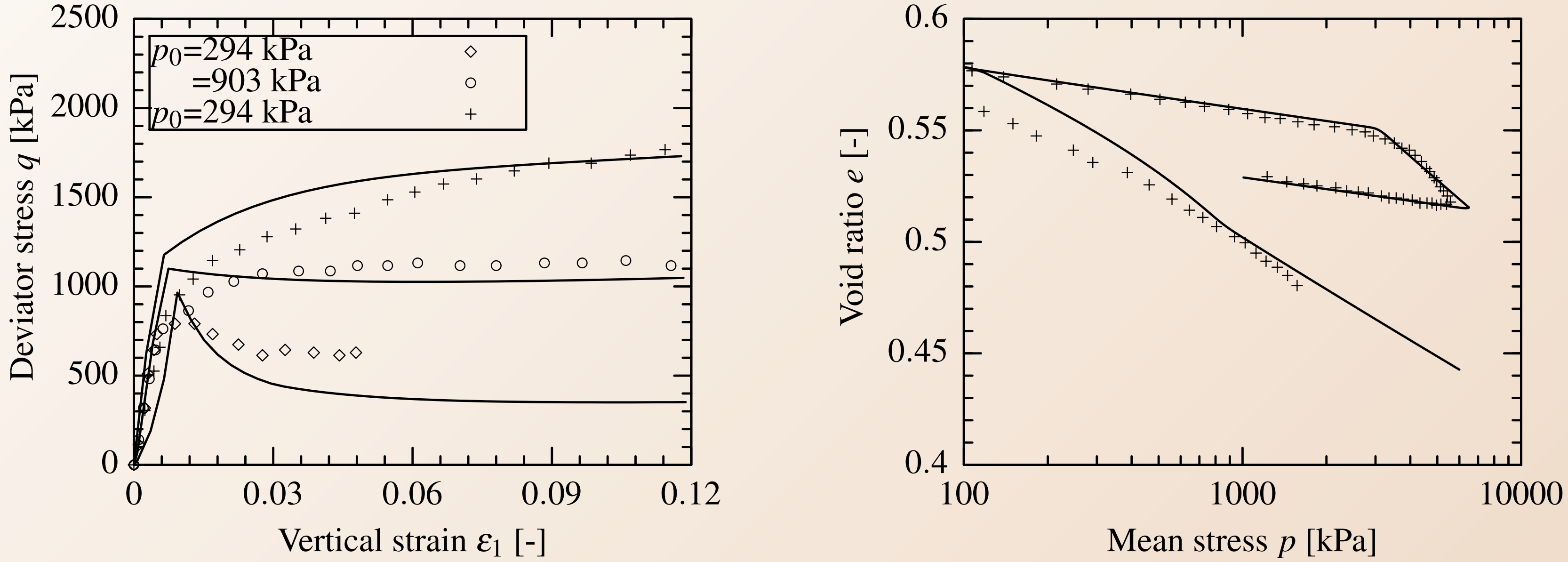
Micro-mechanical investigation of yielding in cemented geo-materials

Nicolás Estrada
Grupo de Investigación en Geotecnia
Universidad de los Andes - Bogotá, Colombia
***C**entro de **E**studios **I**nterdisciplinarios **B**ásicos y **A**plicados en Complejidad*
CeiBA

Advisors:
Arcesio Lizcano - *Universidad de los Andes*
Alfredo Taboada - *Universidad de Montpellier*

Motivation



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

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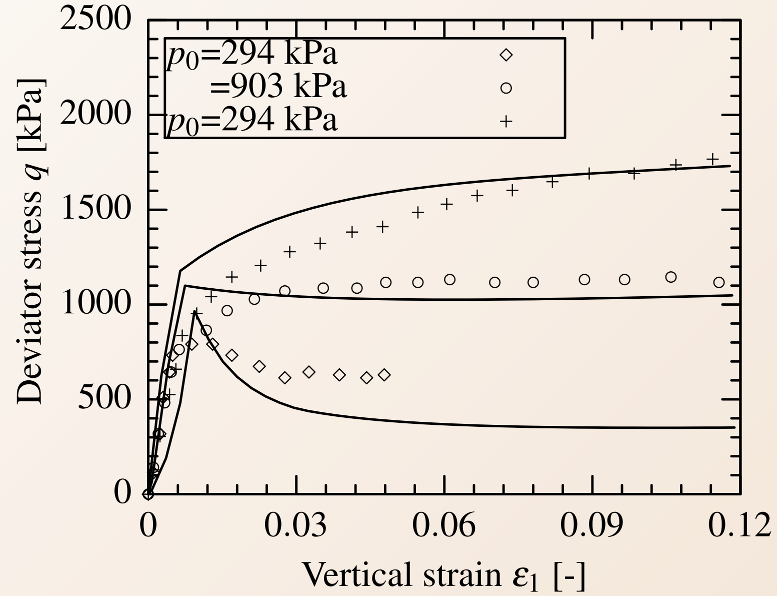

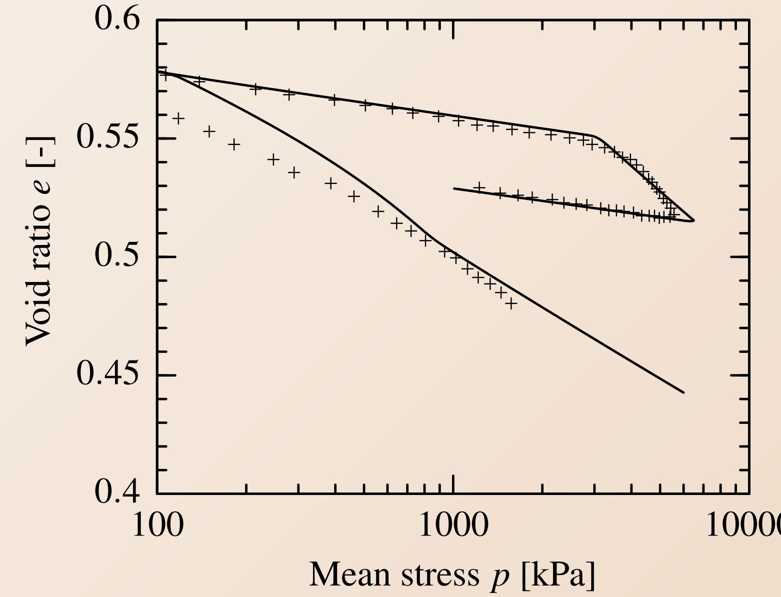

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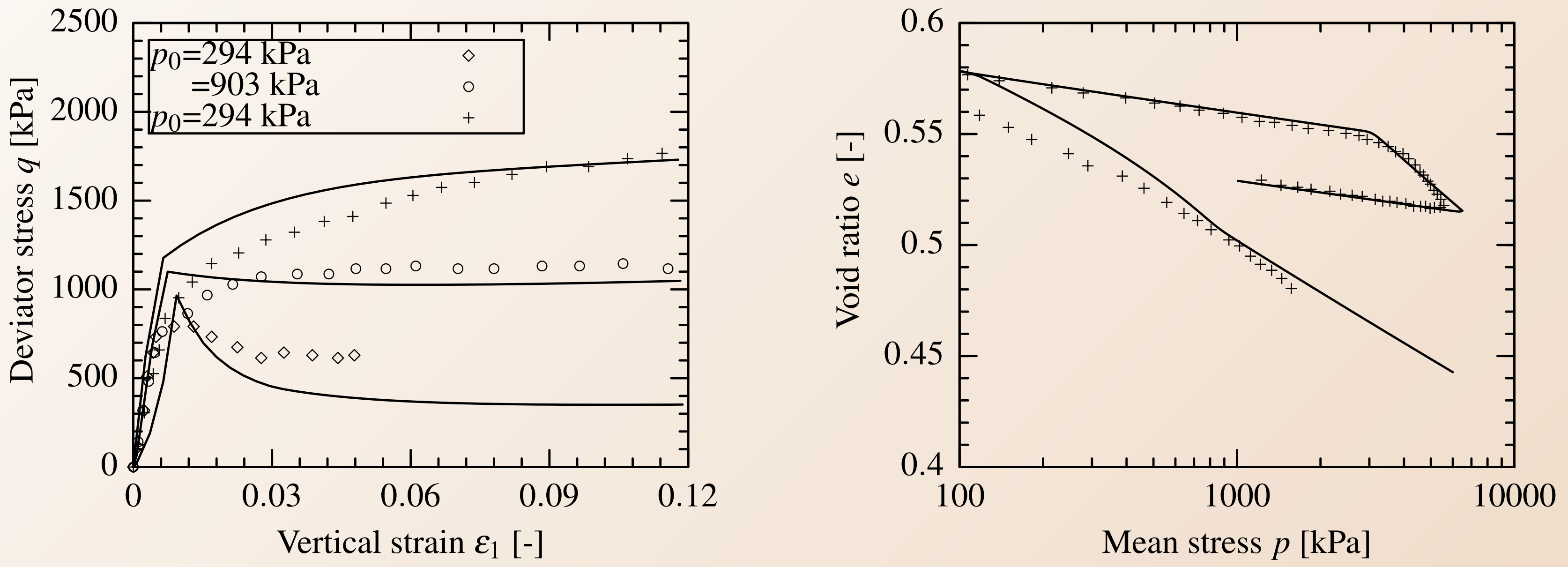
Macroscopic models are useful to describe the behavior of granular cemented soils

Motivation



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

Macroscopic models are useful to describe the behavior of granular cemented soils

However, they represent a limited tool if we want to explain what is really happening at the grains scale

A privileged analysis tool:

→ Discrete Element Methods

The purpose of this work is to investigate yielding in cemented granular materials using discrete element methods

Outline

1. Cementation model (Contact Dynamics)

3. Simple shear device

4. Macroscopic results

5. Microscopic analysis

I. Cementation model

Numerical method

Contact Dynamics (*J. J. Moreau & M. Jean*)

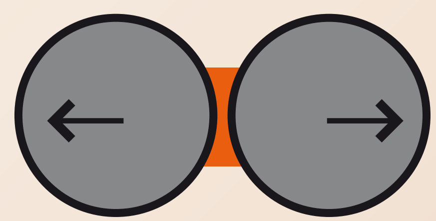
1. Cementation model

Numerical method

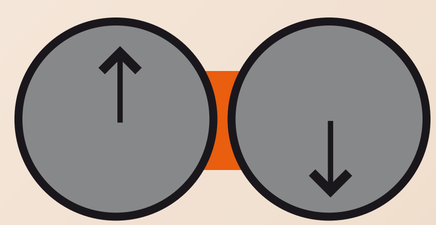
Contact Dynamics (*J. J. Moreau & M. Jean*)

Local cohesion model

Traction:

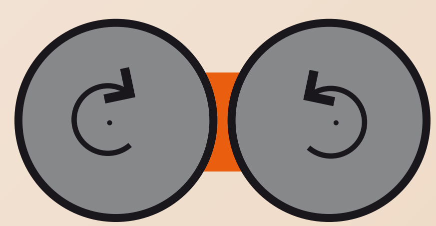


Shear:



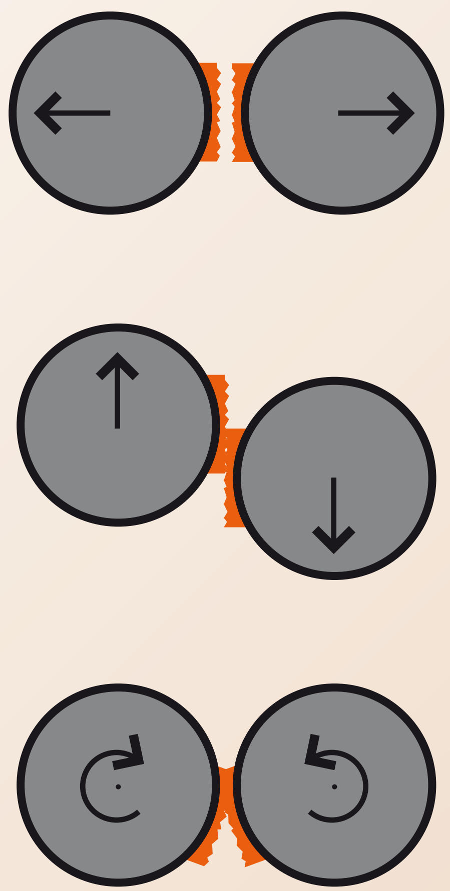
→ *(Coulomb's friction law)*

Flexion:



→ *(Contact law analogous to the Coulomb's friction law)*

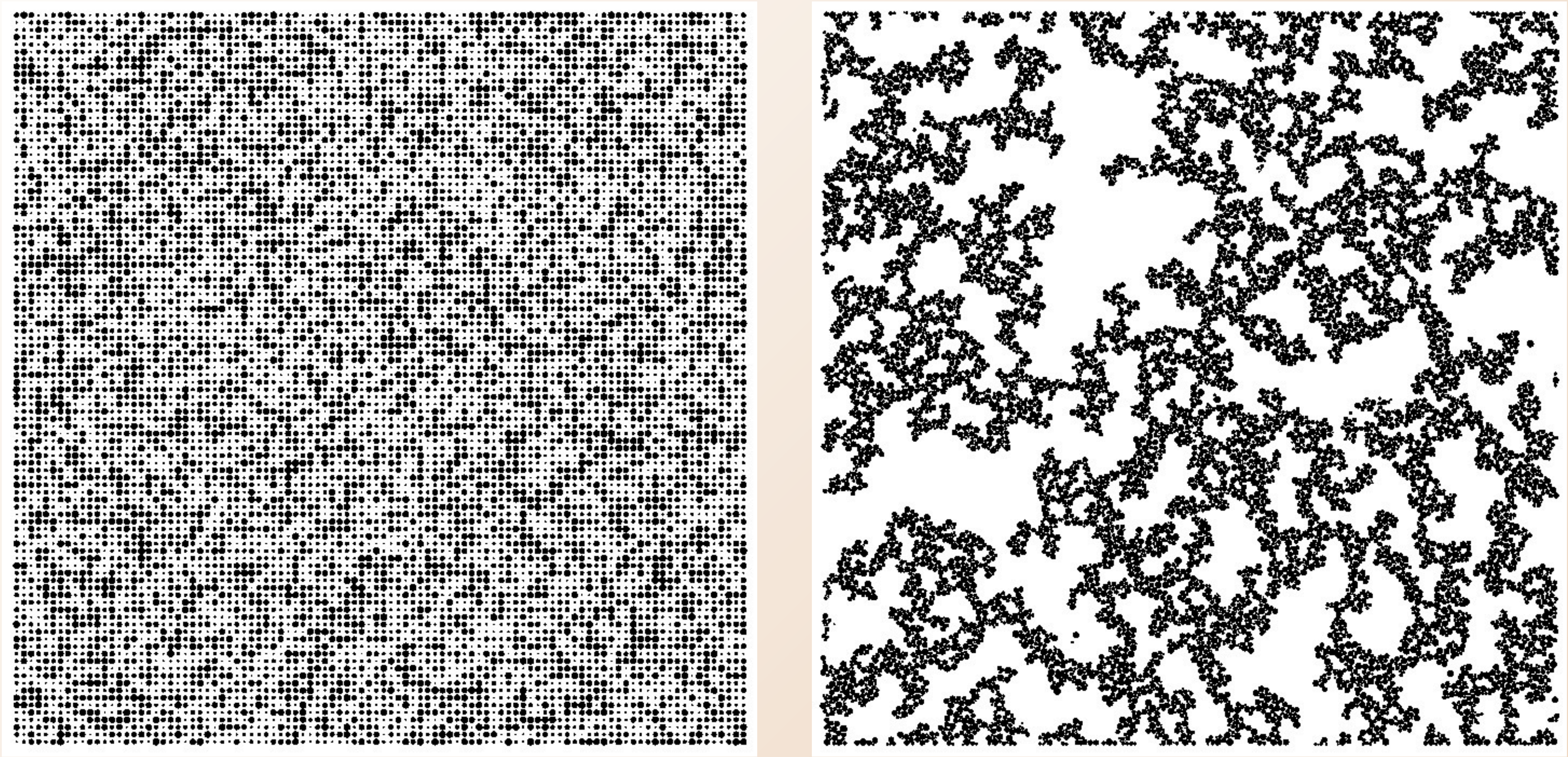
Local rupture conditions

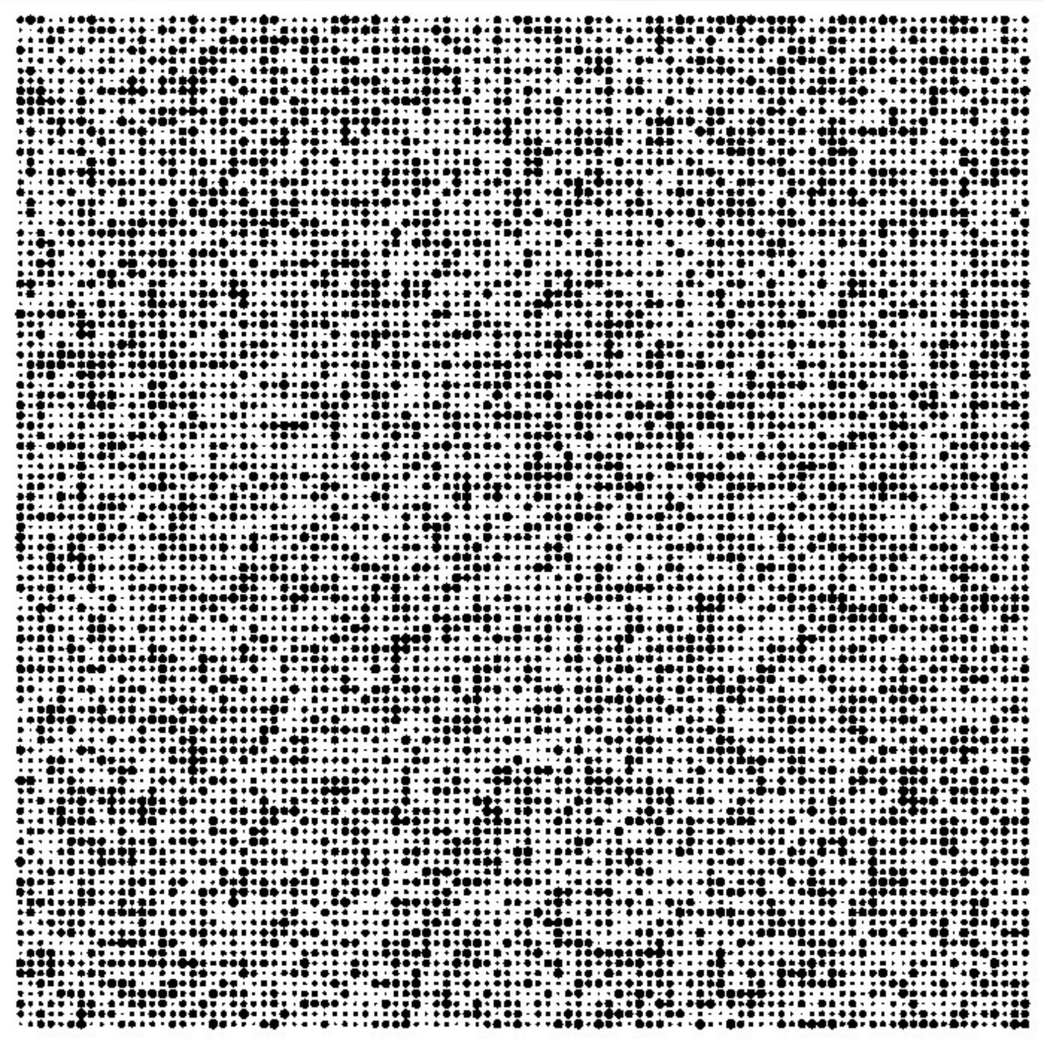


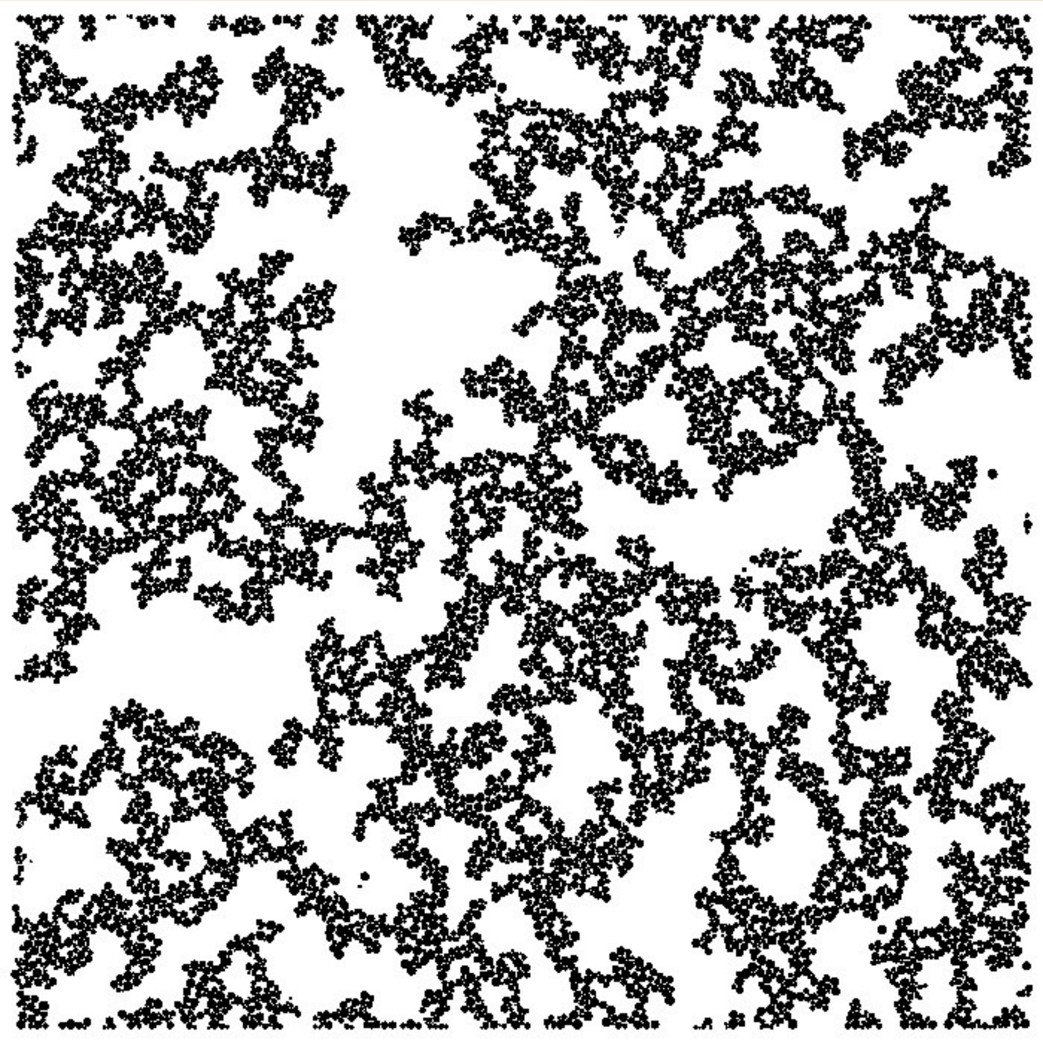
$$f_n = -f_a$$

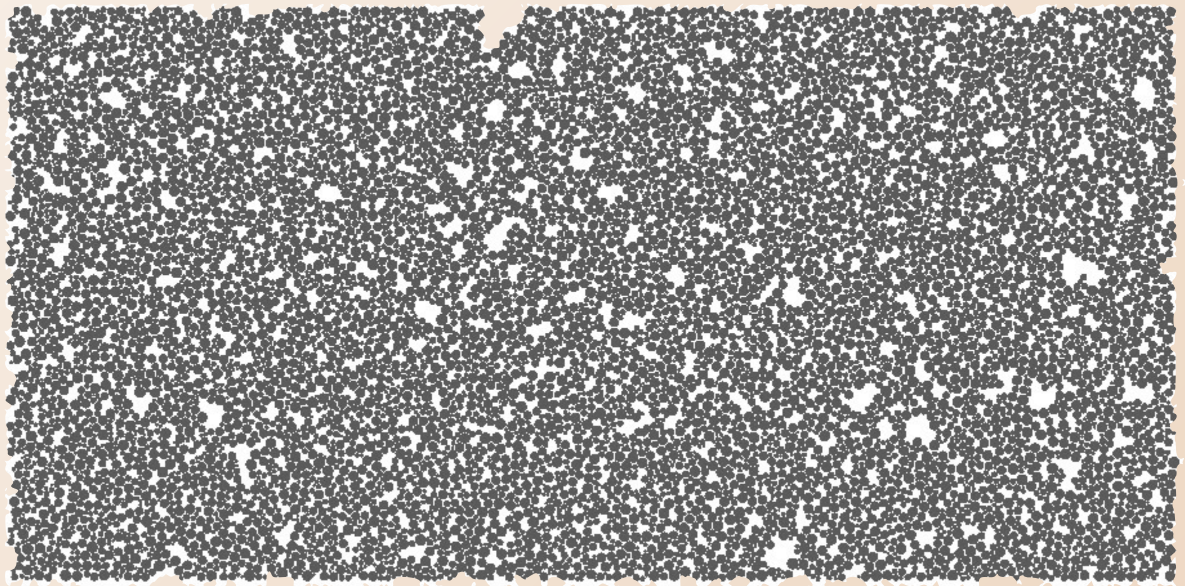
$$f_t = f_t^{max}$$

$$M = M^{max}$$



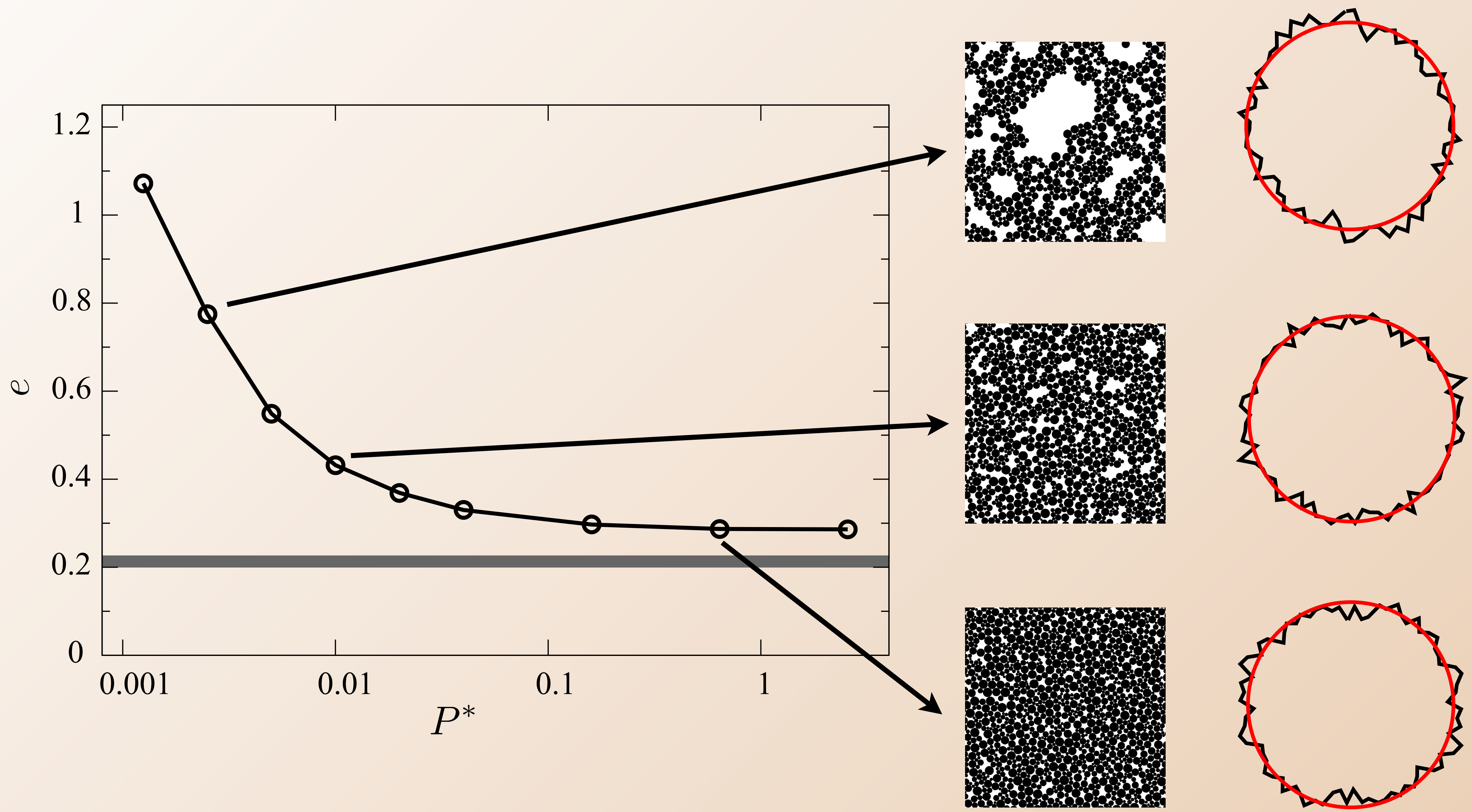






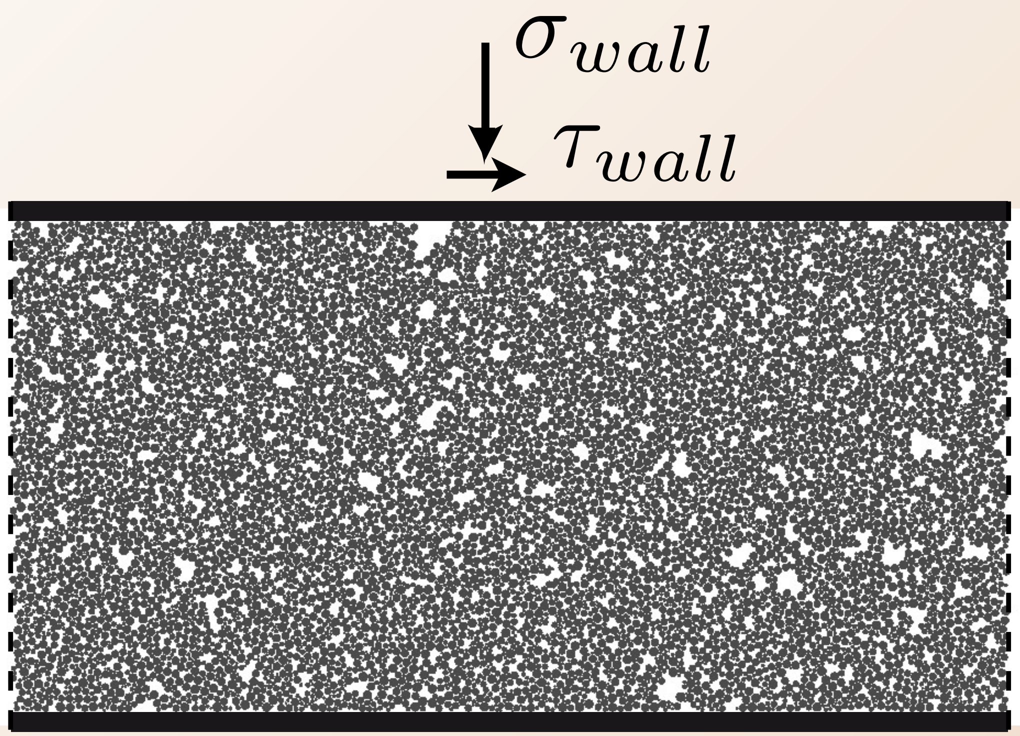
10.000 particles

$e \simeq 0.42$

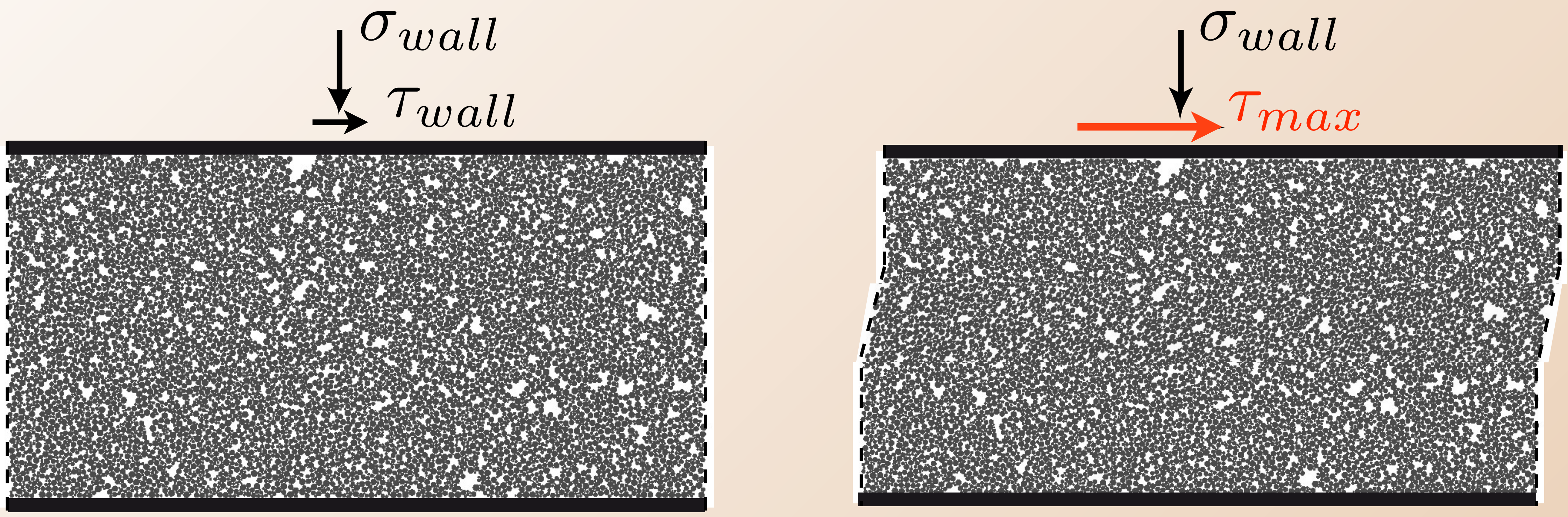


1.2
1
0.8
0.6
0.4
0.2
0
e
0.001
0.01
0.1
1
P*

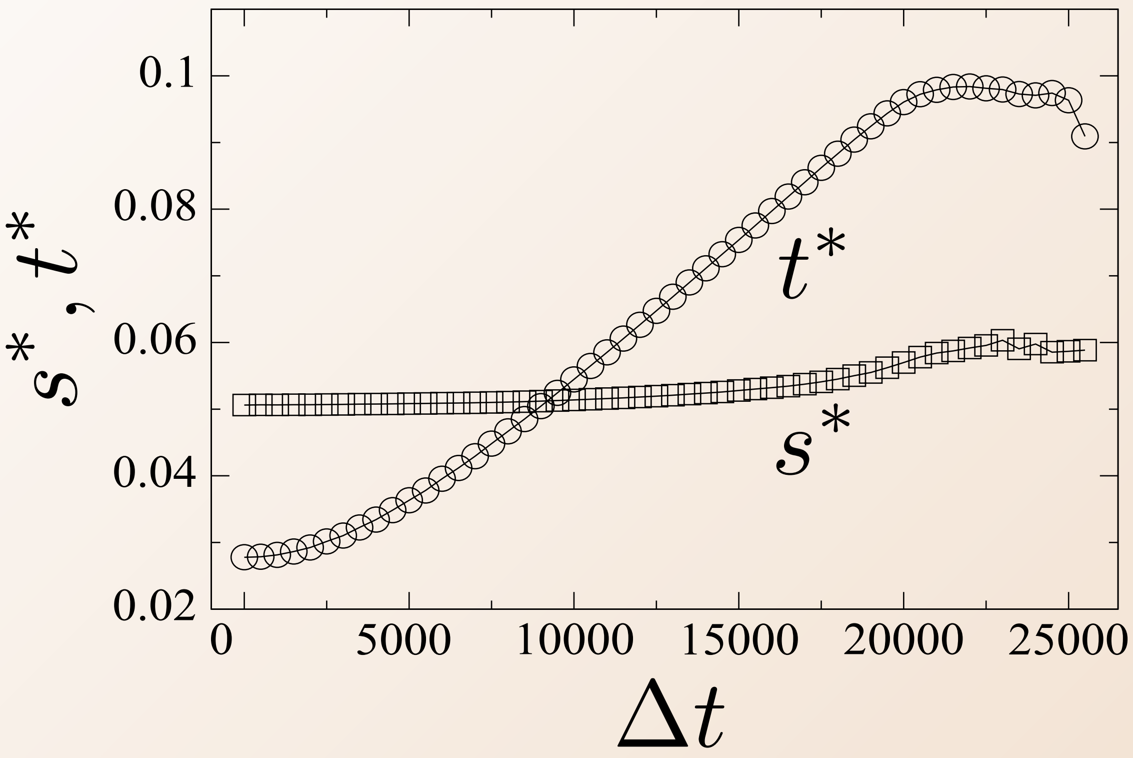
2. Simple shear device



2. Simple shear device



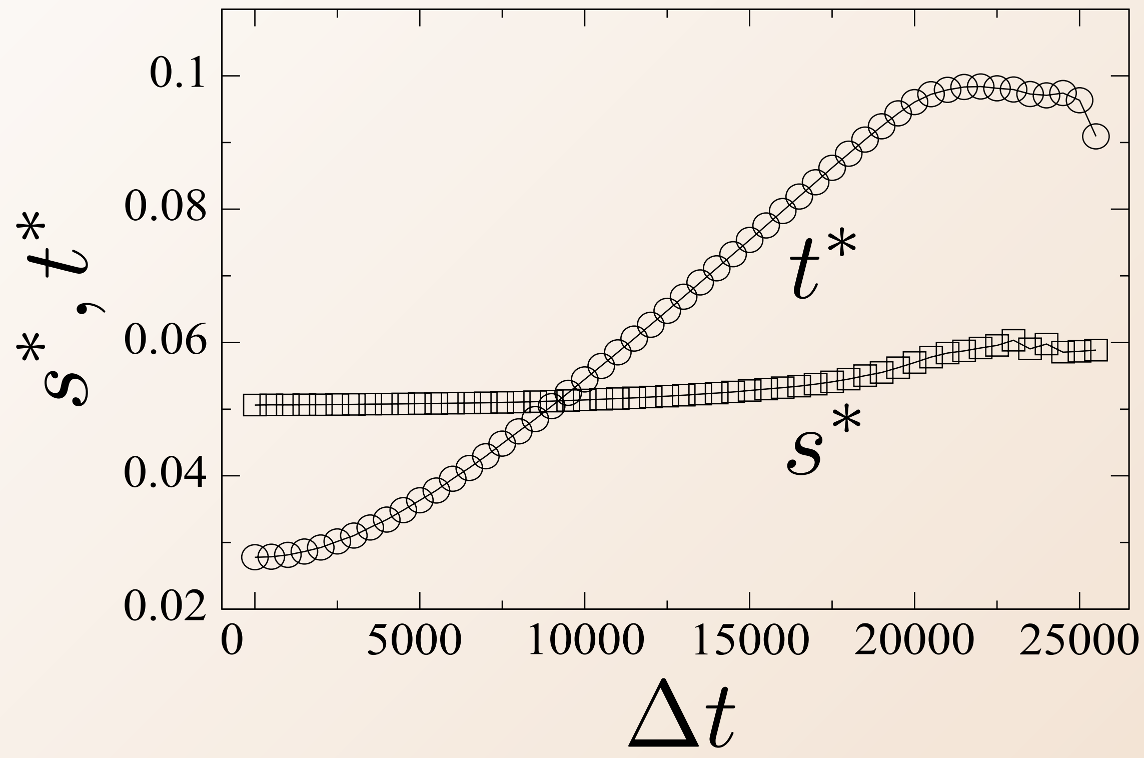
4. Macroscopic results

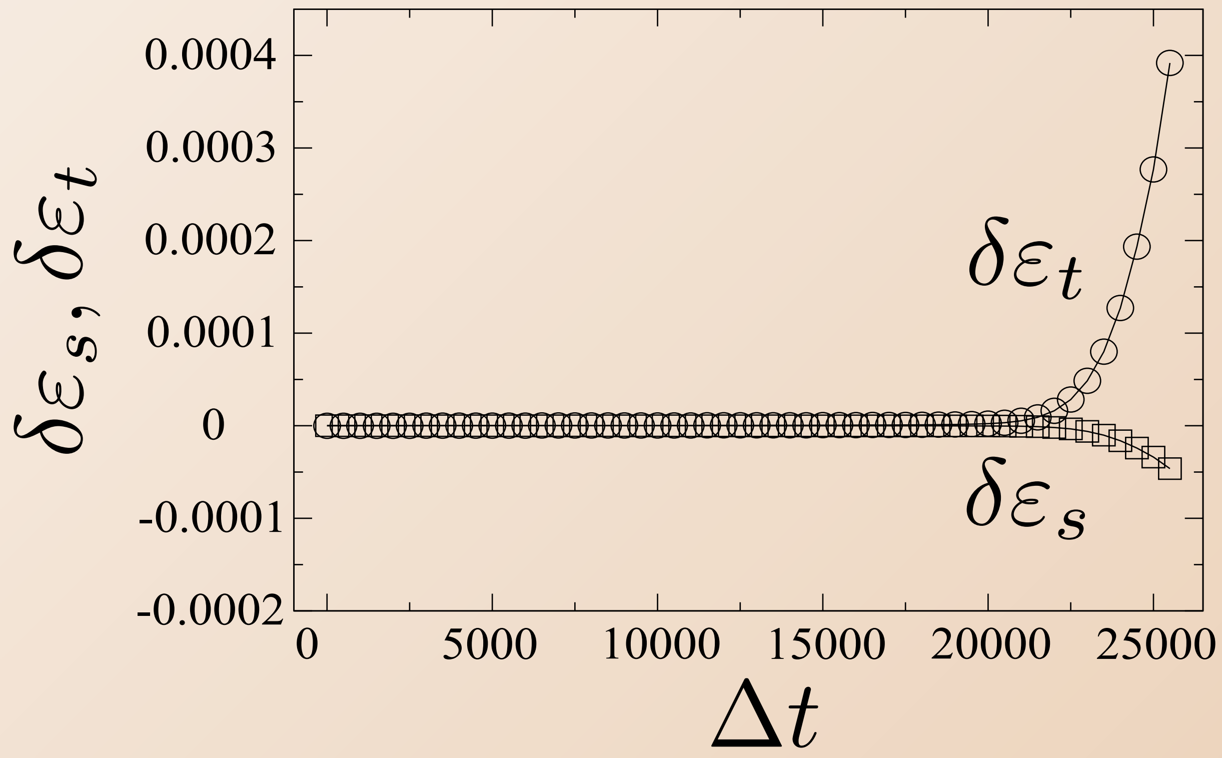


$$s^* \sim \frac{\sigma_1 + \sigma_3}{2}$$

$$t^* \sim \frac{\sigma_1 - \sigma_3}{2}$$

4. Macroscopic results





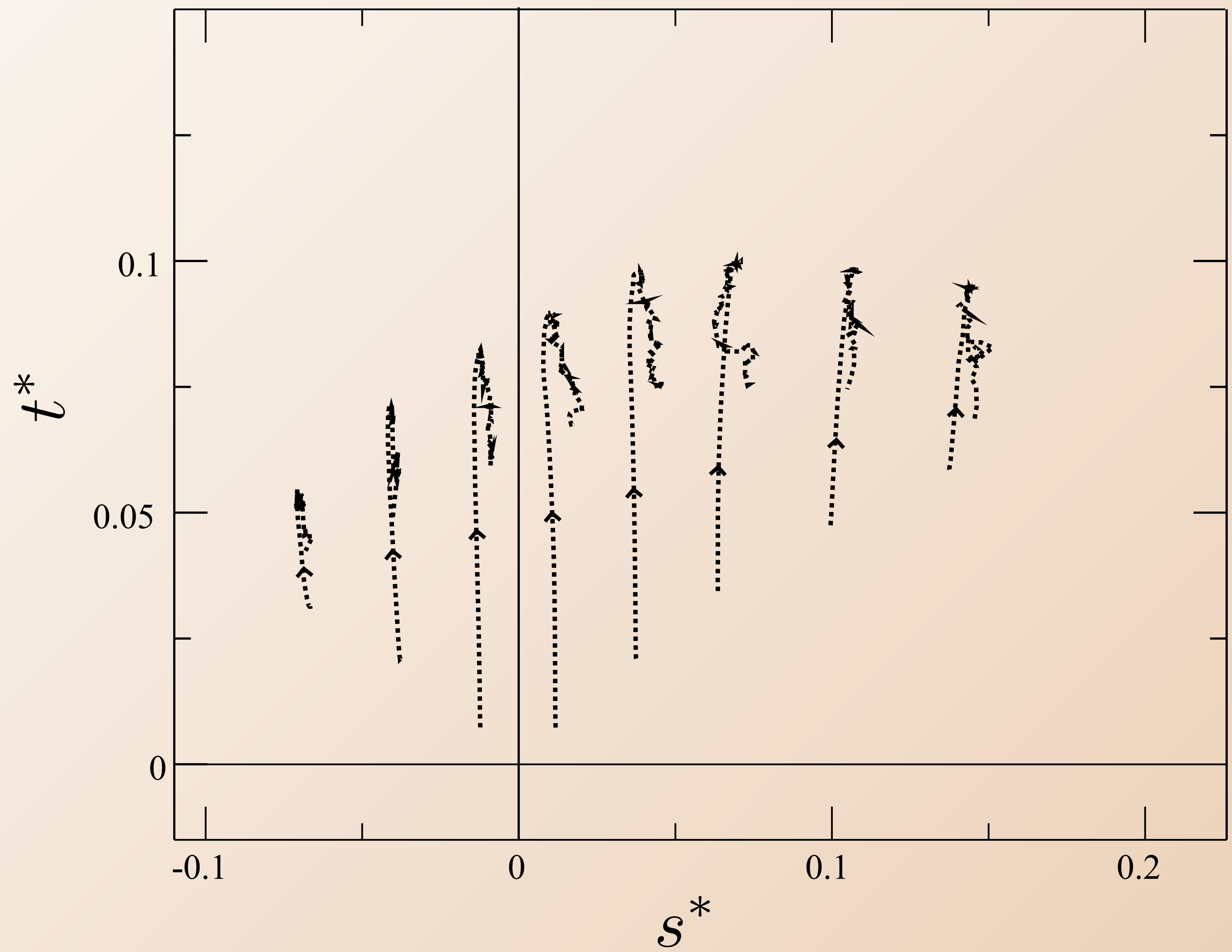
$$s^* \sim \frac{\sigma_1 + \sigma_3}{2}$$

$$t^* \sim \frac{\sigma_1 - \sigma_3}{2}$$

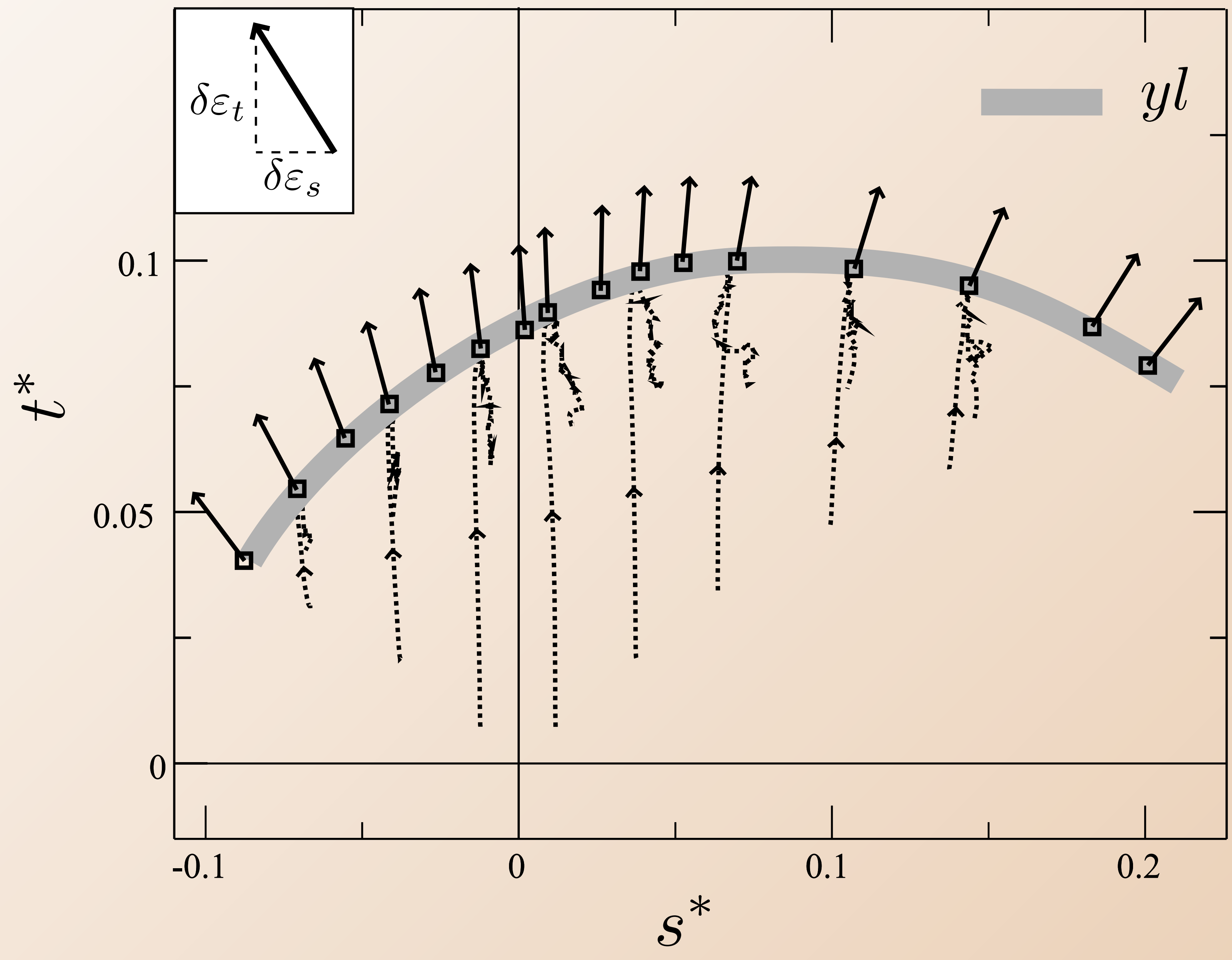
$$\delta\varepsilon_s = \delta\varepsilon_1 + \delta\varepsilon_3$$

$$\delta\varepsilon_t = \delta\varepsilon_1 - \delta\varepsilon_3$$

Yield surface



Yield surface



5. Microscopic analysis

Equilibrium conditions at the contacts scale

$$f_n = -f_a$$

$$f_t = f_t^{max}$$

$$M = M^{max}$$

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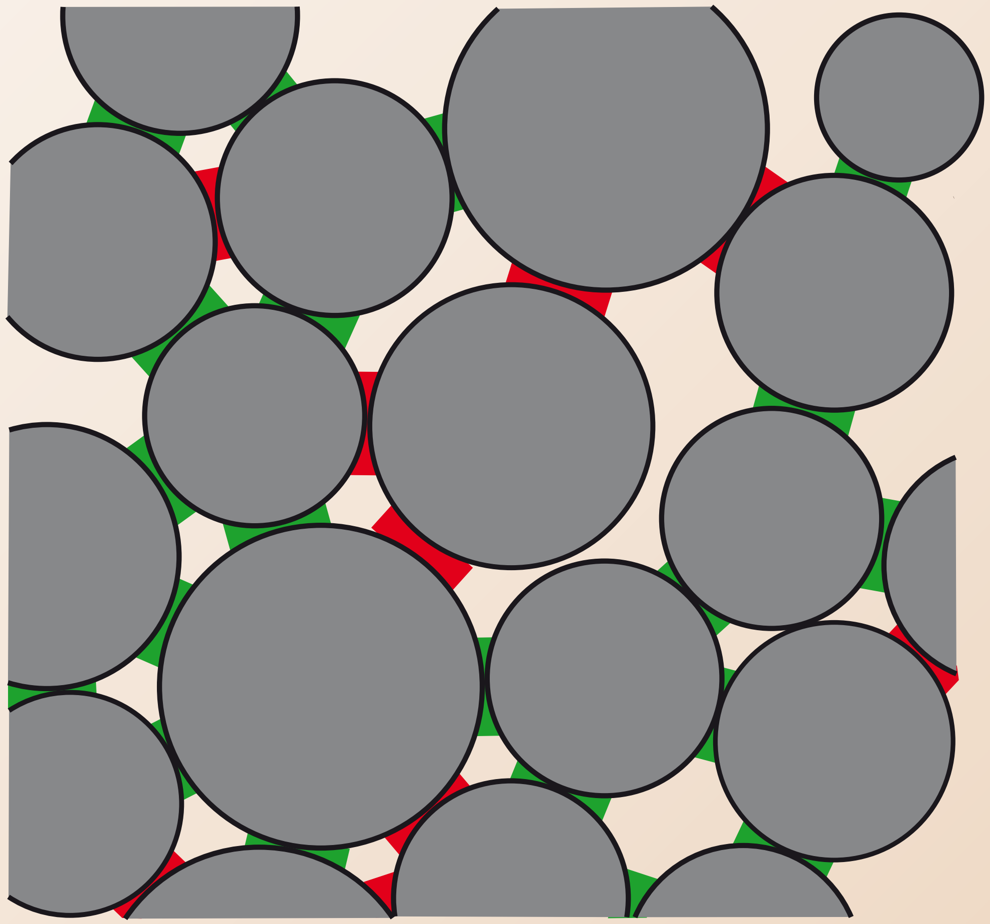

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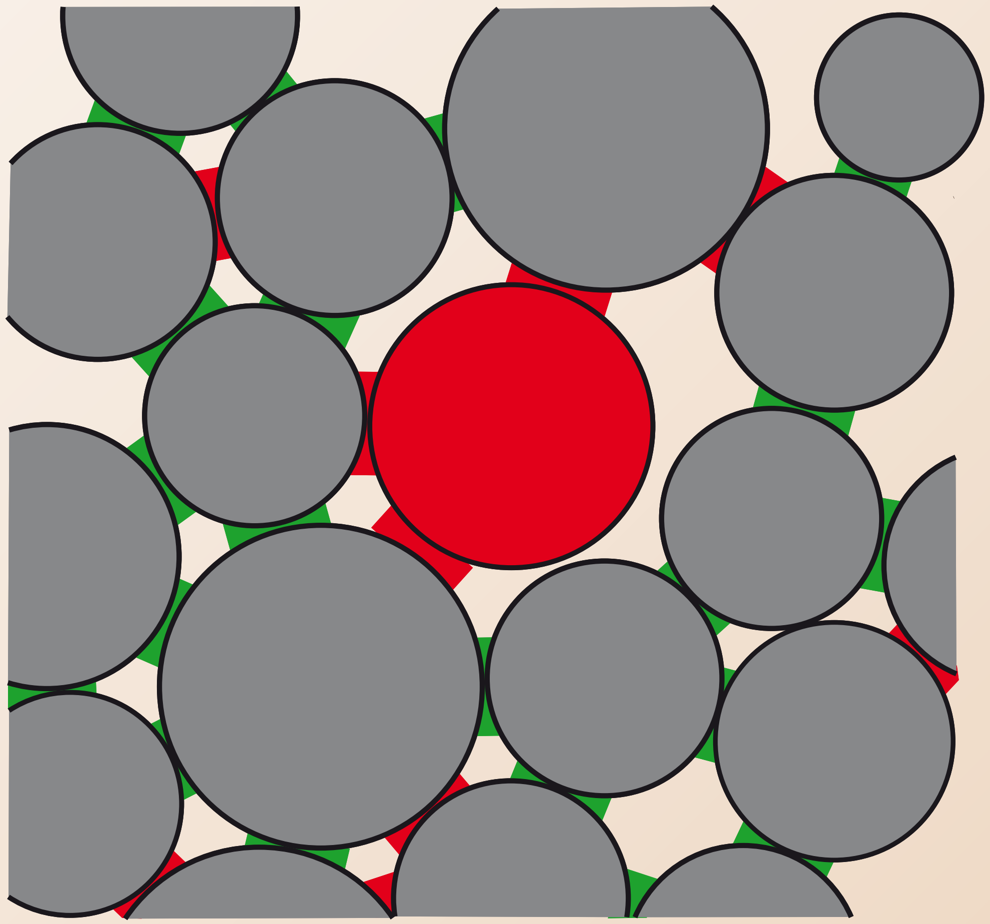

Mobile particles:

particles whose contacts verify all this condition

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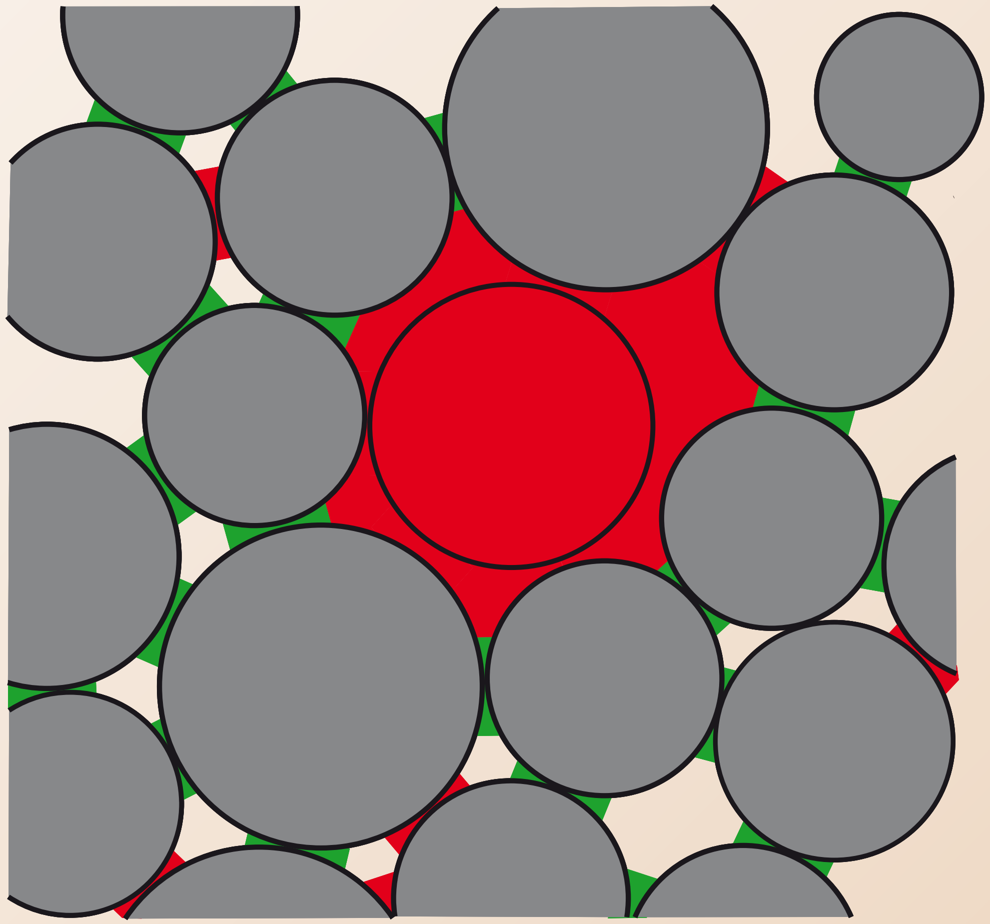

Mobile particles:
particles whose contacts verify all this condition

Mobile zones:
mobile particles +
voids that surround them

5. Microscopic analysis

Equilibrium conditions at the contacts scale

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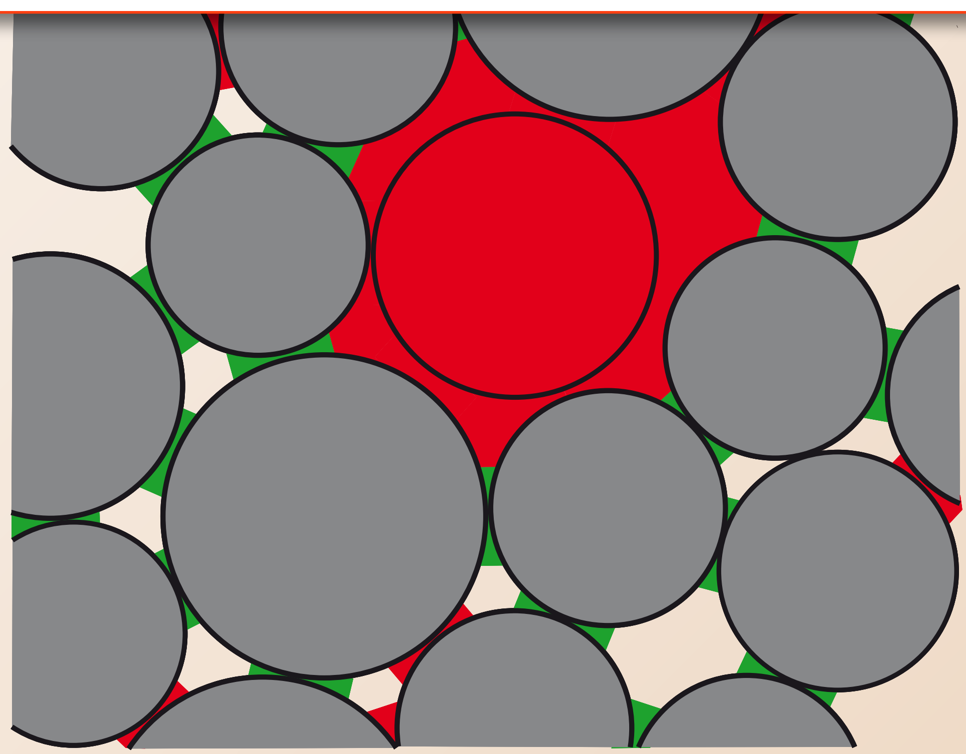
¡Mobile zones are important because they represent regions where yielding is imminent!



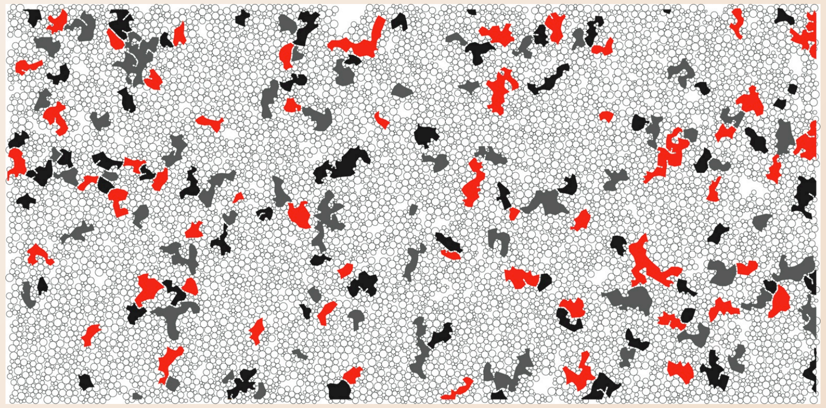
particles whose contacts verify all this condition

Mobile zones:

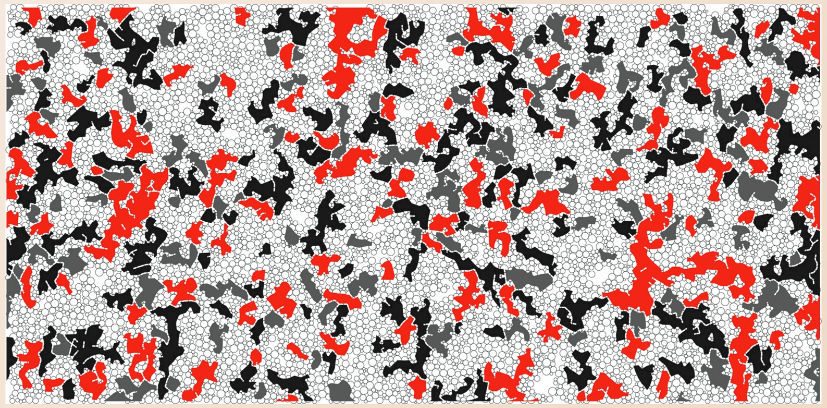
mobile particles +
voids that surround them

When increasing the load τ_{wall} from 0 to the yield condition τ_{max} :

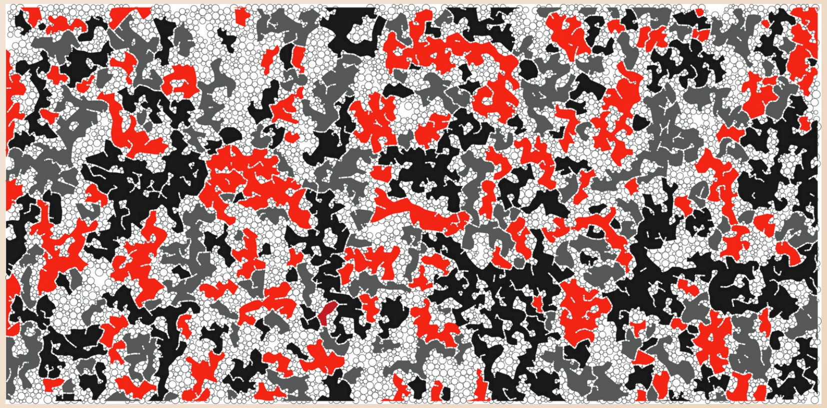
$$\tau_{wall} = 0.25\tau_{max}$$



$$\tau_{wall} = 0.5\tau_{max}$$



$$\tau_{wall} = 0.75\tau_{max}$$



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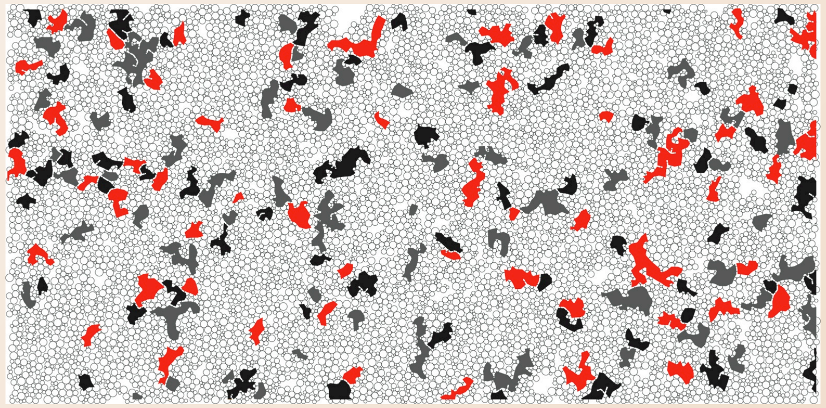

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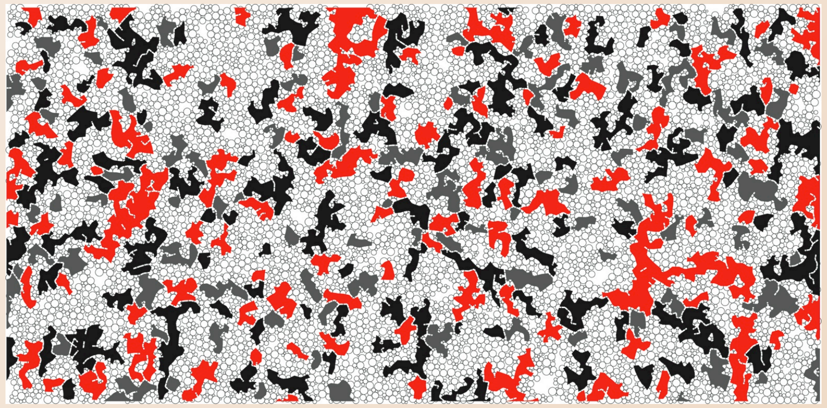

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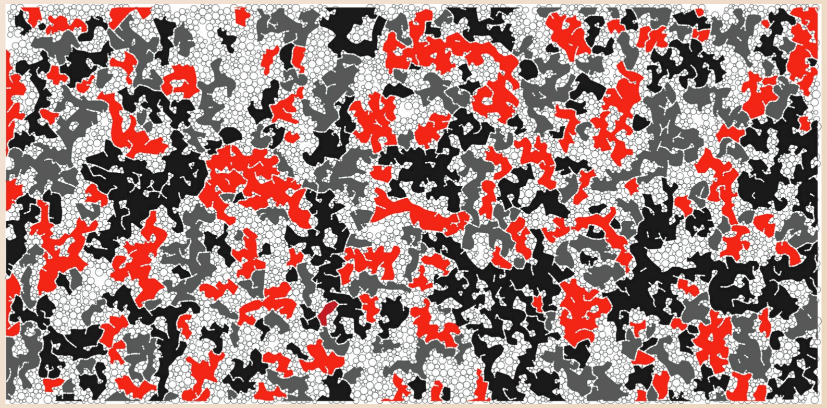
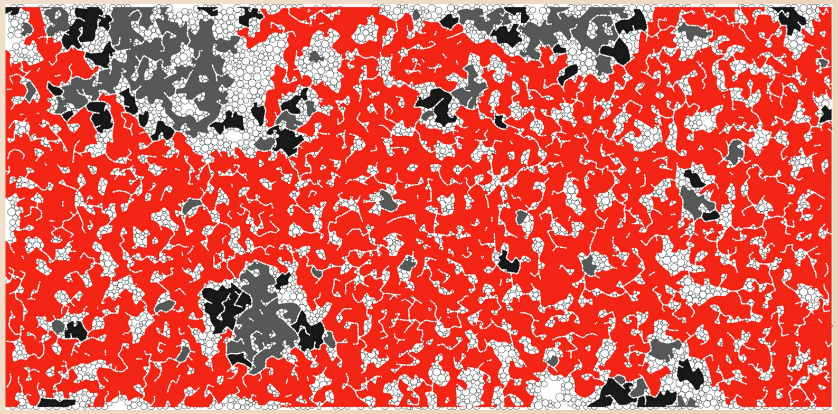
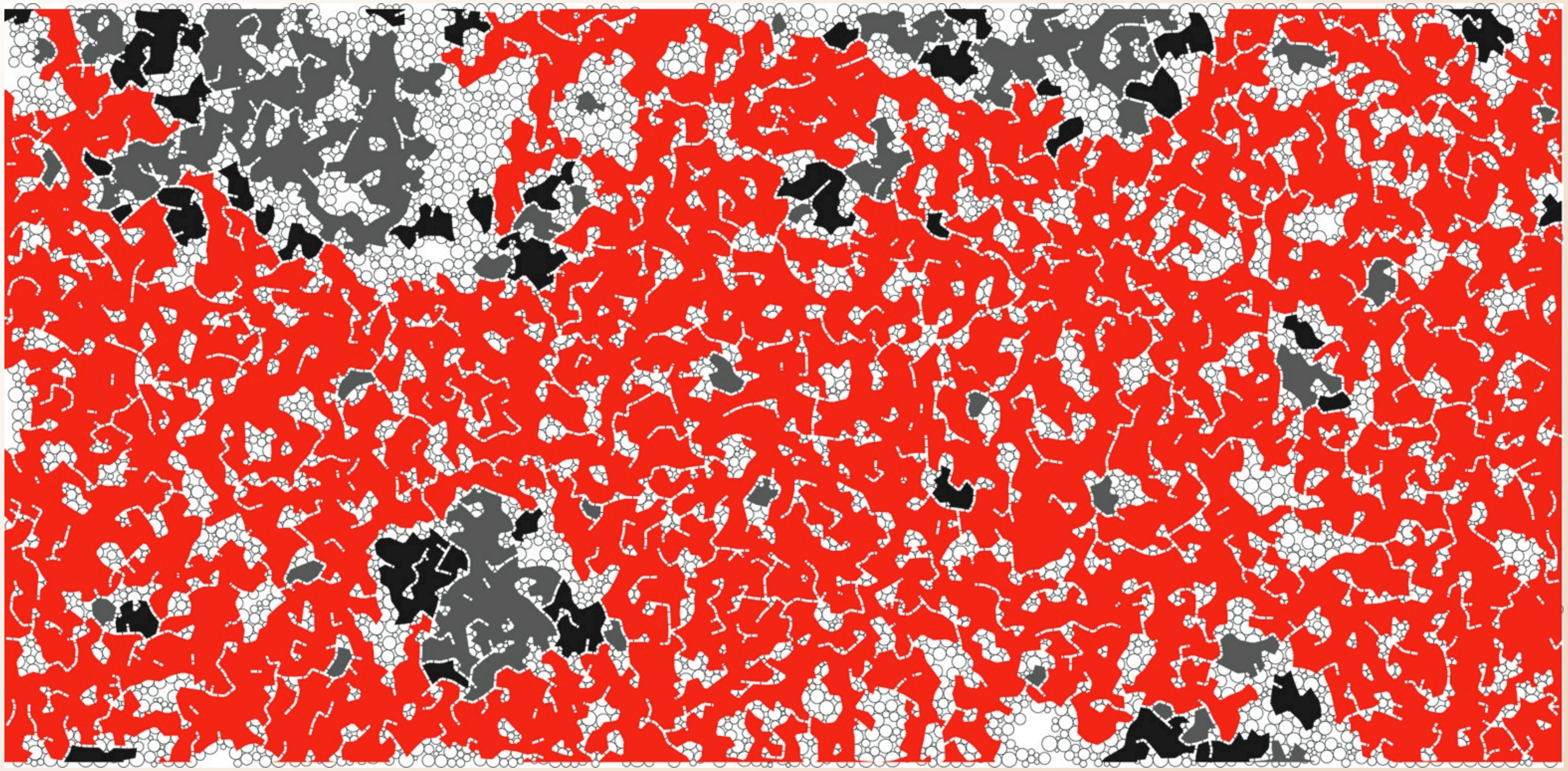


$$\tau_{wall} = \tau_{max}$$





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

→ phase transition

→ kinematically admissible mechanism of deformation

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Acknowledgementes

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Advisors:

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Thank you for your attention

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