INTERPORE

2026

— Géosciences Montpellier

Reactive transport processes in porous rock samples

Role of local heterogeneities

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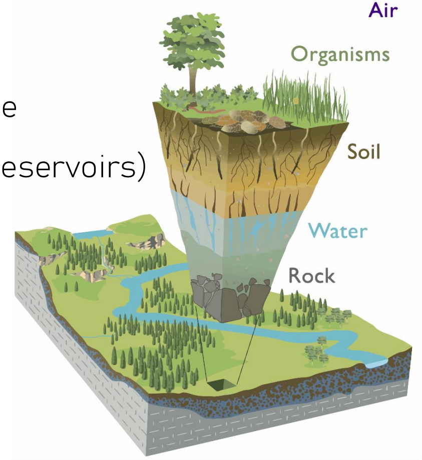
CNRS — Géosciences Montpellier

InterPore 2026

Motivation

Critical zone

(soils and reservoirs)



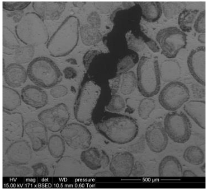
Processus: Dissolution, precipitation, transport, contaminants sorption and degradation

Applications:

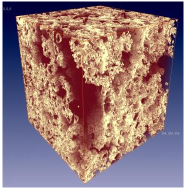
- CO2 geological storage
- Seawater intrusion in coastal aquifers
- Karst formation
- Managed aquifer recharge

Motivation

- Physical heterogeneities



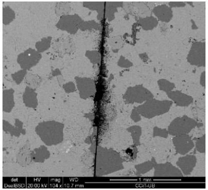
(Luquot, inedit)



(Luquot, inedit)

www.geocatching.com

- Chemical heterogeneities



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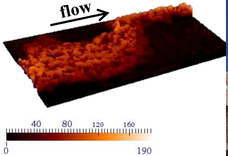
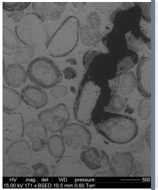


(Luquot, inedit)

Control of physical and chemical heterogeneities on reaction processes

Motivation

- Physical heterogeneities



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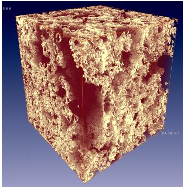

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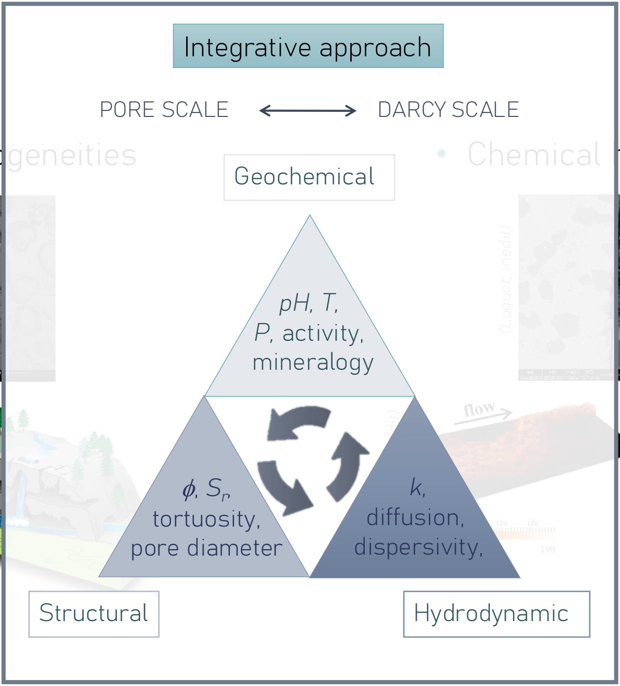


Integrative approach

PORE SCALE ⟷ DARCY SCALE

Geochemical

pH, *T*, *P*, activity, mineralogy

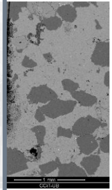
ϕ, S_r, tortuosity, pore diameter

k, diffusion, dispersivity,

Structural

Hydrodynamic

- Chemical heterogeneities

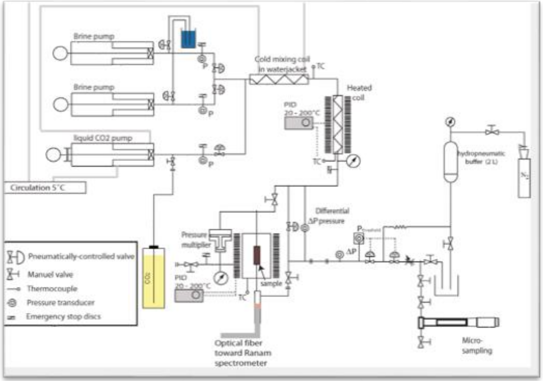


(Luquot, inedit)

Experimental methodology

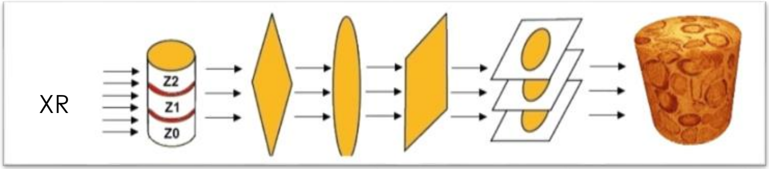
Percolation experiments on natural core samples:

- Pore scale heterogeneities
- Mineral heterogeneities
- Flow and transport effects
- Fluid chemistry controled



X-ray microtomography images:

- 3D visualization of the localization of the processes
- Structural heterogeneities
- Mineral, grain and pore distributions
- Transport properties



Outline

1

Karst formation

Role of mineralogical, structural
and hydrodynamic rock properties
in conduits formation

2

Non-reactive minerals

Role of non-reactive mineral fraction
on dissolution rates and patterns
in carbonate rocks

Experimental conditions

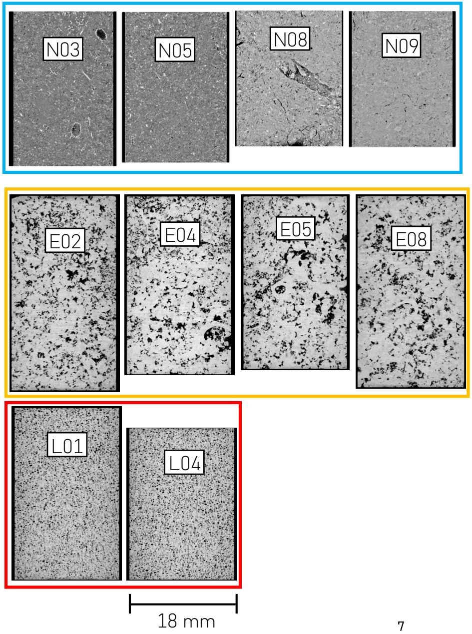
4 Normandie (Chalk), 4 Euville (Limestone), 2 Lexos (Dolomite):

- 4 transport conditions, 4 flow rates conditions:

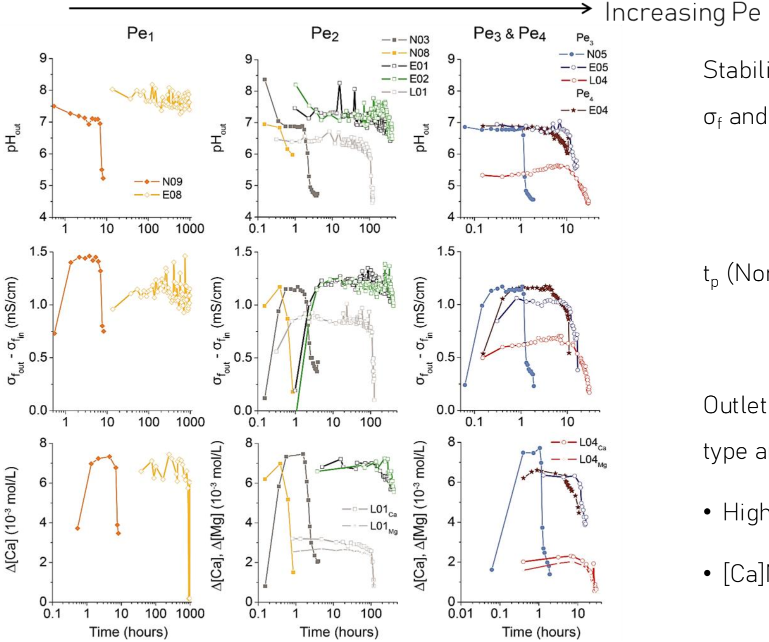
  Pe1 < Pe2 < Pe3 < Pe4

- 1 acid concentration, C_0^2 : 10^{-2} mol/L

	Normandie		**Euville**		**Lexos**	
	Samples	**Flow rate (m^3/s)**	**Samples**	**Flow rate (m^3/s)**	**Samples**	**Flow rate (m^3/s)**
Pe1	N09	8.0e-10	E08	9.3e-11		
Pe2	N03 & N08	7.0e-9	E01 & E02	5.0e-10	L01	3.2e-9
Pe3	N05	1.8e-8	E05	2.5e-9	L04	7.6e-9
Pe4			E04	6.0e-9		



Chemical results



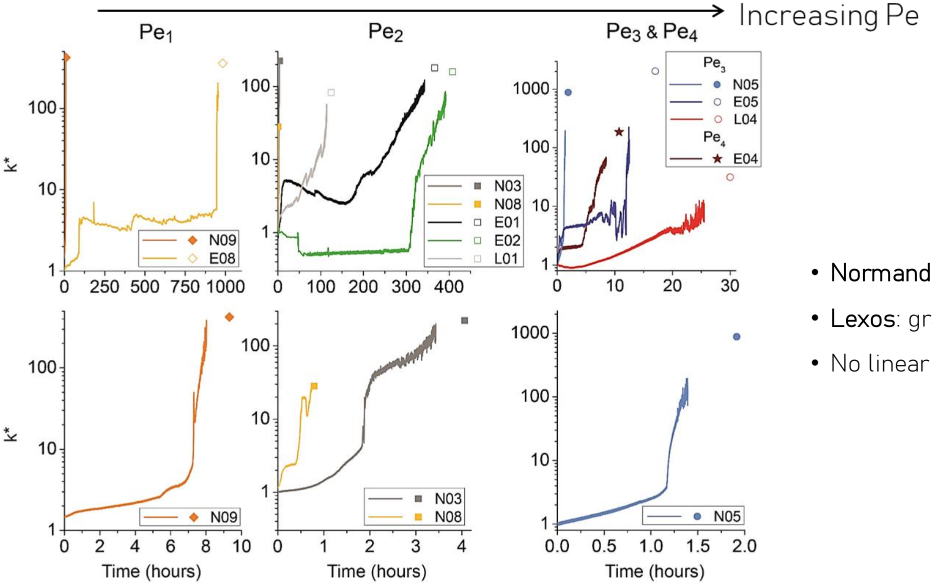
Stabilization and decrease in pH, σ_f and [Ca] for every rock type

t_p (Normandie) ≪ t_p (Euville, Lexos)

Outlet values depend on rock type and Peclet:

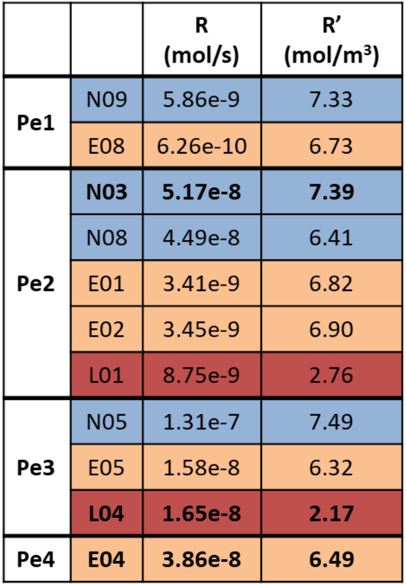
- High Pe: pH, σ, [Ca, Mg] low
- [Ca]N > [Ca]E > [Ca, Mg]L

Permeability changes



- **Normandie and Euville**: sudden increase
- **Lexos**: gradual increase
- No linear relation between Pe and k

Dissolution rates



		R (mol/s)	R’ (mol/m³)
Pe1	N09	5.86e-9	7.33
	E08	6.26e-10	6.73
Pe2	**N03**	**5.17e-8**	**7.39**
	N08	4.49e-8	6.41
	E01	3.41e-9	6.82
	E02	3.45e-9	6.90
	L01	8.75e-9	2.76
Pe3	N05	1.31e-7	7.49
	E05	1.58e-8	6.32
	L04	**1.65e-8**	**2.17**
Pe4	**E04**	**3.86e-8**	**6.49**

- For similar Peclet: R (Normandie) > R (Lexos) > R (Euville)
- All conditions: R’ (Normandie) > R’ (Euville) >> R’ (Lexos)

↳ R controlled by Peclet and structure

↳ R’ controlled by mineralogy

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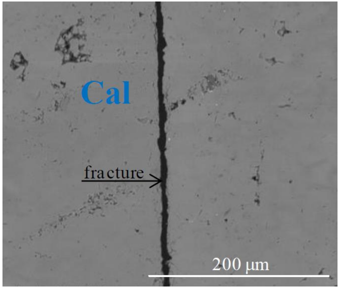
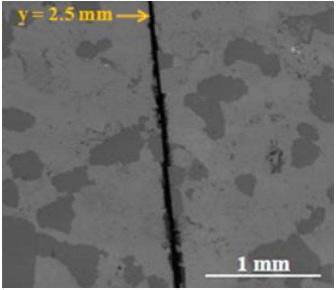
Experimental conditions

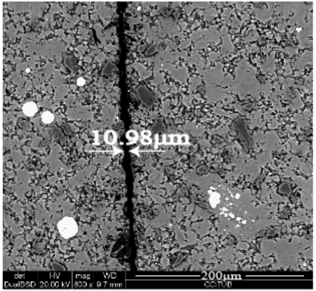
Injection of CO_2-rich brine through fractured core samples T = 60°C, P = 15 MPa, P_{CO2} = 6 Mpa, Q = 60 mL/h



Limestone
(100% calcite)



Sandstone
(67% calcite, 33% quartz)



Marl
(70% calcite, 10% quartz, 18% clays, 2% oxides)

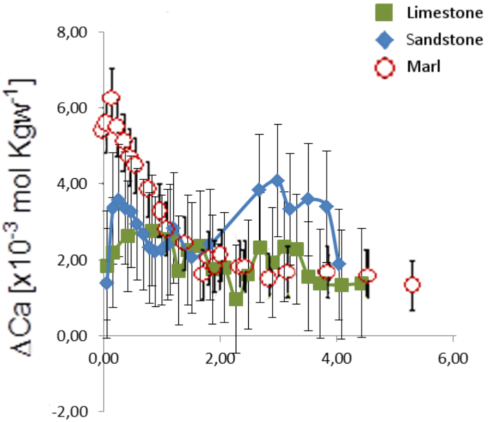
Chemical results

Calcite dissolution for the 3 samples but at different rate:

- Limestone 4,9 mm^3/h
- Sandstone 6,8 mm^3/h

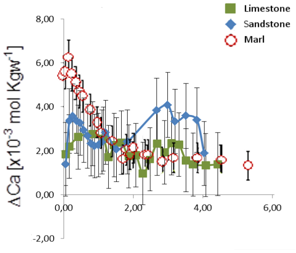
} Constant along the entire experiments

- Marl from 10,3 to 4,6 mm^3/h



Results

Dissolution rates
limestone < sandstone < marl



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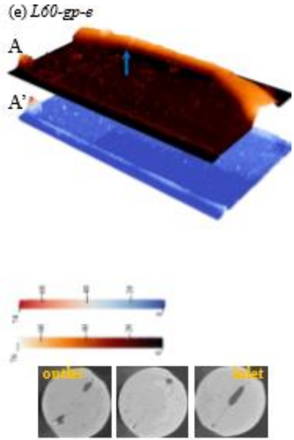
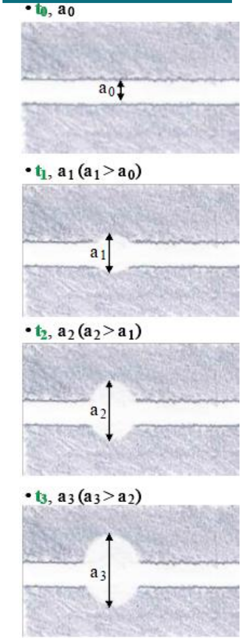


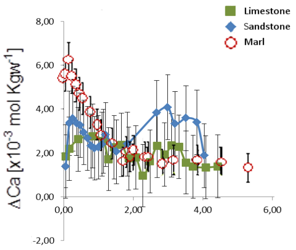


- Limestone: dissolution tended to be localized (wormhole): small reactive surface area and low dissolution rate.

Results

Dissolution rates

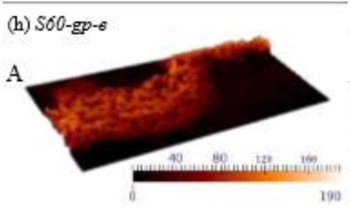
limestone < sandstone < marl

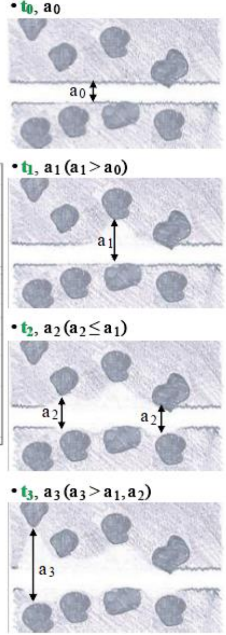


- Limestone: dissolution tended to be localized (wormhole): small reactive surface area and low dissolution rate.
- Sandstone: dissolution tended to be extended (uniform): inert silicate grains favored more extended dissolution features.

Sandstone

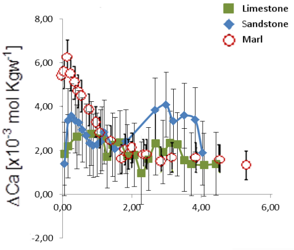
(67% calcite, 33% quartz)





Results

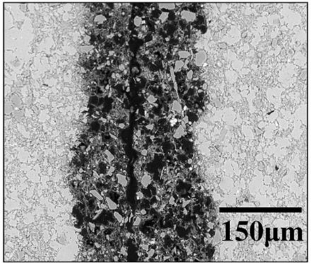
Dissolution rates
limestone < sandstone < marl

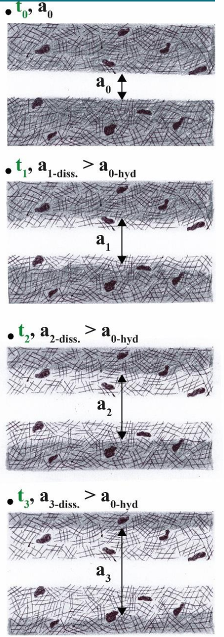


Marl
(70% calcite, 10% quartz, 18% clays, 2% oxides)

- Limestone: dissolution tended to be localized (wormhole): small reactive surface area and low dissolution rate.
- Sandstone: dissolution tended to be extended (uniform): inert silicate grains favored more extended dissolution features.
- Marl: dissolution is uniform along the fracture: Clay skeleton keep the initial fracture aperture and thus the hydraulic aperture

e) S-free 60 mL h^{-1}





Conclusions & take-home messages

1 Karst formation

Controlled by pore size, local connectivity and mineralogy. Non-dissolved grains affect localization & rate of dissolution.

2 Non-reactive minerals

Clay & silicate fraction shifts dissolution from localized (wormhole) → extended/uniform. Mixing at pore-scale controls precipitation.

3 Macroscopic relationships

k–ϕ, Sr–ϕ relations depend on rock structure and transport conditions (Pe, Da numbers). Mixing & mineral distribution drive kinetics.

★ More from our group

W. Zhou

Today 12:20 pm — same room

L. Chapuis

Friday 10:20–11:50 — poster 37

MERCI

Thank you

— Géosciences Montpellier

Questions?

Happy to discuss further

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More about my work

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