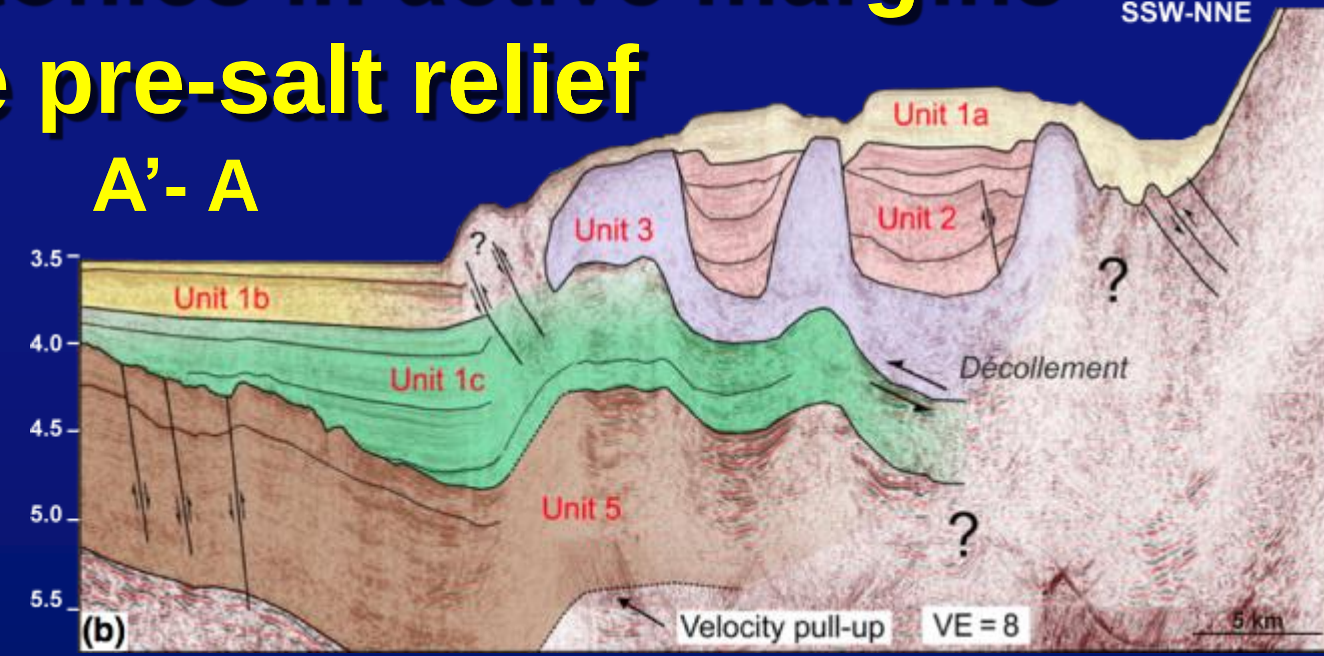
Overview B: salt tectonics in active margins above large pre-salt relief

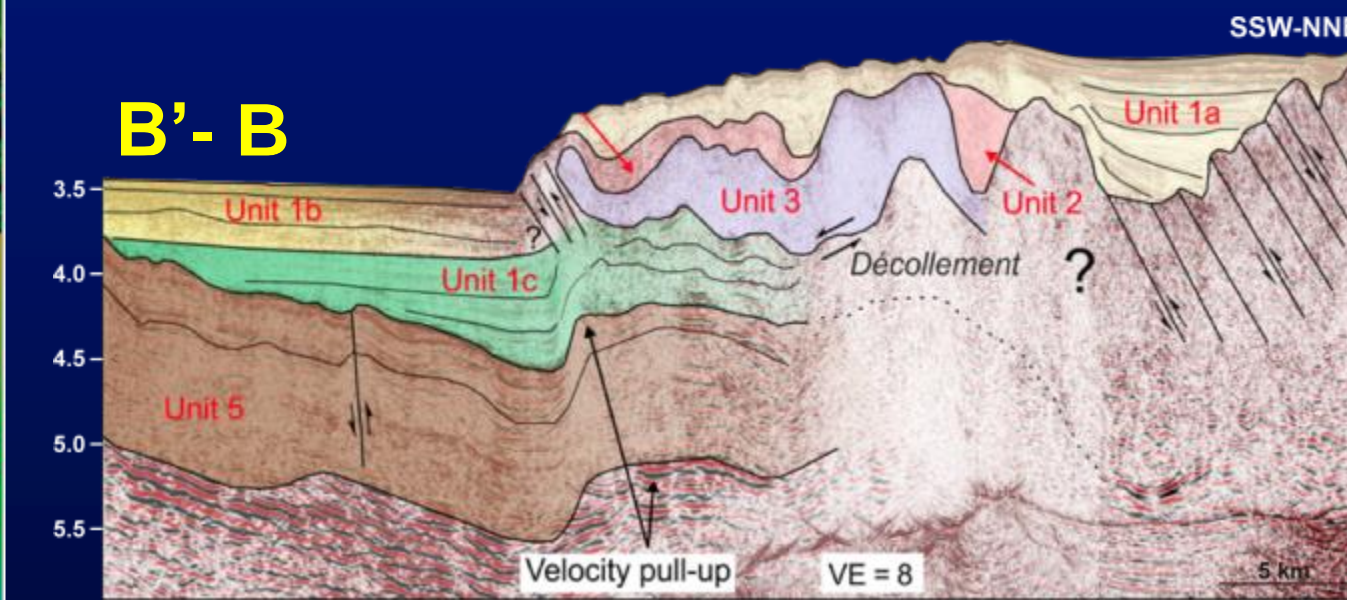


Reiche et al., 2016

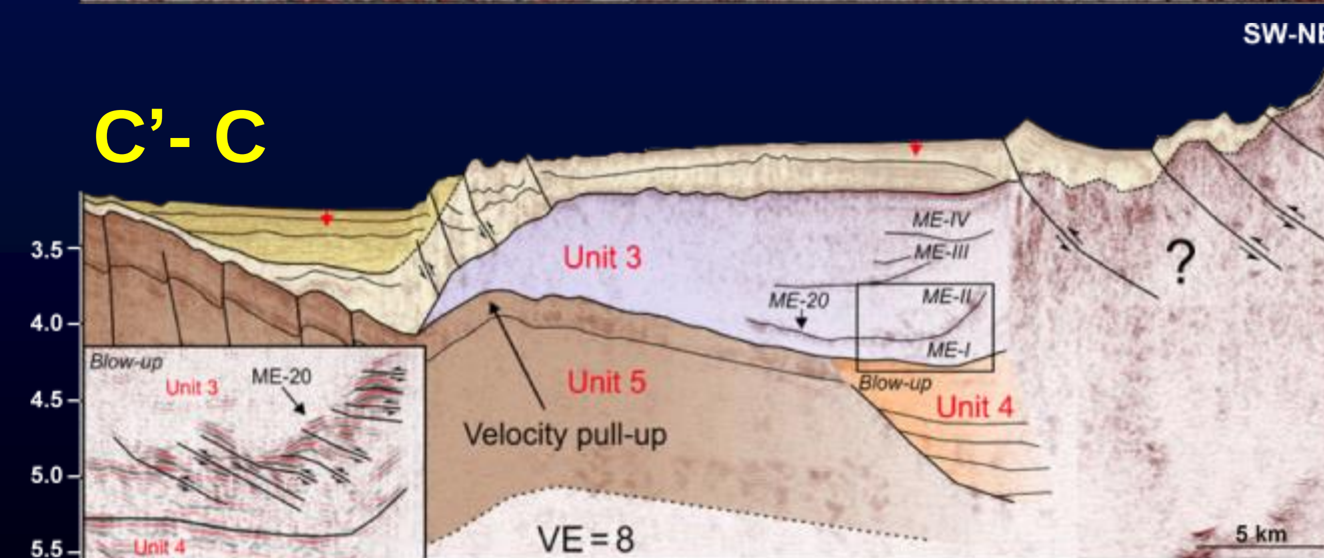
A'- A



B'- B



C'- C



Reiche et al., 2016

Units 1a, 1b & 1c	Pliocene / Pleistocene
Units 2 & 3	Messinian
Unit 4	Tortonian / Aquitanian
Unit 5	Oligocene / Eocene

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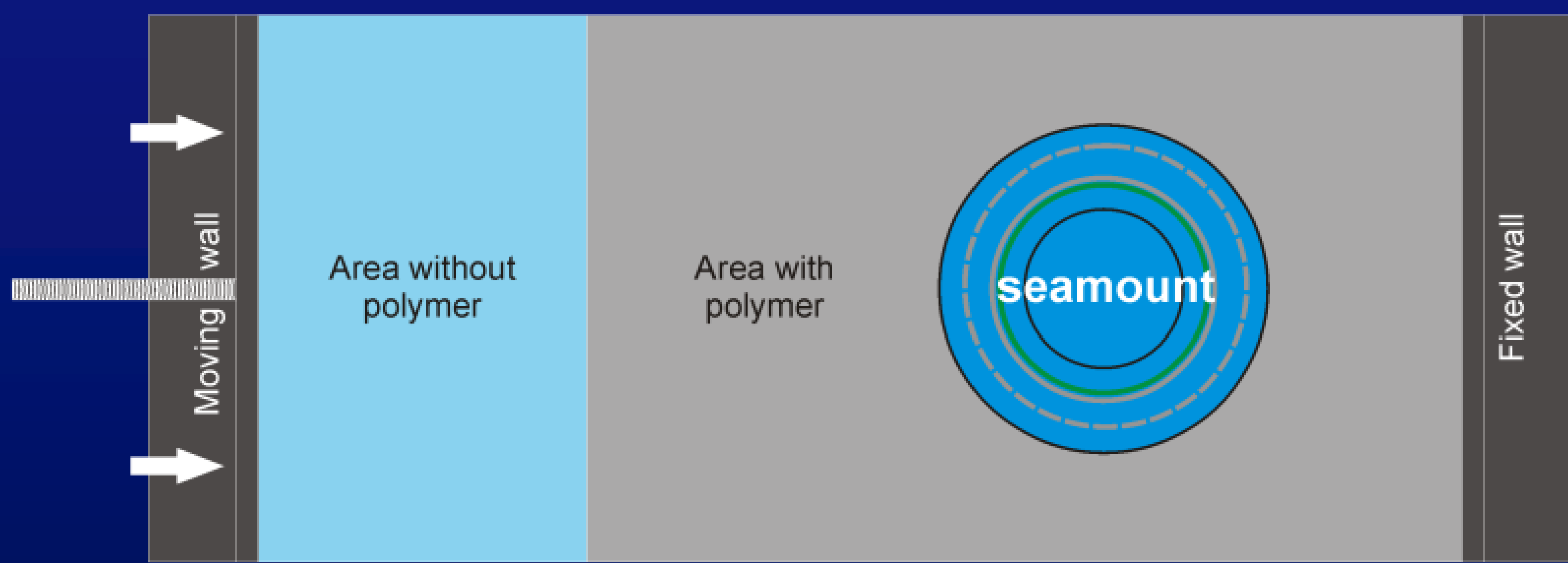
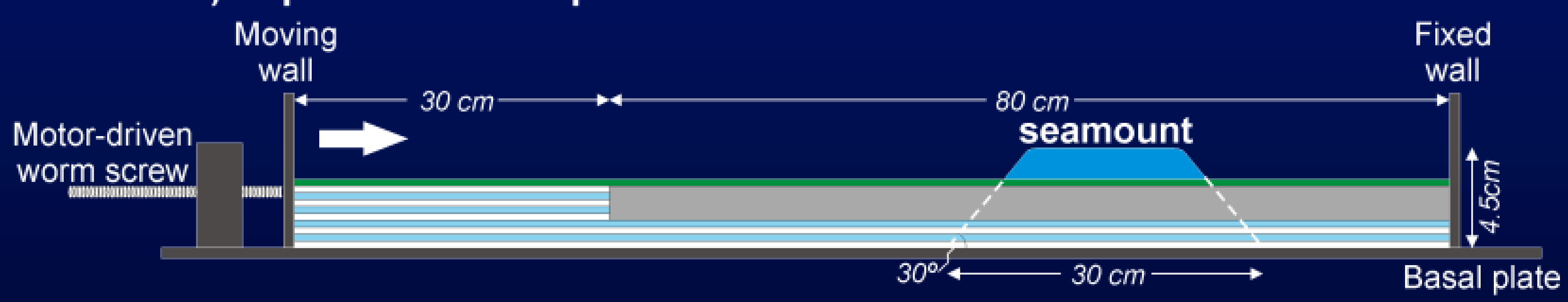
Experimental setup B

Experimental approach

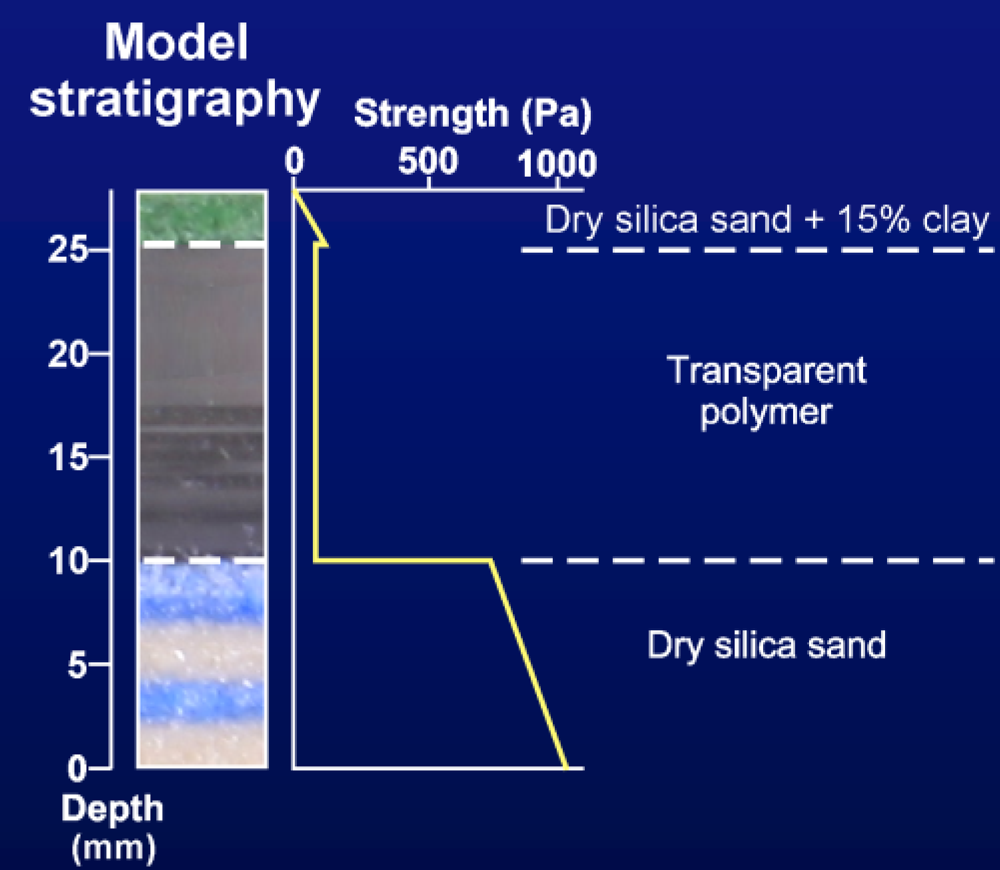
a) Experimental setup plan view



b) Experimental setup section view



Mechanical stratigraphy



Tested parameters

- *Shape of the seamount (height & geometry)*
- *Geometry of a rigid backstop*
- *Salt thickness & stratigraphy*
- *Different degrees of shortening*
- *Syn-tectonic sedimentation*

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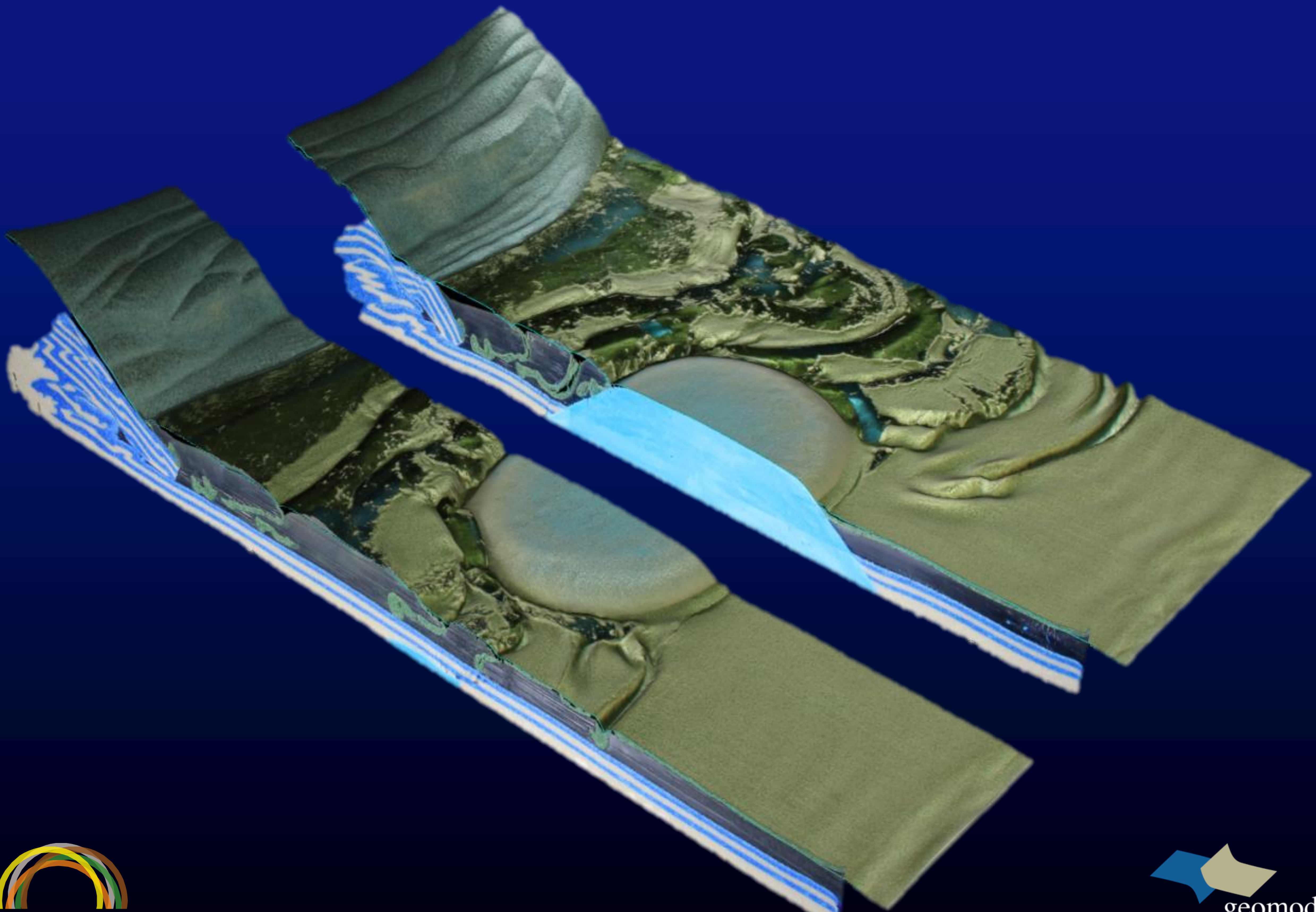
Experimental results B: 3D view



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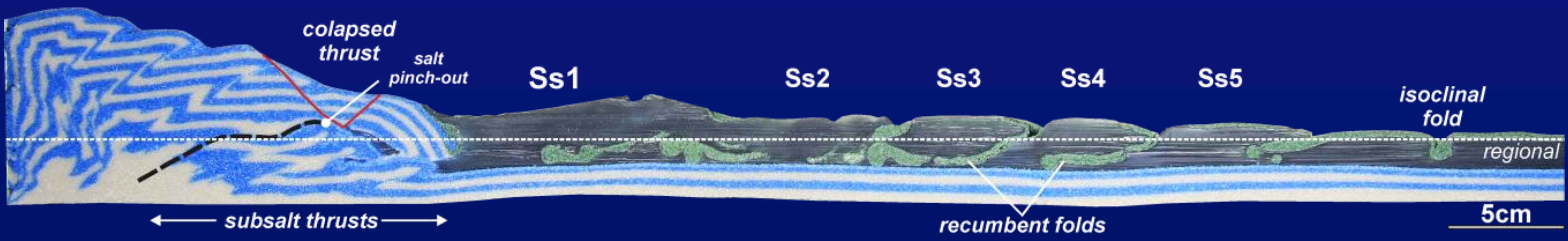
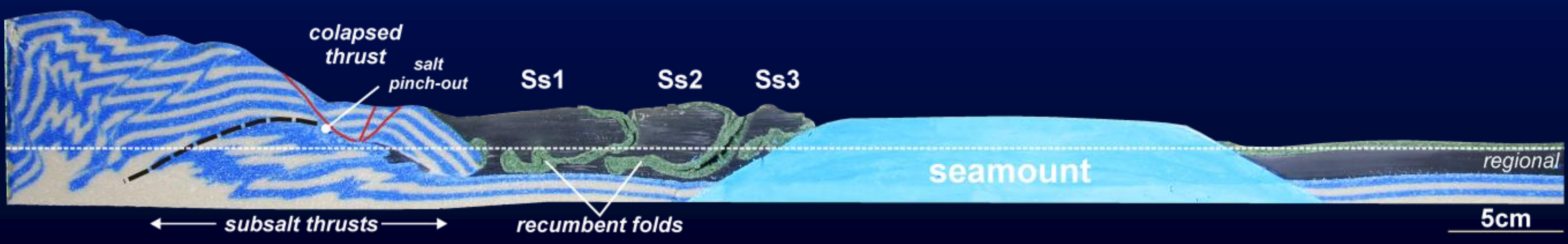
Experimental results B: section view

Baseline section (without seamount)



Section with seamount (central)



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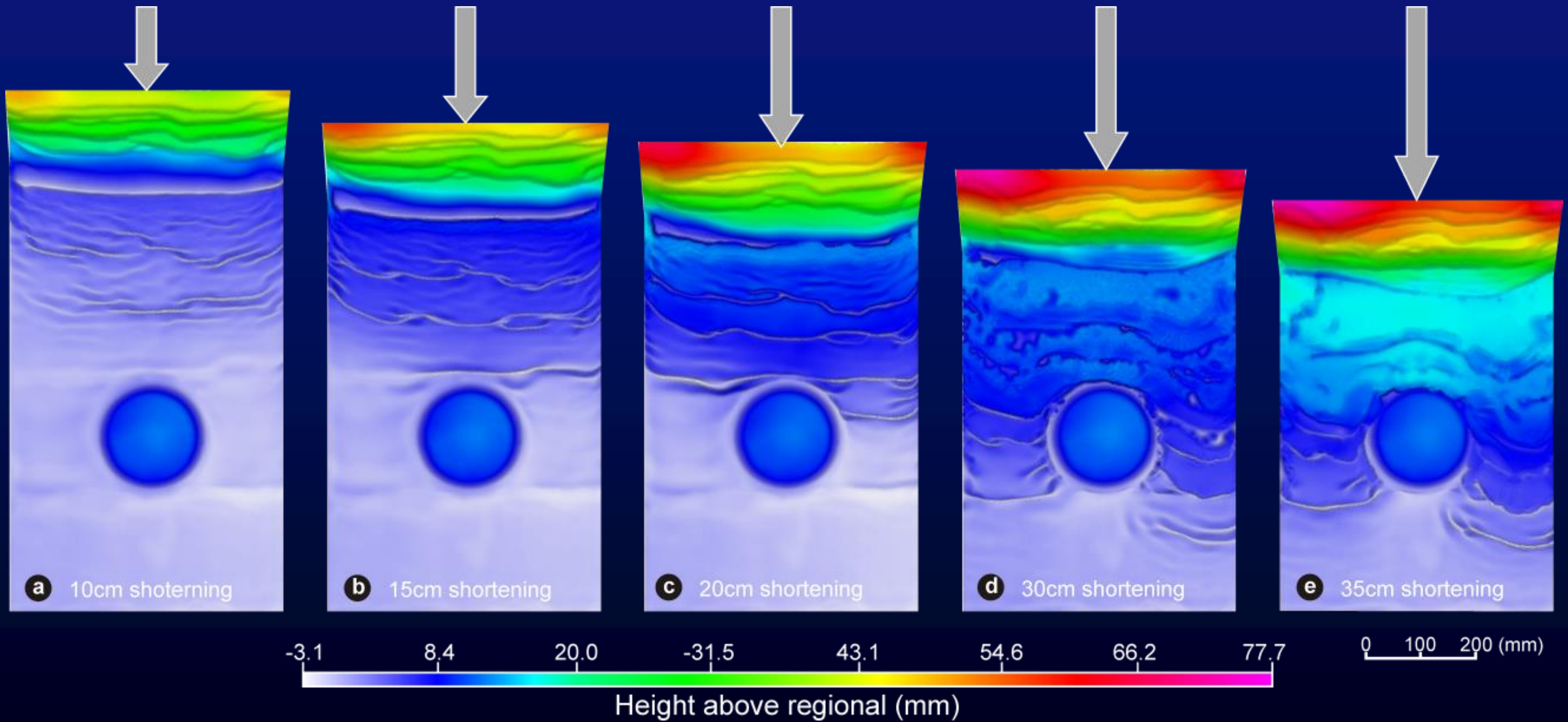
Experiment ESM01 topography evolution



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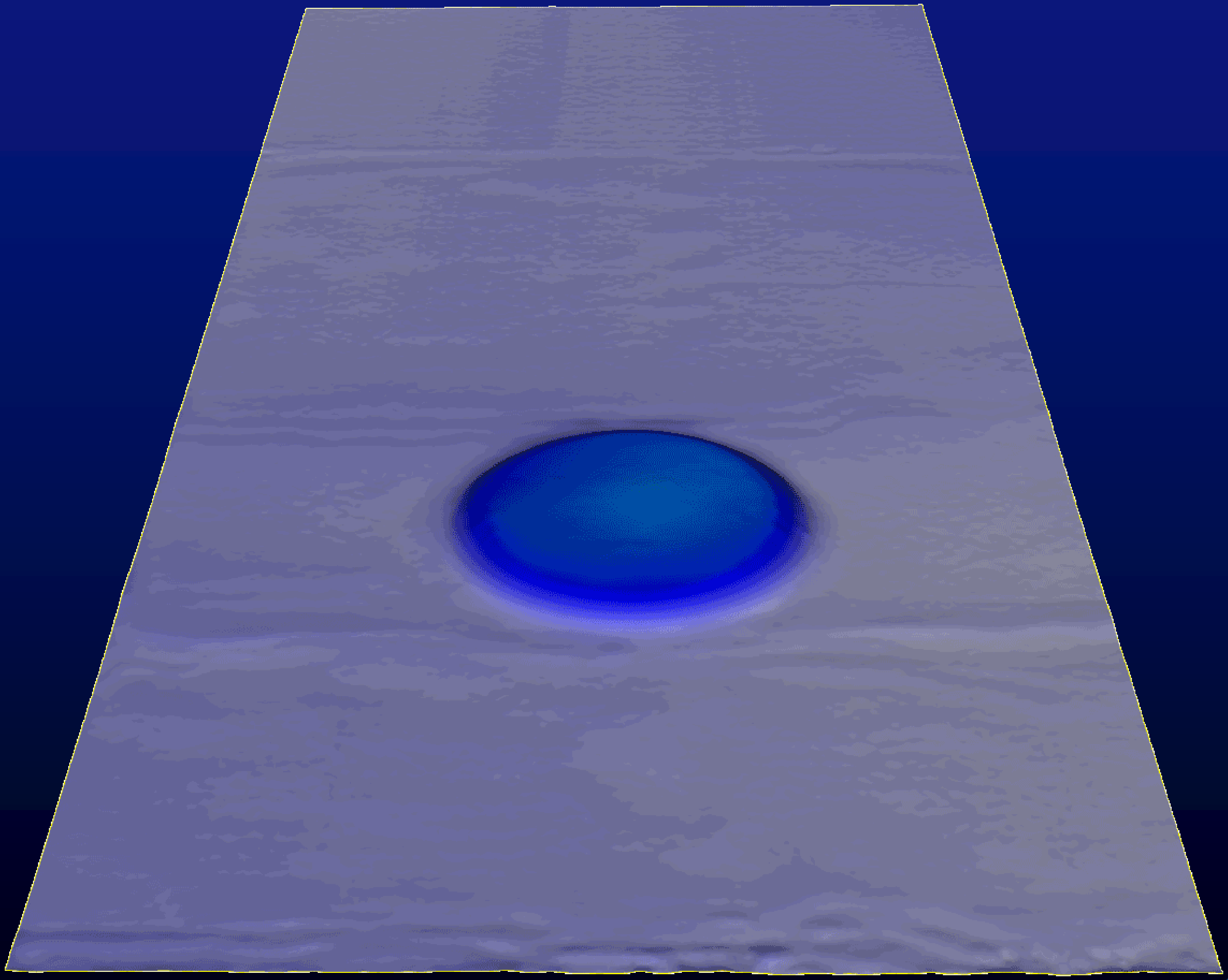
Experiment ESM01 topography evolution



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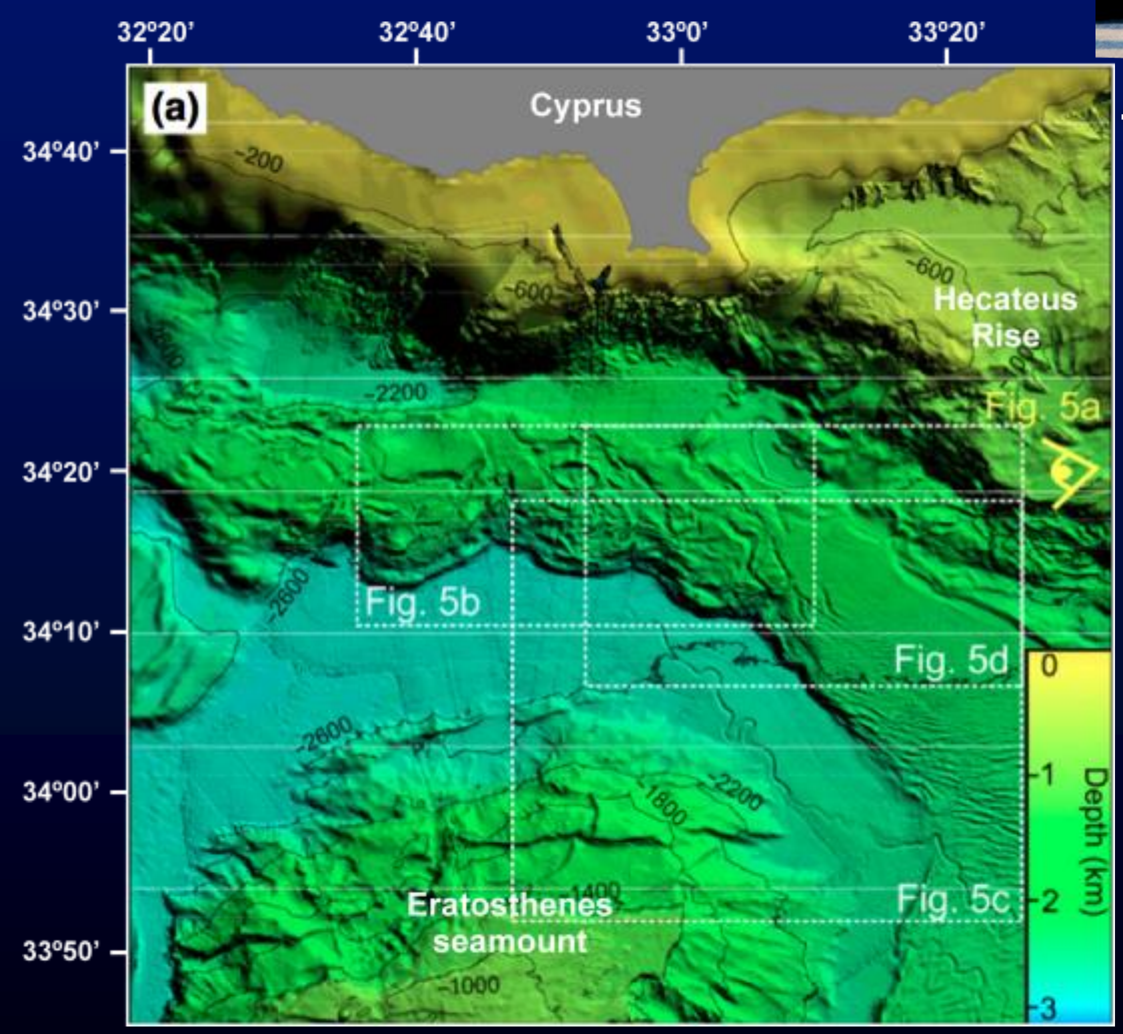
Comparison with natural examples

Experiment oblique view

Cyprus arc & Eratosthenes seamount



Reiche et al., 2015

Reiche et al., 2015

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Conclusions

- ***Using an experimental approach, this research shows that pre-salt "reliefs" in passive/active margins with presence of salt can develop interference structures that modify the regional architecture of the margin***

- ***The development of these structures is influenced by the geometry and position of the seamount apex respect the salt units (heigh of the reliefs)***

- ***Two main evolutionary stages have been identified in the Northwest Mediterranean:***

    - ***First episode without overthrusting of the cover***

    - ***Second episode with cover overthrusting & associated gravitational gliding***

- ***South of the Cyprus Arc the Eratosthenes Seamount acts as a buttress that enhances allochthonous salt inflation, fracturing and compartmentalization of the supra-salt sequence in multiple domains: fracture and pervasive compressional folding in the north, strike-slip around the seamount and extensional***

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Conclusions

- ***South of the Cyprus Arc the Eratosthenes Seamount acts as a buttress that enhances fracturing and compartmentalization of the supra-salt sequence in multiple domains:***

  - ***Fracture and pervasive compressional folding in the north,***

  - ***Strike-slip around the seamount ,***

  - ***Complex interference folding patterns from the seamount towards the East and South***

- ***The lateral transition from the Seamount towards the neighbouring basin is accommodated through a region of complex deformation in which strike-slip deformation gives room to arcuate-trend salt cored detachment folding***

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Thanks for your attention

Gravitational failure structures on asphalt heated by the Sun (Budapest)

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