Lithostratigraphy of the Woodford Shale, Anadarko Basin, West-Central Oklahoma*

Craig D. Caldwell

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1Cimarex Energy Company, Tulsa, OK (CCaldwell@cimarex.com)

Abstract

Since early 2008 over three-hundred horizontal Woodford Shale wells have been completed in the Anadarko basin, west-central Oklahoma, along a northwest-southeast trend approximately 100 miles (161 km) in length and 20 miles (32 km) wide. Shallowest production to date occurs at 10,500 ft (3,200 m), and deepest production occurs at 16,100 ft (4,900 m).

Seven mudrock lithofacies, defined mainly on the basis of percent TOC and variations in mineral content (primarily quartz, clay, and dolomite), make-up the fifteen stratigraphic units that comprise the Lower, Middle, and Upper Woodford in the geographic center of the play where the Woodford is 175 to 330 ft (53 to 100 m) thick. The basal-most units of the Woodford in this area are TOC-poor clayey mudrock (<2% TOC), recording the first transgression of the Woodford seas. The overlying Lower Woodford and the Middle Woodford are composed of 10 to 30 ft (3 to 9 m) intervals dominated by one of three lithologies: clayey mudrock (CM) (38% clay and 41% quartz), clayey siliceous mudrock (CSM) (27% clay and 55% quartz), and less common dolomitic clayey mudrock (DCM) (33% clay, 32% quartz, and 15% dolomite). These mudrock lithologies are organic-rich with TOC values averaging 5 to 6.5%. Clay is predominantly illite, and dolomite is commonly ferroan. Quartz is biogenic and detrital. The Upper Woodford in this area is predominately CSM and siliceous mudrock (SM) (14.5% clay and 75% quartz). CSM and SM units are characterized by density-neutron cross-over and are readily distinguishable on wireline logs. The more silica-rich mudrocks (CSM and SM) are likely dominated by biogenic silica, recording distal deposition in areas less affected by detrital influx.
References


LITHOSTRATIGRAPHY OF THE WOODFORD SHALE, ANADARKO BASIN, WEST-CENTRAL OKLAHOMA

Craig D. Caldwell
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• Location Map & Strat Column
• Woodford Isopach
• Woodford Structure
• Internal Woodford Stratigraphy
• Woodford Mineralogy and Rock Types
• Conclusions
STRAT COLUMN AND MAJOR GEOLOGIC PROVINCES OF OKLAHOMA

Woodford Isopach
Anadarko Basin
Woodford Play
Top Woodford Structure (MD)
Anadarko Basin
Woodford Play
Type Log from Core Area Showing Lithostratigraphy and % Clay for Middle & Upper Woodford
Well Path Showing Woodford Lithostratigraphy and Lateral Placement

Kincaid 1 #8H with Ridenour 1 20 Type Log

WDFD

MW4
MW2
MW1C
MW1B
MW1A

LBS. SAND

TRT PRES.

FRAC STG.
## Woodford Lithofacies
Anadarko Basin Woodford Play

<table>
<thead>
<tr>
<th>LITHOFACIES</th>
<th>% QUARTZ</th>
<th>% CLAY</th>
<th>% TOC</th>
<th>% GAS-FILLED POROSITY</th>
<th>PRv</th>
<th>Brittness Index*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siliceous mudrock</td>
<td>75.2</td>
<td>14.5</td>
<td>4.86</td>
<td>5.4</td>
<td>0.155</td>
<td>0.75</td>
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<td>Clayey, siliceous mudrock</td>
<td>54.8</td>
<td>27.4</td>
<td>6.43</td>
<td>6.8</td>
<td>0.164</td>
<td>0.55</td>
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<tr>
<td>Clayey mudrock</td>
<td>40.6</td>
<td>38</td>
<td>5.97</td>
<td>5.6</td>
<td>0.192</td>
<td>0.41</td>
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<tr>
<td>Organic-poor, clayey mudrock</td>
<td>27.3</td>
<td>52.4</td>
<td>0.6</td>
<td>1.8</td>
<td>0.25</td>
<td>0.27</td>
</tr>
</tbody>
</table>

*B.I.=Quartz/Qtz+Carbonates+Clay
(Sondergeld et. al., 2010)
Anadarko Woodford Mineralogy (XRD) and Rock Types

- Siliceous mudrock
- Clayey, siliceous mudrock
- Clayey mudrock
- Organic-poor, clayey mudrock

QUARTZ (and feldspar)

Upper WDFD
Middle & Lower WDFD
Basal WDFD

DOLOMITE
and PYRITE

CLAY
Lower & Middle Woodford Lithostratigraphy, Anadarko Woodford Play – Core Area

- Clayey mudrock
- Clayey, siliceous mudrock
- Organic-poor clayey mudrock

Quartz/Clay
- MW1B
- MW1A
- LW3
- LW2
- LW1C
- LW1B
- LW1A
- LW1
- LW0

LW
- HNTN

MW
- 27/52
- 55/27
- 41/38
Middle and Upper Woodford Lithostratigraphy, Anadarko Woodford Play – Core Area

- **Quartz/Clay**
  - 75/14

- **LW3**
- **UW3**
- **MISS**
- **MW4**
- **MW2**
- **MW1C**
- **MW1B**
- **MW1A**
- **LW**
- **UW**

- **Clayey, siliceous mudrock**
- **Clayey mudrock**
- **Siliceous mudrock**
Woodford Lithostratigraphy
Anadarko Basin
Woodford Play
Core Area

Siliceous mudrock

Clayey, siliceous mudrock

Clayey mudrock

Organic-poor clayey mudrock
Clayey mudrock

Clayey, siliceous mudrock

Woodford Lithostratigraphy Anadarko Basin
Woodford Play - SE Area

Clayey
siliceous
mudrock

MISS

UW

MW

LW

HNTN
Thin Section Photomicrographs of Woodford Rock Types

UW1 sample showing silicified Tasmanites; sample is 64% quartz and 21% clay. Siliceous mudrock lithofacies.

MW1B sample showing detrital silt; sample is 34% quartz and 38% clay. Clayey mudrock lithofacies.
SEM Photomicrographs of Woodford Microfabrics

UW2 sample showing microcrystalline silica with intercrystalline porosity; sample is 76% quartz and 18% clay. Siliceous mudrock lithofacies.

MW4 sample showing parallel alignment of illite clay; sample is 26% quartz and 44% clay. Clayey mudrock lithofacies.
Bed-limited dolomite-cemented fractures in thin silicic layers
Siliceous mudrock lithofacies
Silicic laminae with dolomite-cemented fracture
Siliceous mudrock lithofacies
Upper Woodford
Arbuckle Mountains
Porosity in organic laminae
Clayey siliceous mudrock
Bioturbated bed
Clayey mudrock
lithofacies
Woodford Lithofacies

- Upper Woodford
- Middle/Lower Woodford
- Basal Woodford

- Distal (?)
- Proximal (?)

BIOGENIC SILICA

DETRITAL CLAY AND SILT

“GOOD” MECHANICAL PROPERTIES

“POOR” MECHANICAL PROPERTIES
CONCLUSIONS:

- A lithostratigraphy/mechanical stratigraphy was developed for the Anadarko Woodford

- Seven mudrock lithofacies were defined in the Core Area on the basis of mineral content and percent TOC.

- The Woodford thins and siliceous rock types are less common to the SE and NW of the Core Area.

- Excluding the basal Woodford, the percent TOC (4.9-6.4%) and gas-filled porosity (5.4-6.8%) display relatively minor variations with Woodford rock types.

- Mechanical properties (including “fracability”) and the occurrence of natural fractures are lithofacies dependent.