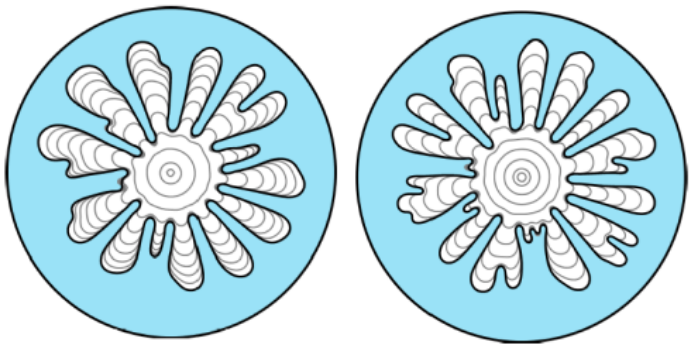
Control Knob Found for Viscous Fingers

The onset time for "viscous fingering"—an instability that can occur at a gas–liquid boundary—depends on the compressibility of the gas, offering a way to control the behavior.

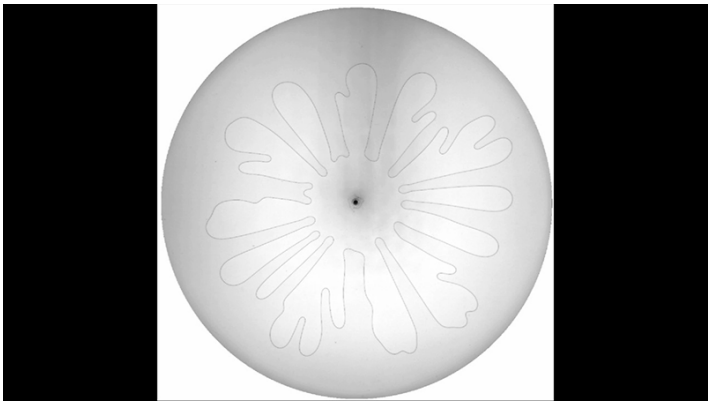
By **Michael Schirber**

In geological applications such as enhanced oil recovery and carbon sequestration, gas is forced into a liquid-filled reservoir. Initially, this gas expands equally in all directions, with a smooth interface forming between the liquid and the gas. But that surface can destabilize, with gas pushing slender protrusions, or "fingers," into the liquid. Now researchers have uncovered a potentially new way to control the time it takes for this instability to appear [**1**, **2**].

"Viscous fingering can be either good or bad, depending on the situation," says Chris MacMinn from the University of Oxford, UK. When gas fingers develop, the rate of liquid displacement drops (bad for oil recovery), but the area of the gas–liquid interface increases (good for carbon sequestration). Previous work had explored how the formation of viscous fingering depends on different inputs, such as the gas injection rate. MacMinn and his colleagues are the first to target gas compressibility as a potential control parameter.



Credit: L. C. Morrow *et al.* [**1**]



Video 1: The formation of fingers is studied in experiments with air forced into the center of a liquid-filled container.
Credit: C. Cuttle/Univ. of Oxford

The researchers injected air through a syringe into a thin layer of silicone oil confined between two circular glass plates. They varied the compressibility of the gas by changing the size of the syringe (and thus the initial volume of gas).

Analyzing time-sequenced images of the expanding gas structure, the researchers found that fingers formed later when the gas had a higher compressibility. The team explained the effect by comparing the gas to a spring: the more compressible it is, the more slowly the pressure builds at the gas–liquid boundary and thus the longer it takes for the viscous fingers to develop. The finding could allow geologists to enhance or suppress viscous fingering, depending on their needs.

Michael Schirber is a Corresponding Editor for *Physics Magazine*

based in Lyon, France.

REFERENCES

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2. C. Cuttle *et al.*, "Compression-driven viscous fingering in a radial Hele-Shaw cell," **Phys. Rev. Fluids 8, 113904 (2023).**