# The Expanding Role of the Geologist in the Estimation of Resources/Reserves in Shale Gas Reservoirs*

**Chuck Boyer**[1]

Search and Discovery Article #120023 (2009)
Posted December 11, 2009

*Adapted from presentation at AAPG Geoscience Technology Workshop, "Geological Aspects of Estimating Resources and Reserves," Houston, Texas, September 9-11, 2009

[1]Schlumberger Data & Consulting Services, Pittsburgh, PA (boyer@pittsburgh.oilfield.slb.com)

## Abstract

Resource and reserves estimation methodology for conventional oil and gas reservoirs is based in large part on the historic precedent of geologic and engineering evaluation over the last 150 years. Conversely, the methods used for shale gas reservoirs are recently developed and still evolving. Gas shale formations display complex reservoir characteristics, including free and adsorbed gas, natural fractures, and very low matrix permeability. These characteristics vary significantly vertically and laterally within shale reservoirs, controlled by both depositional setting and subsequent burial and tectonic history.

During early stages of a shale gas development program, critical data are required to fully assess the gas in place (resources) and the potential for economic recovery of that gas (reserves). These data, including formation geometry, porosity, organic content and composition, gas sorption, and reservoir pressure, are used by the geologist to begin to understand the static reservoir structure. Stochastic techniques are often employed to populate the static geologic model of the exploration area. Subsequent data obtained from completion and production operations begin to define the dynamic reservoir structure, including completed reservoir volume and flow dynamics. Combining traditional deterministic forecasting techniques (analog, volumetric, decline curve) with more specialized methods (shale gas specific analytic and simulation models) provides an initial understanding of reservoir performance and ultimate recovery. Awareness of the reservoir and reservoir property continuity is critical for assessing with reasonable certainty the extent and viability of this continuous play within and outside of the initial exploration area.

Assessing developed plays again relies on a combined stochastic/deterministic approach; however, in this more data-rich setting the geologist will rely on a more deterministic approach for evaluating the changing static and dynamic conditions within the reservoir. From this evaluation, production regions/compartments within the continuous deposit are defined. Production analysis and forecasting at this stage often use a stochastic approach, in part because of the abundant production data and the known variability inherent in shale gas production. Understanding production variability in light of the static and dynamic reservoir conditions can further satisfy the reasonable certainty criteria required for reserves estimation.

Data & Consulting Services
Intelligent **performance**

# The Expanding Role of the Geologist in the Estimation of Resources/Reserves in Shale Gas Reservoirs

Chuck Boyer
Scientific Advisor – Unconventional Reservoirs

Schlumberger

# Very short history of shale gas

1747 - "Shale" defined by Hoosen in *The Miner's Dictionary*

- Recognition of mudstones as a separate class of rocks

1821 – First gas production from shale

- 27-foot deep well in the Dunkirk Shale, western New York

1921 – Big Sandy field discovered

- >1,000 Mcf/d from Ohio Shale, eastern Kentucky

1976-2000 - $127 million research program by DOE and GRI

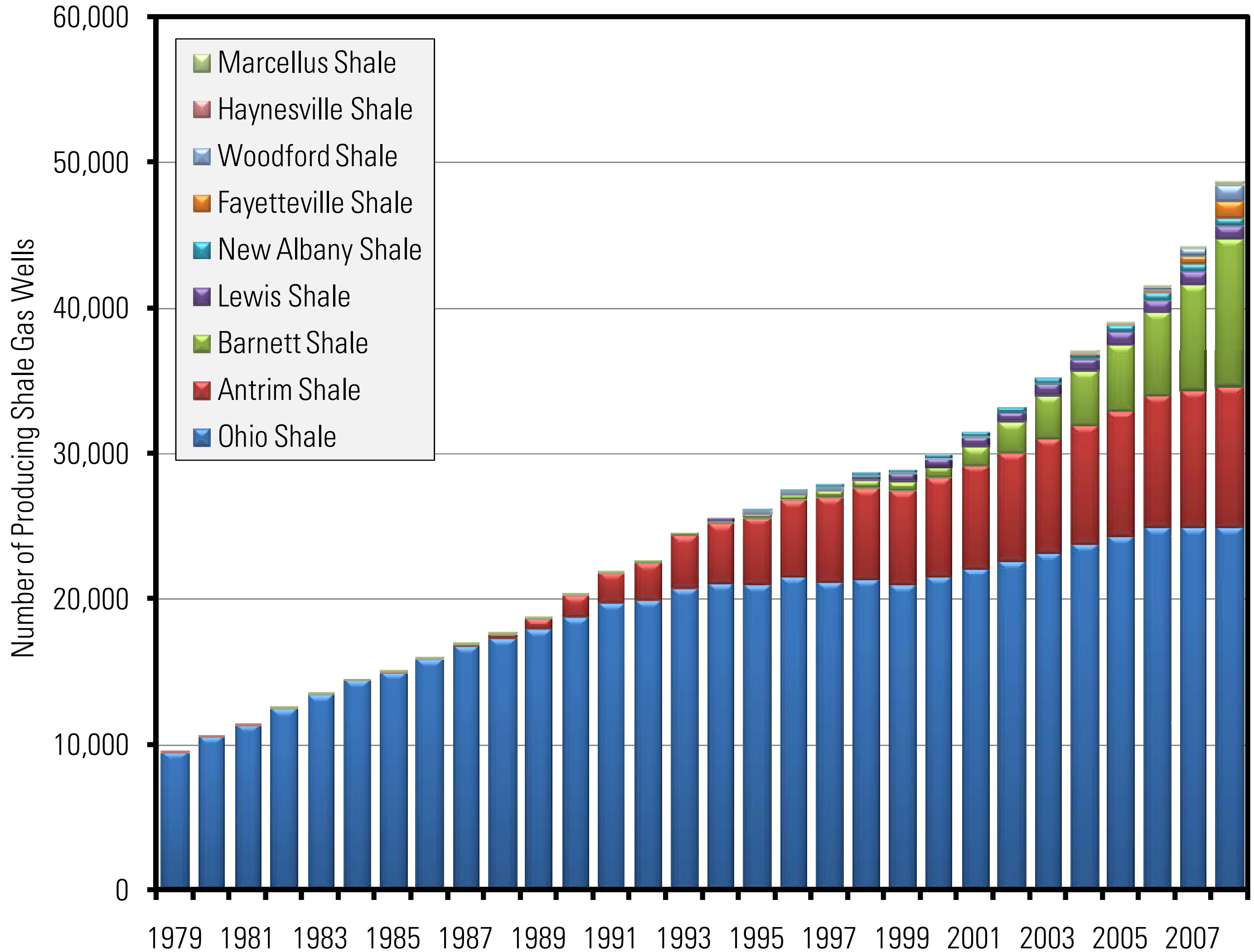
- Development of the Antrim Shale in Michigan

Late 1990's – Mitchell Energy develops optimum completion technique

- Barnett becomes the rising phoenix of shale gas

# Shale gas wells in the US

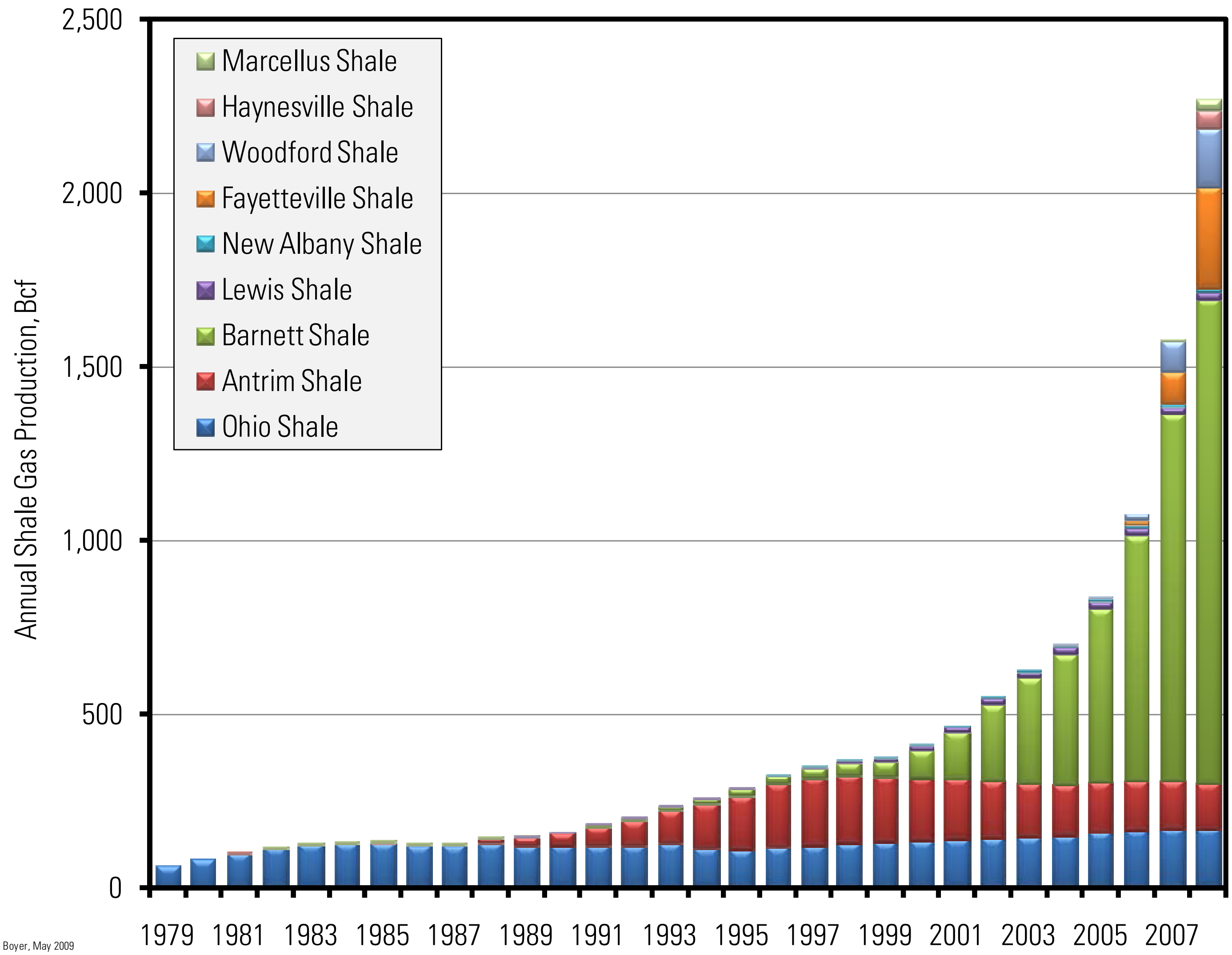





Boyer, May 2009

# Shale gas production in the US

Data & Consulting Services
Intelligent performance




Boyer, May 2009

Schlumberger

# Nature of shale gas reservoirs

## Common reservoir traits

- Organic rich - > 1% TOC
- Adsorbed and free gas
- Complex mineralogy
- Naturally fractured
- Very low matrix permeability

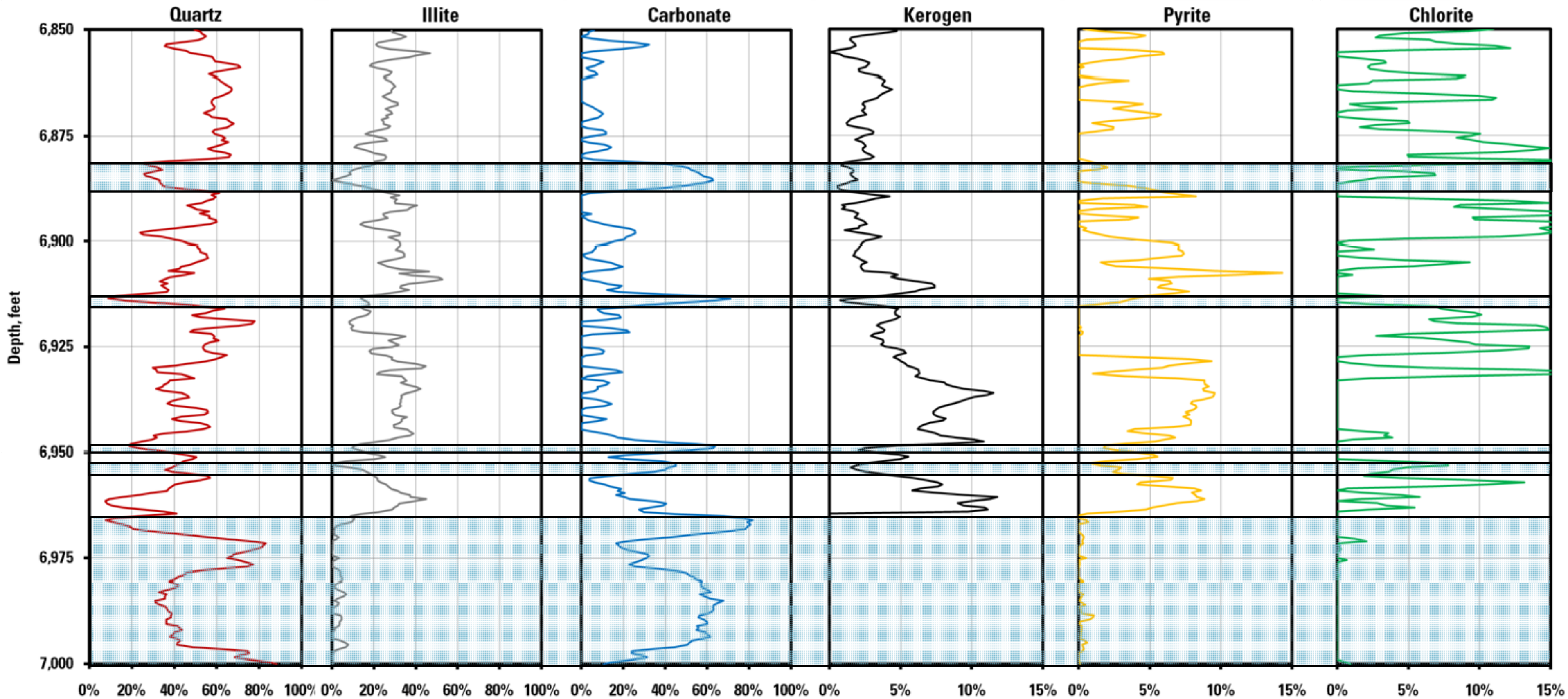
## Common development traits

- Large developments
- Complex drilling and completion practices
- Long well life (> 50 years)



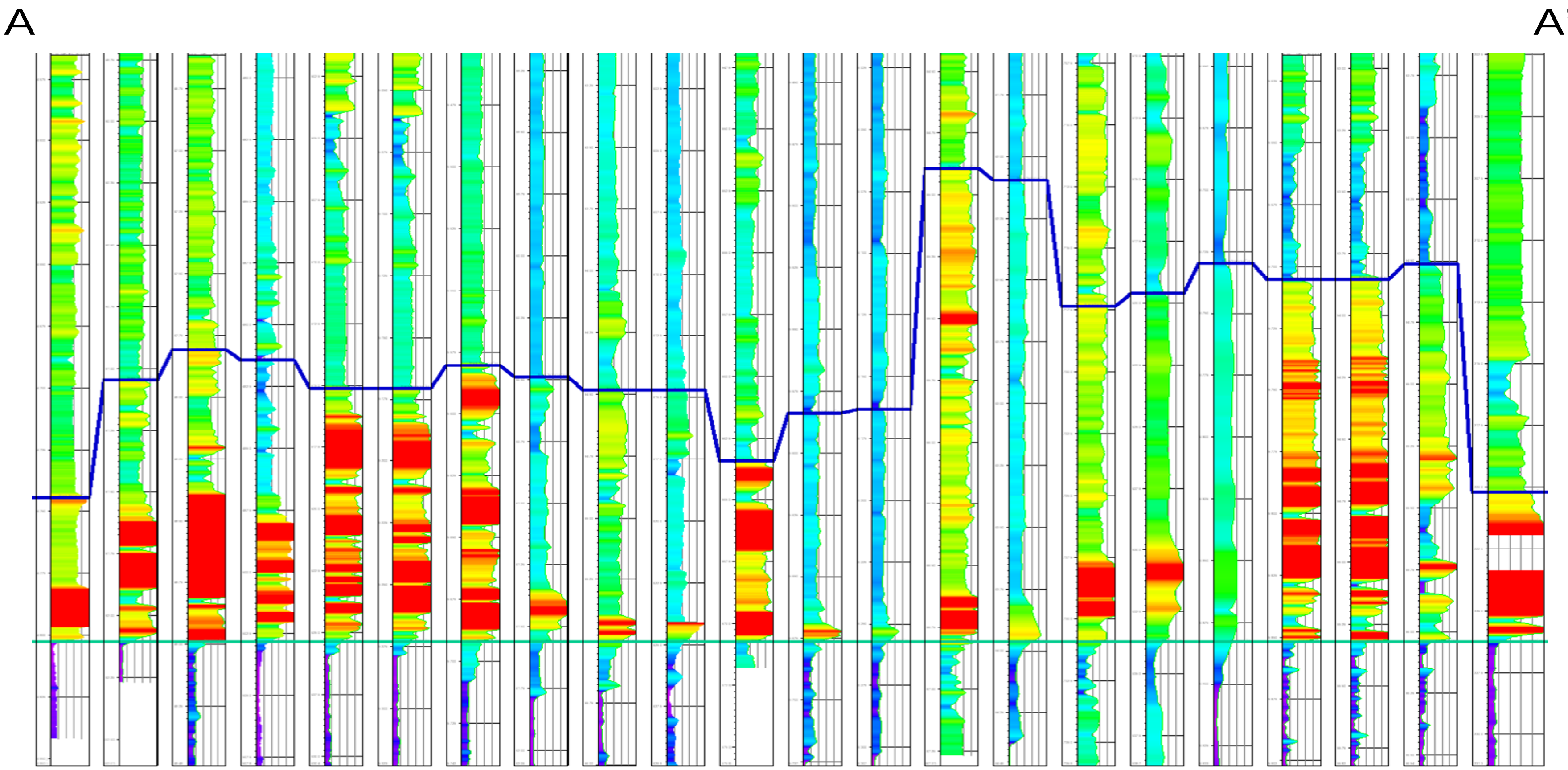
Schlumberger

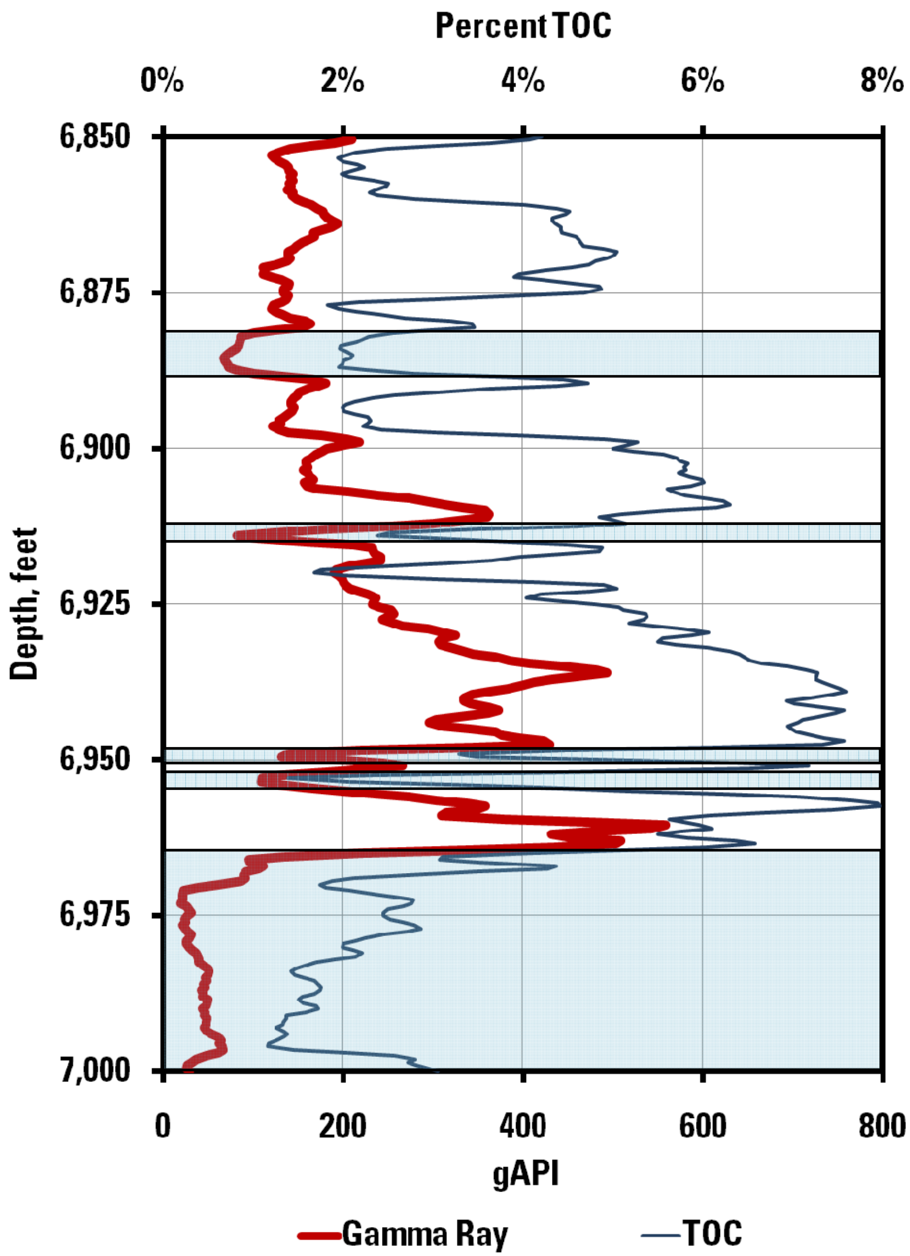
# Mineralogy highly variable




Schlumberger

# Lateral variation follows depositional trends

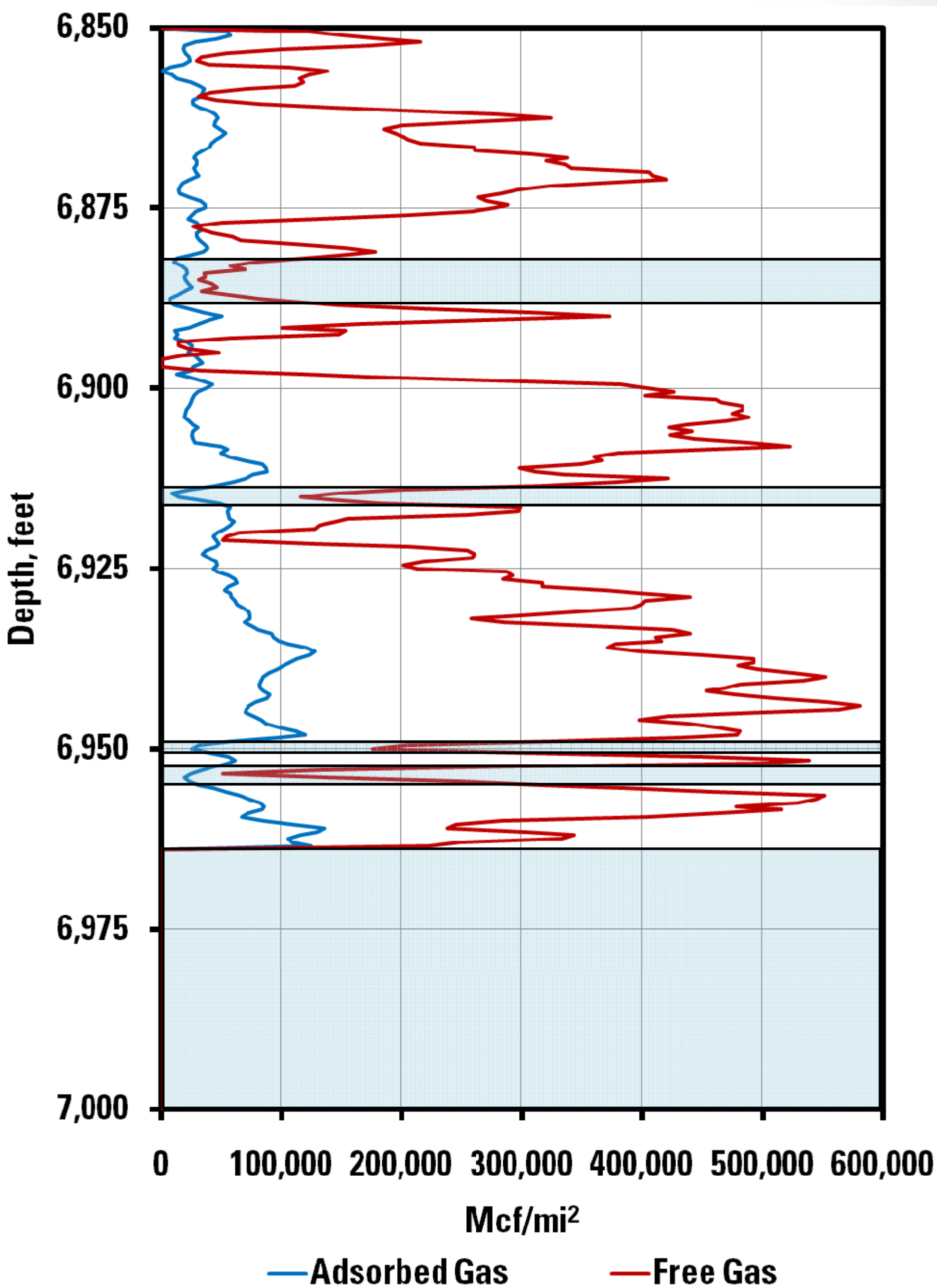


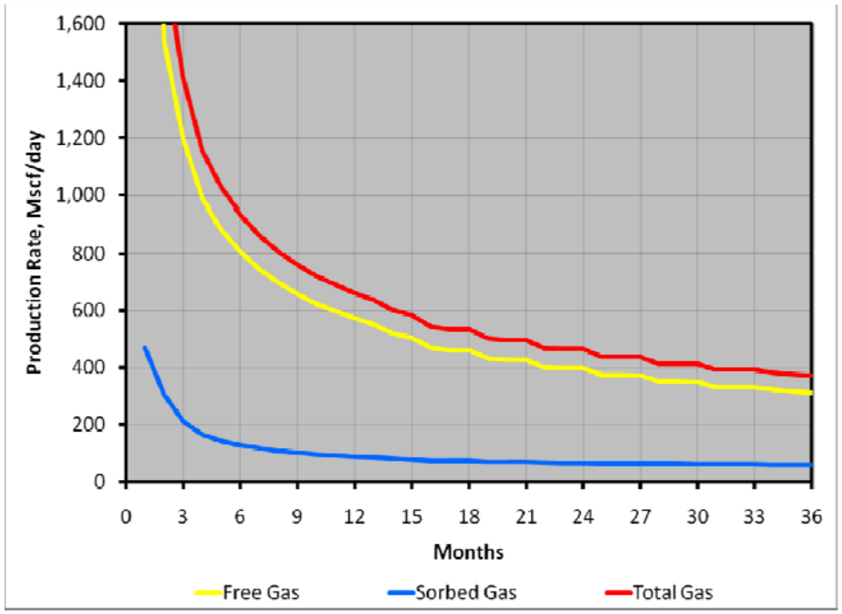



Variability of TOC is common in shale gas reservoirs, controlled by mudrock depositional events

Schlumberger

# Gas concentration varies with reservoir quality




Schlumberger

# Not all fractures are equal



Schlumberger

# Exploration and initial development

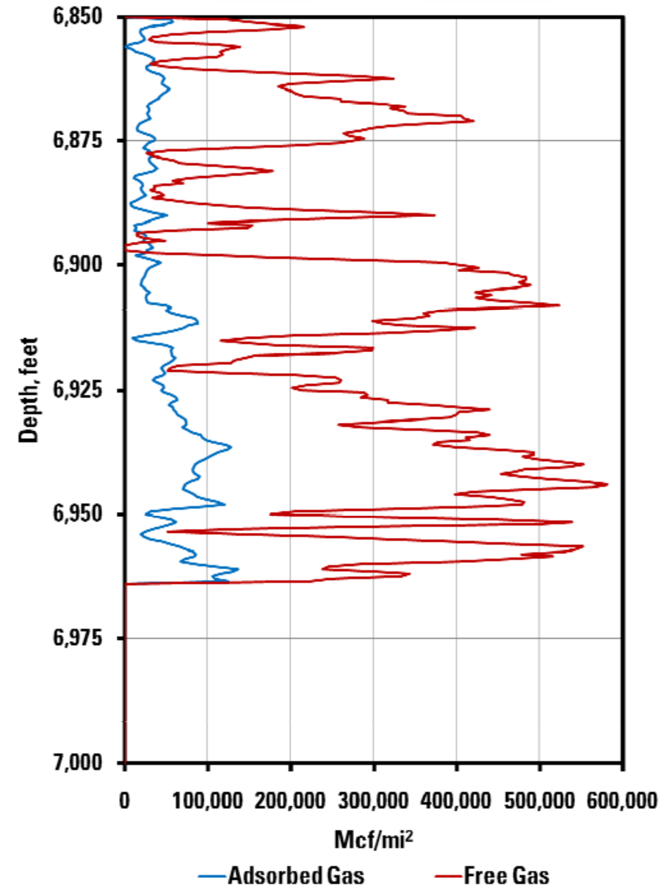
Common characteristics of early shale gas plays:

- Large area for development
  - Tens to hundreds of thousand acres common
- Regional geology generally known
  - Plays have been most often in mature O&G basins
- Conventional O&G well data often available
  - Shale has been penetrated for deeper targets
- Deliverability difficult to quantify
  - Few shale gas wells with short history

# Exploration and initial development

## What is the role of the geologist?

- Confirmation of reservoir continuity
  - Continuous accumulation with diffuse boundaries
  - Identification of vertical and horizontal boundaries
- Determination of reservoir quality
  - Gas in place
    - Vertical and lateral variability
  - Contacted reservoir volume
    - What is the source of the production

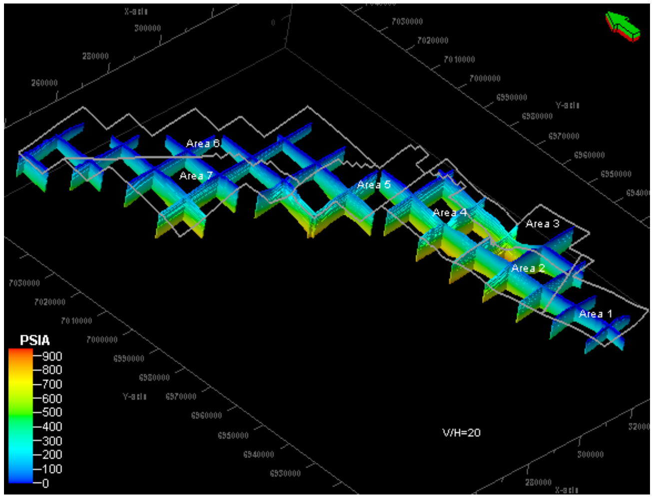



Schlumberger

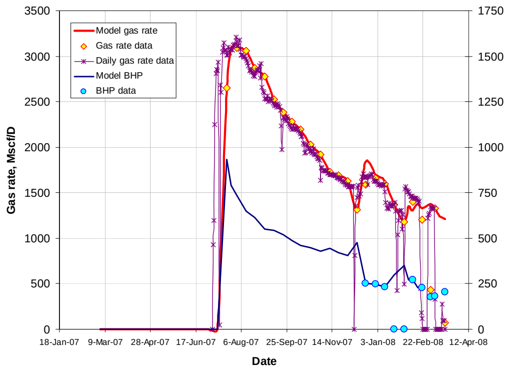
# Exploration and initial development

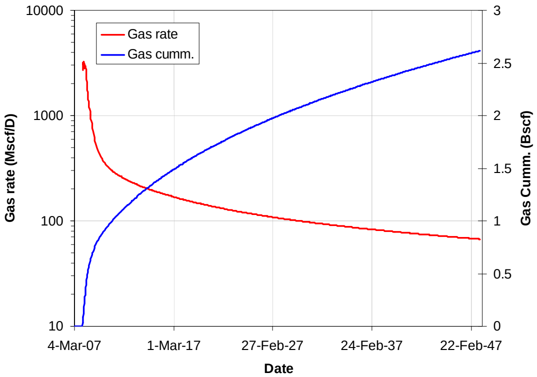
What does the geologist require?

- Seismic (3D)
  - Reservoir continuity
  - Reservoir quality
- Core
  - Reservoir quality
- Logs
  - Reservoir variability
- Microseismic
  - Reservoir volume




Stochastic Shared Earth Model



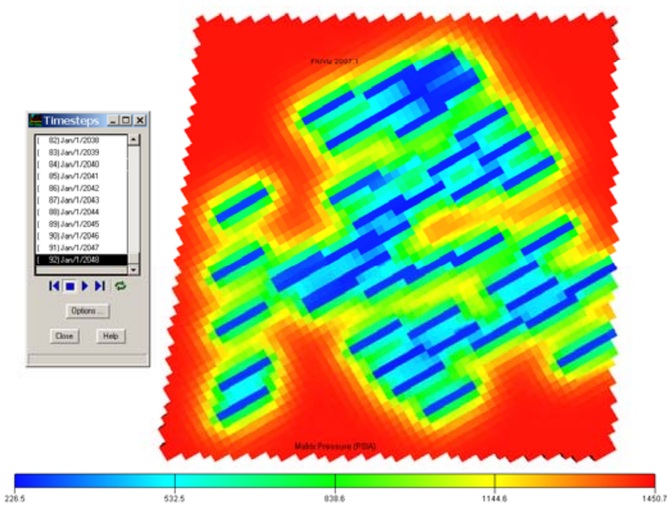




Schlumberger

# Mature development

Common characteristics of mature shale gas plays:

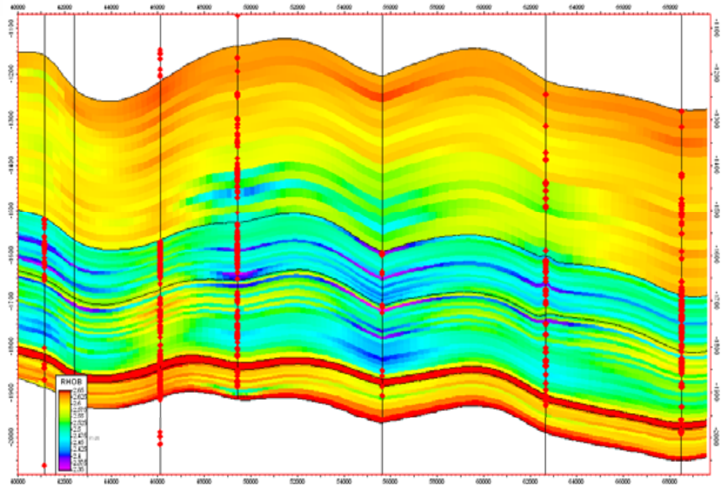
- Tens to hundreds of wellbores
  - Often vertical and horizontal
- Extensive understanding of reservoir geometry
  - Dependent upon well density
- Deliverability well defined
  - Variability identified if not understood

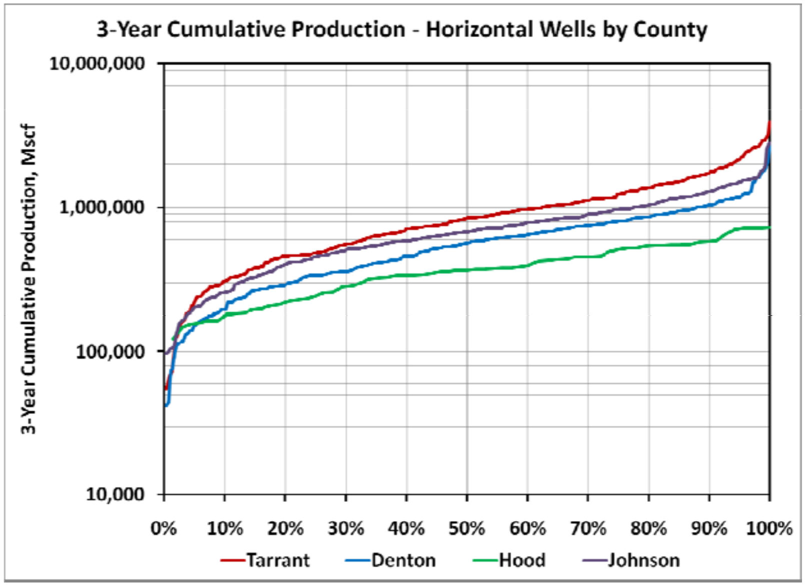


# Mature development

What is the role of the geologist?

- Refinement of reservoir continuity
  - Significant well density
- Refinement of reservoir quality
- Optimizing development
- Understanding of variability
  - Reservoir quality/continuity
  - Production relationships





# Lateral variation follows depositional trends