When 3-D Seismic Is Not Enough: Improving Success by Integrating Hydrocarbon Microseepage Data with 3-D Seismic Data*

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Abstract

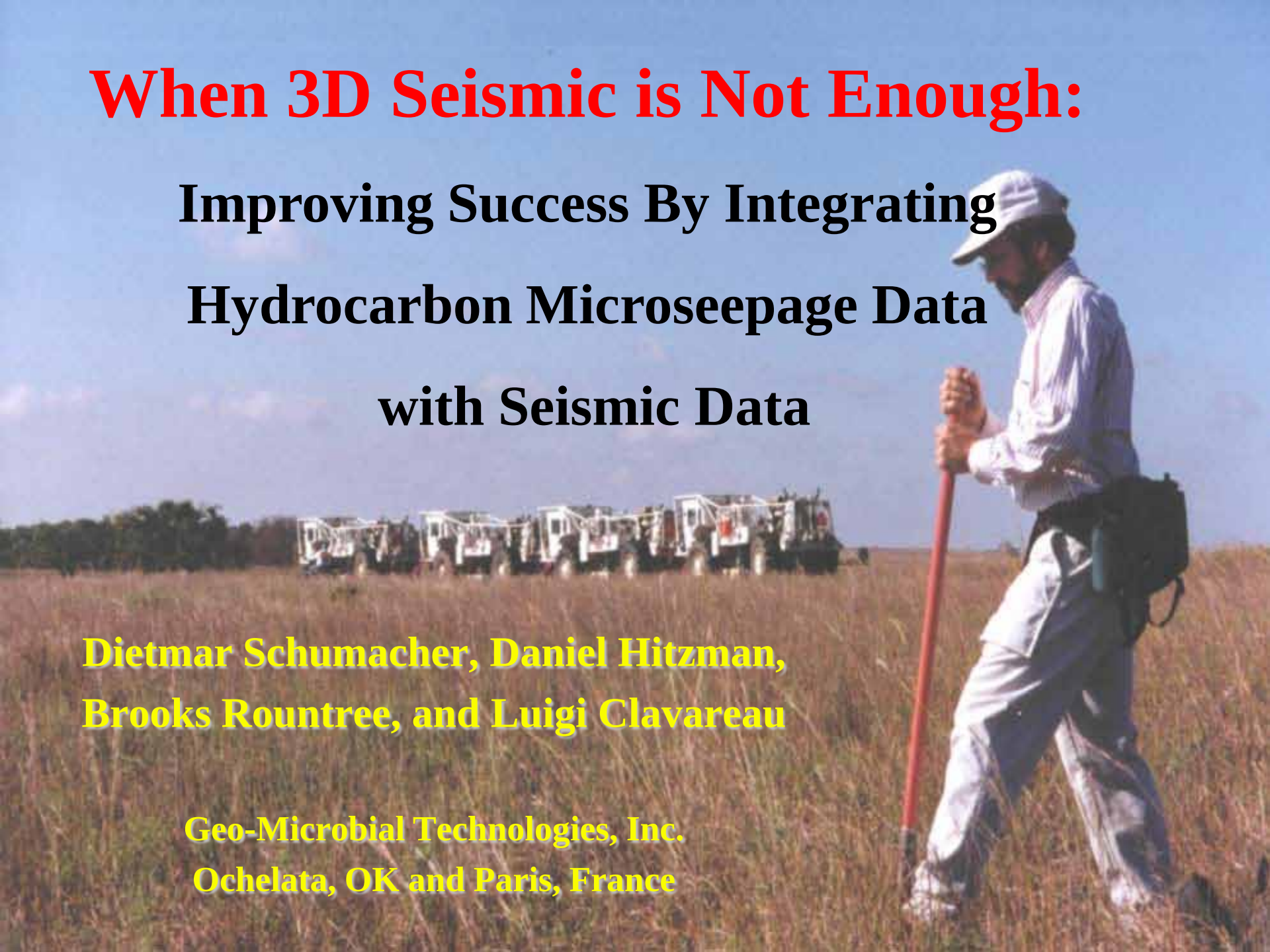
3D seismic data are unsurpassed for imaging trap and reservoir geometry, however, in many geological settings seismic data yield no information about whether a trap is charged with hydrocarbons. Hydrocarbon microseepage data when integrated with 3D seismic data can double exploration success by identifying those traps most likely to be hydrocarbon-charged. This presentation will review the results of integrated 3D seismic and geochemical surveys (1) over pinnacle reefs East Texas, (2) Pennsylvanian channel sandstones in Oklahoma, (3) in the Ft. Worth basin of North Texas, (4) Morrow channel sands in the OK-TX panhandles, (5) over a large, nearly depleted field in Venezuela, and (6) a recent discovery in western Venezuela.

Microseepage data acquired over the Cotton Valley reefs clearly discriminates between hydrocarbon-charged reefs and dry or non-commercial reefs. Gridded hydrocarbon microseepage data over Pennsylvanian channel sandstones in OK and TX distinguished between charged and uncharged reservoirs and/or reservoir compartments. In north Texas, geochemical evaluation of a seismically defined Ordovician Ellenburger structural trap identified a minor seepage anomaly associated with it and an extensive microseepage anomaly over an adjacent structural low. Subsequent drilling yielded a dry hole on the “high” and discovered a new Park Springs Conglomerate (Pennsylvanian) field in the area of the seismic “low.” In Venezuela, survey results identified areas of bypassed pay within the old field, and several new drilling opportunities outside present field boundaries. Lastly, a post-discovery microseepage survey in western Venezuela identified the probable field limits, subsequently documented by further drilling.

Applications such as these require close sample spacing and are most effective when geochemical results are integrated with 3D seismic data. High-resolution microseepage surveys offer a flexible, low-risk and low-cost technology that naturally complements traditional geologic and seismic methods, and can significantly improve exploration success rates.

When 3D Seismic is Not Enough:

Improving Success By Integrating Hydrocarbon Microseepage Data with Seismic Data



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Outline

- Introduction
- Geologic Risk Factors
- Why Hydrocarbon Microseepage Surveys
- Exploration Examples
  - Pinnacle Reefs, TX
  - Pennsylvanian Channel Sands, OK
  - Ft. Worth Basin, TX
  - Morrow Channel Sands, TX
  - Old Field, Venezuela
- Conclusions

GEOLOGIC RISK FACTORS
(after Peter Rose, 2001)

- Hydrocarbon Source Rocks
- Hydrocarbon Migration, Charge
- Reservoir Rock
- Trapping (Closure)
- Containment (Preservation)

Why Hydrocarbon Microseepage Surveys?

- Most Productive Basins Leak
- Most Accumulations Leak
- Leakage is Predominantly Vertical
- Leakage is Dynamic
- Direct Indicator of Hydrocarbons
- Hydrocarbon-Induced Changes
- Minimal Environmental Impact

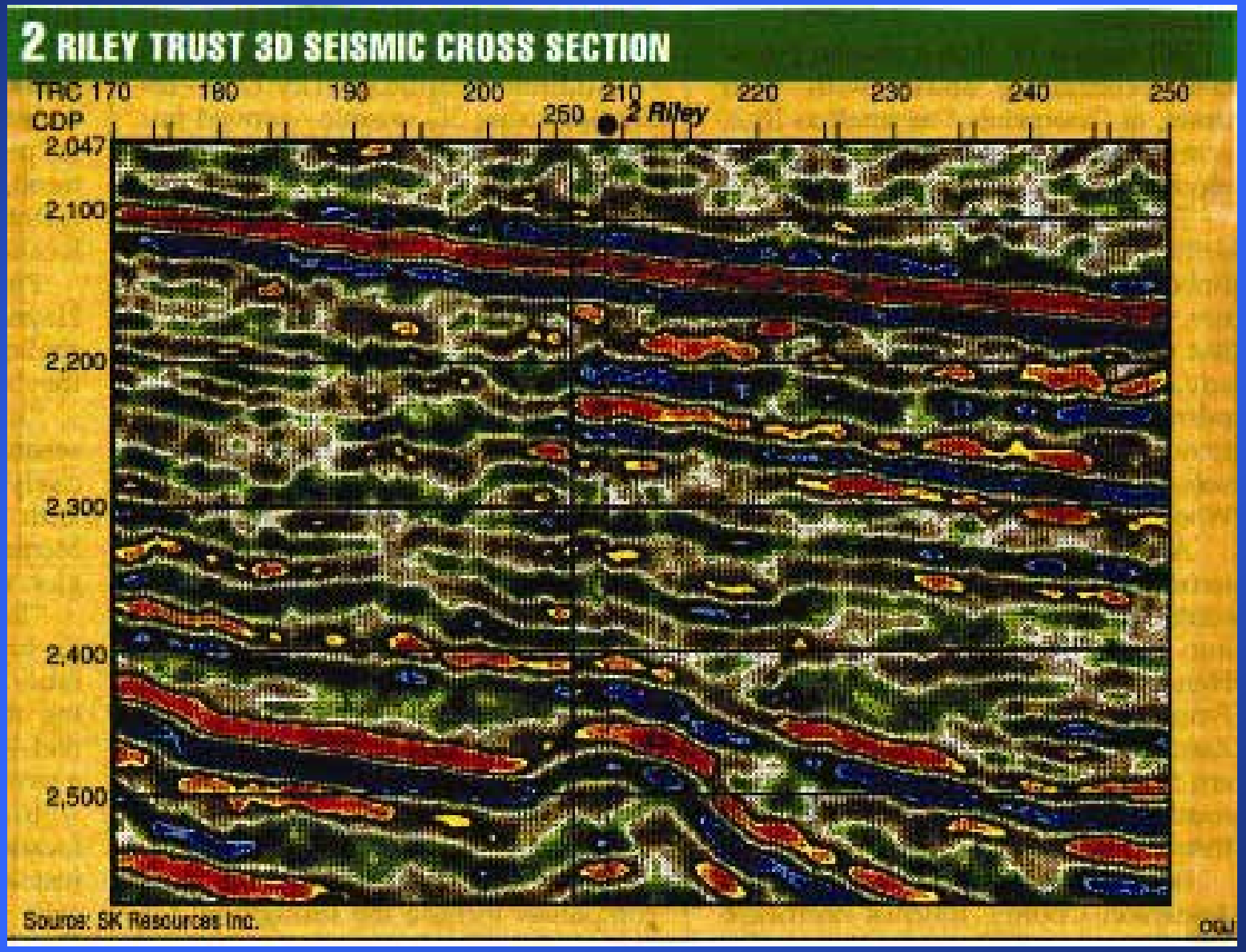
When is 3D Seismic Not Enough

- **When Important to Determine Hydrocarbon Charge**
- **When Composition is Important (Oil versus Gas)**
- **When Quality of Seismic Data is Poor Due to Unfavorable Geology or Surface Conditions**
- **When Targets or Reservoir Compartments are Difficult to Image Seismically**

Exploration Examples

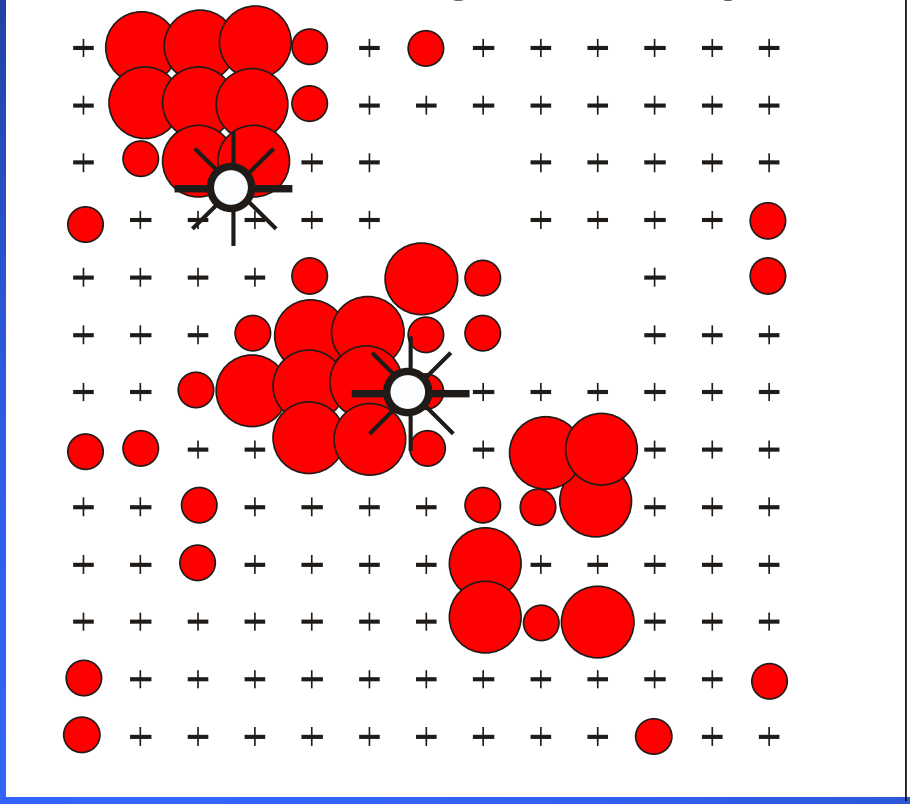
- Cotton Valley Reefs, East Texas
- Pennsylvanian Channel Sands, Oklahoma
- Fort Worth Basin, North Texas
- Morrow Channel Sands, Texas Panhandle
- Old Field, Western Venezuela

Cotton Valley Pinnacle Reef, 3D Seismic

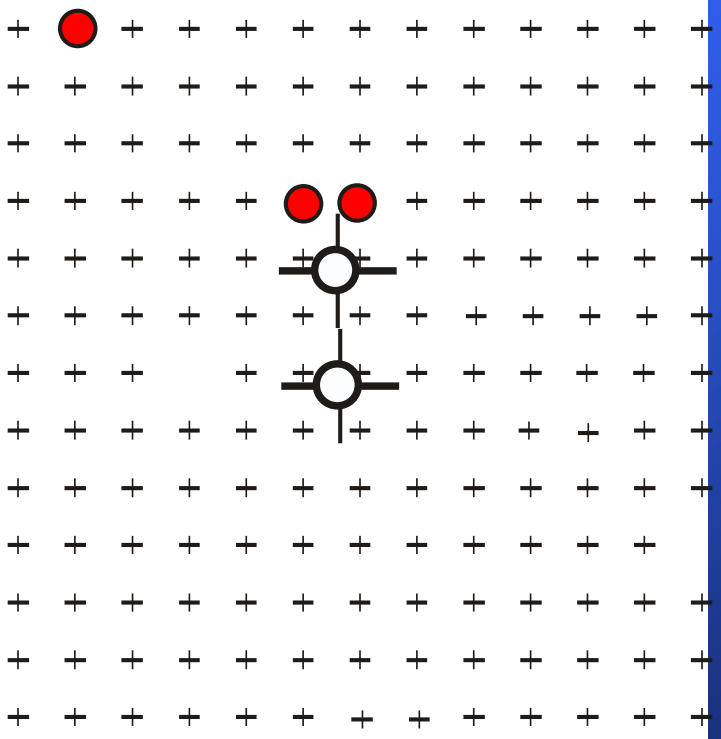


Cotton Valley Pinnacle Reefs
Microbial Survey Method

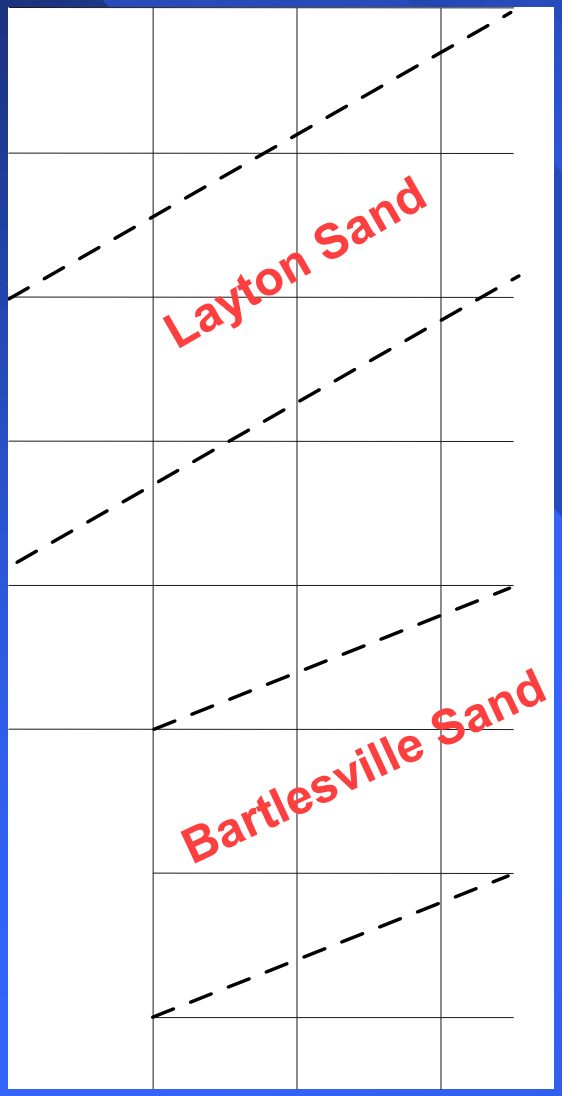
Area A -- Producing Reef Prospects

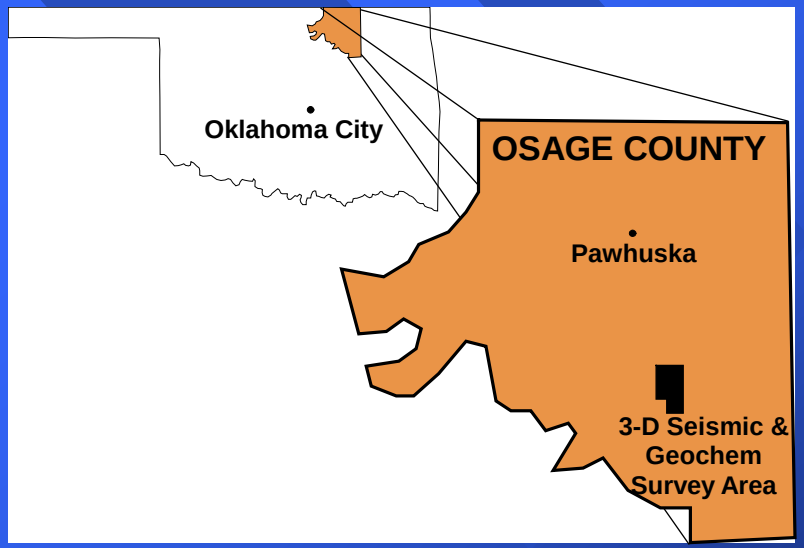


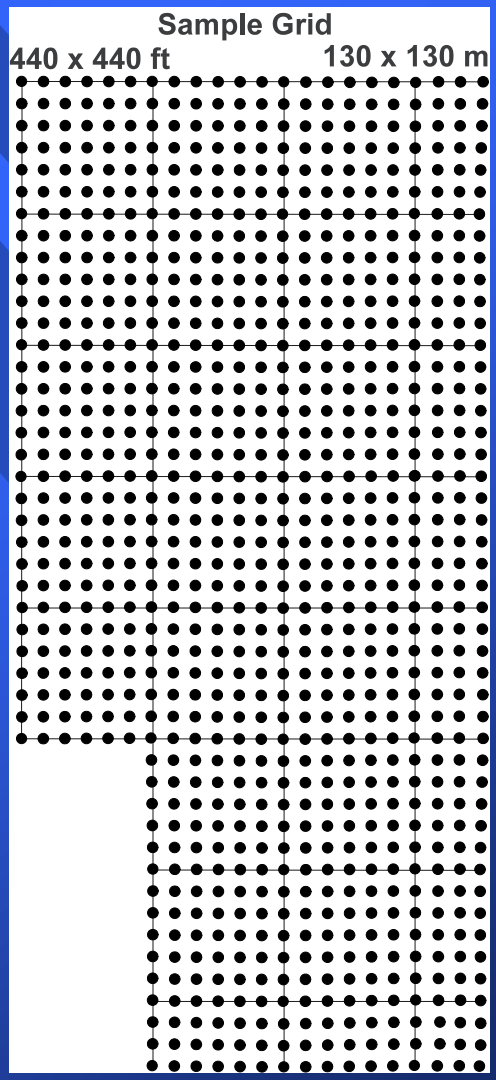
Area C -- Dry Hole Reef



Pennsylvanian Channel Sands
Osage County, Oklahoma







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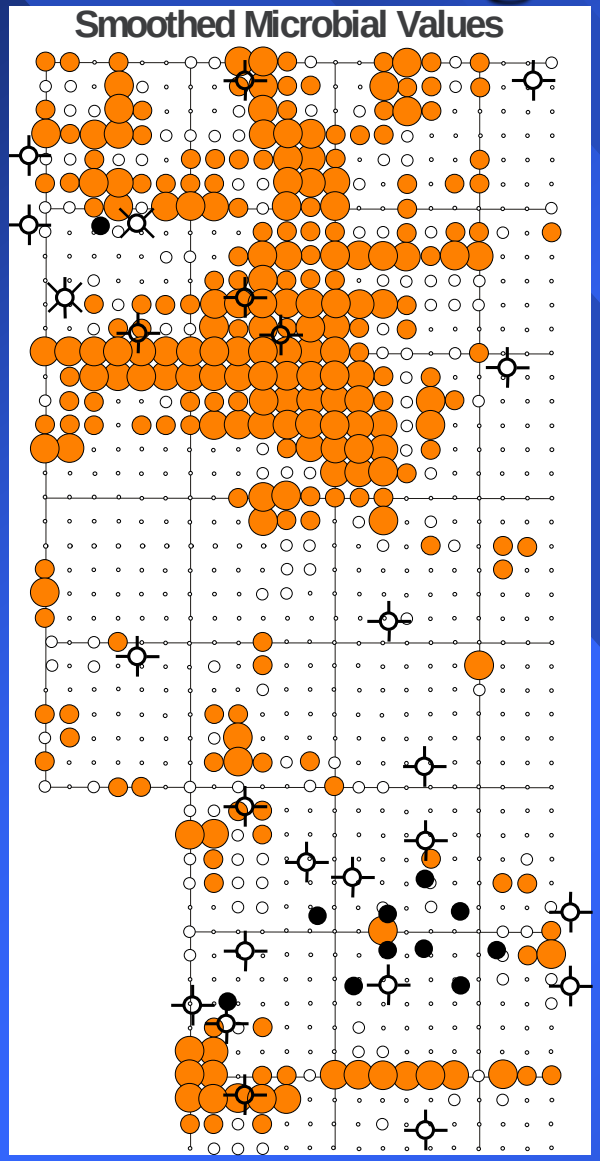
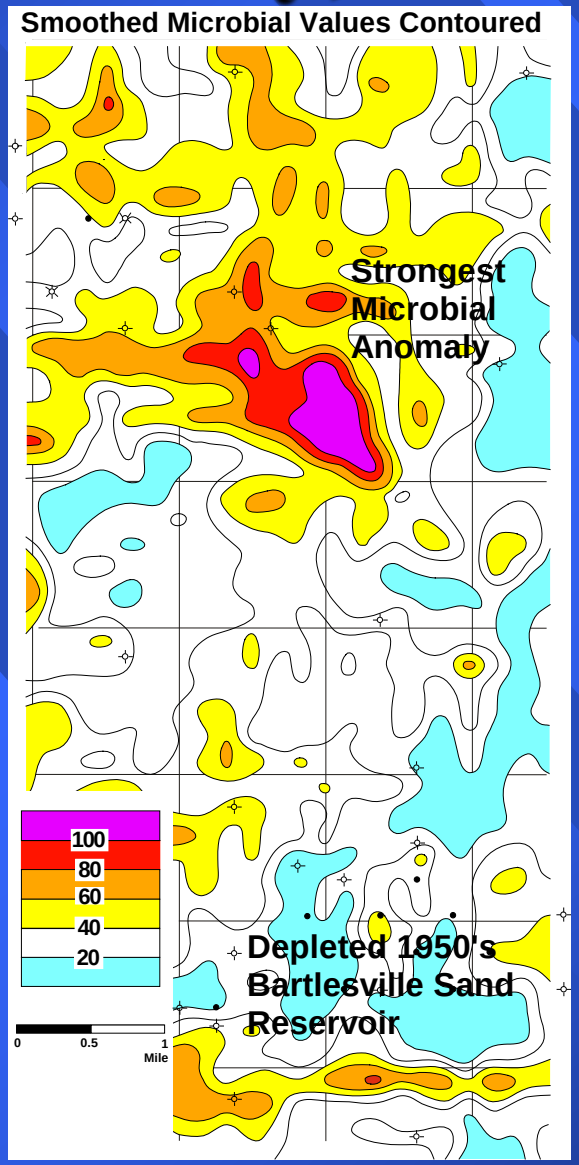
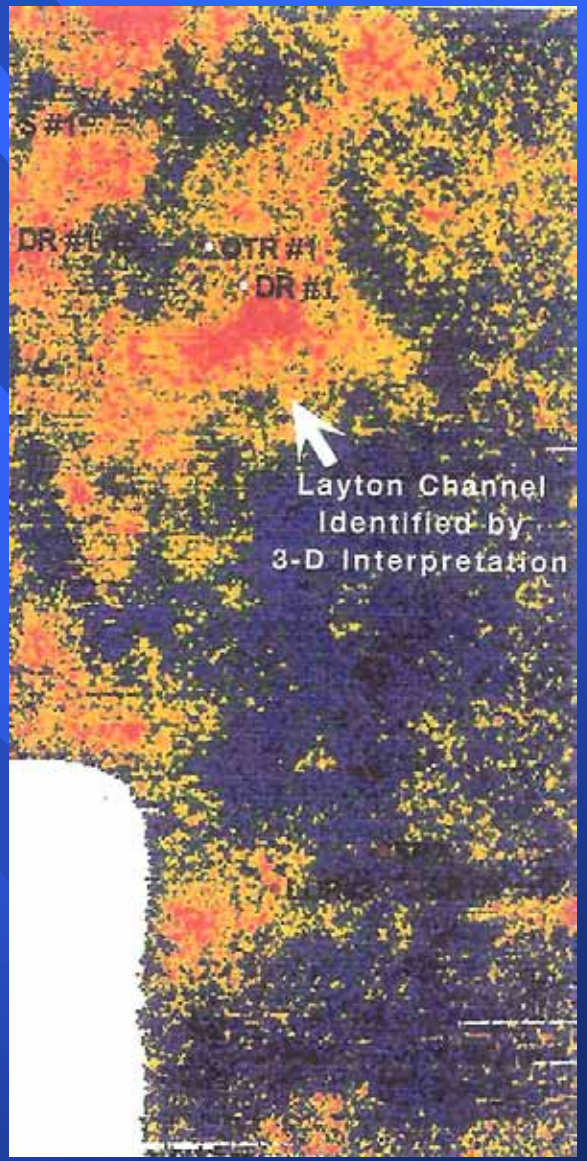
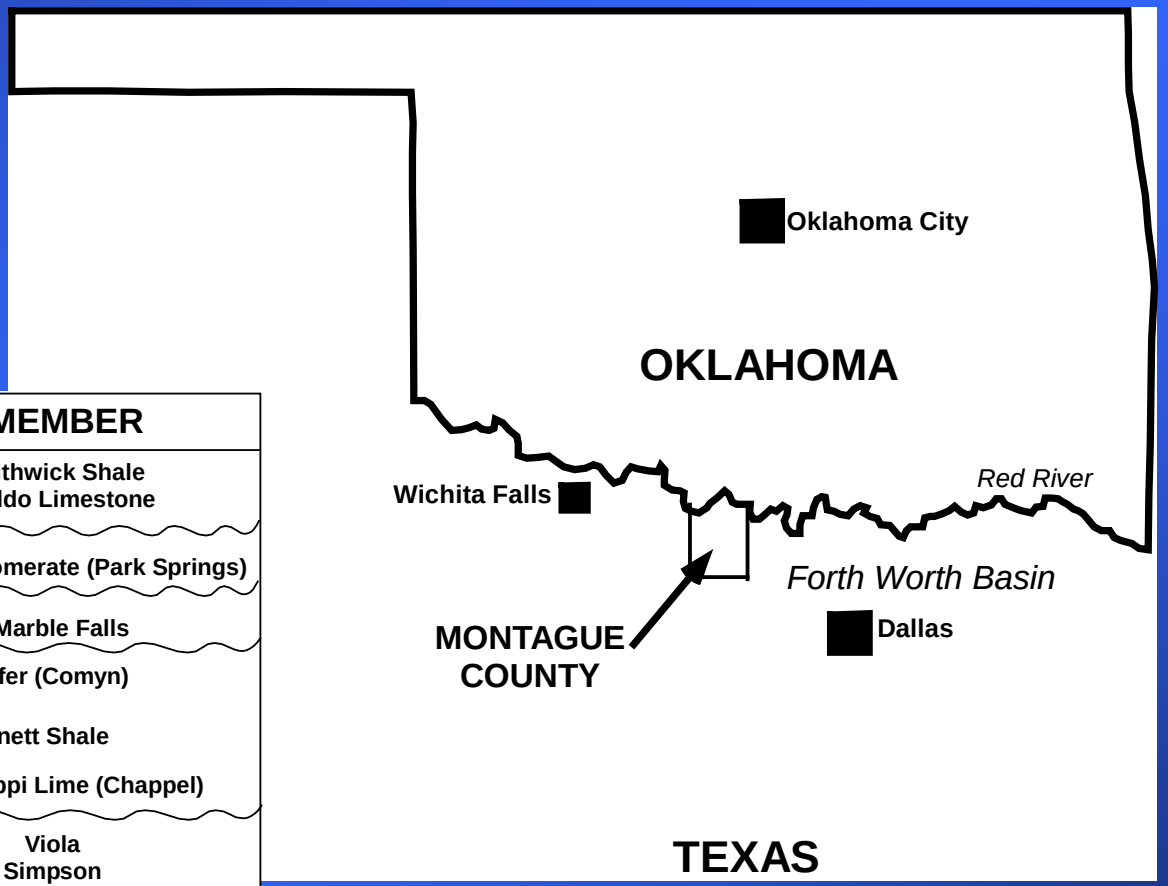




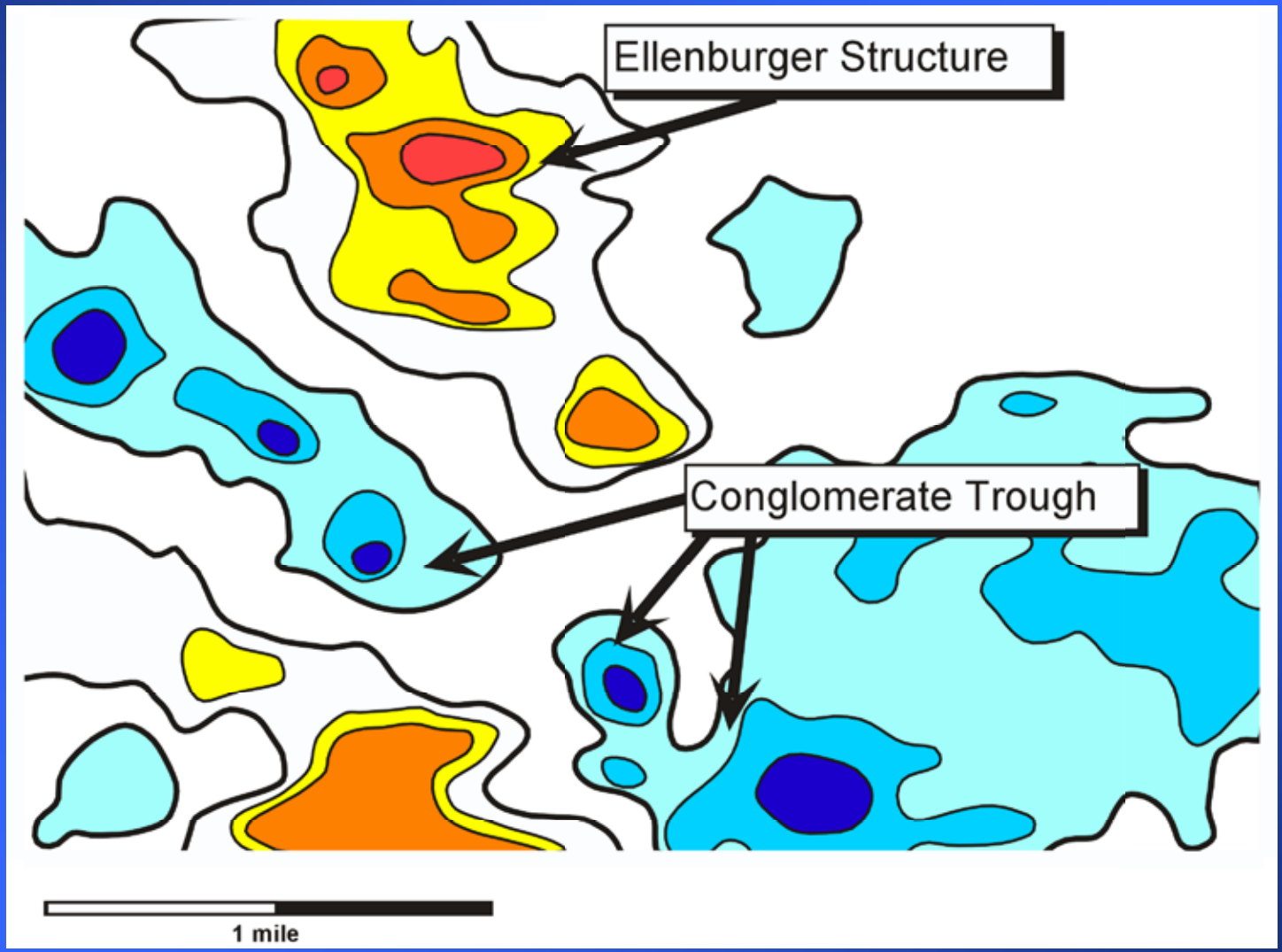


Ft Worth Basin Case History

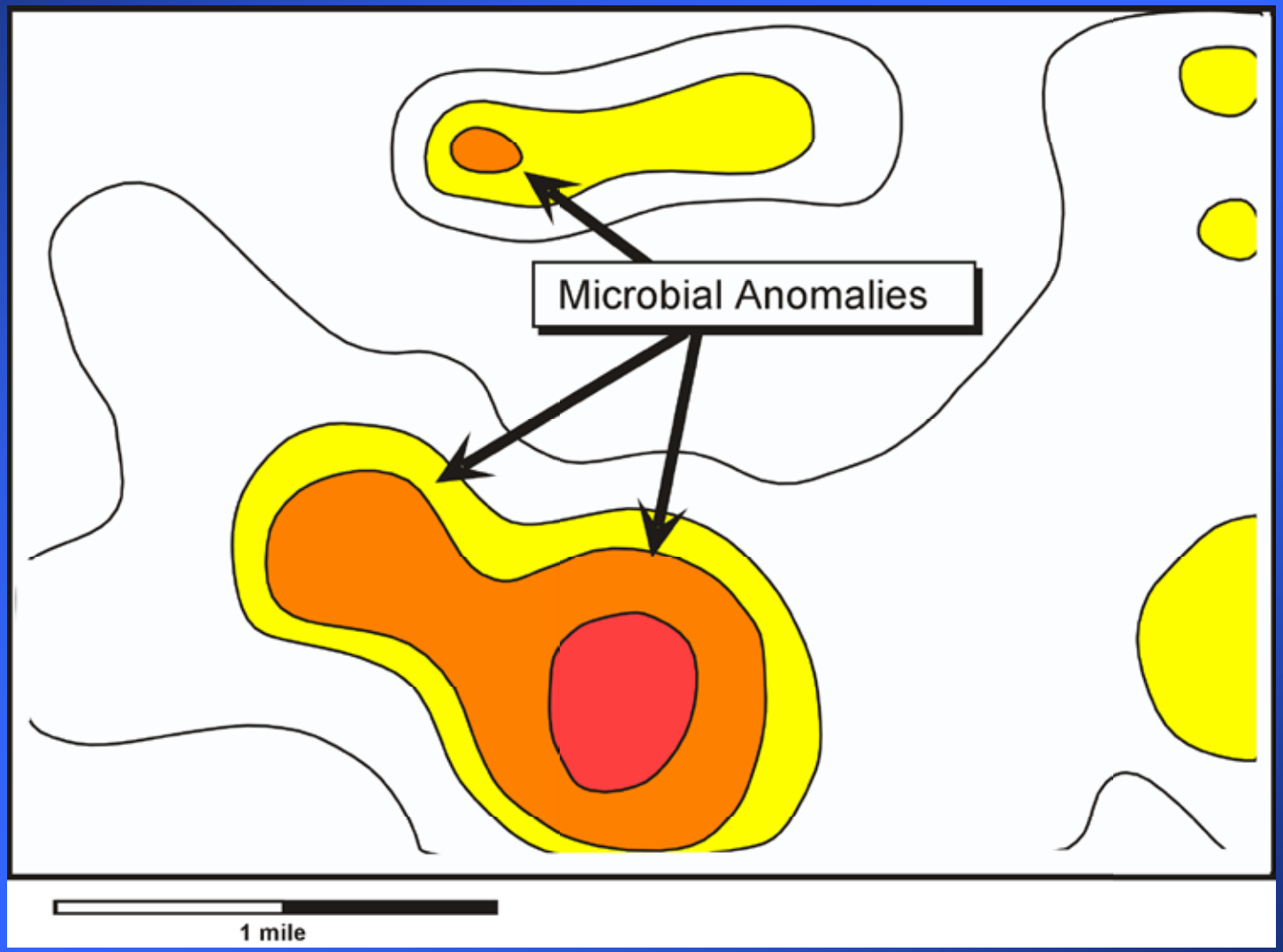
SYSTEM	SERIES	MEMBER
Pennsylvania	Des Moinesian	Smithwick Shale Caddo Limestone
	Atokan	Bend Conglomerate (Park Springs)
	Morrowan	Marble Falls
Mississippian	Chesterian	Duffer (Comyn)
	Meramecian	Barnett Shale
	Osagean	Mississippi Lime (Chappel)
Ordovician		Viola Simpson
Cambrian		Ellenburger (Salona sand)
		Hickory Sand Granite Wash



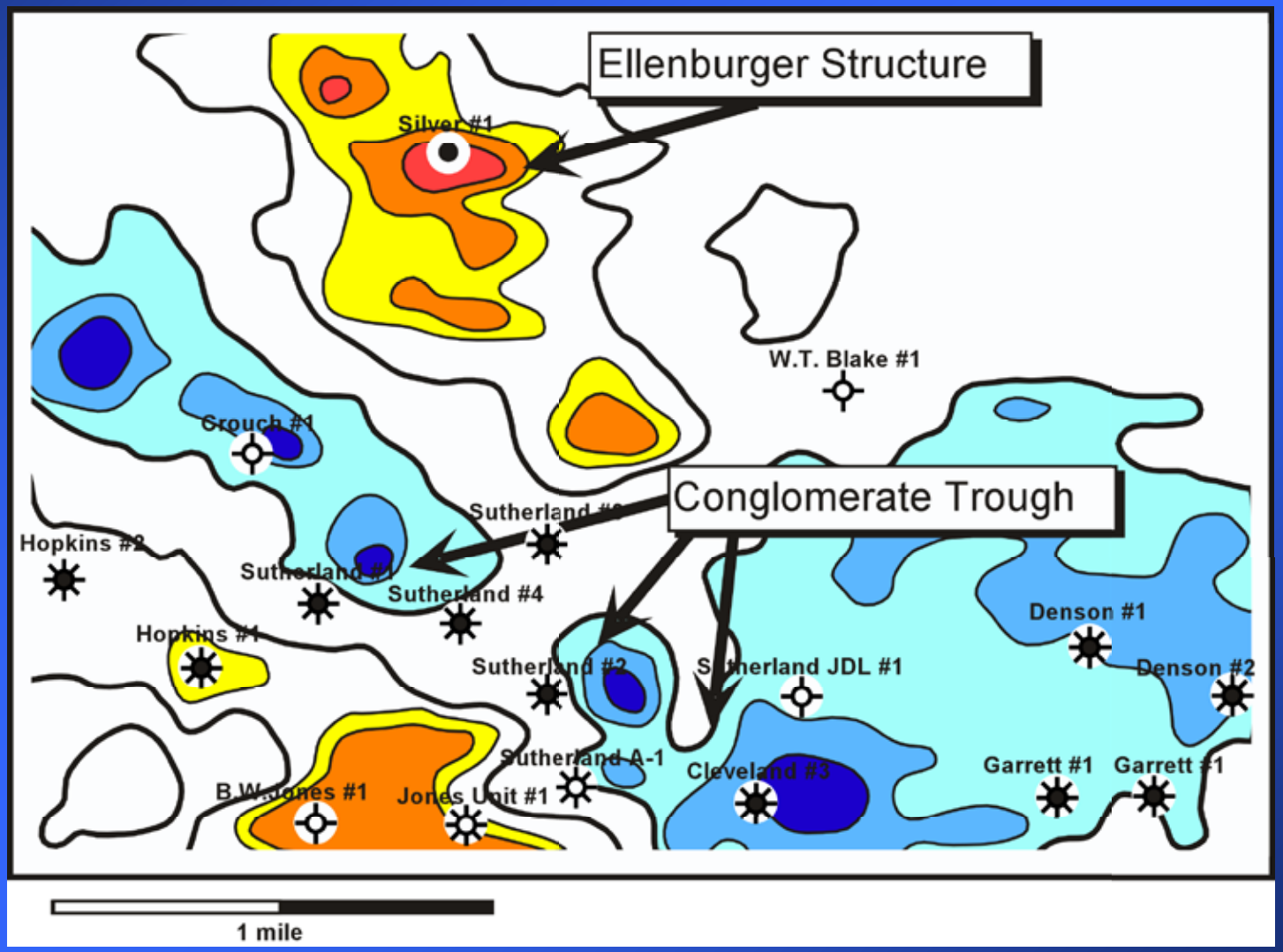
Ft Worth Basin Texas
3D Seismic Survey



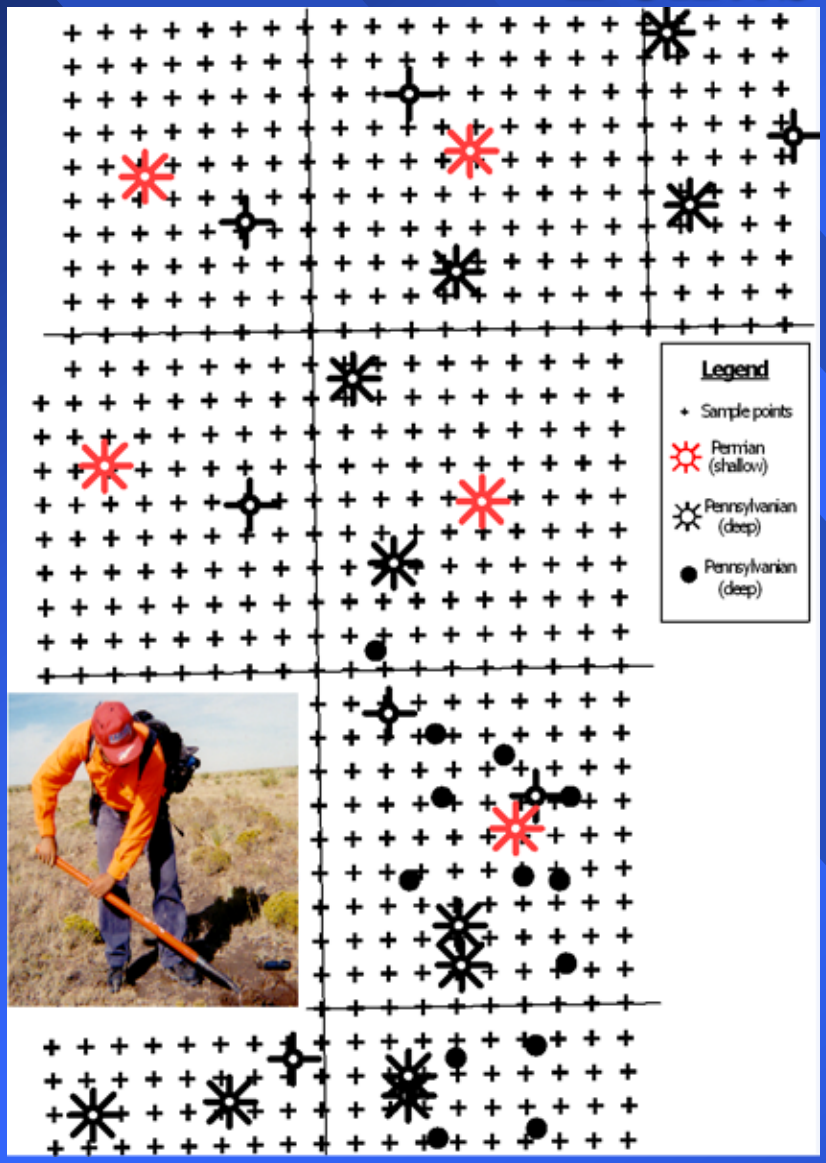
Ft Worth Basin Texas Microbial Values



Ft Worth Basin History



Pennsylvanian Channel Sands
Texas Panhandle



Geologic Setting

Widespread shallow Permian gas production and more recent deeper Pennsylvanian oil and gas prospects

Survey Objective

High-grade seismically-defined Pennsylvanian Morrow prospects on basis of probable hydrocarbon charge

Survey Method

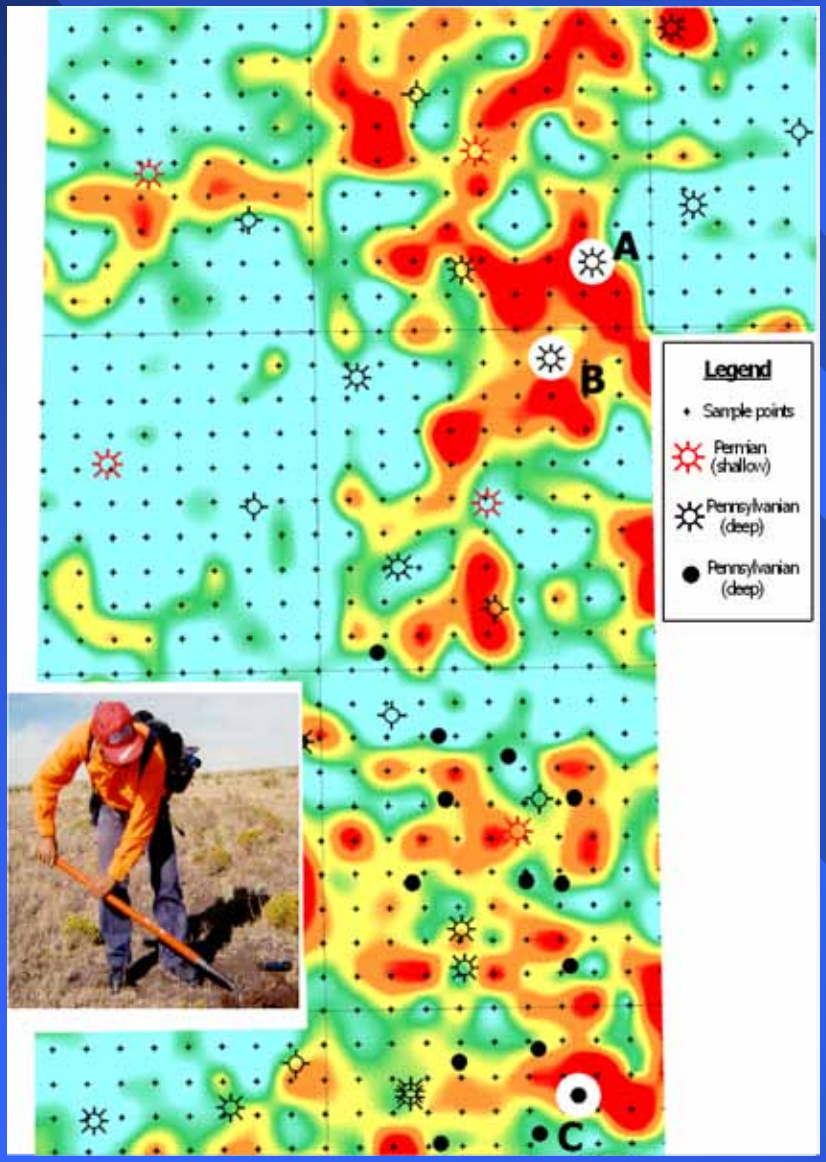
Microbial Oil Survey Technique (MOST);

Soil samples from depth of 8 in. (20 cm.)

Survey Design

Sample grid; 0.1 mile (160m) interval

Pennsylvanian Channel Sands
Texas Panhandle



Geologic Setting

Widespread shallow Permian gas and more recent deeper Pennsylvanian oil and gas.

Survey Objective

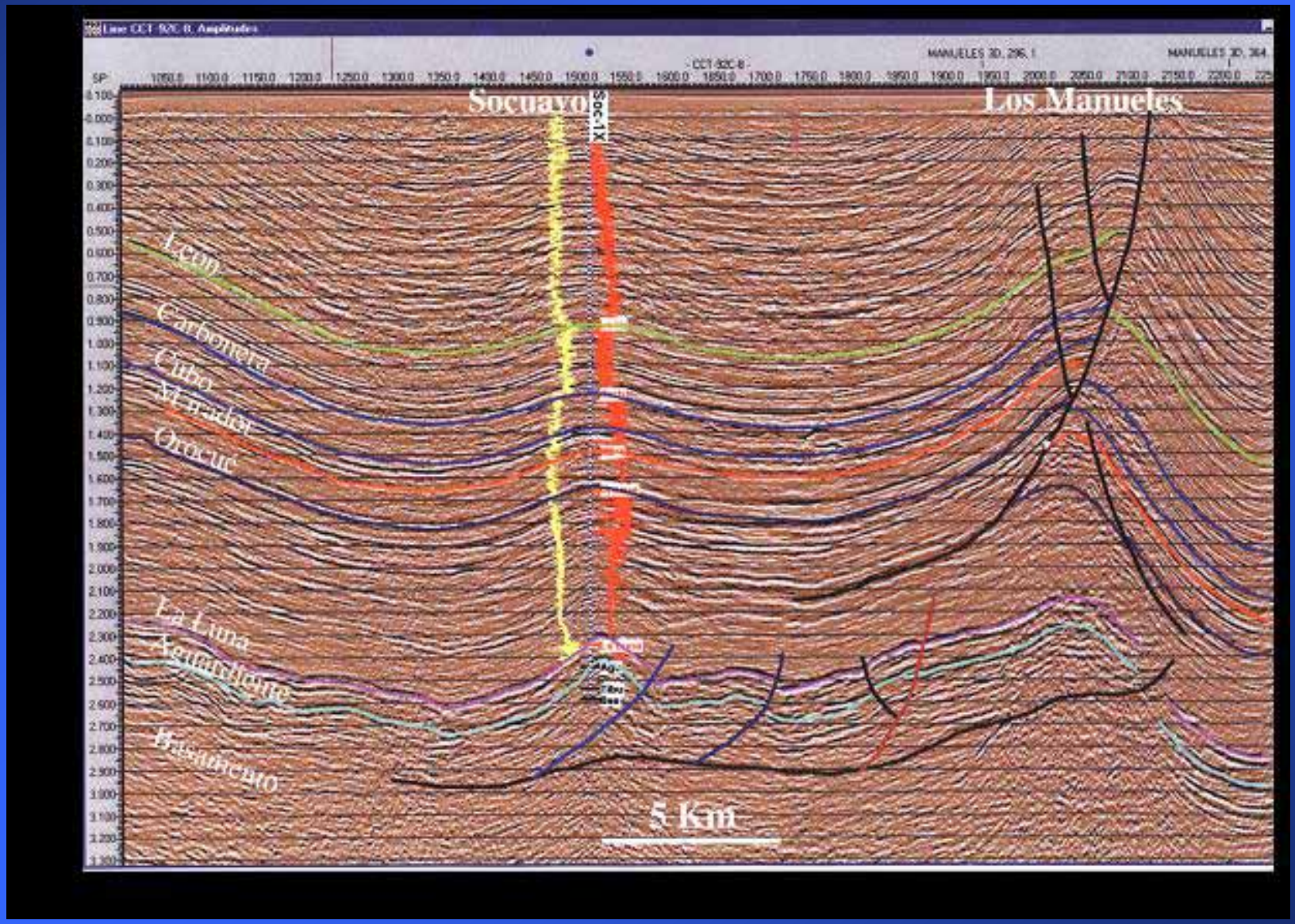
High-grade seismically-defined Morrow prospects on basis of probable charge.

Results

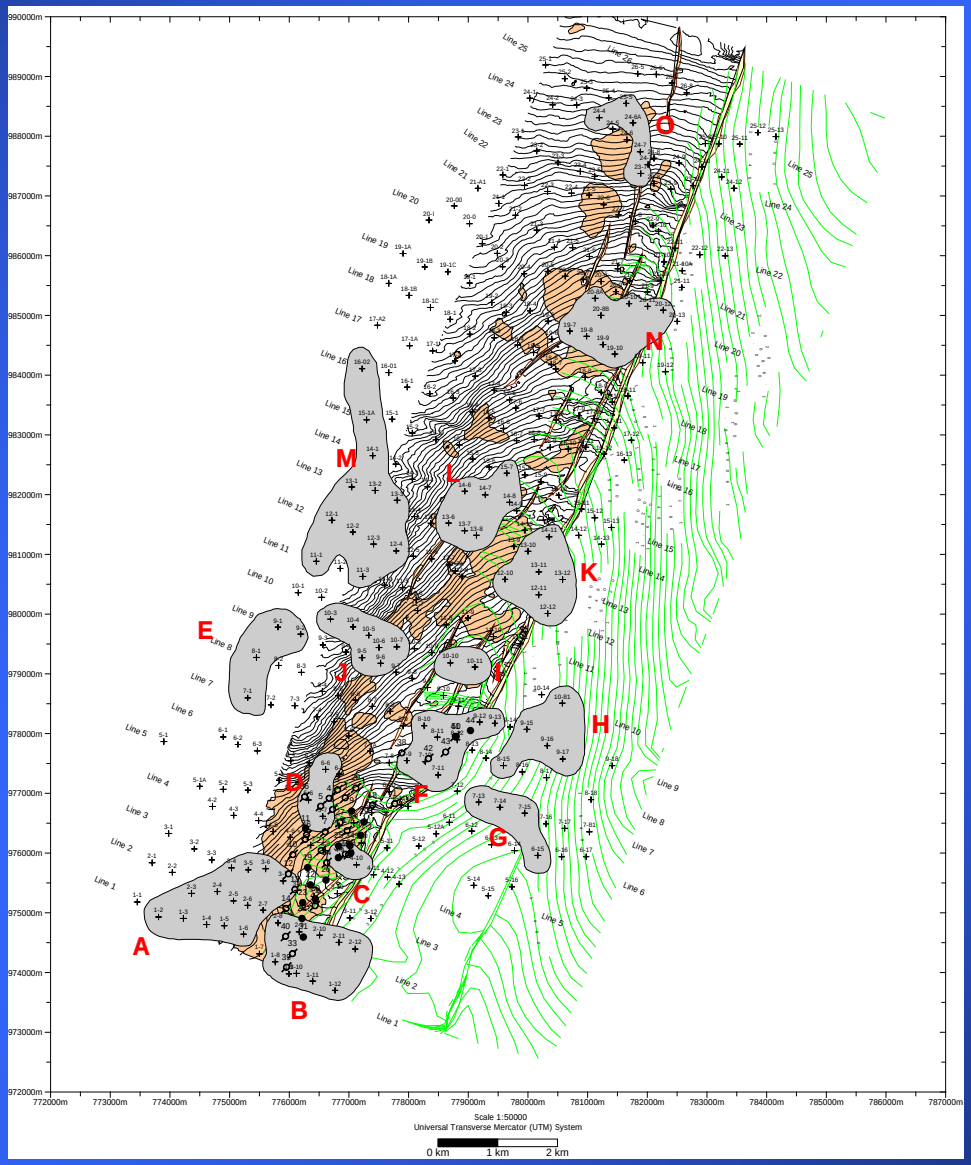
Wells A and B targeted thickening Pennsylvanian channel sands. Well A produced 9 mmcfg/day; Well B produced 2 mmcfg/day.

Offset Well C drilled next to 1980's oil field producing from structurally high algal mound. Well C located within microseepage anomay characteristic of by-passed pay (or undrained reservoir).

Los Manueles, Venezuela



Los Manueles, Venezuela



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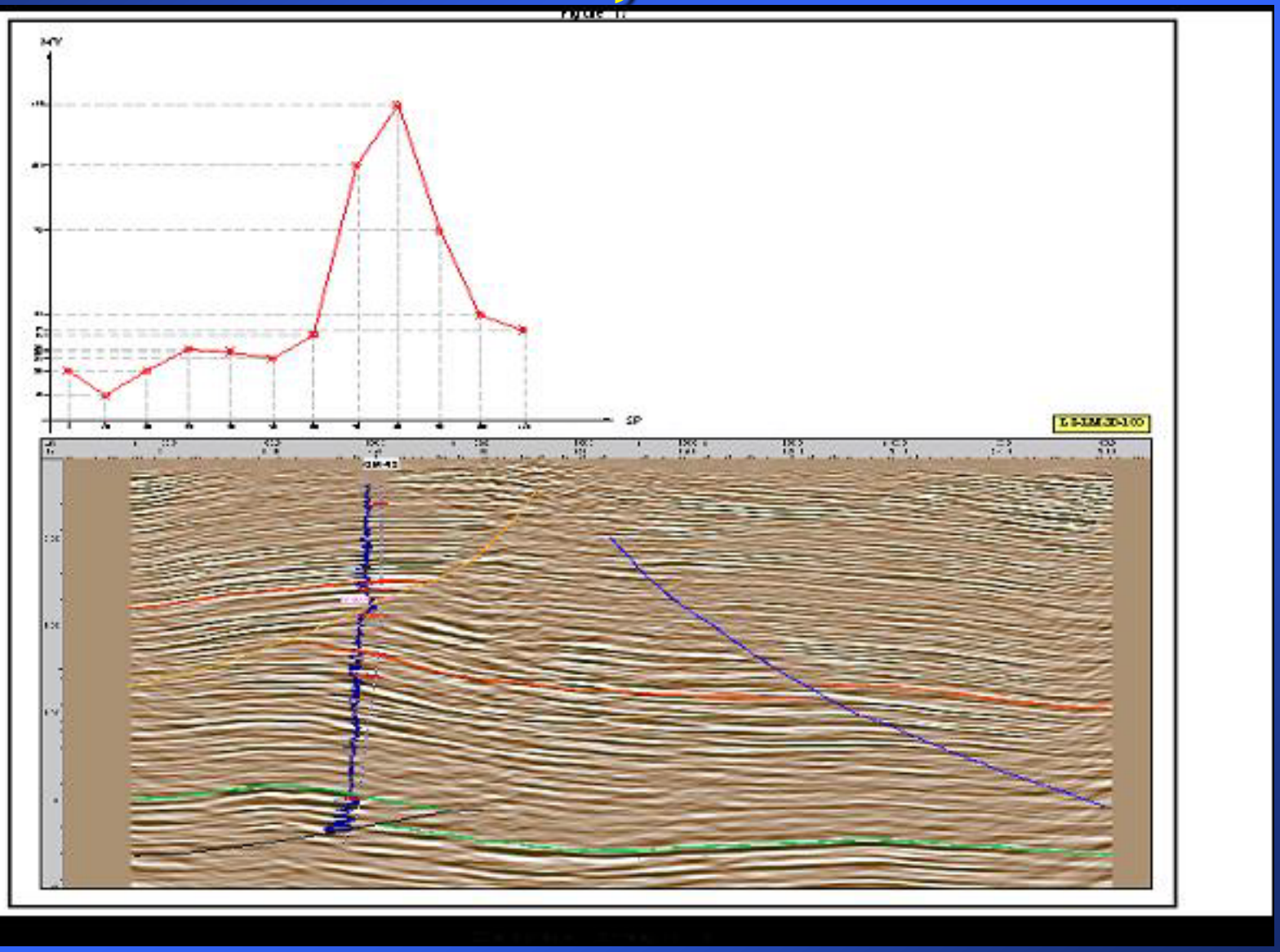


Summary

- 3D seismic data are unsurpassed for imaging trap and reservoir geometry, however, only detailed surface geochemical data can reliably detect hydrocarbon microseepage from those same reservoirs.

- Hydrocarbon microseepage data, properly acquired and interpreted, lead to better prospect evaluation and risk assessment.

Reducing Exploration Risk
Post-Survey Drilling Results

SUMMARY

2766 Wells, Various Companies, Various Methods, Various Basins

In Negative Anomalies

- 1425 Wells Drilled
- 1267 Wells Dry (89%)
- 158 Discoveries (11%)

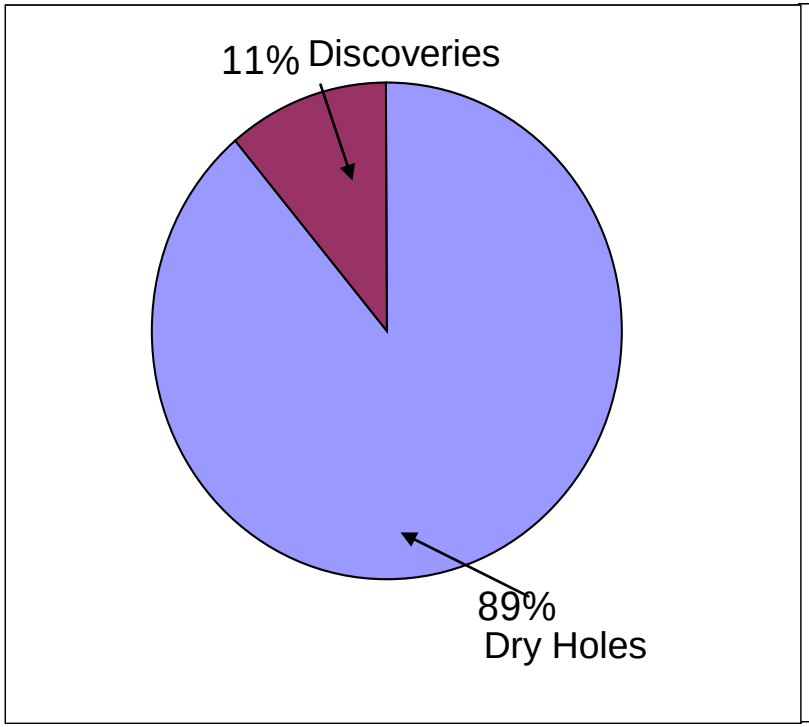
In Positive Anomalies

- 1341 Wells Drilled
- 244 Wells Dry (18%)
- 1097 Discoveries (82%)

Summary

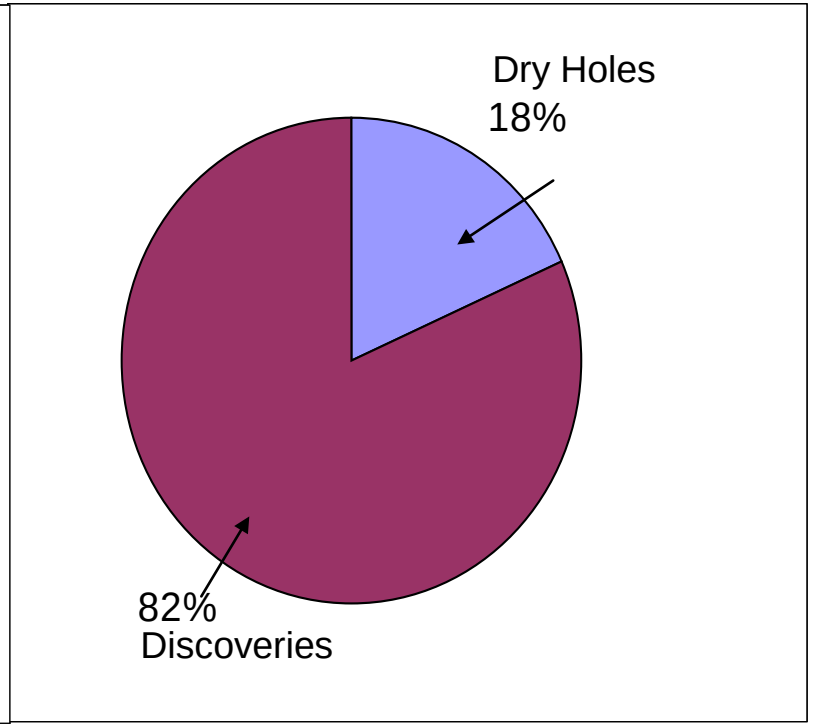
2766 Wells, Various Companies, Various Basins, Various methods

Negative Anomaly



1425 Wells Drilled

Positive Anomaly



1341 Wells Drilled

Summary

High-resolution microseepage surveys, properly integrated with geologic and seismic data have lead to:

- **the discovery of new reserves in old fields**
- **drilling of fewer dry or marginal wells**
- **better placement of in-fill or step-out wells**