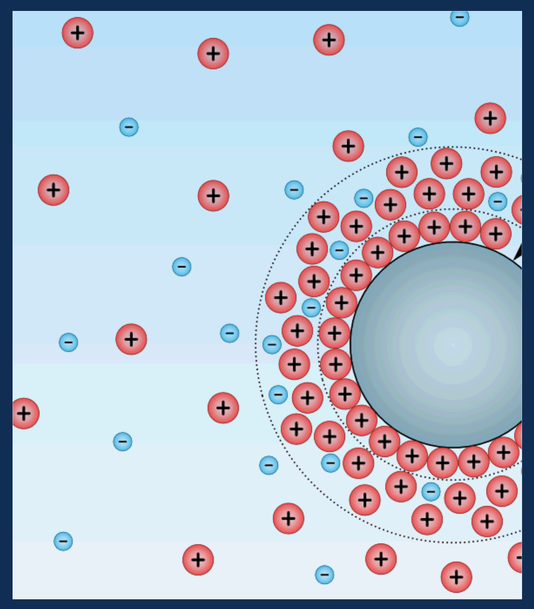

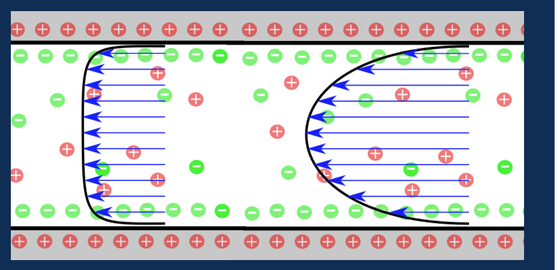

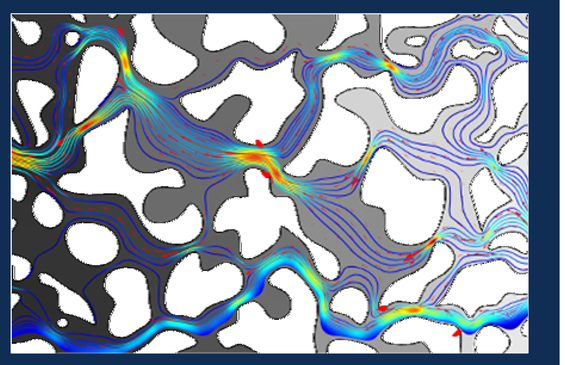

Characterization and Sampling of Ultralow Permeability Geomaterials using Electrokinetics

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Problem: Low-k rocks are critical as barriers and seals as well as source rocks for hydrocarbon, but are difficult to characterize. Existing methods require long-duration tests, have pressure-sensitive responses, or ignore heterogeneity and fractures.

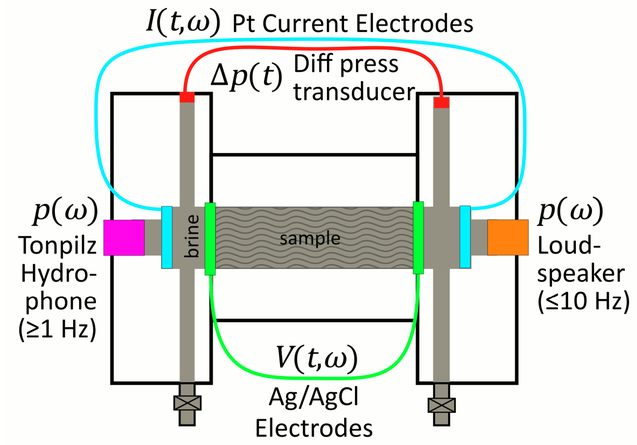
Goals & Technical Approach: This project will develop and extend an electrokinetic (EK) apparatus to quickly characterize low-k cores. We will develop numerical and analytical solutions to interpret data.

Steady-State EK

- *Streaming potential (SP)*
  Move fluids → drag ions
- *Electroosmosis (EO)*
  Move ions → drag fluids

Charge flux: $\bar{J} = -\sigma_0 \frac{\partial \Phi}{\partial x} - [\quad]$ (Ohm's law; SP)

Fluid flux: $\bar{q} = -[\quad] - \frac{k_0}{\eta}\frac{\partial P}{\partial x}$ (EO; Darcy's law)



Instrument design:

1. Piezoelectric hydrophones
2. Differential pressure transducer
3. Potentiostat-galvanostat (*Metrohm*)

Method:

Apply	Measure
AC current $I(\omega)$	: $V(\omega)$ & $\Delta p(\omega)$
Piezonelectric $p(\omega)$:	$V(\omega)$ & $I(\omega)$

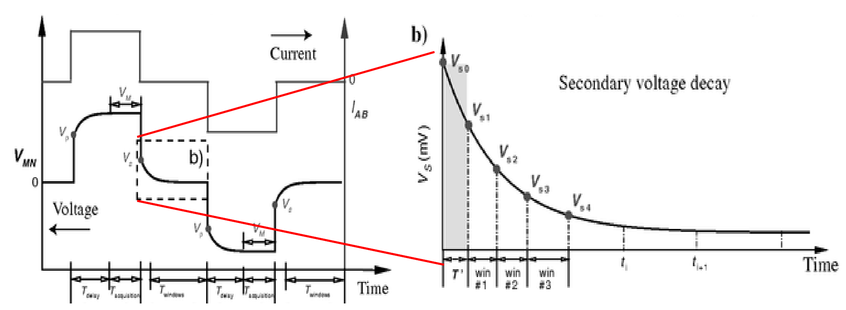
Transient EK

Induced Polarization / Impedance Spectroscopy

Capacitance in porous media:

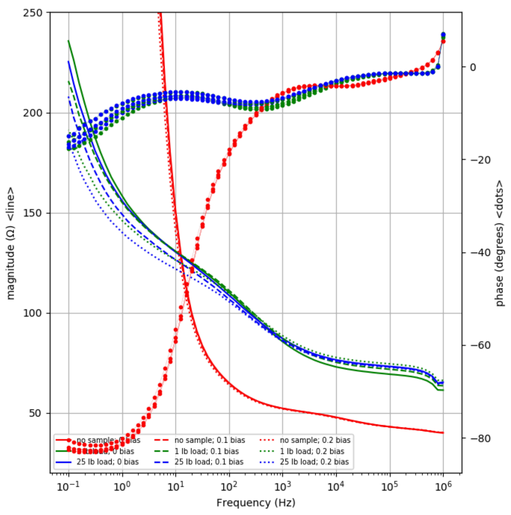
- Ionic Vibration Potential (<< sec)
- Ion alignment with $\boldsymbol{E}$ (<< sec)
- EDL distortion (≤ sec)
- Exclude ions (membrane polarization)
- Sorption/desorption (≤ hrs)

1) Measure $V(t)$ in time domain



2) Measure $V(\omega)$ in frequency domain

Preliminary data: Ottawa sand/KCl brine



Frequency-dependent sample impedance with variable DC offset (Warburg Impedance) and multiple loading to probe diffusion layer In pores.

LDRD Laboratory Directed Research and Development

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