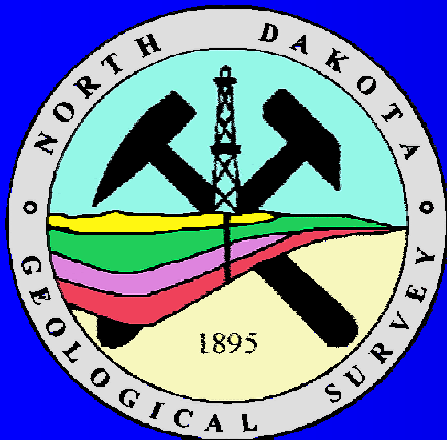
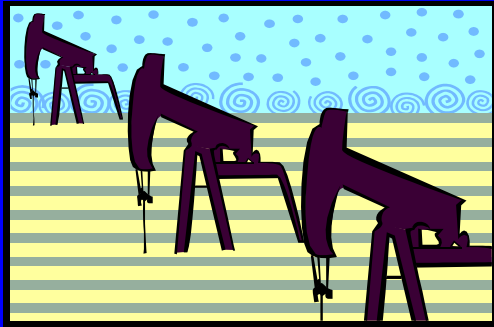


Evolution of Oil Production in the Bakken Formation



Julie A. LeFever
North Dakota Geological Survey



Plays of the Bakken Formation

- **Conventional Bakken (pre-1987)**
 - **Cycle 1 – Antelope Structure (1950s – 60s)**
 - **Cycle 2 – Depositional Edge (1970s – 80s)**
- **Horizontal Drilling of the Bakken Shale (post-1987)**
- **Horizontal Drilling of the Bakken Middle Member (2001 to present)**

Conventional Bakken Cycle 1 – Antelope Field

➤ Discovery Well

➤ Stanolind - #1 Woodrow Starr

➤ Initial Potential (536 BO; 0.1 BW)

➤ Antelope Field

➤ 52 wells; 12.5 million BO; 10 BCF Gas

➤ “Sanish Sand”

➤ Completion Method

Conventional Bakken Exploration between Cycles

➤ **Elkhorn Ranch**

➤ **Shell Oil Co. - #41X-5-1 Government**

➤ **Nesson Anticline**

➤ **#1 B.E. Hove**

➤ **IP - 756 BOPD, 3 BWPD**

➤ **Completion Method**

Conventional Bakken

Cycle 2 – Depositional Limit

➤ **Stratigraphy & Structure**

- **Thin Bakken**
- **Multiple Pays**
- **Folds, Faults or Both**
- **Completion Methods**

Horizontal Drilling of the Upper Bakken Shale

- **Meridian - #33-11 MOI**
 - **Drilled vertical**
 - **Cored, Logged, Drill Stem Tested**
 - **Drilled Horizontally - 2603 ft**
 - **8 ft - upper Bakken Shale**
 - **IP: 258 BOPD & 299 MCF gas**
 - **Cost: \$2 million**

Learning Curve

- **Meridian -#33-11 MOI**
 - **57 days to drill**
 - 27 days to drill vertical borehole
 - 12 days to drill horizontal section
 - **\$2 million**
- **3 set of 10 wells**
 - 35 days to drill at a cost \$1.08 million
- **End of Play**
 - **\$900,000 (same as a vertical well)**

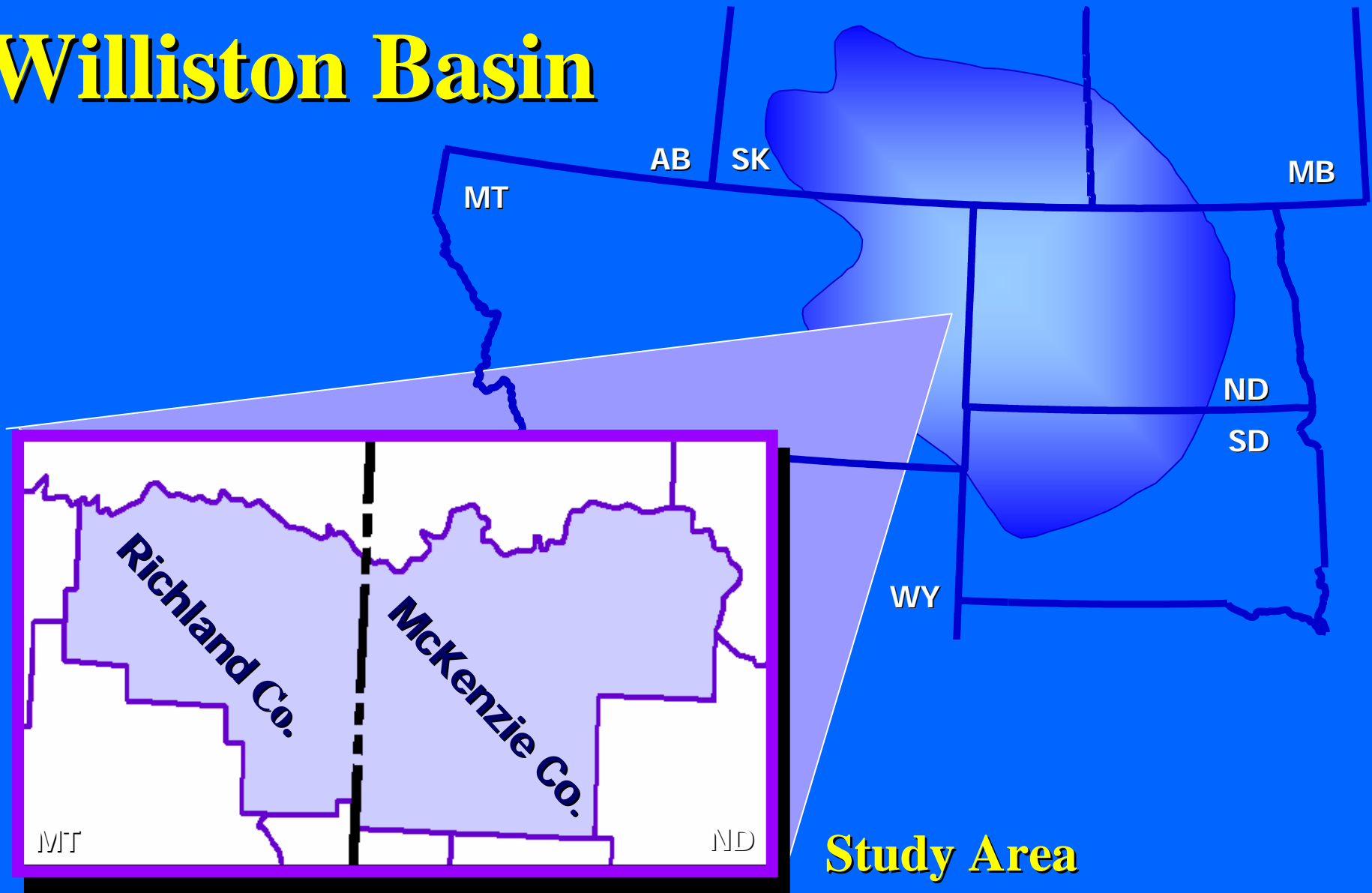
Horizontal Drilling of the Upper Bakken Shale

- **Drilling Methods**
- **General Problems**
- **Successful well = high volumes of oil**

Horizontal Drilling of the Bakken Middle Member

- **Richland County, Montana**
- **North Dakota**

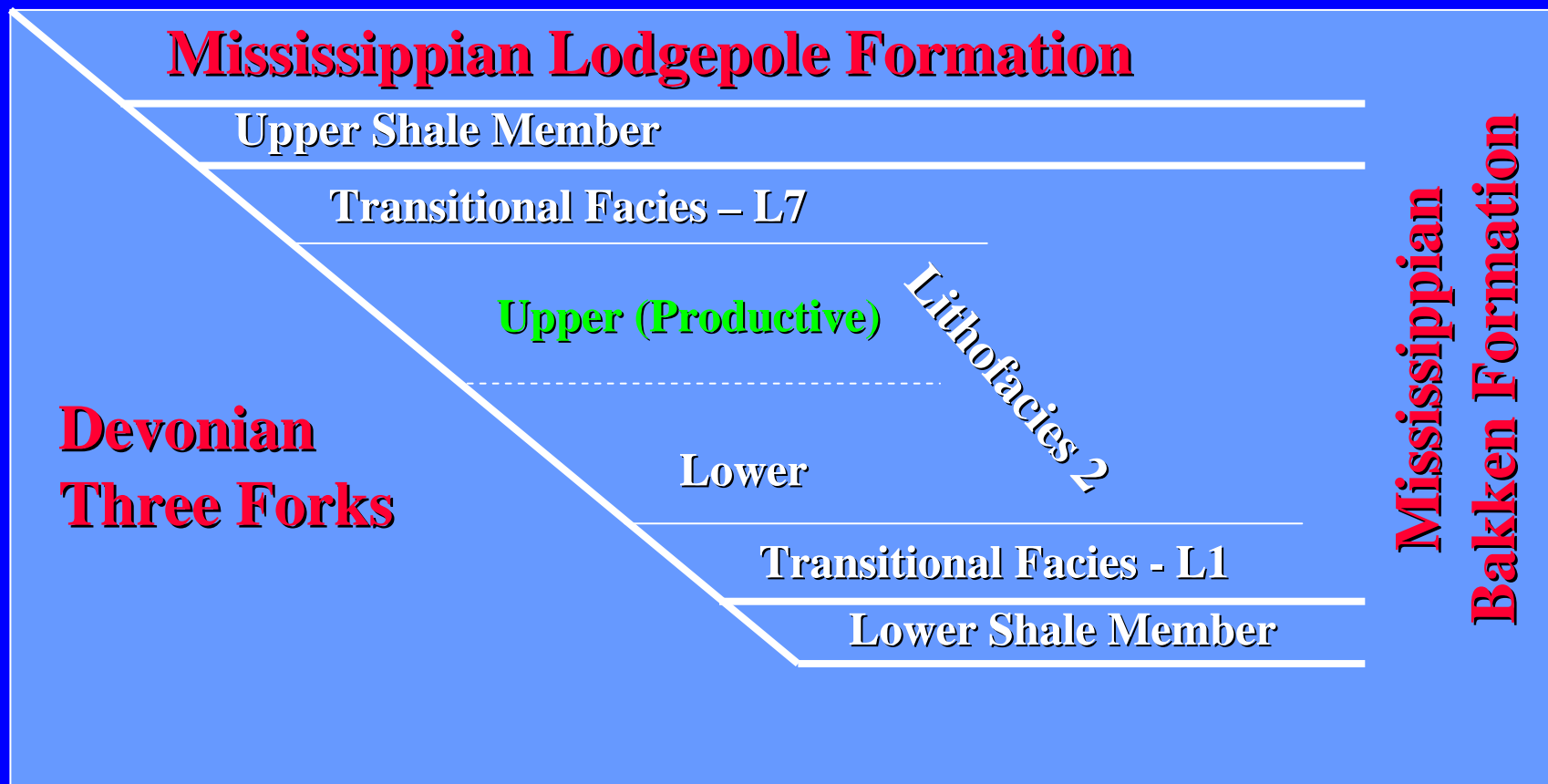
Williston Basin



Richland County, MT Stratigraphy

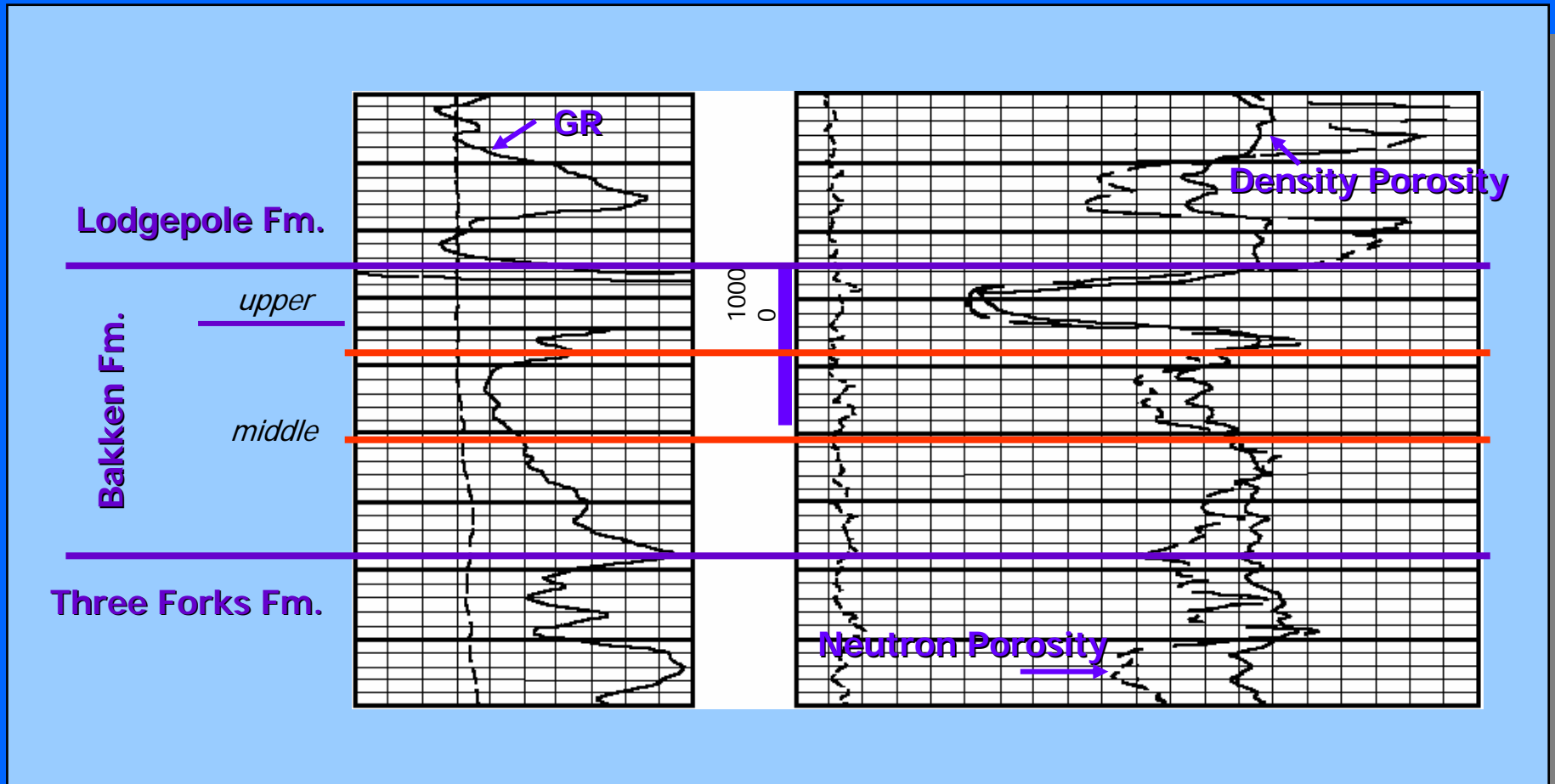
South

North



Balcron Oil - #44-24 Vaira

SESE Sec. 24, T.24N., R.54E.

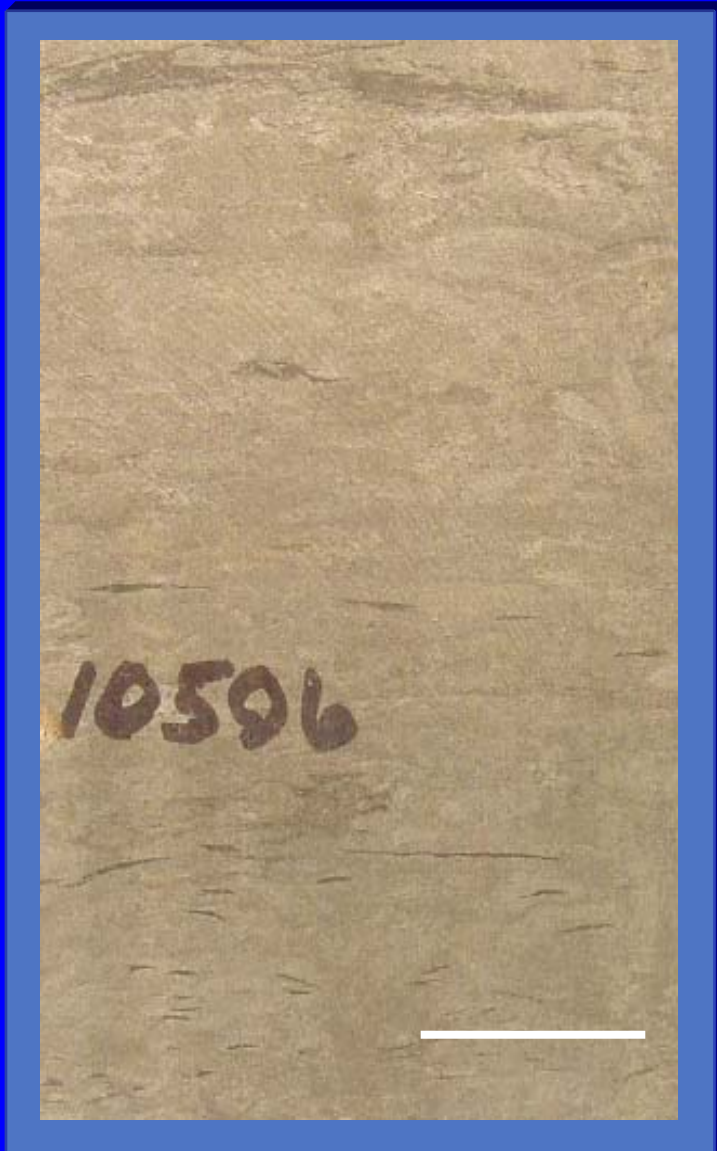


10604.5 ft.



**SESW Sec. 13, T.23N.,R.56E.
AHEL #1 H8 Nevins
Richland County, MT**

**Bakken/Three Forks
Contact**



SESW Sec. 13, T.23N.,R.56E.

AHEL #1 H8 Nevins

Richland County, MT

**Middle Member
Lithofacies 2**



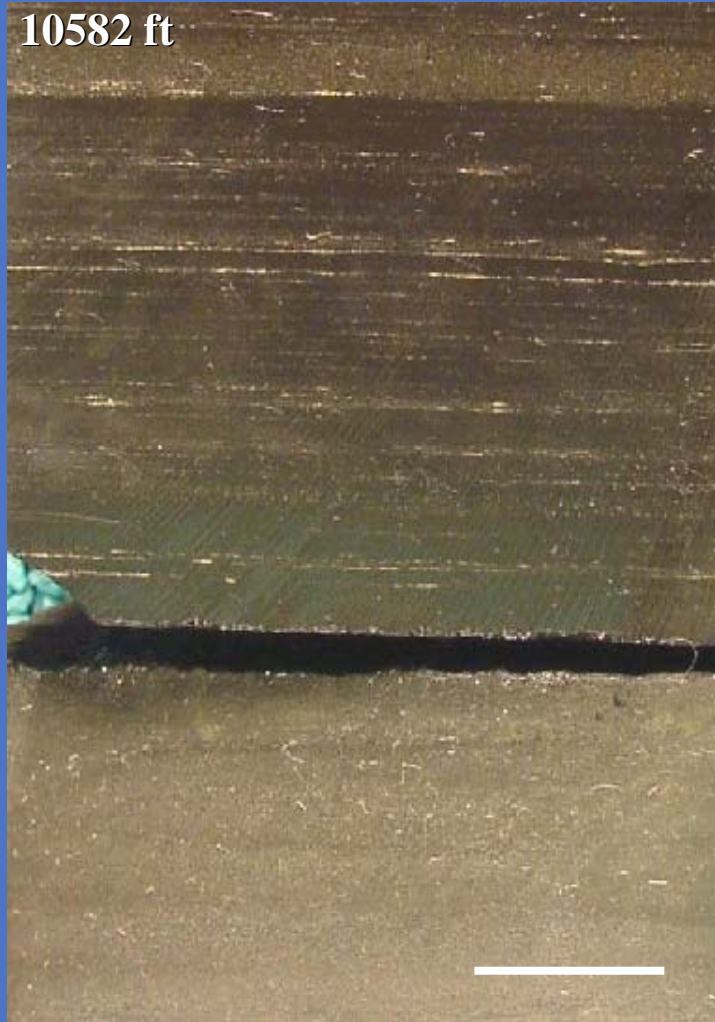
SESW Sec. 13, T.23N.,R.56E.

AHEL #1 H8 Nevins

Richland County, MT

**Middle Member
Lithofacies 2
(producing facies)**

10582 ft



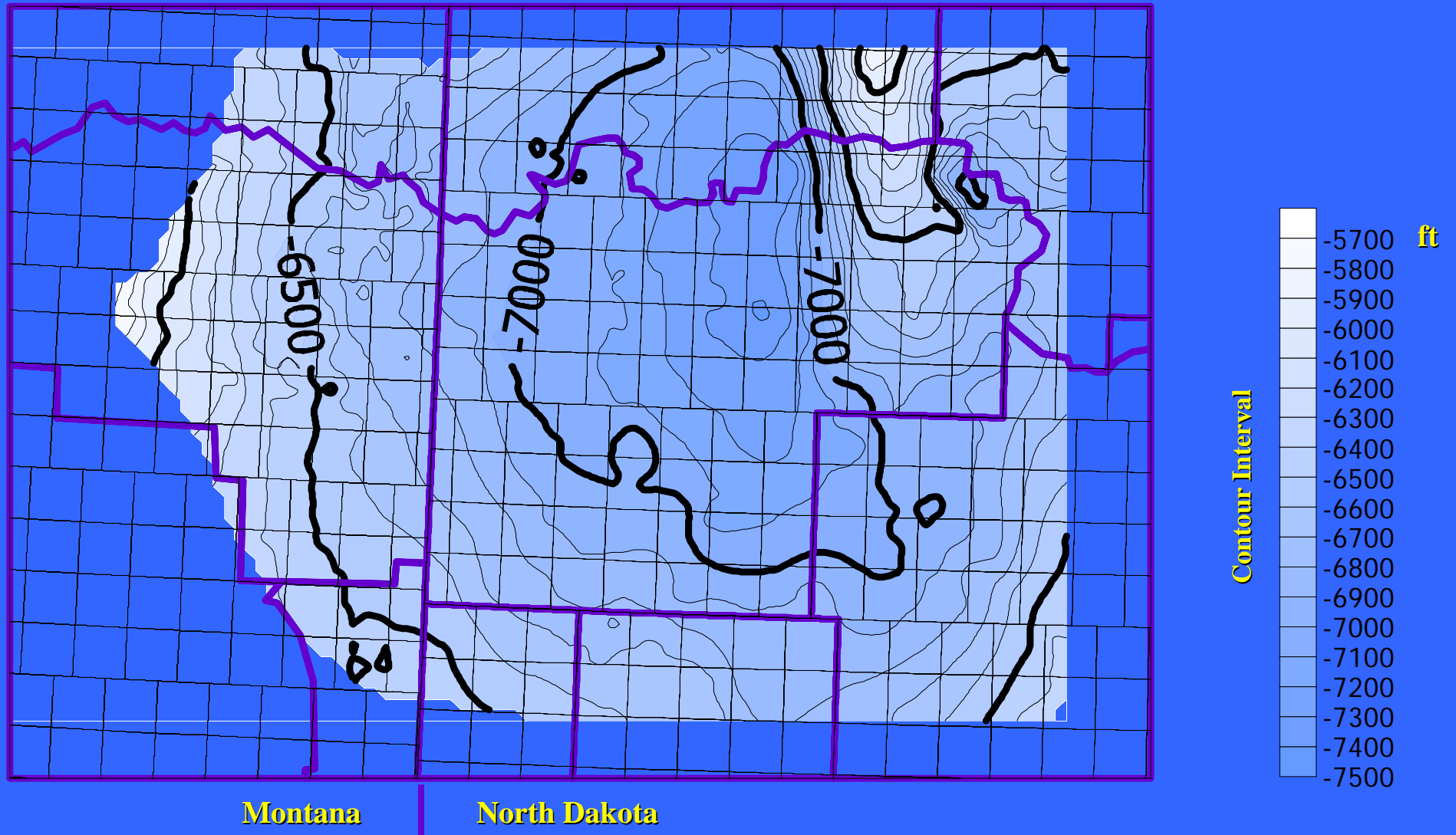
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AHEL #1 H8 Nevins

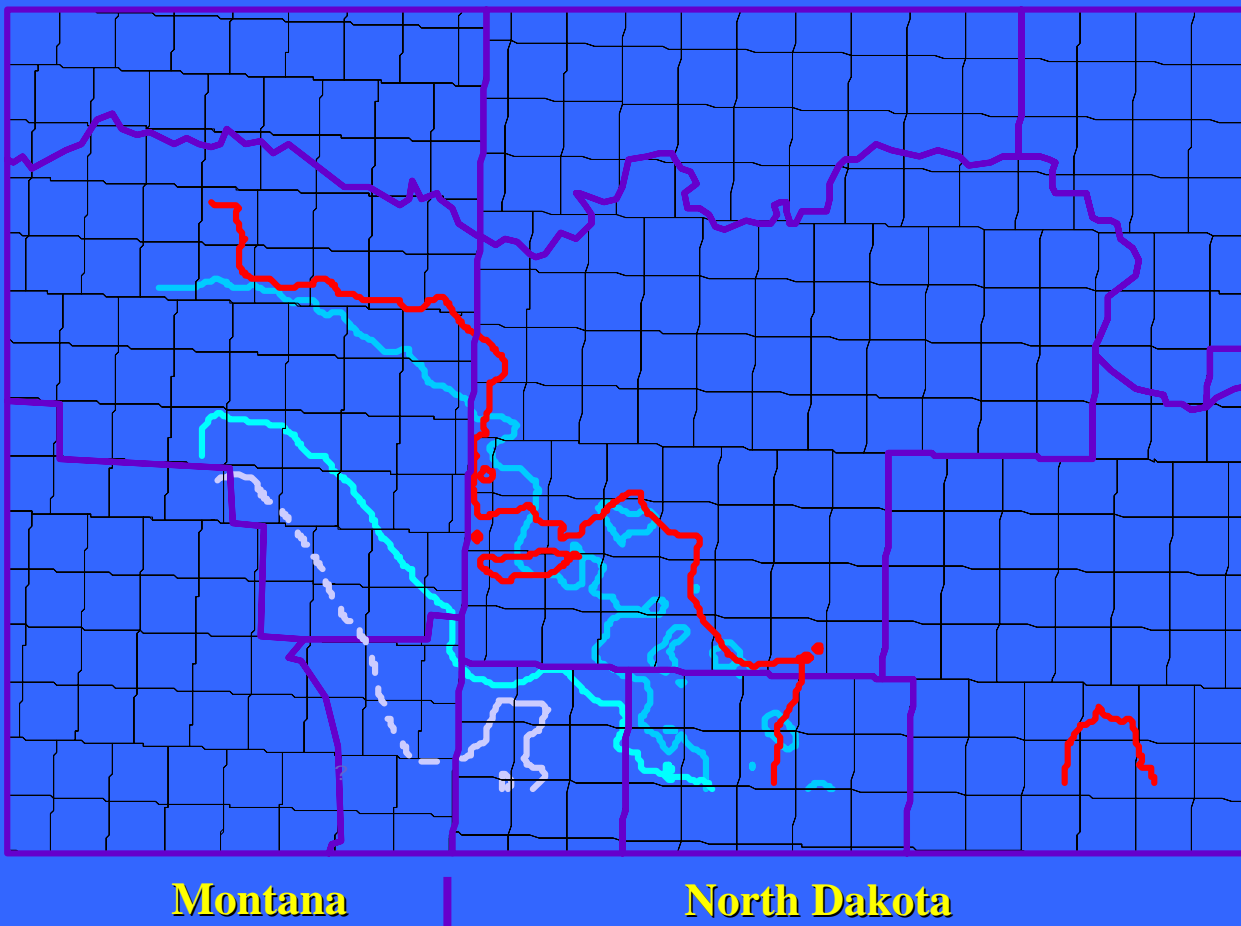
Richland County, MT

**Upper Shale/Middle Mbr
Contact**

BLCS Structure Map



Formation Limits



Bakken Formation

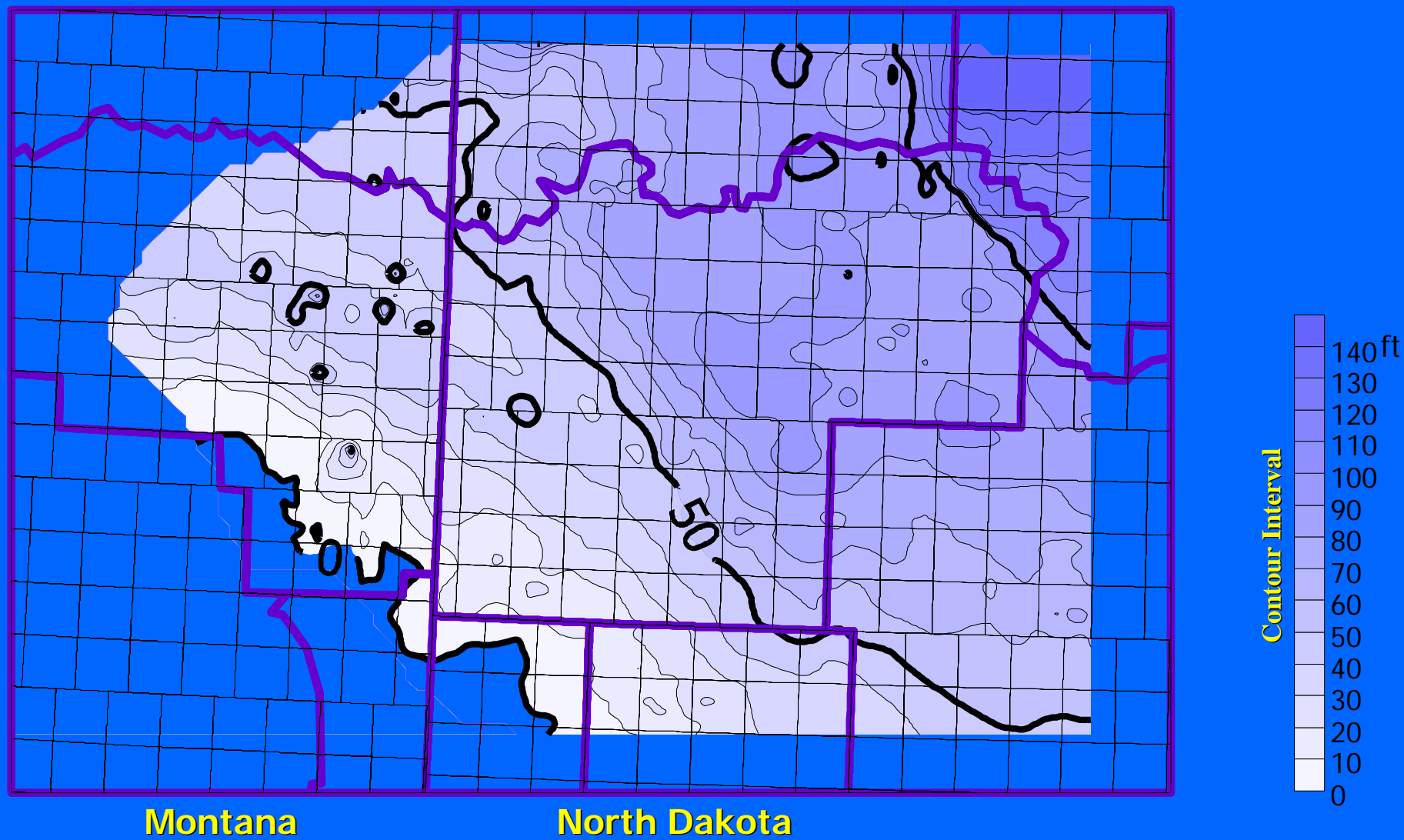
Upper

Middle

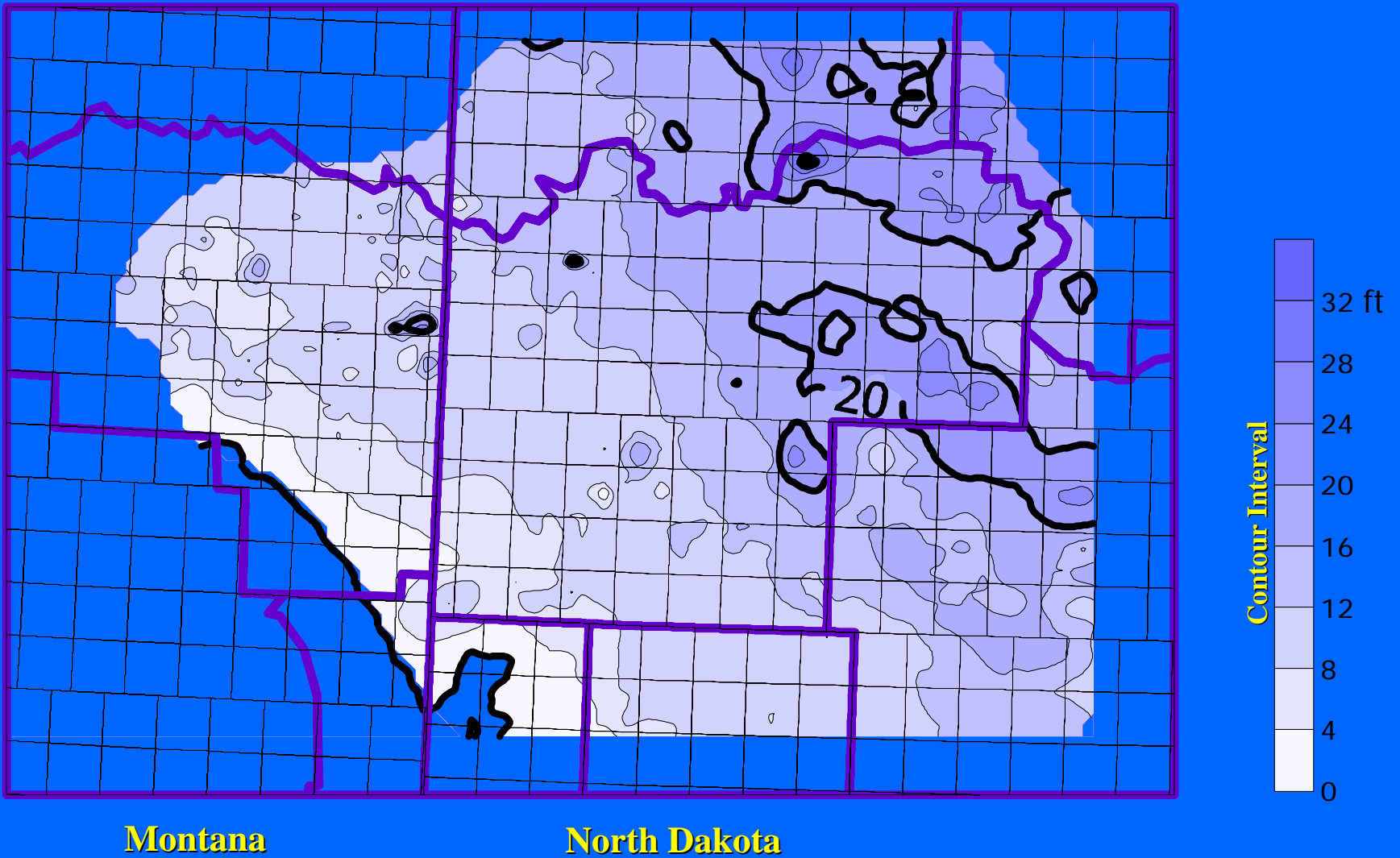
Lower

Prairie Salt Edge

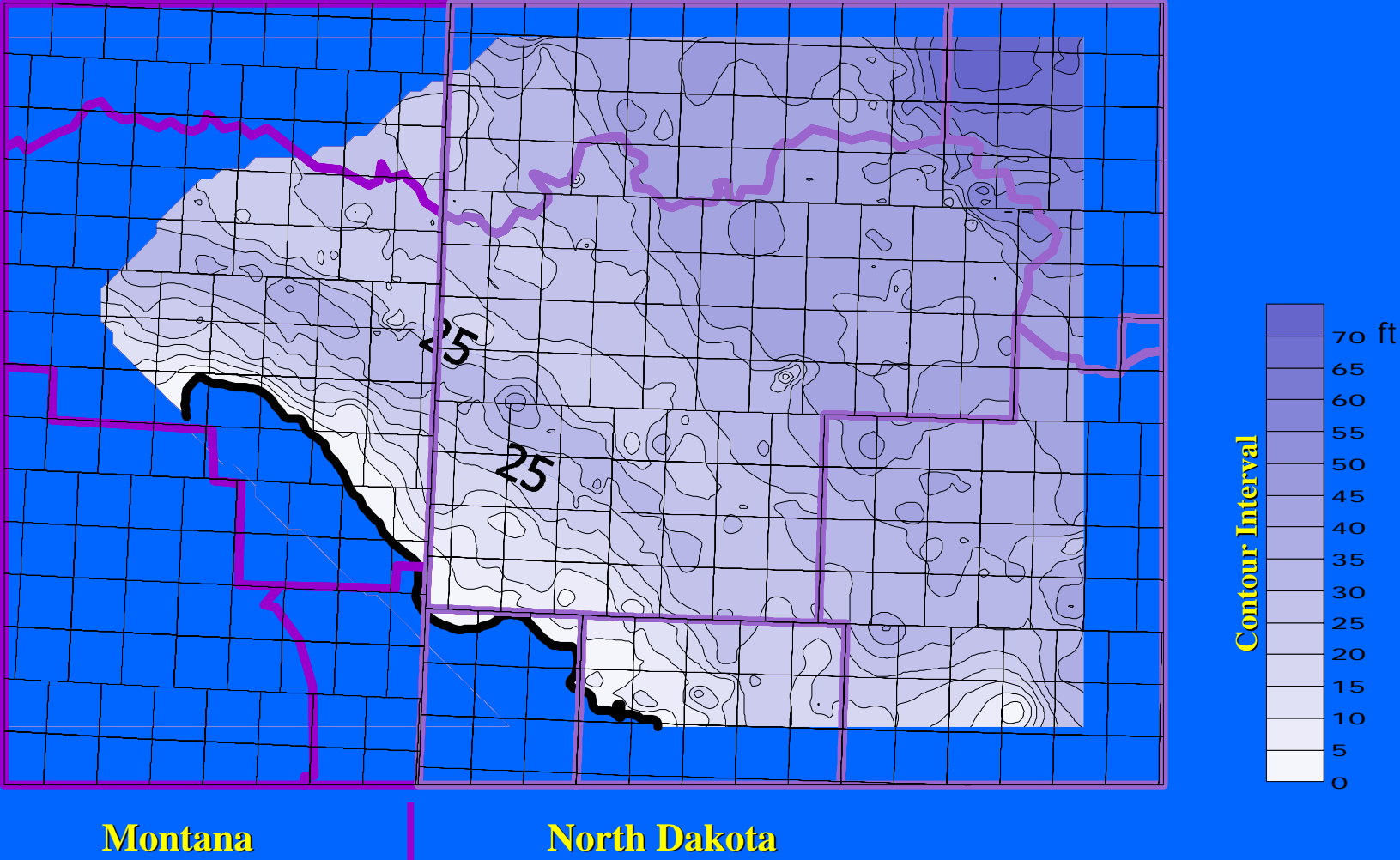
Isopach of the Bakken Formation



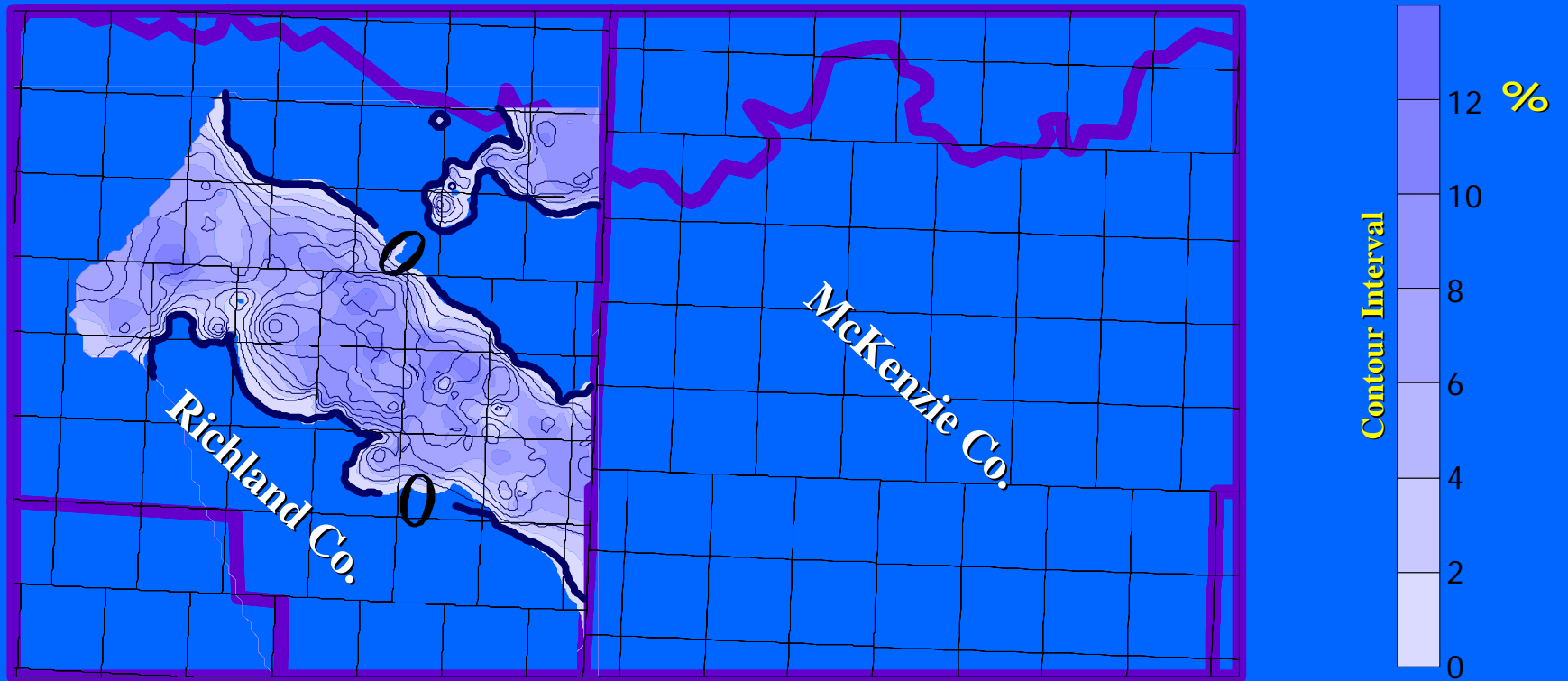
Isopach of the Upper Member Bakken Formation



Isopach of the Middle Member Bakken Formation

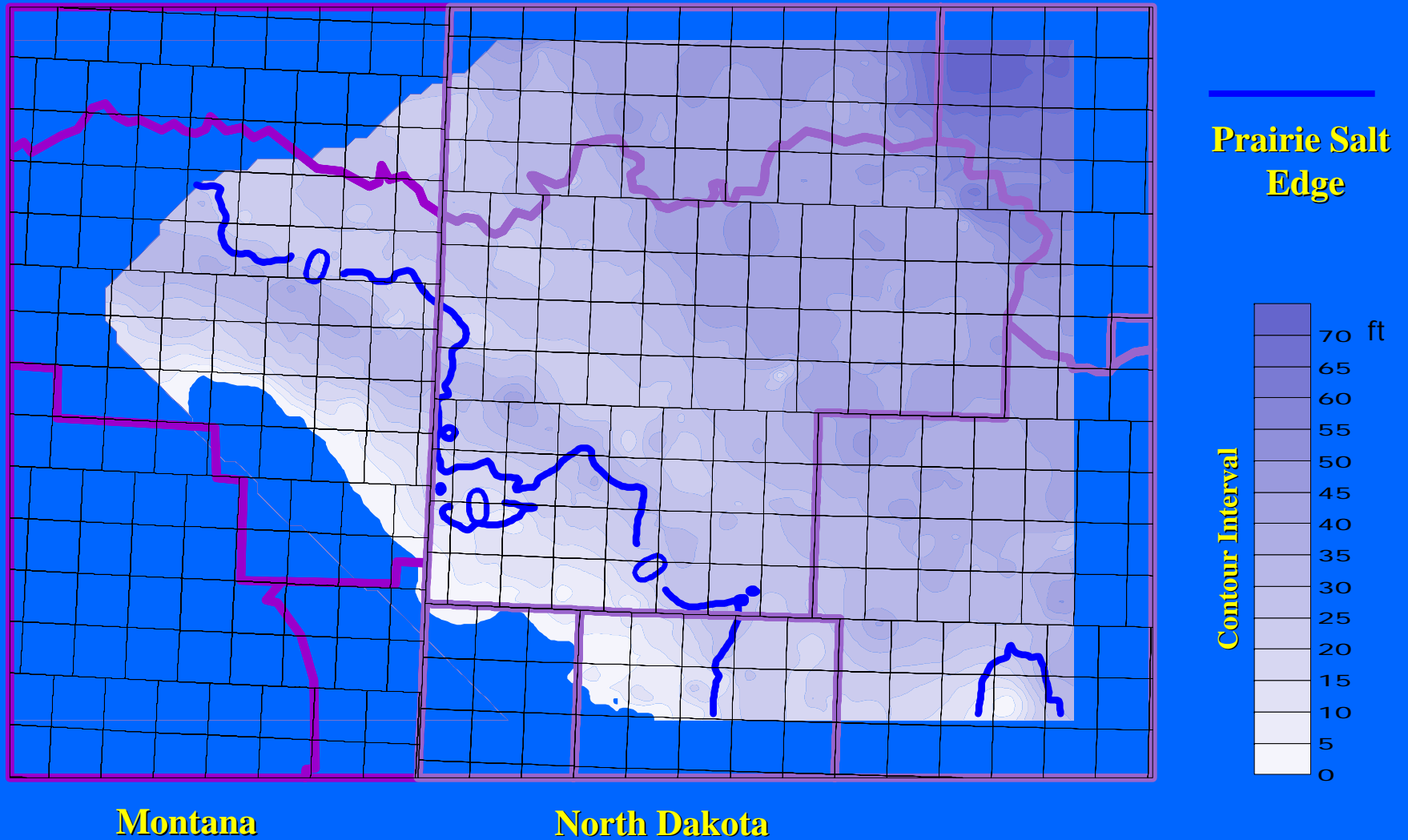


Middle Member Porosity Zone

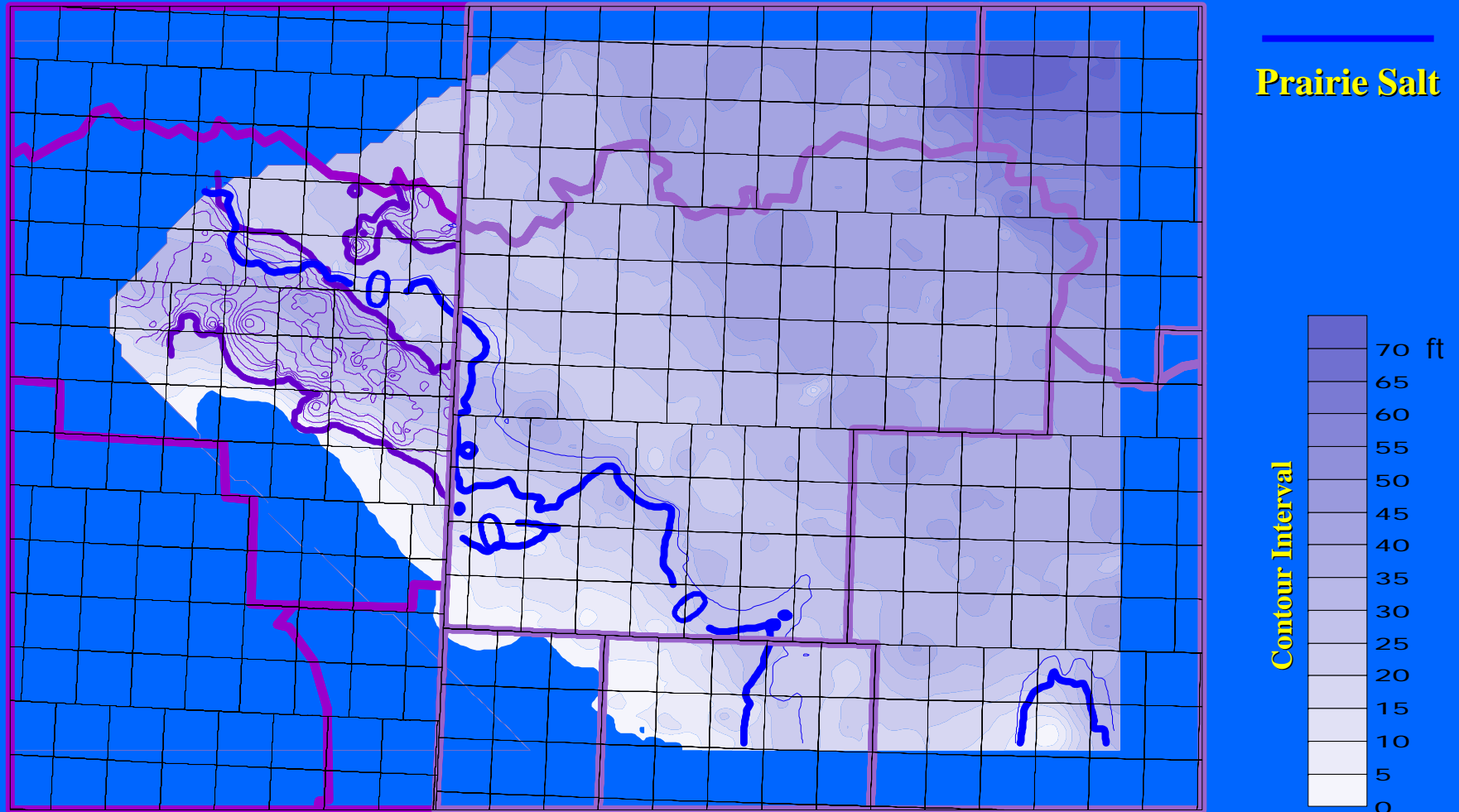


Contour Interval: 2 ft.

Bakken Middle Member Prairie Salt



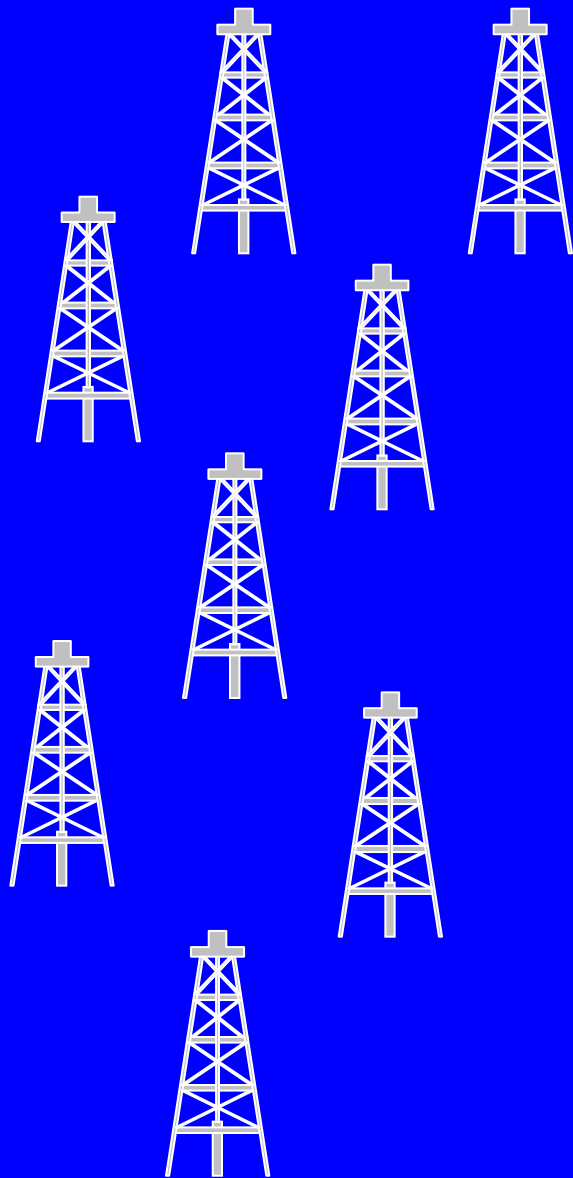
Bakken Middle Member Prairie Salt



Montana

North Dakota

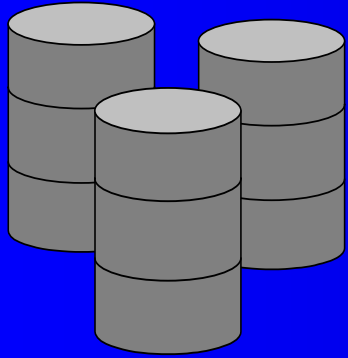
Richland County



80 Producing Fields

1. Red River Fm
2. Madison Fm
3. Bakken Fm
4. Duperow Fm
5. Interlake Fm

**20 Fields produce(d) from the
Bakken Formation**



Bakken Formation Richland County, MT

- **Historically –**
 - 42 Bakken wells + 8 commingled wells
- **Currently –**
 - 127 Bakken Producers
 - **Horizontals – 92 producers, 1 PNA, 1 Dry**
 - **Total production**
 - 2000 – 2,618,982 BO
 - 2003 – 5,284,378 BO
 - 2004 – 3,275,061 BO (thru August, 2004)
 - **86 Producing Fields, 23 - Bakken Production**

Drilling & Completion Bakken Horizontals

- **Two laterals to a 1280 spacing unit**
- **Well is stimulated with large fracture treatment (~920,000#, gelled water/sand frac)**
- **Cost \$2.2 million**
 - **500-700 BOPD initially**
 - **Virtually no water**

Horizontal Drilling of the Bakken Middle Member

- Richland County, Montana
- North Dakota

Lithofacies of the Middle Member



Upper Shale

Lithofacies 5 - Siltstone

**Lithofacies 4 – Interbedded Dark Grey Shale
and Buff Silty Sandstone**

Lithofacies 3 - Sandstone

Productive

**Lithofacies 2 – Interbedded Dark Grey Shale
and Buff Silty Sandstone**

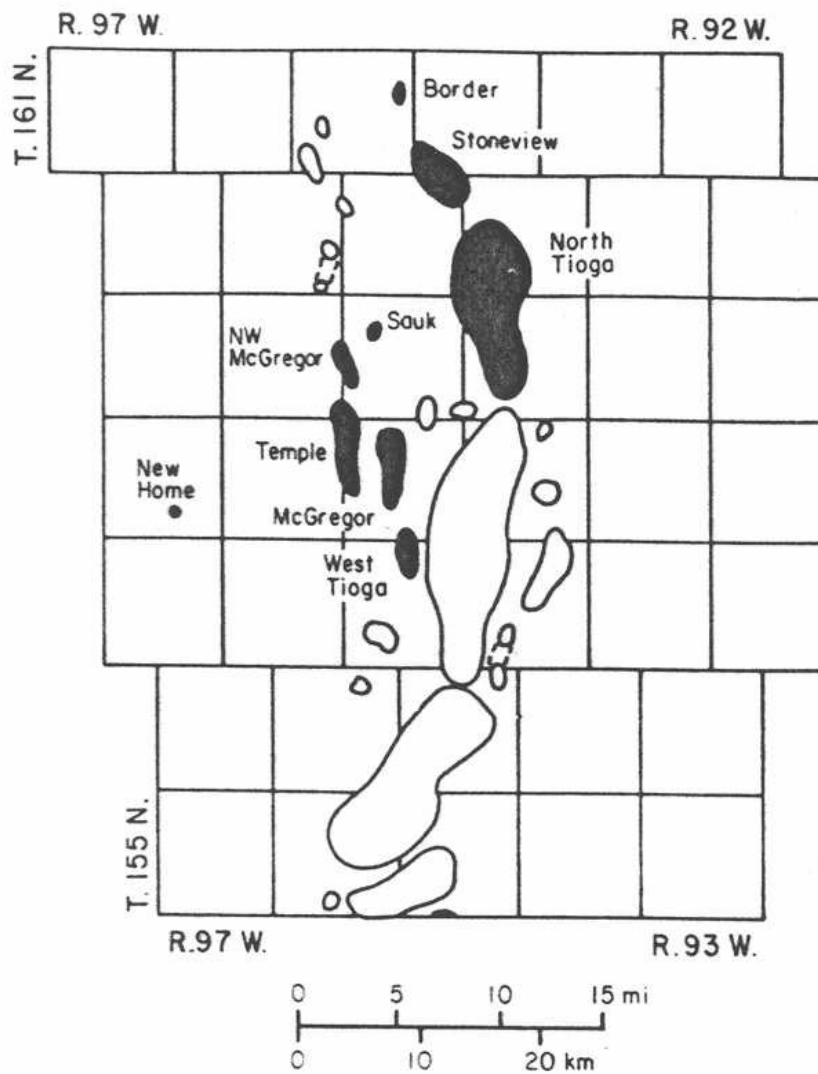
Productive in MT

Lithofacies 1 - Siltstone



Lower Shale

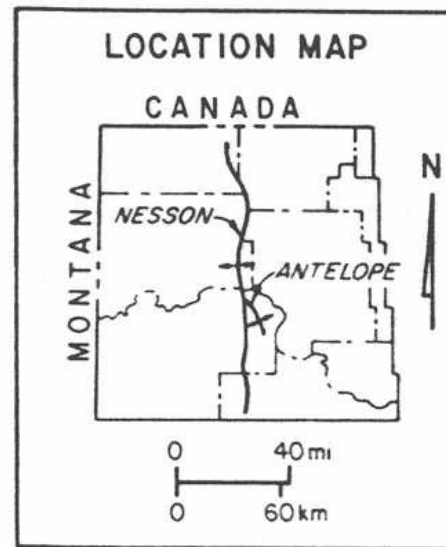
(From LeFever and others, 1991)

Lithofacies 3

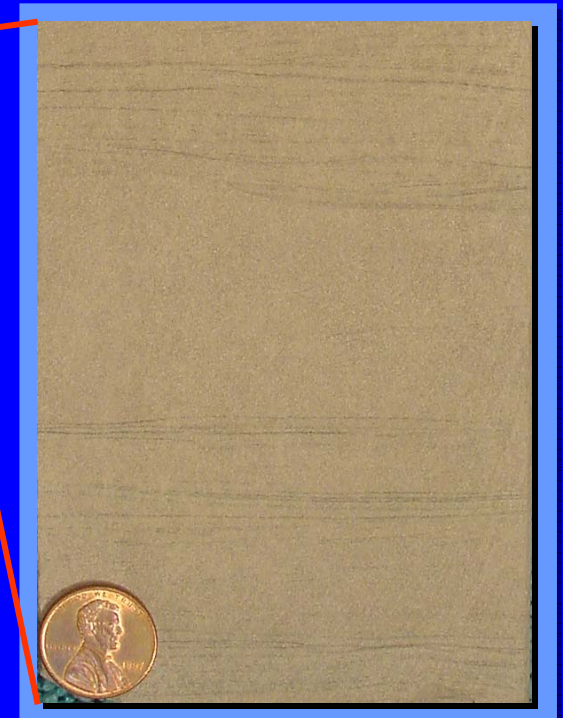
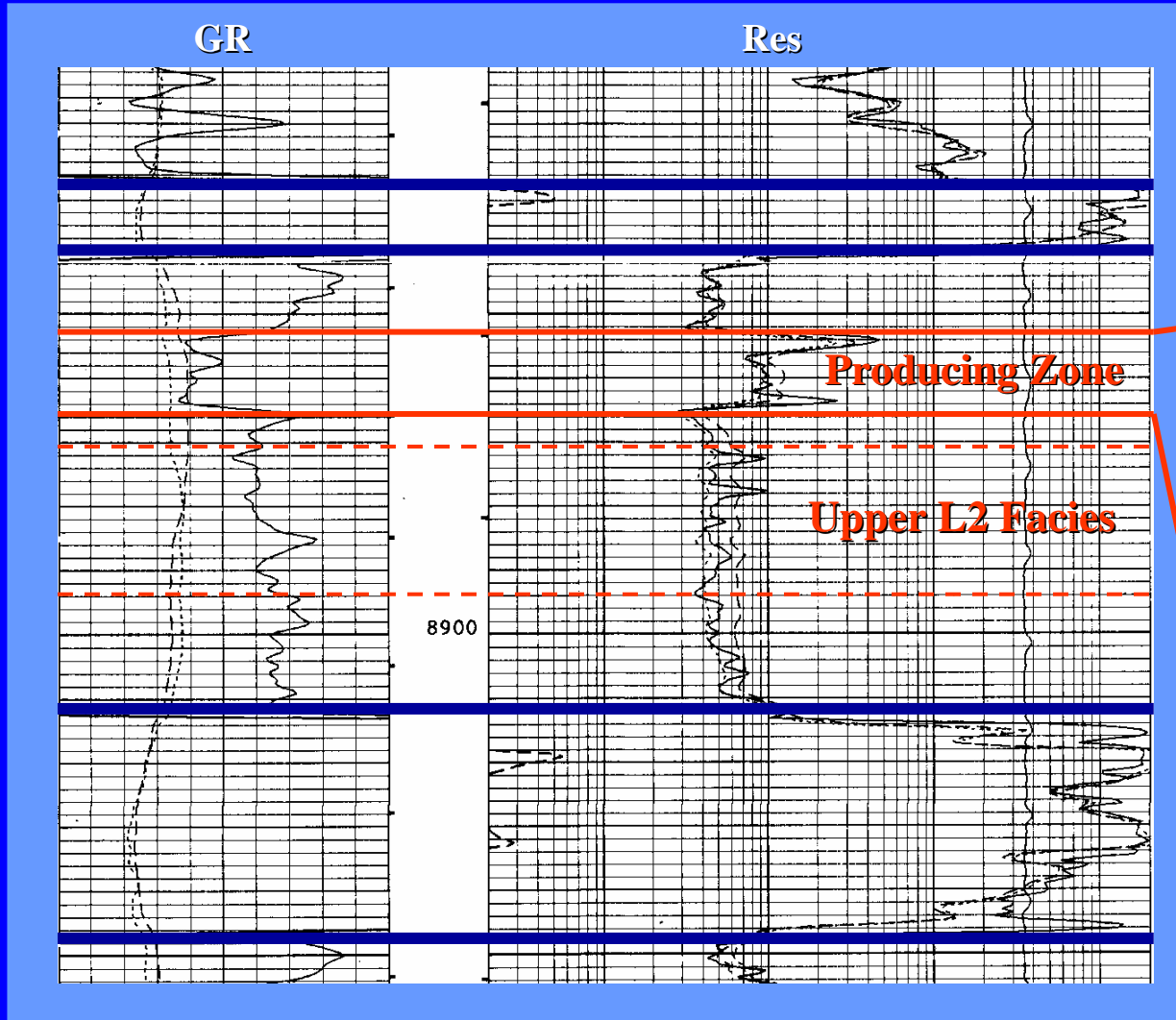


EXPLANATION

-  PRODUCING FIELD - BAKKEN POOL
-  PRODUCING FIELD



SENW Sec. 11, T160N, R95W Conoco, Inc. - #17 Watterud "A"



Joilette Oil (USA), LLC.

#1-17R Robert Heuer

- **Sadler Field**
- **Re-entry of a Madison Test (02/13/1981)**
- **Bakken Completion**
 - **03/05/2004**
 - **IP – 87 BOPD, 150 MCF, 142 BWPD**
 - **Fracture Stimulated**
- **Producing Zone – Lithofacies 3**

What Do We Know?

- **Rocks Types (Montana=North Dakota)**
 - **Additional Productive Section**
 - **Lithofacies 3, “Sanish”, lower Lodgepole Limestone**
- **Salt Collapse**
- **Completion Methods**
- **High Production Rates**

Conclusions

➤ **Horizontal Drilling**

Middle Member = Success