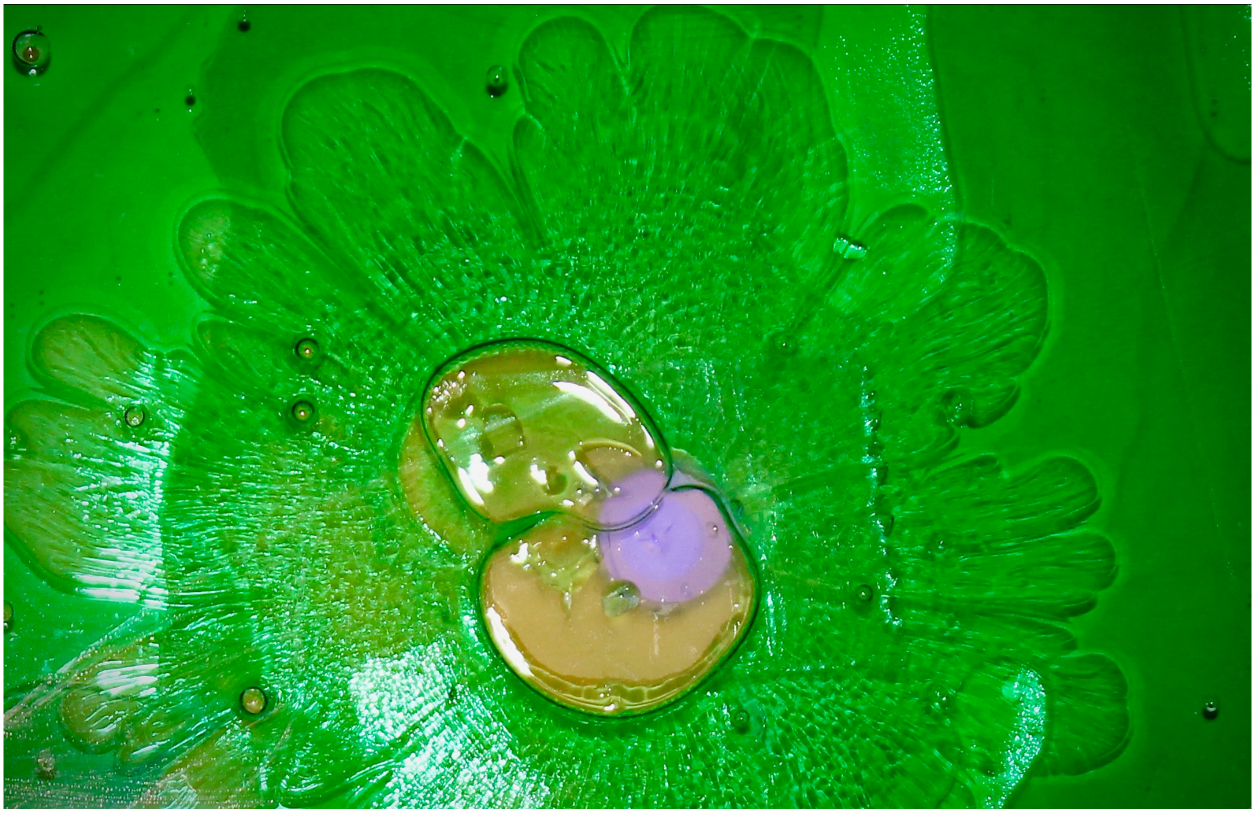

MCEN 4151- Flow Visualization

Team First Report

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In Conjunction With:
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Section 001
10/06/2023

I. OVERVIEW

This image was created in collaboration with Jess Holmes, Nicole Nageli, and Cameron Sprenger for the Team First Assignment. The intent was to capture the Saffman- Taylor instability using a Hele- Shaw cell. The Hale- Shaw cell was generously provided by Professor Hertzberg.

II. EXPERIMENTAL SET UP

The image was shot on a Nikon D800 with a 90mm macro lens. This image was produced by sandwiching corn- syrup which had been dyed green in between the two glass plates of the Hele-Shaw cell. We then injected water into the corn- syrup through an opening in the cell. A figure of the setup is shown below:

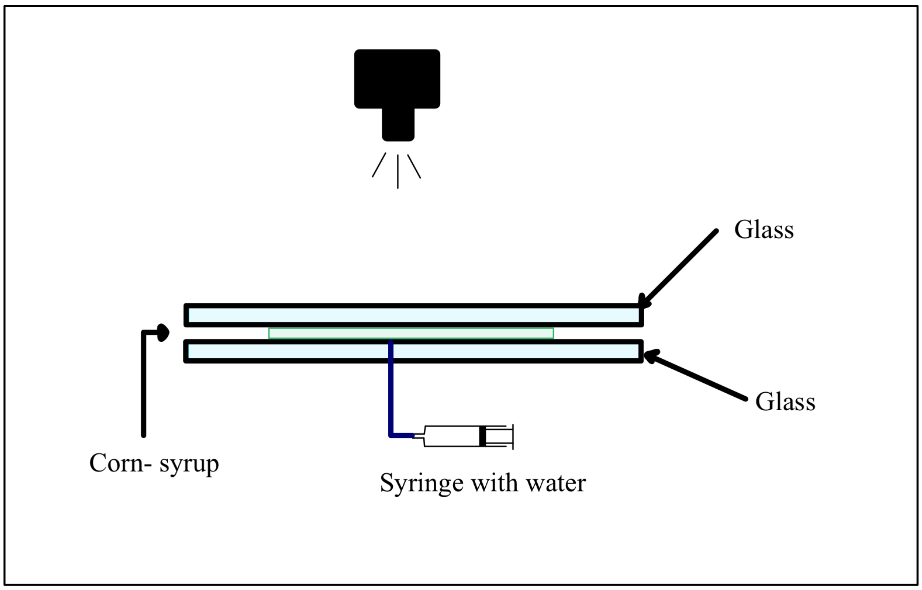


Figure 1.
Experimental Set- up

III. FLUID DYNAMICS

The Saffman- Taylor instability, which is also referred to as viscous- fingering is driven by the interactions of two fluids with substantially different viscosities [1]. When a fluid pushes another, higher viscosity fluid, a "finger" looking boundary layers begins to form, due to instability. This instability is caused by local curvature in the interface; assuming a constant pressure along the interface. The more viscous fluid advances in front of the curvature at a faster rate because there is less fluid volume [2]. The Saffman- Taylor instability is a type of Stokes flow, which are characterized by low Reynold's numbers [3]. The Reynolds number is given by the following equation:

$$Re = \frac{\rho U L}{\mu}$$

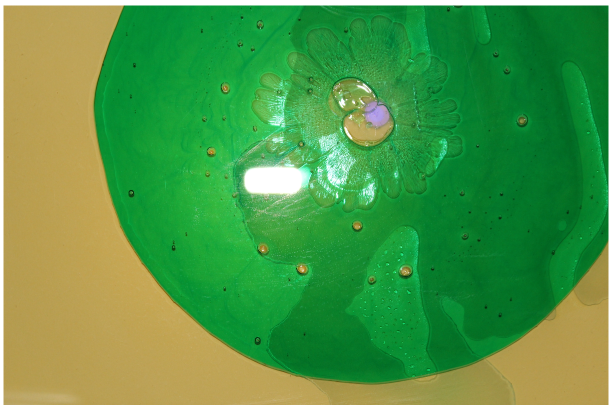
Where $\rho = 1.48\ \frac{g}{cm^3}$, $U = 2\ \frac{cm}{s}$, $L = 0.1\ cm$, and $\mu = 15000\ \frac{g}{cm \cdot s}$15,000. Plugging this all in yields:

$$Re = 1.97 \times 10^{-5}$$

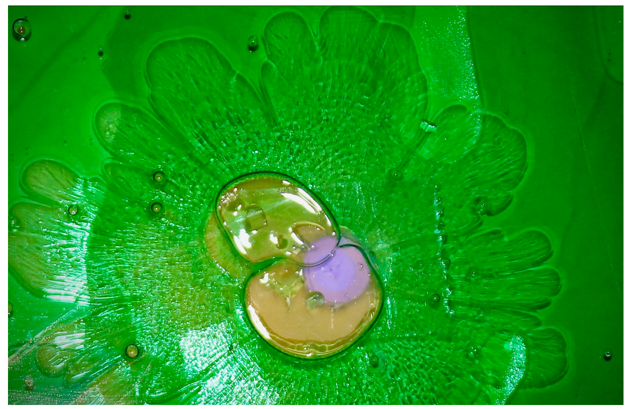
The Reynolds number is significantly less than 1, meaning that the flow is primarily driven by viscosity, and it is indeed a Stokes flow.

IV. PHOTOGRAPHIC AND VISUALIZATION TECHNIQUES

Original Image:



Edited Image:



The field of view was larger than it needed to be, about 5x6 inches, so I ended up cropping the image during post- processing. The original image had 5184 x 3456 pixels, and the edited image had 1962 x 1263 pixels. During post- processing I also increased the saturation, vibrance, definition, and intensity to brighten up the green and enhance the borders between the fingers. There was no added lighting or flash as the overhead fluorescent already provided enough light. Since we were using a macro lens, the camera was held about a foot above the Hale- Shaw cell. Additional camera settings are shown in the table below:

Table 1.

Camera	Nikon D800
Focal Length	55
F- Stop	5.6
Aperture	5
Shutter Speed	1/64
ISO	400

V. CONCLUSION

I think that the team and I succeeded in capturing the “fingers” that form due to the Saffman-Taylor instability in great detail. I’m very happy with how the image turned out. If I were to do this again, I think it would be interesting to use a few more fluids with varying vicocities, potentially at the same time.

VI. RERERNCES

[1] “Saffman–Taylor Instability.” *Wikipedia*, Wikimedia Foundation, 3 Jan. 2023, en.wikipedia.org/wiki/Saffman%E2%80%93Taylor_instability.

[2] Fadoul, Oumar Abdoulaye, and Philippe Coussot. “Saffman–Taylor Instability in Yield Stress Fluids: Theory–Experiment Comparison.” *MDPI*, Multidisciplinary Digital Publishing Institute, 16 Mar. 2019, www.mdpi.com/2311-5521/4/1/53#:~:text=Introduction,fluid%20in%20a%20confined%20geometry.

[3] *Saffman-Taylor - New Jersey Institute of Technology*, web.njit.edu/~kondic/capstone/2015/saffman-taylor.pdf. Accessed 6 Oct. 2023.