

COST-EFFECTIVE TECHNIQUES FOR THE  
INDEPENDENT PRODUCER TO IDENTIFY  
CANDIDATE RESERVOIRS FOR  
HORIZONTAL DRILLING IN MATURE OIL & GAS FIELDS

by

Paul Gerlach

Kansas Geological Survey  
Open-file Report 99-56

*Disclaimer*

The Kansas Geological Survey does not guarantee this document to be free from errors or inaccuracies and disclaims any responsibility or liability for interpretations based on data used in the production of this document or decisions based thereon. This report is intended to make results of research available at the earliest possible date, but is not intended to constitute final or formal publication.

Kansas Geological Survey  
1930 Constant Avenue  
University of Kansas  
Lawrence, KS 66047-3726

**AAPG INTERNATIONAL HORIZONTAL WELL SYMPOSIUM**  
*FOCUS ON THE RESERVOIR*



**Kansas  
Geological Survey**

**Presentation to the  
American Association of Petroleum Geologists  
Hedberg Conference**

**October 13, 1999**

by

**Paul Gerlach**  
Research Scientist  
Petroleum Research Section  
Kansas Geological Survey

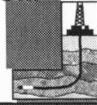
**AAPG INTERNATIONAL HORIZONTAL WELL SYMPOSIUM**  
*FOCUS ON THE RESERVOIR*



**Cost-Effective Techniques  
for the  
Independent Producer  
to  
Identify Candidate Reservoirs  
for  
Horizontal Drilling in Mature Oil & Gas Fields**

by

**Paul Gerlach**  
Petroleum Research Section  
Kansas Geological Survey



*Outline of Presentation*

**Why Identify Horizontal Candidates in Mature Basins ?**

**Horizontal Technology Applicable in Kansas**

**Tools for Identifying Candidate Reservoirs**

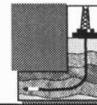
- Production Data Analysis
- Mapping Geological Data
- Integrate Production and Geologic Data
- Field Level Volumetrics
- Petrophysical Analysis
- Lease Level Volumetrics
- Reservoir Simulation

**The Learning Curve**

**Acknowledgements**

**Why Identify Horizontal Candidates in Mature Basins ?**

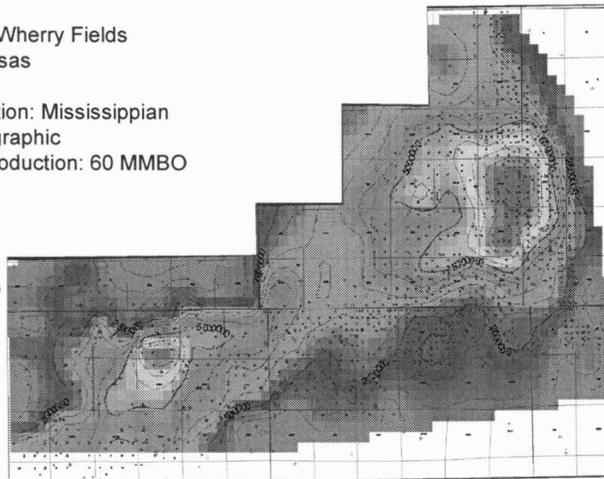
- » Exploit Remaining Oil and Gas Reserves
- » Economic Impact



**Remaining Mobile Oil in Place per Quarter Section (1997)**

Welch-Bornholdt-Wherry Fields  
Rice County, Kansas  
Discovered: 1924  
Producing Formation: Mississippian  
Trap Type: Stratigraphic  
Cumulative Oil Production: 60 MMBO

CI: 500 MBO  
Color Grid  
Red = 7 MMBO  
Blue = 2.5 MMBO



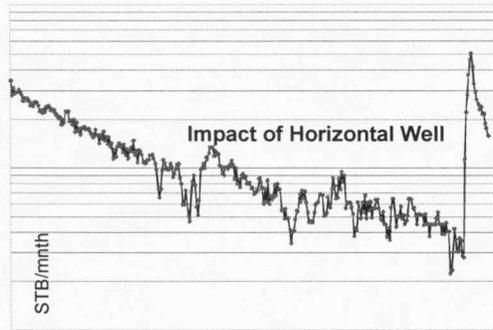
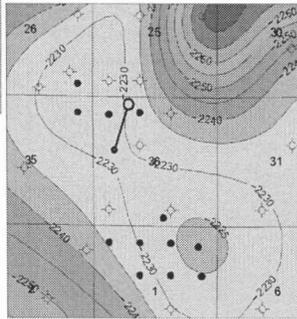
## Why Identify Horizontal Candidates in Mature Basins ?

- » Exploit Remaining Oil and Gas Reserves
- » Economic Impact

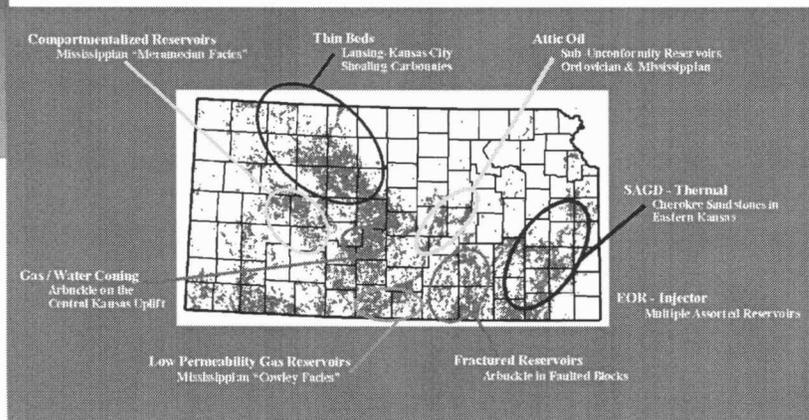
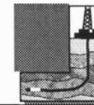


**Oppy South Field**  
 Hodgeman County, Kansas  
 Discovered: 1962

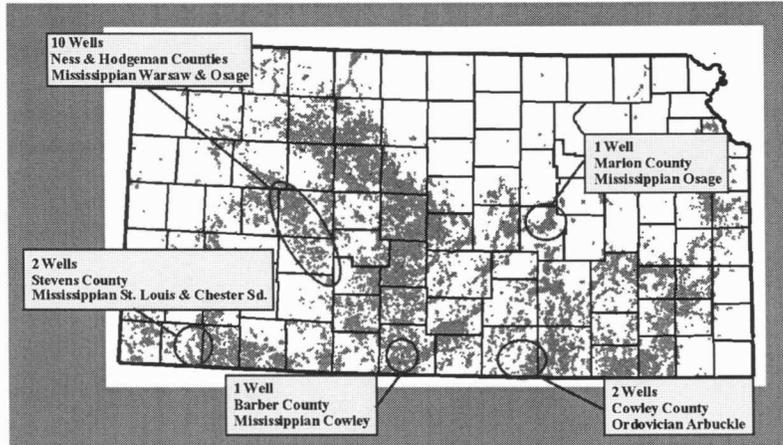
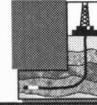
**Producing Formation: Mississippian**  
**Cum. Oil Prod.: 800 MBO**



## Horizontal Technology Applicable in Kansas

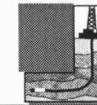


## Horizontal Drilling Activity in Kansas

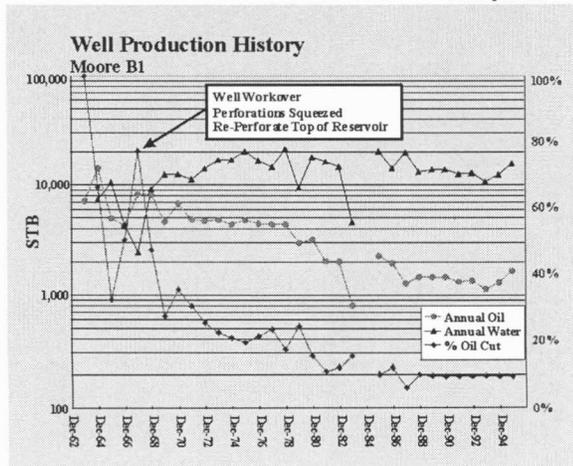


## Tools for Identifying Candidate Reservoirs

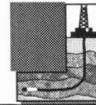
- » Production Data Analysis
- » Plot Oil Cut Changes



### High Vertical Permeability Results in Poor Horizontal Sweep

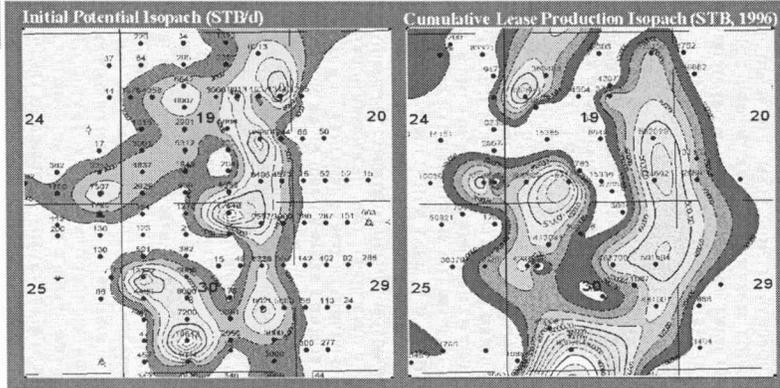


**Tools for Identifying Candidate Reservoirs**  
 » Production Data Analysis  
 » IP and Cumulative Maps

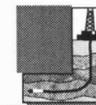


**Production Trends**

Welch-Bornholdt-Wherry Field  
 Rice County, Kansas  
 Discovered: 1924  
 Producing Formation: Mississippian

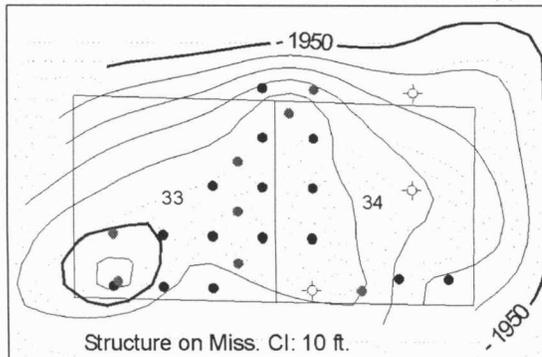


**Tools for Identifying Candidate Reservoirs**  
 » Production Data Analysis  
 » Compare Primary and Infill Production per Well



**Excessive Spacing and Inadequate Drainage**

Aldrich Field  
 Ness County, Kansas  
 Discovered: 1929  
 Producing Formation: Mississippian  
 Cum Prod: 1,044 MSTB  
 15 wells on 40 acre spacing  
 Approx: 70 MSTB/well

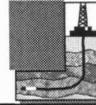


- 8 Vertical Infill Wells**
- Infill Well
  - Original Well

**Tools for Identifying Candidate Reservoirs**

» Production Data Analysis

» Compare Primary and Infill Production per Well

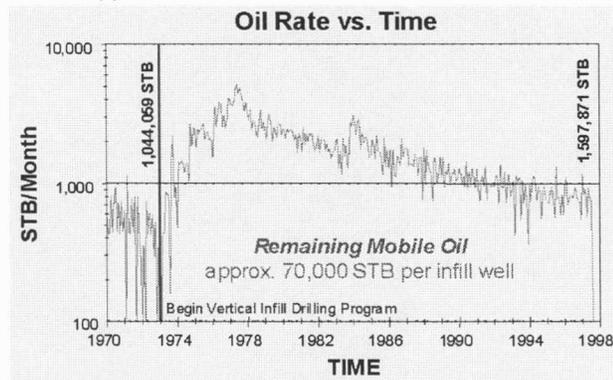


**Excessive Spacing and Inadequate Drainage**

8 Vertical Infill Wells

Cumulative Production: 553 MSTB

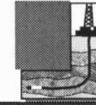
Approx: 70 MSTB / Infill well



**Tools for Identifying Candidate Reservoirs**

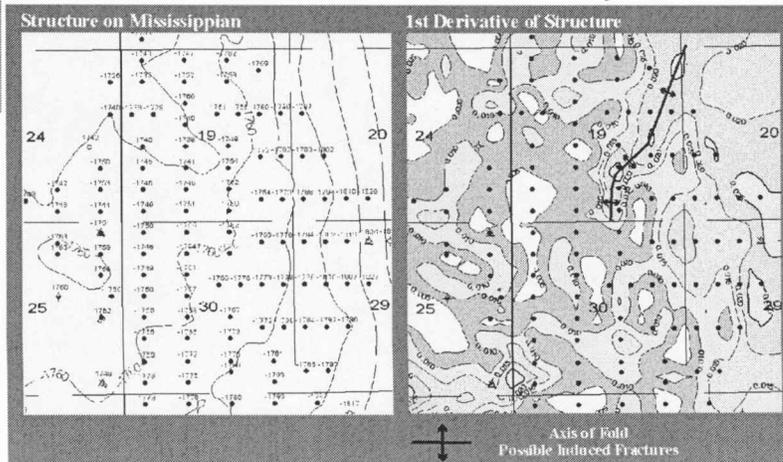
» Mapping Geologic Data

» Structure and 1st Derivative Map

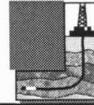


**Fold Induced Fractures**

Welch-Bornholdt-Wherry Field  
Rice County, Kansas

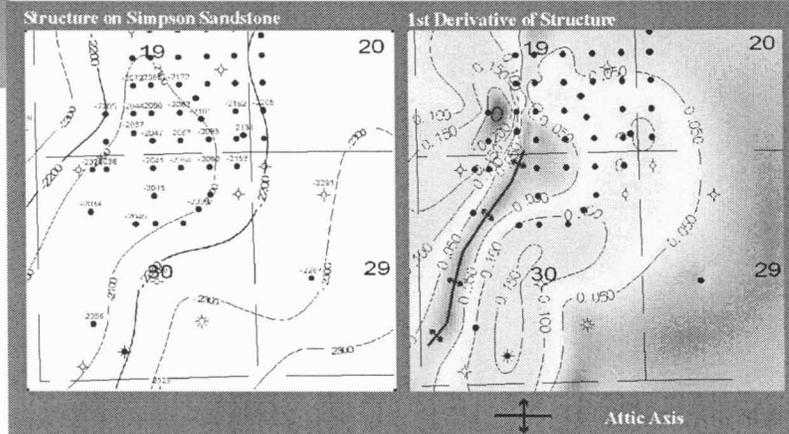


**Tools for Identifying Candidate Reservoirs**  
**» Mapping Geologic Data**  
**» Structure and 1st Derivative Map**

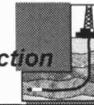


**Axis of Anticlinal Attic**

Hollow-Nikkel Field  
 Harvey County, Kansas  
 Discovered: 1931

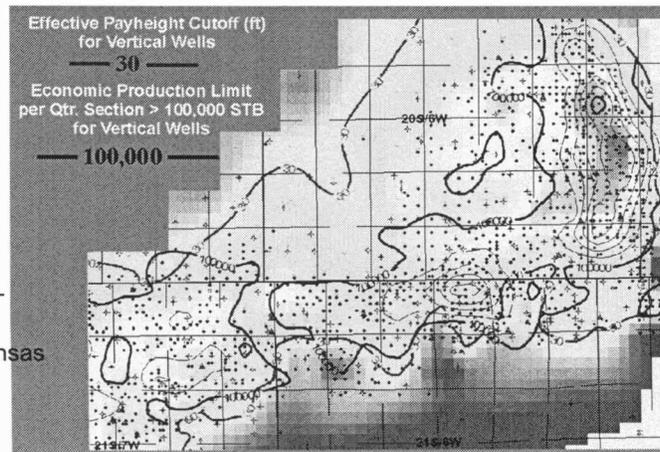


**Tools for Identifying Candidate Reservoirs**  
**» Mapping Production & Geologic Data**  
**» Payzone Isopach & Cumulative Oil per Quarter Section**



**Poor Sweep by Vertical Wells**  
**in Thin Pay of Updip Stratigraphic Trap**

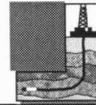
Welch-Bornholdt-  
 Wherry Field  
 Rice County, Kansas



**Tools for Identifying Candidate Reservoirs**

» **Mapping Field Level Volumetrics**

» **Original Oil in Place per Quarter Section**



**Welch-Bornholdt-Wherry Fields**

Discovered: 1924

Producing Reservoir: Mississippian Osage

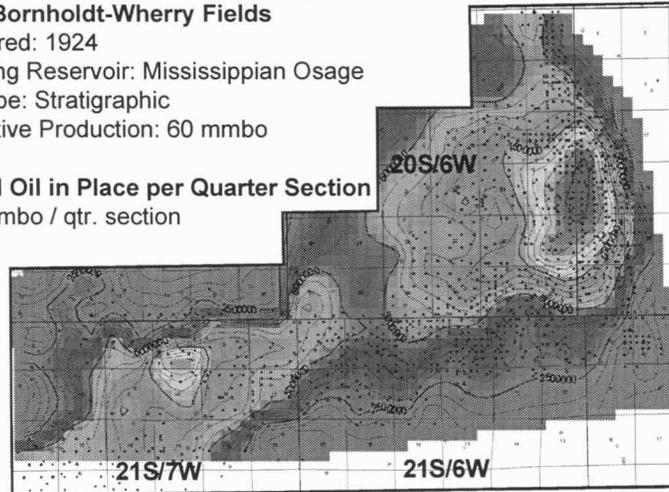
Trap Type: Stratigraphic

Cumulative Production: 60 mmbo

**Original Oil in Place per Quarter Section**

CI: 500 mbo / qtr. section

Using data  
from one well  
per 1/4 section



● = 10 mmbo

● = 5 mmbo

**Tools for Identifying Candidate Reservoirs**

» **Mapping Field Level Volumetrics**

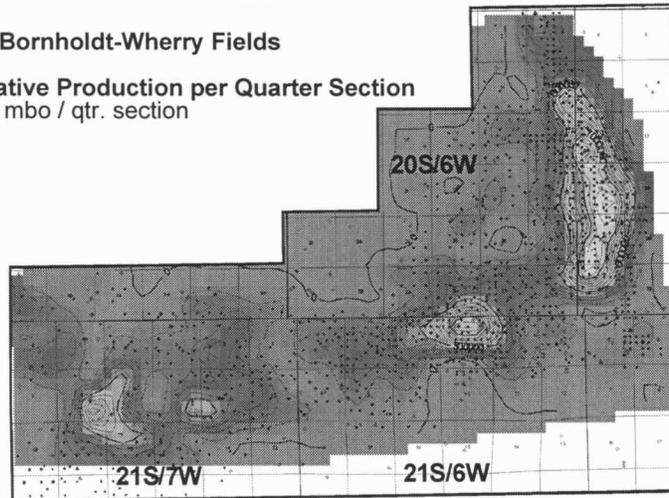
» **Cumulative Production per Quarter Section**



**Welch-Bornholdt-Wherry Fields**

**Cumulative Production per Quarter Section**

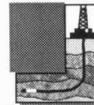
CI: 100 mbo / qtr. section



● = 1.5 mmbo

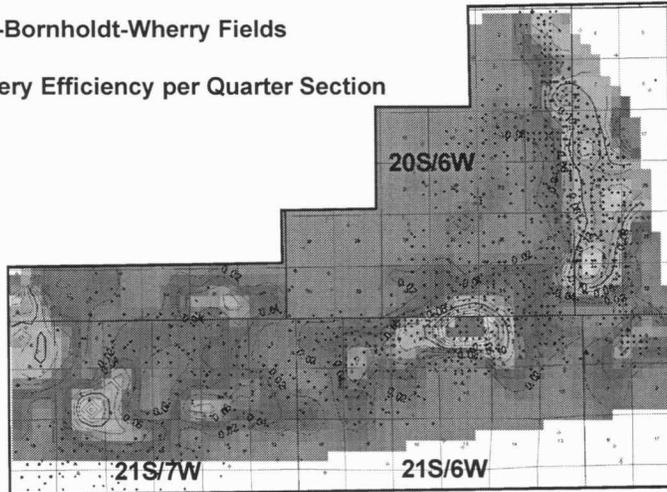
● = 0.4 mmbo

**Tools for Identifying Candidate Reservoirs**  
 » Mapping Field Level Volumetrics  
 » Recovery Efficiency per Quarter Section



**Welch-Bornholdt-Wherry Fields**

Recovery Efficiency per Quarter Section  
 CI: 2%



● = 18%

● = 2%

**Petrophysical Analysis for Lease Level Volumetrics**

» Super Pickett Plot  
 » Reservoir Porosity, Saturation, Pay Height, and BVW

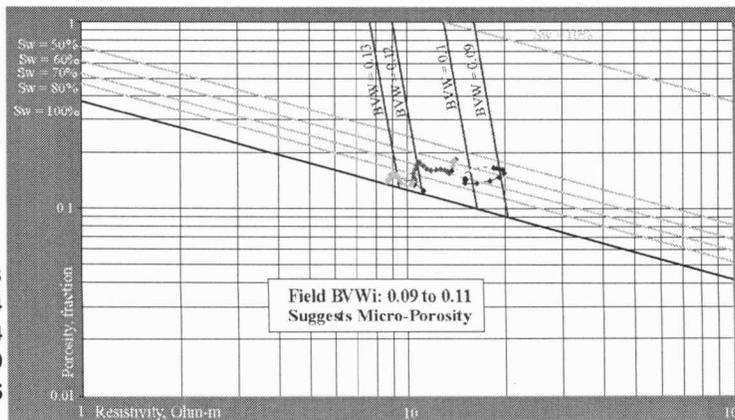


**Schaben Field**  
 Ness County, Kansas  
 Lyle Schaben # 2P

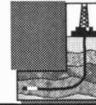
Mississippian Carbonate  
 Archie constants  
 $a = 1$ ,  $m = 2.1$ ,  $n = 2$   
 and  $R_w = 0.13$

Depth, ft.

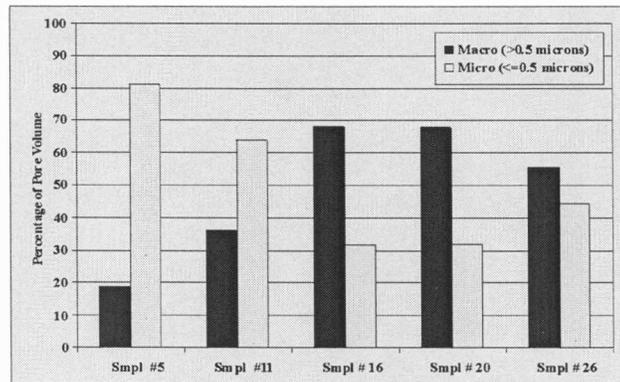
- 4414-4423
- 4400-4414
- 4400-4404
- 4395-4399
- 4390-4395



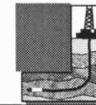
**Petrophysical Analysis for Lease Level Volumetrics**  
 » Pore-Print from Capillary Pressure  
 » Micro-Porosity (qualitative measure)



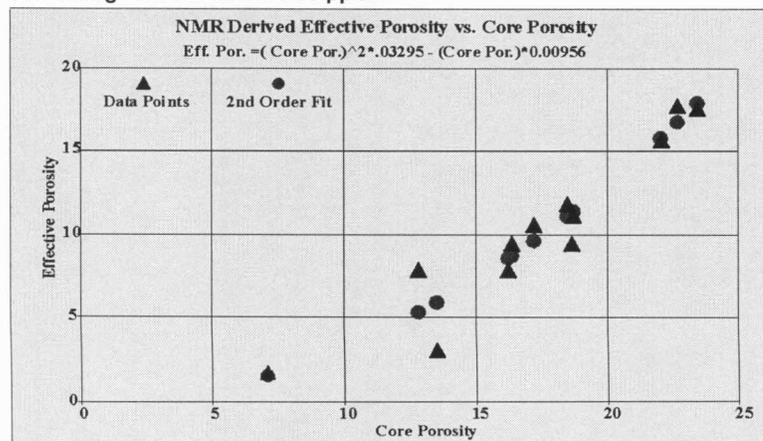
Schaben Field  
 Ness County, Kansas  
 Foos "A-P" #1 Twin  
 Producing Formation: Mississippian



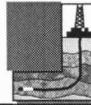
**Petrophysical Analysis for Lease Level Volumetrics**  
 » Core Plug and NMR Porosity Comparison  
 » Micro-Porosity (quantitative measure)



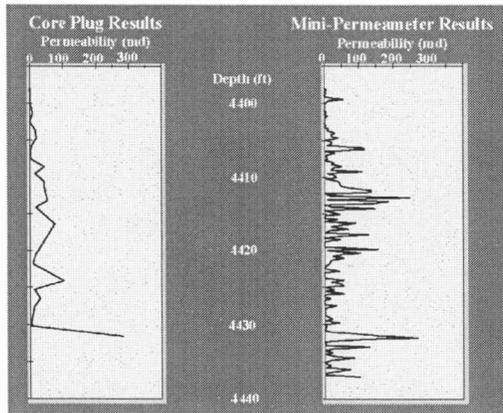
Schaben Field  
 Ness County, Kansas  
 Producing Formation: Mississippian



**Petrophysical Analysis for Lease Level Volumetrics**  
 » Core Plug and Mini-Permeameter Comparison  
 » Vertical Stratification of Horizontal Permeability

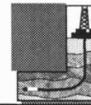


Schaben Field  
 Ness County, Kansas  
 Foss "A-P" #1 Twin  
 Producing Formation: Mississippian



**Tools for Identifying Candidate Reservoirs**

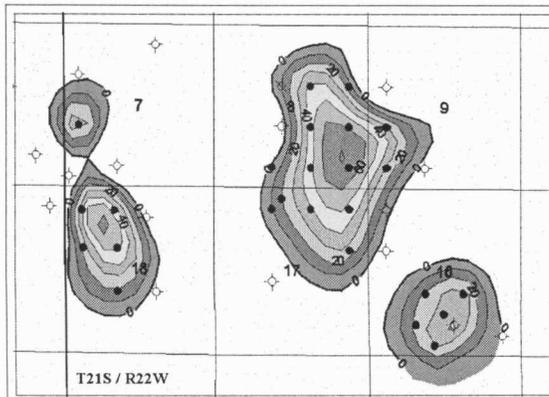
» Lease Level Analysis  
 » Volumetrics and Recovery Efficiency



Wieland and Wieland West Fields  
 Hodgeman County, Kansas  
 Discovered: 1956  
 Producing Formation: Mississippian

Payzone isopach  
 CI: 10 ft

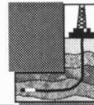
Color Grid  
 Red = 60 ft  
 Blue = 20 ft



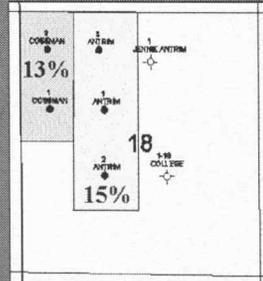
## Tools for Identifying Candidate Reservoirs

» Lease Level Analysis

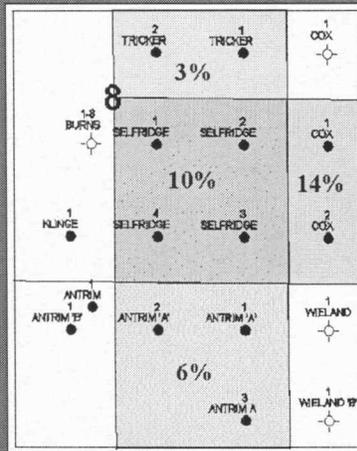
» Volumetrics and Recovery Efficiency



Wieland West Field



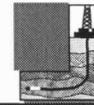
Wieland Field



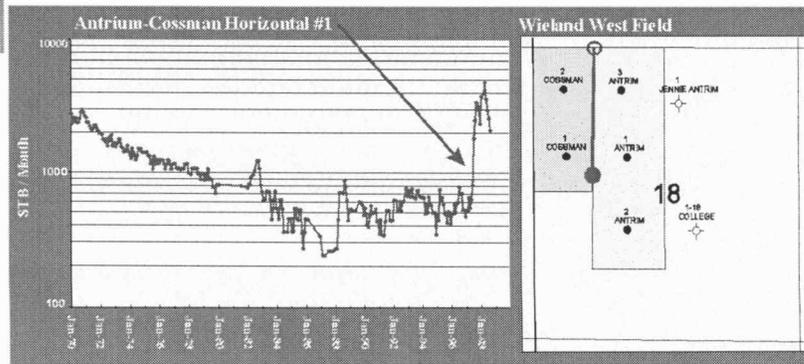
## Tools for Identifying Candidate Reservoirs

» Lease Level Analysis

» Volumetrics and Recovery Efficiency

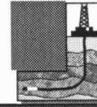


### Horizontal Well Application in a Lease with Low Recovery Efficiency



## Tools for Identifying Candidate Reservoirs

- » Reservoir Simulation
- » Cost Effective ?

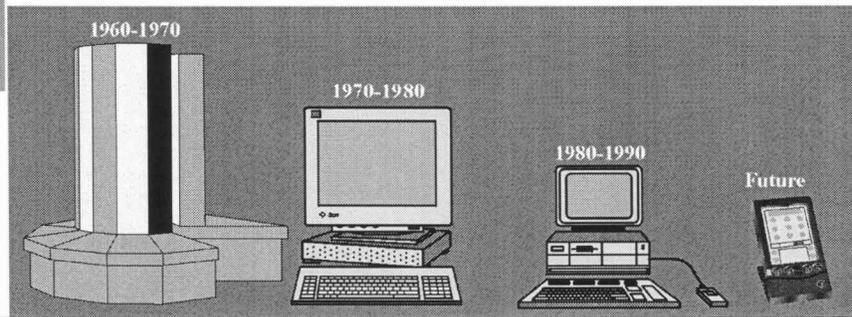


### In the Past...

- » Performed on Core Assets of Large Companies
- » Required Expensive Hardware and Software

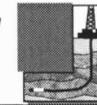
### At the Present...

- » Advances in PC-Based Hardware and Software
- » Reservoir Simulation within Reach of Independent Producer
- » DOE Simulators: Boast 4 and Boast VHS (freeware)



## Tools for Identifying Candidate Reservoirs

- » Reservoir Simulation for Performance Prediction



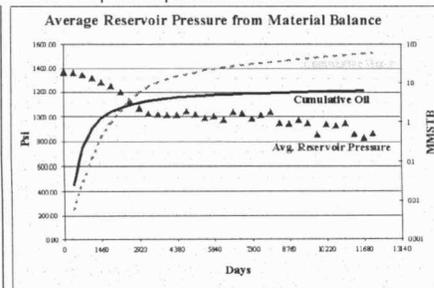
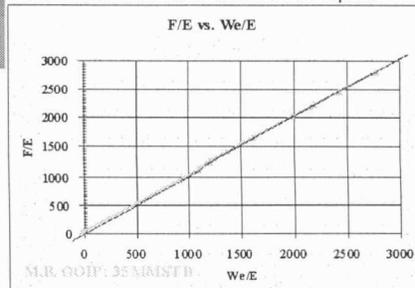
### Material Balance Validates

- » Volumetrics
- » Drive Mechanism
- » Aquifer Properties

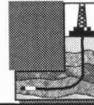
Schaben Field  
Ness County, Kansas  
Volumetric OOIP: 39 MMSTB

F = Volume withdrawn from reservoir  
N = OOIP  
We = volume of water influx from aquifer

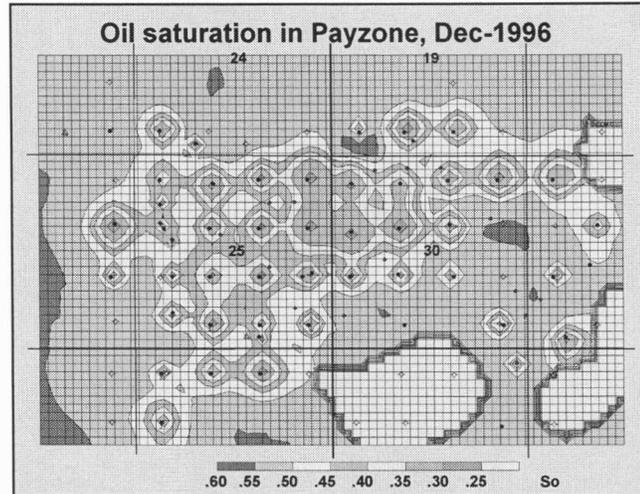
$E = E_o + E_{fw}$   
 $E_o$  = change in volume of oil and dissolved gas  
 $E_{fw}$  = Aq. wtr expansion and reduction of PV



**Tools for Identifying Candidate Reservoirs**  
 » Reservoir Simulation for Performance Prediction  
 » Identify ROIP



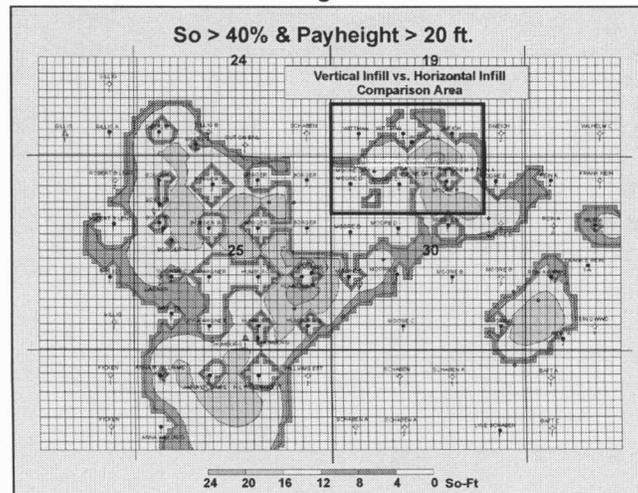
Boast 4 Simulation Schaben Field



**Tools for Identifying Candidate Reservoirs**  
 » Reservoir Simulation for Performance Prediction  
 » Best Areas for Infill Drilling in Pay > 20 ft.

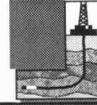


Best Areas for Infill Drilling Schaben Field

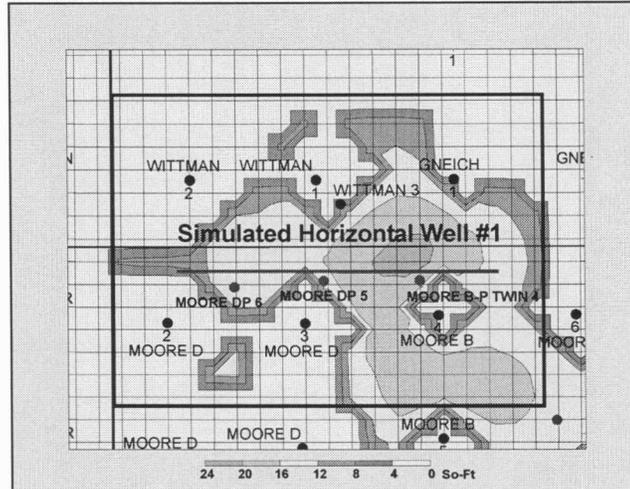


## Tools for Identifying Candidate Reservoirs

- » Reservoir Simulation for Performance Prediction
- » Best Areas for Infill Drilling in Pay > 20 ft.



### Vertical Infill vs. Horizontal Infill Schaben Field

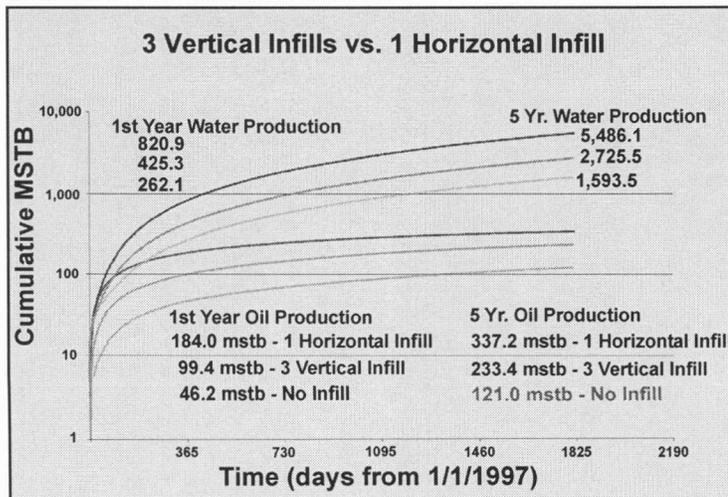


## Tools for Identifying Candidate Reservoirs

- » Reservoir Simulation for Performance Prediction
- » Performance of Horizontal Well in Pay > 20 ft.

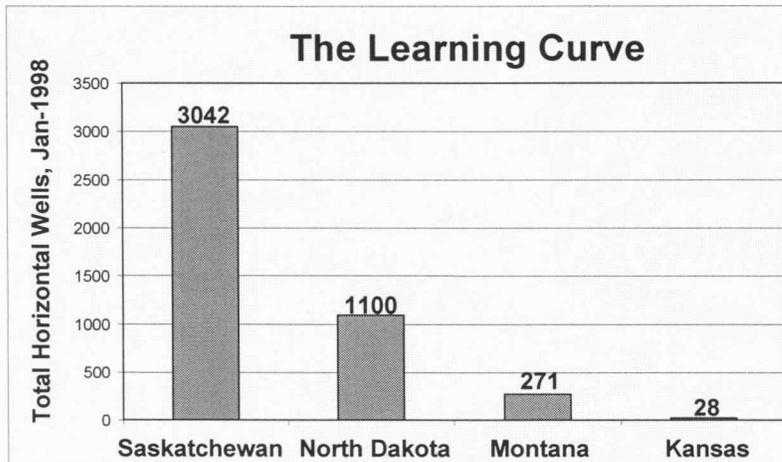


### Boast VHS Performance Prediction





### The Learning Curve



### Acknowledgements

