3D Seismic Attribute Interpretation from the Red River Formation

By Mark Sippel

Luff Exploration Company

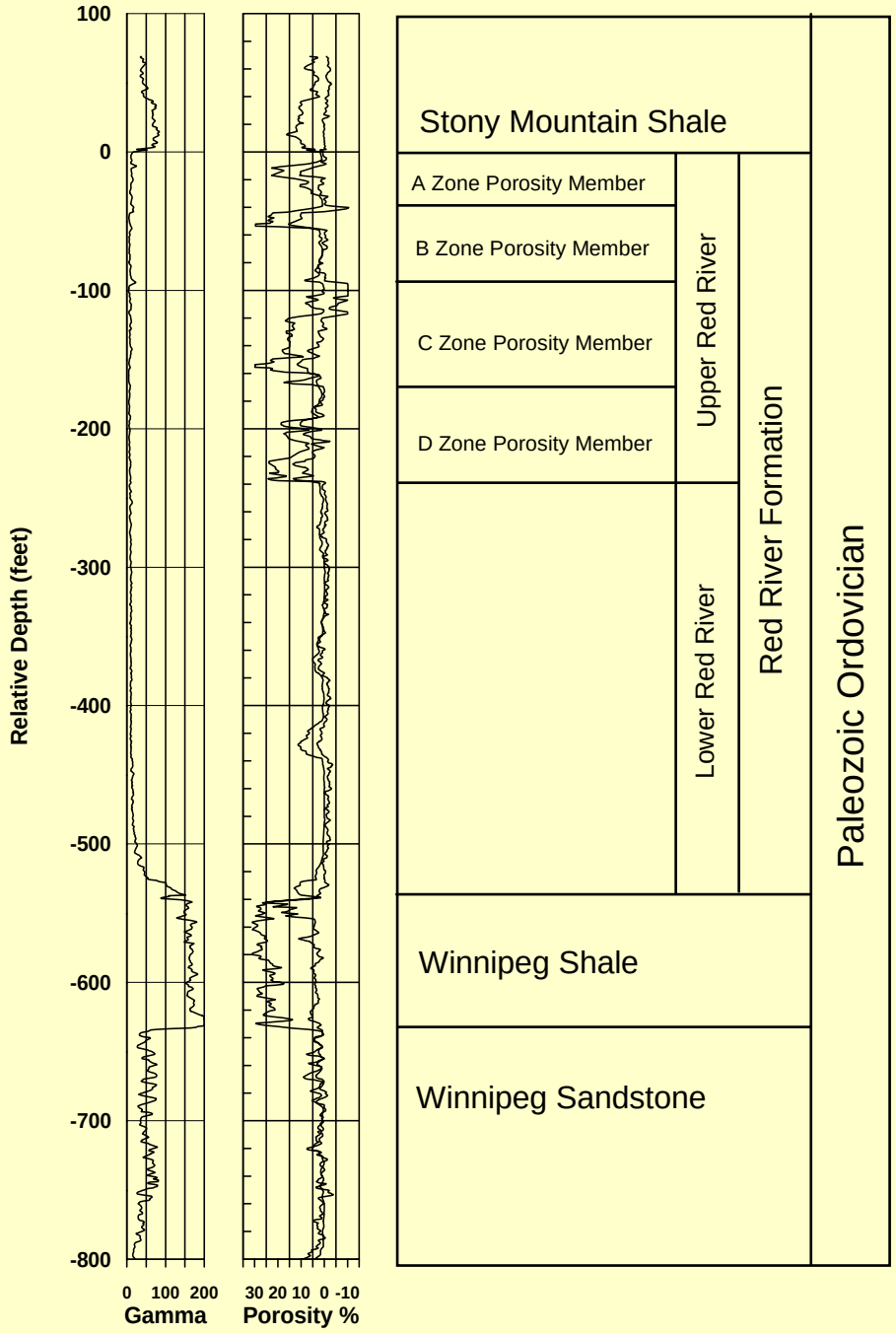
for the

14th Williston Basin Petroleum Conference & Prospect Expo

Presentation Outline

- Introduction and Location
- Overview of Red River Reservoirs
- Seismic Response and Modeling
- Description of Red River B Reservoirs
- Prediction of Depositional Setting
- Transforms to Reservoir Properties

Area of Interest Map

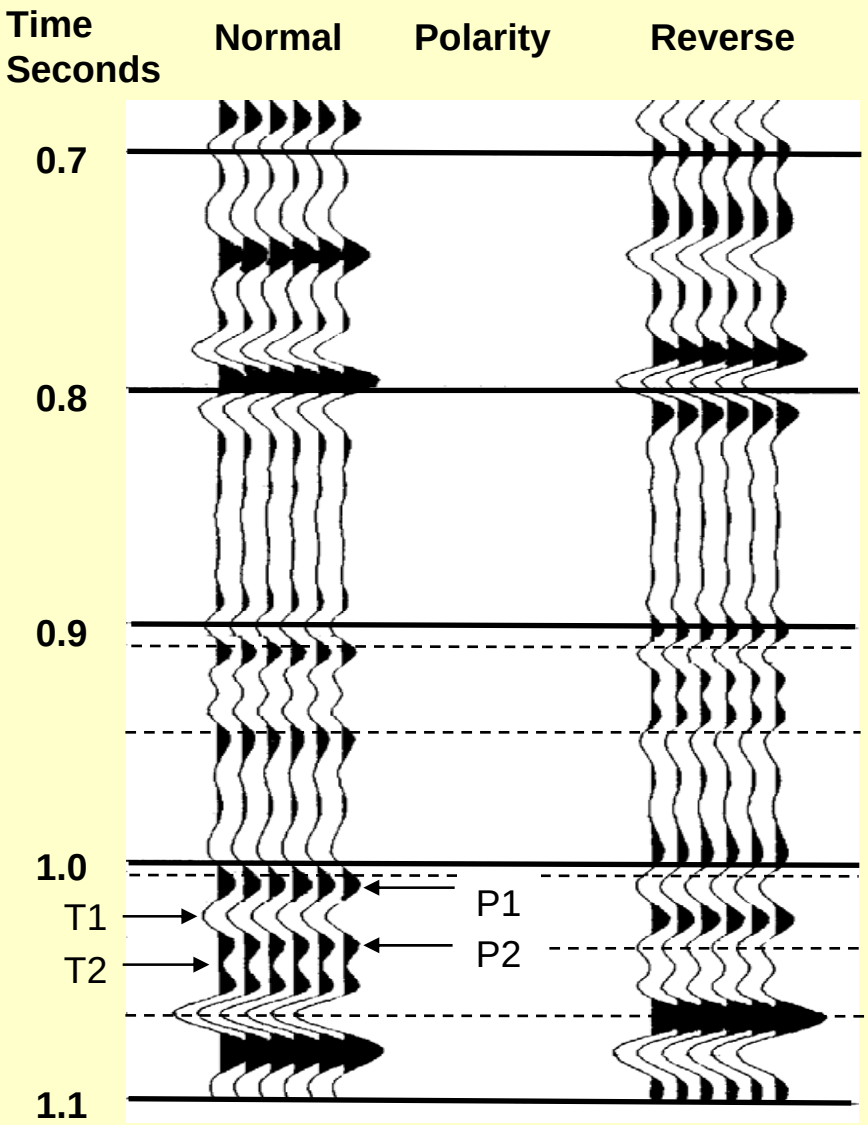


Type Log for Red River Formation

The Upper Red River Consists of Four Episodes in Shallow Shelf Setting

Main Reservoirs are:
Red River B Zone
Red River D Zone

Forward Seismic Modeling

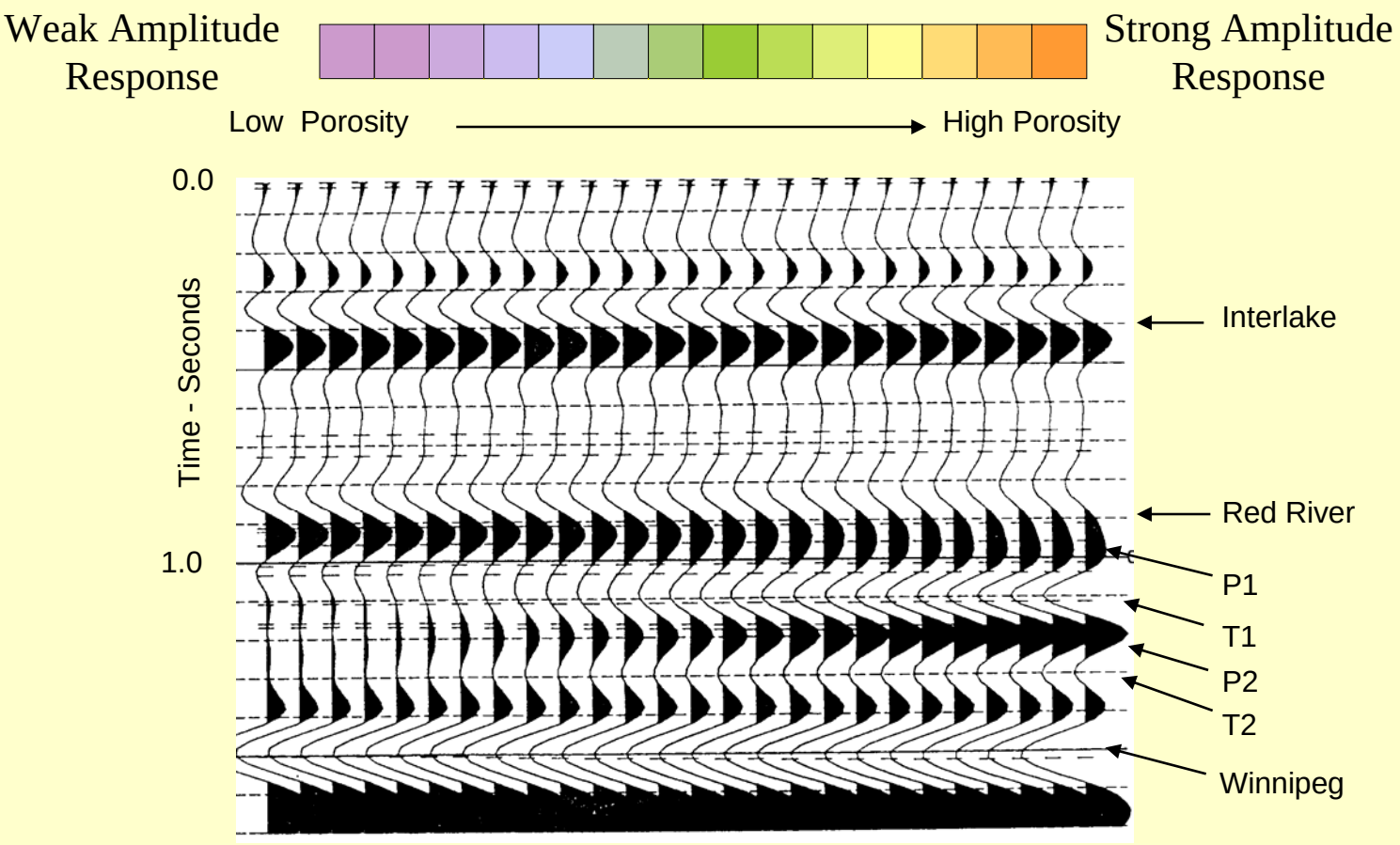


Upper Red River Reservoirs Are "Seismic Thin Beds"

Reservoir Information Contained in Two Peak-Trough Pairs

Each Event Consistently Labeled in Every Seismic Survey

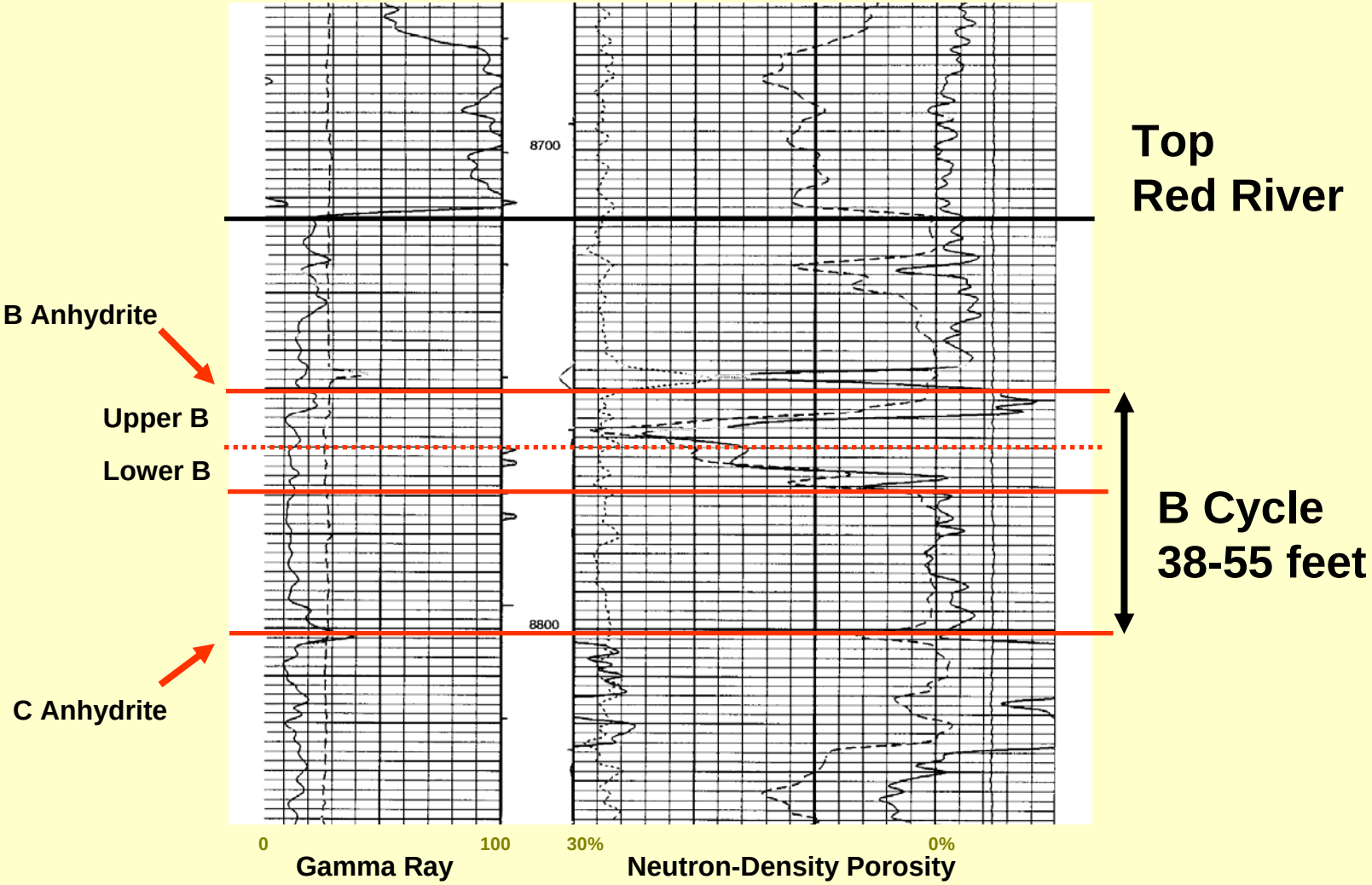
Use Synthetic Seismogram for Study of Response to Thickness and Porosity Variation



Description of Red River B Reservoirs

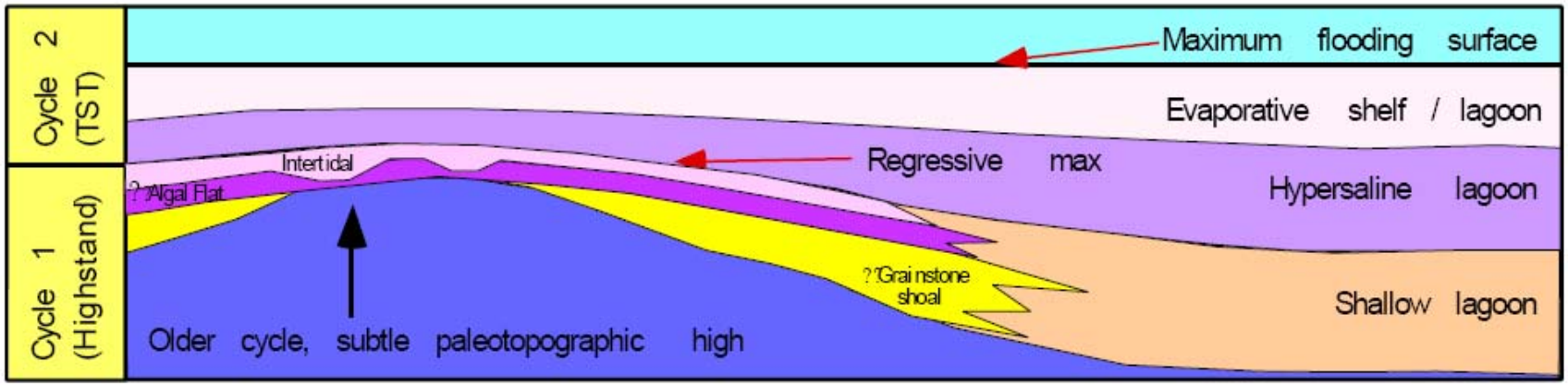
- Red River B Porosity Averages Thickness of 7 Feet
- Develops at the Top of B Cycle Between Two Anhydrite Layers
- Red River B Porosity is Divided into Two Members – Upper and Lower
- Red River B (Upper) is Productive Layer
- Red River B Development is Strongly Influenced by Depositional Setting
- B Cycle Thickness Can Be Predicted from Seismic Attributes

Type Log from Red River B Reservoir



Depositional Model of Red River B

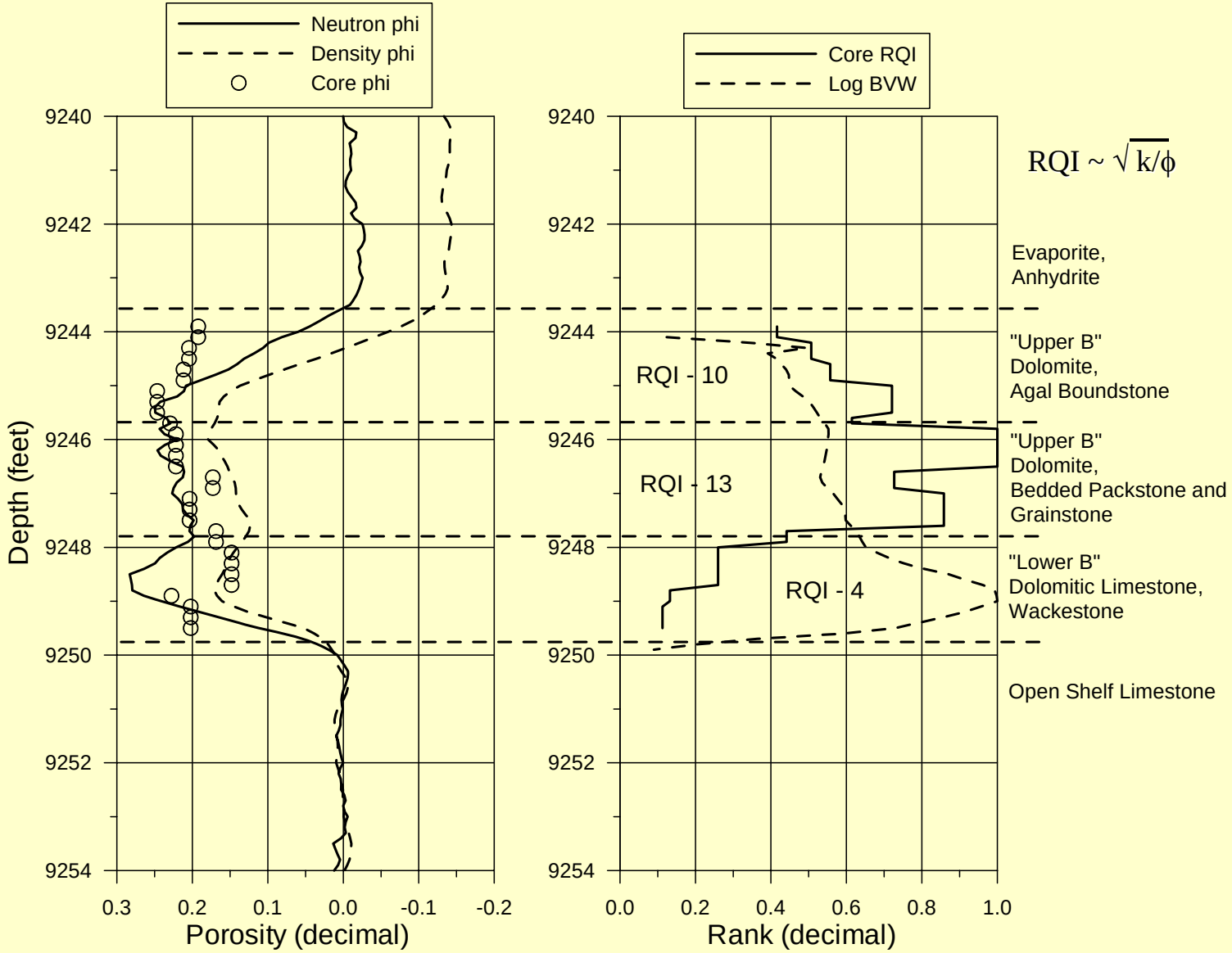
Interpretation by Lyn Canter



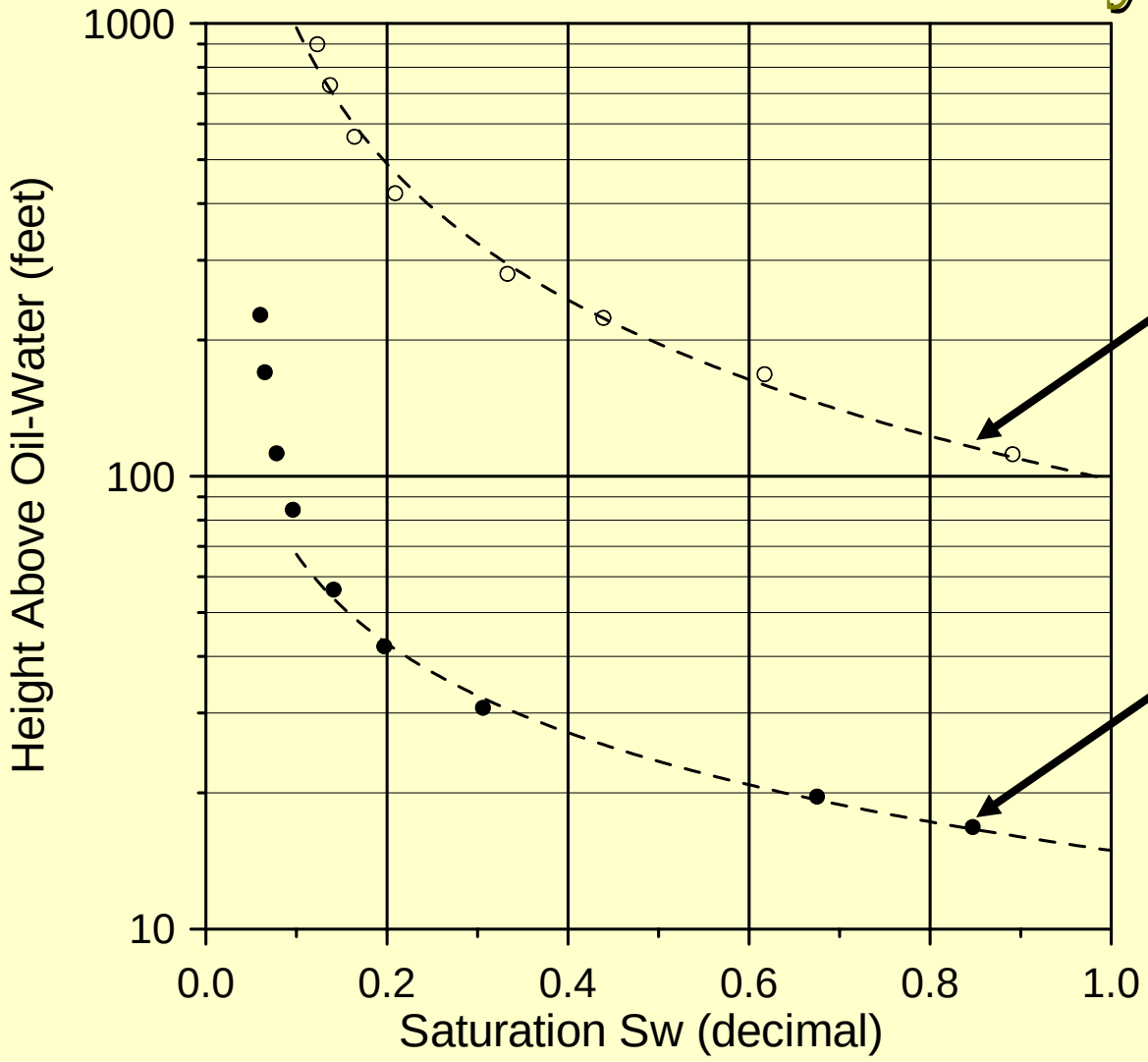
Lithology and typical rock types:

- Limestone
- Dolomite (algal boundstone)
- Anhydritic dolomite (mudstone)
- Argillaceous dolomite (burrowed mudstone)
- Dolomite (Mudstone and packstone)
- Anhydrite (bedded anhydrite)
- Dolomite (grainstone)

Analytical Description of Red River B



Capillary Properties - Red River B Rock Types



RQI = Rock Quality Index

RQI ~ $\sqrt{k/\phi}$

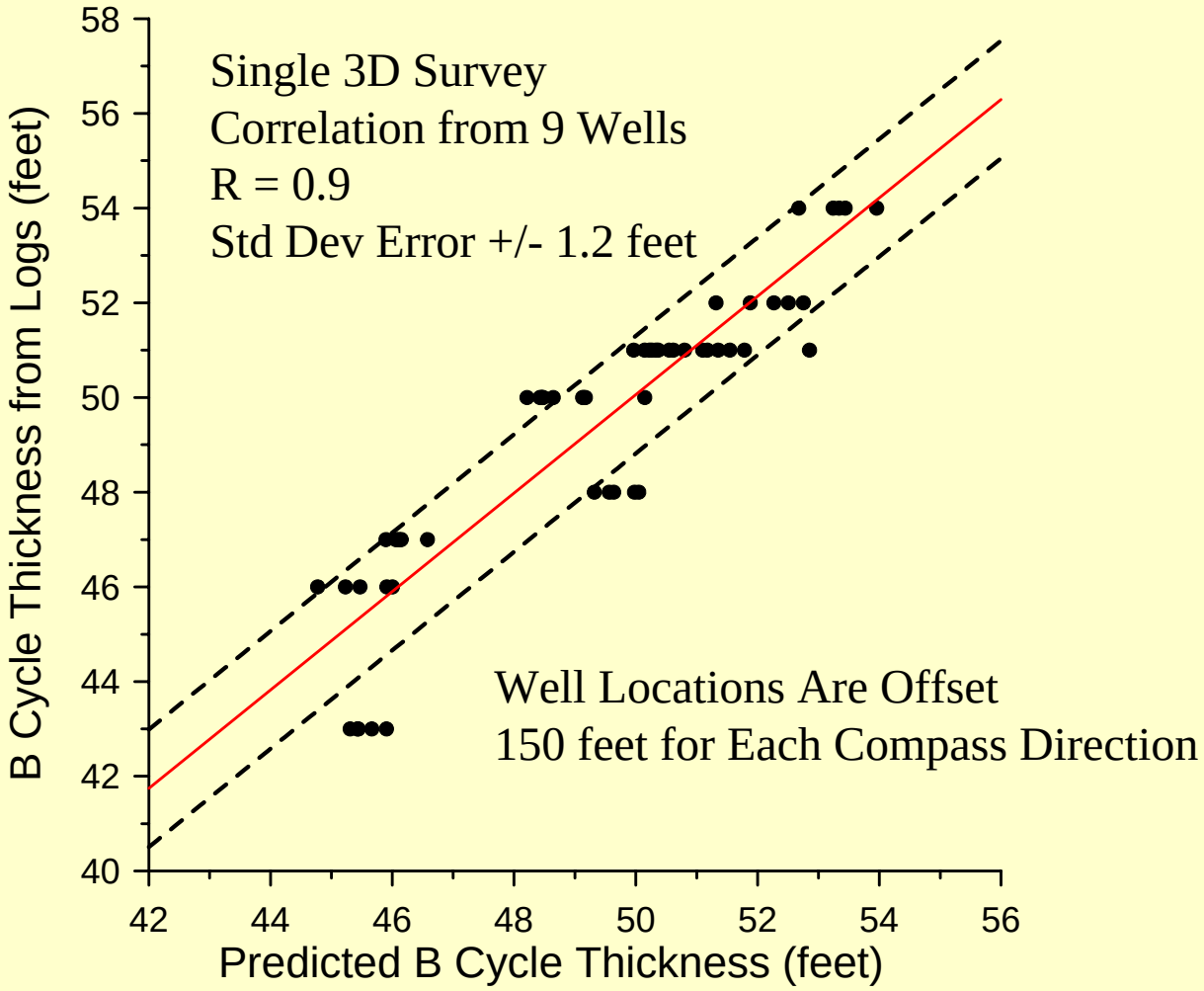
Lower B
RQI ~ 2
~ 0.3 microns
Pore Throat Diameter

Upper B
RQI ~ 16
~ 3.0 microns
Pore Throat Diameter

Prediction of B Cycle Thickness from Seismic Attributes

- Understand Seismic Response from Forward Modeling
- Pick Consistent Times and Amplitudes of Events in Red River Interval
- Normalize Each Attribute (Interval Times and Amplitudes) to Mean of 0 and Standard Deviation of 1
- Integration of Multiple 3D Surveys
- Determine Thickness of B Cycle from Well Logs in 3D Seismic Surveys
- Capture Seismic Attributes at Well Locations
- Perform Statistical Correlation of B Cycle Thickness and Seismic Attributes

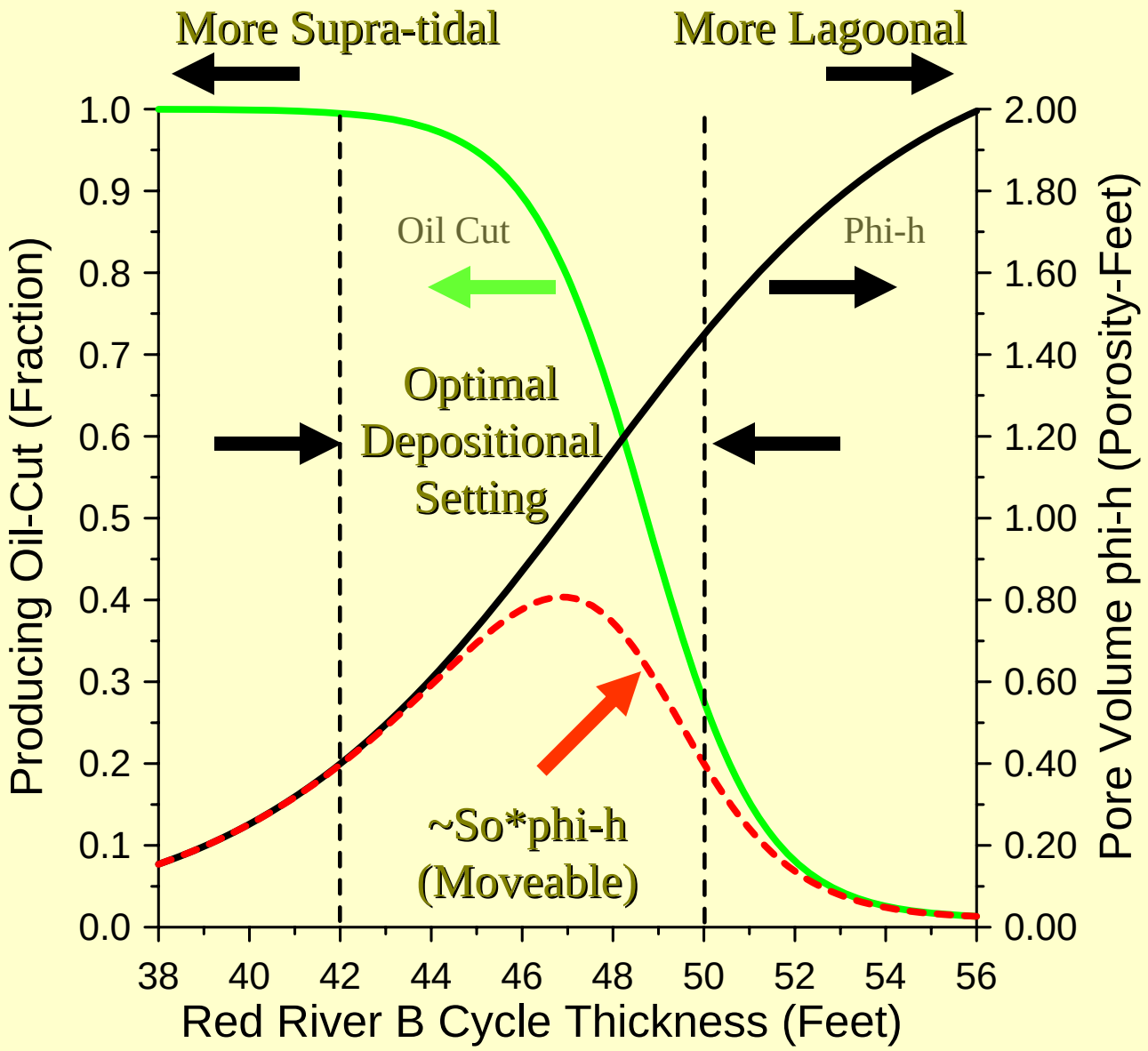
Transform of B Cycle Thickness from Seismic Attributes



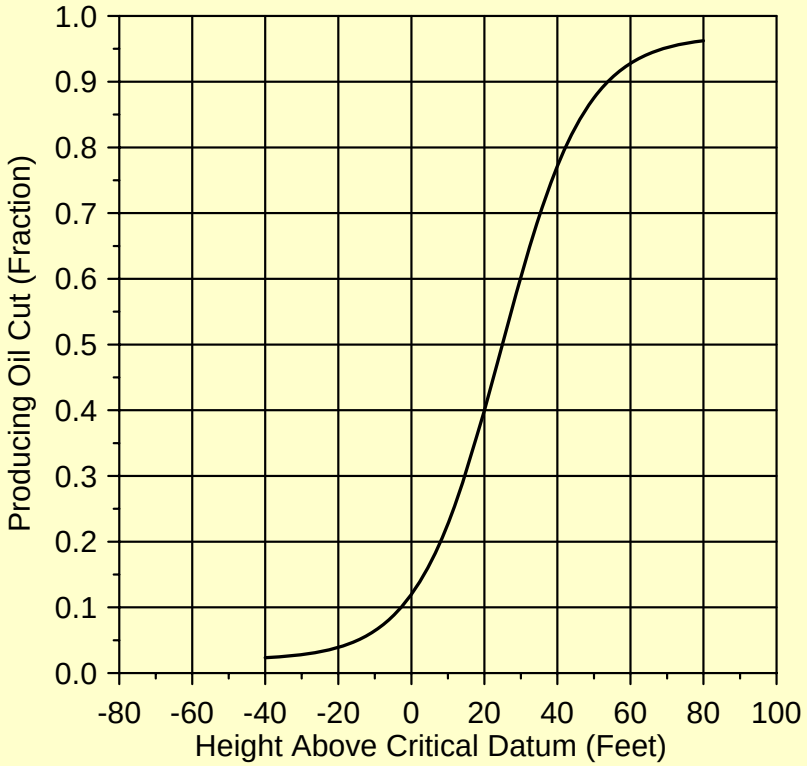
Inferred Reservoir Properties from B Cycle Thickness

- Log Analysis – Porosity and Saturation
- Drill Stem Tests – Permeability and Oil Cut
- Production History – Oil Cut
- Thin B Cycle Wells Usually Have Poor Porosity and Permeability But High Oil-Cut
- Thick B Cycle Wells Usually Have Thick Porosity and Low Oil-Cut

Reservoir Properties with Depositional Setting



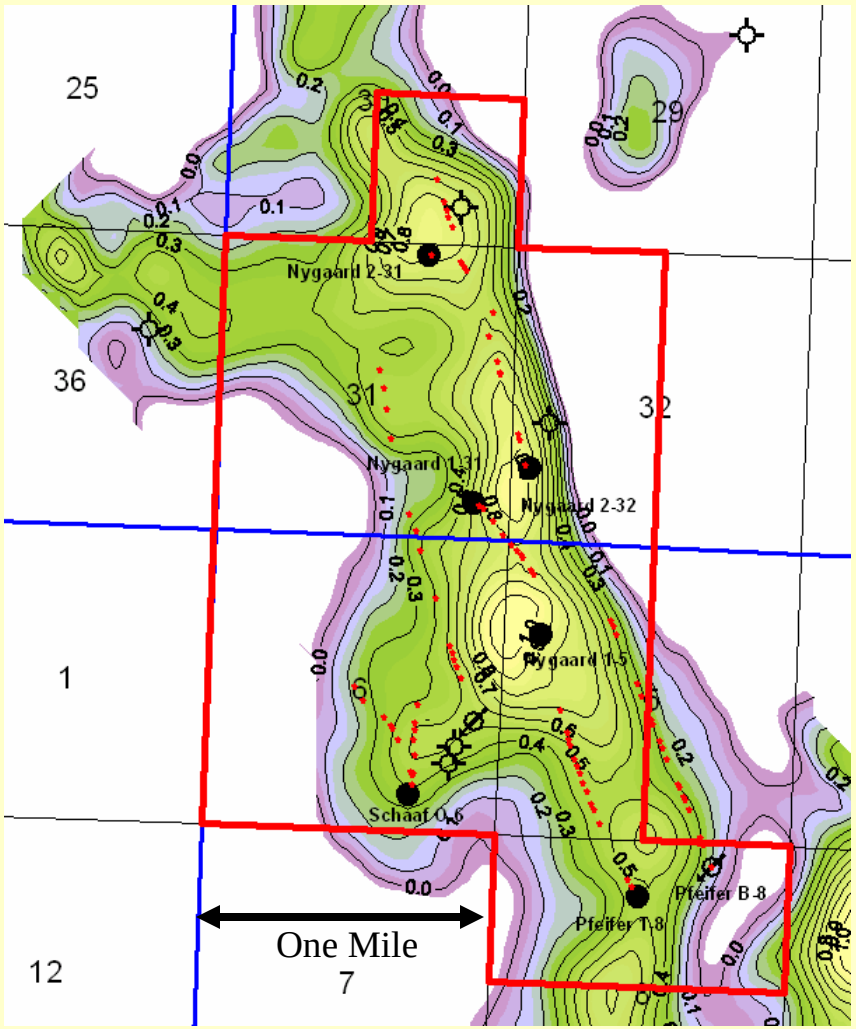
Producing Oil Cut from Structure



- Red River B Production Characteristics Are Also Affected by Structure
- Height Above Regional Depth Trend Has High Correlation with Oil-Cut

Producing Oil-Cut Transform Example

Amor South Red River Unit
Bowman County, ND



- Map of Oil-Cut Transform from B Cycle Thickness and Height Above Regional Depth Trend
- Map of Oil Saturation Can Be Inferred from Capillary Pressure Properties and Oil-Cut
- Map of Oil Pore-Volume Can Be Estimated from Average or Mapped PHI-H and Oil Saturation