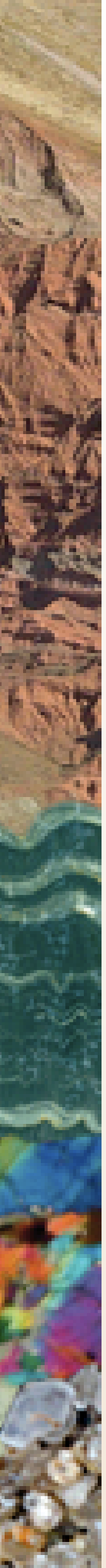

micro-macro Mechanical Investigation of Soil Behavior

CeiBA - TECHNE

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(3) An example: Yielding of cemented granular materials

Motivation

Soil behavior can be described using different approaches

(1) Continuum approach:

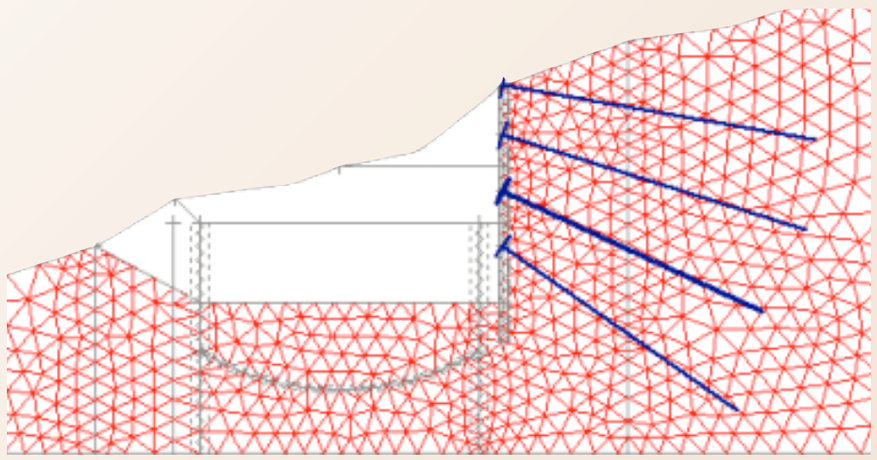

Image from: FINE - Civil Engineering Software - GEO5

- Practical for solving real problems

- The physical meaning of some variables is not always clear

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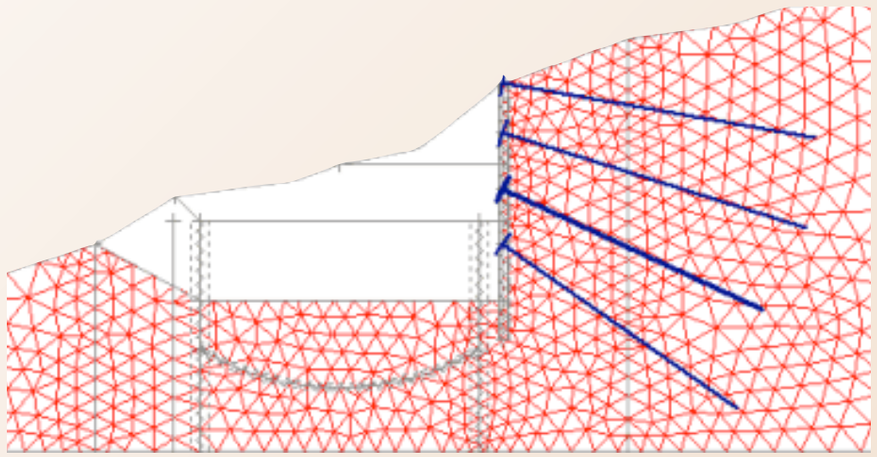

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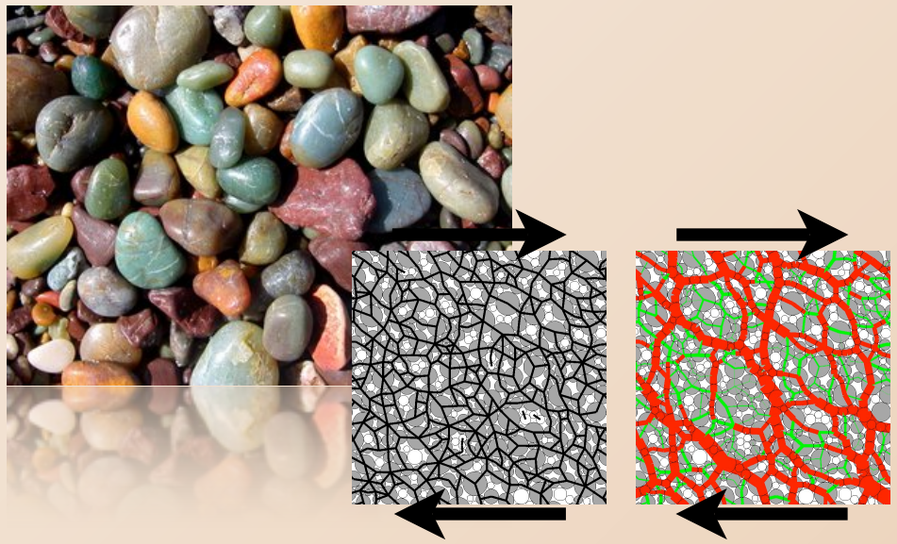

- Useful to understand what is happening at the grains scale

- The simulation of a problem with a realistic number of grains would be extremely time consuming

Motivation

Soil behavior can be described using different approaches

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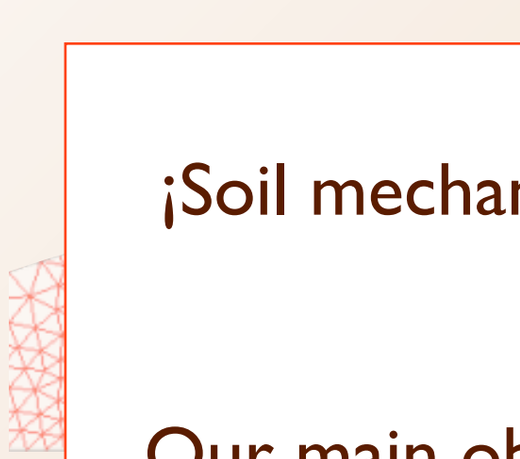

Imag

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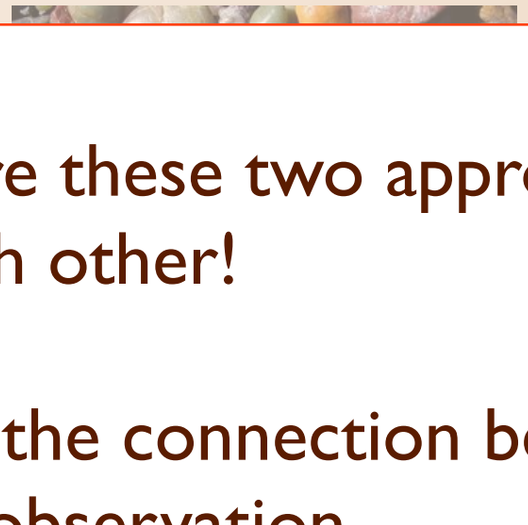


is happening at the grains scale

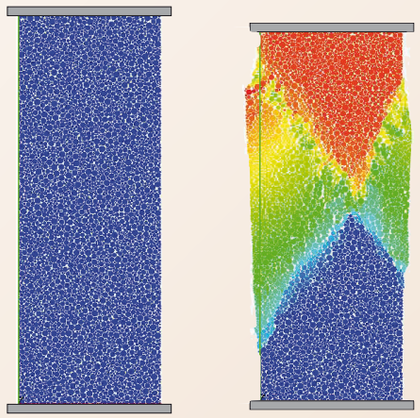
- The simulation of a problem with a realistic number of grains would be extremely time consuming

¡Soil mechanics is a domain where these two approaches complement each other!

Our main objective is to explore the connection between these two scales of observation

Problems studied in the group

- Strain localization



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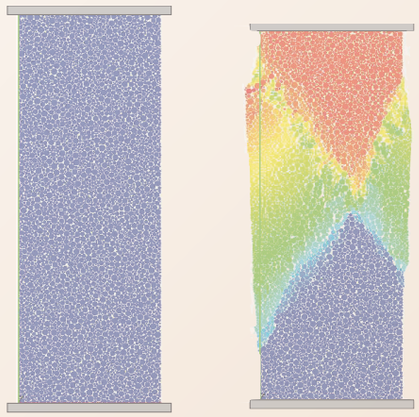
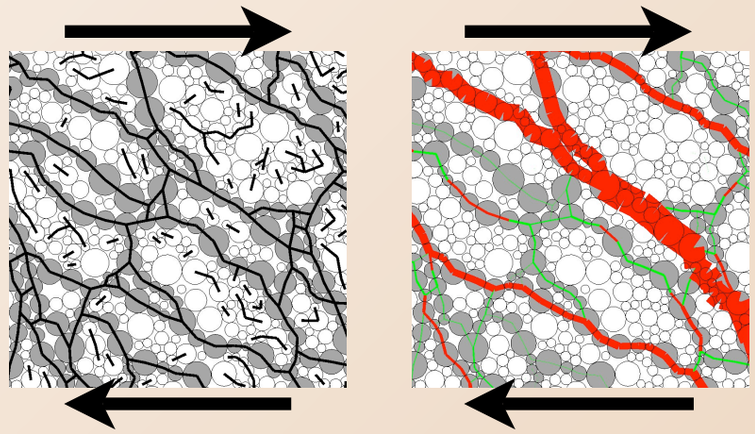


- Anisotropy in granular materials



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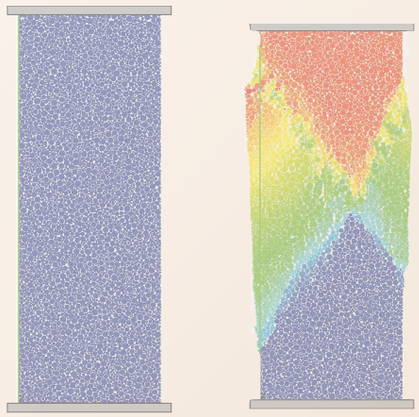

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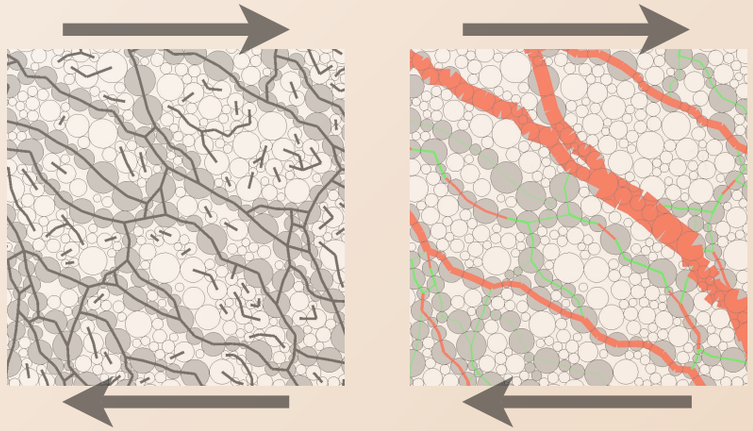

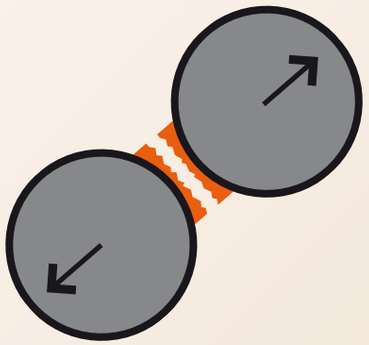

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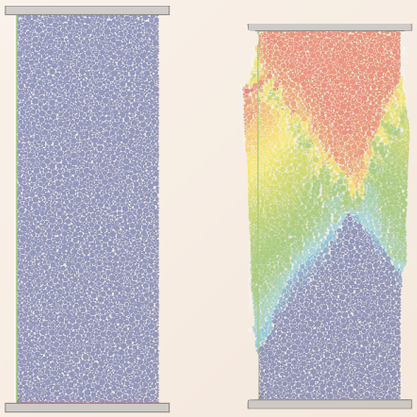

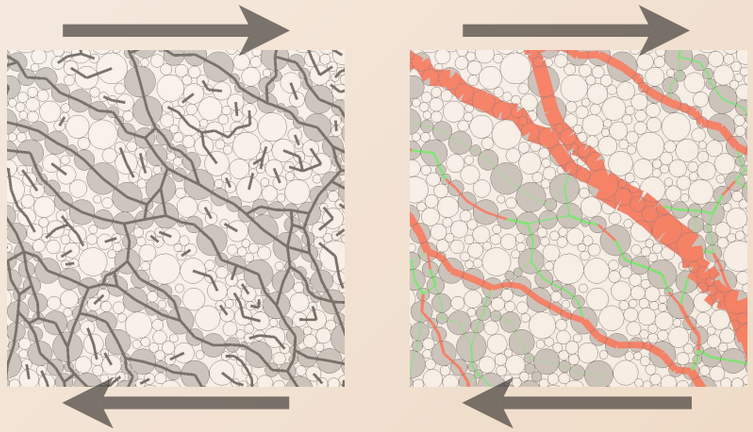

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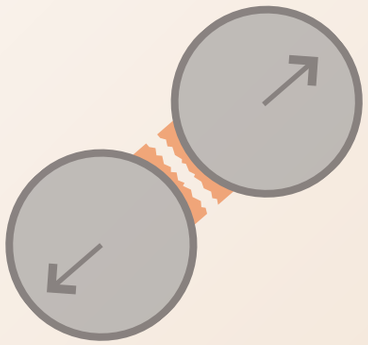

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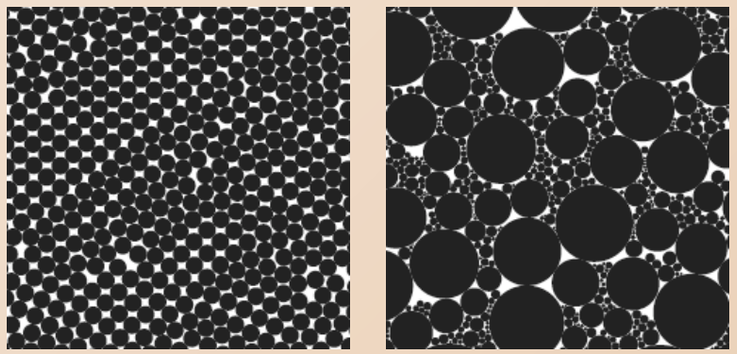

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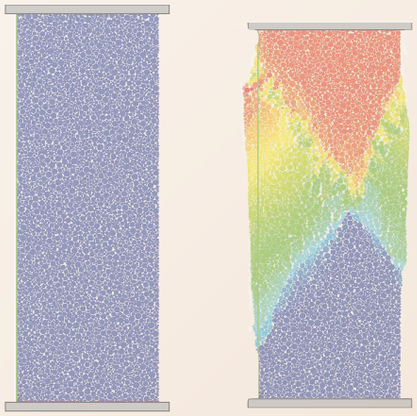

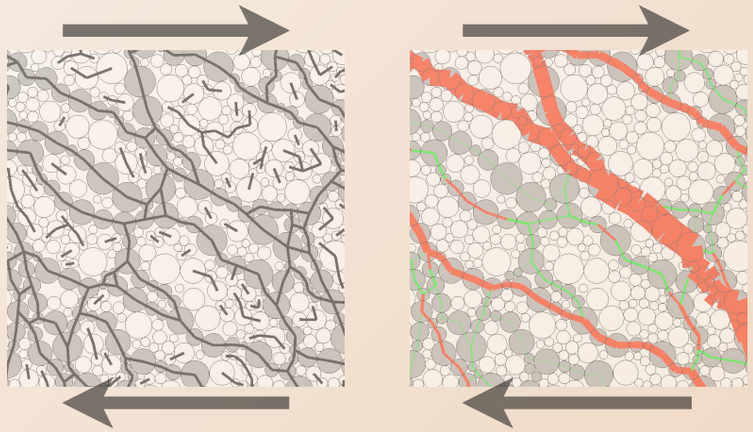

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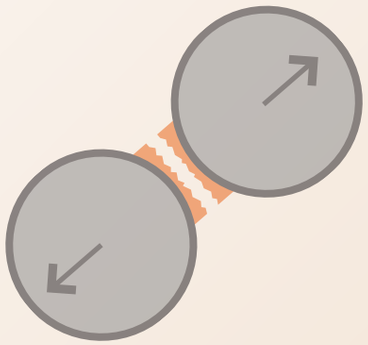

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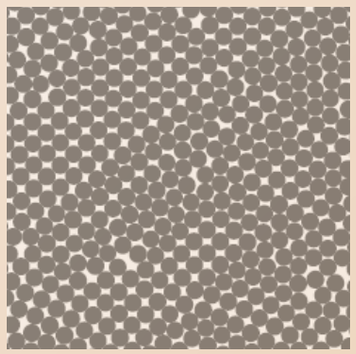

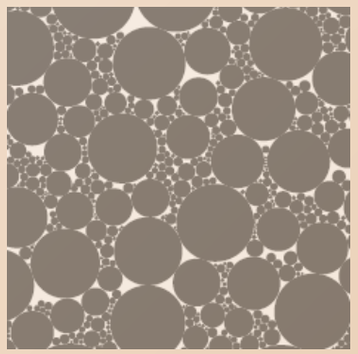

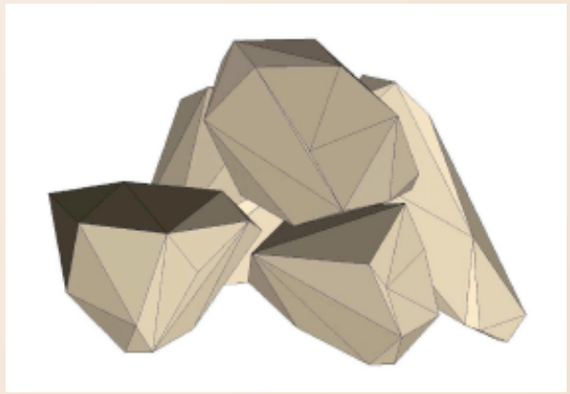

- Effect of the grains shape

Problems studied in the group

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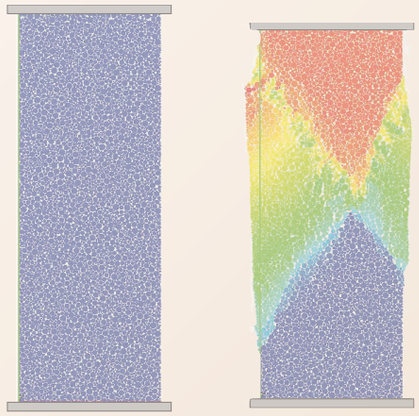

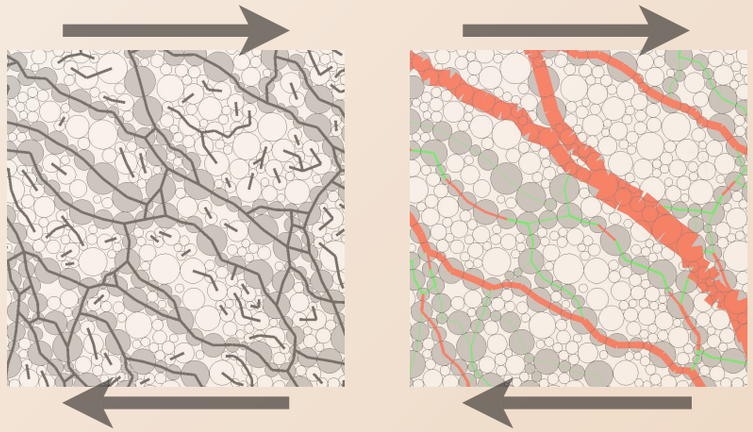

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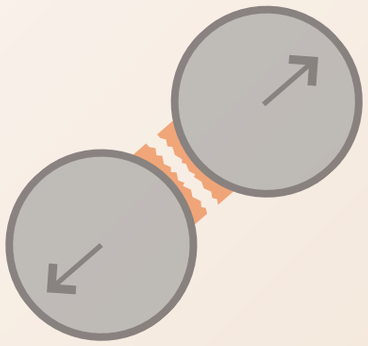

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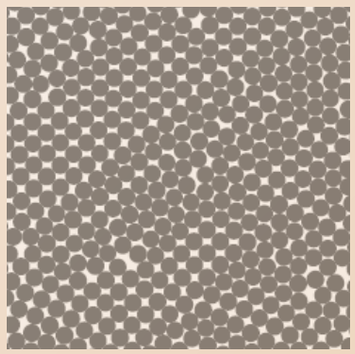

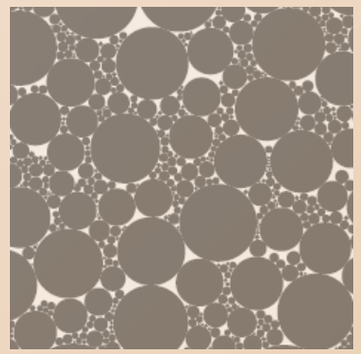

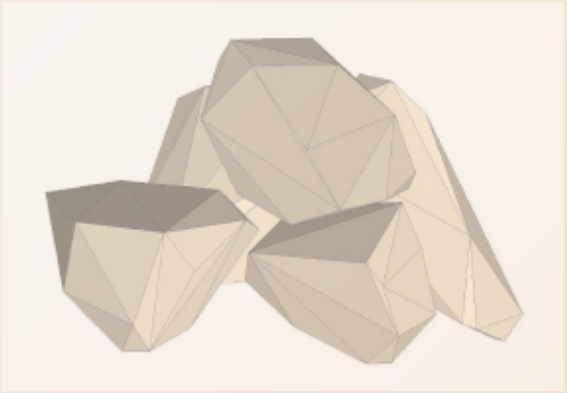

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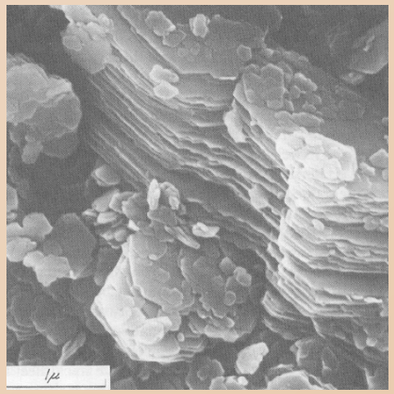


- Granular media composed of “small” particles (clays)

An example:

Yielding of cemented granular materials

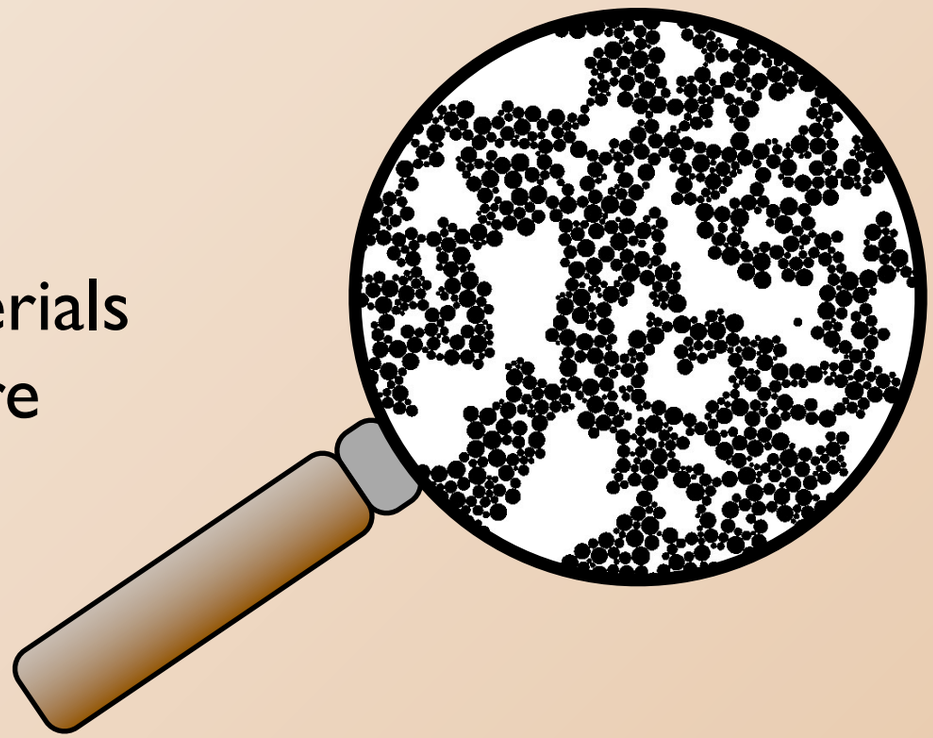
Cementation is a common property among geomaterials:

Steep slopes in volcanic ash soils near Manizales

Cementation is a common property among geomaterials:

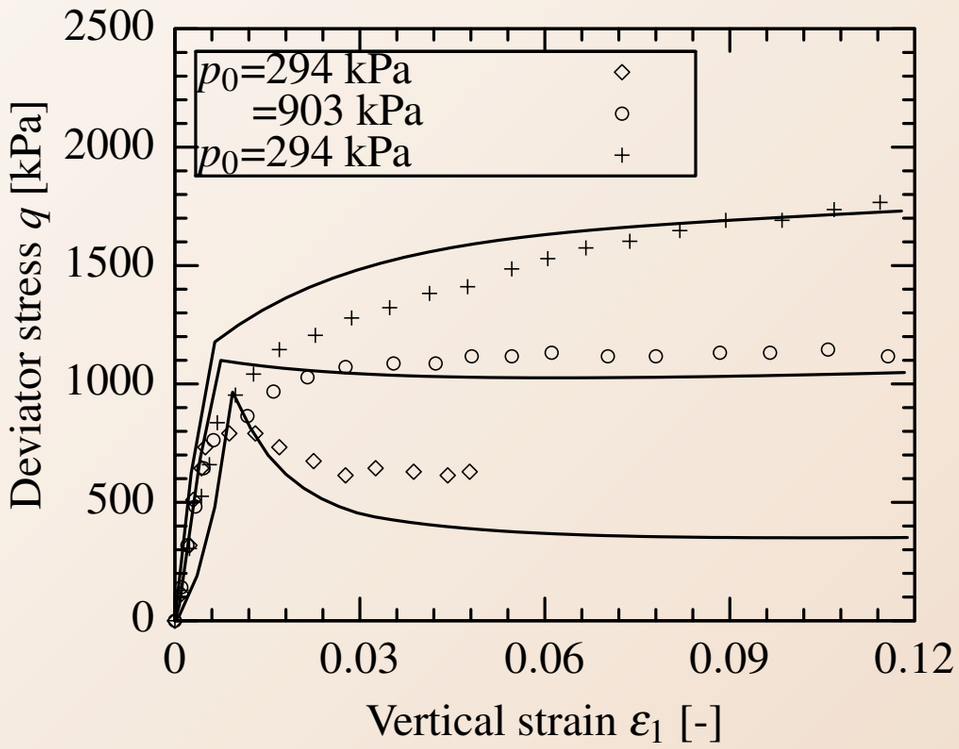
Steep slopes in volcanic ash soils near Manizales

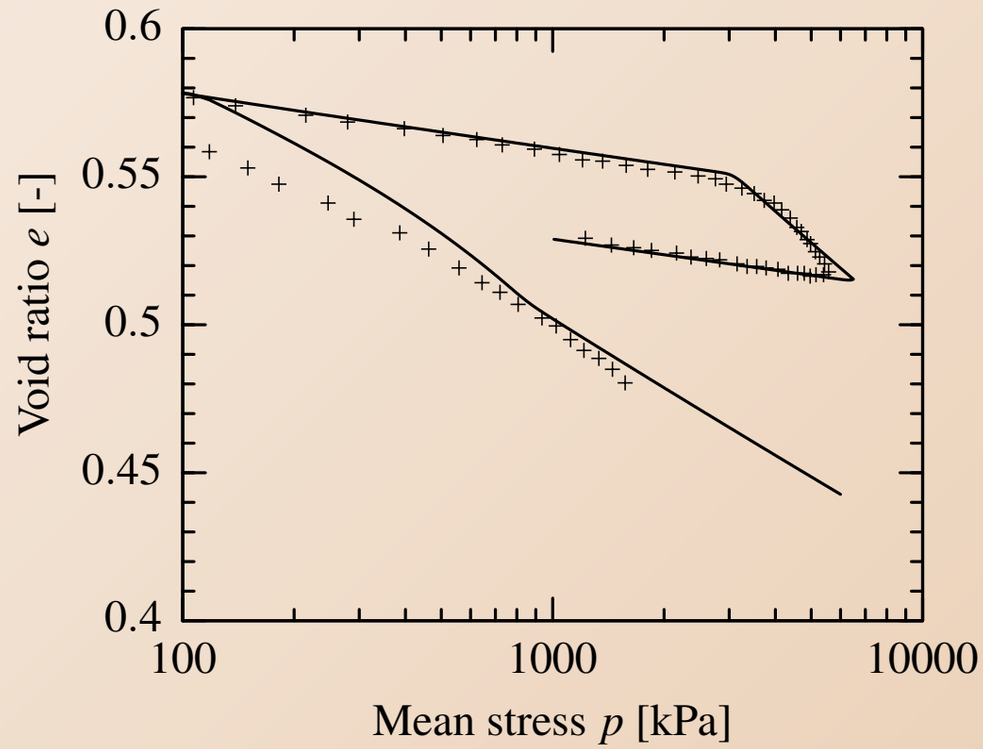
The mechanical description of these materials is not a simple task ⟹ Soil structure



Several Macroscopic models exist:

(*Vatsala et al 2001, Nova et al 2003, CeiBA 2009*, etc.)

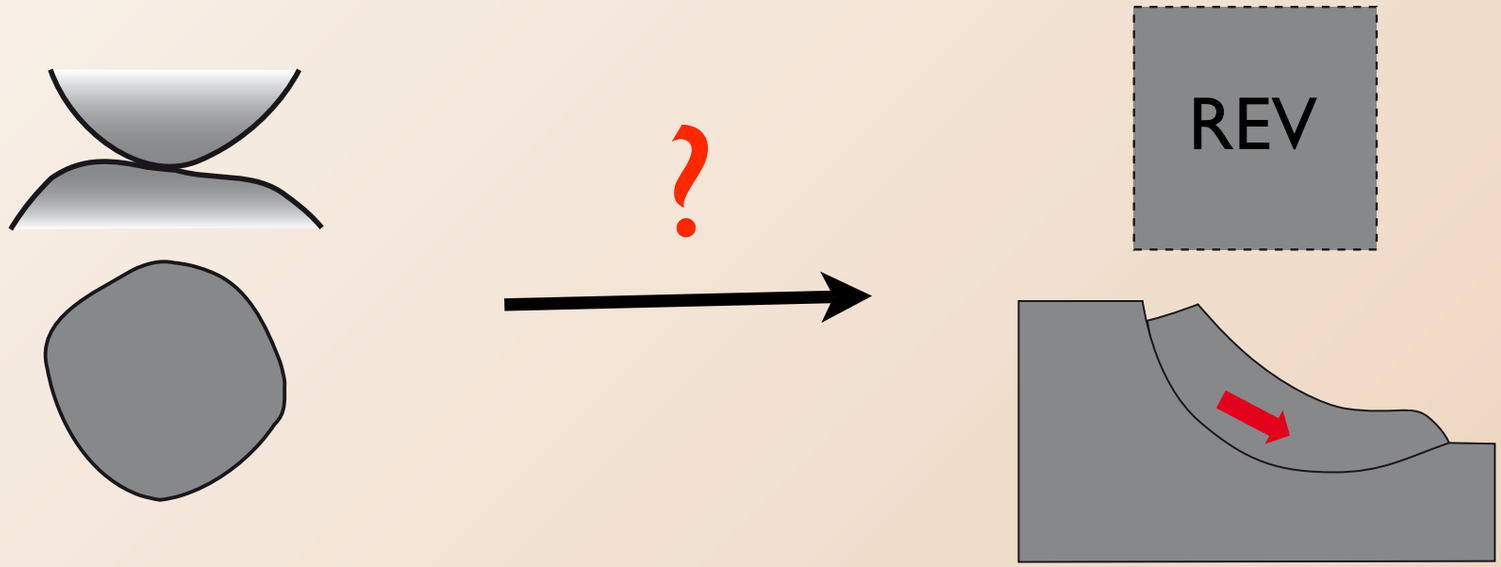




$$\overset{\circ}{\mathbf{T}} = f_b \hat{L} : (\mathbf{D} - \mathbf{D}^v)$$

Fuentes 2009, Simulation of a cemented granular soil using a modified Visco-hypoplastic constitutive model

However, little is known about what is really happening at the grains scale



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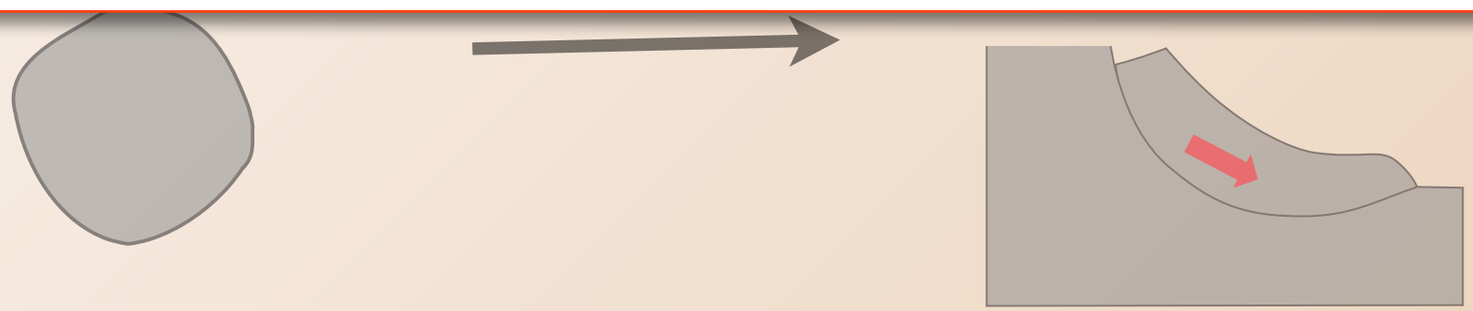
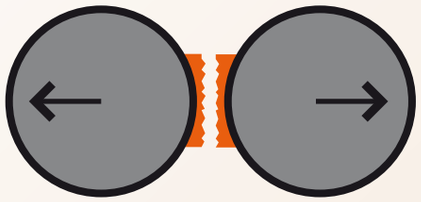
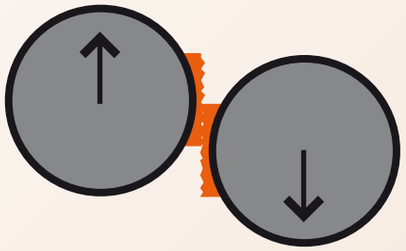
¡A privileged analysis tool: Discrete Element Methods!



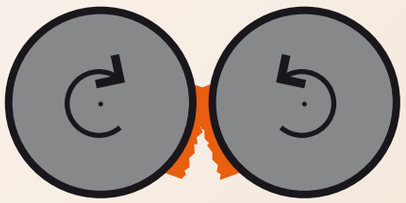
Cementation model:



$$f_n \geqslant -f_a$$

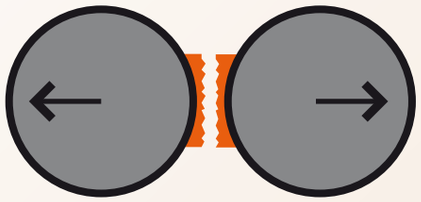


$$|f_t| \leqslant f_t^{max} \longrightarrow \textit{(Coulomb's friction law)}$$



$$|M| \leqslant M^{max}$$

Cementation model:



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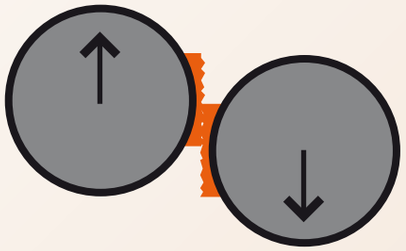

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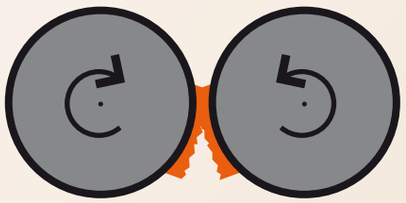
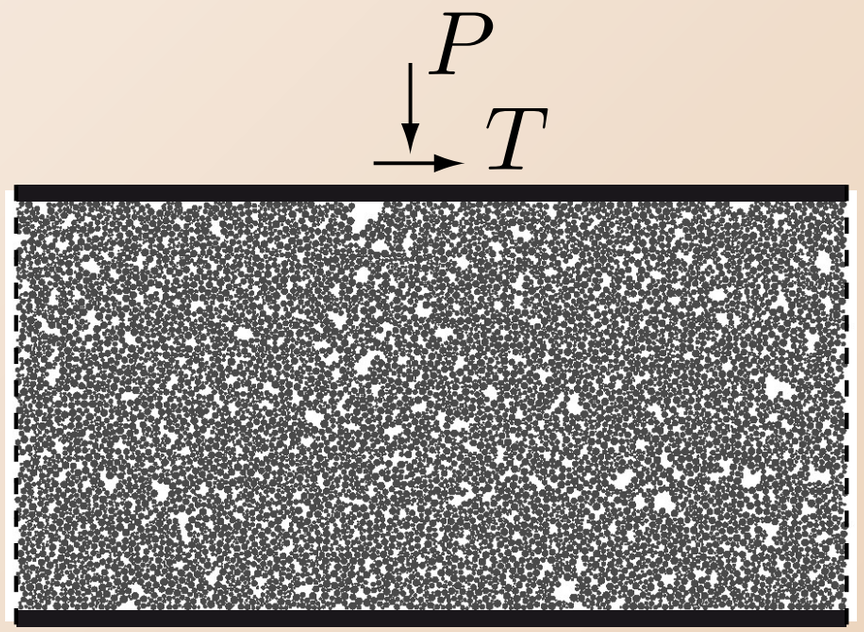
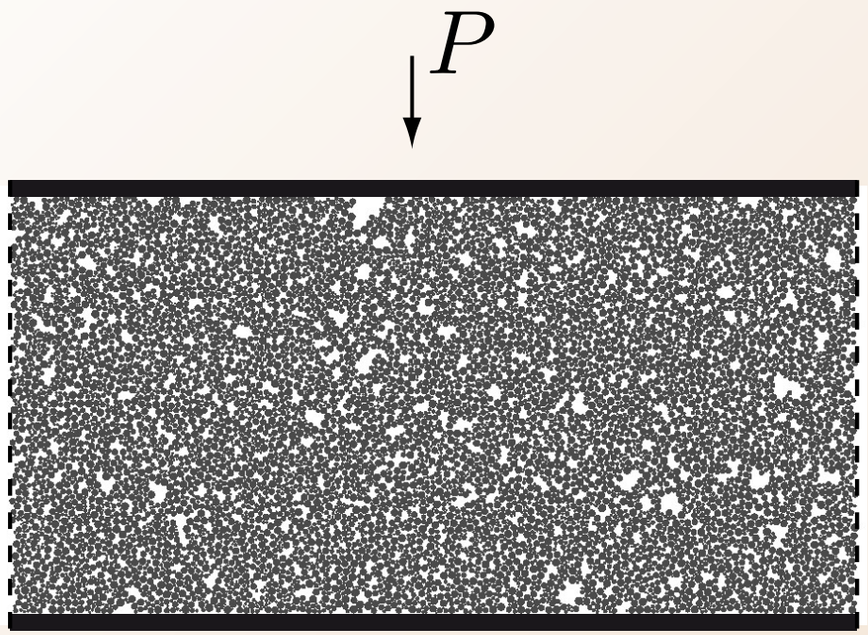


$$|M| \leqslant M^{max}$$

Simple shear device:

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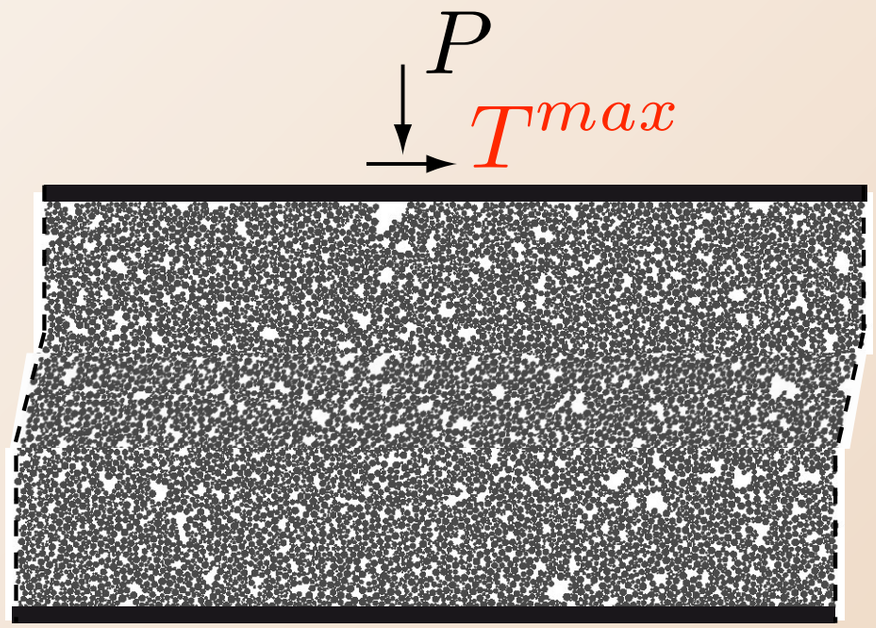
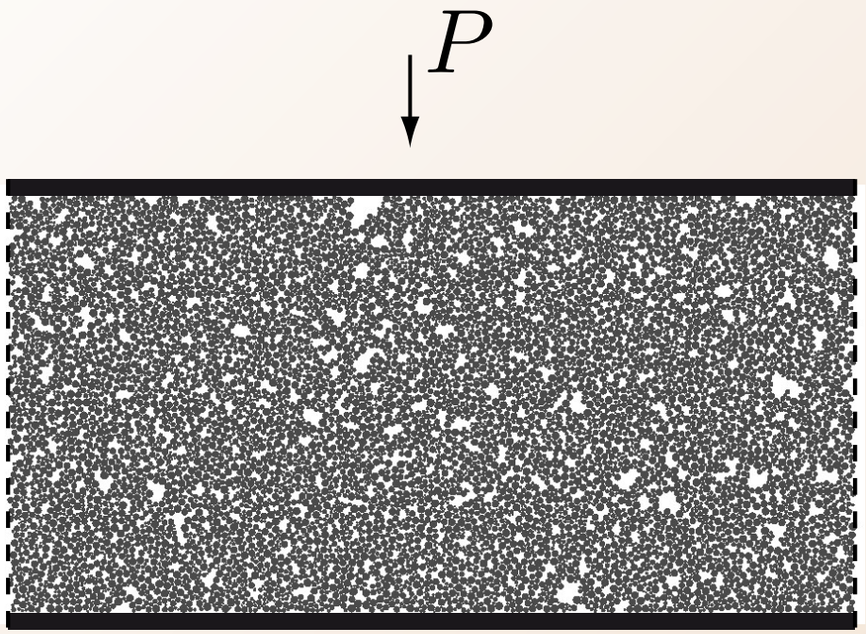
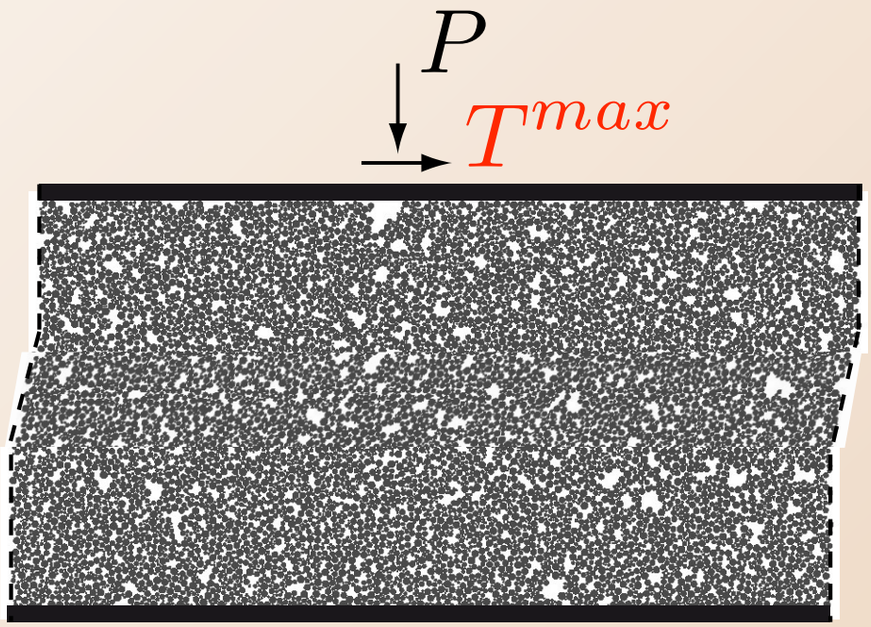

P
T^{max}





¿What are the micro-mechanical conditions that trigger yielding in this material?

→ Yielding Precursors

It is useful to define three objects:

- Critical contacts
- Mobile particles
- Mobile regions

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Critical contacts:

$$f_n = -f_a \quad \text{or} \quad |f_t| = f_t^{max} \quad \text{or} \quad |M| = M^{max}$$

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Particles whose contacts are all critical contacts

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Mobile particles:

Particles whose contacts are all critical contacts

Mobile regions:

Mobile particles + voids that surround them

It is useful to define three objects:

- Critical contacts
- Mobile particles
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¡Mobile regions are zones where plastification in imminent!

Mobile particles:

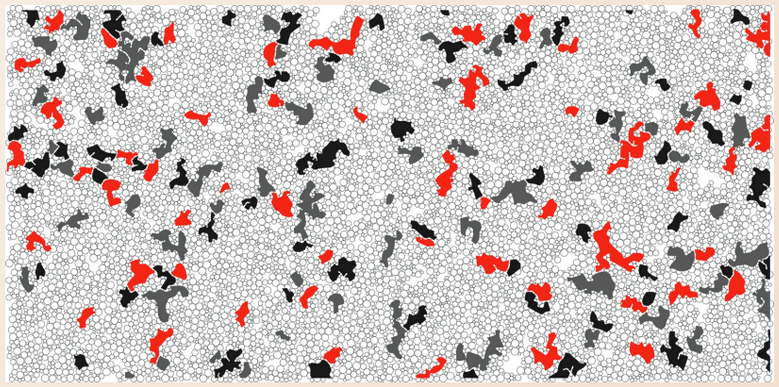
Particles whose contacts are all critical contacts

Mobile regions:

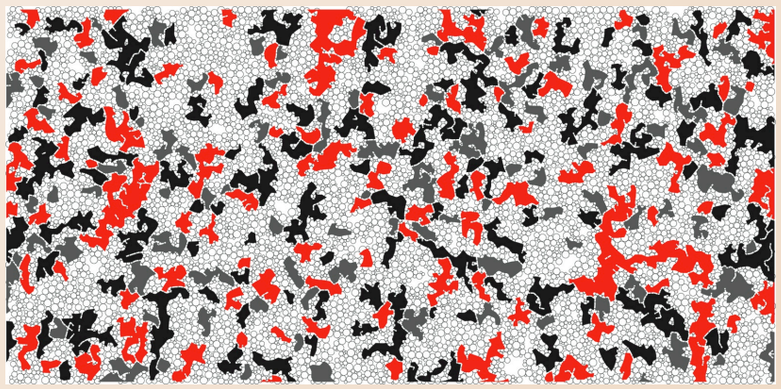
Mobile particles + voids that surround them

When increasing the load T from 0 to the yield condition T^{max}

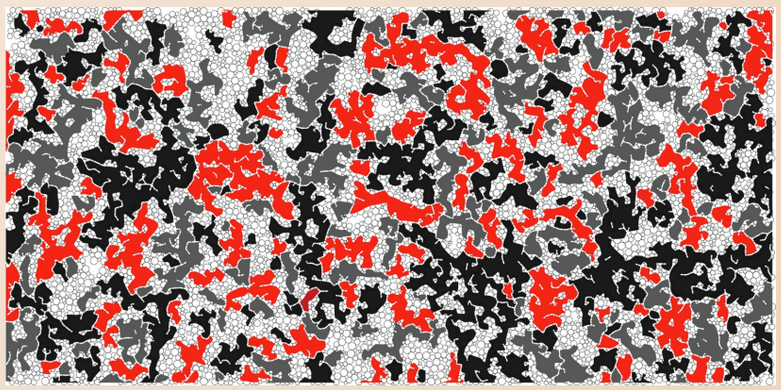
$T = 0.25\ T^{max}$



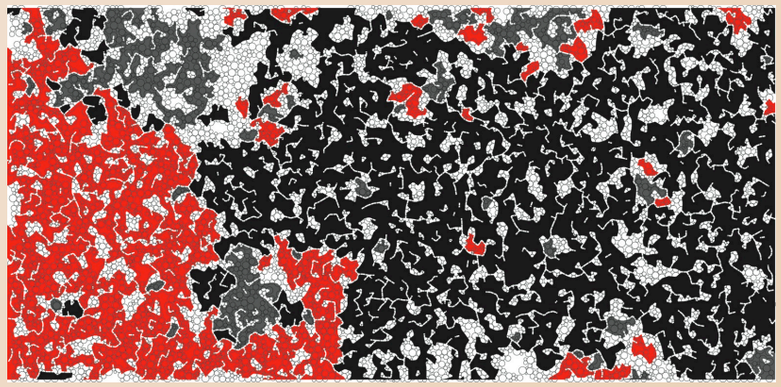
$T = 0.5\ T^{max}$



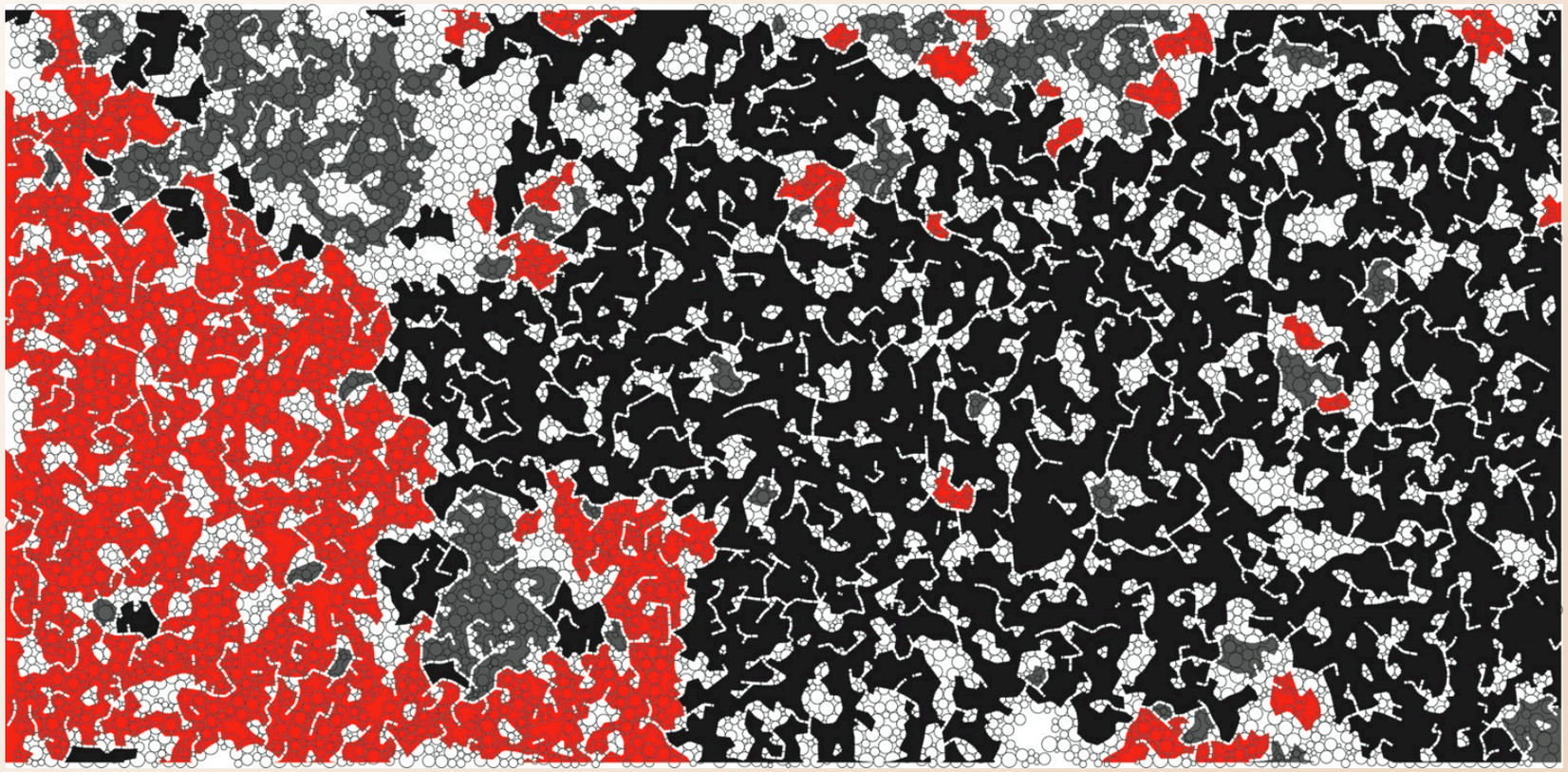
$T = 0.75\ T^{max}$



$T = T^{max}$



$$T = T^{max}$$



Yielding can be explained as the percolation of the condition here called “mobility”

¡Thank you for your attention!

CEIBA