



The Devonian Three Forks Formation:

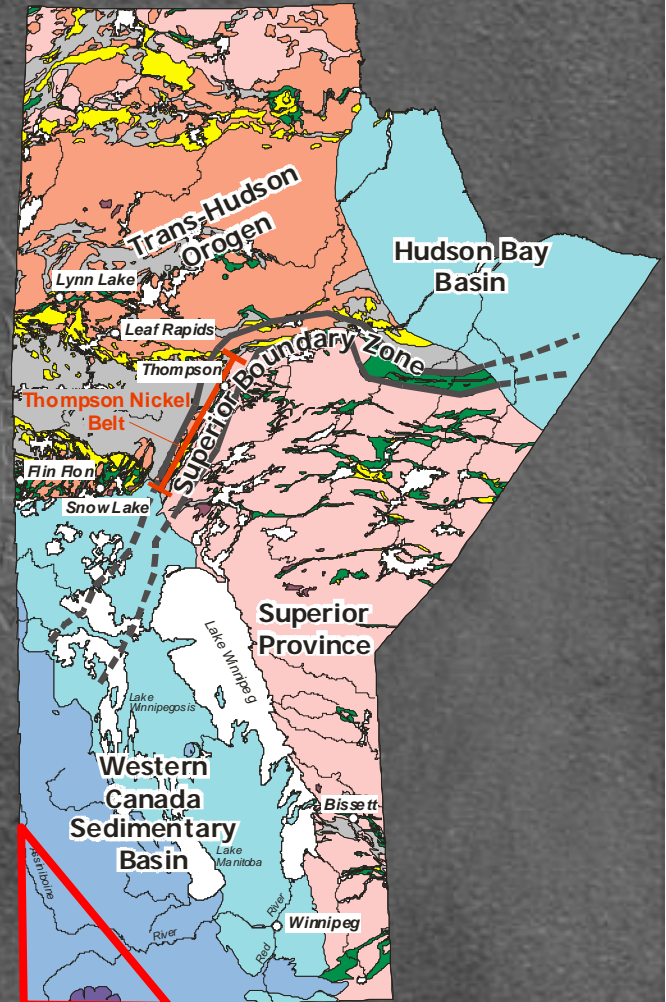
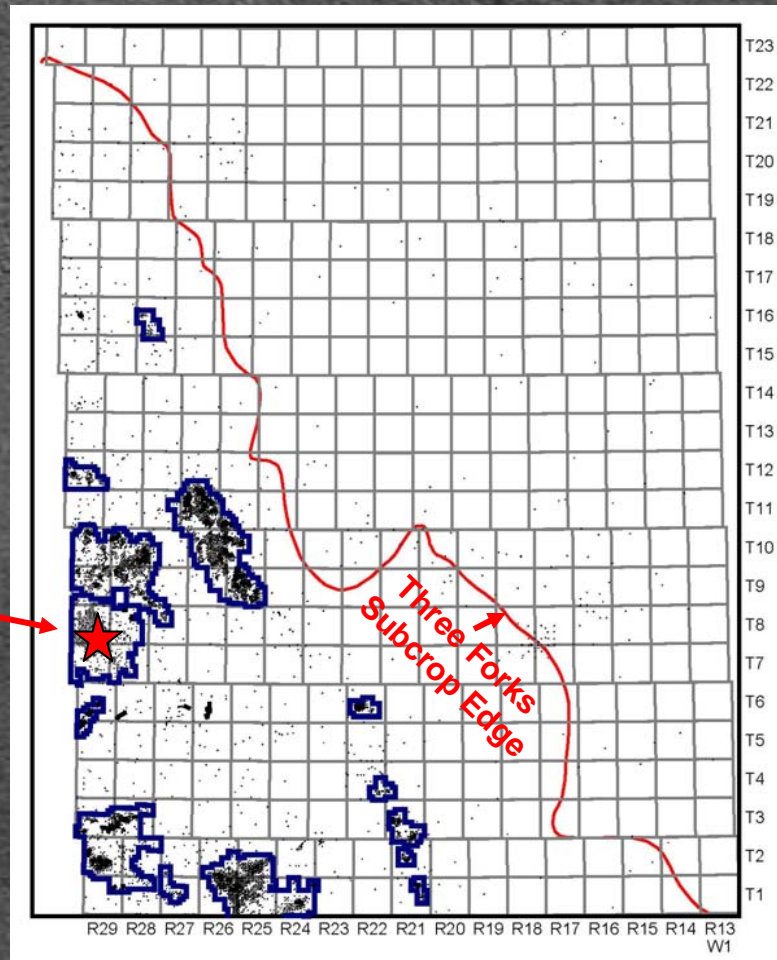
Manitoba's Newest Oil Play

Michelle Nicolas, P. Geo.
Manitoba Geological Survey



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 m³



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)

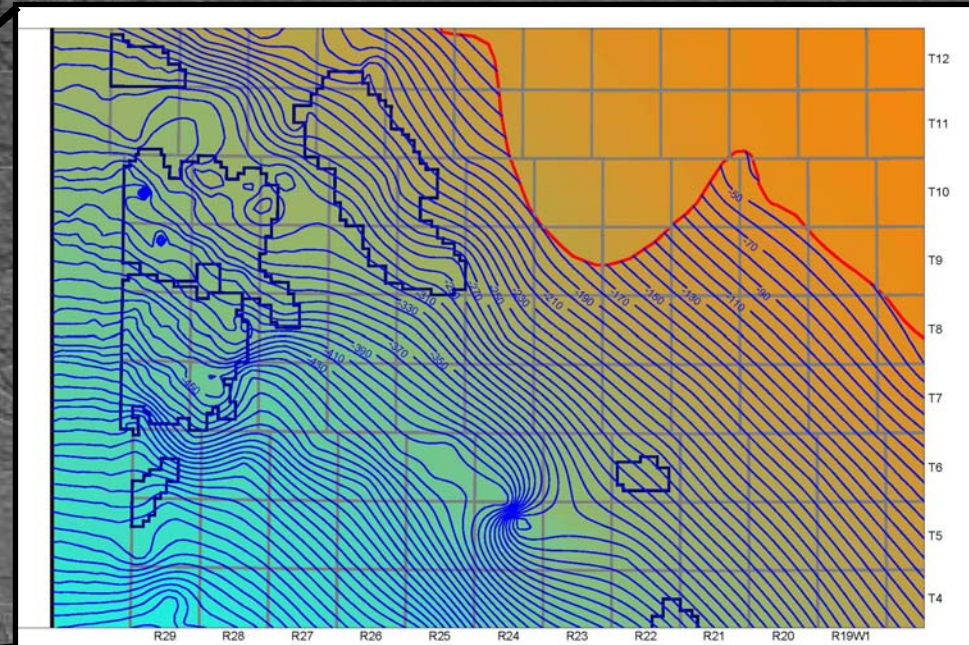
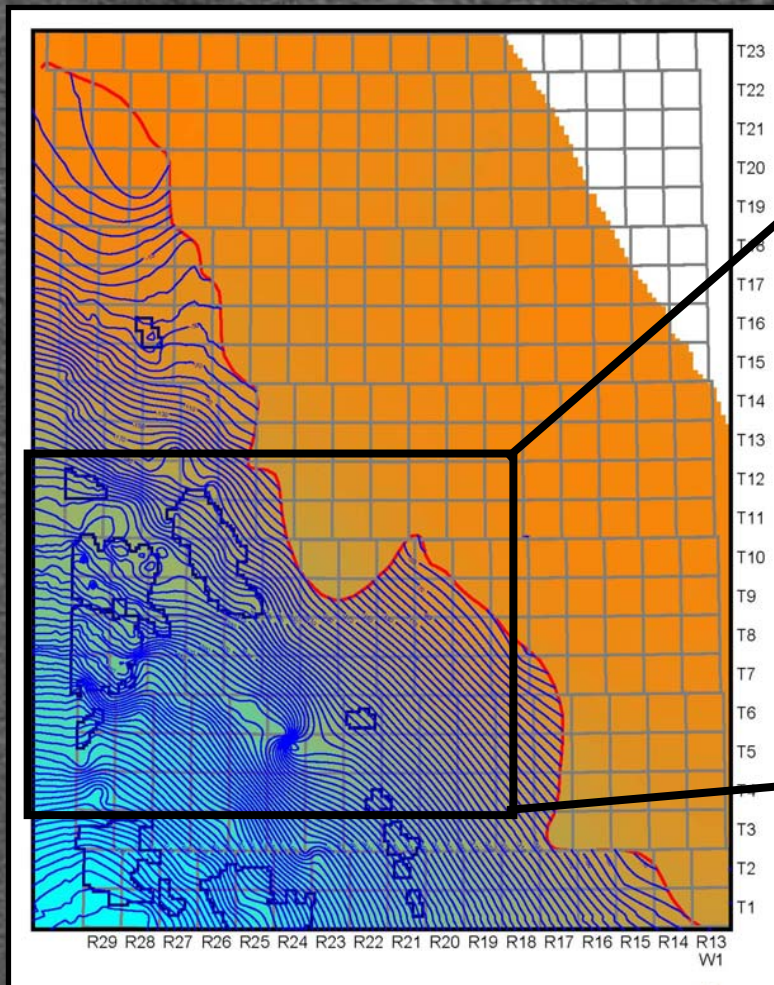


Three Forks Stratigraphy

Era	Southeastern Saskatchewan			Manitoba		North Dakota				
Mississippian	Three Forks Group	Bakken Formation	Upper Bakken Member	Bakken Formation	Upper Bakken Member	Bakken Formation	Upper Member			
			Middle Bakken Member		Middle Bakken Member		Middle Member			
Lower Bakken Member			Lower Bakken Member		Lower Member					
—?—	Big Valley Formation									
Devonian	Three Forks Group	Torquay Formation	Unit 6	Qu'Appelle Group	Three Forks Formation	Unit 4	Three Forks Formation			
			Unit 5					Unit 3		
			Unit 4						Unit 2	
			Unit 3							Unit 1
			Unit 2							
			Unit 1							
Saskatchewan Group	Birdbear Formation	Upper Birdbear	Saskatchewan Group	Birdbear Formation	Upper (biohermal facies)	Jefferson Group	Birdbear Formation			
Lower Birdbear		Lower (platform facies)								



Three Forks Structure

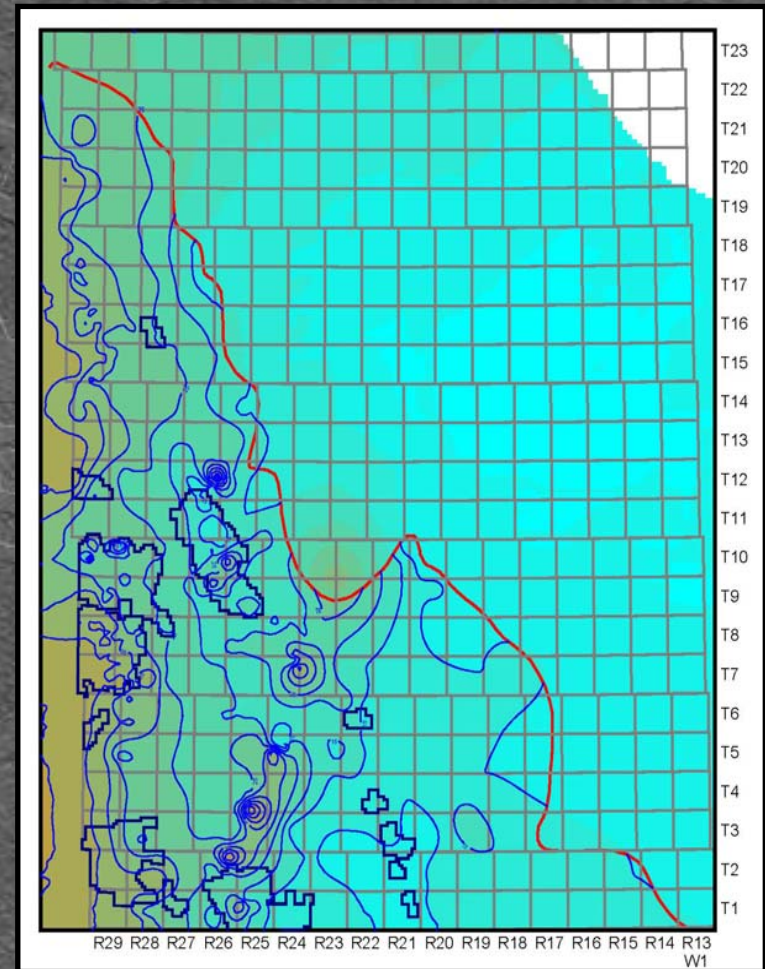


Contour Interval = 10 m



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

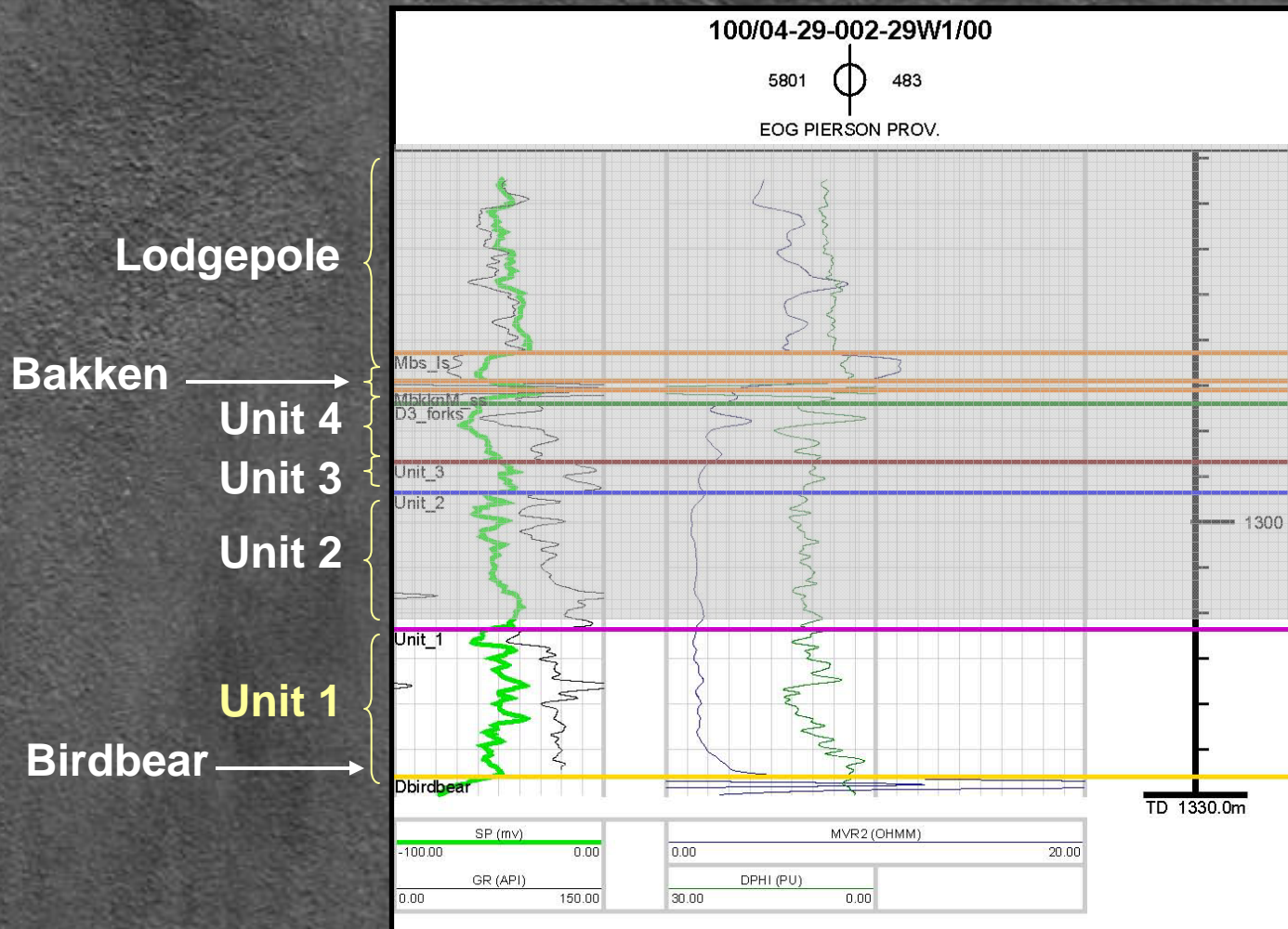
- Lowermost unit
- Highly oxidized with reduction halos
- Original fabric:
Brecciated argillaceous dolomite with grey-green silty shale matrix
- Limited core availability



14-32-10-24W1



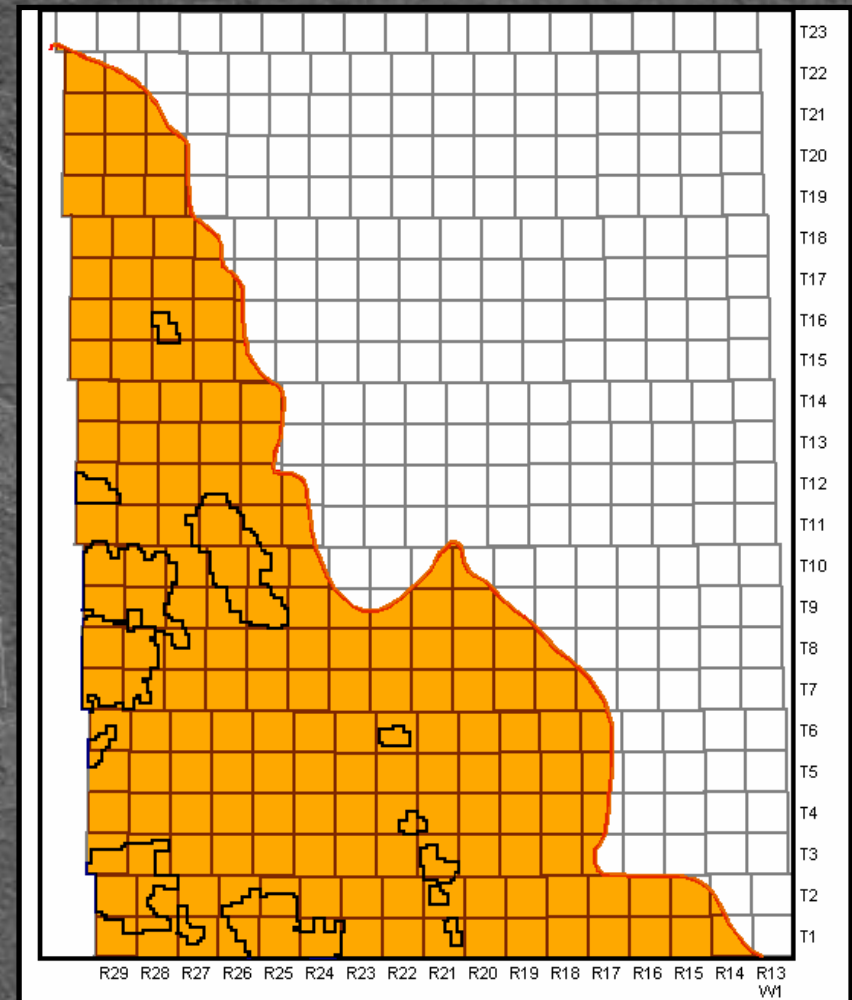
Reference Log – Unit 1





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

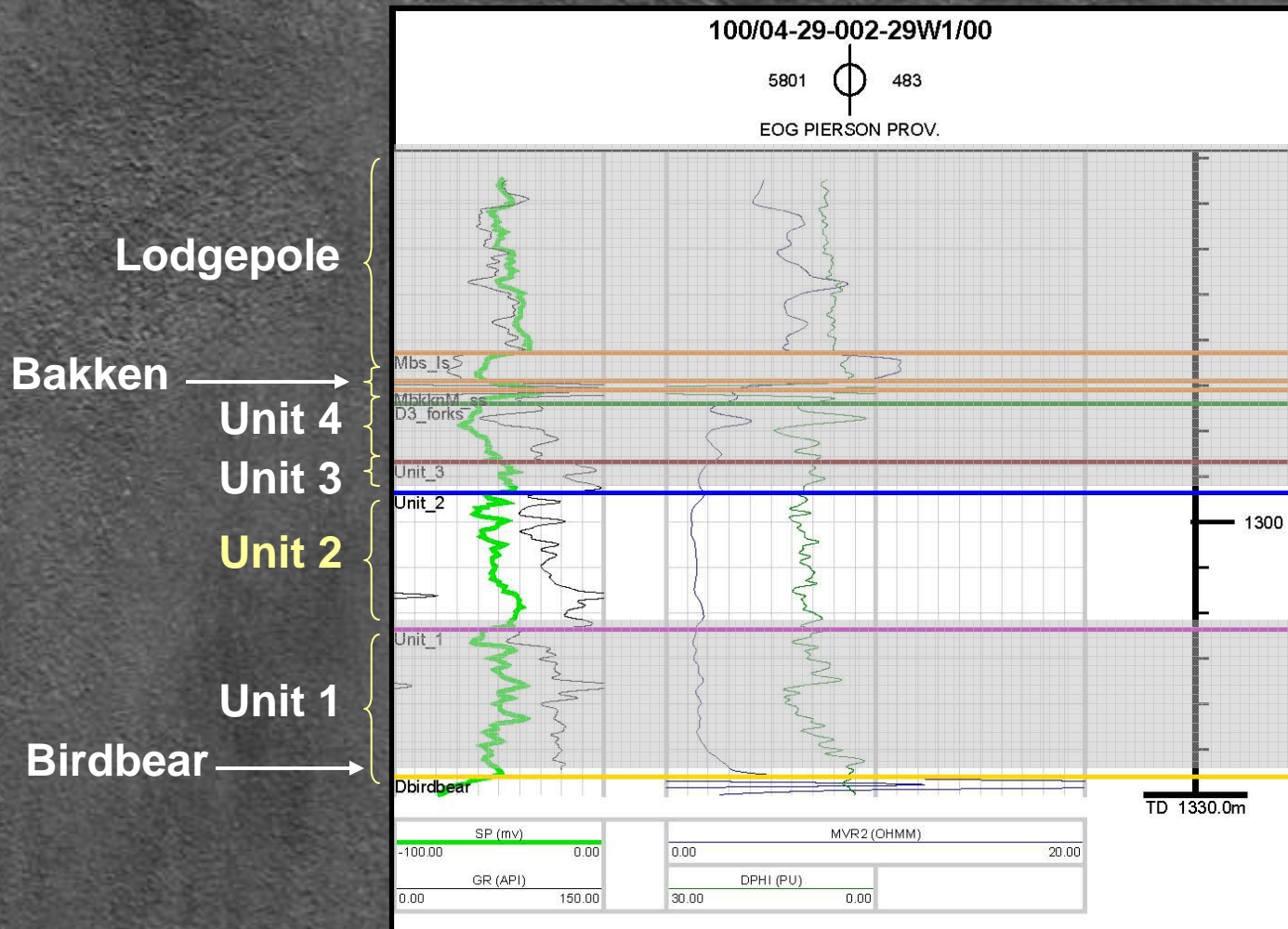
- Interbedded siltstone, shales and claystones
- Massive and brecciated in places
- Partially oxidized
- Porosity decreases with depth



2-2-8-29W1



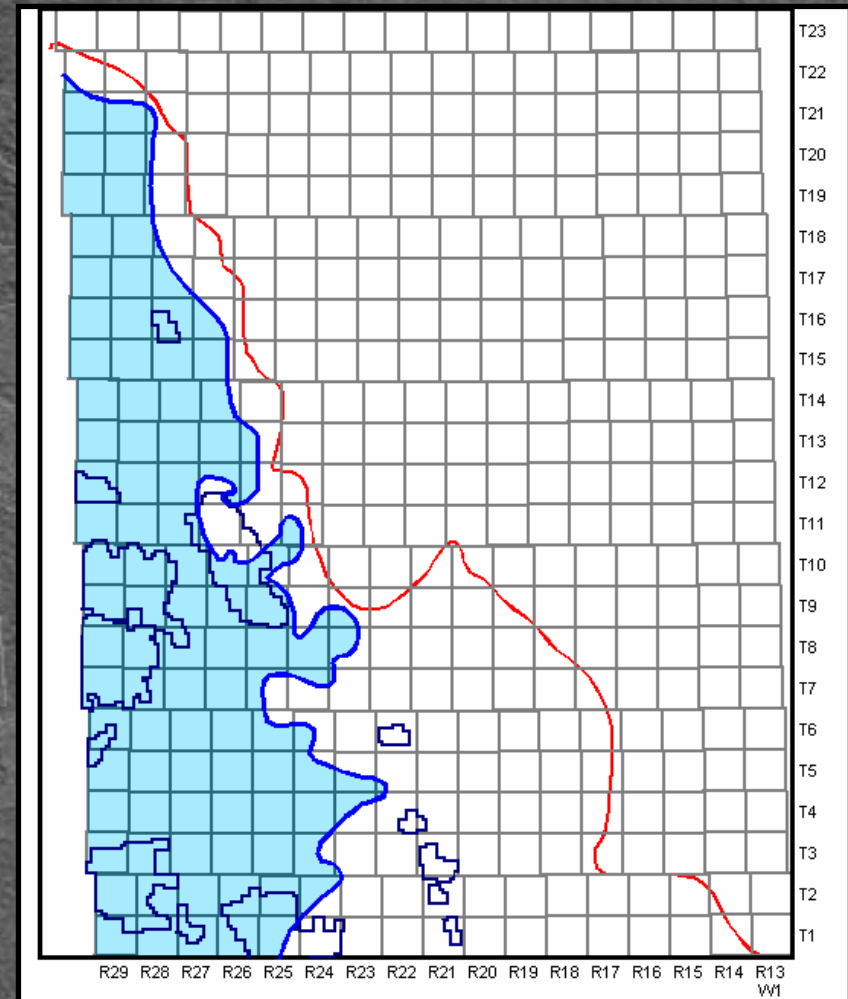
Reference Log – Unit 2





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

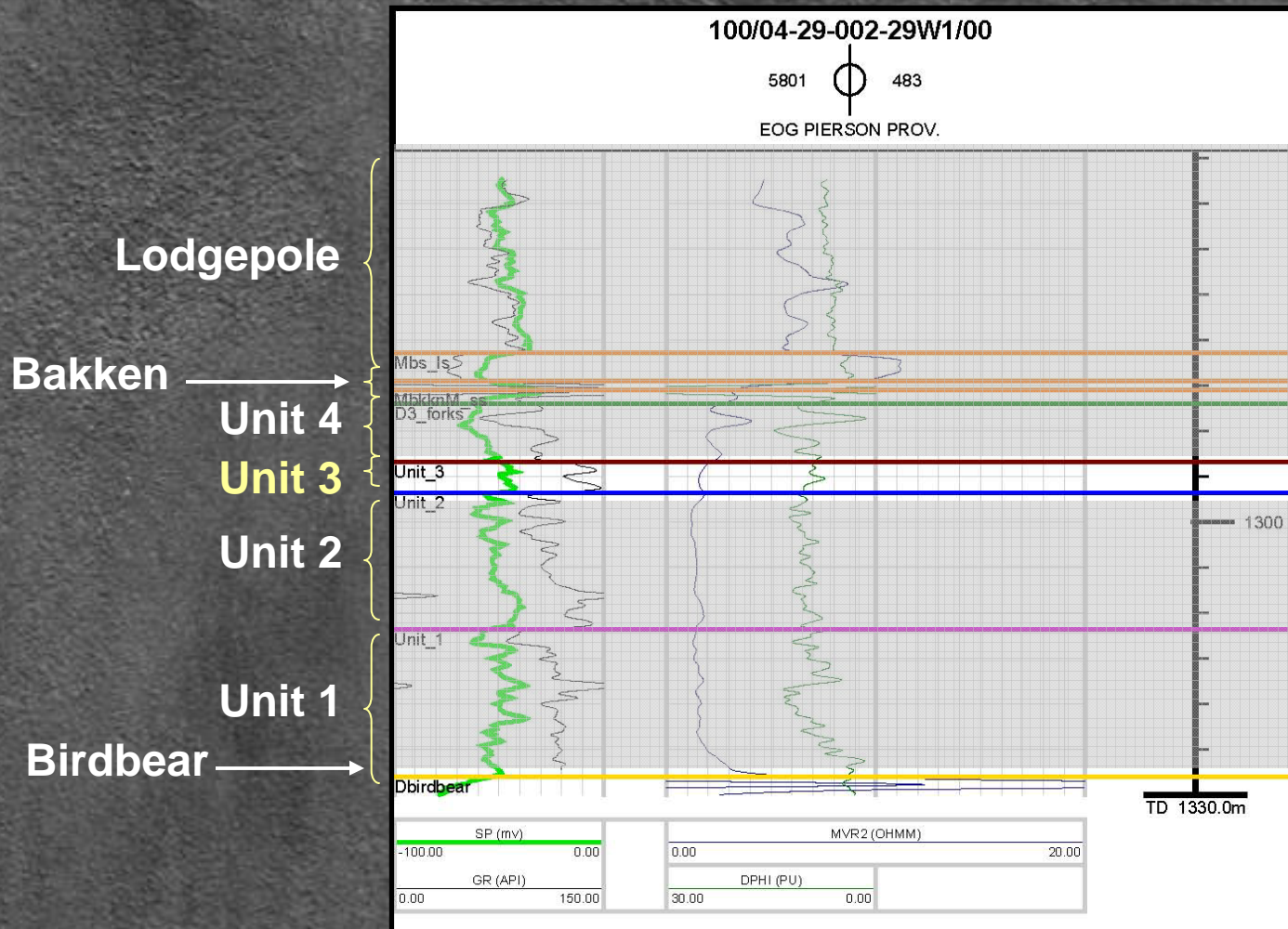
- Red-brown highly oxidized silty dolomitic shale
- Rare reduced halos
- Thinnest unit
 - 3.5 m isopach
- Not a good reservoir, but productive when at unconformity in Sinclair



2-2-8-29W1



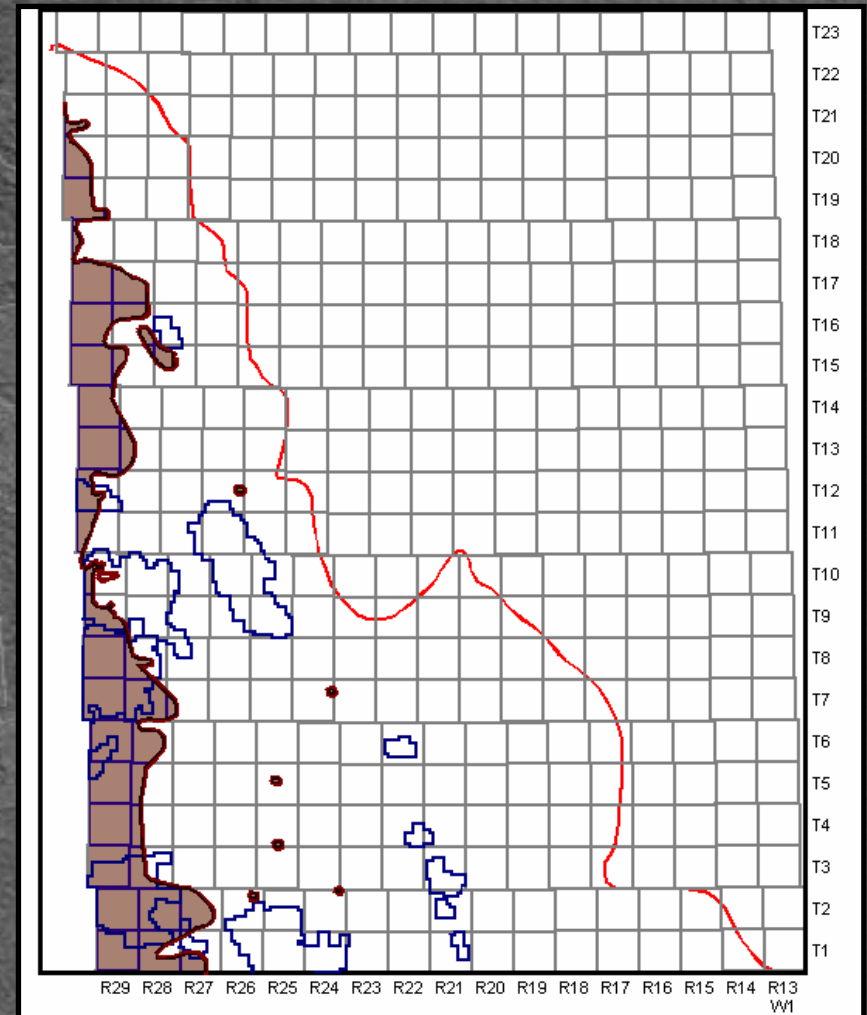
Reference Log – Unit 3





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



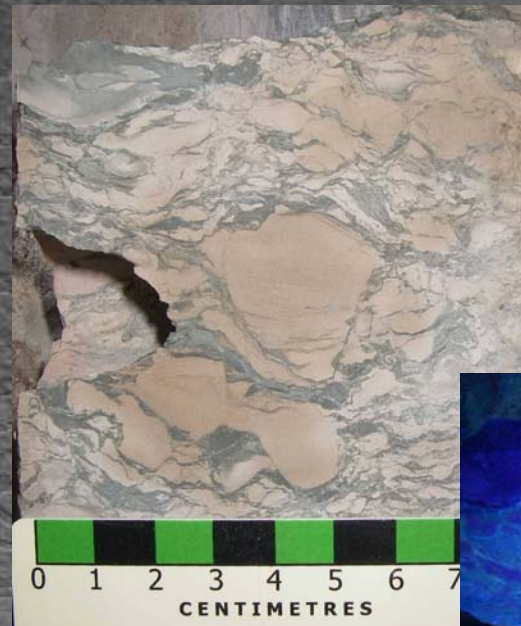
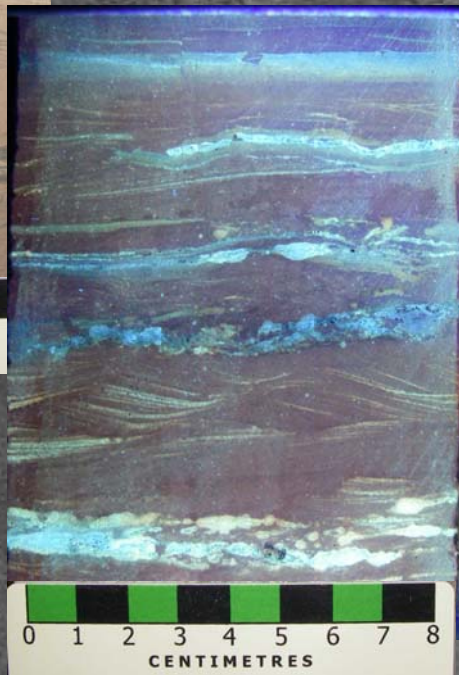
2-2-8-29W1



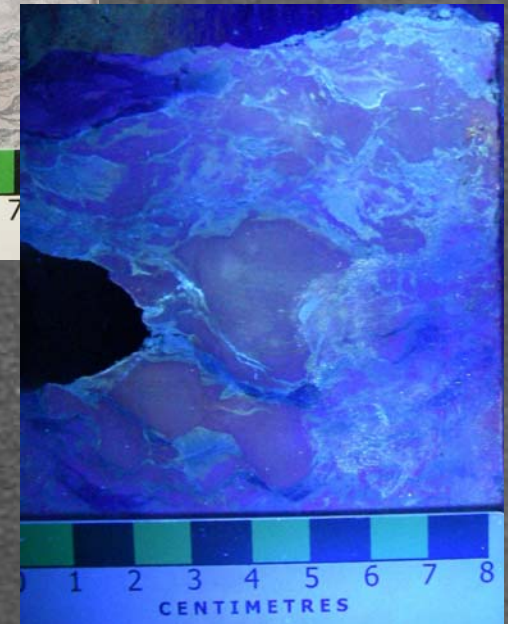
Three Forks – Unit 4



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

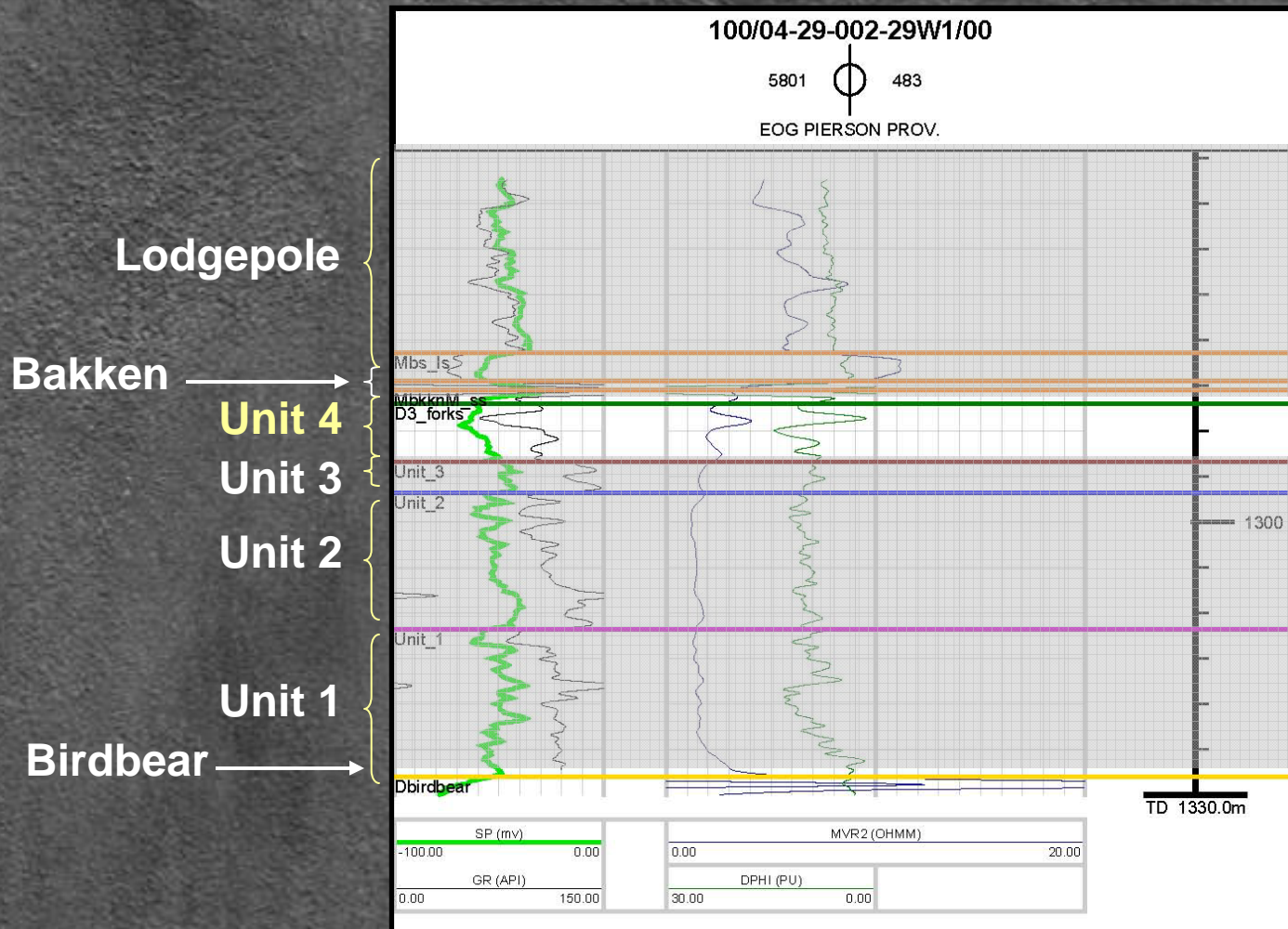


Subunit 4b
4-29-8-29W1
Plain and UV light





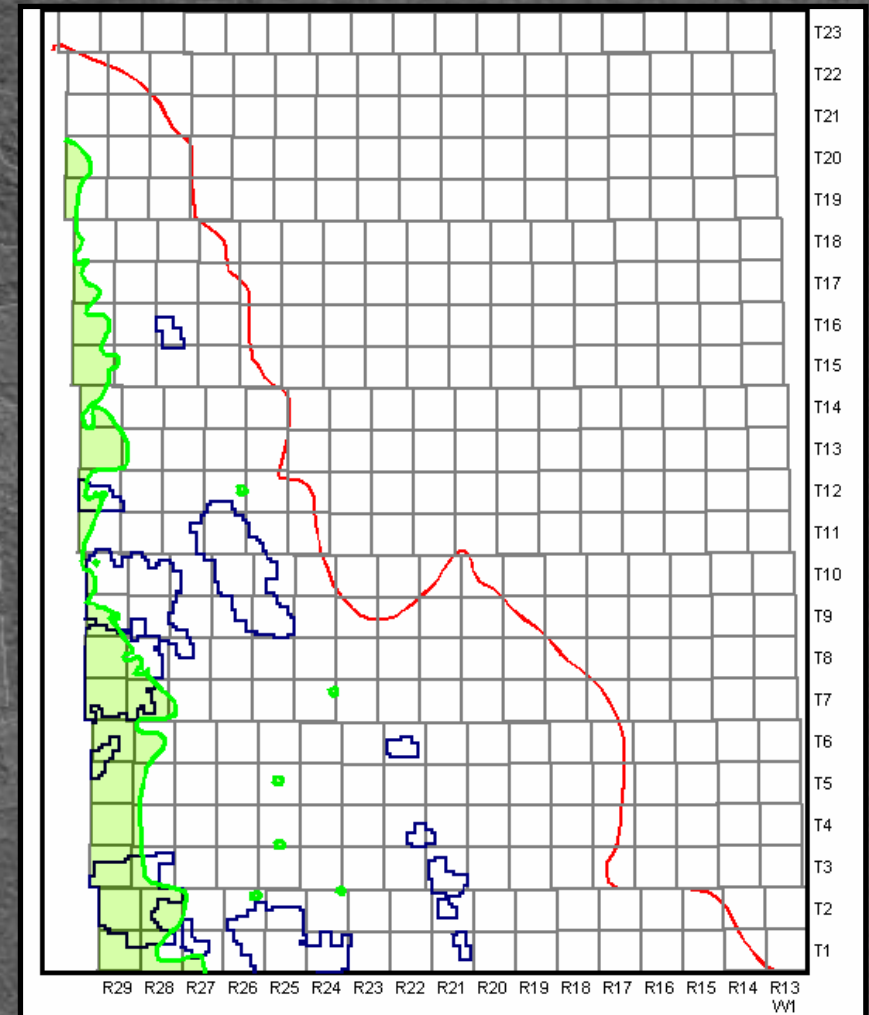
Reference Log – Unit 4





Three Forks – Unit 4

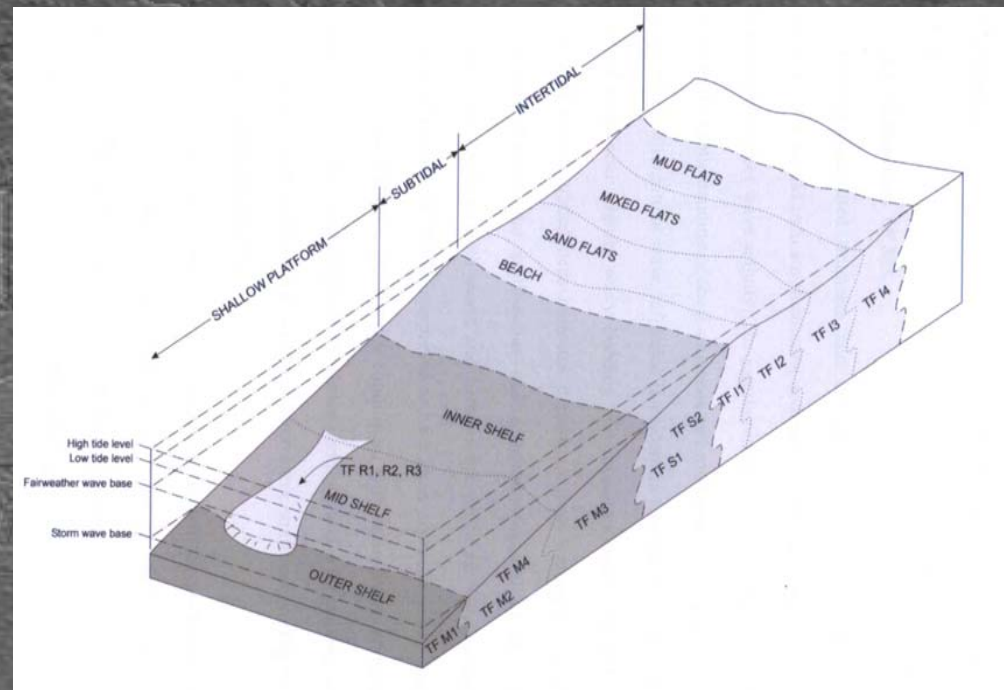
- Isopach: 1-14 m
 - average = 6 m
- Limited distribution
 - Restricted to the Ranges 29 & 28 W1
 - More section preserved in isolated wells in the east
- Primary reservoir at Sinclair
 - Also SW Daly and Kirkella
- Average core K = 4.3 mD
- Average core \emptyset = 16.5%
- Oil Saturation = 7.0-34.0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





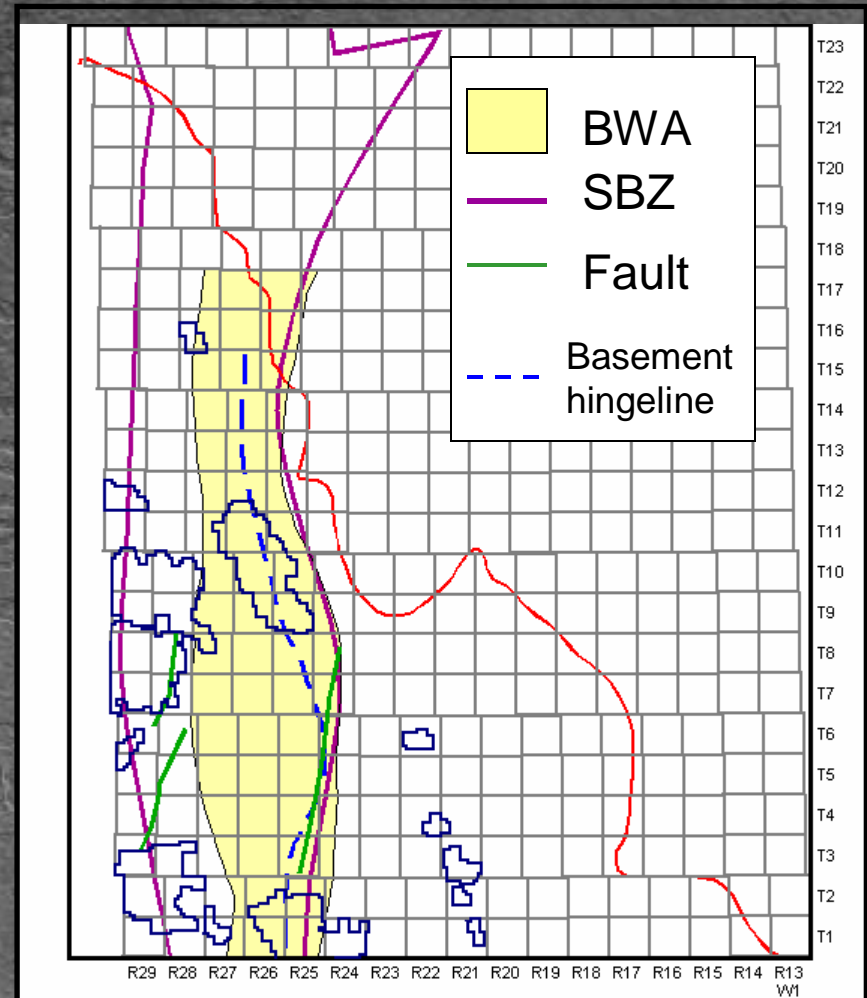
Diagenesis

- 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-feldspar, illite; late stage)
 - **Anhydrite** (latest stage)



Tectonic Controls

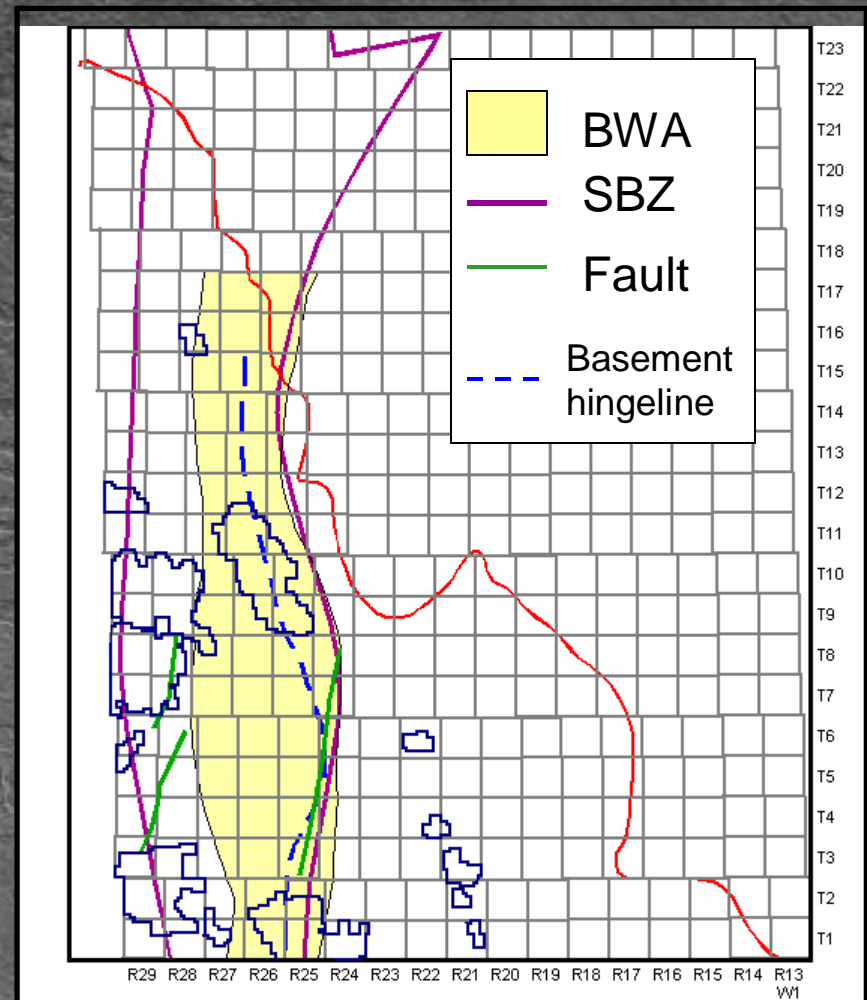
- Birdtail-Waskada Axis (BWA)
- Superior Boundary Zone (SBZ)
- Basement hingeline
- Faulting
 - Basement
 - Salt dissolution





Tectonic Controls - Evidence

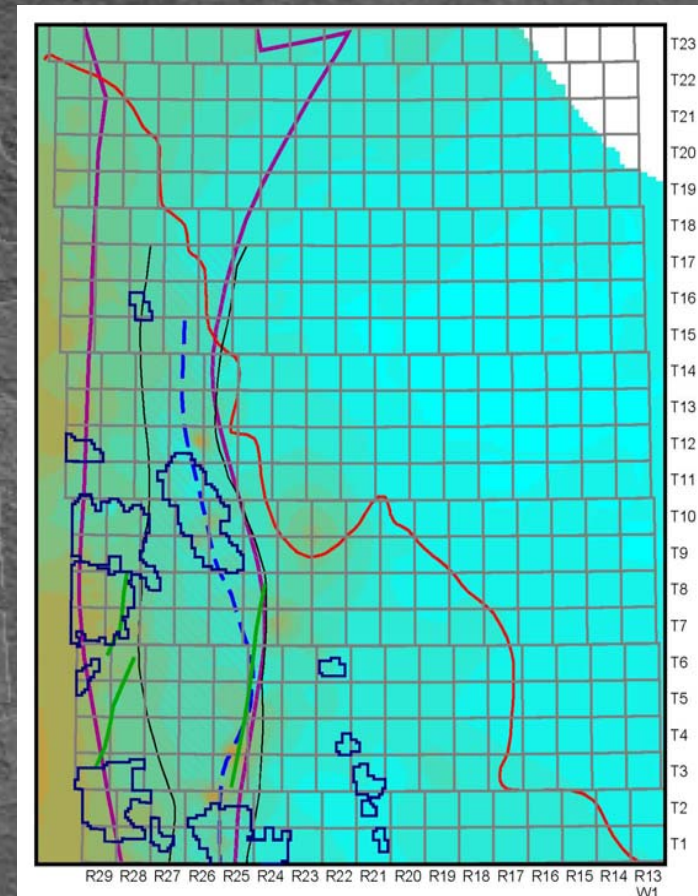
- Isopach variations and Unit 4 edge parallel to areas of proposed faulting.
- Rapid truncation of Unit 4 (up to 20 m offset)
- Unit 2 edge coincident with BWA-SBZ eastern edge.
- Unit 2 isopach “plateau” over BWA.
- Documented faults in seismic:
 - shallow Devonian faulting in west
 - deep basement-derived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



Conclusions - Targets

Three Forks Exploration Targets

