

# The North Dakota Bakken Play - Observations

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North Dakota Geological Survey



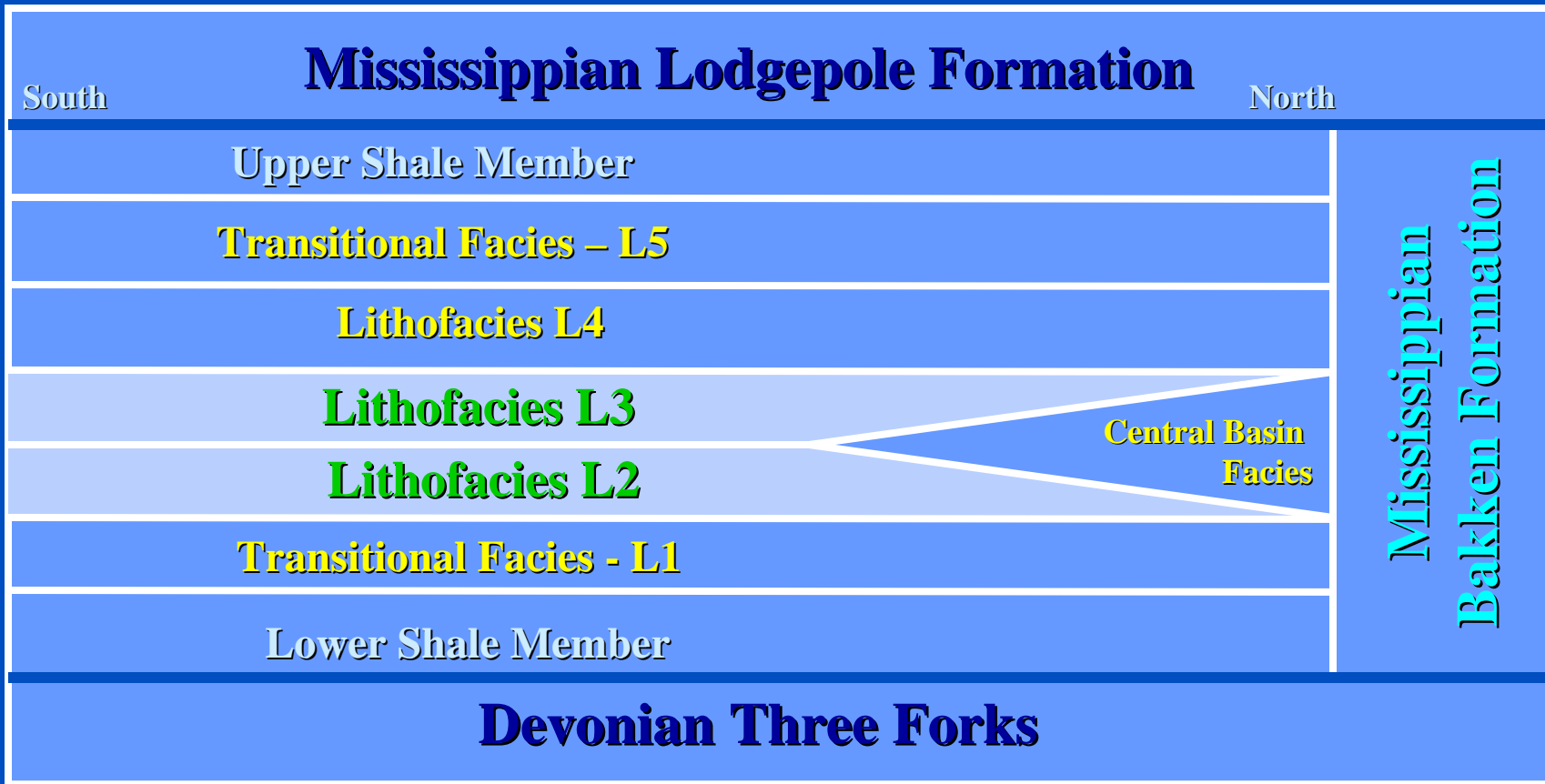
# The Basics

## Bakken Formation in North Dakota

- Upper & Lower Black Shale
  - World Class Source Rock
    - TOC's as high as 40%
    - HC Generation - 200 to 400 BBbls of Oil
- Clastic Middle Member
  - 5 Lithofacies
    - Primarily Sandstones and Siltstones with Interbeds of Dolostone and Limestone
    - Low Porosity & Permeability

# Stratigraphy

## Central Bakken Basin in North Dakota

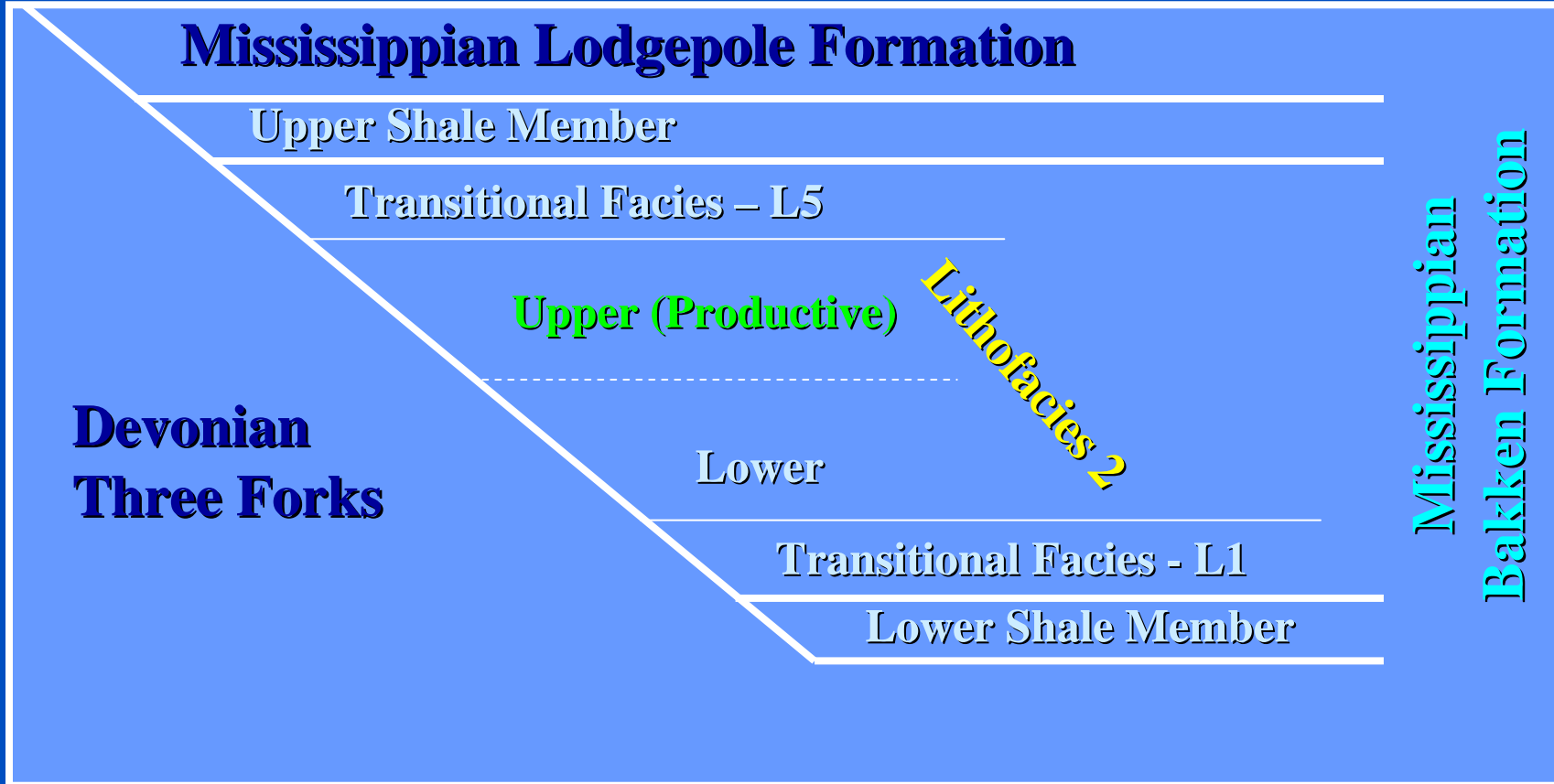


# Stratigraphy

## Bakken Limit in North Dakota

South

North





*Upper Shale*

**Lithofacies 5**

**Lithofacies 4**

**Lithofacies 3**

**Lithofacies 2**

**Lithofacies 1**

*Lower Shale*



**Conoco, Inc.  
#17 Watterud "A"**

**Shell Oil Co.  
#32-4 Young Bear**



*Upper Shale*

**Lithofacies 5**

**Lithofacies 4**

**Lithofacies 3**

**Lithofacies 2**

**Lithofacies 1**

*Lower Shale*

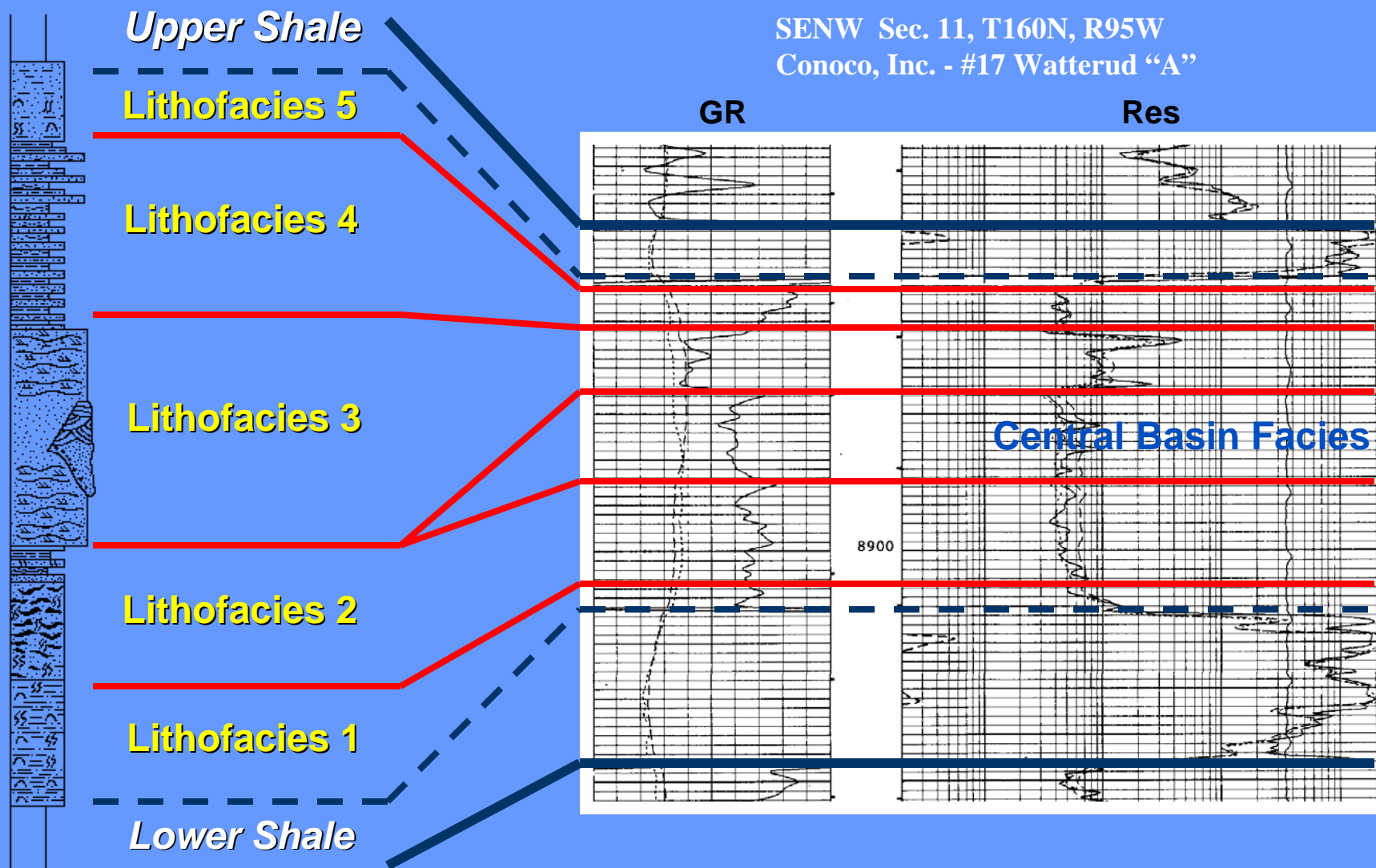


**Shell Oil Co.  
#32-4 Young Bear**

**Meridian Oil, Inc.  
#44-27 MOI**



# Lithofacies of the Middle Member



(From LeFever and others, 1991)

# Bakken Formation

Middle Member (Sandstones, Siltstones & Carbonates)

- **Mineralogy**
  - Detrital Quartz
  - Calcite and/or Dolomite
  - Ankerite (Iron-rich Dolomite)
  - Pyrite ( $\text{FeS}_2$ )
  - **Clay**
    - Illite
    - Chlorite
    - Mixed-layer Clays (Illite & Smectite)



# Mineralogy Related Problems

- **Ankerite (Iron-bearing Dolomite) & Siderite**

**HCl**



**Iron Hydroxides**



**Plugged pore throats & pores resulting in a decrease in permeability**

# Example

Pan American Petroleum - #1 B.E. Hove

- **I.P. - 756 BO & 3 BW**
- **Completion –**
  - 10,000 gal of acid
  - 2 workovers
    - Acid treatments
    - Water-based fracture stimulation treatment
- **P&A – non-commercial production**

# Mineralogy Related Problems

- **Clays**

  - Illite, Chlorite & mixed-layer Clays**

    - Response to Acid

    - Response to Water

- **Organic Material**

  - TOC's > 0.5%**

    - Wireline Log Effects

# Middle Member Bakken

## Porosity Types

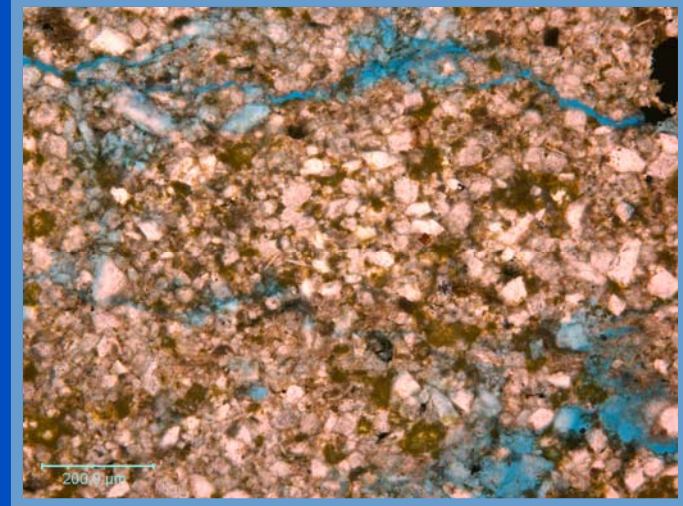
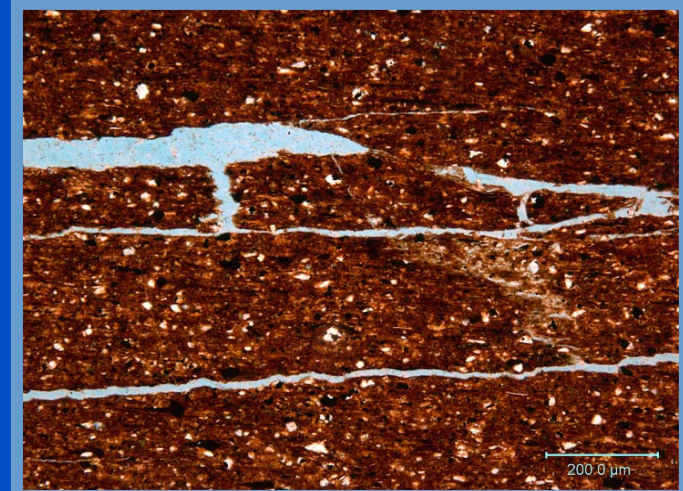
- **Primary Porosity**
  - Interparticle
  - Intercrystalline
- **Secondary Porosity**
  - Dolomitization
    - Matrix
    - Cement
- **Microporosity**



# Middle Member Bakken

## Porosity Types

- **Natural Fractures**
  - Regional
  - HC Generation
- **Microporosity**



# Middle Member Bakken

## Porosity Types

- **Artificial Fractures**
  - **Pro**
    - Enhance existing  $\phi$  and K and fractures
    - Production pathway for the shales
  - **Con**
    - Frac out of zone
      - Water-bearing zones
    - Increase borehole stability problems

# **Microporosity**

## **Primary, Secondary or Fracture**

- **Avoid water-based drilling and completion fluids**
  - **Water Blocking** – the Bakken is “Oil Wet”
- **Avoid heavy muds (balanced or slightly under-balanced)**
  - **Minimize formation damage**
- **Avoid rapid drawdown**
  - **Minimize closing microfracture porosity**



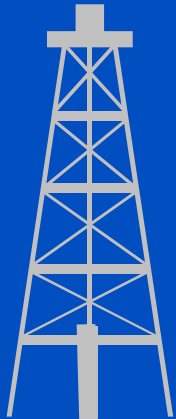
# Example

Oryx Energy Co - #1-HD Marmon

- Heavy muds to kill well
- I.P. – 15 BO, 500 MCF, 0 BW

# North Dakota

## Bakken Middle Member Wells



- **52 Horizontal Wells**
  - **3 Dry Holes**
  - **49 Producers**
    - **9 wells > 300 BOPD**
    - **17 wells – 100 – 200 BOPD**
    - **23 wells < 100 BOPD**

# Recommendations

## Past History - Vertical & Horizontal Bakken Wells

- **Shorten the Lateral Leg**
  - **Pro**
    - **Faster to drill – Less Formation Damage**
    - **Cheaper**
    - **Same ultimate production**
    - **Ability to do multiple legs with cross-cutting fracture stimulation**
  - **Con**
    - **Acreage**

# Recommendations

## Past History - Vertical & Horizontal Bakken Wells

- **Drilling**
  - **Oil-based muds (preferably Bakken crude)**
  - **Balanced to slightly underbalanced**
    - **Minimizes formation damage and keeps the hole clean of fines**

# Recommendations

## Past History - Vertical & Horizontal Bakken Wells

- **Completions**
  - 3 or 4 months of production prior to fracture stimulation
  - Smaller fracture stimulation treatment
  - Re-stimulate

# **Ideal Bakken Well**

- **Short lateral well**
  - **Potential for additional laterals**
  - **Base of the middle member section**
- **Drilled with Bakken crude-based muds**
  - **under-balanced or slightly under-balanced**
- **Produced for 3 or 4 months**
- **Fracture stimulated with Bakken crude-based fluids**
- **Potential for fracture re-stimulation**