# The Pronghorn Member of the Bakken Formation, Williston Basin, USA: Lithology, Stratigraphy, Reservoir Properties*

**Rebecca L. Johnson**[1]

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## Abstract

In the North Dakota portion of the Williston Basin, the Pronghorn Member of the Bakken Formation produces hydrocarbons in Sanish, Parshall, and Billings Nose Fields. In other areas of the basin, the Pronghorn is not present, unproductive, or untested. This study describes the lithology, sequence stratigraphy, and reservoir properties of the Pronghorn Member.

The Upper Devonian and Lower Mississippian Bakken Petroleum System (BPS) is present within portions of the 30,000-square-mile intracratonic Williston Basin. The Bakken Petroleum System consists of the Upper Devonian Three Forks Formation and the Upper Devonian and Lower Mississippian Bakken Formation. The Bakken Formation contains four members. In ascending order these are: (1) the Pronghorn Member (2) the Lower Bakken Shale (3) the Middle Bakken Member, and (4) the Upper Bakken Shale. The organic-rich Upper and Lower Bakken Shale members were deposited in anoxic marine environment during relative sea-level highstand. These shales are both source and seal within the BPS. The Middle Bakken and Pronghorn members were deposited in shallow subtidal to open marine environments and are reservoirs within the Petroleum System. The Three Forks Formation is divided into three units: Lower, Middle, and Upper. The formation consists of interbedded dolomite, siltstone, sandstone, and anhydrite beds that were deposited in sabkha and intertidal environments. The Upper Three Forks silty dolomite beds are reservoirs.

This study focuses on the Pronghorn Member and its relationship to the underlying Upper Three Forks Member and the overlying Lower Bakken Shale. The lithofacies of the Pronghorn Member include in ascending order: (1) heavily burrowed, well sorted, angular to subrounded, very fine- to fine-grained sandstone, (2) interlaminated shale and burrowed dolomitic siltstone, (3) fossiliferous lime mudstone to lime packstone, and (4) shale with thin, interlaminated siltstone and very fine- to fine-grained sandstone. Pronghorn Lithofacies 1 is equivalent to the “Sanish Sand” of North Dakota. Pronghorn facies are laterally discontinuous and vary in thickness. Facies discontinuity may, in part, be related to the energy of the depositional setting. Underlying Prairie Salt dissolution may have resulted in local thickness variations.

The Pronghorn Member was deposited as part of an overall deepening cycle. A regionally correlative, unconformable surface of erosion lies at the contact between the Upper Three Forks and Pronghorn Lithofacies 1. A second significant surface lies at the contact between Pronghorn Lithofacies 3 and Lithofacies 4. This surface is marked by a skeletal lag associated with a Transgressive Surface of Erosion (TSE). The contact between Lithofacies 4 and the Lower Bakken Shale is variable, and is transitional and locally sharp and erosional.

The limestone of Pronghorn Lithofacies 3 and the upper shale of Pronghorn Lithofacies 4 have distinct well-log characteristics. The other lithofacies are commonly indistinguishable on logs. For well-log correlations, the Pronghorn was divided into two facies: the upper silty shale Lithofacies 4 (PRNR ) and Lithofacies 1, 2, and 3 (PRNR1). The PRNR1 well-log facies has good reservoir potential, with the highest production potential present in the southwestern portion of the North Dakota. The gross reservoir map of the PRNR1 well-log facies correlates with current and proposed production from the Pronghorn in southern North Dakota. Currently, the Pronghorn is not reported as a separate producing zone; consequently, petrophysical maps of the Pronghorn were compared to production values reported for the Three Forks Formation. Where fracture-stimulated, the lower Pronghorn interval (PRNR1) is probably in communication with the Upper Three Forks. The upper silty shale of the Pronghorn Lithofacies 4 (PRNR) is possibly a vertical migration barrier between the oil-rich Lower Bakken Shale and the Upper Three Forks. In targeting the Upper Three Forks, drilling through thick and tight Pronghorn Lithofacies 4 may decrease production potential.

## References Cited

Blakey, R., 2013, North American Paleogeographic Maps, Late Devonian (360 Ma): Web accessed June 21, 2013. http://www2.nau.edu/rcb7/namD360.jpg

Pitman, J.K., L.C. Price, and J.A. LeFever, Diagenesis and fracture development in the Bakken Formation, Williston Basin: Implications for Reservoir Quality in the Middle Member, U.S. Geological Survey Professional Paper 1653, 24 p.

# The Pronghorn Member of the Bakken Formation

## Lithology, Stratigraphy, Reservoir Properties

Rebecca L. Johnson

May 21, 2013

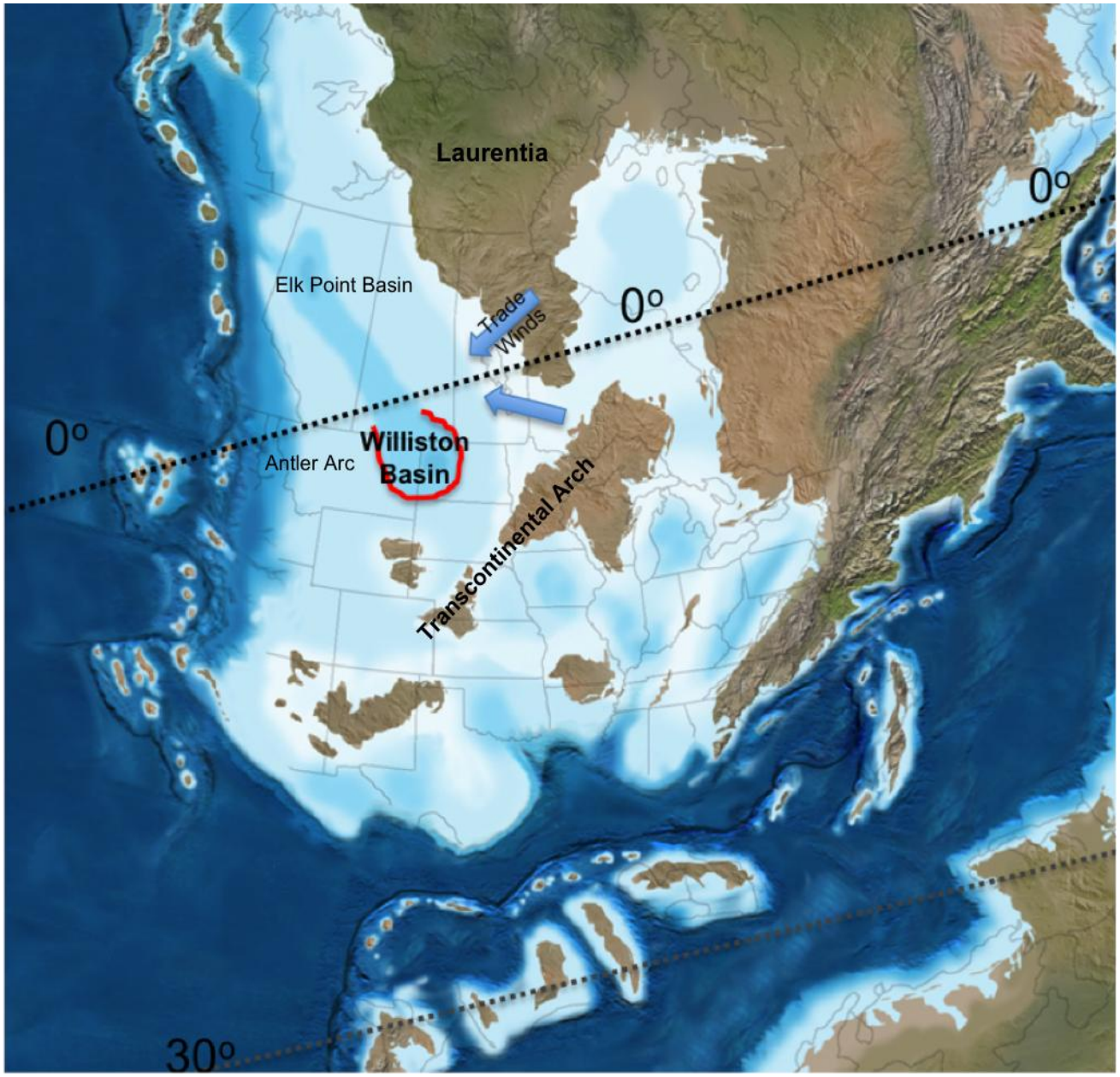
# OUTLINE

- Study Area
- Bakken Petroleum System
- Pronghorn Facies and Core Descriptions
- Correlations
- Petrophysical and Reservoir Properties
- Conclusions and Recommendations

# Study Area

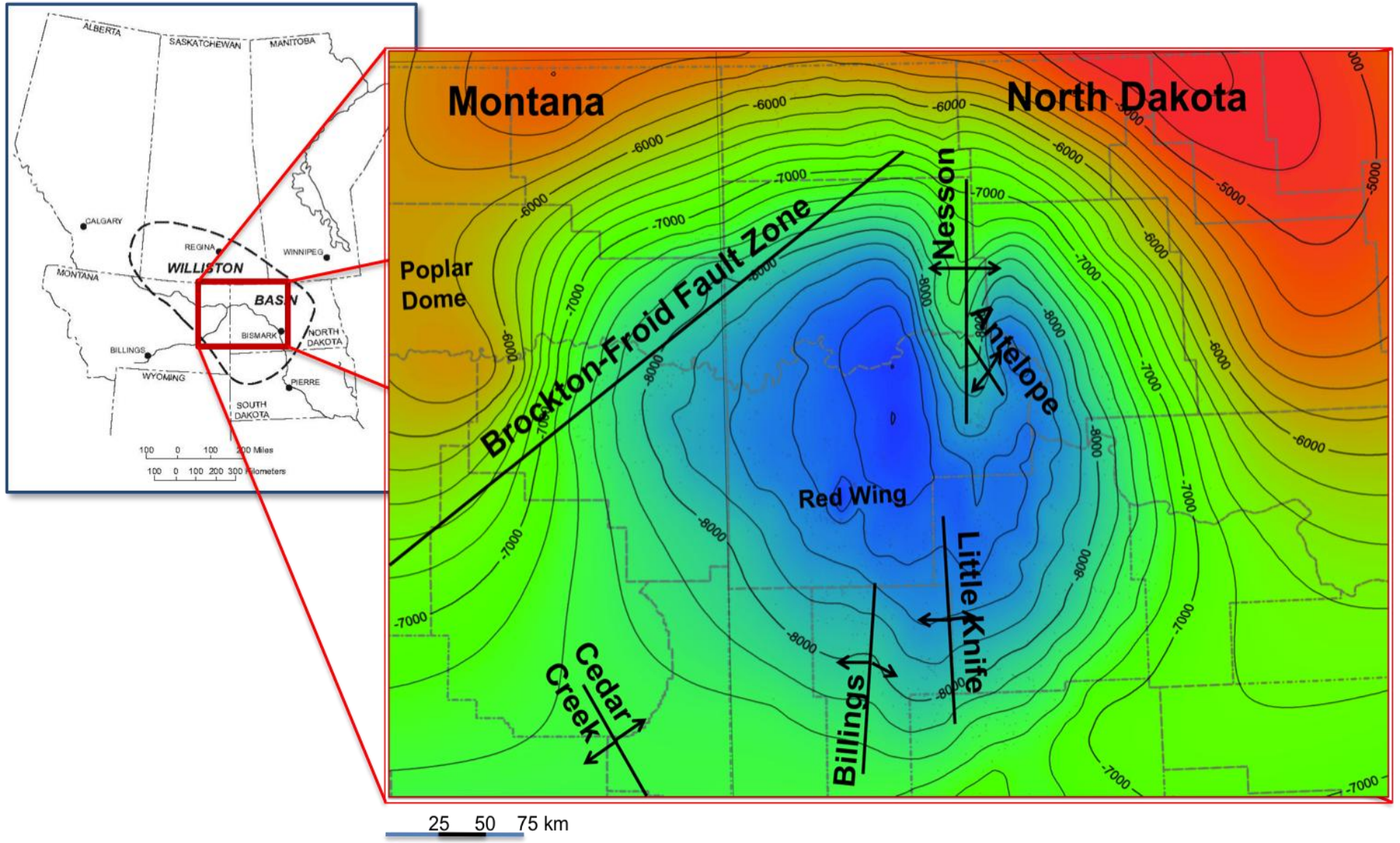

Pitman et al. (2001)

# Study Area

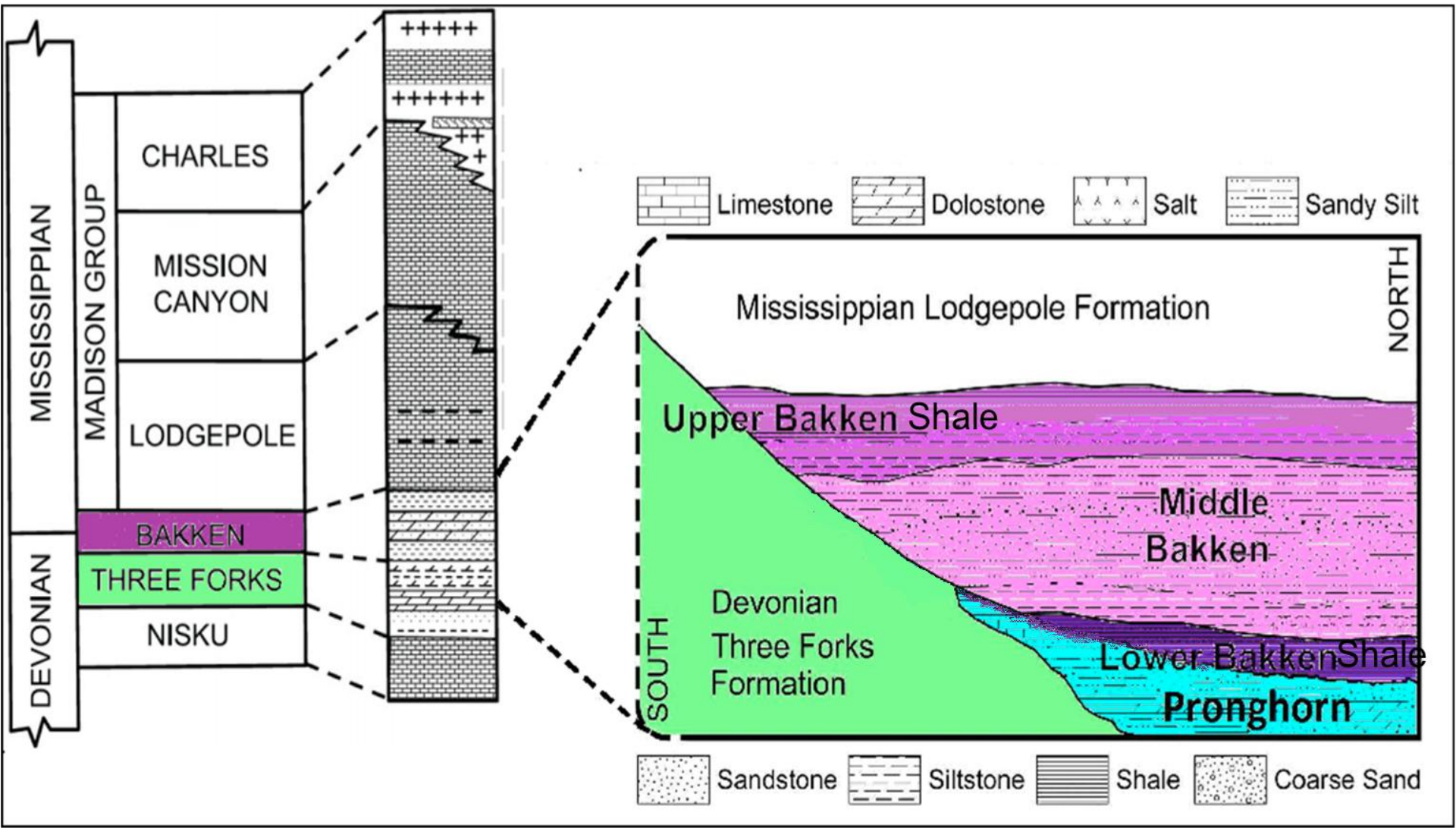



After Blakey (2013).

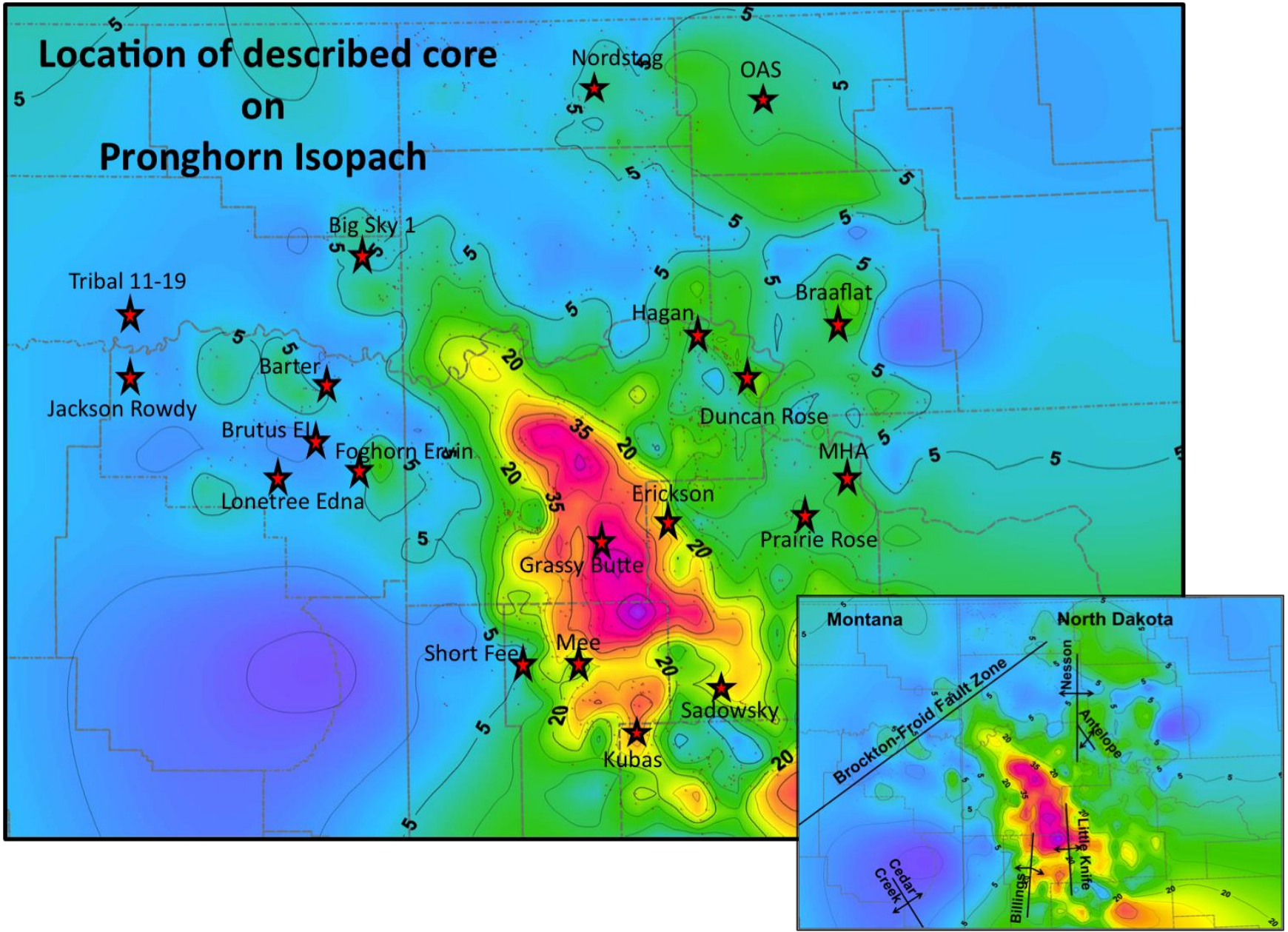
# Study Area


ALBERTA
SASKATCHEWAN
MANITOBA
CALGARY
REGINA
WINNIPEG
MONTANA
WILLISTON
BASIN
BISMARK
NORTH DAKOTA
BILLINGS
WYOMING
PIERRE
SOUTH DAKOTA
100 0 100 200 Miles
100 0 100 200 300 Kilometers
Montana
North Dakota
Poplar Dome
Brockton-Froid Fault Zone
Nesson
Antelope
Red Wing
Little Knife
Billings
Cedar Creek
-5000
-6000
-7000
-8000
25 50 75 km

# Bakken Petroleum System



# Core Descriptions



# Conclusions

- 4 Pronghorn lithofacies
- 2 significant surfaces
- Rise in sea level
- Paleo-structure and syn-depositional salt dissolution influence deposition and preservation
- Lower Pronghorn lithofacies have reservoir potential in southern basin, augment Upper Three Forks production

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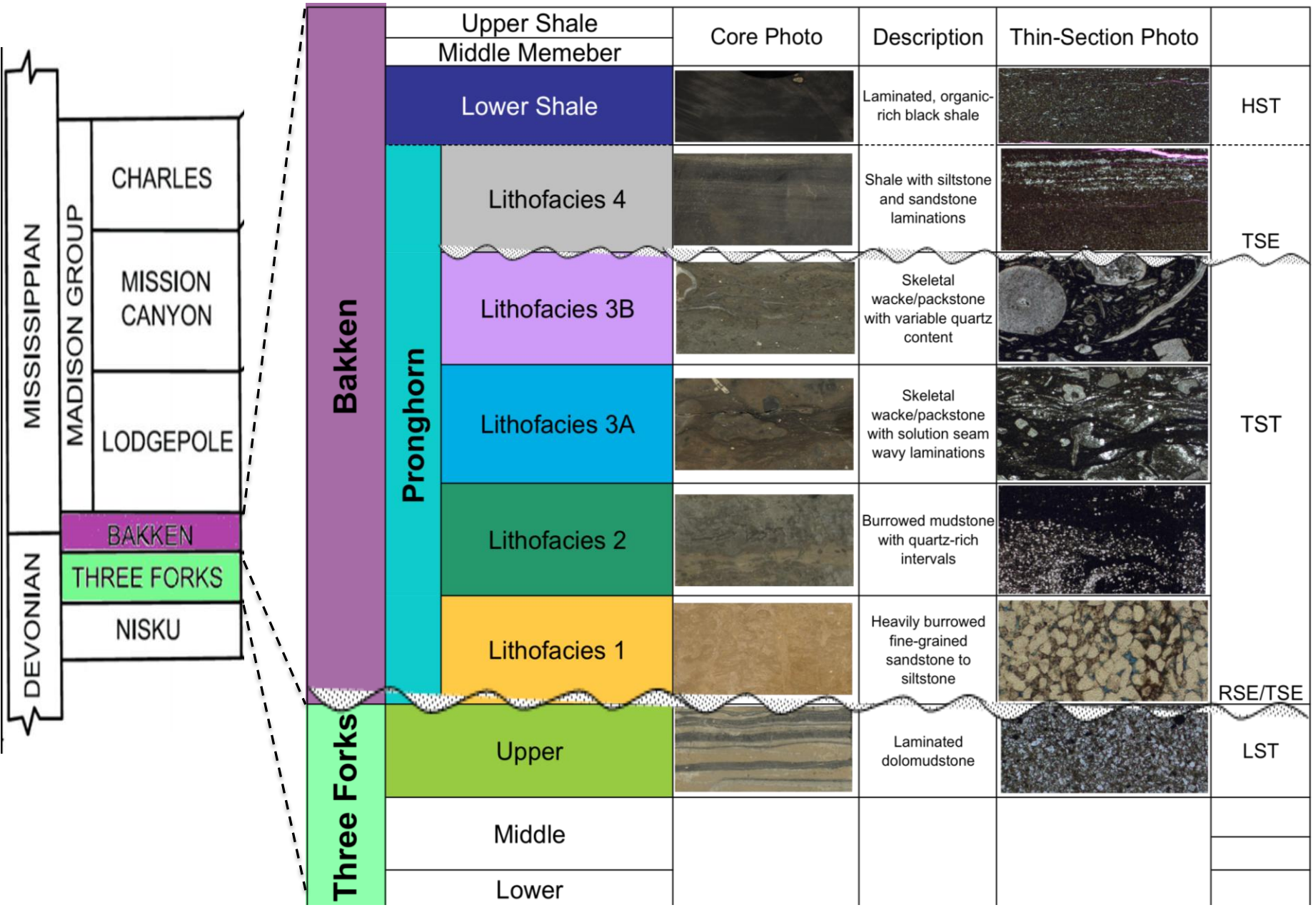
# Pronghorn Lithofacies



# Three Forks – Pronghorn Contact

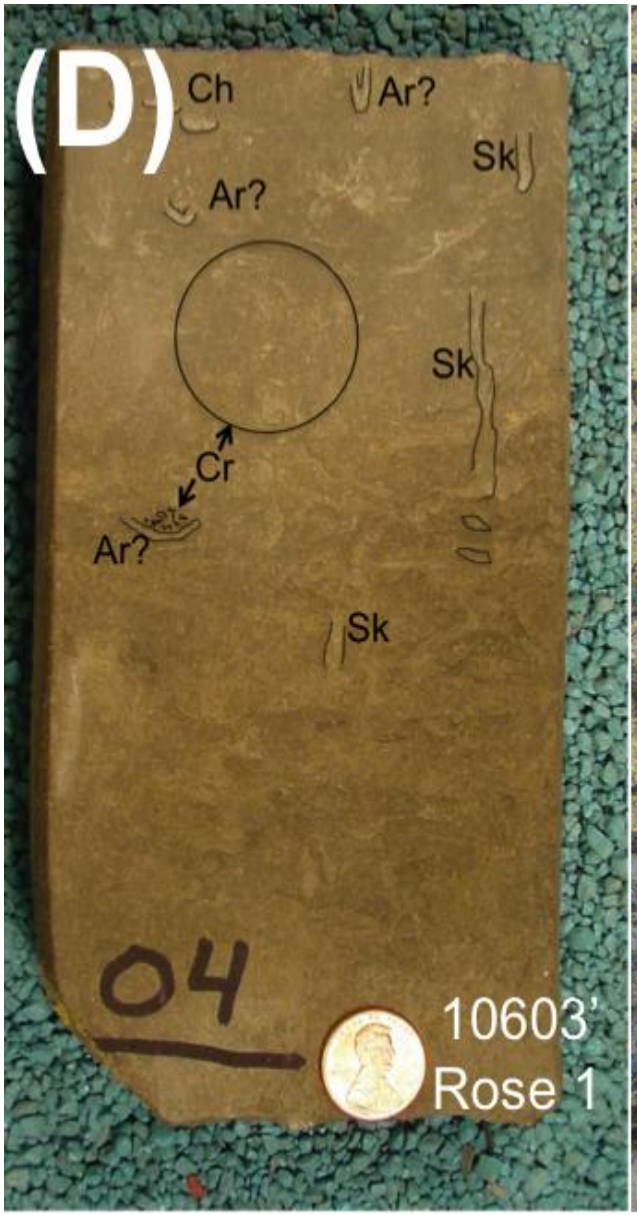
Anschutz Sadowsky 24-14H at 10529’

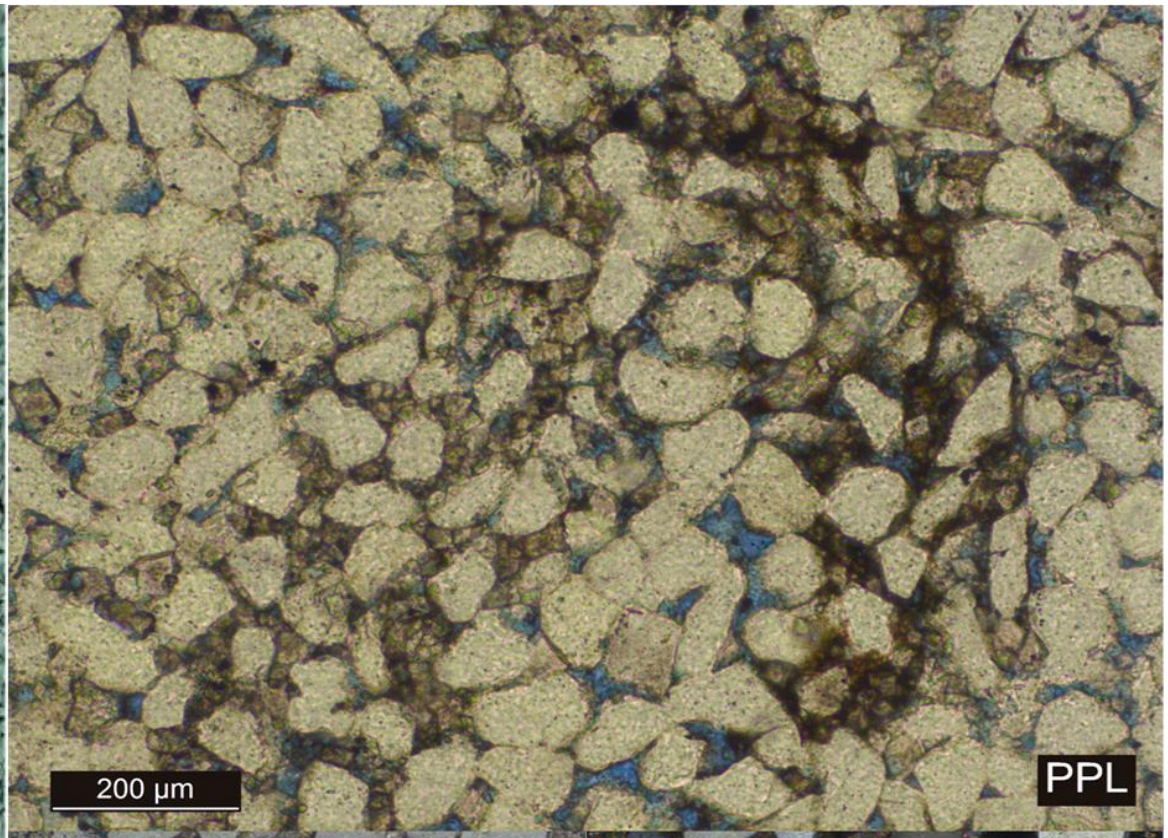

PRNR

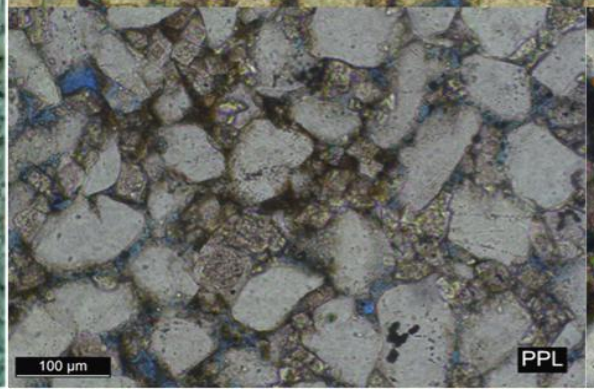
**RSE / TSE**

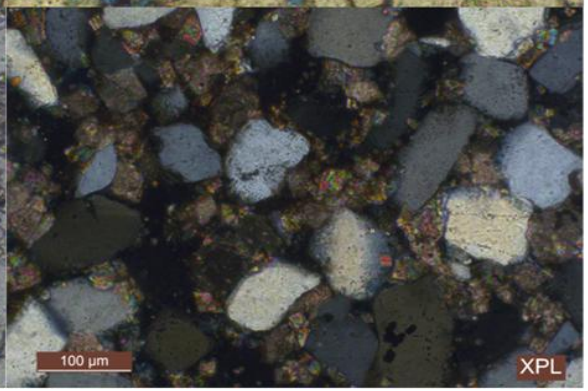
TRFK

# Pronghorn Lithofacies 1

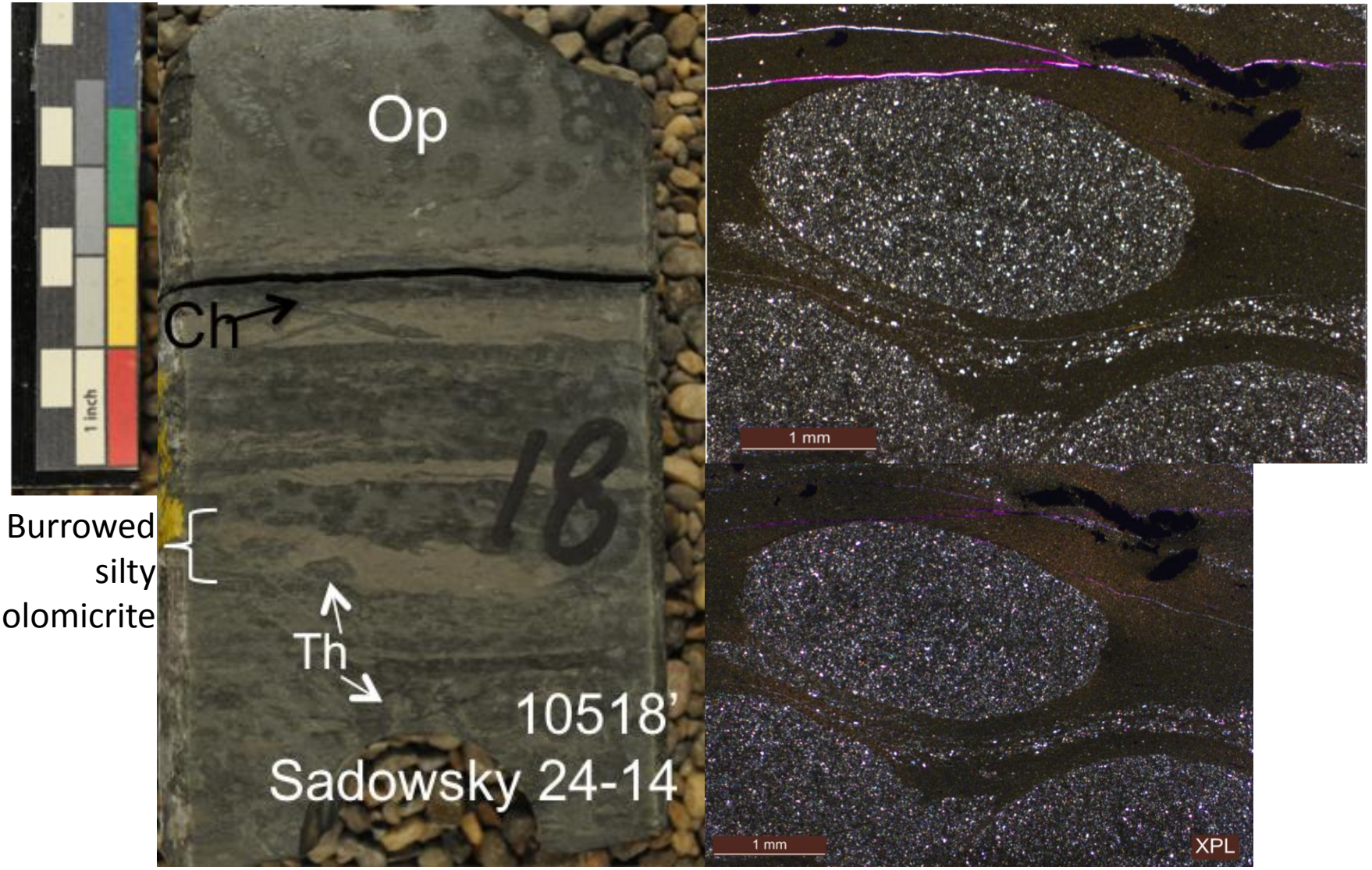


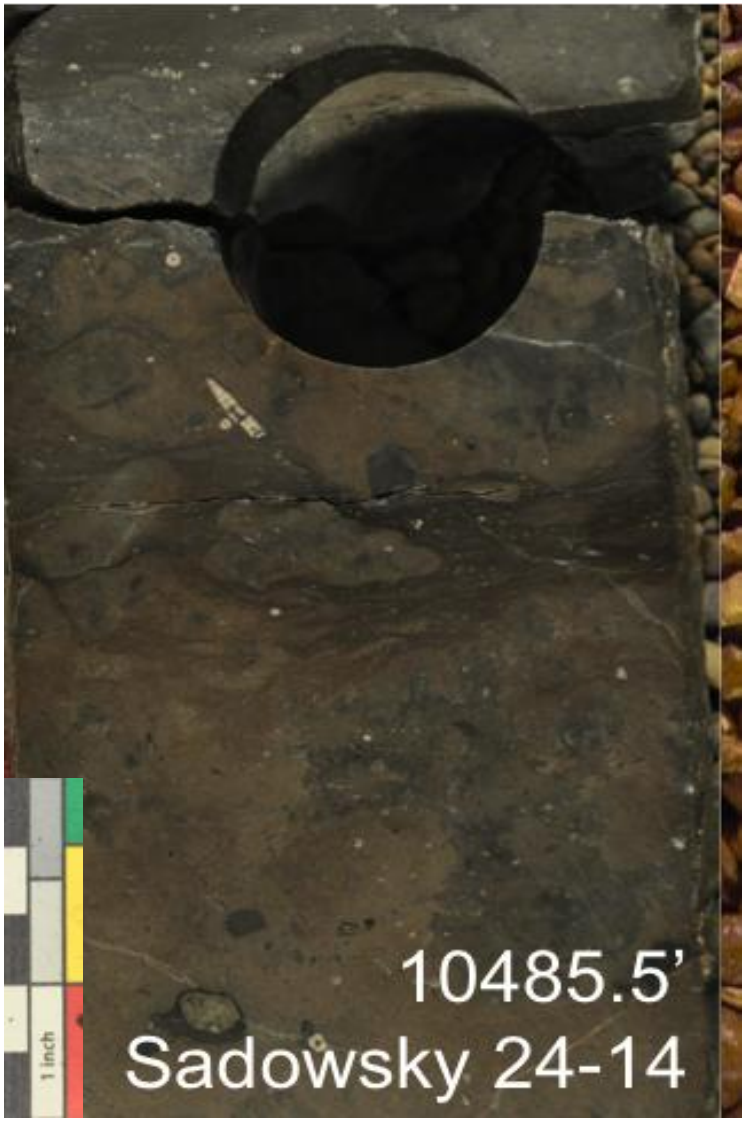



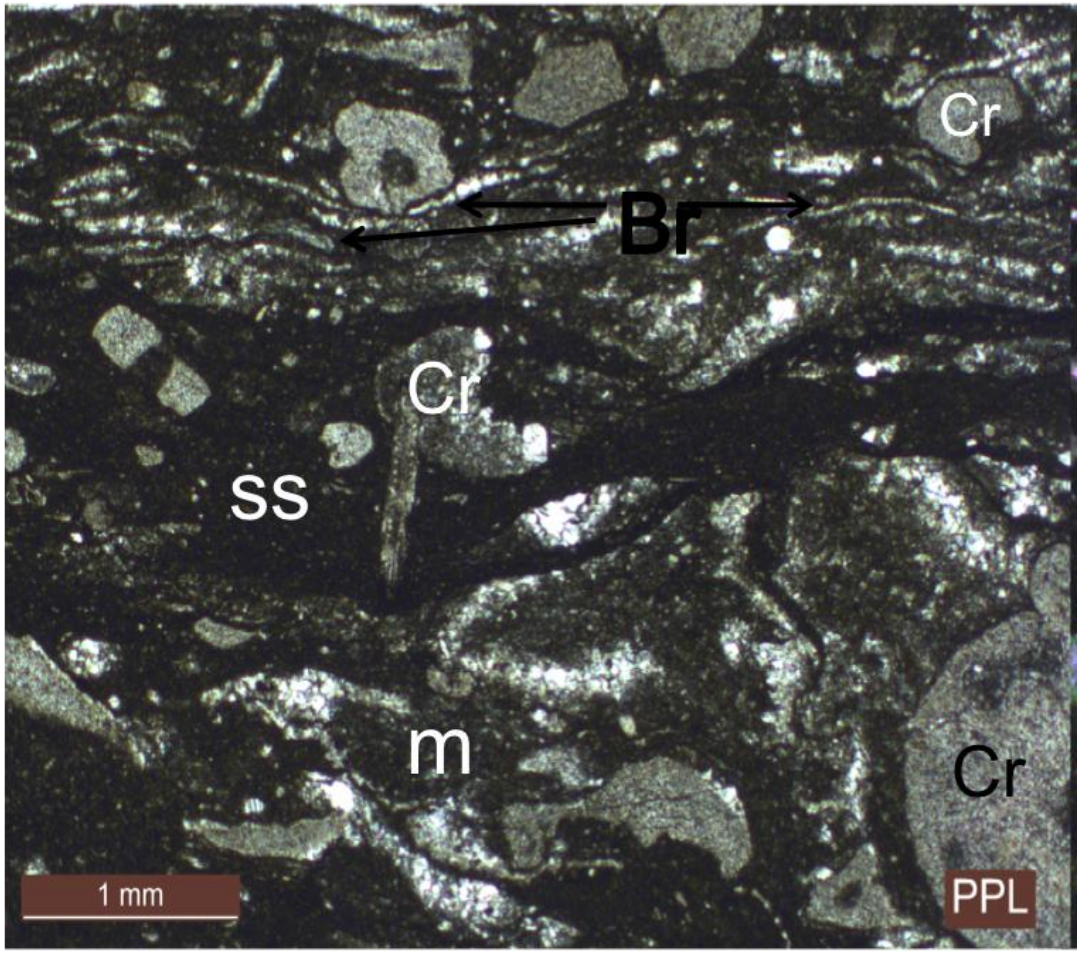
# Pronghorn Lithofacies 2



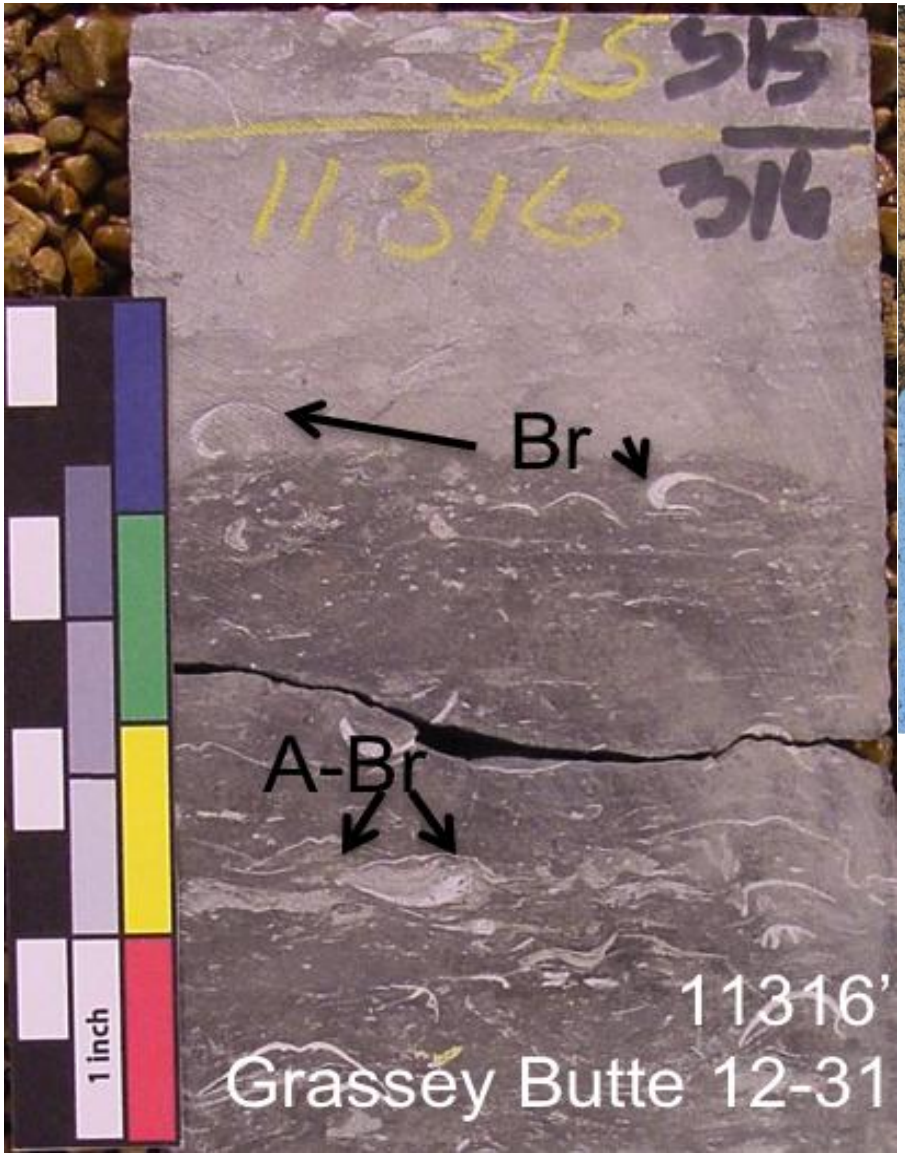

Burrowed silty dolomicrite

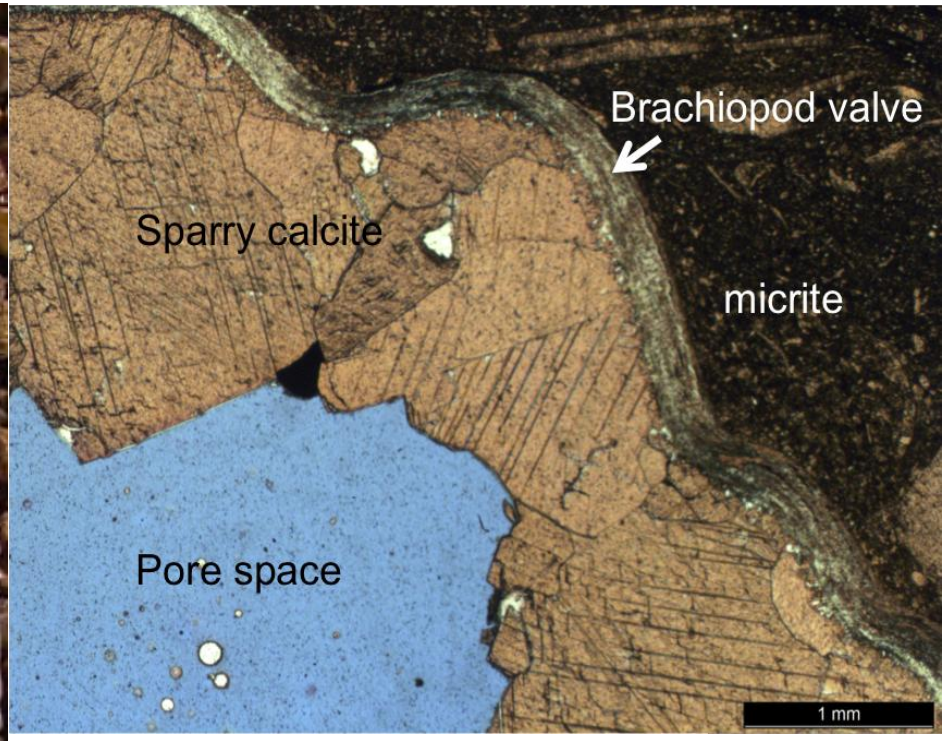
# Pronghorn Lithofacies 3



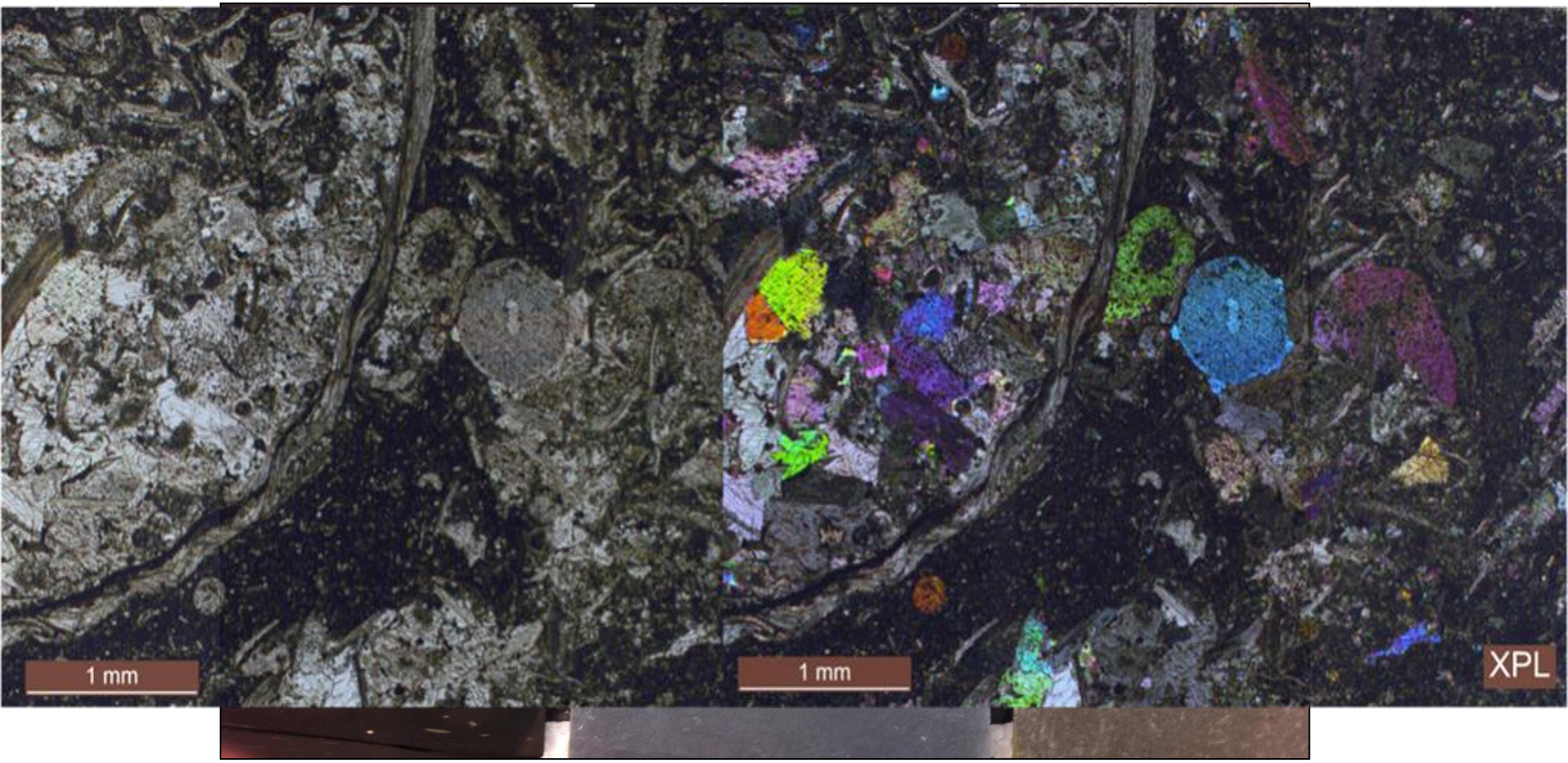



# Pronghorn Lithofacies 3

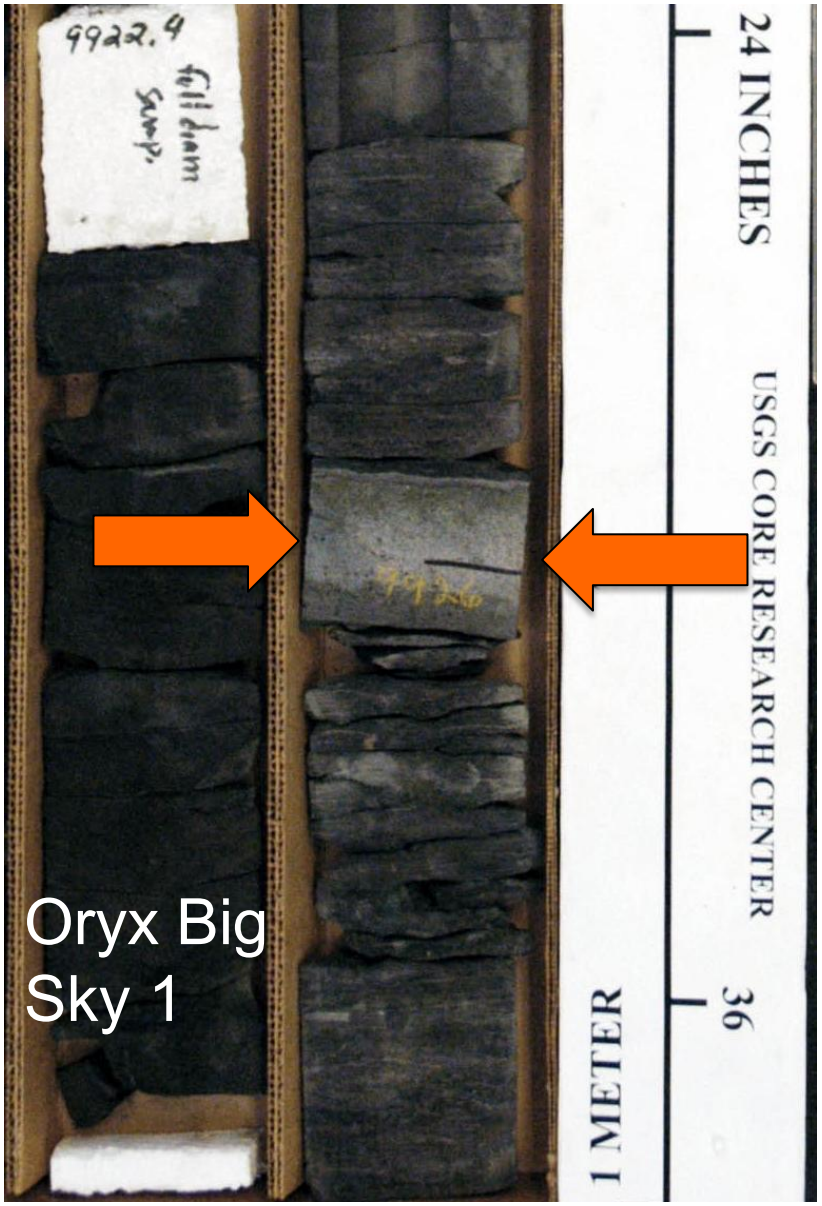


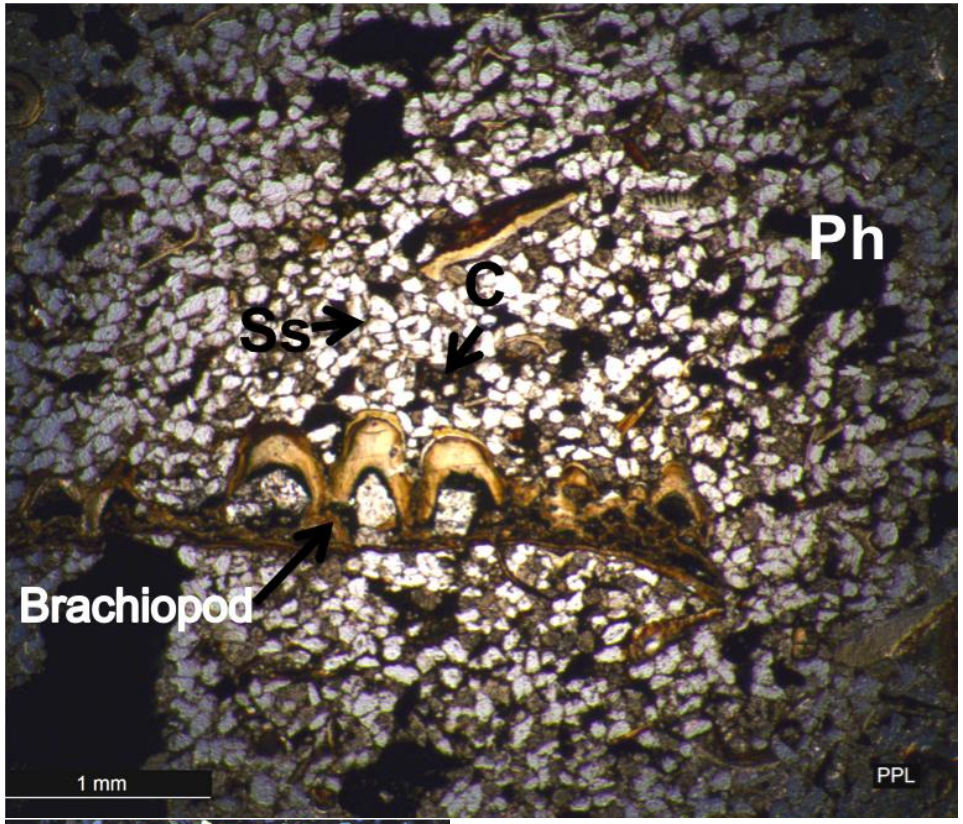
# Transgressive Lag – North Dakota



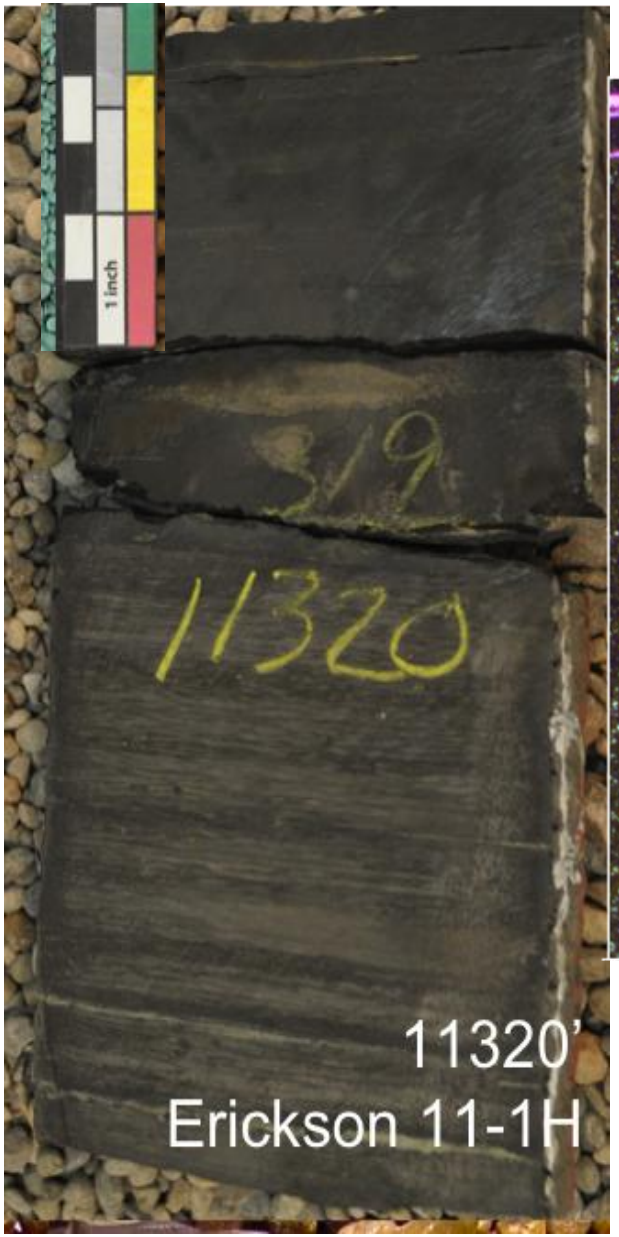
# Transgressive Lag - Montana

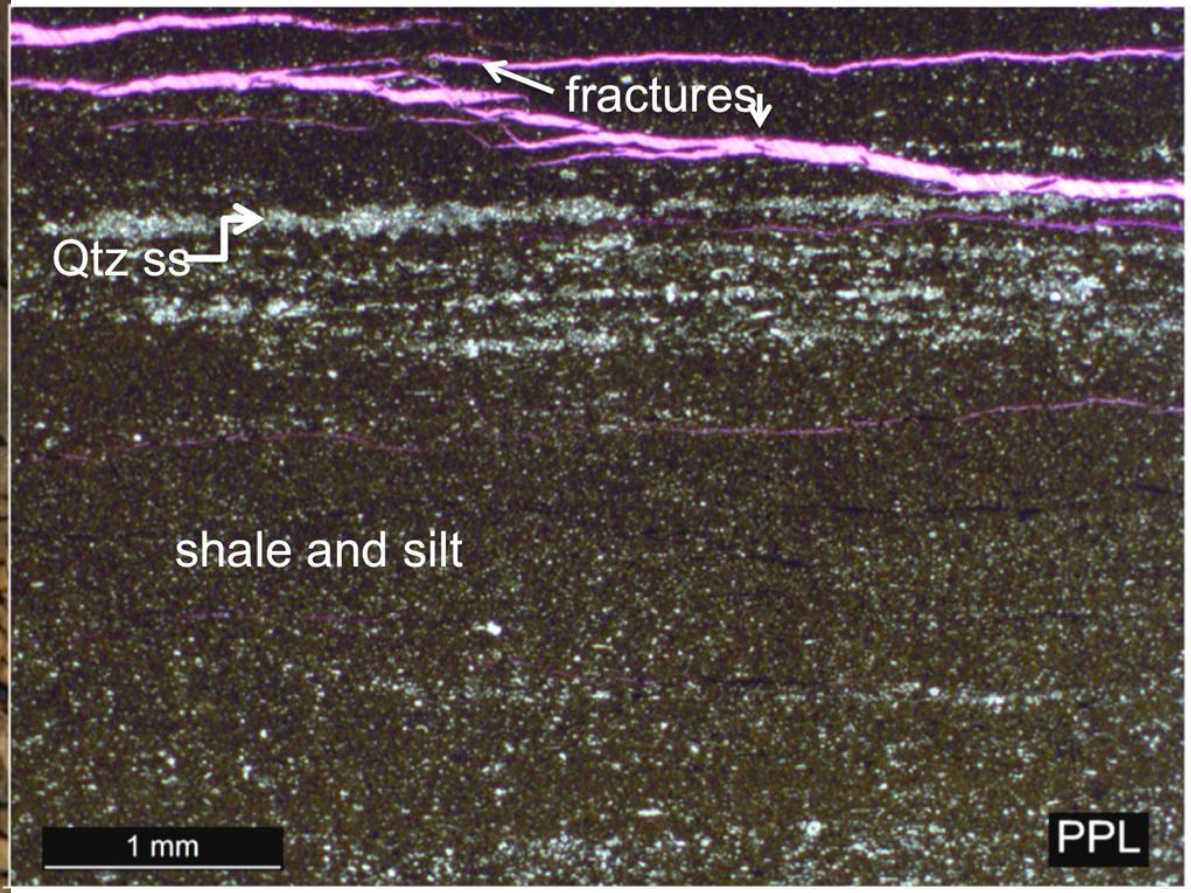



Oryx Big Sky 1

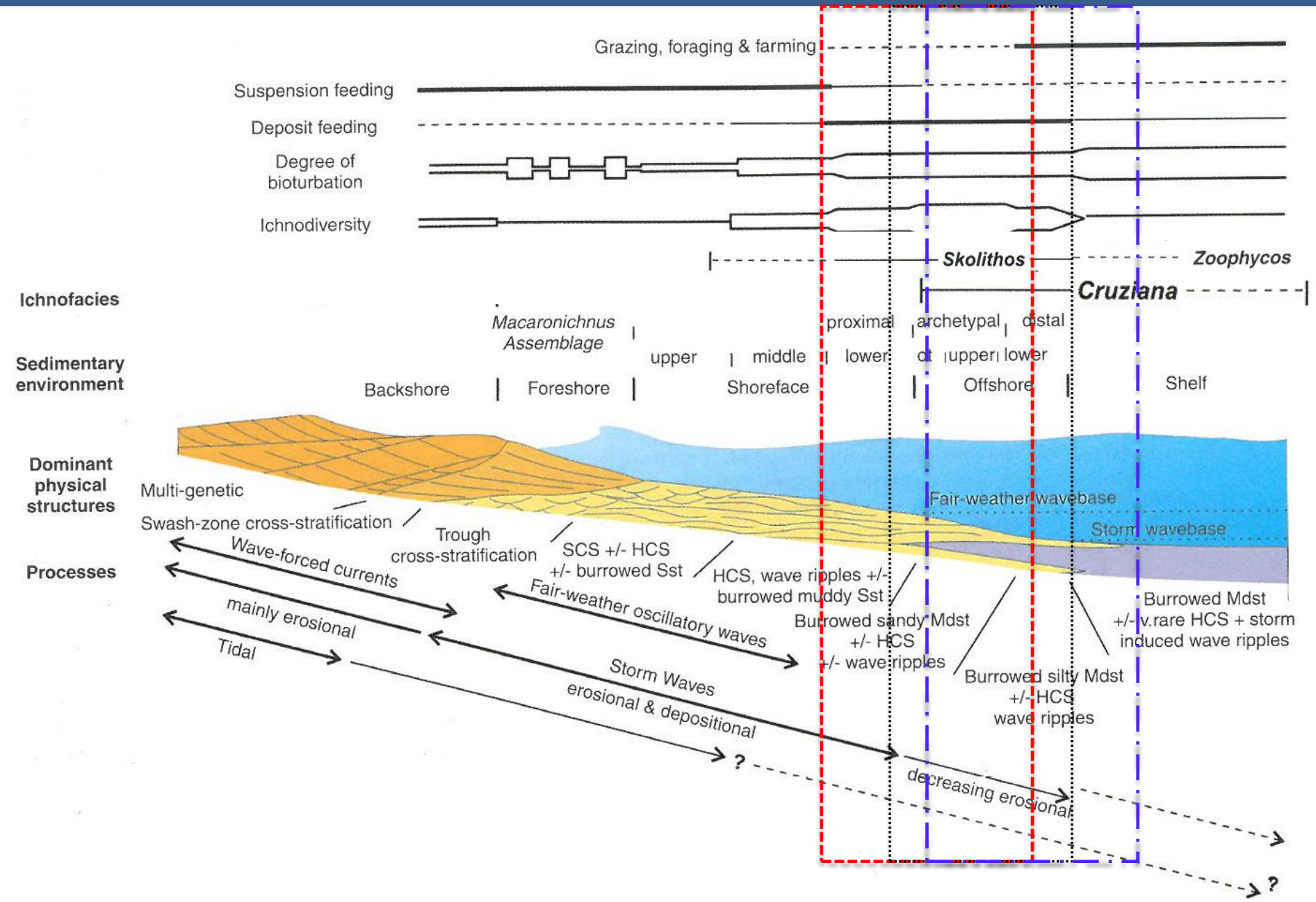



# Pronghorn Lithofacies 4



Litho1 Litho2 Litho3



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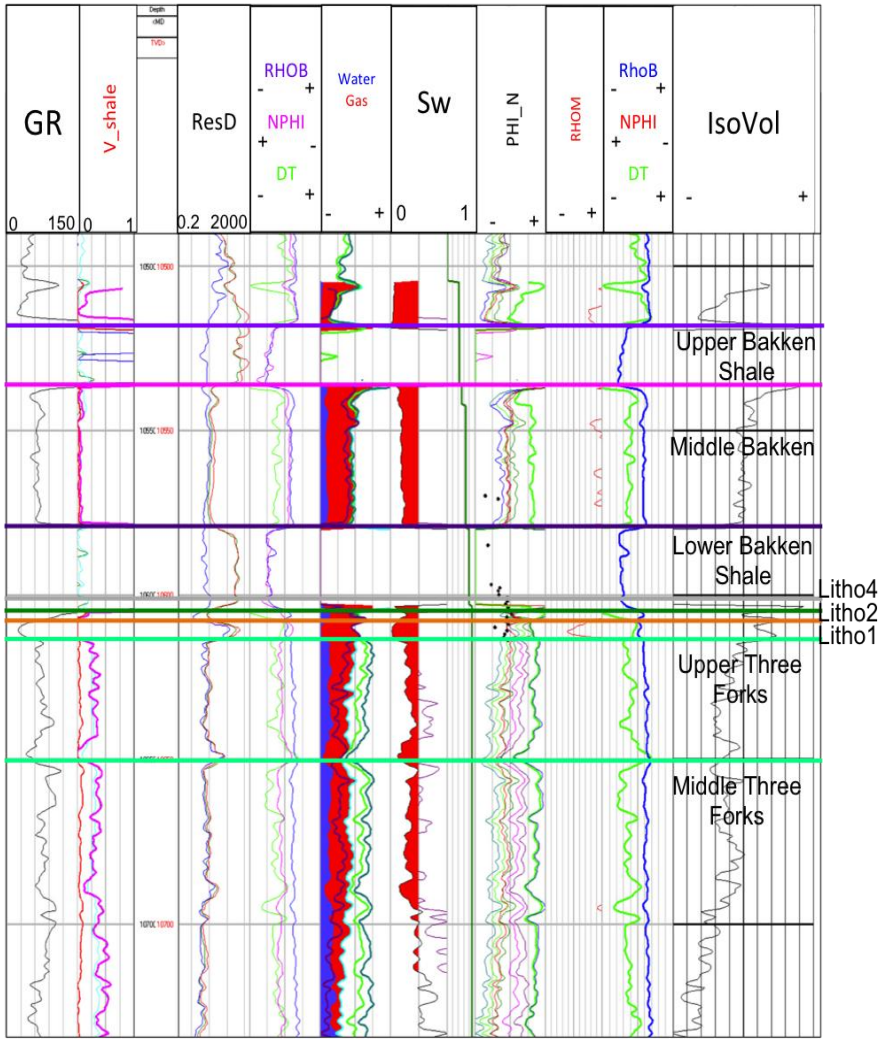
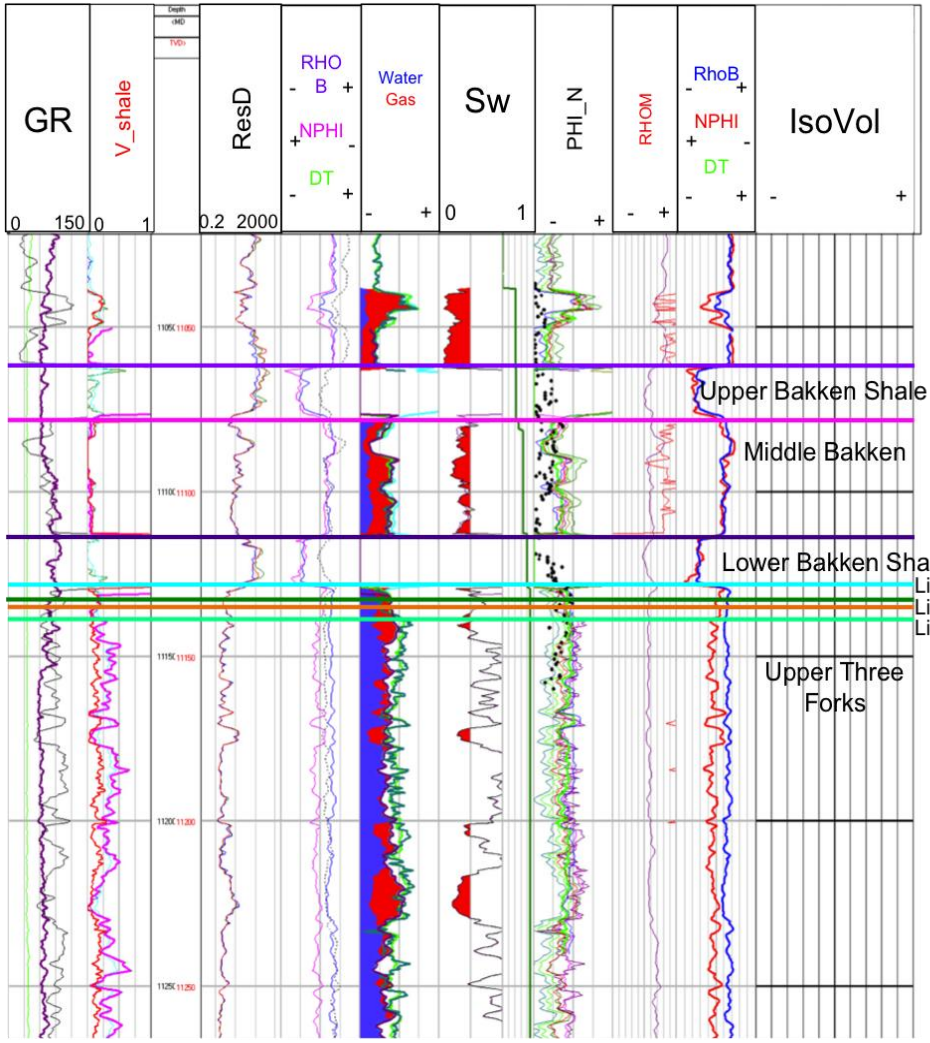
# Well Log Properties

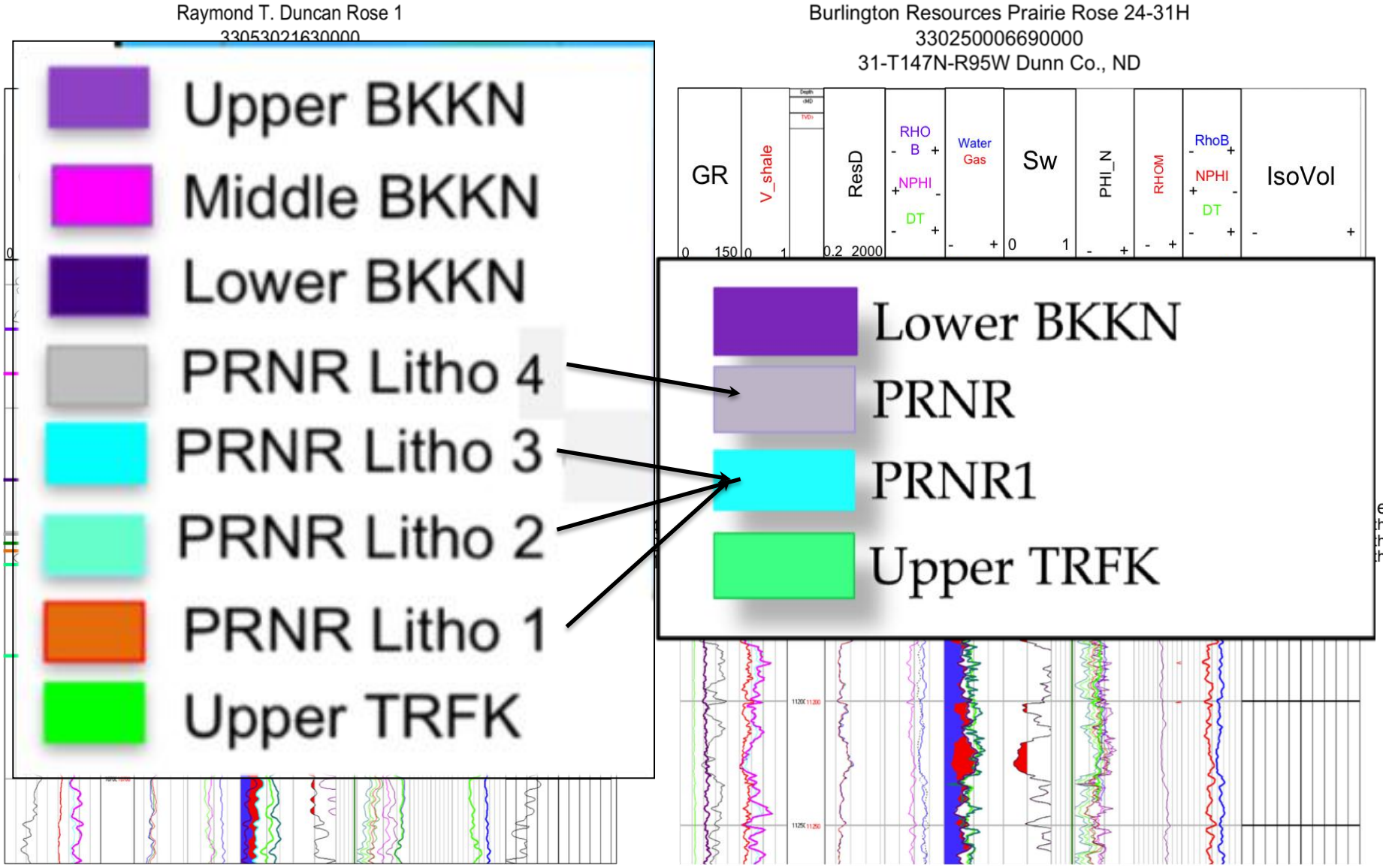
Raymond T. Duncan Rose 1
33053021630000
33-T152N-R94W McKenzie Co., ND



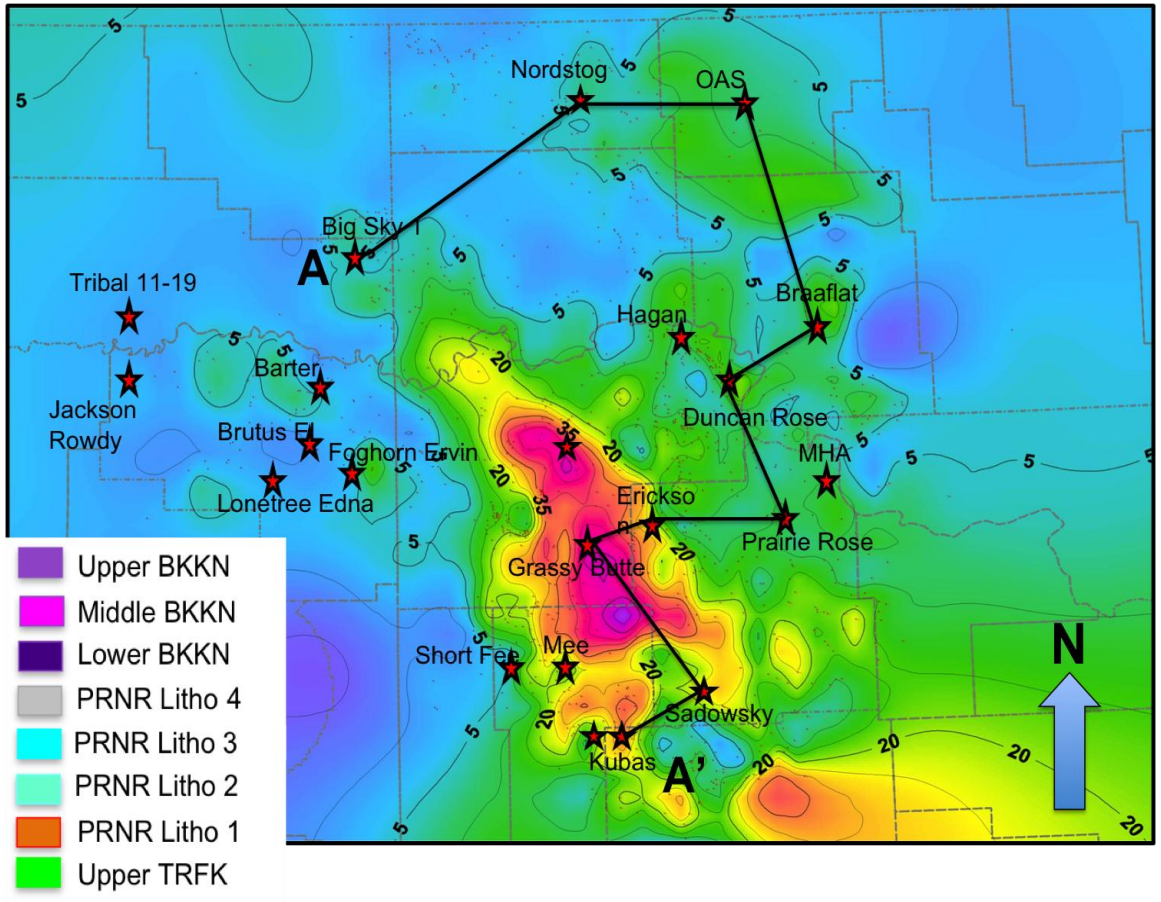

Burlington Resources Prairie Rose 24-31H
330250006690000
31-T147N-R95W Dunn Co., ND



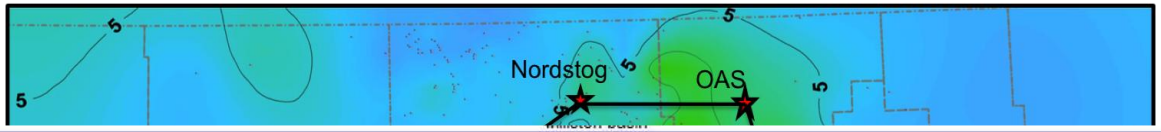
# Well Log Properties

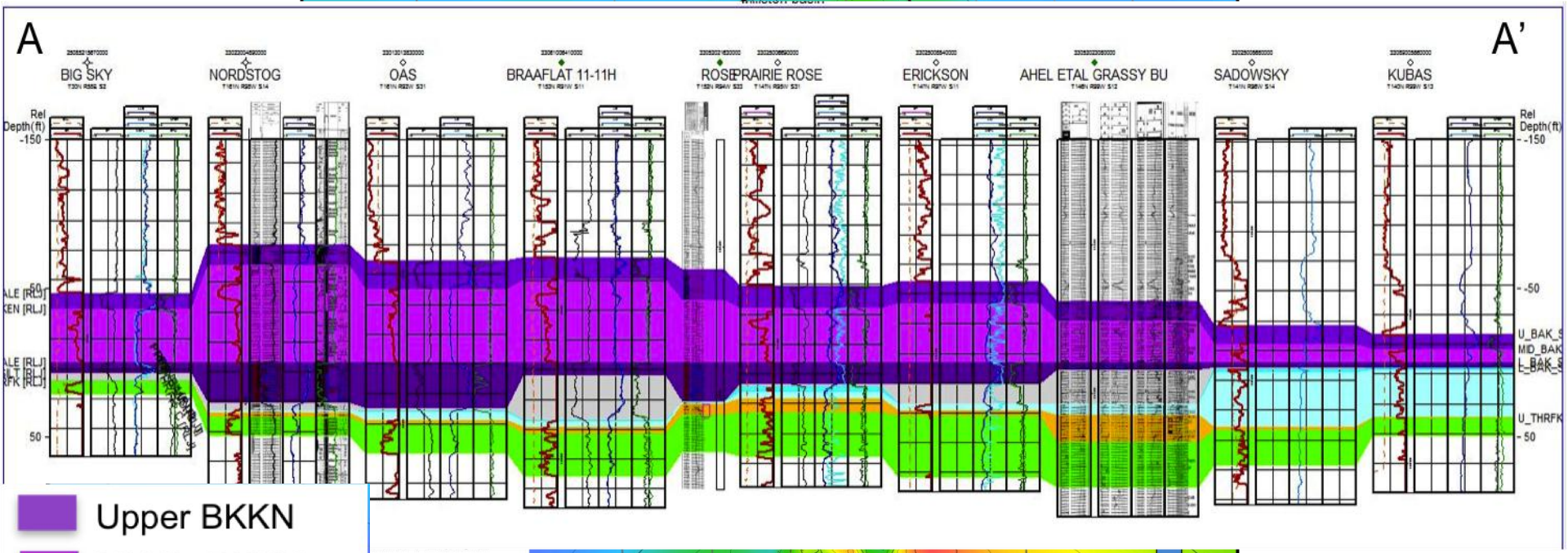


# Basin-Wide Cross Section



# Basin-Wide Cross Section



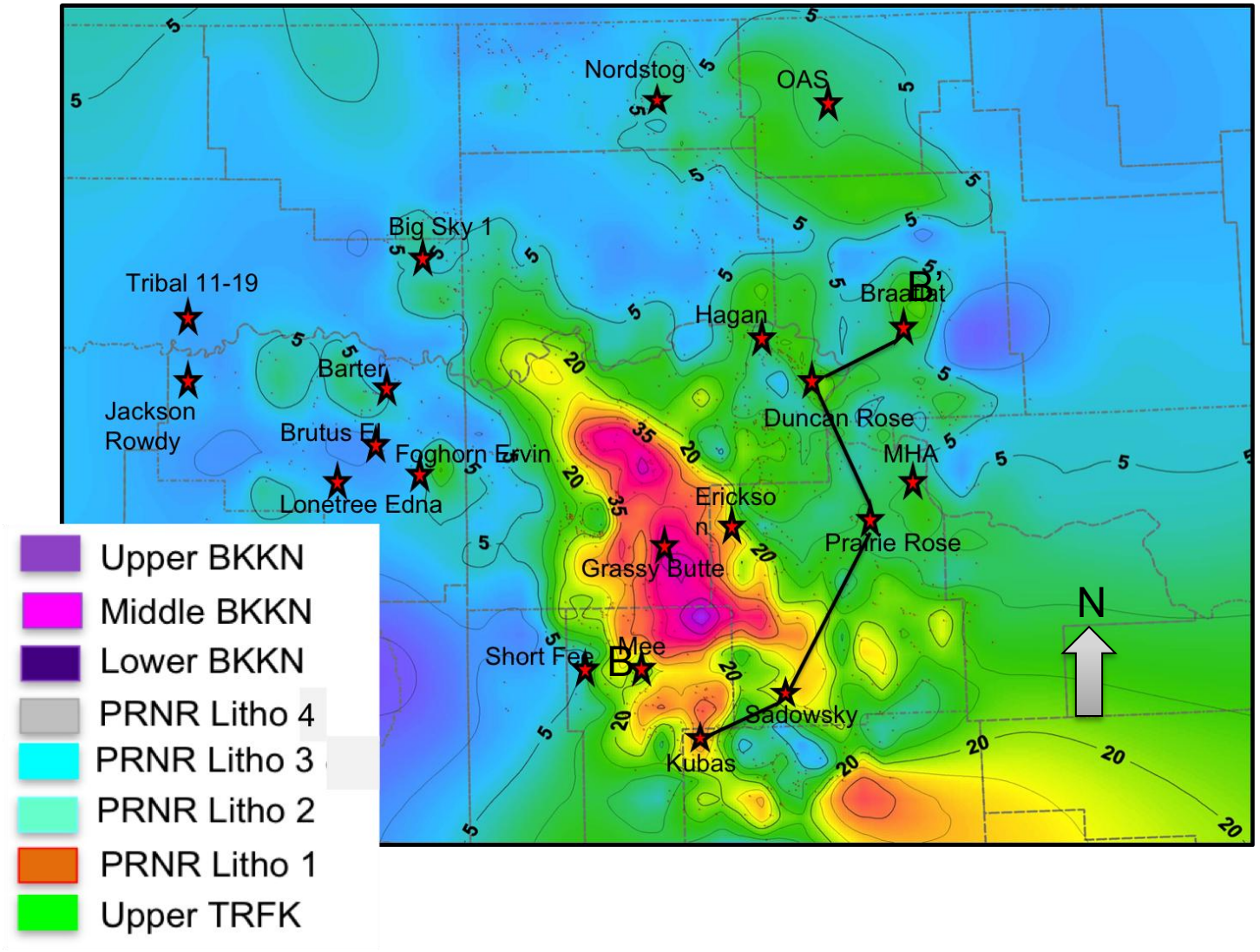





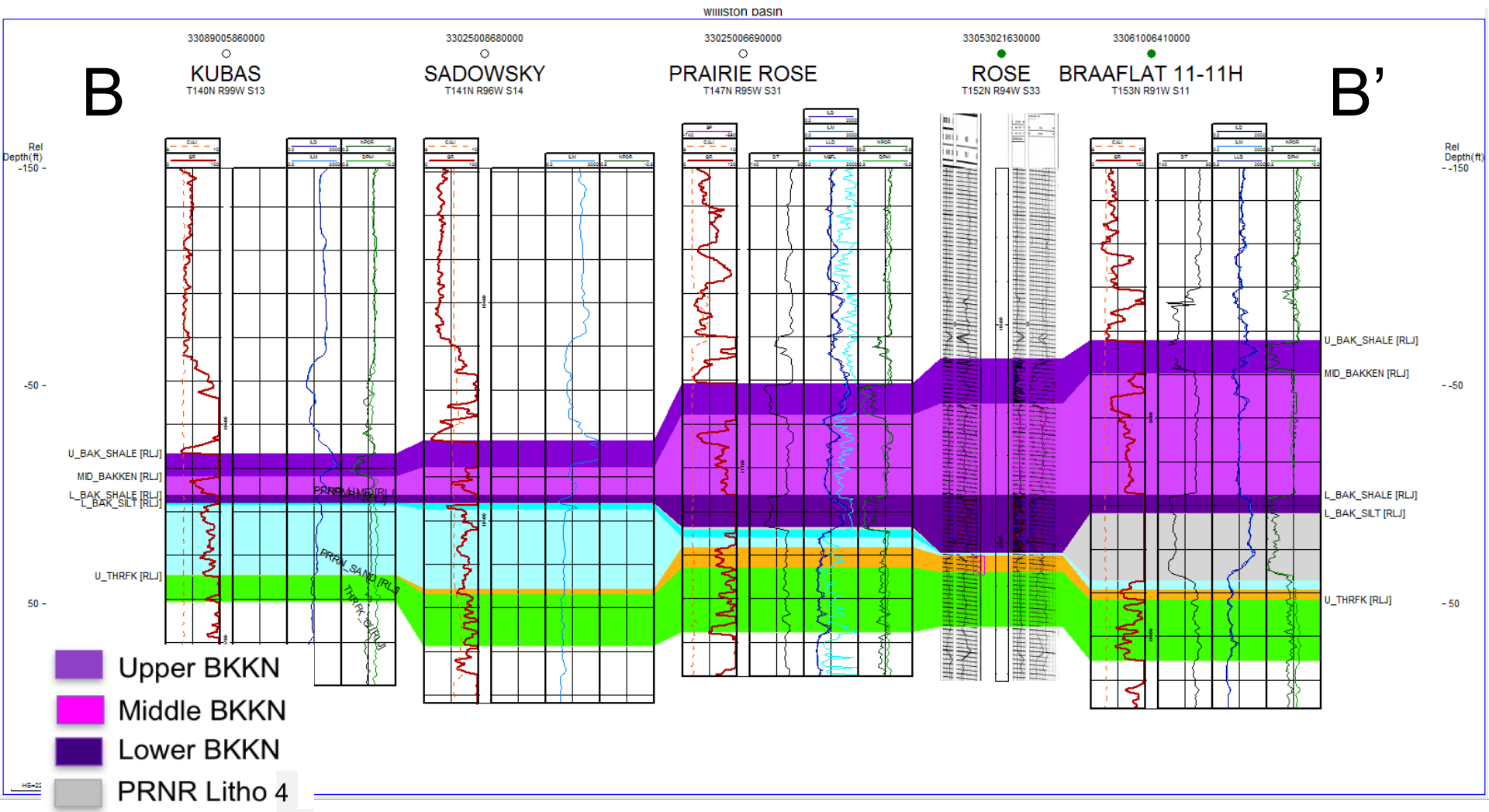
PRNR Litho 1
Upper TRFK

- Upper BKKN
- Middle BKKN
- Lower BKKN
- PRNR Litho 4
- PRNR Litho 3
- PRNR Litho 2
- PRNR Litho 1
- Upper TRFK

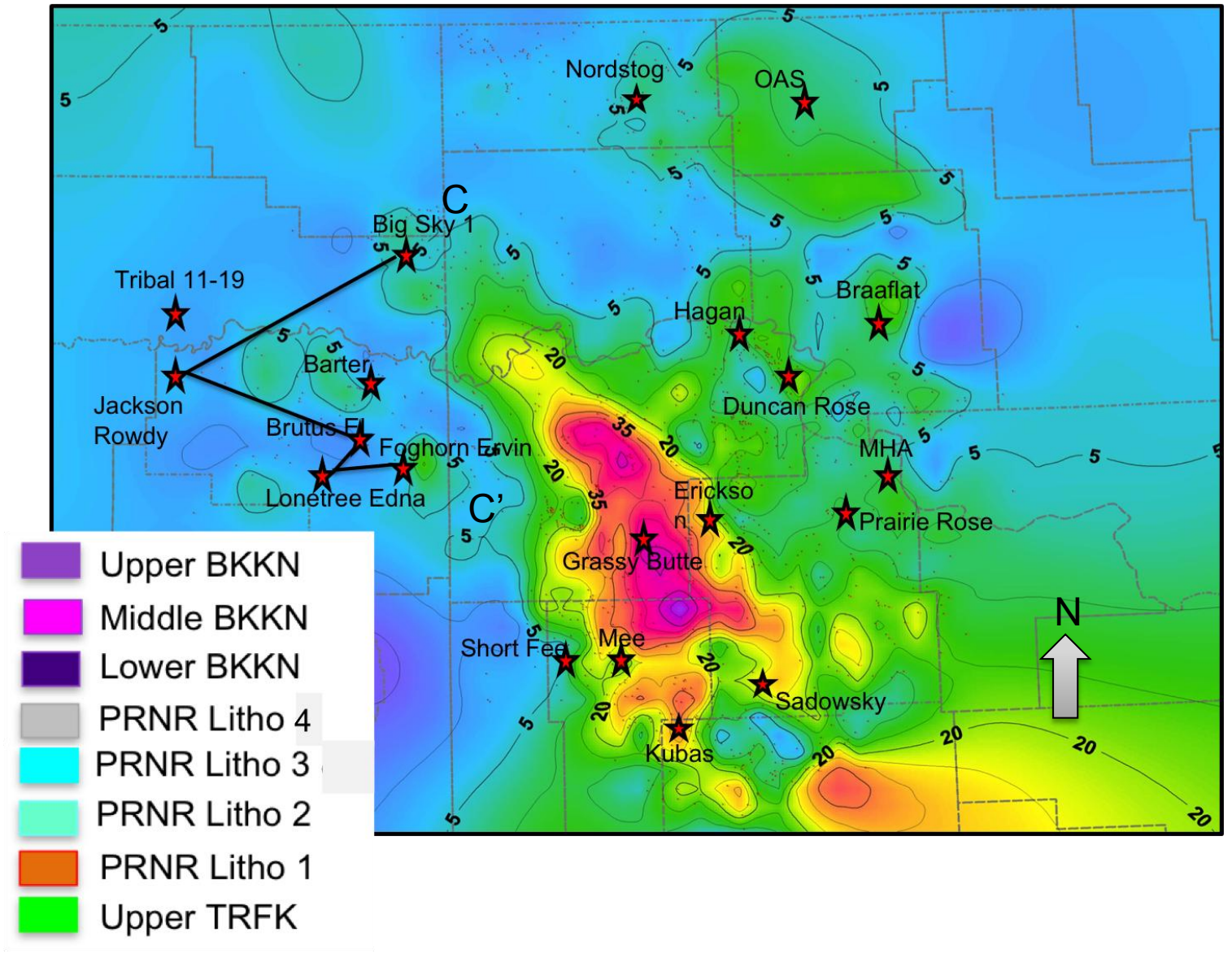
# North Dakota Cross-Section



# North Dakota Cross-Section



# Montana Cross-Section



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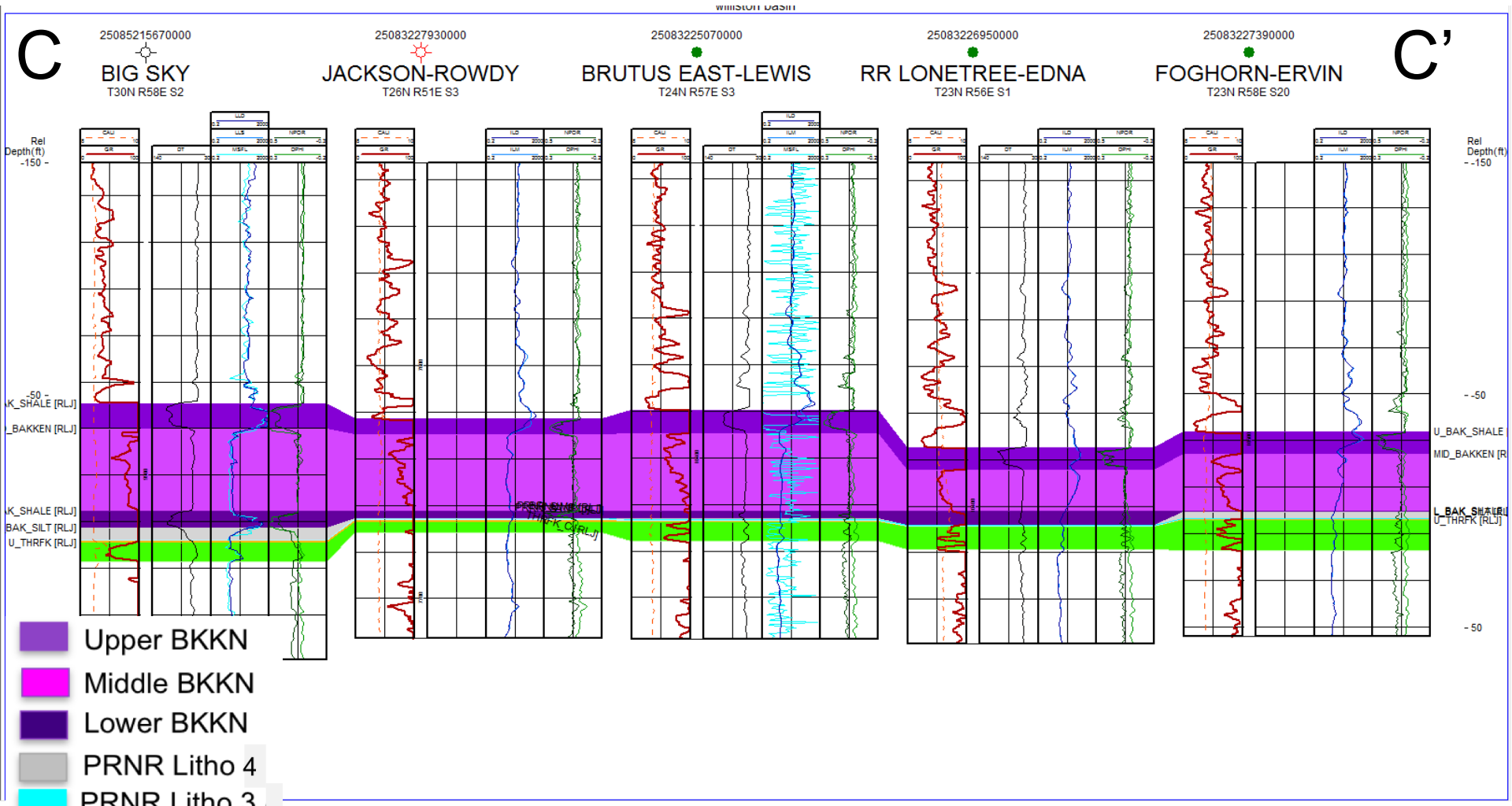
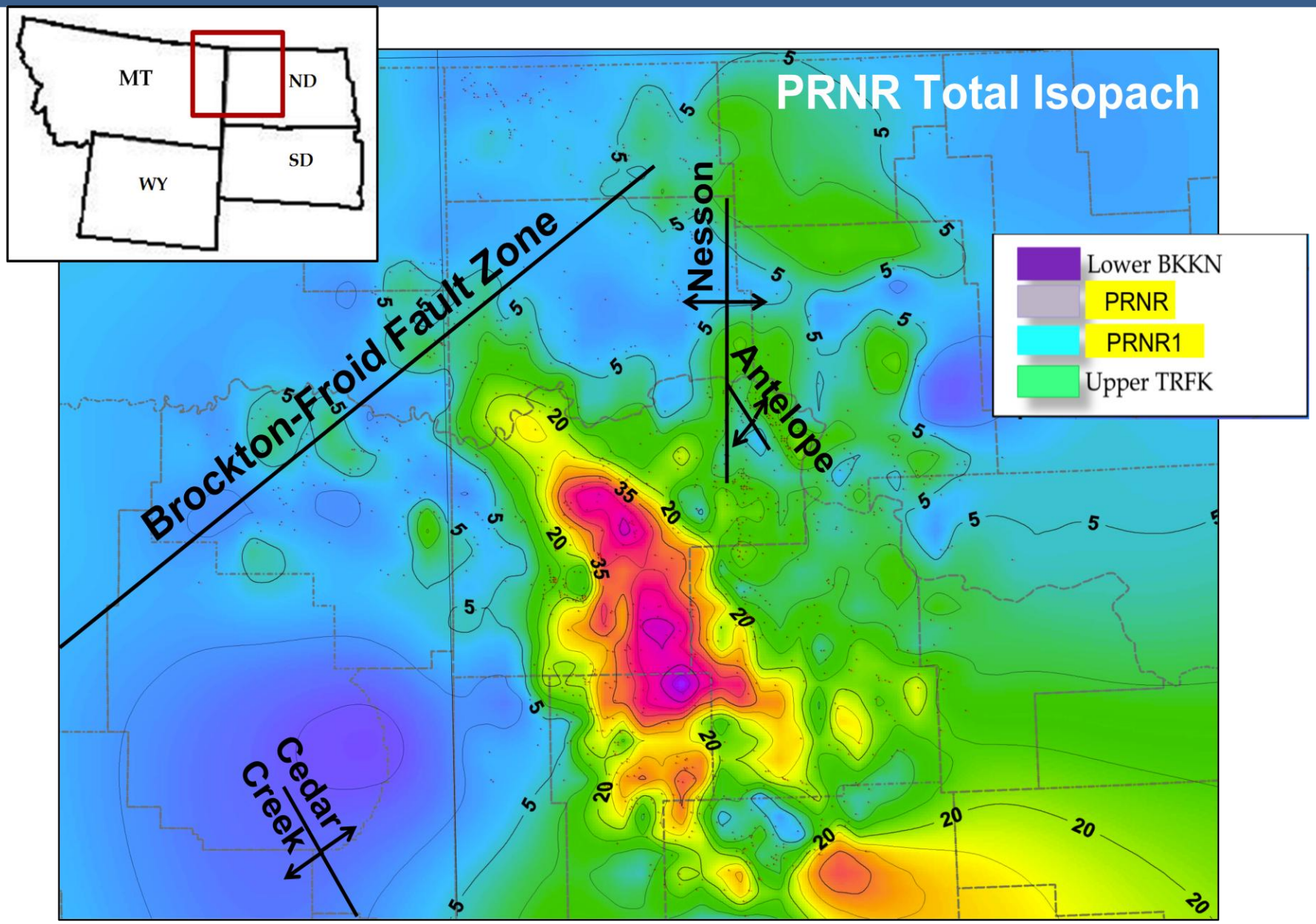
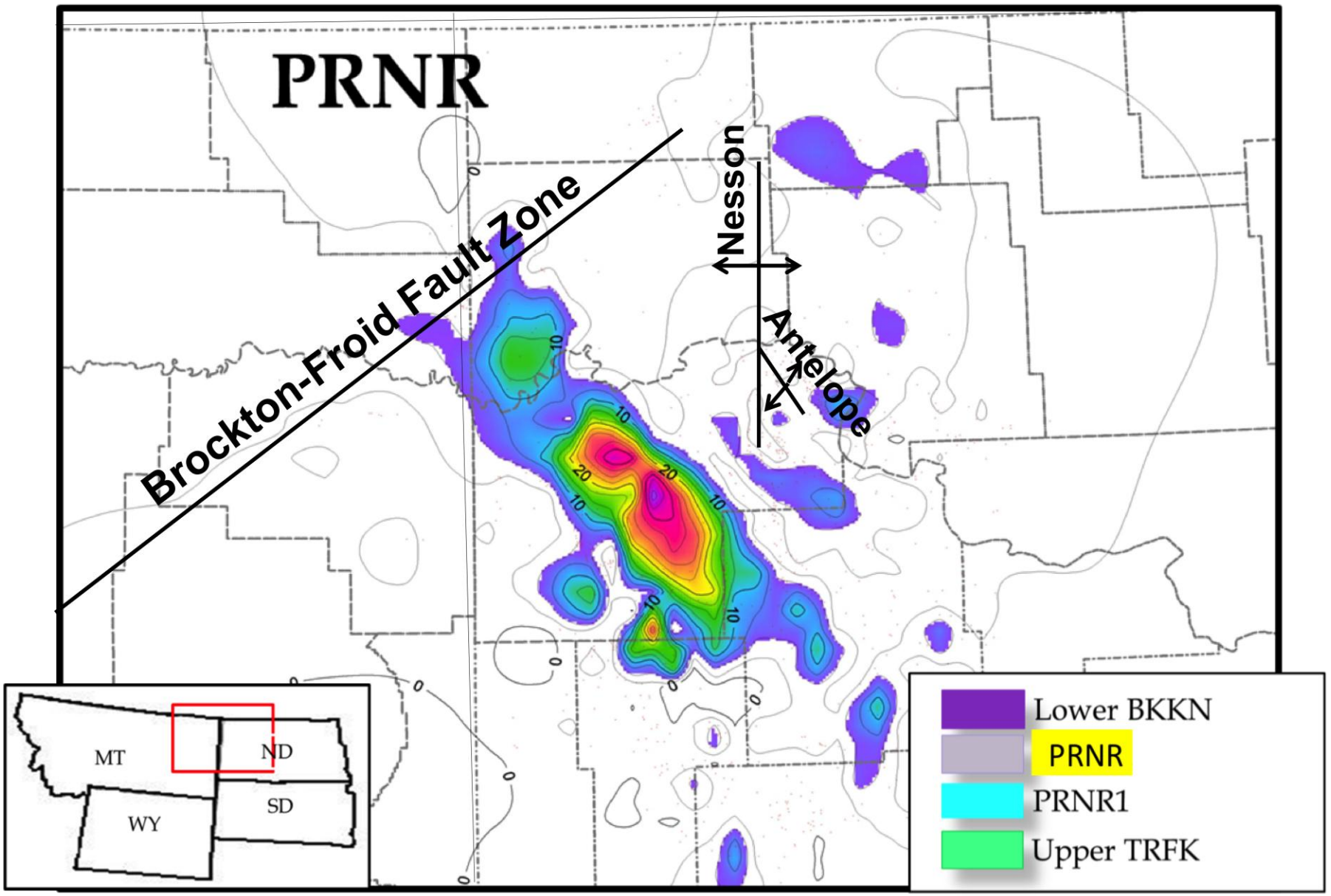


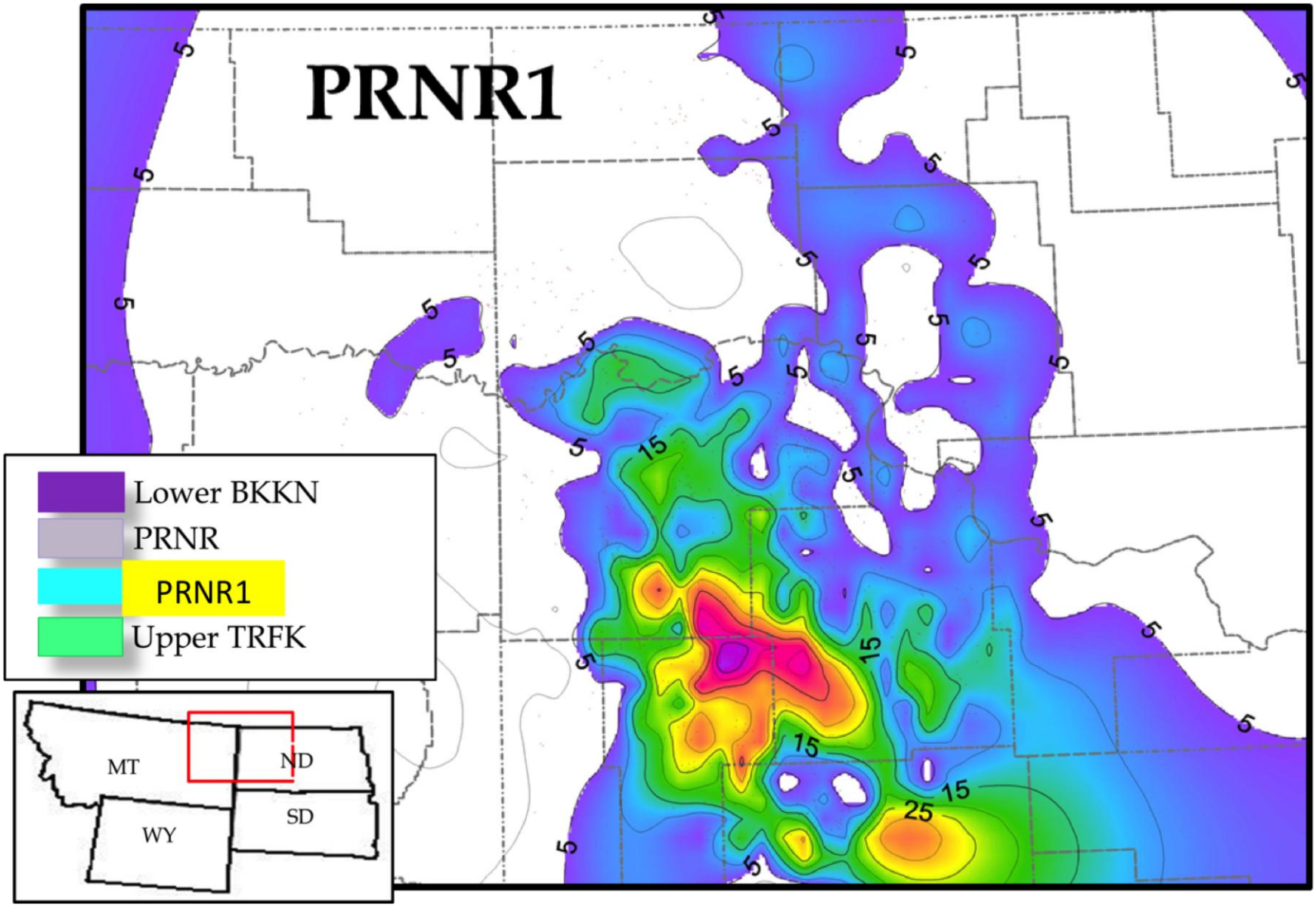
# Pronghorn Isopach



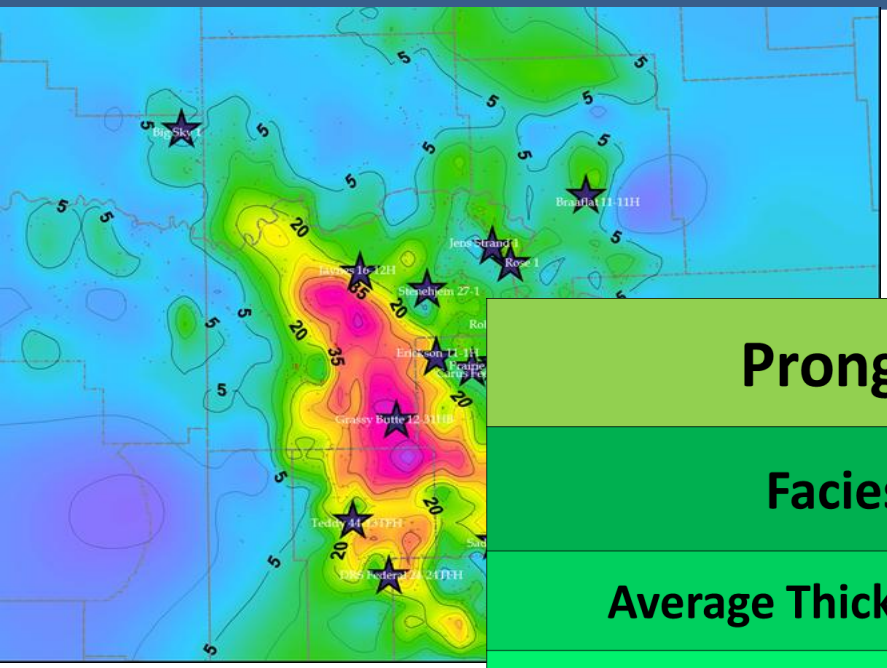
# Pronghorn Lithofacies 4 Isopach



# Pronghorn Lithofacies 1-3 (PRNR1) Isopach

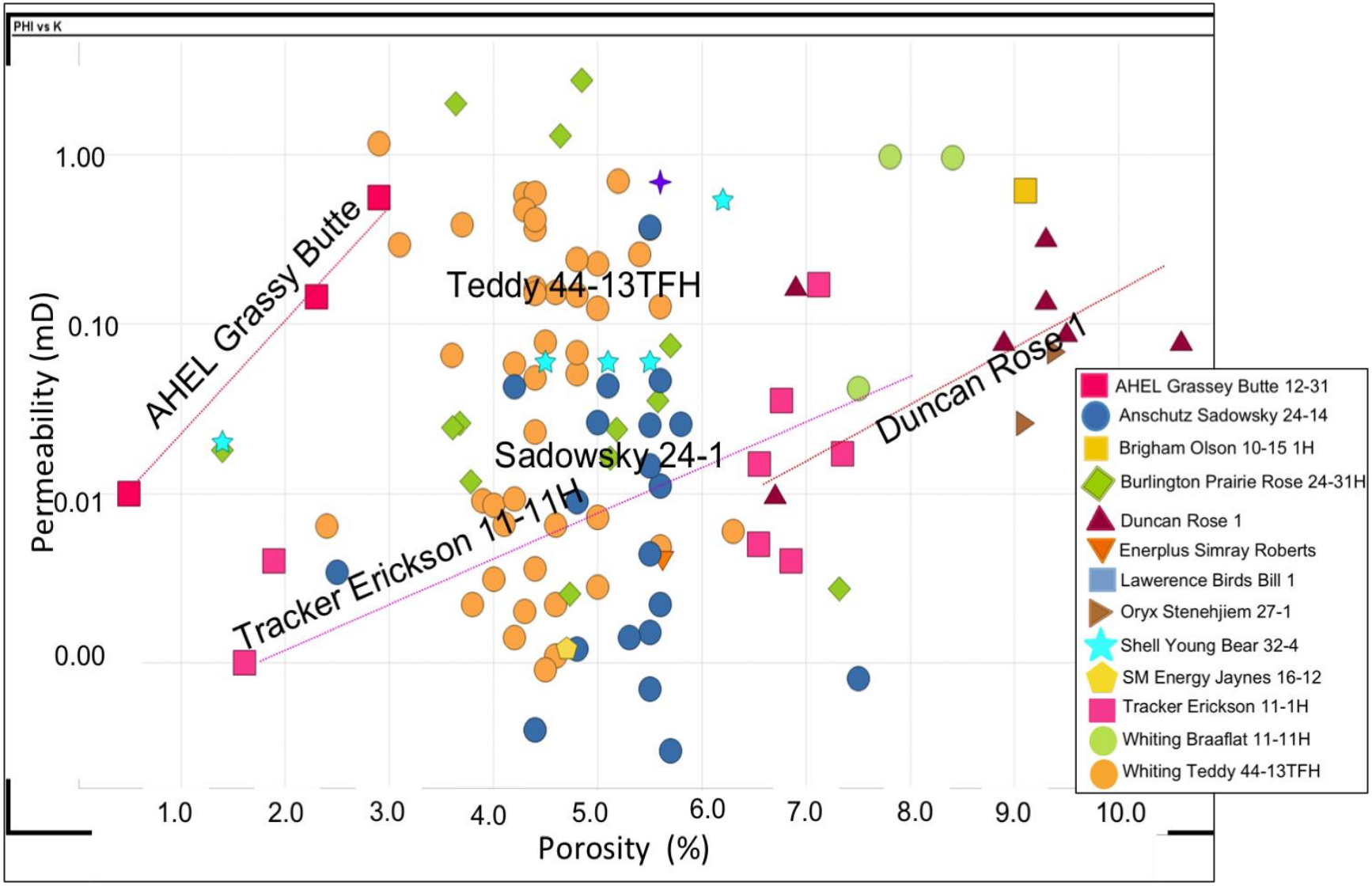


# Pronghorn Reservoir Properties

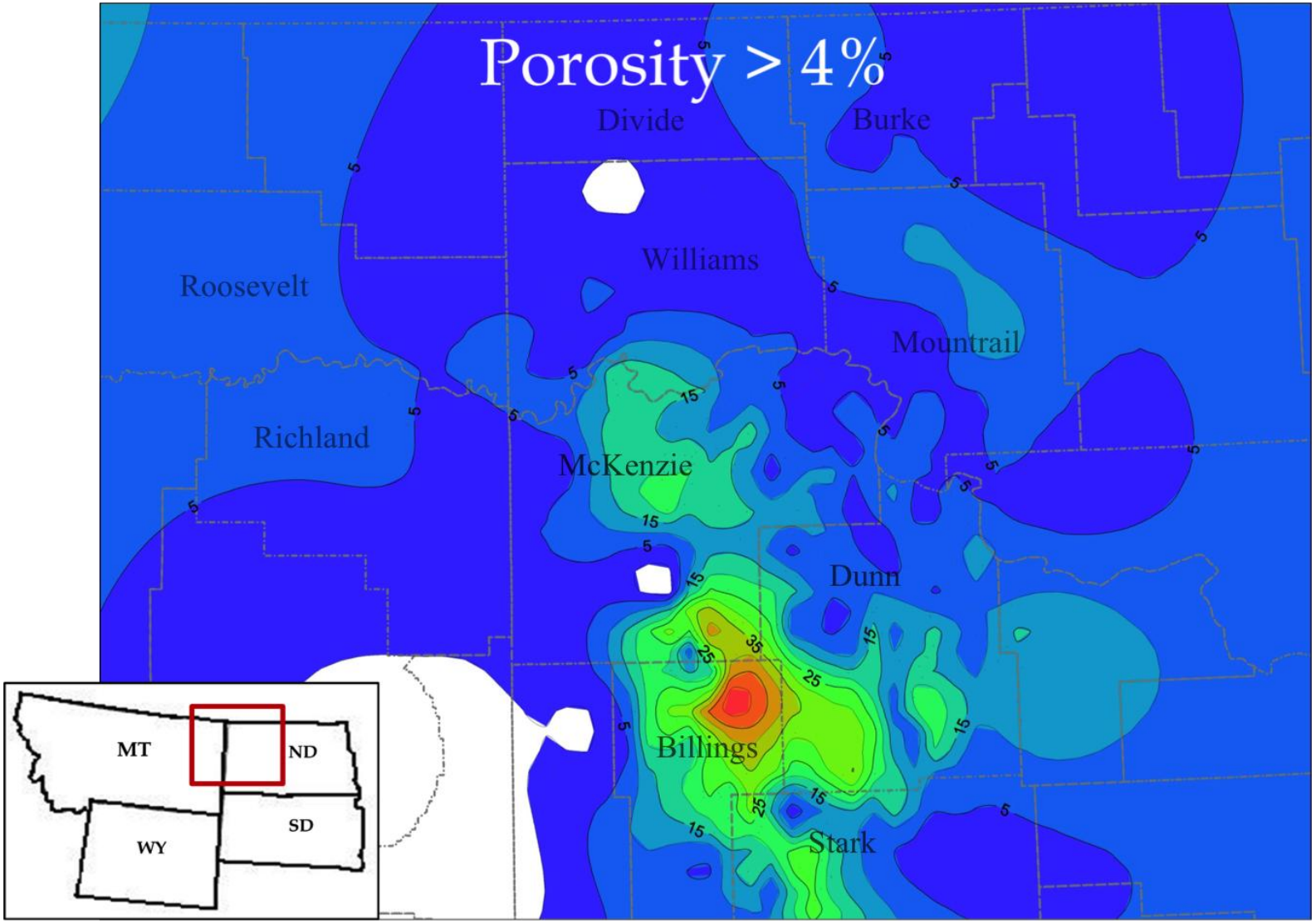



| Pronghorn Reservoir Properties | | |
|---|---|---|
| **Facies** | **PRNR silt** | **PRNR1** |
| **Average Thickness (ft)** | **5.5** | **12** |
| **Average Log Porosity (%)** | **7** | **5** |
| **Average Core Porosity (%)** | **6** | **5** |
| **Average Core Permeability (mD)** | **0.6** | **0.4** |
| **Average Oil Saturation** | **32** | **31** |

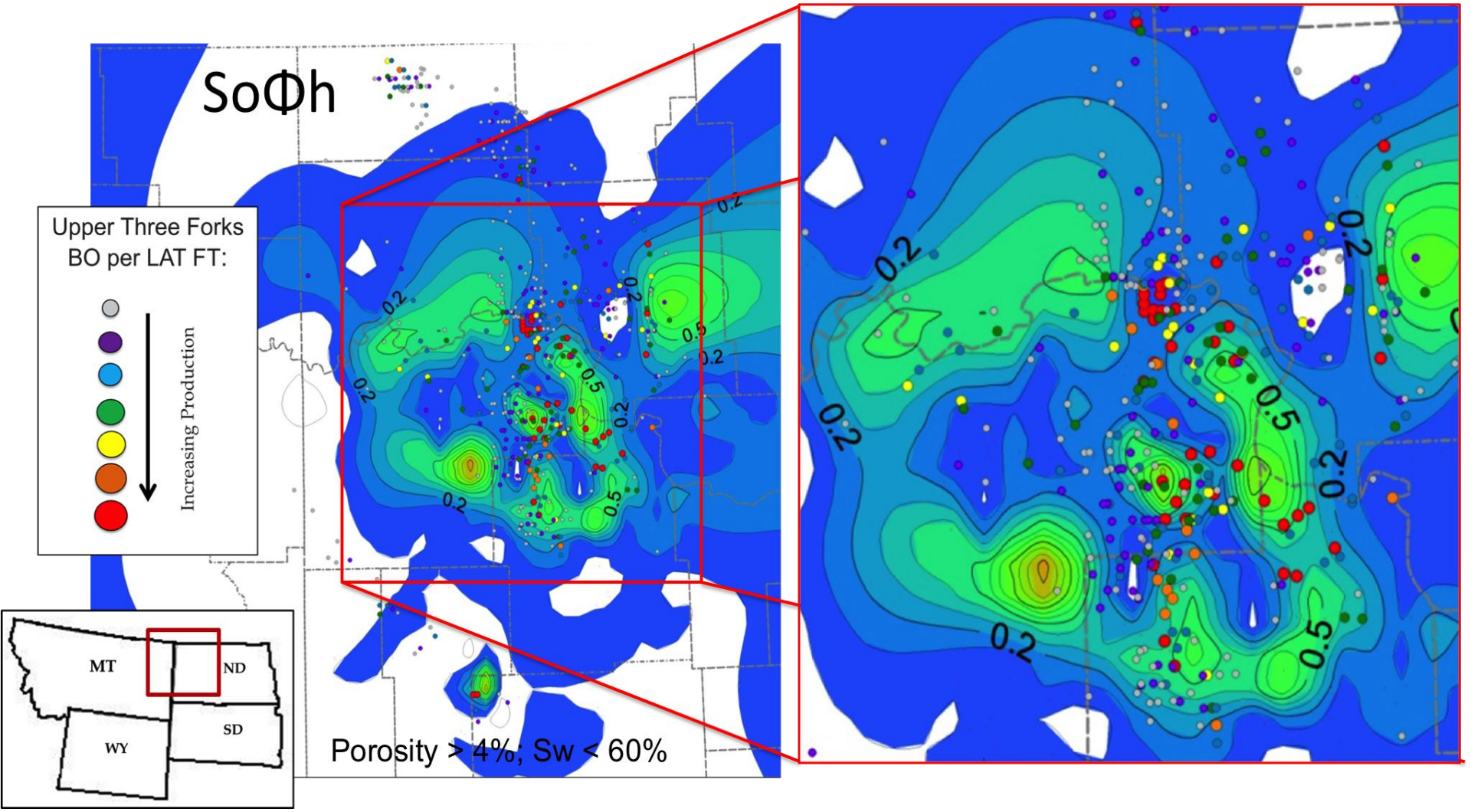
# PRNR1: K vs. ϕ


PHI vs K
Permeability (mD)
1.00
0.10
0.01
0.00
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Porosity (%)
AHEL Grassy Butte
Teddy 44-13TFH
Sadowsky 24-1
Tracker Erickson 11-11H
Duncan Rose 1
AHEL Grassey Butte 12-31
Anschutz Sadowsky 24-14
Brigham Olson 10-15 1H
Burlington Prairie Rose 24-31H
Duncan Rose 1
Enerplus Simray Roberts
Lawerence Birds Bill 1
Oryx Stenehjiem 27-1
Shell Young Bear 32-4
SM Energy Jaynes 16-12
Tracker Erickson 11-1H
Whiting Braaflat 11-11H
Whiting Teddy 44-13TFH

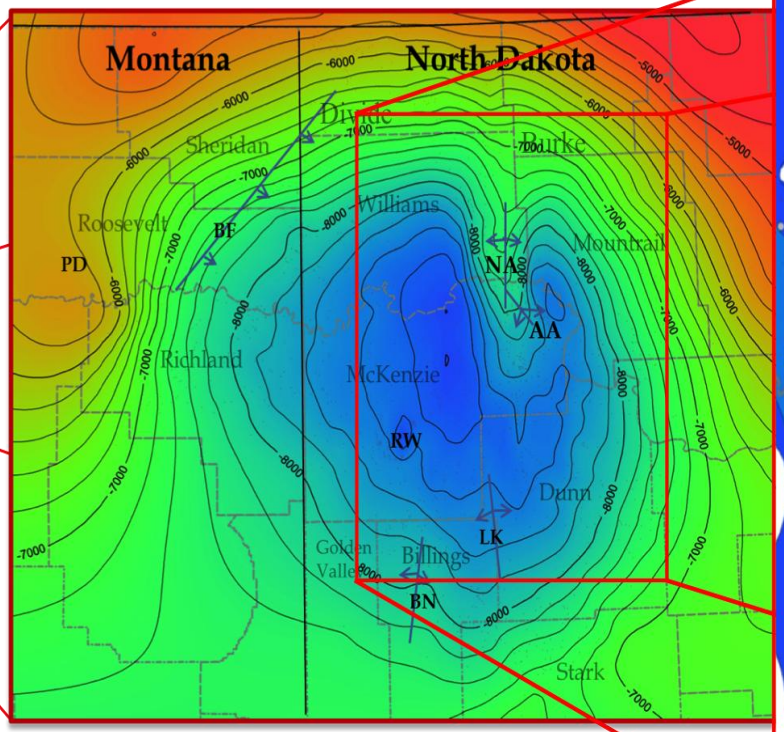
# Pronghorn Gross Reservoir

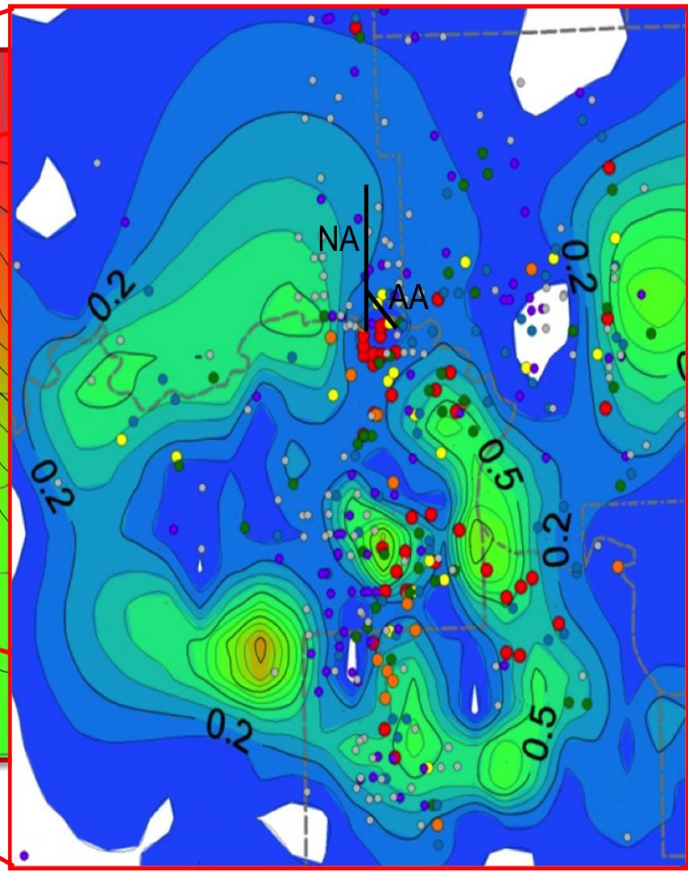


# Pronghorn PRNR1 SoΦh



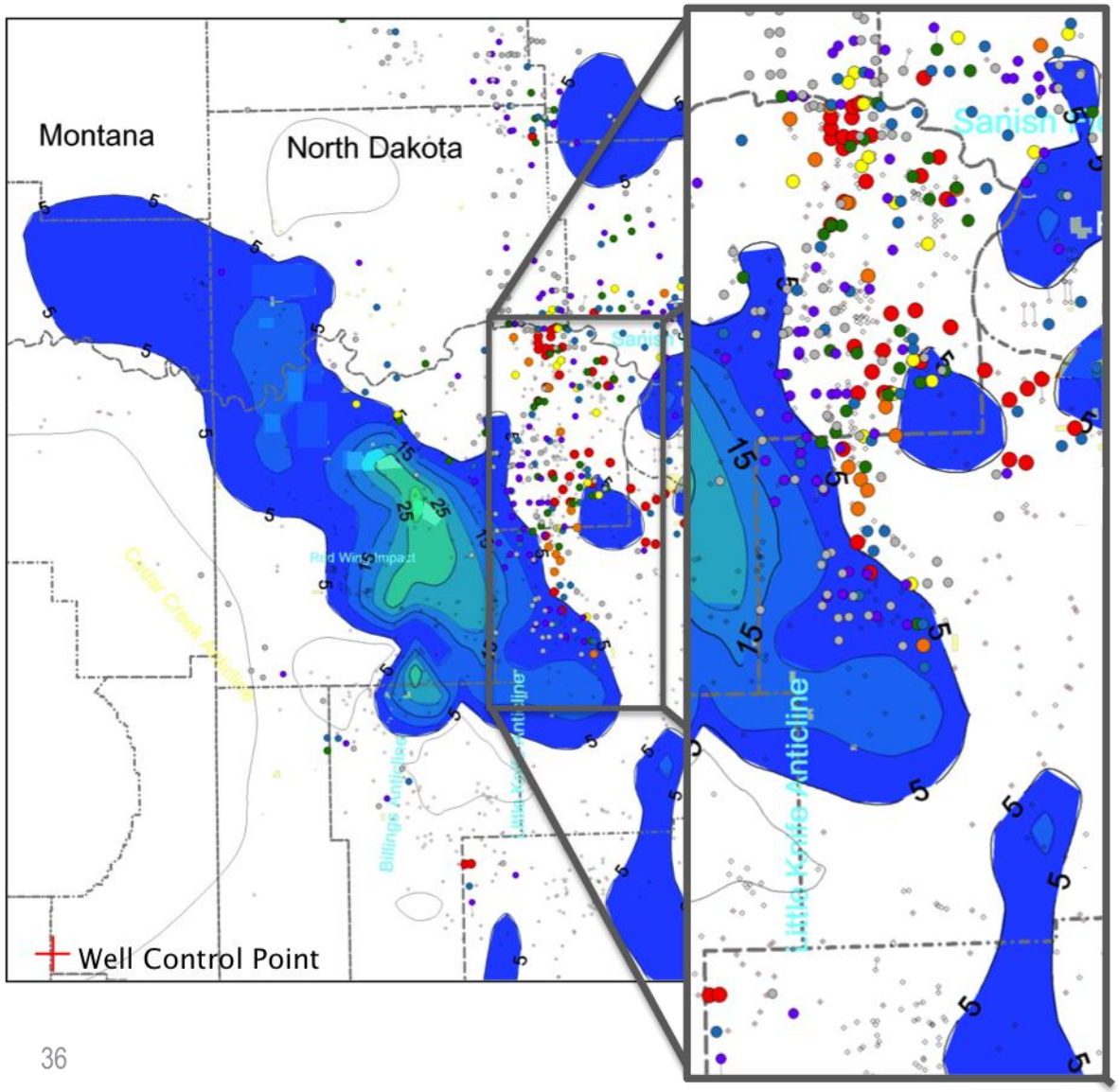
# Pronghorn PRNR1 Soϕh

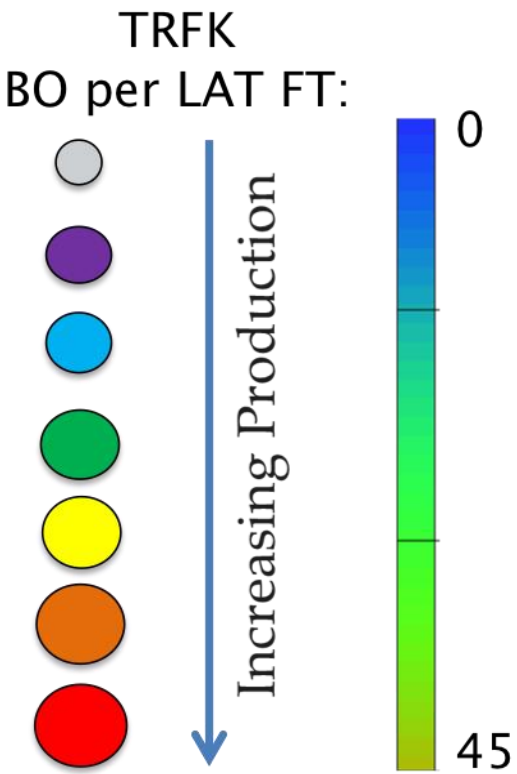




Key:
AA: Antelope Anticline
BF: Brockton-Froid Fault Zone
BN: Billings Nose
LK: Little Knife Anticline
NA: Nesson Anticline
PD: Poplar Dome
RW: Red Wing Impact Structure

# PRNR Sum ϕH porosity > 3%



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