Horizontal Drilling of Deep Granite Wash Reservoirs, Anadarko Basin, Oklahoma and Texas*

John R. Mitchell1

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1Consulting Geologist / Managing Partner, Fall River Exploration Company LLC, Tulsa, OK (mtgeologist@yahoo.com)

Abstract

More than 1000 horizontal oil and gas wells have been drilled and completed since 2007 in the Granite Wash trend in a five-county area (Wheeler County, Texas; Roger Mills, Beckham, Washita, and Custer Counties, Oklahoma) of the deep Anadarko Basin of Texas and Oklahoma. Over 90% of the horizontal wells drilled to date have targeted Granite Wash strata of Pennsylvanian age and have been drilled since January 2008.

Before 2007, the Granite Wash reservoirs had been exploited by over 2000 vertical wells across the report area. These vertical wells are generally characterized by poor recovery efficiency and economic performance due to the extremely low permeability of the various arkosic sandstone and conglomerate reservoirs. Horizontal drilling and completion technology now provide the oil and gas industry with much better tools for efficiently producing gas, oil and condensate from these reservoirs.

Daily production from horizontal Granite Wash completions in the five-county area, as of late 2013, was reported to be greater than 46,500 barrels of oil and 962 million cubic feet of gas. Total cumulative production from 1048 horizontal wells has reached 69.6 million barrels of oil (MMBO) and 1.5 trillion cubic feet of gas.

This article includes geologic descriptions of the Granite Wash play, including a look at four key oil and gas “sub-play” areas that have been horizontally drilled.

References Cited


Horizontal Drilling of Deep Granite Wash Reservoirs Anadarko Basin, Oklahoma & Texas

John Mitchell, Managing Partner Fall River Exploration LLC Tulsa, Oklahoma
HORIZONTAL GRANITE WASH PLAY: KEY POINTS

• Located in the deep Anadarko Basin along the northern flank of the Amarillo-Wichita uplift in Oklahoma & Texas
• Granite Wash petroleum reservoirs are primarily arkosic sandstones and conglomerates with very low porosity & permeability
• Wash sediments were locally sourced from the Amarillo-Wichita uplift
• The middle and upper Pennsylvanian-age Granite Wash stratigraphic section exceeds 7000 feet in thickness
• Reservoirs were laid down in depositional systems varying from alluvial fans to deep-water turbidite and debris-flow deposits five to thirty miles north of the Amarillo-Wichita uplift
• Dozens of individual stratigraphic and structural-stratigraphic oil and gas traps are present in a highly complex “tight oil and gas sandstone” resource system
HORIZONTAL GRANITE WASH PLAY: KEY POINTS

- Production depths range from 9000 to 15,500 feet
- Individual petroleum reservoirs are 25 to 150 feet thick
- Porosity: 2% to 14%
- Permeability generally <0.1 millidarcy
- Oil Gravity: 44-60° API
- Four Granite Wash sub-play areas have been identified based on structure, stratigraphy, and trapping styles
- More than 2000 vertical Granite Wash wells were drilled prior to transition to horizontal drilling in 2007
- Since 2007 over 1760 horizontal Granite Wash wells have been drilled with only 86 dry holes
- 111 active permits currently awaiting drilling
HORIZONTAL GRANITE WASH PLAY: KEY POINTS

- One thousand forty-eight (1048) horizontal Granite Wash wells have produced 69,600,000 barrels of oil and 1.5 trillion cubic feet of gas since 2007 from the study area.
- Late 2013 reported daily production in Wheeler, Hemphill, Beckham, Roger Mills, Custer and Washita Counties was >46,500 barrels oil and 962 million cubic feet of gas from 1408 horizontal wells.
- Late 2013 reported daily production *in Wheeler County alone* was >33,700 barrels oil and 553 million cubic feet of gas from 648 horizontal wells.
Deep Wash Play Area

HORIZONTAL GRANITE WASH PLAY LOCATION MAP

Anadarko Basin

TEXAS

OK

TX

OK

OK

TX

ROGER MILLS

CUSTER

WHEELER

BECKHAM

WASHITA

STUDY AREA
HORIZONTAL GRANITE WASH PLAY

Regional Structure Map – U. Desmoinesian Wash

Contour Interval = 500 Feet
HORIZONTAL GRANITE WASH PLAY: WHAT IS GRANITE WASH?

Granite Wash (ˈgran-ət ˈwāsh) (geology)

Material eroded from granites and re-deposited, forming a sedimentary rock with the same major mineral constituents as the original rock.
HORIZONTAL GRANITE WASH PLAY

• Core data shows common Granite Wash *mineralogical* composition to be:
  – 30-40% Quartz (quartz in sand, igneous fragments, quartz overgrowths)
  – 20-30% Plagioclase Feldspar
  – 10-20% Potassium Feldspar
  – 7-18% Clay, primarily authigenic Chlorite

• Cores also show Granite Wash *framework grains* to be commonly composed of:
  – 10-40% Plutonic and Volcanic rock fragments (granite and rhyolite, varies with conglomeratic vs. sandstone rock types)
  – 20-30% Quartz in individual grains
  – 20-30% Plagioclase Feldspar in individual grains
  – 10-20% Potassium Feldspar in individual grains

Data from Core Lab, published data
DESMOINESIAN WASH – STILES RANCH FIELD, TX
Layered Sheet Sandstone and Shale Distal Lobe Grading
Upward into Amalgamated Proximal Lobe Sheet Sandstone
DESMOINESIAN WASH – N.E. MAYFIELD FIELD
BECKHAM CO., OK

Marmaton Wash

13655 ft

13669 ft

One Foot

14265 ft

Skinner Wash

14278 ft
Nine feet of conglomeratic sandstone, sandstone and shale from core cut in the Valero #1 Brauchi well
Sec. 36, T11N R23W
Beckham Co., Oklahoma
MARMATON WASH – SWEETWATER FIELD

Five feet of conglomeratic sandstone from core cut in the Gulf #1 Payne Community Sec. 13, T10N R26W, Beckham Co., OK

Core @ Oklahoma Geological Survey
HORIZONTAL GRANITE WASH PLAY
Common Framework Grains

Abundant Plutonic and Volcanic Lithic Fragments

Feldspar Intergrowths and Plagioclase

Vrf = Volcanic Rock Fragment; Prf = Plutonic Rock Fragment;
Q = Quartz; FI = Feldspar Intergrowths; PL = Plagioclase Feldspar
P = Porosity

Photomicrographs Courtesy of Core Lab
Mineralogy, Grain Types, Clay

Grain Types/Mineralogy
KF = Potassium Feldspar
M = Muscovite
PL = Plagioclase Feldspar
Q = Quartz
P = Pore Space

Chlorite Lining Pores

Courtesy of Core Lab
HORIZONTAL GRANITE WASH PLAY
Rock Textures

Mechanical Compaction

Poor Sorting & Rounding

More Open Framework

Photomicrographs Courtesy of Core Lab
Porosity averages ~6 %, often as low as 2-3%
Permeability ranges from .0001 to 0.1 md
Porosity dominantly exists as microporosity with minor intergranular porosity
Original porosity was reduced by mechanical compaction and diagenetic cementation
Pennsylvanian stratigraphic column, deep Anadarko Basin, Texas & Oklahoma

<table>
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<tr>
<th>SERIES / STAGE</th>
<th>GROUP</th>
<th>UNIT</th>
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<td>VIRGILIAN</td>
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<td>Douglas/Cisco</td>
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<td>Lansing/Hoxbar</td>
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<td>Lower Skinner Shale (Pink Ls Marker)</td>
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<td>MORROWAN</td>
<td>Atoka</td>
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<td>L. Morrow (Primrose)</td>
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ANADARKO BASIN - MOUNTAIN FRONT - OKLAHOMA
Low-Relief Land
Shallow Marine to Deltaic
Deep Marine
Shallow Marine
Carbonates - Shallow Marine

Modified from Moore 1979
Deepwater Submarine Fan Lobes (Proximal to Medial to Distal)

Fan Delta

Distal Fan Lobe

Proximal to Medial to Distal

Adapted From Bouma, 2000
GRANITE WASH DEPOSITION

• 7000 feet+ thick succession of conglomerate, sandstone and shale in Middle and Upper Pennsylvanian-age Granite Wash

• “Coarse-grained sand-rich” depositional systems varying from alluvial-fan delta to deep-water turbidite/debris-flow deposits

• Granite Wash oil and gas reservoirs consist primarily of submarine-fan-lobe sequences (50-400 feet thick) separated by highstand correlative shales (5-20 feet thick)
  – Proximal Lobes Most Common (channel to lobe transition)
    • Comprised of conglomerates and amalgamated sheet sandstones to layered-sheet sandstones & minor shale
  – Distal Lobe or Lobe Fringe
    • Comprised of layered-sheet sandstones
    • Shale suspension deposits (highstand) occur between turbidite fan lobe sandstone sequences provide vertical seals
HORIZONTAL GRANITE WASH PLAY
LOWER ATOKAN PALEOGEOLOGIC MAP

WHEELER
TEXAS
OKLAHOMA
ROGER MILLS
CUSTER
WASHITA
GRANITE WASH
PRODUCTION AREA
GRANITE WASH
PRODUCTION AREAS

BASIN AXIS

Dolomite Wash
DOsh

COa

LLINGSWORTH
BECKHAM

Mountain View Fault

LEGEND
Lower Atoka Paleogeologic Map
Pml: Morrowan
Mwsp: Springer to Woodford
DOsh: Hunton to Simpson
COa: Arbuckle

Tectonic Map From McConnell (1989), Basement Composition from Ham, Denison & Merritt (1964)
HORIZONTAL GRANITE WASH PLAY
UPPER ATOKAN PALEOGEOLOGIC MAP

LEGEND
Upper Atokan Paleogeologic Map
Pml: Morrowan
Mwsp: Springer to Woodford
DOsh: Hunton to Simpson
COa: Arbuckle

Tectonic Map From McConnell (1989), Basement Composition from Ham, Denison & Merritt (1964)
HORIZONTAL GRANITE WASH PLAY
LOWER DESMOINESIAN PALEOGEOLOGIC MAP

LEGEND
Lower Desmoinesian Paleogeologic Map
Pml: Morrowan
Mwsp: Springer to Woodford
DOsh: Hunton to Simpson
COa: Arbuckle

GRANITE WASH PRODUCTION AREA
GRANITE WASH PRODUCTION AREAS

Mountain View Fault
Basin Axis

Tectonic Map From McConnell (1989), Basement Composition from Ham, Denison & Merritt (1964)
HORIZONTAL GRANITE WASH PLAY
UPPER DESMOINESIAN PALEOGEOLOGIC MAP

LEGEND
Middle Desmoinesian Paleogeologic Map
Pml: Morrowan
Mwsp: Springer to Woodford
DOsh: Hunton to Simpson
COa: Arbuckle

Tectonic Map From McConnell (1989), Basement Composition from Ham, Denison & Merritt (1964)
HORIZONTAL GRANITE WASH PLAY
MARMATON (U. DESMOINESIAN) WASH ISOPACH

LEGEND
Isopach Map
Marmaton Wash Interval
Contour Interval: 100 Feet

Tectonic Map From McConnell (1989), Basement Composition from Ham, Denison & Merritt (1964)
Granite Wash Oil and Gas Production

Mills Ranch Oil Field, Wheeler County, Texas
GRANITE WASH PLAY
OIL AND GAS PRODUCTION AREAS

Granite Wash Reservoir Production Cumulatives:

98 MMBO & 1.9 TCFG from ~2,100 Vertical Wells Since 1947
46 MMBO & 856 BCF from 816 Horizontal Wells Mainly Since 2008
Drilled Horizontally To Date

**Avg. Initial Potential**
- 707 BOPD
- 1.8 MMCFGD
- GOR=2,507
- 194 Wells

**Avg. Initial Potential**
- 264 BOPD
- 5.0 MMCFGD
- GOR=18,984
- 1020 Wells

**Avg. Initial Potential**
- 18 BOPD
- 8.3 MMCFGD
- GOR>400,000
- 30 Wells

**Increasing Gas/Oil Ratio & Oil Gravity**
Granite Wash Oil and Gas Production

Virgilian to Atokan Age Oils
44 to 60 Degree API Gravity
Type Log
Missourian Wash, Deep Anadarko Basin, Texas & Oklahoma;
Chesapeake #1-28
Mary K well, Sec. 28, T11N R23W, Beckham Co., Oklahoma

1300+ feet of Missourian Series
Granite Wash section

Missourian Wash Has Produced 19.6 MMBO and 78 BCFG from 220 Horizontals Since 2010
Type Log
Desmoinesian Wash, Deep Anadarko Basin, Texas & Oklahoma:
Devon #16-4 Truman-Zybach, Sec. 16, Block R&E Survey, Wheeler Co., Texas

2000+ feet of Desmoinesian Series Granite Wash section

Desmoinesian Wash Has Produced 50 MMBO and 1.3 TCFG from 1,132 Horizontals Since 2002
HORIZONTAL GRANITE WASH PRODUCTION

- One thousand forty-eight (1048) horizontal Granite Wash wells have produced 69,600,000 barrels of oil and 1.5 trillion cubic feet of gas since 2007 from the study area.
- Late 2013 reported daily production in Wheeler, Hemphill, Beckham, Roger Mills, Custer and Washita Counties was >46,500 barrels oil and 962 million cubic feet of gas from 1408 horizontal wells.
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Granite Wash Reservoir Production Cumulatives:
98 MMBO & 1.9 TCFG from ~2,100 Vertical Wells Since 1947
46 MMBO & 856 BCFG from 816 Horizontal Wells Mainly Since 2008
Wheeler County Cum. Hrz. Prod. = 29 MMBO & 565 BCFG
Washita County Cu. Hrz. Prod. = 14 MMBO & 256 BCFG
HORIZONTAL GRANITE WASH PLAY
MARMATON (U. DESMOINESIAN) WASH ISOPACH

Key Medial to Distal Wash Producing Areas

Tectonic Map From McConnell (1989), Basement Composition from Ham, Denison & Merritt (1964)
Horizontal Granite Wash Play
Missourian Wash Activity Areas

Cottage Grove Wash Mills Ranch Field

Twelve Miles
Porosity isolith map of the Upper Cottage Grove Wash with density porosity >10% on 2.71 gm/cc matrix; Contour interval = 10 feet ; Mills Ranch and Stiles Ranch fields, Wheeler Co., TX

Cum. Production Vertical Wells: 750,000 BO / 19 Wells

Calculated 130 MMBO of Original Oil in-Place
Porosity isolith map of the Upper Cottage Grove Wash with density porosity >10% on 2.71 gm/cc matrix; Contour interval = 10 feet; Mills Ranch and Stiles Ranch fields, Wheeler Co., TX

Calculated 130 MMBO of Original Oil in Place
Type porosity log, Upper Cottage Grove Wash pay zone, SM Energy #2-60H Ruth pilot hole; NW NW NW Sec. 60, Block A-7, Stiles Ranch field, Wheeler Co., TX; porosity on lime matrix.
Structure map of the Upper Cottage Grove Wash; Contour interval = 100 feet
Mills Ranch and Stiles Ranch fields, Wheeler Co., TX

Chesapeake #7-59H Bass
Horizontal Cottage Grove Wash
Completed: March 2011
IPF: 996 BOPD; 1,126 MCFGD

Sanguine #4-21H Ledbetter
Horizontal Cottage Grove Wash
Completed: March 2011
IPF: 1,011 BOPD; 1,000 MCFGD

SM Energy #4-60H Ruth
Horizontal Cottage Grove Wash
Completed: May 2011
IPF: 1,255 BOPD; 1,583 MCFGD

Sanguine #7-59H Bass
Horizontal Cottage Grove Wash
Completed: September 2010
IPF: 912 BOPD; 1,127 MCFGD
CONCLUSIONS

• Located in the deep Anadarko Basin along the northern flank of the Amarillo-Wichita uplift in Oklahoma & Texas
• Granite Wash petroleum reservoirs are primarily arkosic sandstones and conglomerates with very low porosity & permeability
• Wash sediments were locally sourced from the Amarillo-Wichita uplift
• The Middle and Upper Pennsylvanian-age Granite Wash stratigraphic section exceeds 7000 feet in thickness
• Reservoirs were laid down in depositional systems varying from alluvial fans to deep-water turbidite and debris-flow deposits five to thirty miles north of the Amarillo-Wichita uplift
• Dozens of individual stratigraphic and structural-stratigraphic oil and gas traps present in a highly complex “tight oil and gas sandstone” resource system
CONCLUSIONS

- Production depths range from 9000 to 15,500 feet
- Individual petroleum reservoirs are 25 to 150 feet thick
- Porosity: 2% to 14%
- Permeability generally <0.1 millidarcy
- Oil Gravity: 44-60° API
- Four Granite Wash sub-play areas have been identified based on structure, stratigraphy, and trapping styles
- More than 2000 vertical Granite Wash wells were drilled prior to transition to horizontal drilling in 2007
- Since 2007 over 1760 horizontal Granite Wash wells have been drilled with only 86 dry holes
- 111 active permits currently awaiting drilling
CONCLUSIONS

- One thousand forty-eight (1048) horizontal Granite Wash wells have produced 69,500,000 barrels of oil and 1.5 trillion cubic feet of gas since 2007 from the study area.
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- Late 2013 reported daily production in Wheeler County alone was >33,700 barrels oil and 553 million cubic feet of gas from 648 horizontal wells.
I would like to also thank my wife Carol Mitchell for her support and patience over 36 years of marriage to a roving geologist.
Appendix

• Additional illustrations prepared during this study of the Granite Wash Play.
Principal Oil and Gas Field Production Information

>3.7 TCFG + 126 MMBO Cumulative Production from > 4,000 wells
>1,500 Horizontal Granite Wash Wells

Spud Through April 2012
HORIZONTAL GRANITE WASH PLAY

Regional Cross Section Index Map
Regional Cross Section Index Map

Horizontal Granite Wash – Colony-Braithwaite Field

Washita County-Colony Wash Play
Cum. Production: 8.3 MMBO & 117 BCFG from 141 Horizontal Wells
Daily Production: ~8,000 BOPD & 117 MMCFGPD (Feb. 2011)
Estimated Ultimate Recovery: >500 BCFE?
Type porosity log, Marmaton “D” Wash pay zone, CHK #1-13H Huls pilot hole; SW SW SW Sec. 13, T11N R19W, Breathwaite field, Washita Co., OK; porosity on lime matrix; porosity exhibits gas effect (red shading) on log and is target zone for horizontals.

2nd Marmaton Wash Flooding Surface

Marmaton “D” Wash: Colony Pay Zone

3rd Marmaton Wash Flooding Surface

Marmaton “E” Wash

4th Marmaton Wash Flooding Surface
Colony Wash Play:
77 Horizontal Marmaton Wash Wells with EUR Calculations Done:
EUR 3.4 BCFE (Includes 134 MBO Per Well) / EUR ~8X per Vertical Wells

North Braithwaite Field:
9 Vertical Marmaton Wash Wells 0.4 BCFE Per Well

Horizontal Drilling in Marmaton “D” Reservoir Since December 2006
Horizontal Granite Wash – Colony-Braithwaite Field

Breathwaite Field
Chesapeake Operating Inc.
#1-13H Huls Pilot Hole
S/2 SW SW Sec. 13, T11N R19W
Washita Co., Oklahoma
February 2009

Breathwaite Field
Meridian Oil Co.
#2-10 Charter
C/S2 Sec. 10, T11N R18W
Washita Co., Oklahoma
October 1986

Clinton South Field
Crow Creek Operating Inc.
#1-7 Lau-Re
C/NW Sec. 7, T11N R16W
Washita Co., Oklahoma
November 2005

C

K.B. 1712’

12400

12500

12600

12700

12800

12900

13000

13100

13200

13300

13400

13500

13600

MARMATON WASH "C"

0

50 Ft

100 Ft

Flooding Surface #2

MARMATON WASH "D"

MARMATON WASH "E"

Datum: Marmaton Wash
Flooding Surface #3

MARMATON WASH "F"

Flooding Surface #4

UPPER SKINNER SHALE

C'

K.B. 1561’

12000

12100

12200

12300

12400

12500

12600

12700

12800

12900

13000

13100

13200

13300

13400

13500

13600

MARMATON WASH "C"

50 Ft

Neutron/Density
Porosity
Crossover
(L.S. Matrix)

STRATIGRAPHIC CROSS SECTION C-C’

Washita Co., Oklahoma

Datum: 3rd Marmaton Wash Flooding Surface
Note: All Porosity Logs Run On 2.71 gm/cc (Ls.) Matrix
Horizontal Granite Wash – Colony-Braithwaite Field

Washita Co. Marmaton Wash Play: Avg. Max Month Production Data for 90 Horizontals
5.4 MMCFD & 516 BCPD

Max Month Production Daily Average Rates Since December 2006

Chesapeake #1-13H Huls
15.6 MMCFD, 398 BCPD

Chesapeake #2-8H Don
8.9 MMCFD, 571 BCPD

Chesapeake #1-13H Wise
9.9 MMCFD, 642 BCPD

Chesapeake #1-18H Kliewer
6.3 MMCFD, 495 BCPD

Chesapeake #1-22H Gwendolyn
11 MMCFD, 1021 BCPD

Net Ss. Isolith Map: Marmaton “D” Wash Contour Interval = 20 Feet
Horizontal Granite Wash – Colony-Braithwaite Field

- Vertical Marmaton Wash Wells EUR: ~0.4 BCFE
- Horizontal Marmaton Wash Wells EUR: ~3.4 BCFE
- 8X Reserve Uplift
- Avg. IPF: 379 BOPD; 520 BNGLPD; 3225 MCFGPD
Washita County Marmaton Wash EURs (MCFe)

P10: 6.45 BCFe
P50: 2.72 BCFe
P90: 1.05 BCFe
Mean: 3.40 BCFe

77 Wells
Graph showing number of permitted horizontal Granite Wash wells by operator in Washita County, Oklahoma through June 30th, 2011.
Horizontal Granite Wash
North Canute to Elk City Area

Hogshooter Wash (Missourian)
Structure map on 2nd Marmaton Shale, Contour Interval = 200 feet; color fills show areas of recent expansion of horizontal Wash drilling in T11-12N, R20-22W, Washita, Beckham, and Custer Cos., Oklahoma; rig symbols indicate wells being actively drilled, completed or permitted in June 2011.
Type porosity log, Hogshooter Wash pay zone, Apache #1-5H McRee pilot hole; NW NW NE Sec. 5, T11N R20W, Canute field, Washita Co., OK; porosity on lime matrix; porosity exhibits gas effect (red shading) on log and is target zone for horizontals.
Horizontal Granite Wash - North Canute Area

- **Chesapeake #1-6H McConnell**
  - Horizontal Hogshooter
  - Completed: March 2011
  - IPF: 544 BOPD, 843 MCFGD, 272 BWPD

- **Apache #1-32H McRee**
  - Horizontal Hogshooter
  - Completed: February 2011
  - IPF: 729 BOPD, 1,547 MCFGD, 1,740 BWPD

- **Apache #1-5H Edler**
  - Horizontal Hogshooter
  - Completed: August 2010
  - IPF: 1,588 BOPD, 3,019 MCFGD, 802 BWPD

- **Apache #1-5H Gregory Properties**
  - Horizontal Hogshooter
  - Completed: April 2011
  - IPF: 1,750 BOPD, ? MCFGD, ? BWPD

- **Apache #1-5H Edler**
  - Horizontal Hogshooter
  - Completed: August 2010
  - IPF: 1,588 BOPD, 3,019 MCFGD, 802 BWPD

- **Apache #3-8H Shelton**
  - Horizontal Hogshooter
  - Completed: April 2011
  - IPF: 1,291 BOPD, 1,812 MCFGD, 501 BWPD

- **Cimarex #1-4H Kephart**
  - Horizontal Hogshooter
  - Completed: April 2011
  - IPF: 654 BOPD, 1,692 MCFGD, 332 BWPD

Isolith map - L. Hogshooter Wash, Density Porosity >4% w/ gas effect; Contour interval = 20 feet; Canute field, T11N R20W, Washita Co., OK
Horizontal Granite Wash - North Canute Area

Structure map of the 1st Hogshooter shale; Contour interval = 100 feet; Canute field, T11N R20W, Washita Co., OK; star indicates location of type log well.
Horizontal Granite Wash-Wheeler County Play Area

Wheeler County Wash Play
Cum. Production: 6.3 MMBO & 194 BCFG from 181 Horizontal Wells
Daily Production: ~20,000 BOPD & 455 MMCFGPD (June 2011)
Estimated Ultimate Recovery: ?
Structure Map:
2\textsuperscript{nd} Marmaton Wash Shale
Contour Interval = 100 Feet
Color Fill Showing Marmaton “C”
Gross Sand Thickness

Six Miles
Horizontal Granite Wash Play – Wheeler Co., Texas
Gross Ss. Isolith Map: Gamma Ray <90 API Units
Marmaton “C” Wash (Granite Wash “A”)
Contour Interval = 20 Feet

- Vertical Marmaton Wash Wells EUR: ~0.6 BCFE
- Horizontal Marmaton Wash Wells EUR: ~4.9 BCFE
- 8X Reserve Uplift
- Avg. IPF: 330 BOPD; 840 BNGLPD; 6000 MCFGPD
Wheeler County Marmaton Wash EURs (MCFe)

- P10: 7.61 BCFe
- P50: 4.36 BCFe
- P90: 2.21 BCFe
- Mean: 4.88 BCFe

86 Wells
Graph showing number of permitted Granite Wash horizontal wells by operator in Wheeler County, Texas through June 30th, 2011.
Porosity isolith map of the Marmaton “B” Wash w/ neutron-density crossover & density porosity >8% on lime matrix; Contour interval = 20 feet; Sweetwater field, T11N R26W, Beckham Co., OK
Type porosity log, Marmaton “B” Wash pay zone, St. Mary #1-27 McEntire; NE SW Sec. 27, T11N R26W, Sweetwater field, Beckham Co., OK; porosity on lime matrix; lower portion of Marmaton “B” has better porosity, exhibits gas effect (red shading) on log and is target zone for horizontals in Sweetwater field.
Structure map on the 2nd Marmaton Shale; Contour interval = 100 feet; Sweetwater field, T11N R26W, Beckham Co., OK; star indicates location of type log well.

- **SM #1-34H Norma**
  - Horizontal Marmaton “B”
  - Completed: June 2011
  - IPF: 327 BOPD; 7,284 MCFGD

- **SM #1-27H McEntire**
  - Horizontal Marmaton “B”
  - Completed: June 2010
  - IPF: 319 BOPD; 8,623 MCFGD

- **SM #1-27H Bill**
  - Horizontal Marmaton “B”
  - Completed: March 2011
  - IPF: 288 BOPD; 5,059 MCFGD

- **Chesapeake #3-28H**
  - Horizontal Marmaton “B”
  - Completed: June 2011
  - IPF: 618 BOPD; 9,133 MCFGD

- **Chesapeake #1-33H Schweke**
  - Horizontal Marmaton “B”
  - Completed: April 2011
  - IPF: 518 BOPD; 8,106 MCFGD

- **Chesapeake #1-34H Sage**
  - Horizontal Marmaton “B”
  - Completed: June 2011
  - IPF: 332 BOPD; 6,154 MCFGD

- **SM #1-34H Norma**
  - Horizontal Marmaton “B”
  - Completed: June 2011
  - IPF: 327 BOPD; 7,284 MCFGD

- **SM #1-6H McGuire**
  - Horizontal Marmaton “B”
  - Completed: June 2010
  - IPF: 128 BOPD; 4,118 MCFGD

- **SM #1-27H Bill**
  - Horizontal Marmaton “B”
  - Completed: March 2011
  - IPF: 288 BOPD; 5,059 MCFGD
Graph showing number of permitted horizontal Granite Wash wells by year in study area through June 30th 2011. * Note that permits for 2011 are for the first half of the year only.
Map showing locations of thirty-two horizontal Granite Wash wells spudded prior to January 1, 2007
Yellow symbols on map showing locations of 115 horizontal Granite Wash wells during 2008
Yellow symbols on map showing locations of 95 horizontal Granite Wash wells spudded during 2009
Yellow symbols on map showing locations of 335 horizontal Granite Wash wells spudded during 2010
Yellow symbols on map showing locations of 294 horizontal Granite Wash wells spudded to date (mid-September) in 2011
Graph showing number of permitted horizontal Granite Wash wells by county in study area through June 30th 2011.
Graph showing number of horizontal Granite Wash wells per target interval as identified by author in study area through June 30th, 2011.
Graph showing numbers of permitted horizontal Granite Wash wells by operator in the study area through June 30th, 2011. Total permits issued are six-hundred and ninety-nine (699).
Yellow symbols on map showing locations of 343 horizontal Granite Wash wells spudded to date by Chesapeake
Yellow symbols on map showing locations of 78 horizontal Granite Wash wells spudded to date by Newfield
Yellow symbols on map showing locations of 74 horizontal Granite Wash wells spudded to date by Forest.
Yellow symbols on map showing locations of 71 horizontal Granite Wash wells spudded to date by Devon
Yellow symbols on map showing locations of 69 horizontal Granite Wash wells spudded to date by Apache
Yellow symbols on map showing locations of 49 horizontal Granite Wash wells spudded to date by Cimarex
Yellow symbols on map showing locations of 47 horizontal Granite Wash wells spudded to date by Linn
Yellow symbols on map showing locations of 42 horizontal Granite Wash wells spudded to date by Samson
HORIZONTAL GRANITE WASH PLAY

Granite Wash Horizontal Max Month Initial Potentials in BOPDE
(Bbls of Oil Per Day Equivalent @ 6 mcf/g= 1 BO)
Horizontal Granite Wash Wells with >2500 BOPD Equivalent (6 MCFG=1 BO)

Map showing 38 wells (stars) having available production data September 2011 and with initial daily production rates exceeding 2500 BOPD equivalent @ 6 mcfg/bbl oil.
Map showing 256 wells (stars) having available production data September 2011 and with initial daily production rates exceeding 1000 BOPD equivalent @ 6 mcfg/bbl oil.
Map showing 587 wells (stars) with available production data

September 2011: 331 wells (56%) had initial daily production rates below 1000 BOPD equivalent @ 6 mcfg/bbl oil