Has Unconventional Become Conventional?

SPEE Luncheon Presentation
February 4, 2015

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Conventional Reservoirs
Small volumes, ‘easy’ to develop

Unconventional Reservoirs
Large volumes, difficult to develop

Present
- Improved technology
- Increased price

Future

Past

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North America Shale Plays

http://pacwestcp.com/

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World Unconventional Gas

http://pacwestcp.com/
A World of Oil

North America:
15.4 MMbbls/day
50 Billion bbls
2805 billion bbls

South America:
6.9 MMbbls/day
98.5 Billion bbls
2174 Billion bbls

Africa:
8.1 MMbbls/day
77.4 Billion bbls
184 Billion bbls

Middle East:
22.5 MMbbls/day
685 Billion bbls
470 Billion bbls

Asia:
8 MMbbls/day
38.7 Billion bbls

Former Soviet Union:
9.0 MMbbls/day
79 Billion bbls
2254 Billion bbls

Europe:
7 MMbbls/day
18.3 Billion bbls
52 Billion bbls

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Top Producing Countries, 1960-2006

Crude Oil

Million Barrels per Day

14-
12-
10-
8-
6-
4-
2-
0-


United States

Former U.S.S.R.

Saudi Arabia

Russia

Iran

Source: US DOE, Energy Information Administration
Annual Energy Review 2006
Production and Price

Source: eia.doe.gov
Crude oil prices 1861–2013

US dollars per barrel

World events

- Pennsylvanian oil boom
- Russian oil exports began
- Sumatra production began
- Discovery of Spindletop, Texas
- Fears of shortage in US production
- Growth of Venezuelan production
- East Texas field discovered
- Post-war reconstruction
- Loss of Iranian supplies
- Suez crisis
- Yom Kippur war
- Iranian revolution
- Netback pricing introduced
- Iraq invaded Kuwait
- Asian financial crisis
- Invasion of Iraq

1861–1944 US average.
1945–1983 Arabian Light posted at Ras Tanura.

BP Statistical Review of World Energy 2014
© 2014 BP p.l.c.
Permeability and Volume

Post 2006: Shale Matrix Permeability range

Simplified Vertical Profile Showing Unconventional Gas Reservoirs

SOURCE: US Energy Information Administration (EIA)
Carbonate Deposition
Shale Deposition

Guillermo Rocha, P. G. / Brooklyn College Geology Department  http://academic.brooklyn.cuny.edu/geology/grocha/monument/shale.html
Wolfcamp as a Source Rock

Source “Kitchens”
Now Unconventional Resource Plays

Source: http://www.sec.gov/Archives/edgar/data/1405073/000119312513141665/d516183dex991.htm
Qualitative Well Concepts

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Quantitative Well Design Criteria
Operational Challenge

- Hydraulic fracture planes propagate perpendicular to minimum stress independent of the horizontal well direction.
- Operators frequently drill horizontal wells in other directions.
Middle Permian Basinal Siliciclastic Deposition in the Delaware Basin: The Delaware Mountain Group (Guadalupian)

DMG Outcrop

Waterflood?

Organic-rich siltstones

$\phi \sim 15\%$
$S_o \sim 20\%$
$S_w \sim 50\%$
$k \sim 10\ \text{md}$

$\phi \sim 5\%$
$S_o \sim 20\%$
$S_w \sim 60\%$
$k \sim 0.01\ \text{md}$
TOC up to 46\%

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DMG Outcrop

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Reality Check: Oil price > $110/STB and rising
Natural Gas Supply

Source: DOE QTR Report 2011

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Natural Gas Emerging Markets

- Electricity Generation
- Petrochemical feedstock
- Transportation
- LNG export
- Condensate export
Football Question

How much pressure will the football lose when inflated at 70 °F and in play at 35 °F?