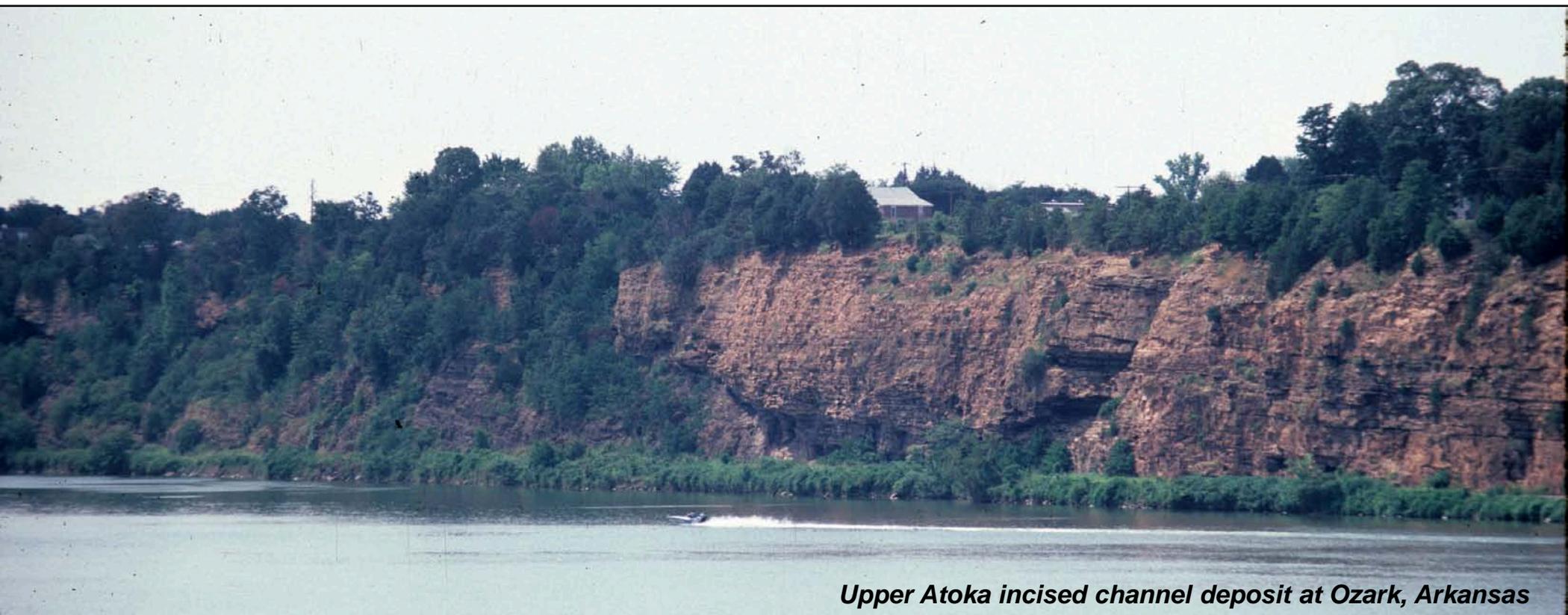


# Natural Gas Assessment of the Arkoma Basin, Ouachita Thrust Belt, and Reelfoot Rift

## *Introduction & Methodology Overview*



*Upper Atoka incised channel deposit at Ozark, Arkansas*

**Dave Houseknecht**

U.S. Department of the Interior  
U.S. Geological Survey

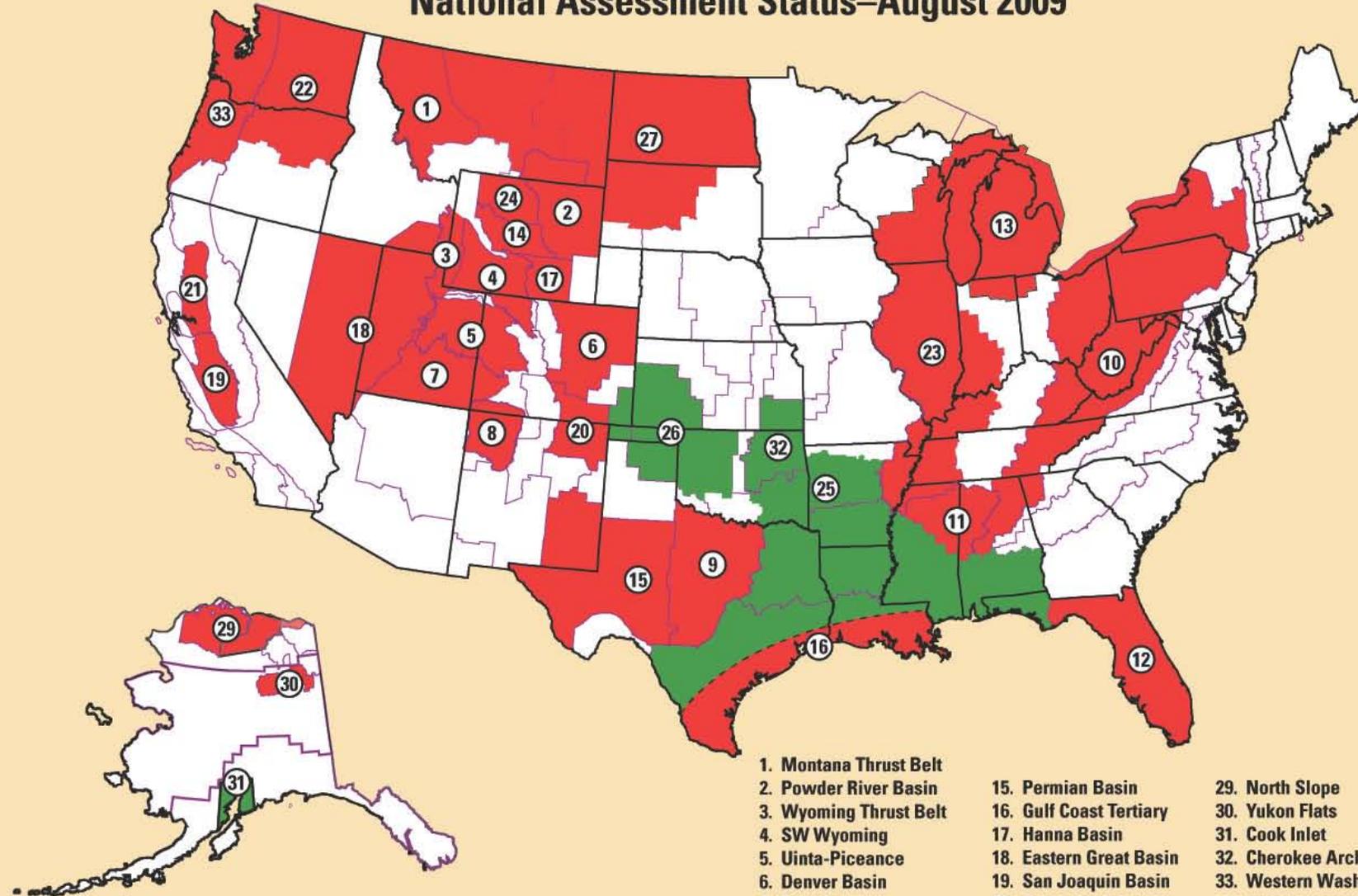
# **Energy Policy and Conservation Act of 2000 (EPCA) *and* Energy Policy Act of 2005 (EPAAct 2005)**

## ***Some Pertinent Directives Included in These Laws***

- **These acts of Congress direct the Secretary of the Interior to conduct an inventory of oil and natural gas resources beneath onshore Federal lands.**
- **The EPCA Phase III inventory includes the entire onshore United States.**
- **USGS Responsibility: the inventory shall identify the USGS estimates of oil and gas resources underlying these lands.**
- **Methodology: the Secretary of the Interior shall use the same assessment methodology across all geological provinces, areas, and regions in preparing and issuing national geological assessments to ensure accurate comparisons of geological resources.**
- **Updates: the USGS estimates of oil and gas resources shall be regularly updated and made publicly available.**

# Status of USGS National Oil and Gas Assessment

## National Assessment Status—August 2009

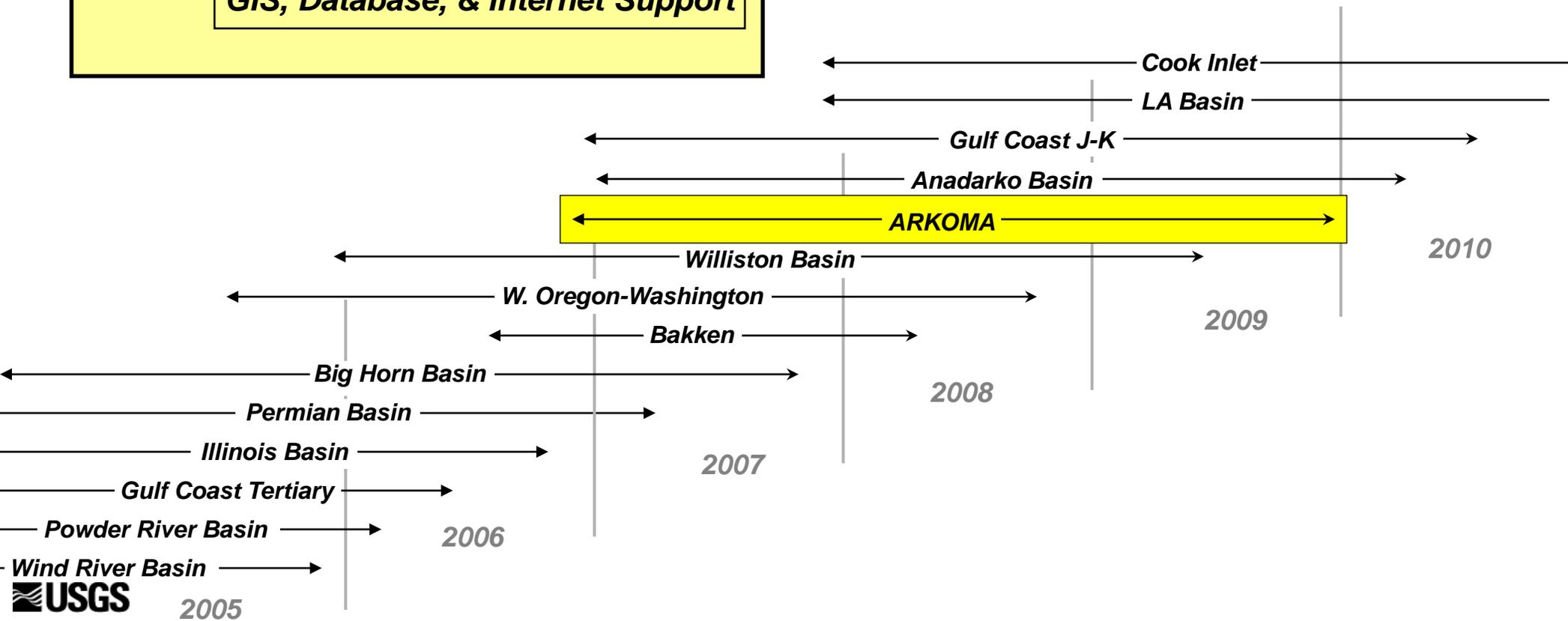
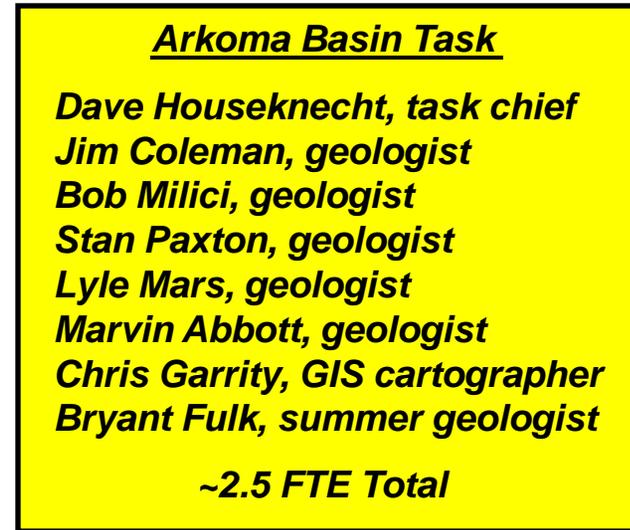
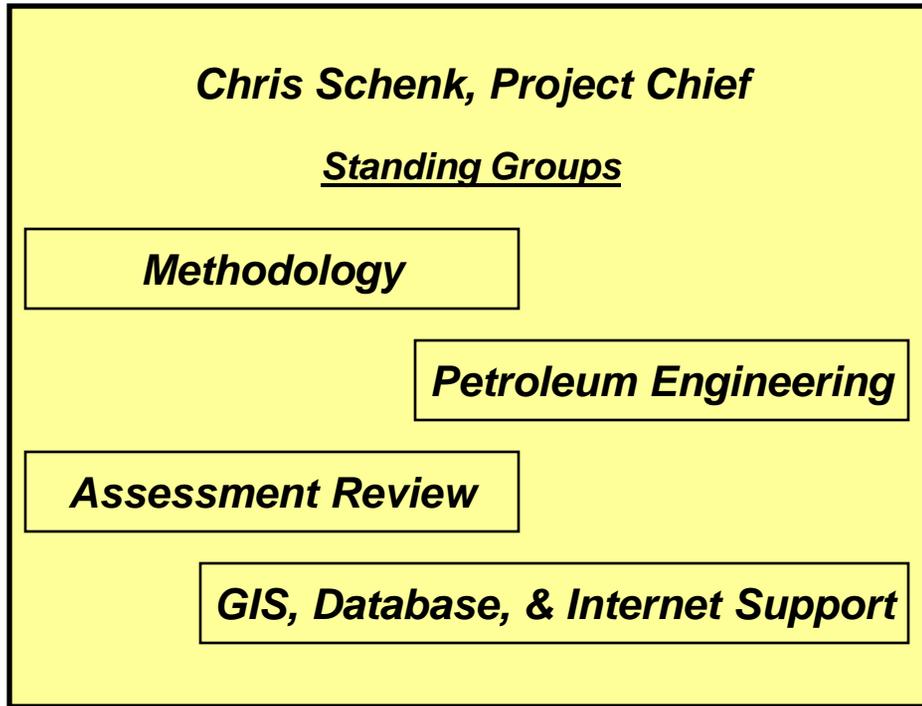


Assessed  
 Ongoing Assessments

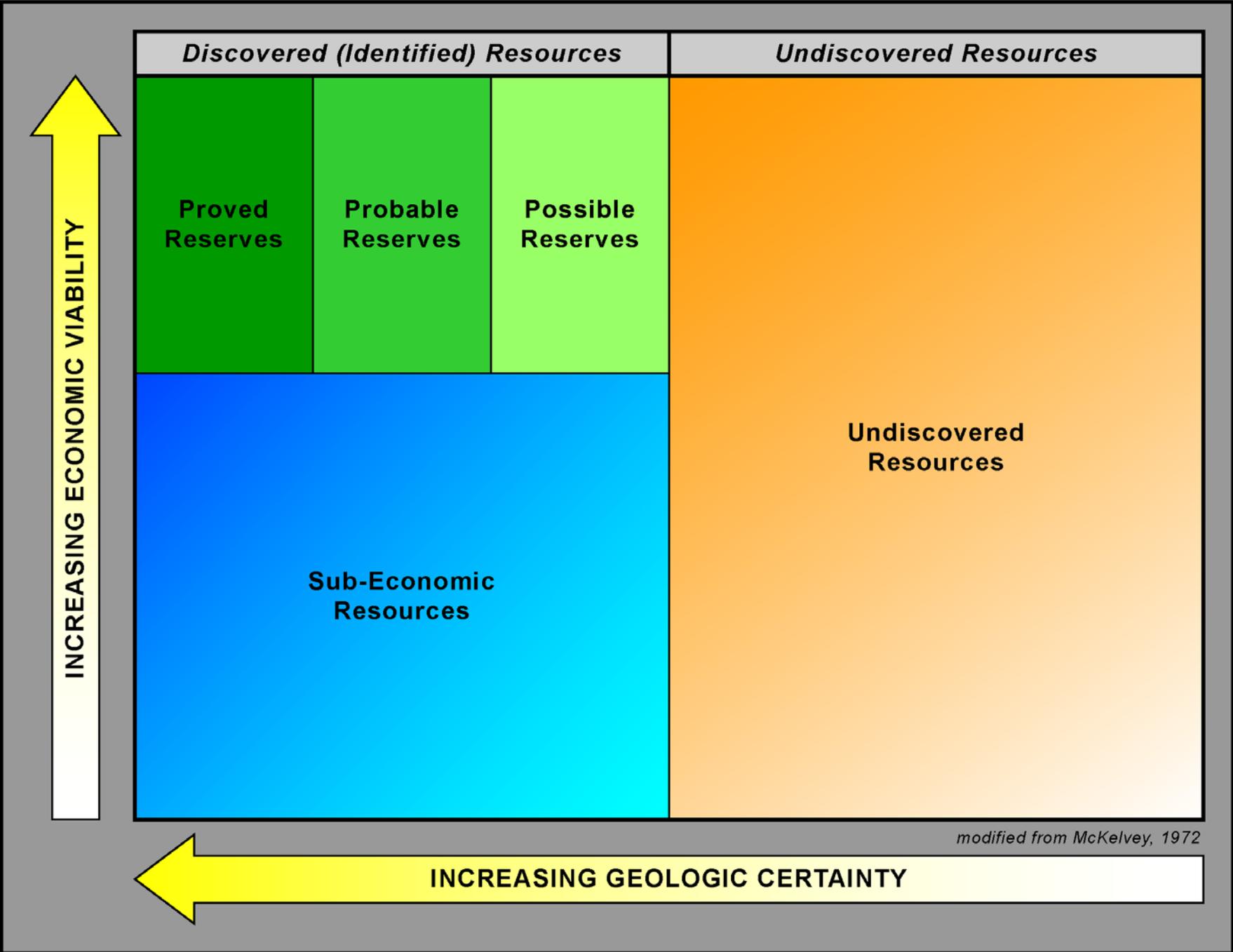
- |                        |                                  |                               |
|------------------------|----------------------------------|-------------------------------|
| 1. Montana Thrust Belt | 15. Permian Basin                | 29. North Slope               |
| 2. Powder River Basin  | 16. Gulf Coast Tertiary          | 30. Yukon Flats               |
| 3. Wyoming Thrust Belt | 17. Hanna Basin                  | 31. Cook Inlet                |
| 4. SW Wyoming          | 18. Eastern Great Basin          | 32. Cherokee Arch             |
| 5. Uinta-Piceance      | 19. San Joaquin Basin            | 33. Western Washington—Oregon |
| 6. Denver Basin        | 20. Raton Basin                  |                               |
| 7. Paradox             | 21. Sacramento Basin             |                               |
| 8. San Juan            | 22. E. Washington - Oregon Basin |                               |
| 9. Dallas-Ft. Worth    | 23. Illinois Basin               |                               |
| 10. Appalachian        | 24. Big Horn Basin               |                               |
| 11. Black Warrior      | 25. Arkoma Basin                 |                               |
| 12. Peninsula Florida  | 26. Anadarko Basin               |                               |
| 13. Michigan Basin     | 27. Williston Basin              |                               |
| 14. Wind River Basin   |                                  |                               |



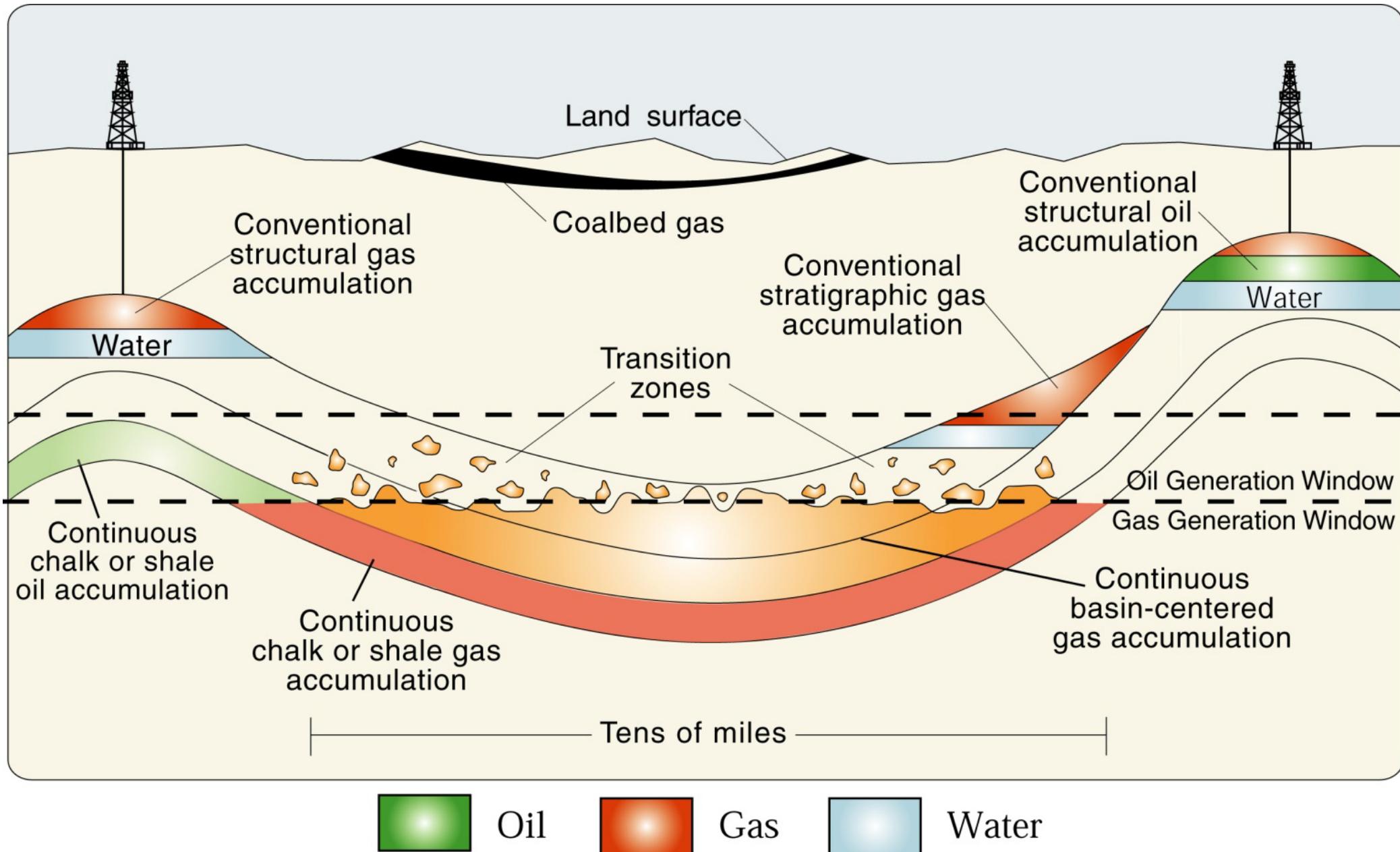
# USGS National Oil and Gas Assessment – Organization & Schedule



# USGS Role in Assessing Petroleum Resources



# Conventional & Continuous Accumulations



# Conventional Accumulations

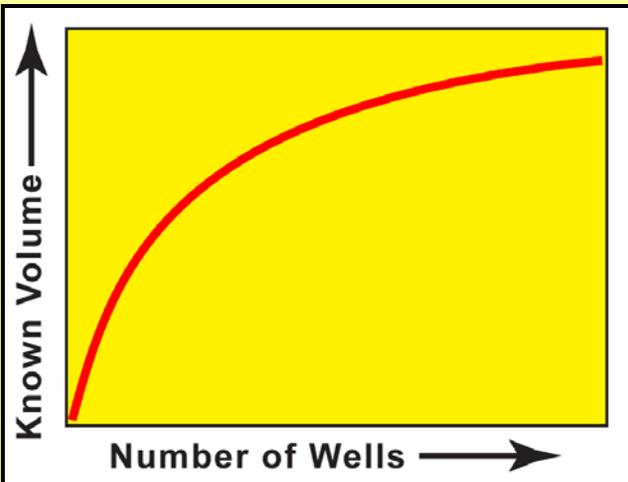
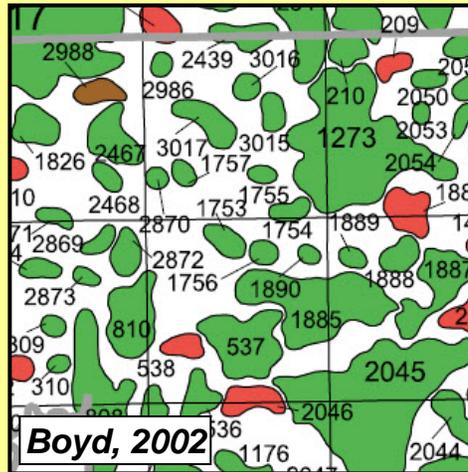
## Fundamental Characteristics

### Conventional Accumulations

- Occupy limited, discrete volumes of rock defined by traps, seals, and down-dip water contacts.
- Depend on buoyancy of oil or gas in water for their existence.

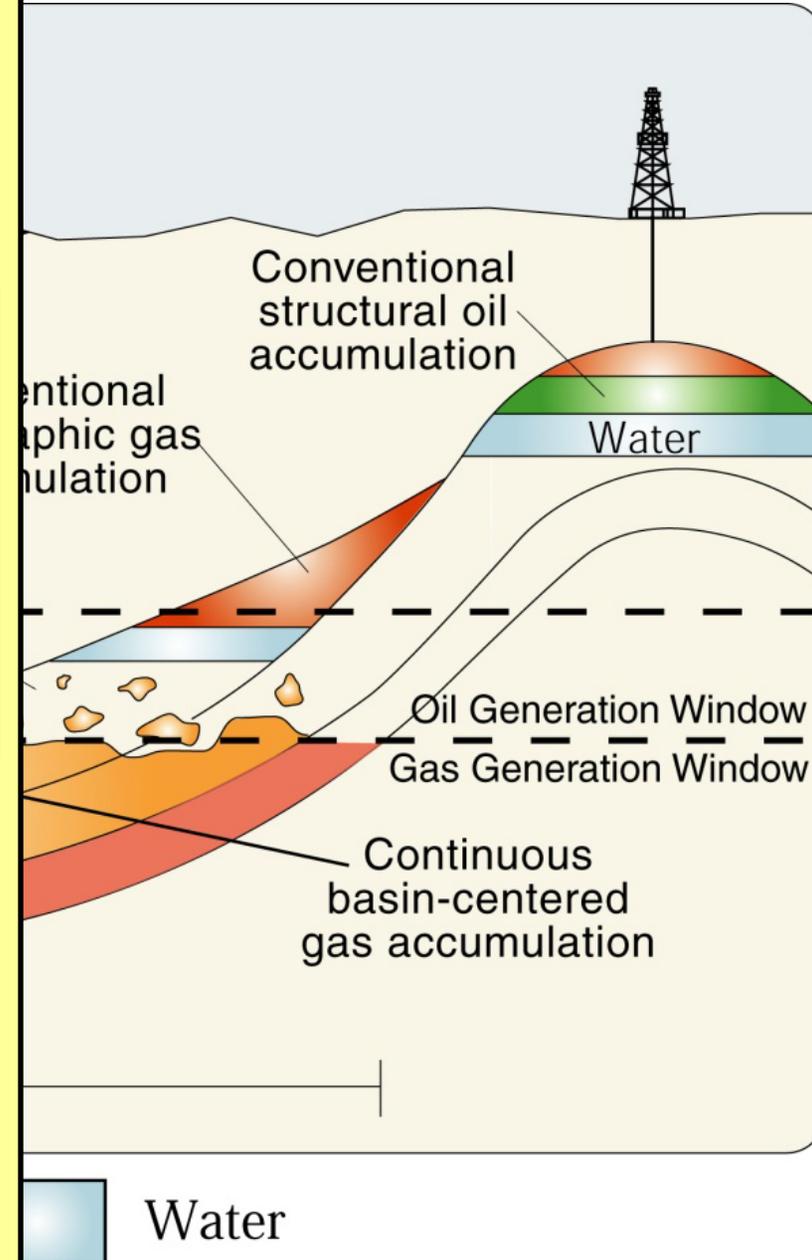
### Map View

- Discrete
- Little or no expansion in area after initial development



### Production History

- Rapid identification of most known petroleum volume
- Modest additions with additional effort

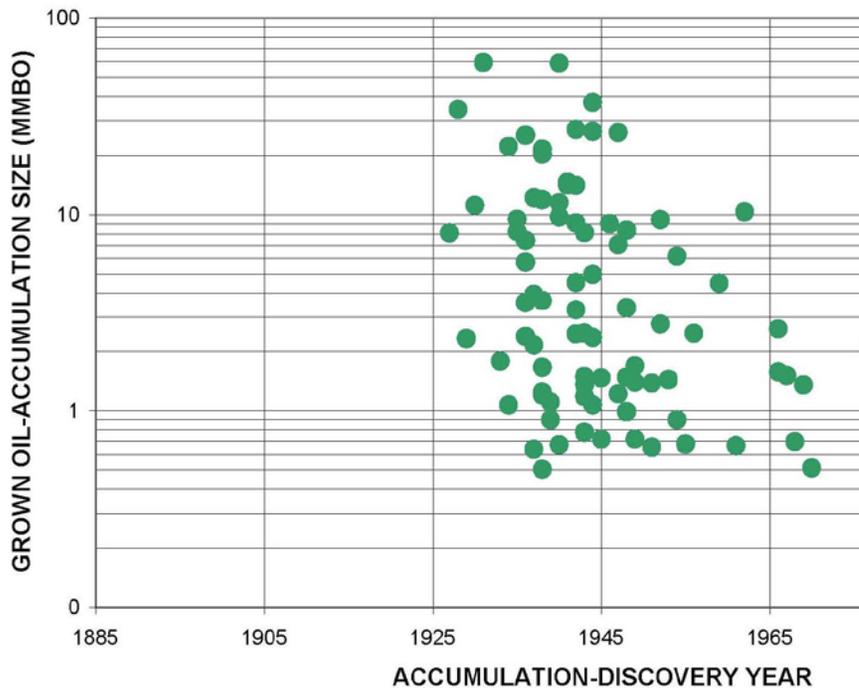


# Conventional Accumulations – Assessment Methodology

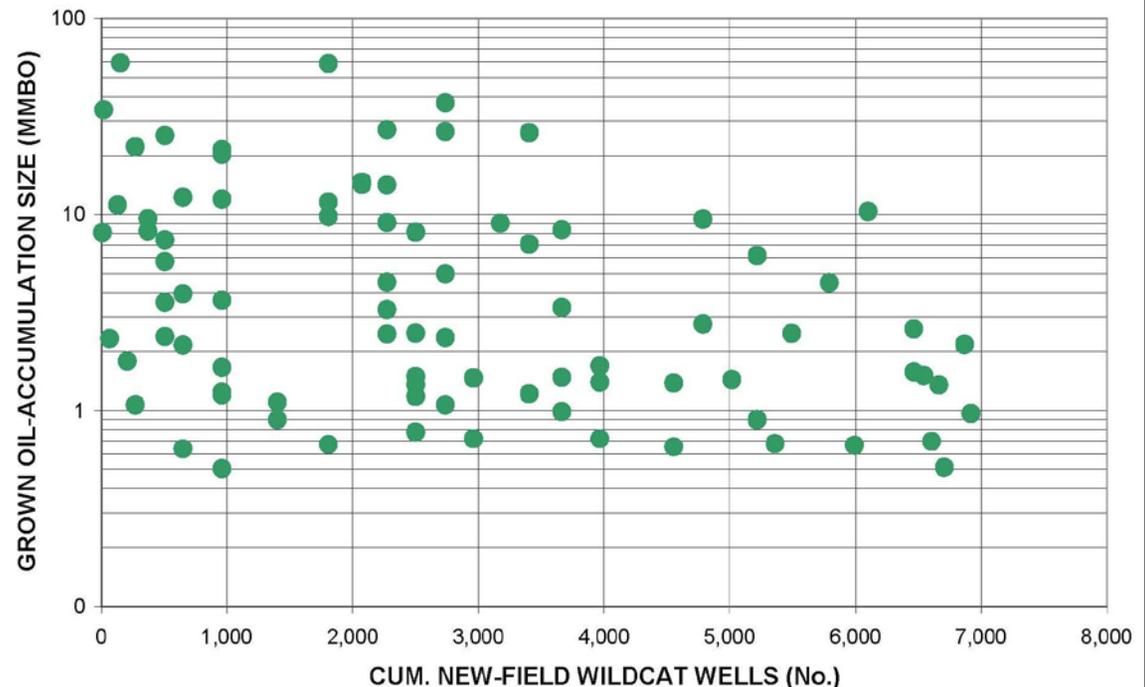
## USGS Methodology

- **Estimates of SIZES and NUMBERS of undiscovered accumulations**
- **Relies heavily on discovery history trends, including exploration maturity**
- **Geologic analysis focuses on new reservoirs and new concepts**

Middle Devonian Carbonates, Assessment Unit 50630304



Middle Devonian Carbonates, Assessment Unit 50630304



*Example of discovery history trend:  
Michigan Basin Middle Devonian Carbonates AU  
(Klett, in press)*

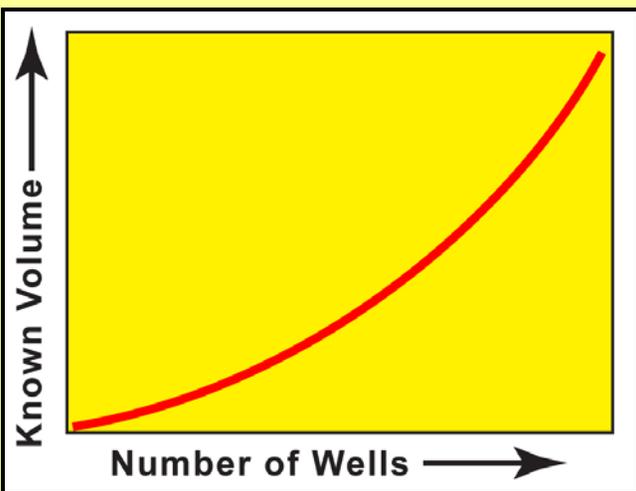
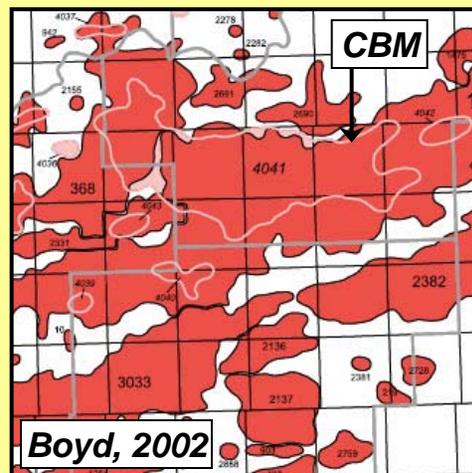
# Continuous Accumulations - *Fundamental Characteristics*

## Continuous Accumulations

- Consist of large volumes of rock pervasively charged with oil or gas.
- Do NOT depend on buoyancy of oil or gas in water for their existence.

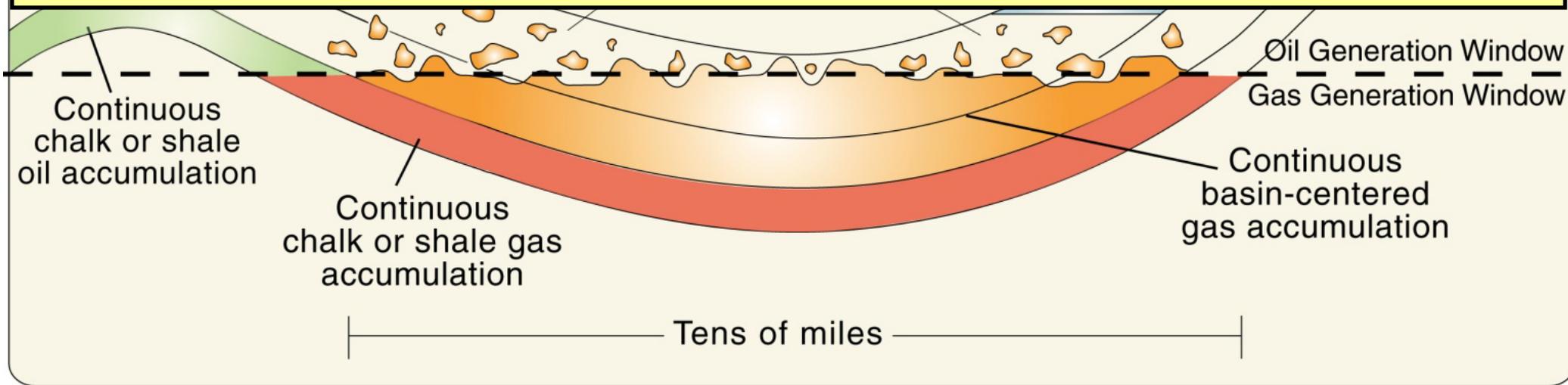
### Map View

- Extensive accumulations
- Expansion in area during development



### Production History

- Known petroleum volume grows with effort (wells, knowledge, technology)
- Significant additions through time with additional effort



Oil



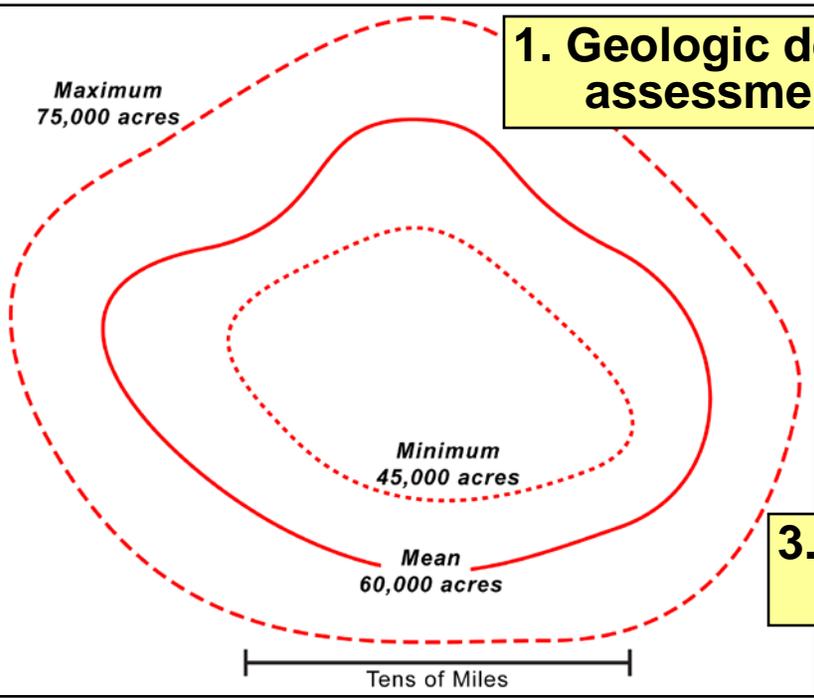
Gas



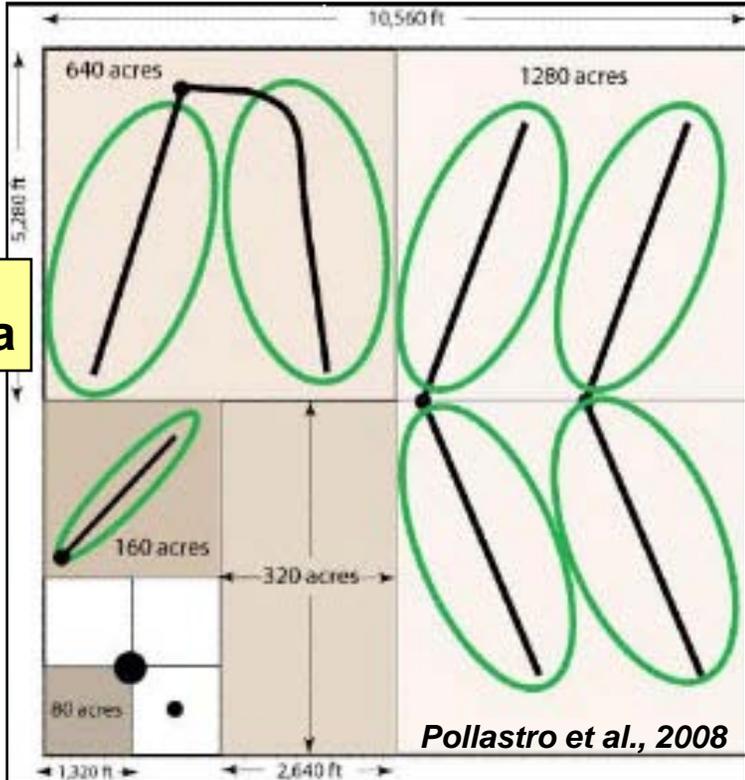
Water

# Continuous Accumulations – Main Assessment Steps

**1. Geologic definition of assessment unit**

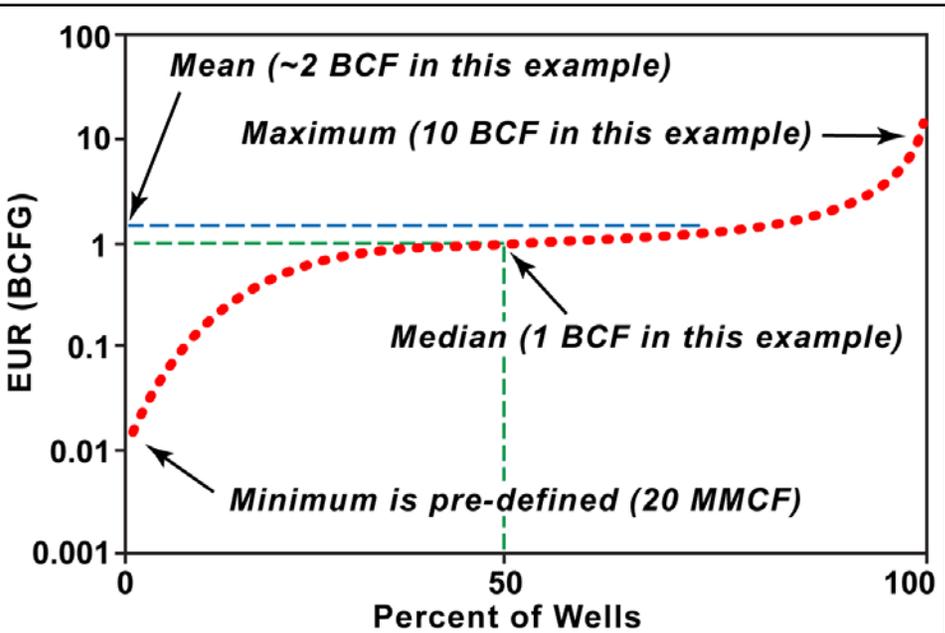


**2. Estimation of drainage area**

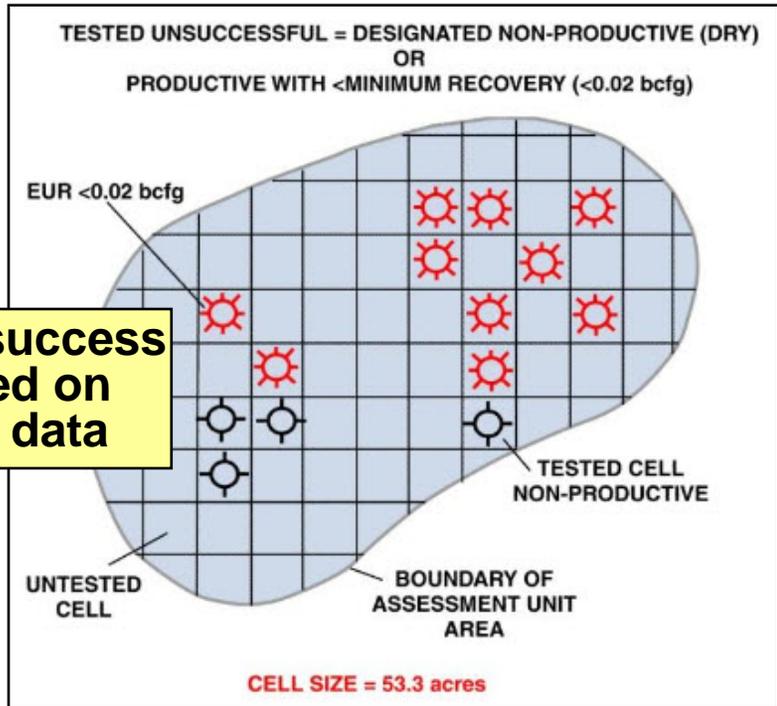


**3. Number of potential cells in AU**

**4. EUR distribution based on historical production**



**5. Estimate success ratio based on historical data**



# Summary of USGS Assessment Methodology

## Conventional Accumulations

- **SIZES and NUMBERS of undiscovered accumulations**

## Continuous Accumulations

- **CELLS and EURs**

## Documentation & AAPG Reviews of USGS Methodologies

- ***http://energy.cr.usgs.gov/oilgas/noga/methodology.html***

## Numerous published examples of USGS assessments

- ***Publication list: http://energy.cr.usgs.gov/oilgas/noga/products.html***

### U.S. Geological Survey Assessment Concepts for Continuous Petroleum Accumulations

By James W. Schmoker

Chapter 13 of  
**Petroleum Systems and Geologic Assessment of Oil and Gas  
Southwestern Wyoming Province, Wyoming, Colorado, and  
Utah**  
By USGS Southwestern Wyoming Province Assessment Team

U.S. Geological Survey Digital Data Series DDS-69-D



### FORSPAN Model Users Guide

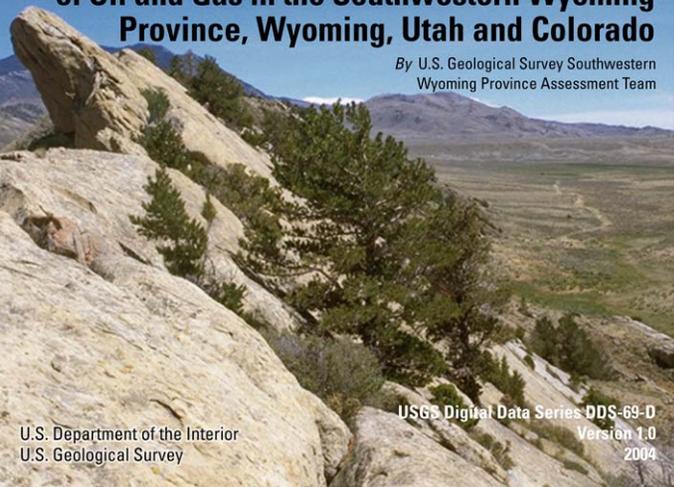
T.R. Klett and Ronald R. Charpentier

U.S. Geological Survey Open-File Report 03-384



### National Assessment of Oil and Gas Project: Petroleum Systems and Geologic Assessment of Oil and Gas in the Southwestern Wyoming Province, Wyoming, Utah and Colorado

By U.S. Geological Survey Southwestern  
Wyoming Province Assessment Team



U.S. Department of the Interior  
U.S. Geological Survey

USGS Digital Data Series DDS-69-D  
Version 1.0  
2004

# Assessment Schedule

August 2009: USGS internal geology review meeting

November 2009: Public geology review meeting hosted by OGS

January 2010: USGS final assessment meeting

Release of products to follow as soon as possible:

- **USGS Fact Sheet (spring 2010)**
- **Results & GIS added to online National database (spring 2010)**
- **USGS publications summarizing all aspects of the assessment will be released online and/or on cd-rom later in 2010**
- **External papers summarizing certain aspects of the assessment will be published over the next few years**

**Assessment of Undiscovered Hydrocarbon Resources of the Western Oregon and Washington Province**

Using a geology-based assessment methodology, the USGS estimated undiscovered natural gas and 13 million barrels of oil (MBO) in the Western Oregon and Washington Province. More than 87 percent, or 2.2 TCF, of the undiscovered natural gas is continuous gas estimated to be coalbed gas in Tertiary coal in western Oregon and Washington.

**Introduction**

The U.S. Geological Survey (USGS) recently completed an assessment of the undiscovered, technically recoverable oil and gas resources of the Western Oregon and Washington Province (Fig. 1). The province includes all of Oregon and Washington north of the Klamath Mountains and west of the crest of the Cascade Range. It extends offshore to the 24th and 30th State waters on the west and to the International Boundary in the Straits of Juan de Fuca and Canada to the north. The province encompasses about 150 north-south and 100 east-west, encompassing more than 51,000 mi<sup>2</sup> (Fig. 1).

The assessment of the Western Oregon and Washington Province is geology based and used the petroleum system (TPS) concept. The geologic elements of a TPS include hydrocarbon source rocks (source rock maturation and hydrocarbon generation and migration), reservoir rocks (quality and distribution), and traps for hydrocarbon accumulation. Using these geologic criteria, the USGS assessment team defined two conventional and one unconventional (continuous) total petroleum systems with one assessment unit (AU) in each TPS: (1) the Cretaceous-Tertiary Composite TPS and the Western Oregon and Washington Conventional Gas AU, (2) the Tertiary Coalbed Gas TPS and the Tertiary Marine Gas AU, and (3) the Tertiary Coalbed Gas TPS and the Eocene Coalbed Gas AU, in which a coalbed methane system was defined.

The province (Fig. 1) occupies a complex geologic setting along the well-defined continental margin of North America. Some 5,000 ft to more than 12,000 ft of Paleogene volcanic rocks, marine sandstones and shales, and Tertiary sandstones, shales, and siltstones underlie the province in the Basin and Range province. These rocks include potentially mature source rocks and reservoir rocks.

Before 1970, the only oil and gas production was in the Washington part of the province, near Oyster Harbor, from 1937 to 1960 (Fig. 1). It values about 12,000 barrels of oil and associated gas were produced. Consistently, the only hydrocarbon production within the province is from the gas field in northwestern Oregon.

U.S. Department of the Interior  
U.S. Geological Survey

## Powder River Basin, Pro...

**Table 1. Western Oregon and Washington Province assessment results (D&GR) million barrels of oil, BCFG, billion cubic feet of gas, MBOEGL, and equivalents, all liquids are included in the TFC, current gas liquids. Oils are a 65 percent class of oil based on resource obtained, other fractions are defined petroleum systems, AU, assessment unit; CBO, current gas; GGR, gas data tables.**

State Petroleum System (TPS) and Assessment Unit (AU)	Field	Oil	Gas	Equivalents
	TPS	TPS	TPS	TPS
Continental Gas AU	Oil	0	0	0
Tertiary Marine Gas AU	Oil	0	0	0
Tertiary Coalbed Gas AU	Oil	0	0	0
<b>Total Conventional Petroleum</b>	<b>Oil</b>	<b>0</b>	<b>0</b>	<b>0</b>
Tertiary Coalbed Gas TPS	Oil	0	0	0
Eocene Coalbed Gas AU	Oil	0	0	0
<b>Total Continuous Petroleum</b>	<b>Oil</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Total Undiscovered Oil and Gas Resources</b>	<b>Oil</b>	<b>0</b>	<b>0</b>	<b>0</b>

**Basin Results Assessment**

**Basinwide Data: Download GIS Here**

**Mowry Total Petroleum System: Download GIS Here**

**Tertiary-Upper Cretaceous Coalbed Methane: Download GIS Here**

**Paleozoic-Mesozoic Total Petroleum System: Download GIS Here**

**Pennsylvanian-Permian Composite Total Petroleum System: Download GIS Here**

**Cretaceous Biogenic Gas Total Petroleum System: Download GIS Here**

**Niobrara Continuous Oil Total Petroleum System: Download GIS Here**

## Total Petroleum Systems and Geologic Assessment and Gas Resources in the Powder River Basin, Wyoming and Montana

**Richard M. Pollastro**

**Need Technical Support?**

**Basin Results Assessment**

**Basinwide Data: Download GIS Here**

**Mowry Total Petroleum System: Download GIS Here**

**Tertiary-Upper Cretaceous Coalbed Methane: Download GIS Here**

**Paleozoic-Mesozoic Total Petroleum System: Download GIS Here**

**Pennsylvanian-Permian Composite Total Petroleum System: Download GIS Here**

**Cretaceous Biogenic Gas Total Petroleum System: Download GIS Here**

**Niobrara Continuous Oil Total Petroleum System: Download GIS Here**

## Total petroleum system assessment of undiscovered resources in the giant Barnett Shale continuous (unconventional) gas accumulation, Fort Worth Basin, Texas

**Richard M. Pollastro**

**AUTHOR**  
RICHARD M. POLLASTRO -- Central Energy Resources Team, U.S. Geological Survey, Box 25046, MS 859, Denver, Colorado 80225; pollastro@usgs.gov

Rich received an M.A. degree in geology from the State University of New York at Buffalo in 1977. He joined the U.S. Geological Survey in 1978 and serves as a province geologist on the national and world energy assessment projects. His recent accomplishments include petroleum system assessments of the Fort Worth, Permian, and South Florida basins, and the Arabian Peninsula.

**ACKNOWLEDGEMENTS**

The author is grateful to several individuals and independent exploration companies for valuable discussions of the Barnett Shale play and for providing data and information for the assessment of gas resources in the Barnett continuous accumulation. The author is particularly thankful for the cooperative efforts of Dan Jarvie and his associates at Humble Geochemical Services to define the Barnett-Paleozoic total petroleum system, and to Troy Cook, U.S. Geological Survey petroleum engineer, who generated estimated ultimate resource distributions and provided helpful discussions on unconventional reservoir production. Kent Bowler, Craig Adams (Adco Production Co.), Brad Curtis and Dan Steward (Republic Energy), David Martineau (Rifts Oil and Gas), Tony Carvalho (Chief Oil and Gas), and Robert Cluff (Discovery Group) were also especially helpful in sharing their knowledge and experience on geologic and production characteristics of the Barnett play, which greatly facilitated the assessment process. Special thanks are due to Chris Schenk, chief of the U.S. Geological Survey National Oil and Gas Assessment Review Committee, Ron Charpentier, Tom Ahlbrandt, and Tim Klett, for sharing their wisdom and advice during the assessment. Ron Hill and Mitch Henry (U.S. Geological Survey) provided essential assistance in the collection, analysis, and interpretation of oil and gas samples. Jim Scholmer provided early versions of the manuscript and provided helpful discussions on methodology and data input. I am also grateful to constructive reviews by AAPG reviewers Kent Bowler, Brian Bötcher, William Fischer, and William Hill. Finally, this article benefited greatly from critical and detailed review by Dick Keefler.

**ABSTRACT**

Undiscovered natural gas having potential for additions to reserves in the Mississippi Barnett Shale of the Fort Worth Basin, north-central Texas, was assessed using the total petroleum system assessment unit concept and a cell-based methodology for continuous-type (unconventional) resources. The Barnett-Paleozoic total petroleum system is defined in the Bend arch-Fort Worth Basin as encompassing the area in which the organic-rich Barnett is the primary source rock for oil and gas produced from Paleozoic carbonate and clastic reservoirs. Exploration, technology, and drilling in the Barnett Shale play have rapidly evolved in recent years, with about 3500 vertical and 1000 horizontal wells completed in the Barnett through 2005 and more than 85% of them completed since 1999. Using framework geology and historical production data, assessment of the Barnett Shale was performed by the U.S. Geological Survey using vertical wells at the peak of vertical well completions and before a transition to completions with horizontal wells. The assessment was performed after (1) mapping critical geological and geochemical parameters to define assessment unit areas with future potential, (2) defining distributions of drainage area (cell size) and estimating ultimate recovery per cell, and (3) estimating future success rates.

Two assessment units are defined and assessed for the Barnett Shale continuous gas accumulation, resulting in a total mean undiscovered volume having potential for additions to reserves of 26.2 TCFG. The greater Newark East fracture-barrier continuous Barnett Shale gas

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AAPG BULLETIN, V. 91, NO. 4 (APRIL 2007), PP. 551-578 551

# Schedule for Arkoma – Ouachita – Reelfoot Workshop

1. Introduction and Overview of USGS Assessment Methodology (*Houseknecht*)
2. Regional Geologic Framework (*Houseknecht*)
3. Arkoma “Fairway” Resources (*Houseknecht*)
  - Arkoma Shelf AU
  - Arkoma Deep Basin Conventional AU
  - Arkoma-Ouachita Foredeep Continuous AU
4. Shale-Gas Resources (*Paxton, Milici, & Houseknecht*)
  - Woodford Shale Gas AU
  - Chattanooga Shale Gas AU
  - Fayetteville Shale Gas AU
  - Caney Shale Gas AU
5. Arkoma Coalbed Gas Resources (*Milici*)
  - Arkoma Coalbed Gas AU
6. Frontier Gas Resources (*Coleman*)
  - Ouachita Thrust Belt AU
  - Arkansas Novaculite AU
  - Post-Ouachita Successor Basin AU
  - Reelfoot Rift Elvins Shale Gas AU
6. Poster Session (*USGS*)
  - Spectrum of topics on geologic framework of the assessment

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