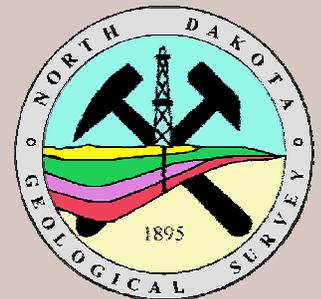


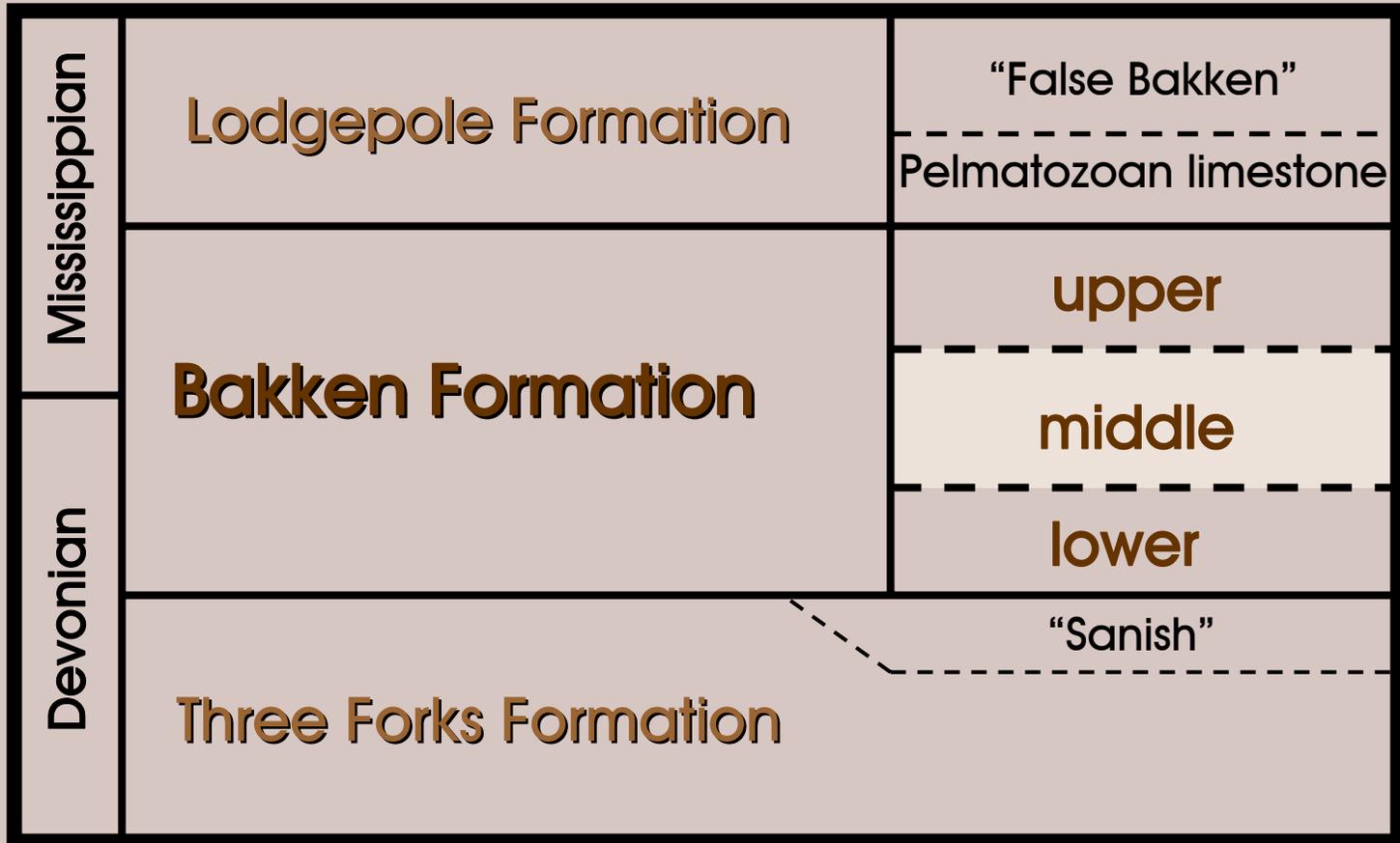
Overview of Bakken Stratigraphy and “Mini-Core” Workshop

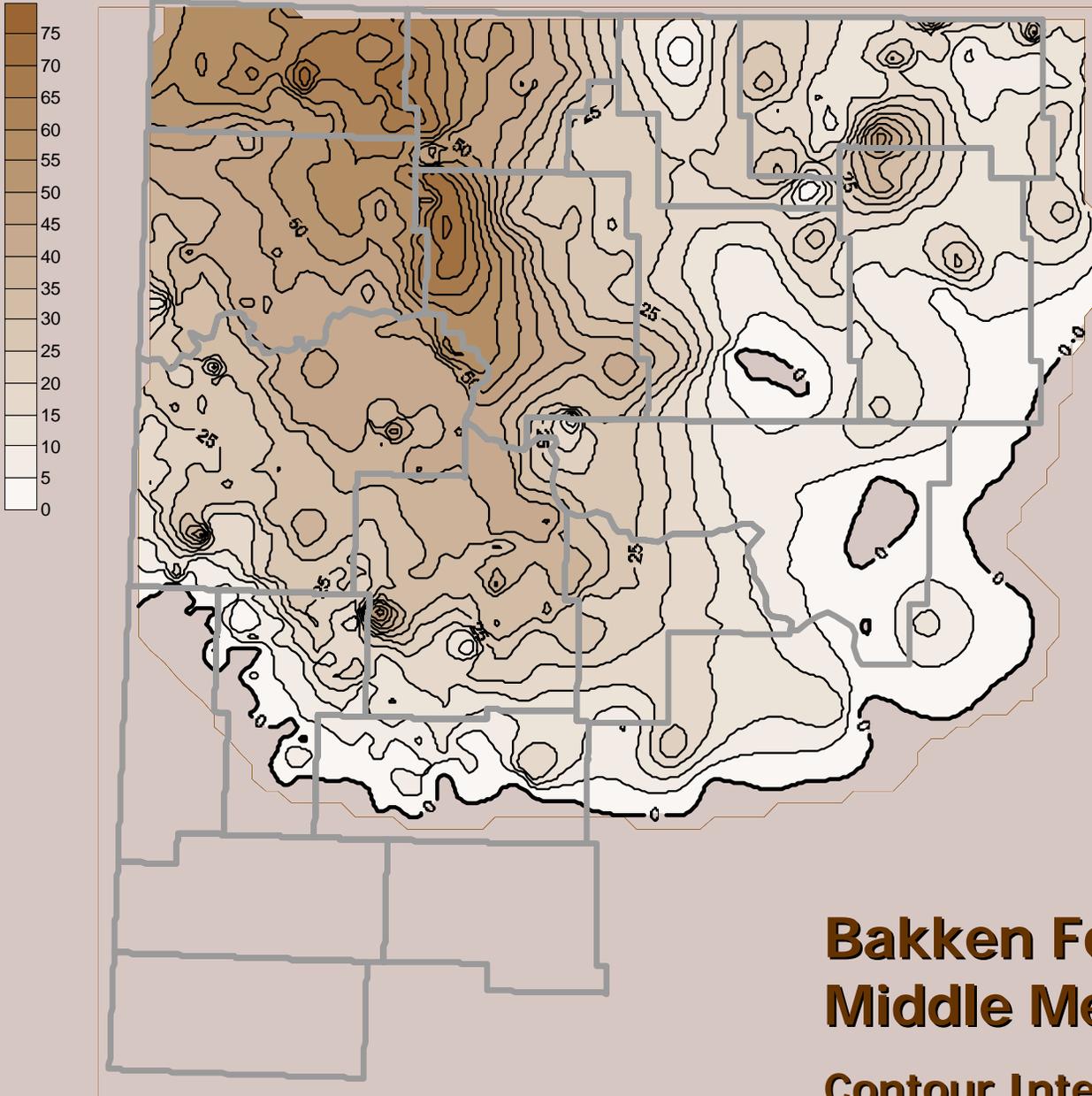
Julie A. LeFever

North Dakota Geological Survey

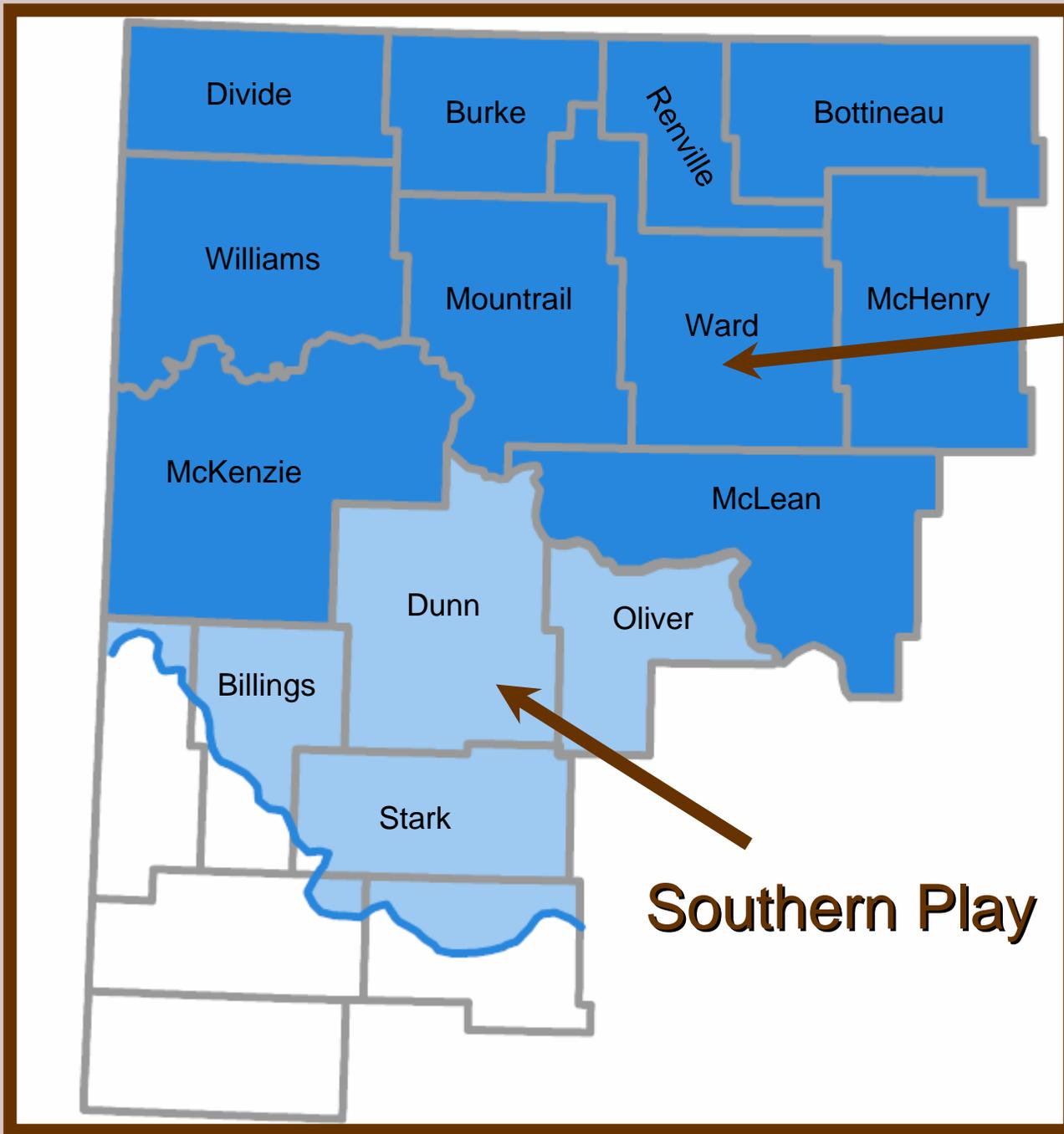


Stratigraphy





**Bakken Formation
Middle Member
Contour Interval 5 ft**



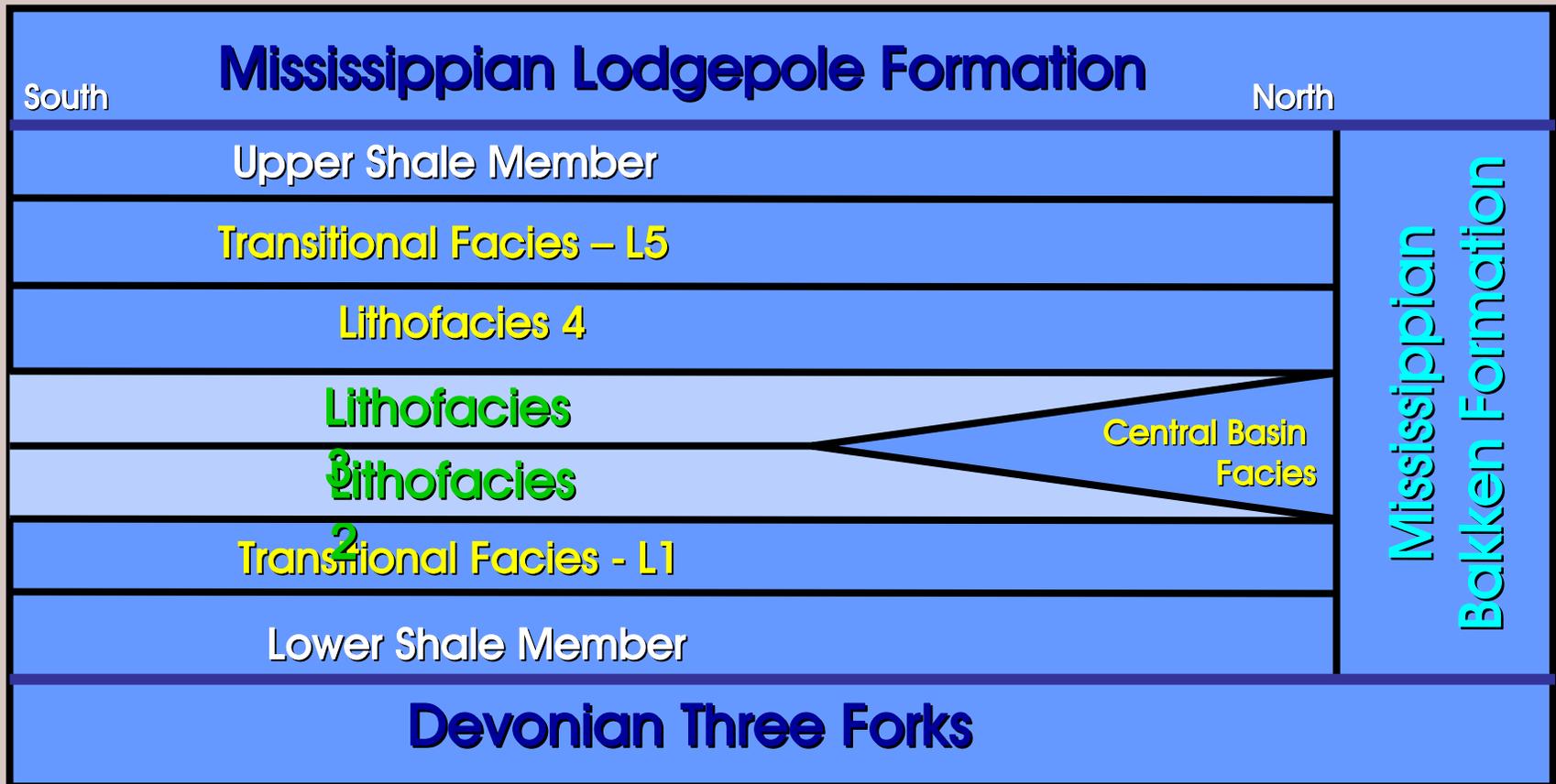
Northern Play

**Bakken Areas
of Interest**

Southern Play

Stratigraphy

Central Bakken Basin in North Dakota

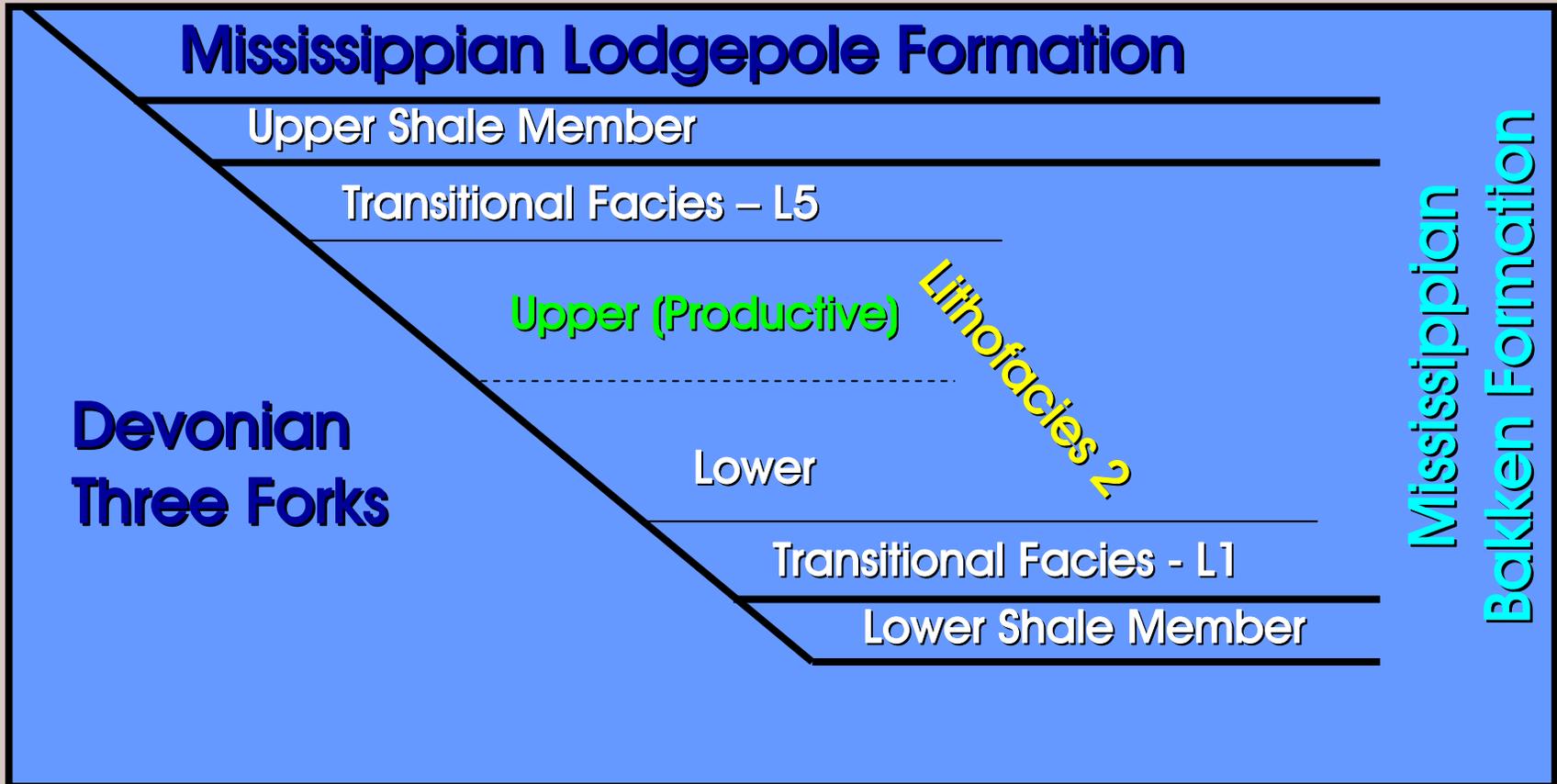


Stratigraphy

Bakken Limit in North Dakota

South

North

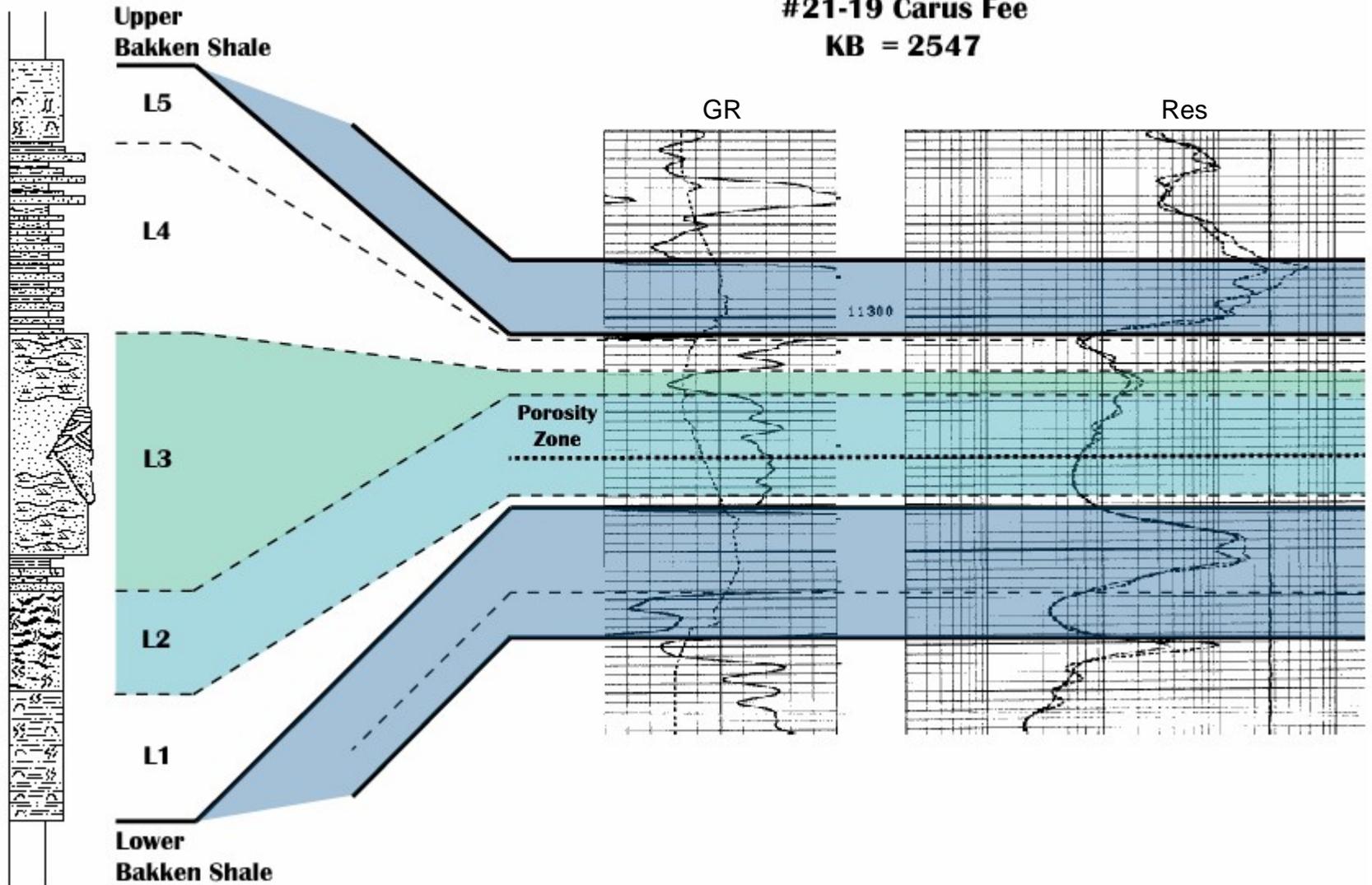


NENW Sec. 19, T.147N., R.96W.

Maxus Exploration Co.

#21-19 Carus Fee

KB = 2547



Lithofacies of the Middle Member



Upper Shale

Lithofacies 7 - Siltstone

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

Lithofacies 3 - Sandstone

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

Lithofacies 1 - Siltstone

Lower Shale

(From LeFever and others, 1991)



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



Duncan Petroleum Corp.
#1 Rose
SENE Sec. 2, T.153N, R.94W.

Three Forks Formation

- Apple-green & tan
- Interbedded shales, dolostones, siltstones, and sandstones
- 250 feet thick
- Subtidal to supratidal



**Duncan Petroleum Corp.
#1 Rose
SENE Sec. 2, T.153N, R.94W.**

“Sanish Sand”

- medium brown, highly burrowed argillaceous siltstone to very fine-grained sandstone
- pyrite is common near lower shale
- dolomitic cement
- 0 – 24 ft thick
- mappable on wireline logs

Three Forks Formation-Lower Bakken Shale Contact

Oryx Energy Co. - #1-27 Stenejhem HD
NESE Sec. 27, T150N, R97W



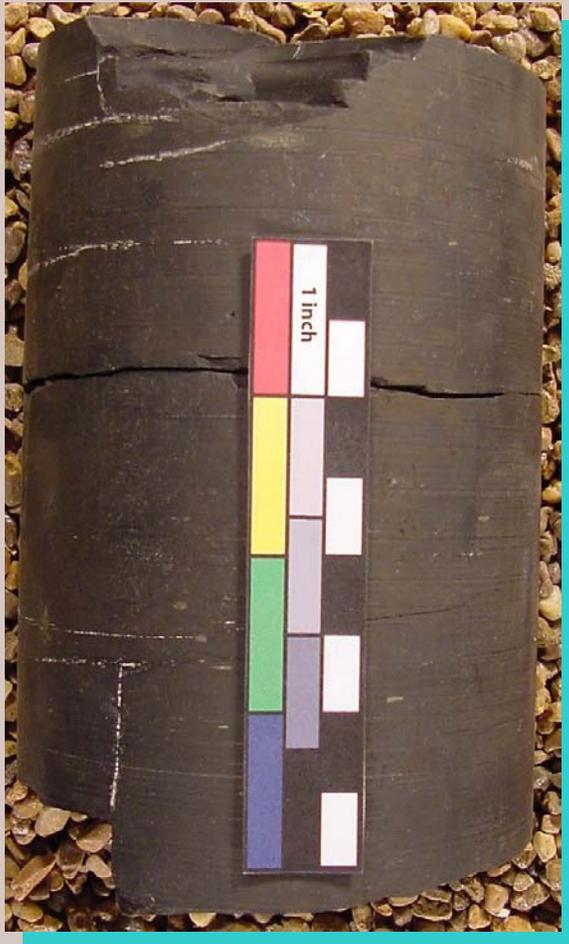
10992.2 ft

AHEL - Nevins #1 H8
SESW Sec. 13, T23N, R56W



Duncan Petroleum Corp.
#1 Rose
SENE Sec. 2, T.153N, R.94W.

Lower Bakken Shale



10575.5 ft



10575.5 ft



Shell Oil Company
#32-4 Young Bear
SWNE Sec. 4, T.148N, R.92W.

Lower Bakken Shale - Lithofacies 1

- Contact
 - unconformable
 - lags
 - conformable



**Shell Oil Company
#32-4 Young Bear
SWNE Sec. 4, T.148N, R.92W.**

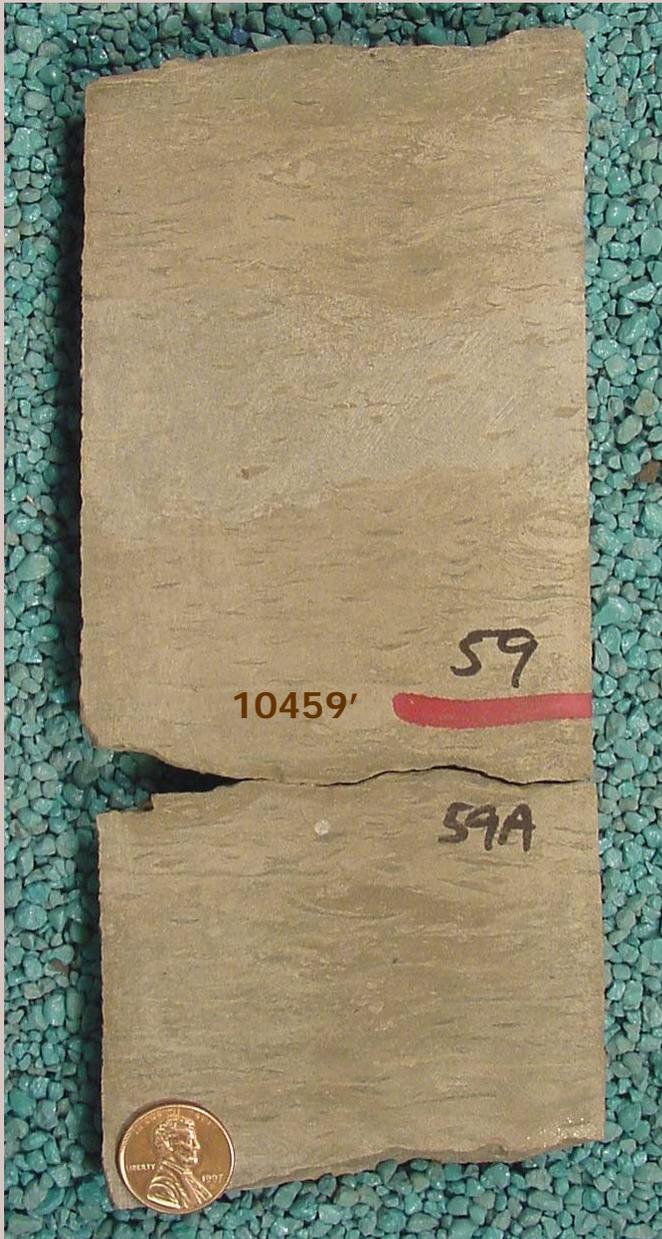
Lithofacies 1

- Argillaceous siltstone
- Massive with scattered fossils
 - crinoids and brachiopods
- Abundant pyrite
- 1.5 to 6 ft thick

Shell Oil Company
#32-4 Young Bear
SWNE Sec. 4, T.148N, R.92W.

Lithofacies 2

- Argillaceous siltstone to very-fine grained sandstone with small clay drapes
- Burrowed with scattered crinoids and brachiopods
- Calcite cement
- 0 to 33 ft thick



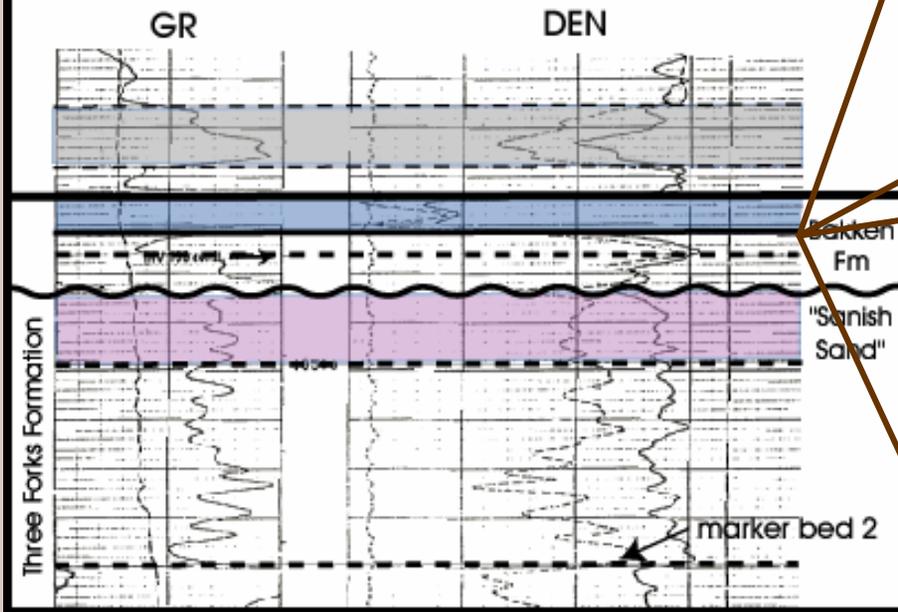


Shell Oil Company
#32-4 Young Bear
SWNE Sec. 4, T.148N, R.92W.

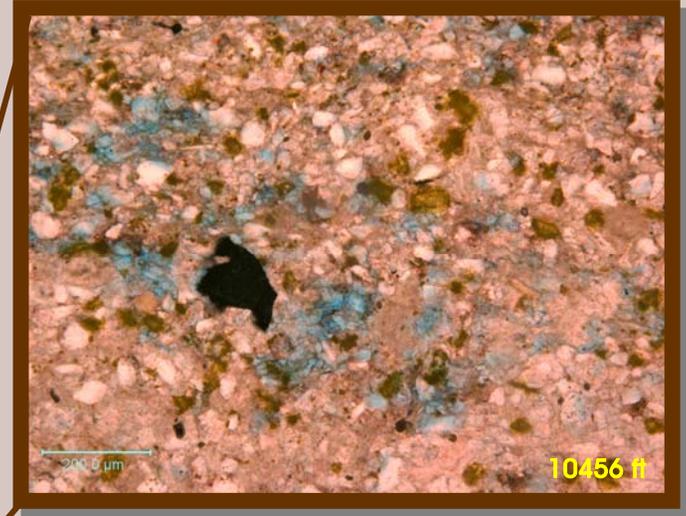
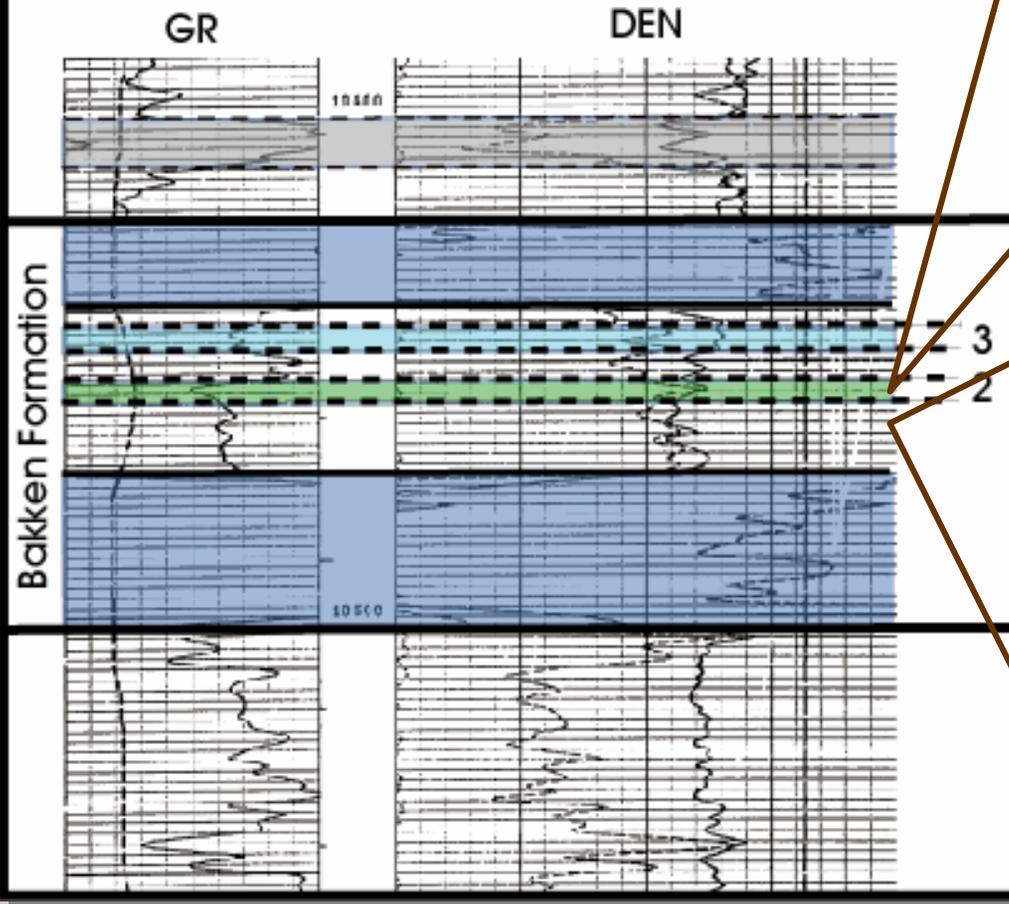
Upper Lithofacies 2 Porosity Zone

- Argillaceous siltstone to very-fine grained sandstone with rare clay drapes
- Heavily burrowed
- Calcite cement
- Mappable on wireline logs

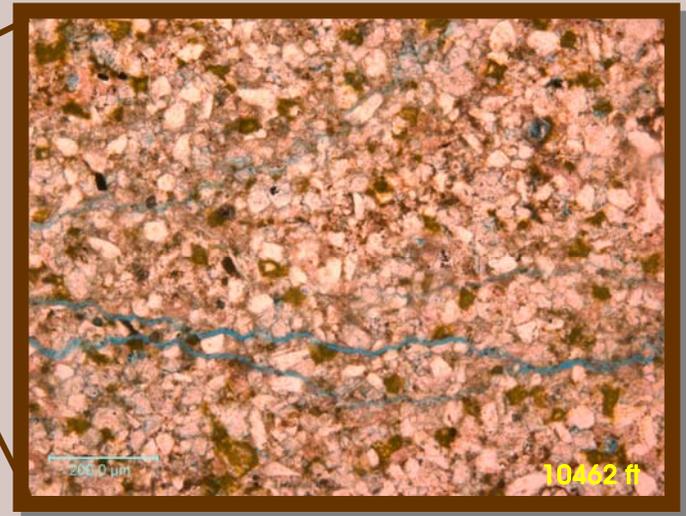
33-007-00820
NWSE Sec. 6, T.144N., R.101W.
Supron Energy Corp.
#3 F-6-144-101



33-025-00347
SWNE Sec. 4, T.148N., R.92W.
Shell Oil Company
#32-4 Young Bear BIA



Upper Lithofacies 2



Lower Lithofacies 2



Oryx Energy Co.
#1-27 Stenejhem HD
NESE Sec. 27, T150N, R97W

Lithofacies 3

- Very fine- to fine-grained sandstone
- Massive, cross-bedded, to thinly laminated
 - may have load or channel features
- Calcite cement (occasionally pyrite)
- 0 to 15 ft thick

**Exeter Exploration Company
#8-30 Schmitz
SENE Sec. 30, T.152N, R.85W.**

Lithofacies 3

- Very fine- to fine-grained sandstone
- Massive, cross-bedded, to thinly laminated
 - may have load or channel features
- Calcite cement, in some cases pyrite



**Conoco Oil Company
#17 Watterud "A"
SESW Sec. 11, T.160N, R.95W.**

Lithofacies 3

- Argillaceous siltstone to very fine-grained sandstone
- Thinly laminated, irregularly or wavy laminated
- Not cemented or dolomitic
- 0 to 6.5 ft thick

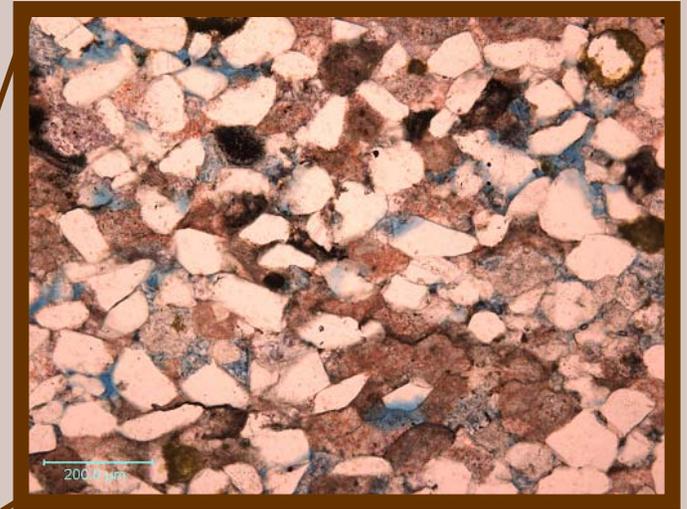
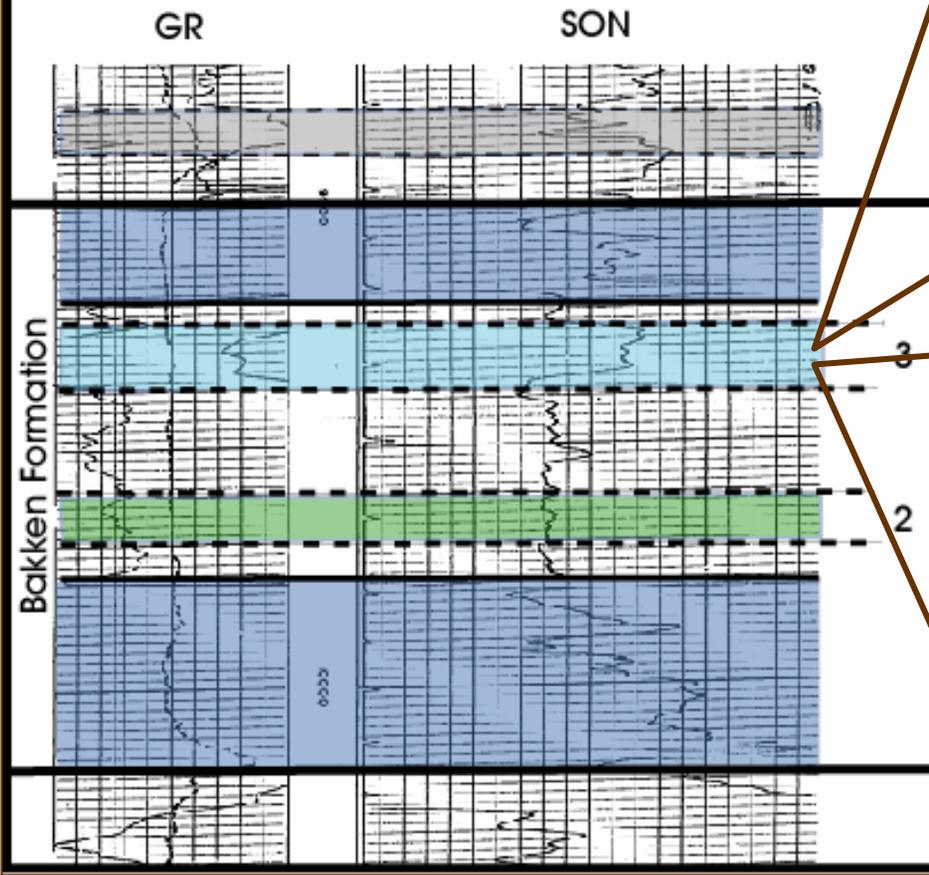


33-105-00667

SWSW Sec. 2, T.154N., R.95W.

Pan American Petroleum Corp.

#1 Clifford Marmon

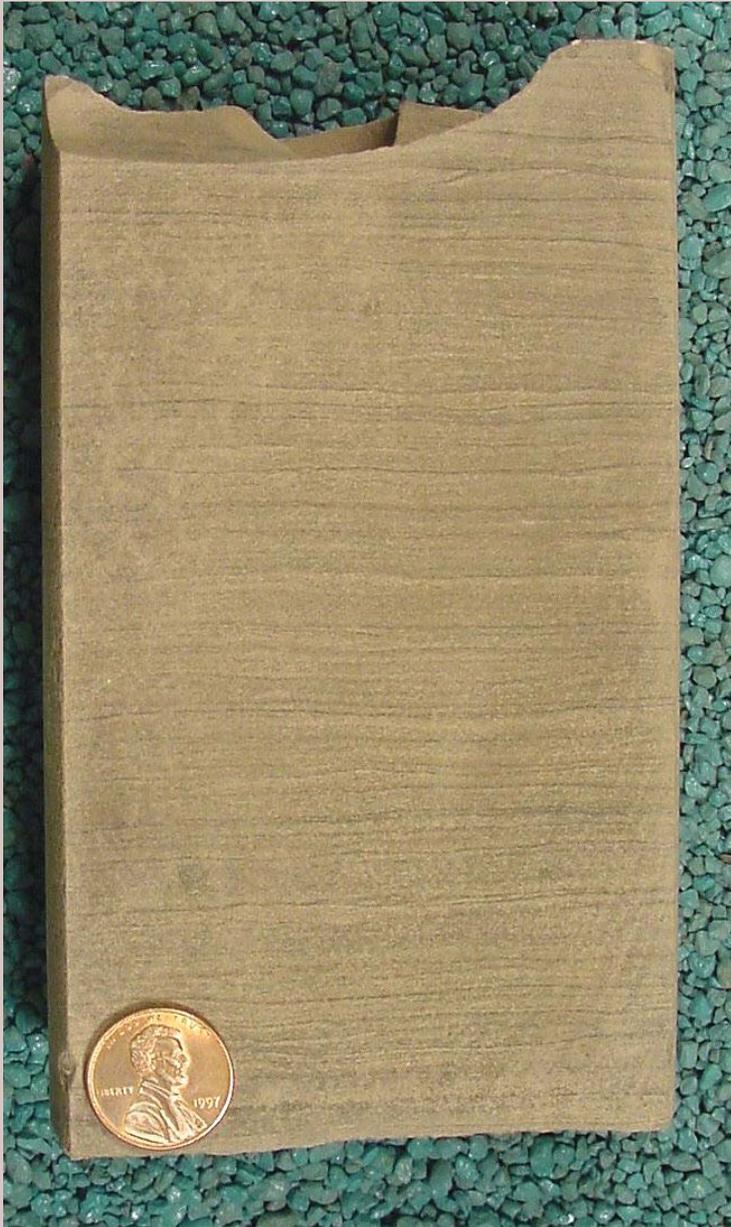




Oryx Energy Company
#1-27 Stenejhem HD
NESE Sec. 27, T.150N, R.97W.

Central Basin Lithofacies

- Sequence of argillaceous siltstones, fine-grained sandstones, and dark grey shales
- Laminated, cross-bedded, to highly disturbed
- Not cemented or dolomitic
- 0 to 16 ft thick



**Conoco Oil Company
#17 Watterud "A"
SESW Sec. 11, T.160N, R.95W.**

Lithofacies 4

- alternating sequence argillaceous siltstone, fine-grained sandstone, dark grey shale laminae
- thinly laminated, parallel or slightly undulatory
- local dolomite cement
- 2 to 3.5 ft thick



**Conoco Oil Company
#17 Watterud "A"
SESW Sec. 11, T.160N, R.95W.**

Lithofacies 4

- alternating sequence of grey siltstone, brown/black shale, and very fine-grained sandstone
- basal beds – thinly laminated with burrows
- argillaceous content varies locally
- 3 to 10.5 ft thick

Shell Oil Company
#32-4 Young Bear
SWNE Sec. 4, T.148N, R.92W.

Lithofacies 5

- medium to light grey argillaceous siltstone
- massive to wispy laminated
- brachiopods through entire section, crinoids and bryozoan fragments in the central basin
- pyrite increase toward contact with upper shale
- 2 to 6 ft thick



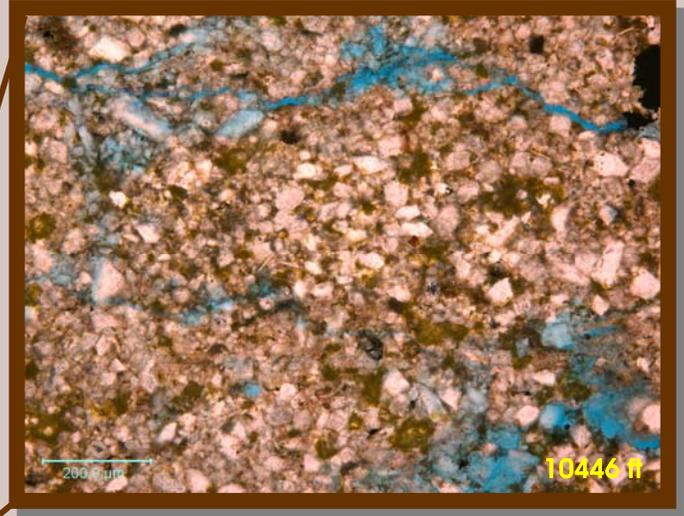
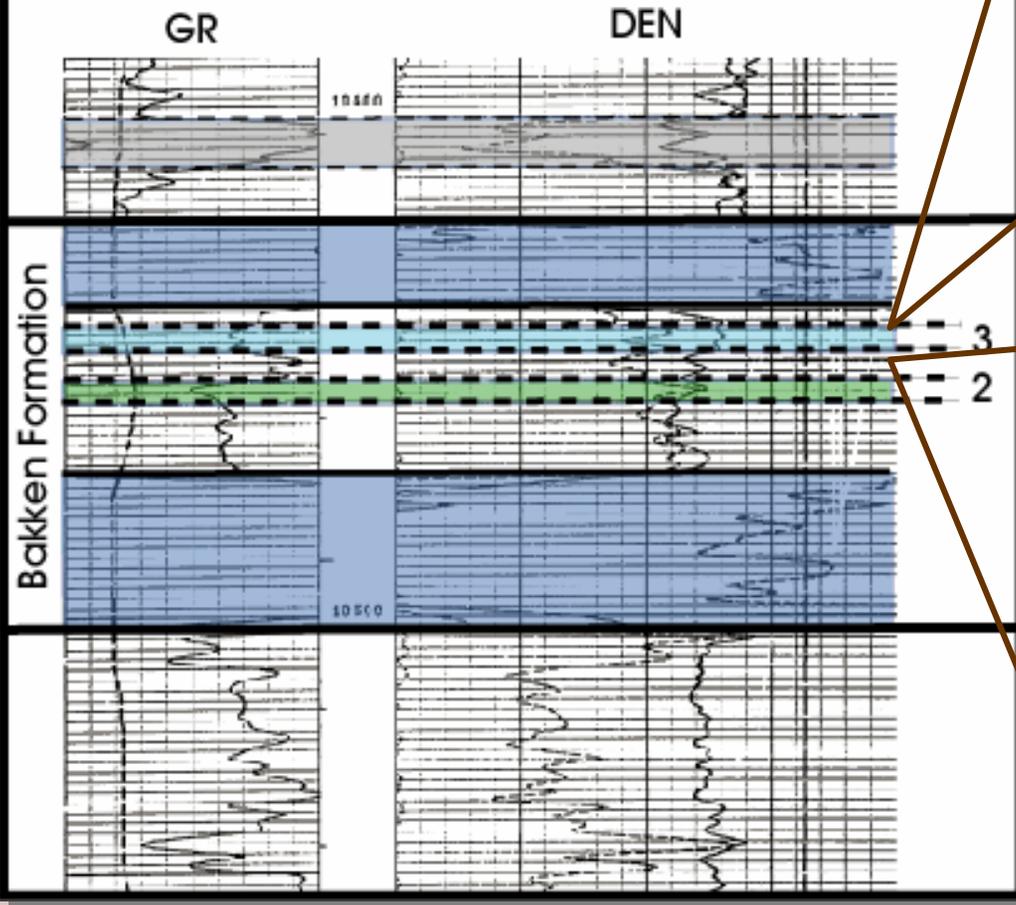


**Meridian Oil Company
#4-27 MOI
SESE Sec. 27, T.143N, R.102W.**

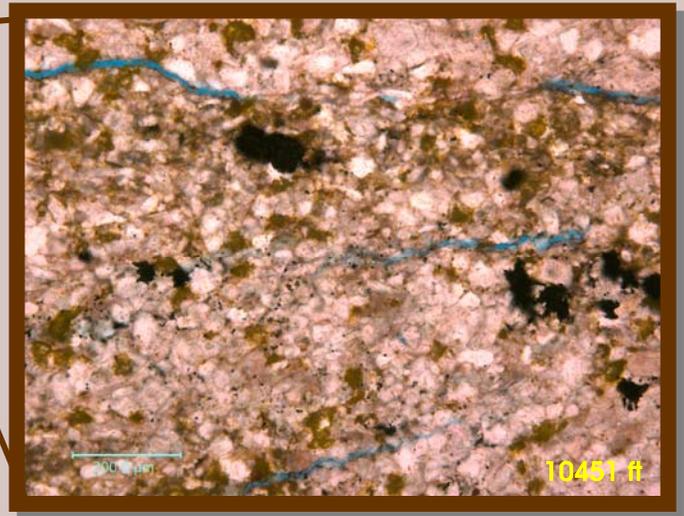
Upper Bakken Shale - Lithofacies 5

- **Contact**
 - conformable
 - unconformable
 - lag

33-025-00347
SWNE Sec. 4, T.148N., R.92W.
Shell Oil Company
#32-4 Young Bear BIA



Lithofacies 3

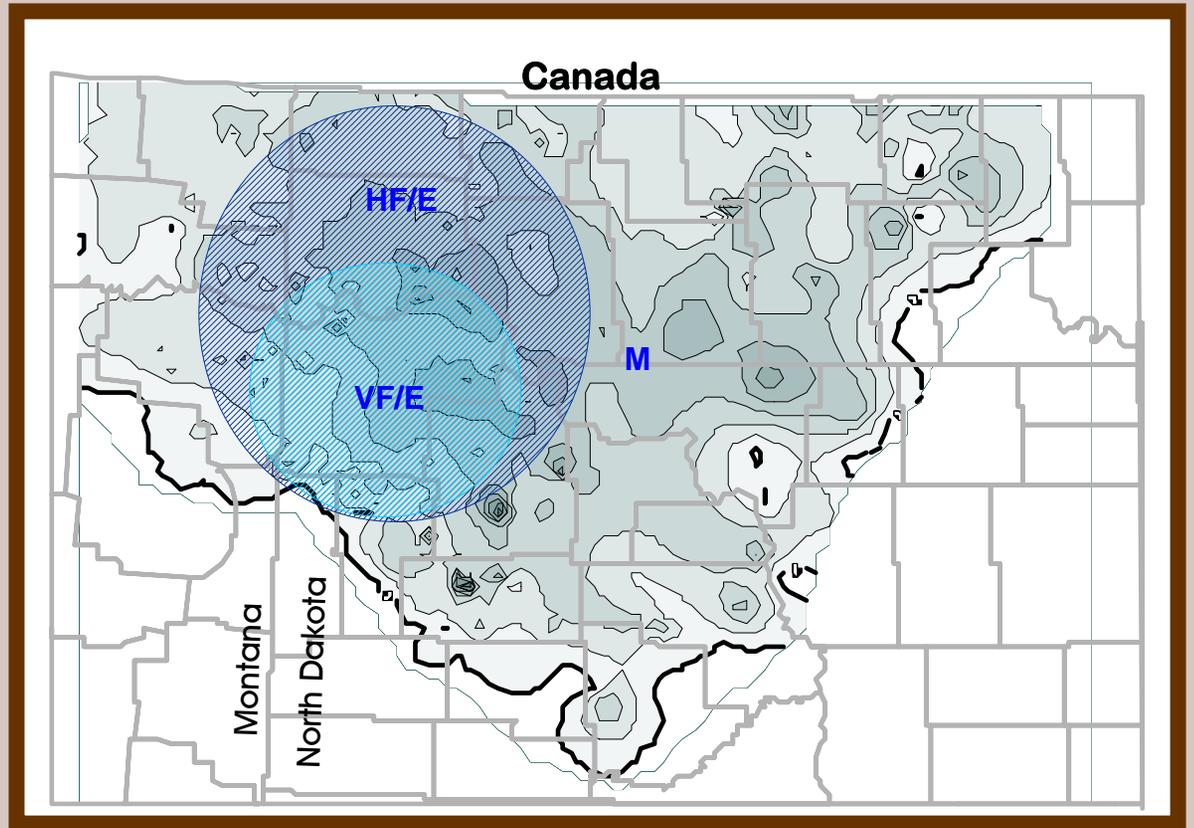


Central Basin Facies

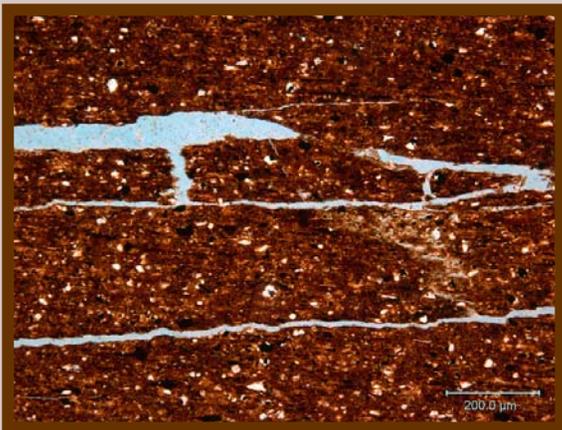
Texaco, Inc - #1-5 Thompson



Upper Bakken Shale



Shell Oil Co. - #32-4 Young Bear



Conclusions

- Lithofacies are present basinwide
- Multiple potential pay sections within the middle member
 - Additional productive sections
 - “Sanish” section – Three Forks Formation
 - Lower Lodgepole
 - Primary reservoir porosity may be enhanced by diagenesis, tectonic fractures, and/or fractures from HC generation
 - Porosity enhancement is not restricted to a single lithofacies within the Middle Member

Conclusions

- **Fractures enhance the potential for production**
- **Numerous subtle changes in lithology**