A ViSUaLizer (**VSUL**) for Demonstration of CCS Dynamics

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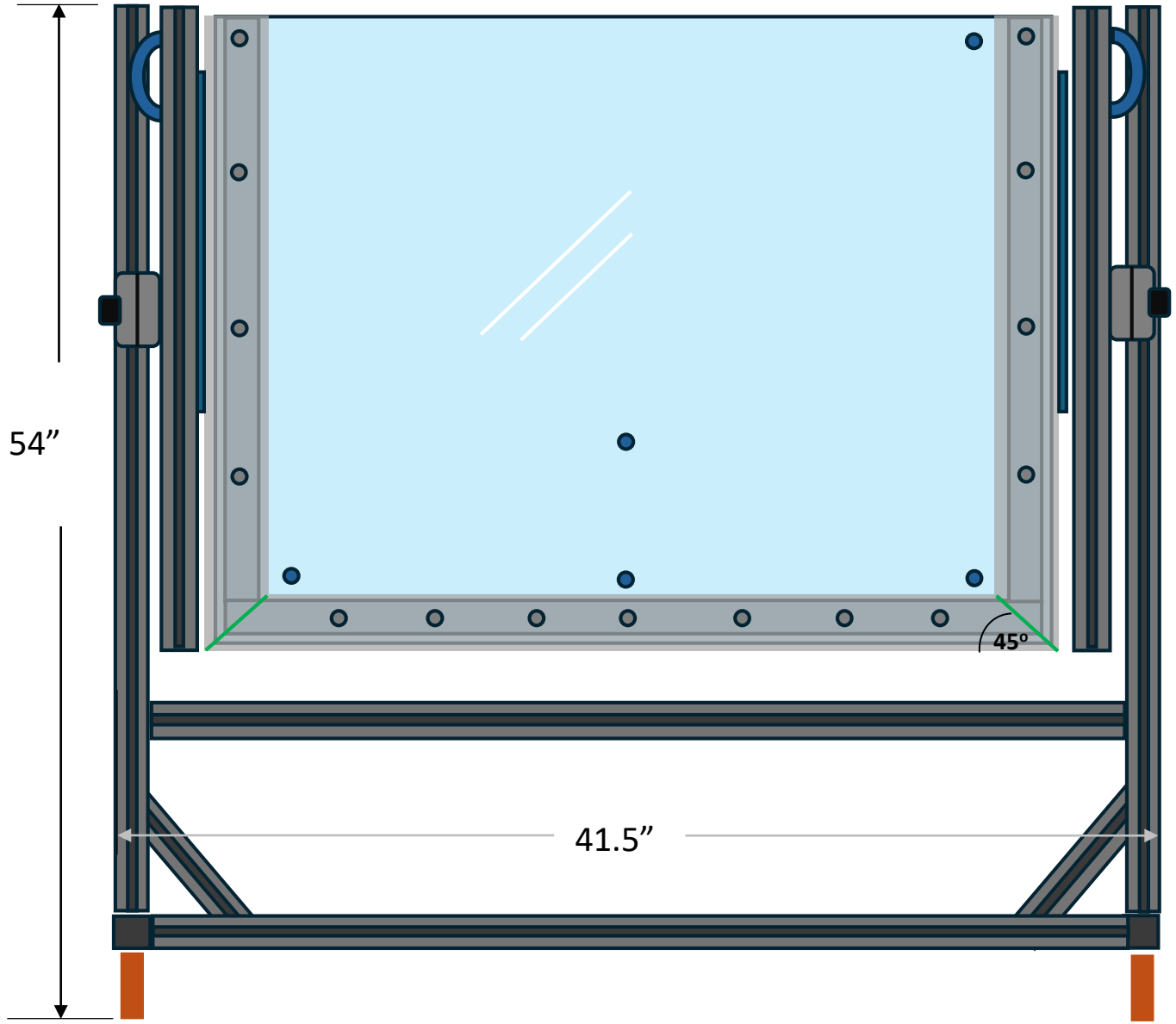
Outline

- Background
- Objectives
- First **VSUL**
- Results
- Next steps
- Acknowledgement



Background

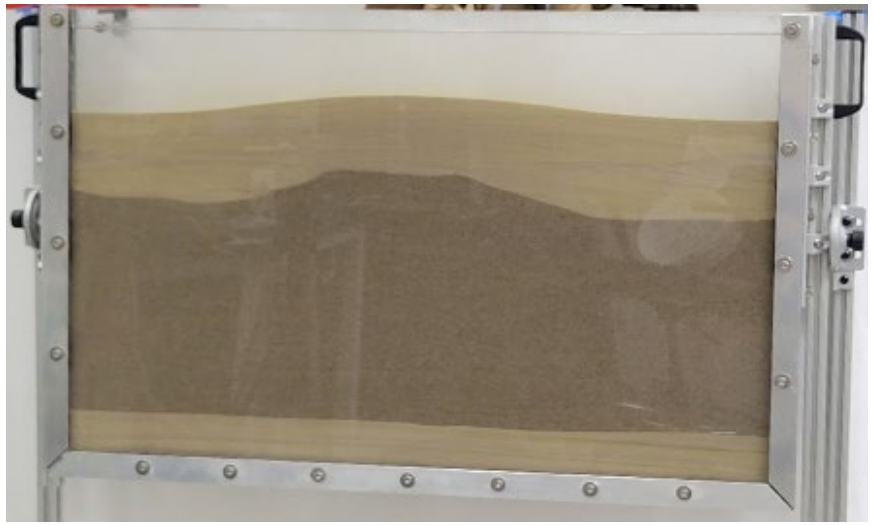
- …carbon “storage” methods are unproven and unpredictable. There’s no guarantee that all that carbon will stay put — plus the process creates all kinds of harms and risks.
- https://www.foodandwaterwatch.org/2023/09/06/carbon-storage-bad-idea/

- Experiential learning—learning by participating
  - build practical understanding to connect theories and knowledge to real-world situations
  - enhance knowledge retention, motivation, and additional skill development
  - gain nuanced understanding and a broader view of the world
  - pictorial demonstrations are an equitable approach to learning

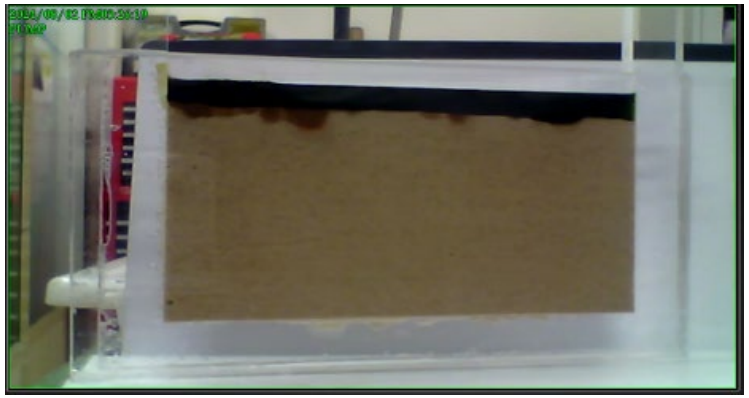
Project objectives

- plan, build, and deploy 2D visualization apparatuses for CO_2 storage dynamics with porous media geometry analogous to Gulf of Mexico stratigraphy

- 60 by 100 cm, demonstrations and also for quantitative experiments



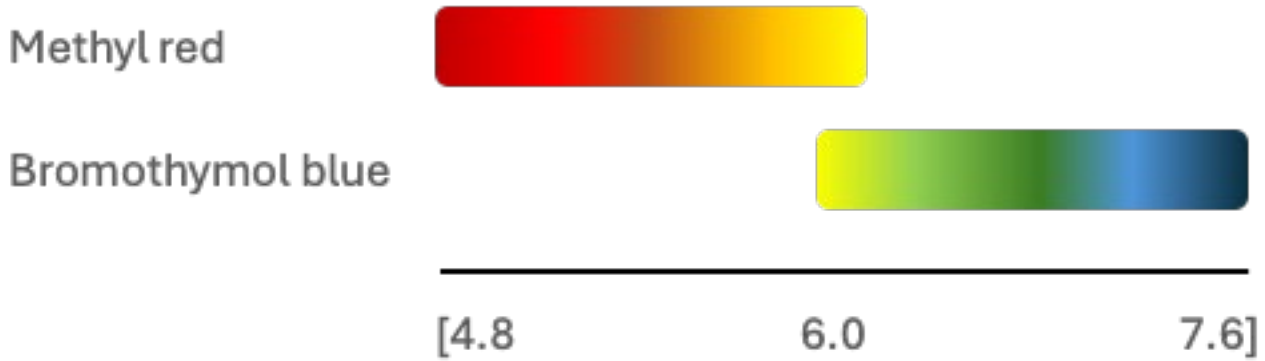
- 30 by 20 cm, portable, and suitable for students as well as interested community members



VSUL: 60 by 100 cm model

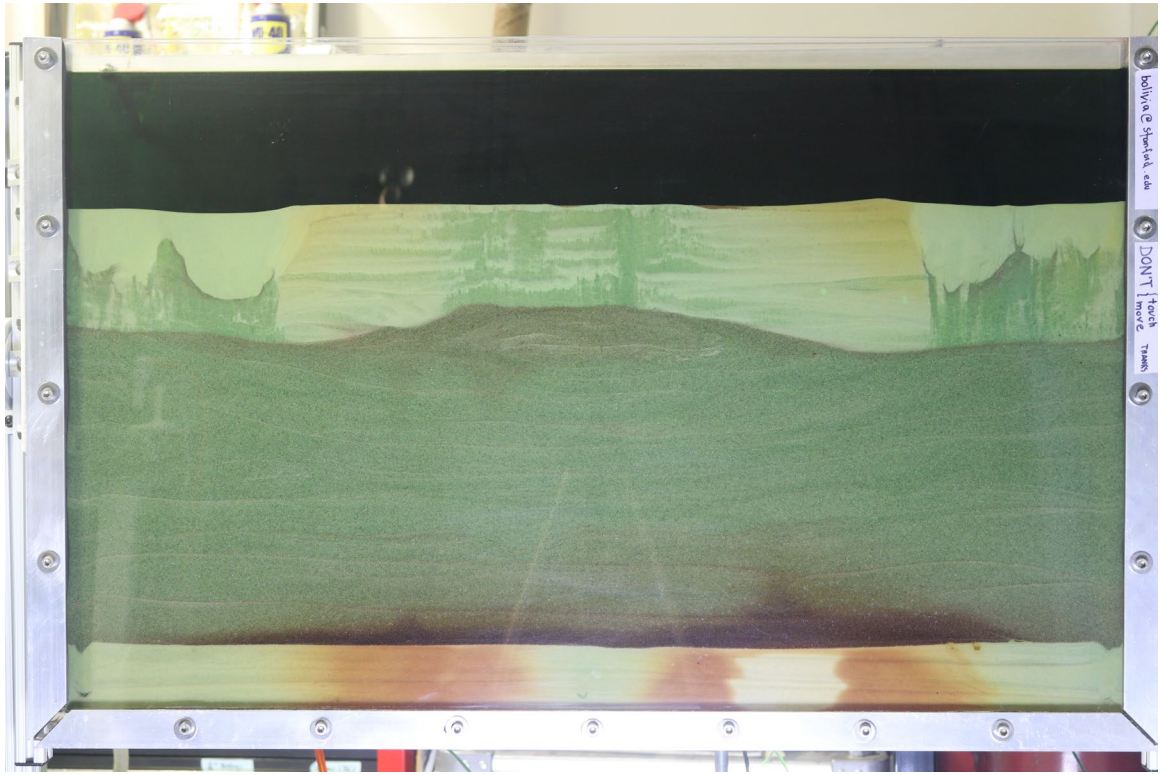
Details

- Sides and bottom are closed, top is constant pressure
- Gaseous CO_2 (near atmospheric pressure)
- pH sensitive dyes for visualization

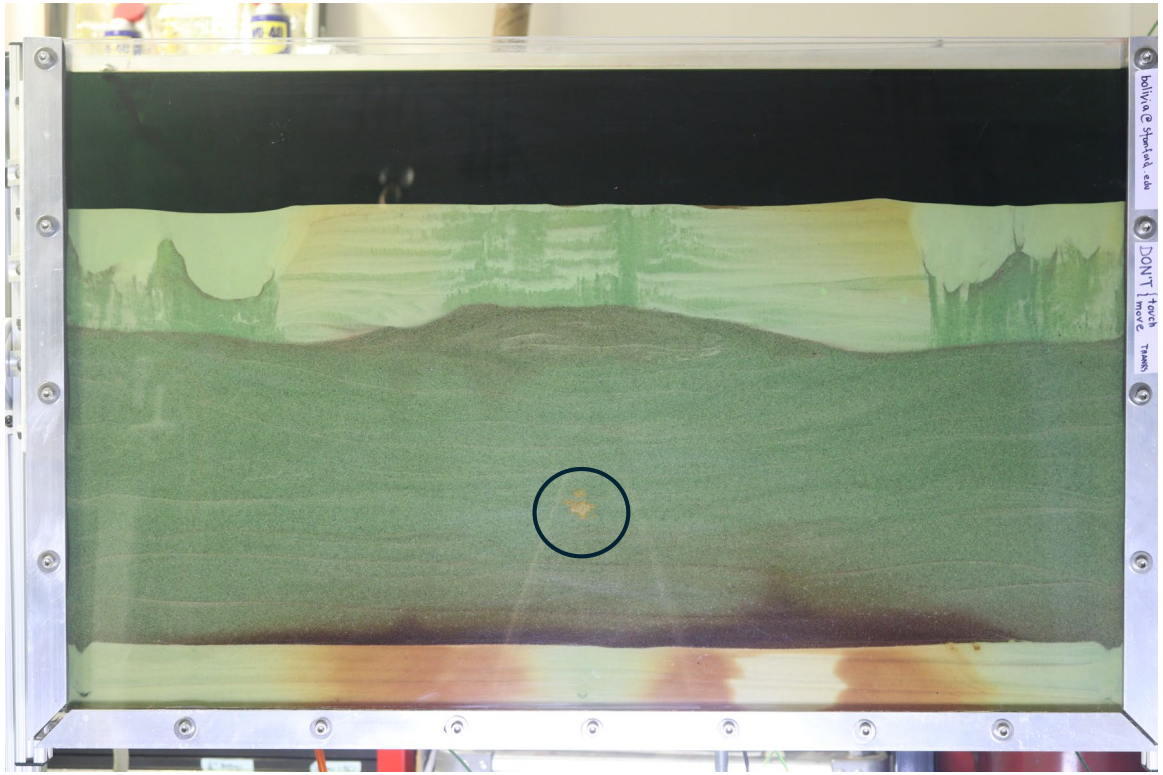


Demonstration

Rate = 0.5 mL/min, Injection time = 5.5 hrs



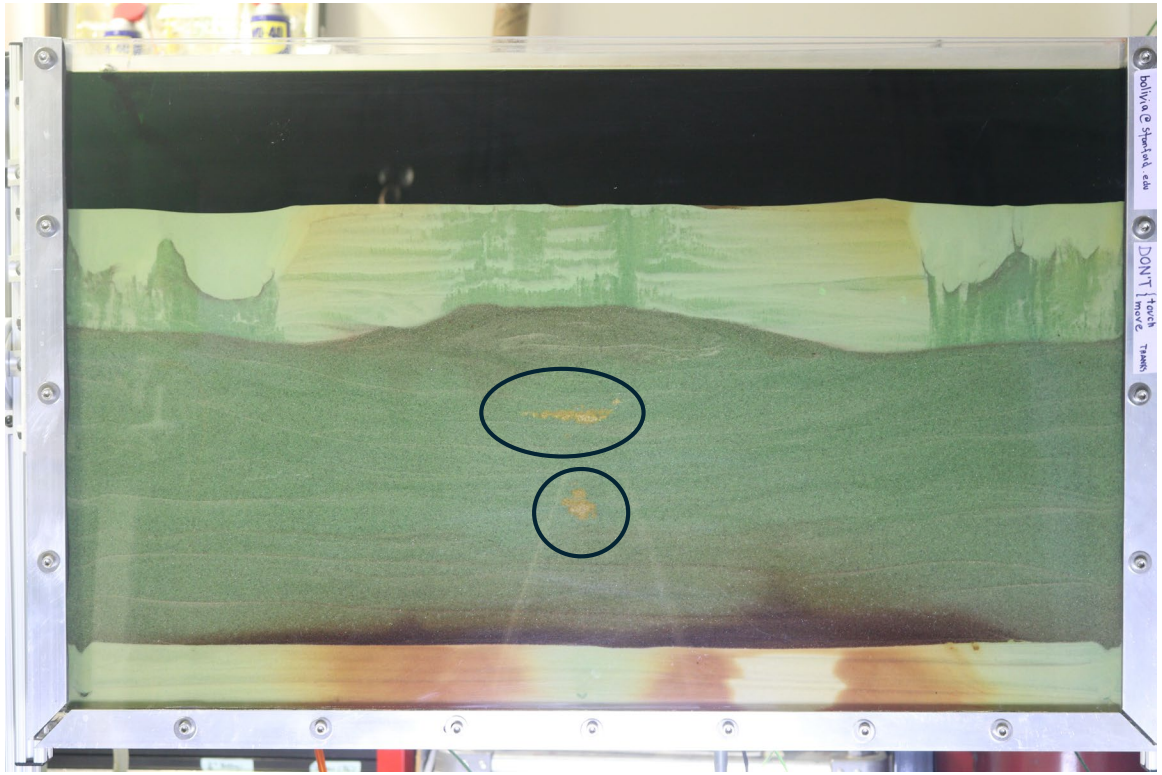
Initial condition, t = 0



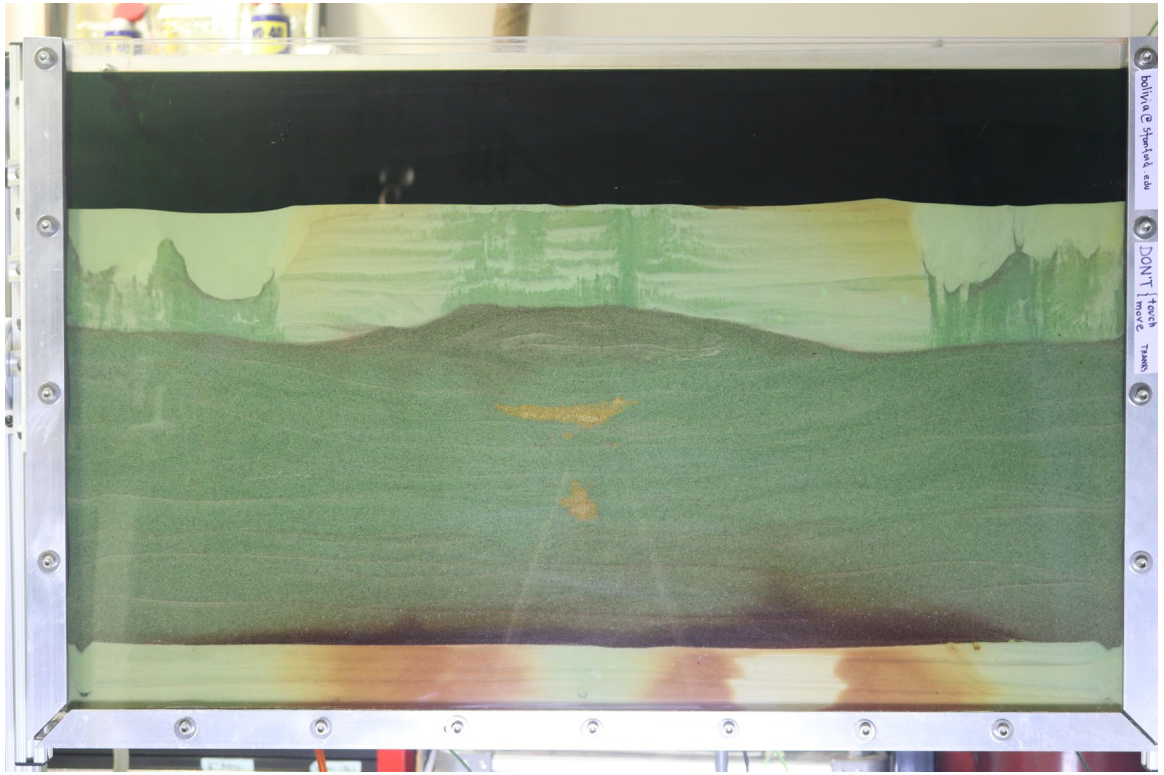
7 min

Demonstration

Rate = 0.5 mL/min, Injection time = 5.5 hrs



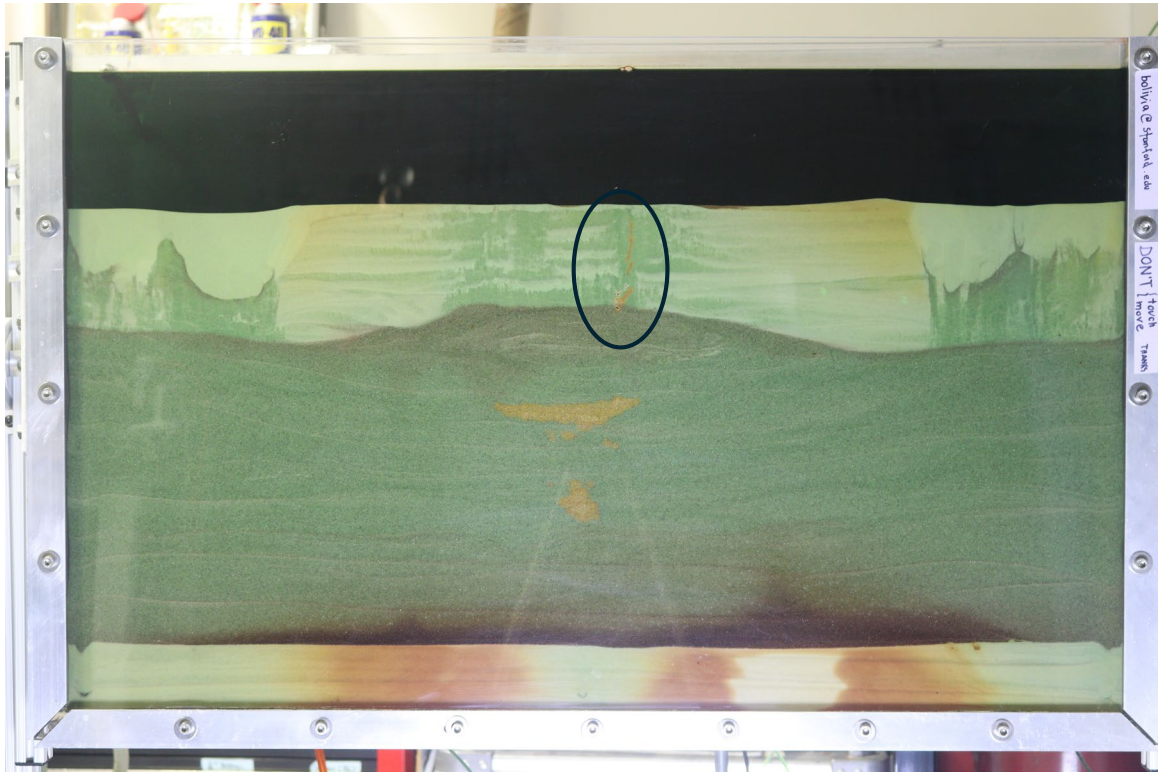
13 min



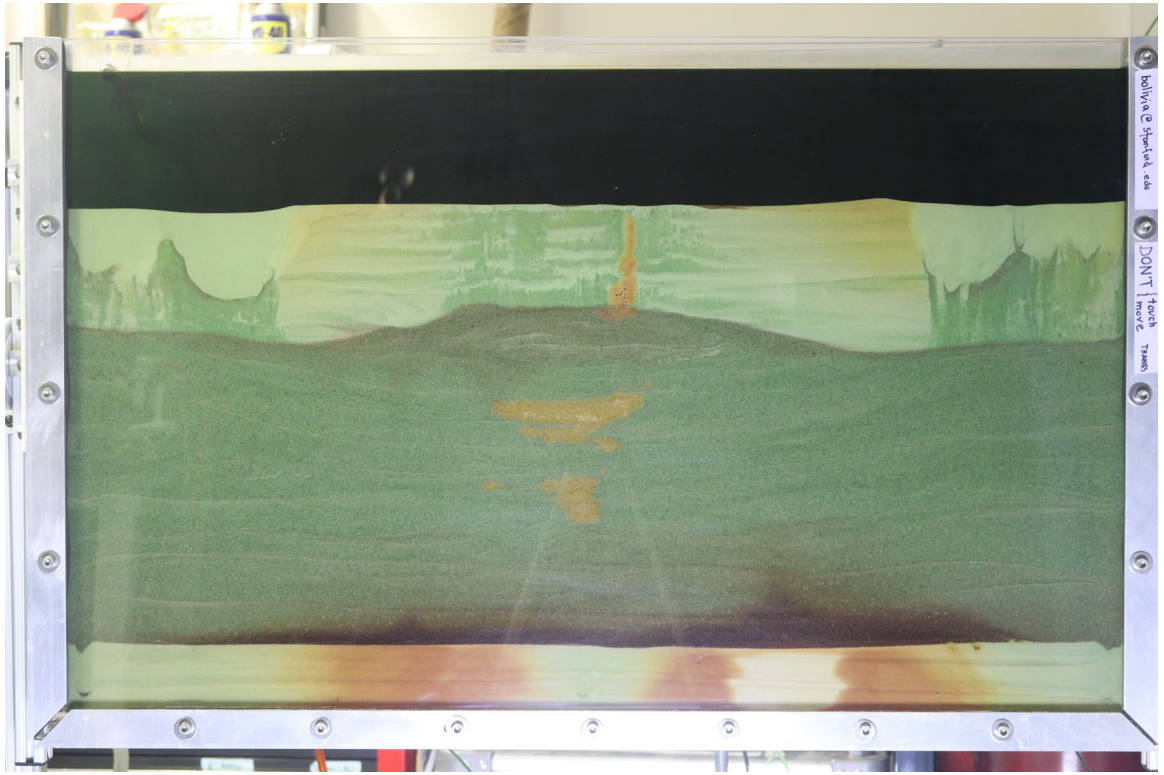
23 min

Demonstration

Rate = 0.5 mL/min, Injection time = 5.5 hrs



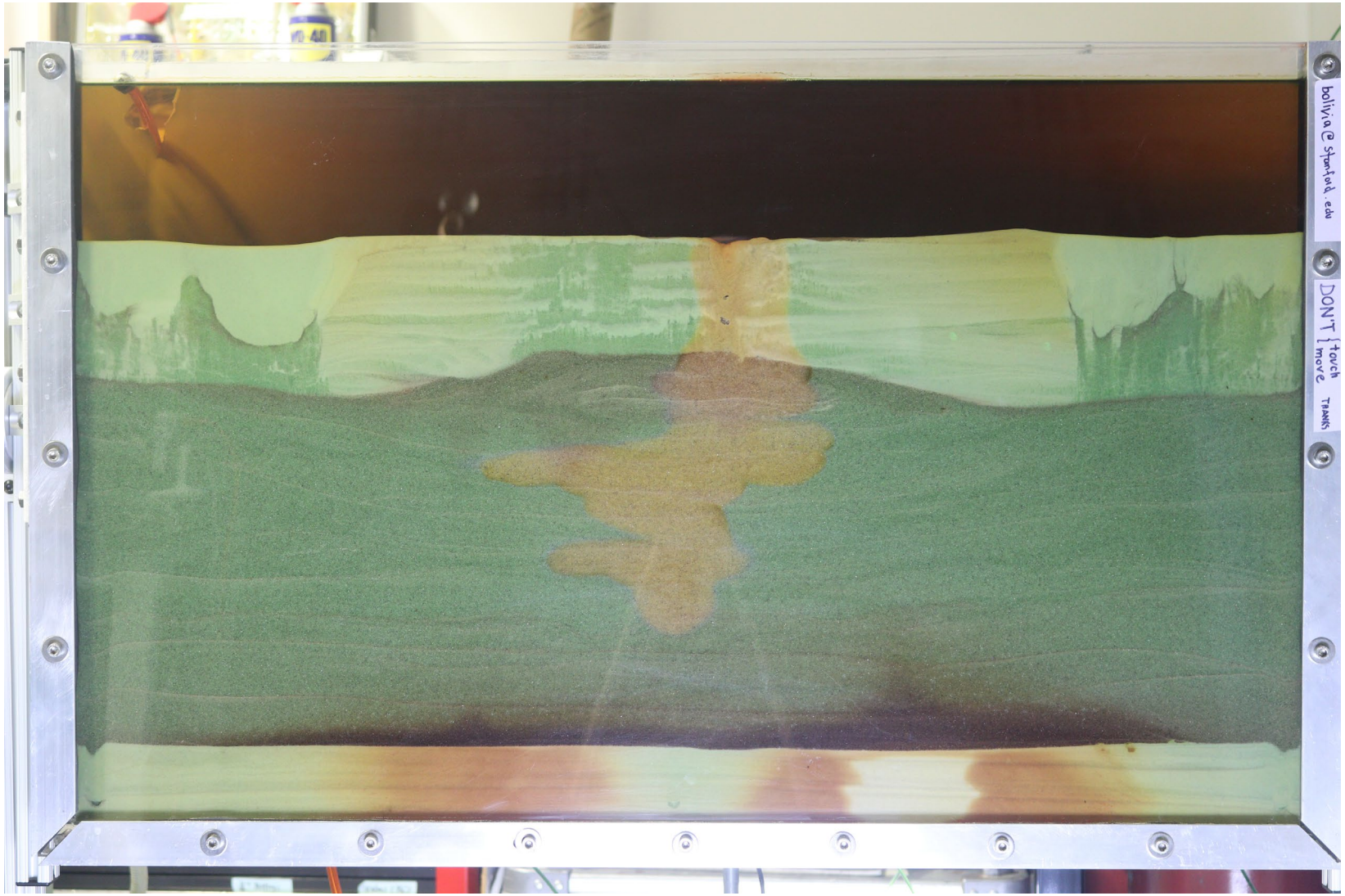
31 min



62 min

Demonstration

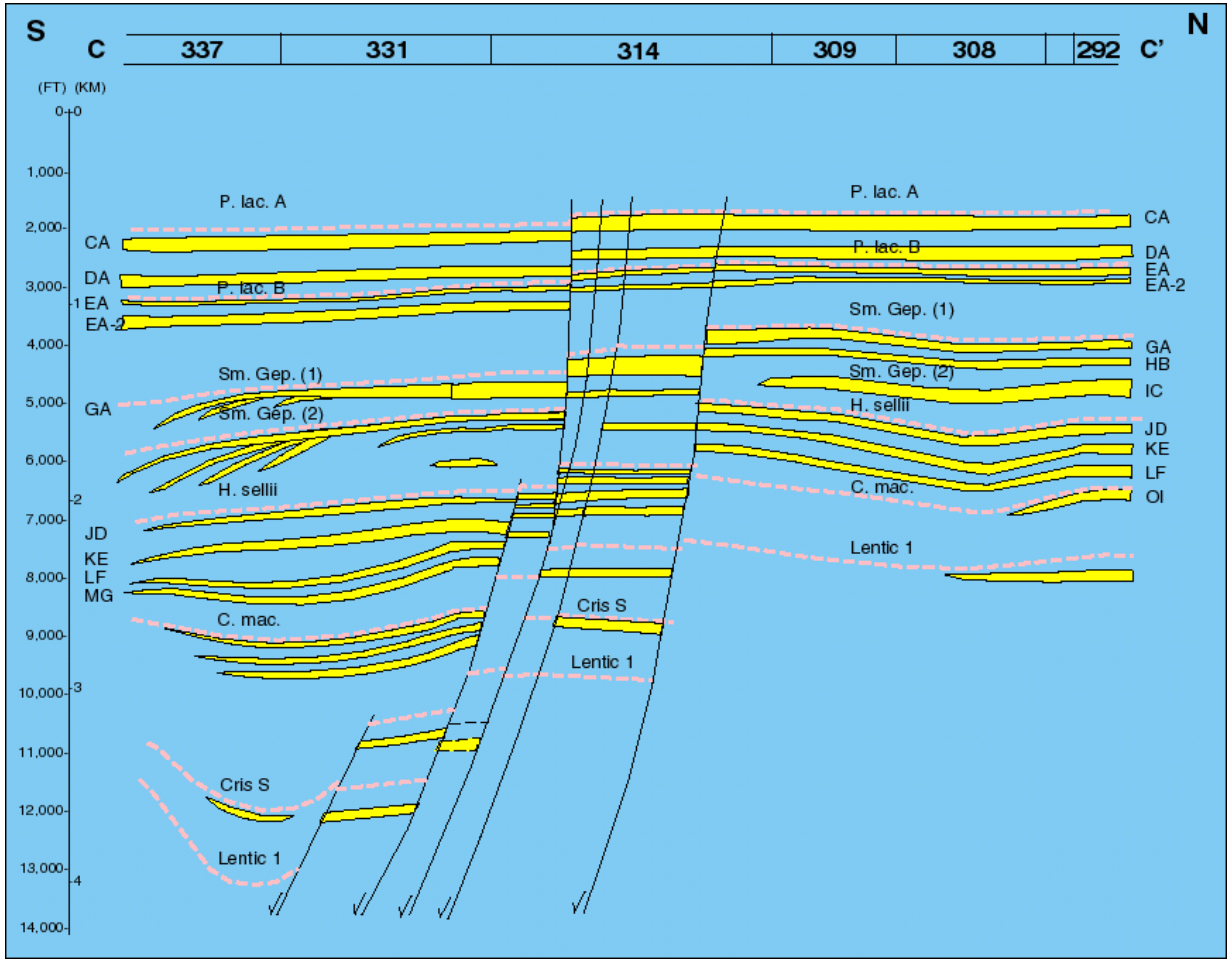
Rate = 0.5 mL/min, Injection time = 5.5 hrs



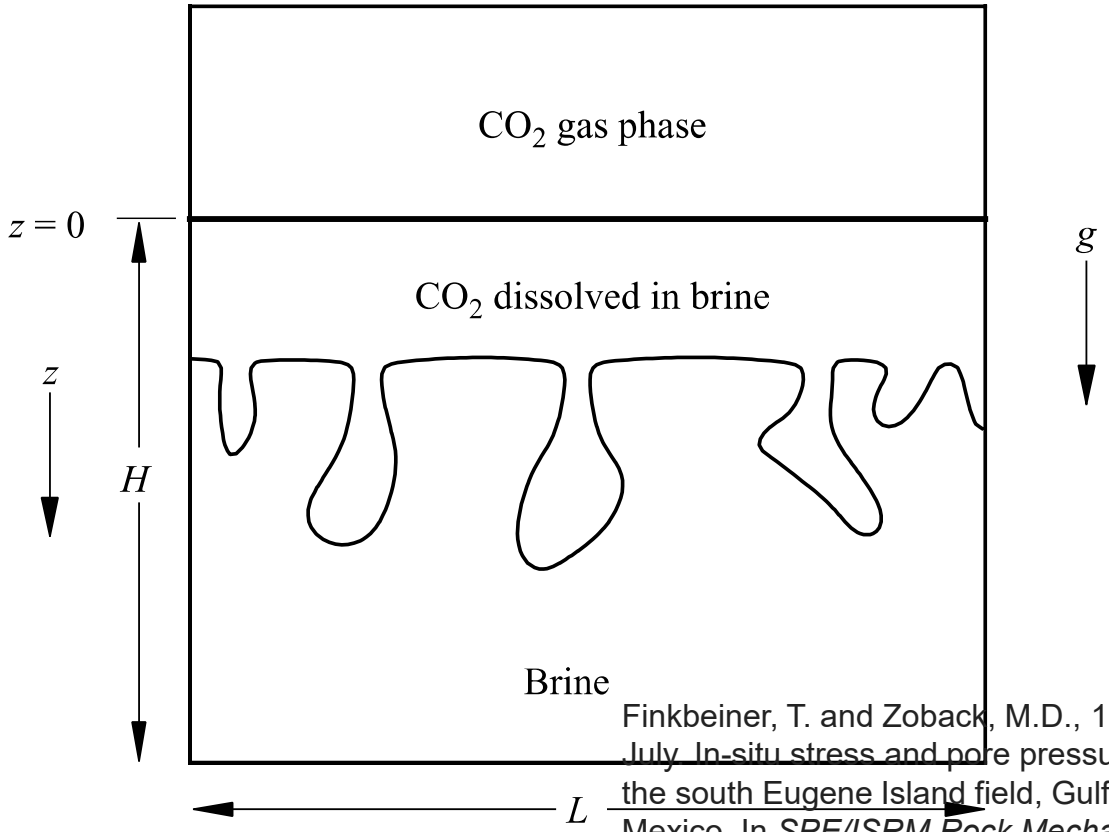
7.5 hours

Next steps

- Sand geometry



- Convective mixing

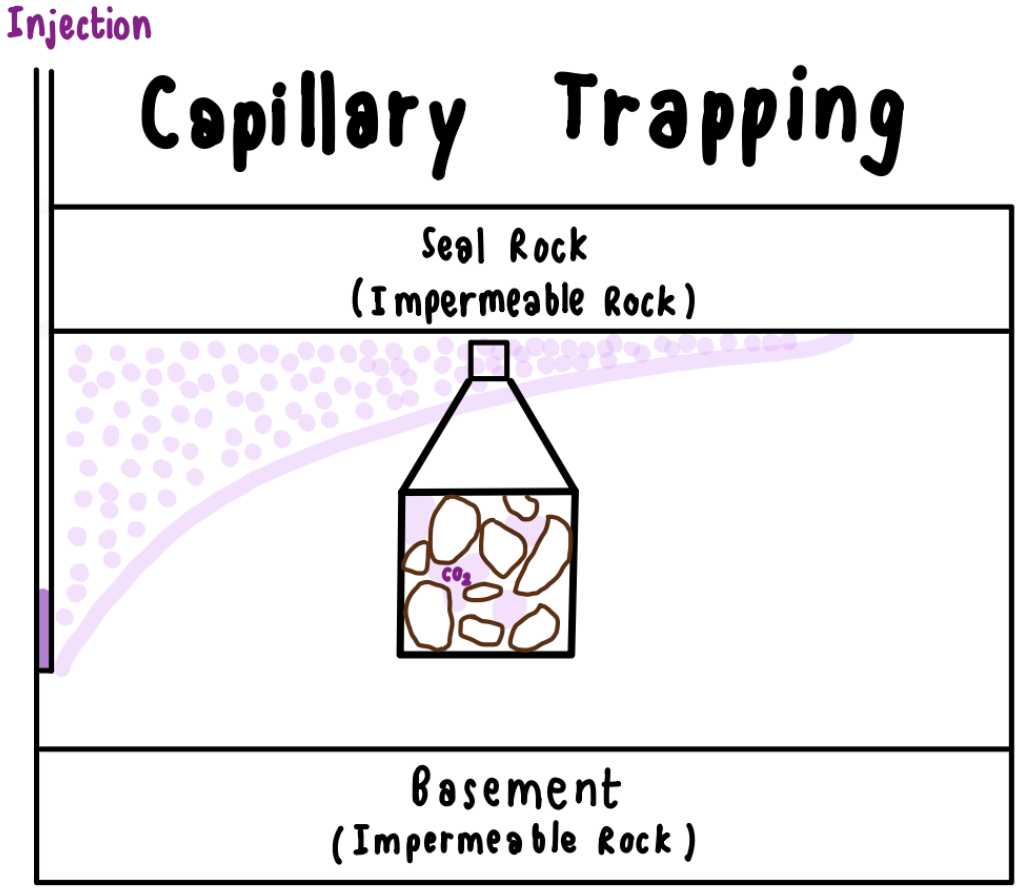


Finkbeiner, T. and Zoback, M.D., 1998, July. In-situ stress and pore pressure in the south Eugene Island field, Gulf of Mexico. In *SPE/ISRM Rock Mechanics in Petroleum Engineering* (pp. SPE-47212). SPE.

Riaz, A., Hesse, M., Tchelepi, H. A., & Orr, F. M. (2006). Onset of convection in a gravitationally unstable diffusive boundary layer in porous media. *Journal of Fluid Mechanics*, *548*, 87-111.

Next steps

- Small **VSUL (30 by 20 cm)**



- Educational modules

https://sustainability.stanford.edu/admissions-education/k-12-outreach

Cabbage juice pH indicator

anthocyanins are water-soluble, biological pigments that appear as red, purple, blue or black, ***depending on their pH***

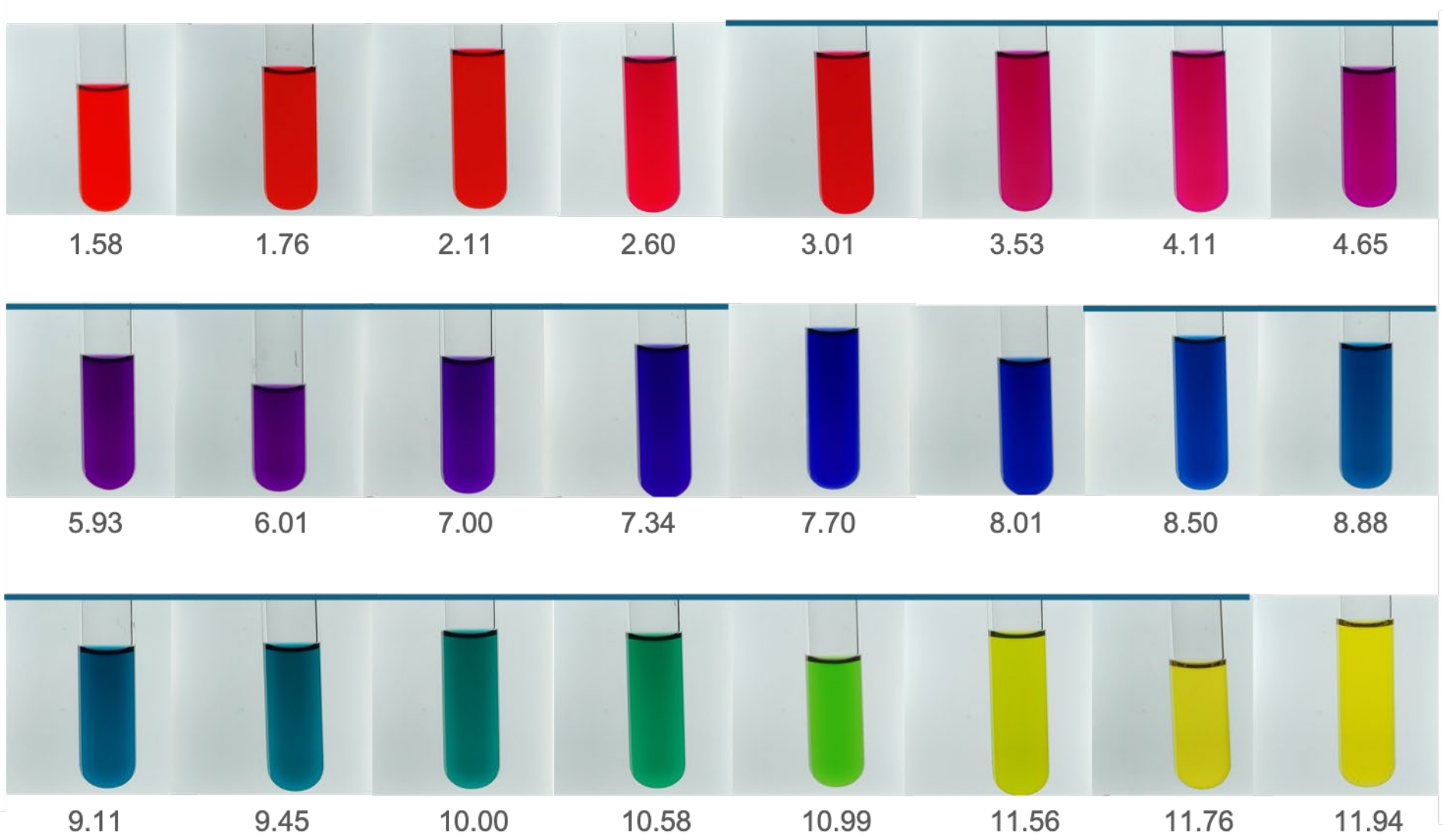
red cabbage

Red cabbage anthocyanins

[acidic alkaline]

sensitivity intervals

Anthocyanins



Acknowledgment

- We thank ExxonMobil Research and Engineering through the Strategic Energy Alliance for funding.
- Prof. Martin Fernø University of Bergen, Flow rigs for CCUS

1-4 September 2025, Bergen Norway

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> Real-world impact

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ARMA american rock mechanics association

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NCS 2030 National Centre for Sustainable Subsurface Utilization of the Norwegian Continental Shelf
Universitetet i Stavanger

UNESCO United Nations Educational, Scientific and Cultural Organization

uniTwin UNESCO Chair in Green Transition for Carbon Neutrality and Climate Change