

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.*

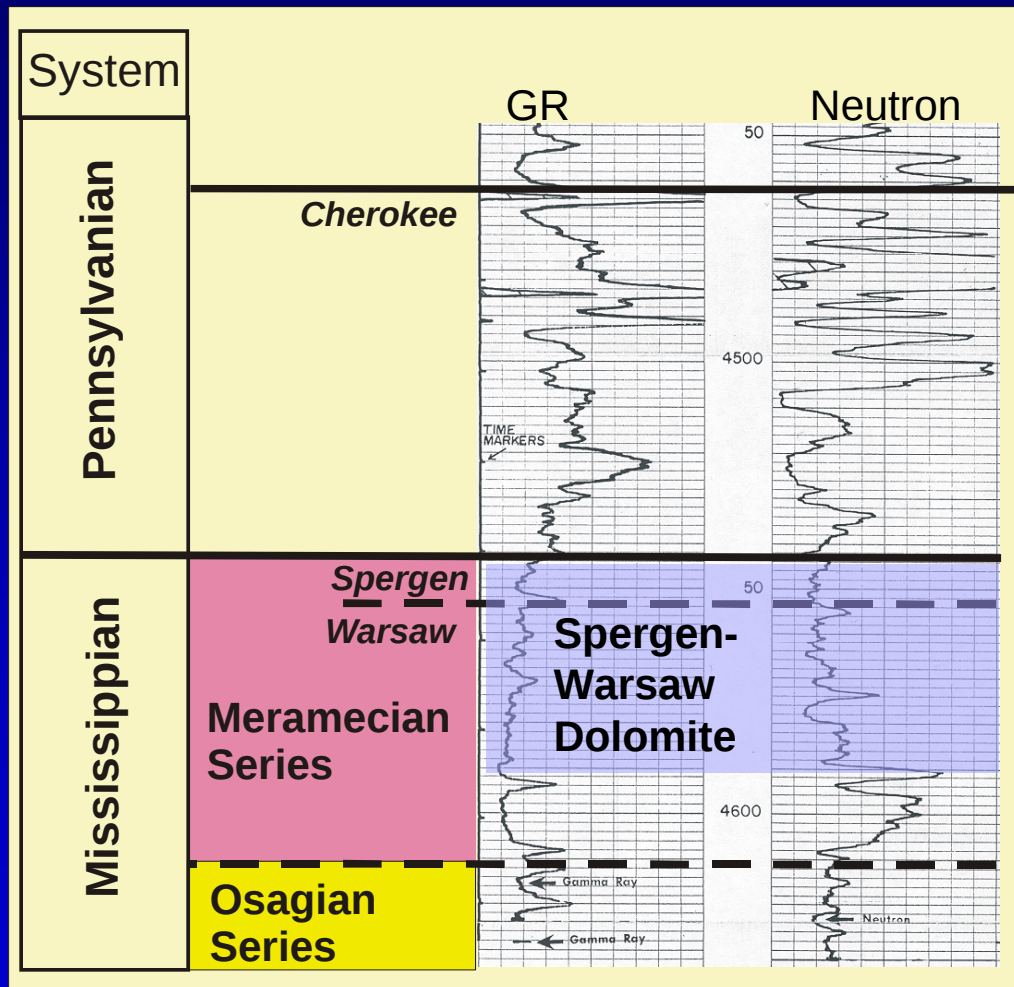


Kansas Geological Society Meeting, November 20, 2003

Focus on Facies in Dolomites

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

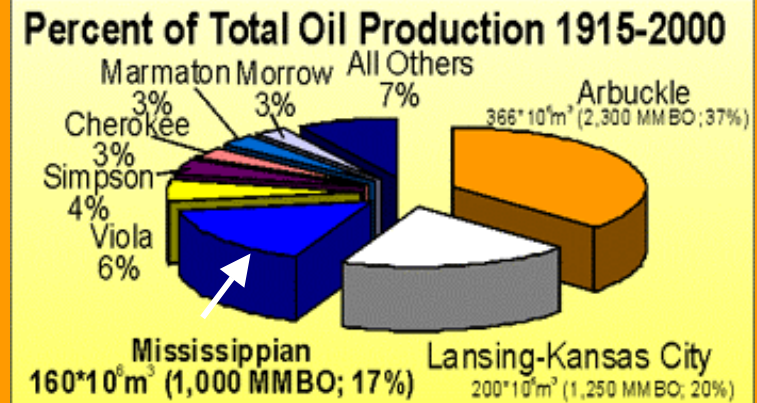
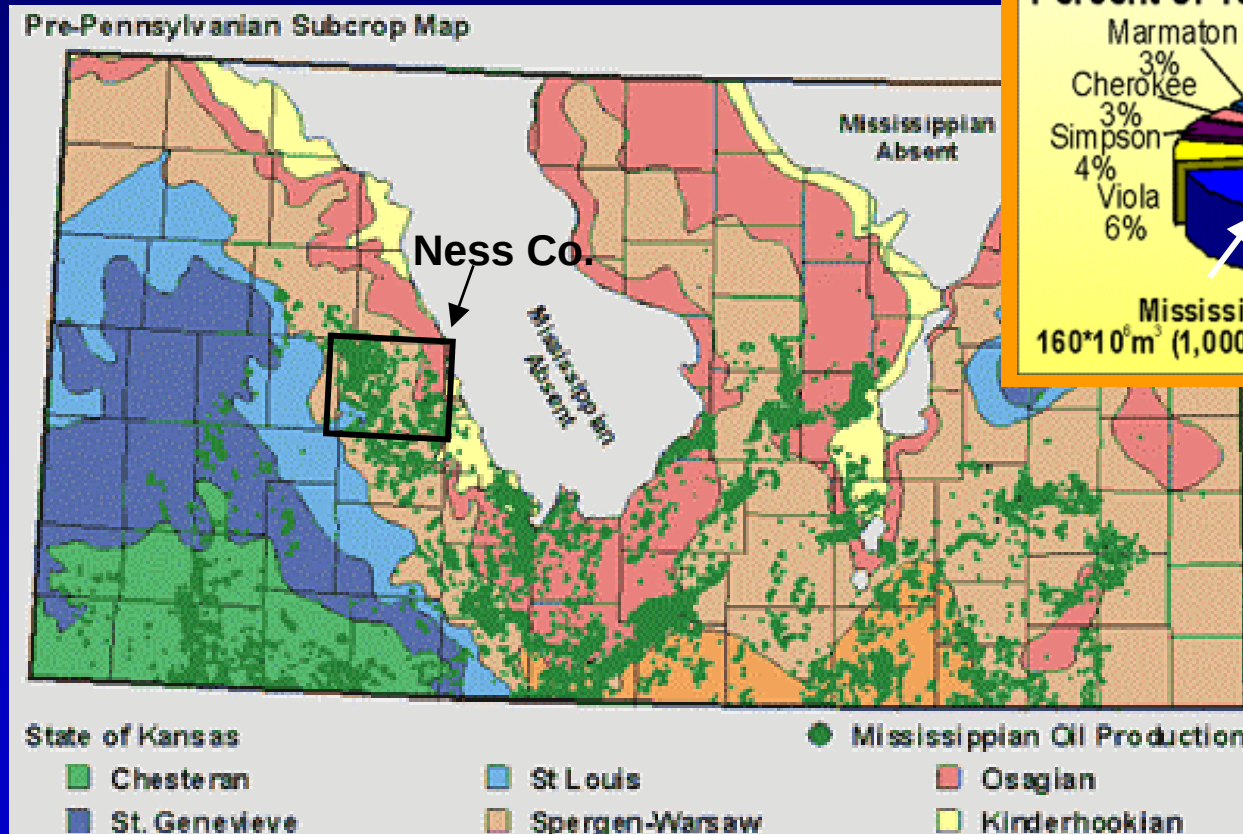
1. Limited amount of core
2. Relatively few deep penetrations hinders correlations
3. Diagenetic overprint
 - Early dissolution and extensive dolomitization**
 - Micro and macro scale karst**
4. Erosional truncation (angular unconformity)

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

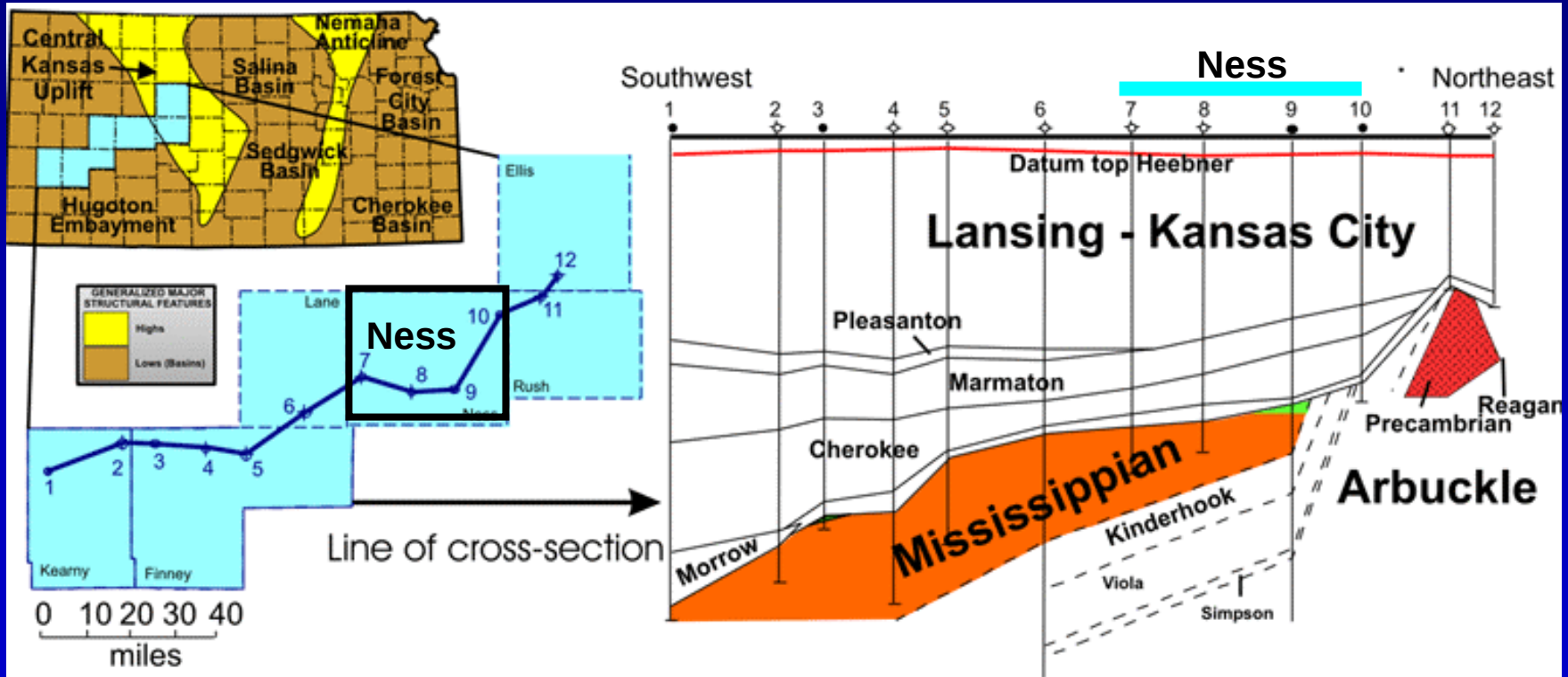
- 1 Billion BO Cum.
- 33% of Current

Gerlach, 1998

Pre-Penn. Subcrop Map of Kansas
Miss Oil Production in Green



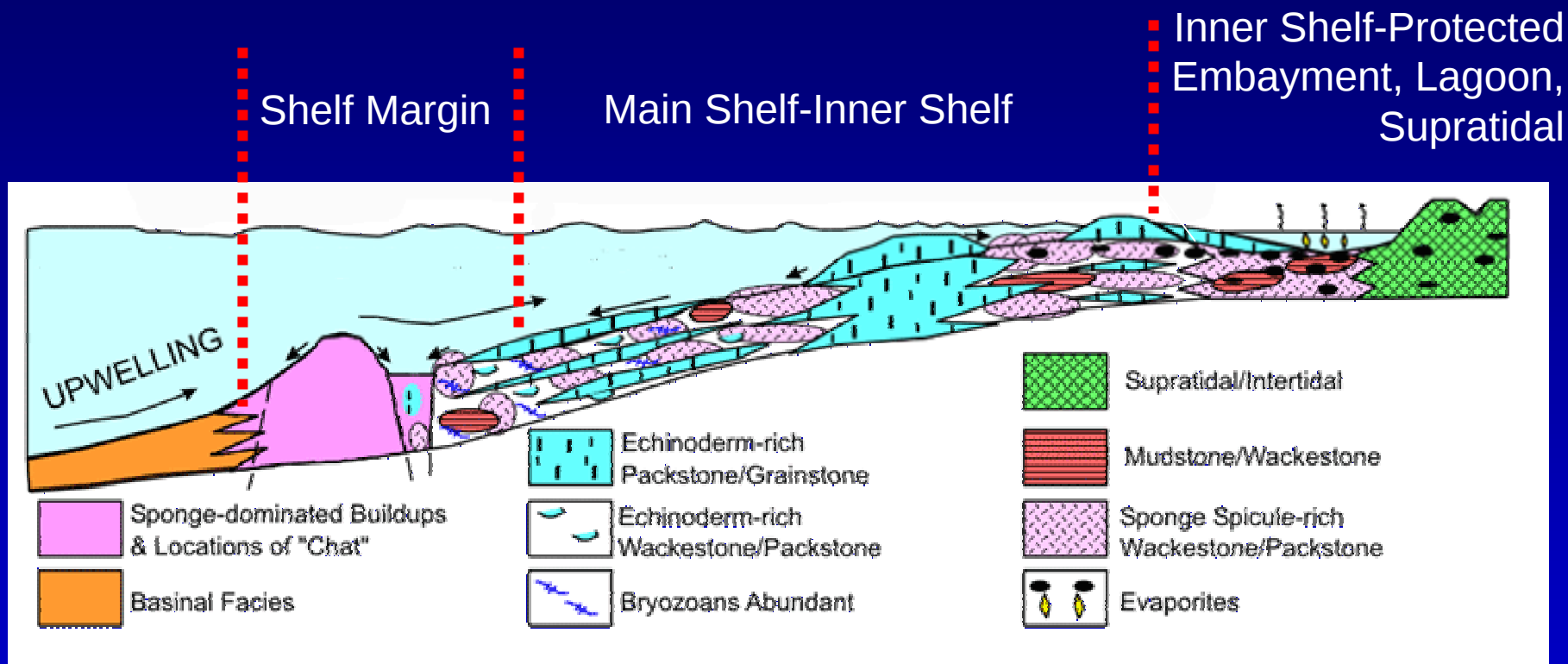
Structural and Subcrop Setting



Modified after Gerlach, et al, 1998



Lower Mississippi Ramp Depositional Environments



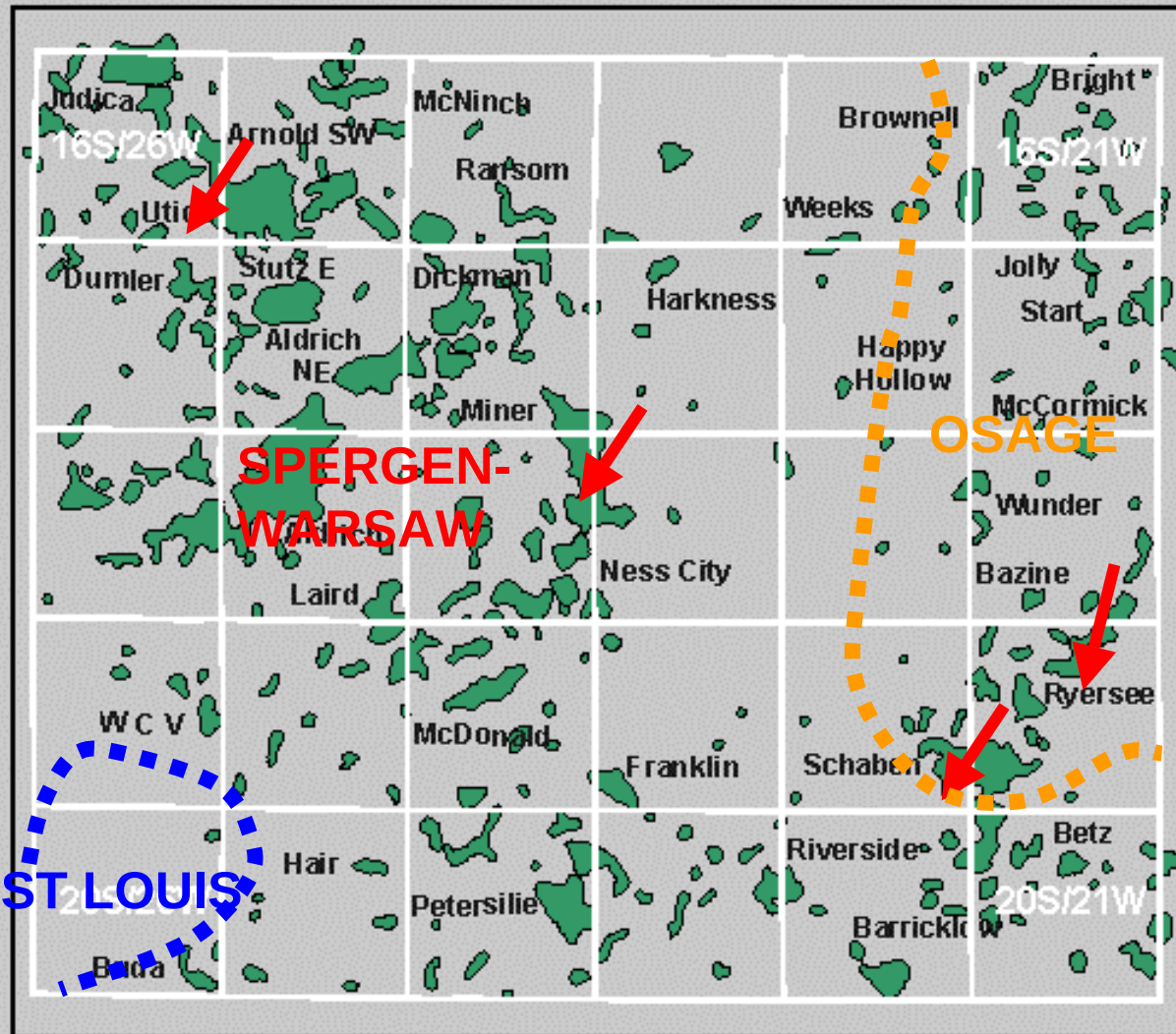
Byrnes, **Franseen**, Watney and Dubois, 2003

<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.



Oil and Gas Fields



Ness County, Kansas

Ness
County
Study
Area

.....
Approx.
subcrop
limit

Primary
Core Data

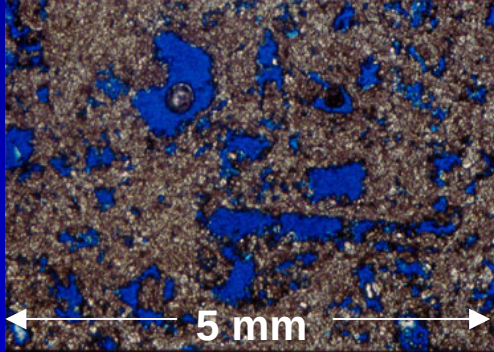


Facies and Petrophysical Properties

- 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



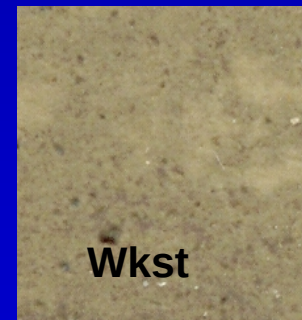
Those with larger grains (and less mud), generally have larger pores, larger pore throats, lower threshold pressures for saturating the rock with oil and higher oil saturations for a given height above free water



Grnst



Pkst



Wkst

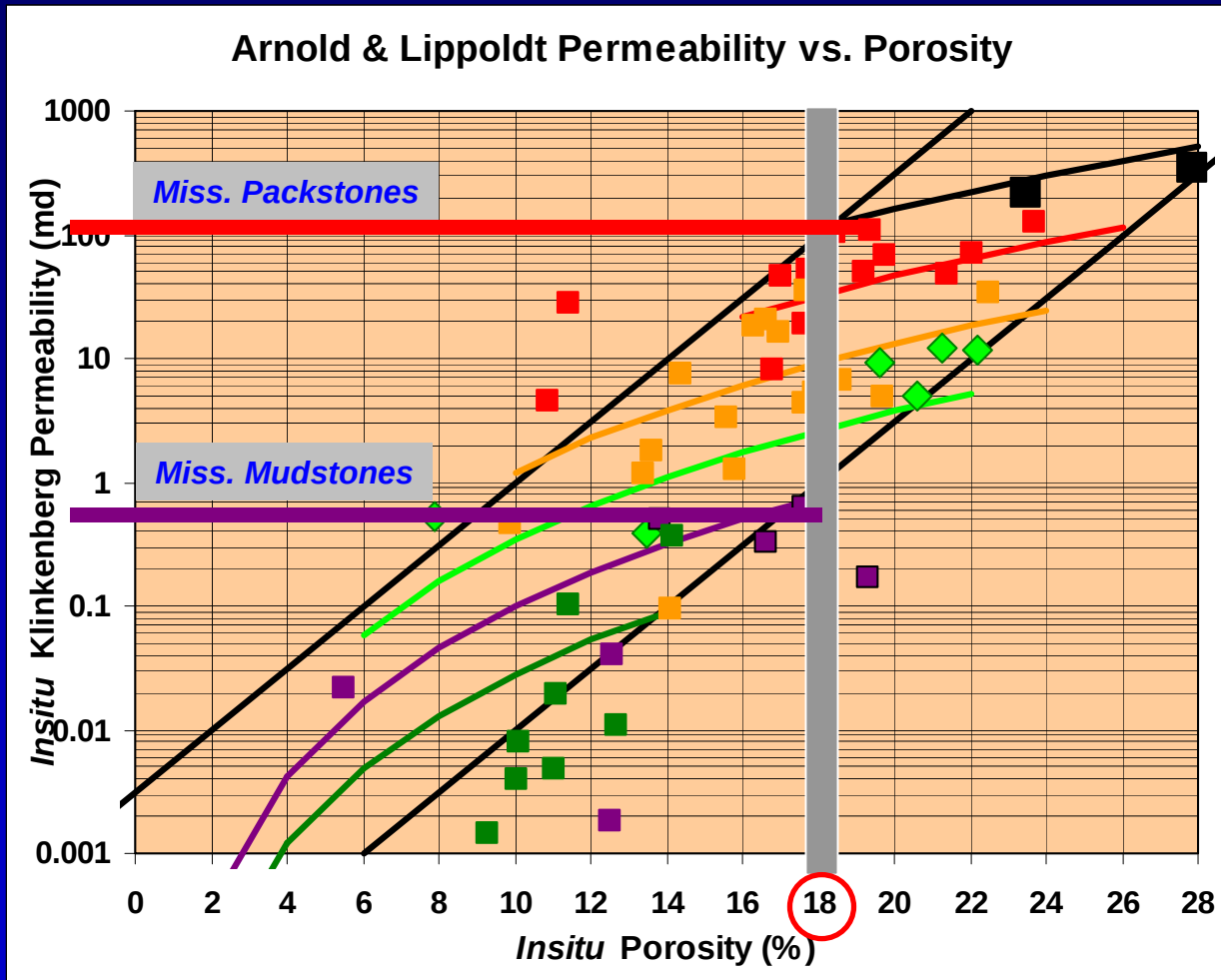


Mdst

(Original texture (pre-dolomitization) 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

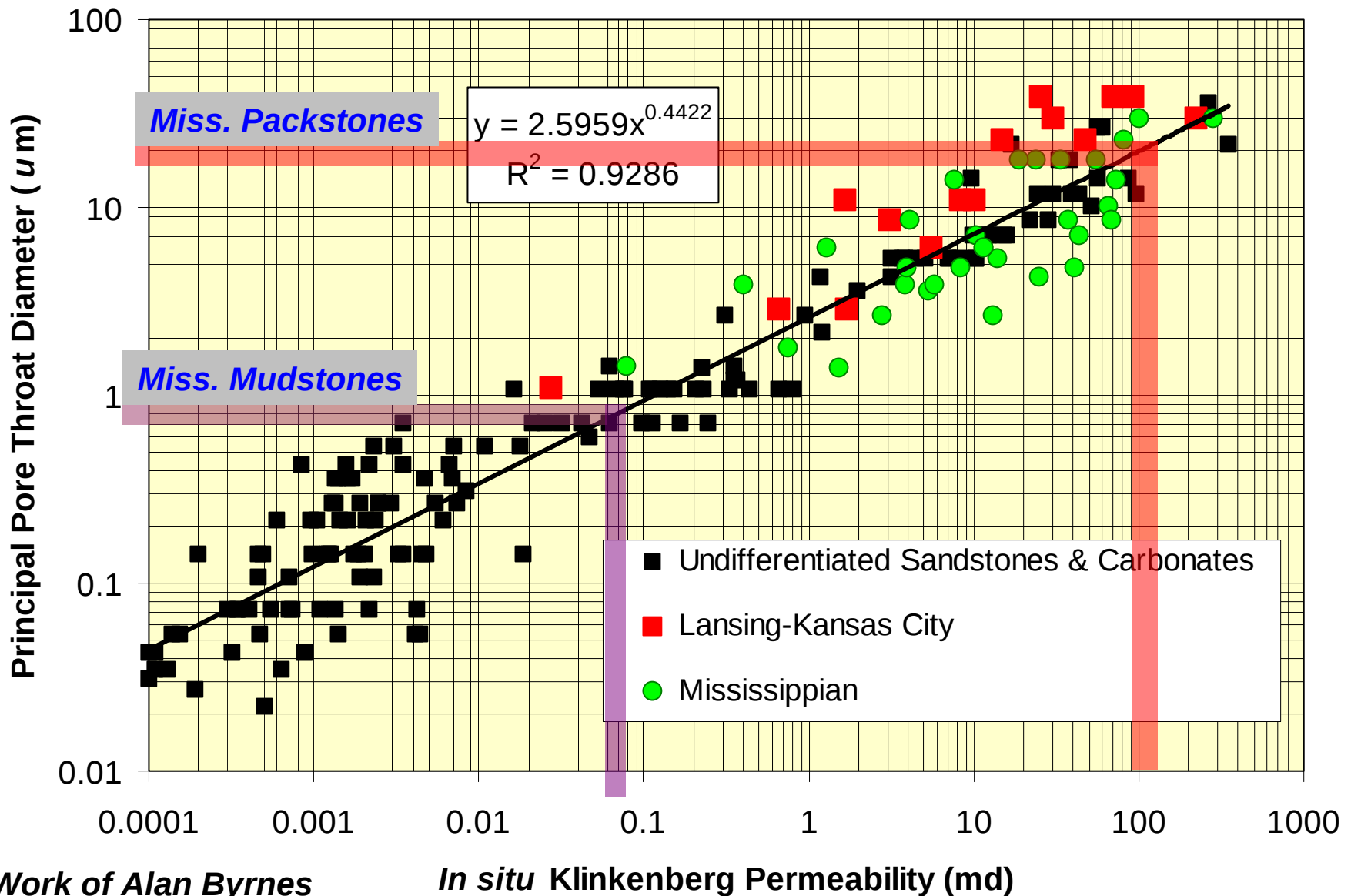
Curves Dependent on

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

Work of Alan Byrnes



Permeability vs Pore Throat Diameter



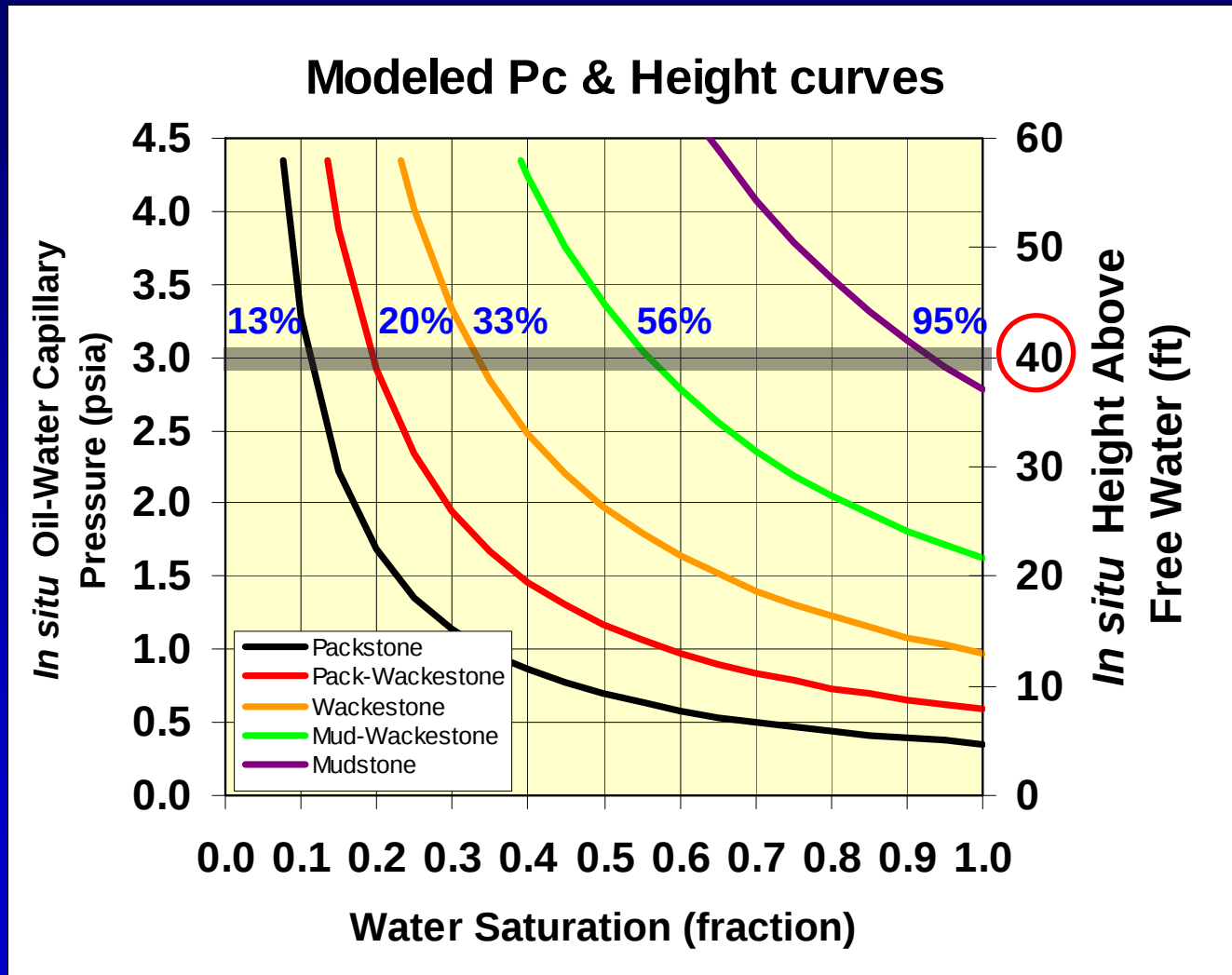
Work of Alan Byrnes

In situ Klinkenberg Permeability (md)



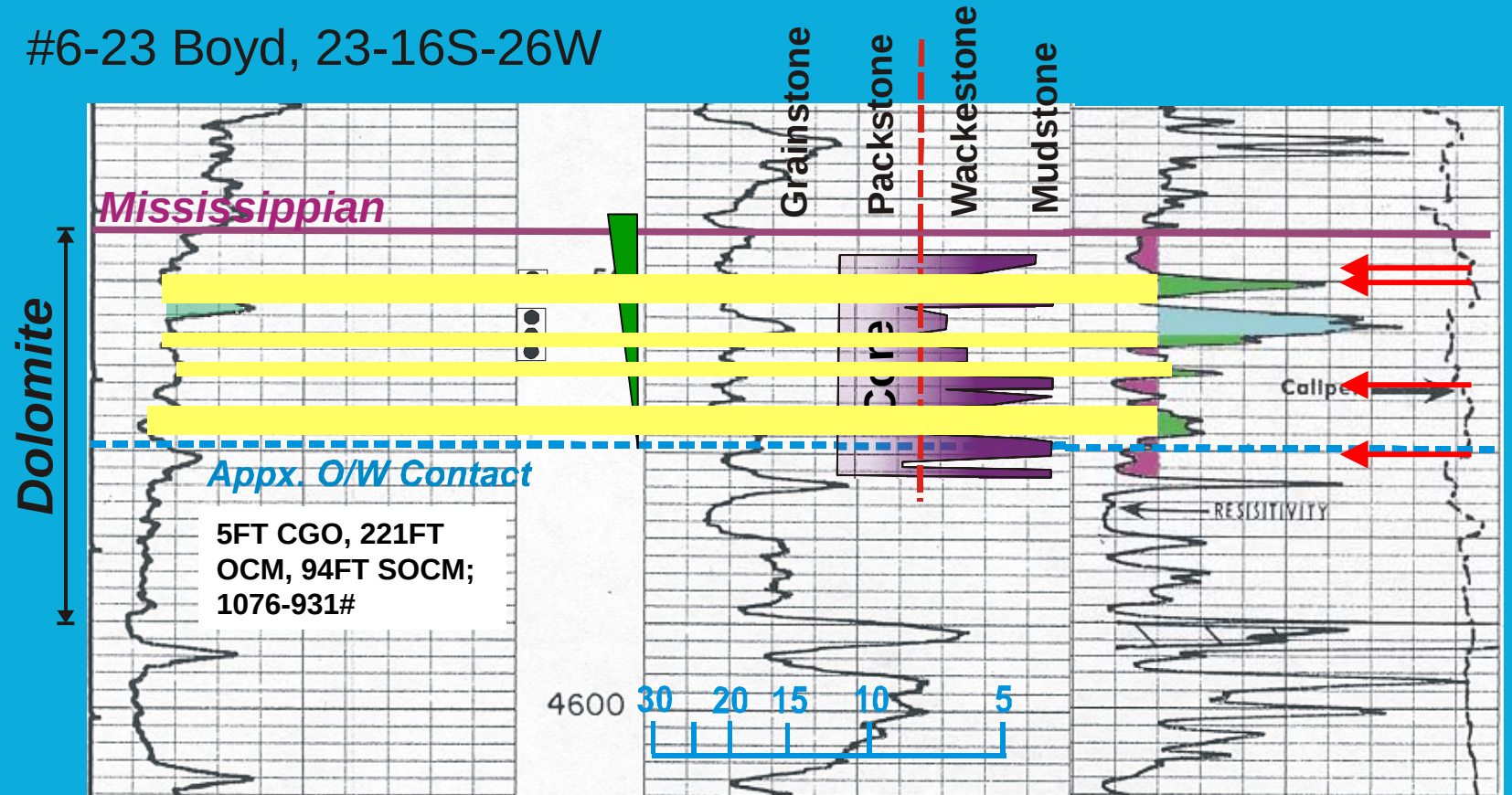
Capillary Pressure vs Lithofacies

(Example for porosity = 18%)



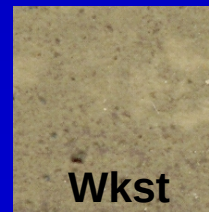
Core Facies to Log Curve Patterns

#6-23 Boyd, 23-16S-26W



Subsequent Slides,
top to bottom

Pay



Mudstone-Wackestone

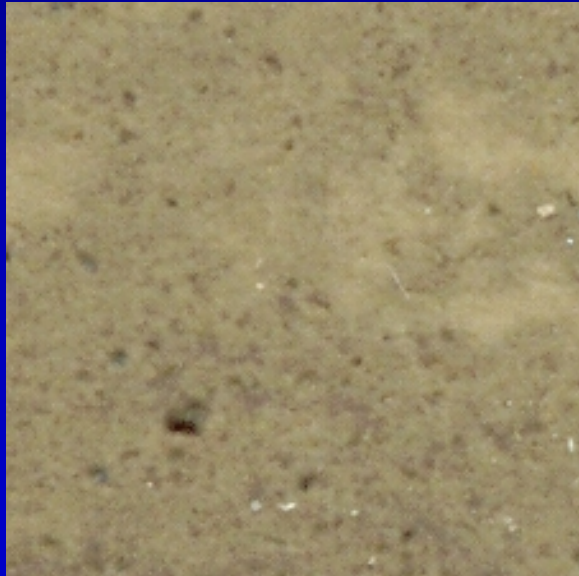
4548 (log)

Phi 20.6 %

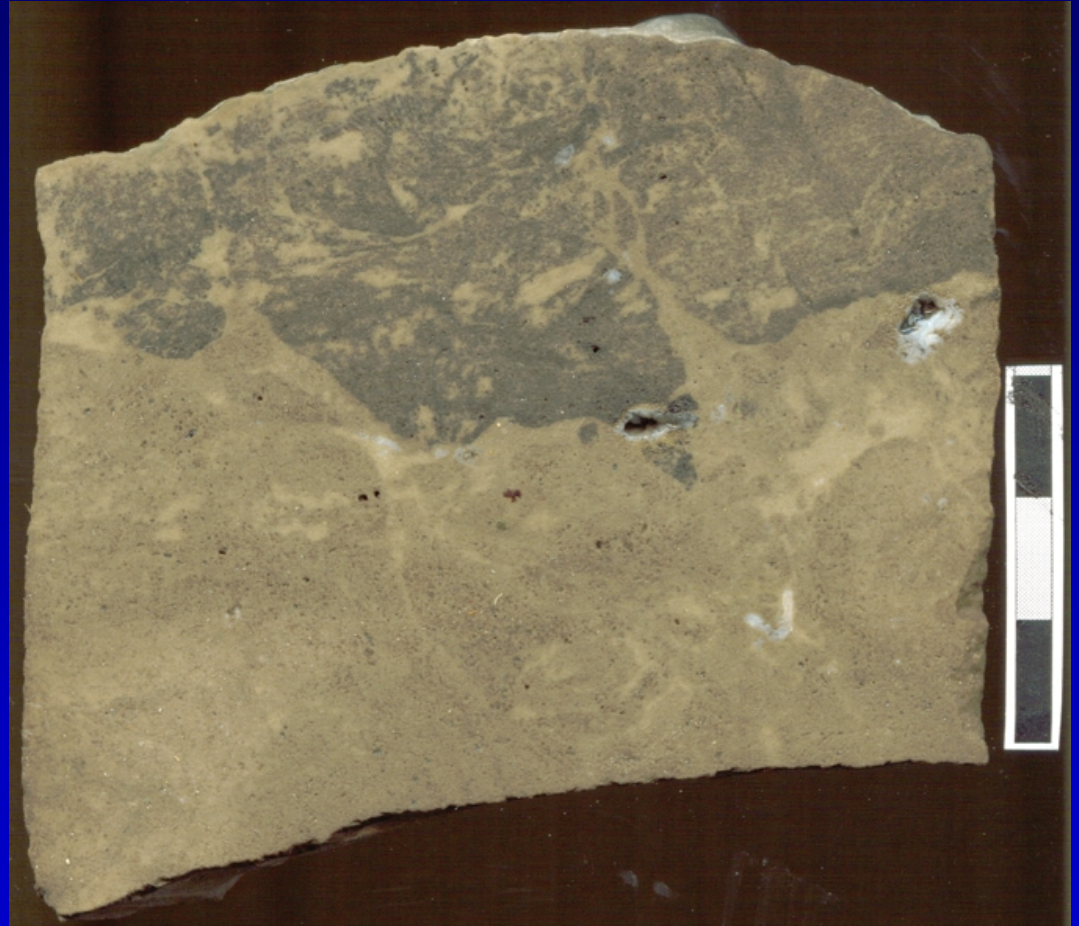
Perm 5.05 md

Dens 2.84 g/cc

Sw % 63% (log)



← 1 cm →



Packstone-Grainstone

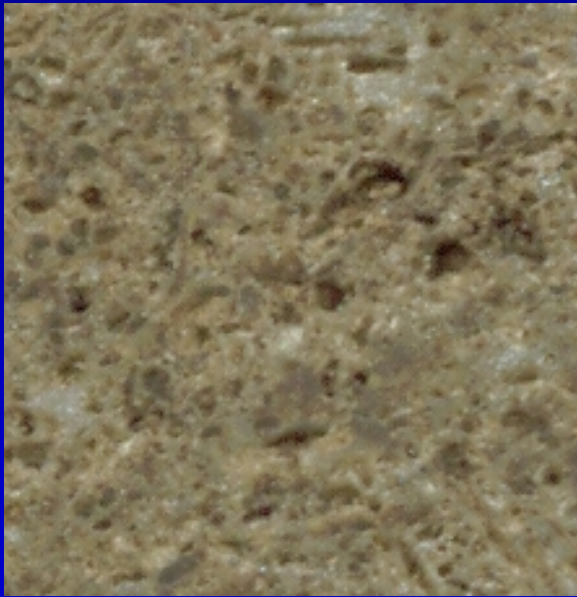
4551 (log)

Phi 27.9%

Perm 350.7 md

Dens 2.84 g/cc

Sw % 29% (log)



← 1 cm →



Mudstone

4561 (log)

Phi 17.6%

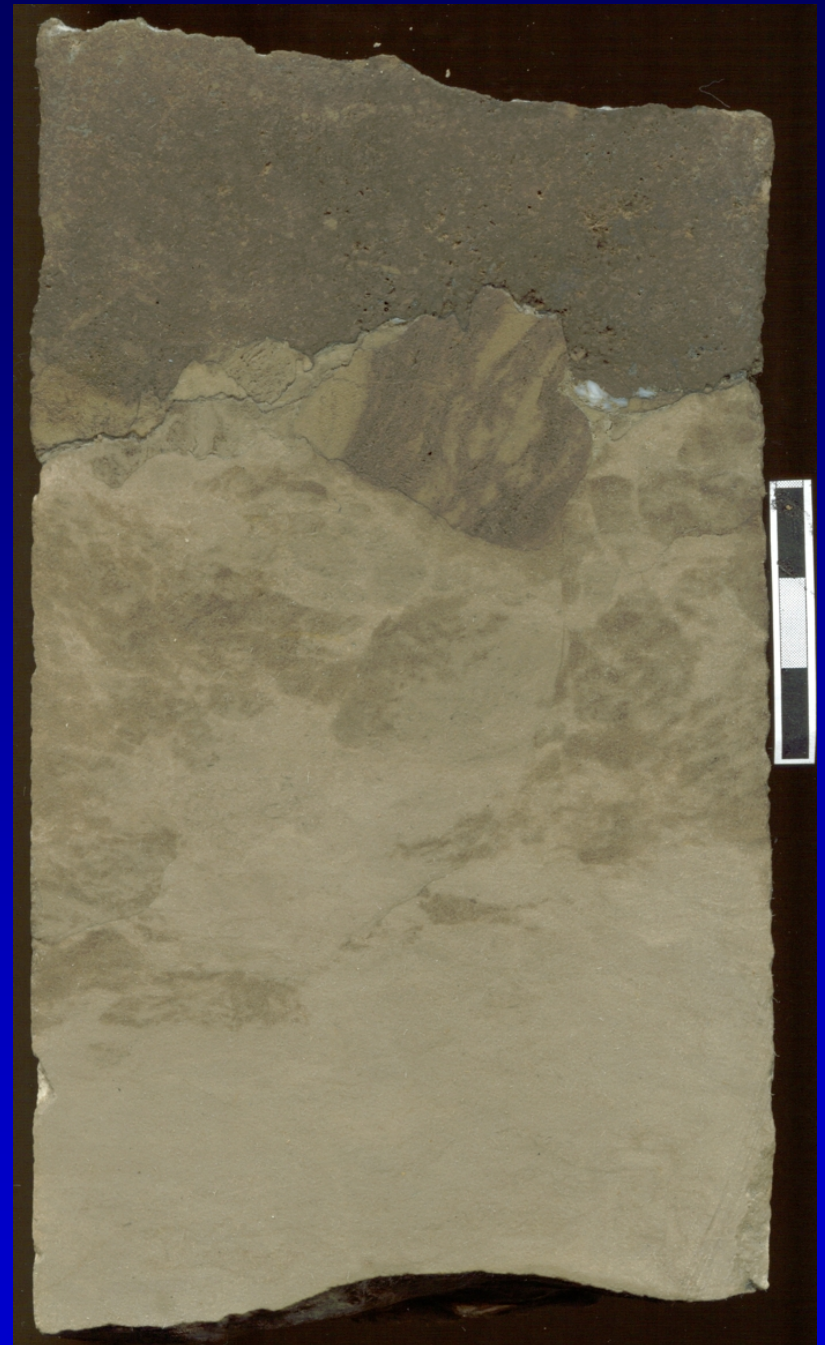
Perm 0.7 md

Dens 2.81 g/cc

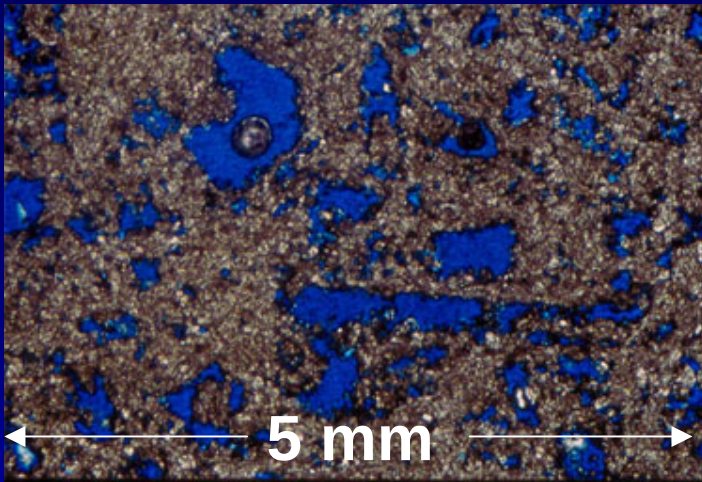
Sw % 78% (log)



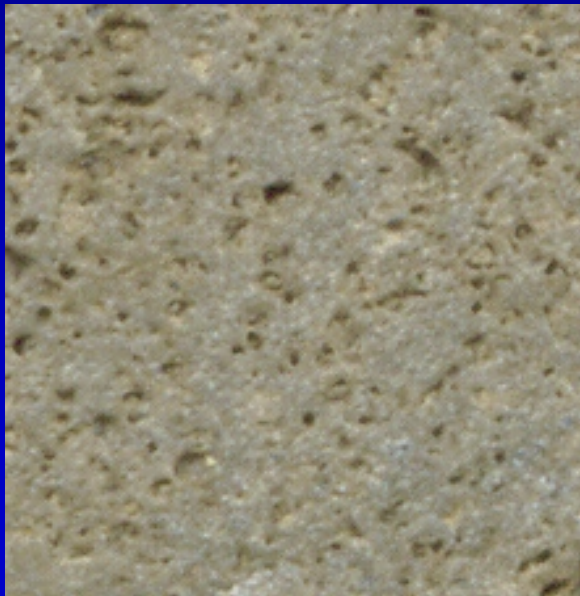
← 1 cm →



Packstone-Wackestone



(Representative sample. Not from this core.)



Log curves and samples provide clues to facies and layering

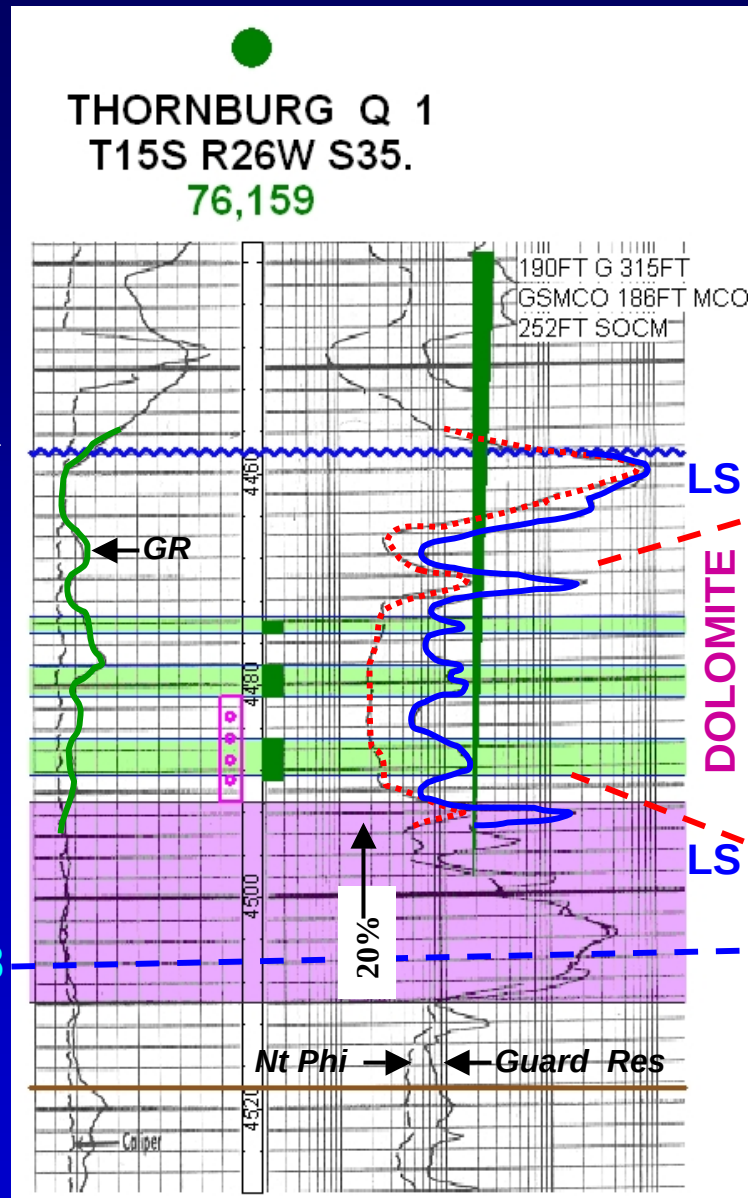
Mississippi
(Spergen)

Warsaw ?



O/W -1938

Osage



LS, off-wh, foss

Dol, gray, vfxln and dol sucrosic,
strks w/ stn and ssfo

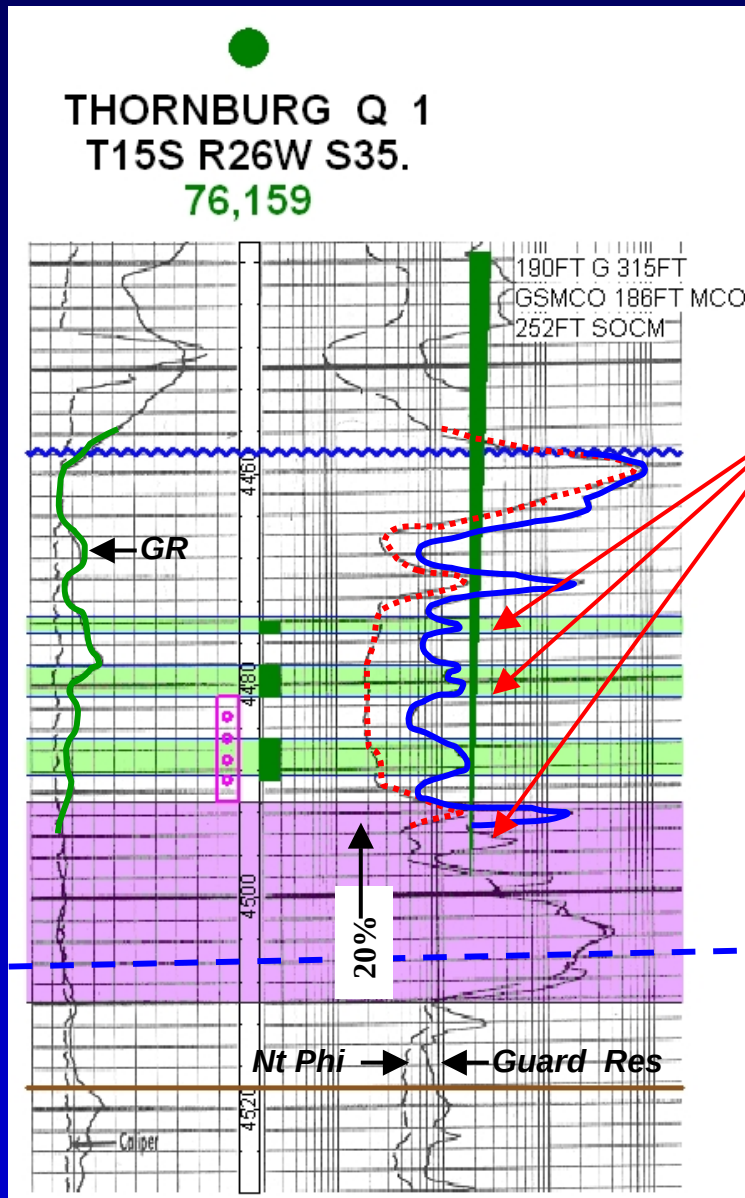
Dol, brwn stnd, vfxln, gd vuggy
por, ssfo

Dol, brwn stnd, vfxln, fr-gd vuggy
por, fr-gd sfo, fr odor

*Excerpts from
sample descriptions*



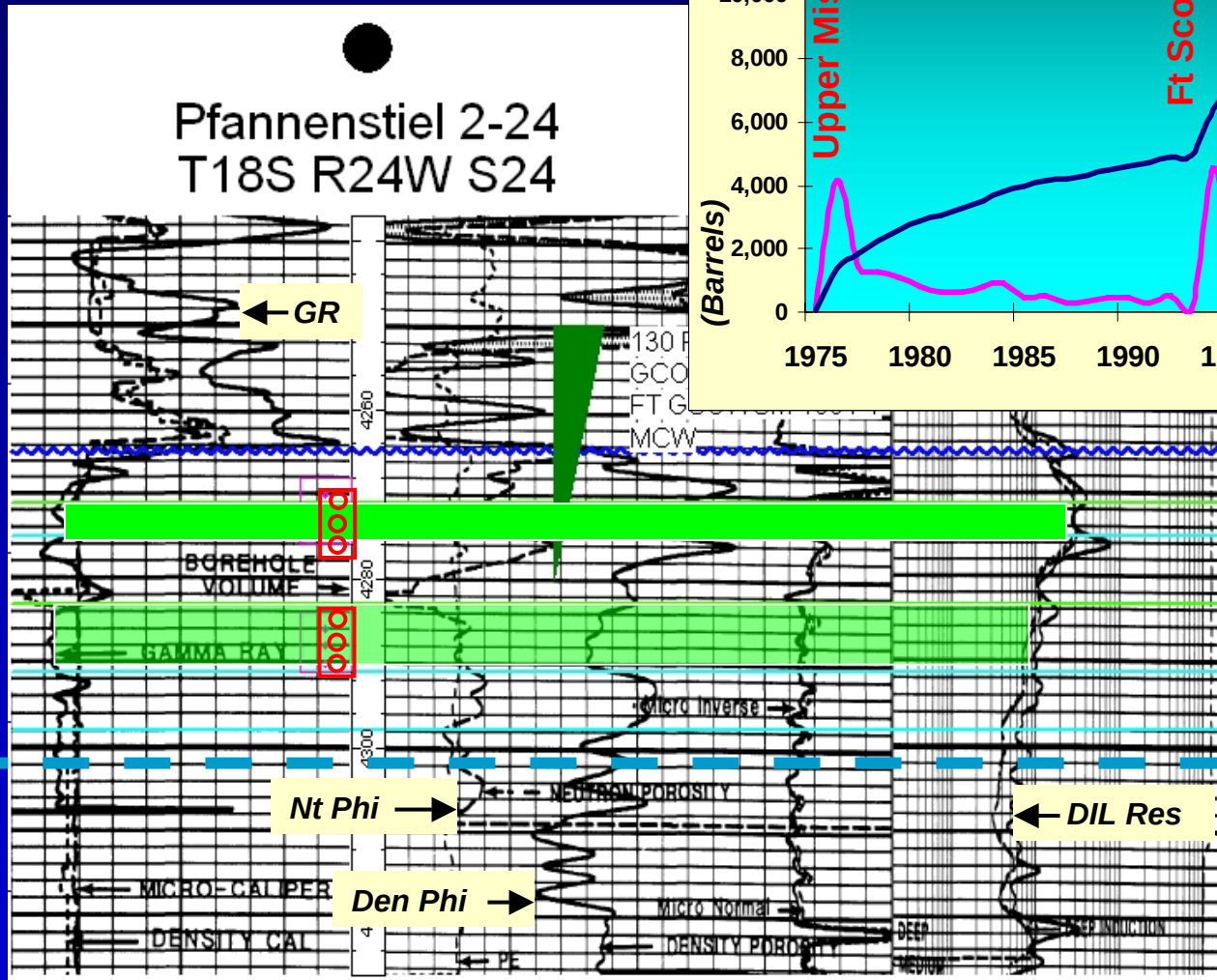
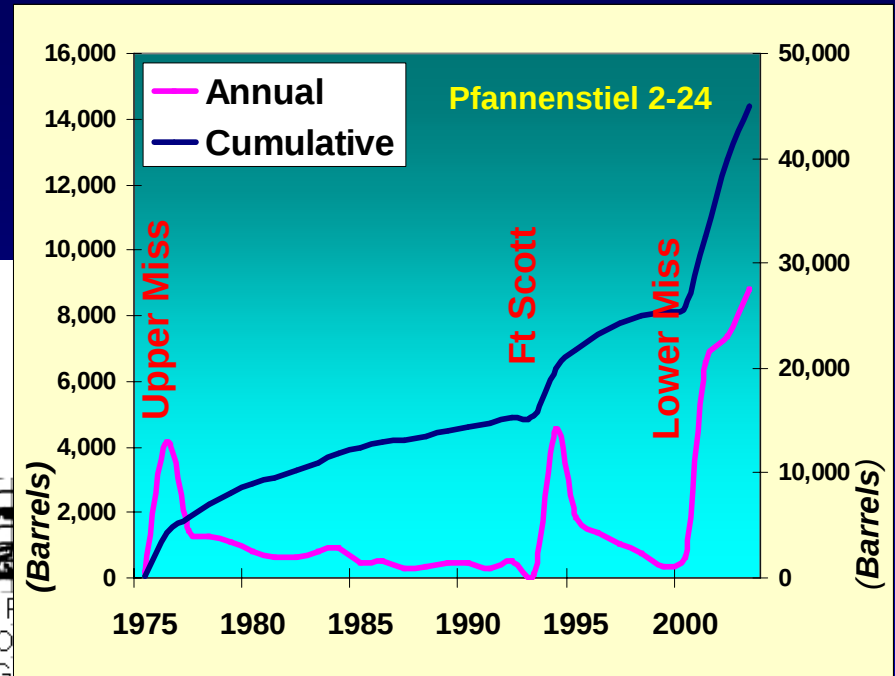
Zones that could be perforated



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

$R_w = 0.12$
 $m \text{ \& } n = 2$

Bypassed pay in Pfannenstiel 2-24



Mississippi
(Spergen)

Warsaw ?

O/W

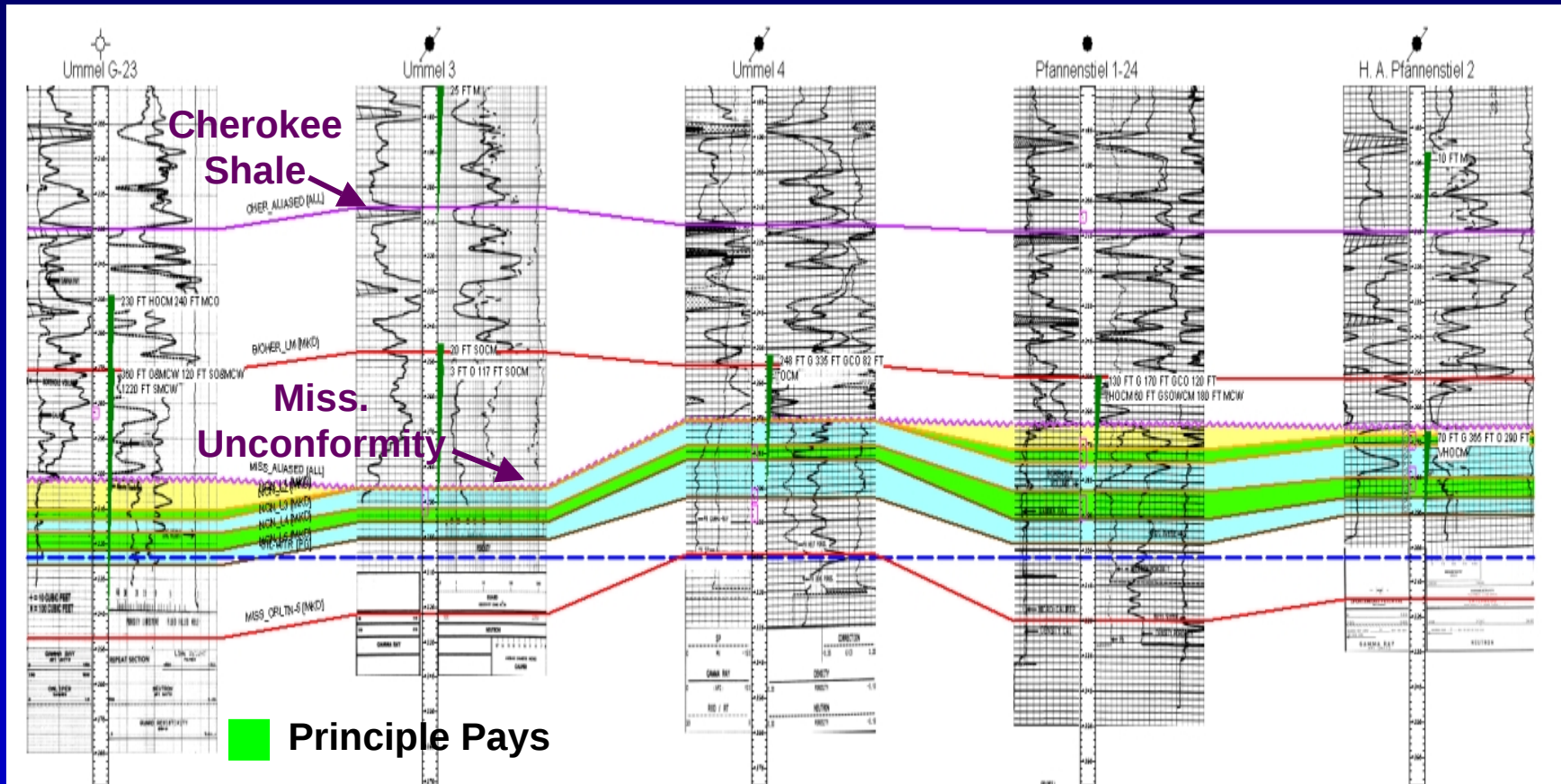
1975 perfs

2001 perfs

Pay



Ness City North 4-Layer Model

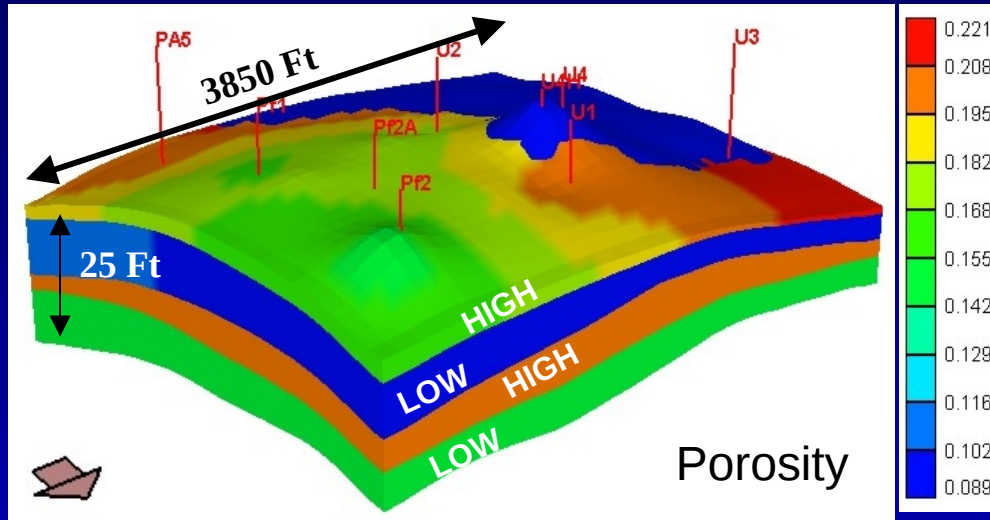


West

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

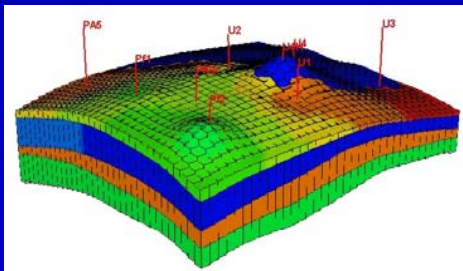
East

Ness City North Cellular Models

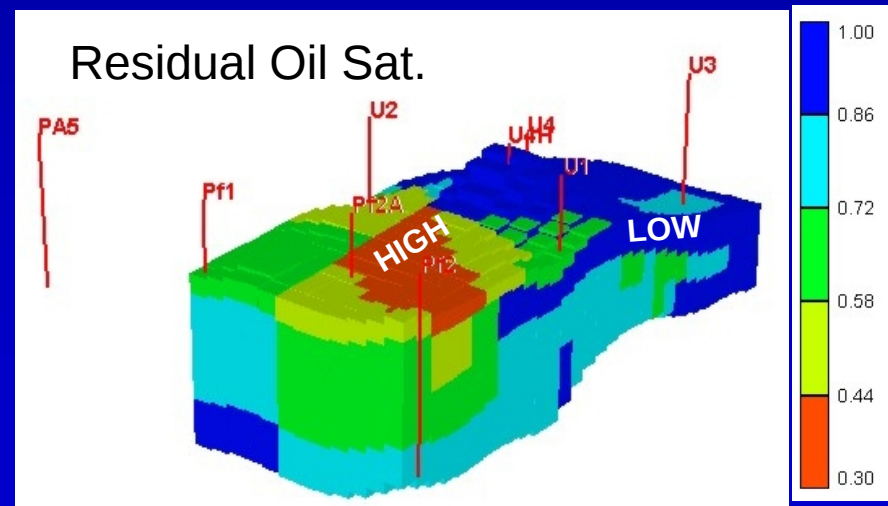


Facies recognition is critical to reservoir characterization, geomodeling and reservoir simulation.

4-Layer Model, 110 foot grid cells



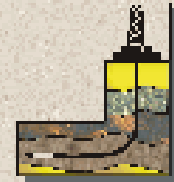
Work of Saibal Bhattacharya



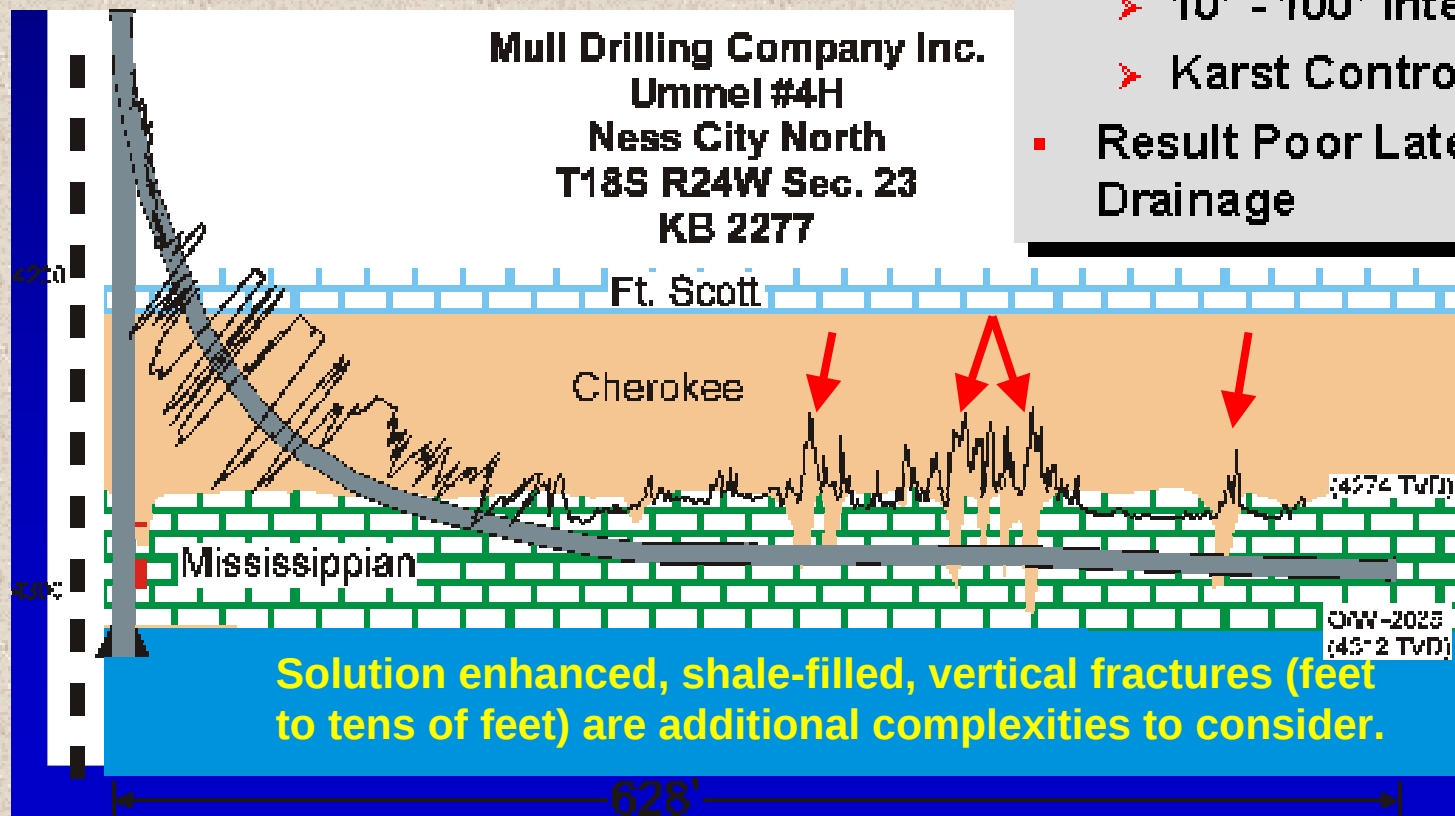
Reservoir Heterogeneity

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.

