# Mississippian Permeability vs Porosity

$$k = A \, \nearrow^{3.45}$$



Arnold & Lippoldt Permeability vs. Porosity

Miss. Packstones

Miss. Mudstones

Insitu Klinkenberg Permeability (md)

Insitu Porosity (%)
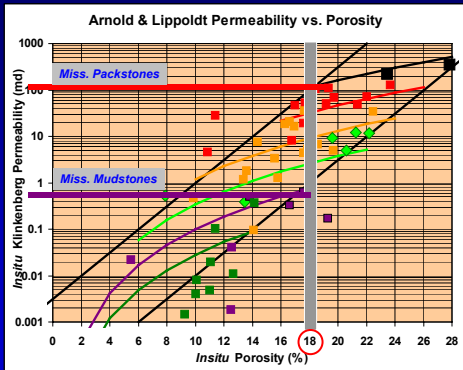
| Lithofacies | A |
|---|---|
| Packstone | 0.00525 |
| Pack-Wackestone | 0.00150 |
| Wackestone | 0.00043 |
| Mud-Wackestone | 0.00012 |
| Mudstone | 0.00004 |
| Shaly Mudstone | 0.00001 |

Curves Dependent on
- $\pm$ 5X
- Lithofacies
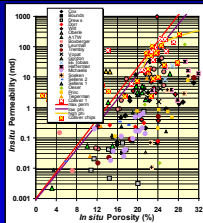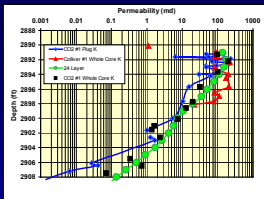- Grain type
  - Echinoderm
  - Sponge spicule
- Moldic content

# L-KC CO2 I#1



Gamma Ray    Neutron-Density Porosity %

Lansing

"B"

"C"

"D"
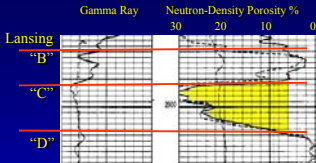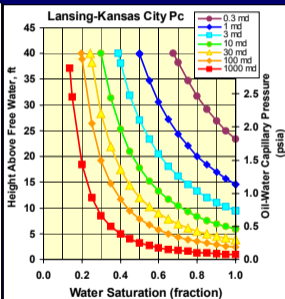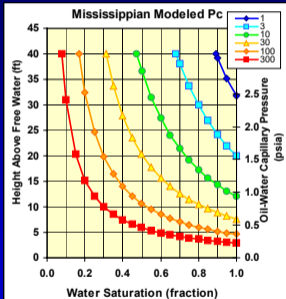
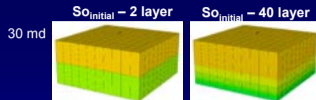$\log k_i = 0.090\ x^2 + 0.47\ MCI - 3.2\quad (SE=5.5x)$

- Permeability also dependent on:
  - depth below unconformity surface
  - location within crossbed set
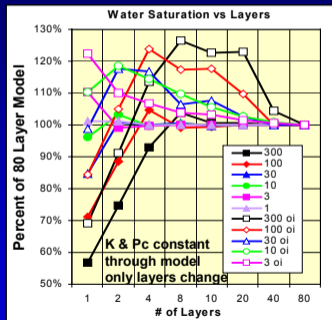- $\log k = -0.157\ D + 0.035\ x^2 + 1.653$

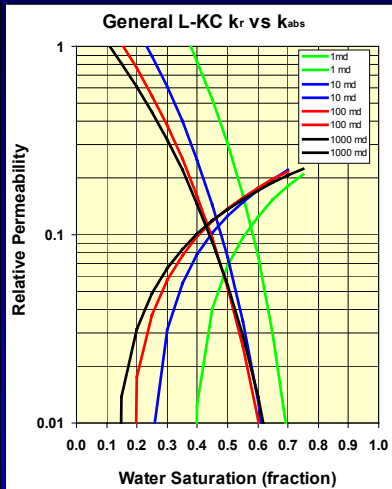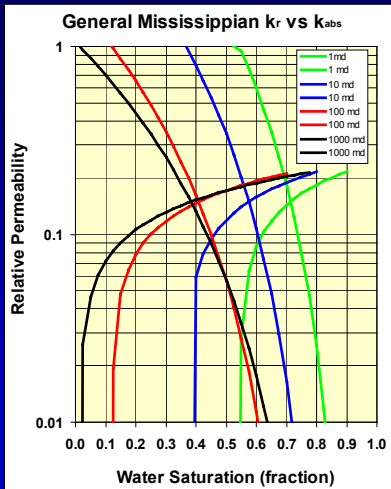## Both L-KC & Miss Sw is sensitive to height and permeability



**Mississippian Modeled Pc**

Legend: 1, 3, 10, 30, 100, 300

X-axis: Water Saturation (fraction), 0.0 to 1.0
Left Y-axis: Height Above Free Water (ft), 0 to 45
Right Y-axis: Oil-Water Capillary Pressure (psia), 0 to 2.5

**Lansing-Kansas City Pc**

Legend: 0.3 md, 1 md, 3 md, 10 md, 30 md, 100 md, 1000 md

X-axis: Water Saturation (fraction), 0.0 to 1.0
Left Y-axis: Height Above Free Water, ft, 0 to 45
Right Y-axis: Oil-Water Capillary Pressure (psia), 0 to 2.5

## Scaling for Capillary Pressure

So$_{initial}$ – 2 layer    So$_{initial}$ – 40 layer

30 md

- Upscaling static Sw is algebra

<u>but</u>

- Upscaling Pc to obtain accurate Sw dependent on layers and Pc curve
- Height of transition zone to total pay interval
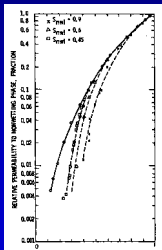- Decoupling Sw and Pc sets up Pc conflict in simulation



**Water Saturation vs Layers**

X-axis: # of Layers, 1 to 80
Y-axis: Percent of 80 Layer Model, 50% to 130%

Legend: 300, 100, 30, 10, 3, 1, 300 oi, 100 oi, 30 oi, 10 oi, 3 oi

K & Pc constant through model only layers change
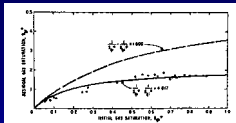
Mississippian

# Kr shifts with absolute permeability

## Kr is dependent on initial oil saturation

$$\frac{1}{S_{nwr}} - \frac{1}{S_{nwi}} = C$$

Land, 1971

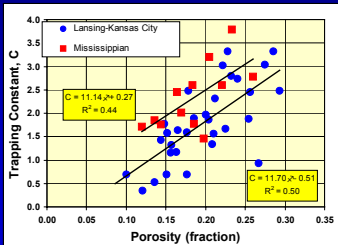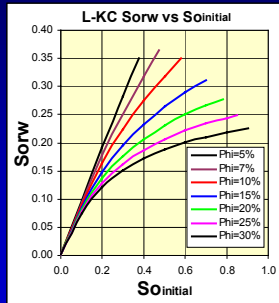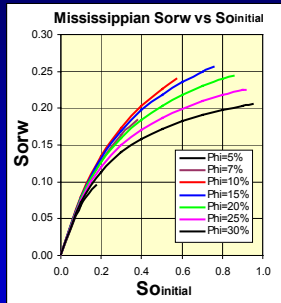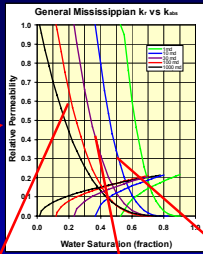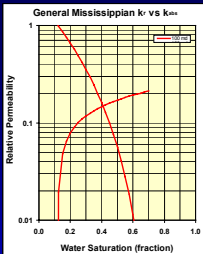Geffen et al, 1951
Osoba et al, 1951
Land, 1971
Killough, 1976
Carlson, 1981
Hiraski, 1995

(Land, 1971)

(Carlson, 1981)

Byrnes & Bhattacharya, ElPaso Hedberg, March 15-18, 2004

$C = 11.14 x^2 + 0.27$
$R^2 = 0.44$

$C = 11.70 x - 0.51$
$R^2 = 0.50$

Trapping Constant, C vs Porosity (fraction)
- Lansing-Kansas City
- Mississippian

## Residual Oil vs C and $S_{oi}$

**Mississippian Sorw vs So initial**
- Phi=5%
- Phi=7%
- Phi=10%
- Phi=15%
- Phi=20%
- Phi=25%
- Phi=30%

**L-KC Sorw vs So initial**
- Phi=5%
- Phi=7%
- Phi=10%
- Phi=15%
- Phi=20%
- Phi=25%
- Phi=30%

Byrnes & Bhattacharya, ElPaso Hedberg, March 15-18, 2004

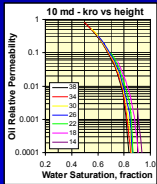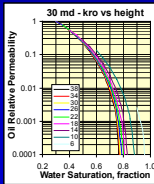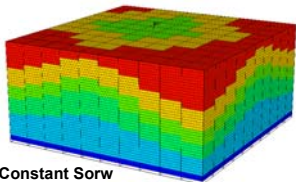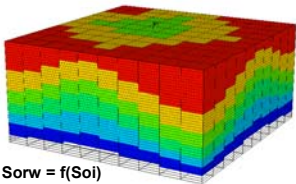**Kr Family Tree**

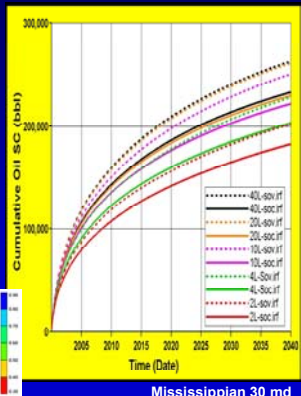kr = f(k_abs)

**Simple kr**

kr = f(k_abs, S_oi)
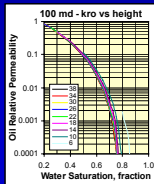
# Simulation Results



Constant Sorw

Sorw = f(Soi)

Mississippian 30 md