Role of diffusiophoresis in colloidal transport through porous media: Microfluidics experiments

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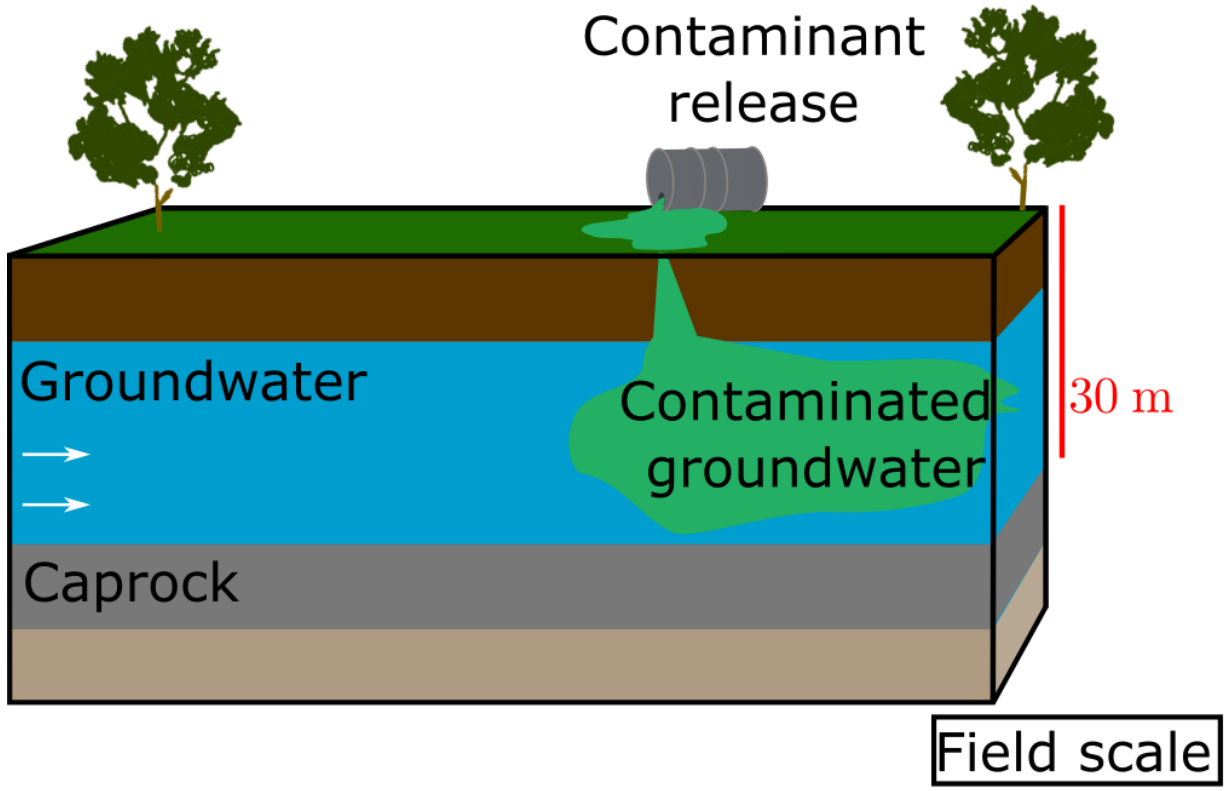
Context: groundwater remediation



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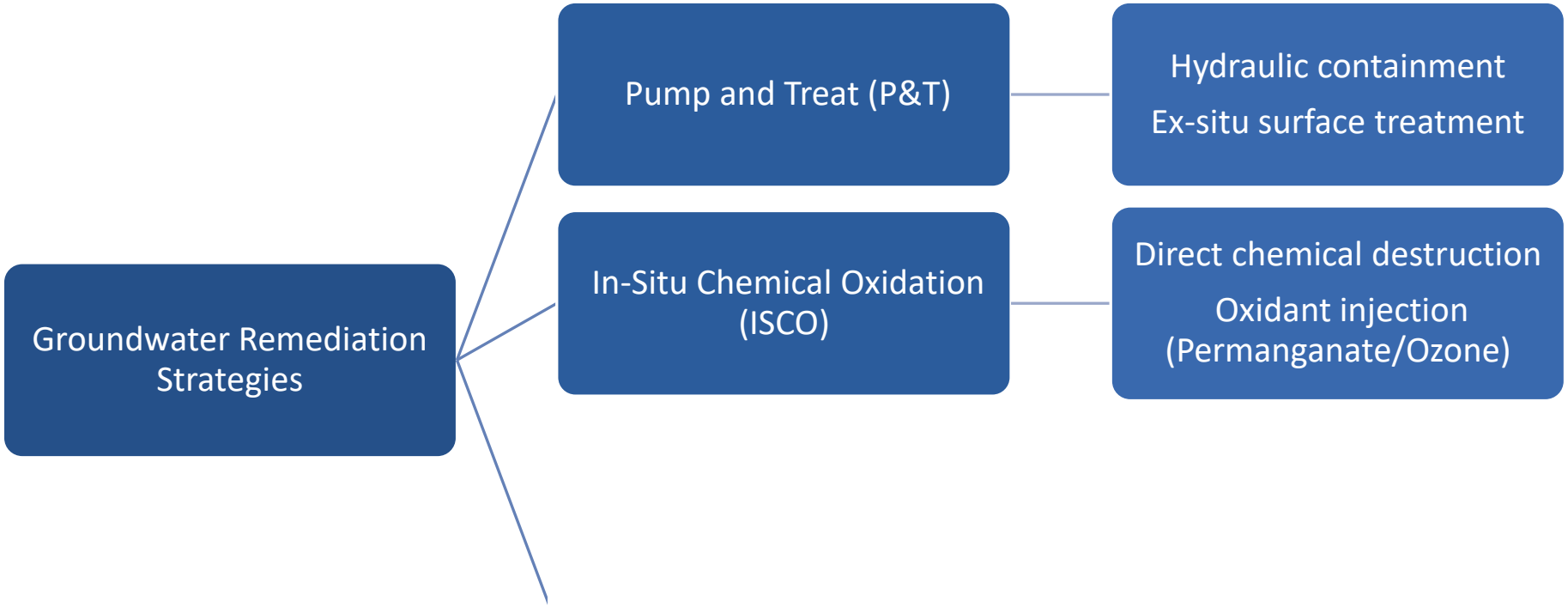

Sources: SelecDEPOL
Roustaei and Bagherzadeh, 2015
Hendraningrat et al. 2013b
Zhang et al., 2014

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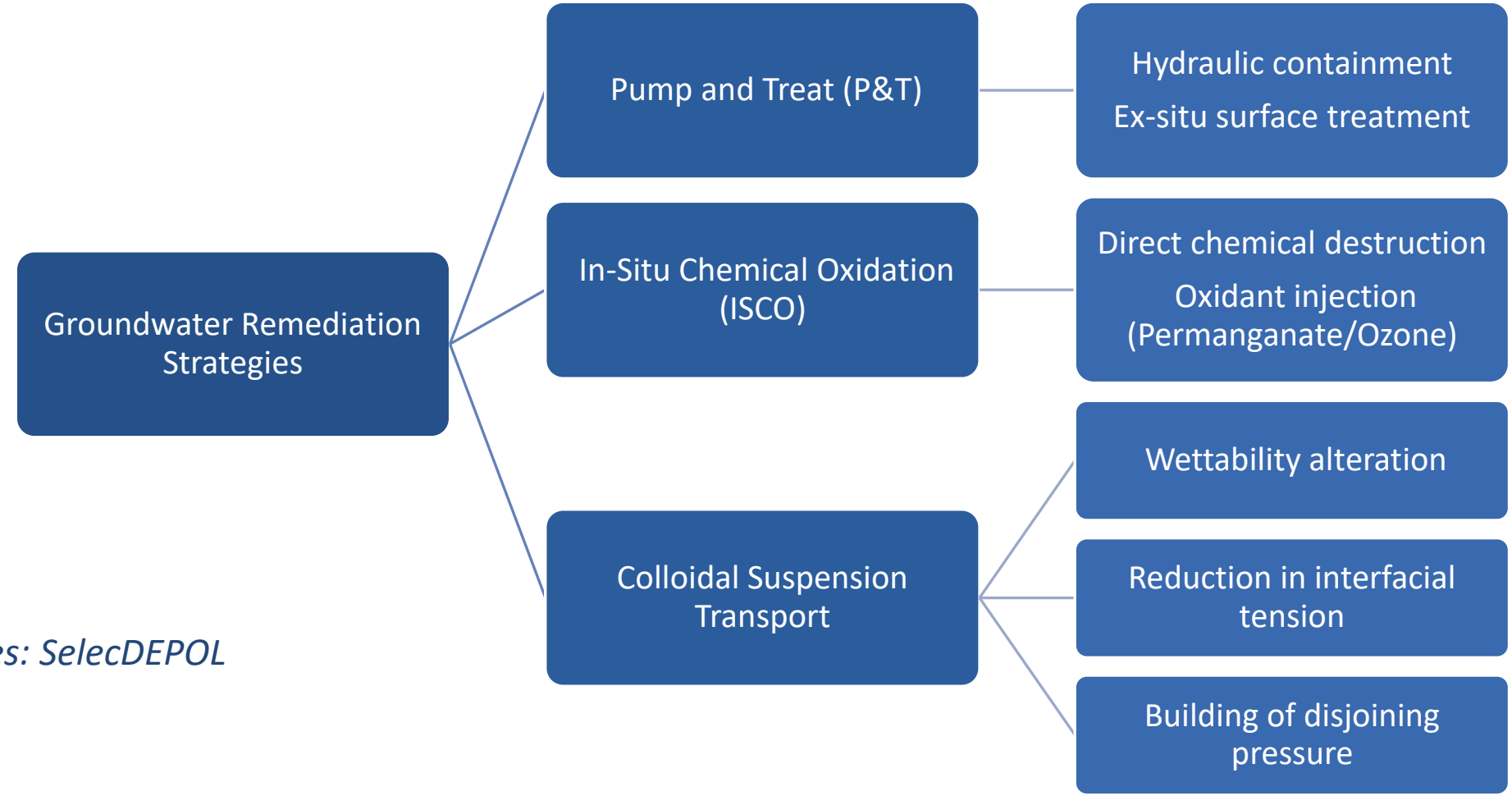

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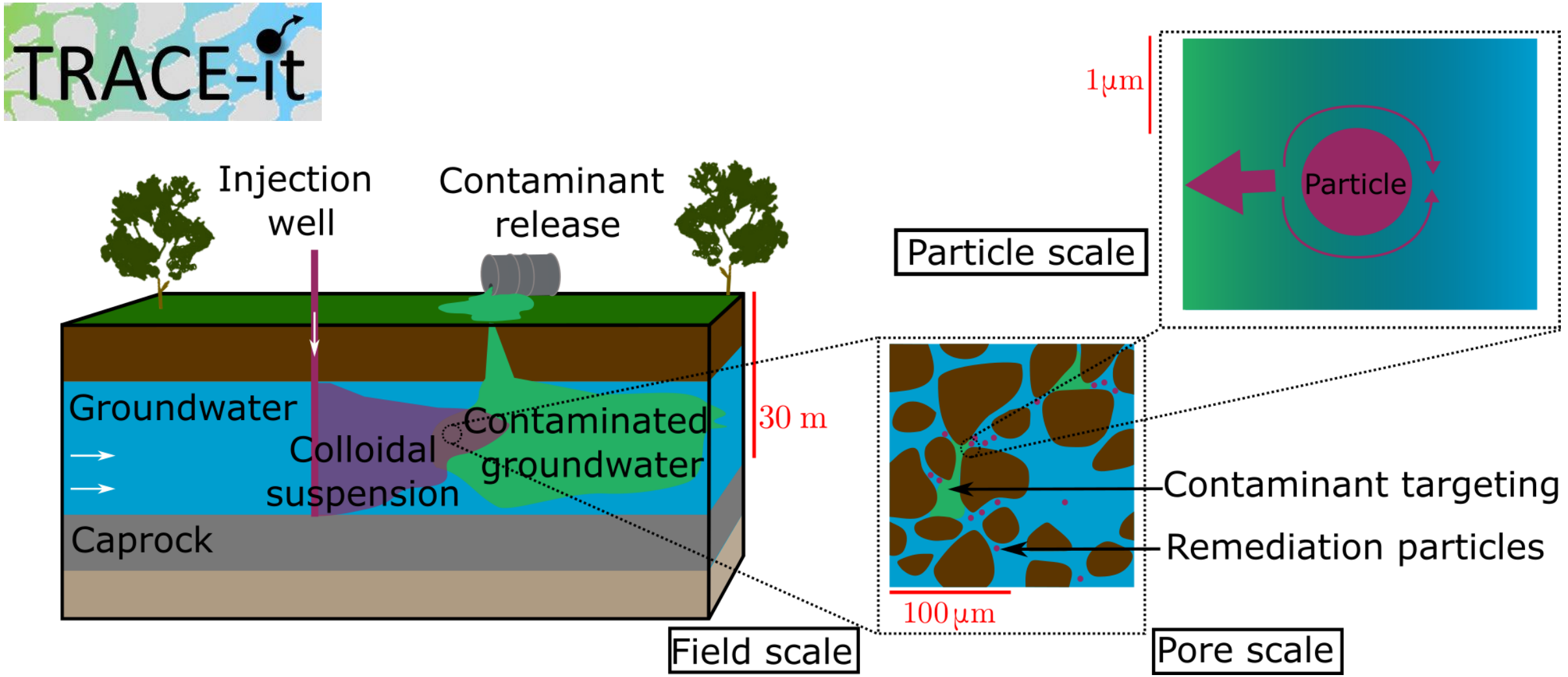
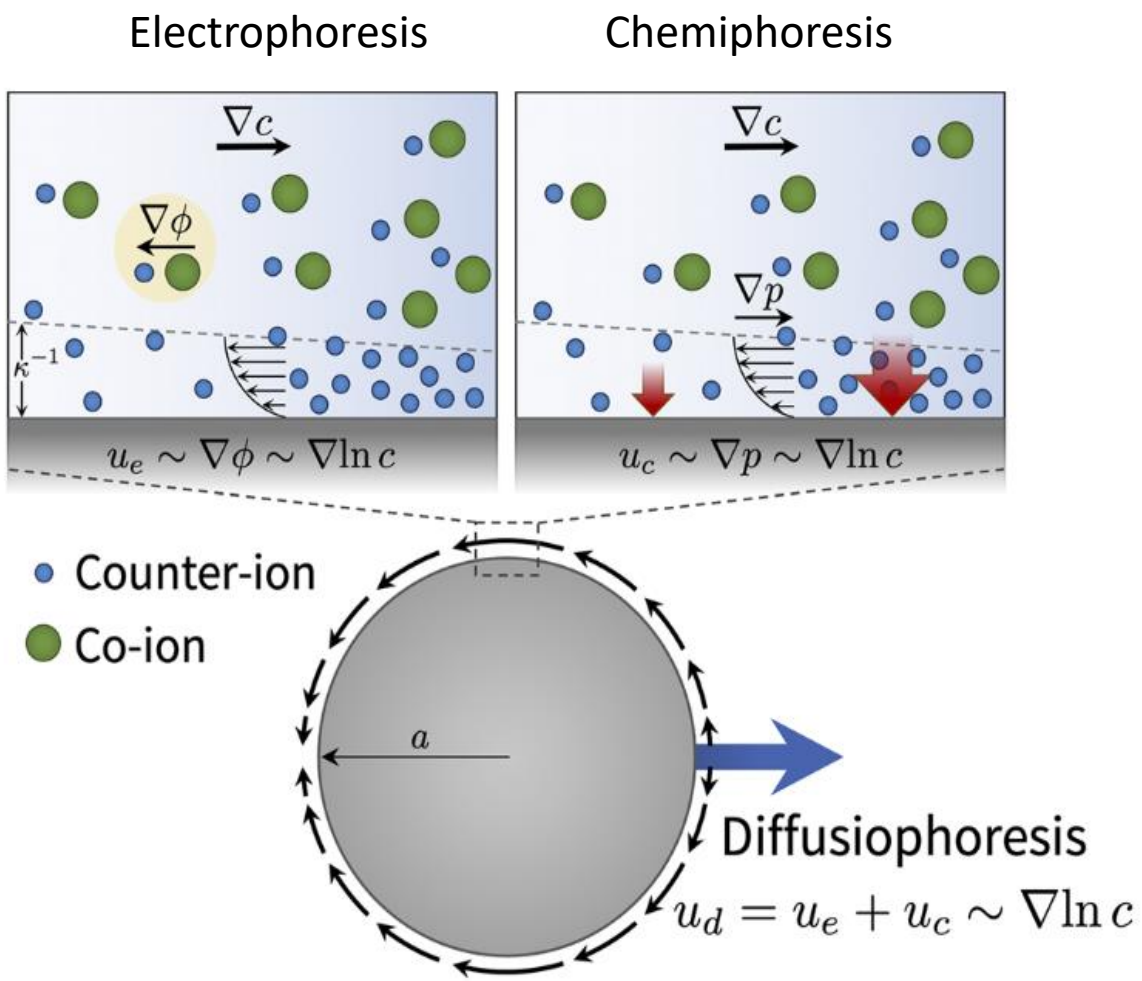
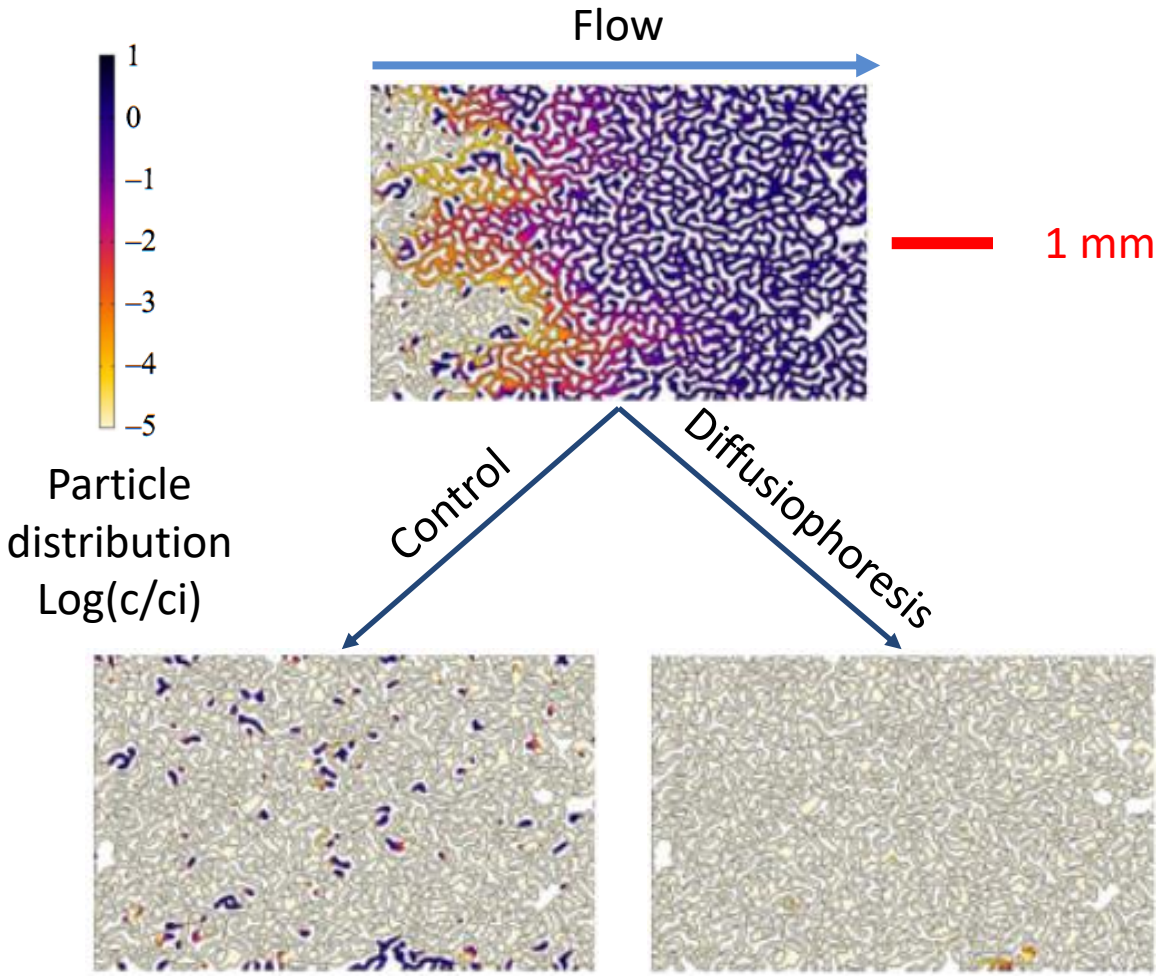


Particles driven by salt gradients: Diffusiophoresis



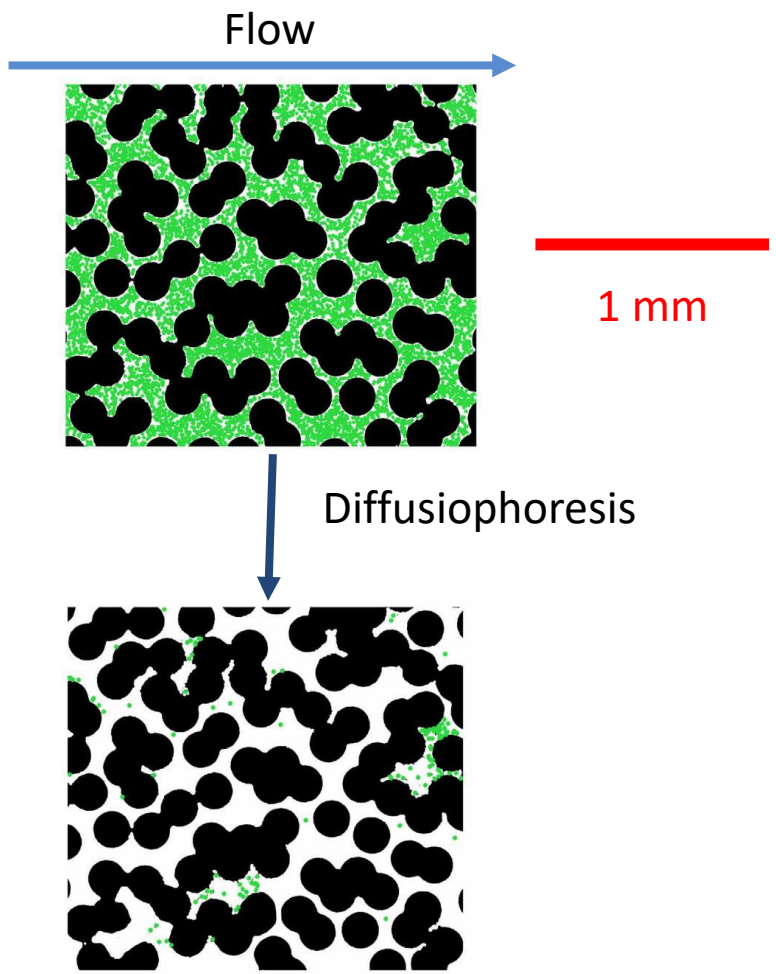
Shin et al., *Physics of Fluids* (2020)

Diffusiophoresis in porous media



numerical

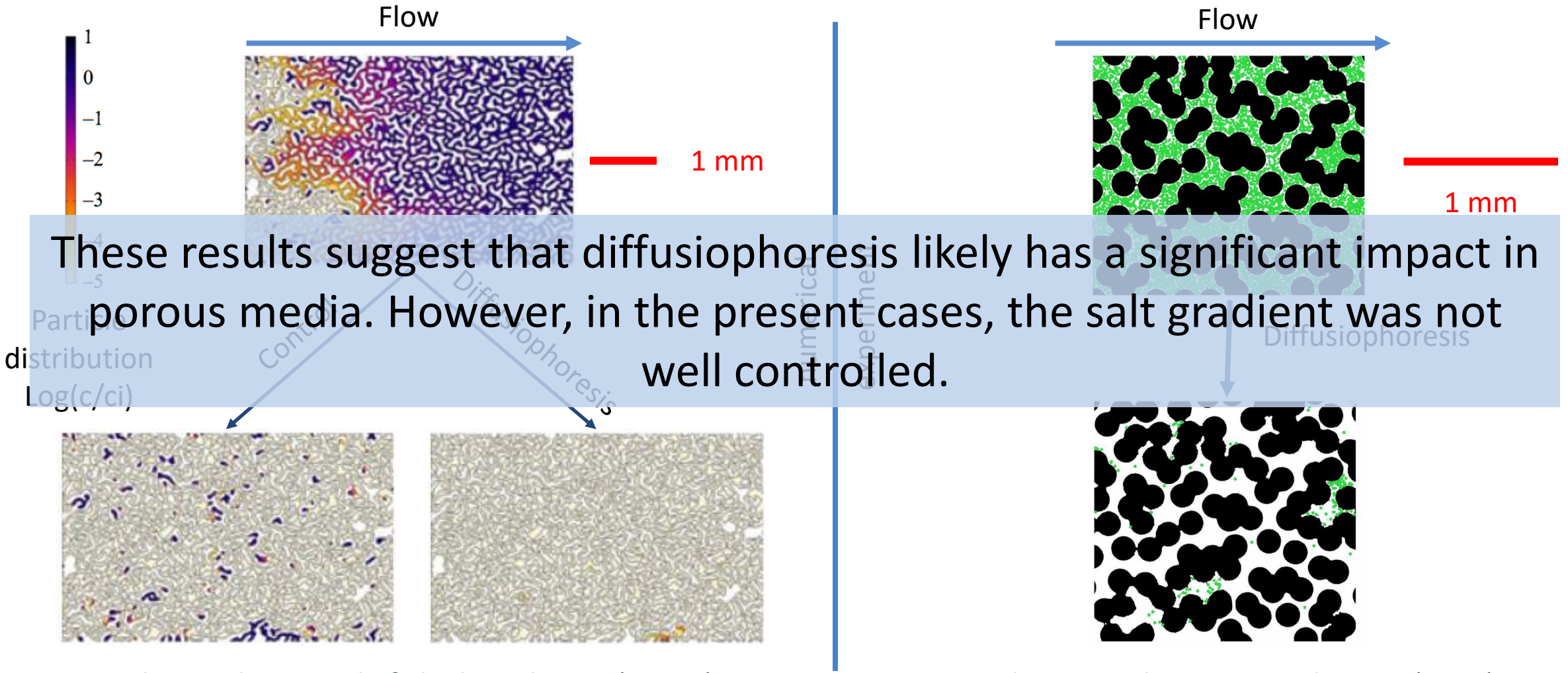
experiment



Jotkar et al., *Journal of Fluid Mechanics* (2024a)

Alipour et al., *Science Advances* (2026)

Diffusiophoresis in porous media



These results suggest that diffusiophoresis likely has a significant impact in porous media. However, in the present cases, the salt gradient was not well controlled.

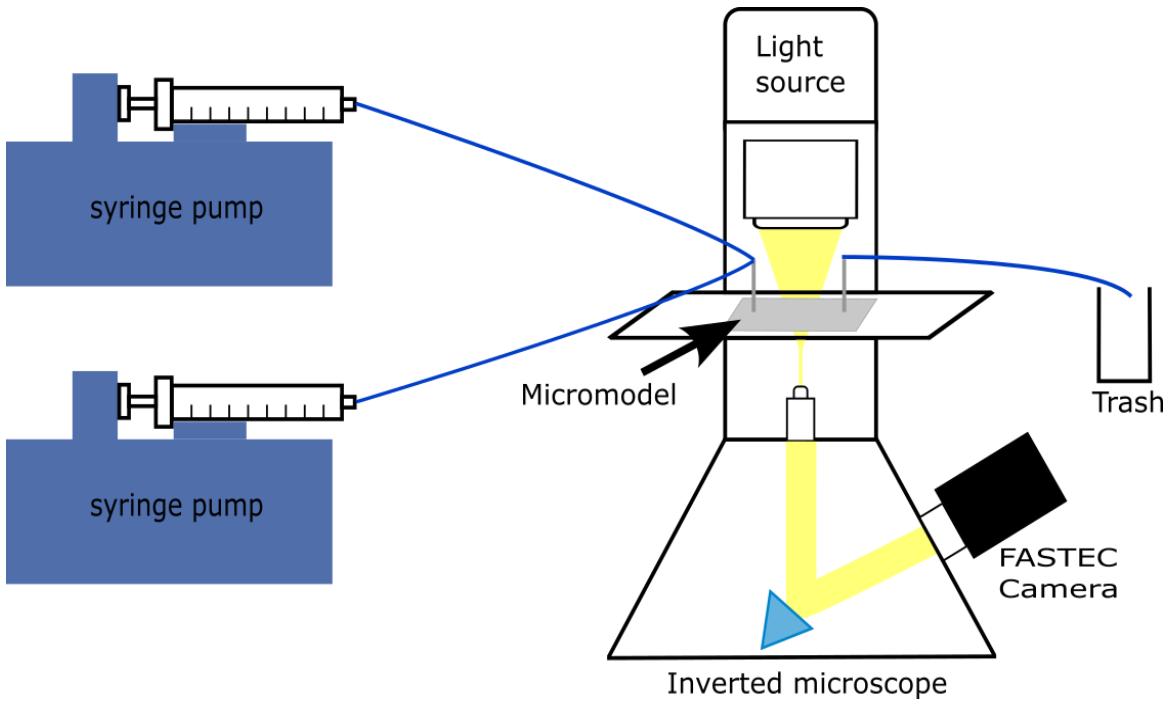
Jotkar et al., *Journal of Fluid Mechanics* (2024a)

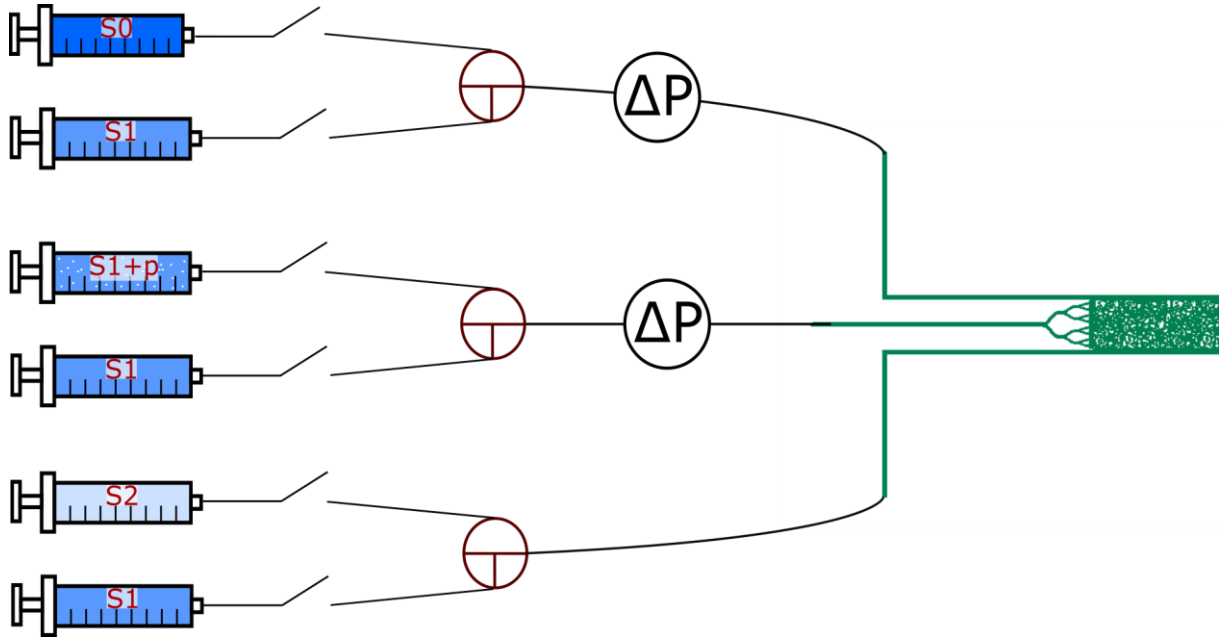
Alipour et al., *Science Advances* (2026)

How does diffusiophoresis concretely influence the transport and spatial distribution of colloids within a heterogeneous pore network?

- Is it possible to establish and maintain a controlled, steady-state salt gradient?
- How does a salt gradient cause particle motion and affect particle behavior?
- In which regimes does diffusiophoresis have an impact?

Experimental set-up





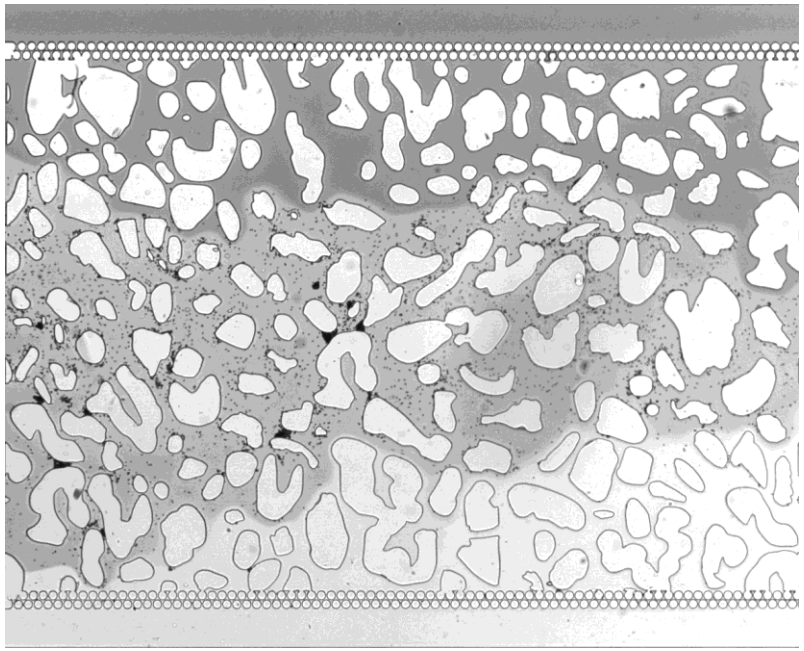
Solutions	[NaCl]	Dye	Particles
S0	10 mM	19 g/L	
S1	5 mM	9.5 g/L	
S1 + p (-)	5 mM	9.5 g/L	Yes
S2	0.1 mM	0.2 g/L	

Péclet number: $Pé = \frac{\text{Velocity} \times \text{Depth}}{\text{Diffusion of NaCl}}$

Formation of the salt gradient

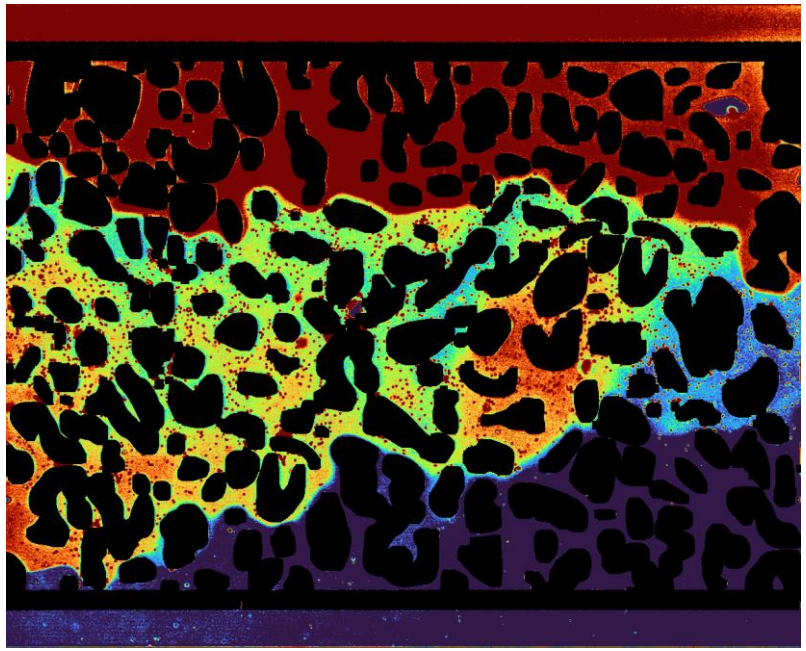
ISTO PORE
Bridging Scales for Coupled Subsurface Processes through Numerical Models and Microfluidic Expertise

Experiment

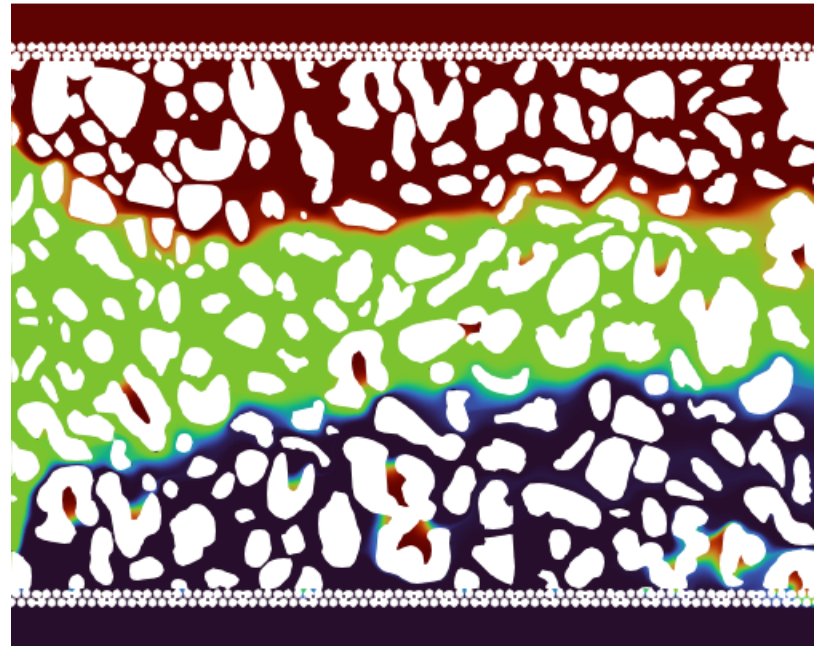


0.2 mm

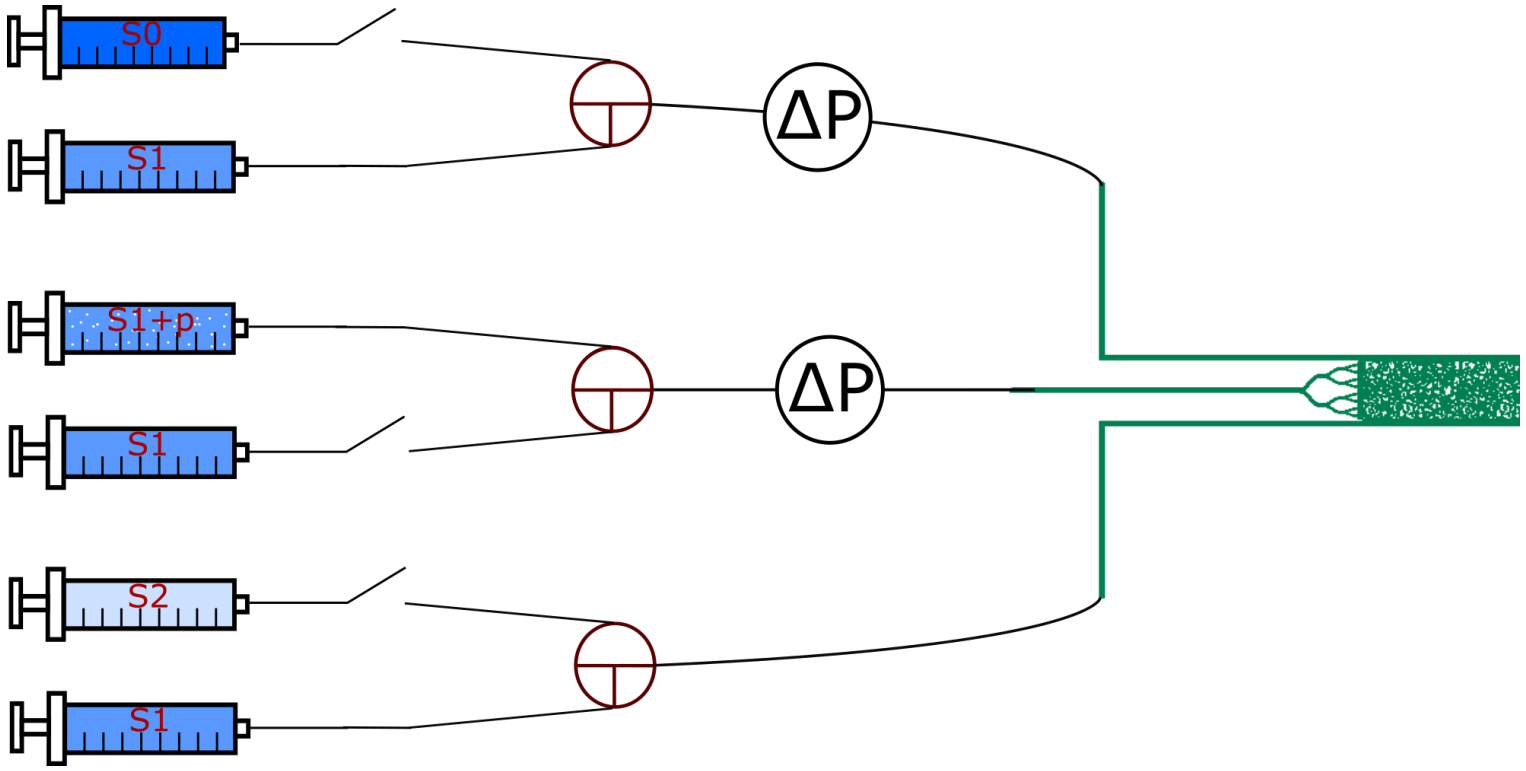
Recolorised experiment



Simulation



Particle injection with no salt gradient: control



Solutions	[NaCl]	Dye	Particles
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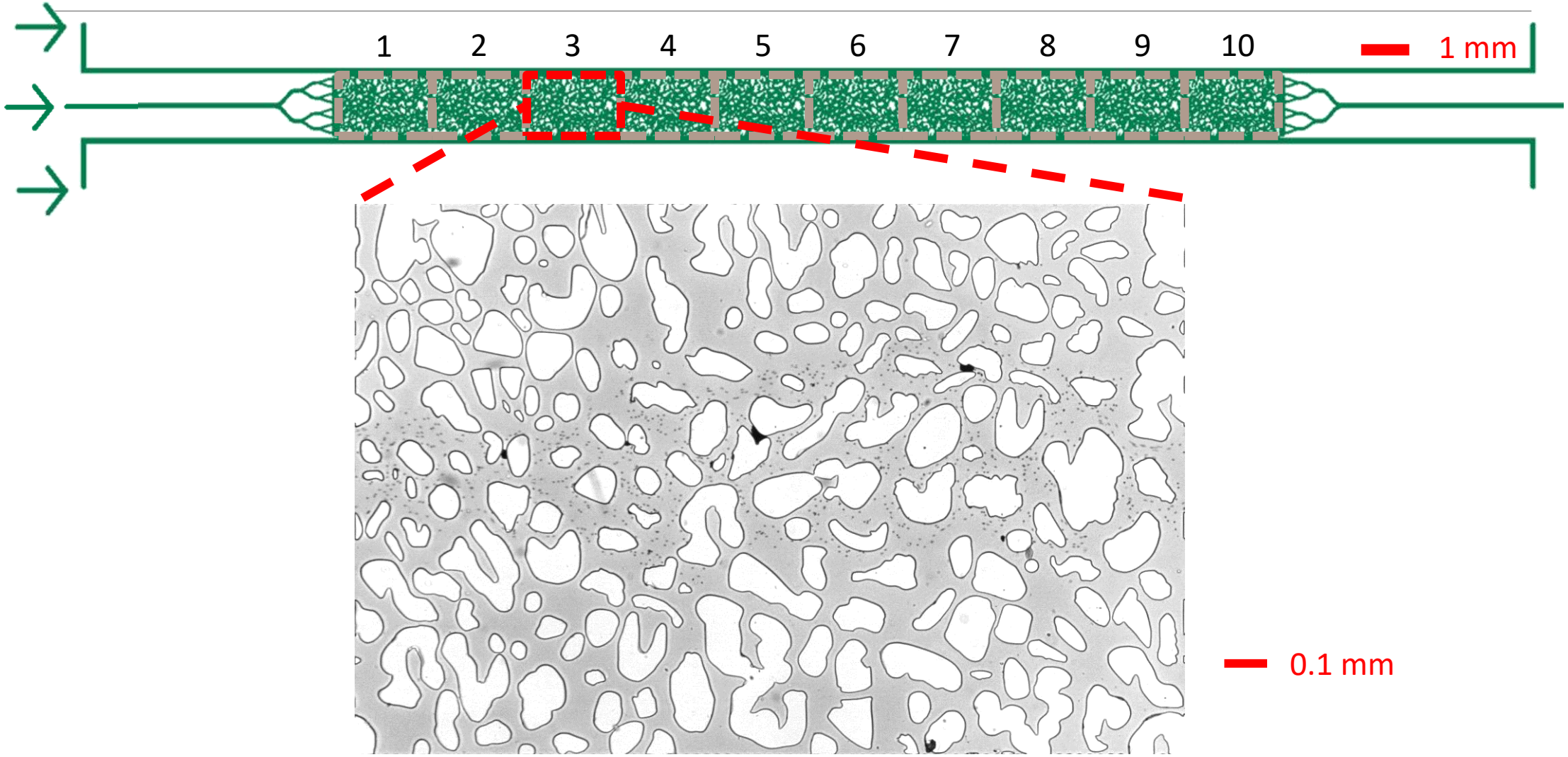

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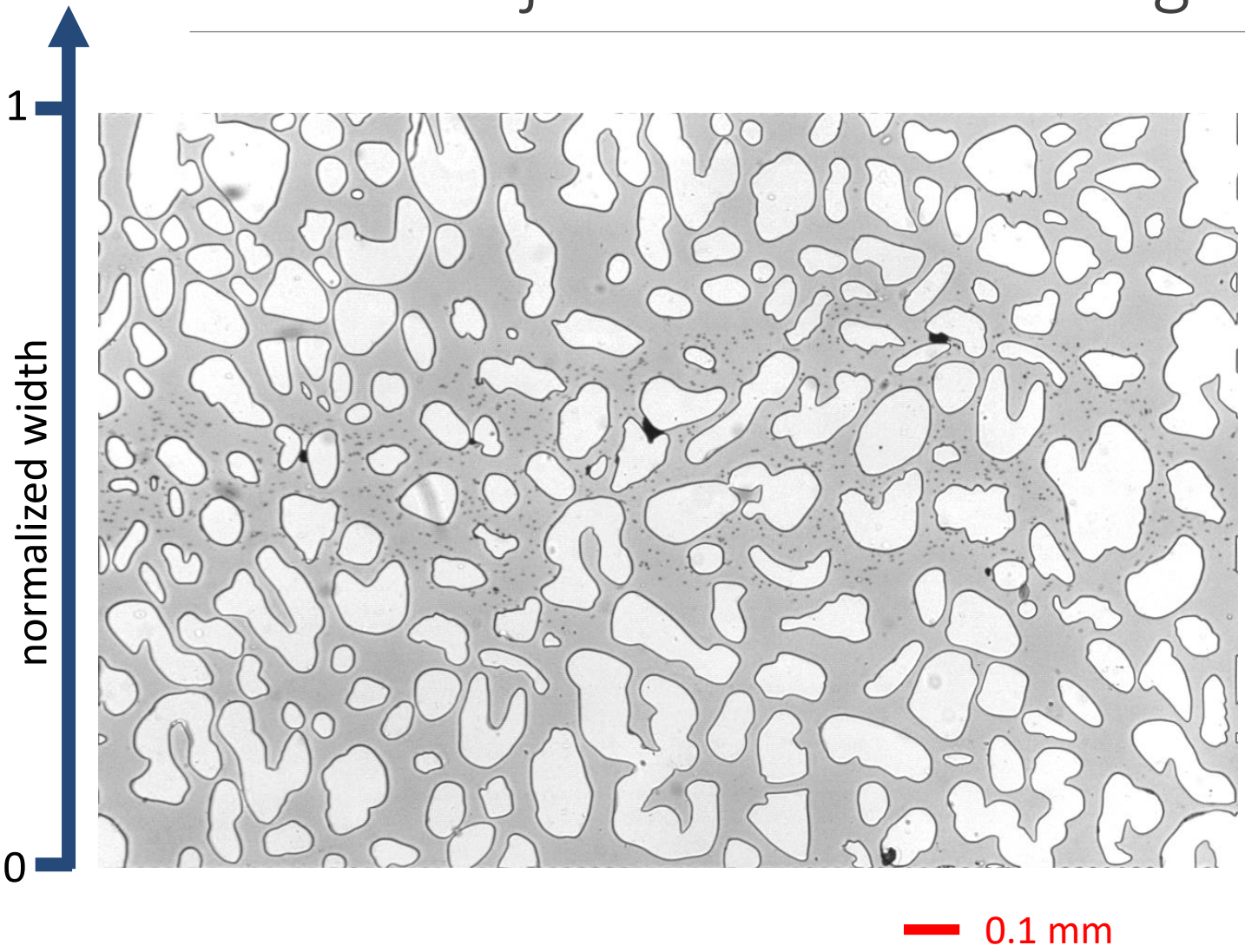
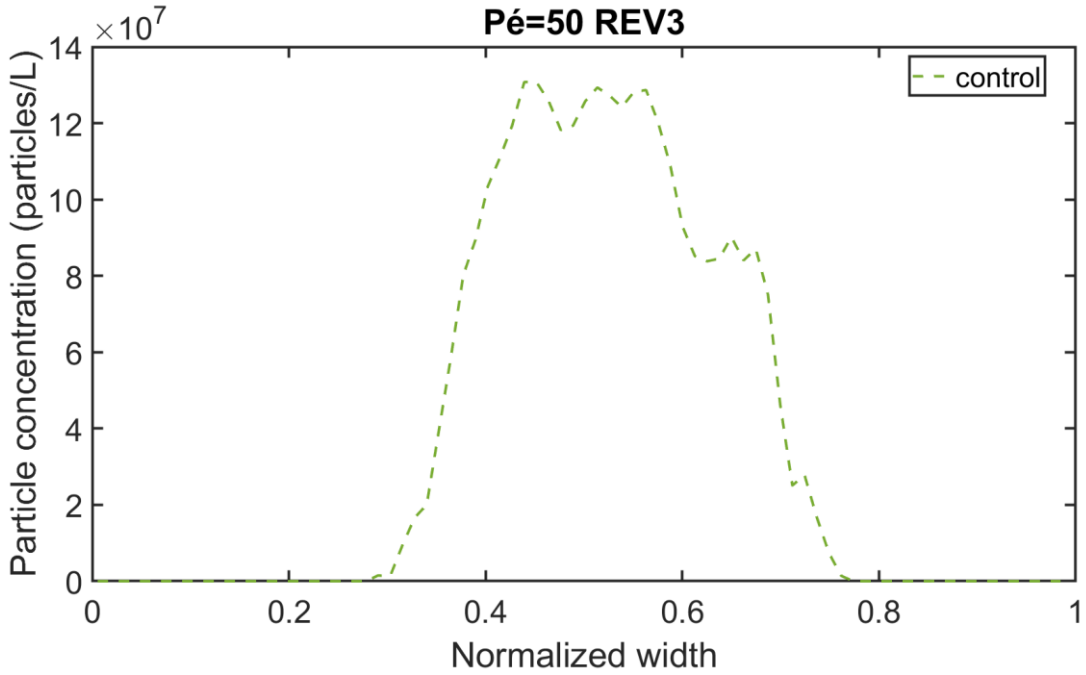
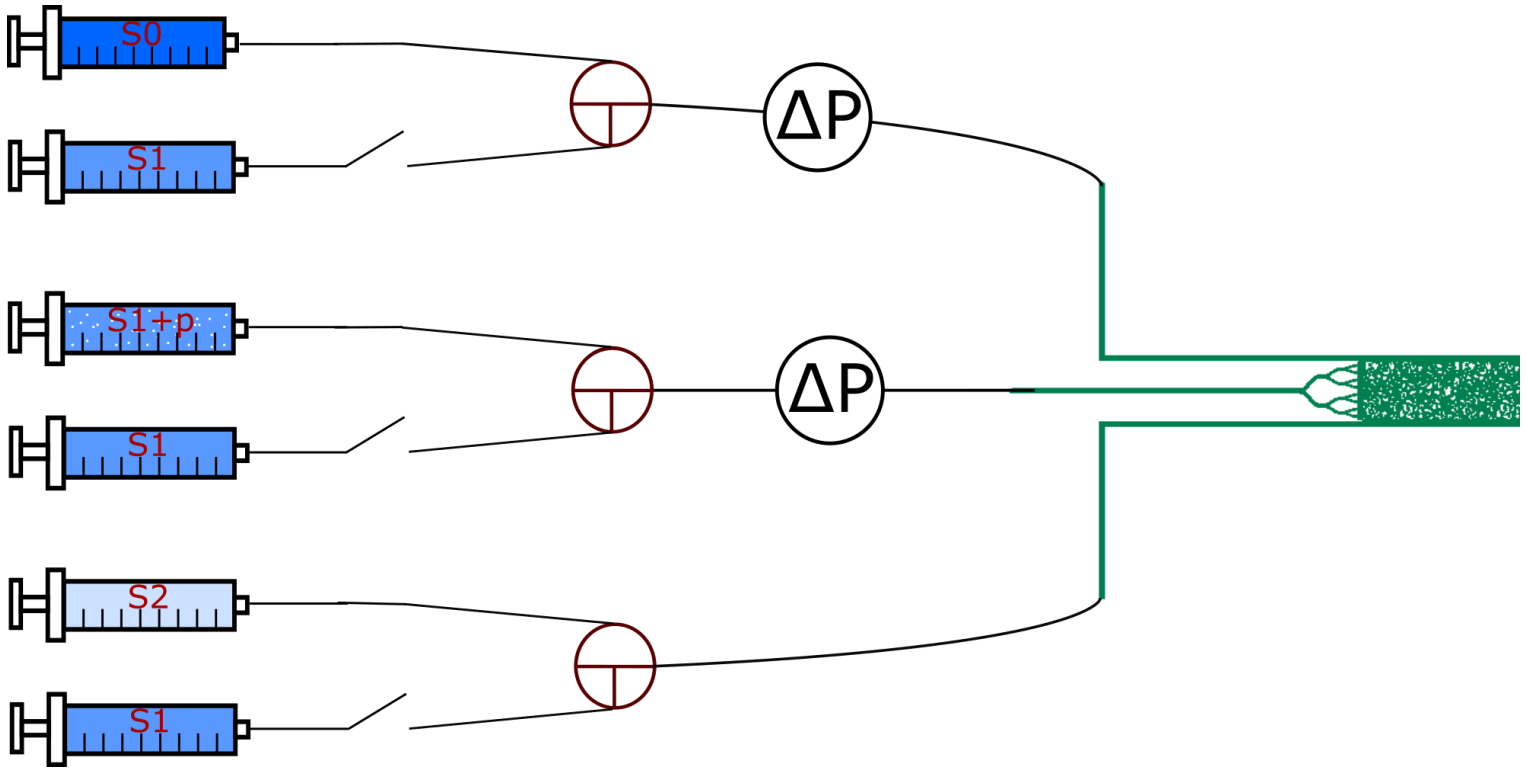




Particle injection with salt gradient



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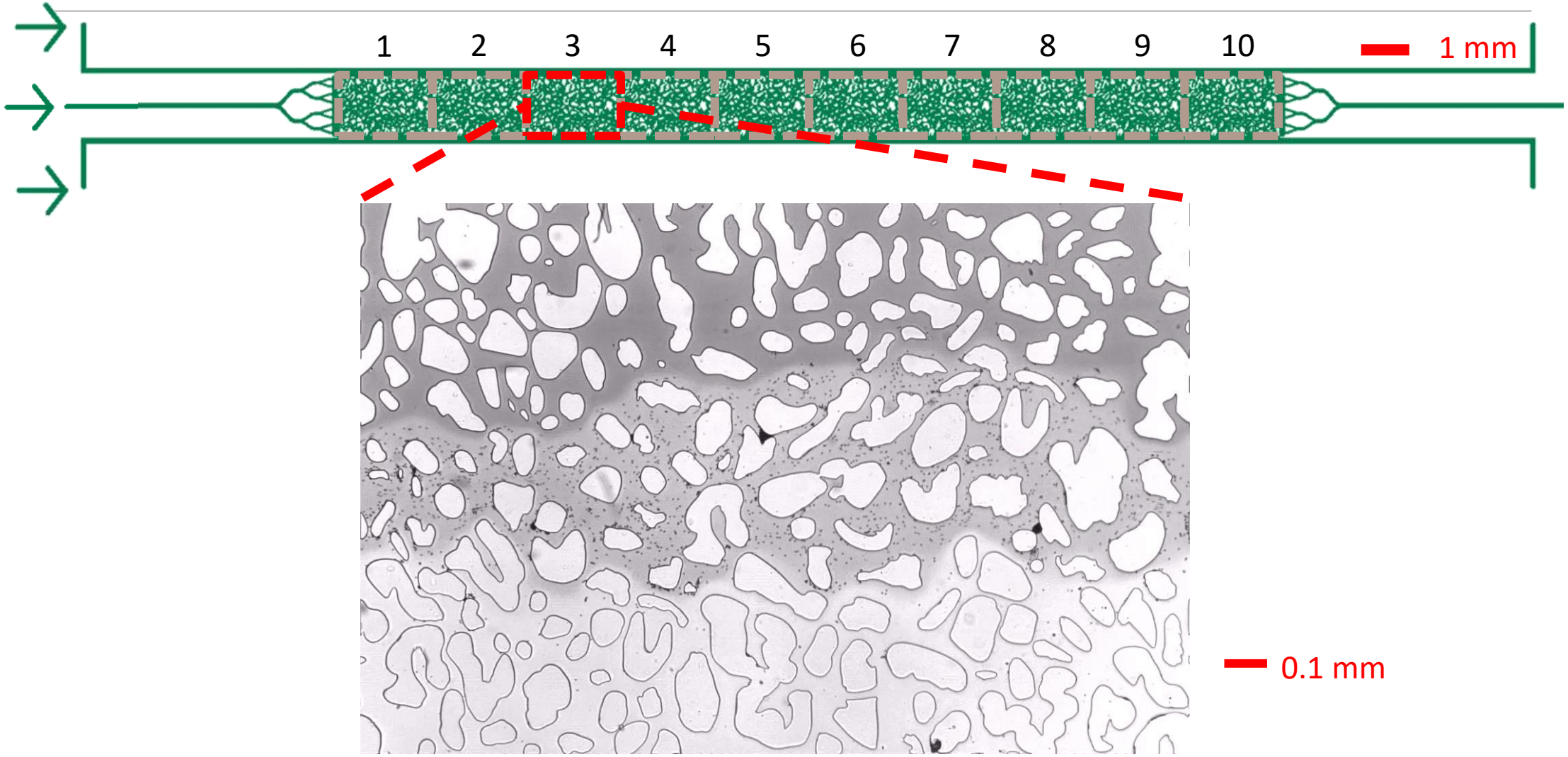

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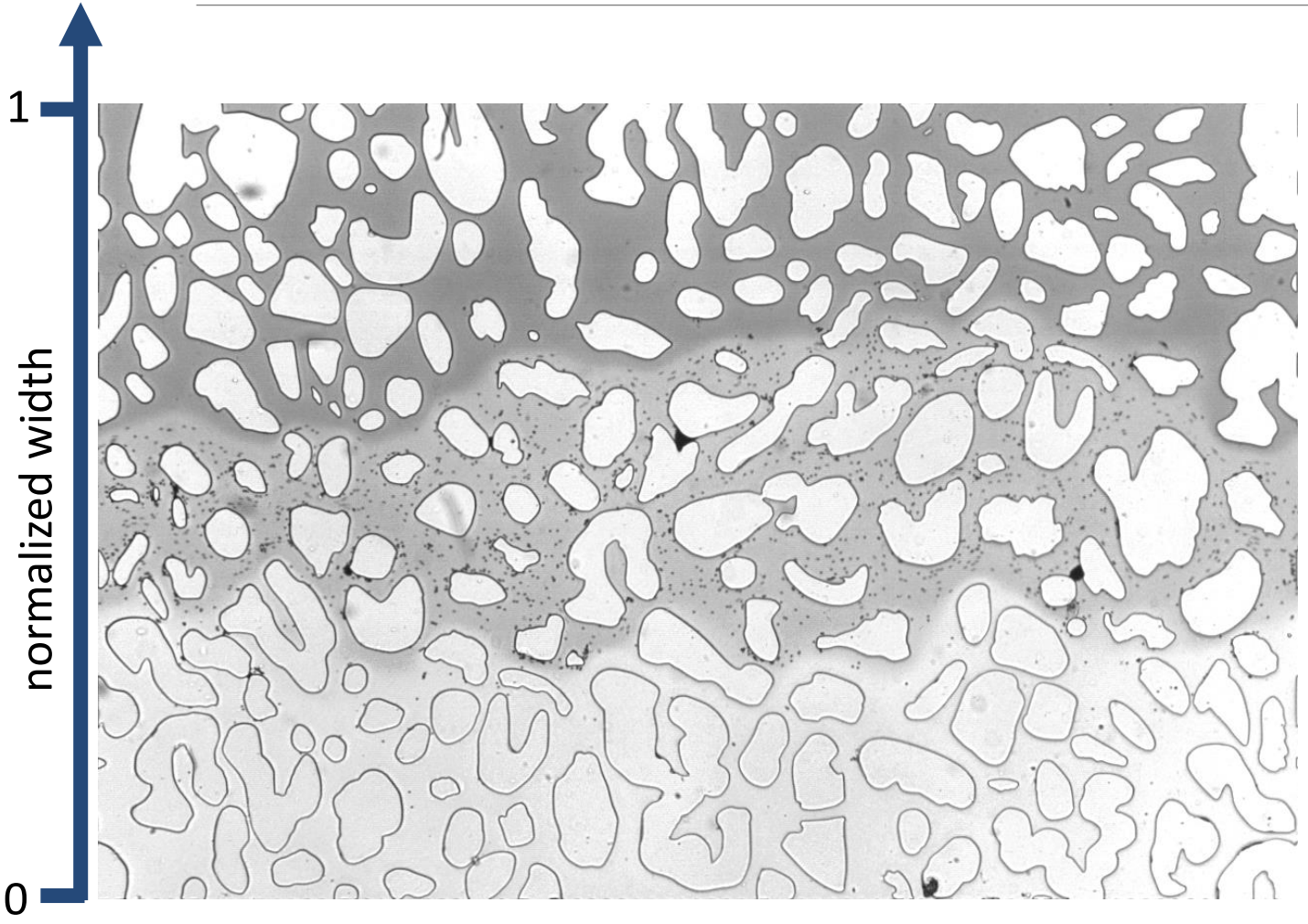
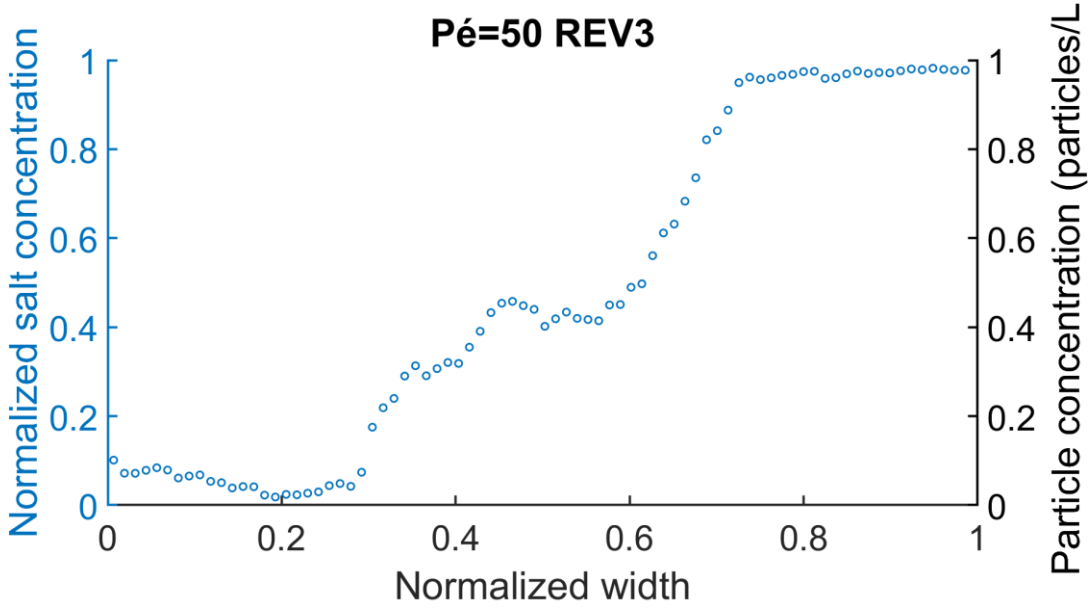


0.1 mm



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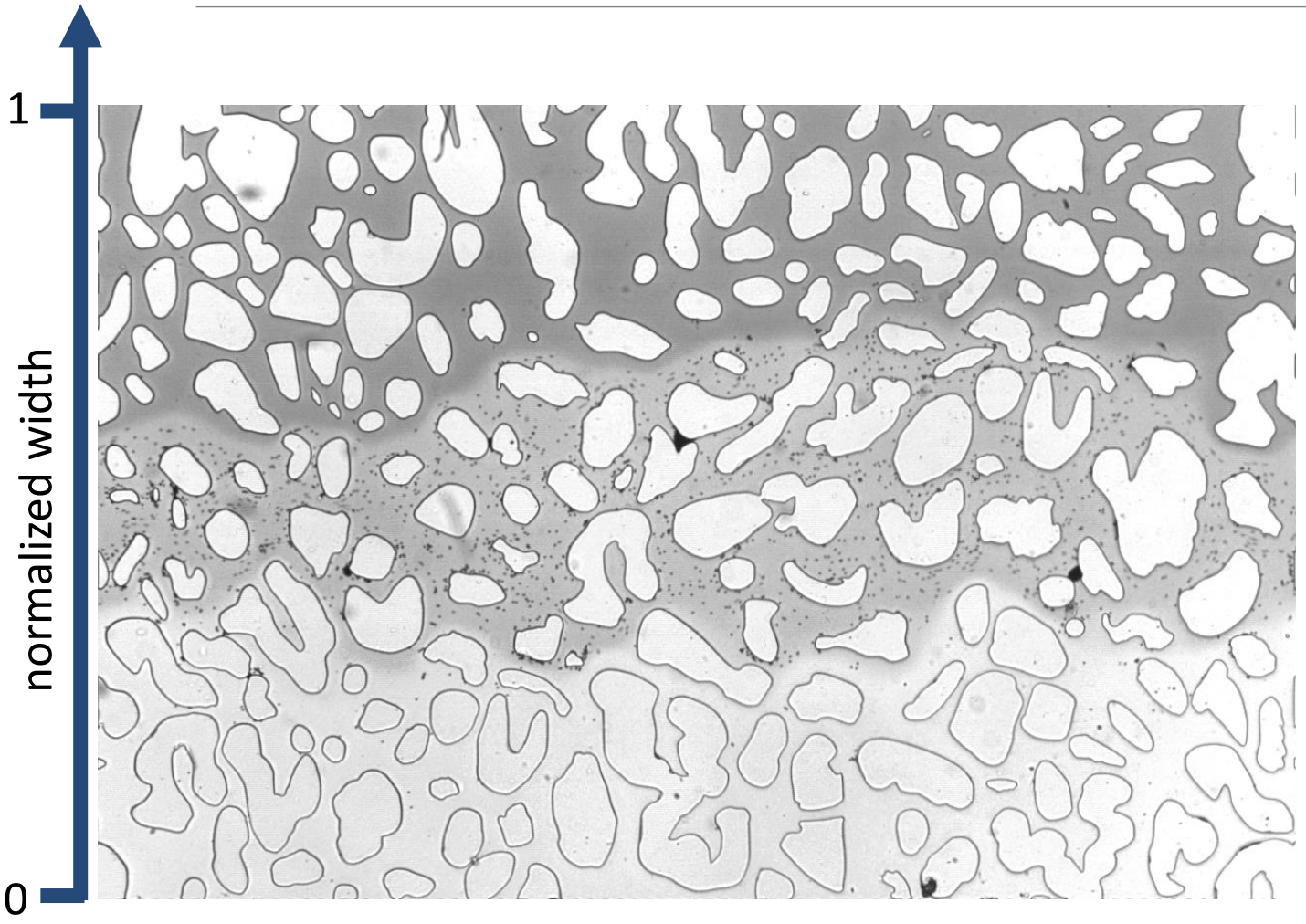

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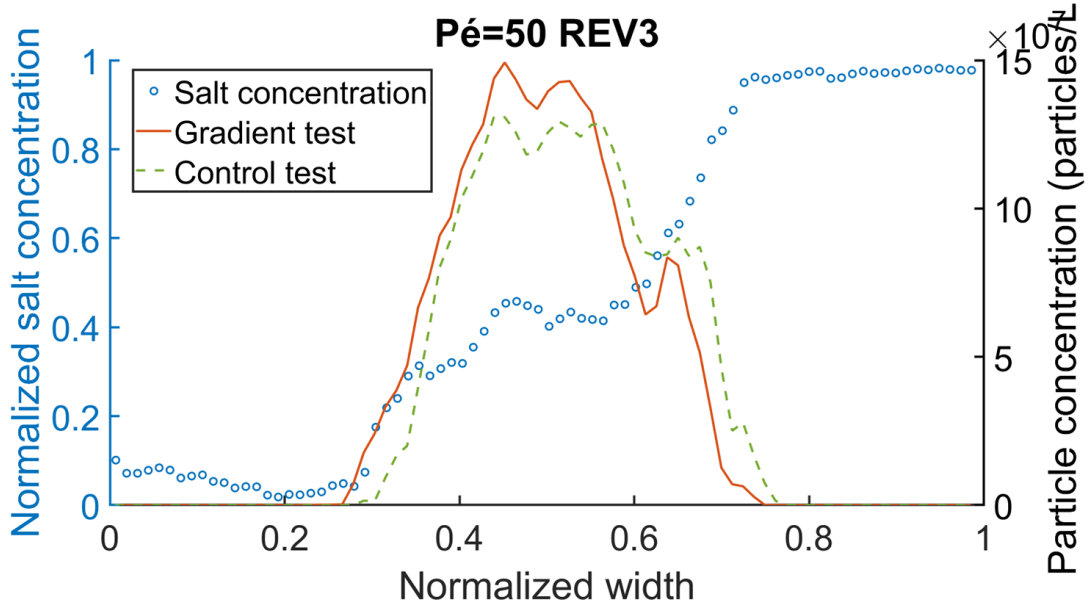

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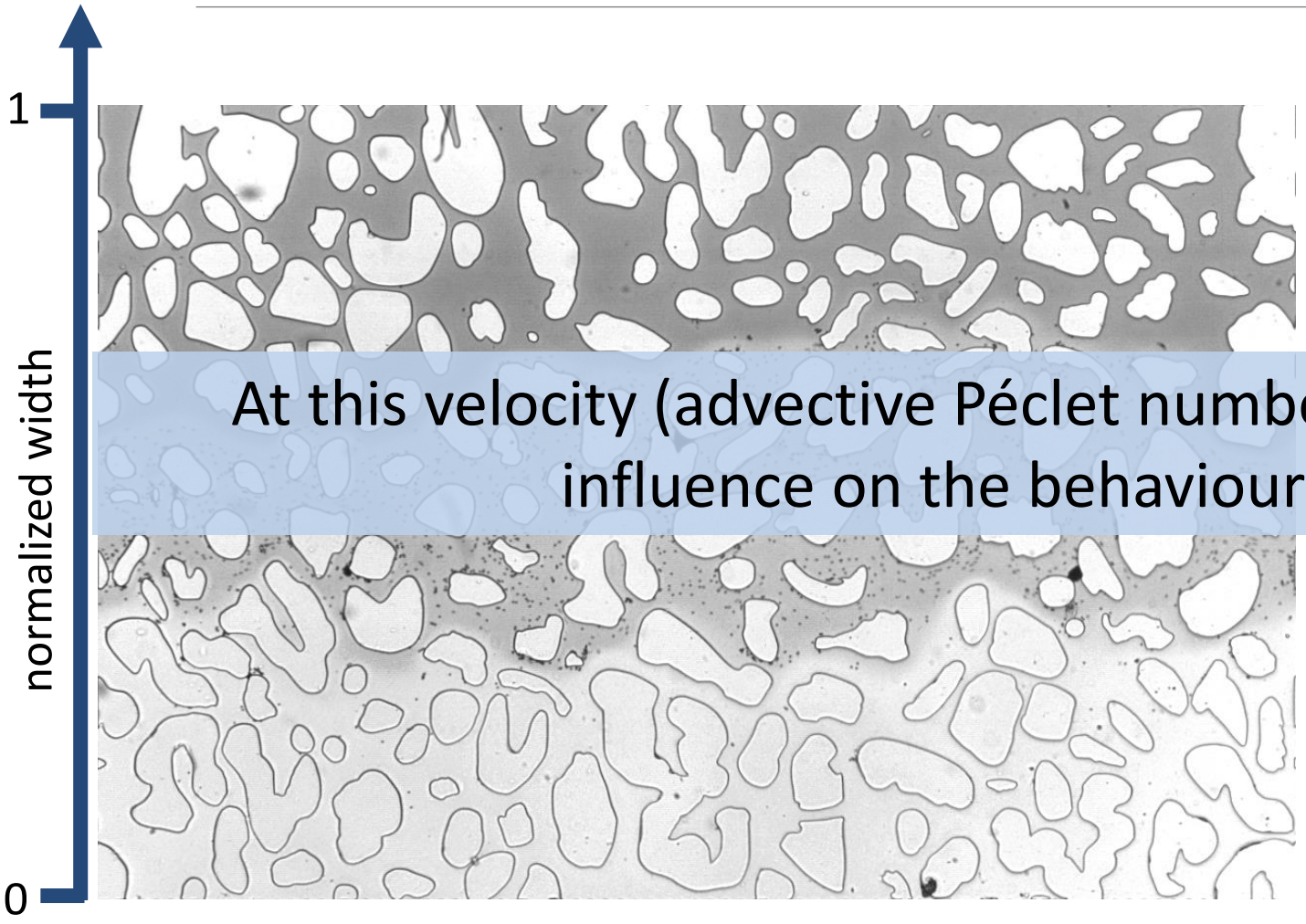
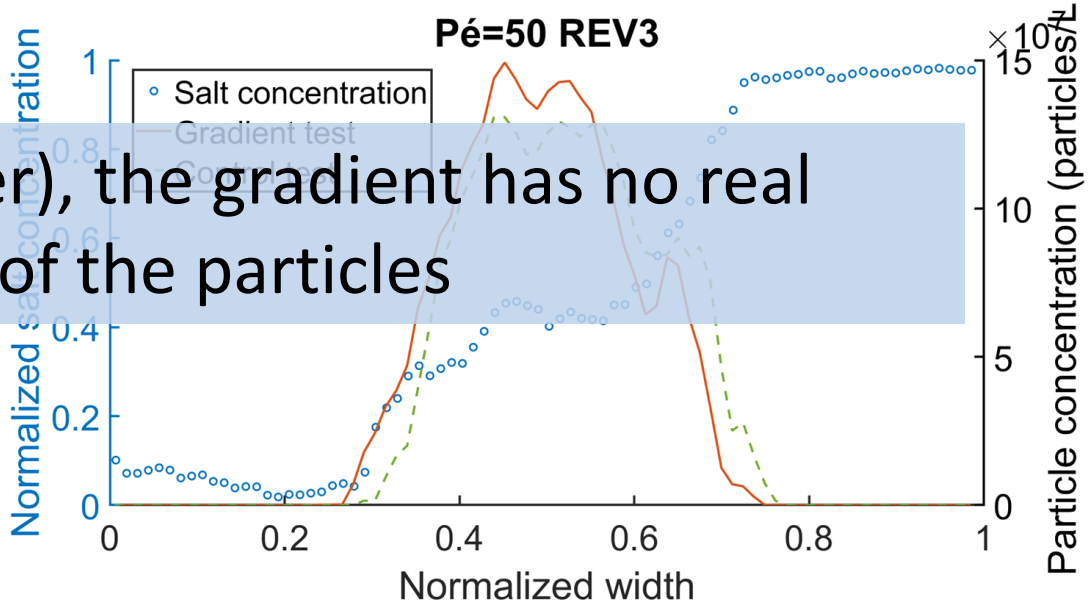
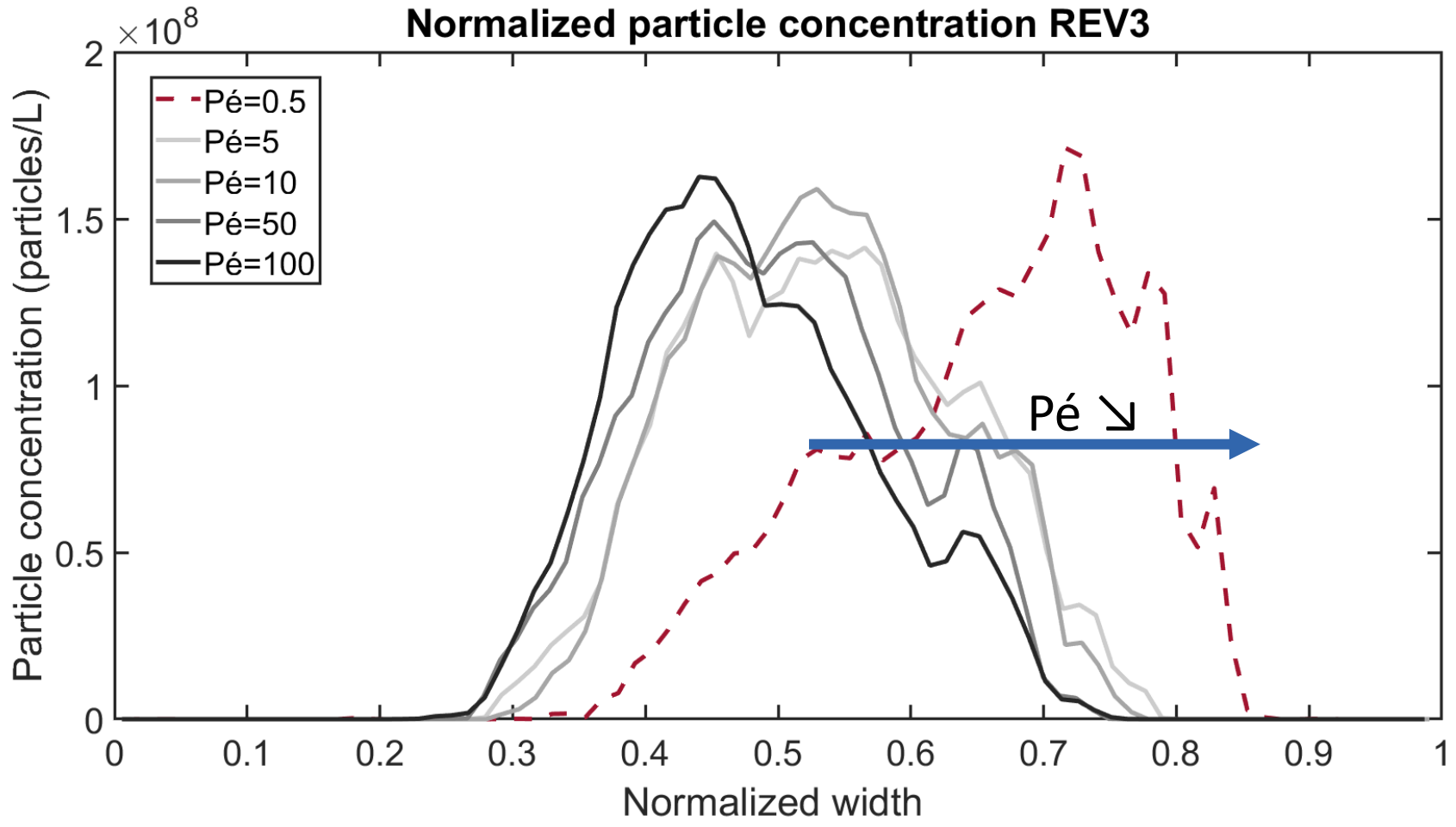




At this velocity (advective Péclet number), the gradient has no real influence on the behaviour of the particles

0.1 mm

Influence of Péclet number on particle behavior



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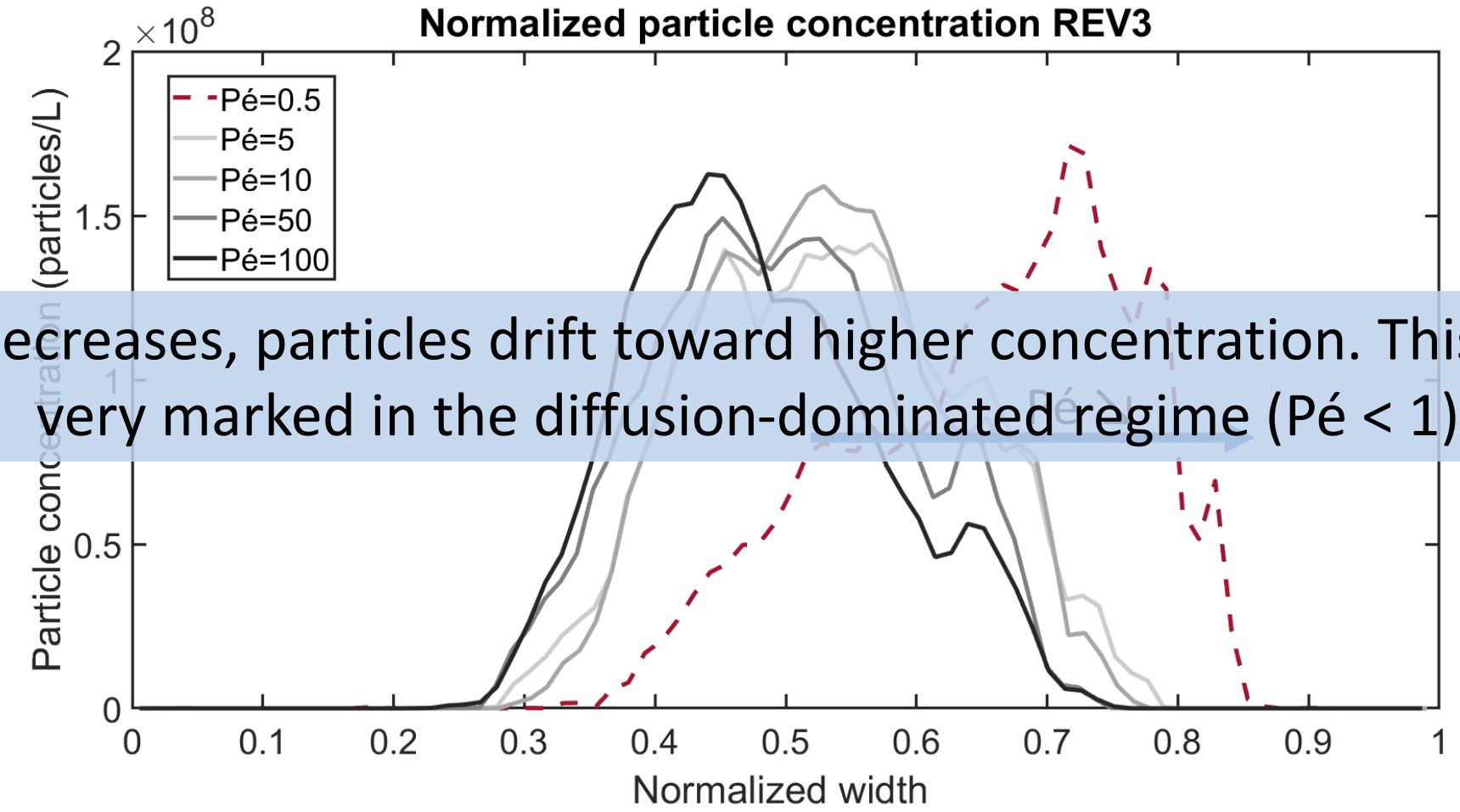

As Pé decreases, particles drift toward higher concentration. This effect is very marked in the diffusion-dominated regime (Pé < 1).

Conclusion and perspectives

Conclusion

- A stable concentration gradient is established and sustained during particle injection.
- For advection-dominated regime, diffusiophoresis shifts particles toward the higher concentration region.
- For diffusion-dominated regime, the particle distribution exhibits a different shape.

Perspectives

- Influence of salt and particle properties on diffusiophoretic transport in porous media.
- Comparing the results with numerical models.

Thank you for your attention!

I would be happy to take any questions.

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TRACE-it

Context

PHYSICAL REVIEW FLUIDS **10**, L032501 (2025)

Letter

Inhibition of mineral dissolution by aggregation of colloidal particles driven by diffusiophoresis

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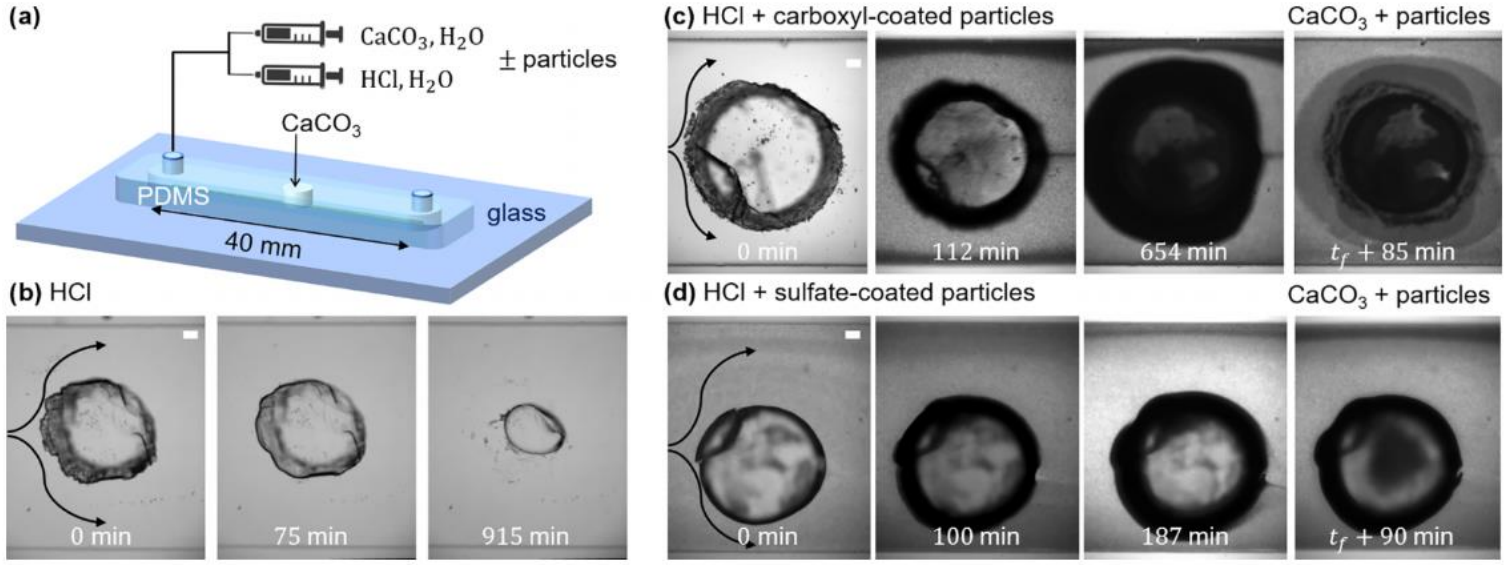
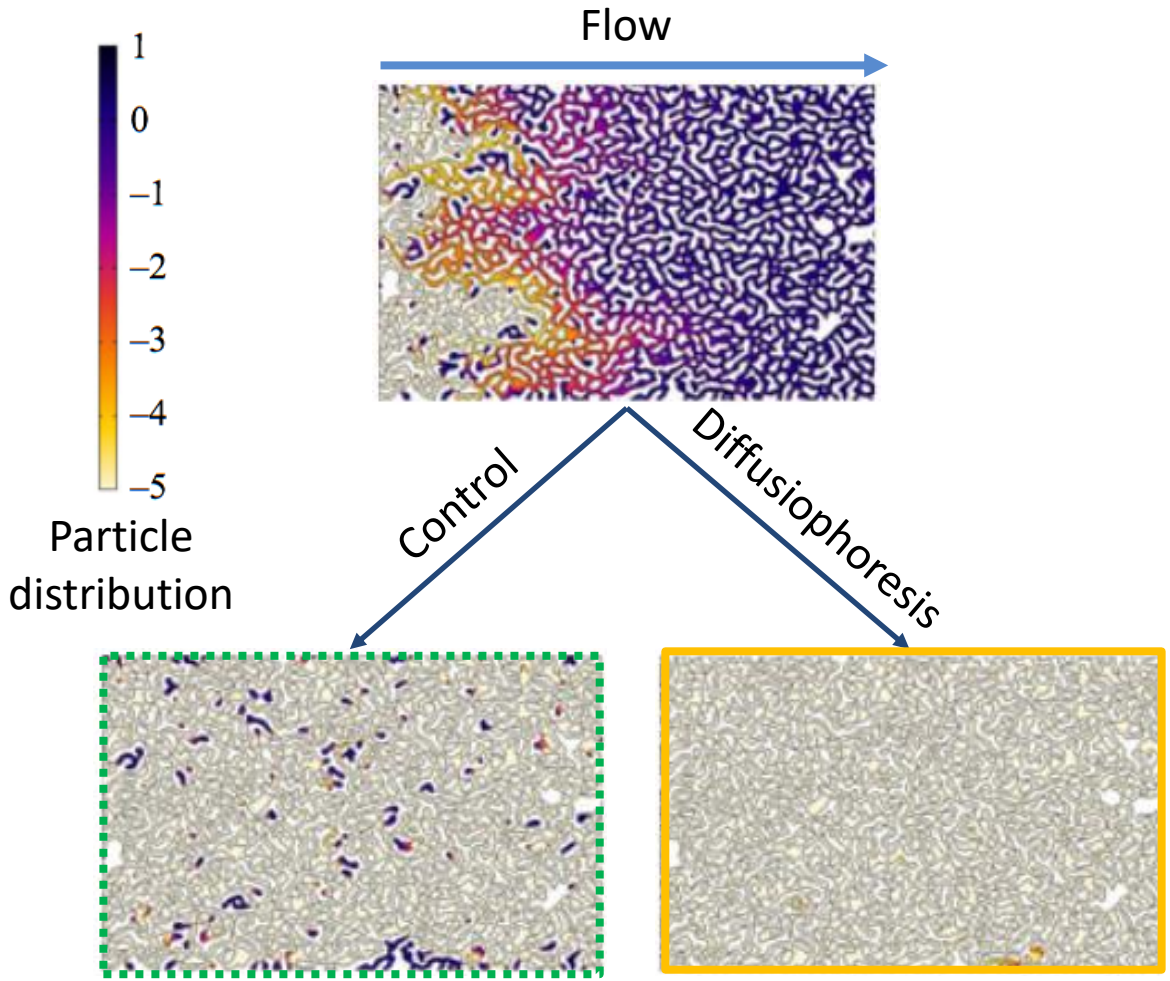
ISTO, UMR 7327, Université Orleans, CNRS, BRGM, OSUC, F-45071 Orléans, France

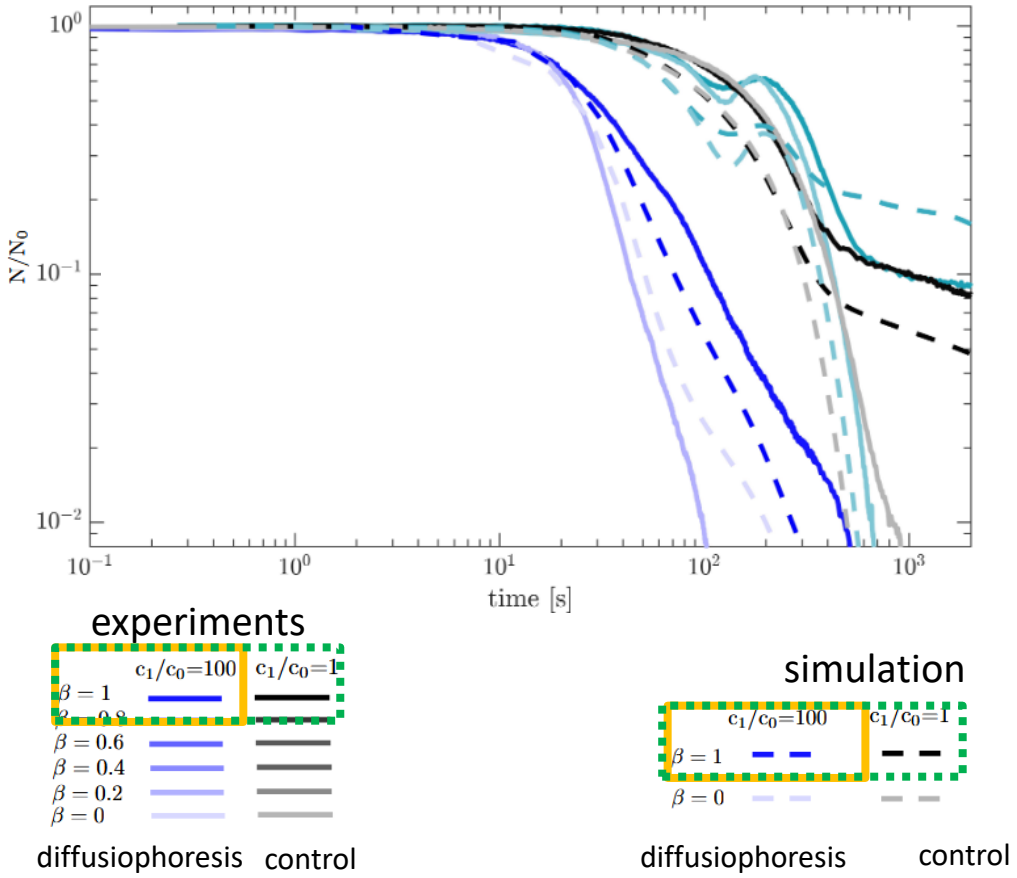
(Received 22 September 2024; revised 24 November 2024; accepted 15 January 2025; published 18 March 2025)



Diffusiophoresis in porous media



Jotkar et al., *Journal of Fluid Mechanics* (2024a)



Alipour et al., *Science Advances* (2026)

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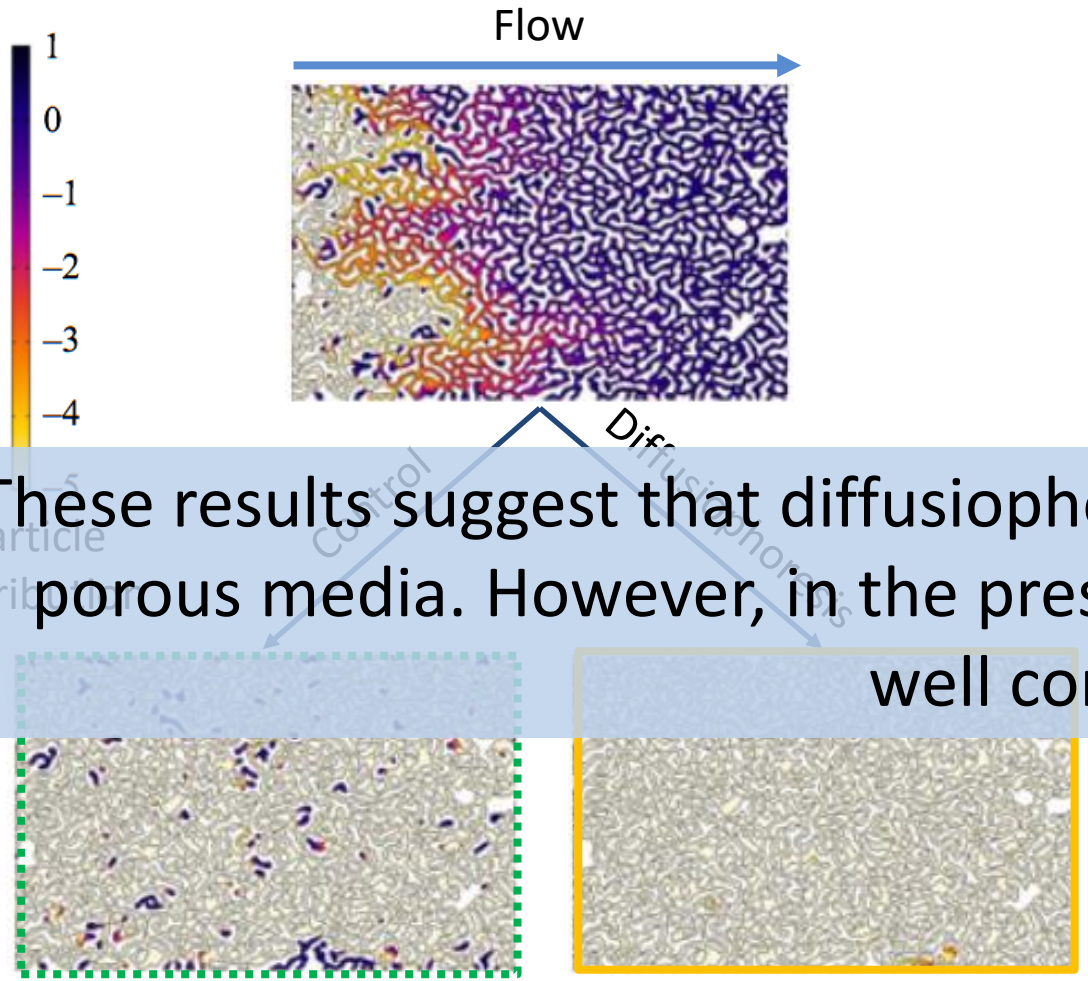

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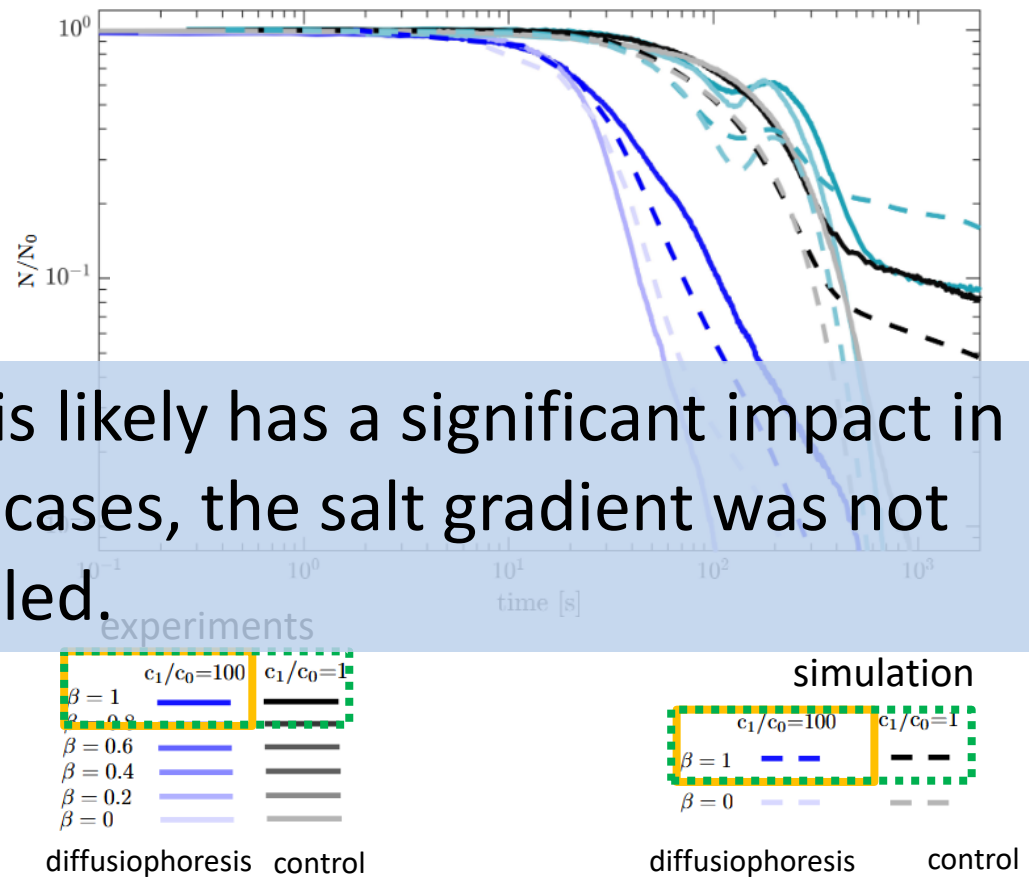

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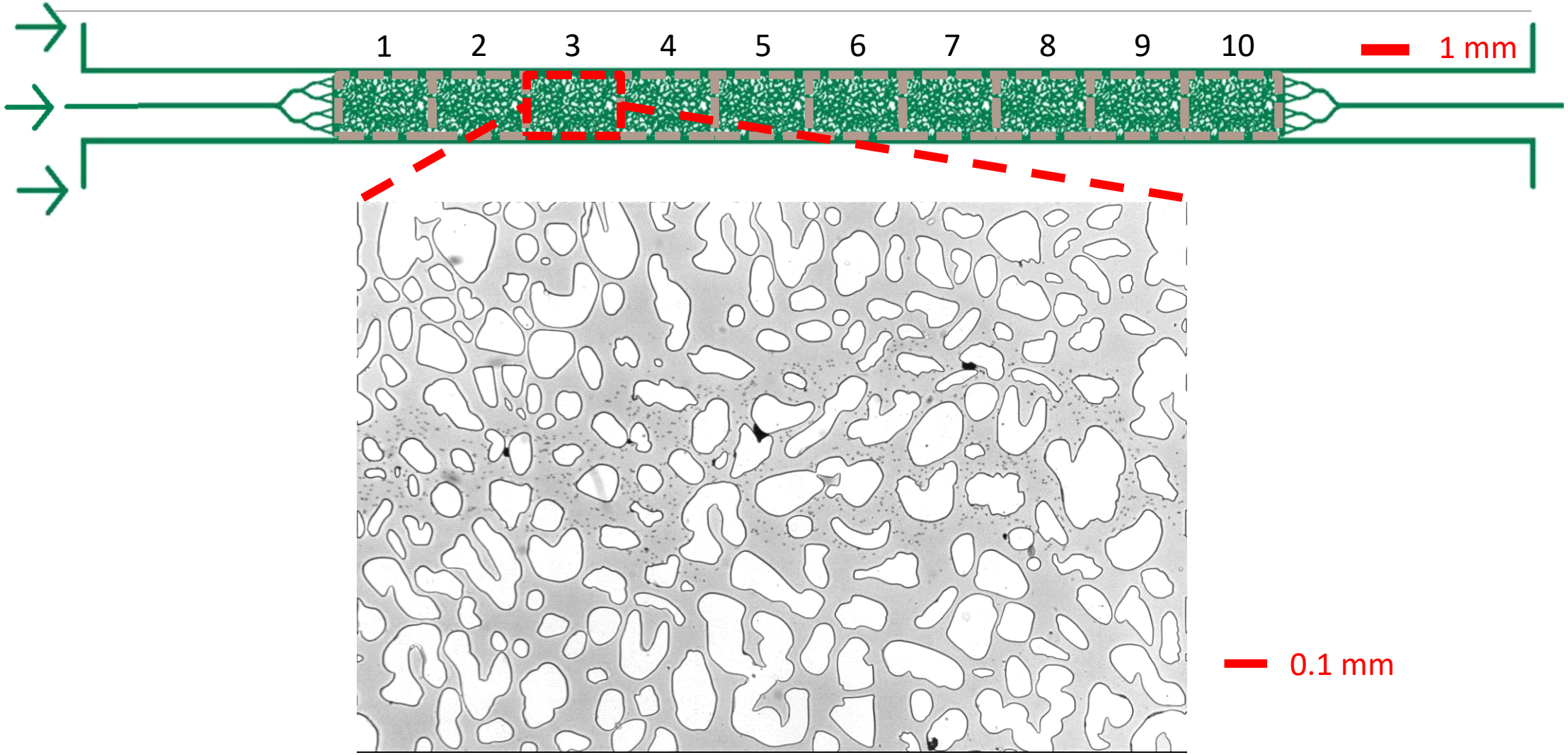
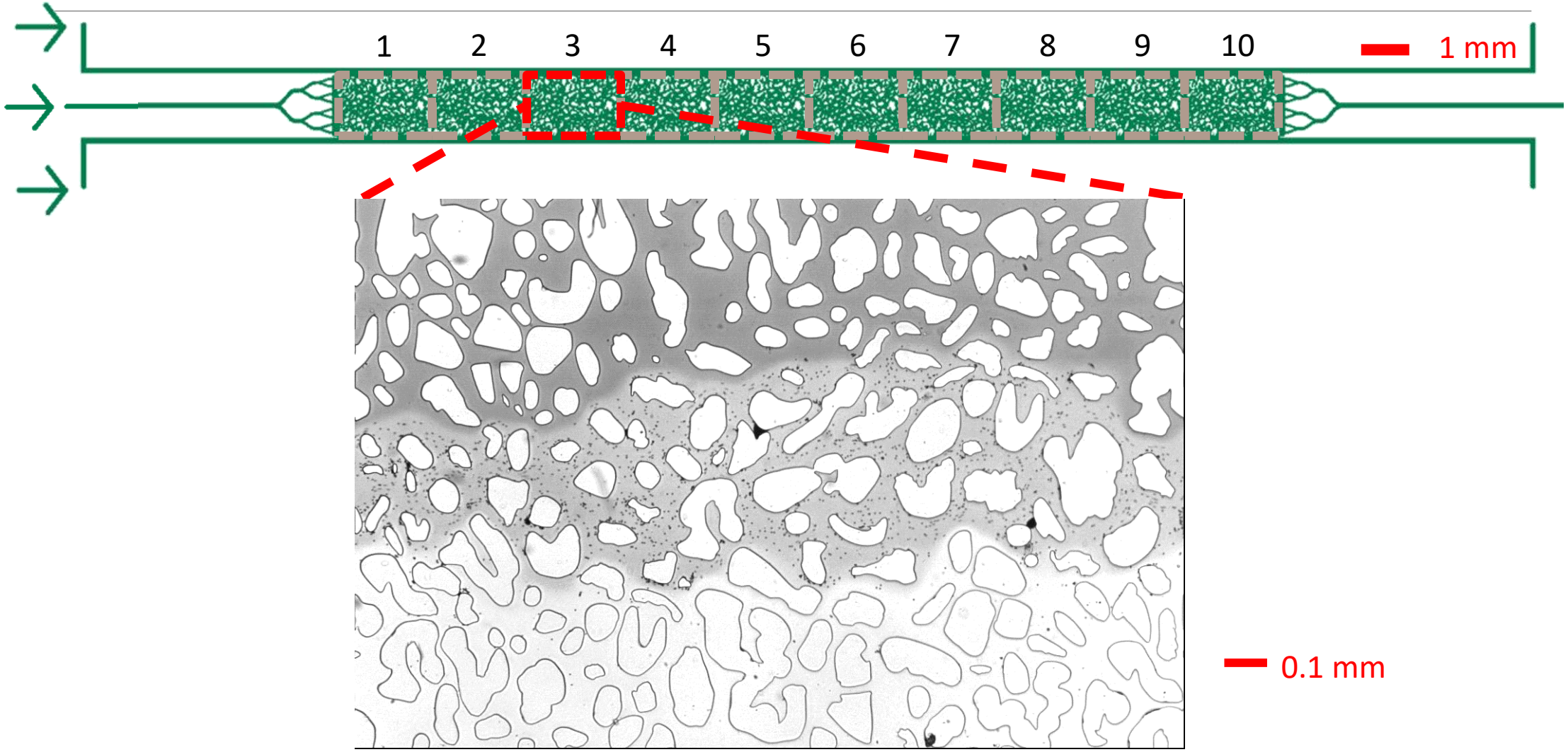


Particle injection with salt gradient



Addition of the gradient for different Péclet number