Flow of Liquid Through a Stagnant Foam in a Model Fracture

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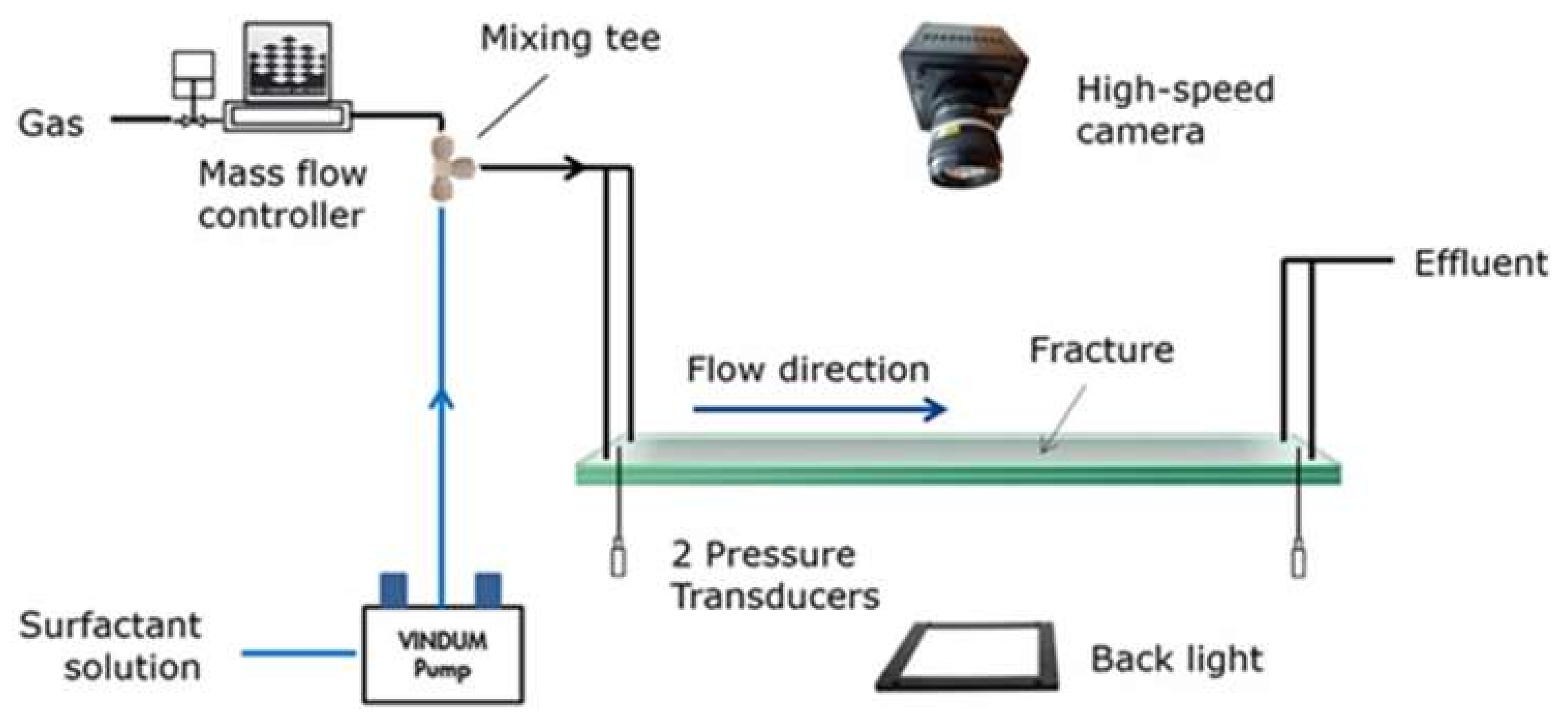
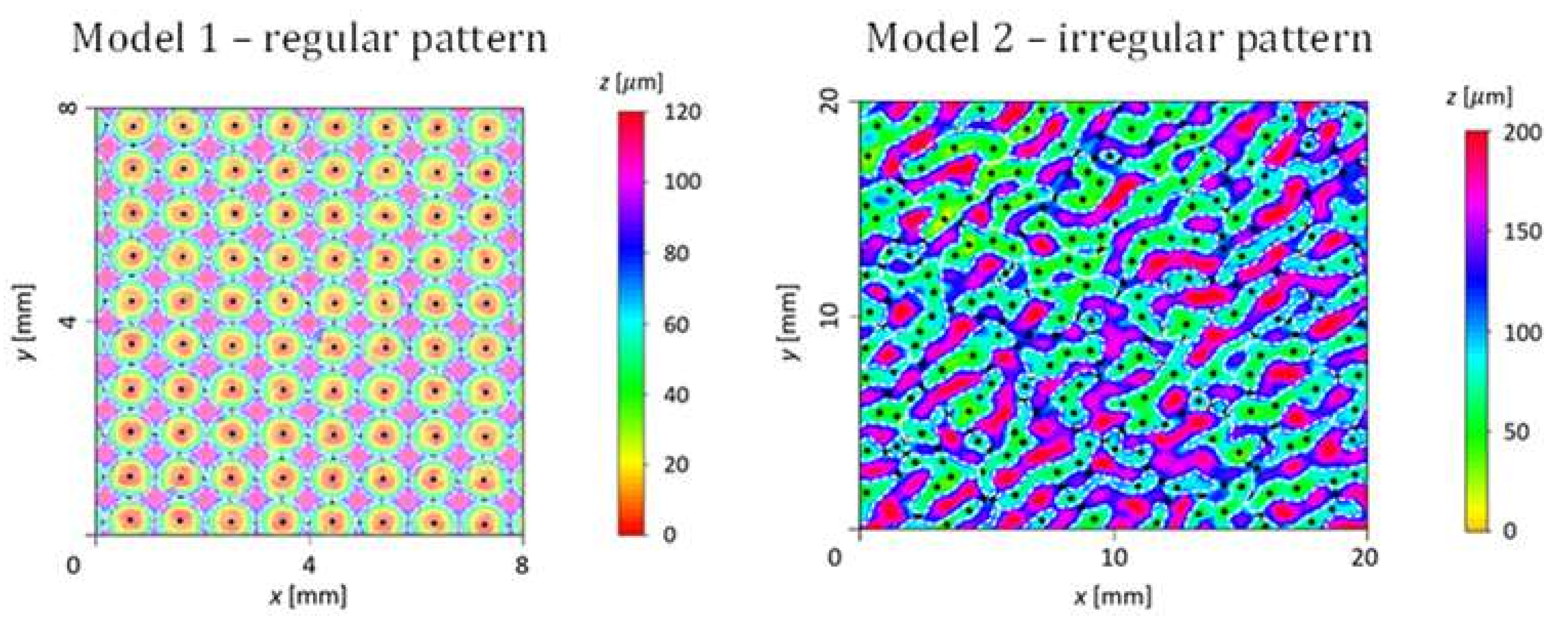
As part of a larger study of foam in model fractures we studied diffusion between bubbles in immobile foam ("Ostwald ripening"), using large glass models with narrow, but variable, aperture. One can infer both water saturation and capillary pressure P_c within the models from 2D images of water distribution in these experiments, knowing the aperture distribution, because water occupies the narrowest locations. One must assume P_c is nearly uniform with region of view (~1 cm²) at all times. Water transport occurs through the Plateau borders of the foam to equalize P_c. Here we demonstrate that this assumption of uniform P_c in the region of view is valid.

Experimental Apparatus



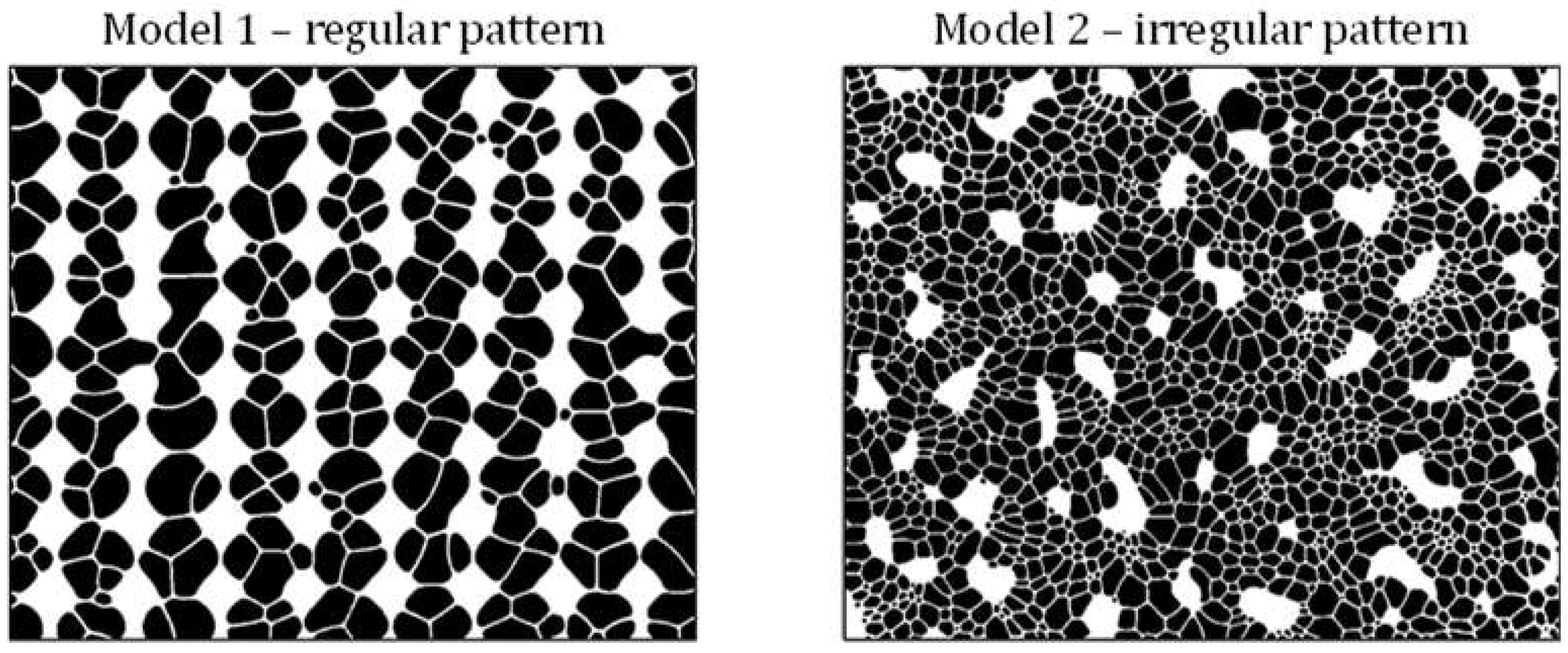
Aperture distribution in two models



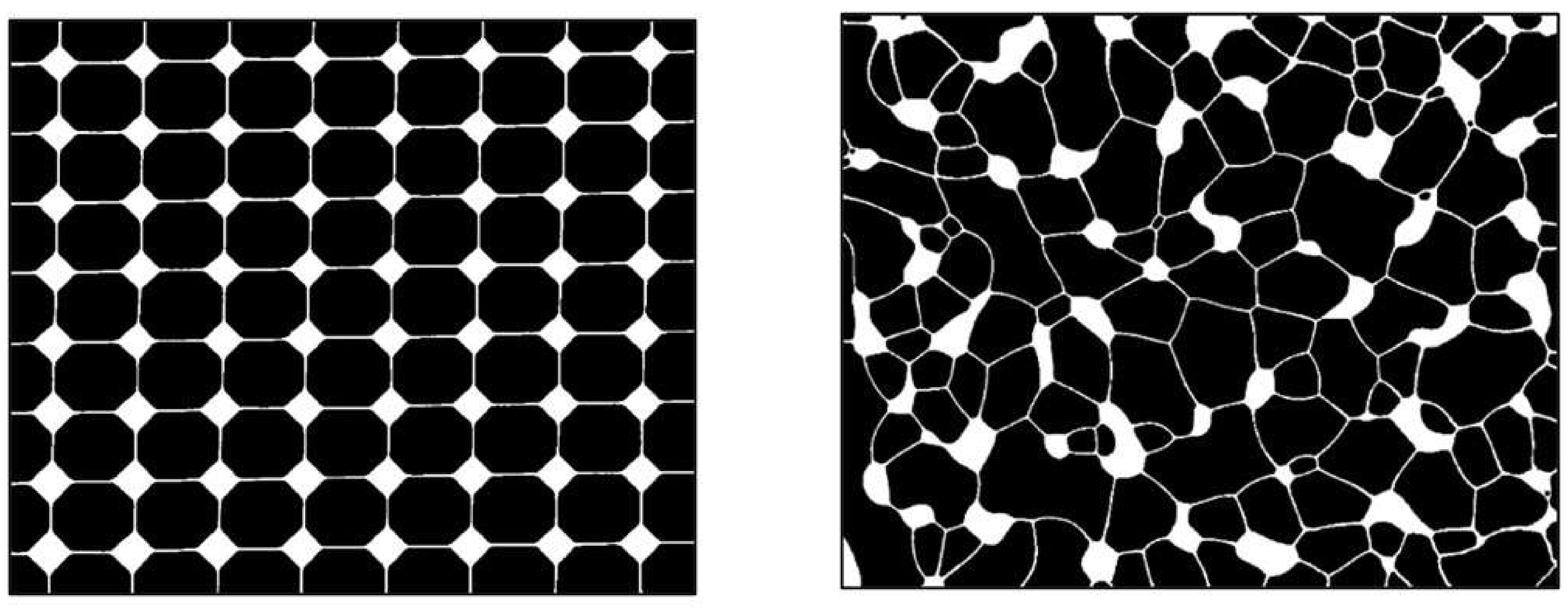
Hydraulic aperture: *46 μm* Hydraulic aperture: *78 μm*

2D images of water distribution in models

Model 1 – regular pattern Model 2 – irregular pattern



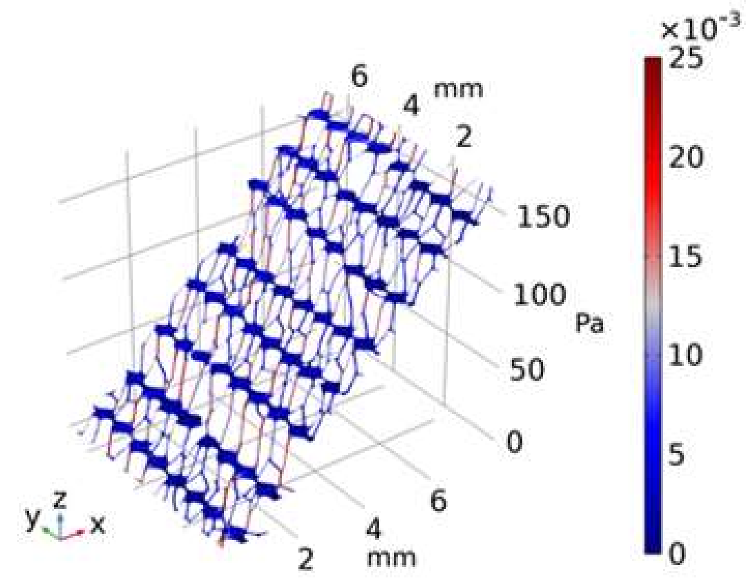
Experiment duration = 0.09 hours *Experiment duration = 0.1 hours*



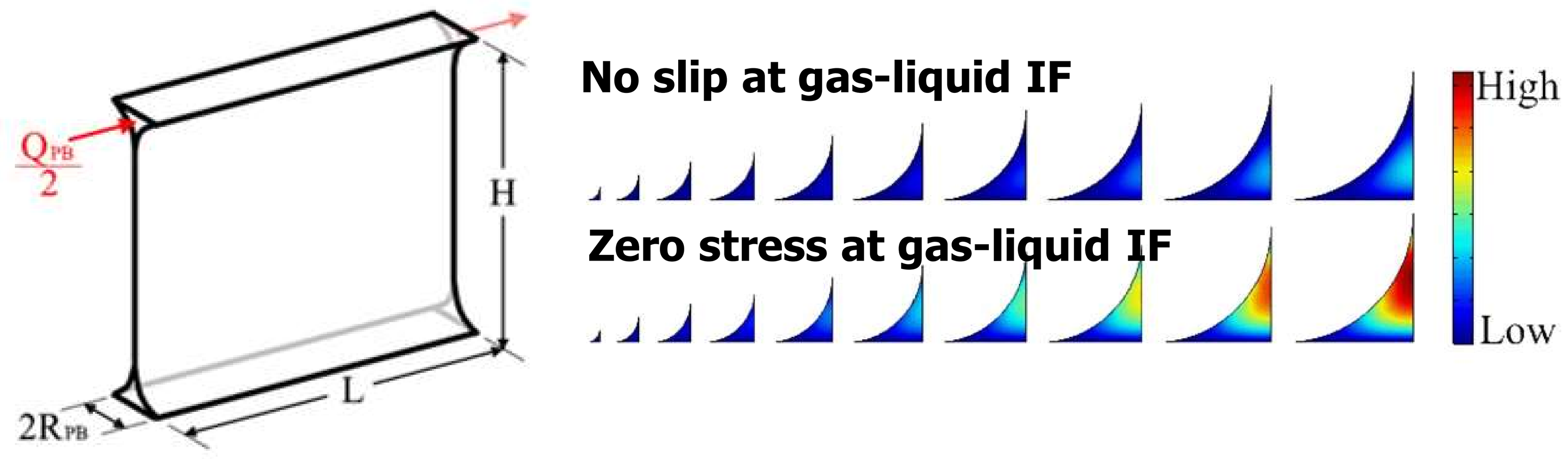
Experiment duration = 5.08 hours *Experiment duration = 5.10 hours*

Method

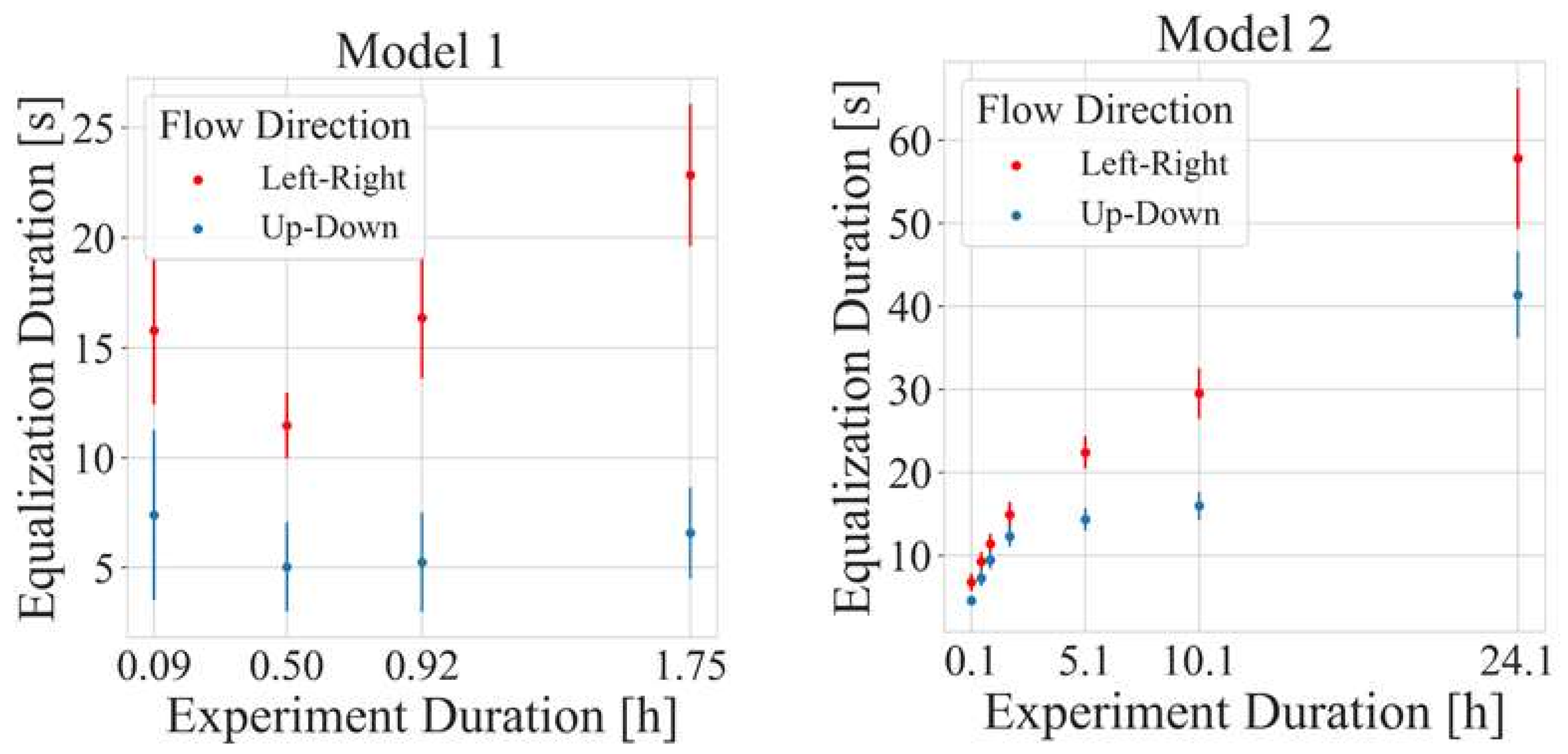
Using ImageJ software, obtain digital map of water-filled locations and paths of foam films. Using COMSOL, solve for flow through 2D network of films. This COMSOL 2D solution assumes rectangular channels instead of Plateau borders.



Solve numerically for flow conductivity of Plateau borers as function of P_c, which determines their width. Rescale COMSOL flow rate to foam using this result. Calculate time required for 10% of total liquid volume in image in image to flow from one side to other, with $\Delta P = P_c/10$.



Results



Through all experiments (lasting hours), equilibration takes 10s seconds. Assumption of uniform P_c justified.

References

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