The New Bakken Play in Eastern Montana*

Stephen A. Sonnenberg[1]

Search and Discovery Article #10424 (2012)**
Posted July 16, 2012

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Long Beach, California, USA, April 22-25, 2012.

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Abstract

New exploration drilling northeast of Elm Coulee Field and southeast of the Brockton-Froid Fault System (BFFS) in eastern Montana (eastern Roosevelt and northeast Richland counties) is targeting the middle Bakken. Active companies in the area include EOG, Brigham, Whiting, XTO, Continental, Oasis Petroleum, and others. Operators report initial production ranging from 369 Boepd to 2962 Boepd. The area is characterized by higher water cuts than other Bakken producing areas. The source of the water may be the middle Bakken. The majority of wells are being drilled on 1280 spacing units and the orientation of the laterals is north-south.

The middle Bakken is 30 to 40 ft thick in the new area, and both the upper and lower Bakken shales are present. The middle Bakken thickens to over 50 ft northwest of the BFFS and thins to a wedge-edge southwest of Elm Coulee Field.

Other potential horizons within the Bakken petroleum system in the new area include the upper and middle Three Forks. To date, these intervals have not been tested. Oil saturation throughout the Three Forks interval in a core at Poplar Dome suggests these intervals will be targets for exploration in the future.

High heat flow characterizes the new area and typical bottom-hole temperatures at the Bakken level are in excess of 225^{o}F. Pressure gradients for the Bakken appear to be slightly over 0.5 psi/ft in the area. The upper and lower Bakken shales are thermally mature in the area, based on source-rock analysis (SRA data), bottom-hole temperatures, and high resistivity.

The new play area is an exciting development for the Bakken Petroleum System of the Williston Basin. Initial well results are encouraging. Shallower and deeper production also occurs in the new play area (i.e., Madison, Red River, Nisku, etc.).

Several operators consider the area northwest of the BFFS to be a more conventional play area. Both temperature and pressure gradients decrease northwest of the BFFS. In addition, the middle Bakken ‘D’ facies thickens in this area and generally has better reservoir properties than other areas of the basin. The continuity of the Bakken ‘D’ facies along with better reservoir properties may enable the unit to behave

like a traditional carrier bed. Structures in this area may be needed for trapping. Source beds still appear to be mature, based on resistivity, however. This area northwest of the BFFS has Three Forks potential.

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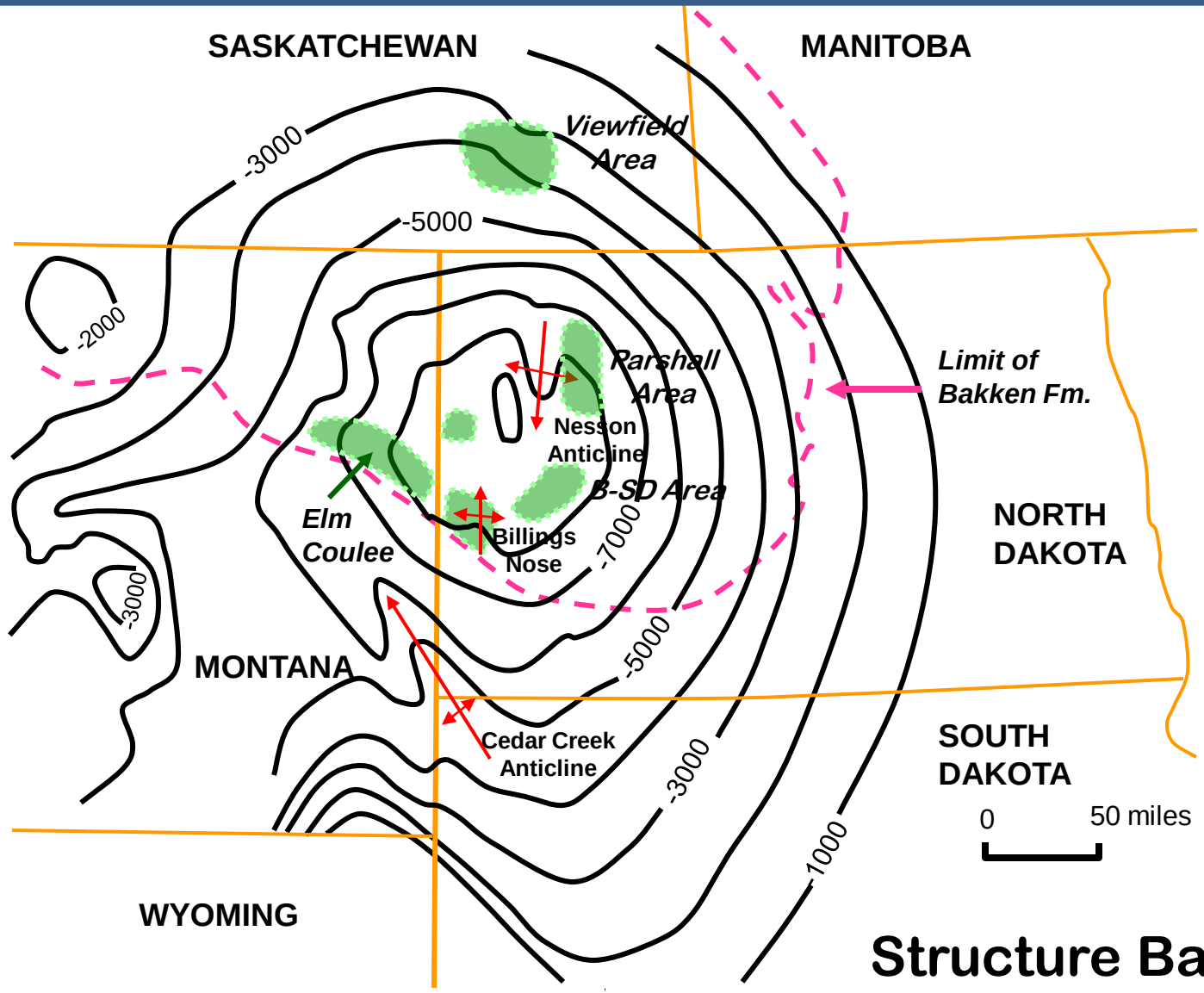
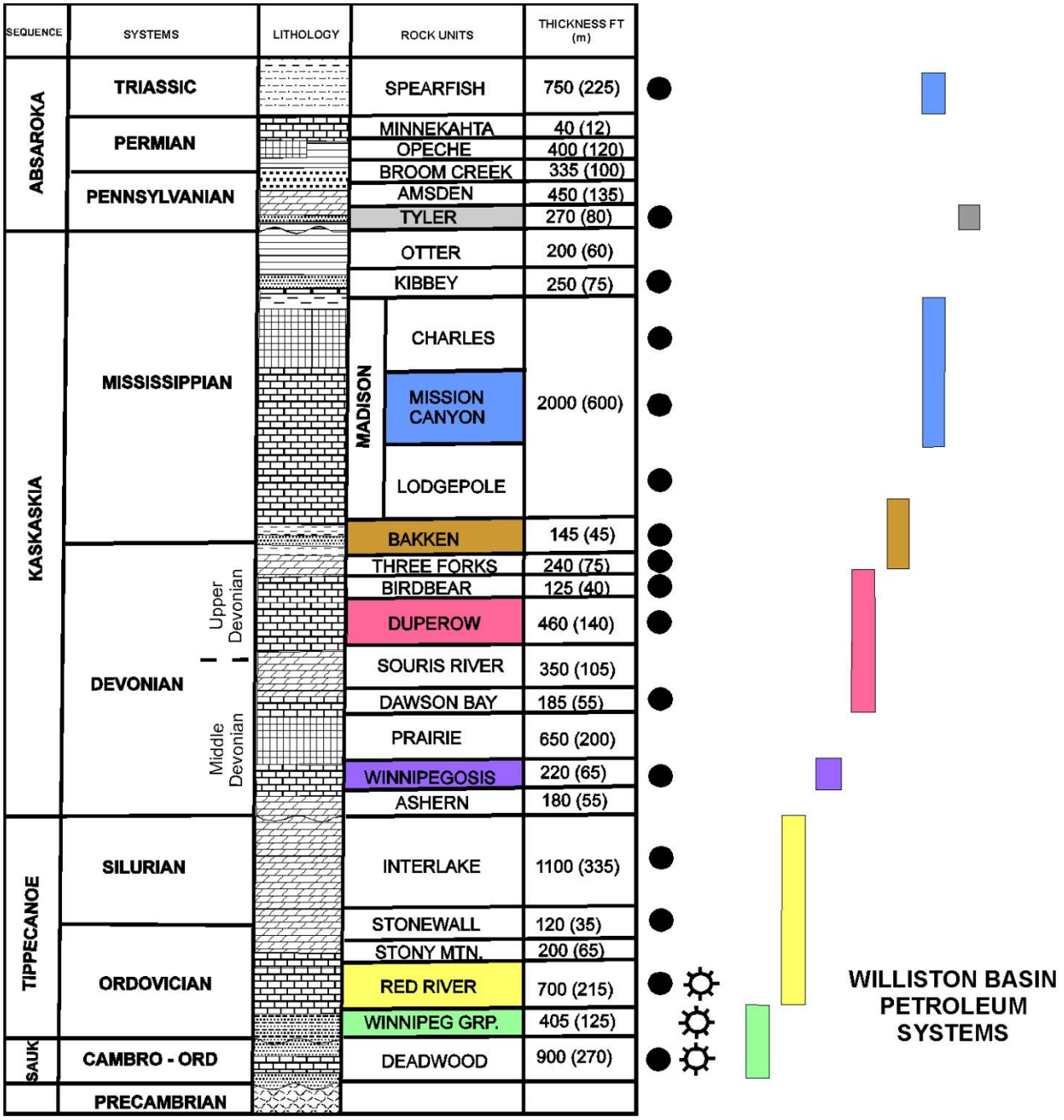
The New Bakken Play in Eastern Montana

Stephen A. Sonnenberg
Colorado School of Mines

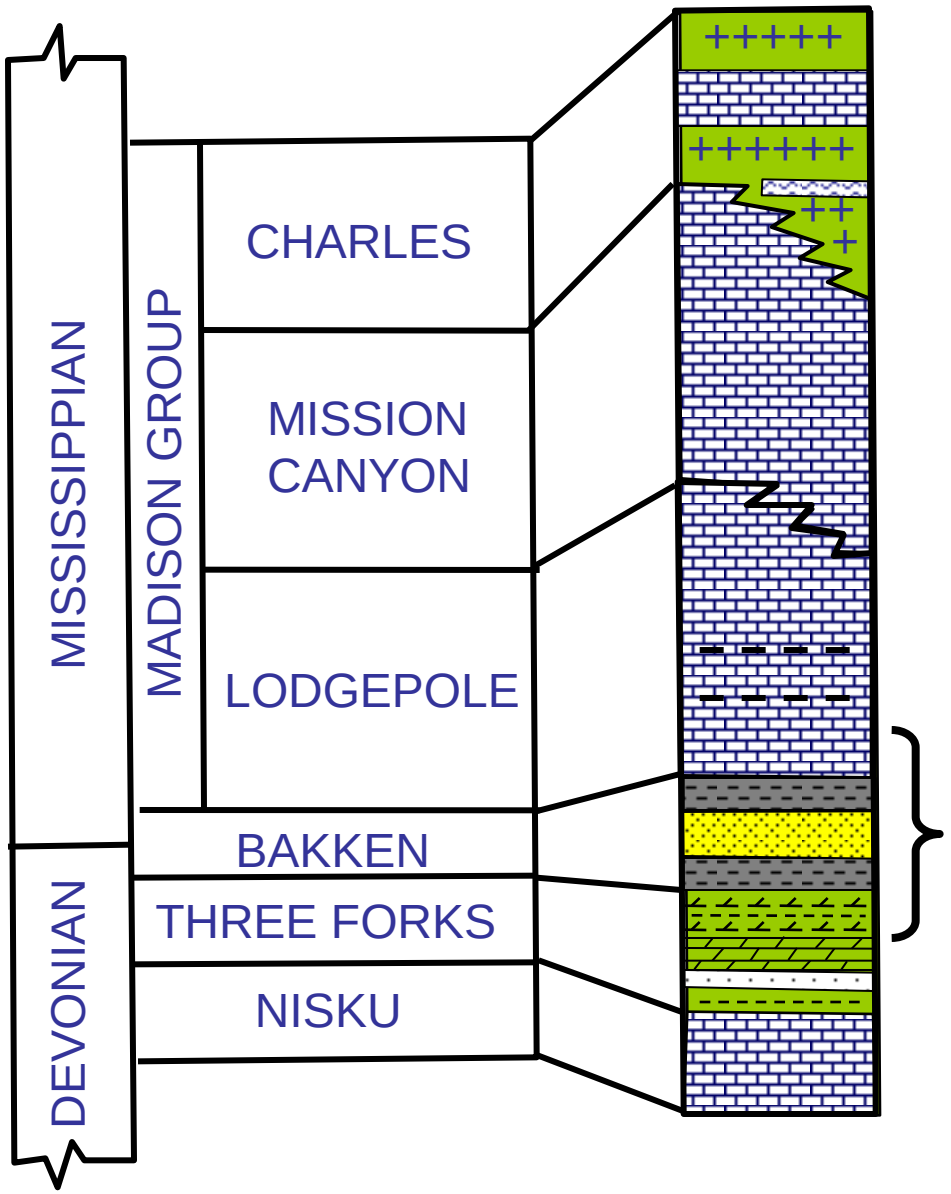
The Bakken Petroleum System of the Williston Basin: a Tight Oil Resource Play



Structure Base Miss



Modified from LeFever 1992; Anna, 2009



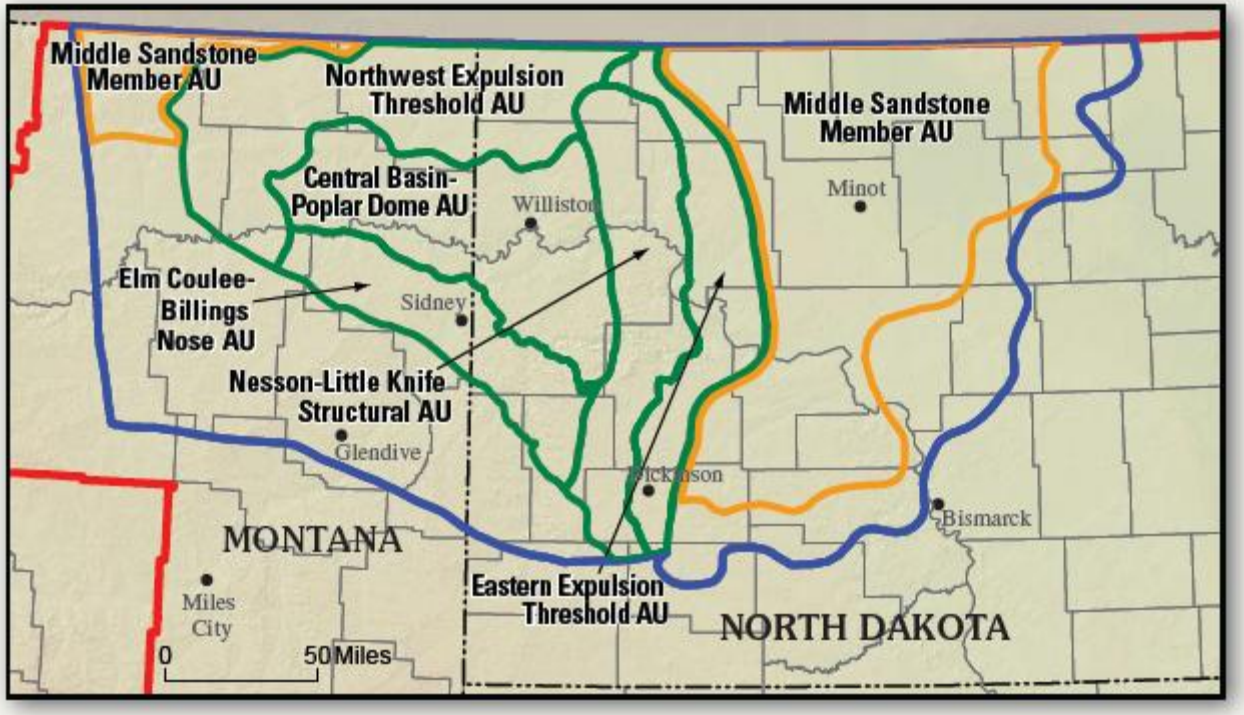
Modified from Webster, 1984

NDIC (2010) estimated ultimate production Bakken Petroleum System:

Bakken: 2.1 Billion barrels
Three Forks: 1.9 Billion barrels

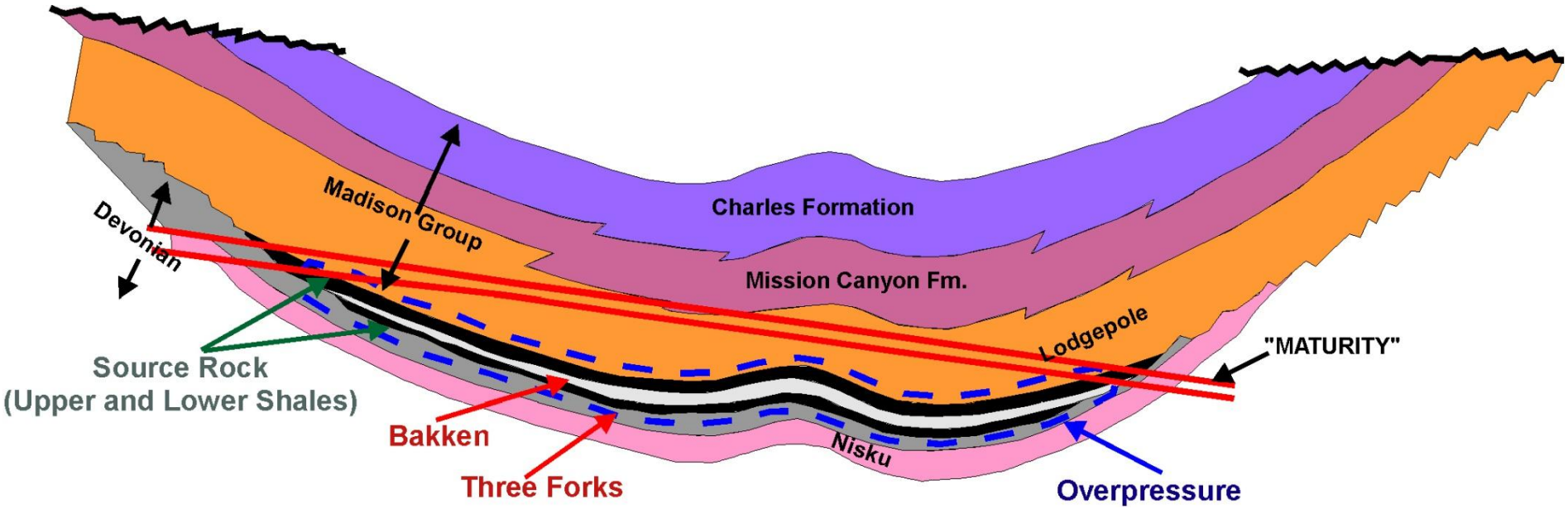
USGS 2008
Technically Recoverable
3645 MMBO
1848 BCFG
148 MMBNGLs

	Total Petroleum System and Assessment Unit	Field Type	Total Undiscovered Resources											
			Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Continuous Oil Resources	**Bakken-Lodgepole TPS**													
	Elm Coulee–Billings Nose AU	*Oil*	374	410	450	410	118	198	332	208	8	16	29	17
	Central Basin–Poplar Dome AU	*Oil*	394	482	589	485	134	233	403	246	10	18	35	20
	Nesson–Little Knife Structural AU	*Oil*	818	908	1,007	909	260	438	738	461	19	34	64	37
	Eastern Expulsion Threshold AU	*Oil*	864	971	1,091	973	278	469	791	493	20	37	68	39
	Northwest Expulsion Threshold AU	*Oil*	613	851	1,182	868	224	411	754	440	16	32	64	35
	Total Continuous Resources					3,645				1,848				148
Conventional Oil Resources	Middle Sandstone Member AU	*Oil*	1	4	8	4	1	1	3	2	0	0	0	0
	Total Conventional Resources					4				2				0
	Total Undiscovered Oil Resources					3,649				1,850				148



USGS 2008

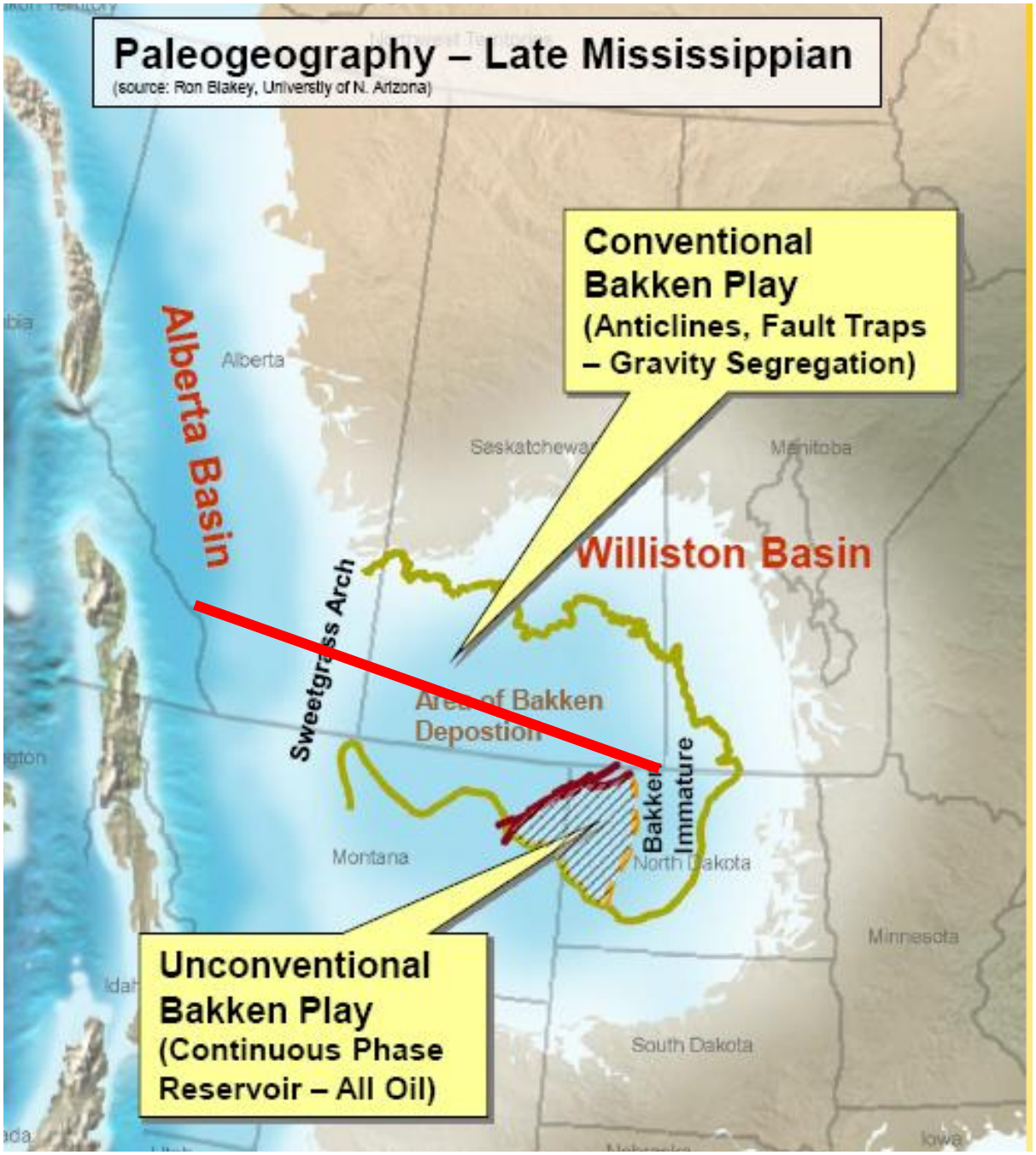
Bakken Petroleum System



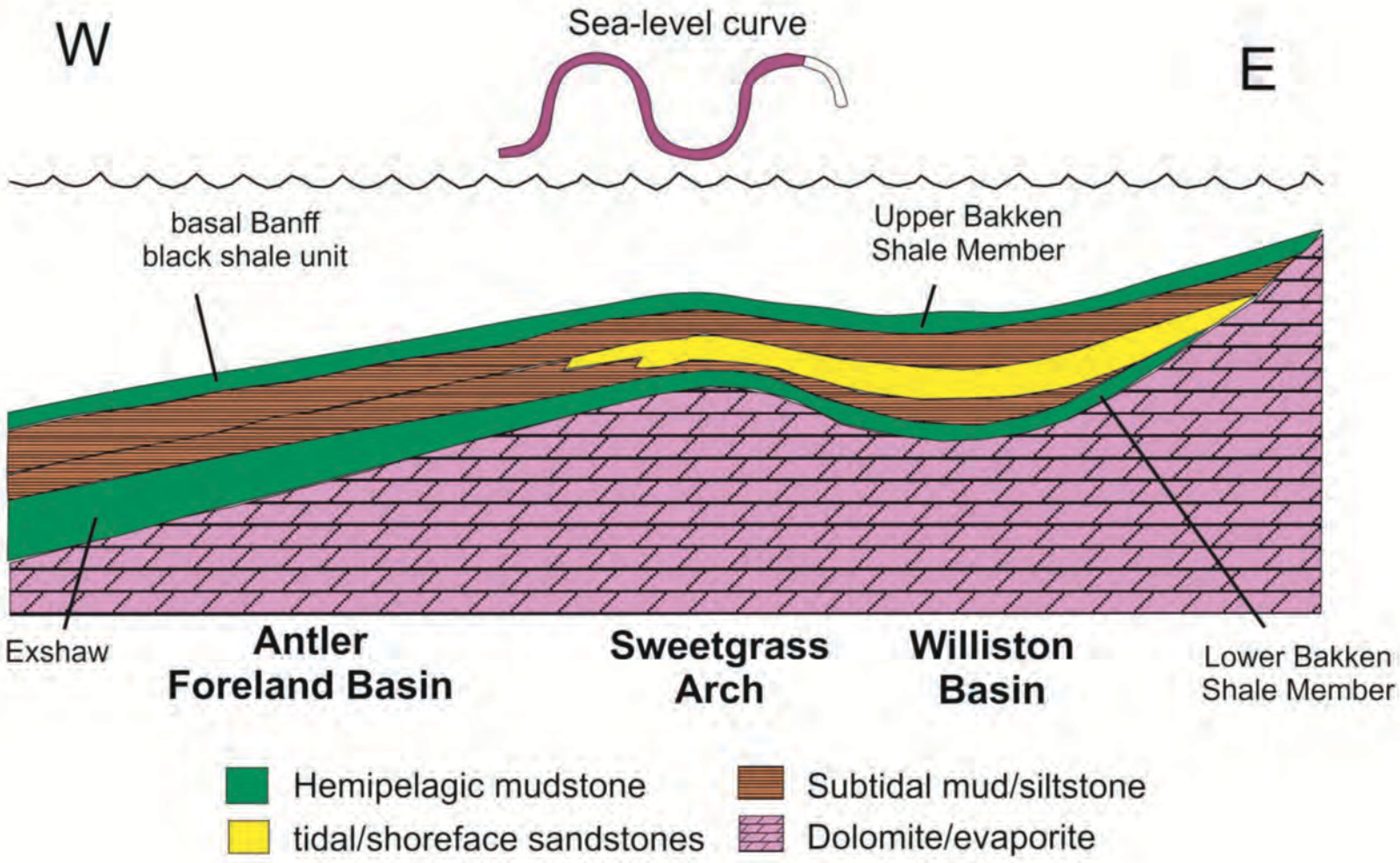
Reservoirs:
Middle Bakken & Three Forks

Source Beds:
Upper & Lower Bakken Shales

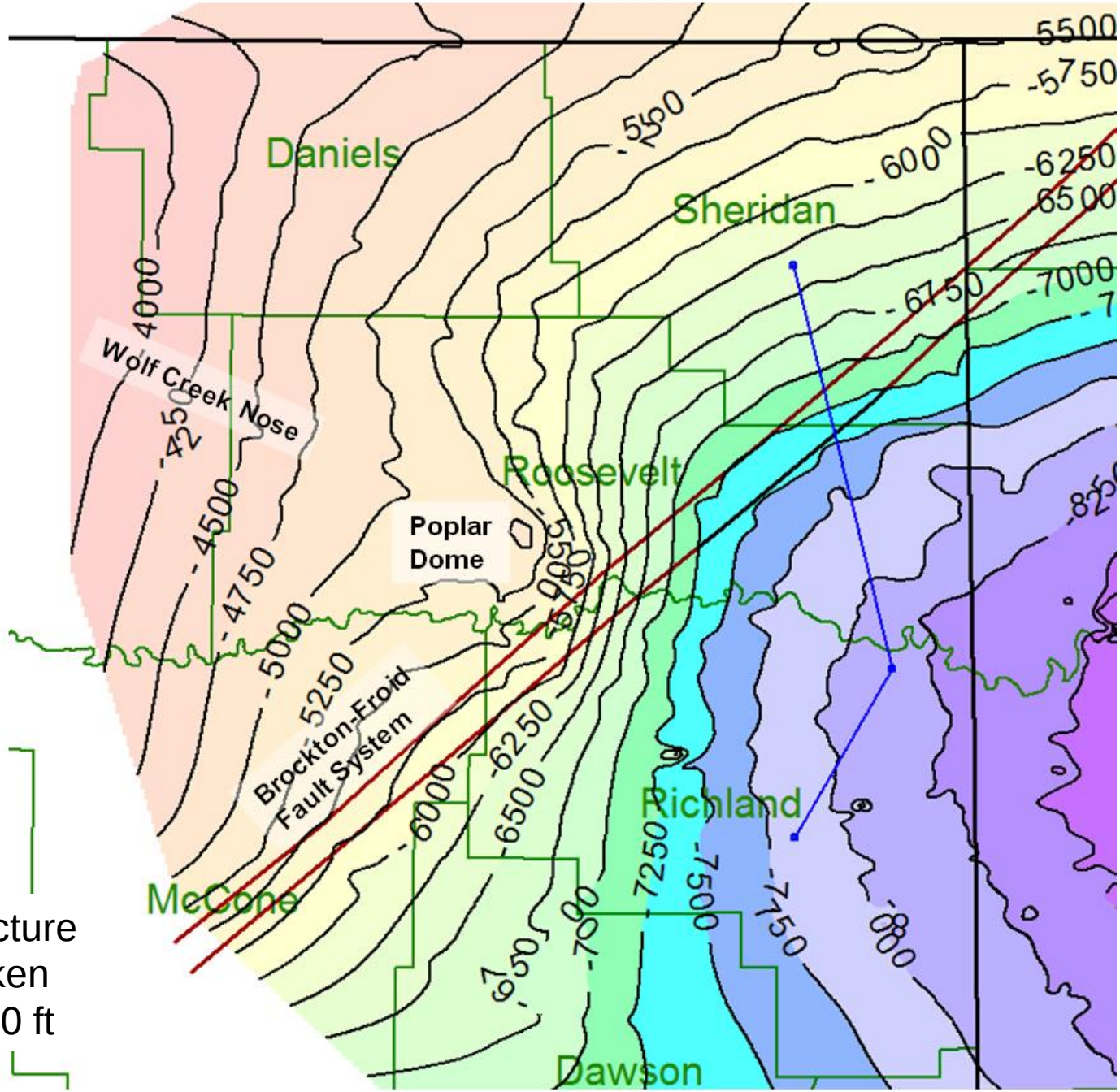
“what was made in the Bakken, stayed in the Bakken PS”


Paleogeography – Late Mississippian
(source: Ron Blakey, University of N. Arizona)
Conventional
Bakken Play
(Anticlines, Fault Traps
– Gravity Segregation)
Alberta Basin
Alberta
Saskatchewan
Manitoba
Williston Basin
Sweetgrass Arch
Area of Bakken
Depostion
Bakken Immature
Montana
North Dakota
Minnesota
South Dakota
Unconventional
Bakken Play
(Continuous Phase
Reservoir – All Oil)

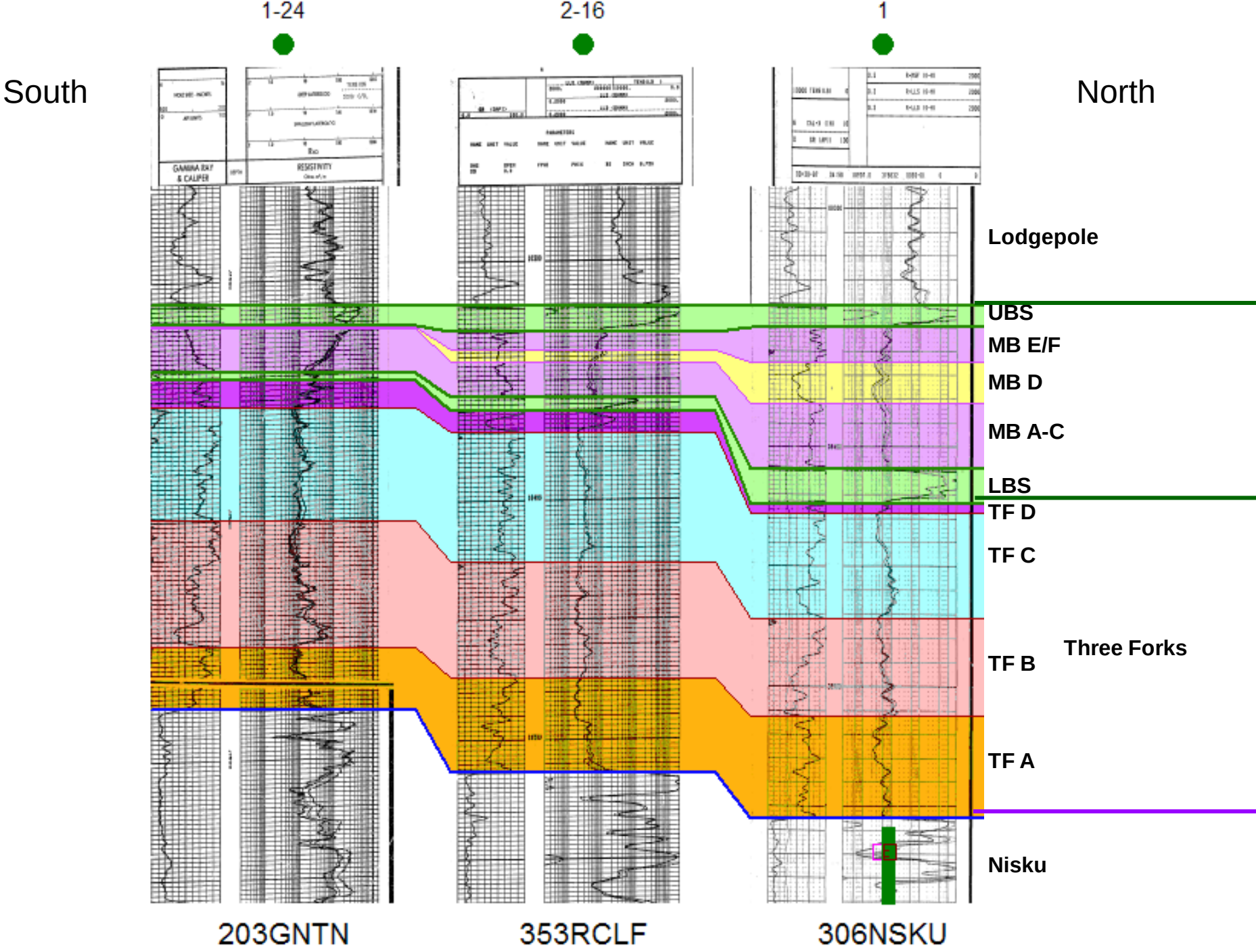
Volker, 2011



modified from Smith, and Bustin and Capla, 1995

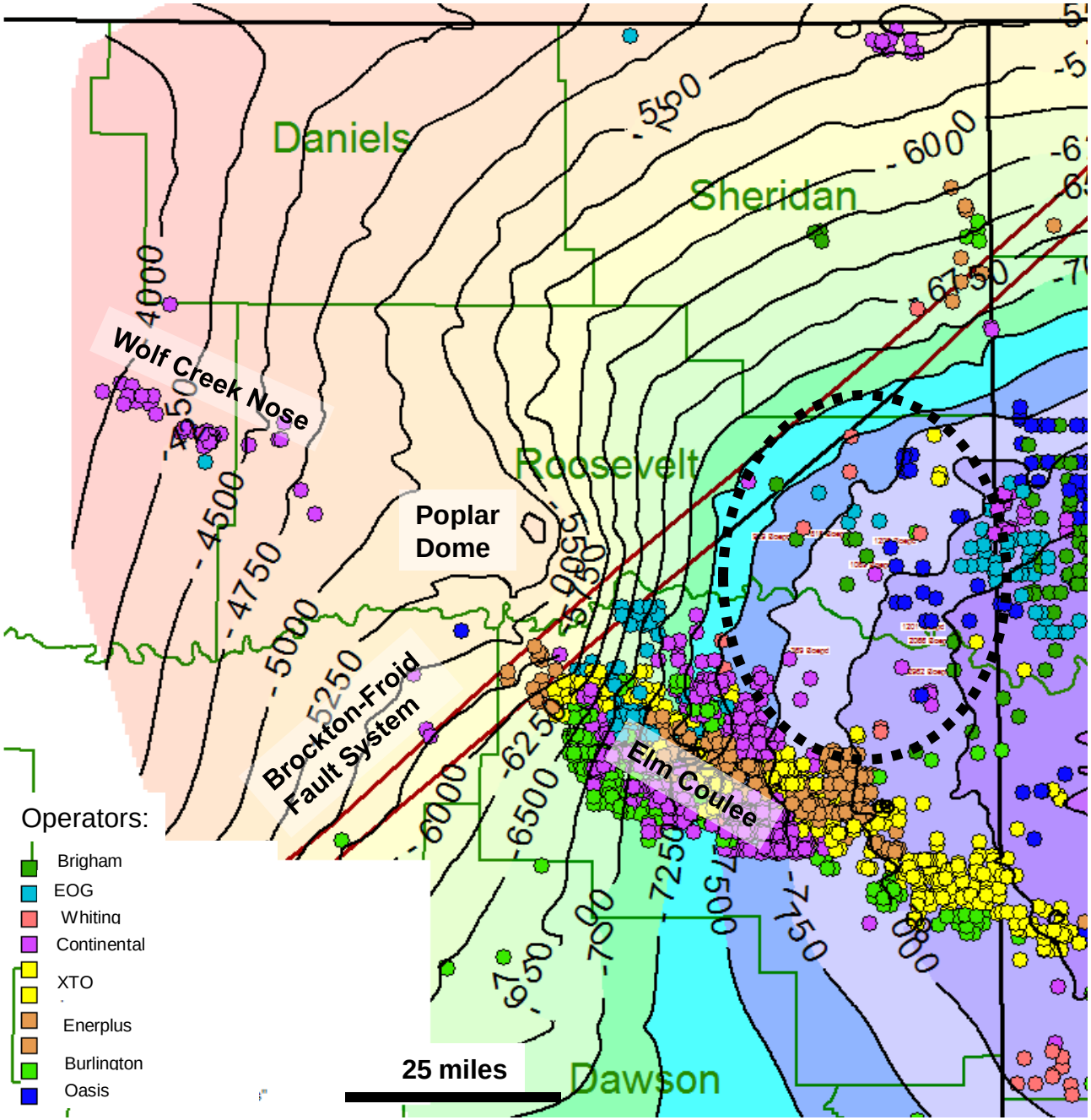


Structure
Bakken
CI: 50 ft

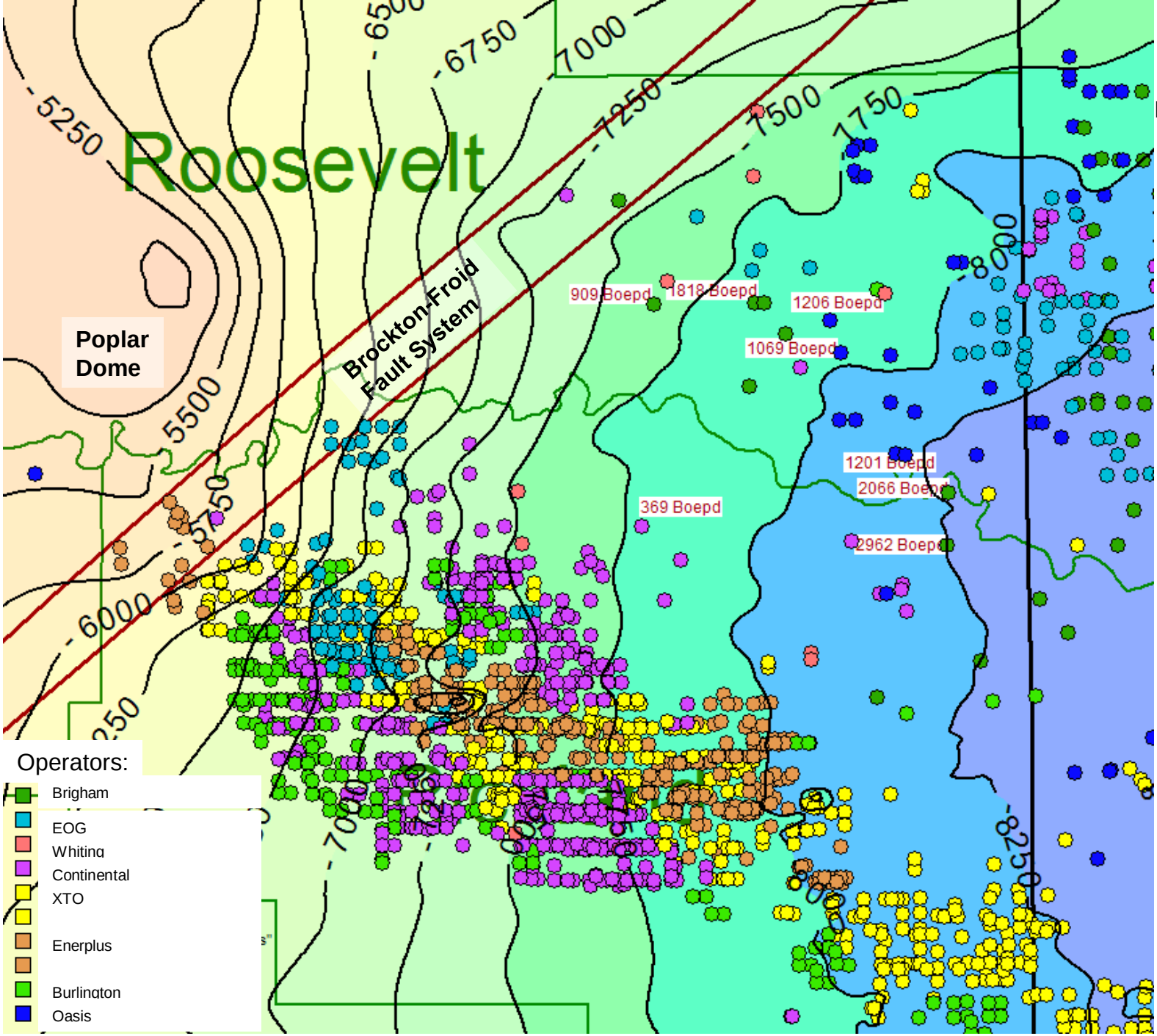

1-24
2-16
1
South
North
Lodgepole
UBS
MB E/F
MB D
MB A-C
LBS
TF D
TF C
TF B
TF A
Three Forks
Nisku
203GNTN
353RCLF
306NSKU

New Plays

- Elm Coulee extensions
- Middle Bakken north-central area
- Upper and Middle Three Forks north area
- Middle Bakken and Three Forks – Wolf Creek Nose area
- Poplar Dome area
- False Bakken source rocks, south of Elm Coulee



Structure
Bakken
CI: 50 ft

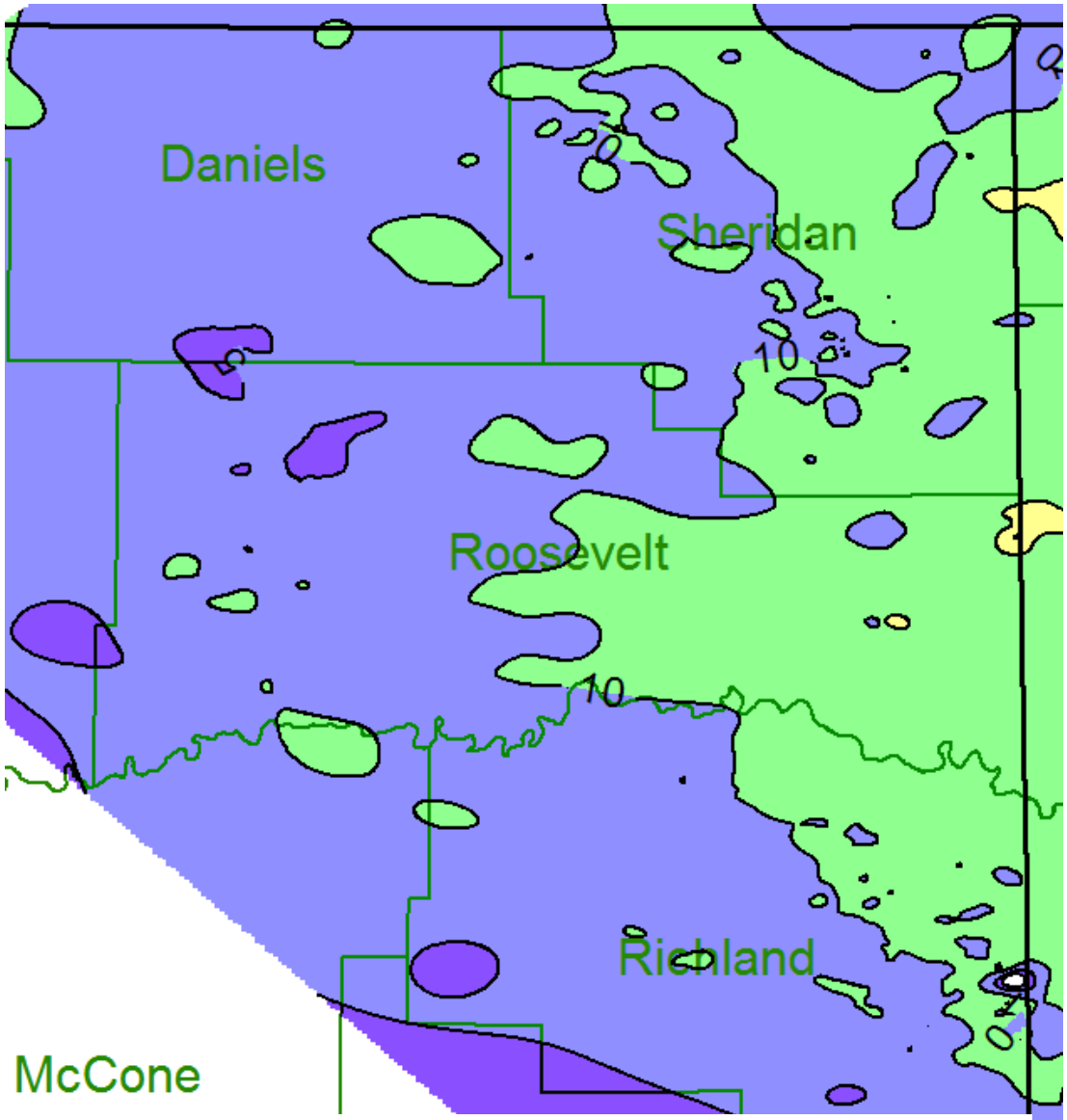

Roosevelt
Poplar Dome
Brockton-Froid Fault System
Bull Butte
Painted Woods
909 Boepd
1818 Boepd
1206 Boepd
1069 Boepd
1201 Boepd
2066 Boepd
369 Boepd
2962 Boepd
-5250
-5500
-5750
-6000
-6250
-6500
-6750
-7000
-7250
-7500
-7750
-8000
-8250
Operators:
Brigham
EOG
Whiting
Continental
XTO
Enerplus
Burlington
Oasis

Murray, 1968

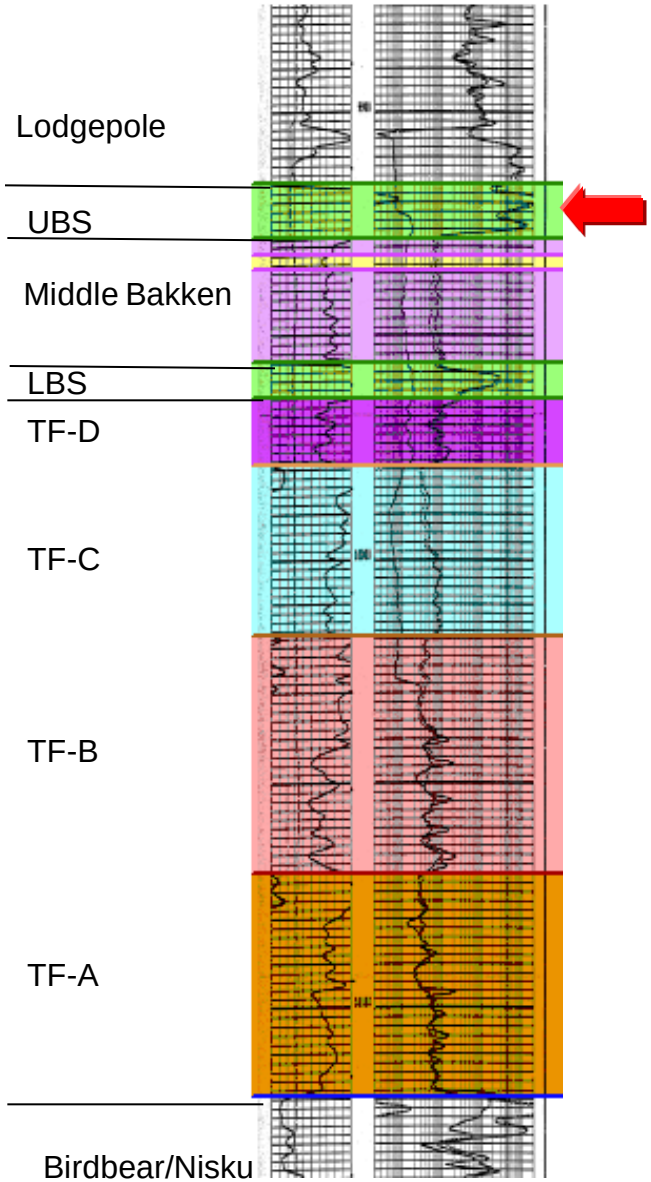
- Comments on the Bakken shales:

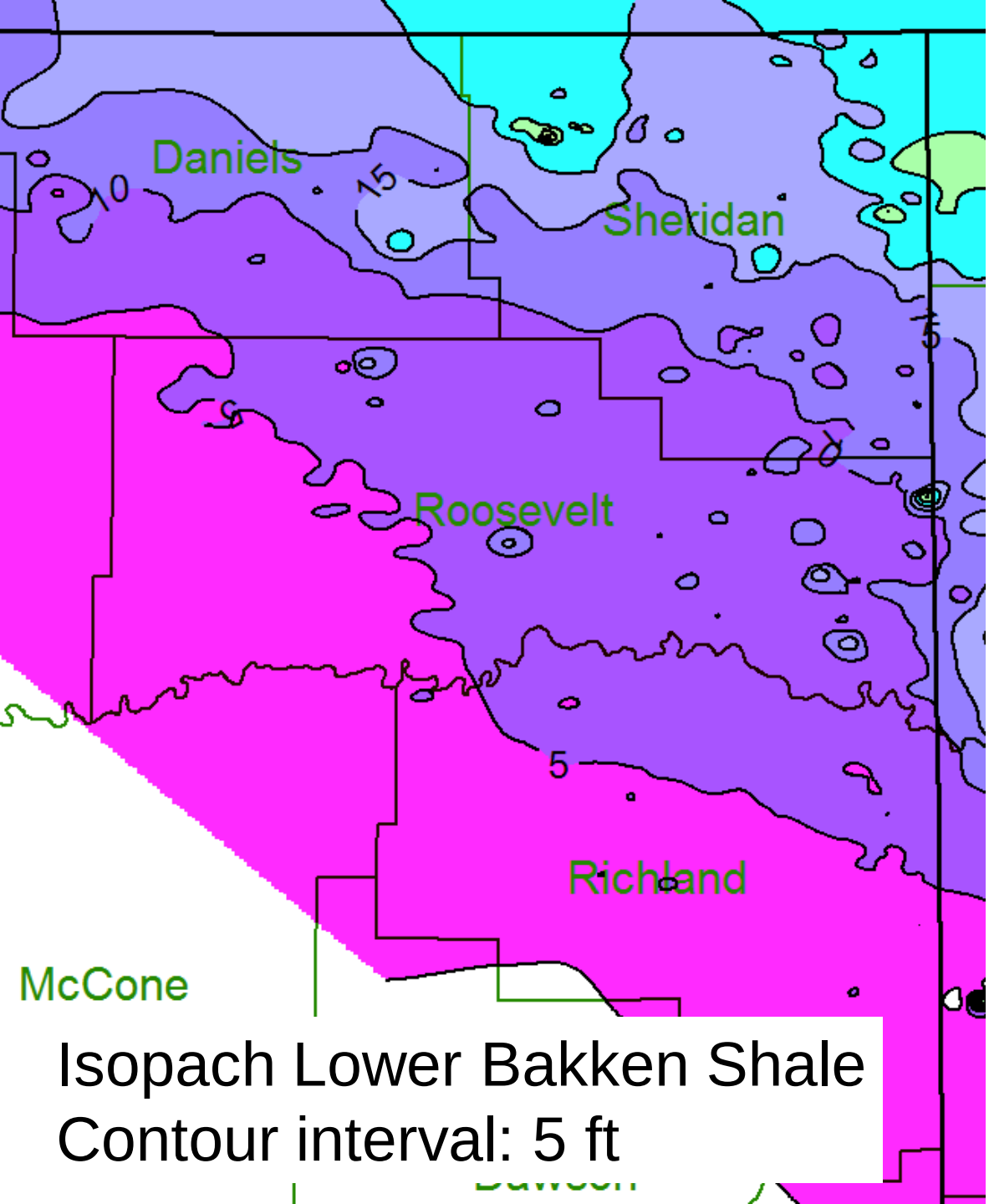
"any restricted reservoir in direct contact with either of the two shale units should be productive anywhere in the deeper part of the basin, regardless of structural position"

"one of the most important conclusions is the recognition that the upper and lower Bakken shale beds are supercharged oil shales and that they probably are the immediate source of most of the oil"

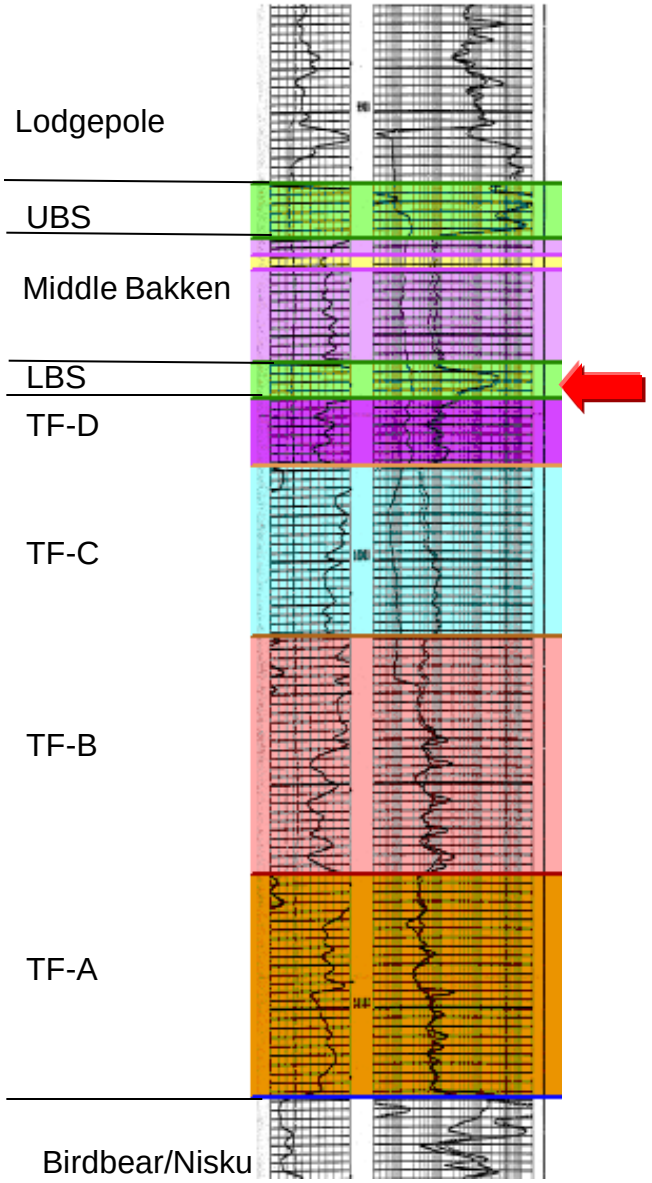


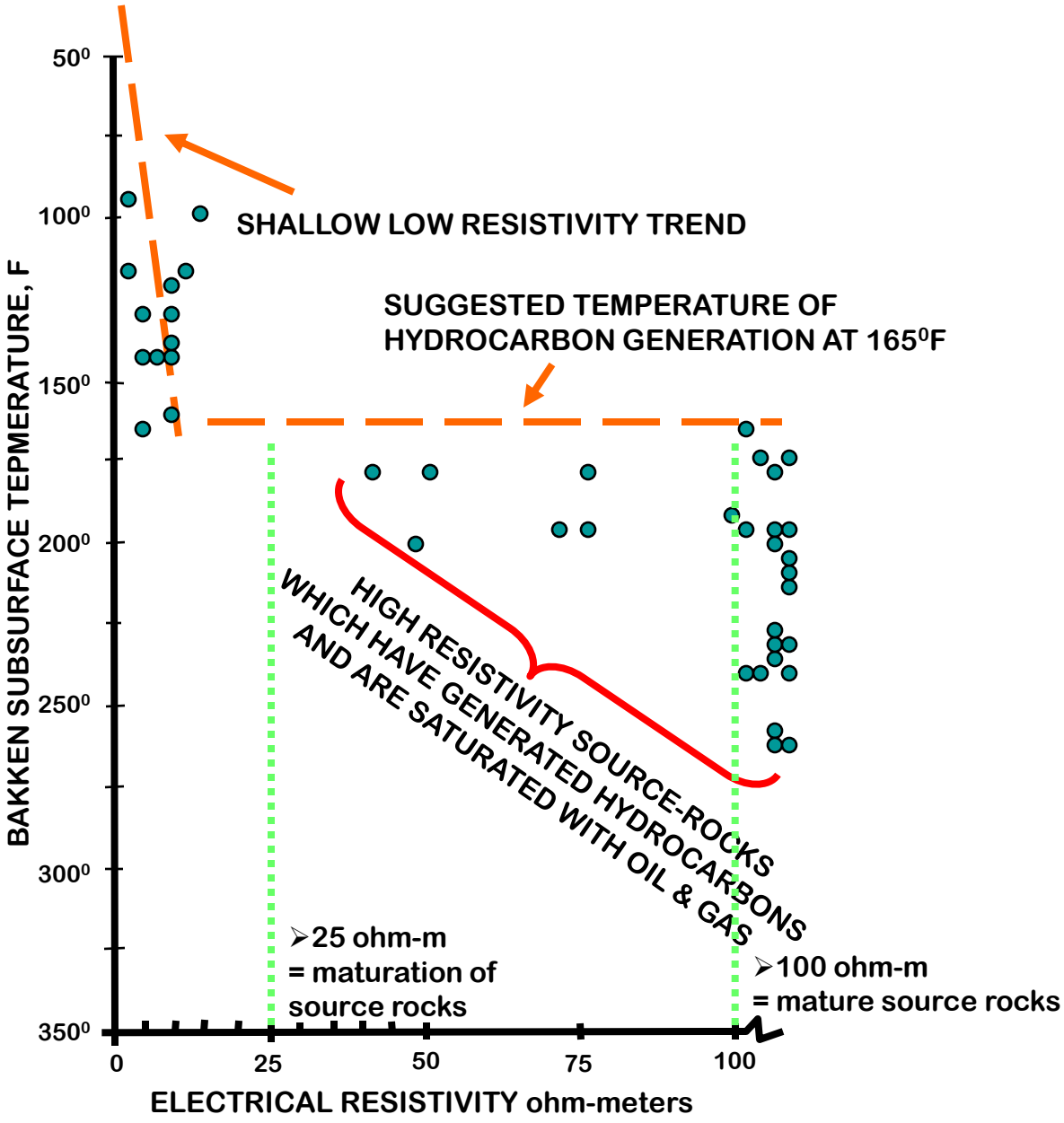
Isopach Upper Bakken Shale
Contour interval: 5 ft





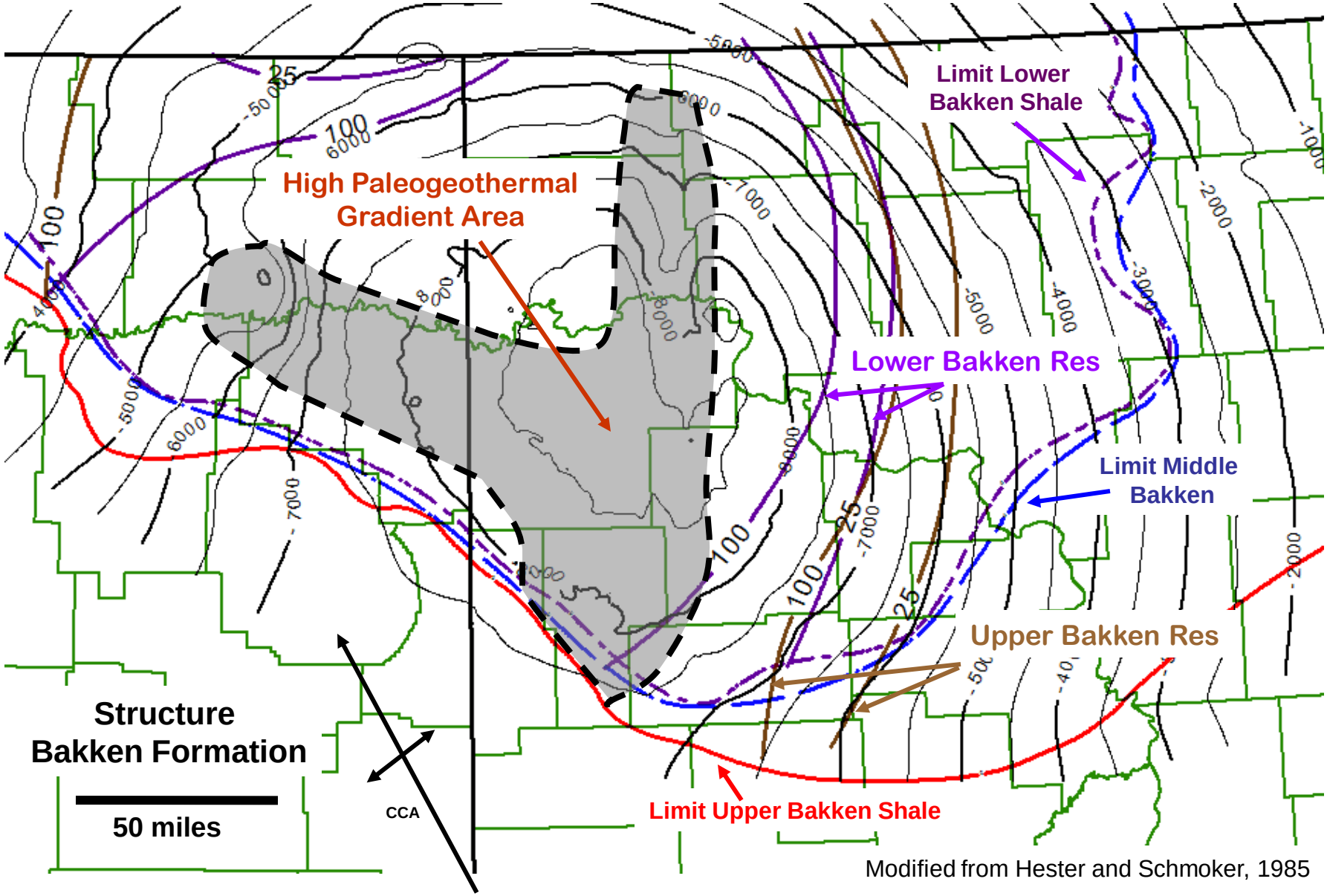
Isopach Lower Bakken Shale
Contour interval: 5 ft



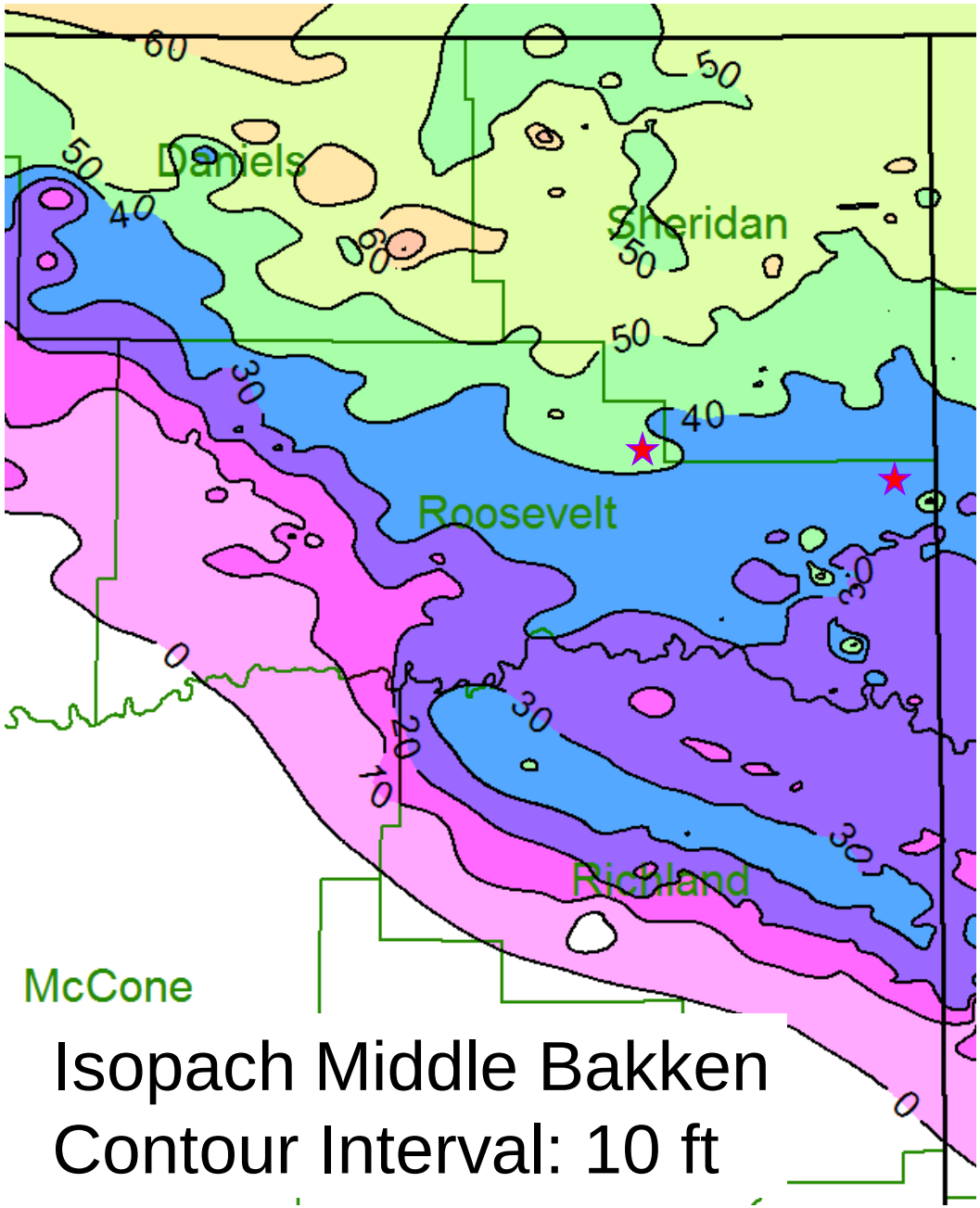


- Suggested temperature of HC generation = 165°F or 74°C

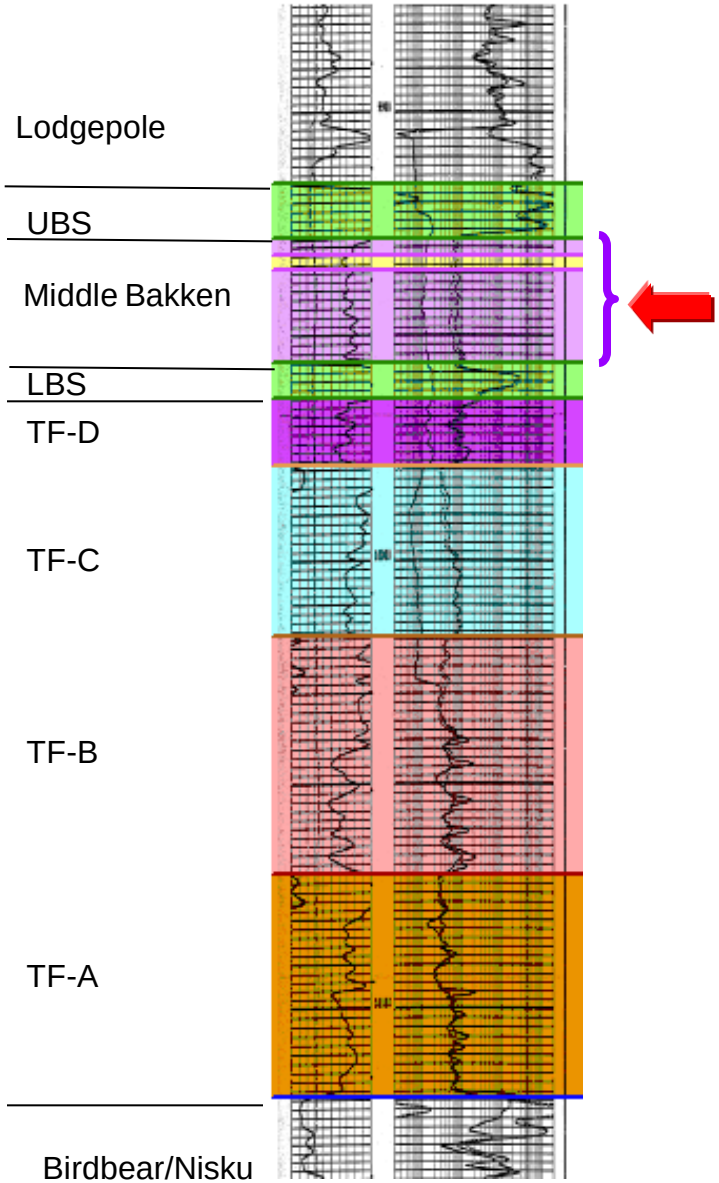
Modified from Meissner, 1978



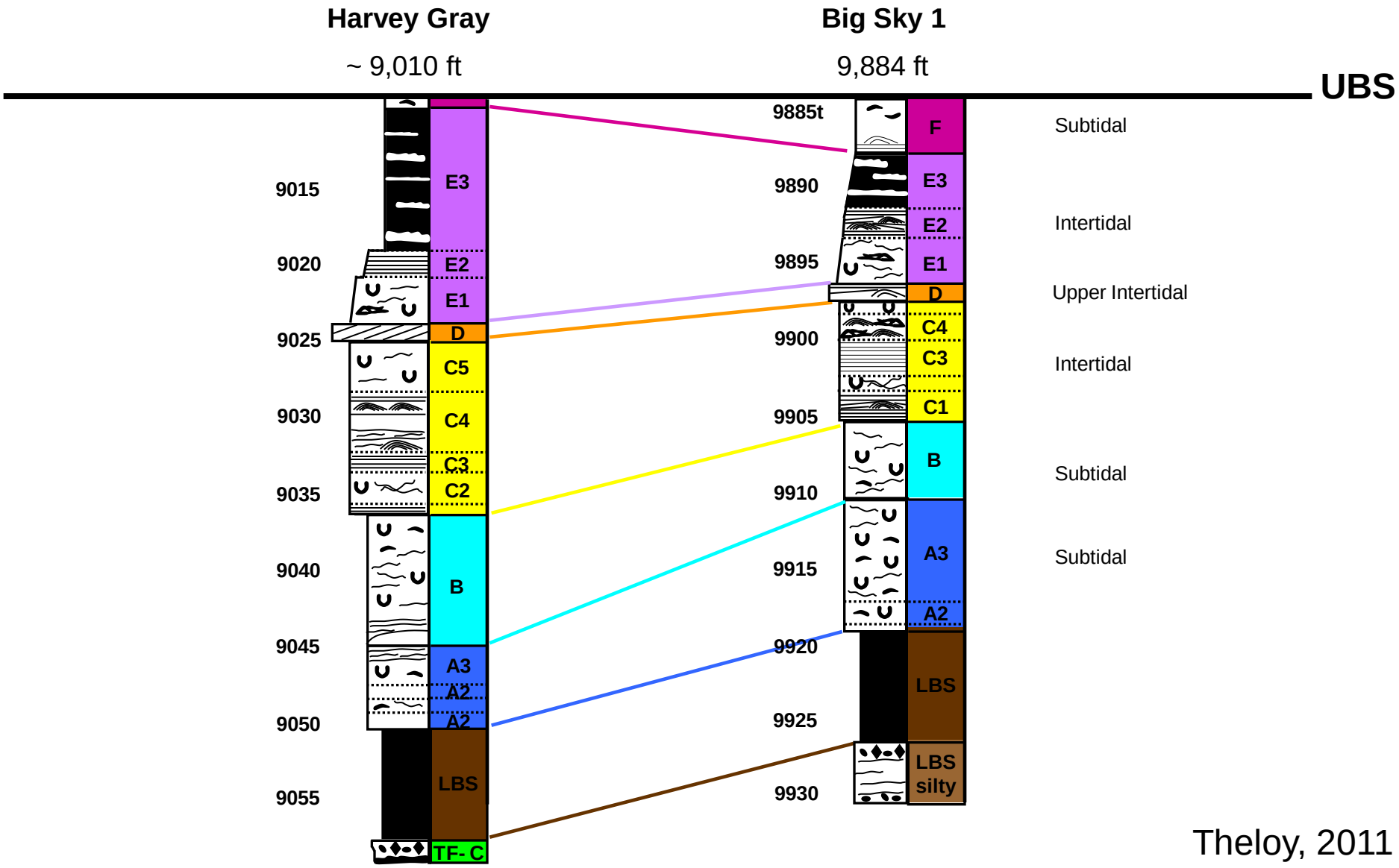
Resistivities Bakken Shales



Isopach Middle Bakken
Contour Interval: 10 ft

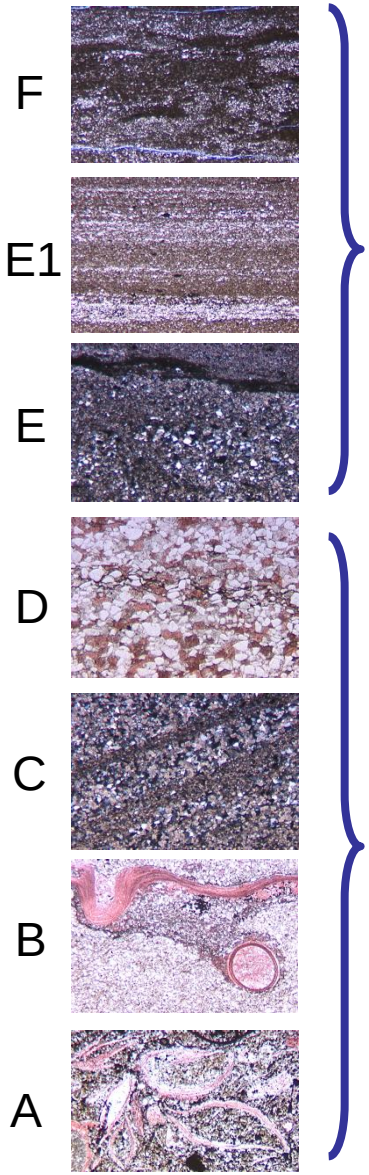


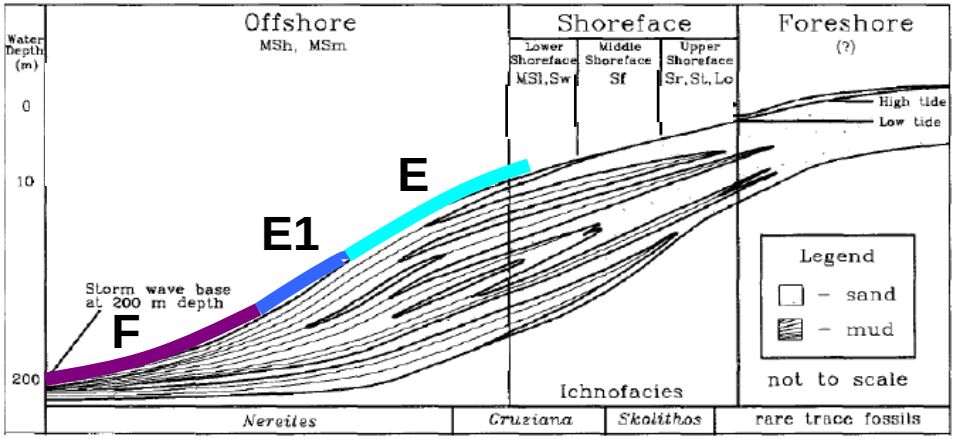
Correlation cross-section



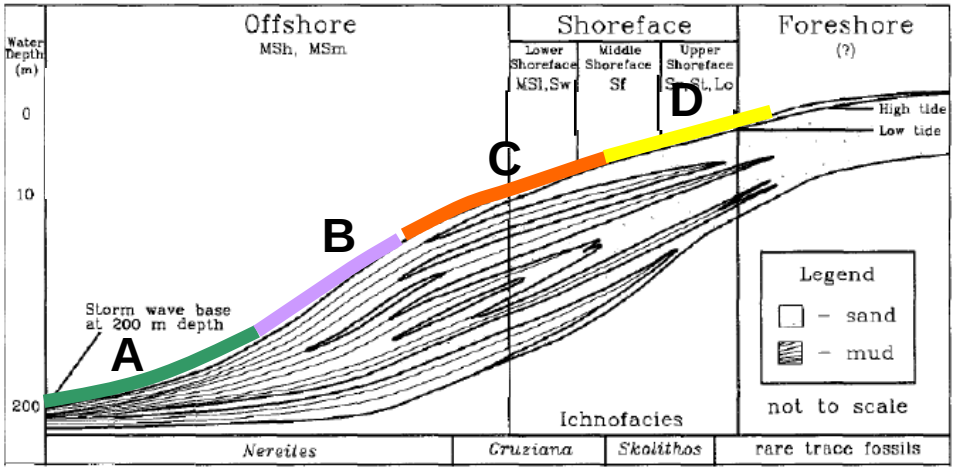
Theloy, 2011

Depositional Environment: Shallow Shelf





sea level rise

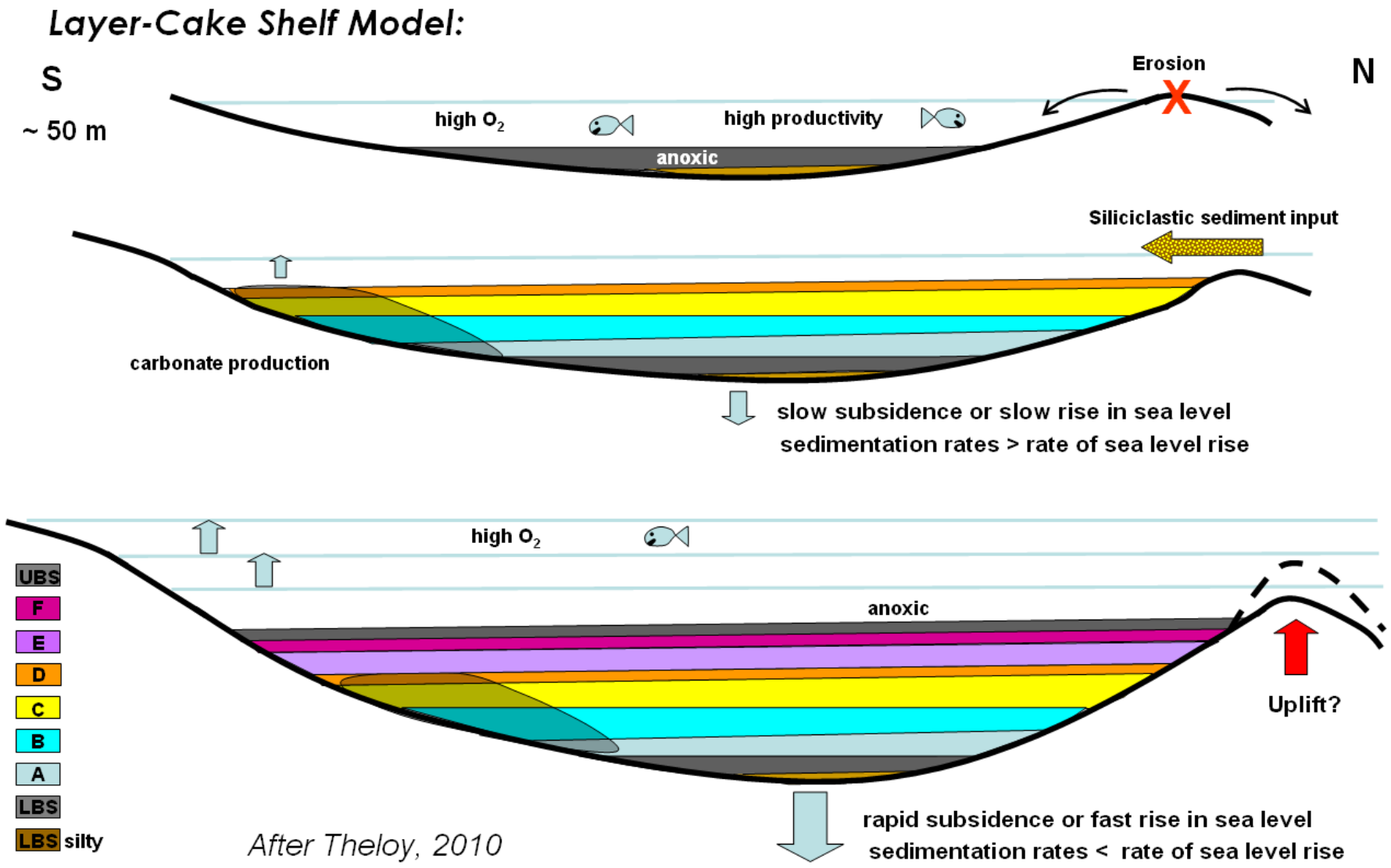


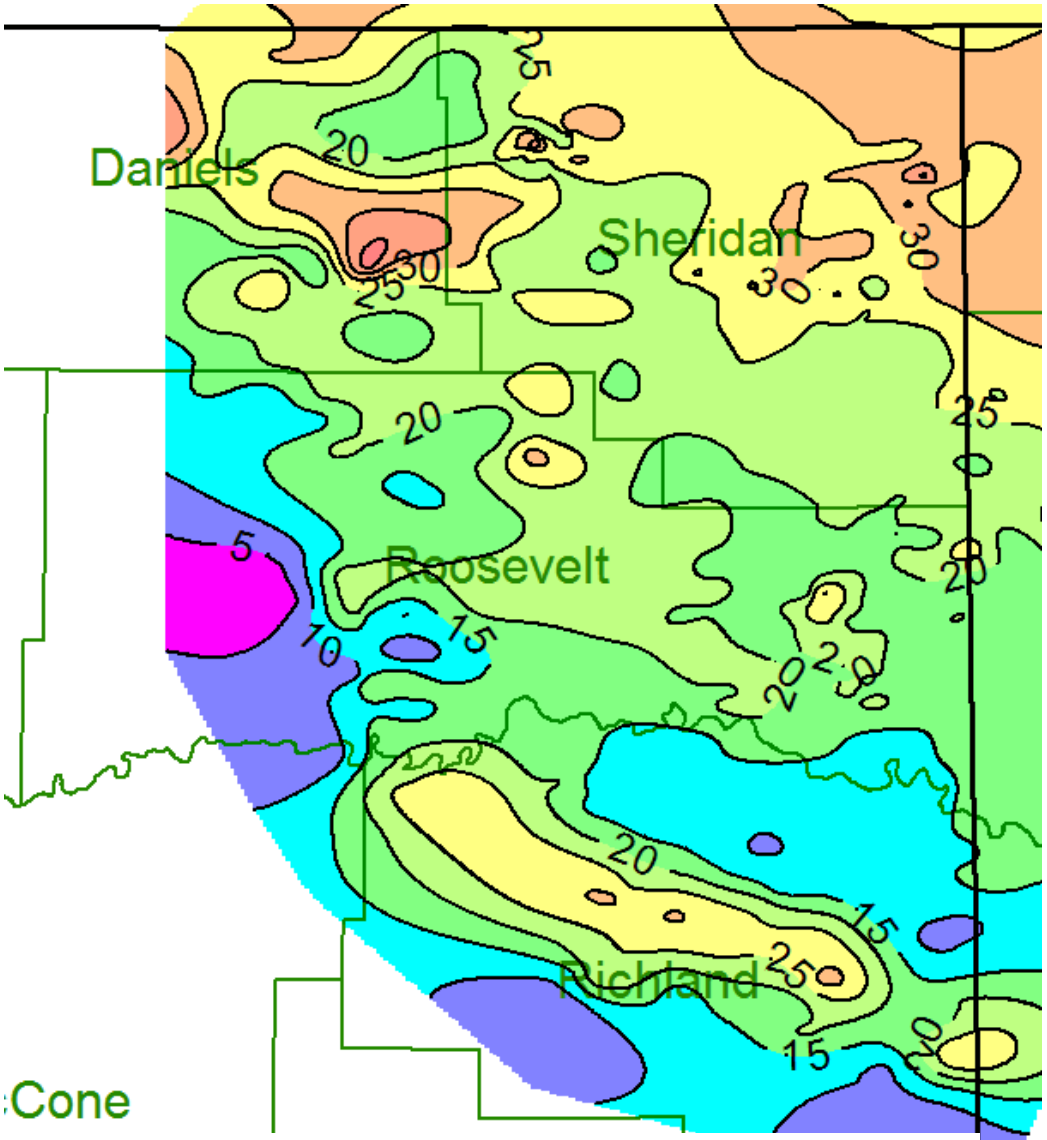
sea level drop

after Walker and Plint (1992) from Smith and Bustin, 1996

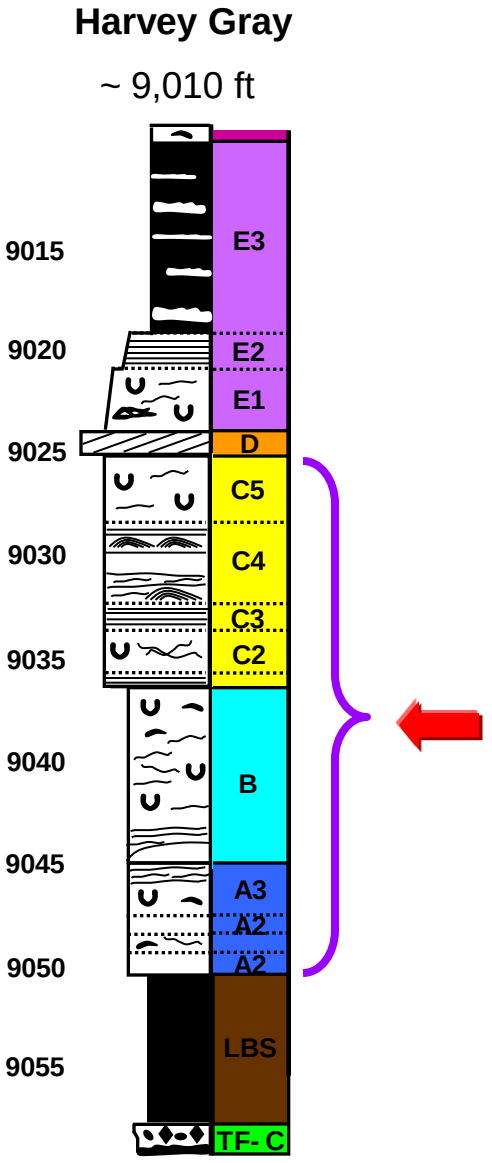
Theloy, 2010

Depositional Environment: Shallow Shelf

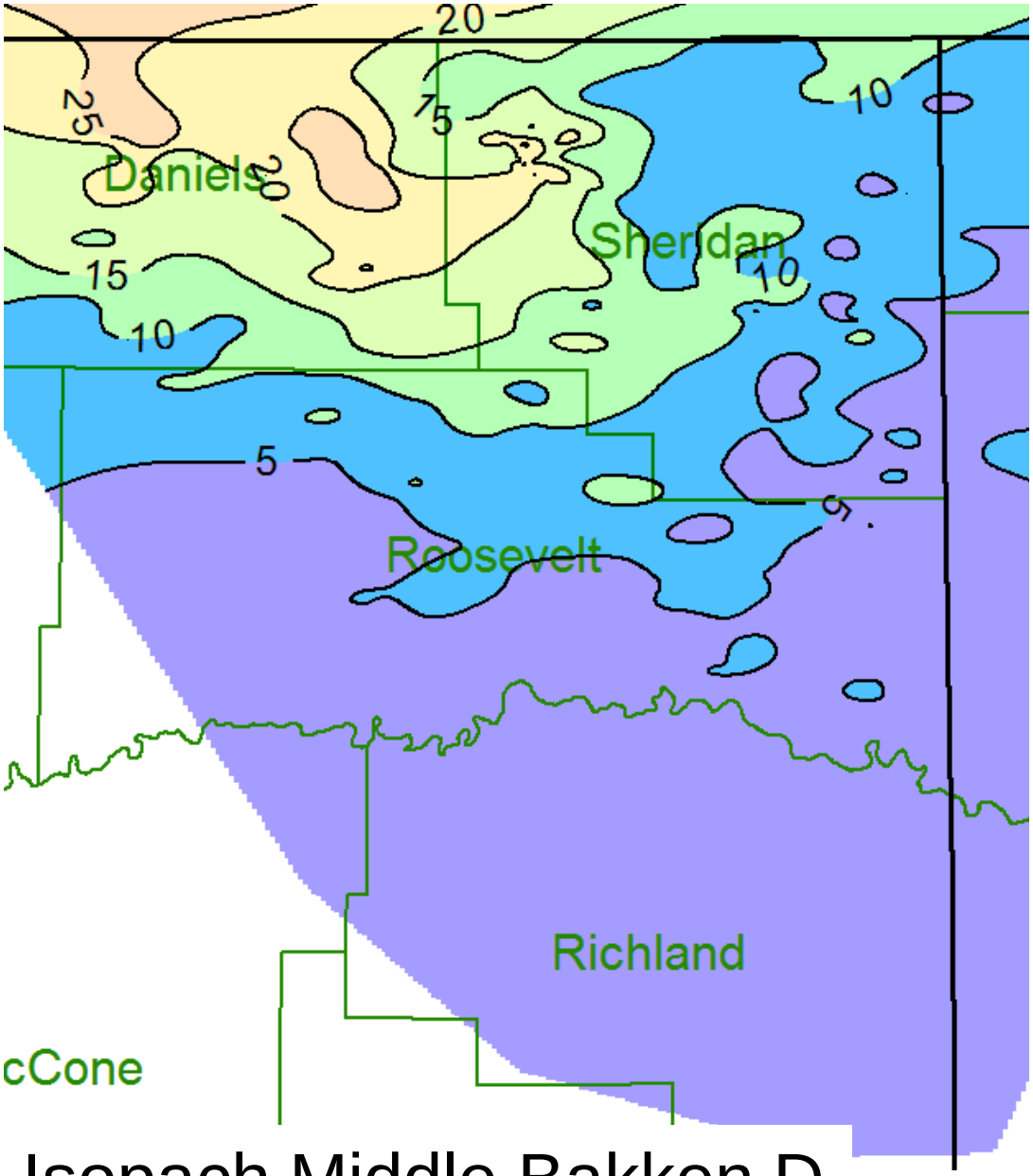


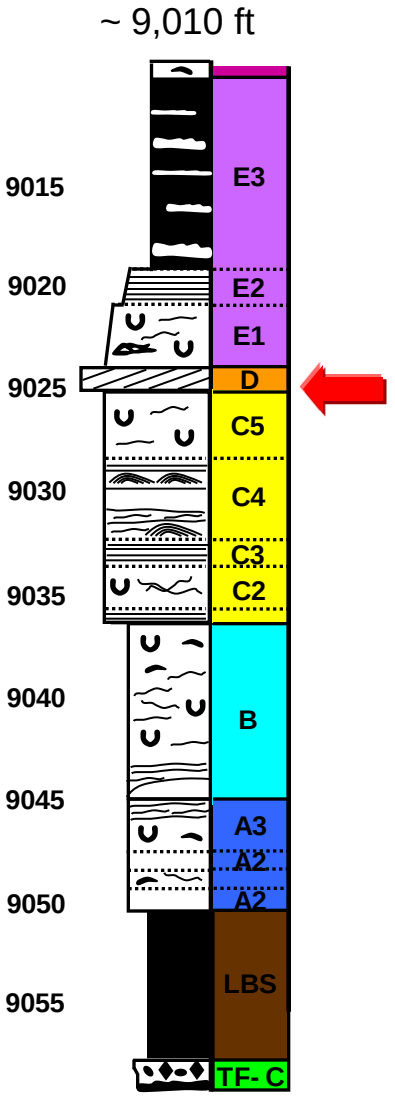


Isopach Middle Bakken A-C
Contour interval: 5 ft



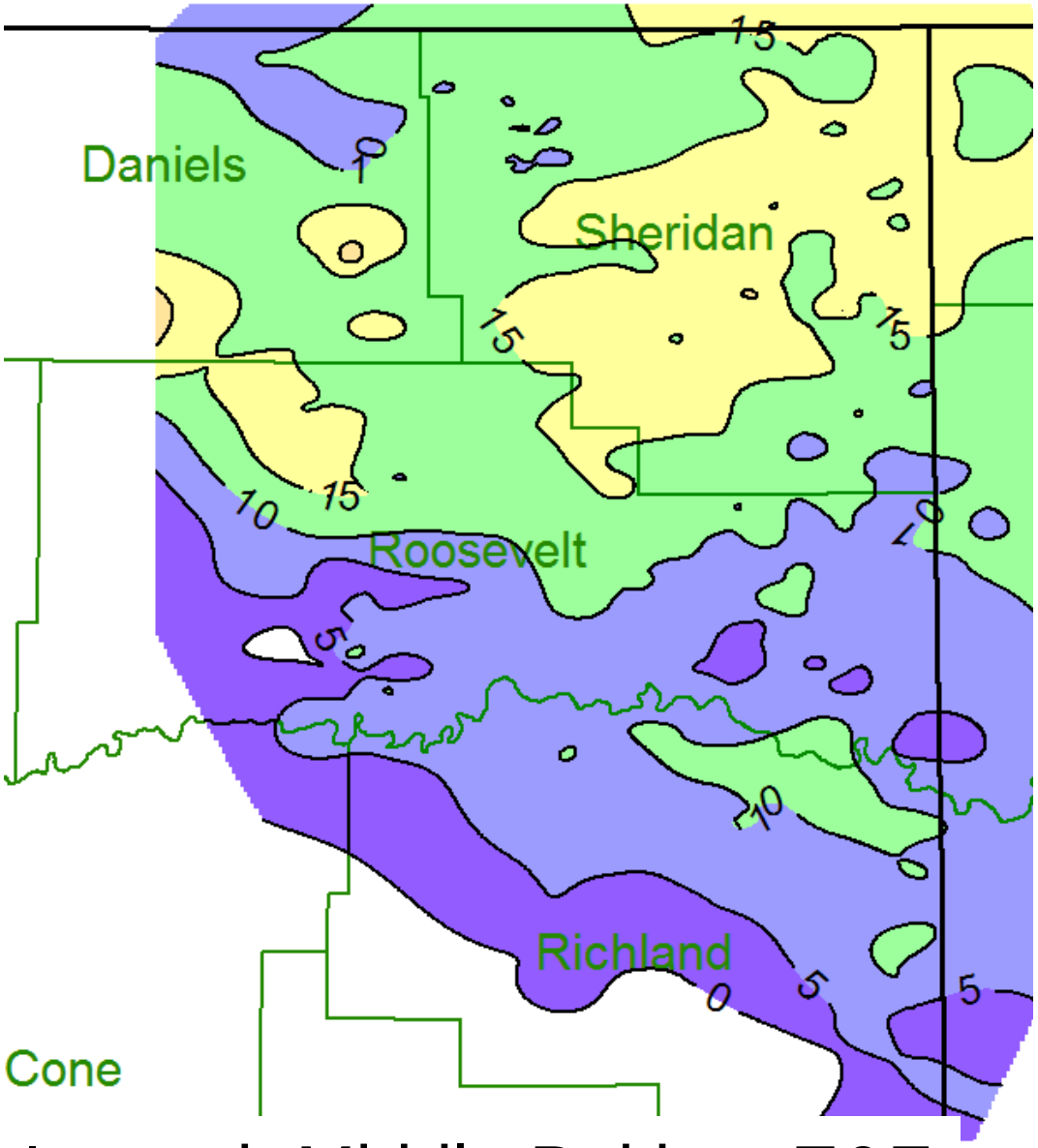
Theloy, 2011

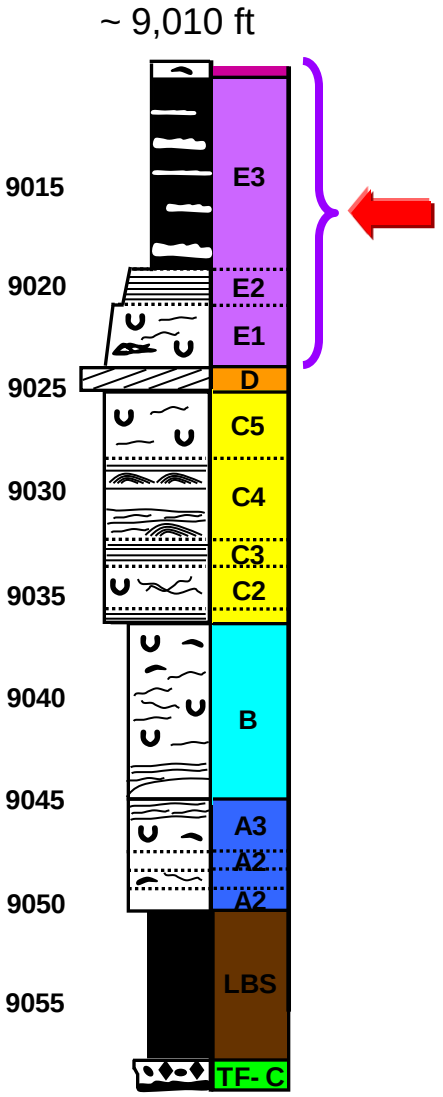




Theloy, 2011

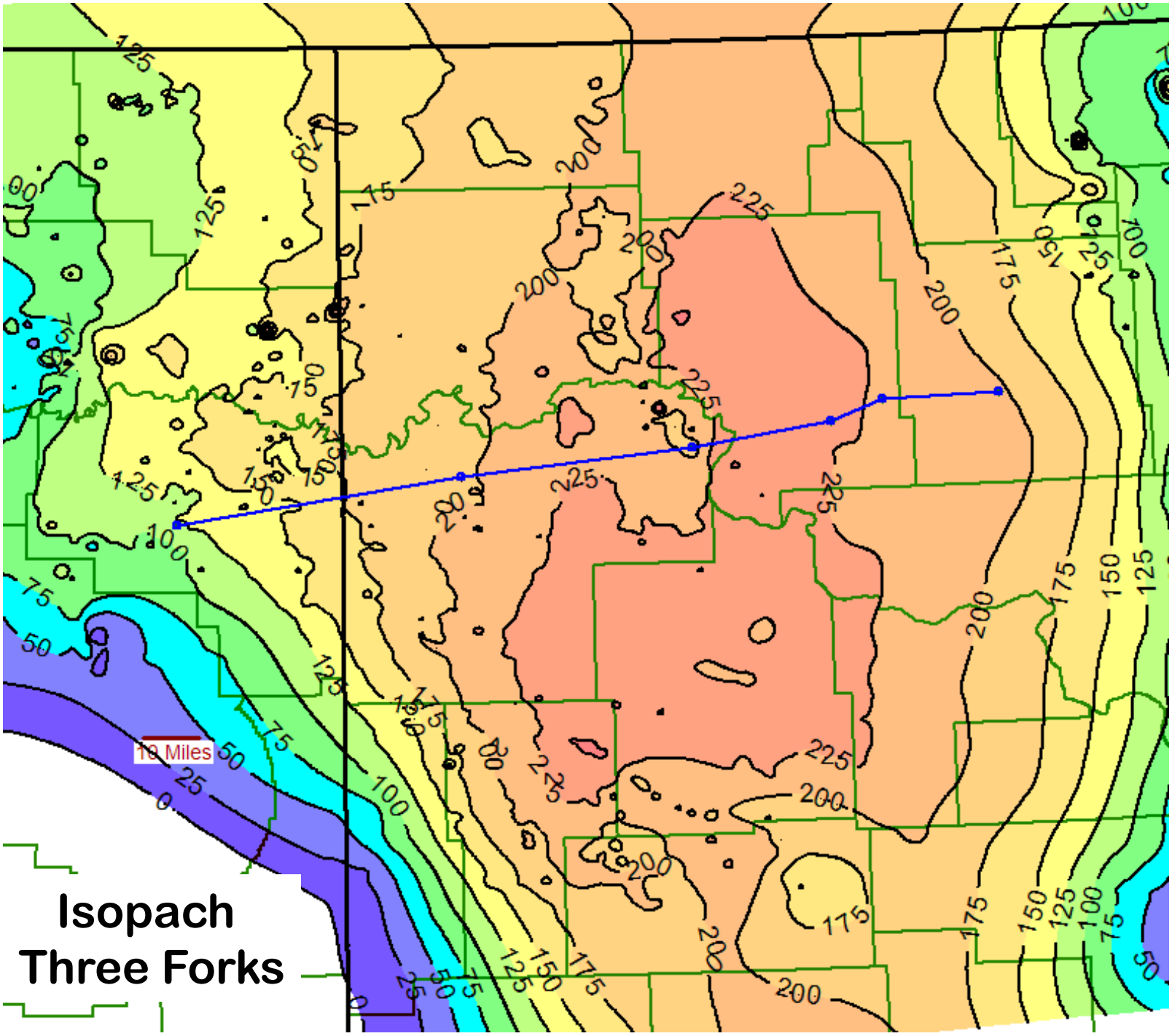
Isopach Middle Bakken D
Contour interval: 5 ft

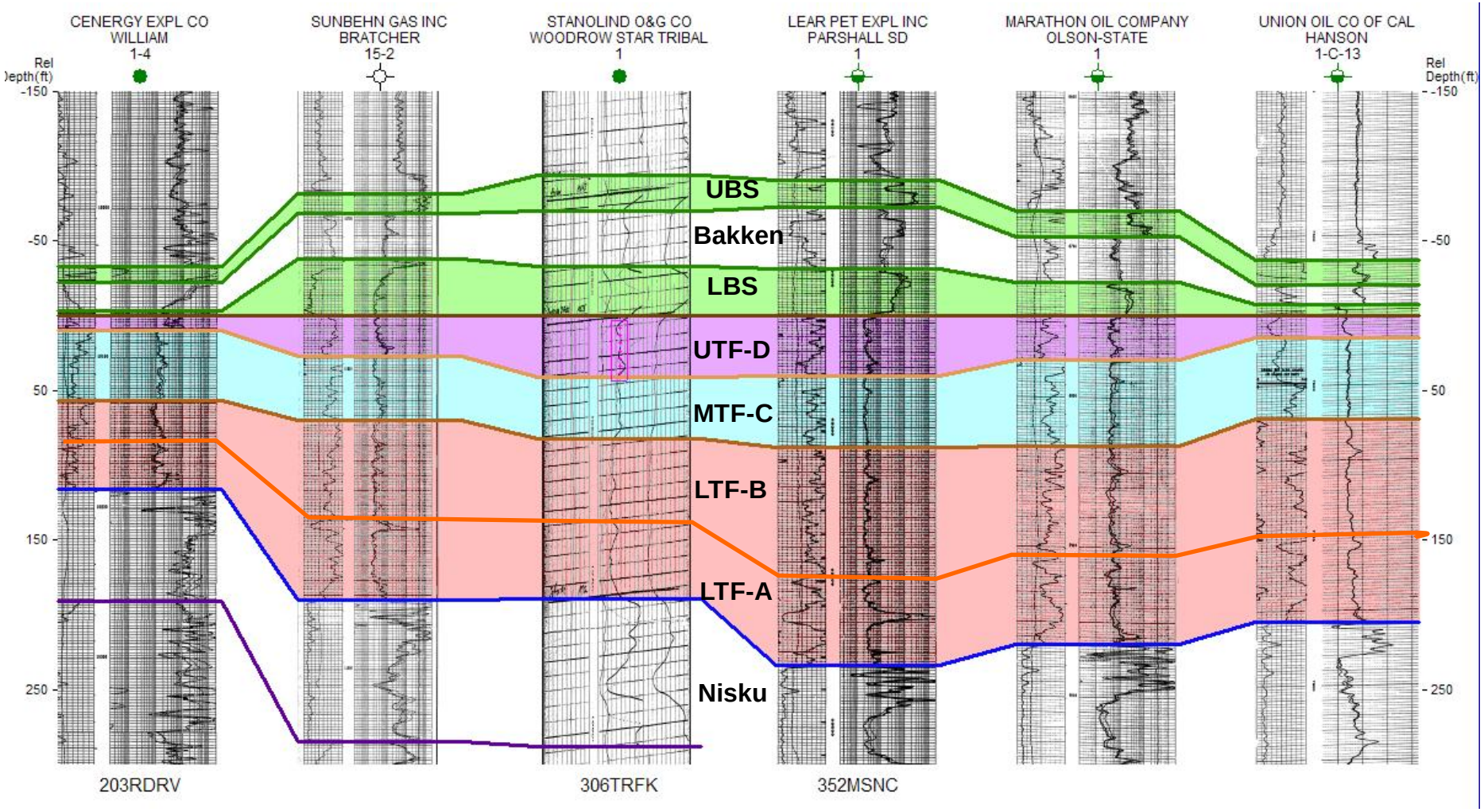


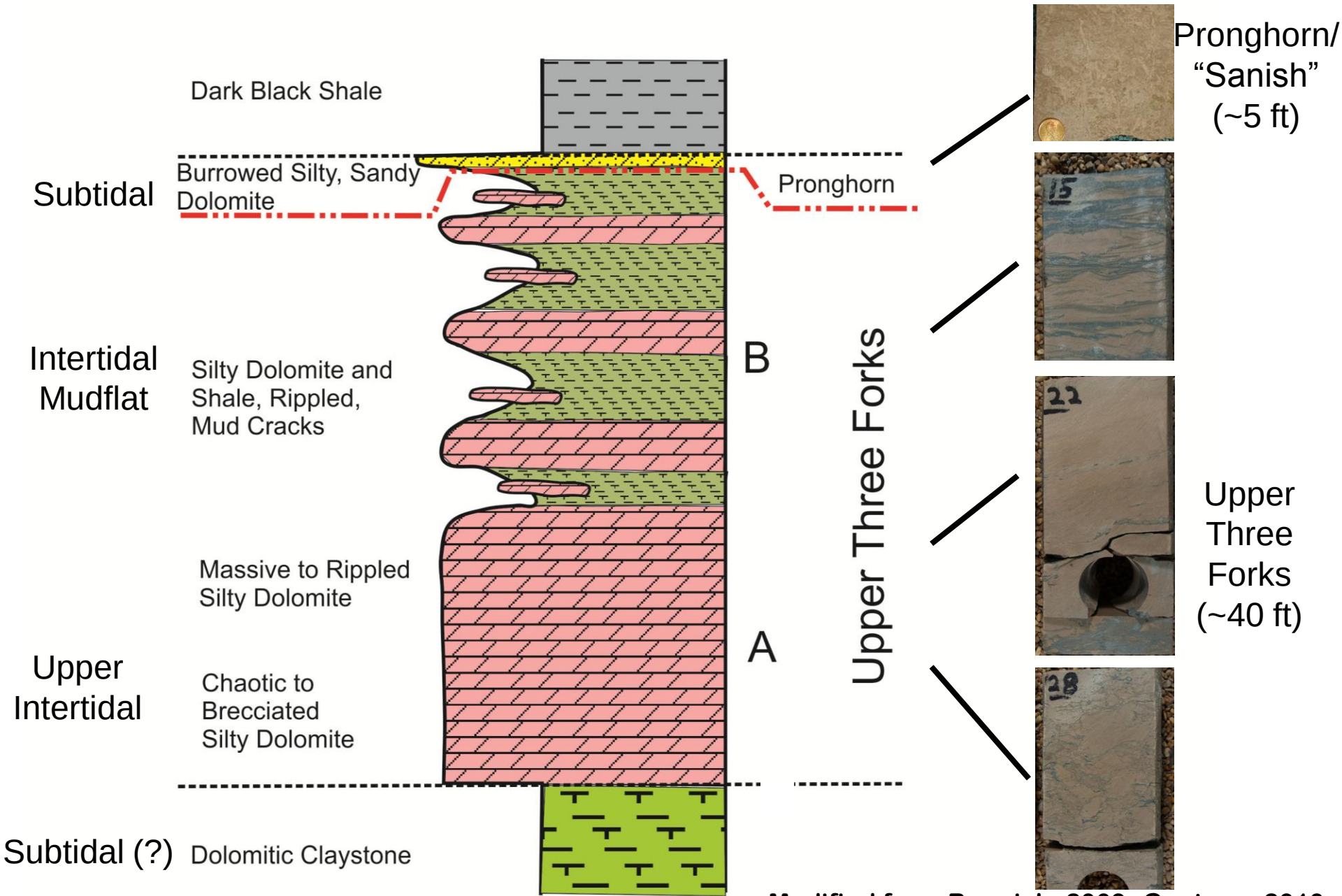


Theloy, 2011

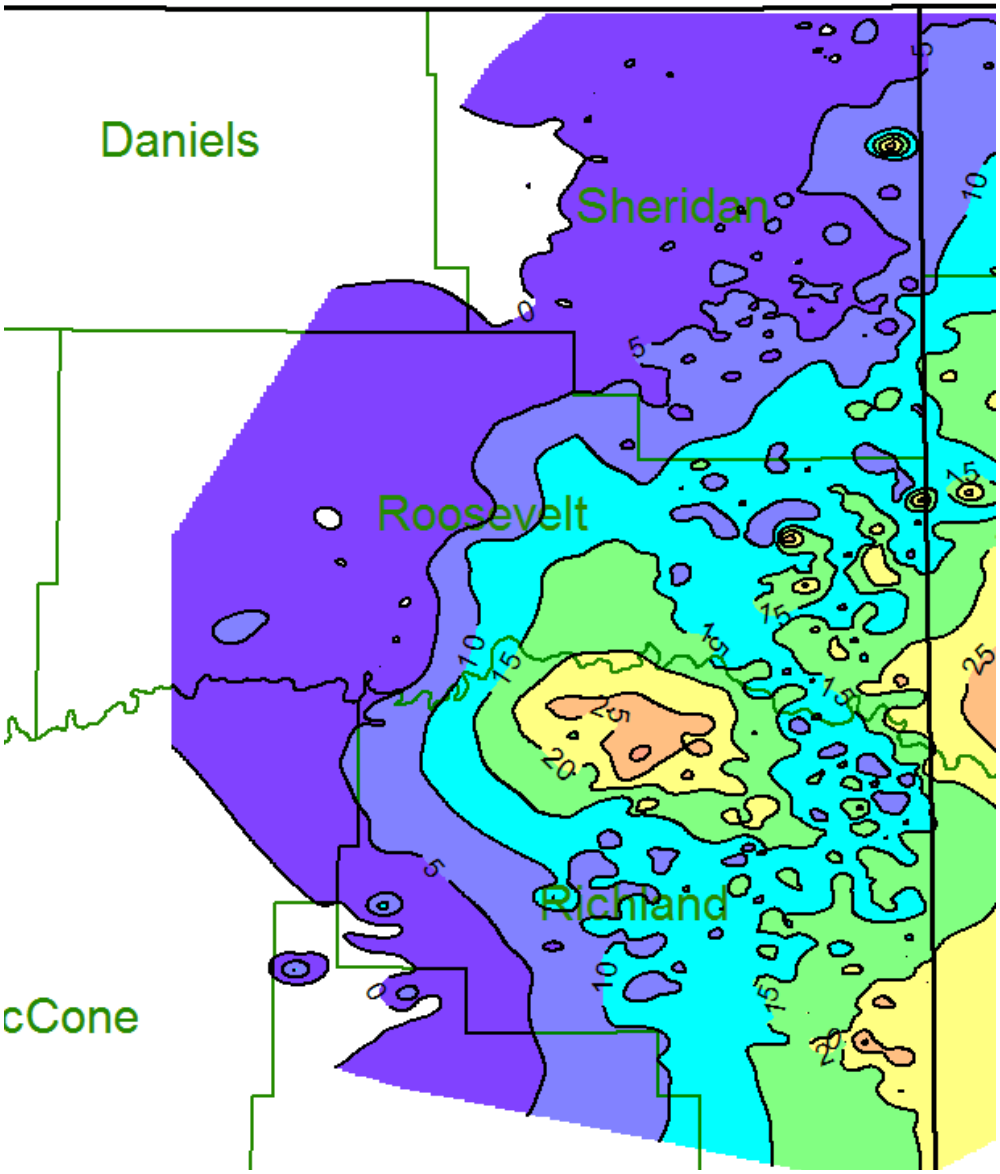
Isopach Middle Bakken E&F
Contour interval: 5 ft

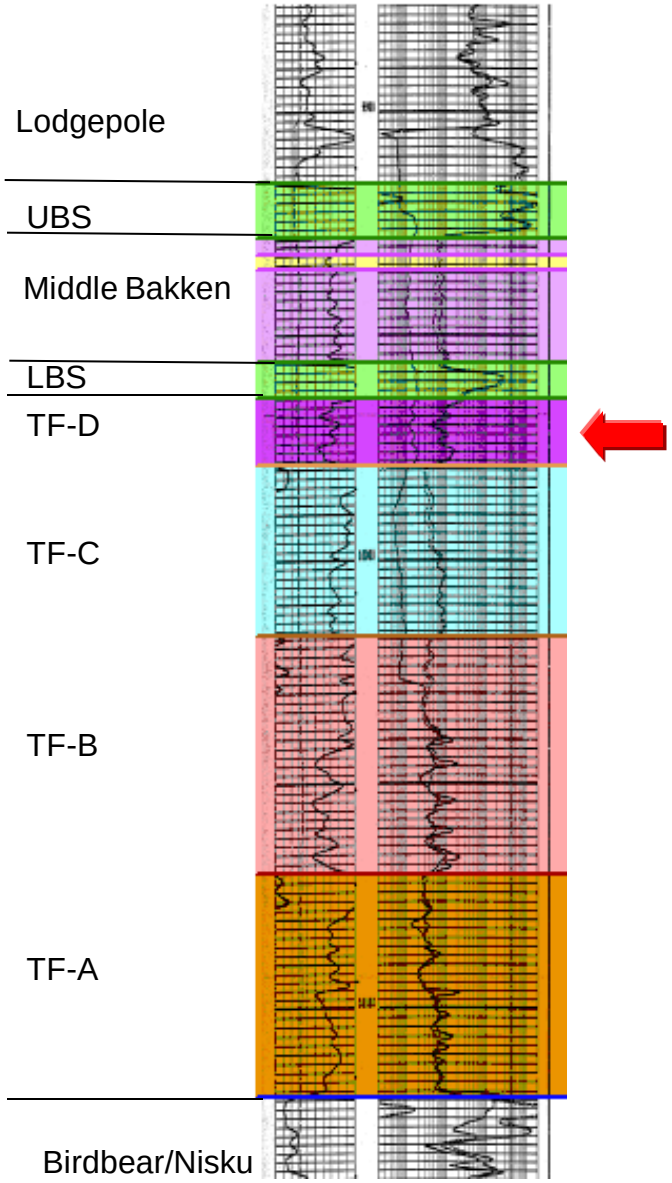

10 Miles
Isopach
Three Forks


CENERGY EXPL CO
WILLIAM
1-4
SUNBEHN GAS INC
BRATCHER
15-2
STANOLIND O&G CO
WOODROW STAR TRIBAL
1
LEAR PET EXPL INC
PARSHALL SD
1
MARATHON OIL COMPANY
OLSON-STATE
1
UNION OIL CO OF CAL
HANSON
1-C-13
Rel
Depth(ft)
-150
-50
50
150
250
UBS
Bakken
LBS
UTF-D
MTF-C
LTF-B
LTF-A
Nisku
203RDRV
306TRFK
352MSNC

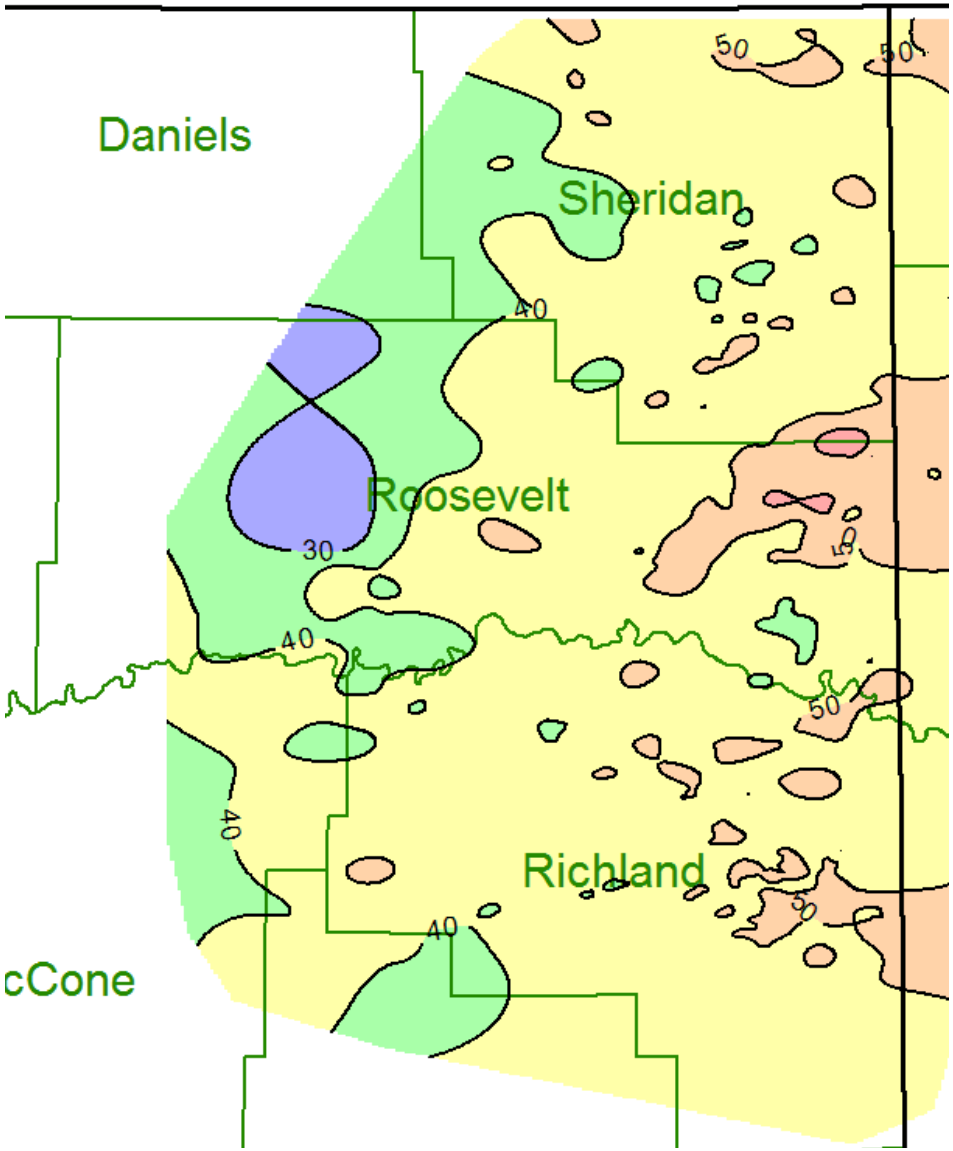


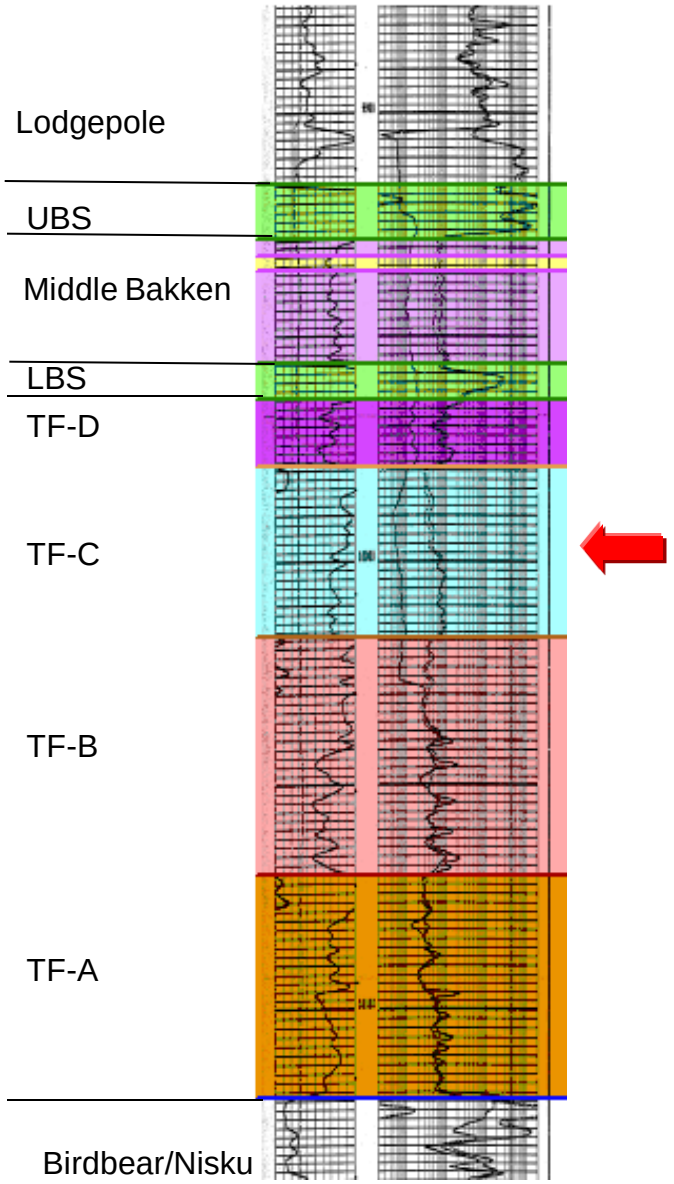
Modified from Berwick, 2009; Gantyno, 2010





Isopach Upper Three Forks
Contour interval: 5 ft





Isopach Middle Three Forks

Contour interval: 10 ft

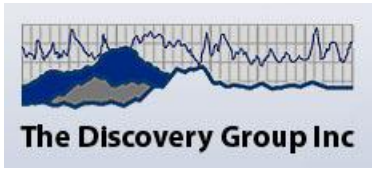
Meissner, 1978

"Relationship between source-rock maturity, hydrocarbon generation, geopressuring and fracturing suggest an opportunity in exploration for unrecognized and unlooked-for "unconventional" accumulations of potentially very large regional extent"

Summary NE Montana

- Mature source rocks over large area
- Favorable facies present in Middle Bakken and Three Forks
- New Bakken drilling north of Elm Coulee with good initial potentials
- Elm Coulee extensions
- Wolf Creek, Poplar areas
- Brockton-Froid FS fuzzy LOD

Colorado School of Mines
Bakken Consortium



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Bakken/Three Forks Tight Oil Resource Play

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