Mimicking Rock Heterogeneity in the Laboratory to Better Understand Effects on CO_2 Migration and Trapping

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This research fabricates novel engineered sand packs for buoyancy-driven fluid migration experiments conducted at the meter scale using glass beads packed in a quasi 2D glass cell (60 x 60 x 1 cm) and complementary reduced physics simulations. We have constructed a novel, automated technique to build sandpacks that mimic natural sedimentary features. The heterogeneous sedimentary structures are built by vertically depositing commercial silica sand (ranging from 100 to 1000 microns) into the glass cell in an automated manner through a hopper mounted on a programmable dual axis (horizontal and vertical) linear actuator system (Fig 1). By programming the coordinated motion of the two axes the creation of previously unachievable crossbedding and ripple like deposits (Fig 2). The features can be re-generated in a highly reproducible manner (Fig. 3).

Fluid migration experiments are then conducted at ambient conditions using a surrogate fluid pair (Fig. 4) that mimics density and viscosity contrasts, and interfacial tension of in-situ reservoir brine and supercritical CO_2. A peristaltic pump is used to inject the supercritical CO_2 analogue at the bottom of the glass cell at low flow rates such that capillary forces are dominant.

Light transmission techniques and image processing are used for visualization, and to calibrate and quantify saturation of the trapped non-wetting fluid during the experiments. With the ability to generate different types of heterogeneous structures in a reproducible manner, a systematic investigation of the effect of heterogeneity on trapping and migration behavior becomes possible.

These novel experiments can be summarized with the following:

1. We can <u>engineer sandpacks</u> to specification mimicking cm-scale natural heterogeneity at meter-scale with high repeatability.
2. We can <u>visualize and quantify</u> (mass and pressure) buoyant flow at analog subsurface conditions using surrogate fluids. Time constraints are very high value. Extrapolate to field scale?
3. We can <u>validate</u> flow conformance with numerical simulations: build confidence. FOAK demonstrated match of complex sand tank model observations to numerical simulation.
4. Quantitative summary forthcoming, but we expect to be able to predict 2D tank saturations and flow times given basic geologic characterization (grain size contrast and fabric). With simulator conformance we gain trust in 3D simulation results of complex systems that are difficult to work with in the lab.

We seek someone to continue leading this groundbreaking research initiative.
Contact Dr. Tip Meckel – tip.meckel@beg.utexas.edu +1-512-471-4306

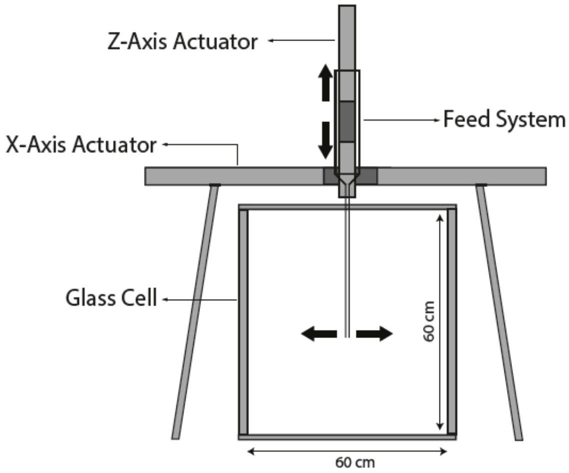


Fig 1: Schematic of the automated packing system, further developed from Griffith et al., 2013.

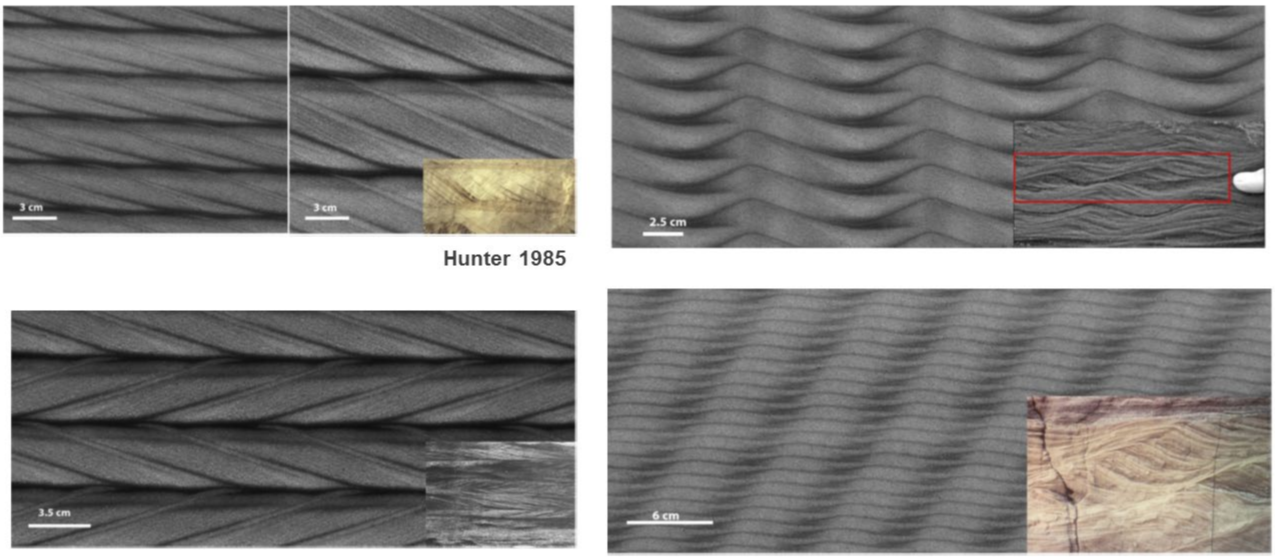
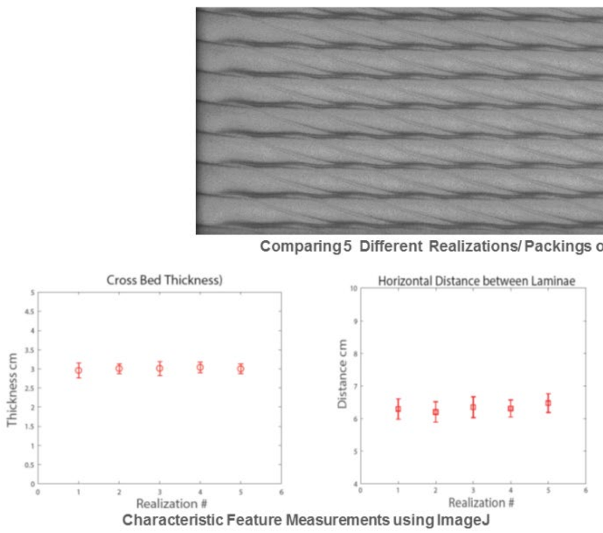


Fig 2: Sandpack configurations generated by the automated system. Inset images show actual geologic outcrops for comparison.

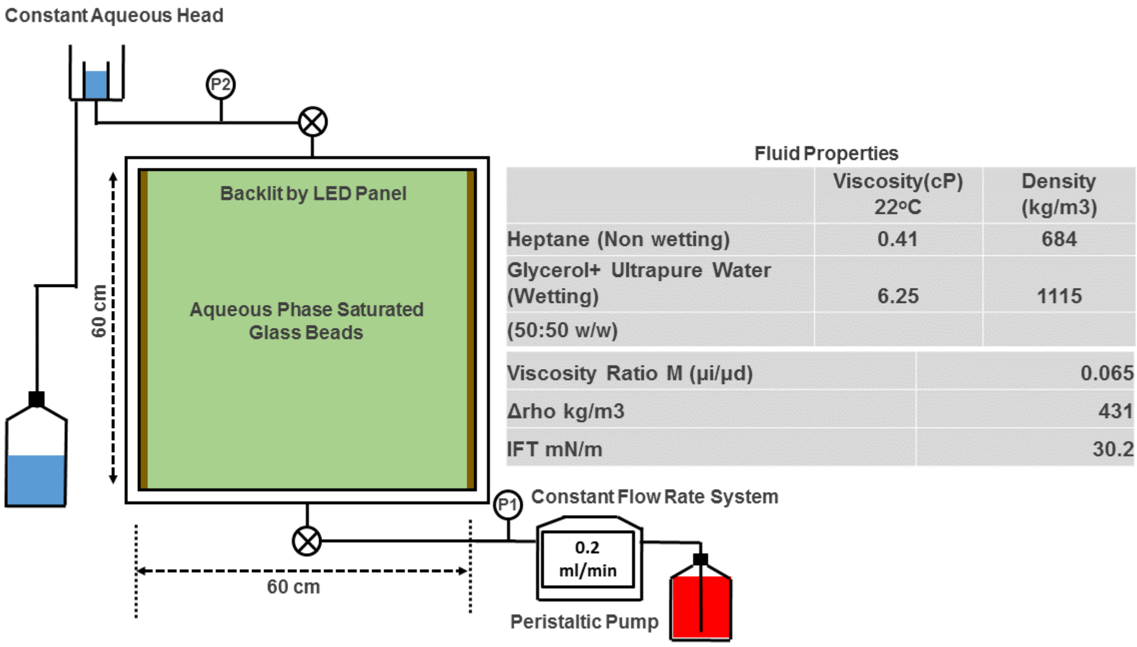


	Trial 1 vs 2	Trial 1vs 3	Trial 1 vs 4	Trial 1vs 5
SSIM	0.998	0.98	0.997	0.97

Comparison of eigenvalues of images using structural similarity index (SSIM)

5

Fig 3: High reproducibility afforded by programmable system.

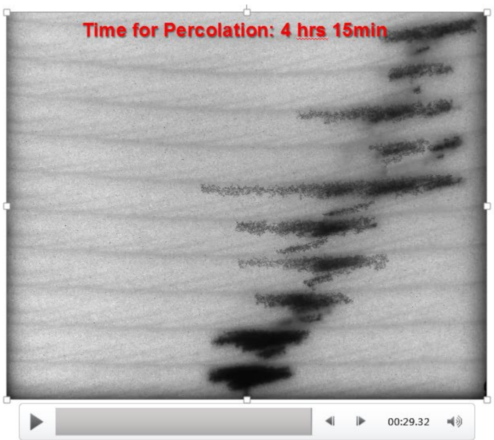


Fluid Properties

	Viscosity(cP) 22°C	Density (kg/m3)
Heptane (Non wetting)	0.41	684
Glycerol+ Ultrapure Water (Wetting) (50:50 w/w)	6.25	1115

Viscosity Ratio M (μi/μd)	0.065
Δrho kg/m3	431
IFT mN/m	30.2

Fig 4: Setup for multi-phase buoyant flow experiments using surrogate fluids for subsurface conditions.



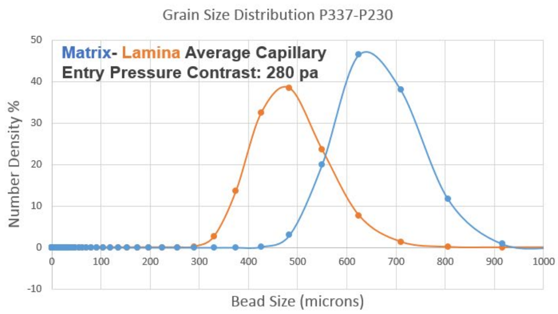


Fig 5: Preliminary results demonstrating effects of capillary entry pressure contrast.