NORTH DAKOTA

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NORTH DAKOTA GEOLOGICAL SURVEY 1895

NORTH DAKOTA

OIL AND GAS DIVISION

Department of Mineral Resources

North Dakota
Bakken Formation Resource Study

By

M. Bohrer, S. Fried, L. Helms, B. Hicks, B. Juenker, D. McCusker
F. Anderson, J. LeFever, E. Murphy, S. Nordeng

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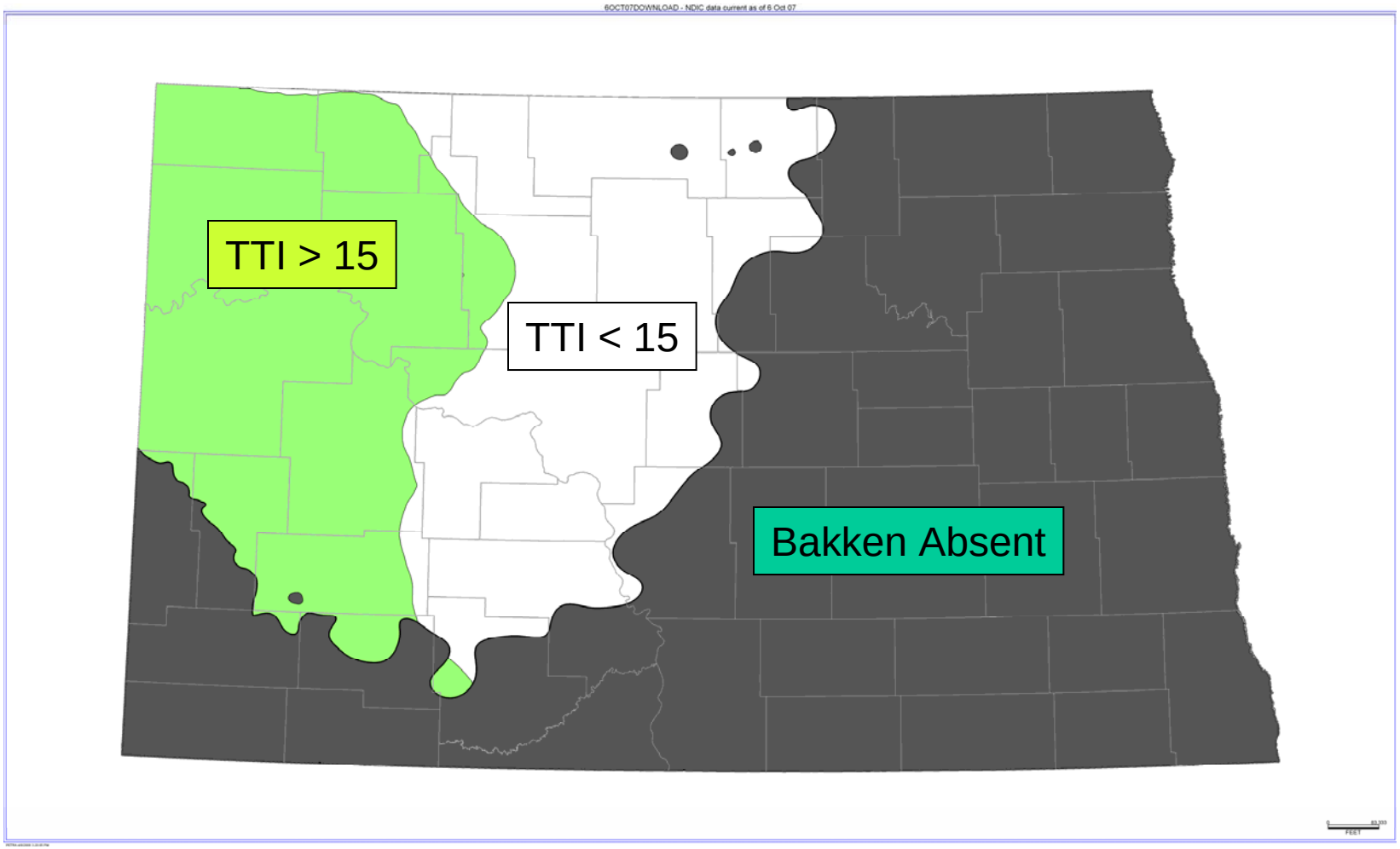
This paper presents:
Results and Methodology
Estimated Original Oil In Place
and Recoverable Reserves.

Previous publications on the Bakken Formation from Dow (1974) to Flannery and Kraus (2006) focused on the potential of the formation as a source rock.

The OOIP in the Bakken Formation within the thermally mature region in the State of North Dakota is estimated to be **149.2 billion barrels**.

This estimate supports the highest oil generation estimates of Price (unpublished) and Flannery and Kraus (2006).

Our estimates are presented by county and separated into the Upper, Middle, and Lower Bakken members.


6OCT07DOWNLOAD - NDIC data current as of 6 Oct 07
TTI > 15
TTI < 15
Bakken Absent
FEET

The process:
Compile data presented as expert testimony from June 2004 - December 2007.

Database contains the information from 496 cases broadly distributed across the state

included as a spreadsheet on the CD; along with figures, maps, and core data; as well as the tabulations of Acres, Acre-ft, porosity, Sw, Bo, OOIP, EUR, and RF by county.

Sorted by county and evaluated using standard statistical methods to determine mean, minimum, and maximum values.

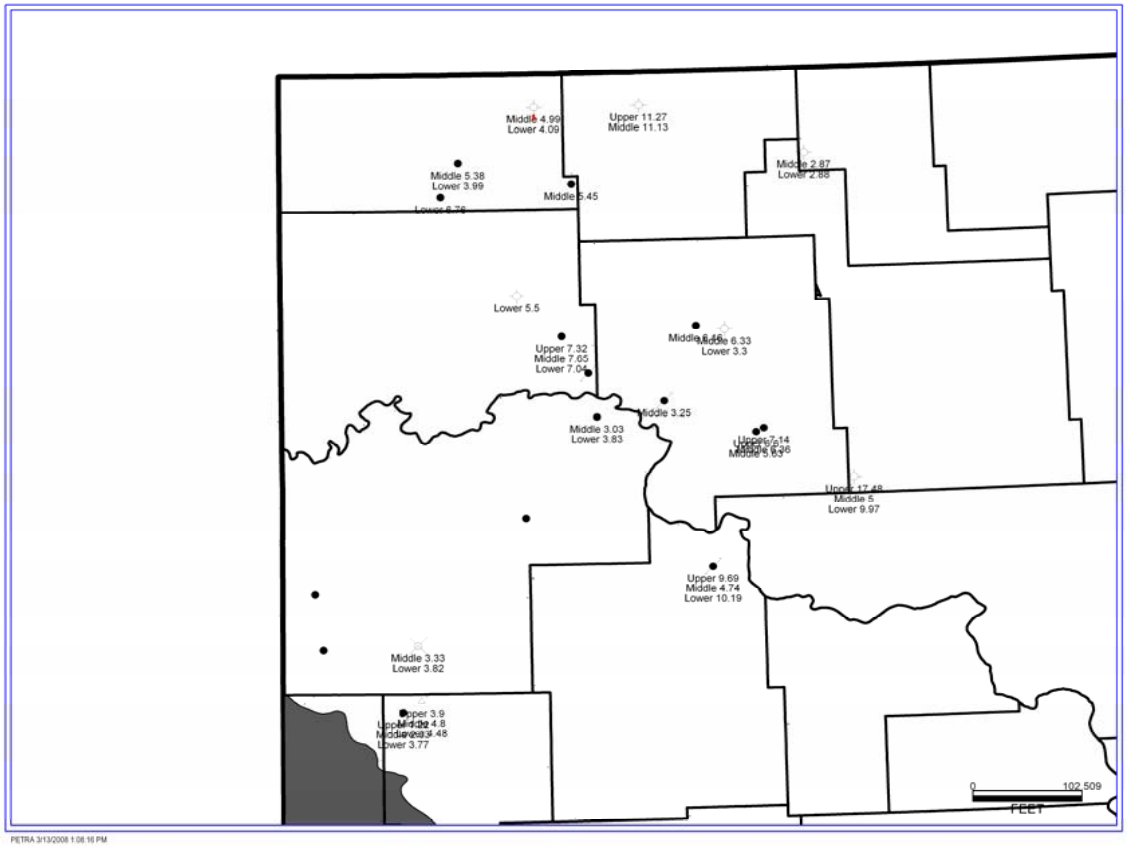
NDIC Bakken Resource Data Base

Date Hearing, Order Number, Case Number,
Case Description, Signing Date, Case Type, Twp,
Rng, Sec, Field name, County, Spacing, well type,
zone, Lithology, Depth TVD, Net H, MBM H, Gross H
Ref Well #, Sanish H, Porosity, Permeability,
Water Saturation, Initial Reservoir Pressure,
Reservoir Temperature, Oil Gravity, GOR,
Bubble Point Pressure, OIL FVF, OOIP / 640, EUR / 640,
Recovery Factor, Oil Price, Gas Price, Well Cost,
Monthly Op Cost, Qi, Qf, Initial Decline Rate, B factor,
Payout, PV, DF, ROI

The process:
Additional data was required to evaluate the upper and lower shale members.

A total of 601 core derived porosity analyses from the Bakken Formation are included.

Cores with measured porosities

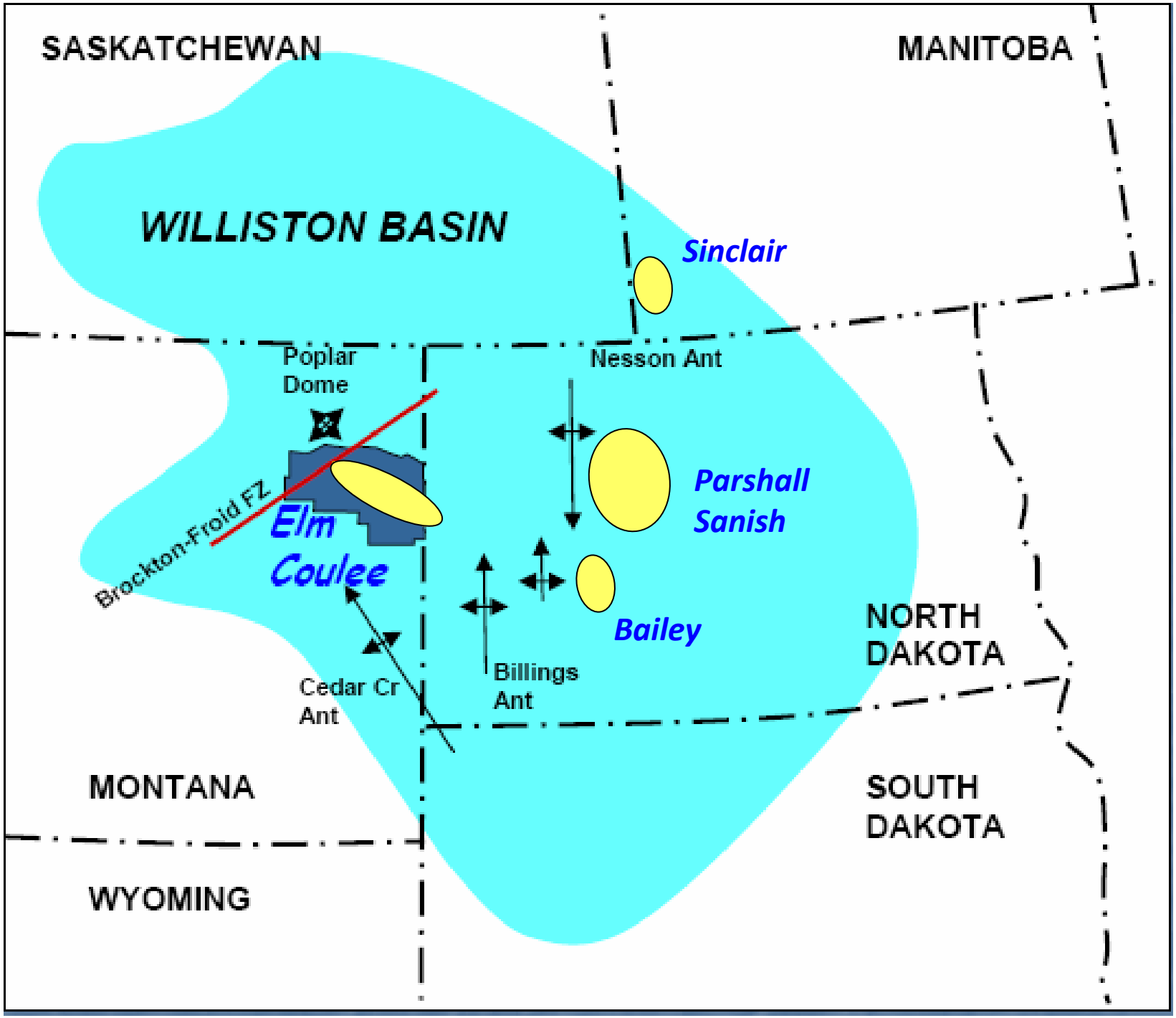


PETRA 3/13/2008 1:08:16 PM

We estimate that additional resources of
10.5-17.6 billion barrels has migrated from the thermally mature region into areas that are not mature.

Note production from the upper Three Forks Formation in the Sinclair Field

Possible migration pathways:
Major lineament trends such as the Brockton-Froid
Bakken Formation “thicks” associated with sub-basins

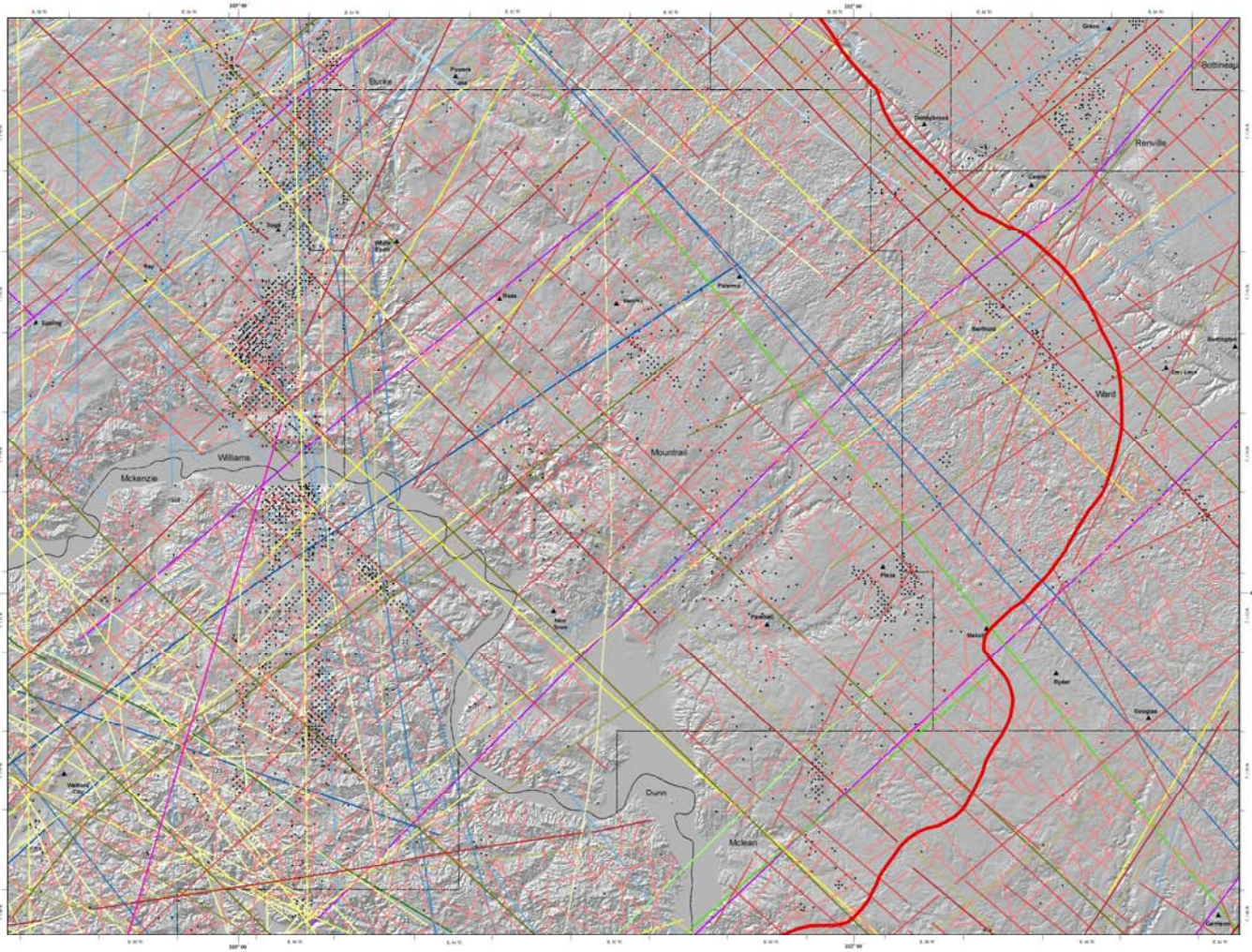

SASKATCHEWAN
MANITOBA
WILLISTON BASIN
Sinclair
Nesson Ant
Poplar Dome
Parshall
Sanish
Brockton-Froid FZ
Elm Coulee
Bailey
NORTH DAKOTA
Billings Ant
Cedar Cr Ant
MONTANA
SOUTH DAKOTA
WYOMING

North Dakota Geological Survey
Geologic Investigations No. x

Edward C. Murphy, State Geologist
Lynn D. Helms, Director Dept. of Mineral Resources

PLATE 1 - HISTORICAL LINEAMENTS MAPPED IN THE PARSHALL AREA, NORTH DAKOTA

Fred J. Anderson, Julie A. LaFever, Shannon M. Heinle and Stephan H. Nordeng



MAPPING AND ANAYLSIS OF HISTORIC LINEAMENTS

EXPLANATION

LANDSAT - 1983
- < 30 miles
- 30 to 200 miles
- 200 to 500 miles
- More than 500 miles

CENOZOIC
- (Kreis-Kent,2000) Present
- (Freisatz,1995) Present
- (Shurr,1995) Present
- (Mollard,1987) Present
- (Oglesby,1987) Present
- (Downey-etal,1987) Present
- (Anna,1986) SF
- (Hayes,1984) SF
- (Cooley,1983) ND-Present
- (Kent,1974) Present
- (Thomas,1974) Present
- (Erickson,1970) Present

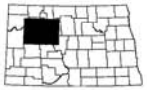
MESOZOIC
- (Anna,1986) UpperK-Pierre
- (Downey-etal,1987) M-Jurassic-K
- (Shurr,1995) Cretaceous

PALEOZOIC
- (Penner-Cosford,2006) Mississippian
- (Penner-Cosford,2006) Devonian
- (Shurr,1995) Mississippian
- (Inden-Burke,1995) Devonian
- (Gerhard-etal,1987) Mix
- (Brown-Brown,1987) Paleozoic
- (Downey-etal,1987) Paleozoic
- (Peterson-MacCray,1987) Paleozoic
- (Maughan-Perry,1986) Middle Phanerozoic
- (Maughan-Perry,1986) Pennsylvanian
- (Hindman,1984) MississippianWB
- (Hindman,1984) Mississippian

PRECAMBRIAN
- (Gibson,1995) Precambrian

HAMAN, P. J., 1975
- Lineament - Tectonic Study

Other Features
- Drill Hole
- Towns
- County Boundaries
- State and US Highways



The map area is a constructed 250k sheet. Belden, Belden SE, Belden SW, and Sikes Dam are the four center 24k quadrangles.

Scale 1:250,000

0 5 10 15 20 Miles

0 5 10 15 20 Kilometers

Mercator Projection — 1927 North American Datum
Standard parallel 47° 22' 30" — Central meridian 102° 07' 30"
USGS NED Shaded Relief - Vertical Exaggeration 9x

N W E S

We estimate an additional resource of
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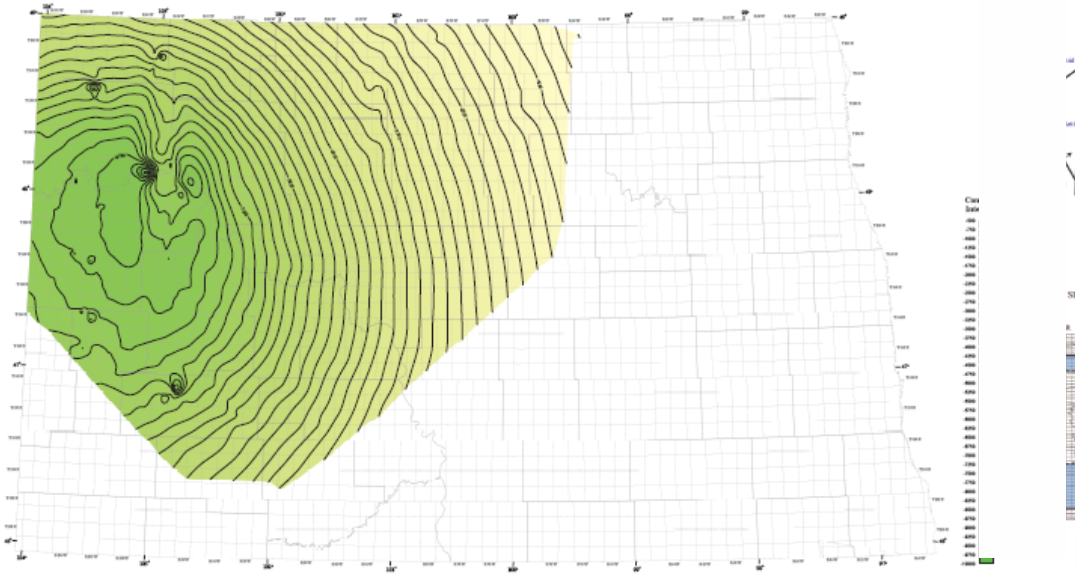
North Dakota Geological Survey
Geologic Investigations No. 39
Bakken Formation Map Series: Sheet 5
2006

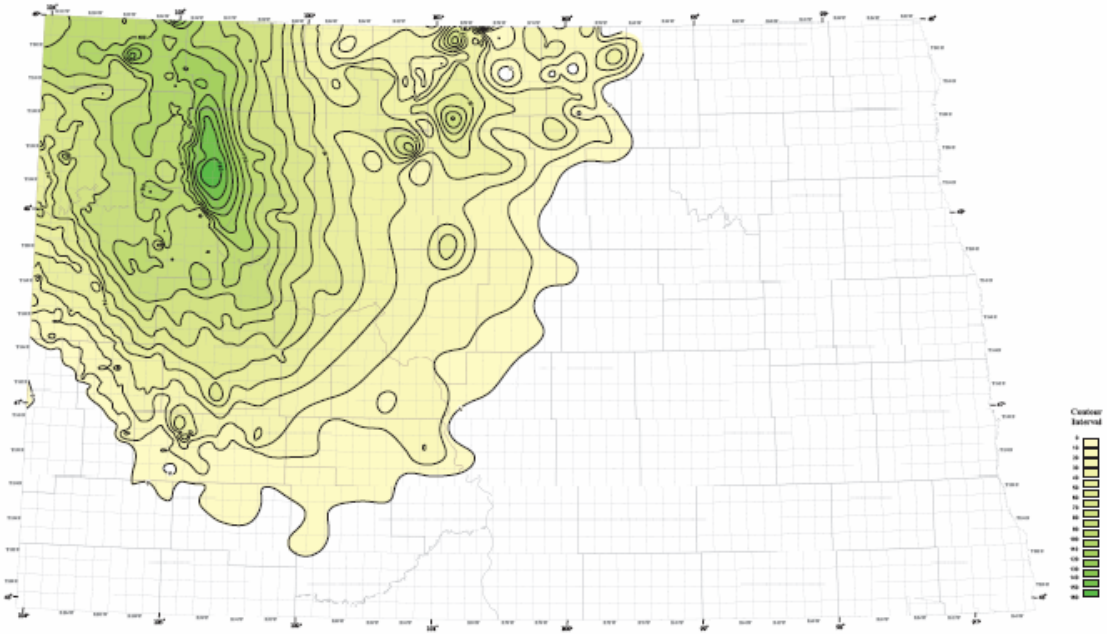
Structure on the Top of the Bakken Formation

Julie A. LeFever



Isopach of the Bakken Formation

Julie A. LeFever



Analysis of 1280 Well Performance

Well Type	Qi	Di	EUR	Well Cost	Sample
Dual | |	800	83	394	6,900,000	6
Dual V	469	80	202	4,299,000	26
Dual <	300		199	2,900,000	14
Dual >	353	81	179	3,920,000	22
Dual /\	305		146	5,371,000	14

Analysis of 1280 Well Performance

Well Type	Qi	Di	EUR	Well Cost	Sample
Single \	250	90	248	4,712,000	34
Single /	298		202	4,450,000	19
Single --	224		205	4,483,000	24
Single |	228	89	198	4,236,000	87

Analysis of 1280 Well Performance

Well Type	Qi	Di	EUR	Well Cost	Sample
Tri |/	431		218	4,854,000	8
Tri <-	400		173	4,150,000	12
Tri ->	291		211	5,003,000	35
Tri ¯/|	315		166	5,937,000	2