DETERMINING OSMOTIC PRESSURE IN NIOBRARA CHALK & CODELL SANDSTONE USING HIGH-SPEED CENTRIFUGE

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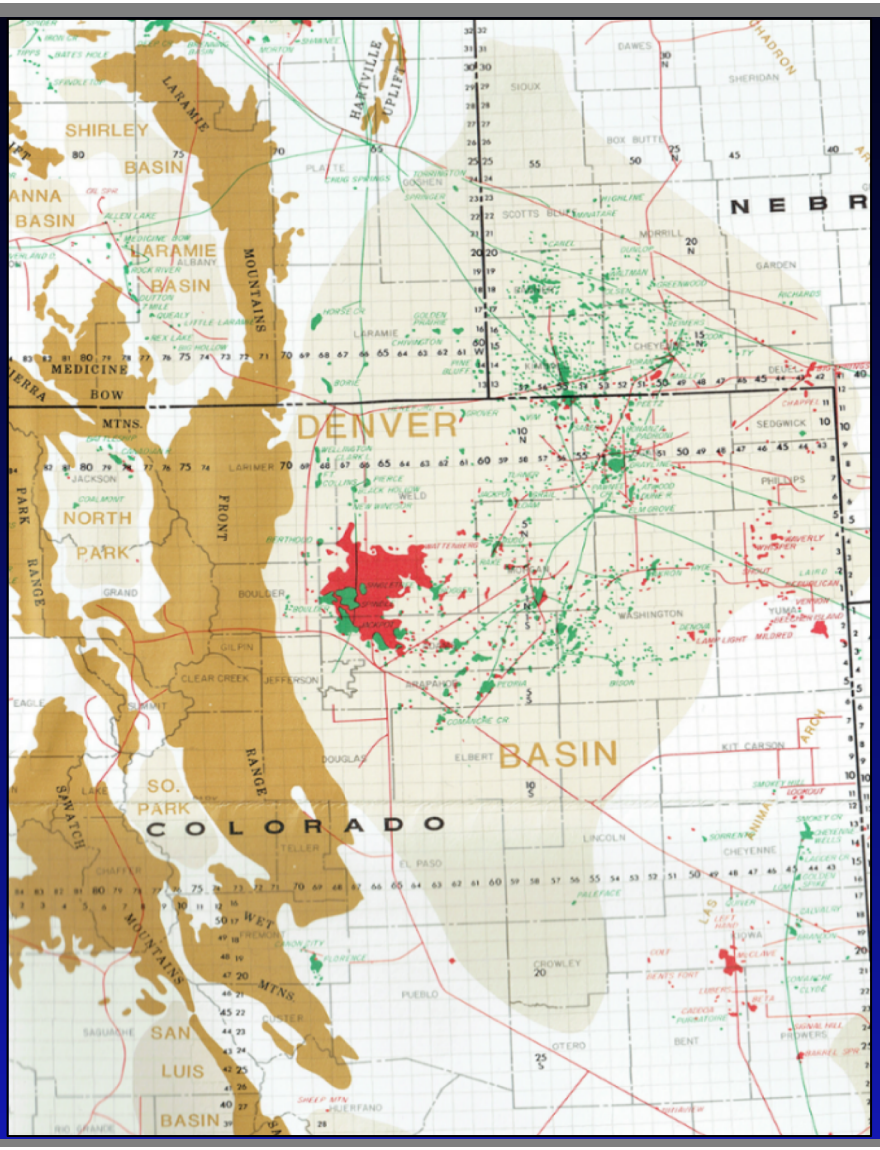
Problem Statement

- **Salinity contrast** between stimulation fluids and formation **could lead** to large **osmotic pressures**. It is potentially possible to measure osmotic pressure as a function salinity contrast using **high-speed centrifuge**; thus, this research.

Problem Statement

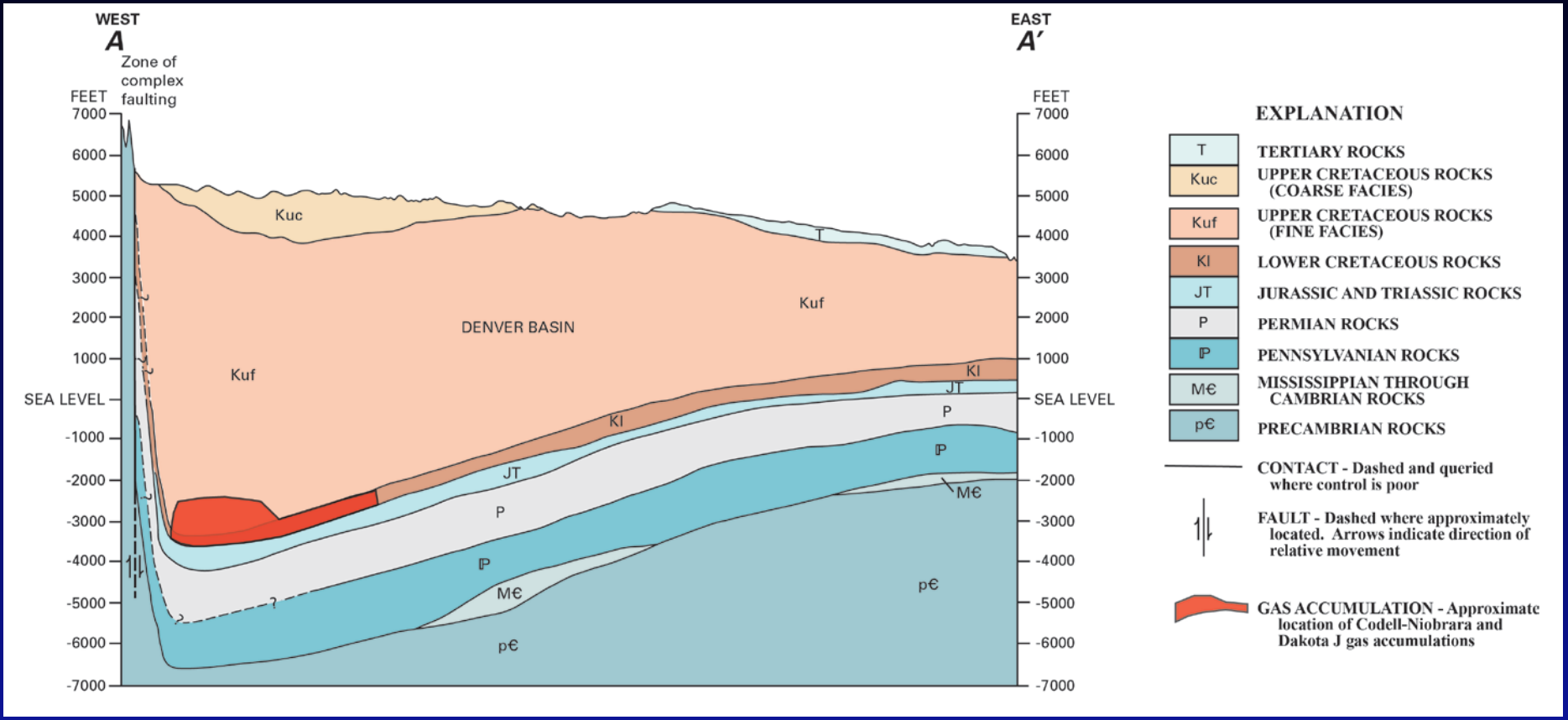
- **Gas trapping** also is a major issue in many water drive reservoirs. This research explores the use of centrifuge to measure **trapped gas saturation**.

Niobrara Formation Map



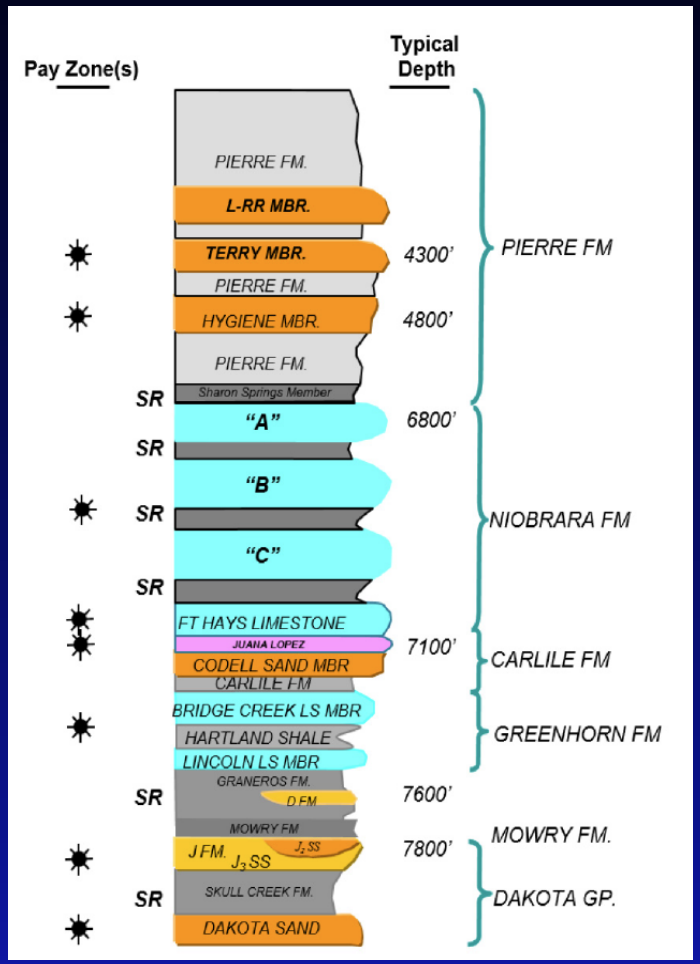
(Kent and Porter 1980)

DJ Basin Cross-Section

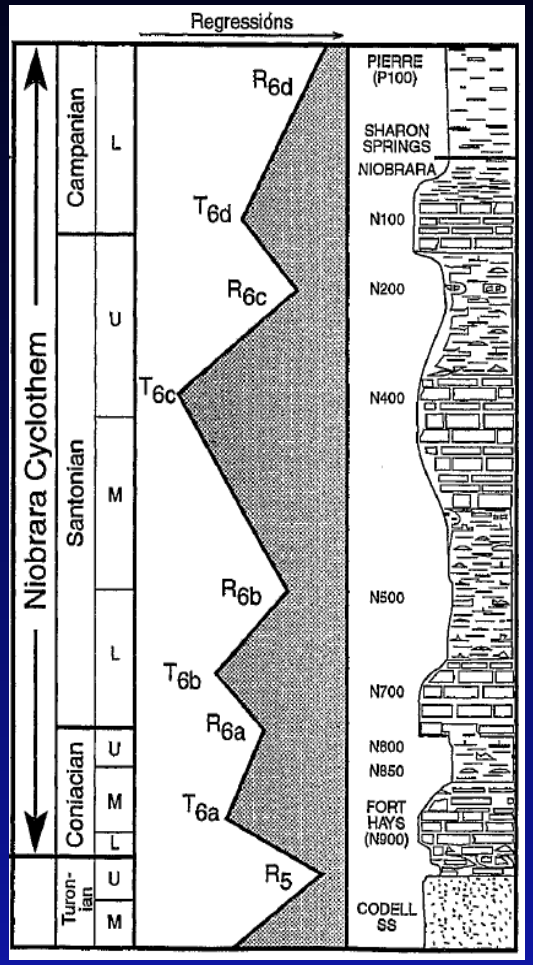


(Nelson, P.H. and Santus, S.L., USGS, 2011)

Typical Stratigraphic Column in Wattenberg Field

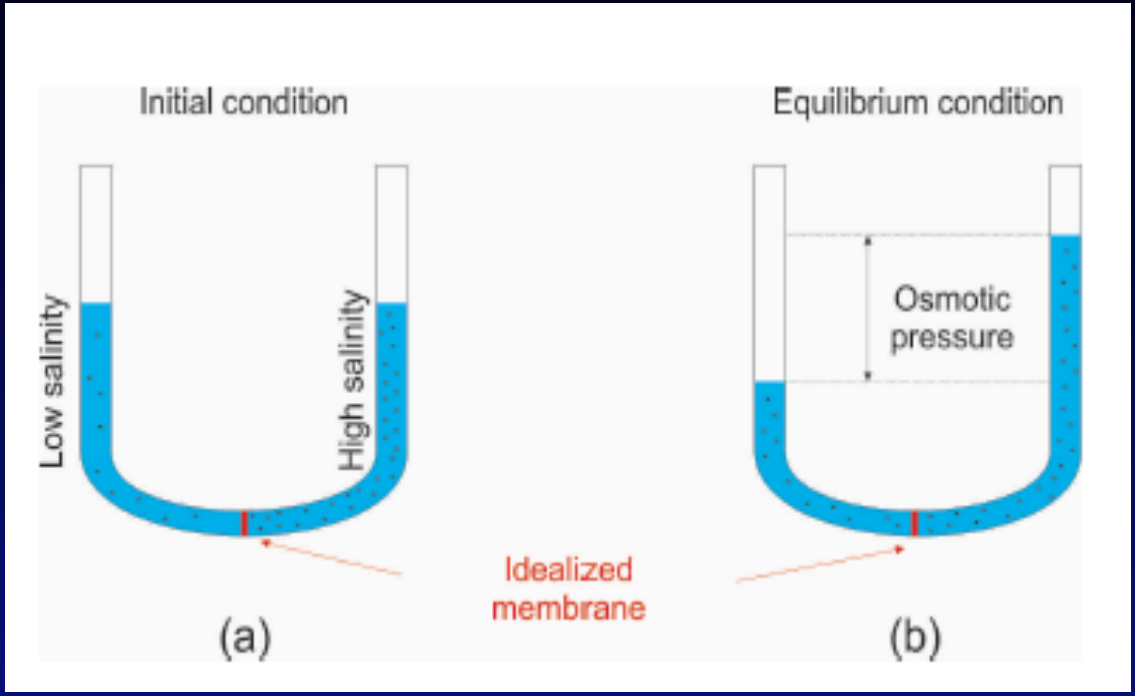


(Sonnenberg, 2015)



(Longman, 1998)

Osmotic Pressure



Osmosis results from the tendency of solutions to equalize concentration on both sides of a permeable membrane.

Early Formulation of Osmotic Pressure

Early Formulation of Osmotic Pressure

$$J_{os} = -k\Delta c$$

Later Formulation of Osmotic Pressure

Capillary Pressure

$$p_c = \frac{2\sigma \cos\theta}{r}$$

σ : Interfacial Tension

θ : Contact Angle

r : Pore Throat Radius

Osmotic Pressure (Ideal)

$$\pi = \frac{n_{solute} RT}{V}$$

n_{solute} : Molar Concentration

R : Gas Constant

T : Temperature

V : Molar Volume

Osmotic Pressure (Real)

$$\pi = \frac{RT}{V} \ln\left(\frac{a_I}{a_{II}}\right)$$

R : Gas Constant

T : Temperature

V : Molar Volume

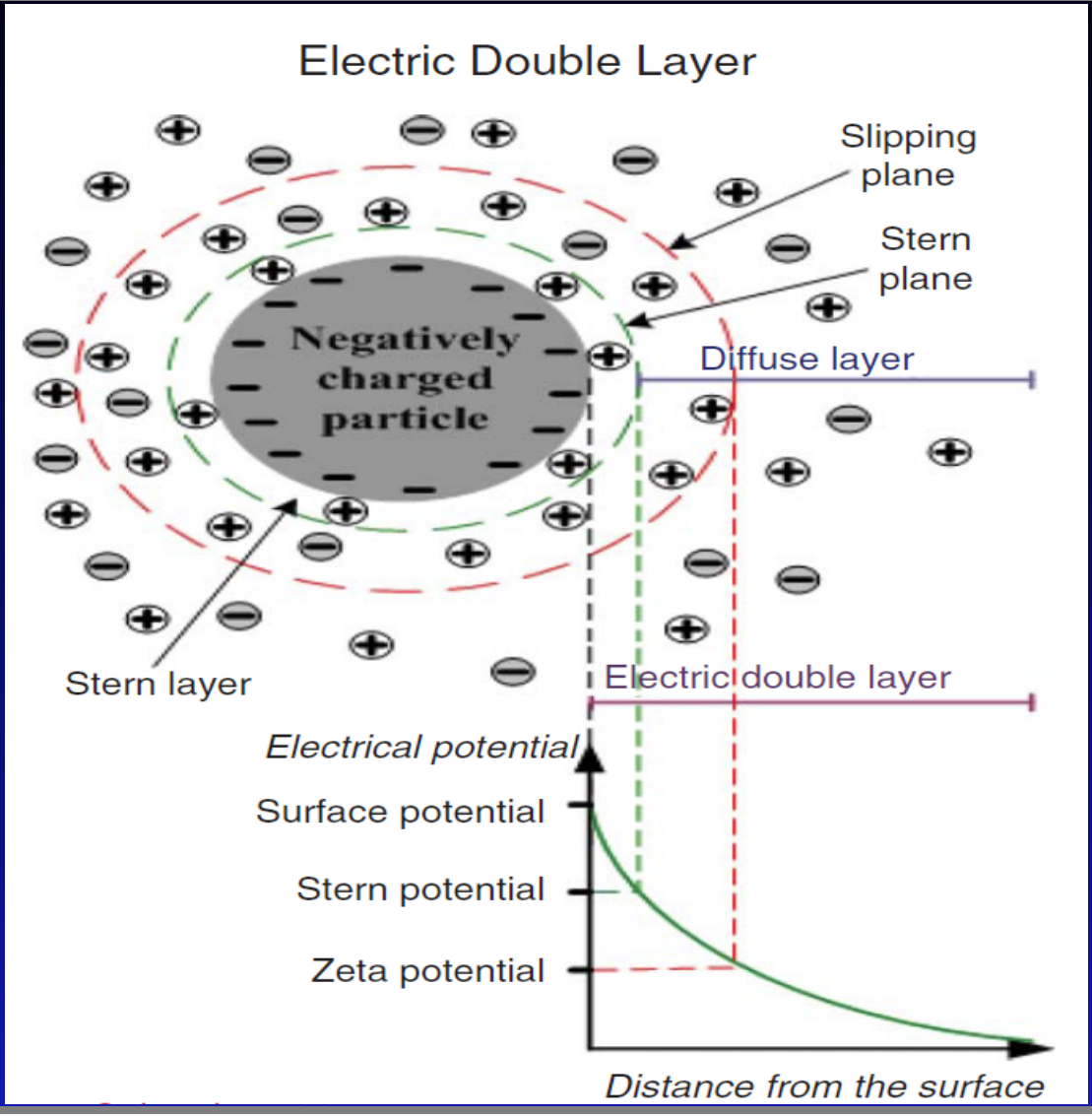
a_I and a_{II} : Water activity of different brine solutions

Osmotic Pressure

- **Reverse osmosis** could be a cause of high salinity in porous media because water is potentially squeezed out from the pores.

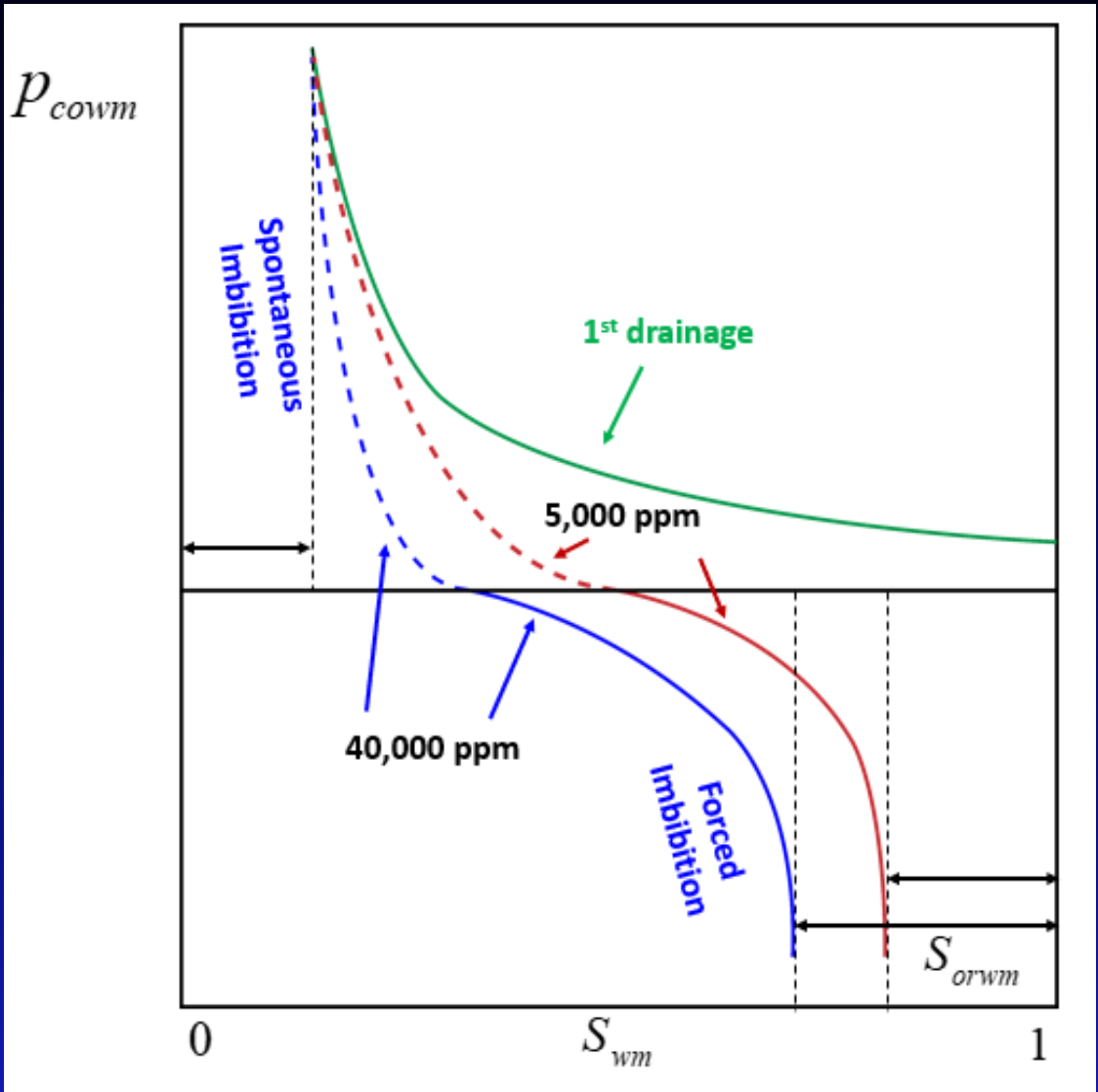
- **Water adsorption** on clays creates an **electrical double layer** which makes porous media behave like a semi-permeable membrane.

Electrical Double-layer



(Subtechs 2017)

Capillary Pressure Curves

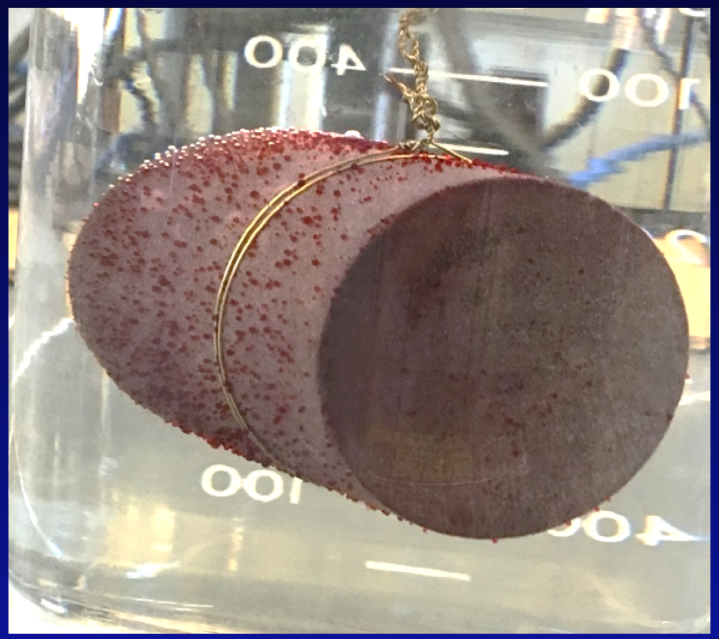


Number of Laboratory Experiments

Cases	Imbibition Salinity (ppm)	Initial Saturation Salinity (ppm)
Case 1	5,000	40,000
Case 2	15,000	40,000
Case 3	25,000	40,000
Case 4	40,000	40,000

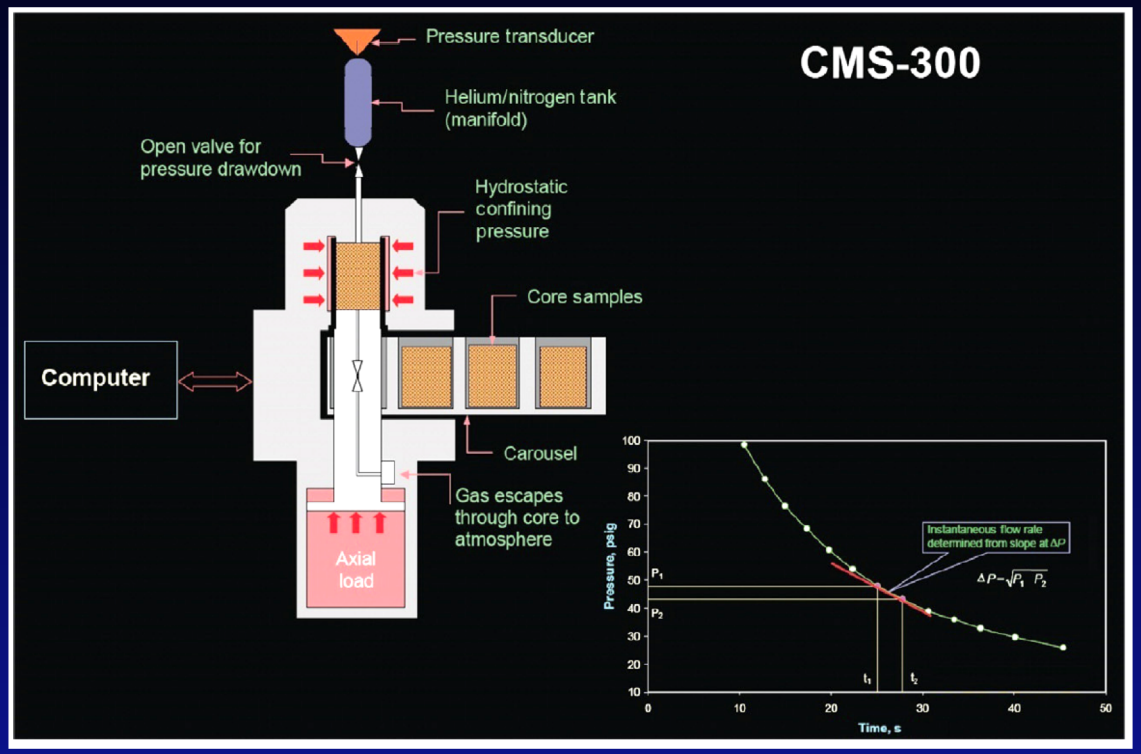
Laboratory Experiments

Salinity = 5,000 ppm



Salinity = 40,000 ppm

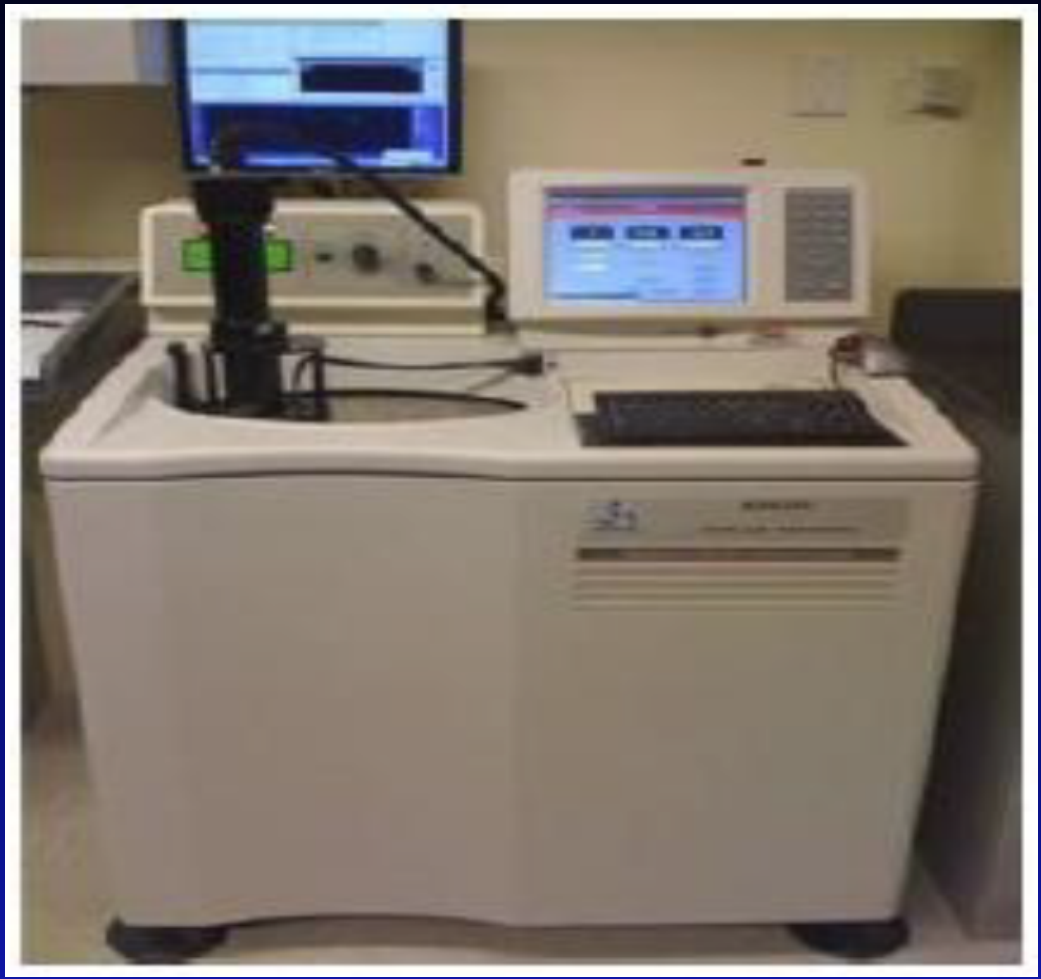
Laboratory Experiments



- Porosity
- Permeability
- Pore Volume

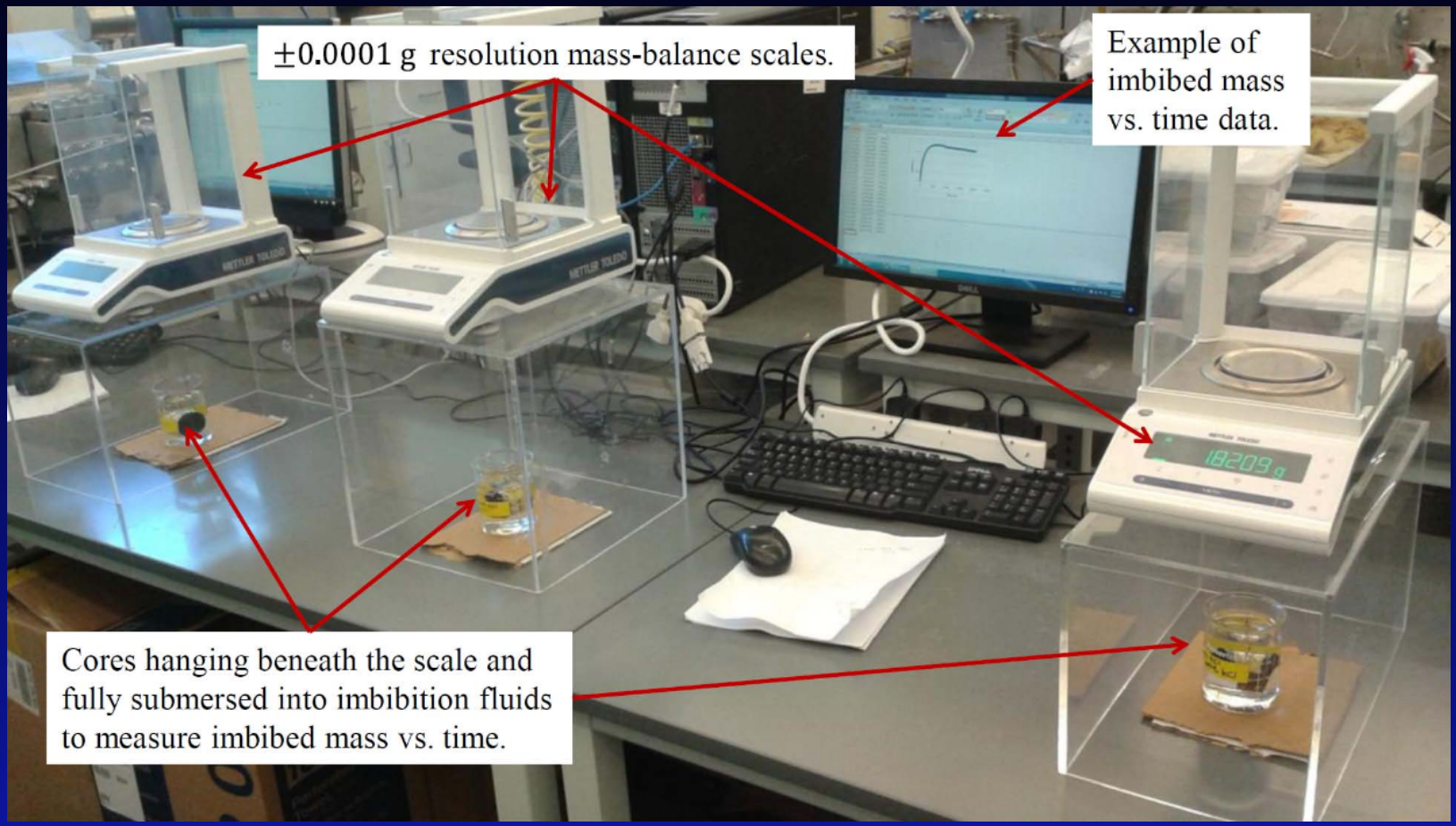
(Cubitt and Wales 2015)

Laboratory Experiments



- Drainage
- Forced Imbibition

Laboratory Experiments



Thank you!
Question?