# The Devonian Three Forks Formation:

## Manitoba's Newest Oil Play

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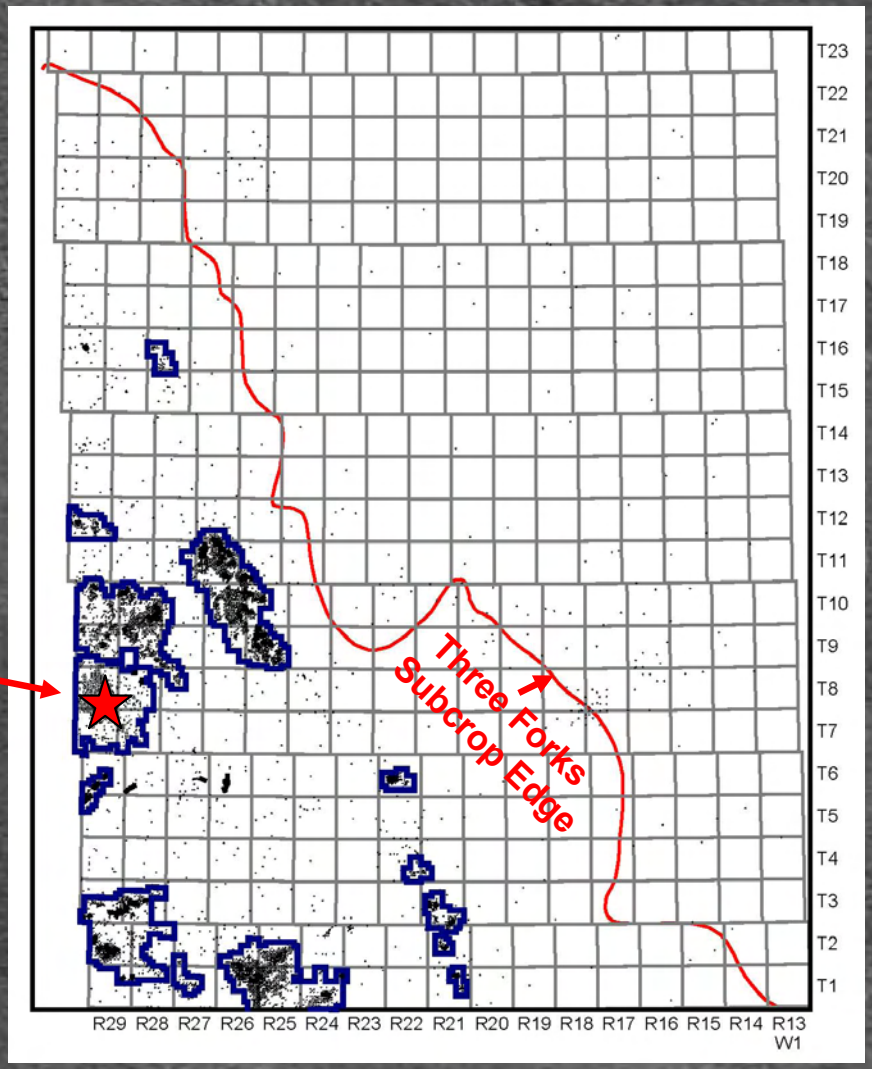
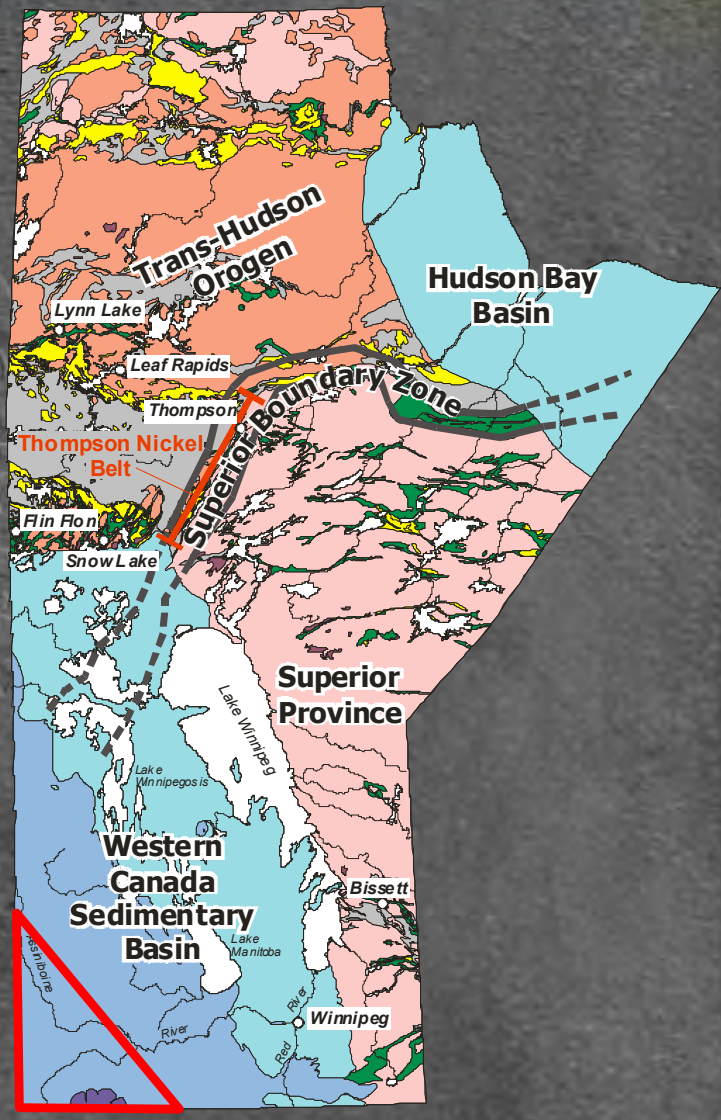
Manitoba

# Three Forks Study Area

Sinclair



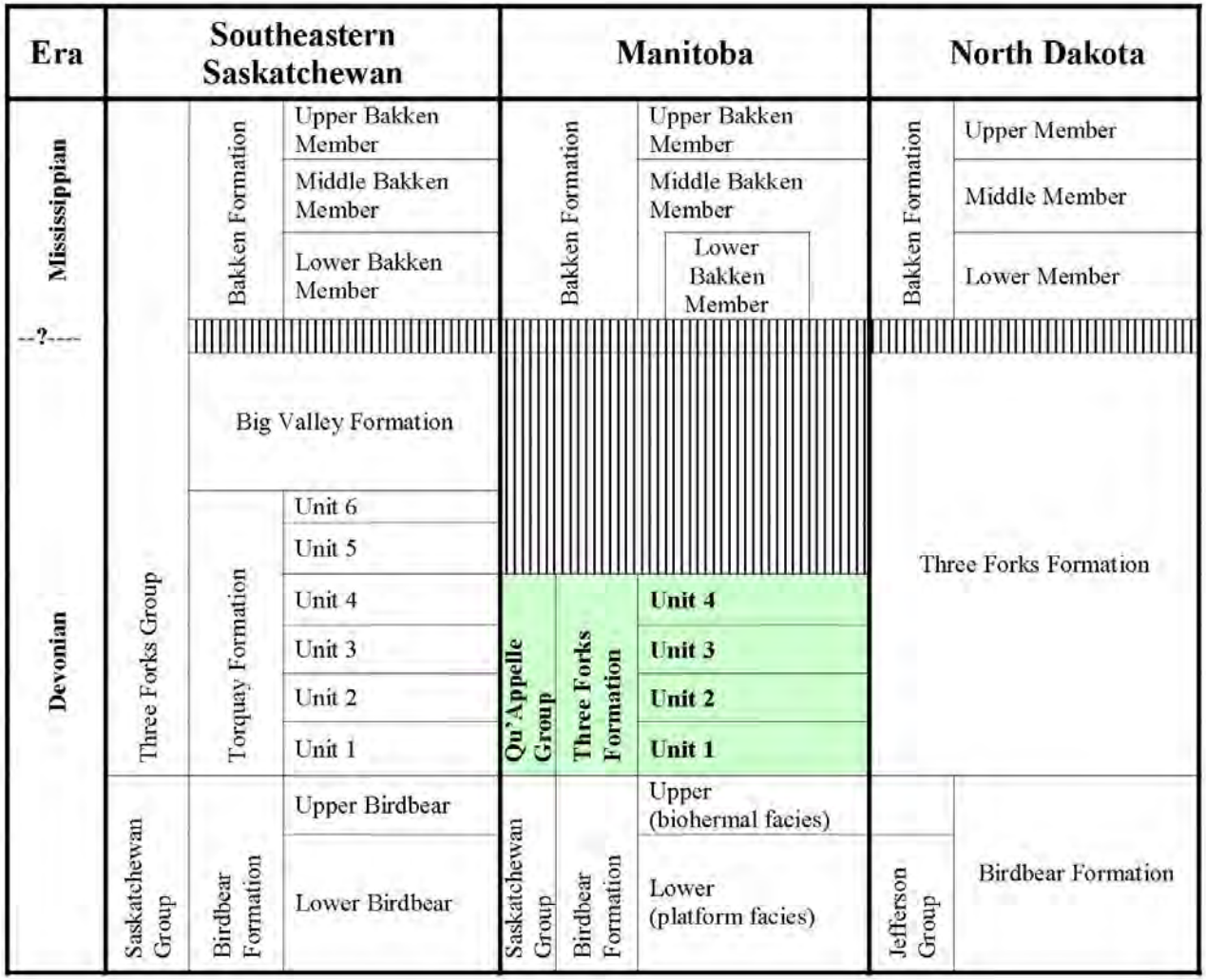
# Sinclair Field

- Early exploration efforts → Dry wells
- Renewed exploration in 2003
- Field status by 2005
- Over 32 000 hectares in area
- Sinclair Unit No. 1 running by 2006
- 608 wells drilled at Sinclair to date
- 530 currently producing
- Estimated reserves: 6.8 million $m^3$

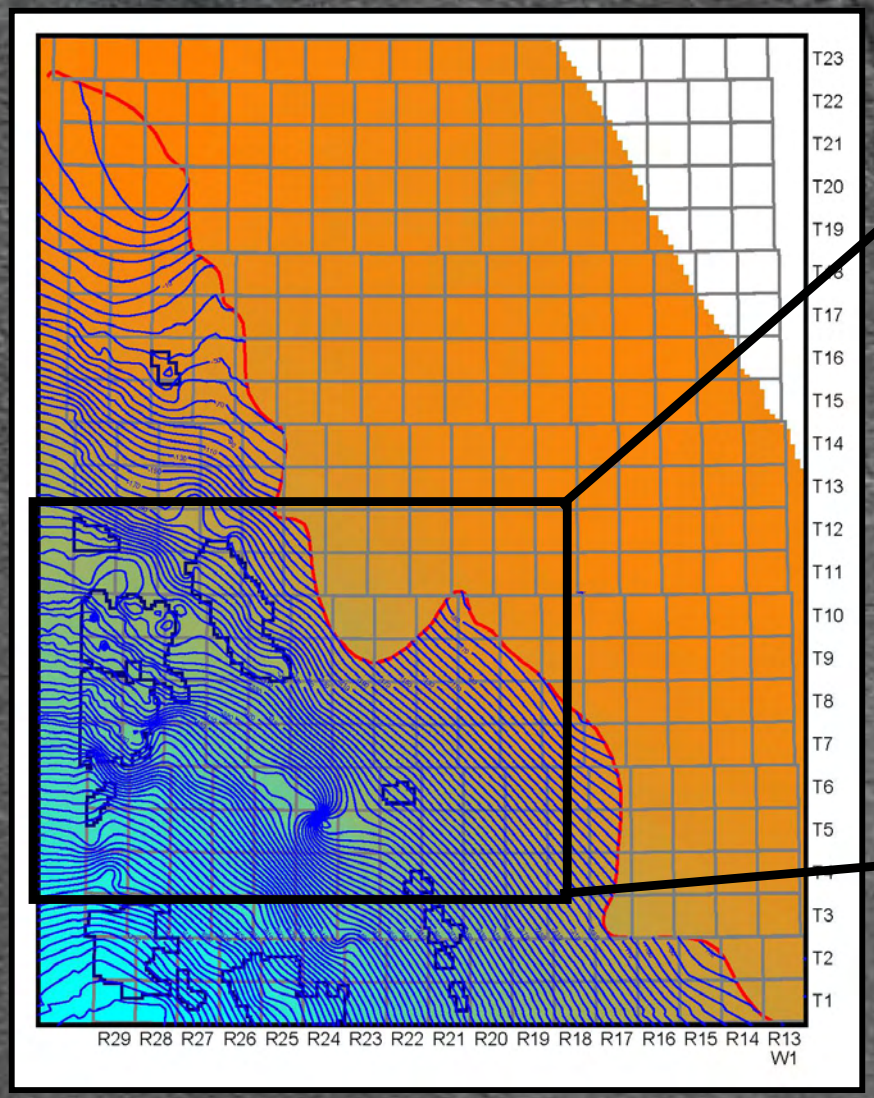
# Three Forks Formation

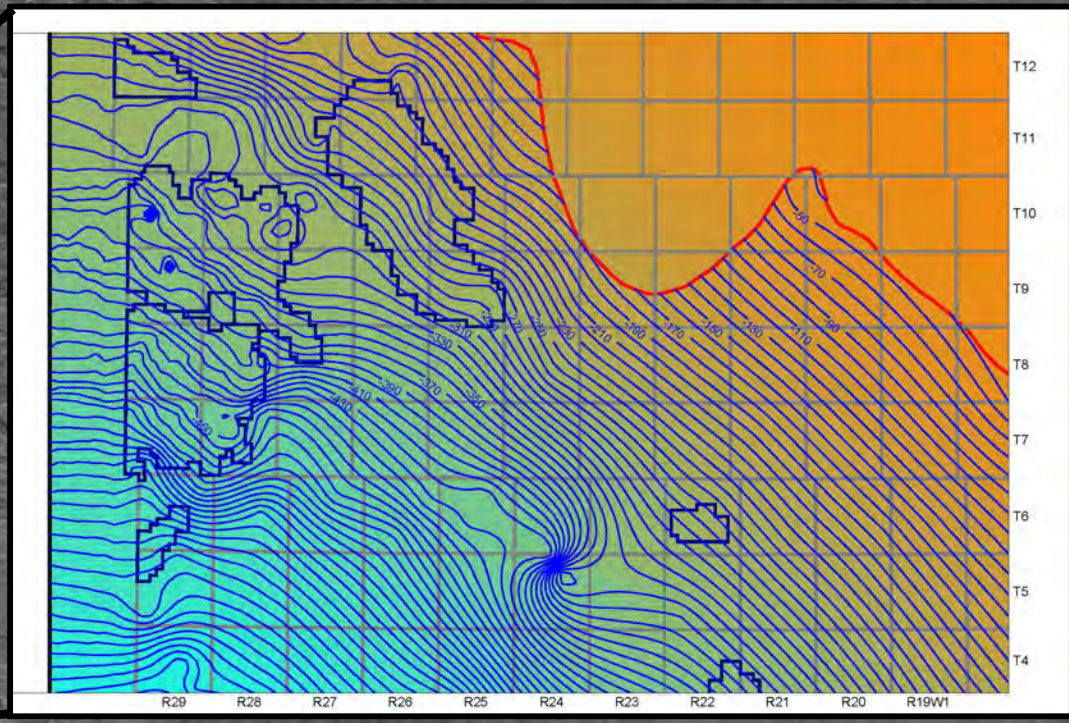
- Cyclical transgressive-regressive sequence of argillaceous dolomites, brecciated, interbedded and interlaminated with silty dolomitic shales and claystones.
- Complex diagenetic and oxidation-reduction history.
- Primary producing unit at Sinclair Field.
- Secondary producing unit at Daly and Kirkella Fields.
- Commingled with Middle Bakken.
- Subdivided into four units
  - Units subdivision equivalent to units in Christopher (1961)

# Three Forks Stratigraphy



# Three Forks Structure

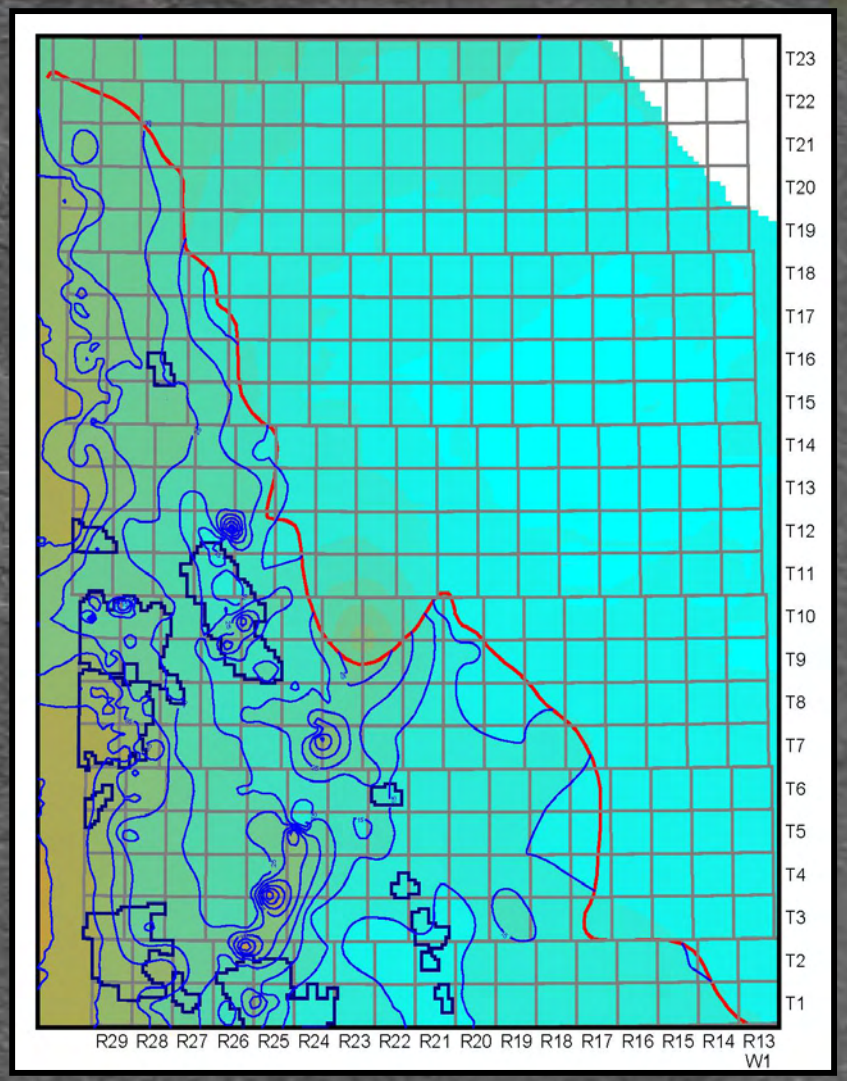



Contour Interval = 10 m

# Three Forks Isopach

- Thickest in the west along the MB-SK border
- Localized thickening in the east



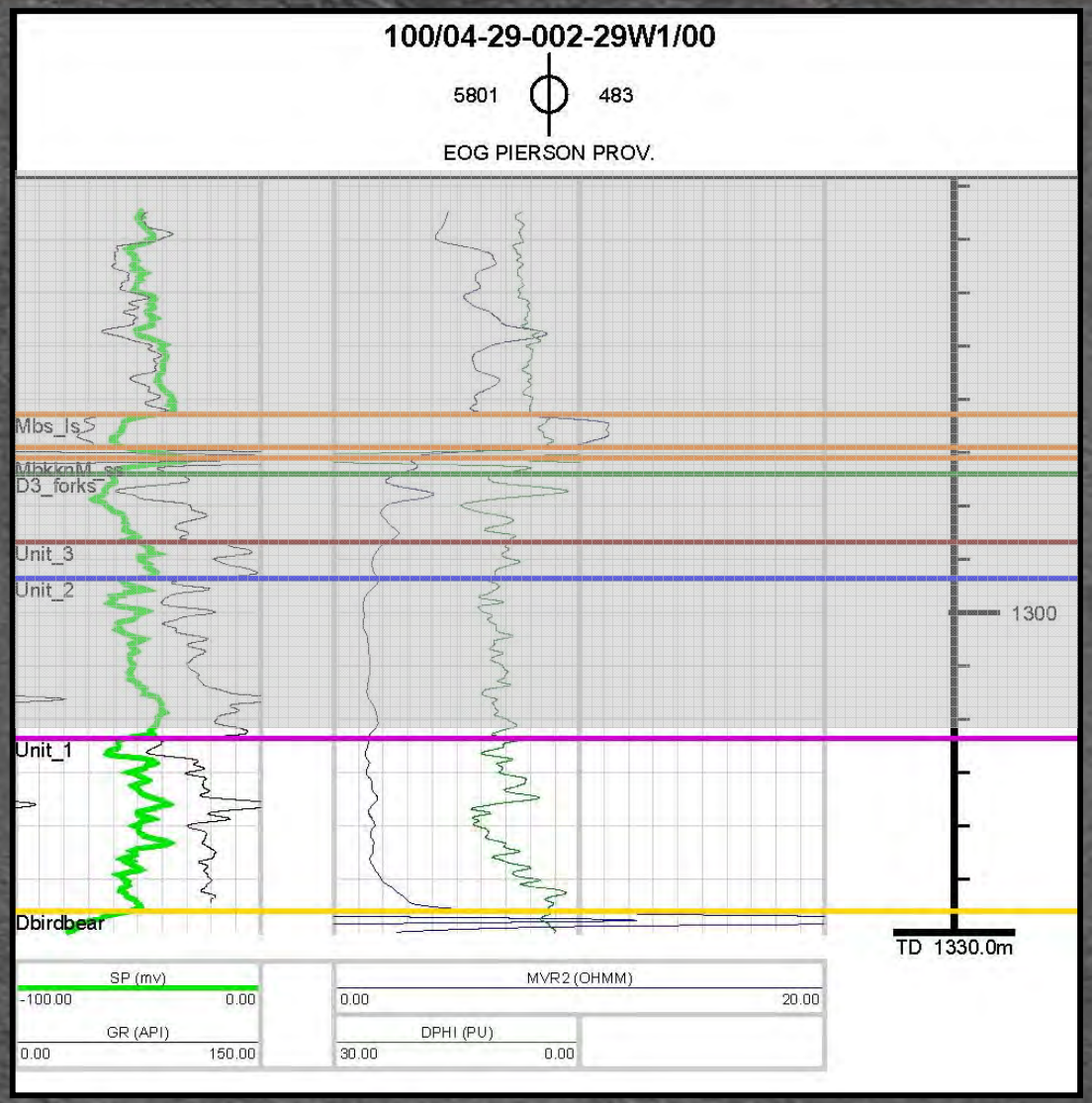

Contour Interval = 5 m

# Three Forks – Unit 1

- Lowermost unit
- Highly oxidized with reduction halos
- Original fabric: Brecciated argillaceous dolomite with grey-green silty shale matrix
- Limited core availability

14-32-10-24W1

# Reference Log – Unit 1




Lodgepole

Bakken

Unit 4

Unit 3

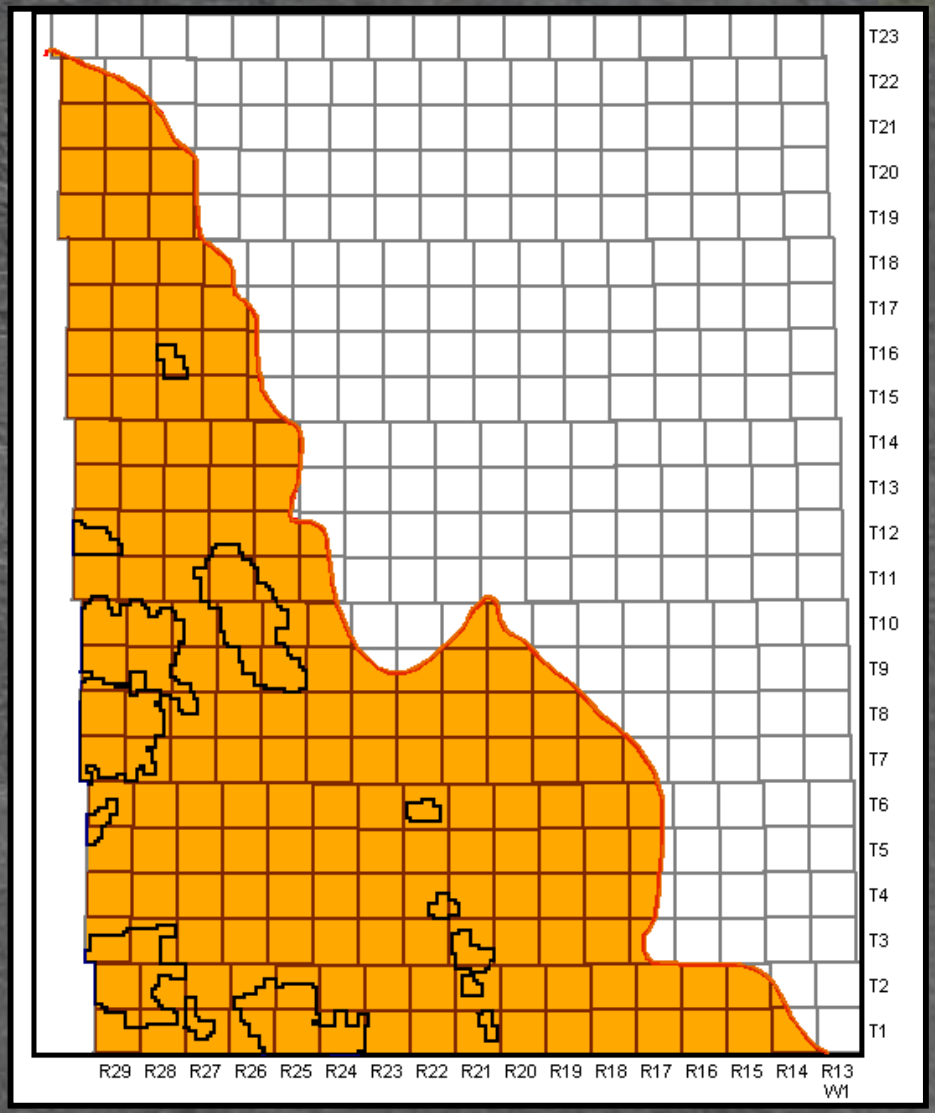
Unit 2

Unit 1

Birdbear

# Three Forks – Unit 1

- Widespread distribution
- Fairly constant isopach
  - average = 16 m
- Productive in small isolated pools at Sinclair
- Future reservoir potential is unknown

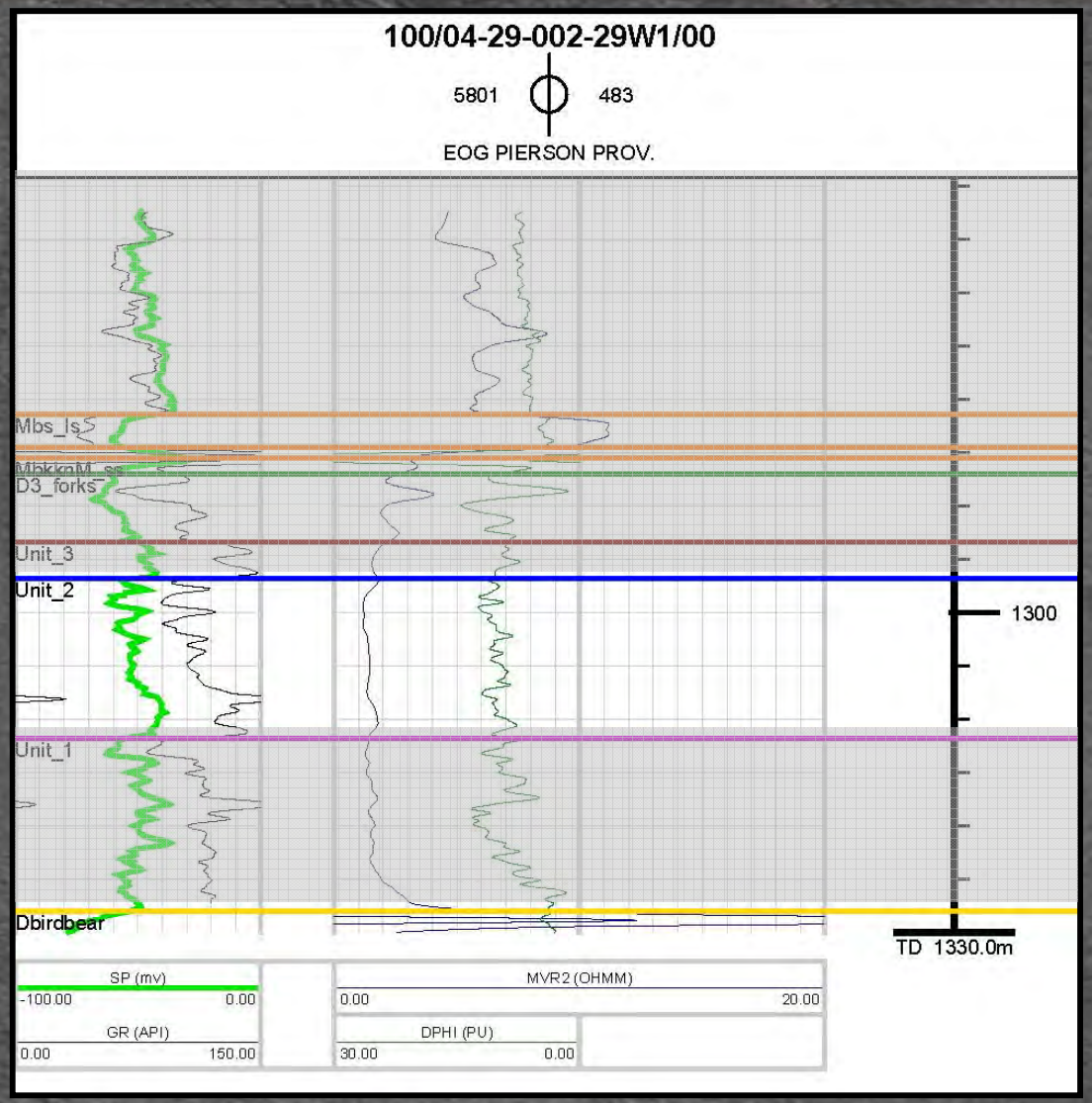


# Three Forks – Unit 2

- Interbedded siltstone, shales and claystones
- Massive and brecciated in places
- Partially oxidized
- Porosity decreases with depth

2-2-8-29W1

# Reference Log – Unit 2




Lodgepole

Bakken →

Unit 4

Unit 3

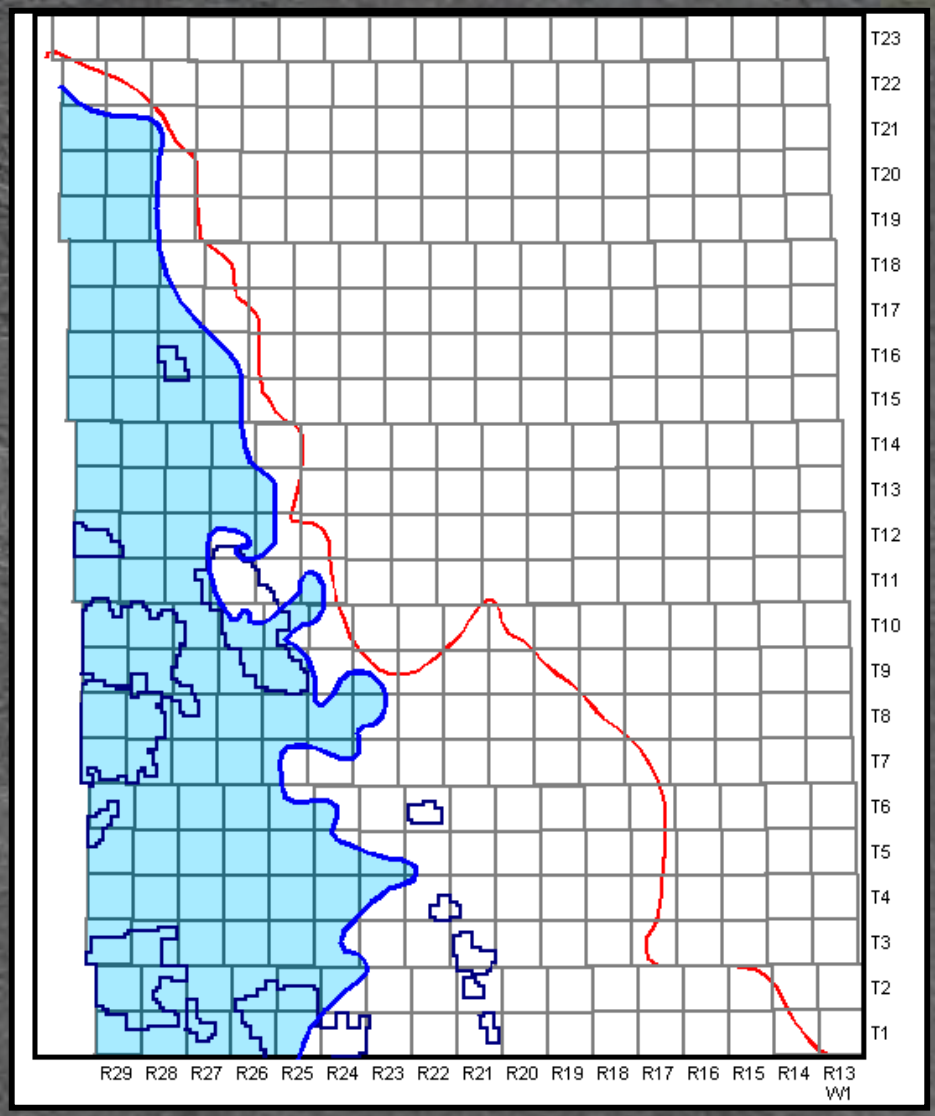
Unit 2

Unit 1

Birdbear →

# Three Forks – Unit 2

- Isopach: 1-19m
  - Uneroded: ~15 m
- Edge roughly follows the eastern boundary of the BWA & SBZ
- Primary reservoir in Daly
- Secondary reservoir unit in Sinclair

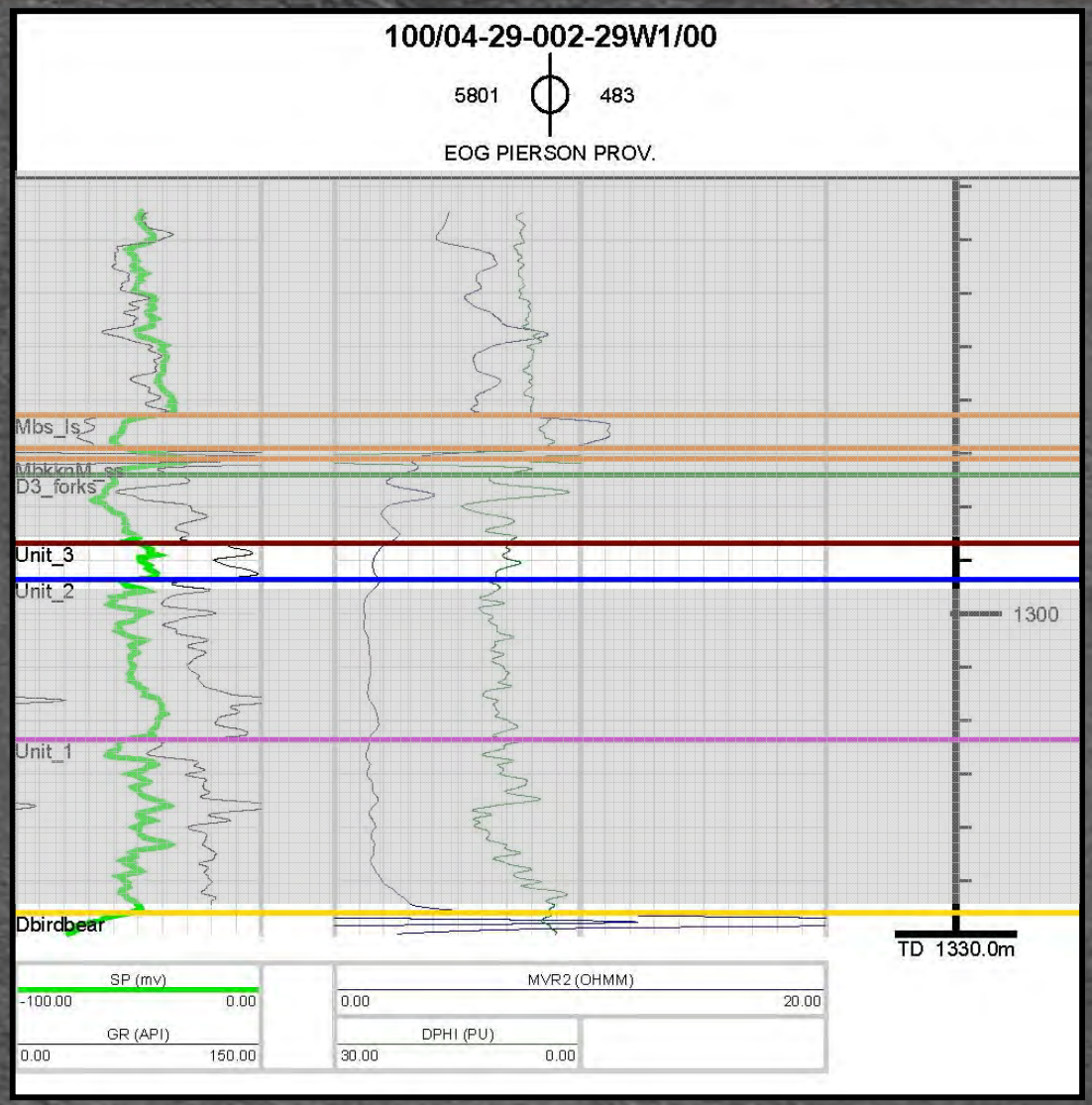


# Three Forks – Unit 3

- Red-brown highly oxidized silty dolomitic shale
- Rare reduced halos
- Thinnest unit
  - 3.5 m isopach
- Not a good reservoir, but productive when at unconformity in Sinclair

2-2-8-29W1

# Reference Log – Unit 3




Lodgepole

Bakken

Unit 4

Unit 3

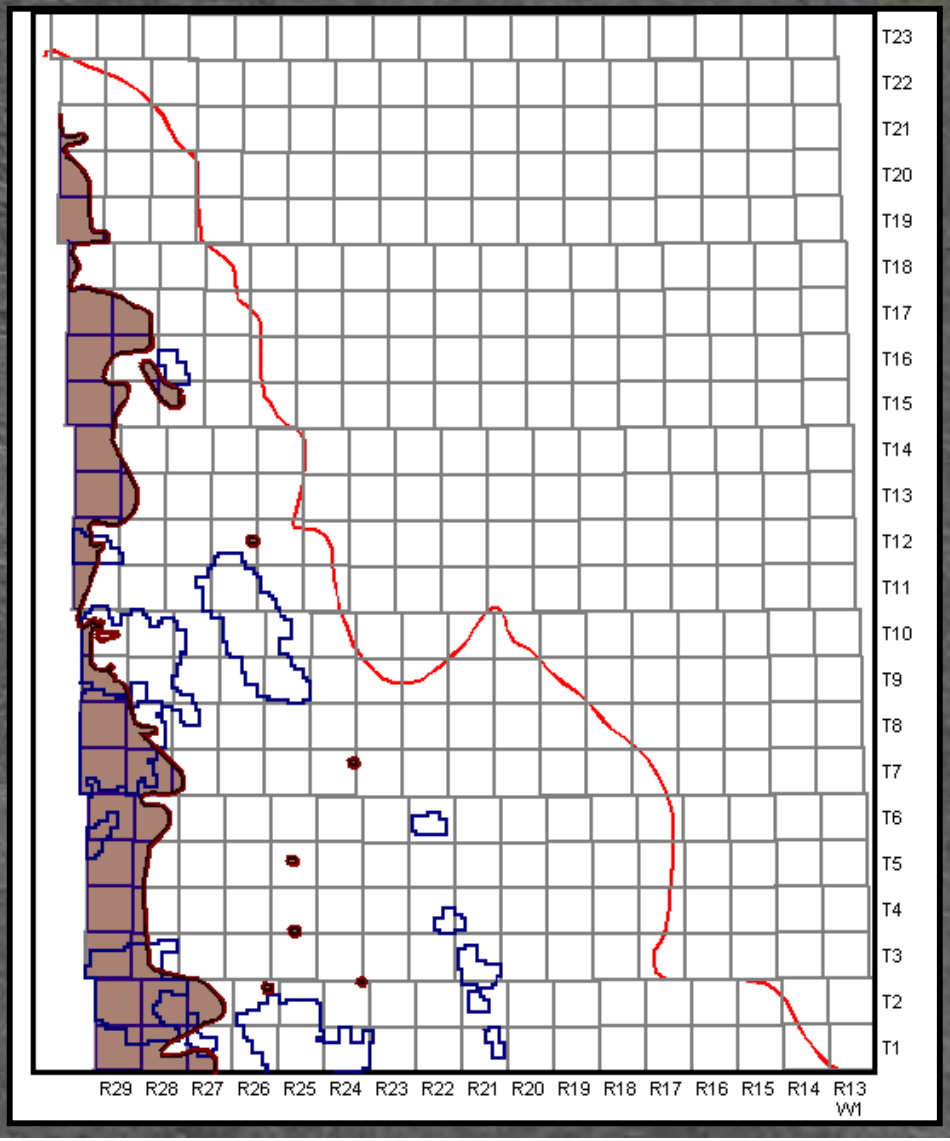
Unit 2

Unit 1

Birdbear

# Three Forks – Unit 3

- Distribution follows Unit 4 closely
- More section preserved in isolated wells in the east



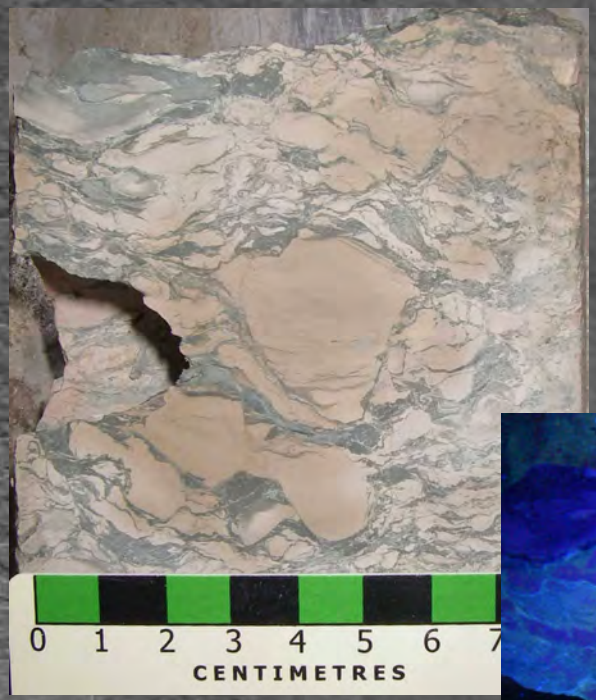
# Three Forks – Unit 4

- Interbedded siltstone, argillaceous dolomites and silty dolomitic shale with thick subunits of distorted bedding and brecciated dolomitic siltstone
- Primary, most productive reservoir unit

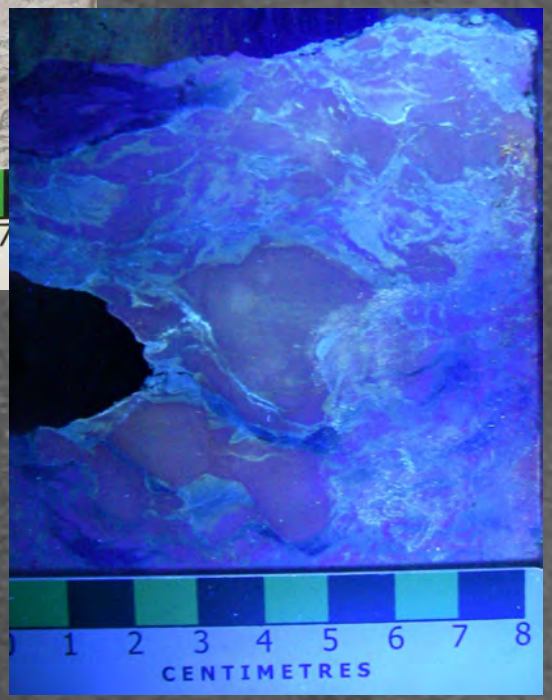
2-2-8-29W1

# Three Forks – Unit 4

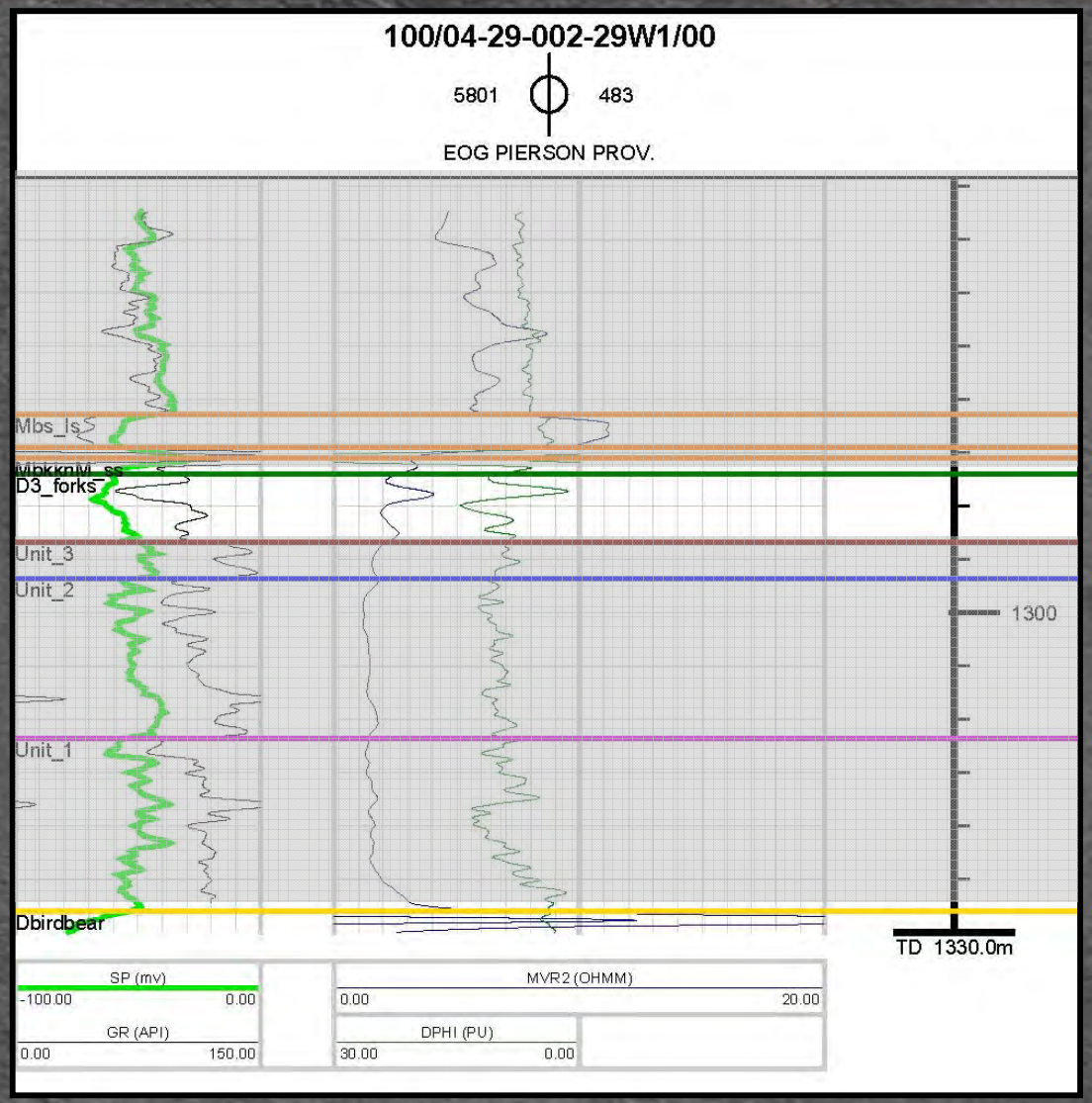

Subunit 4c
4-29-8-29W1
Plain and UV light


Subunit 4b
4-29-8-29W1
Plain and UV light



# Reference Log – Unit 4




Lodgepole

Bakken

Unit 4

Unit 3

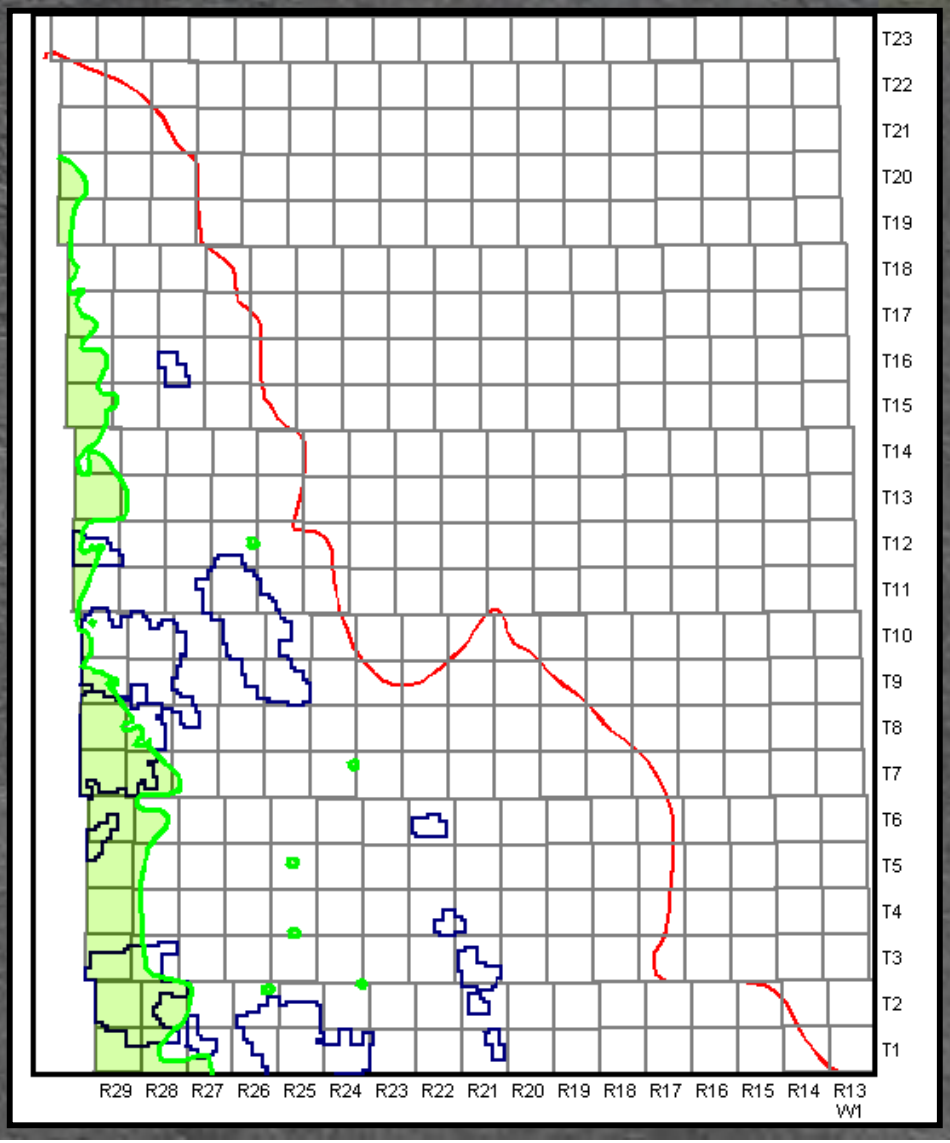
Unit 2

Unit 1

Birdbear

# Three Forks – Unit 4

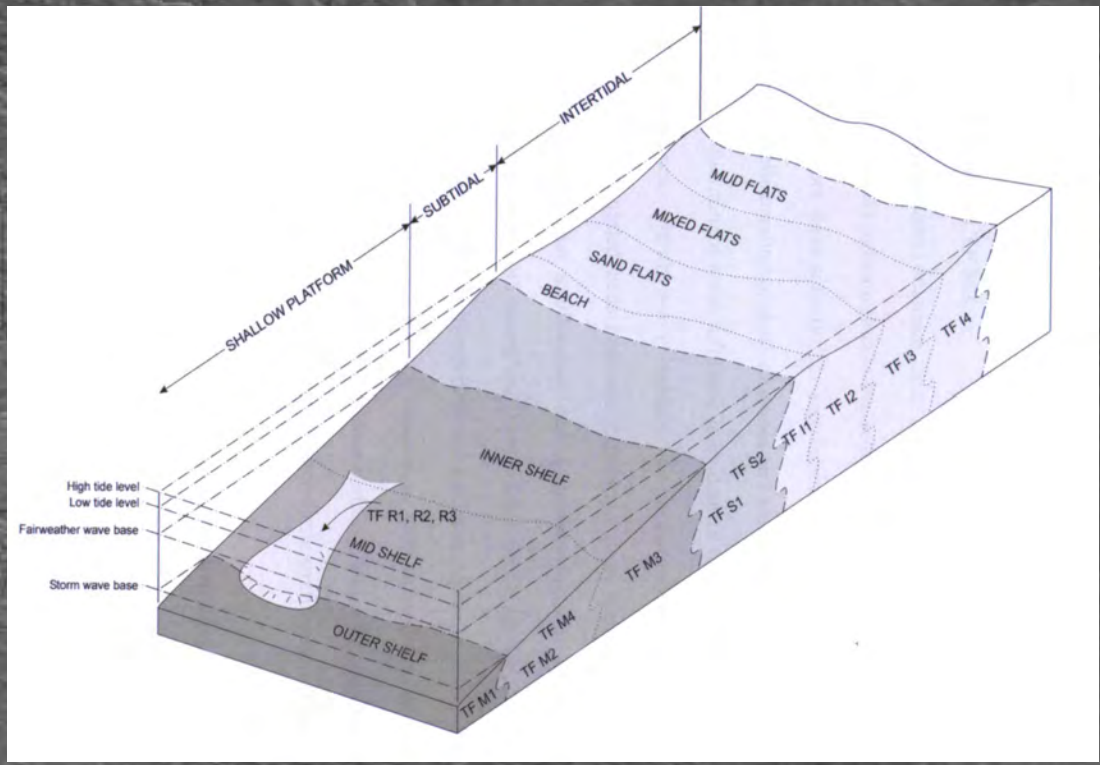
- Isopach: 1-14 m
  - average = 6 m
- Limited distribution
  - Restricted to the Ranges 29 & 28 W1
  - More section preserved in isolated wells in the east
- Primary reservoir at Sinclair
  - Also SW Daly and Kirkella
- Average core K = 4.3 mD
- Average core Ø = 16.5%
- Oil Saturation = 7.0-34.0 % (Karasinski, 2006)



# Depositional Environment

- "Deposited along a temperate, carbonate tidal flat that grades basinward towards an unrimmed carbonate platform." (Karasinski, 2006)

- Karasinski (2006)
  - Unrimmed platform facies
  - High-energy peritidal facies
  - Subaqueous debris flow facies

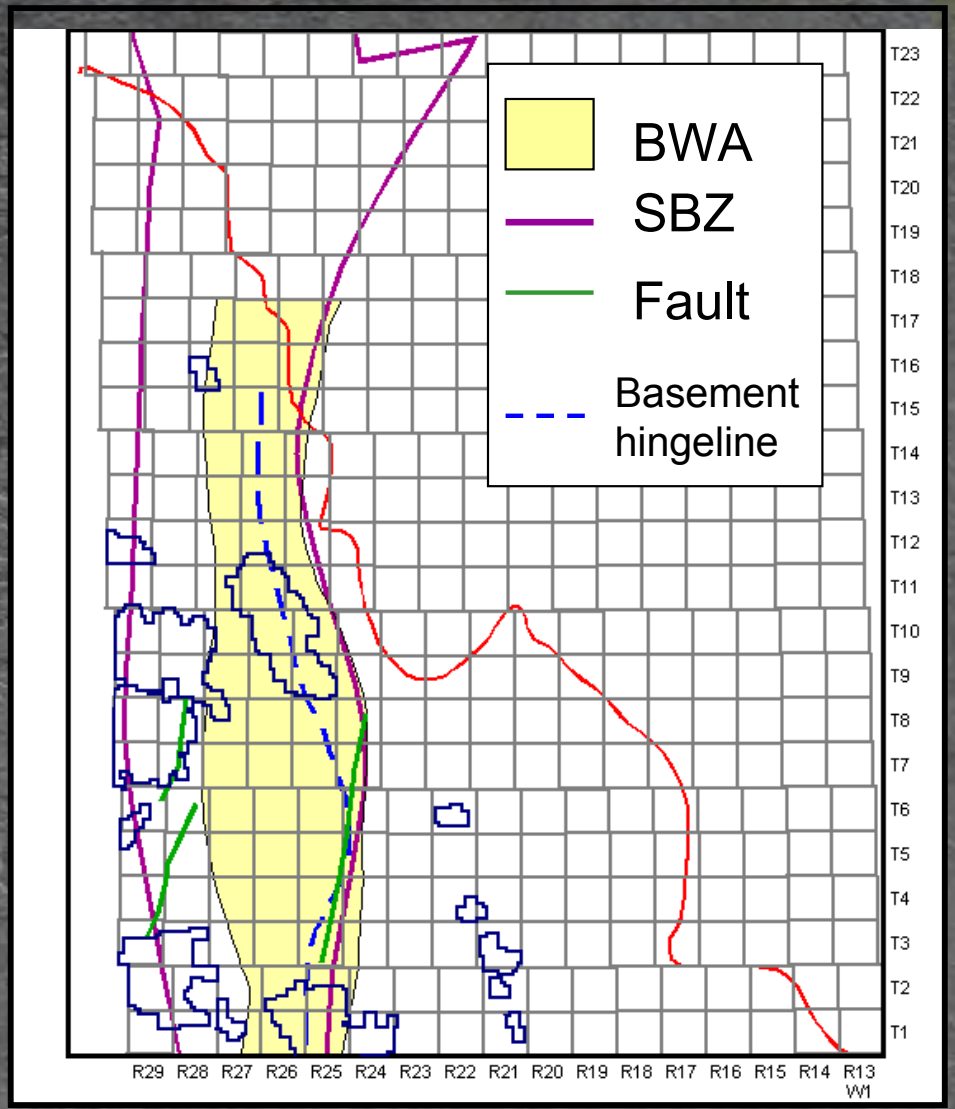


# Diagenesis

- Karasinski (2006)
  - Complete dolomitization
    - Early stage: Upper Devonian & Mississippian seawater
    - Late stage: post-Middle Bakken shallow burial and diluted meteoric waters
  - Porosity
    - Fracture porosity
    - Vuggy porosity
    - Moldic porosity
  - Mineralization/cementation
    - Phosphates (early stage)
    - ***Pyrite*** (early and late stage)
      - » Reducing environment
    - Ferric minerals (hematite and Fe-sulphates; late stage)
      - » Oxidizing environment
    - Halite (late stage)
    - Authigenic silicates (quartz, K-feldpar, illite; late stage)
    - ***Anhydrite*** (latest stage)

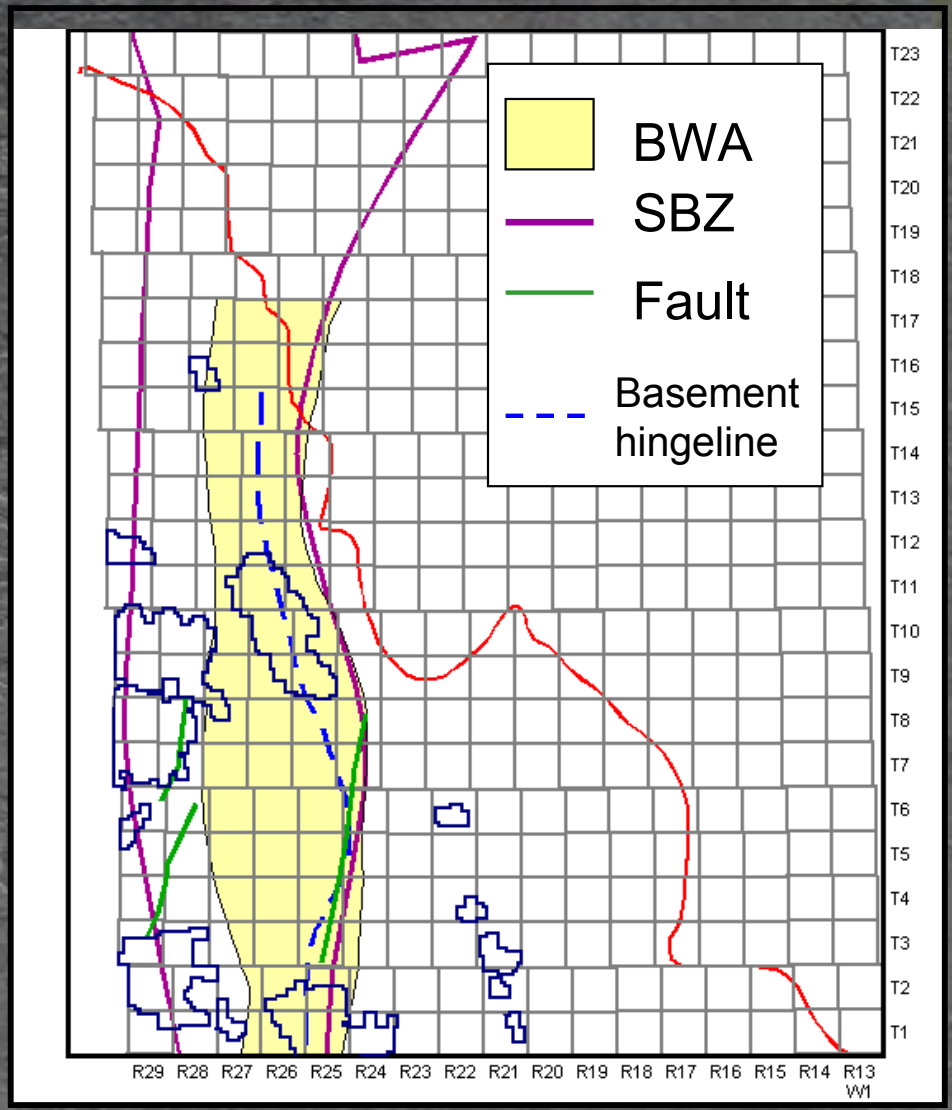
# Tectonic Controls

- Birdtail-Waskada Axis (BWA)
- Superior Boundary Zone (SBZ)
- Basement hingeline
- Faulting
  - Basement
  - Salt dissolution



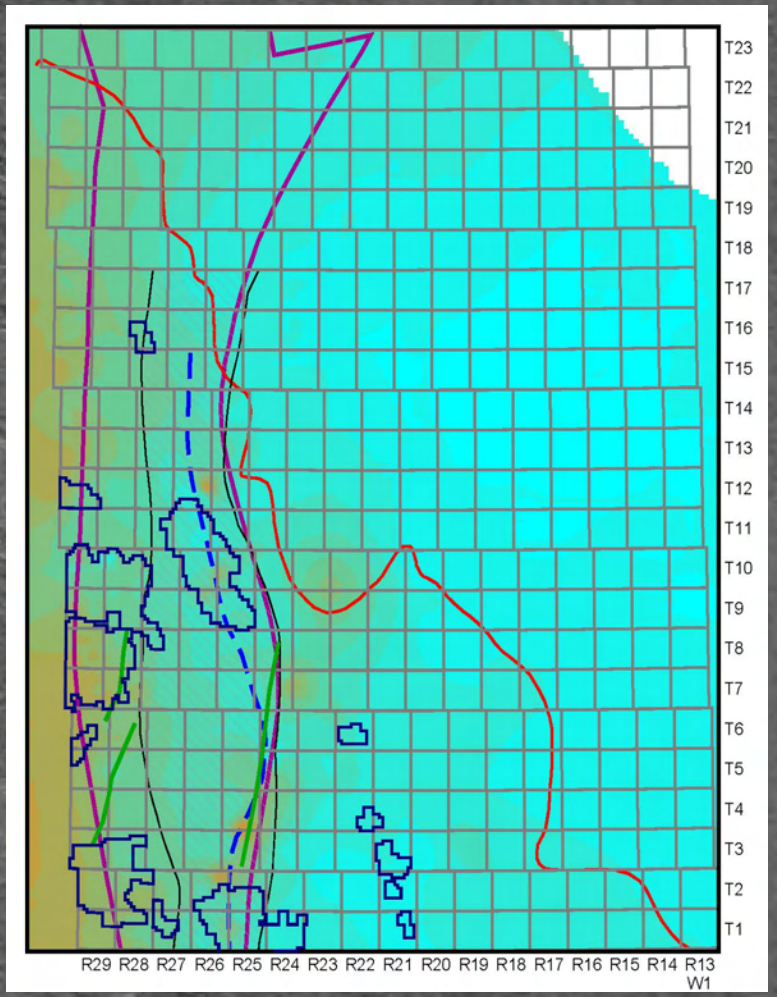
# Tectonic Controls - Evidence

- Isopach variations and Unit 4 edge parallel to areas of proposed fautling.
- Rapid truncation of Unit 4 (up to 20 m offset)
- Unit 2 edge coincident with BWA-SBZ eastern edge.
- Unit 2 isopach “plateau” over BWA.
- Documented faults in seismic:
  - shallow Devonian faulting in west
  - deep basement-derived faulting in east



# Tectonic Controls - Evidence

- Thickening coincident with tectonic elements
- Eastern anomalies likely basement driven




Isopach Contour Interval = 5 m

# Conclusions

- Sinclair is the newest oil field in Manitoba with excellent reserves
- Sinclair Field still growing
- Stratigraphic and structural/tectonic controls on reservoir and oil accumulations
- Largely unexplored and has excellent exploration potential
- Preliminary  mapping shows areas of potential targets

# Conclusions - Future Work

- Core and sample logging throughout Three Forks depositional area
- Three Forks reservoir overview
  - Sinclair
  - Daly
  - Kirlella
  - Other Areas
- Exploration model

# Conclusions - Targets

## Three Forks Exploration Targets