2008
U.S. Geological Survey Petroleum Resource Assessment
of the
Bakken Formation,
Williston Basin Province, Montana & North Dakota

U.S. Department of the Interior
U.S. Geological Survey

April 2008

Energy Policy and Conservation Act (EPCA) Amendments of 2000

Public Law 106–469, SEC. 604. SCIENTIFIC INVENTORY OF OIL AND GAS RESOURCES.

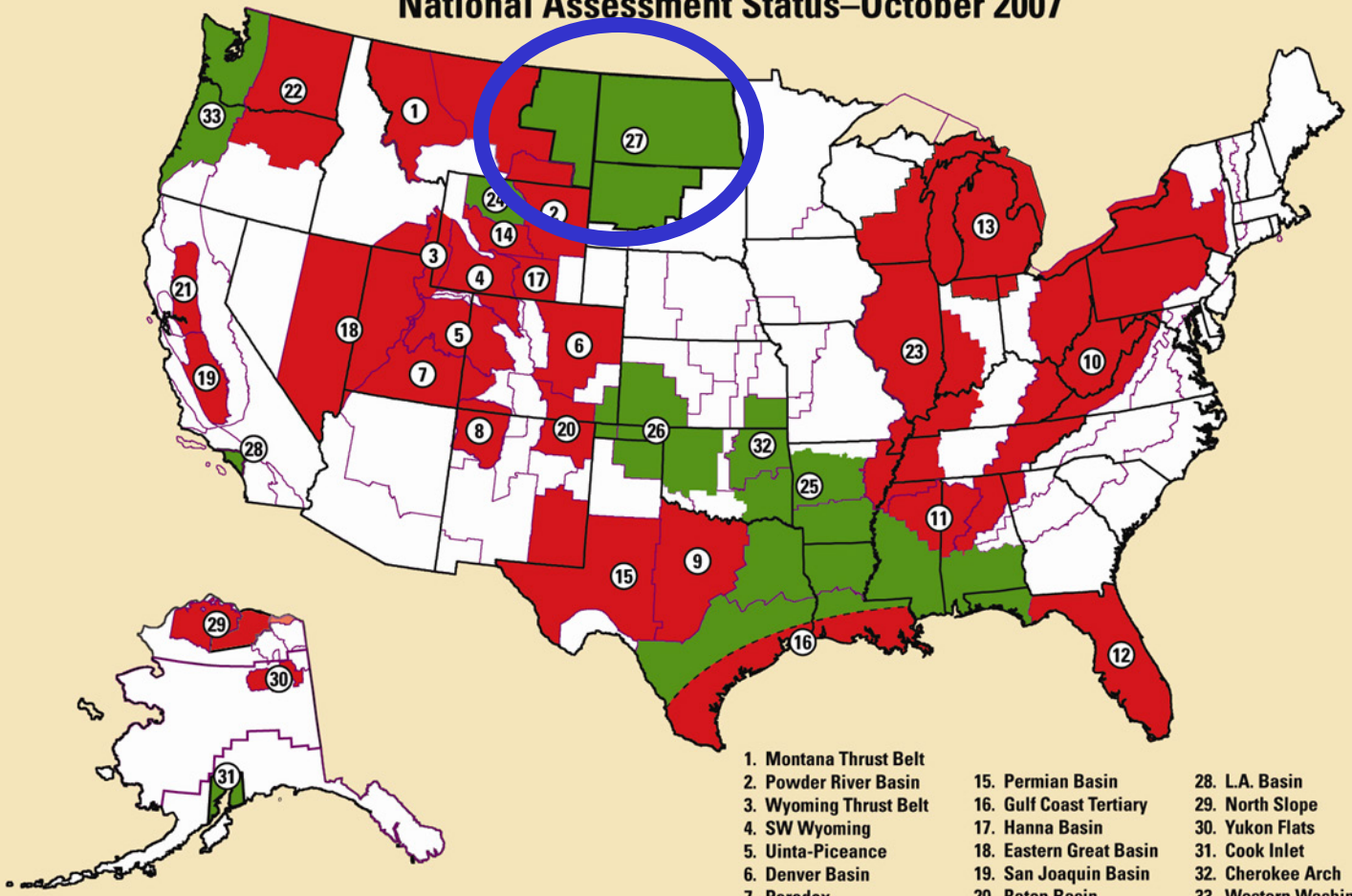
(a) IN GENERAL.—The Secretary of the Interior, in consultation with the Secretaries of Agriculture and Energy, shall conduct an inventory of all onshore Federal lands. The inventory shall identify—
(1) the United States Geological Survey resource estimates of the oil and gas resources underlying these lands; and
(2) the extent and nature of any restrictions or impediments to the development of such resources.
(b) REGULAR UPDATE.—Once completed, the USGS resource estimates and the surface availability data as provided in subsection (a)(2) shall be regularly updated and made publicly available.

The Williston Basin is an EPCA priority basin

Photo by Don Thompson (Source-Montana Oil & Gas Commission)

USGS

National Assessment Status–October 2007



Assessed

Ongoing Assessments

1. Montana Thrust Belt
2. Powder River Basin
3. Wyoming Thrust Belt
4. SW Wyoming
5. Uinta-Piceance
6. Denver Basin
7. Paradox
8. San Juan
9. Dallas–Ft. Worth
10. Appalachian
11. Black Warrior
12. Peninsula Florida
13. Michigan Basin
14. Wind River Basin
15. Permian Basin
16. Gulf Coast Tertiary
17. Hanna Basin
18. Eastern Great Basin
19. San Joaquin Basin
20. Raton Basin
21. Sacramento Basin
22. E. Washington - Oregon Basin
23. Illinois Basin
24. Big Horn Basin
25. Acoma Basin
26. Anadarko Basin
27. Williston Basin
28. L.A. Basin
29. North Slope
30. Yukon Flats
31. Cook Inlet
32. Cherokee Arch
33. Western Washington–Oregon

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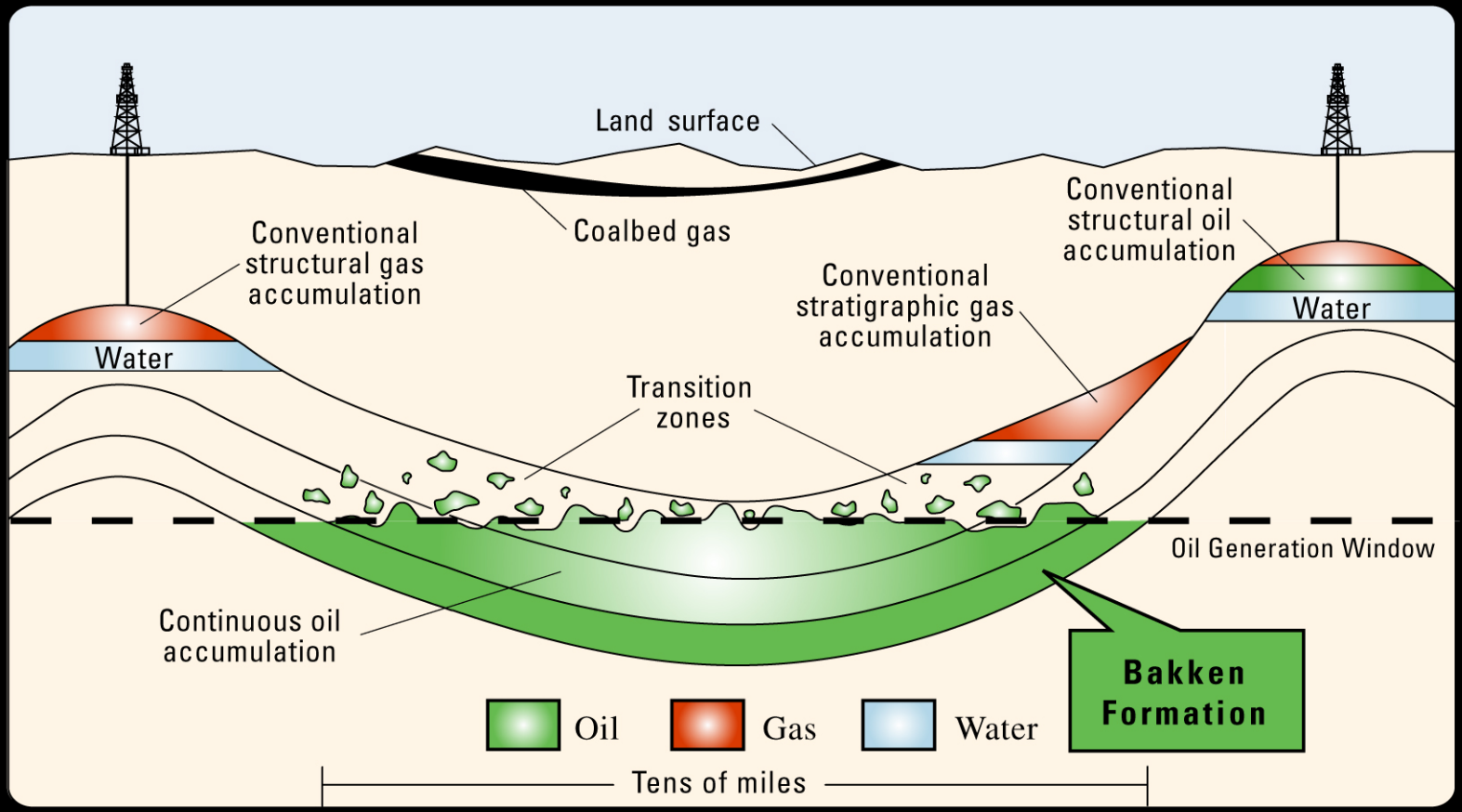
Conventional vs Continuous Resources

Continuous Shale Accumulations



REQUIREMENT… the shale is now, or was at sometime in its history, within the oil or gas generation window

USGS

USGS Assessment Methodology

For Continuous-Type Accumulations

1. **Based on Geology and Geological Models**
2. **Identify and Outline Total Petroleum System(s)**
3. **Total Area and 'Cell' Area**
   - Drainage Area (Cells)
   - Numbers of Potential Cells of Undrilled Area
4. **Historical Exploration and Production Analyses**
   - Well-Performance Based – Time and Technology
   - EUR (Estimated Ultimate Recovery)
   - Success/Failure (Historical and Future Success Ratio)
5. **Undiscovered, Technically Recoverable Resource**
   - Not Economically Recoverable Resource Estimates
   - Not In-Place Resource Estimates
6. http://energy.cr.usgs.gov/oilgas/noga/methodology.html

Non USGS Cooperators

Meetings, Discussions, and Data

Industry

- Humble Geochemical
- Rose Exploration
- EOG Resources
- Whiting Petroleum
- Tethys Geoscience
- Hohn Engineering
- Kodiac Oil & Gas
- Headington Oil
- St. Mary Land & Exploration (formerly Nance Petroleum)
- Discovery Group
- Frontier
- Consulting Geologists

State and others

- North Dakota Geological Survey
- Northern Alliance of Independent Producers

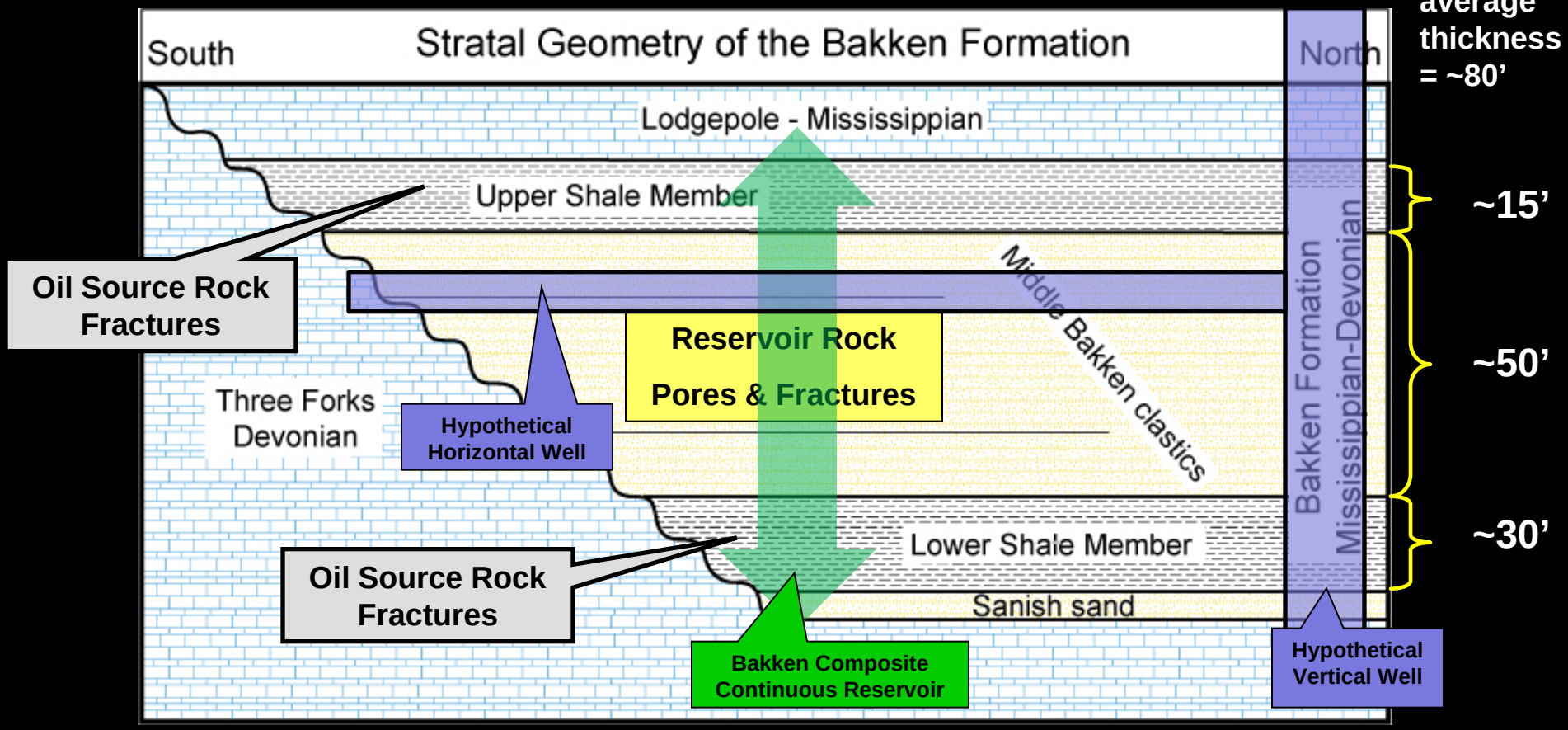
Universities

- Colorado School of Mines
- University of British Columbia

Bakken Formation

Stratigraphic Cross Section Relations

Average production depth = 9,000-10,000’



Bakken Formation is only in the subsurface and consists of three members, which comprise the Bakken composite continuous reservoir.

Modified from LeFever (2006)

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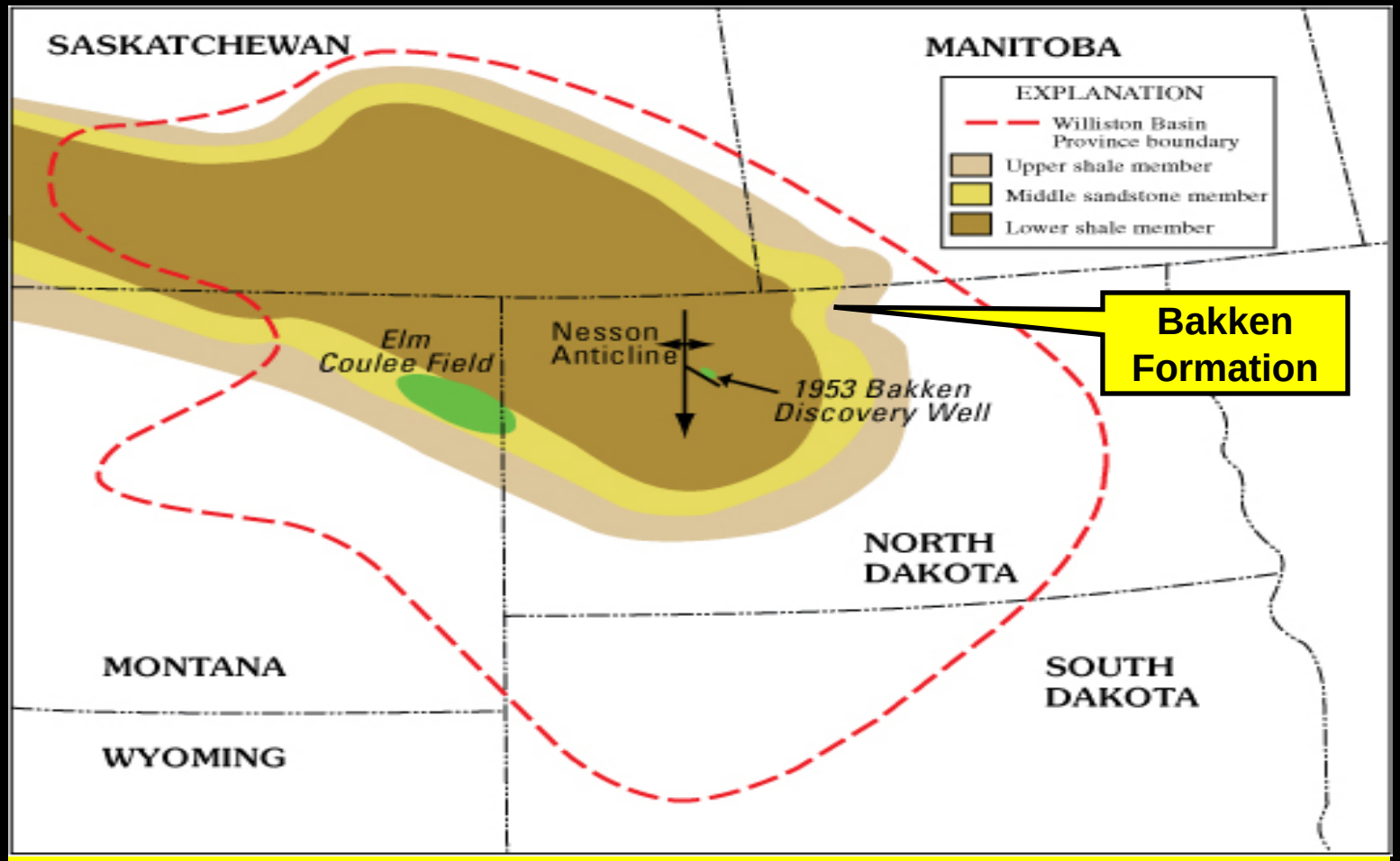
Bakken Formation, U.S. Williston Basin

The Bakken Formation was deposited in the more central and deeper portion of the Williston Basin, Montana and North Dakota



Each succeeding member of the Bakken Formation is of greater areal extent.

Modified from Walker and others (2006)

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Renewed Bakken Interest

- Exploration and Production ‘Cycles’ Since 1953
- 2000 Elm Coulee Field (MT) Discovery and Success
- Technical Advances In Horizontal Drilling (such as Barnett Shale) – “Technology Plays”
- 2006 ‘Surprise’ Discovery at Parshall – “Oil Generation Window?”
- Subsequent Successes by Whiting, Marathon, Hess, etc.
- The Price of Oil

Key Geologic Factors Defining Variability in Bakken Production

1. Oil Generation
- Where, When and What Level?
- Not How Much!

2. Fractures
- Vertical
- Horizontal – “Expulsion”

3. Structural Features
- Anticlines
- Faults and Lineaments
- Underlying Salt Movement

4. Thickness of Formation
- Reservoir Net Pay

5. Porosity of Middle Sandstone Member/Sanish Sand
- Dolomite
- Sandstone

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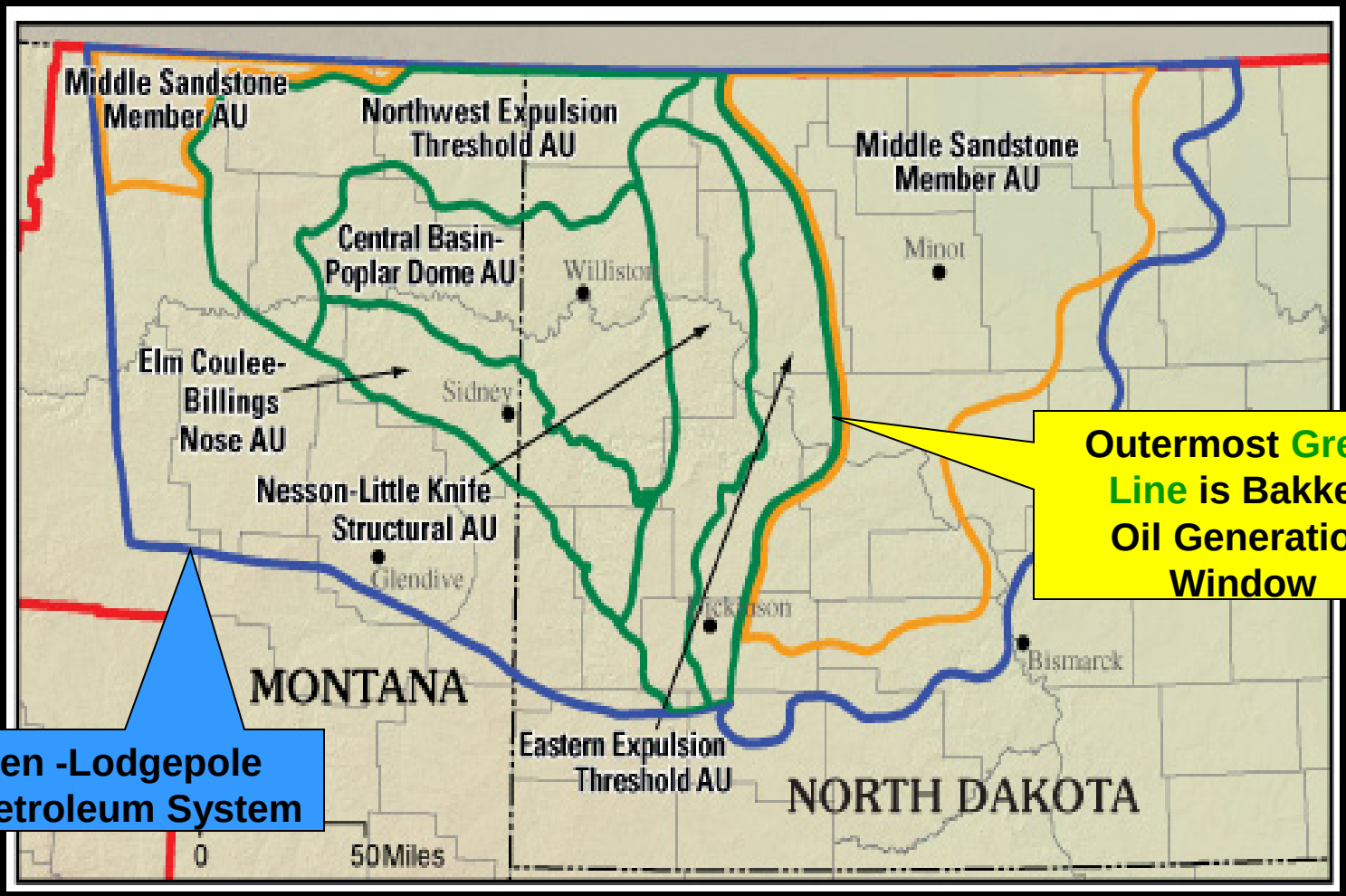
Bakken Formation Assessment Units (AU)

Application of the Bakken Oil Generation Window



Outermost Green Line is Bakken Oil Generation Window

Bakken -Lodgepole Total Petroleum System

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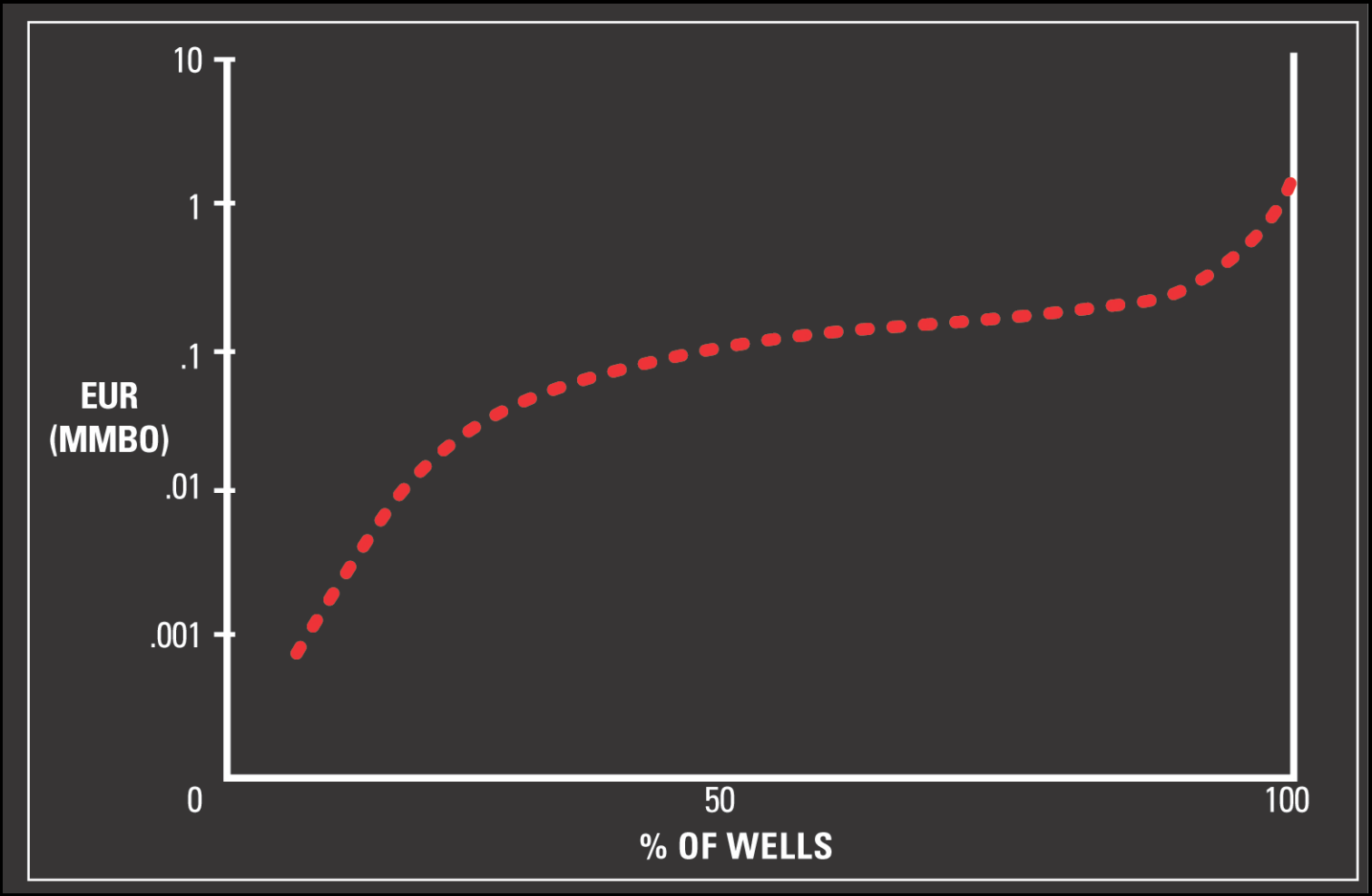
Historical Production Analysis – Estimated Ultimate Recovery (EUR)
Hypothetical Example



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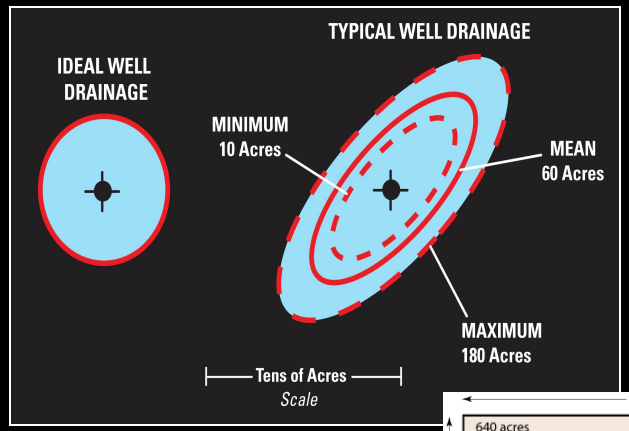
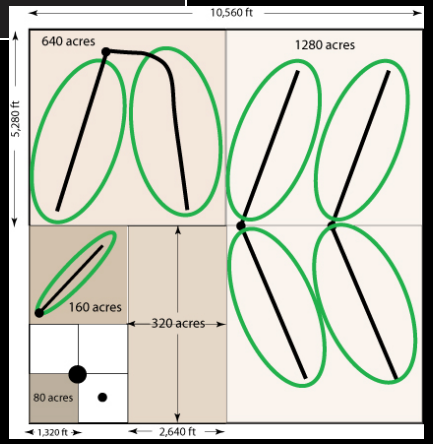
Cell Size and Undiscovered Potential

Hypothetical Examples

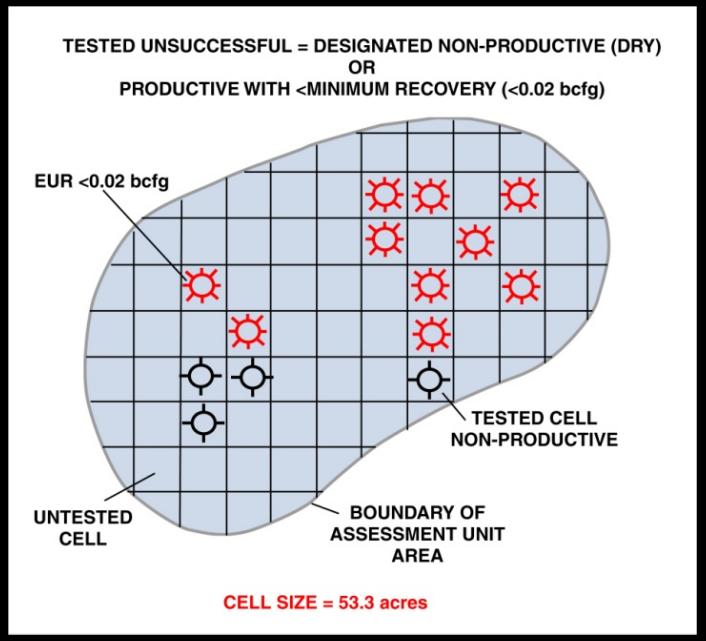
Drainage area estimation - Vertical and Horizontal





From Pollastro and others (2008)

Success, failure, and remaining potential



From Pollastro (2007)

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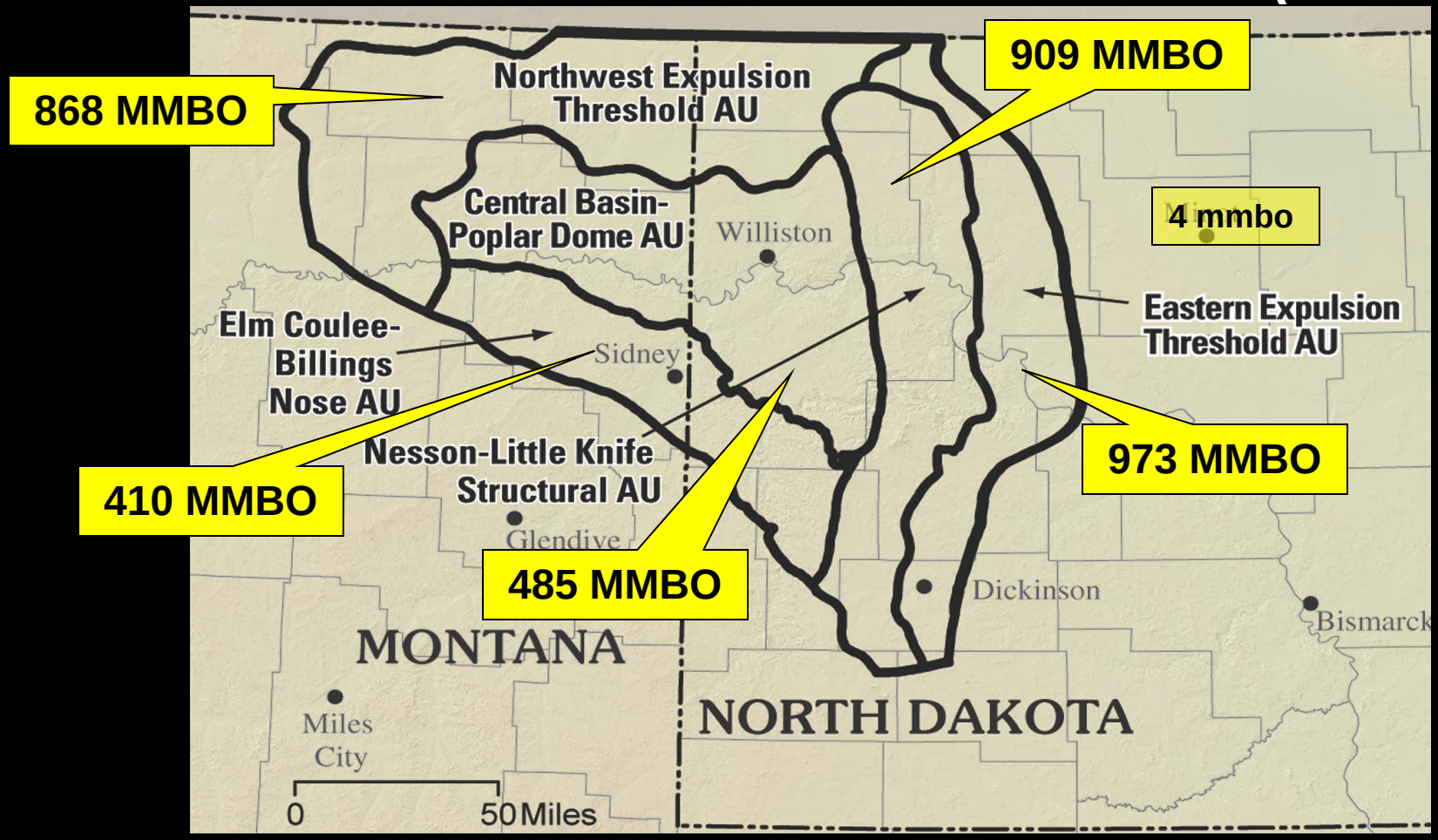
Bakken Formation Assessment Results per Assessment Unit

Mean Volume in Millions of Barrels of Oil (MMBO)



TOTAL 3.65 BBO (F95=3.0 BBO; F5=4.3 BBO)

USGS

Bakken Formation (U.S.) Assessment Summary

Undiscovered, Technically Recoverable Oil Resources

Continuous Oil Resources (5 Assessment Units)

- **Oil: 3.65 billion barrels of oil (BBO)**
- **Associated Gas: 1,848 billion cubic feet of gas**
- **Natural Gas Liquids: 148 million barrels (MMB) natural gas liquids**

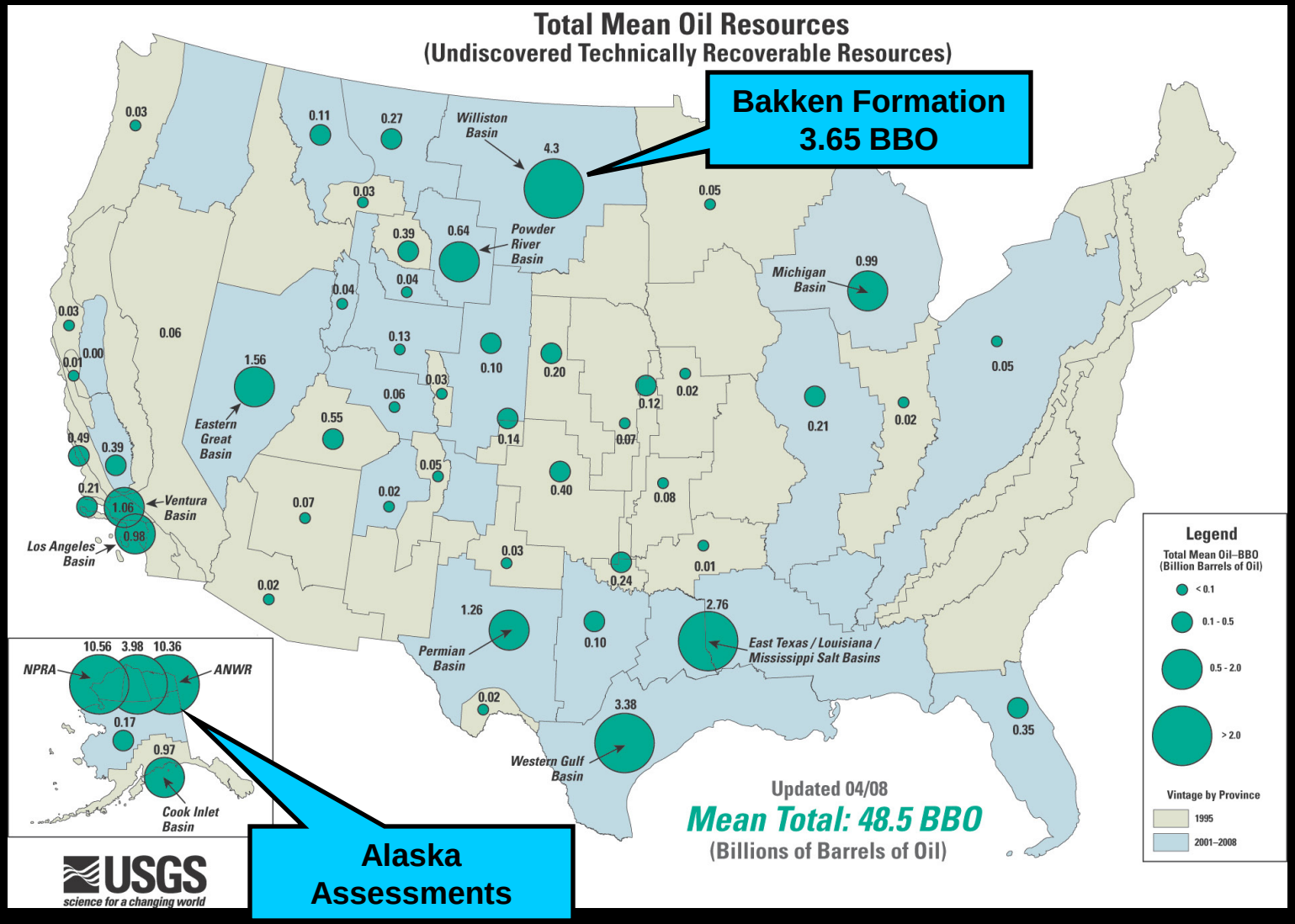
Conventional Oil Resources (1 Assessment Unit)

- **Oil: 4 million barrels of oil**

3.65 BBO (F95=3.0 BBO; F5=4.3 BBO)

1995 USGS Bakken Assessment – Mean 151 MMBO

The Bakken Formation is the Largest Oil Accumulation Assessed by USGS in the Lower 48



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Oil Production from the Bakken Formation

- Cumulative to date: 135 MMBO (since 1953 through 2008)
- ~36 MMBO/year for 2008
- Total monthly production in September, 2008 of 3MMBO

USGS

References Cited

- LeFever, J.A. (2006) Evolution of Oil Production in the Bakken Formation: North Dakota Geological Survey web presentation. Available online at: https://www.dmr.nd.gov/ndgs/bakken/bakken.asp

- Pollastro, R.M., 2007, Total petroleum assessment of undiscovered resources in the giant Barnett Shale continuous (unconventional) gas accumulation, Fort Worth Basin, Texas: American Association of Petroleum Geologists Bulletin, v. 91, no. 4, p. 551-578.

- Pollastro, R, Roberts, L., Cook, T., and Lewan, M., 2008, Assessment of undiscovered oil and gas resources of the Bakken Formation, Williston Basin, Montana and North Dakota 2008: 2008 Rocky Mountain Section, American Association of Petroleum Geologists, Denver, CO

- Walker, W., Powell A., Rollins, R., and Shaffer, R. (2006) Elm Coulee Field, Middle Bakken Member (Lower Mississippian/Upper Devonian) Richland County, Montana: American Association of Petroleum Geologists, Search and Discovery Article #20041 (2006). Available online at: http://www.searchanddiscovery.net/documents/2006/06131walker/index.htm

USGS