Devonian Shale Plays of the Black Warrior Basin and Appalachian Thrust Belt in Alabama*

Jack C. Pashin1

Search and Discovery Article #80095 (2010)
Posted August 16, 2010

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, New Orleans, Louisiana, April 11-14, 2010

1Geological Survey of Alabama, Tuscaloosa, AL (jpashin@gsa.state.al.us).

Abstract

The Black Warrior basin and Appalachian thrust belt of Alabama are frontier areas for shale gas production, and diverse opportunities for development exist in Devonian strata. The Chattanooga Shale is being developed along the southeast margin of the Black Warrior basin. Unnamed pre-Chattanooga shale, by comparison, is prospective in the interior of the Appalachian thrust belt. Integrated geological analysis indicates that the characteristics of each area differ markedly, and these characteristics should be taken into account during exploration and development.

The Chattanooga Shale is an organic-rich, cratonic shelf facies in the Black Warrior basin. Development in the northeastern part of the basin is focused along the hinges of fault-related folds with geometry ranging from detachment folds to breakthrough fault-propagation folds. The crestal regions of these folds are major zones of meteoric recharge, and significant quantities of water are produced from the Chattanooga in this region. Reservoirs are about 2500 feet deep and are characterized by low temperature, low pressure, and maturity near the base of the thermogenic gas window. Isotherms indicate that a large part of the adsorbed gas fraction can be recovered as reservoir pressure is reduced by dewatering.

Farther south, where the Chattanooga is deeper than 5000 feet, the shale is being explored in a depocenter along the southeastern margin of the Black Warrior basin. Extensional faults are abundant in the depocenter, and the best opportunities for development are in coherent structural panels between the faults. Pre-Chattanooga black shale in the interior of the Appalachian thrust belt is preserved within large-scale ramp-flat structures. Here, thick black shale units that are interbedded with limestone and siltstone were deposited on a slope near the edge of the Laurussian craton. All wells penetrating this shale section have encountered major gas shows. Thermal maturity is near the top of the thermogenic gas window, and geochemical data indicate that the preserved organic matter is highly gas-prone. Gas capacity in the shale correlates strongly with TOC content. Devonian shale reservoirs in the Black Warrior depocenter and the interior of the thrust belt are warm, deep reservoirs that are sheltered from meteoric recharge. Elevated pressure gradients in the shale are attributed to hydrocarbon overpressure that formed during thermogenesis and may contribute to gas mobility.
References


Devonian Shale Plays of the Black Warrior Basin and Appalachian Thrust Belt in AL

Jack C. Pashin
Geological Survey of Alabama
DEVONIAN EUXINIC BASIN

Pashin and Ettenson (1995)
Laminae

Distal mudflows

Onlapped tilt block

Burrows

Overturned folds

Core width = 4 in
SILURIAN-MISSISSIPPIAN SHALE

B
Southwest

GREENE-HALE SYNCLINORIUM

BLACK WARRIOR BASIN

COALBURG SYNCLINE

A'
Northeast

Miss

Dev

Sil

Ord

10 km

100 m

Rock Types
- Sandstone
- Variegated Ls, Dol
- Chert
- Limestone
- Variegated shale
- Gray to black shale
- Radioactive black shale

Stratigraphic Markers
- Unconformity
- Ferruginous marker bed
FOLDS AND JOINTS
ESTABLISHED PRODUCTION

EXPLANATION
Conasauga antiforms
  Gadsden MUSHWAD
  Palmerdale MUSHWAD
  Bessemer MUSHWAD

Stratigraphy
  Post-orogenic (Mesozoic-Cenozoic) - green, yellow
  Synorogenic (Mississippian-Pennsylvanian) - purple, blue
  Pre-orogenic (Cambrian-Mississippian) - pink, orange
GADSDEN CROSS SECTIONS

Northwest

A

Sequatchie anticline
Coalburg Syncline
Straight Mtn.
Blount Mtn. Syncline
Big Canoe Valley

Big Canoe Creek Field
Coosa Synclinorium

B

Sequatchie anticline
Coalburg Syncline
Birmingham anticlinorium
Cahaba Synclinorium
Coosa Synclinorium

PALMERDALE MUSHWAD

GADSDEN MUSHWAD

Bretton Syenite
Basement

Birmingham Graben

No vertical exaggeration

0 5 10 km

M-P Mississippian-Pennsylvanian
S-D Silurian-Devonian
C-O Cambrian-Ordovician carbonate
C Cambrian Shale
Basement Crystalline basement

Thomas and Bayona (2005)
DEVONIAN GAS SHOWS

BAYNE-ETHERIDGE 36-9 #1 WELL

GREENE COUNTY, AL
PETROLOGY, DEVONIAN SHALE

- **Platy illite**
- **Illite lath**
- **Framboidal pyrite**

Porosity of 1-3% typical; ~half gas-filled
KEROGEN ANALYSIS

Greene-Hale synclinorium
GAS STORAGE

**CH₄ SORPTION AND TEMPERATURE**

**Adsorption**
- High gas mobility
- Uniform gas mobility
- Limited gas mobility

**Free storage**

Graph showing sorption capacity (cc/g) versus pressure (MPa) for different temperatures (22°C, 102°C, 207°C, 307°C) by Yang and Saunders (1985).
ADSORPTION ISOTHERMS

Devonian shale
Bayne Etheridge 36-9 #1

\[ y = 20.23x + 2.35 \]

\( r = 1.00 \)
WORK CONTINUES

• Stratigraphy, sedimentation and structure
• Basin hydrodynamics and geothermics
• Petrology and gas storage
• Resources and reserves
• Technology Transfer
WORK CONTINUES

• Stratigraphy, sedimentation and structure
• Basin hydrodynamics and geothermics
• Petrology and gas storage
• Resources and reserves
• Technology Transfer

AAPG 2010 Field Trip

2010 INTERNATIONAL
COALBED & SHALE GAS SYMPOSIUM