PROJECT TITLE

Application of Cutting-Edge 3-D Seismic Attribute Technology to the Assessment of Geological Reservoirs for CO2 Sequestration

Presenter: Tom Bjorklund, Department of Geosciences, University of Houston

CONTRIBUTORS

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Consultant

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OUTLINE OF PRESENTATION

- Introduction to seismic attributes
- Description of project
- Highlights of the past year
- Planned work flow

Seismic attributes: A working definition

A seismic attribute is any measure of seismic data that helps to better visualize or characterize subsurface features of interest.

There are hundreds of statistically valid 'special' attributes!

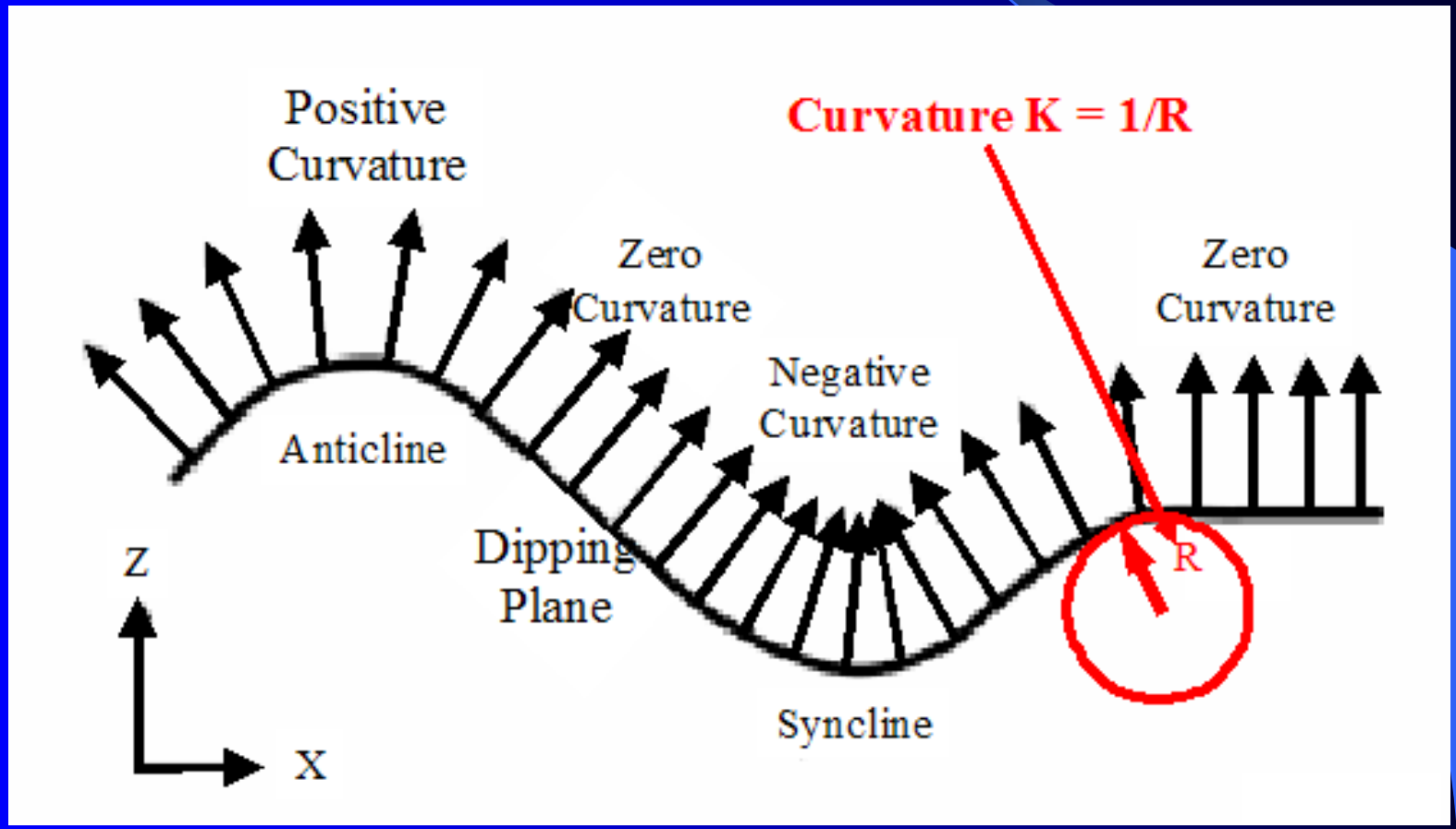
(after Marfurt, 2006)

Some commonly applied attributes

- **Dip and azimuth:** Estimates of reflector orientation
- **Curvature:** Estimate of reflector shape
- **Coherence:** Measure of waveform similarity
- **Amplitude filter:** Change in amplitude along a reflector
- **Impedance:** Correlative with layer properties

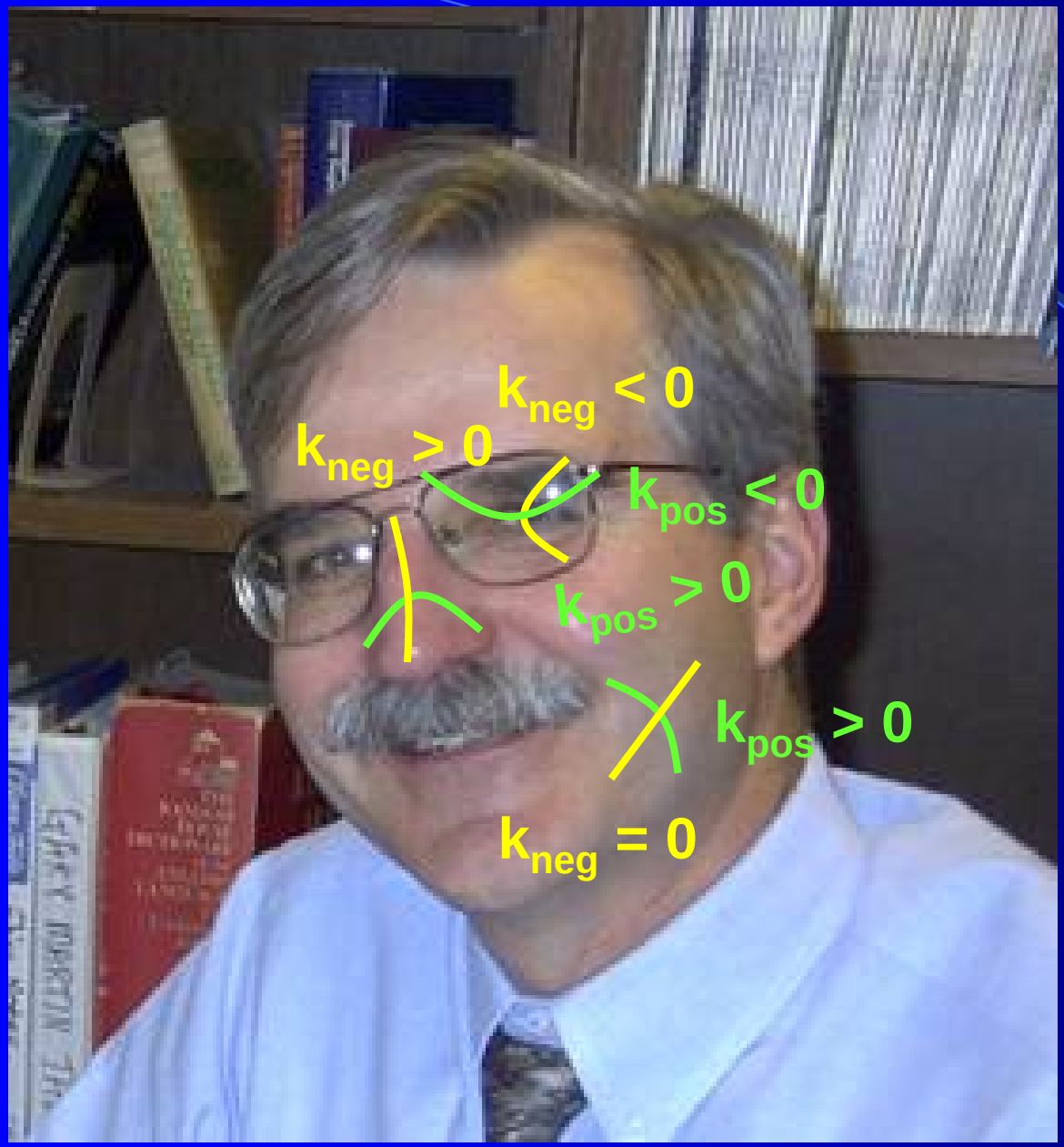
The concept of curvature

Curvature (k) is approximately the rate of change of slope of a reflector. Sign convention is: Anticlinal: $k > 0$, Planar: $k = 0$, Synclinal: $k < 0$.



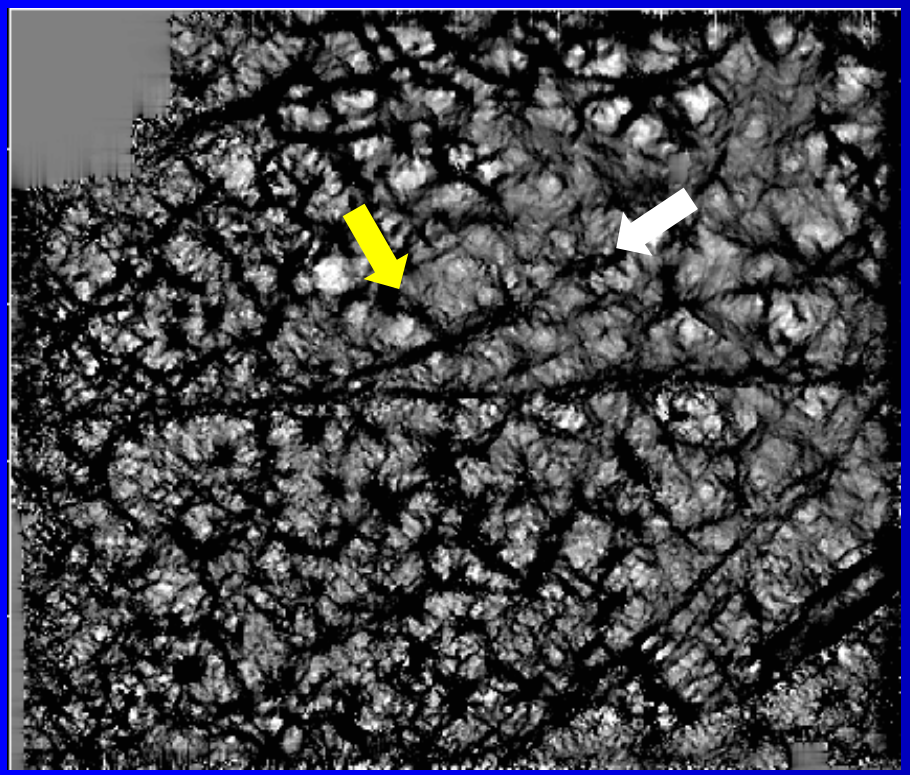
(Roberts, 2001)

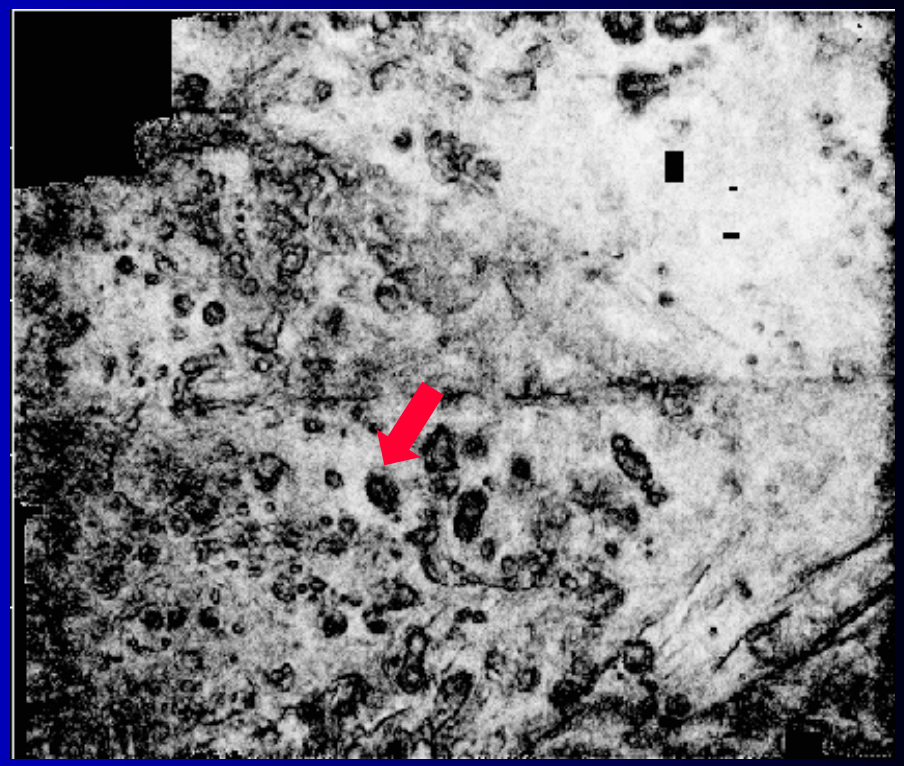
Kurt Marfurt, 2006



Curvature and Biometric Identification of Suspicious Travelers

Attribute time slices of Ellenburger Formation





Most negative curvature map

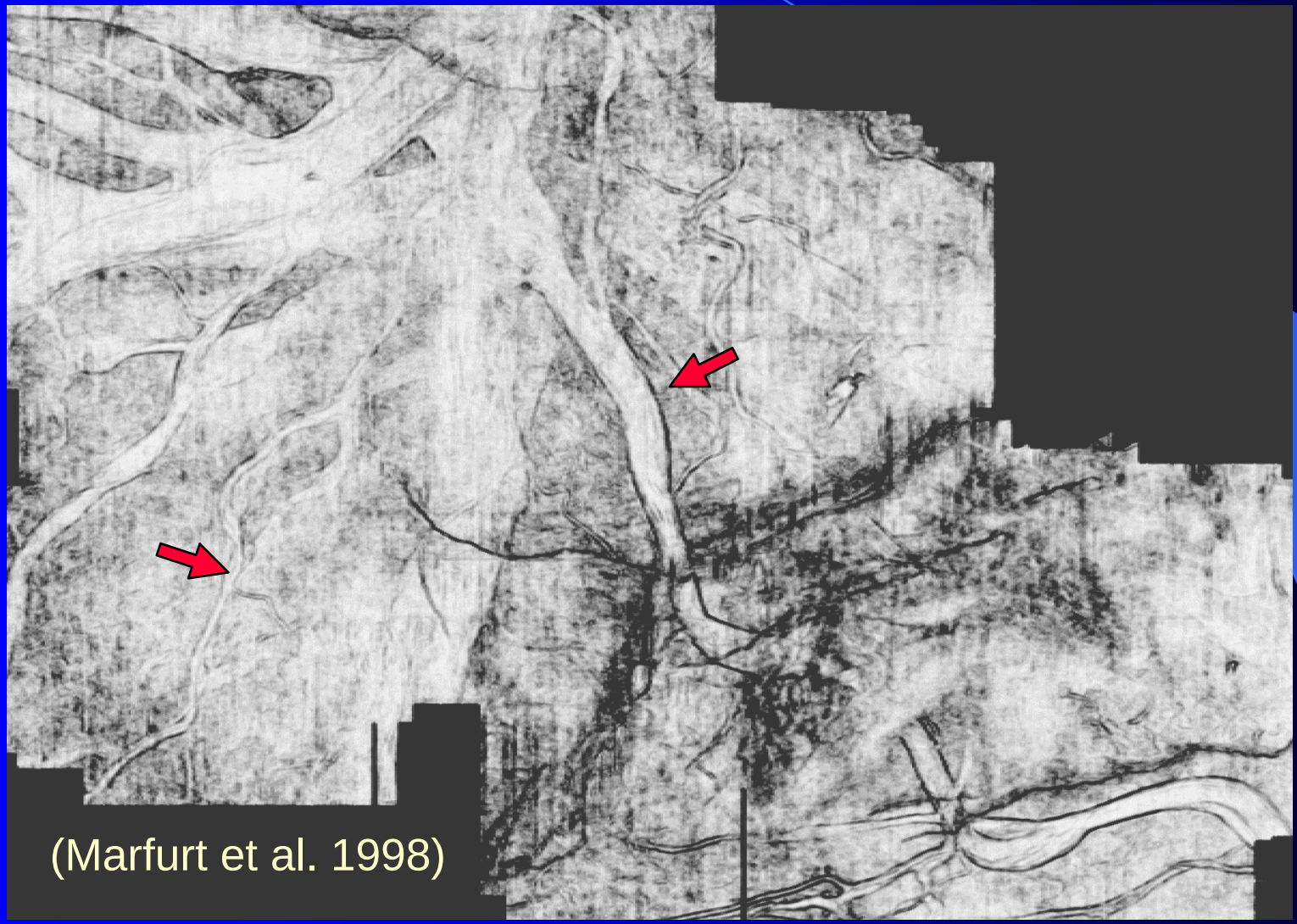
5 km

Coherence map

(al-Dossary and Marfurt, 2006)

Map view of coherence attribute

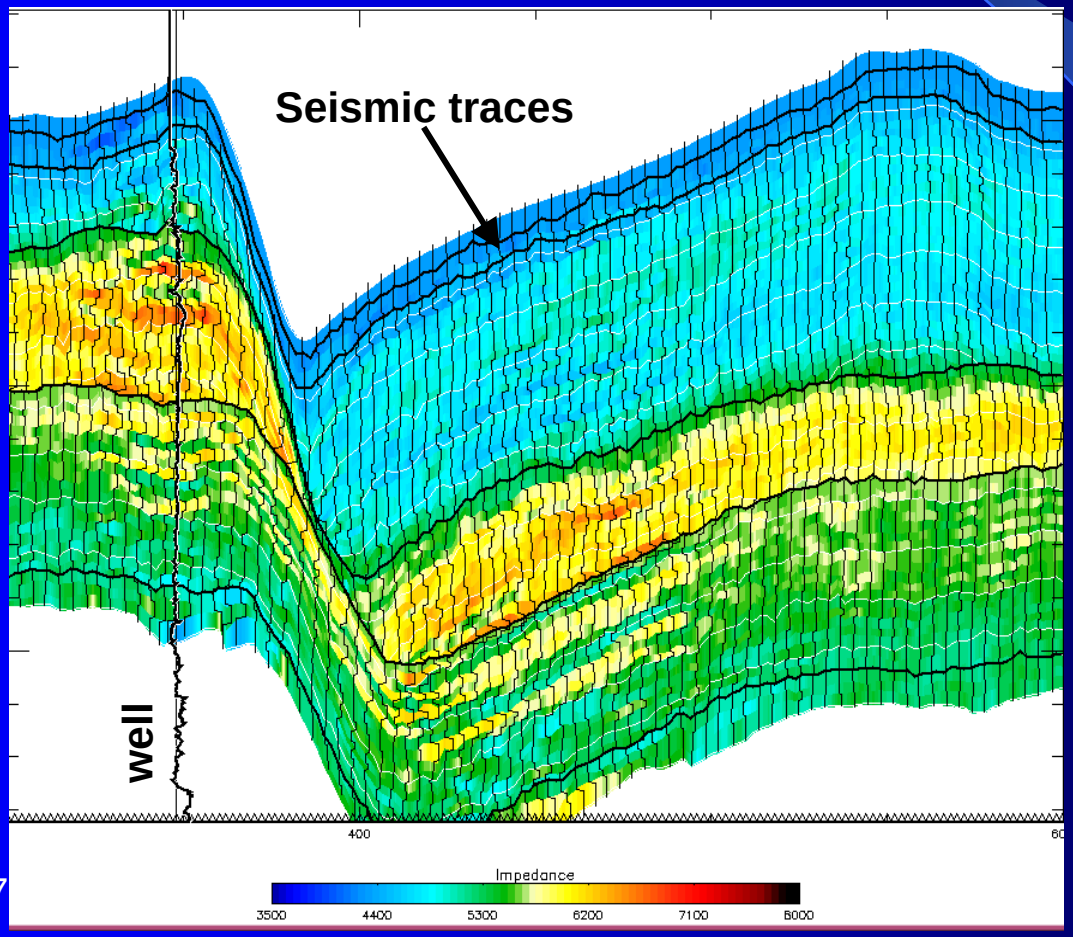
Used to map the areal distribution of a Pleistocene-age Mississippi river distributary channel system in the subsurface.



(Marfurt et al. 1998)

Cross section of impedance volume

Used to extrapolate well log derived values (e.g., reservoir lithology, thickness, porosity, or hydrocarbon saturation) into areas of no well data.



(Veekan et al, 2002)

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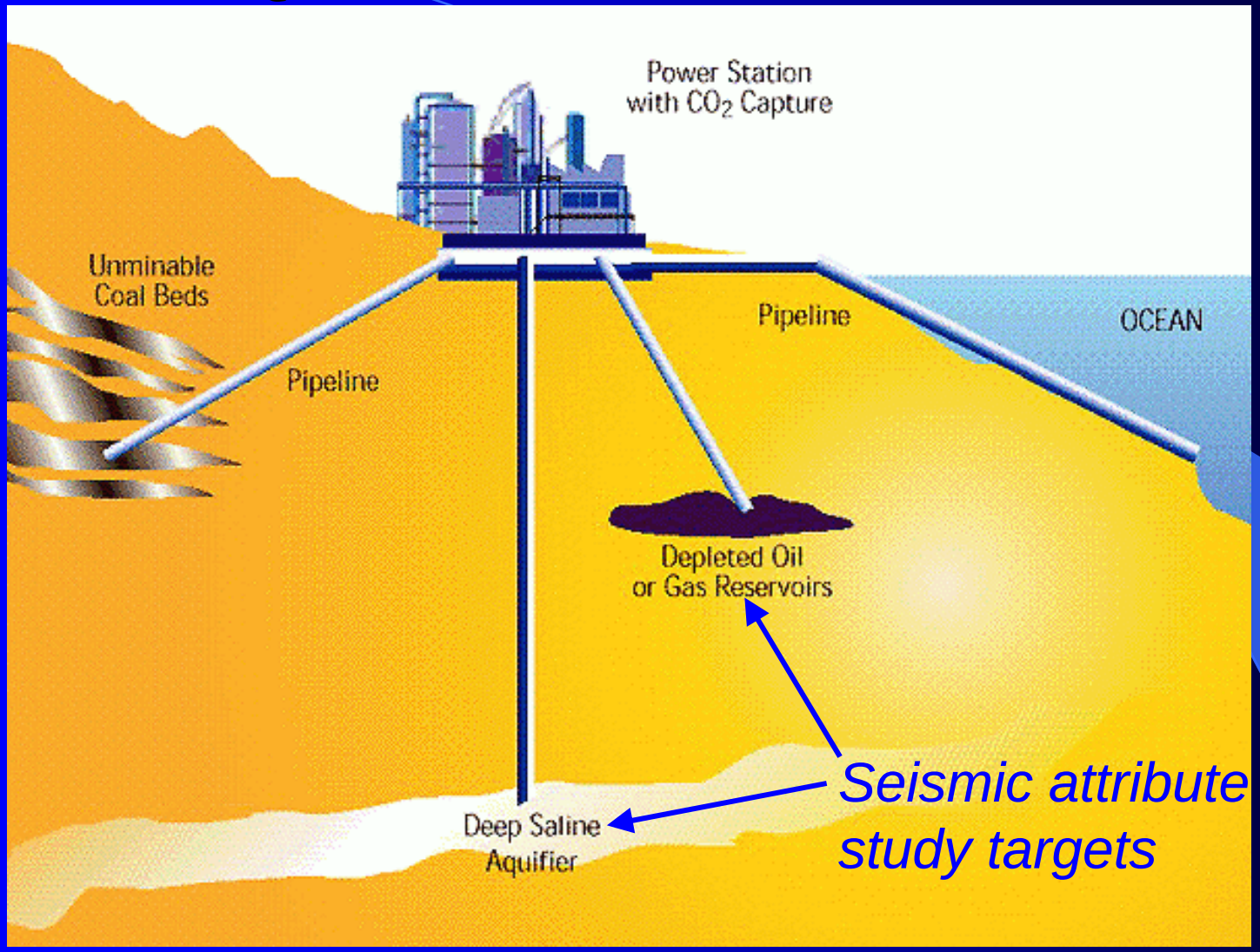
CO2 SEQUESTRATON POSSIBILITIES



From: International Energy Agency Greenhouse Gas R&D Program

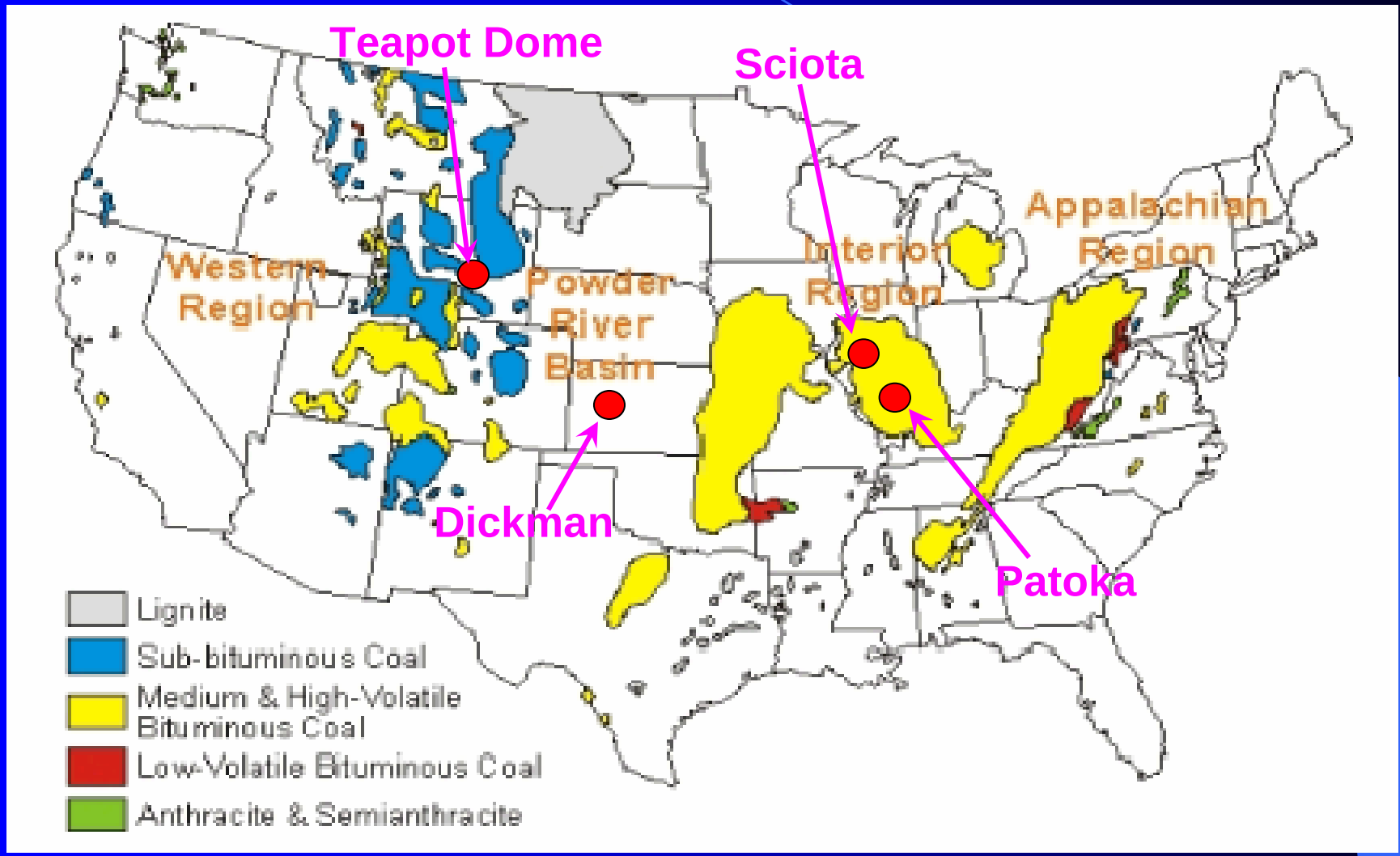
CO2 SUBSURFACE STORAGE OBJECTIVES

- Provide for large storage capacity
- Ensure long-term storage
- Minimize increases in electricity costs

SPECIFIC PROJECT OBJECTIVES

- Use seismic attributes to map 3-D reservoir properties (*thickness, porosity, permeability and hc saturation*) of subsurface targets.
- Construct a reservoir model and validate with simulation studies of production.
- Use model to predict CO2 injectivity and storage potential.

CO2 Sequestration Field Study Areas



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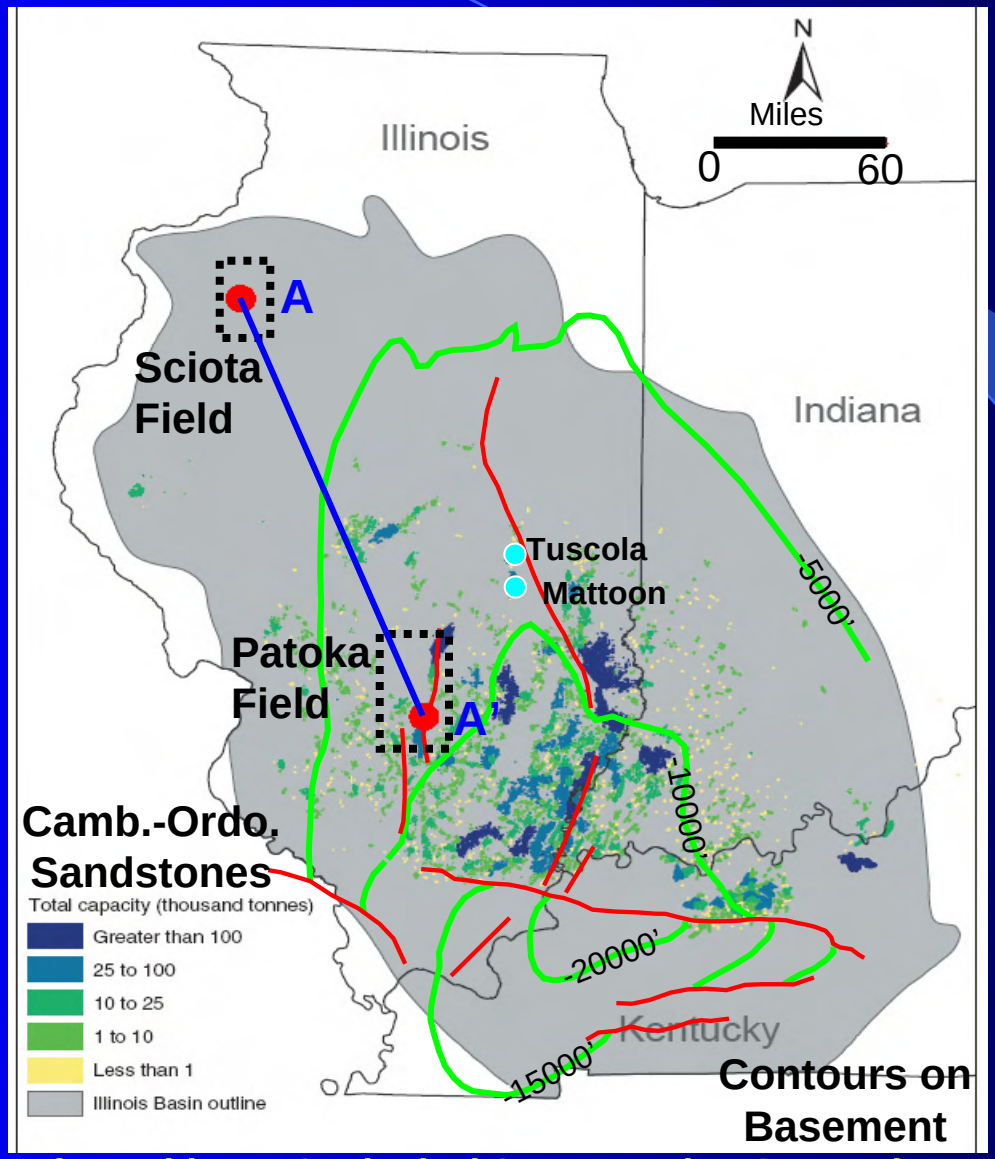
Patoka and Sciota Fields
Illinois Basin

6/19/2007

FutureGen – a DOE consortium project to build the world's cleanest coal-fueled power plant

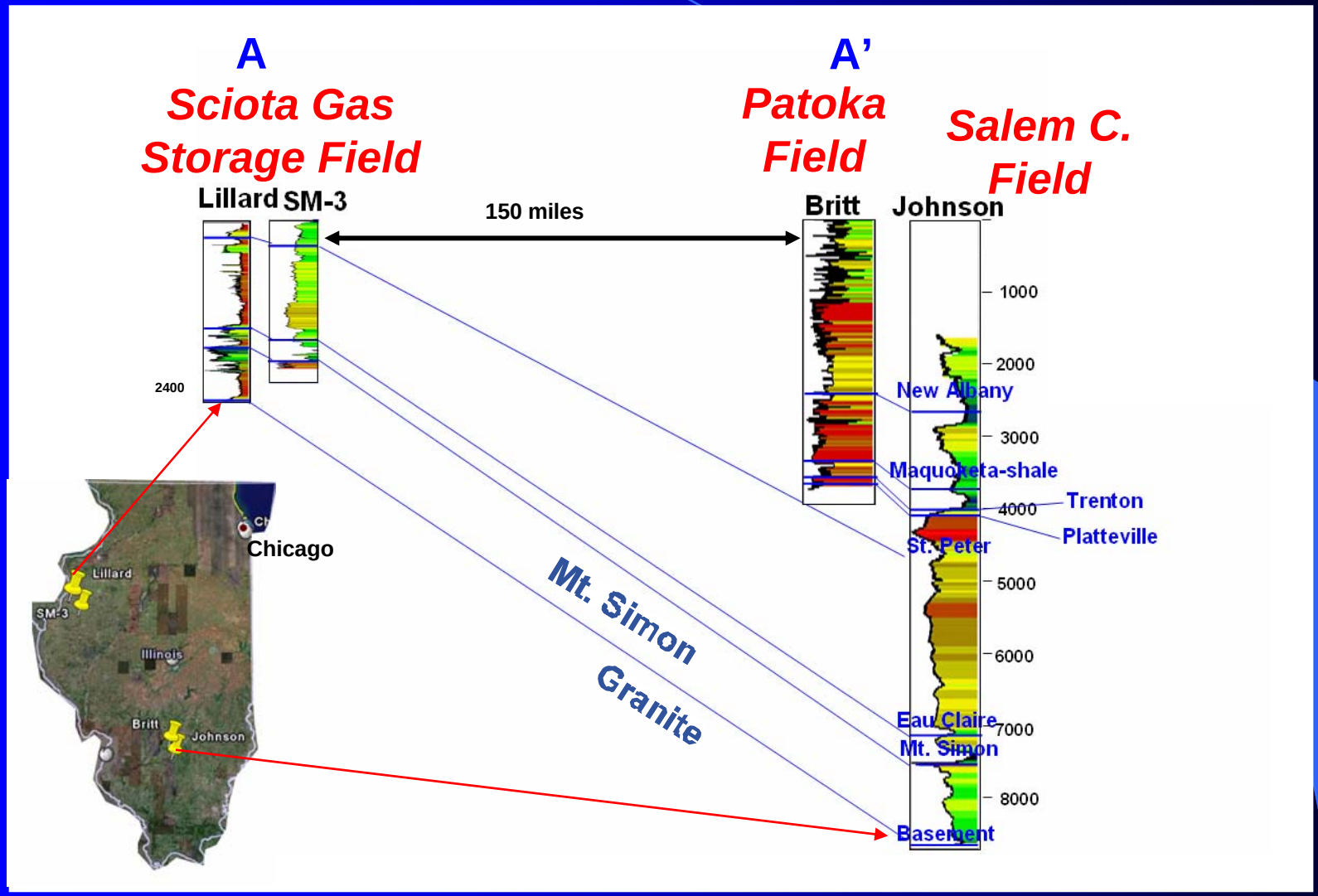
Possible sites: Mattoon, Ill.; Tuscola, Ill.; Jewett, Tex.; and Odessa, Tex.

Illinois Basin Map
CO2 Storage Capacity



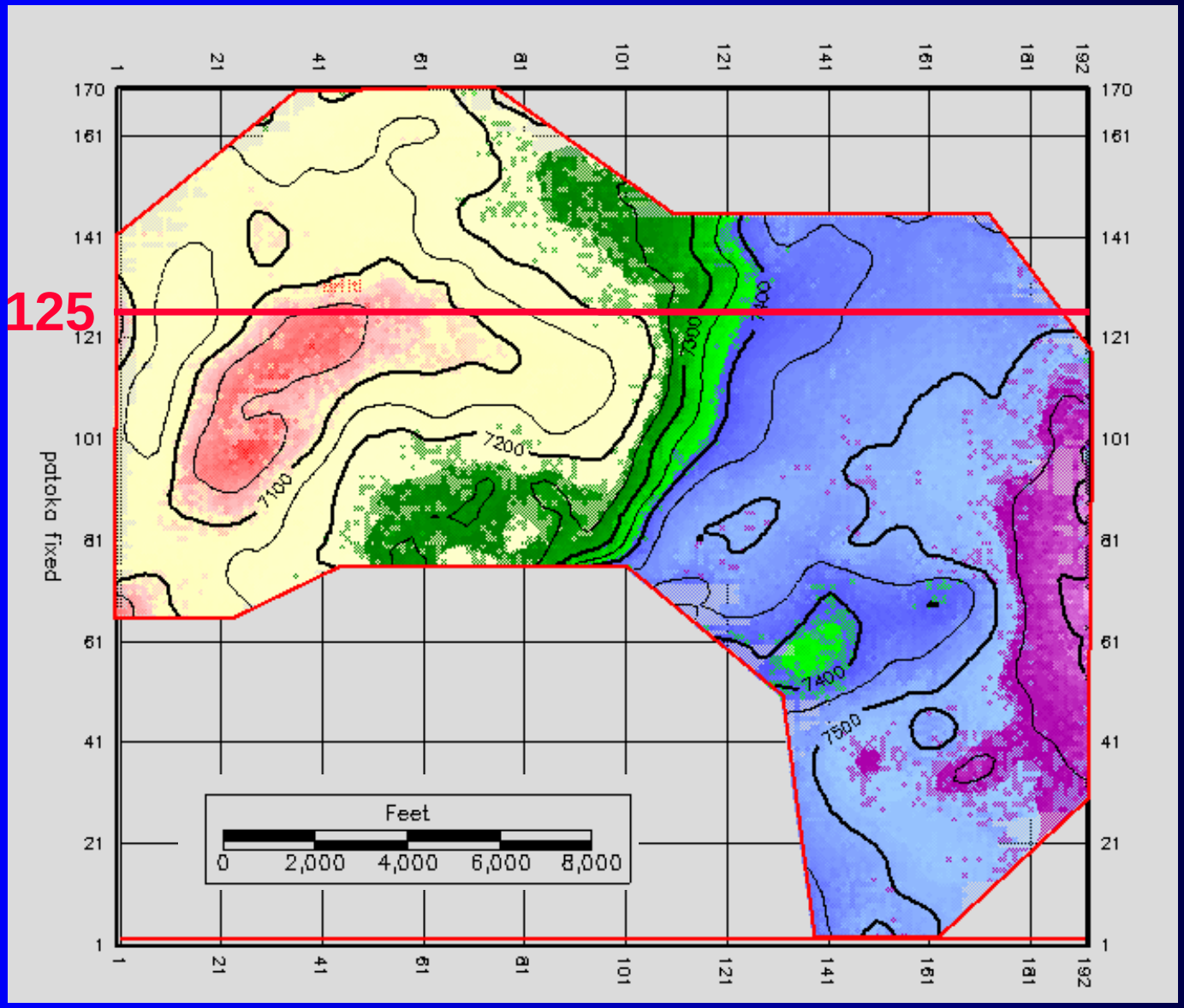
After: Midwest Geological Sequestration Consortium

STUDY AREAS IN ILLINOIS BASIN



By: Jenny Zhou & Mingya Chen

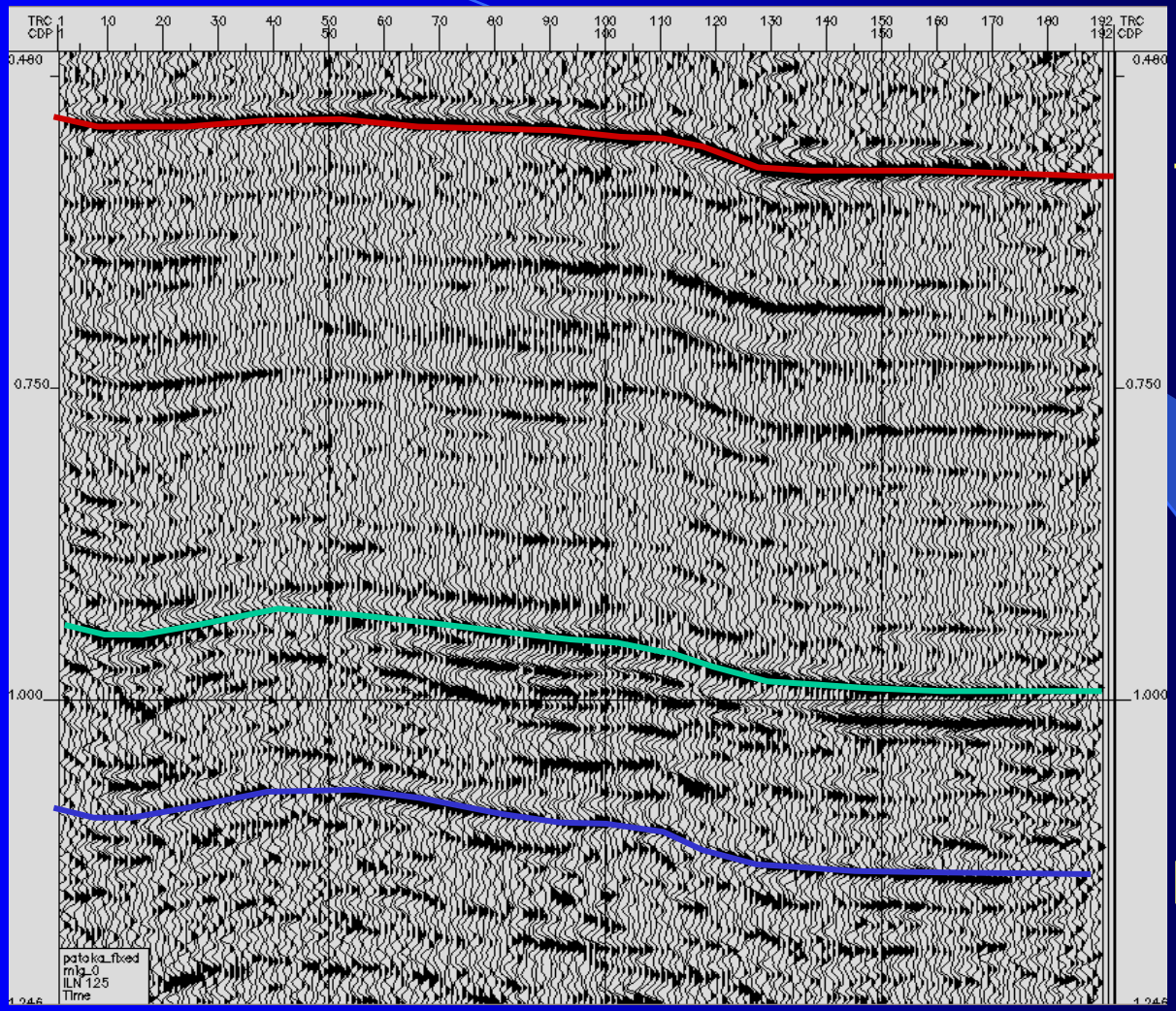
PATOKA FIELD-MT. SIMON STRUCTURE MAP



PATOKA FIELD

WEST

EAST



Trenton

Mt. Simon

Basement

Post-stack profile with interpretations of horizons-Inline 125.

By: Jenny Zhou

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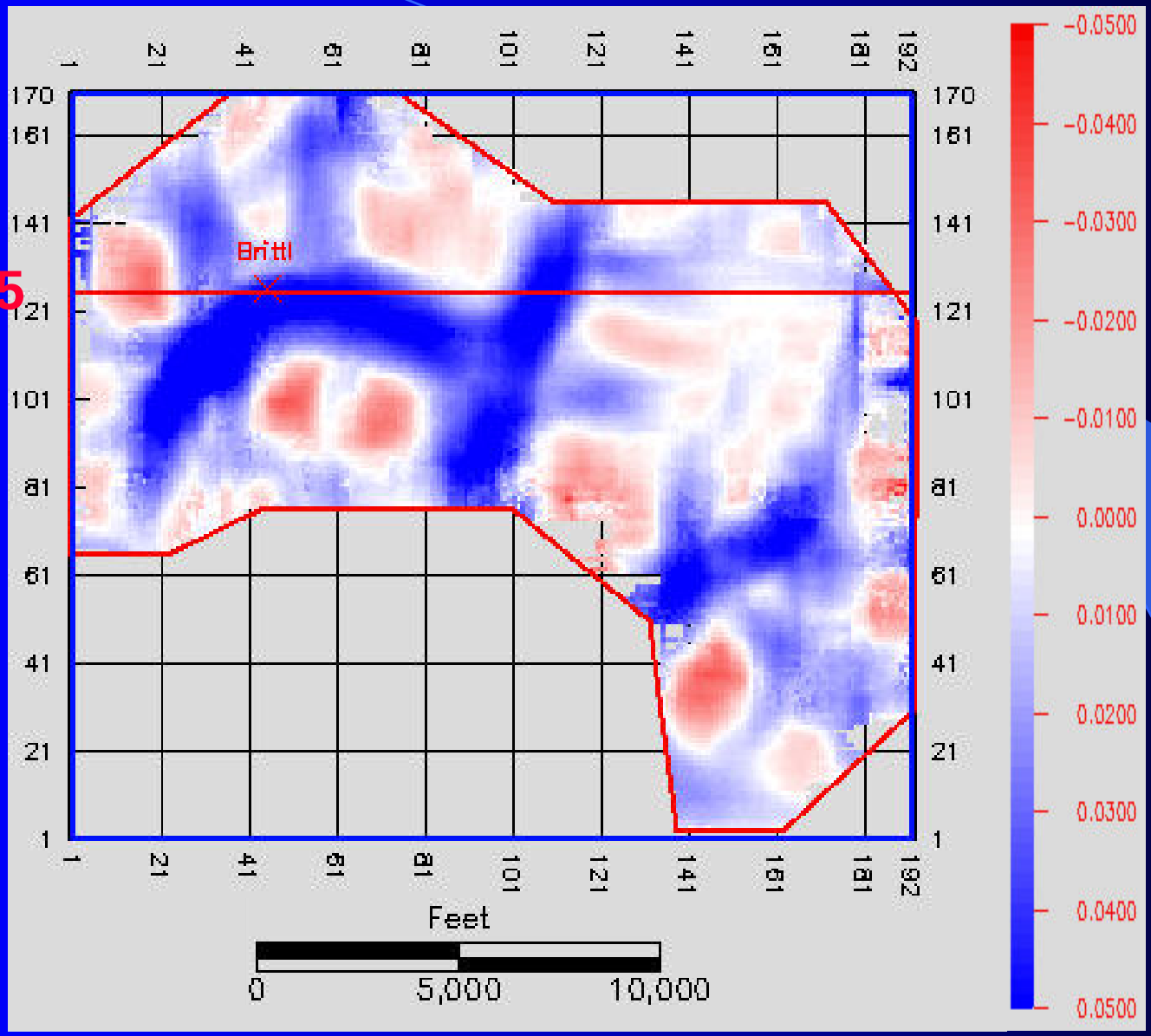
PATOKA FIELD-MT.SIMON CURVATURE MAP

Inline 125



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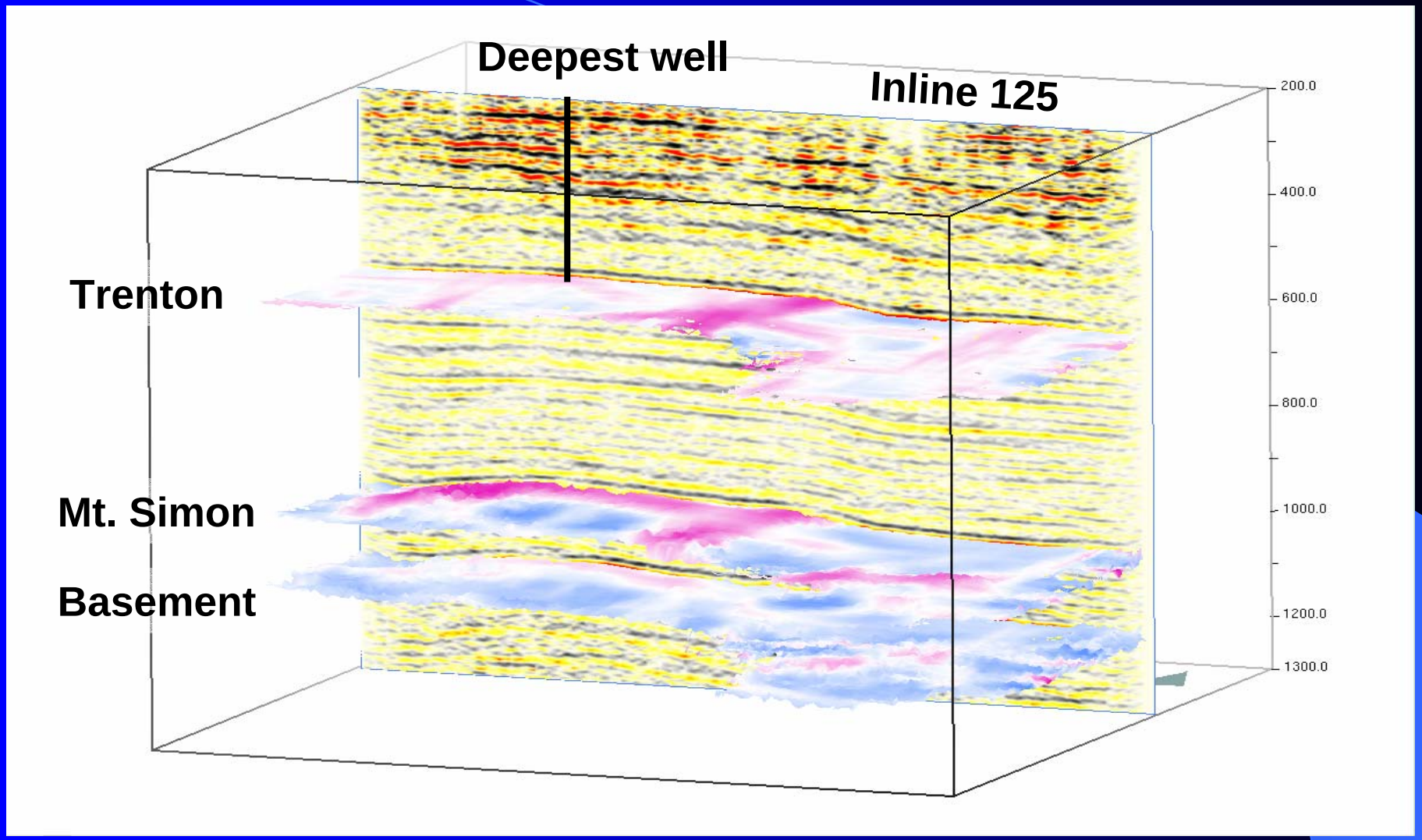
PATOKA FIELD



3-D perspective and maximum positive curvature attributes

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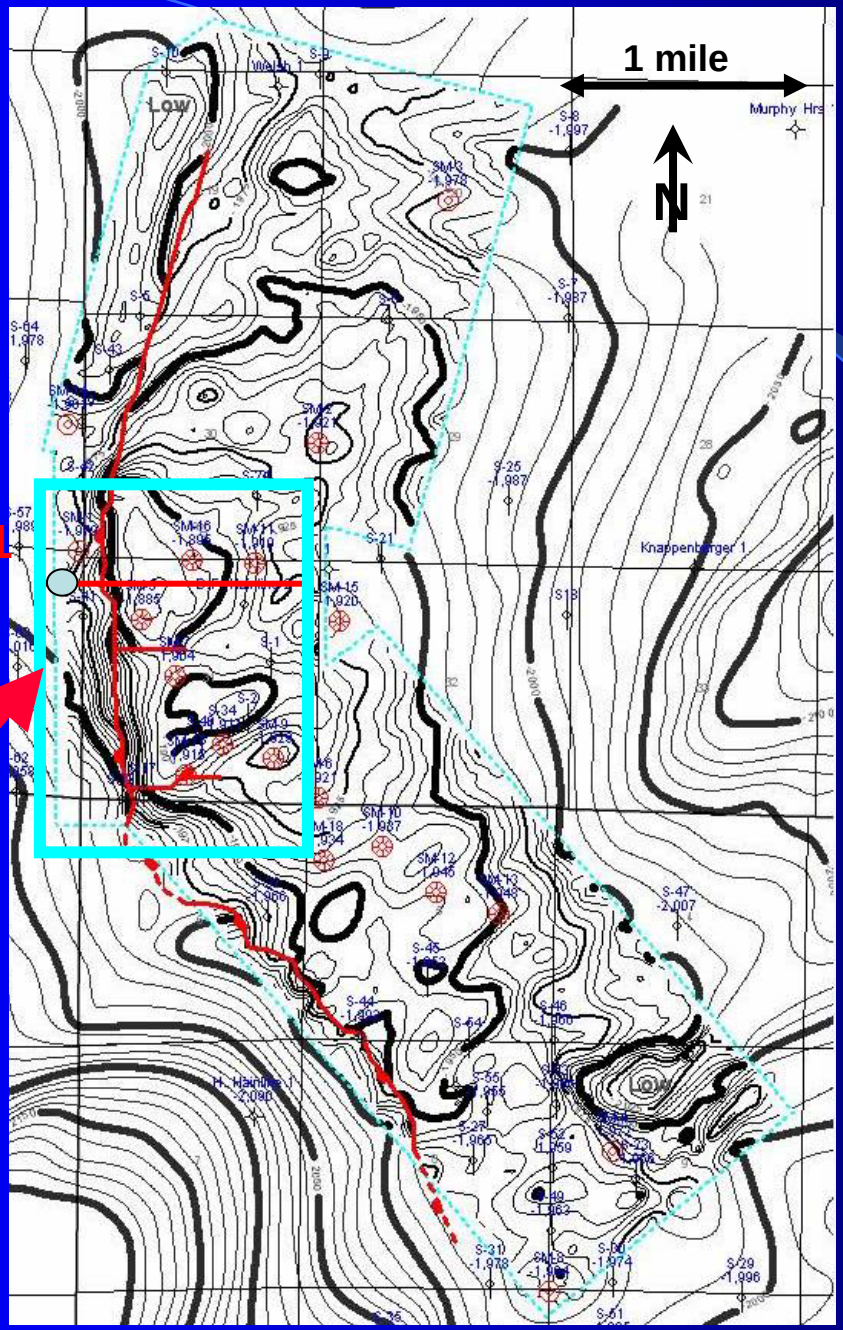
SCIOTA FIELD-MT. SIMON STRUCTURE MAP



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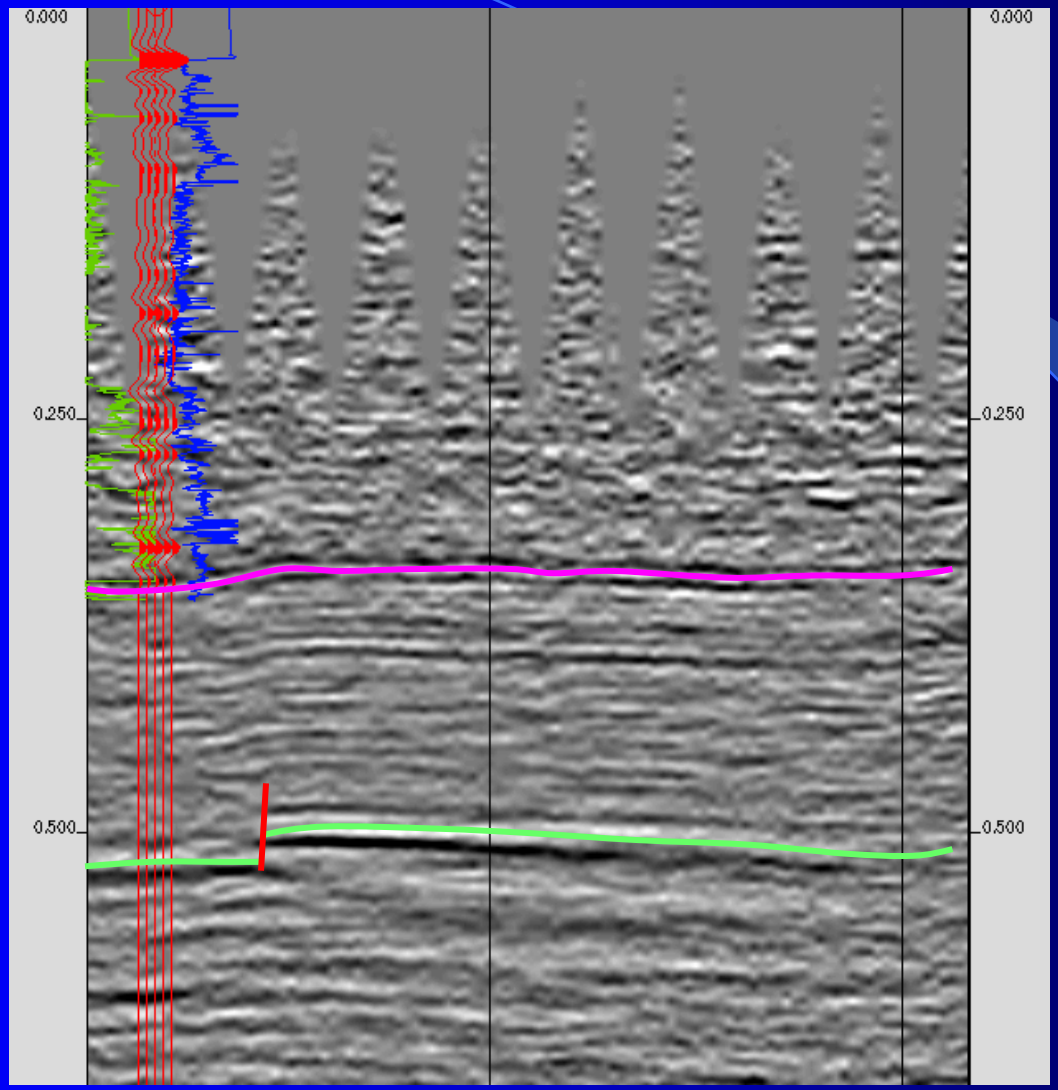
By: Ameren

SCIOTA FIELD

WEST *SM-1* EAST



Mt. Simon

Basement

Post-stack profile with interpretations of horizons.

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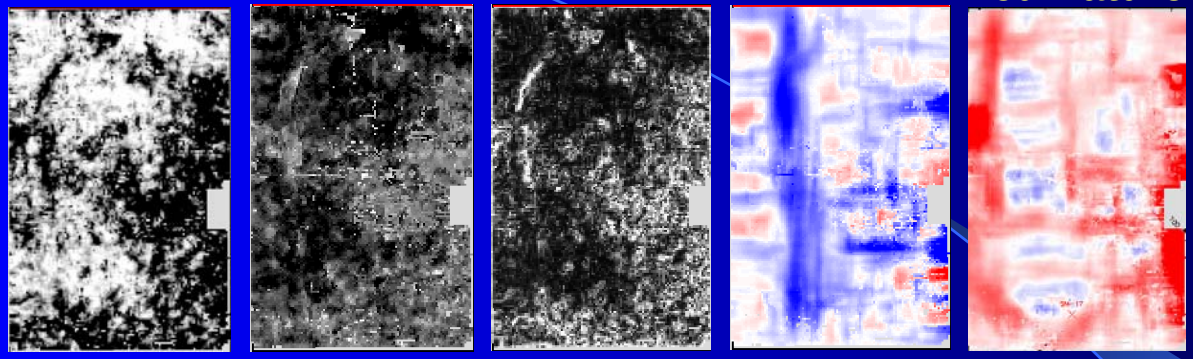
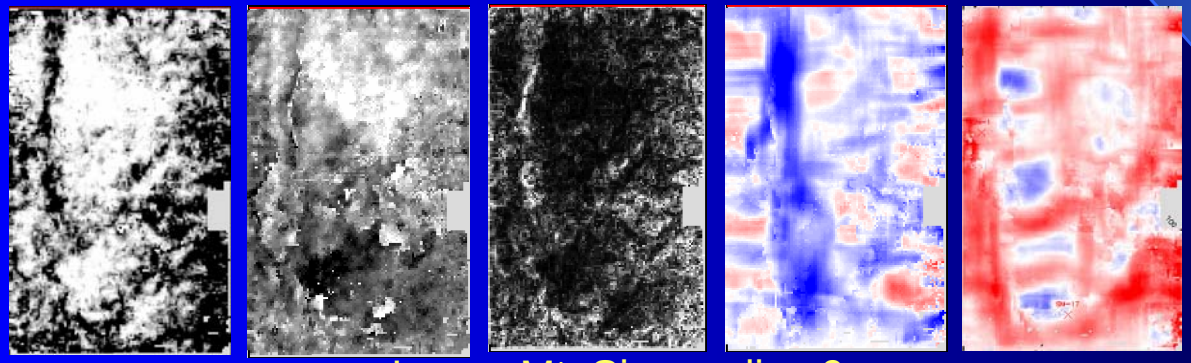
By: Minga Chen

SCIOTA FIELD

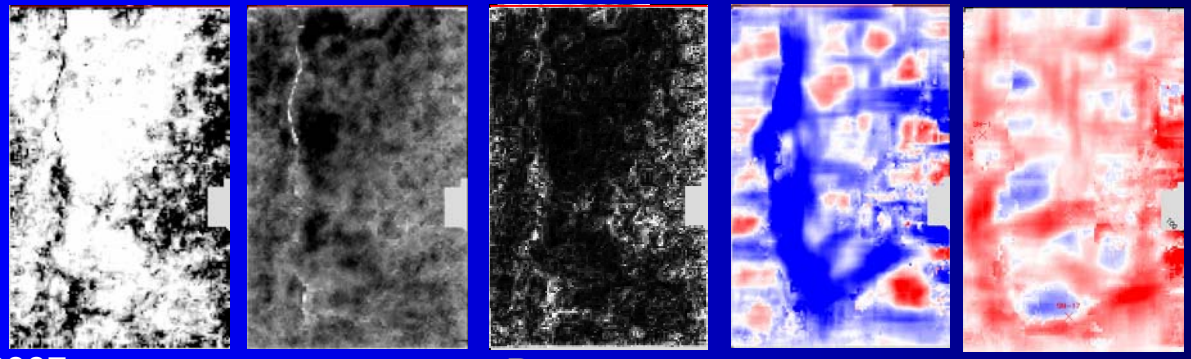
Coherence | Structure-oriented filter | Sobel filter | Positive curvature | Negative curvature



Upper Mt. Simon slice 3



Lower Mt. Simon slice 9



Basement

Geometric attributes

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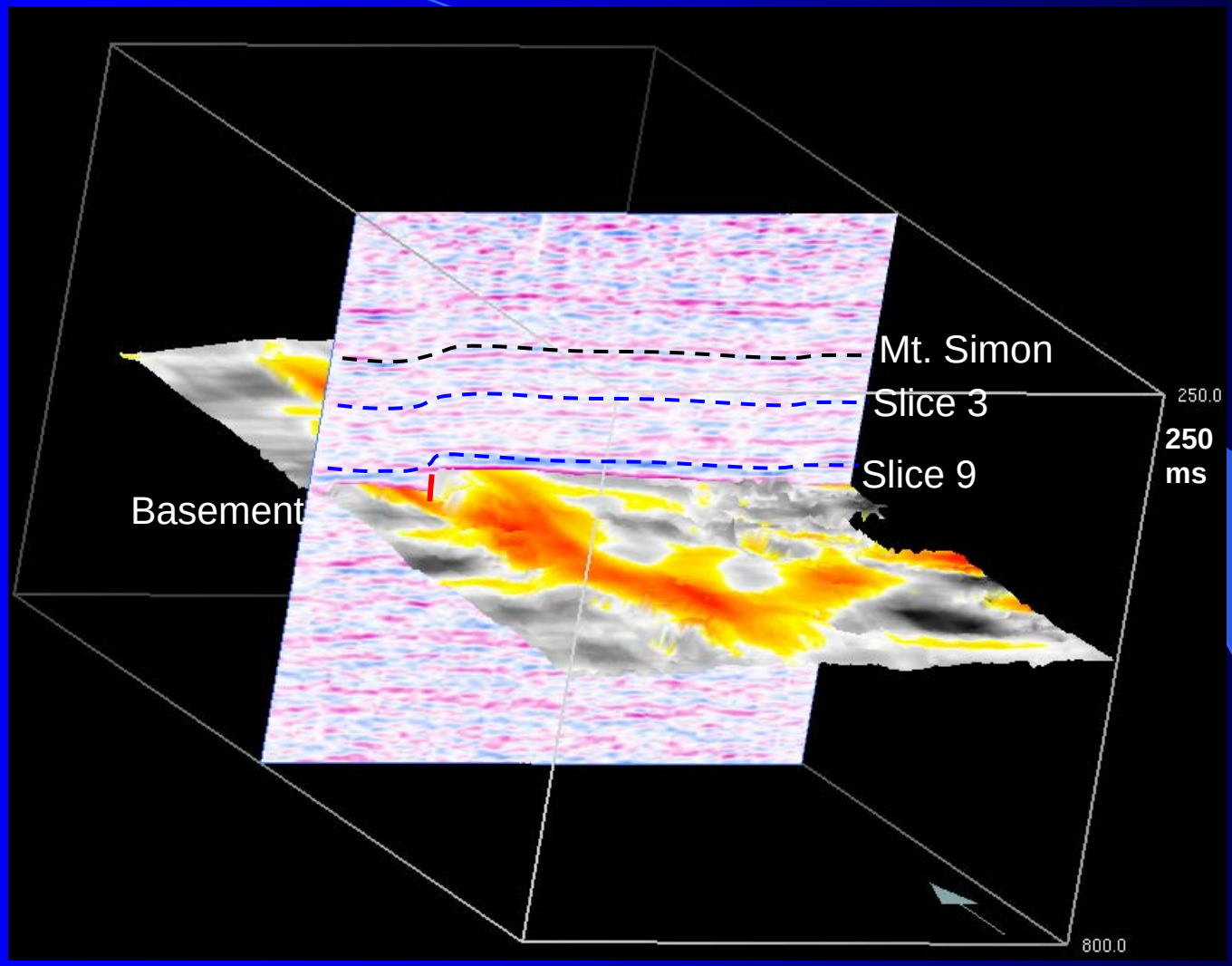
By: Minga Chen

SCIOTA FIELD



3-D perspective and maximum positive curvature attribute near top basement.

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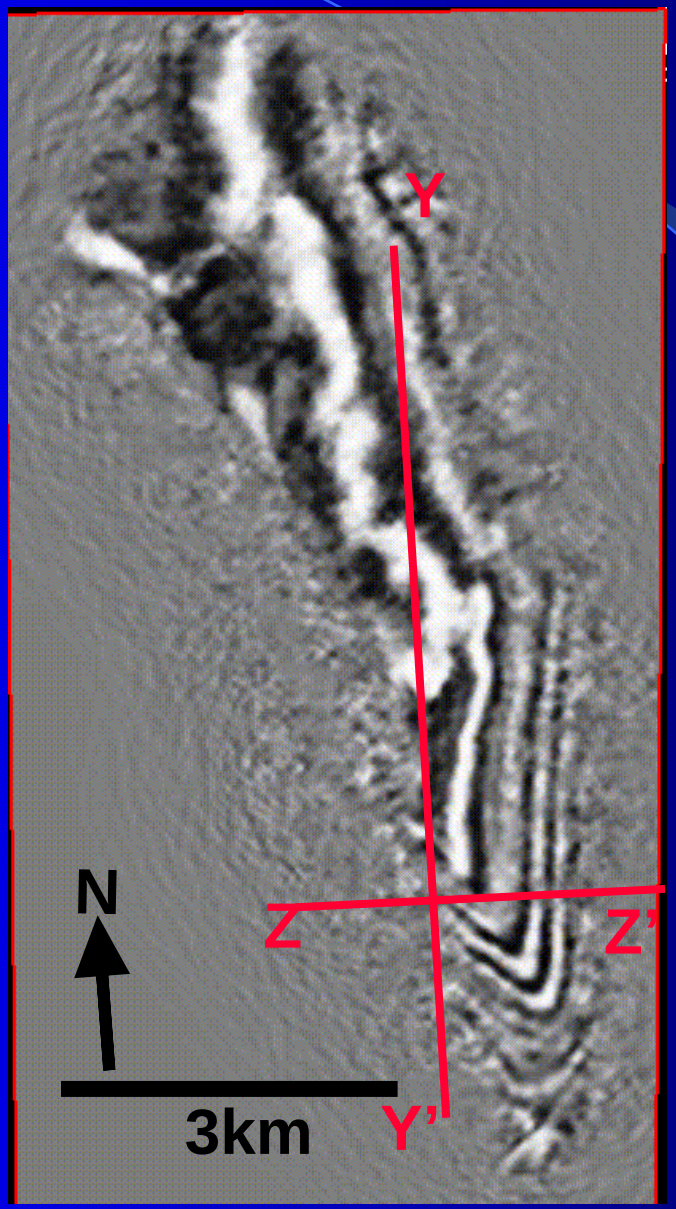
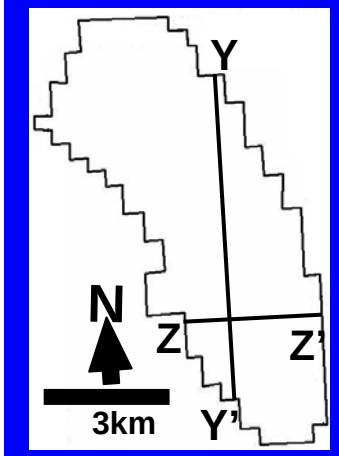
Teapot Dome Field
Powder River Basin
Wyoming

6/19/2007

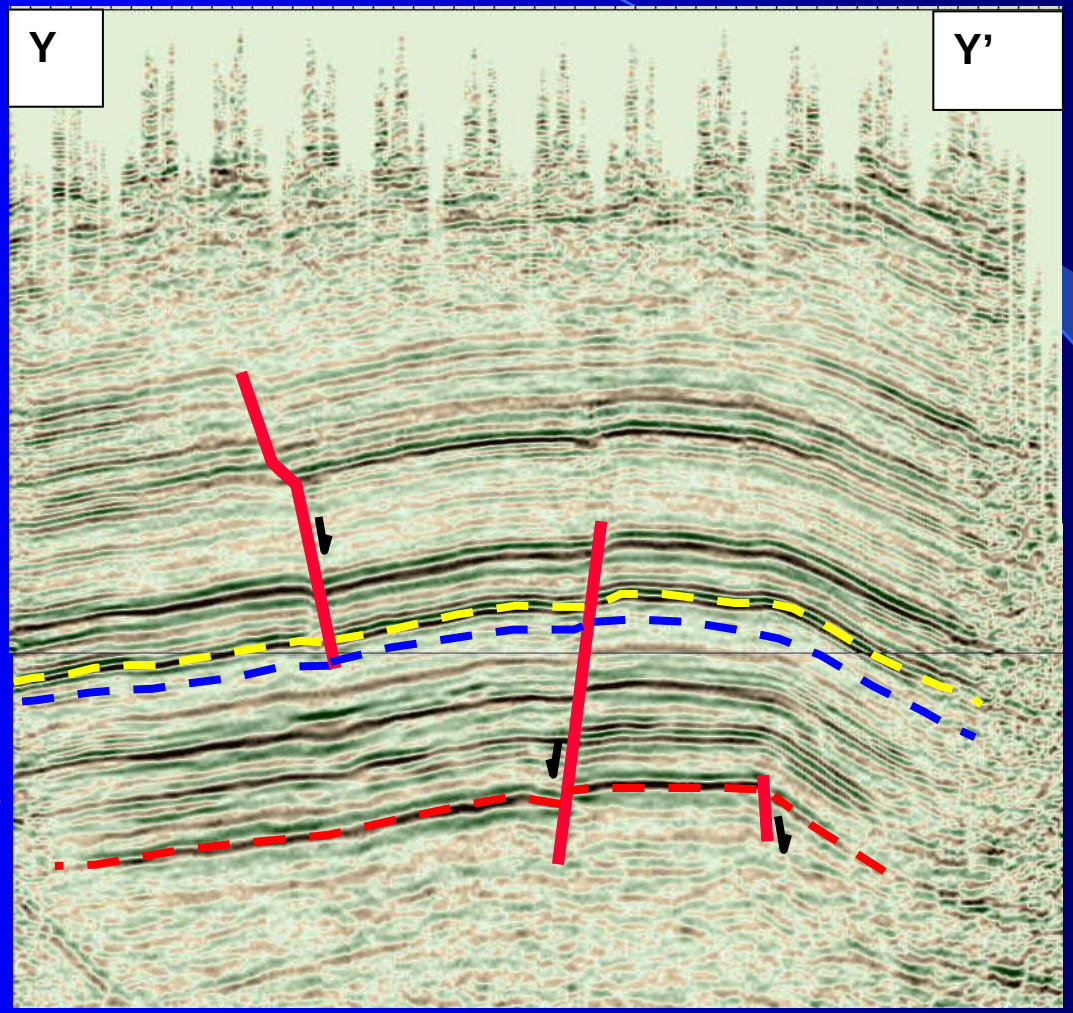
TEAPOT DOME FIELD-TIME SLICE OF PSTM DATA NEAR BASEMENT

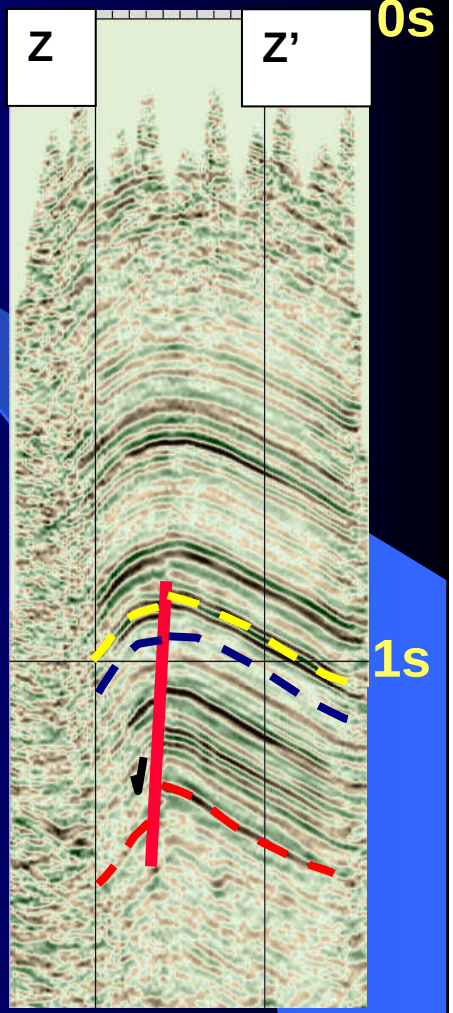


TEAPOT DOME FIELD



Teapot Dome Unit Map





Pre-stack profiles with interpretations of horizons and faults.

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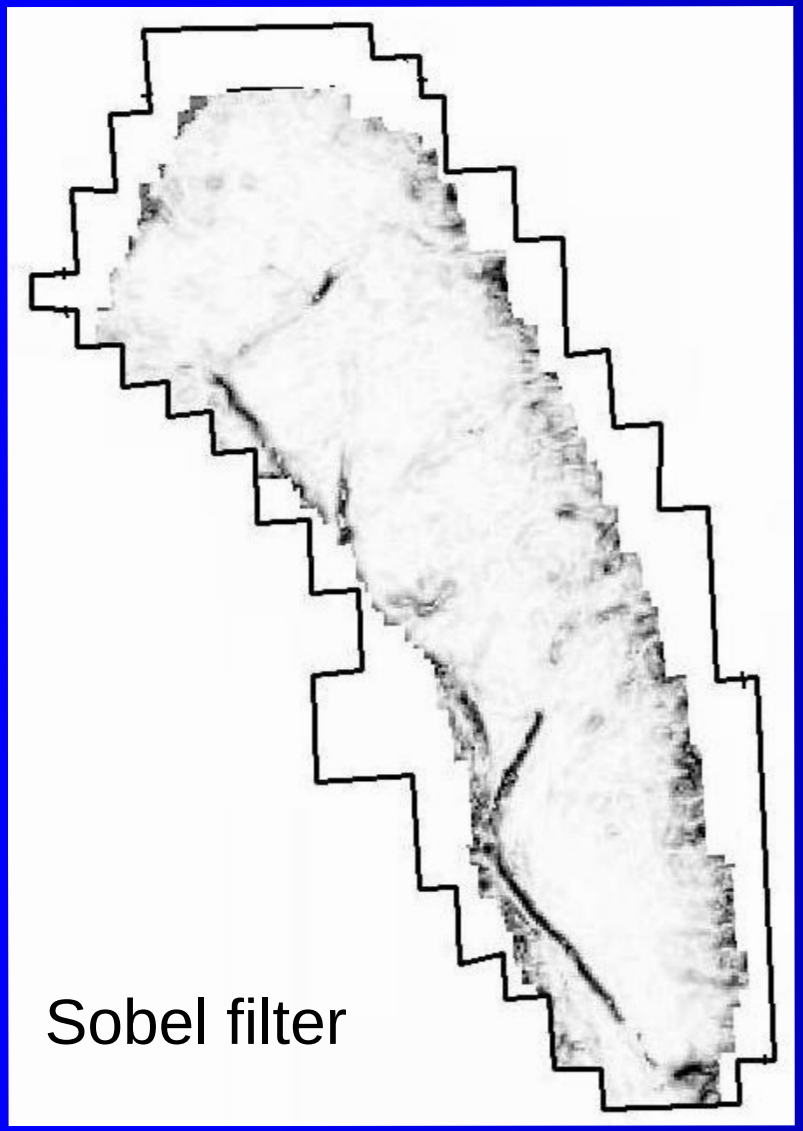
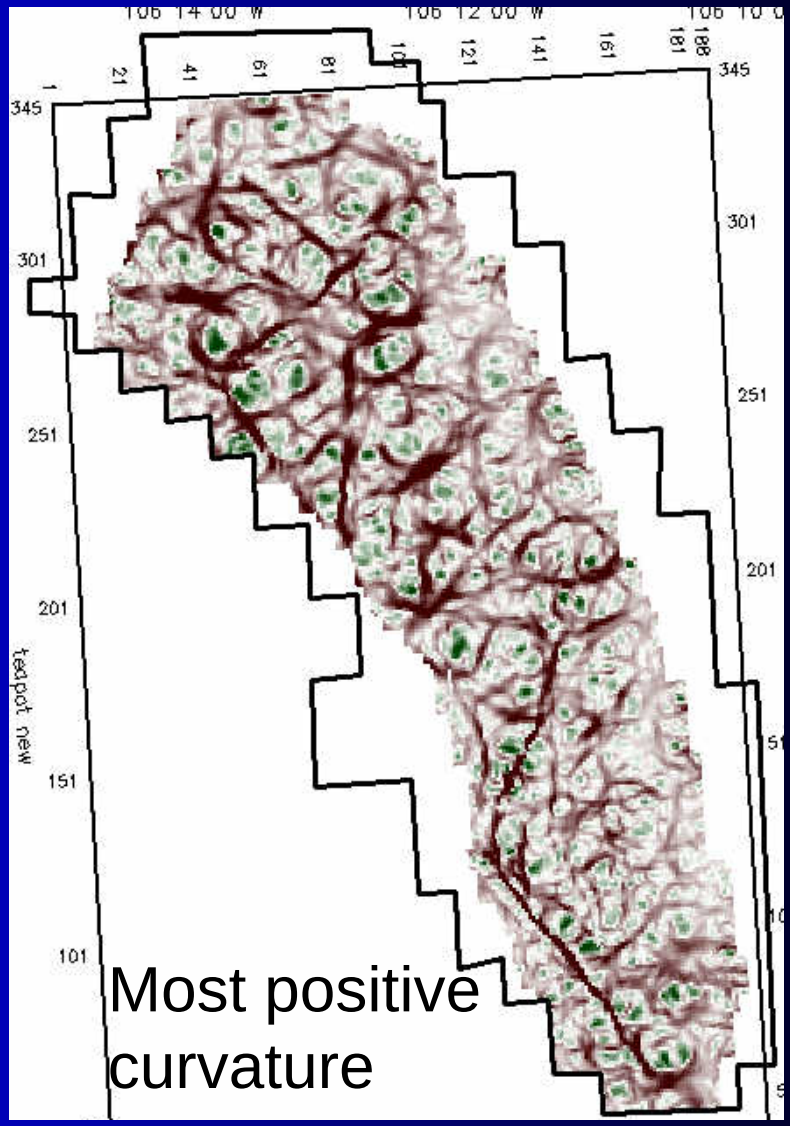
TEAPOT DOME FIELD-ATTRIBUTE MAPS NEAR BASEMENT



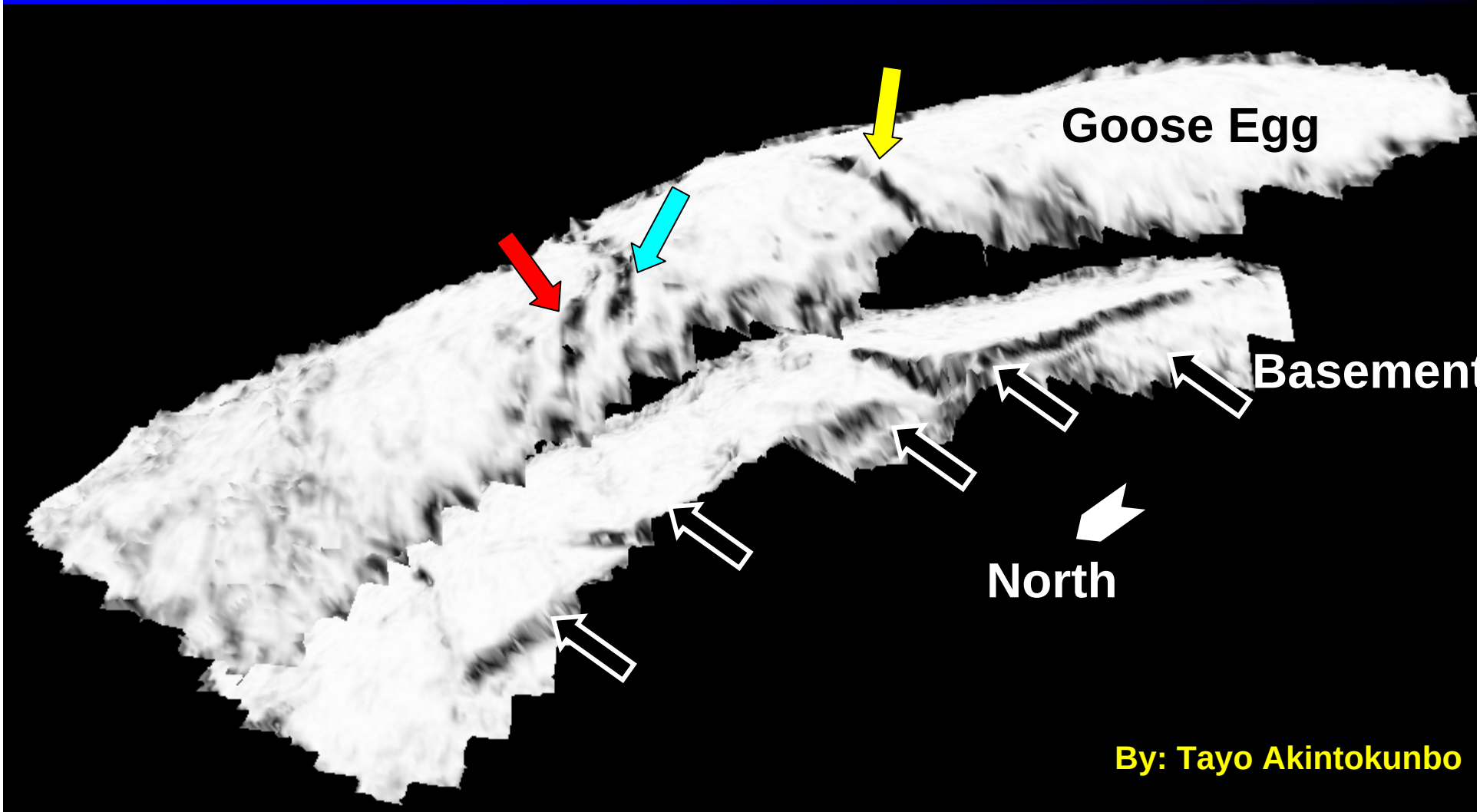
Sobel filter



Most positive curvature

By: Tayo Akintokunbo

TEAPOT DOME FIELD

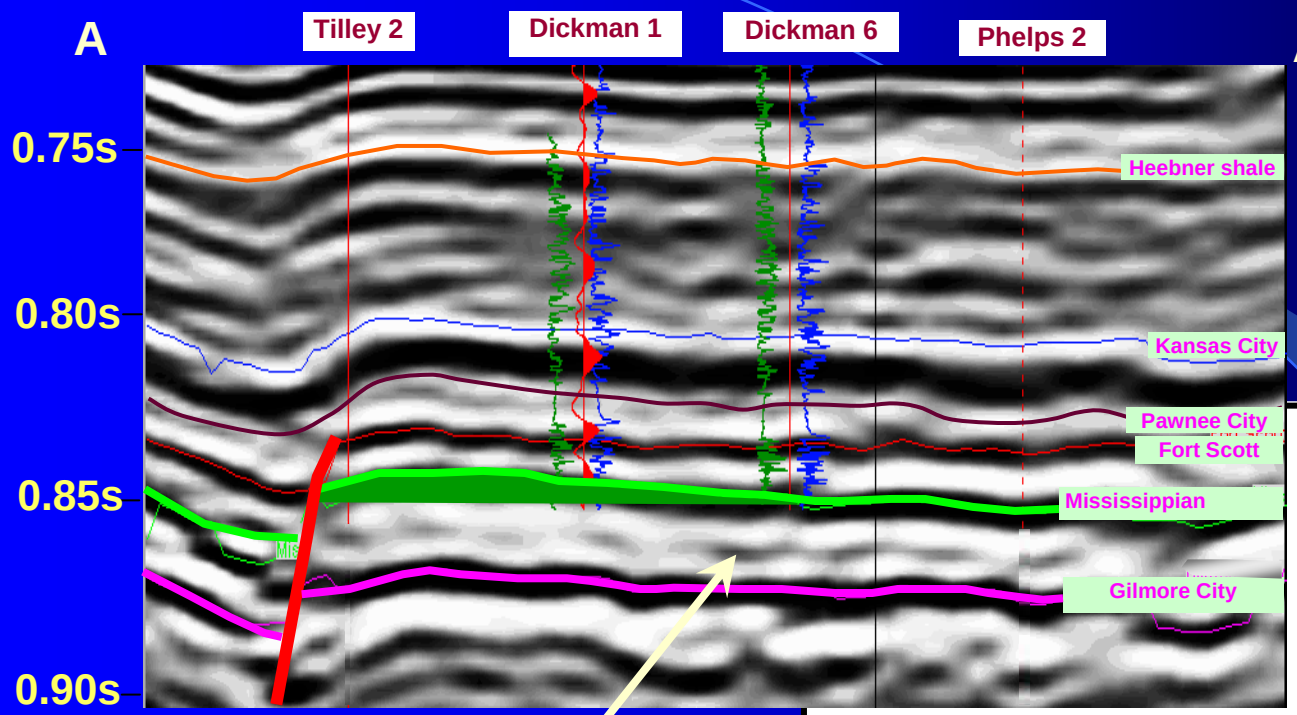


3-D perspective of Sobel filter attribute maps near basement and Tensleep (below Goose Egg) horizons.

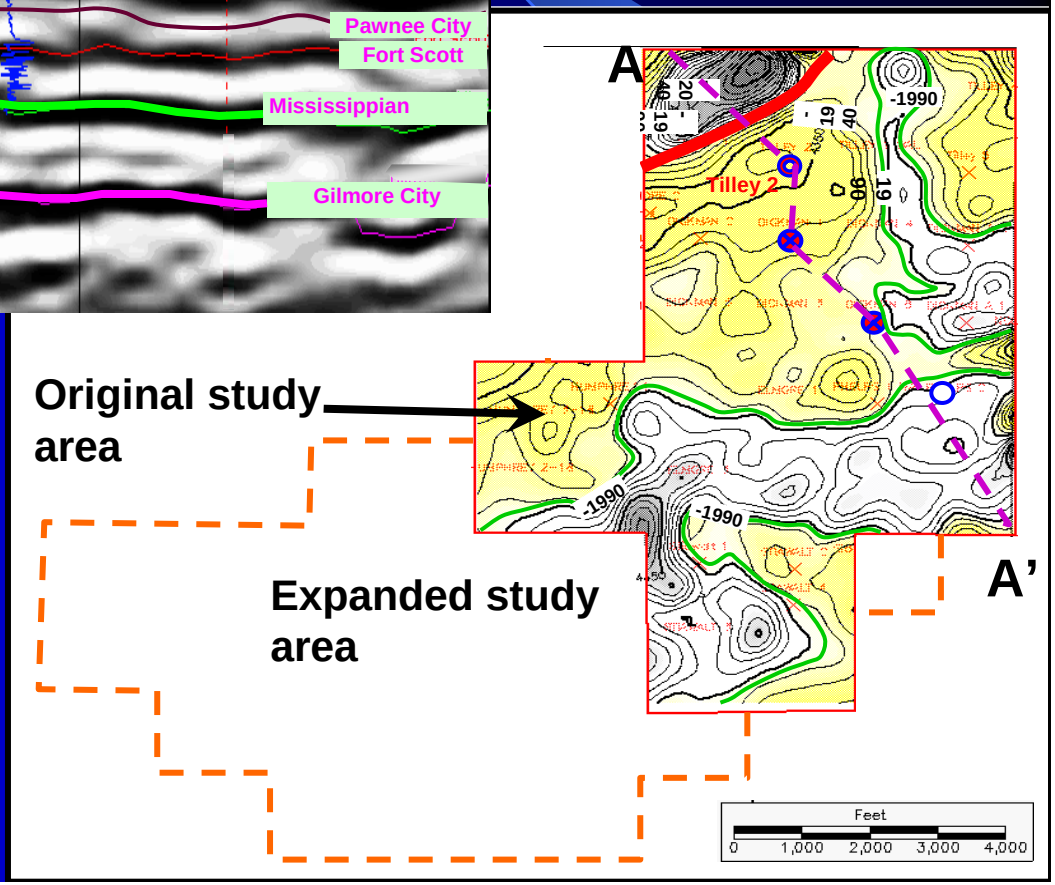
Dickman Field
Kansas

6/19/2007

Dickman Mississippian Oil Field, Kansas



Porous Mississippian Saline Aquifer
(Western Interior Plains Aquifer System)



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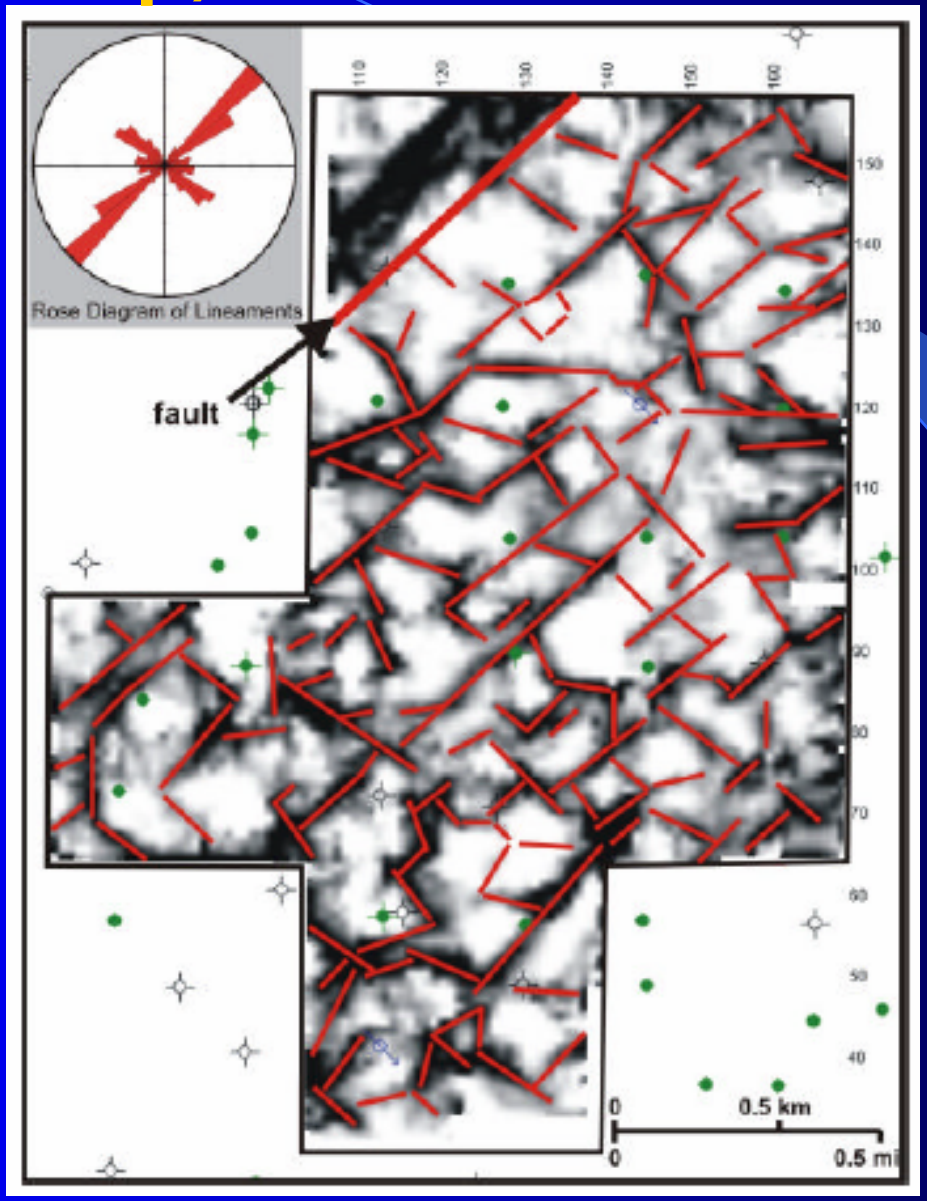
By: Na Li

Base Miss. Porosity-Most Negative Curvature Map, Dickman Field



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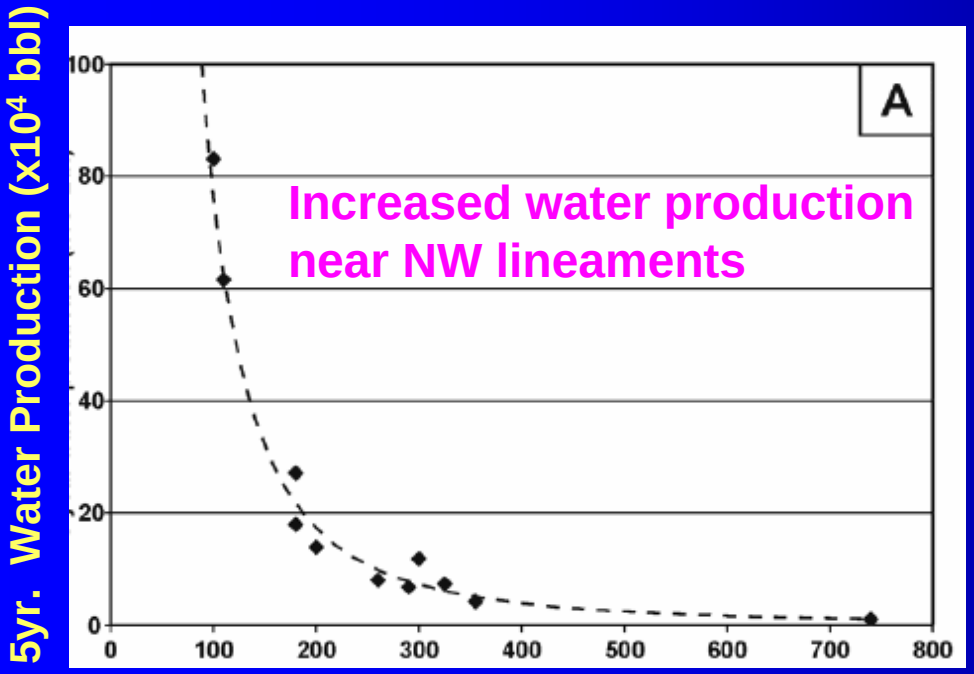
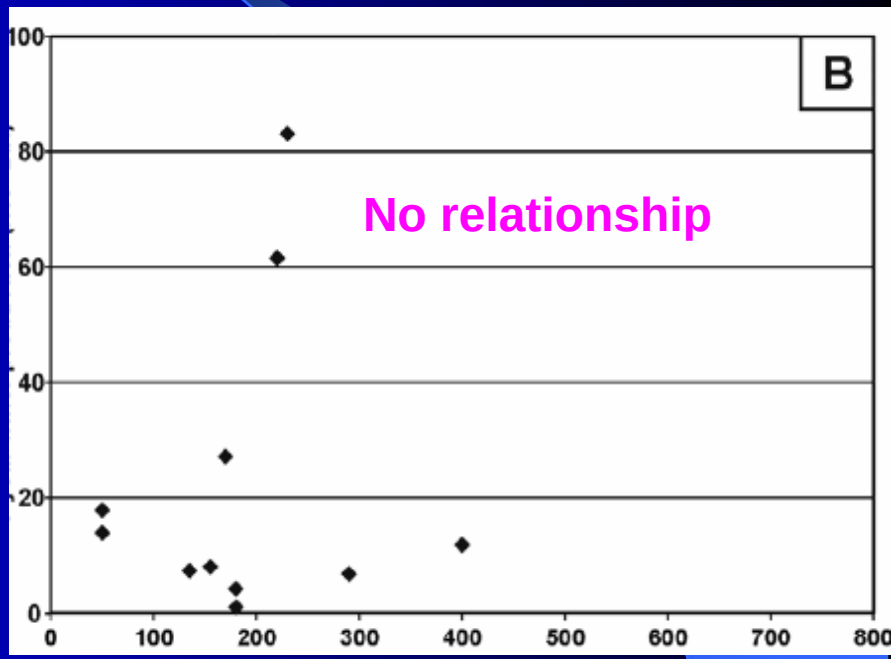
By: Susan Nissen

Dickman Field
Water Production Vs. Distance to Lineaments



Distance to NW lineament



Distance to NE lineament

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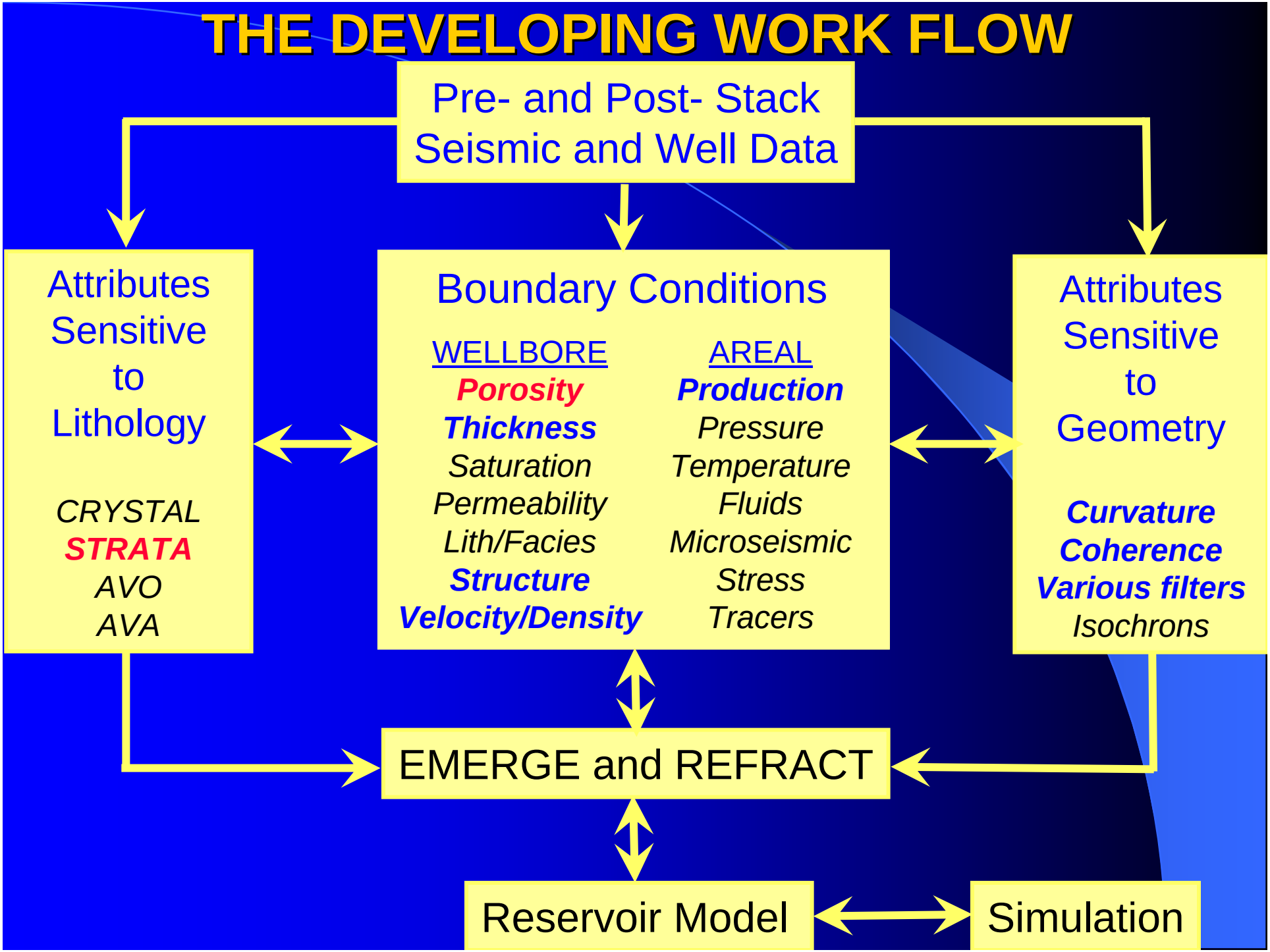
THE DEVELOPING WORK FLOW
Pre- and Post- Stack Seismic and Well Data
Attributes Sensitive to Lithology
CRYSTAL
STRATA
AVO
AVA
Boundary Conditions
WELLBORE
Porosity
Thickness
Saturation
Permeability
Lith/Facies
Structure
Velocity/Density
AREAL
Production
Pressure
Temperature
Fluids
Microseismic
Stress
Tracers
Attributes Sensitive to Geometry
Curvature
Coherence
Various filters
Isochrons
EMERGE and REFRACT
Reservoir Model
Simulation

THE NEXT STEPS

- Complete time migrations of pre-stack 3-D seismic data.
- Establish correlations between well data and seismic attributes.
- Construct 3-D geomodels of reservoirs.
- Simulate oil production and CO2 injectivity in Dickman Field.
- Develop “best practices” workflow for seismic attribute studies.

ACKNOWLEDGMENT OF SUPPORT

Department of Energy

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Ameren

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Kansas Geological Survey

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Stanford University, Geophysics Department

Illinois State Geological Survey

Schlumberger

Prism Seismic

GeoPLUS

Great Lakes Geophysical

Exploration Development, Inc.

West Virginia University, Geology/Geography Dept.

THE END!