

# **The Niobrara Petroleum System, A Major Tight Resource Play in the Rocky Mountain Region\***

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Search and Discovery Article #10355 (2011)

Posted September 12, 2011

\*Adapted from oral presentation at AAPG Rocky Mountain Section meeting, Cheyenne, Wyoming, USA, June 25-29, 2011

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## **Abstract**

The Niobrara Petroleum System of the U.S. Rocky Mountain Region is a major tight petroleum resource play. The Niobrara is self-sourced and reservoirs are low-permeability chinks, shales, and sandstones. Source beds have total organic carbon contents that range from 2- to 8-weight percent. Source beds are thermally mature in the deeper parts of many of the Laramide basins in the Rocky Mountain region. Continuous or pervasive accumulations occur in thermally mature areas.

The Niobrara source rocks are dominantly Type II (sapropelic). Oil accumulations occur where source beds are still in the thermogenic oil window (e.g., Denver Basin). Thermogenic gas accumulations occur where the source beds have entered the gas generating window in deeper parts of basins (e.g., Piceance Basin). Biogenic methane occurs in shallow chalk reservoirs on the east flank of the Western Interior Cretaceous Basin. In addition shallow gas fields are found in northern Montana.

Natural fractures are important in controlling sweet spots in the play and form in response to several causes. Several models create fractures in the Niobrara and include Laramide tectonics, Neogene extensional tectonics, solution of evaporites, hydrocarbon generation, and regional stress patterns.

The Niobrara is a technology reservoir that requires horizontal drilling and multi-stage hydraulic fracturing. The Niobrara petroleum system is present over most of the Rocky Mountain Region and is prospective in many areas.

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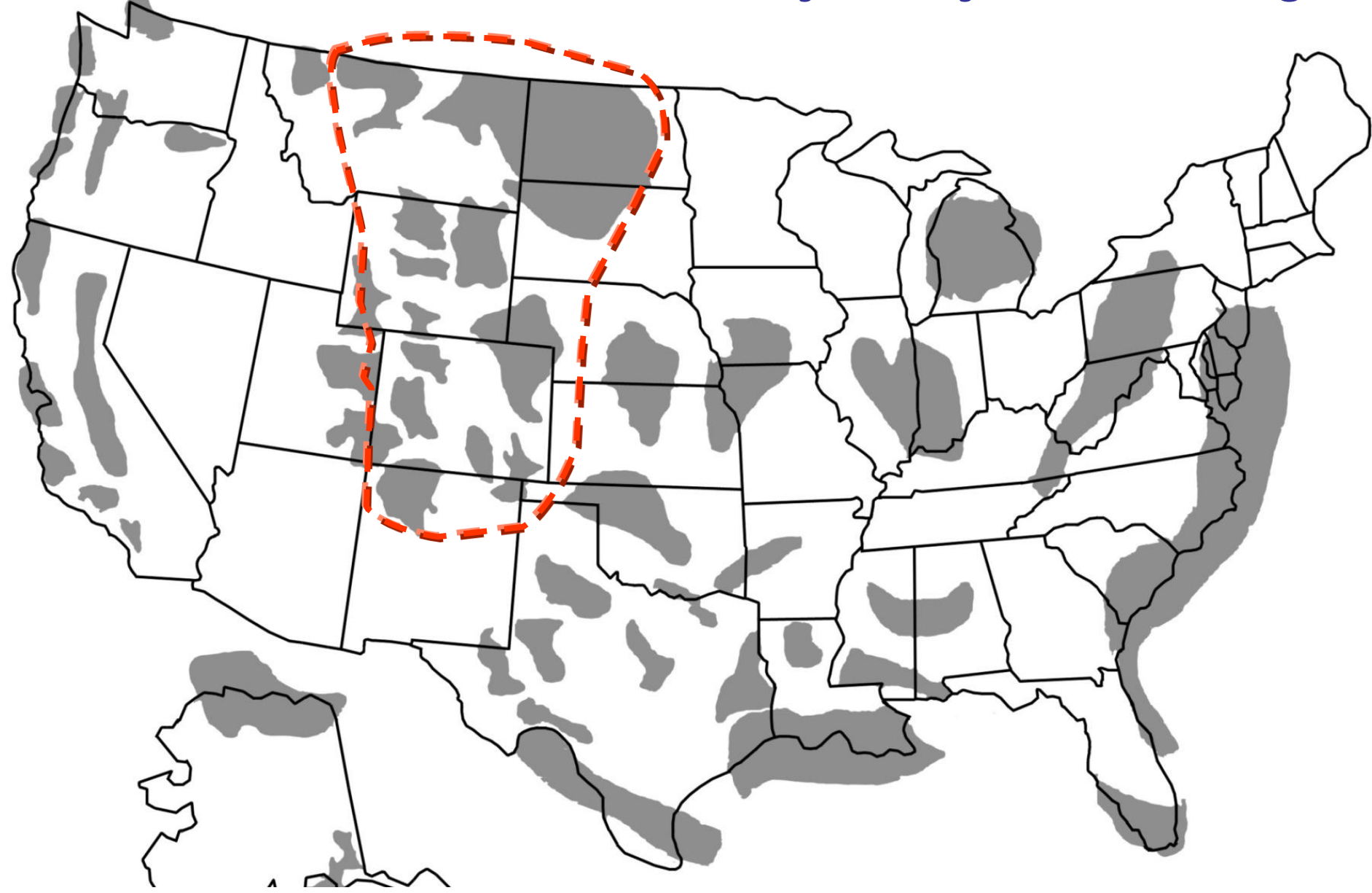
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# The Niobrara-Mancos Oil & Gas Play, Rocky Mountain Region



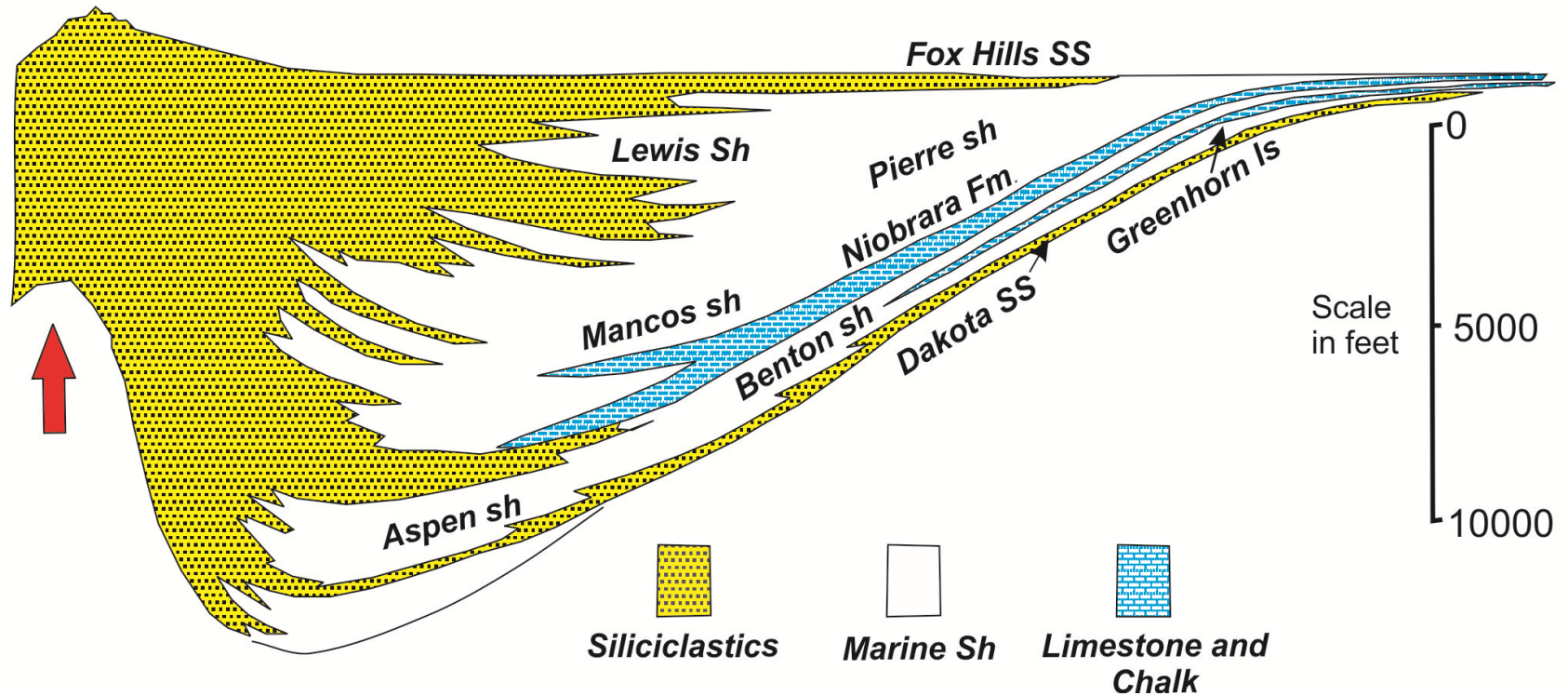
Utah

Colorado

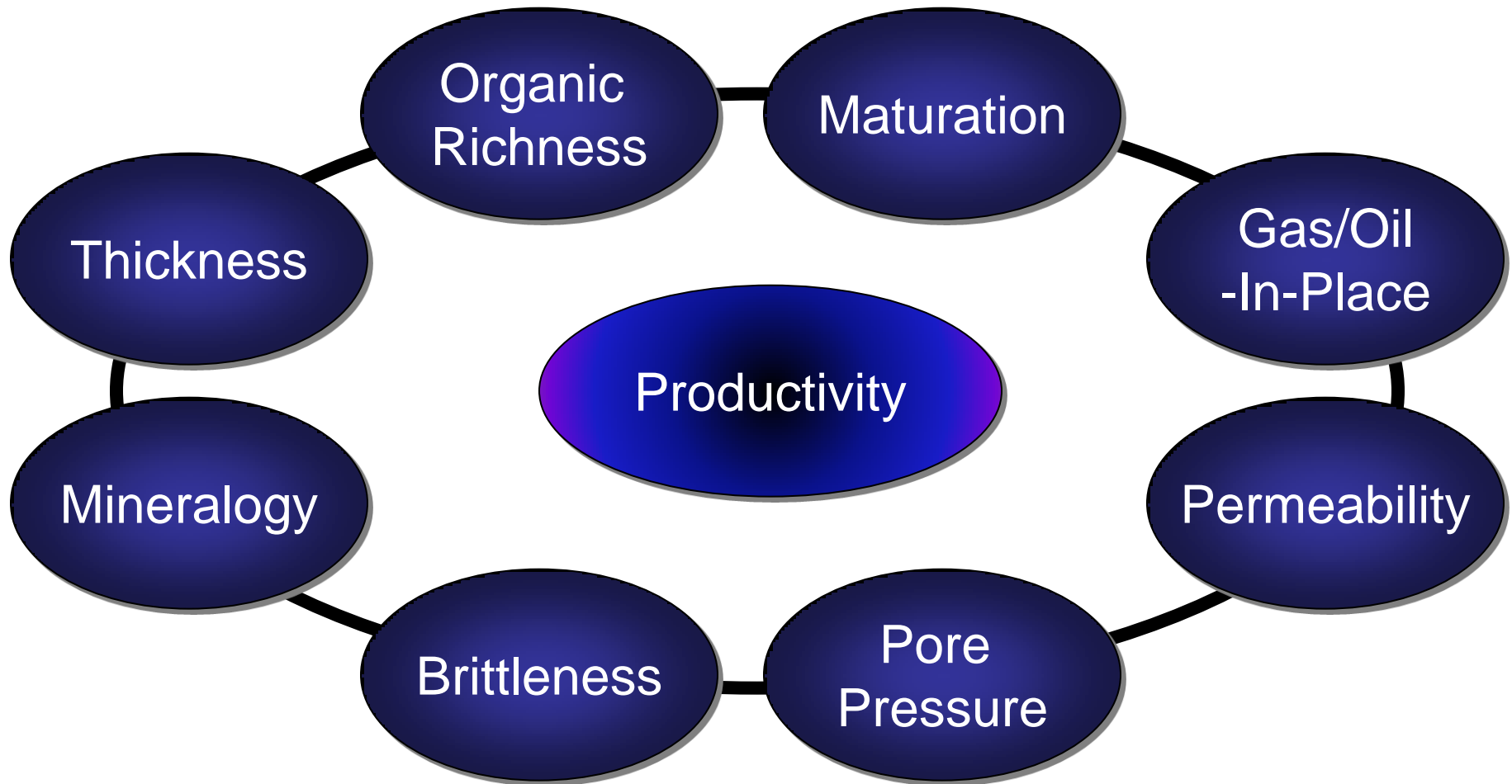
Kansas and Nebraska

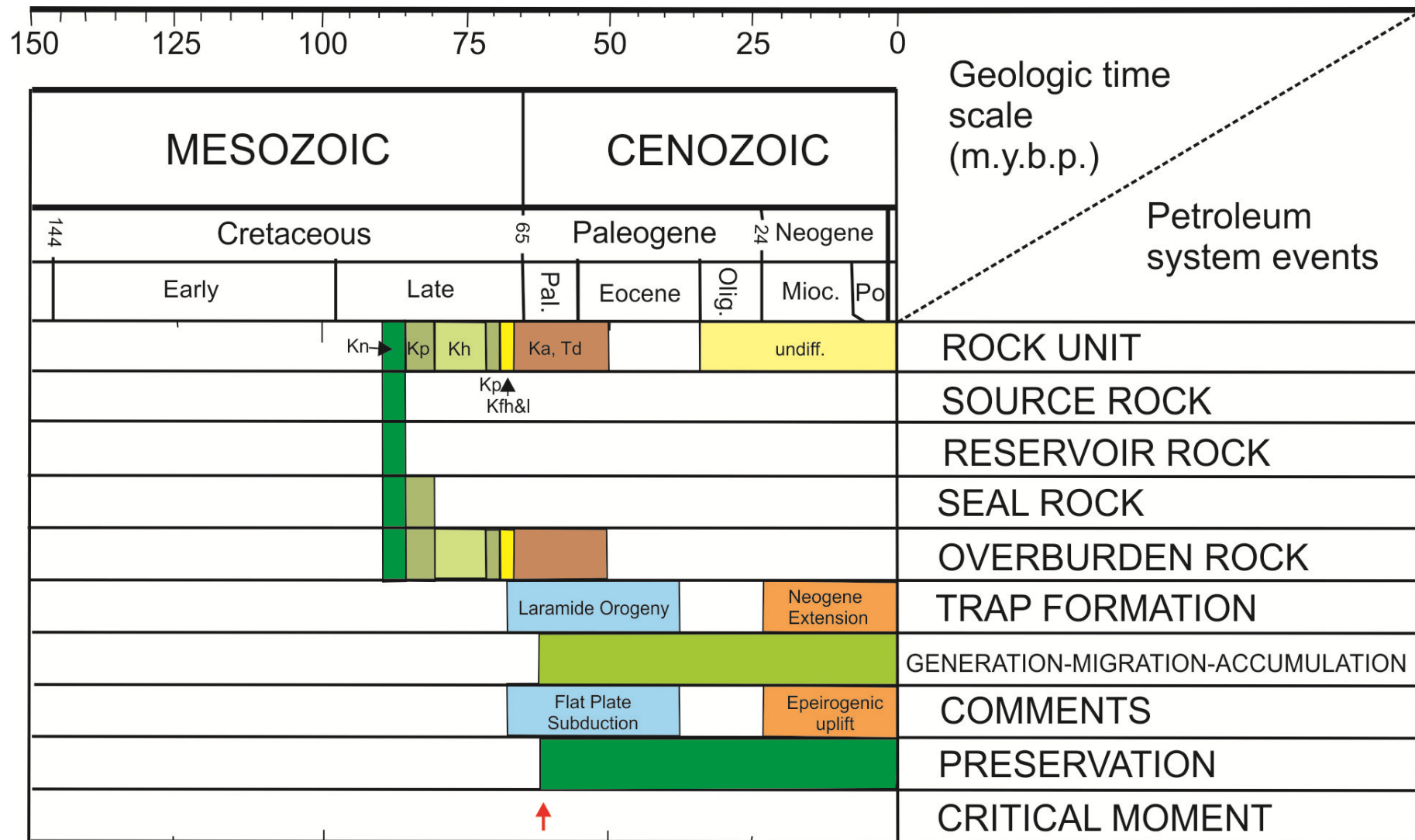
Iowa

**Wasatch Mtns.**



# Elements of a Successful Tight-Oil Play





# Niobrara Production

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- Structural Fields (folds and faults)
  - Anticlines (Rangely, Rio Blanco County, CO)
  - Structural noses (Buck Peak, Moffat County, CO)
  - Monoclines (Puerto Chiquito, San Juan County, New Mexico)
- Continuous Accumulations (the new paradigm)
  - Denver Basin (the Silo “sweet spot”)
  - Southern Powder River Basin
  - Deep Piceance



# Niobrara Production

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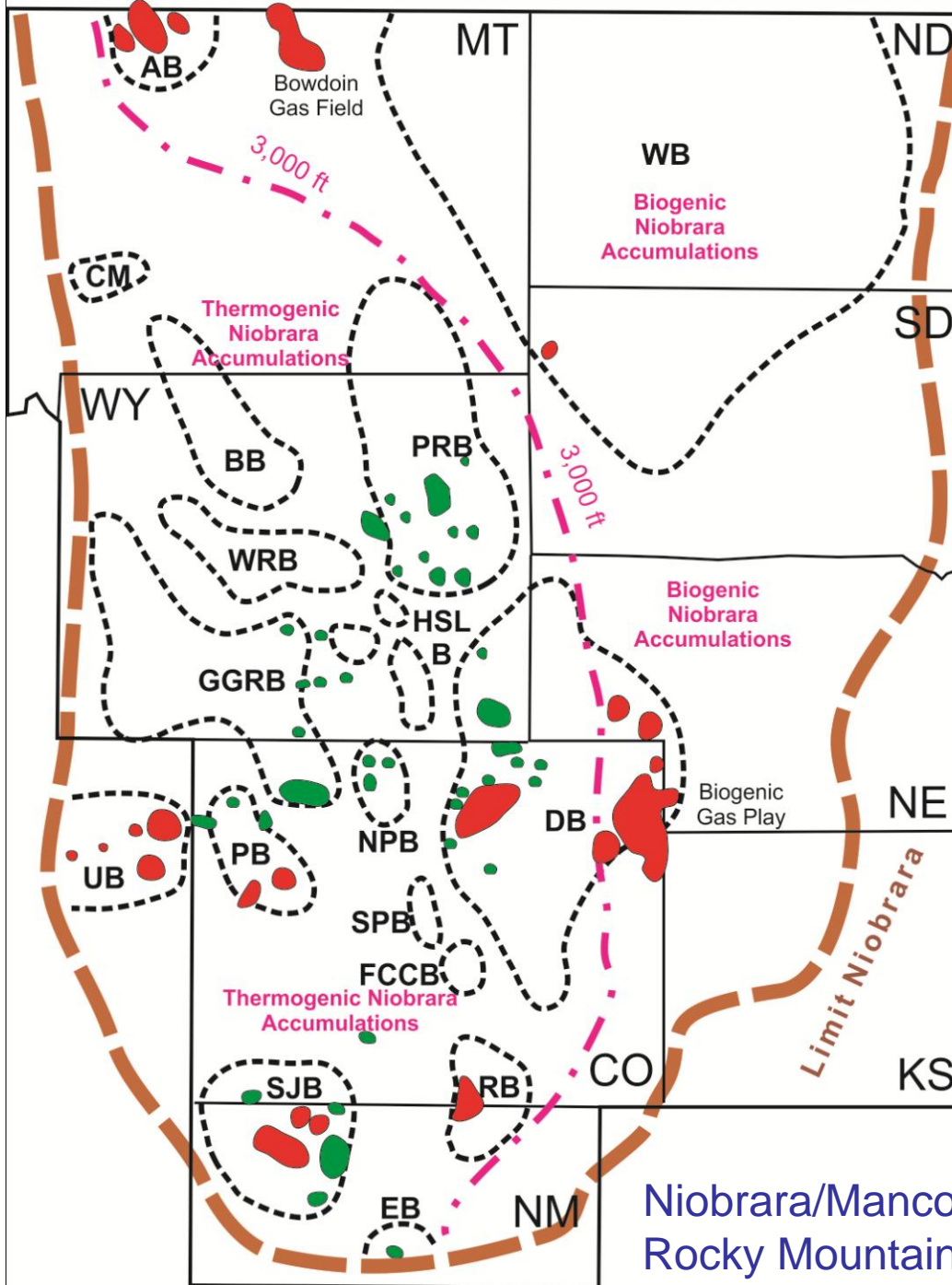
- Long recognized as a very tight reservoir
- Fractures are key!
- Matrix contribution (?)



# Origin of Fractures

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- Folding and Faulting (Laramide)
  - Tectonic, diapiric, slumping
  - Wrench faults
- Geologic History of Fractures
  - Recurrent movement on basement shear zones
- Solution of evaporites
- High Fluid Pressure
  - Maturation of source rocks
- Compaction and dewatering
- Regional stress field
- Regional epeirogenic uplift



## Fracture Related Fields

### Florence Cañon City (Pierre Shale)

- 1881
- 15.3 MMBO

### Boulder (Pierre Shale)

- 1901
- 1 MMBO

### Rangely (Mancos)

- 1902
- 11.7 MMBO, 12.2 BCF

### Salt Creek

- 1907
- “Upper shale” Cretaceous

### Tow Creek (Niobrara)

- 1924
- 3 MMBO; 0.3 BCF

### Buck Peak (Mancos, Nio)

- 1956
- 4.7 MMBO; 8.2 BCF

### Puerto Chiquito (Mancos/Nio)

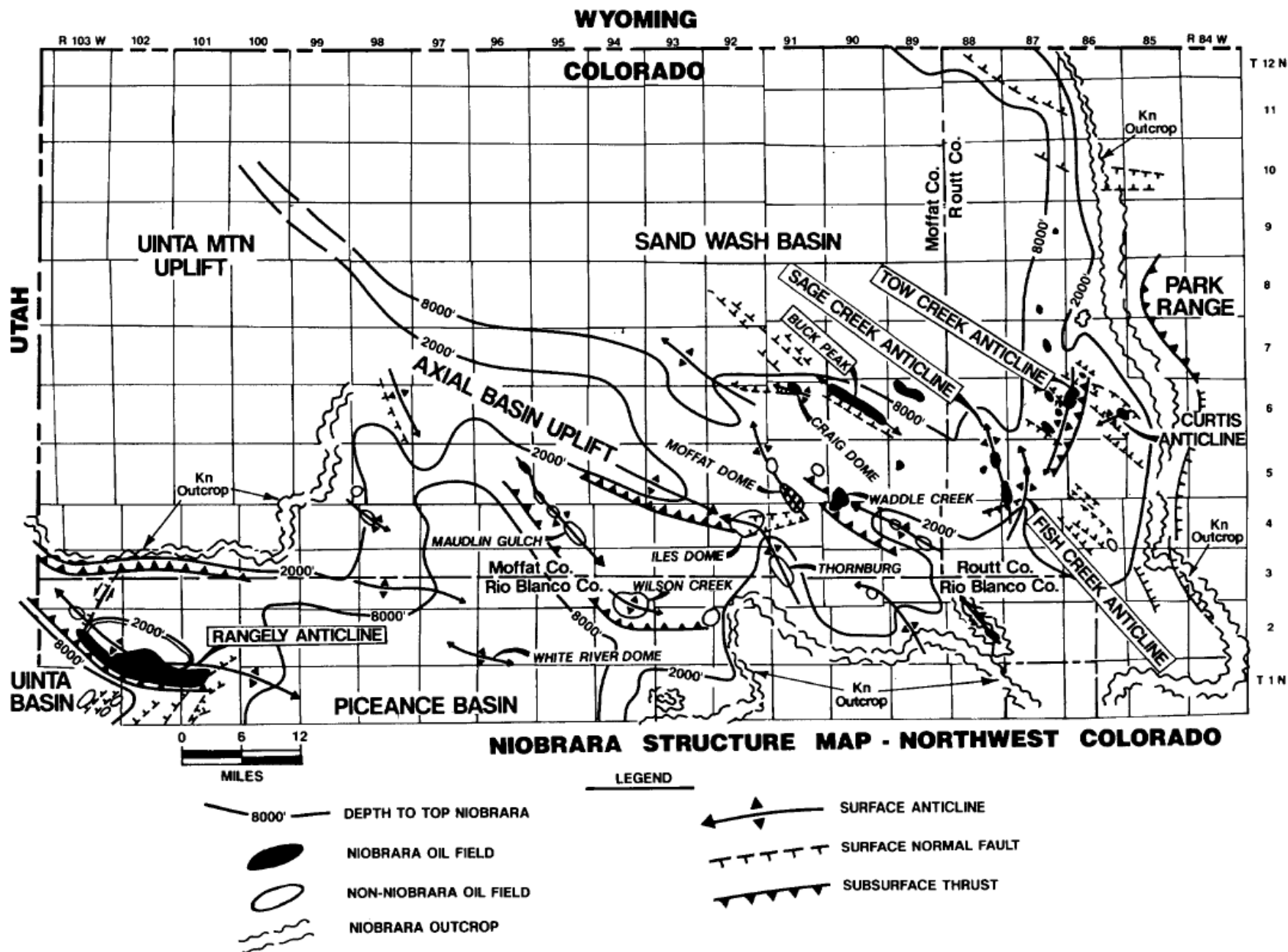
- 1960
- 18.7 MMBO; 52 BCF

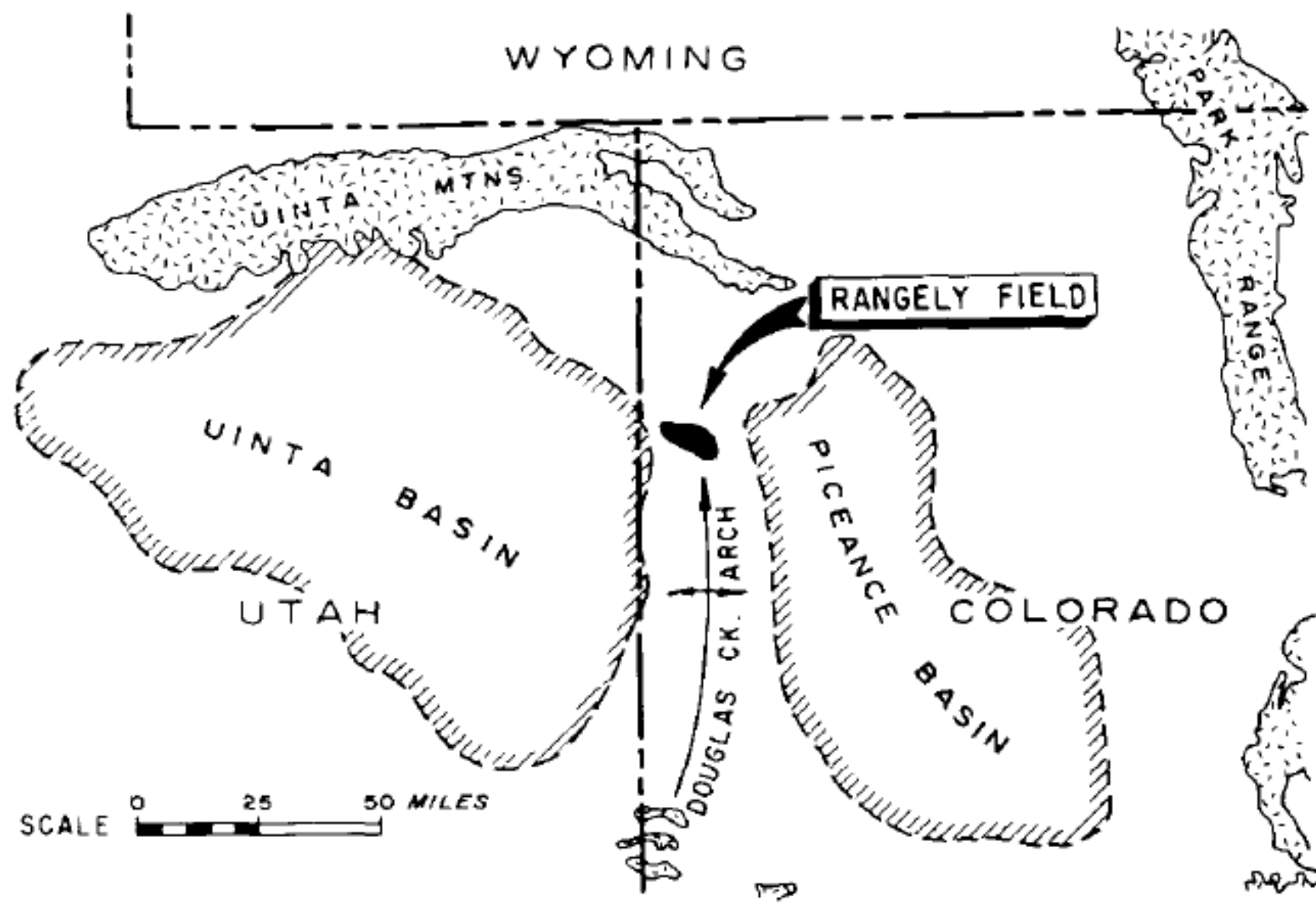
### Wattenberg (Nio, Codell)

- 1970
- 86 MMBO, 1.1 Tcf

### Silo (Niobrara)

- 1981
- 10.4 MMBO; 8.2 BCF





# Rangely Anticline

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- 30 miles long
- 2,000 ft structural closure

# Rangely Mancos Pool

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- NW-trending anticline expressed at surface
- Largest fractured oil field in NW CO
- First well, 1901 completed in 1902 flowing one barrel of oil per day
- Pay zones depths: 100 to 4,000 ft
- Crude: sweet, light green, water-free, 40°-44° gravity
- Cum: > 13 MMBO

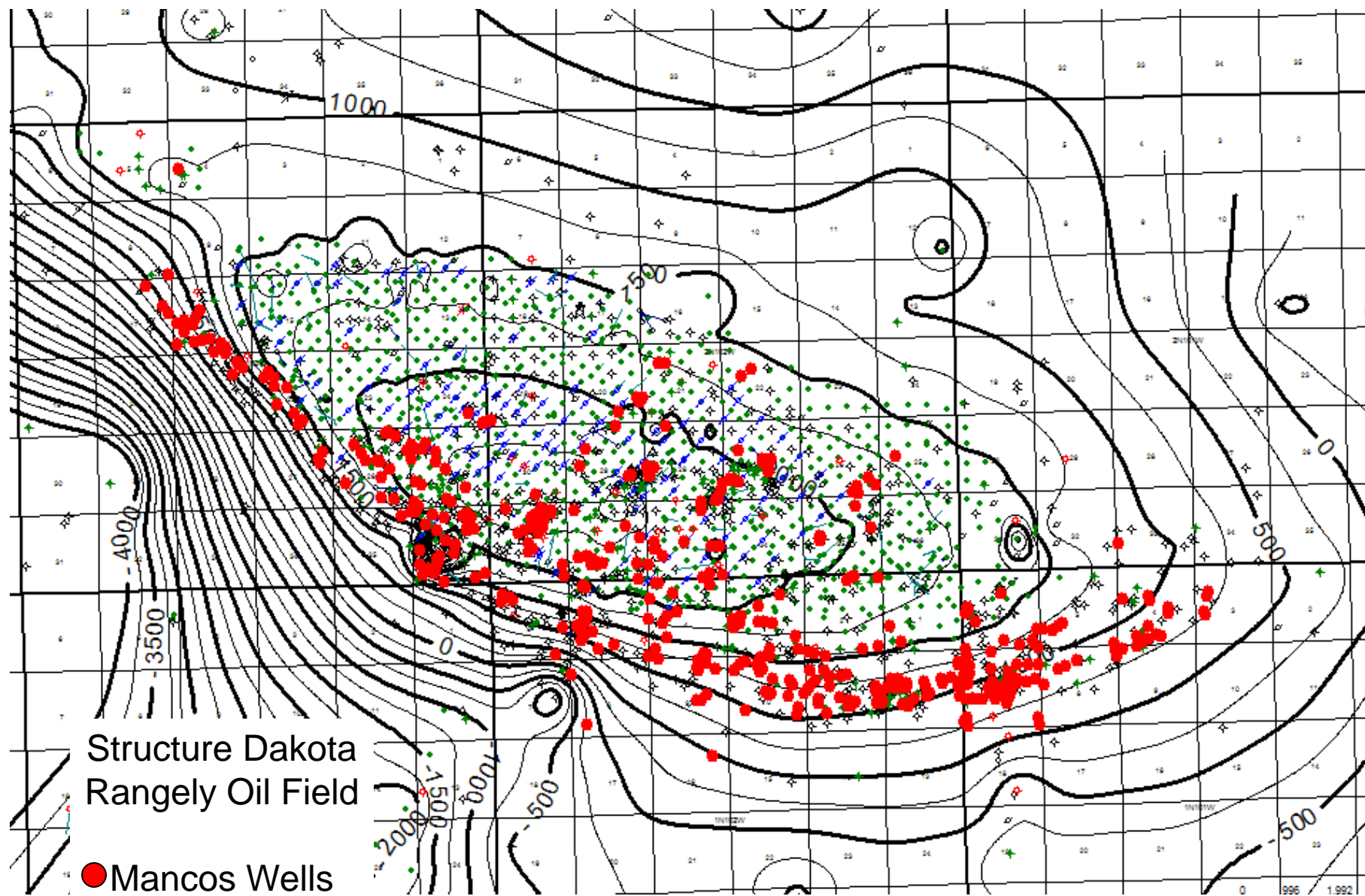
# Fracture Trends

## Mancos, Rangely Field

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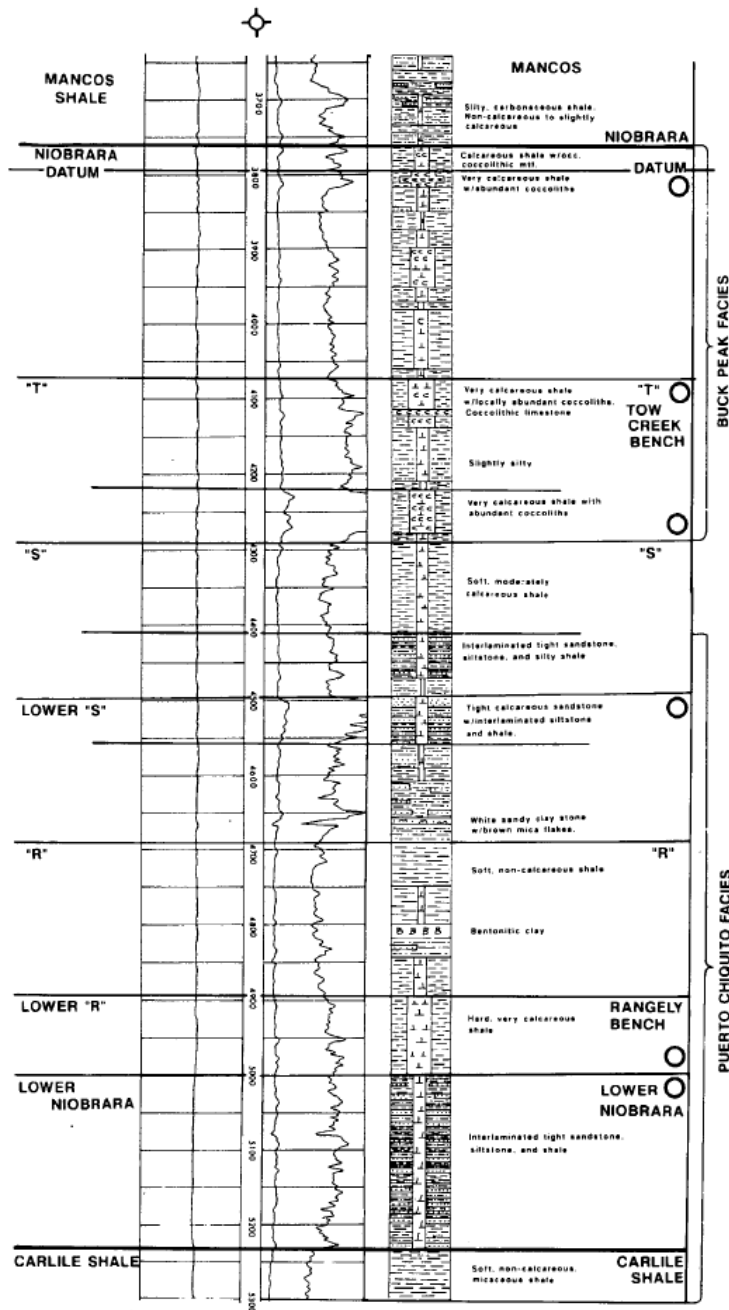
- Two distinct systems:
  - System trending northeast-southwest across the field
  - System situated south of and parallel with the axis of the fold





LA GLORIA, 2-1 GOV'T  
NE NW NE 2-1N-101W

# NIOBRARA LITHOLOGY LOG RANGELY AREA



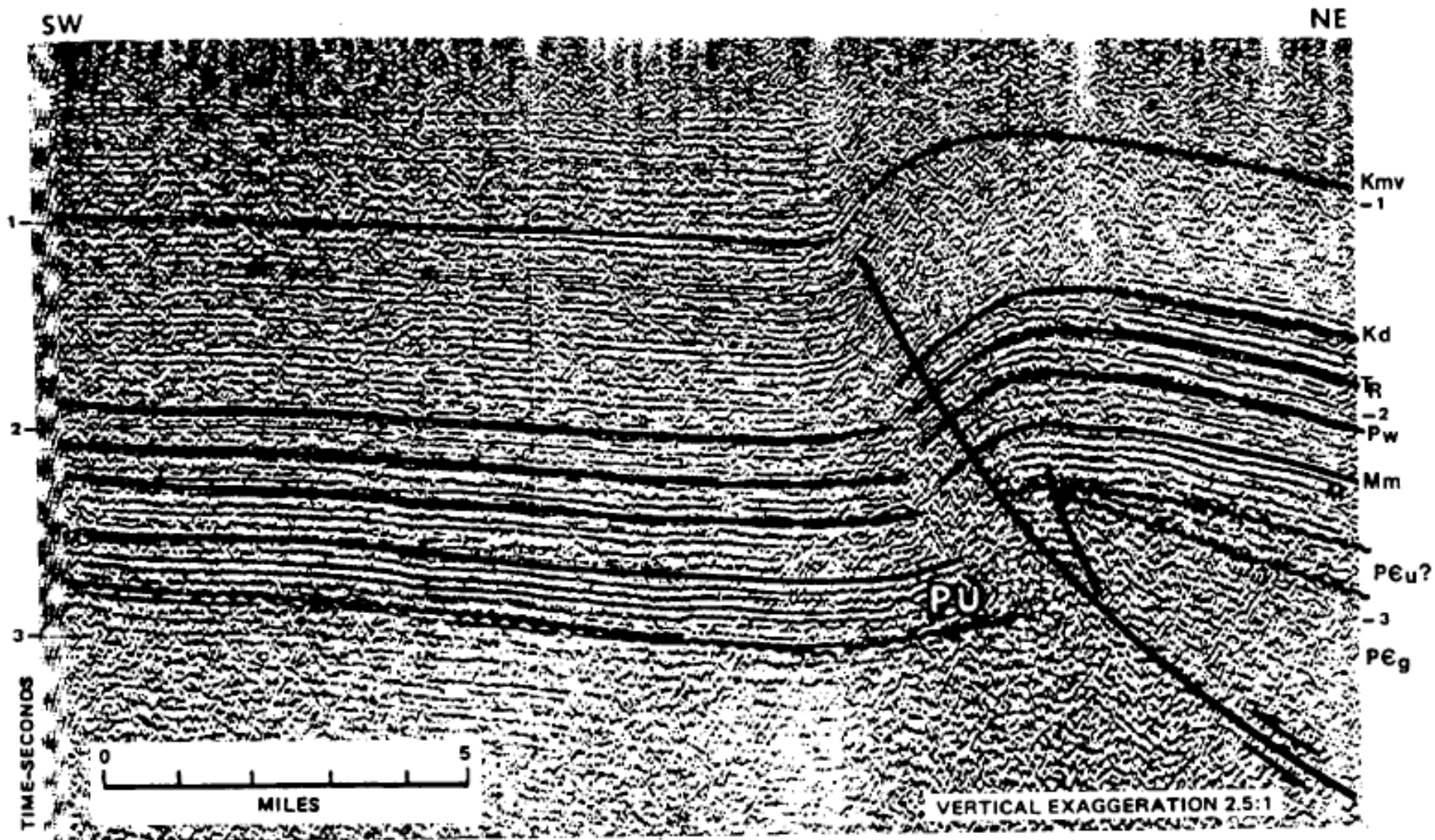
## Niobrara/Mancos Rangely Field

~1400 ft thick

Upper facies: calcareous shales with abundant coccolith debris

Lower facies: interlaminated tight calcareous siltstones and sandstones interbedded with calcareous shales

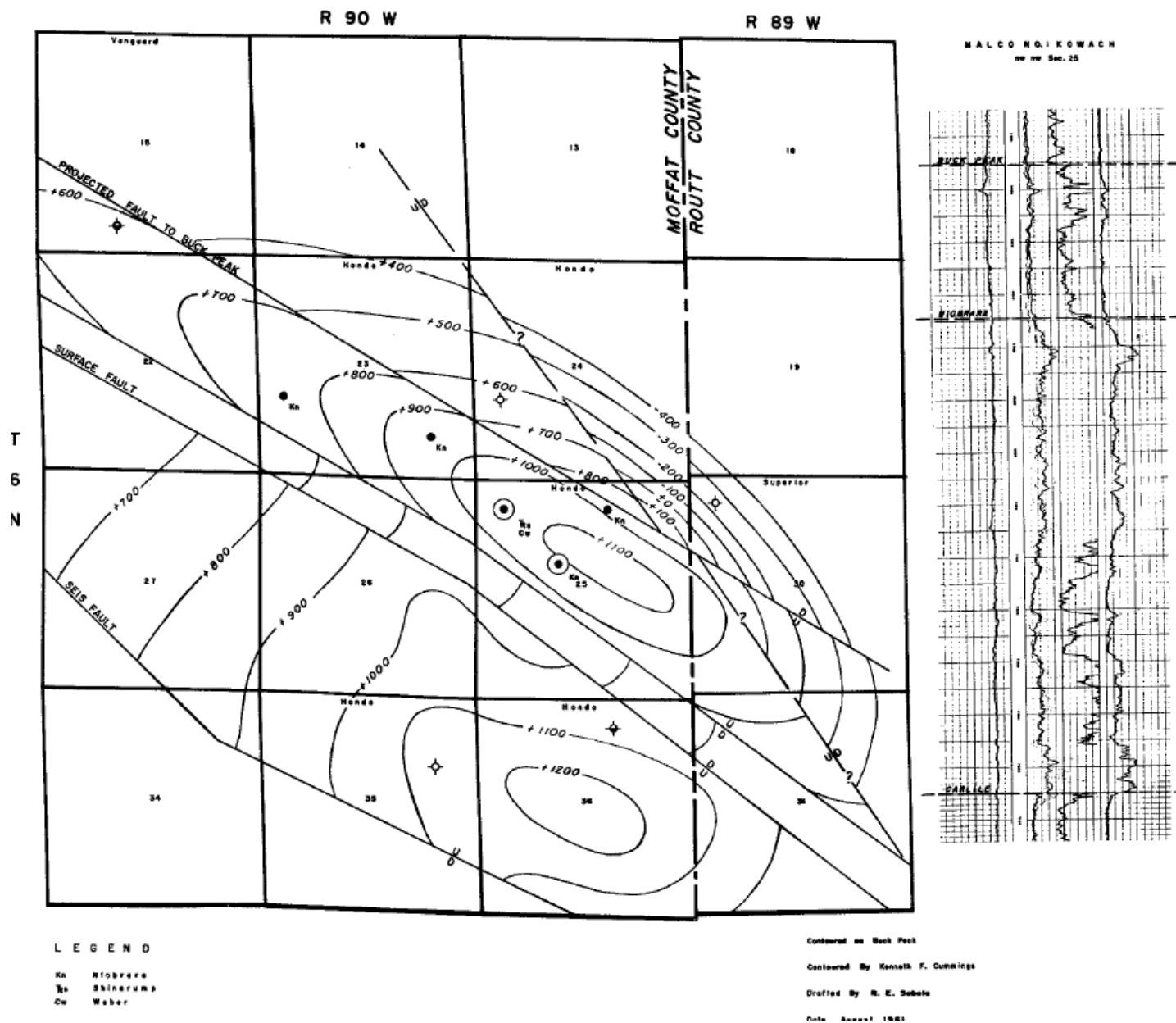




# Buck Peak (1956)

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- Field produces from fractures in calcareous beds of the Niobrara
- Maximum thickness of the fractured reservoir is reported as 1200 ft
- Niobrara depths in field: 6650 to 7600 ft
- Cum: 4.8 MMBO
- Lithology: shale, grey-black, carbonaceous, calcareous, speckled, fractured with calcite and aragonite crystals
- Well spacing: 80 acres
- Oil gravity: 39° API

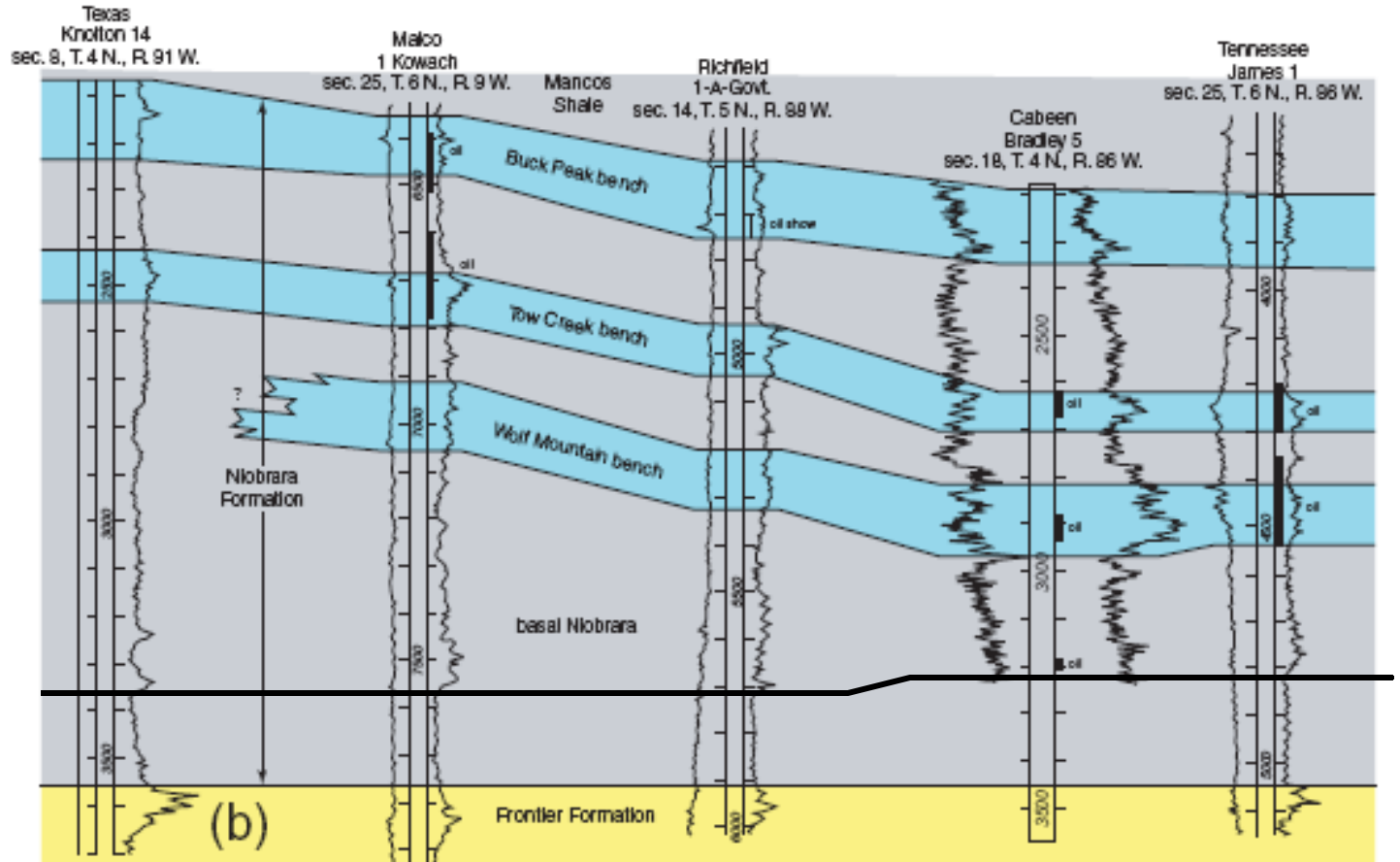
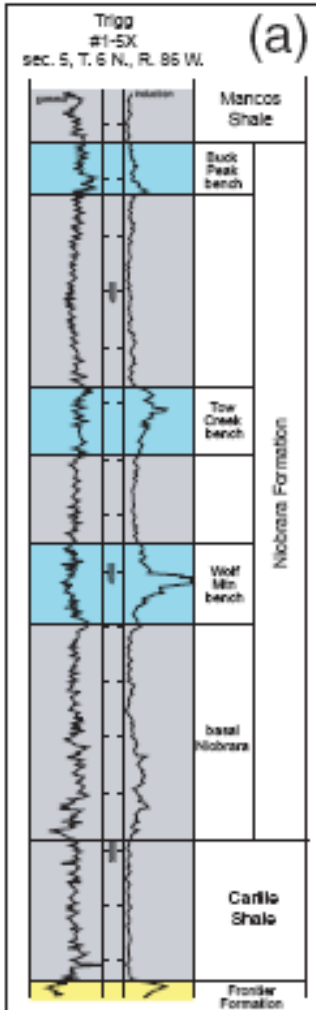


# Buck Peak

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- Underpressured reservoir, original pressure gradient of 0.285 psi/ft
- Oil column in excess of 2,000 ft which favors gravity drainage
- Initial water-free production

# Niobrara NW Colorado



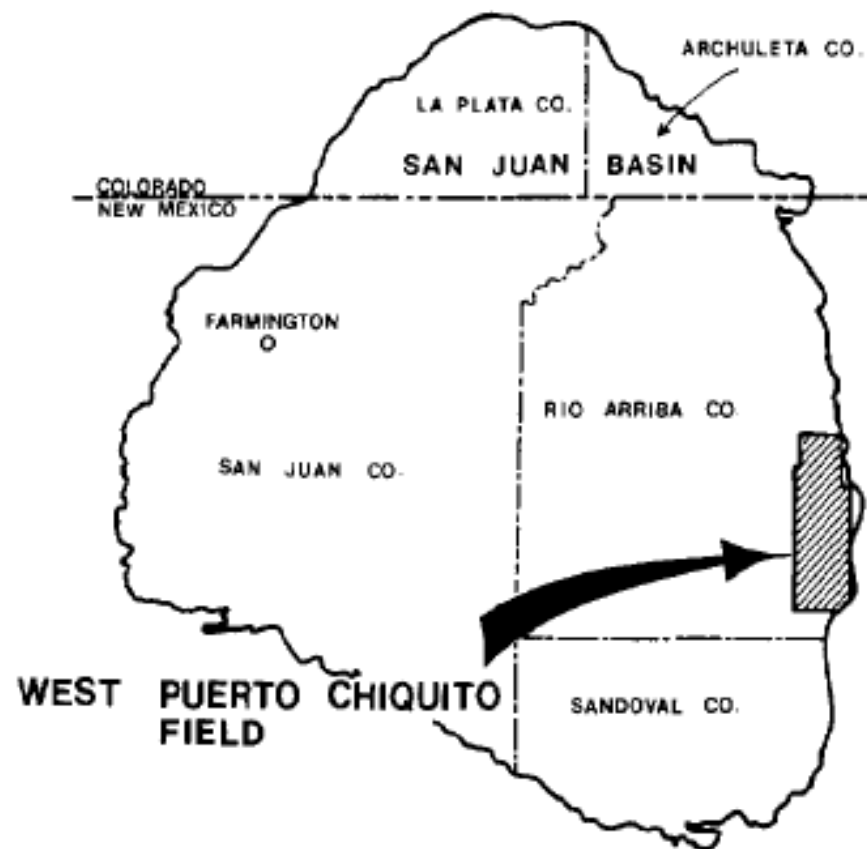


# Puerto Chiquito Fields

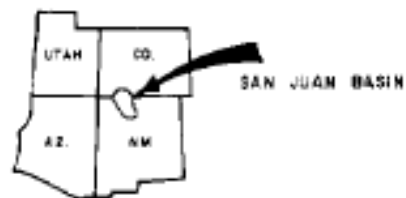
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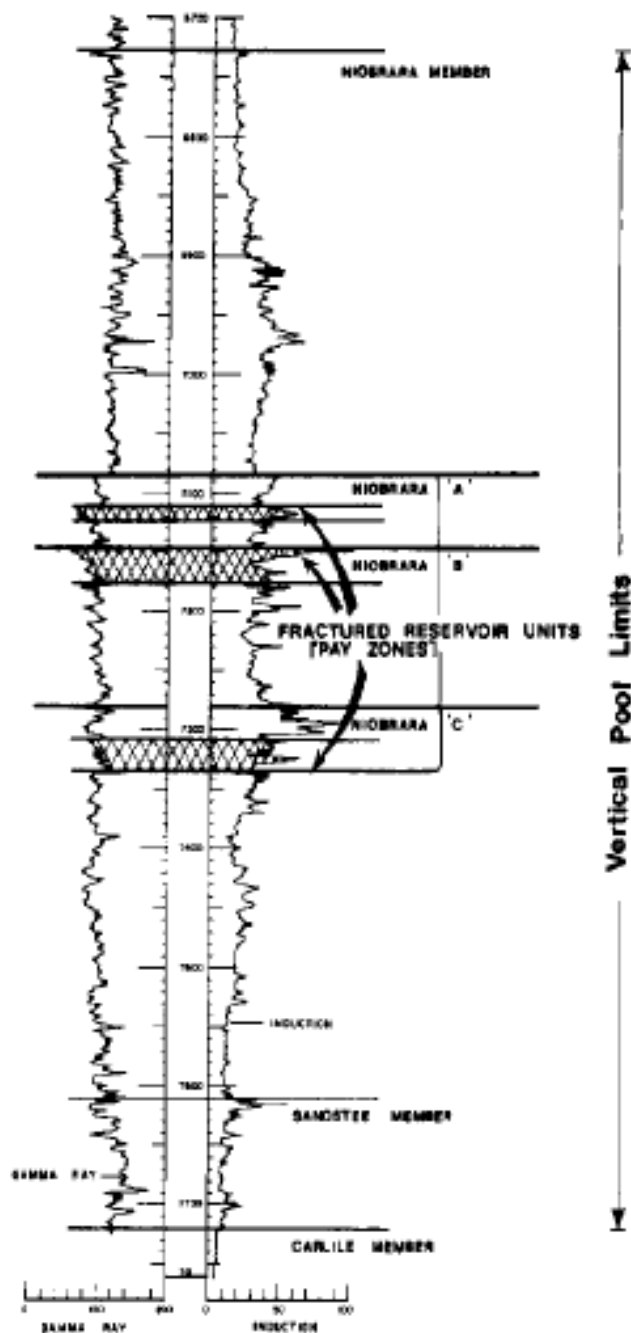
- Eastern central margins of San Juan Basin
- East PC discovered in 1960
- West PC discovered in 1963
- Designated east and west pools because two separate fracture areas
- Fracture systems extend vertically through much of Niobrara equivalent of Mancos Shale
- ~1100 ft thick
- Cum: East and West – 19.3 MMBO





INDEX MAP





- Little matrix porosity
- Most porosity is fracture related
- IPs 1000 to 3000 BOPD
- West Puerto Chiquito, synclinal flexure parallel to the Hogback monocline
- Type of drive: gravity drainage
- Oil gravity: 39° to 40° API
- No produced water
- Approved spacing: 320 acres
- Gross reservoir thickness: 250 ft; net 30 to 100 ft

R I E



**Well Converted To Gas Injection**

## Greer, 1978

# Continuous Accumulations

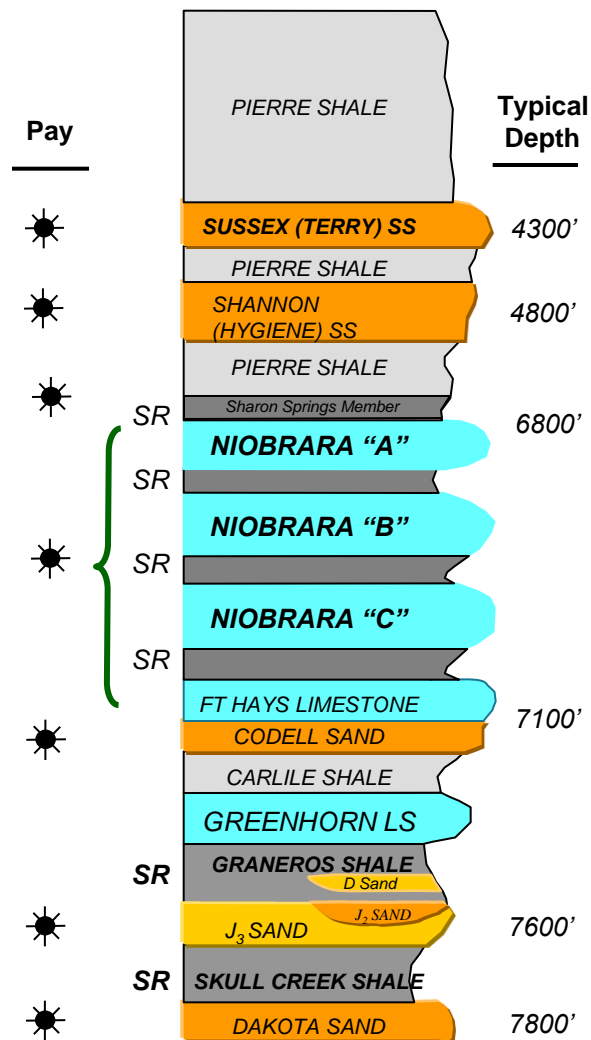
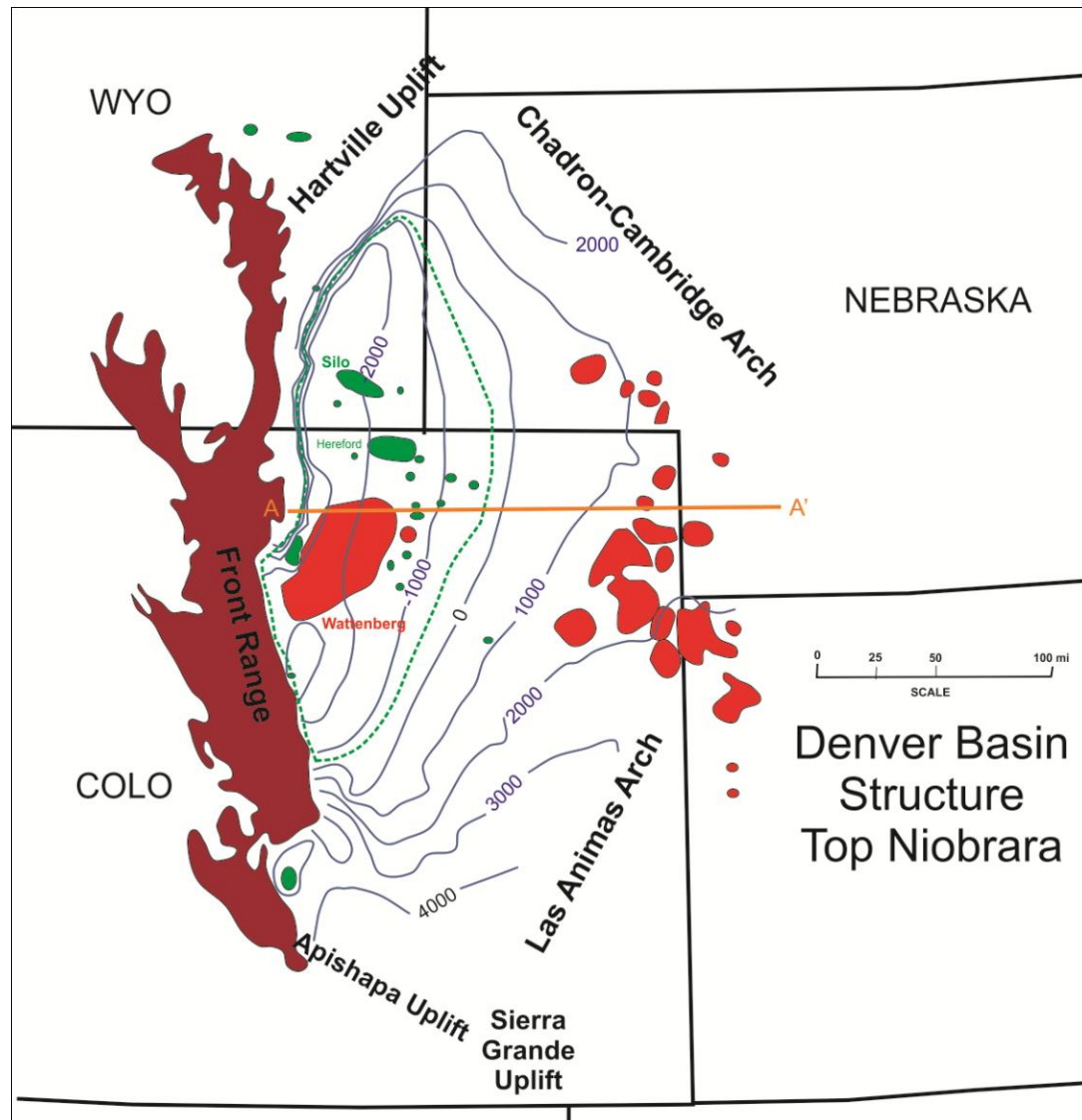
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- No down-dip hydrocarbon/water contact
- Some water production
- Abnormally pressured (+ or -)
- Production independent of structural closure
- Sweet spots controlled by fractures

# Niobrara Petroleum System - Denver Basin

## Shallow Biogenic Gas

## Deep Thermogenic Oil and Gas



COQUINA OIL CORP  
BERTHOUD-STATE  
3

T4N R69W S16  
NE SW

NOBLE ENERGY PROD  
JEFFERS  
42-35

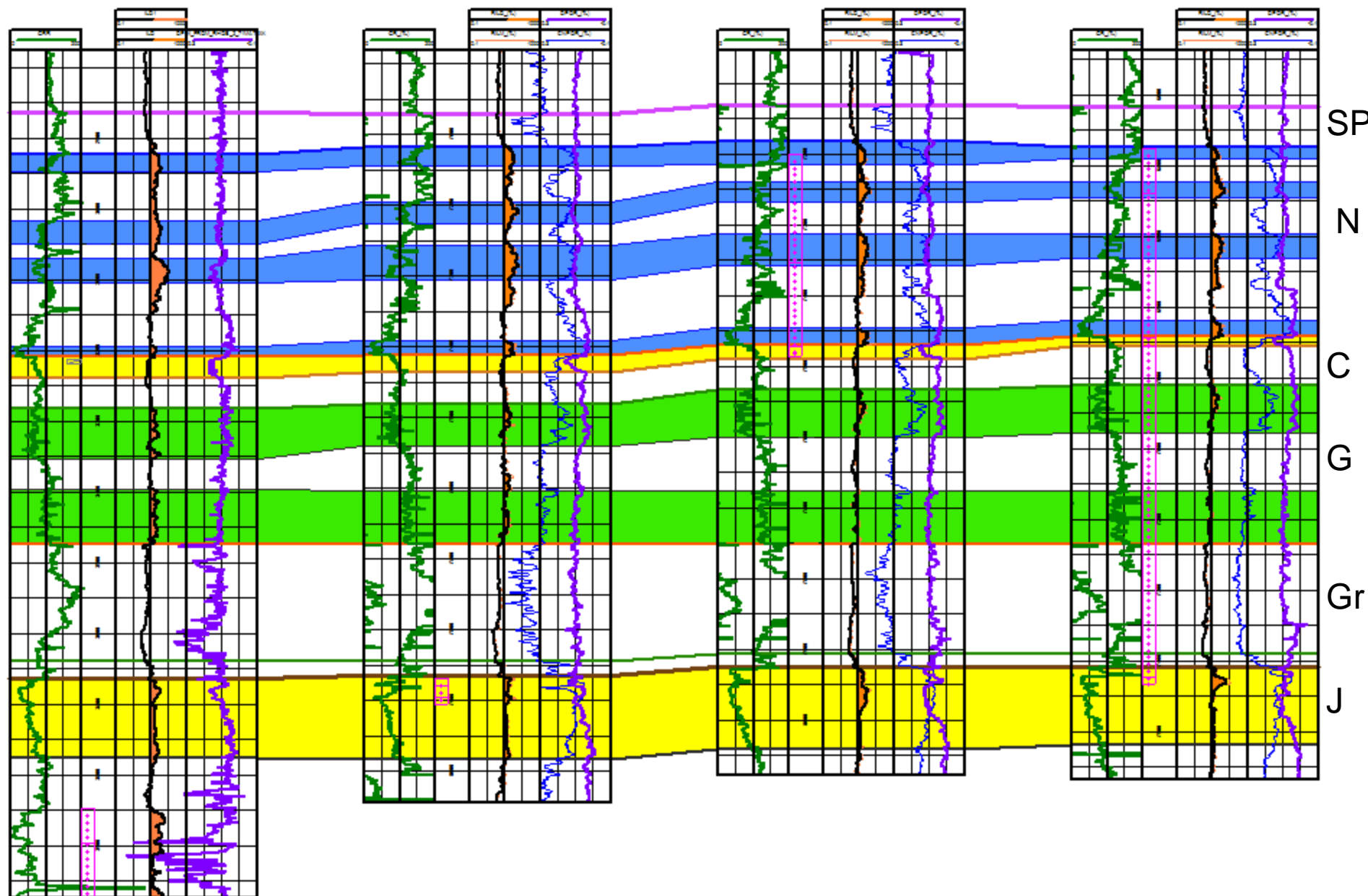
T4N R68W S35  
NW SE NE

KERR-MCGEE O&G ON LP  
ROBERTS  
37-22

T3N R68W S22  
SW SW SE

NOBLE ENERGY INC  
FRONT RANGE D  
9-33

T3N R64W S9  
W2 SW



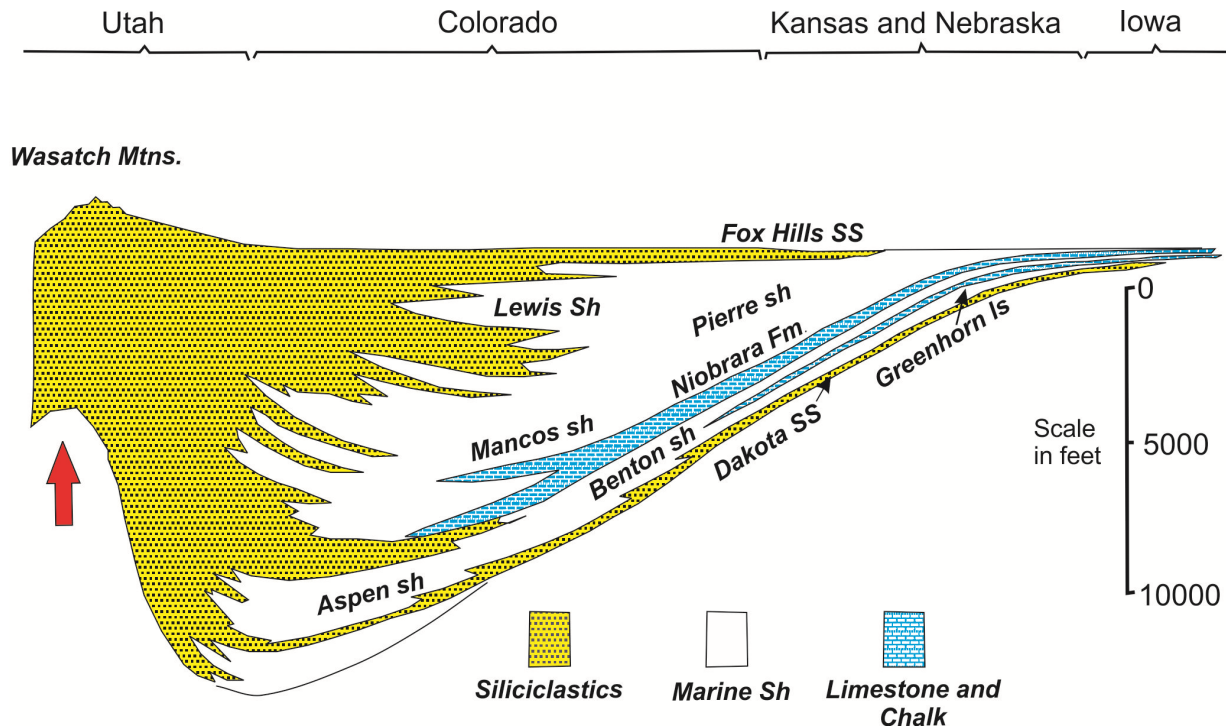
# Summary

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- Structural Fields (folds and faults)
  - Gravity drainage and other drive mechanisms
  - Underpressuring and large oil columns
  - Both synclinal and anticlinal areas produce
- Continuous Accumulations
  - The new game
  - Regional fractures and other structural models important (“sweet spots”)
  - Examples:
    - Denver Basin
    - Southern Powder River Basin
    - Deep Piceance



# Colorado School of Mines Niobrara Consortium



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