Experimental set-up for measuring electrokinetic properties of rocks in the laboratory.

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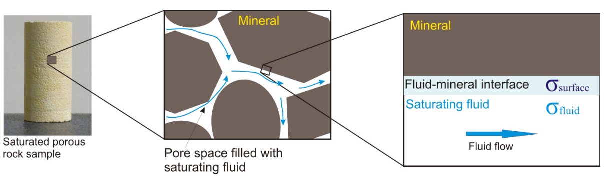
Objectives

→ To measure and understand the electrical and electrokinetic properties of different model rocks in the DC regime as a function of various parameters.
→ To measure and understand the electrical and electrokinetic properties of different model rocks in the AC regime.

The understanding of electrokinetic phenomena is extremely important. Electrokinetic potential variations have been measured and studied in hydrothermal areas *(Corwin & Hoover, 1979)*, before major earthquakes *(Mizutani et al., 1976)*, and immediately prior to volcanic activity *(Hashimoto & Tanaka, 1995)*. Furthermore electrokinetic coupling has recently been used in the development of electroseismic exploration methods *(Mikhailov et al., 2000)*, which have the potential to become as powerful a method of hydrocarbon exploration as the seismic method. However, the theories behind electrokinetic phenomena are not well understood, and we currently lack sufficient data to improve them. This problem is particularly acute in the AC regime where almost no data exist and there is only a rudimentary theory available.

Streaming (electrokinetic) Potential

Electrokinetic phenomena couple electrical flow and hydraulic flow *(Revil et al. 1999)*. In other words, in a saturated porous medium, an electrical potential difference appears when you flow an aqueous fluid through the rock. The resulting potential is called the electrokinetic or the streaming potential. The opposite is also true; when an electrical potential is applied to a saturated porous medium, the saturating fluid moves, and this effect is called electroosmosis.



The charge that each mineral surface has the ability to attract mobile ions from a saturating fluid. This results in a depletion of the fluid of some ions which then become adsorbed to the mineral surface *(Parks, 1990)*. The adsorbed layer on the mineral surface and the depleted layer in the fluid compose what is called the electrical double layer (EDL). It is in this electrical structure that surface conduction takes place, and the electro-kinetic phenomena have their cause.

$$\begin{bmatrix} Q \\ J \end{bmatrix} = - \begin{bmatrix} L_{11} & L_{12} \\ L_{21} & L_{22} \end{bmatrix} \begin{bmatrix} \nabla P \\ \nabla \varphi \end{bmatrix}$$

Darcy's law, $L_{11} = k/\eta$

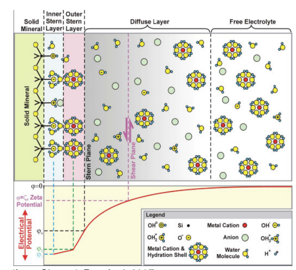
Ohm's law, $L_{22} = \sigma_f$

Electrokinetic phenomenons, $L_{21} = L_{12} = \varepsilon\zeta/\eta$,

k: permeability of the medium (m²)
σ_f : fluid conductivity (S/m)
ε : fluid dielectric constant
ζ :zeta potential (V)
η : fluid viscosity (Pa.s)
P: fluid pressure (Pa)
φ : electrical potential (V)
Q : fluid flow (L/m²)
J : electrical current density (A/m²)

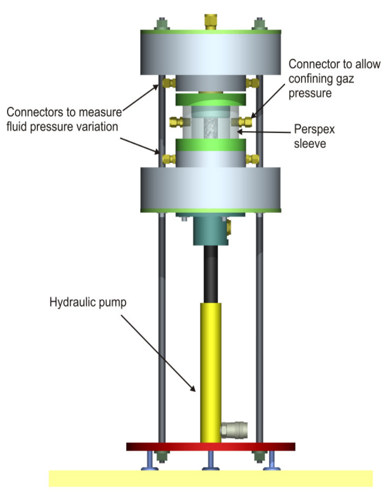
Electrokinetic coupling coefficient :

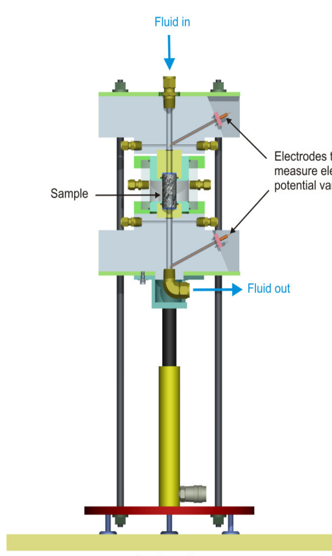
$$C_s = \frac{\Delta V}{\Delta P} = \frac{\varepsilon\,\zeta}{\eta\,\sigma}$$



(from *Glover & Ransford, 2007*)

DC measurements set-up



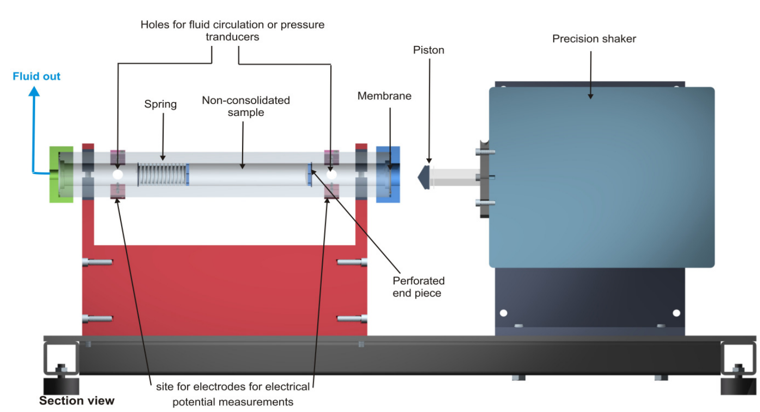


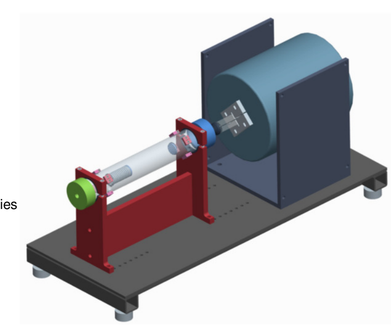
Set-up testing: Glass bead samples
« Fluid samples »
Samples previously tested in literature

Measurements: Pressure difference
Electrical potential

Experiments: For different type of rocks
For different pH → pH=2 to pH=10
For different fluid concentrations → 2 M. to 10^{-5} M.
For different degrees of saturation
For different controlled temperatures
For different fluid flows

AC measurements set-up





Measurements: Pressure difference
Electrical potential
Frequency of fluid injection

Experiments: For different type of rocks
For different pH
For different fluid conductivities

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