Application of Vitrinite Reflectance to Four Woodford Gas-Shale Plays in Oklahoma

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Woodford Gas-Shale Plays

MAJOR FAULTS

Surface faults

Subsurface faults

Normal faults identified by hachures on relatively downthrown block.
Thrust faults identified with solid barbs on hanging wall block.

Geologic provinces from Northcutt and Campbell, 1995
ZONES OF PETROLEUM GENERATION AND DESTRUCTION

Hydrocarbon Source Rocks

ORGANIC MATTER TYPE

PEAK OIL GENERATION

AMORPHOUS (OIL) LIPTINITIC

MIXED

COALY (GAS) HUMIC

PEAK WET GAS GENERATION

WET GAS

PEAK DRY GAS GENERATION

DRY GAS

OIL FLOOR

DRY GAS GENERATION LIMIT

WET GAS FLOOR

DRY GAS PRESERVATION LIMIT


(DOW, 1977)
## Guidelines for the Barnett Shale (Based on Rock-Eval Pyrolysis)

<table>
<thead>
<tr>
<th>VRo Values</th>
<th>Maturity</th>
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<tbody>
<tr>
<td>&lt;0.55%</td>
<td>Immature</td>
</tr>
<tr>
<td>0.55-1.15%</td>
<td>Oil Window (peak oil at 0.90% VRo)</td>
</tr>
<tr>
<td>1.15-1.40%</td>
<td>Condensate–Wet-Gas Window</td>
</tr>
<tr>
<td>&gt;1.40%</td>
<td>Dry-Gas Window</td>
</tr>
</tbody>
</table>

*From Jarvie and others, 2005*
Completed 2003–2010

Woodford Gas-Shale Wells

1,397 Wells
19 Caney/Woodford
11 Sycamore/Woodford
308 Vertical Woodford
1,058 Horizontal/Directional Woodford (76%)
1 Sylvan/Woodford
Distribution of 112 Woodford Shale samples with vitrinite-reflectance data

Cardott, in preparation
Isoreflectance Map of the Woodford Shale in Eastern Oklahoma (Updated October 2009)

Mississippian and Older Outcrop Area (different than Ozark Uplift Province boundary)

Map prepared by R. Vance Hall using Petra

Cardott, in preparation
Woodford Shale Structure & Vitrinite Isoreflectance Map
Woodford Shale Play
Arkoma Basin, OK
Key Geologic Features

EIA Website:

Woodford Shale Producers by Type
- Gas Only
- Condensate / OIL (GOR > 10,000 and Liquid Production Reported)
- OIL (GOR < 10,000)
- Commingled Woodford Shale and Non-Shale

Woodford Shale Structure, subsue feet (Cardott, Itall 2006)
Woodford Shale Thickness, feet (Corner, 1992)
Woodford Thermal Maturity, Mean vitrinite reflectance, % Ro (Cardott, 2009)
All other values of Ro
Ro = 1.4% (NW edge of Gas Window, Cardott 2010)

Normal Fault (Ball and Bar on Downthrown Block)
Thrust Fault (Sawteeth on Upper Plate)
Basins

Woodford Shale-Only IP on Isoreflectance Map

(From Andrews, 2009)
Woodford Oil/Condensate/Gas Production Caveat

- **Gas** production is reported by the Oklahoma Corporation Commission by WELL.

- **Oil/condensate** production is reported by the Oklahoma Tax Commission by LEASE [production by well is only on single-well leases]

(Production data supplied by PI/Dwrights LLC, © 2010, IHS Energy Group)
Woodford Shale-Only Oil/Condensate/Gas Production (1,366 wells; 2005-2009)

Condensate based on 54.4 API DEG

Oil-based drilling mud FLOWBACK?
Condensate from High Thermal Maturity Arkoma Basin Wells

- Production in first few months is interpreted as flowback from oil-based drilling mud;
- Spikes in production may be from intermittent trucking
Liquids production only in first few months interpreted as flowback @ 2.05%VRo
Intermittent liquids production in the first few months is interpreted as trucking flowback.

(2) Cimarex 3-34H Hall
(34-3N-11E; Coal Co.; IP 1,740 Mcfd)

@ 2.05%VRo
Woodford Shale-Only Condensate Wells Excluding Early Month Spikes
Example of Woodford condensate produced later in well’s life
(4) Antero 30-1H Harris
(30-1S-11E; Coal Co.; IP 1,334 Mcfd)

@ 1.6%VRo
Anadarko Basin

Woodford Shale Isoreflectance Map based on 81 wells (Cardott, 1989)
Woodford Shale Play, Anadarko Basin, OK and TX: Key Geologic Features


EIA Website: http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/maps/maps.htm
Anadarko Basin (2007-2010)

Woodford Shale Isoreflectance Map (Cardott, 1989)

Woodford-Only “Cana” Play

Woodford Vertical

Horizontal/Directional

1.46%
Anadarko Basin Initial Potential

Devon Energy
1-11H Ratliff

Blaine

Canadian

Caddo

Grady

Legend:
- ★ 7 MMcfd
- 6 MMcfd
- 5 MMcfd
- 4 MMcfd
- 3 MMcfd
- 2 MMcfd
- 1 MMcfd
- <1 MMcfd
(1) Cimarex Energy 1H-27 Jameson
(27-14N-10W; Canadian Co.)

IP: 2,760 Mcfd, 61 Bopd
Cum: 794 MMcf, 13,292 BBls condensate

12,486 ft TVD

1st Anadarko Basin Woodford Horizontal Well
(2) Devon Energy 1-11 Ratliff (11-13N-10W; Canadian Co.)

- IP: 6,601 Mcfd, 105 Bopd
- Cum: 1.6 Bcf (ave 2.8 MMcfd), 18,730 BBls condensate
- 172 MMcfd
- 2,826 BBls
- 12,912 ft TVD
(3) Devon Energy 1-36H Hancock (36-13N-10W; Canadian Co.)

Monthly Production

- Gas (Mcf)
- Condensate (BBls)

IP: 668 Mcfd; Cum: 389 MMcf, 2,864 BBls condensate

12,892 ft TVD
Structure and Vitrinite Reflectance of Woodford Shale, Southern Oklahoma

Cardott, in preparation
Woodford Shale Play 
Ardmore Basin, OK and TX 
Key Geologic Features

EIA Website: 

Ardmore Basin Woodford (2005-2009)
Ardmore Basin Woodford (2005-2009)
BNK Petroleum 2-1H Dunn (2-4S-3E; Carter Co.; Oil Well)

IP: 2,200 Mcfd; Cum: 611 MMcf, 35,347 BBls oil

10, 796 ft TVD
BNK Petroleum 11-1H Wiggins (11-4S-3E; Carter Co.)

10,903 ft TVD

IP: 525 Mcfd; Cum: 46 MMcf,
1,795 BBls oil
Cherokee Platform Initial Potential on Isoreflectance Map
Cherokee Platform Production on Isoreflectance Map

Some Biogenic Methane (note outcrop)

Dutcher oil from same lease as Woodford well

19-7 Collins
8-2 Johnson

Woodford Oil Well
Woodford Oil/Condensate
Woodford Gas Well
Dry and Abandoned
WCT Operating
19-7 Collins (19-17N-18E; Wagoner Co.)

1,052 ft deep

IP: 25 Mcfd; Cum: 33 MMcf,
Coronado Great Plains
8-2 Johnson (8-16N-18E; Wagoner Co.)

IP: 307 Mcfd; Cum: 77 MMcf,

841 ft deep
Woodford-Only Production

1,201 wells with production data; excludes 19 OWWO

Cumulative: 562 Bcf, 1,485,841 Bo
SUMMARY OF WOODFORD GAS SHALE PLAYS

1. Main Woodford Shale gas play is in the Arkoma Basin at <1.15% to >3.0% Ro

2. Woodford Shale gas and condensate play in Anadarko Basin shelf @1.1% to >1.5% Ro

3. Woodford Shale gas and oil play is in the Ardmore Basin at <1.2% Ro

4. Woodford Shale biogenic methane play is in the Cherokee Platform at <1.2% Ro
For more information, please visit the Oklahoma Geological Survey Web Site

http://www.ogs.ou.edu