# Interface Evolution during Miscible Viscous Fingering

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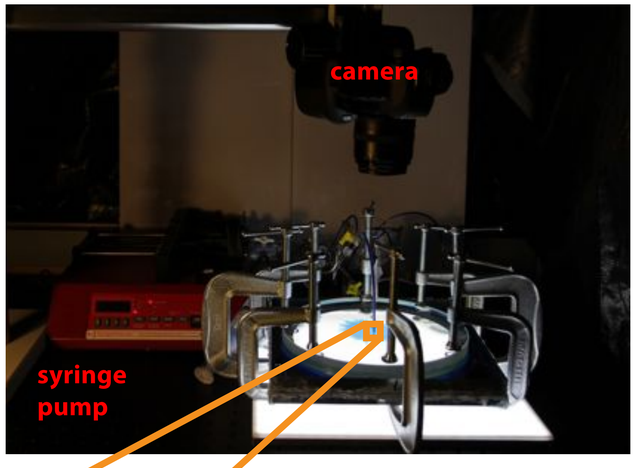
## Motivation

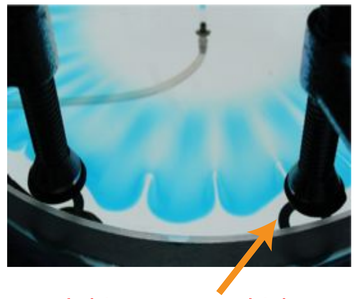
Viscous fingering occurs when a less viscous fluid displaces a more viscous one. The interface created from these complex patterns affect mixing, and is therefore of critical importance in applications such as enhanced oil recovery and bioremediation. However, the evolution of these patterns remains poorly understood.


## Experimental Setup

A radial Hele-Shaw cell is used as an analog to point injections in porous media, and fluid pairs of different viscosity ratios are created using glycerol-water mixtures.



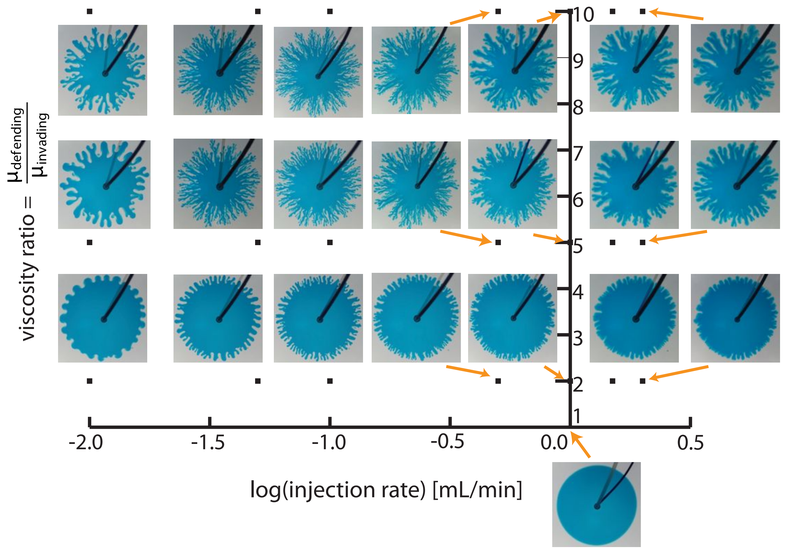





This setup allows for the systematic variation of three control parameters: injection rate, viscosity ratio, and gap thickness.

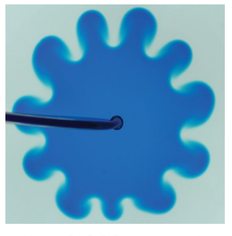
## Results

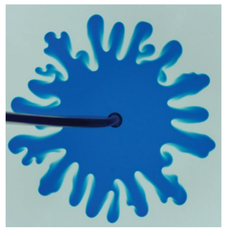
The following phase diagram is created from a series of experiments conducted using a 50 micron gap thickness.

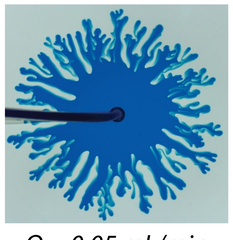


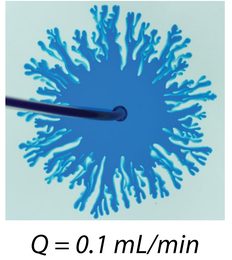

We observe that fingering occurs for all viscosity ratios larger than one, and that the size of the compact core depends largely on the viscosity ratio.

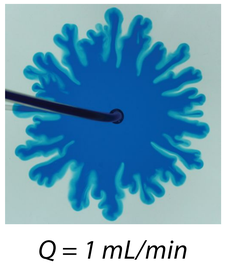
We also observe non-monotonic finger behavior for an increasing injection rate ($Q$), with the viscosity and gap thickness held constant. Finger widths decrease only up to a certain injection rate, after which they begin to widen.

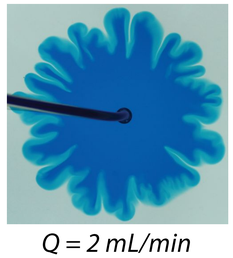

*Q = 0.002 mL/min*


*Q = 0.01 mL/min*


*Q = 0.05 mL/min*

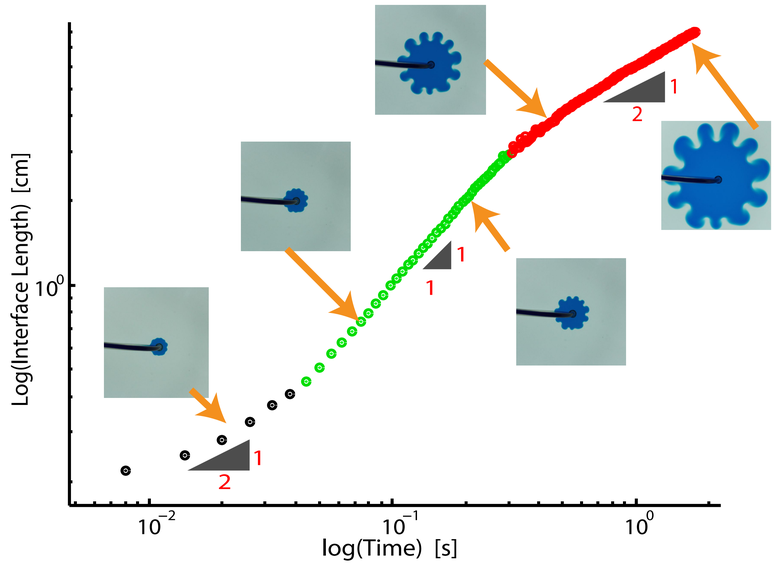

*Q = 0.1 mL/min*


*Q = 1 mL/min*


*Q = 2 mL/min*

Further analysis of the experimental data shows that the interface growth rate exhibits three different regimes:

1) Compact radial expansion before fingering
2) Accelerated growth of interface length due to fingering
3) Radial expansion with fixed fingers




## Conclusion

Through this set of experiments, we better understand the evolution of a fingering pattern. Most notably, we observe the unexpected non-monotonic behavior of finger widths with increasing injection rates. The experiments also suggest that the growth of the interface occurs in 3 power law regimes, where viscous fingering affects the last two: the scaling of the interface growth rate at intermediate times, but only the coefficient of scaling at late times.

Understanding when and how a fingering pattern moves through these three regimes, and when the non-monotonic behavior in finger widths occurs is necessary for accurately determining the interface available for mixing when viscous fingering is observed.