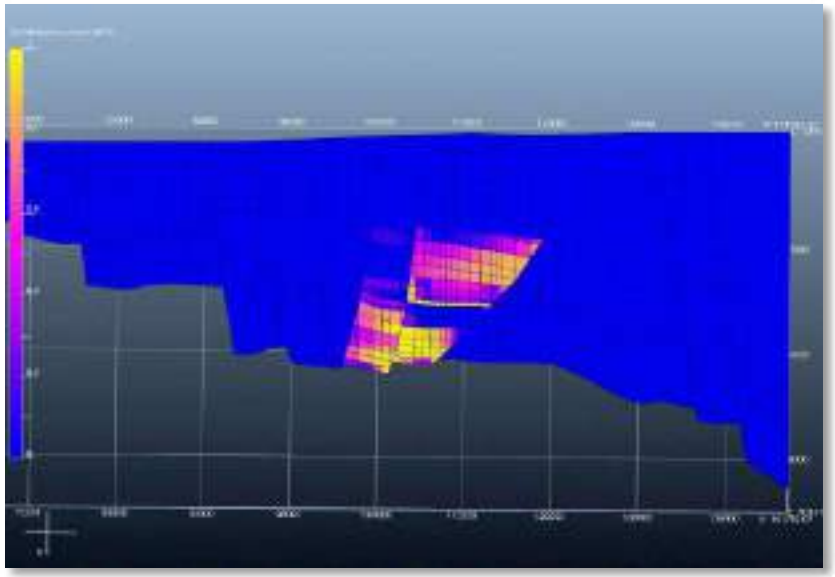








Mitigating injectivity decline in geothermal well doublets in siliciclastic reservoirs: experimental investigation of particle mobilization in porous media

David ROUSSEAU, Jalila BOUJLEL,
Fatma RAHIL and Emma RAO

Geothermal Innovation Days
Delft, The Netherlands
13-14 October 2026

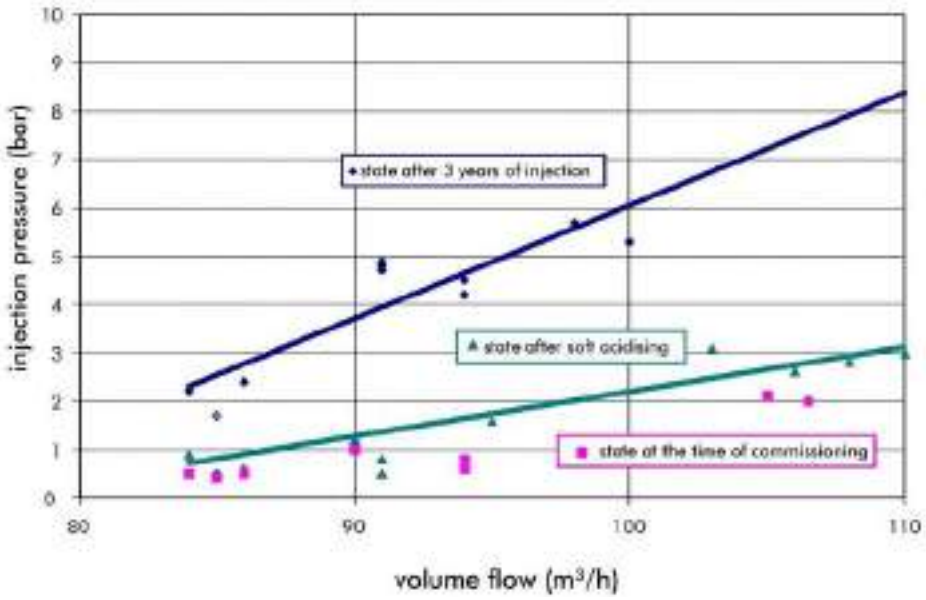
INJECTIVITY DECLINE IN SILICICLASTIC RESERVOIRS
FEEDBACK FROM FIELD OPERATIONS

ÉNERGIES NOUVELLES

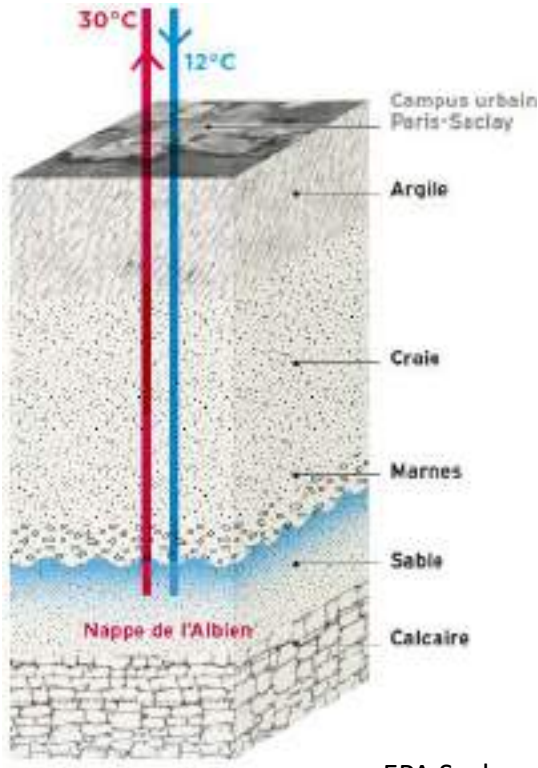
Injectivity decline is a common problem, with industrial solutions that are often unsatisfactory



Alfortville case study (Ypresian sands): continuous decline in injection rate (Luc Burté, PhD thesis, 2018)



Neustadt-Glewe case study (Middle Triassic/Rhaetian sandstone): increase in injection pressure after three years. Remedied by acid treatment. Identified cause: iron hydroxide and aragonite particles
(Menzel et al., World Geothermal Congress, 2000)



source: EPA Saclay

Saclay Plateau case study (Albian sands):
- **late 2019: commissioning of two doublets**
- **Early 2020: operation of the doublets halted due to loss of injectivity**
- **Since 2021: operation maintained with periodic backwashing of the injector**

- **Significant impact on performance: decline in injection rate**
- **Effects often unforeseen (causes frequently poorly understood)**
- **Remediation methods can be burdensome and are not always sustainable**

INJECTIVITY DECLINE IN SILICICLASTIC RESERVOIRS
PARTICLES ARE A MAJOR CAUSE

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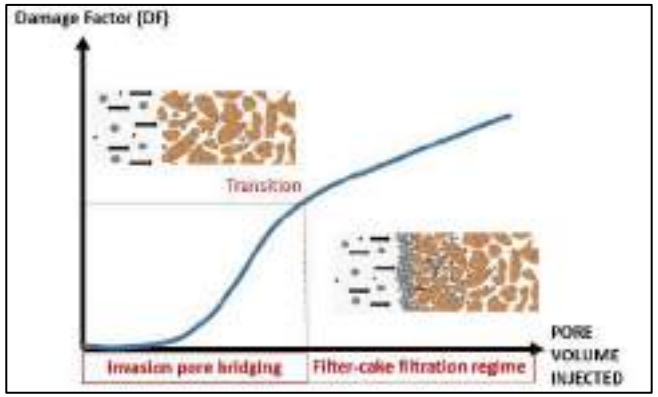
Mineral phases originating from the reservoir: clays, silica, carbonates, …

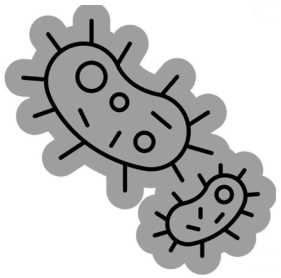
particle mobilization:
focus of the present study



Mineral phases resulting from precipitation in the installations: calcite, …

Mechanism of particles-induced formation damage





Particles resulting from bacterial activity



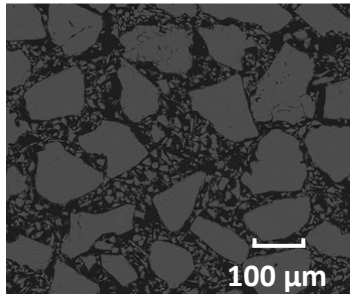
Oxidation products: corrosion, oxidation of dissolved iron

INVESTIGATION OF PARTICLES MOBILIZATION MECHANISMS
EXPERIMENTAL APPROACH

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- **Principle:** collect the fine particles released from a porous medium on a membrane filter

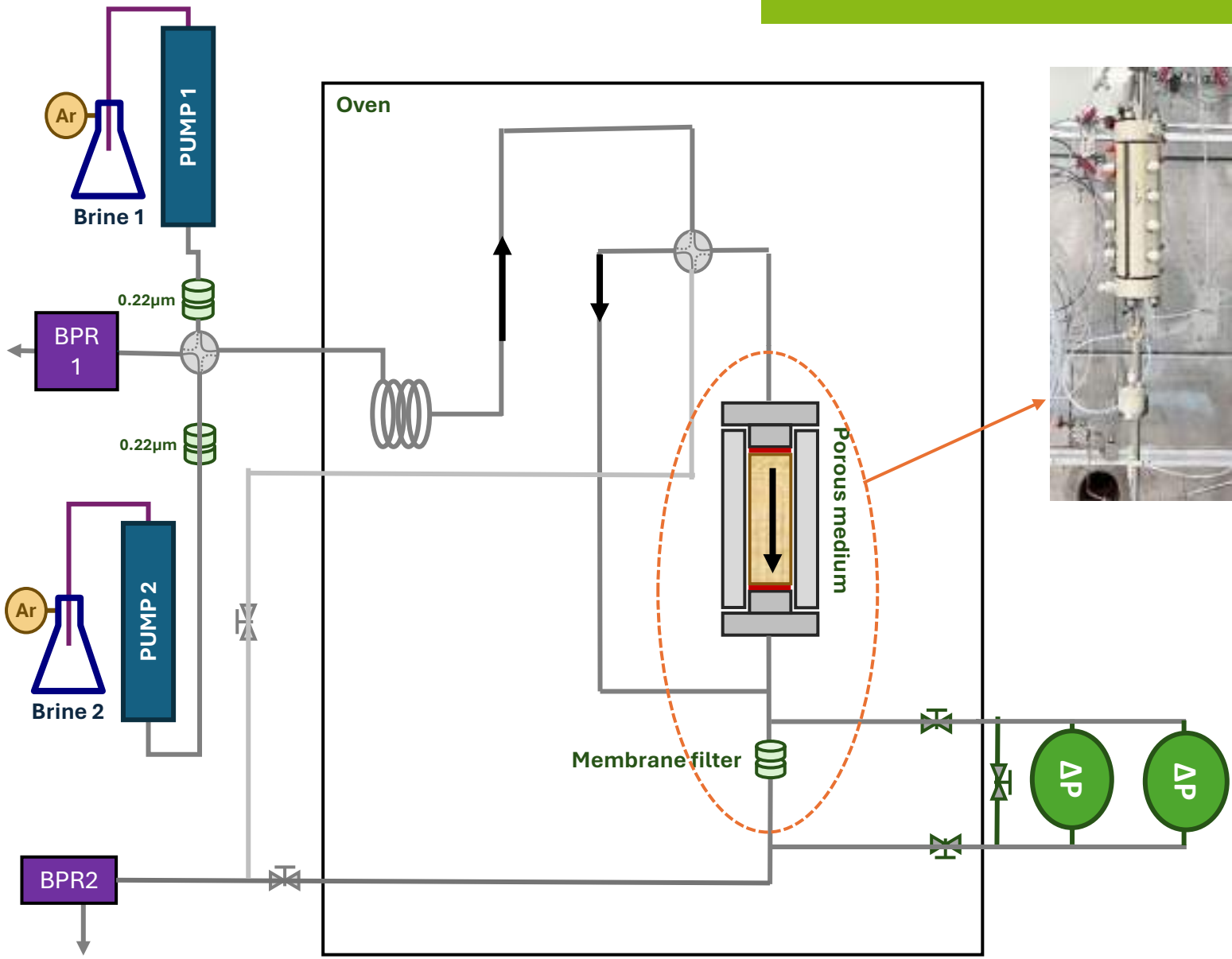
- Representative granular porous medium
  - matrix grains and fine particles
  - homogenous pack



typical SEM image of a granular porous medium

- Procedure
  - inject representative waters/brines at set representative velocities (on individual membrane filters)
  - observables: amount of particles released (TR – by weighting), damage factor on the filter (DF – from the pressure drop)

➔ make recommendations to optimize operations



INVESTIGATION OF PARTICLES MOBILIZATION MECHANISMS
SYNTHETIC CASE / CONDITIONS

ÉNERGIES NOUVELLES

- **Porous media: matrix + one common fine particles mineral**

Matrix
Fontainebleau sandstone **- pure quartzic (SiO_2) sand** **- D50 = 110 µm** **(monodispersed distribution)**

- matrix grains cannot be released (net with 50µm mesh opening at porous medium's outlet)
- fine particles mass fraction: 20%
- pore throats size of the matrix: 20 µm ➔ *release rate (TR) calculations based on <20µm fraction of size distributions*

Fine particles
Kaolinite **- lab standard (Thermo Scientific)** **- D50 = 17 µm**
Illite **- I77 from Puy-en-Velay** **- D50 = 50 µm**
Smectite **- MX80 Wyoming Montmorillonite** **- D50 = 54 µm**
Quartz fines **- ground and sieved Fontainebleau sandstone** **- D50 = 20µm**

- **Injection velocities**
  - **from 2.4 m/day (27.4 mL/h): in-depth reservoir flow**
  - **to 226 m/day (2500 mL/h): near wellbore**

- **Waters:**

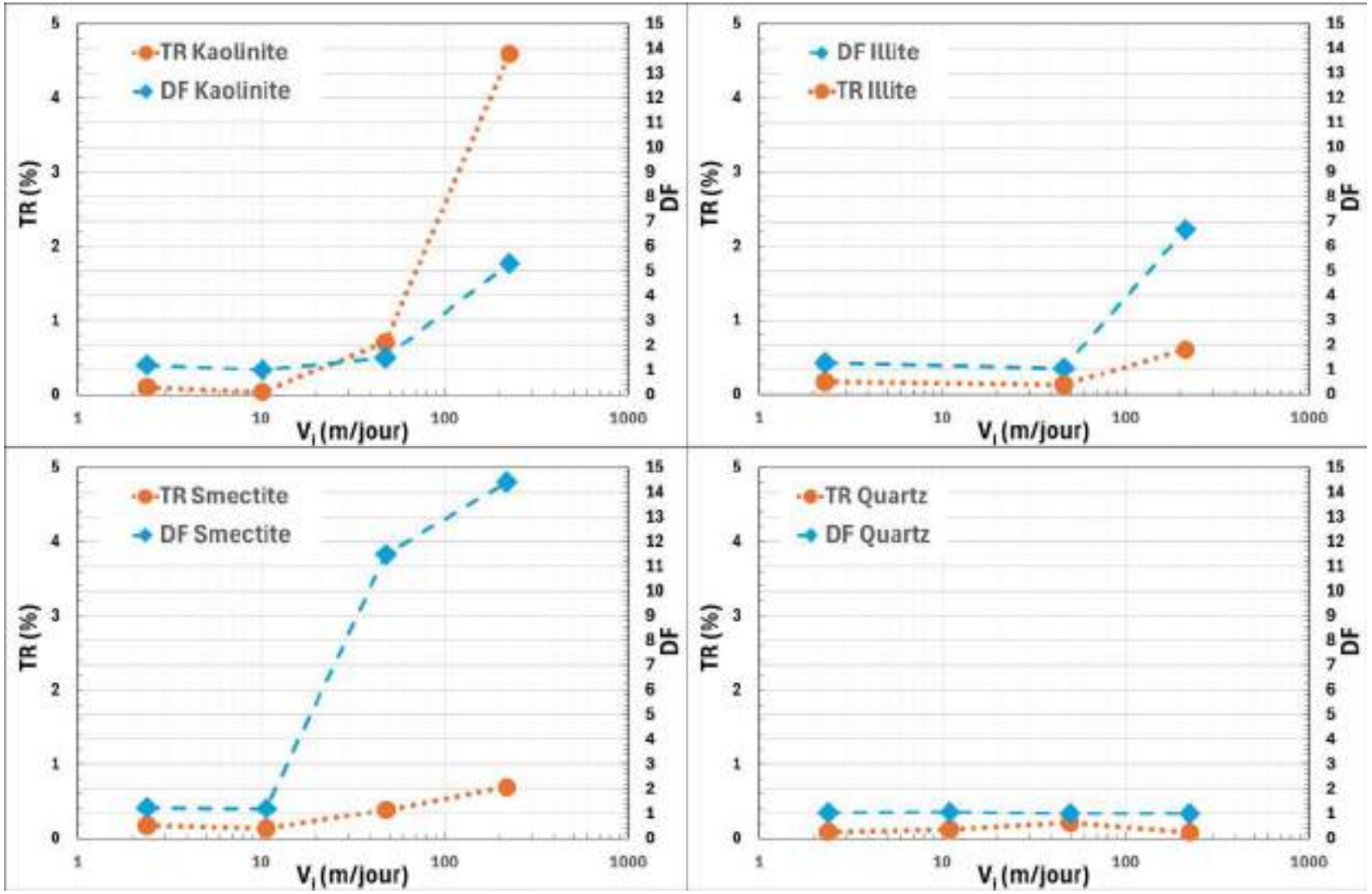
  Albian water & very high salinity synthetic brine

Salt	Albian (g/L)	Albian*1000 (g/L)
NaCl	0.017	17.3
KCl	0.018	17.7
$CaCl_2,2H_2O$	0.136	135.7
$MgCl_2,6H_2O$	0.069	68.6
TDS	**0.17**	**170**

INVESTIGATION OF PARTICLES MOBILIZATION MECHANISMS

SYNTHETIC CASE / RESULTS:
IMPACT OF VELOCITY IN ALBIAN WATER

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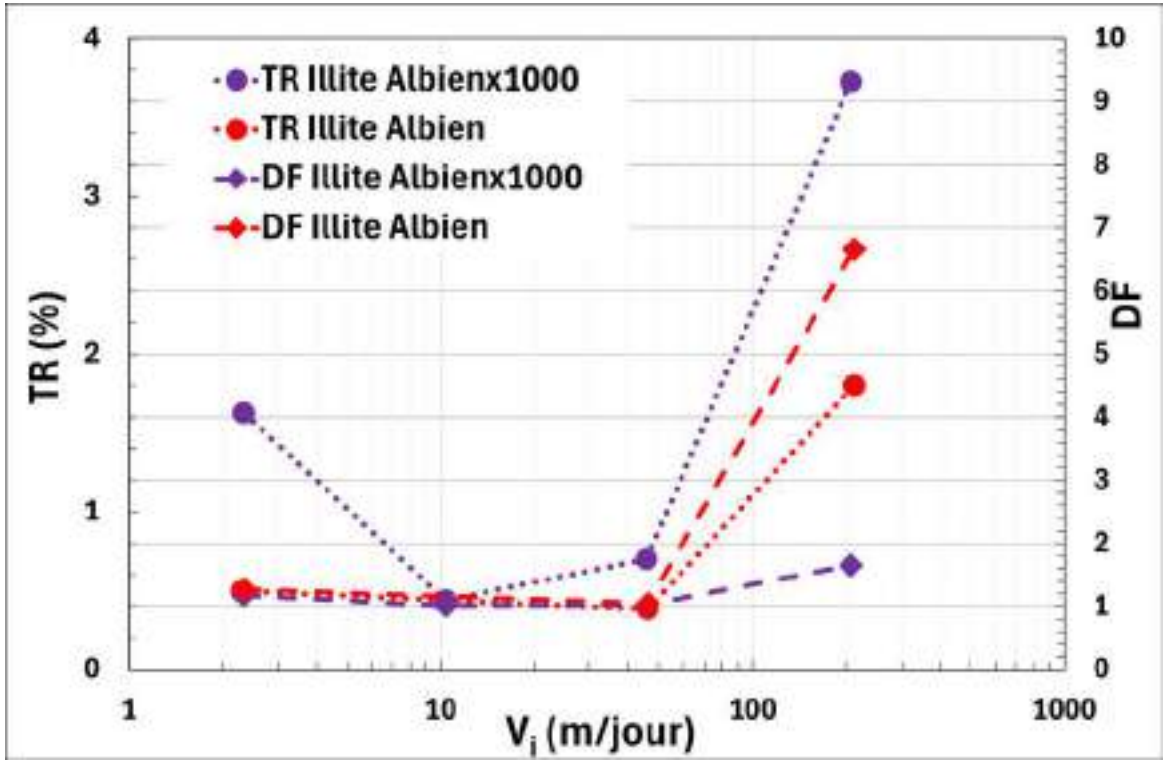


- **Clay particles**
  - evidence of particle release thresholds
  - kaolinite
    - between 10 and 50 m/day
    - beyond threshold: increase TR and DF
  - illite
    - above 50 m/day
    - beyond threshold: marked increase of DF, low increase of TR
  - smectite
    - between 10 and 50 m/day
    - beyond threshold: marked increase of DF, low increase of TR
- **Quartz fines**
  - no particle release threshold

INVESTIGATION OF PARTICLES MOBILIZATION MECHANISMS

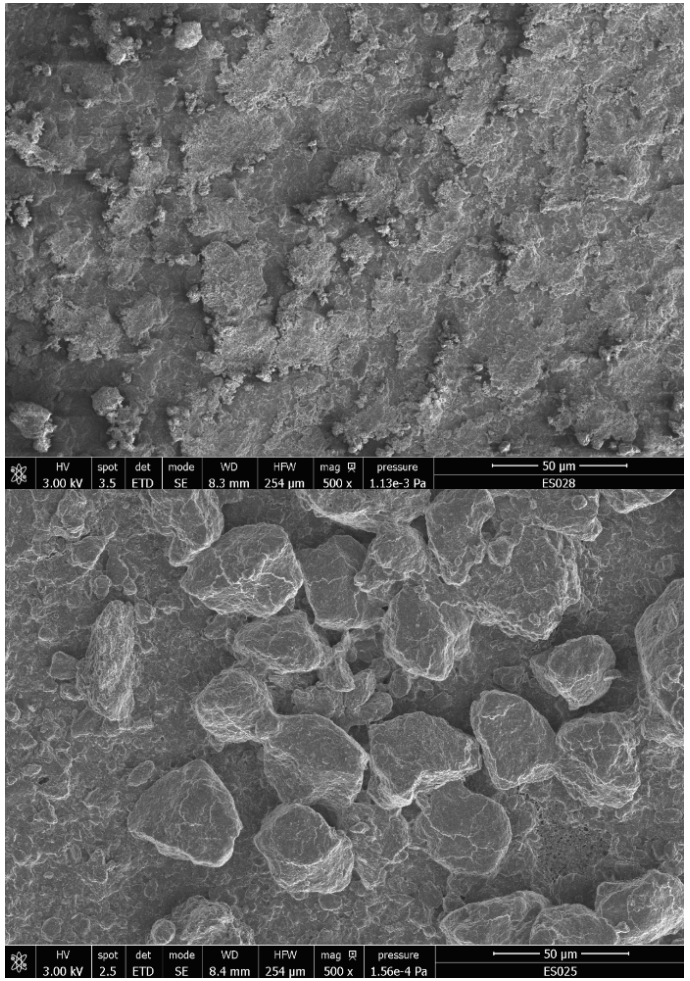
SYNTHETIC CASE / RESULTS: IMPACT OF SALINITY - ILLITE

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- more particle release but lower DF in high salinity brine
  - ➔ coarser (aggregated particles) entails less formation damage

"postmortem" SEM observation of filters



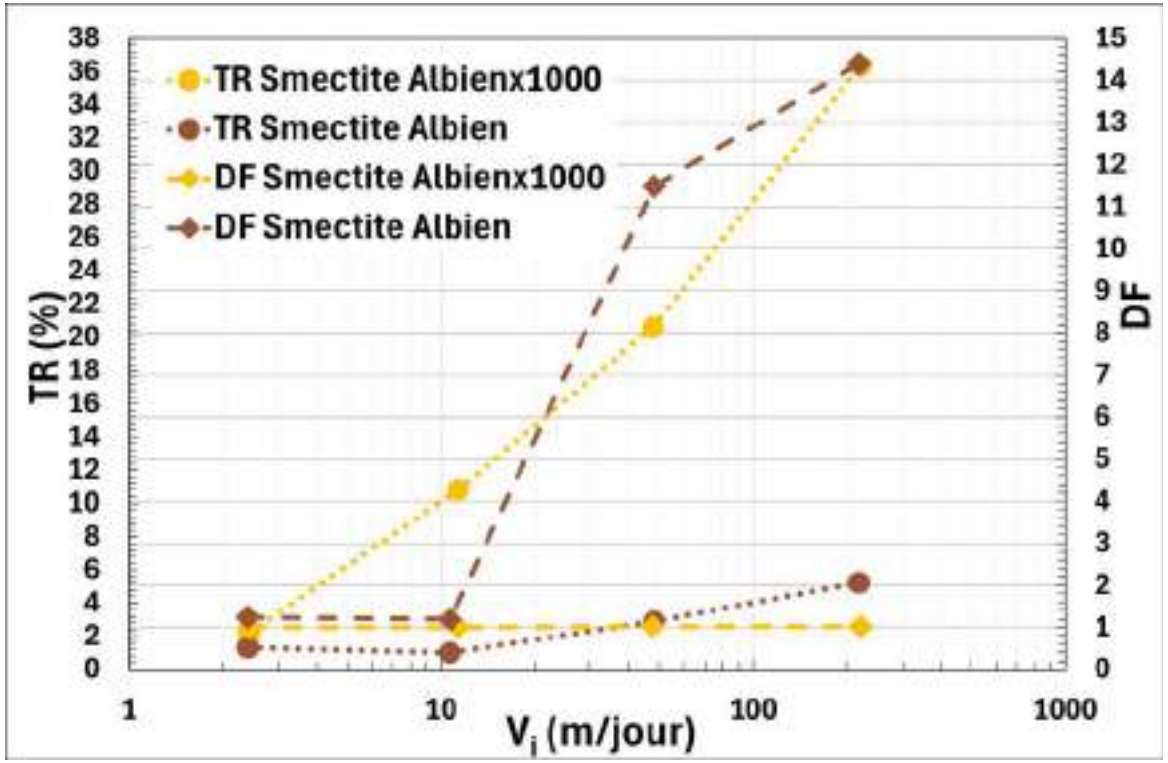
Albian water

Albianx1000 brine

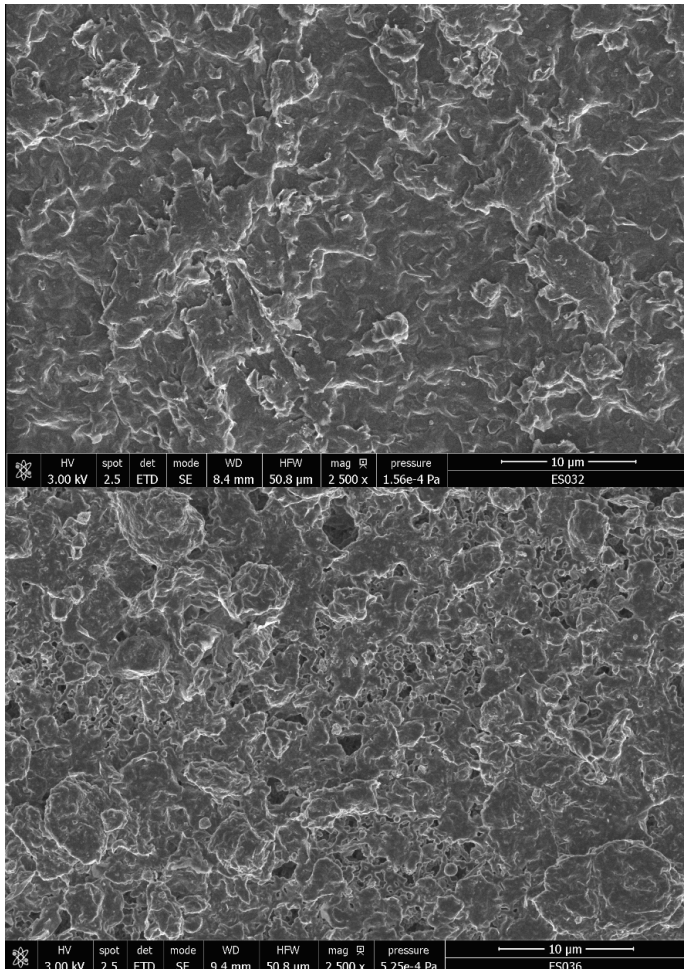
INVESTIGATION OF PARTICLES MOBILIZATION MECHANISMS

SYNTHETIC CASE / RESULTS: IMPACT OF SALINITY - SMECTITE

ÉNERGIES NOUVELLES



"postmortem" SEM observation of filters



Albian water

Albianx1000 brine

- massive particle release in high salinity brine … but no permeability damage (DF=1)
  - ➔ swollen smectite particles in low-salinity environment are not easily released but create low-permeability filter-cake ➔ significant formation damage

INVESTIGATION OF PARTICLES MOBILIZATION MECHANISMS
CONCLUSIONS

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Summary of results

Fine particle type	Velocity threshold	Particle release rate and damage factor above threshold
Kaolinite	50 - 200 m/day	Marked particle release and damage factor
Illite		
Smectite	Albian water: 10 - 50 m/day	Low particle release but very marked damage factor
	high salinity brine: from 2 m/day	Massive particle release but no permeability damage
Quartz	no threshold	No particle release, no permeability damage *in the study's experimental conditions*

Recommendations

- ***if possible***: control flow rate so that interstitial velocity remains below the release threshold, which depends on the minerals
- ***if operational conditions correspond to above-threshold velocities***: implement fine-meshed filtration in surface facilities
- check compatibility of formation with saline drilling muds

Thank you !