Development of tectono-sedimentary mélanges in accretionary wedges : Insights from Analog Modeling

Genti, M.[1], Malavieille, J.[1], Molli, G.[3], Dominguez, S.[1], Taboada, A.[1], Vitale-Brovarone, A.[1,2]

[1] = Université Montpellier 2, CNRS UMR 5243, Lab. Géosciences Montpellier, 34095 Montpellier cedex 5, France and LIA-ADEPT 536 CNRS-NSC, France-Taiwan.
[2] = ISTEP, Université Paris 06-UPMC, UMR UPMC CNRS 7193, 4 place Jussieu, F-75005, Paris, France
[3] = Dipartimento di Scienze della Terra, Universita` di Pisa, Via S.Maria 53, I-56126 Pisa, Italy

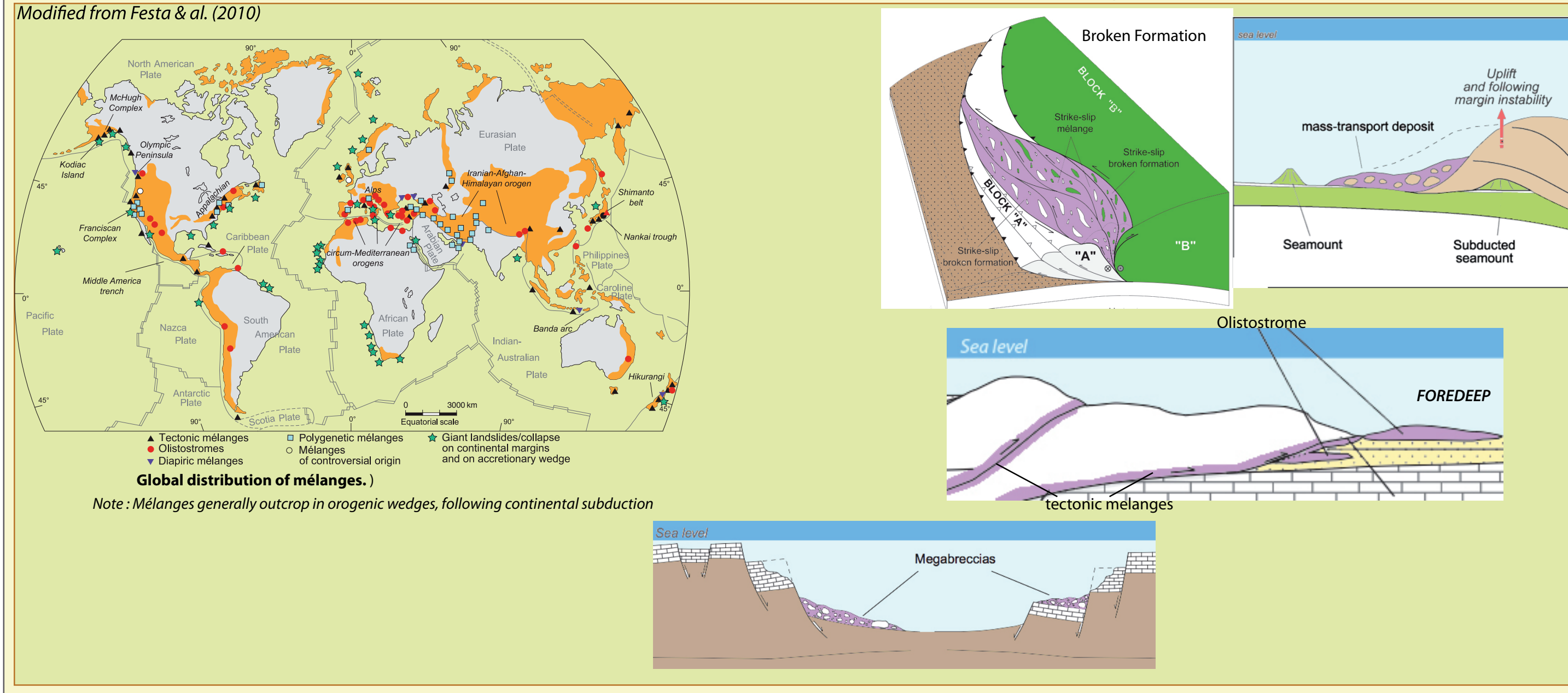
contact : *genti@gm.univ-montp2.fr*

Session TS4.1/GM3.5/SSP3.4: A443

Purpose :

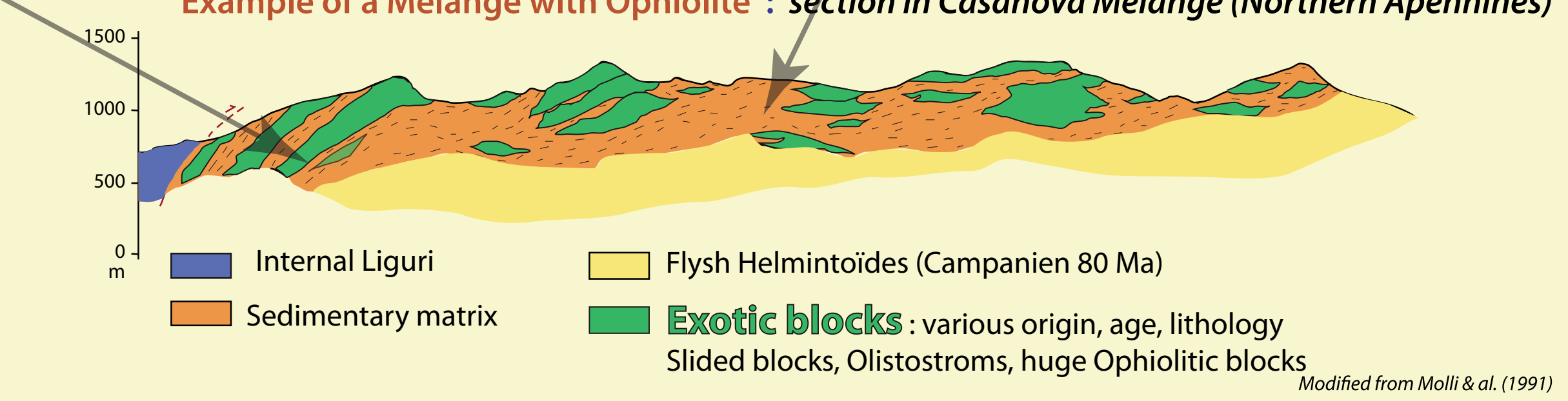
Orogenic wedges locally present chaotic tectonostratigraphic units that contain exotic blocks of various size, origin, age and lithology, embedded in a sedimentary matrix.

Mélange



Different processus and tectonic settings

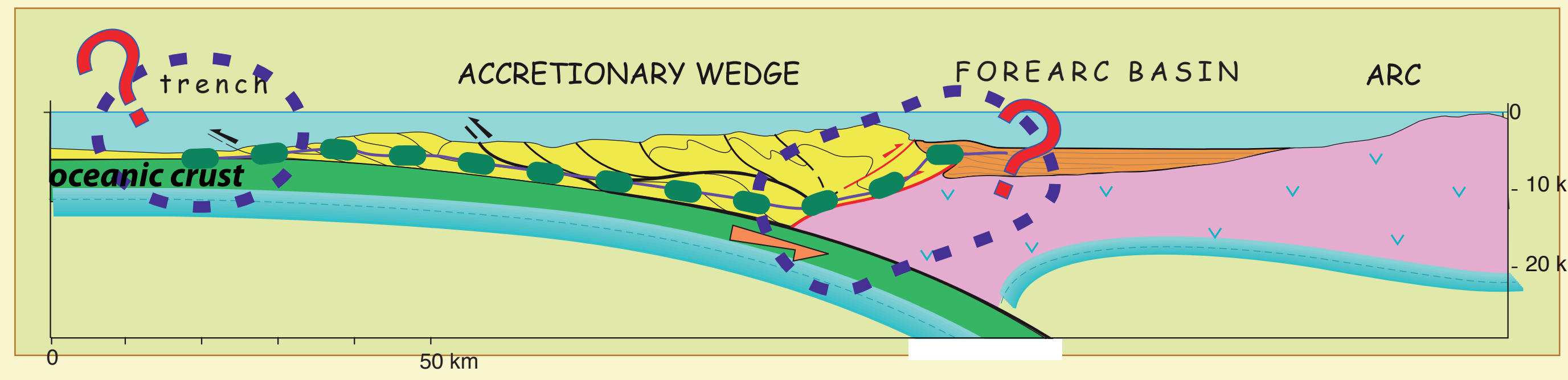
Example of a Mélange with Ophiolite : *section in Casanova Mélange (Northern Apennines)*



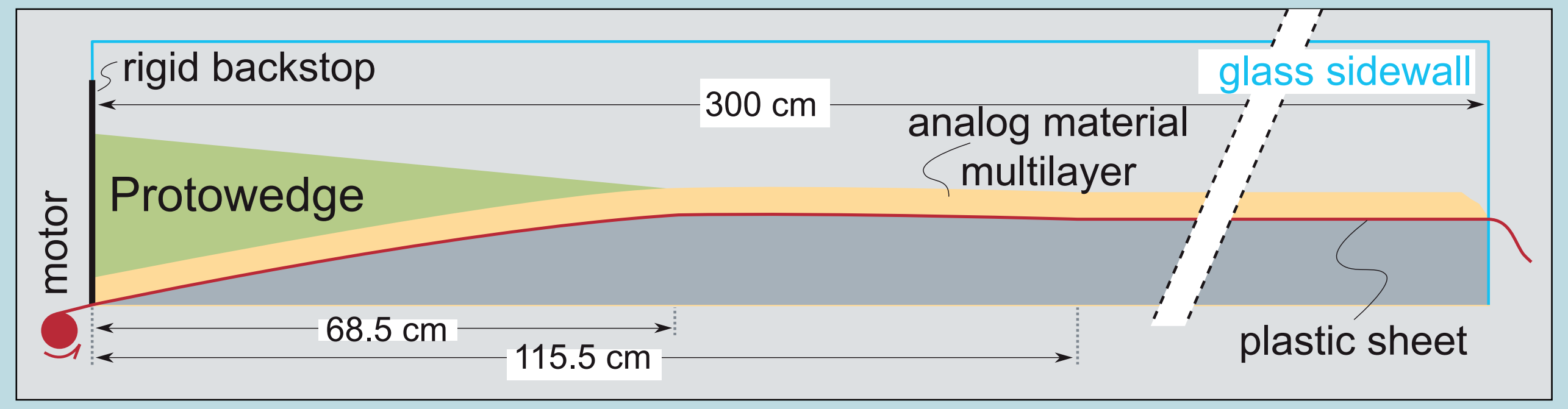
This study focus on tectono-sedimentary mélanges with **ophiolitic blocks**
like **Lichi Mélange** in Taïwan, and **Casanova Mélange** in Northern Apennines (fig.1).

?¿ Questions addressed: ?¿

*Mechanisms responsible for the **incorporation of ophiolitic rocks** in accretionary wedges ?*
*Mechanisms allowing **exhumation and redeposition** of these exotic elements in «tectono-sedimentary mélanges» during wedge growth ?*



Analog Modeling : interaction between tectonics-erosion-sedimentation



Sandbox device

A motor pulls on the plate a 10 cm wide plastic sheet with a rough surface simulating a high basal friction. Analogue materials are deposited on the sheet. They have frictional properties satisfying the Coulomb theory.

The shortening leads to the **development of the model thrust wedge** against a rigid backstop, with no subduction window at its base.

Erosion and sedimentation are performed regularly.

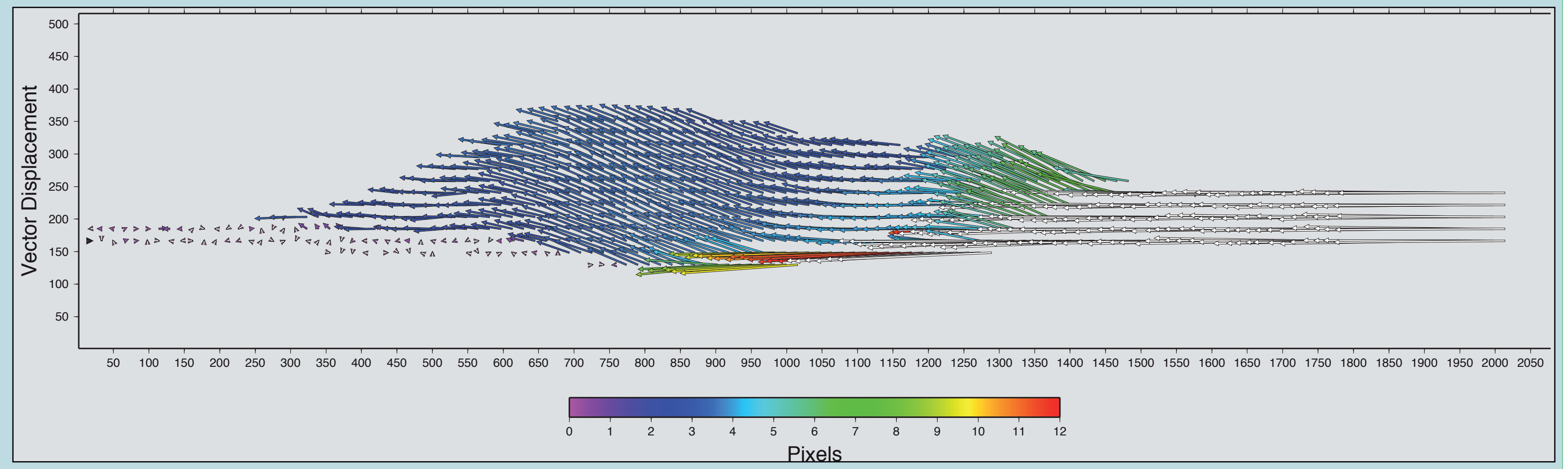


Image correlation and Vector displacement
One camera records all stages of the experiment, taking a picture each 5 mm of shortening. Thanks to a texture in the sand we use «ADAPTE» (ENVI/CEA/DASE, R.Binet 2010) and GMT software (develop with Dominguez, S.) to process each couple of pictures.

Discussion of experimental results :

Analog models allow a dynamic view of tecto-sedimentary processes associated to accretionary wedges development.

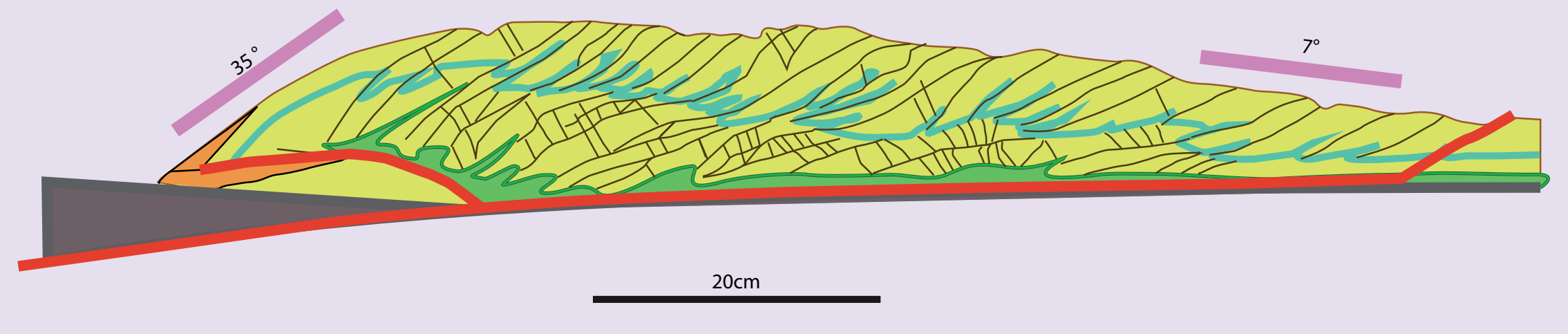
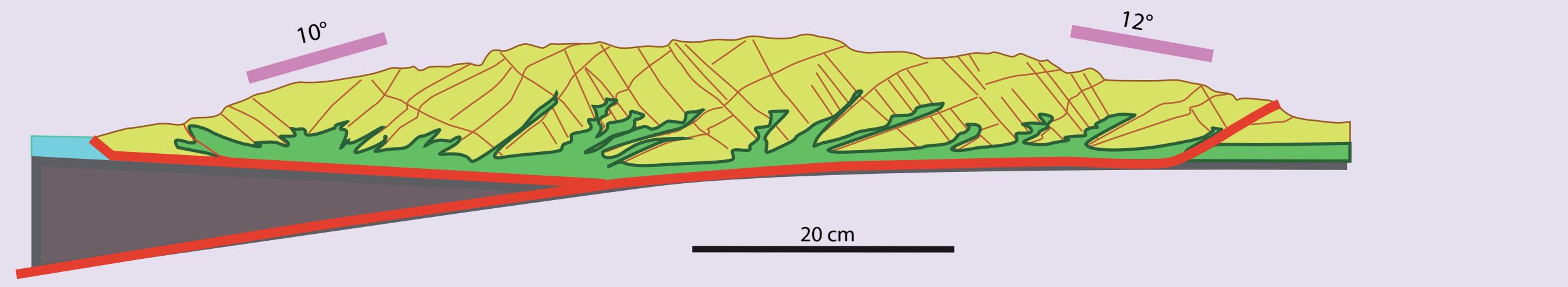
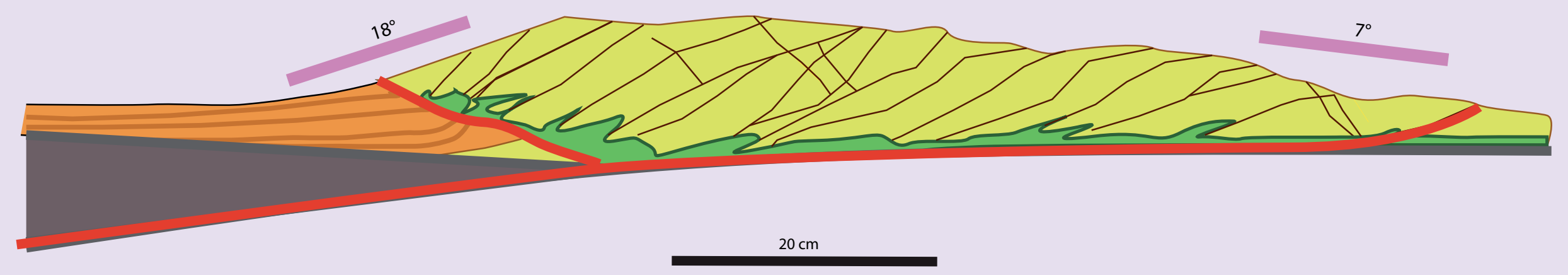
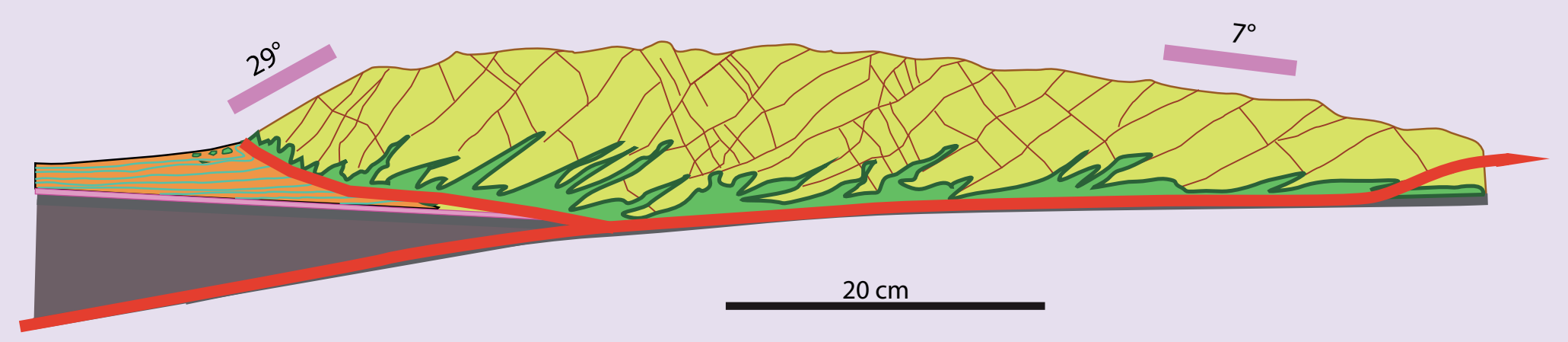
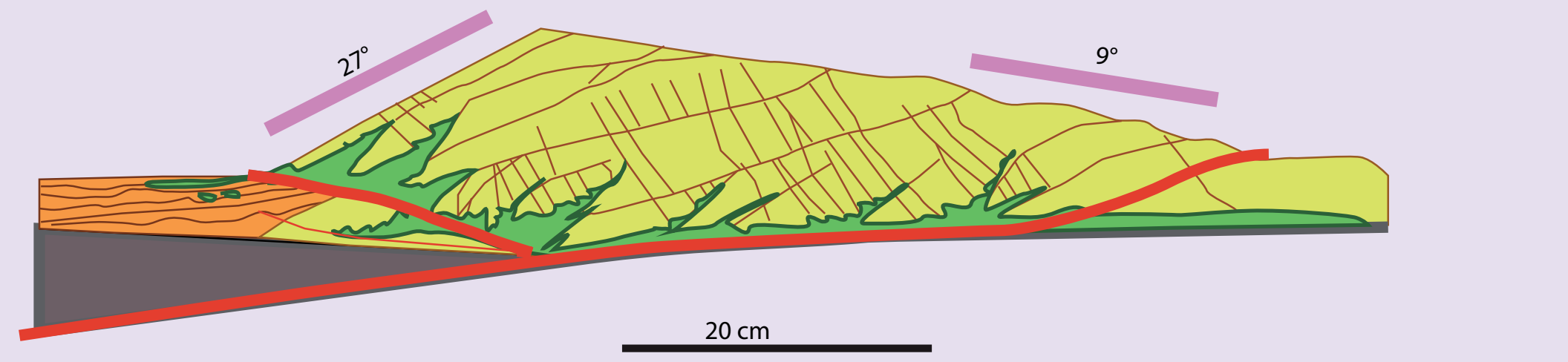
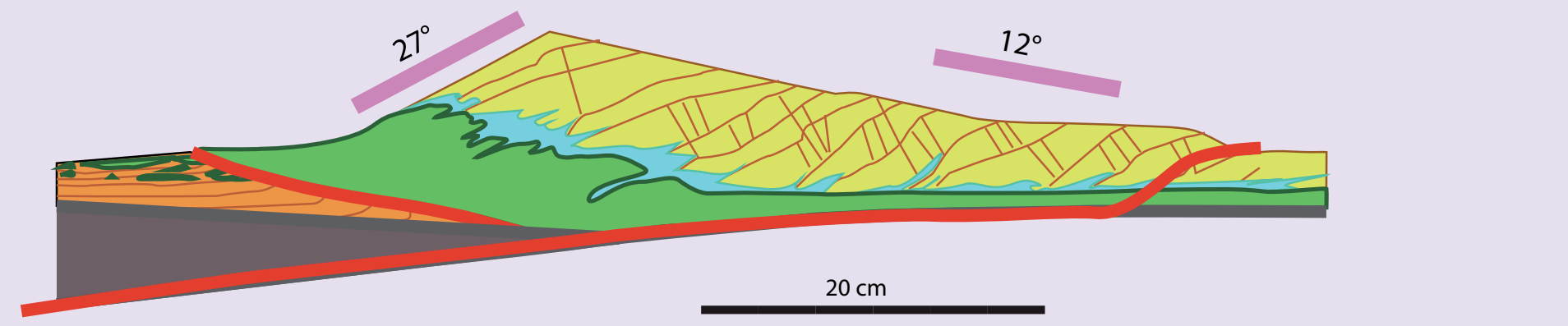
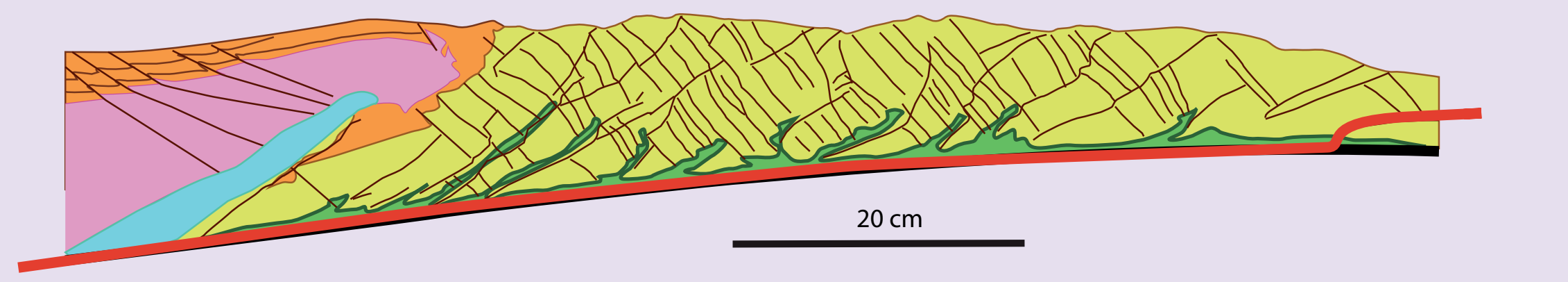
Insights from **premilinary results** suggest that the development of tectono-sedimentary mélanges with ophiolites requires a particular setting and boundary conditions :

- A steep retrowedge slope (requires a rigid backstop and with High Friction to develop),
- Important erosion,
- Few sedimentation,
- Exhumation of ophiolites is favored by backthrusting and erosion in the retrowedge,
- Erosion and the behavior of analog material exert an influence on the steepness of the backtrhust,
- Steepness of the backthrust can help the ophiolites to reach the surface of the retrowedge.

The tectonic evolution of the back part of a doubly vergent accretionary wedge is mainly controled by backthrusting and gravity driven surface processes in the retrowedge slope involving erosion.
This **erosion allows exhumation of the ophiolitic fragments** formerly accreted at the base of the wedge and then reworked as tectono-sedimentary «mélanges» redeposited in proximal basins located at the base of the retrowedge slope. These basin deposits are then continuously involved in backthrusting induced deformation.

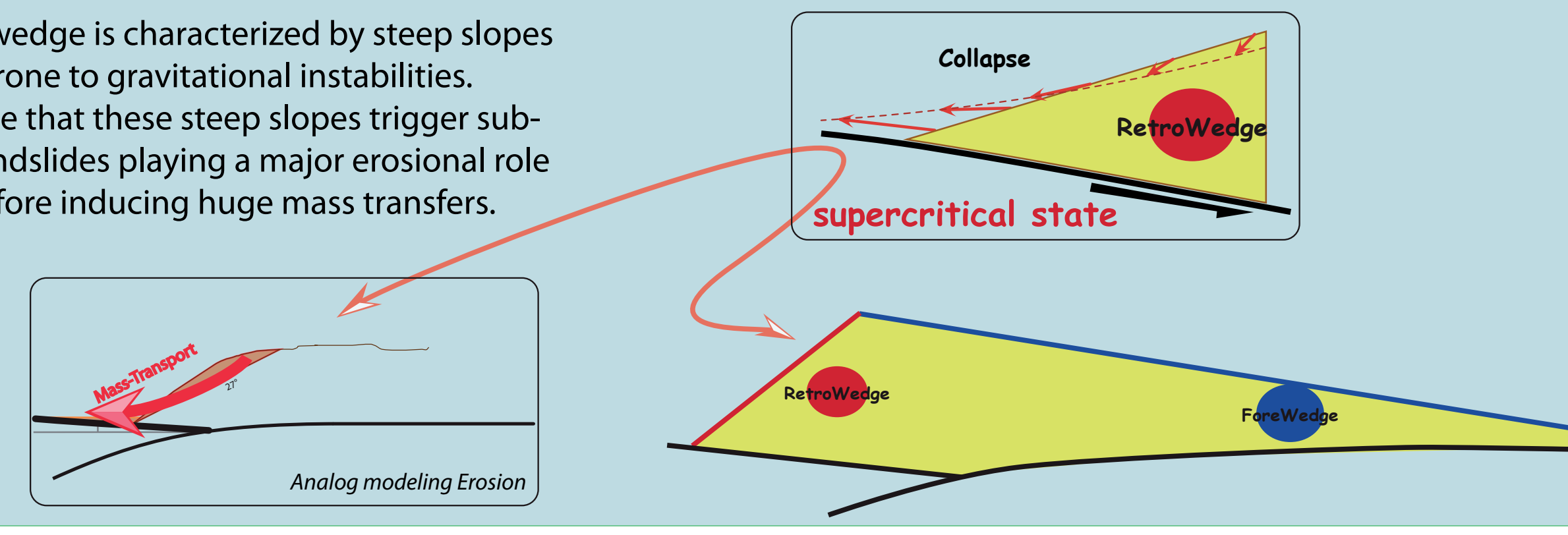
Experimental results :

Please have a look at the movies

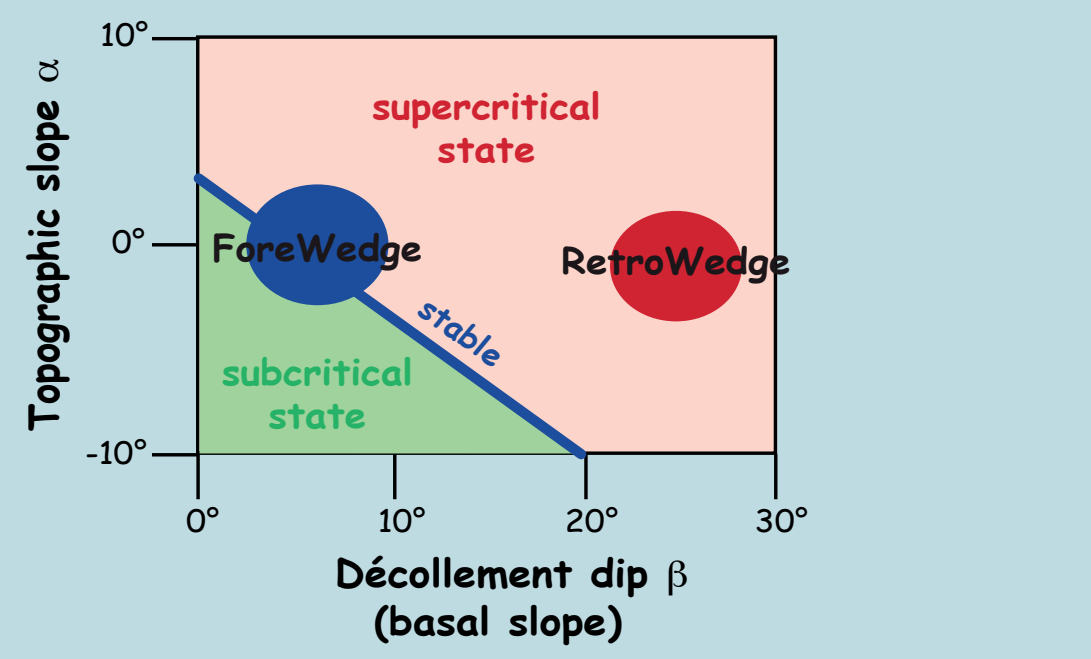
Backstop : Rigid, High Friction Material : Sand & Glass beads Erosion : No Sedimentation : No Shortening : 160 cm		Development of a doubly vergent wedges with differents slope angles : retrowedge slope is steeper than forewedge During the growth : the steep retrowedge slopes exceed the value of angle of internal friction, triggering erosion by gravitational collapse. The retrowedge overlap the newly deposited material thanks to the backthrust . Deformation partitioning occurs in the forewedge due to décollement layer "Model ophiolites" do not reach the surface
Backstop : Rigid, Low Friction & Glass beads Material : Sand Erosion : No Sedimentation : No Shortening : 170 cm		Development of a doubly vergent wedge with similar slope angles No gravitational instabilities Backthrusting develops following the surface of the low friction low angle slope backstop Large backthrusting favor development of a wide retrowedge. "Model ophiolites" do not reach the surface
Backstop : Rigid, High Friction Material : Sand Erosion : each 4 cm of shortening Sedimentation : each 2 cm of shortening Shortening : 150 cm		Development of a doubly vergent wedge : steep slope retrowedge affected by erosion. Backthrust dip angle reflect Mohr Coulomb behavior. "Model ophiolites" goes up thanks to backthrusting but sedimentation in the basin does not allow complete exhumation and deposition in the basin
Backstop : Rigid, Low Friction & 0,5 cm Silica powder Material : Sand Erosion : each new frontal accretion Sedimentation : 1/2 replace quantity eroded by Glass beads in bassin Shortening : 164 cm		Development of a doubly vergent wedge : The steep slope retrowedge is submitted to erosion. Erosion of retrowedge slightly modify forewedge growth. Backthrust dip increases when basin develops. At 60cm shortening, "model ophiolites" are exhumed and reach the surface in the retrowedge, then they are redeposited in the bassin.
Backstop : Rigid, High Friction Material : Sand Erosion : each 4 cm of shortening Sedimentation : No Shortening : 176 cm		Development of a doubly vergent wedge : steep slope retrowedge affected by important erosion. First, a low dip angle bakthrust develops during initial filling of the trench, it is then replaced by a major backthrust that is continuously active during shortening. At 136cm shortening, "model ophiolites" are exhumed and reach the surface in the retrowedge, then they are redeposited in the bassin.
Backstop : Rigid, High Friction Material : Sand & Glass beads Erosion : each 4 cm of shortening Sedimentation : No Shortening : 180 cm		Development of a doubly vergent wedge : steep slope retrowedge affected by erosion. Backthrust dip angle does not reflect Mohr Coulomb behavior, it's steepless due to the erosion Deformation partitioning occurs in the wedge due to the presence of a décollement layer in the incoming sequence. Décollement induces basal accretion and favor underplating of "model ophiolites". A large amount of "model ophiolites" reach the retrowegde surface at 80 cm of shortening allowing redeposition in the basin.
Backstop : Deformable, Silica powder & Glass beads Material : Sand Erosion : No Sedimentation : each 2 cm at the beginning Shortening : 176 cm		The wedge does not present a classical shape. Part of the material is underthrusted below the deformable backstop. Due to high basal friction, numerous backthrusts develop. The deformable backstop and the basin are involved in retrowedge deformation "Model ophiolites" never reach the surface

Why do we perform erosion of the retrowedge ?

The retrowedge is characterized by steep slopes that are prone to gravitational instabilities.
We assume that these steep slopes trigger submarine landslides playing a major erosional role and therefore inducing huge mass transfers.



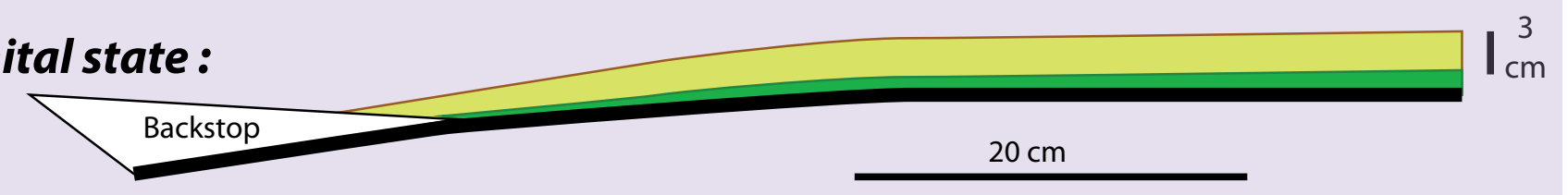
Wedges mechanical state



Modified from Willett (1992) & Hickman et al. (2002)

Legende :

Inital state :



Analogue material :

🟨 Aeolian Sand (Mohr Coulomb)
🟪 Silica powder (Cohesive)
🟦 Glassbeads (weak décollement layer)

Interpretation :

🟩 Ophiolites (part of oceanic crust accreted)
🟧 Basin (reception of Mass deposit, arc and trench sedimentation)
━ Actifve Backthrust — Backthrust — Fault