USGS Open-File Report 03-472 Assessment of the Mesaverde Total Petroleum System in Southwestern Wyoming Province: a petroleum system approach to assessing undiscovered oil and gas resources

by

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General Approach

- Geologic assessment using petroleum systems approach
- Estimate potential additions to reserves during the next 30 years
- Different from USGS 1995 approach
- "sweet spot" vs. ultimate assessment



We do not estimate how much of that resource will be economic





A range of probability values for potential additions to reserves is presented



On-going USGS National Oil and Gas Assessment

- 25 priority basins (~96% of resource)
- Define Petroleum Systems
- Divide systems into Assessment Units
- Is a resource conventional or continuous?
- Most of gas in Southwestern Wyoming Province was assessed as continuous





USGS National Oil and Gas Assessment

(Areas Highlighted in Yellow are Assessment Priorities)



Total Petroleum System (TPS) Definition

"The TPS is the essential elements (source, reservoir, seal, and overburden rocks) and processes (generationmigration-accumulation and trap formation) - all genetically related petroleum, both discovered and <u>undiscovered</u>, whose provenance is a pod(s) of active source rock."

> Magoon and Schmoker (2000)



Total Petroleum System - Assessment Unit Concept





Conventional vs Continuous Type Accumulations





- Petroleum systems are easier to define in oil-prone systems than in gas-prone systems
- It is seldom possible to unequivocally tie natural gas back to a particular source rock



Identified 9 petroleum systems in the Southwestern Wyoming Province

- Phosphoria
- Niobrara
- Mowry
- Hilliard-Baxter-Mancos
- Mesaverde

- Lewis
- Lance-Fort Union Composite
- Mesaverde-Lance-Fort Union Composite
- Wasatch-Green River Composite



USGS Assessment Procedures



Assessment Committee

- Permanent committee that develops methodology, attends all assessment meetings, and approves all assessments
- Composed of geologists, engineers, and statisticians



Assessment Geologist

- Outlines Total Petroleum System and Assessment Unit areas within the TPS
- Provides geologic model for undiscovered resources
- Completes forms; "7th Approximation" for conventional accumulations, "Forspan" for continuous



Assessing Conventional:

- Historical exploration and production plots (numbers and sizes of fields discovered through time)
- Use grown field sizes
- Defendable estimate of numbers and sizes of undiscovered fields



Assessing Continuous

- Use a cell-based approach
- Historical EUR distribution, well spacing, and success ratio



Continuous Accumulations

- "A continuous accumulation is a collection of petroleum-containing cells, virtually all of which are capable of producing some oil or gas, but which vary significantly in their production (and thus economic) characteristics." (Schmoker, 2003)
- Lack obvious trap and seal, cross-cut lithologic boundaries, low matrix permeabilities, abnormal pressures, and cover large areas



• A cell is considered successful if it can produce the minimum cutoff of 15 million cubic feet of gas



Continuous: Calculating potential for additions to reserves in the next 30 years

- 1) Total assessment unit area
- 2) Area per cell of untested cells that have potential for additions to reserves in the next 30 years (<u>new reserves vs. accelerated depletion</u>)
- 3) Percentage of assessment-unit area that is untested
- 4) Percentage of untested area that has potential for additions to reserves in the next 30 years – "sweet spots"
- 5) Total recovery per cell



Continuous assessment units are very difficult to assess. They are commonly reassessed in light of new data



"Unofficial" USGS Assessments of Continuous Barnett Shale

1. Schmoker and others (1996; USGS Open-File Report 96-254)

Estimated <u>mean</u> volume: 3.4 TCFG

2. Kusskraa and others (ARI/USGS; 1998; Oil and Gas Journal)

Estimated <u>mean</u> volume: 10 TCFG



Barnett Assessment Parameters

ASSESSMENT:	1996	1998	
Cell Size (acres):	*320	*80 - 320	
Untested cells	4,668	10,148	
EUR/well (bcfg)	*0.837	*1.5; 0.84; 0.35	
Success ratio	0.86	0.86	
RESOURCE:	3.36 TCFG	10.0 TCFG	

*Devon (2002) typical Barnett well: 55 acres; 1.25 bcf drill & frac + 0.7 bcf refrac



Assessment of Mesaverde Total Petroleum System, Southwestern Wyoming Province



Structure
 contour
 map on the
 top of the
 Mesaverde
 Group









Divided into four assessment units

- Mesaverde Conventional AU
- Almond Continuous Gas AU
- Rock Springs-Ericson Continuous Gas AU
- Mesaverde Coalbed Gas AU



 Almond, Rock Springs and Ericson were all combined in the 1995 assessment



Mesaverde TPS



BCGA: Basin-centered gas accumulation



Almond Continuous Gas Assessment Unit



Vitrinite
reflectance
at top of
Mesaverde
Group





Almond
 Assessment
 Unit





All Almond wells



Almond shallow vs. Almond deep



Percent of sample

Almond wells less than 11,000 ft by thirds



ZUS65

Possible reasons for recent decline in EUR's for Almond producers

- The best locations were drilled first.
- Recent infill drilling encountered depleted reservoirs.
- Recent completions have increasingly focused on less-productive lenticular fluvial sandstones in the lower part of the Almond Formation.



Almond production greater than 11,000 ft



Rock Springs-Ericson Continuous Gas Assessment Unit



Vitrinite Reflectance At Base of

Mesaverde Group





Rock
 Springs Ericson
 Assessment
 Unit





<u>Rock Springs and Ericson Producers</u> <u>listed in I.H.S. Energy Inc.</u>

- Of the 83 wells listed as Ericson producers only 18 are perforated exclusively in the Ericson Formation. The remaining are perforated in both Almond and Ericson Formations.
- Of the 47 wells listed as Rock Springs producers,
 36 are also perforated in the Almond.
- Thus only 29 wells were identified as exclusively Rock Springs-Ericson producers



<u>There have been few attempts to</u> <u>complete in the Rock Springs-</u> <u>Ericson during the past 10 years.</u>

- Only 10 of the 83 Ericson producers were completed in 1990 or later.
- Only 10 of the 47 Rock Springs producers were completed in 1990 or later.



Rock Springs-Ericson production



Comparison of results from 1995 and 2002 Assessments for continuous sandstone gas

- 1995 Mesaverde Unconventional Play: <u>51.7</u>
 <u>TCF</u>
- 2003 Almond AU: 13.35 TCF
- 2003 Rock Springs-Ericson AU: 12.18 TCF
- Total:

25.53 TCF



Mesaverde Coalbed Gas Assessment Unit









Comparison of results from 1995 and 2002 Assessments for coalbed gas

- 1995 All coalbed gas in Southwest Wyoming Province: <u>3.9 TCF</u>
- 2002 All coalbed gas in Southwest Wyoming Province: <u>1.5 TCF</u>



Southwestern Wyoming Province

- Coalbed methane assessment numbers are down primarily because there has been no significant production from coal beds in the past 8 years
- Attempts to produce coalbed gas have been plagued by the production of large amounts of water and little gas



Mesaverde Conventional Assessment Unit



Mesaverde Conventional Assessment Unit

- That part of the Mesaverde TPS where vitrinite reflectance at the top of the Mesaverde is less than 0.8 percent
- Includes 2 oil fields (Patrick Draw and Desert Springs) and 12 gas fields above the minimum of 0.5 million barrels of oil equivalent



Mesaverde
 Conventional
 Assessment
 Unit





Mesaverde Conventional Gas Assessment Unit

We predict that only 2 oil fields (minimum size: median size: 1 million barrels) and 5 gas fields (median size: 6 BCFG) could be discovered in the next 30 years (the last oil field discovery was in 1959).



Southwestern Wyoming Province, total for all continuous-type accumulations

 Total technically recoverable gas (mean): 1995: 119.30 tcf 2003: 82.17 tcf



Only a small portion of this technically recoverable gas is likely to be economic within the next 30 years



Conclusions

- Southwestern Wyoming gas assessments are significantly lower in the 2003 assessment than in the 1995 assessment
- <u>Causes:</u>
- 1) The 2003 assessment is a 30 year projection of recoverable gas rather than an ultimate recoverable



Conclusions (cont.)

 Enthusiasm for future discoveries in the Southwestern Wyoming province has been dampened by the inability to identify new "sweet spots" in the continuous-type sandstone accumulations and the lack of progress in developing coalbed methane resources

