# Understanding Mississippi Dolomite Reservoirs in Central Kansas

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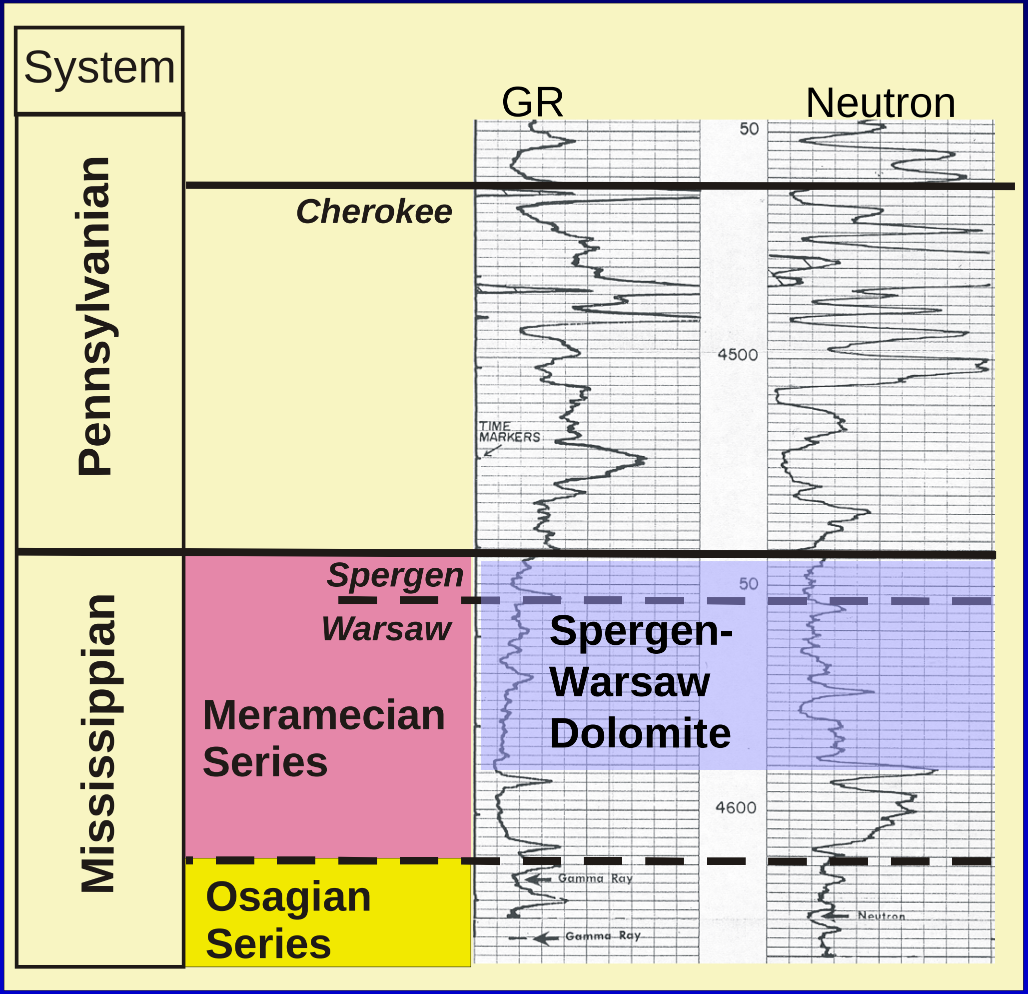
***We wish to acknowledge support by U.S. Department of Energy and Mull Drilling Company, Inc.***

***Kansas Geological Society Meeting, November 20, 2003***

# Focus on Facies in Dolomites




23-16S-26W, Ness Co.

**HIGHLIGHTS**

- Petrophysical properties are facies dependent (original texture)
- Identifying facies critical to reservoir modeling and understanding
- Logs and sample descriptions are enablers
- Understanding leads to more effective exploitation

***Note: Facies as used in this paper is the original facies, prior to dolomitization.***

# Significant Challenges

## PROBLEMS

1. Limited amount of core
2. Relatively few deep penetrations hinders correlations
3. Diagenetic overprint

   **Early dissolution and extensive dolomitization**

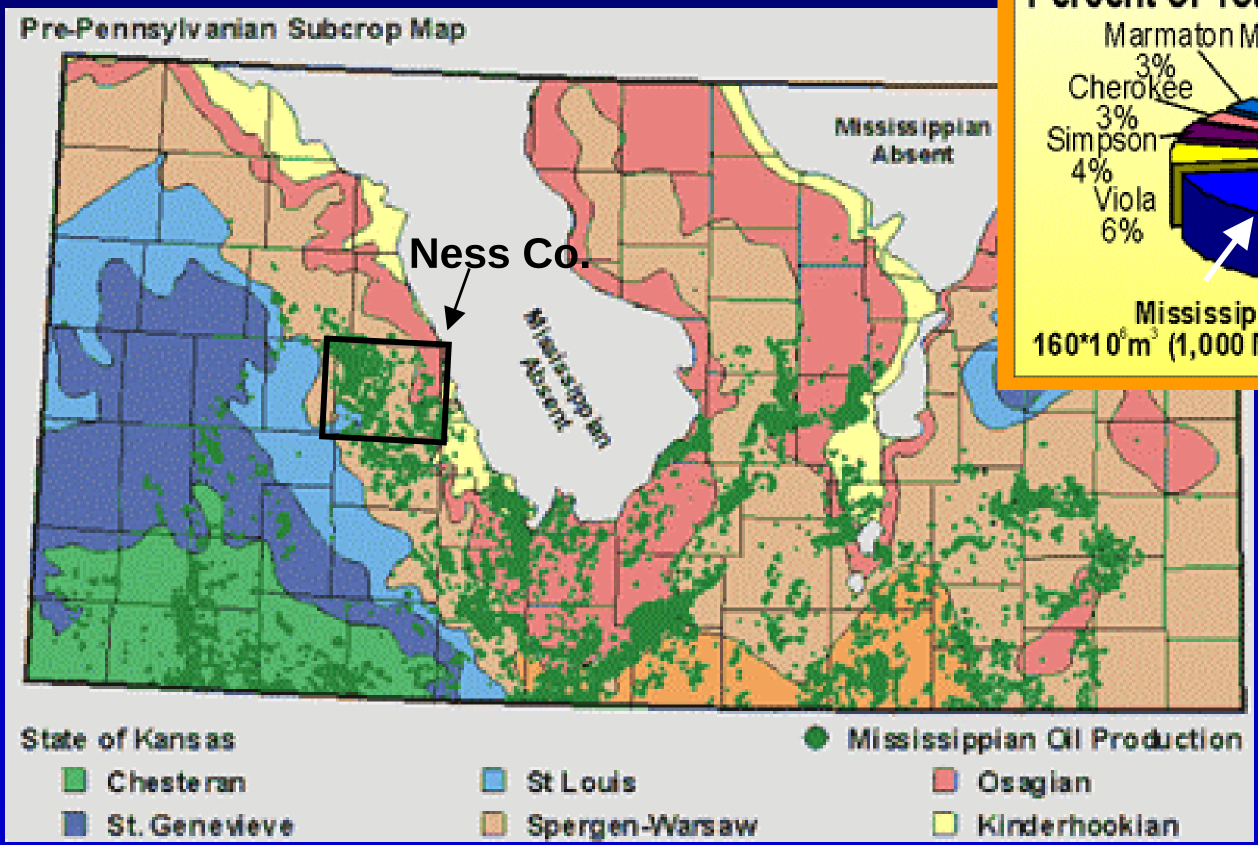
   **Micro and macro scale karst**

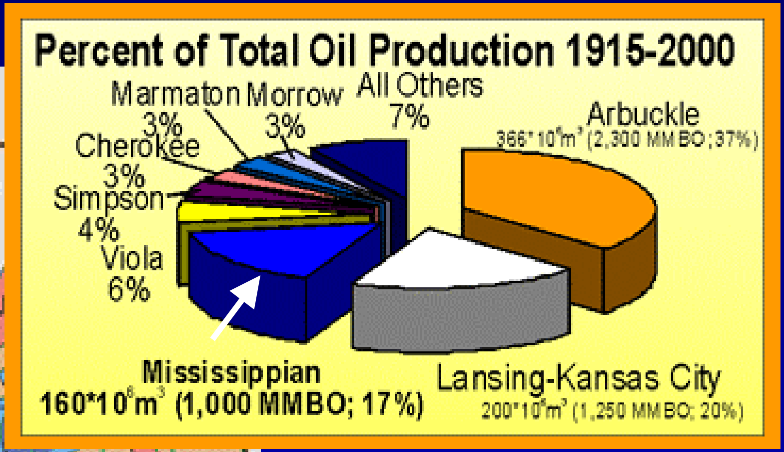
4. Erosional truncation (angular unconformity)

## TOOLS

1. Leverage available core
2. Sample descriptions (well cuttings)
3. By understanding relationships of primary facies, petrophysical properties and log response patterns one can better determine facies from limited data

# Mississippi Dolomite: an Important Kansas reservoir




**From Mississippi**

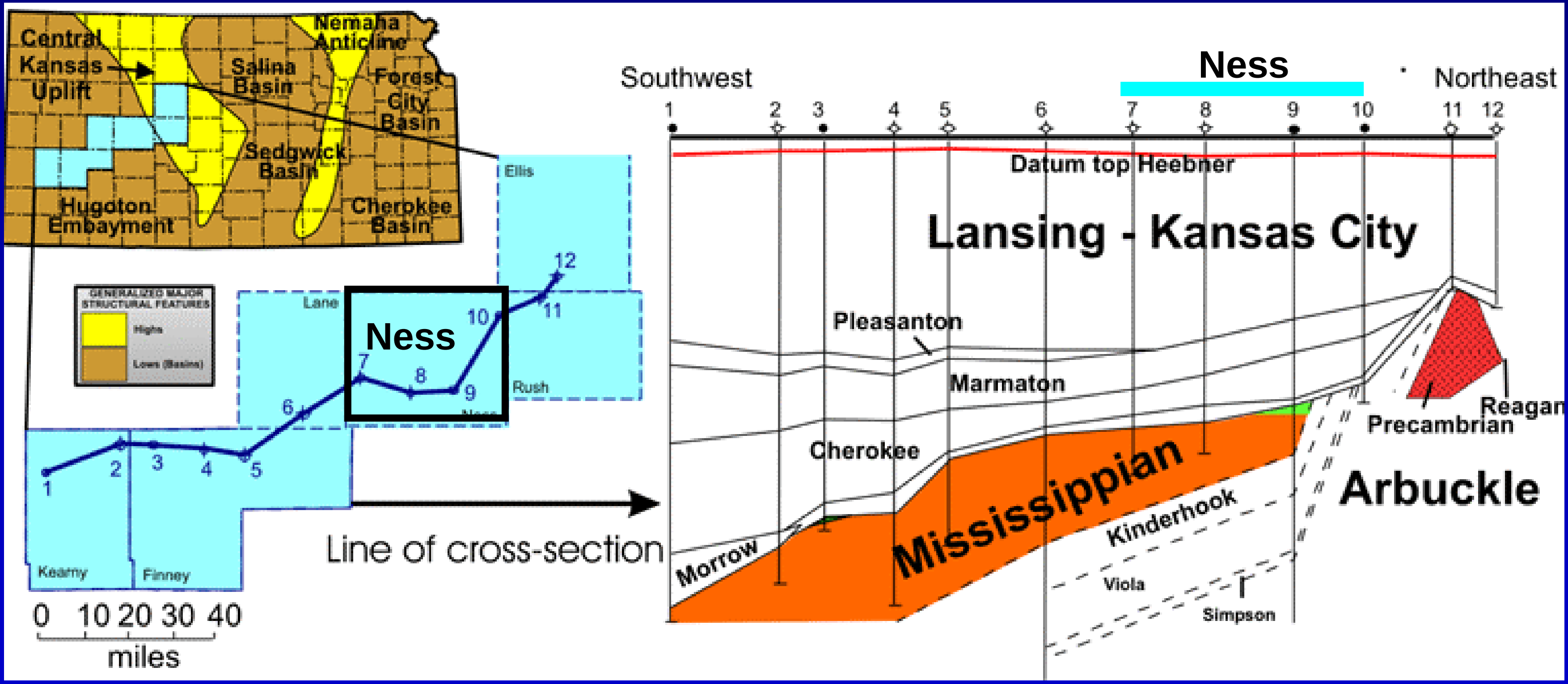
- **1 Billion BO Cum.**
- **33% of Current**

*Gerlach, 1998*

Pre-Penn. Subcrop Map of Kansas

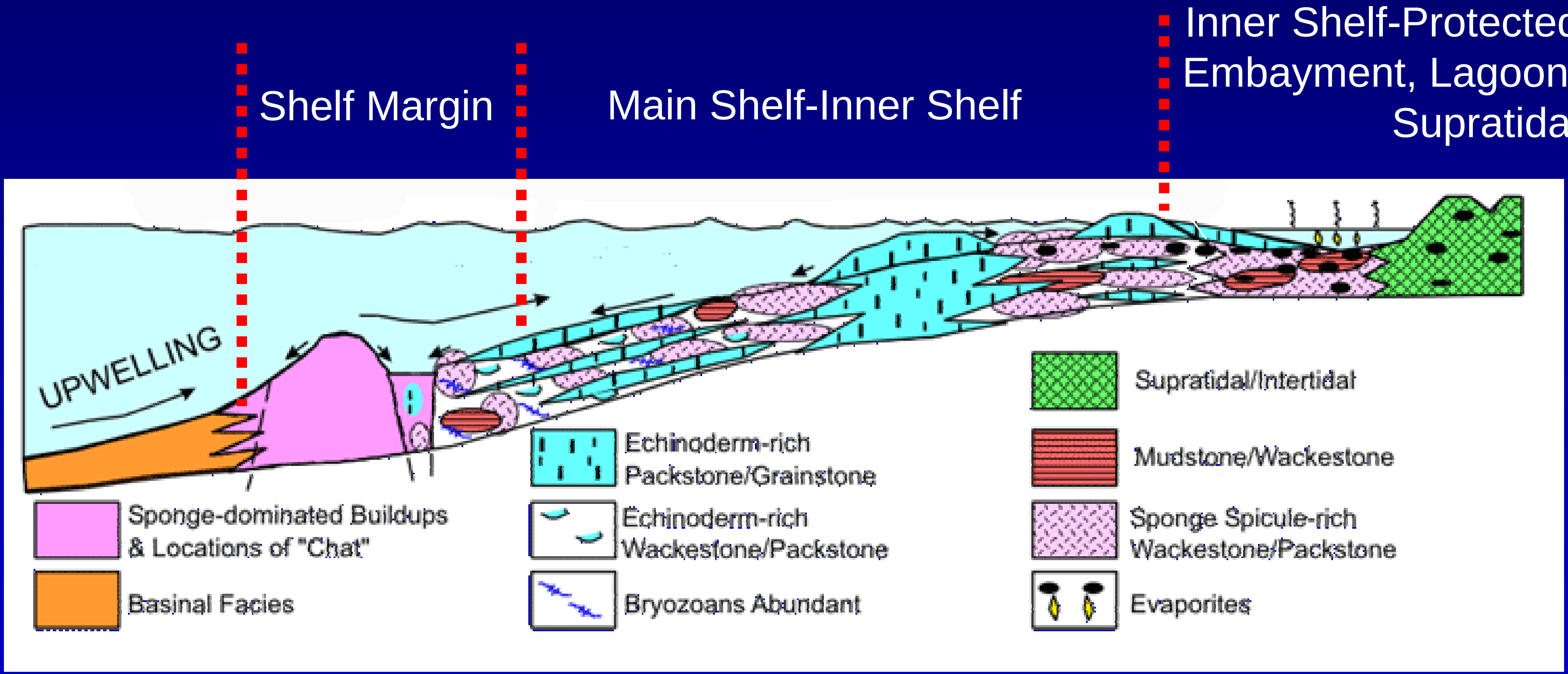
*Miss Oil Production in Green*

# Structural and Subcrop Setting




*Modified after Gerlach, etal, 1998*

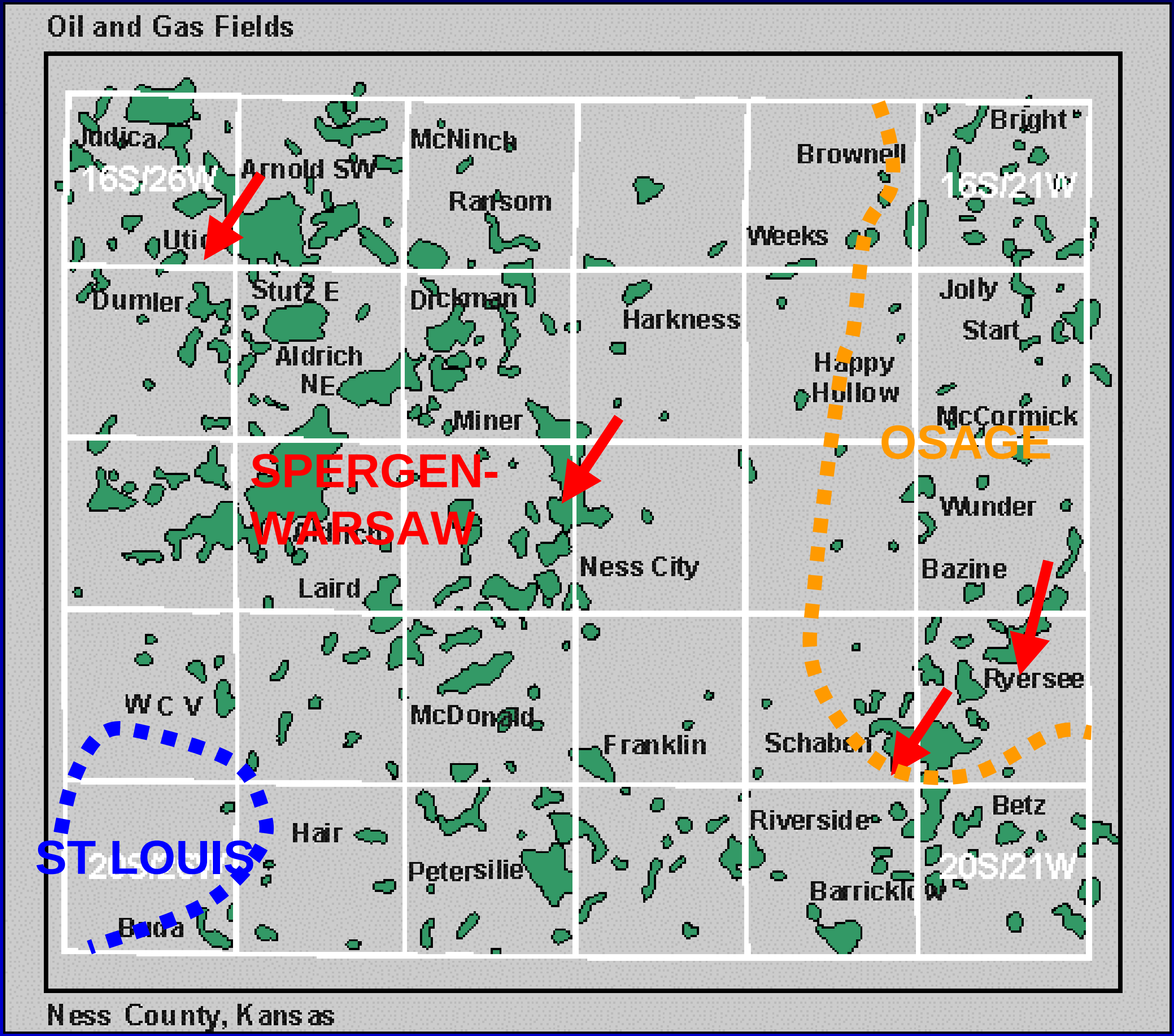
# Lower Mississippi Ramp Depositional Environments




Byrnes, **Franseen**, Watney and Dubois, 2003

http://www.kgs.ku.edu/PRS/publication/2003/ofr2003-32/index.html

Osagean depositional facies model. Spergen-Warsaw similar except for having less sponge and evaporite.




# Ness County Study Area

▪▪▪▪▪▪ **Approx. subcrop limit**

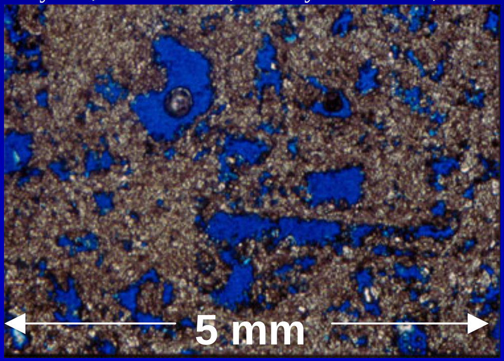
**Primary Core Data**

# Facies and Petrophysical Properties

- Original Facies (primary texture and grain size) control pore geometry
- Pore geometry determines pore throat size which in turn controls permeability and capillary pressure relationships

***FOR A SET OF ROCKS OF DIFFERING ORIGINAL FACIES BUT HAVING SAME POROSITY***

Byrnes, **Franseen**, Watney and Dubois, 2003




Those with larger grains (and less mud), generally have larger pores, larger pore throats, lower threshold pressures for saturating the rock with oil and higher oil saturations for a given height above free water

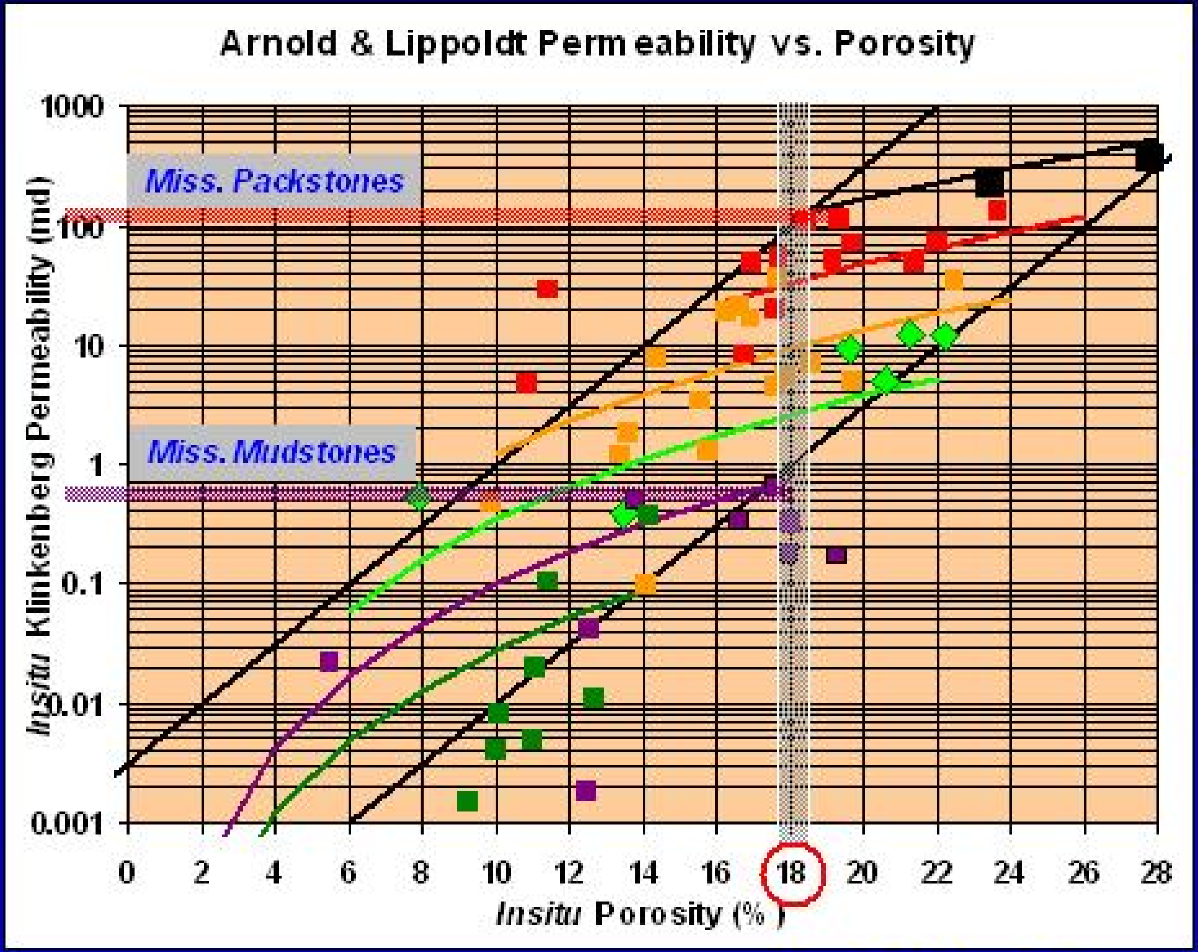




***(Original texture (pre-dolomitzation) indicated)***

# Permeability vs Porosity

$k=A*phi^{3.45}$



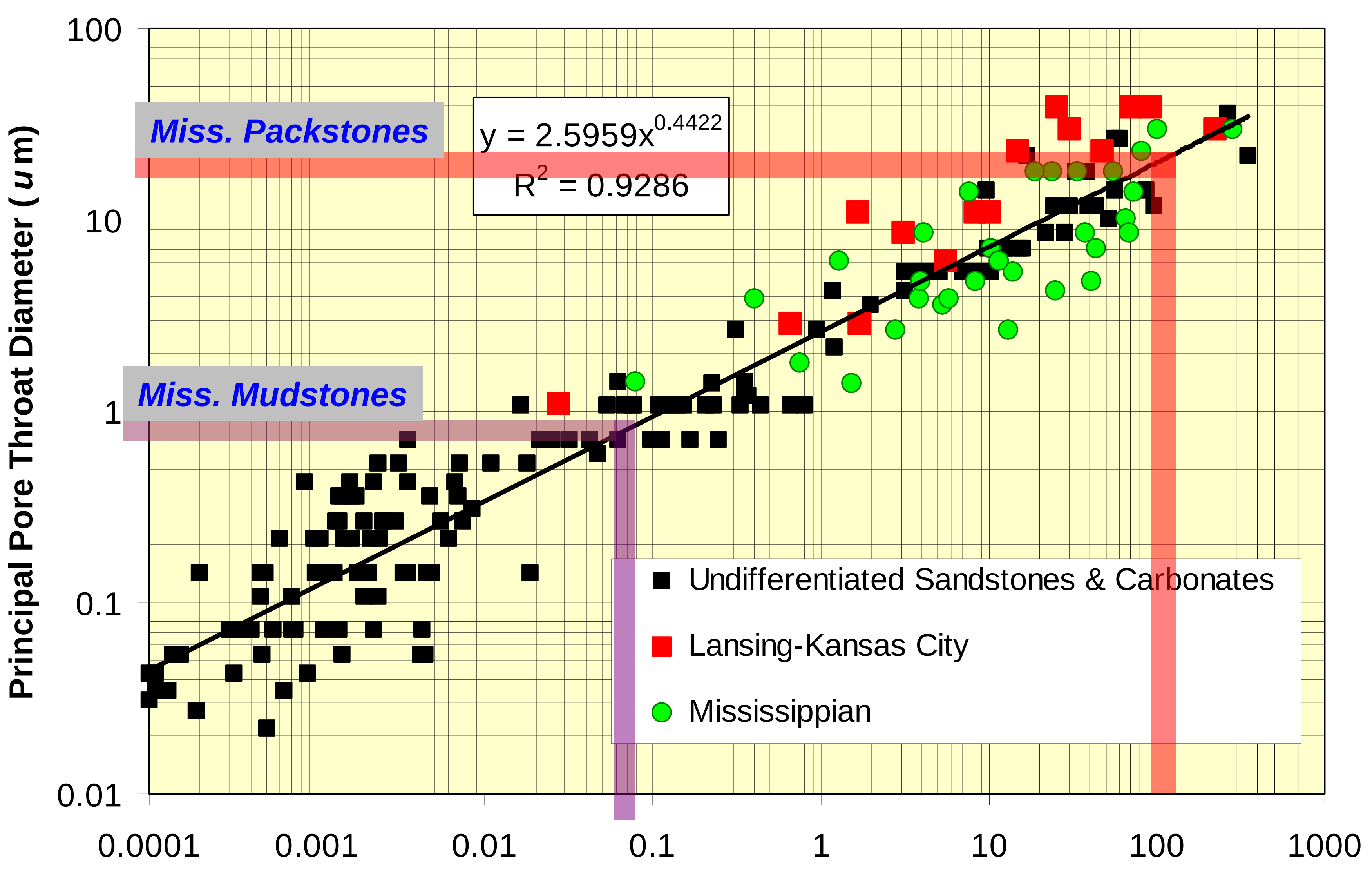

| Lithofacies | A |
|---|---|
| Packstone | 0.00525 |
| Pack-Wackestone | 0.00150 |
| Wackestone | 0.00043 |
| Mud-Wackestone | 0.00012 |
| Mudstone | 0.00004 |
| Shaly Mudstone | 0.00001 |
| | |
| multiplier | 3.5 |

Work of Alan Byrnes

Curves Dependent on

- ± 5X
- Lithofacies
- Grain type
  - –Echinoderm
  - –Sponge spicule
- Moldic content

# Permeability vs Pore Throat Diameter

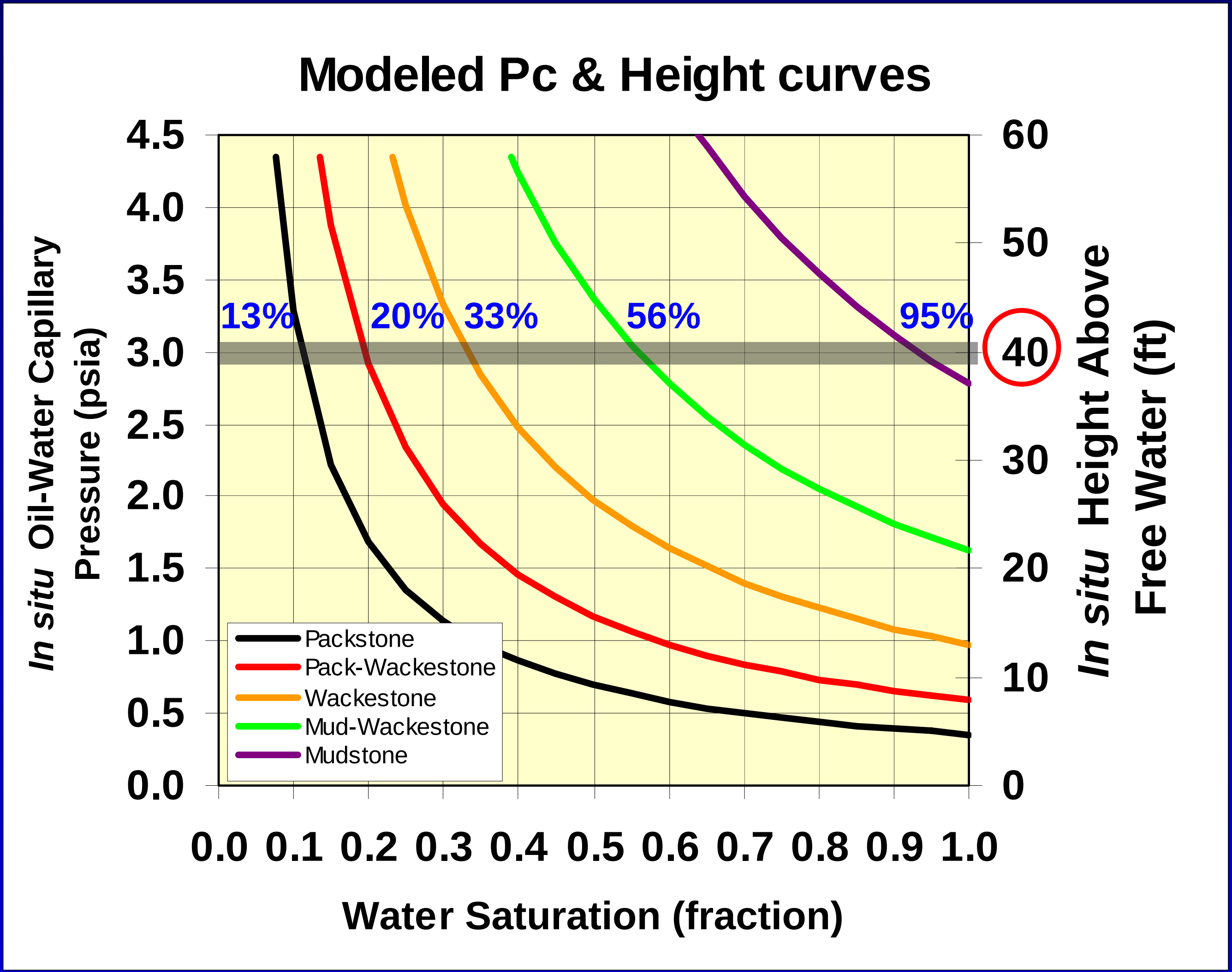



*Work of Alan Byrnes*



(Byrnes et al, 2003)

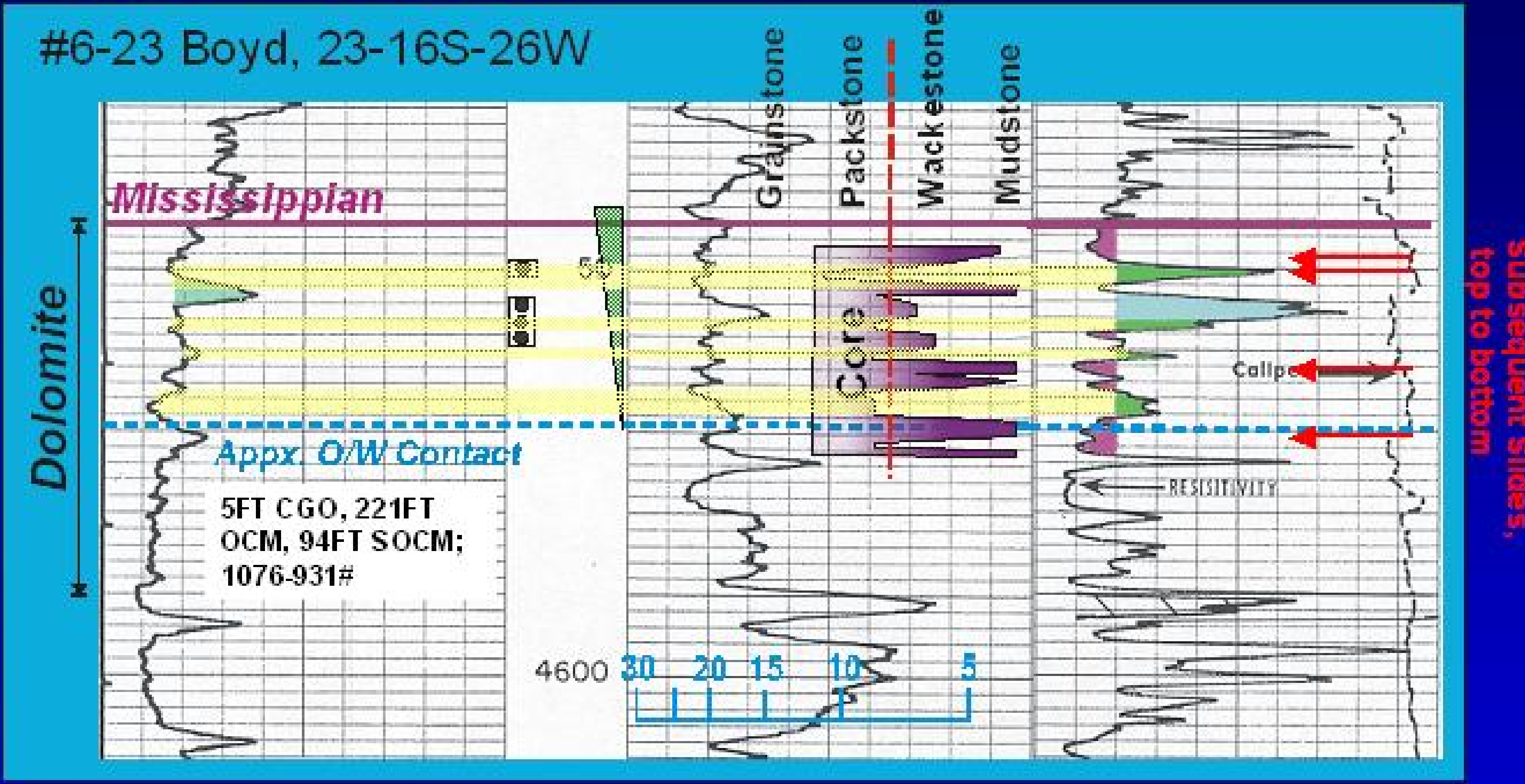
# Capillary Pressure vs Lithofacies
# (Example for porosity = 18%)






*Work of Alan Byrnes*

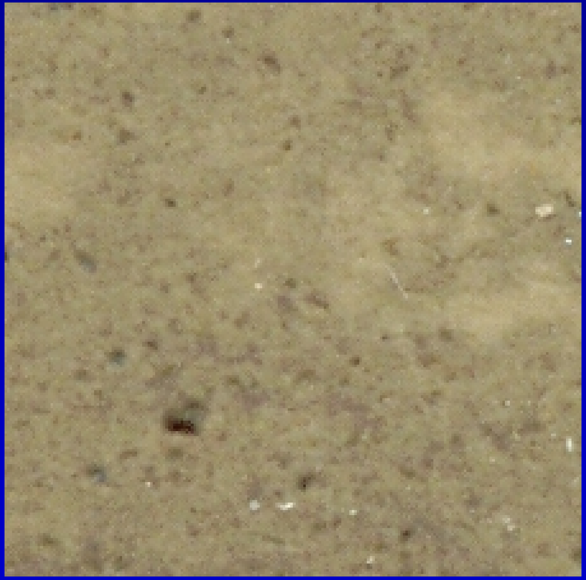
# Core Facies to Log Curve Patterns



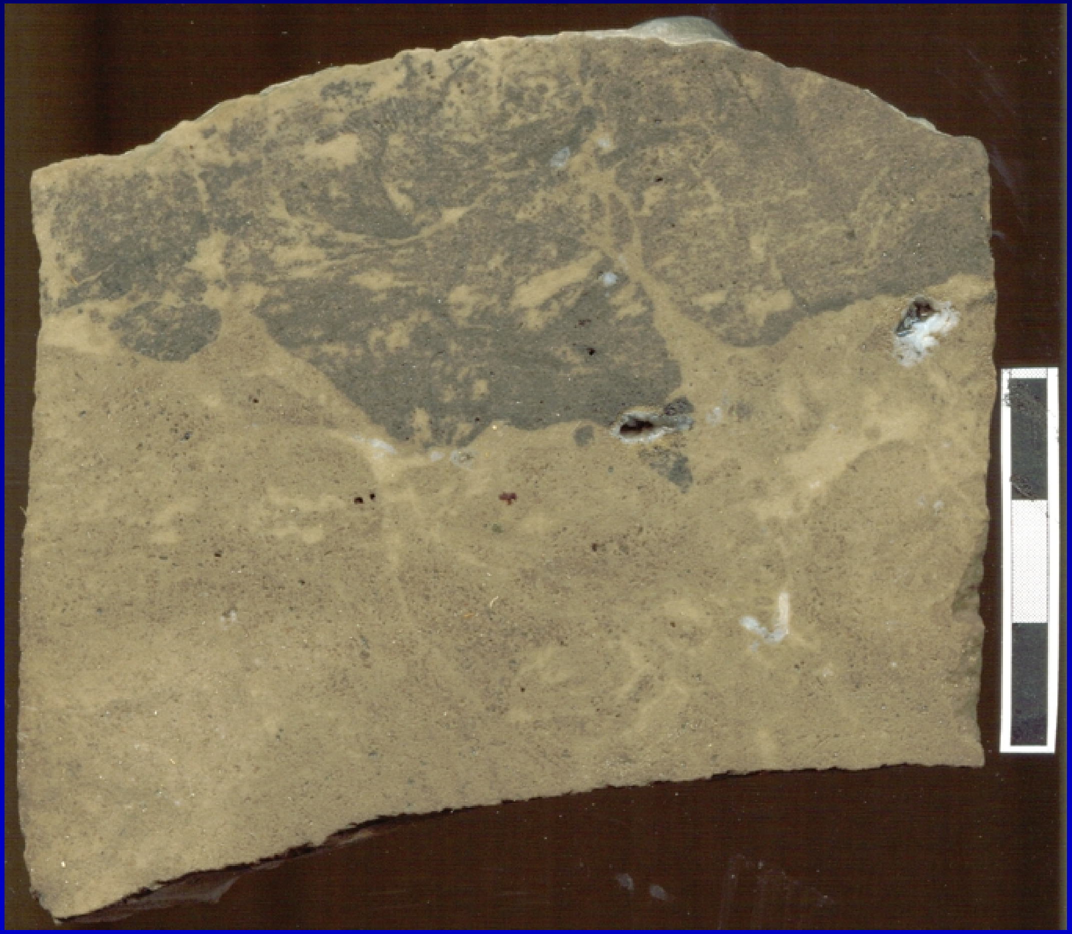

# Mudstone-Wackestone

**4548 (log)**

| | |
|---|---|
| **Phi** | **20.6 %** |
| **Perm** | **5.05 md** |
| **Dens** | **2.84 g/cc** |
| **Sw %** | **63% (log)** |



**← 1 cm →**



# Packstone-Grainstone

**4551 (log)**

| | |
|---|---|
| **Phi** | **27.9%** |
| **Perm** | **350.7 md** |
| **Dens** | **2.84 g/cc** |
| **Sw %** | **29% (log)** |

← **1 cm** →

# Mudstone

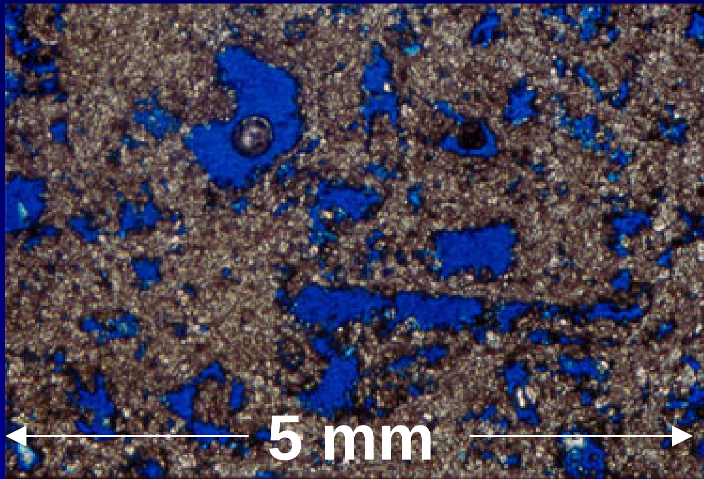
**4561 (log)**

| | |
|---|---|
| **Phi** | **17.6%** |
| **Perm** | **0.7 md** |
| **Dens** | **2.81 g/cc** |
| **Sw %** | **78% (log)** |

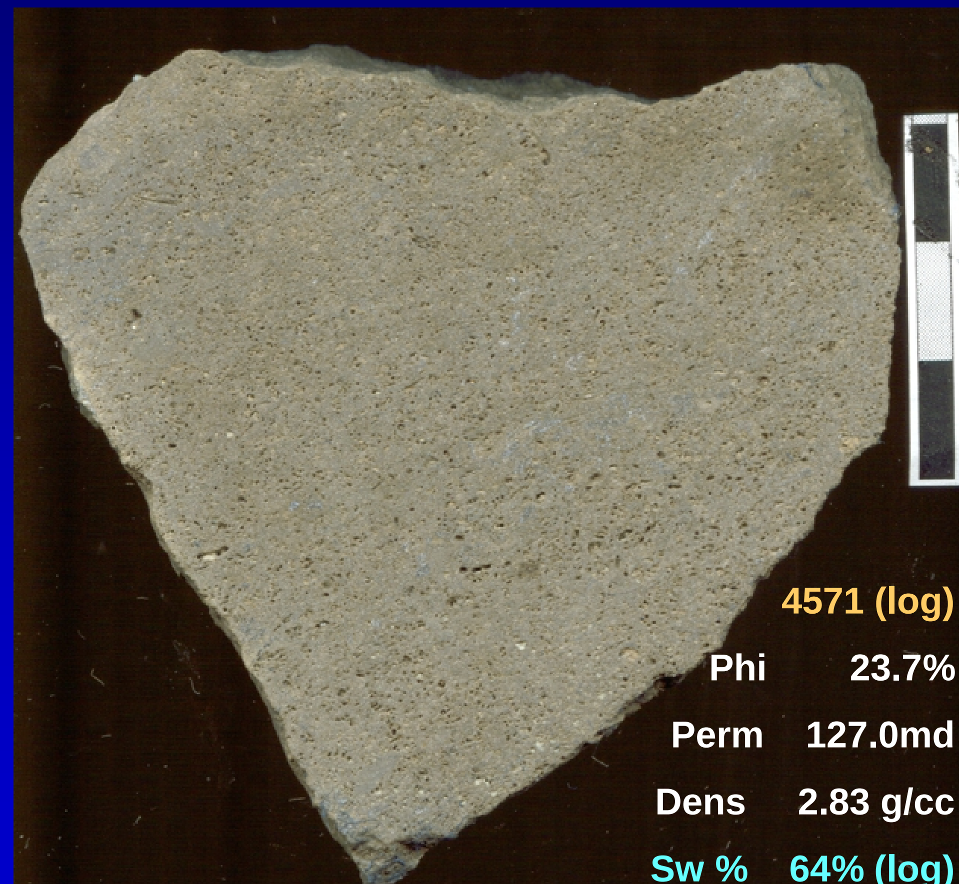
**← 1 cm →**

Byrnes, **Franseen**, Watney and Dubois, 2003

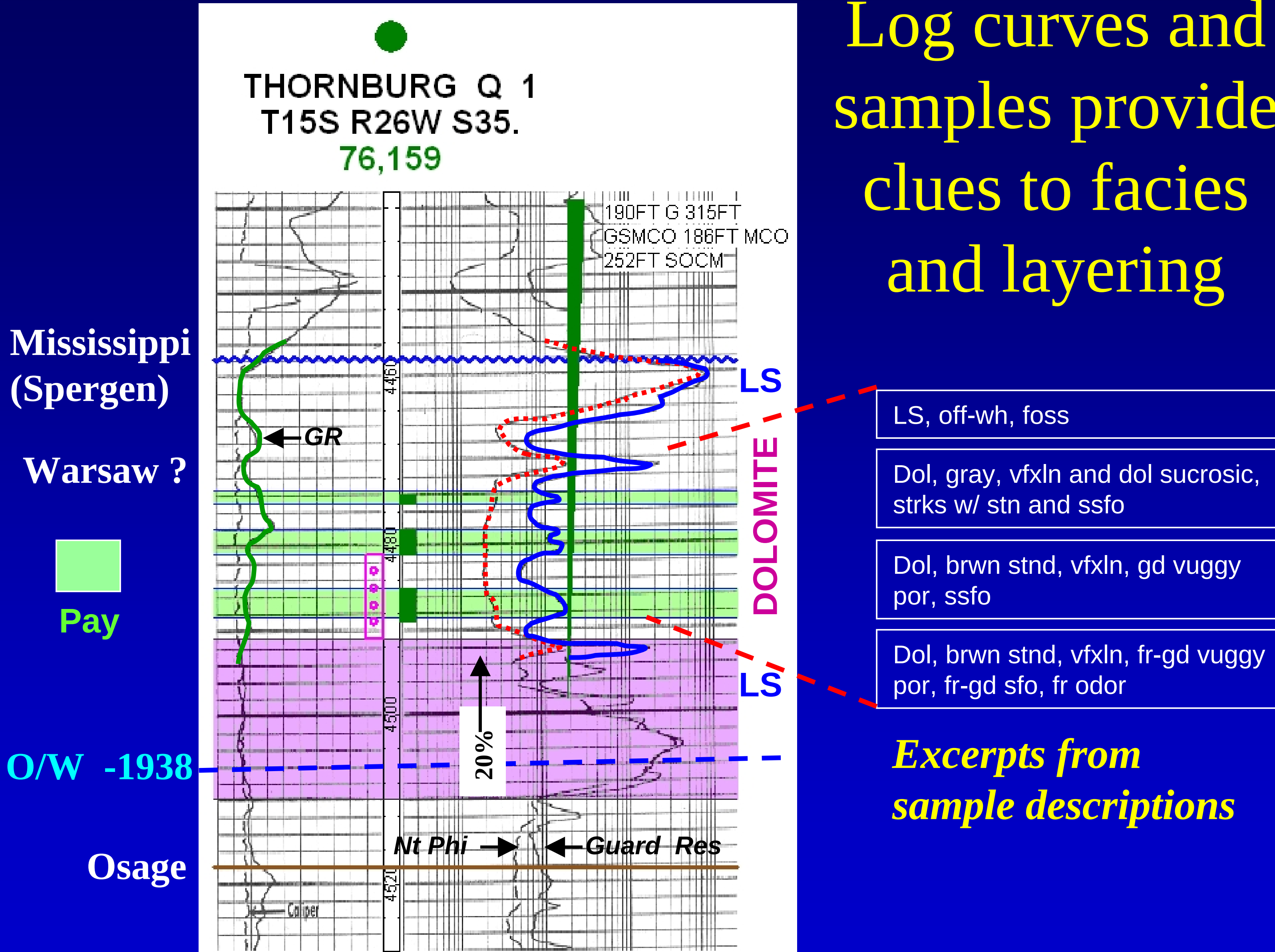
# Packstone-Wackestone




(Representative sample. Not  from this core.)

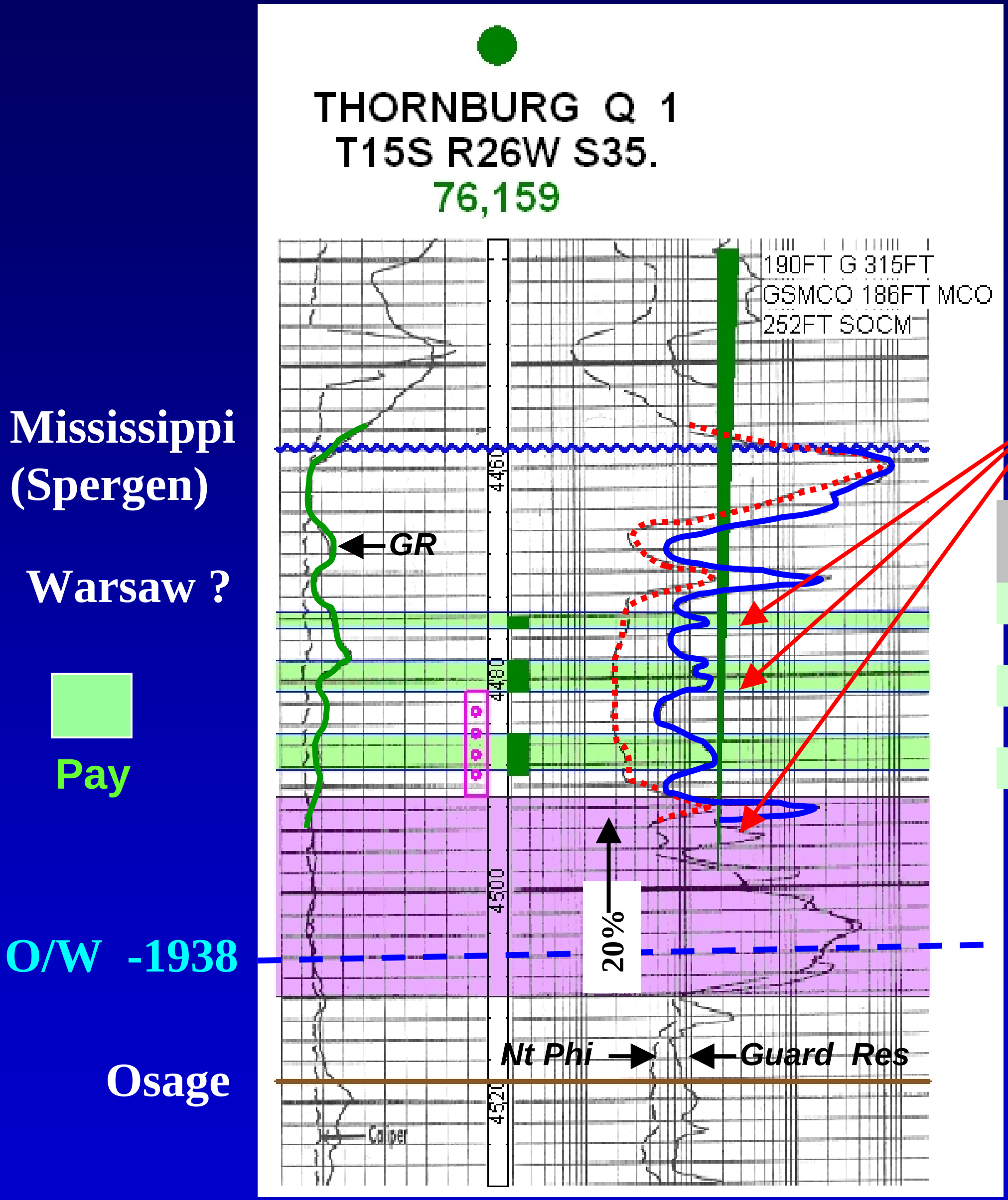



# Log curves and samples provide clues to facies and layering




***Excerpts from sample descriptions***

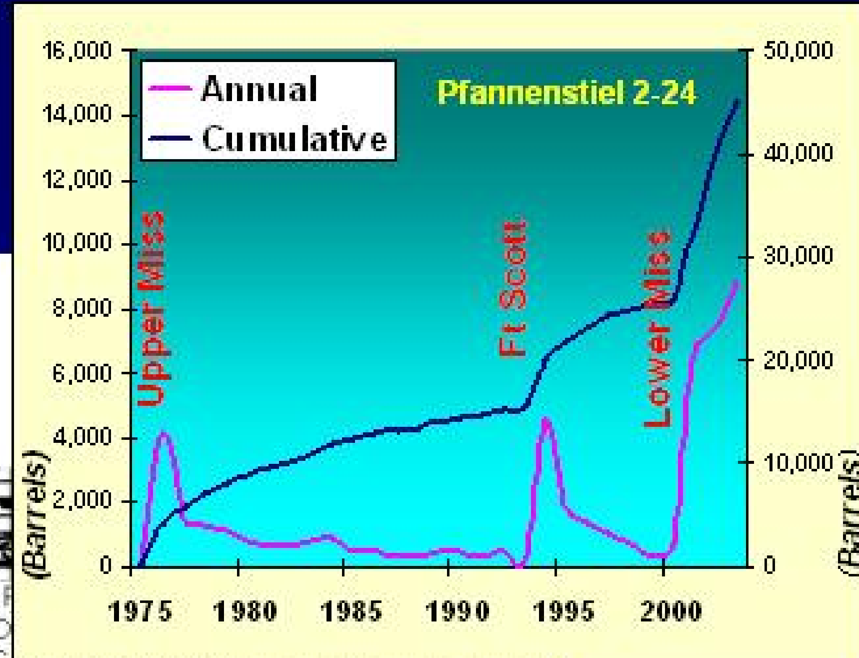
# Sw calculations consistent with interpreted facies

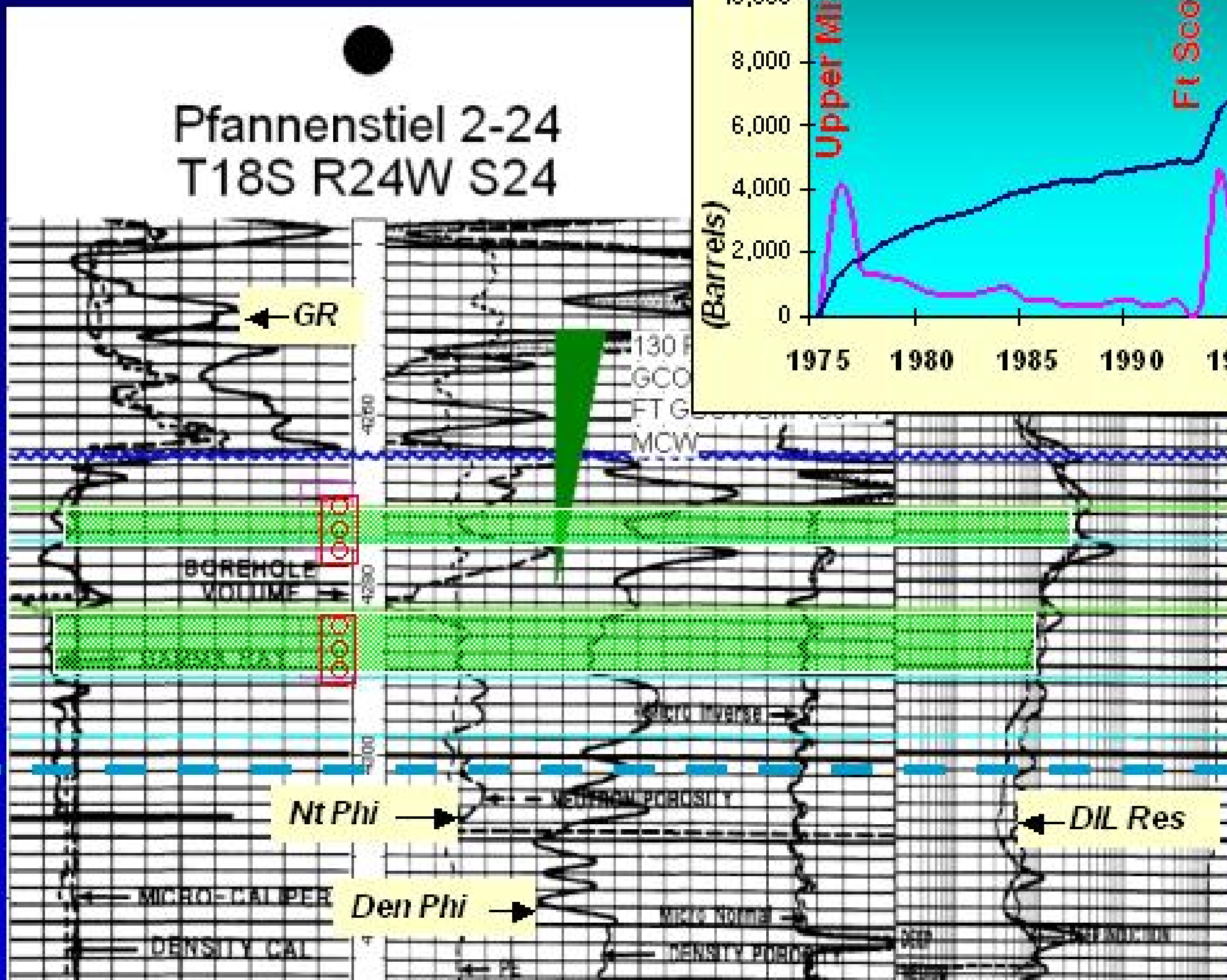



| Probable Facies | Phi | Rt | Archie SW |
|---|---|---|---|
| Wk-Pkst | 0.18 | 17 | 0.467 |
| Mudstone | 0.19 | 7 | 0.689 |
| Wk-Pkst | 0.2 | 15 | 0.447 |
| Mudstone | 0.2 | 5 | 0.775 |
| Packstone | 0.19 | 18 | 0.430 |

*Rw = 0.12*
*m & n = 2*

# Bypassed pay in Pfannenstiel 2-24




Mississippi (Spergen)

1975 perfs

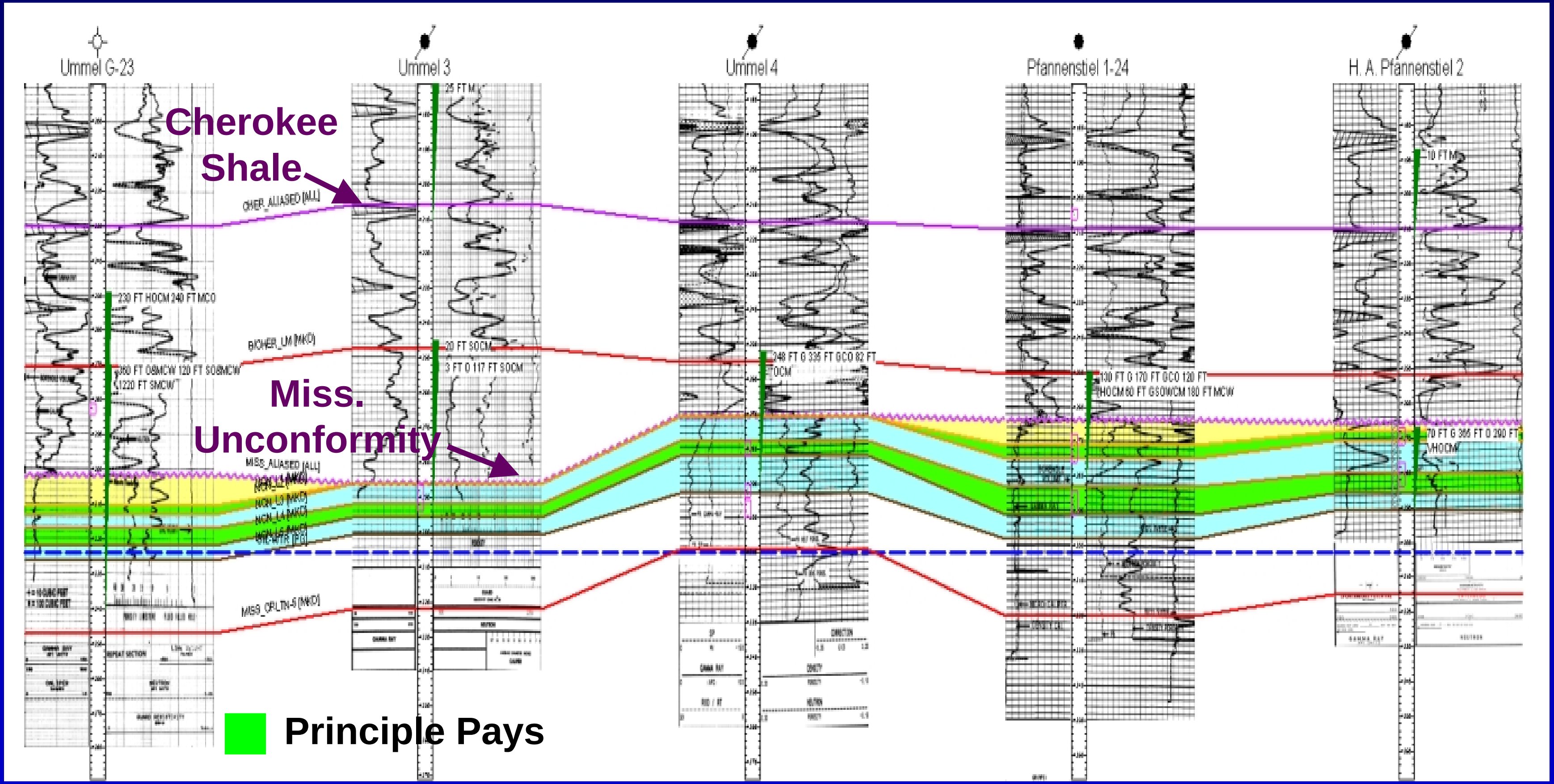
Warsaw ?

2001 perfs

O/W

Pay

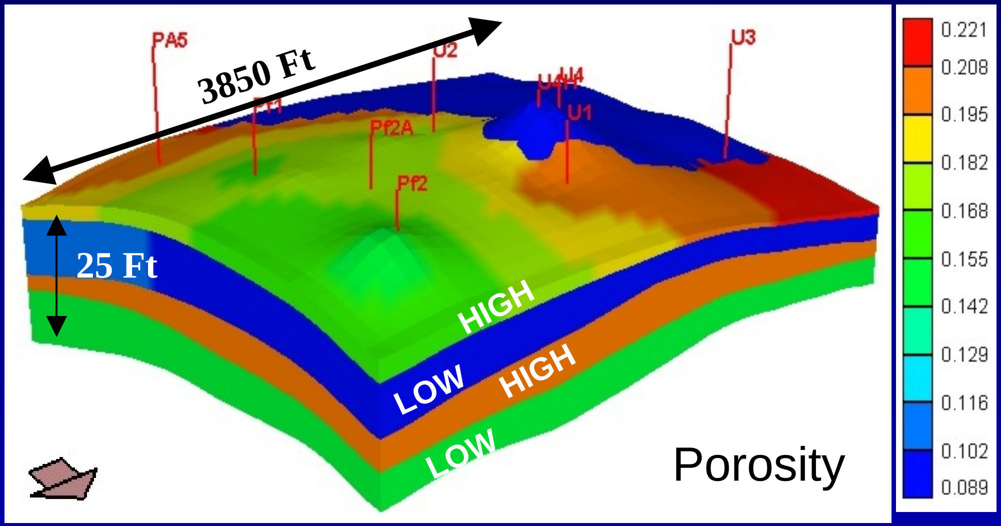
# Ness City North 4-Layer Model




**West** **East**

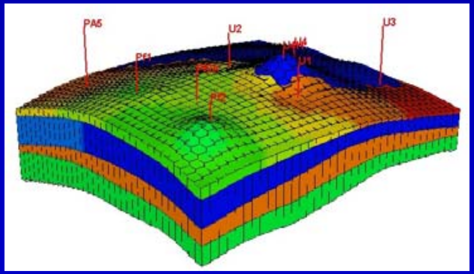
Recognition of log responses to facies enables correlations for more effective geomodels and simulations.

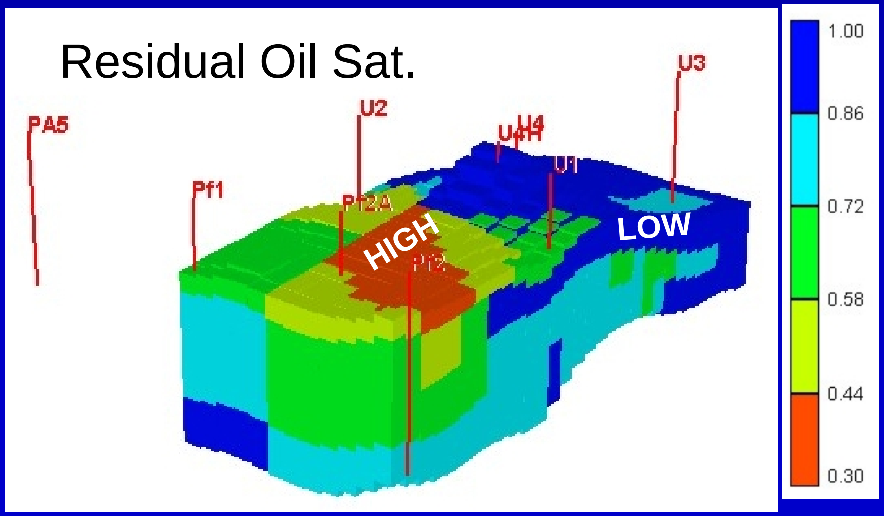
# Ness City North Cellular Models




Facies recognition is critical to reservoir characterization, geomodeling and reservoir simulation.

**4-Layer Model, 110 foot grid cells**





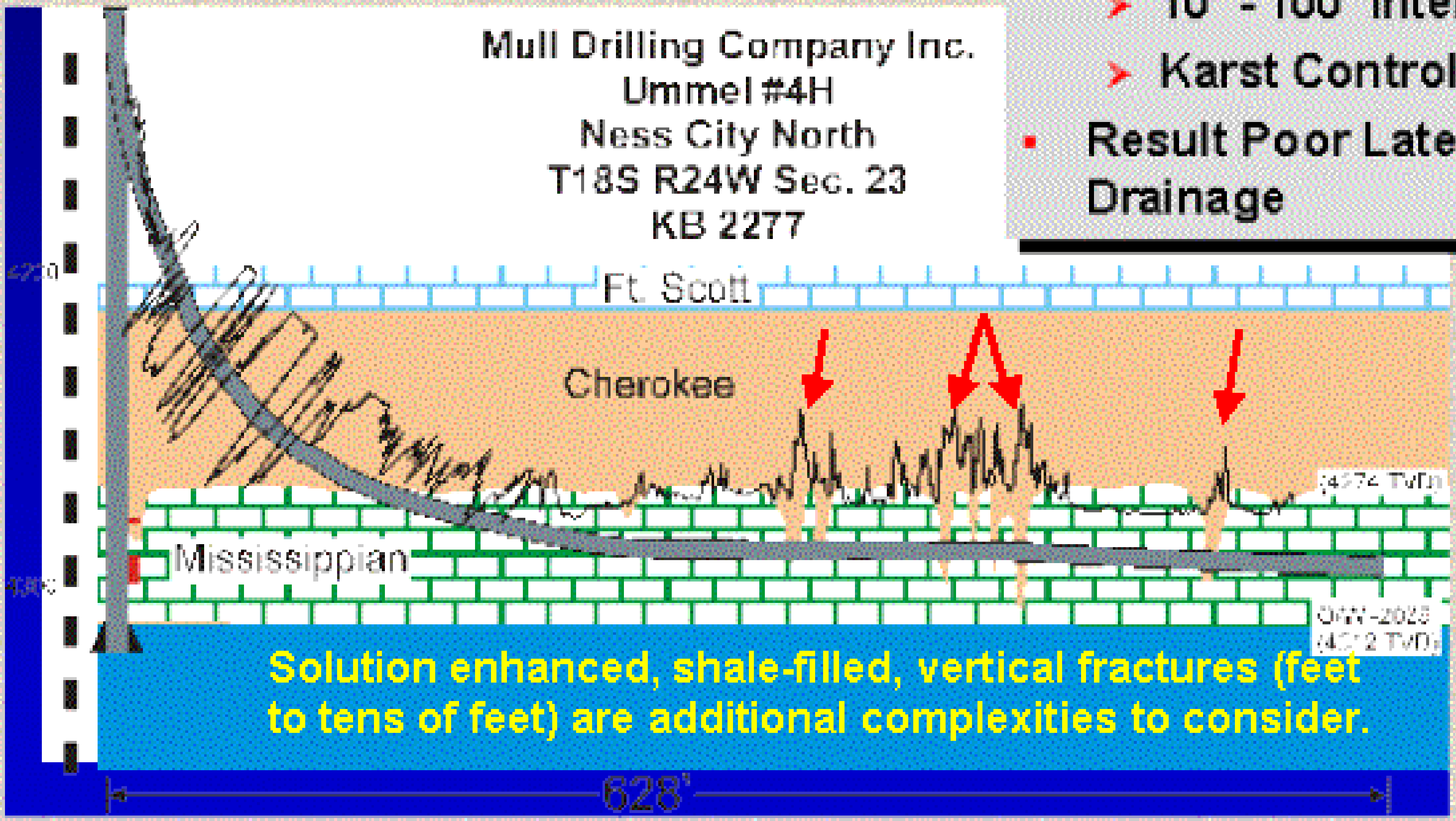

***Work of Saibal Bhattacharya***

# Reservoir Heterogeneity

Carr, Gerlach, Bhattacharya, Pancake, 2001

http://www.kgs.ku.edu/Class2/Tulsa/sld001.htm

- Strong Horizontal Heterogeneity
  - 10' - 100' Interval
  - Karst Controlled
- Result Poor Lateral Drainage



# Concluding Remarks on Mississippi Dolomites, Central Kansas

- Understanding finer scale facies geometries of reservoir units is desirable and possible
- Facies (original texture) and rock properties are intrinsically linked
- Electric log curve patterns aid facies recognition especially when augmented with cuttings descriptions
- Better facies models enables more effective exploitation of Mississippian Dolomite reservoirs

We wish to acknowledge support by U.S. Department of Energy and Mull Drilling Company, Inc. and we thank other "Mississippi scientists", Lynn Watney, Tim Carr, Evan Franseen and Paul Gerlach, from whom we borrowed heavily.