Chapter 2

Introduction to the Assessment of Undiscovered Oil and Gas Resources of the Black Warrior Basin Province of Alabama and Mississippi

Click here to return to
Volume Title Page

By Joseph R. Hatch and Mark J. Pawlewicz

Chapter 2 of
Geologic Assessment of Undiscovered Oil and Gas Resources of the Black Warrior Basin Province, Alabama and Mississippi

Compiled by Joseph R. Hatch and Mark J. Pawlewicz

U.S. Geological Survey Digital Data Series DDS–69–I

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

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia: 2007

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1–888–ASK–USGS

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone:1–888–ASK–USGS

Suggested citation:
Hatch, Joseph, R., and Pawlewicz, Mark J., 2007, Introduction to the assessment of undiscovered oil and gas resources of the Black Warrior Basin Province of Alabama and Mississippi, *in* Hatch, Joseph R., and Pawlewicz, Mark J., compilers, Geologic assessment of undiscovered oil and gas resources of the Black Warrior Basin Province, Alabama and Mississippi: U.S. Geological Survey Digital Data Series DDS–69–I, chap. 2, 6 p.

ISBN 1-411-31775-0

Contents

Figures

Introduction to the Assessment of Undiscovered Oil and Gas Resources of the Black Warrior Basin Province of Alabama and Mississippi

By Joseph R. Hatch and Mark J. Pawlewicz

Introduction

The primary goal of the U.S. Geological Survey (USGS) National Oil and Gas Assessment project is to develop geologically based hypotheses regarding the potential for additions to oil and gas reserves in priority areas of the United States. The focus of the project is to determine the distribution, quantity, and availability of oil and natural gas resources, with an emphasis on quantifying undiscovered natural gas resources that may underlie Federal lands. The approach in the Black Warrior Basin Province of Alabama and Mississippi, as in all provinces, was to establish the framework geology, define the total petroleum systems (TPS), define assessment units (AU) within the TPSs, and assess the potential for undiscovered petroleum resources in each AU. This chapter provides the framework geology for the two TPSs in the Black Warrior Basin Province (fig. 1).

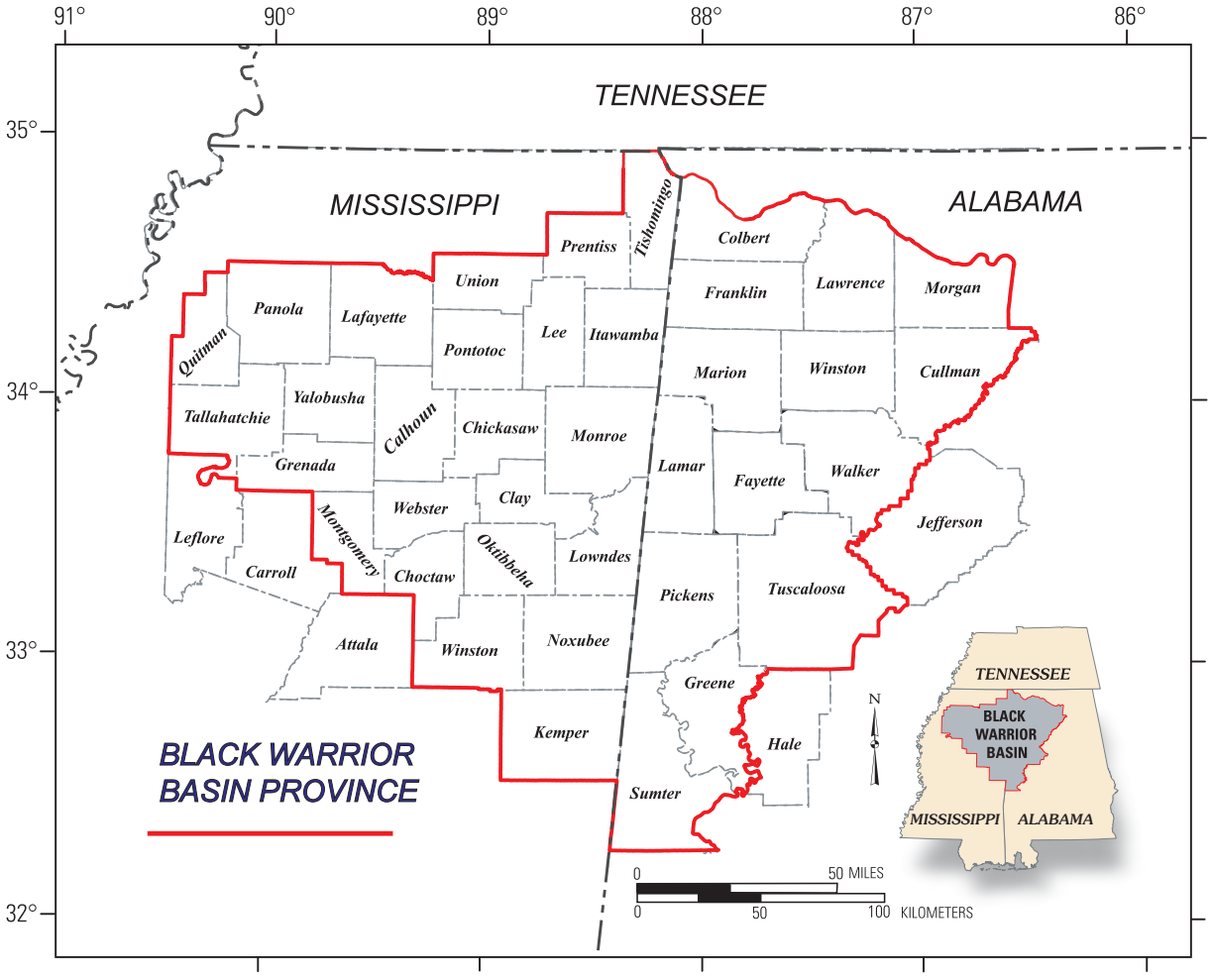

Figure 1. Location of the Black Warrior Basin Province in northwestern Alabama and northeastern Mississippi.

Geologic Setting

The Black Warrior Basin of Alabama and Mississippi is a foreland basin located in the major structural reentrant between the Appalachian orogenic belt to the southeast and the Ouachita orogenic belt to the southwest (fig. 2). The north margin of the basin is bounded by the Nashville dome. The basin extends about 190 mi north to south and 220 mi east to west and has a surface area of about 35,000 mi^2. The overall sedimentary section includes rocks of Paleozoic, Mesozoic, and Cenozoic age (fig. 3), ranging in thickness from about 7,000 ft along the north basin margin to about 31,000 ft in the depocenter located in eastern Mississippi (Ryder, 1995). Most of the Paleozoic rocks in the basin and along its thrust-faulted margins are concealed beneath Tertiary and Cretaceous rocks of the Gulf Coastal Plain and the Mississippi Embayment.

The structural framework of the Black Warrior Basin can be broadly characterized as a homocline that dips southwest toward the Ouachita orogenic belt and contains numerous superimposed folds and faults (Thomas, 1988) (fig. 2). Folds of the Appalachian orogenic belt are superimposed on the southeastern margin of this homocline. Throughout the eastern part of the Black Warrior Basin, the southwest-dipping homocline is broken by normal faults that generally strike northwest. Trace lengths of the subsurface-mappable faults range from about 1 to 8 mi. Fault strikes average about N. 30° W. and range from N. 7° W. to N. 54° W. Faults generally dip between 50° and 70° and form a horst-and-graben system in which about 60 percent of those mapped dip southwest and the remainder dip northeast. The faults tend to be planar or are composed of planar segments with sharp bends. Vertical displacements are typically less than 250 ft, but an offset of nearly 1,000 ft is displayed along a fault in Hale County, Alabama (Pashin and others, 2004). In south-central Mississippi, normal faults, apparently of Early Pennsylvanian age, have placed Mississippian rocks in fault contact with Lower Ordovician and Cambrian rocks. Seismic data from the southwestern part of the basin indicate displacements as much as 9,800 ft on down-to-the-southwest faults (Thomas, 1988).

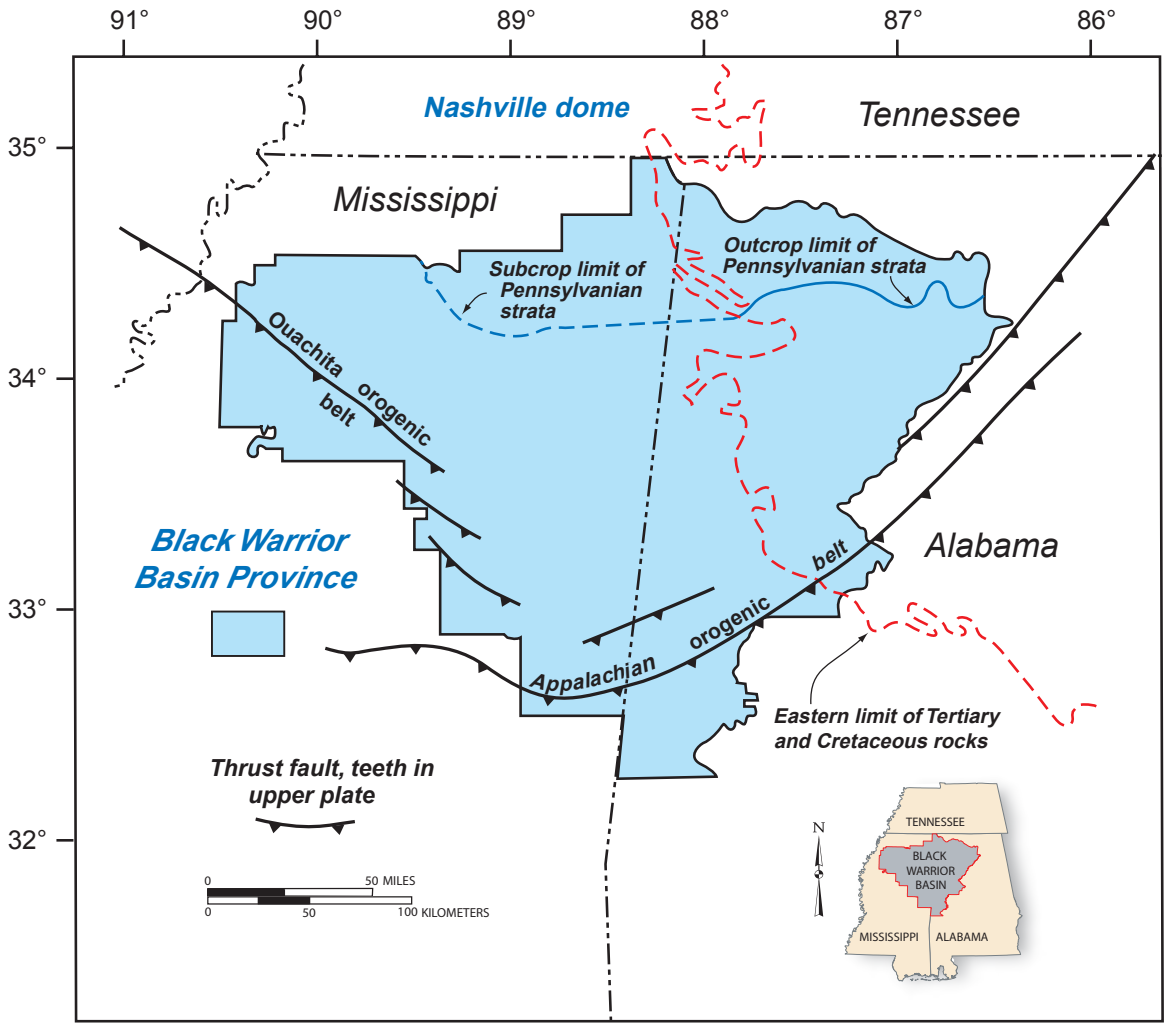

Figure 2. Tectonic setting of the Black Warrior Basin. Modified from Thomas (1988), Ryder (1994), and Popov and others (2001, their fig. 11).

The geotectonic history of the Black Warrior Basin includes six stages (Thomas, 1988):

1. Late Precambrian–Early Cambrian rifting, with associated deposition of coarse clastic sediments.
2. Middle Cambrian–Mississippian passive continental margin, with deposition of shallow-water carbonates.
3. Late Mississippian (Chesterian) continental collision, with deposition of marine deltaic sediments and several major regressive-transgressive cycles.
4. Early-Late (?) Pennsylvanian maximum basin subsidence associated with the Appalachian-Ouachita orogeny and deposition of basin-fill sediments; development of barrier bars, followed by progradation of thick clastic wedges from source areas along the south margin of the basin and deposition of coal-forming materials.
5. Latest Pennsylvanian–early Mesozoic uplift (Montgomery, 1986), resulting in Permian-Cretaceous erosion and nondeposition.
6. Mesozoic rifting, resulting in the basin becoming downwarped to the southwest and eventually being covered by transgressive marine sediments of the Mississippi embayment (Mancini and others, 1983).

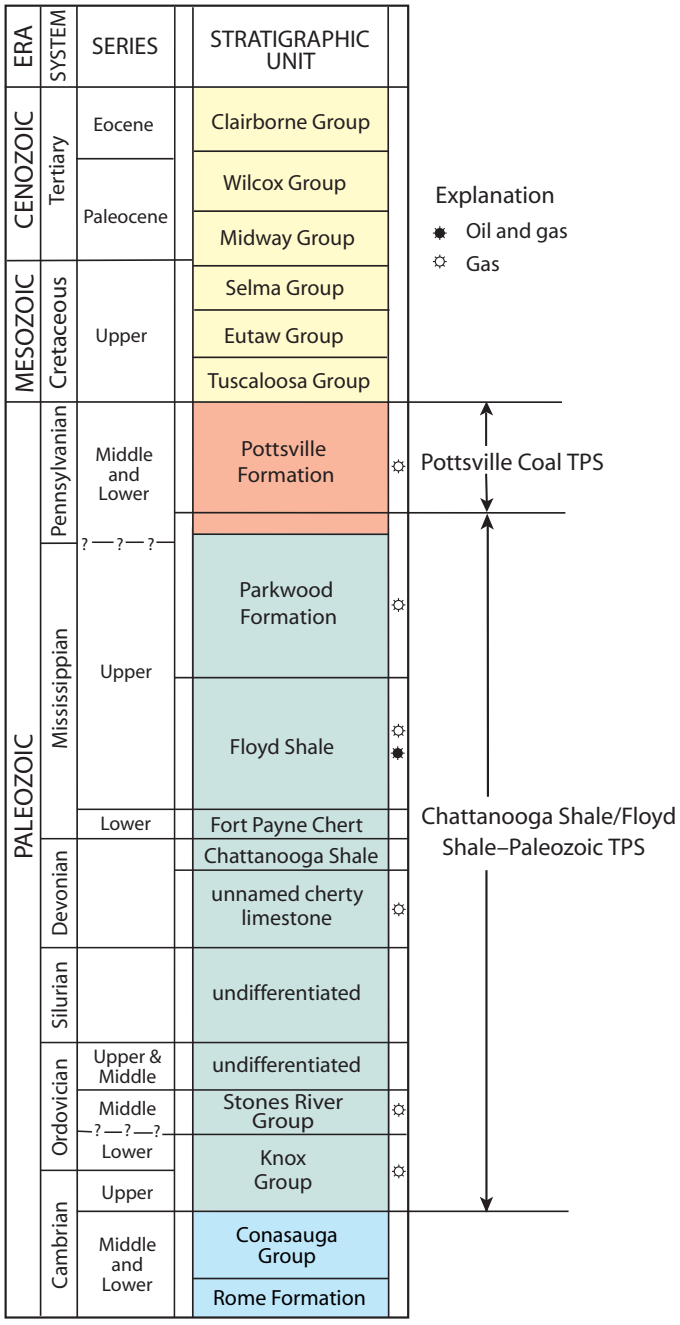

Figure 3. Generalized stratigraphic column for the Black Warrior Basin showing stratigraphic intervals within the Chattanooga Shale/Floyd Shale–Paleozoic and the Pottsville Coal Total Petroleum Systems (TPSs). Modified from Montgomery (1986) and Carroll and others (1995, their fig.1).

Black Warrior Basin Province Petroleum Systems

Two TPSs were identified within the Black Warrior Basin Province: the Chattanooga Shale/Floyd Shale–Paleozoic TPS and Pottsville Coal TPS. The areal extent of the Chattanooga Shale/Floyd Shale–Paleozoic TPS (fig. 4) is defined by the inferred distribution of organic-rich shales in the Upper Devonian Chattanooga Shale and the Upper Mississippian Floyd Shale. The areal extent of the Pottsville Coal TPS (fig. 5) is defined by the distribution of coals and coaly shales in the Lower to Middle Pennsylvanian Pottsville Formation (Rice and Finn, 1995).

Two conventional AUs were identified within the Chattanooga Shale/Floyd Shale–Paleozoic TPS: (1) the Pre-Mississippian Carbonates AU, defined by gas trapped primarily in Cambrian and Ordovician platform-carbonate reservoirs by basement-controlled fault blocks, and possibly in ramp anticlines associated with frontal thrust faults as well as in stratigraphic traps formed by facies changes (Ryder, 1994); and (2) the Carboniferous Sandstones AU, defined by gas and oil trapped in Upper Mississippian and Lower Pennsylvanian fluvial, deltaic, and shallow-marine sandstone reservoirs by a variety of basement-involved fault blocks, stratigraphic traps, and a combination of structural and stratigraphic traps (fig. 4).

One continuous AU, the Black Warrior Basin AU, was identified within the Pottsville Coal TPS (fig. 5). This AU is defined by gas produced from coals and associated coaly shales, primarily in the Alabama portion of the basin.

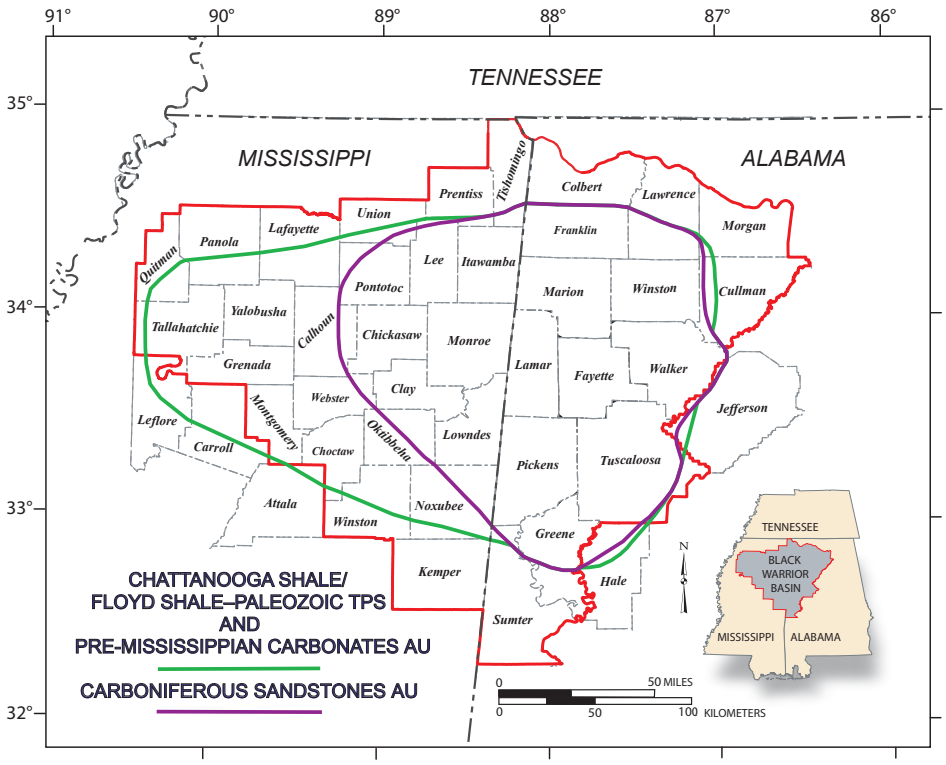

Figure 4. Areal distributions of the Chattanooga Shale/Floyd Shale–Paleozoic Total Petroleum System (TPS), Pre-Mississippian Carbonates Assessment Unit (AU) and the Carboniferous Sandstones AU in the Black Warrior Basin Province of northwestern Alabama and northern Mississippi.

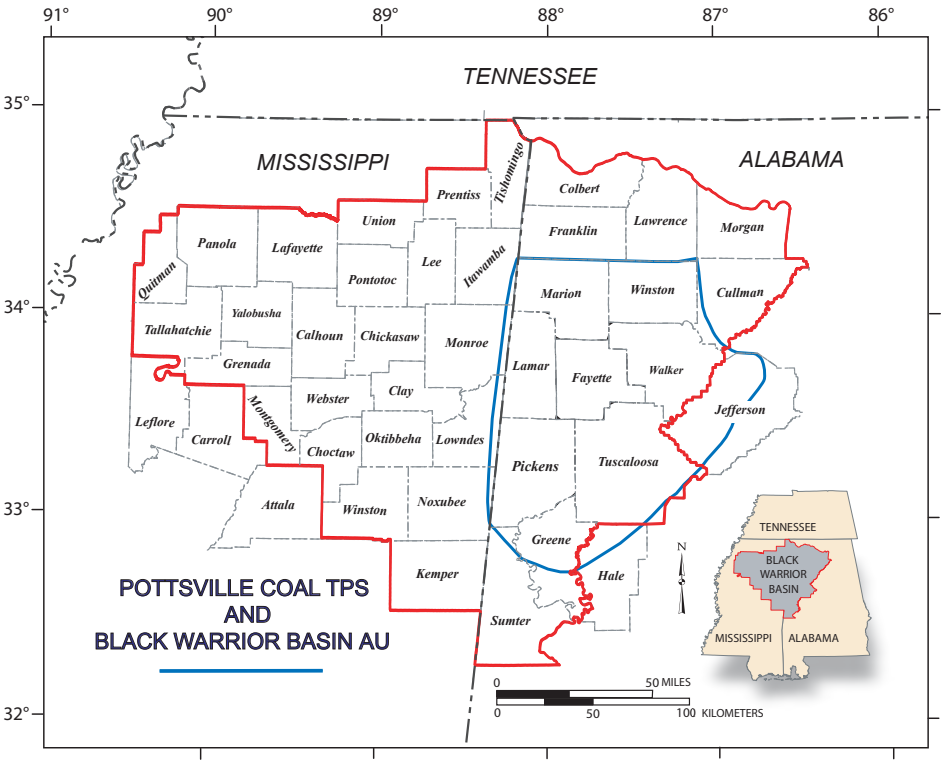

Figure 5. Areal distribution of the Pottsville Coal Total Petroleum System (TPS) and the Black Warrior Basin Assessment Unit (AU) in the Black Warrior Basin Province of northwestern Alabama and northeastern Mississippi.

Hydrocarbon Production Overview

Black Warrior Basin hydrocarbon production history can be summarized as follows:

1. Gas production was first established in 1909 from Pennsylvanian sandstone in Fayette County, Alabama, at a depth of 1,400 ft. In 1926, gas was discovered in Monroe County, Mississippi, in Upper Mississippian sandstone at a depth of 2,400 ft. Exploration in the 1950s and early 1960s in the basin was concentrated in and around Monroe County, resulting in the discovery of several small gas fields and two noncommercial oil accumulations in Upper Mississippian sandstones.

2. Renewed exploration activity in the 1970s and 1980s was initiated by the discovery of the East Detroit field (Lamar County, Alabama) in 1971. Ninety-five gas, gas-associated oil, and oil fields were discovered during these two decades, including the two largest gas fields—Corinne field (Monroe, Lowndes, and Clay Counties, Mississippi) and Blooming Grove field (Fayette and Lamar Counties, Alabama)—discovered in 1972 and 1975, respectively, and the two largest oil fields—North Blowhorn Creek field (Lamar County, Alabama) and South Brush Creek field (Lamar County, Alabama)—discovered in 1979 and 1985, respectively.

3. Through May 2002, 137 conventional nonassociated gas fields, oil-associated gas fields and oil fields were discovered in the Alabama part of the Black Warrior Basin, with the dominant reservoir being the "Carter" sandstone in the Parkwood Formation of Late Mississippian age (quotes around a name indicate driller's term). Through December 2003, 84 conventional nonassociated gas fields, oil-associated gas fields, and oil fields were discovered in the Mississippi part of the basin. The dominant productive reservoirs of these fields are the "Carter" and "Sanders" sandstones in the Parkwood Formation.

4. Most oil fields have cumulative production of less than 0.5 million barrels of oil (MMBO). The most notable exceptions are the North Blowhorn Creek field (cumulative production, 6.2 MMBO) and South Brush Creek field (cumulative production, 1.7 MMBO), both in Lamar County, Alabama.

5. Through December 2003, cumulative gas production from the Upper Cambrian and Lower Ordovician Knox Group in the Maben field (Oktibbeha County, Mississippi) was 31.2 billion cubic feet of gas (BCFG), of which 95 percent (29.5 BCFG) was produced since 1998.

6. Coal-bed gas production in the basin was first established in Tuscaloosa County, Alabama, in 1981 from the Mary Lee/Blue Creek and Pratt coals in the Lower to Middle Pennsylvanian Pottsville Formation. Through 2001, 20 coal-bed gas fields had been discovered in the Pottsville Formation in the Alabama part of the basin; 12 of these were producing gas in 2003. Through 2003, cumulative gas production was about 1.51 trillion cubic feet of gas (TCFG).

Data sources for the above summary statements of hydrocarbon-production history are the Alabama State Oil and Gas Board (accessed in May 2004 at *http://www.gsa.state.al.us/ogb/db_main.html* and the Mississippi State Oil and Gas Board (accessed in May 2004 at *http://www.ogb.state.ms.us/whatsnew.htm*).

References Cited

Carroll, R.E., Pashin, J.C., and Kugler, R.L., 1995, Burial history and source-rock characteristics of Upper Devonian through Pennsylvanian strata, Black Warrior basin, Alabama: Alabama Geological Survey Circular 187, 29 p.

Mancini, E.A., Bearden, B.L., Holmes, J.W., and Shepard, B.K., 1983, Geology of Alabama's Black Warrior Basin: Oil and Gas Journal, v. 81, no. 3, p. 147–154.

Montgomery, S.L., 1986, The Black Warrior Basin—Proving the potential of the southeast, *in* Petroleum Frontiers, Petroleum Information Corporation Quarterly, v. 3, no. 3, 62 p.

Pashin, J.C., Carroll, R.E., Groshong, R.H., Jr., Raymond, D.E., McIntyre, Marcella, and Payton, J.W., 2004, Geologic screening criteria for sequestration of CO_2 in coal— Quantifying potential of the Black Warrior coal-bed methane fairway, Alabama: Final Technical Report, U.S. Department of Energy, National Energy Technology Laboratory, contract DE–FC26–00NT40927, 254 p., 11 plates.

Popov, M.A., Nuccio, V.F., Dyman, T.S., Gognat, T.A., Johnson, R.C., Schmoker, J.W., Wilson, M.S., and Bartberger, Charles, 2001, Basin-centered gas systems of the U.S.: U.S. Geological Survey Open-File Report 2001–135, 1 CDROM.

Rice, D.D., and Finn, T.M., 1995, Black Warrior Basin Province (065), *in* Gautier, D.L., Dolton, G.L., Takahasi, K.I., and Varnes, K.L., eds., 1995 National Assessment of United States oil and gas resources: U. S. Geological Survey Digital Data Series 30, one CD–ROM.

Ryder, R.T., 1994, Black Warrior Basin, *in* Powers, R.B., ed., Petroleum exploration plays and resource estimates, 1989, onshore United States—Region 8, Eastern Interior; Region 9, Atlantic Coast: U.S. Geological Survey Open-File Report 94–211, p. 62–66.

Ryder, R.T., 1995, Black Warrior Basin Province (065), in Gautier, D.L. and others, 1995 National Assessment of United States oil and gas resources: U.S. Geological Survey Digital Data Series 30, one CD–ROM.

Thomas, W.A., 1988, The Black Warrior basin, *in* Sloss, L.L., ed., Sedimentary cover—North American craton, v. D–2 of The geology of North America: Boulder, Colorado, Geological Society of America, p. 471–492.

Click here to return to
Volume Title Page