

U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Plays for assessment in
Region VIII, Eastern
as of October 4, 1993
1995 National Assessment of Oil and Gas

compiled by

D.L. Gautier¹ and K.L. Varnes ¹

Open-File Report 93-596 H

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

¹ U.S. Geological Survey
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The U.S. Geological Survey periodically makes appraisals of the undiscovered oil and gas resources of the Nation. For the 1995 National Assessment the onshore areas and adjoining State waters of the Nation have been divided into eight Regions which are subdivided into 72 provinces. Regions II through VIII comprise the Lower 48 States; Alaska comprises Region I. A map at scale 1:5,000,000 showing the boundaries of Regions II through VIII for this assessment has been released in open file (Dolton, G.L., Varnes, K.L., Gautier, D.L., and Baird, J.K. compilers, 1992, Oil and gas assessment areas, 1992, Lower 48 States: U.S. Geological Survey Open-File Report 92-696, scale 1:5,000,000).

The provinces and assigned USGS Province Geologists for Region VIII are listed in Table 1. The basic assessment unit is the play. Table 2 lists by number and name the plays considered at this time (October 1993) in Region VIII, Eastern. Descriptions of the plays follow; in most cases these descriptions are written by the assigned Province Geologist (Table 1). No maps showing locations or boundaries of plays listed in Table 2 are available at this time.

Because this National assessment is in progress, these listings and descriptions are preliminary. The plays and/or their names may change as the assessment progresses; plays may be added, and others dropped. The descriptions may also change. The plays, play names, and descriptions may or may not duplicate plays appraised in other National assessments.

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Table 1. List of Provinces and Province Geologists, Region VIII, Eastern

Prov.	Province Name	Province Geologist(s)	Telephone No.	Telephone No.
63	Michigan Basin	Dolton, G.L.	(303) 236-5768	
64	Illinois Basin	Macke, D.L.	(303) 236-1559	
65	Black Warrior Basin	Ryder, R.T.	(703) 648-6492	
66	Cincinnati Arch	Ryder, R.T.	(703) 648-6492	
67	Appalachian Basin	Ryder, R.T.	(703) 648-6492	
68	Blue Ridge Thrust Belt	Milici, R.C., and Burruss, R.C.	(303) 236-7726	(303) 236-5795
69	Piedmont	Milici, R.C., and Burruss, R.C.	(303) 236-7726	(303) 236-5795
70	Atlantic Coastal Plain	Milici, R.C., and Burruss, R.C.	(303) 236-7726	(303) 236-5795
71	Adirondack Uplift	Milici, R.C., and Burruss, R.C.	(303) 236-7726	(303) 236-5795
72	New England	Milici, R.C., and Burruss, R.C.	(303) 236-7726	(303) 236-5795

Table 2. List of plays for consideration, Region VIII, Eastern

Prov.	Play No.	Play Name
63	6301	Anticlinal
63	6302	Pennsylvanian Coalbed Methane
63	6303	Mississippian Sandstone Gas
63	6304	Berea Sandstone Stratigraphic
63	6305	Antrim Shale Gas
63	6306	Devonian Carbonate Stratigraphic
63	6307	Northern Niagaran Reef
63	6308	Southern Niagaran Reef
63	6309	Offshore Niagaran Reef
63	6310	Burnt Bluff Stratigraphic
63	6311	Trenton-Black River
63	6312	Ordovician Sandstone Gas
63	6313	Pre-Glenwood Unconformity
63	6315	Pre-Cambrian Rift
63	6317	Impact Structure
64	6401	Post-New Albany
64	6402	Hunton
64	6403	Silurian Reef
64	6404	Pre-Silurian
64	6405	Rough Creek Graben
64	6406	Mississippian Embayment
64	6407	Devonian Shale Gas
64	6408	Pennsylvanian Coal Bed Gas
65	6501	Cambrian-Ordovician Carbonate
65	6502	Upper Mississippian Sandstone
65	6503	Pennsylvanian Sandstone
65	6504	Pennsylvanian Coalbed Gas
65	6505	Devonian Chert and Carbonate
66	6601	Cambrian-Lower Ordovician Carbonate
66	6602	Middle and Upper Ordovician Carbonate
66	6603	Silurian/Devonian (Hunton) Carbonate
66	6604	Devonian Black Shale Gas
66	6605	Mississippian Carbonate
67	6701	Rome Trough Play
67	6702	Upper Cambrian, Ordovician, and Lower Middle Silurian Thrust Belt
67	6703	Beekmantown-Knox Carbonate Oil/Gas
67	6704	Rose Run/Gatesburg/Theresa Sandstone Gas
67	6706	Trenton/Black River Carbonate Oil/Gas
67	6708	Queenston/Bald Eagle Sandstone Gas
67	6710	Tuscarora Sandstone Gas
67	6711	Clinton/Medina Sandstone Gas
67	6712	Clinton/Medina Sandstone Oil/Gas
67	6714	Keefer/Big Six Sandstone Gas
67	6715	Big Six Sandstone Oil/Gas

Table 2. List of plays for consideration, Region VIII, Eastern

67	6716	Upper Silurian Sandstone Gas
67	6717	Silurian Carbonate
67	6718	Silurian and Devonian Carbonate Thrust Belt
67	6719	Devonian Carbonate Gas
67	6720	Oriskany Sandstone Gas/Faulted Anticlines
67	6721	Oriskany Sandstone Gas
67	6722	Upper Devonian Sandstone Gas
67	6723	Upper Devonian Sandstone Oil/Gas
67	6724	Devonian Black Shale Gas
67	6725	Mississippian-Pennsylvanian Sandstone/Carbonate
67	6726	Pennsylvanian Coalbed Gas
68	6801	Southern Appalachian Sub-crystalline Thrust Sheets
68	6802	Champlain Valley/Sub-Taconic Allochthon, New York, Vermont
69	6901	Eastern Mesozoic Basins
70	7001	Eastern Mesozoic Basins
71	7101	Champlain Valley/Sub-Taconic Allochthon, New York, Vermont
72	7201	Champlain Valley/Sub-Taconic Allochthon, New York, Vermont

Descriptions of Plays to be Considered
Region VIII, Eastern

Region VIII, Eastern

Province 63. Michigan Basin

Play 6301 Anticlinal

The play consists primarily of structural accumulations in a series of northwest-southeast-trending anticlines which are clearly delineated at Devonian levels; some of these features appear to have a long history of growth. Production is mainly from Devonian reservoirs (Traverse Lime, Dundee Limestone, Detroit River Group, Richfield, etc.) , but small amounts of oil and gas production is obtained from pools in Middle Ordovician Trenton Group, Silurian Burnt Bluff and Salina carbonates, and Devonian Berea. Occasional oil from Mississippian Michigan Stray sandstone reservoirs is also included, however gas production from Mississippian reservoirs is treated separately. Salt solution structures in the southwestern part of the basin, producing mostly from Salina carbonates, are included within this play.

Play 6302 Pennsylvanian Coalbed Methane

This play comprises gas occurrence in coals situated in the upper part of the Hemlock Lake Formation of Morrowan age at depths of 200 to 1,100 feet. The coals are low-grade bituminous and have been mined in the past. This sequence is generally covered by glacial drift. These coals are expected to contain extractable gas.

Play 6303 Mississippian Sandstone Gas

This play consists of generally small, shallow Mississippian sandstone reservoirs on anticlinal structures in the central basin. Most of the production has been from the "Stray" sandstone of the Mississippian Michigan Formation, and from the Marshall Sandstone. Most of the pools are shallow accumulations on the same anticlines which produce from Devonian and older rocks, however, several accumulations bear stratigraphic overprints.

Play 6304 Berea Sandstone Stratigraphic

This play is defined by accumulations stratigraphically trapped in Late Devonian (or early Mississippian) Berea Sandstones in elongate nearshore deposits of the Bedford-Berea deltaic complex, whose long axes parallel the old shoreline normal to regional transport of sand

from the east. Oil is trapped at updip ends of these bodies, where they are truncated by mud-filled channels, and within the channel systems where traps are formed by fine-grained abandoned channel deposits. This play is on the east side of the Michigan basin.

Play 6305 Antrim Shale Gas

The Antrim Shale play consists of gas accumulation within fractured Antrim shales of Late Devonian age. Besides the Antrim proper, the play includes parts of the Ellsworth Shale in western Michigan and Bedford shale in eastern Michigan. The play appears bounded to the west by the low organic content of the Ellsworth Shale and the loss of thick organic-rich Antrim Shale tongues. Trapping in part may be controlled by hydrodynamic flow and water block at the subcrop. Gas presumably was generated during early catagenesis. Organic maturity within the formation is sufficient to have generated gaseous hydrocarbons peripheral to and within deeper parts of the central Michigan basin. Production appears feasible only where the shales are sufficiently fractured and is mostly confined to the black shale facies (Lachine and Norwood Members) of the Lower Antrim, with principal development in Antrim, Otsego, and Montmorency Counties and to a lesser extent, Kalkaska, Crawford, and Oscosa Counties.

Play 6306 Devonian Carbonate Stratigraphic

The Devonian stratigraphic play consists of accumulations controlled by stratigraphic and diagenetic variations within Middle Devonian rocks, primarily Traverse Limestone, Dundee Limestone, and Detroit River Group. Depositional features, such as bioherms and oolite banks, are believed to occur both off- and on-structure. Local bioherms and biostromal buildups seen in the Traverse, Amherstburg and Reed City offer trapping potential, and locally porous oolite banks are present in the Richfield. Dolomitization is sometimes localized by fracture or fault trends, such as at Deep River Field which appear related to the same northwest-southeast structural trend as in the anticlines.

Play 6307 Northern Niagaran Reef

The Northern Niagaran Reef play consists of oil and gas accumulations trapped in pinnacle reefs of Niagaran (Middle Silurian) age within the northern part of a circular trend of reefs in the northern Michigan basin. Most of the productive reefs are about 50 to 400 acres in area with 200 to 700 feet of relief. Sealing is partially by Salina Group evaporites encasing the reefs, and salt plugging of the reservoir becomes a significant problem in the eastern extremity of the trend.

Play 6308 Southern Niagaran Reef

The Niagaran Reef play consists of oil and gas accumulations trapped in pinnacle reefs of Niagaran (Middle Silurian) age that form a circular trend in the basin. Most of the productive reefs are about 40 to 300 acres in area with 100 to 350 feet of relief. Sealing is primarily by Salina Group evaporites encasing the reefs. The Southern Niagaran Reef play is concerned with the southern, onshore portion of this trend. It is a tract that ranges from 15 to 40 miles in width.

Play 6309 Offshore Niagaran Reef

The Offshore Niagaran Reef play consists of speculated oil and gas accumulations trapped in pinnacle reefs of Niagaran (Middle Silurian) age within the offshore part of the reef trend in Lakes Michigan and Huron. Analog reservoir rocks are within the onshore part of the reef trend. Sealing is mostly by Salina Group evaporites encasing the reefs.

Play 6310 Burnt Bluff Stratigraphic

This hypothetical play encompasses stratigraphic traps due to biohermal buildups and porosity pinchouts in Lower Silurian, Burnt Bluff Group carbonates in the northern Michigan basin. Traps are believed to be primarily coral stromatoporoid reefs and buildups sealed by overlying rocks of the Manistique Group. Reservoirs are within the Henricks Formation and consist of stromatoporoid reefal rocks, containing primary intraparticle and interparticle porosity, and open shelf limestones with solution-generated porosity and dolomitization. This is a hypothetical play based on general stratigraphic setting, observed bioherms within formation and hydrocarbons within the system.

Play 6311 Trenton-Black River

The Trenton-Black River play consists of dominantly stratigraphically controlled accumulations within the Upper and Middle Ordovician Trenton and Black River Groups. The play includes the largest field in the Michigan basin (the Albion-Pulaski-Scipio trend) as well as the oldest production. Rocks of these groups extend over the entire Lower Peninsula and parts of the Upper Peninsula and Wisconsin, but, to date, almost all discoveries have been from the southern part of Michigan's Lower Peninsula and the adjoining Indiana and Ohio parts of the basin. The discovered oil and gas pools are primarily stratigraphic traps caused by porosity and permeability variations in dolomitized limestone. Dolomitization is often localized by fault and fold trends which seem to be generally related to the same northwest-southeast structural trend seen in the anticlines and some of the fracture zones occur on the flanks of these features.

Play 6312 Ordovician Sandstone Gas

This play encompasses nonassociated gas and condensate trapped in Early to Middle Ordovician sandstone reservoirs variously attributed to the Prairie du Chien Group, St. Peter Sandstone, Jordan Sandstone, and Bruggers Sandstone, and to sandstones within the overlying Middle Ordovician Glenwood Formation. Traps are considered to be structural, in some cases associated with production from shallow overlying reservoirs. These sandstones extend over much of the central part of the basin.

Play 6313 Pre-Glenwood Unconformity

This hypothetical play consists of speculative stratigraphic traps associated with the pre-Glenwood unconformity. Ordovician St. Peter, Prairie du Chien, Foster, and Cambrian Trempealeau formations and older Paleozoic rocks show a strong truncation at the southern margin of the Michigan basin. Stratigraphic traps are postulated to occur at this unconformity and may consist variously of truncation, paleorelief, and localized porosity development at or near the surface of unconformity. Structure would tend to provide additional hydrocarbon localization. Stratigraphic entrapment is also possible where the sandstones are interbedded with organic-rich carbonates within the older rocks.

Play 6315 Precambrian Rift

This hypothetical play consists of the occurrence of nonassociated gas in Middle Proterozoic sedimentary rocks associated with a major linear buried rift system, probably an eastern arm of the Mid-Continent rift system, extending southeast through the Michigan basin. More than 5,290 ft of pre-Mt. Simon red beds have been penetrated at the Sparks et al. 1-8 well, Gratiot County, and beds of similar age have been encountered at Beaver Island, where more than 810 ft of sandstone, siltstone, and shale, variously reported as "granite wash," marine, and fluvial in origin. Traps are conceived as principally fault-bounded blocks containing reservoir rocks and stratigraphic combinations with porosity pinch-outs and reservoir truncations. Reservoirs are estimated to be fluvial and lacustrine sandstones and source rocks are hypothesized to be fine-grained lacustrine or paludal, rift sediments. Because of the generally deep structural setting, these rocks are believed to be largely in a gas-generative realm, and any liquids originally present would also have been converted to gas.

Play 6317 Impact Structure

During the Phanerozoic, the Earth has been subject to nearly random bombardment by asteroids and comets and by occasional comet showers. Structures created by impacts provide a unique and proven

habitat for hydrocarbon entrapment and are documented in the Michigan basin.

Province 64. Illinois Basin

Play 6401 Post-New Albany

The Post-New Albany play is a very mature play that includes all Mississippian and Pennsylvanian-age sandstone and carbonate reservoirs producing oil and minor amounts of gas and associated wet gas sourced predominantly from the Late Devonian-Early Mississippian New Albany Shale. Local shales within both the Mississippian and Pennsylvanian act as seals for variable porosity within stratigraphic traps, domes, anticlines, fault traps, and drapes over buried Silurian reefs, which formed prior to the time of major petroleum generation and migration. This play accounts for greater than 95 percent of the hydrocarbon production within the basin.

Play 6402 Hunton

The Hunton play produces oil with little or no associated gas or non-associated gas from Silurian and Devonian age rocks sourced by the overlying New Albany Shale. Production is from intergranular porosity (primary), and secondary dolomite porosity within traps formed as drapes over buried Silurian reefs, stratigraphic traps, domes, anticlines, and fault traps sealed by the New Albany and local shales within limestone and clastic sequences below the New Albany. Approximately 150 to 200 million barrels (4 percent) of the recoverable oil discovered in the Illinois basin has occurred in this play.

Play 6403 Silurian Reef Play

The Silurian Reef play is a mature play that produces oil with little or no associated gas, sourced predominantly by the New Albany Shale, from secondary dolomite within Silurian carbonate-reef stratigraphic traps. All fields >10⁶ barrels of oil currently known in play are within the Illinois part of the basin and most productive reefs are less than 100 feet below the New Albany Shale.

Play 6404 Pre-Silurian

The Pre-Silurian play includes all Ordovician and Cambrian clastic and carbonate reservoirs sourced by the Maquoketa (Upper Ordovician), Dutchtown (Middle Ordovician) and unidentified Lower Ordovician or Cambrian source rocks within structural and stratigraphic traps sealed by the Maquoketa shales over the Trenton and local shale and anhydrite seals in Joachim. Significant production is limited to southern Illinois; there is minor production from this play in central

Indiana and a single well in Webster County, Kentucky. There is no commercial production from the older units in play.

Play 6405 Rough Creek Graben

The Rough Creek Graben play is a speculative gas play that includes Ordovician and Cambrian reservoirs with variable porosity types in traps formed by bounding faults and fault-related structures within the Rough Creek Graben and sealed by the Eau Claire Shale (Cambrian) (for the underlying sandstone reservoirs) or local seals (for the carbonate reservoirs in the overlying the Eau Claire). Postulated source rocks include the Eau Claire, hypothetical organic-rich lacustrine facies in early graben sediments, and possible unidentified Lower Ordovician and Cambrian source beds. Timing of hydrocarbon generation and migration is questionably favorable for oil: hydrocarbon generation would probably have started by the Late Ordovician or Early Silurian, prior to the formation of trapping structures in the basin, but after many of the structures in the Graben formed.

Play 6408 Pennsylvanian Coal Bed Gas

The Pennsylvanian Coal Bed Gas play is a speculative play for self-sourced coal-bed methane within fracture porosity. The play covers entire area of Illinois basin underlain by Pennsylvanian coal-bearing rocks and varies from thermally immature to moderately mature for oil in the Fairfield Basin.

Play 6407 Devonian Shale Gas

The Devonian Shale Gas Play is a self-sourcing, fracture porosity play within the New Albany Shale (Late Devonian and Early Mississippian). The New Albany varies from thermally immature to within the wet-gas window. This play produces a minor amount of gas production, mainly in Indiana, and production extends well beyond the area of gas-window thermal maturity.

Play 6406 Mississippi Embayment

The Mississippi Embayment play is a speculative play that includes Cambrian, Ordovician, Silurian, Devonian, Pennsylvanian, and Cretaceous reservoirs in fault and fault-related structural traps associated with development of both the Reelfoot Rift and Pascola Arch and possible unconformity and stratigraphic traps. A wide variety of porosity types are anticipated, and the thermal maturity is unknown. Source rocks include the Eau Claire, which is considered to have only slight potential as a source rock, unidentified Lower Ordovician and Cambrian source rocks, and the Fayetteville Shale and Pitkin Limestone (Mississippian, Chesterian) buried along the

southern margin of the Pascola arch. Adequate seals are generally lacking in the Paleozoic section, with the possible exception of local shales in the Bonneterre. Local shale seals are possible with the Pennsylvanian and Cretaceous.

Province 65. Black Warrior Basin

Play 6501 Cambrian-Ordovician Carbonate

The Cambrian-Ordovician carbonate play consists of gas trapped in Cambrian and (or) Ordovician platform carbonate reservoirs by basement-controlled fault blocks. In the thrust belt along the southern margin of the Black Warrior basin, ramp anticlines produced by bedding plane detachment in underlying Cambrian and (or) Ordovician shale may have trapped gas. This play covers the entire Black Warrior basin. Prospective reservoirs are vuggy dolomite and limestone, with porosity enhanced by fractures and (or) karst processes, in the Upper Cambrian and Lower Ordovician Knox Group and the Middle Ordovician Stones River and Chickamauga Groups. The source of the gas is unknown. In part the gas has been derived from upper Paleozoic rocks that have been juxtaposed with Cambrian and Ordovician carbonate reservoirs.

Play 6502 Upper Mississippian Sandstone

The Upper Mississippian sandstone play consists of gas and local oil trapped in Upper Mississippian deltaic sandstone reservoirs by a variety of stratigraphic traps, combination traps, and basement-controlled fault blocks. This play covers all of the Black Warrior basin except for its northern margin where Mississippian rocks either crop out or subcrop beneath Cretaceous strata of the Mississippi River embayment. Among the prospective reservoirs are distributary channel sandstones in the Upper Mississippian Carter sandstone, Lewis sandstone, Gilmer sandstone, Millerella sandstone, Abernathy sandstone, Rea sandstone, Evans sandstone, and Parkwood Formation. Primary and secondary intergranular porosity are the dominant porosity types. Dark gray to black shale intercalated with the sandstone reservoirs and black shale of the Upper Mississippian Neal shale (slope facies of Bangor Limestone) are the source of the gas and oil.

Play 6503 Pennsylvanian Sandstone

The Pennsylvanian sandstone play consists of gas and local oil trapped in Lower (?) Pennsylvanian fluvial and deltaic sandstone reservoirs by a variety of stratigraphic traps, combination traps, and basement-controlled fault blocks. This play covers all of the Black Warrior basin except for its northern margin where Pennsylvanian rocks either crop

out or subcrop beneath Cretaceous strata of the Mississippi River embayment. Among the prospective reservoirs are channel sandstones in the Lower (?) Pennsylvanian Pottsville Formation such as the Chandler sandstone, Robinson sandstone, Fayette sandstone, Nason sandstone, and Robertson sandstone. Primary and secondary intergranular porosity are the dominant porosity types. Coal beds and dark gray carbonaceous shale beds in the Pottsville Formation are the source of the gas and oil.

Play 6505 Devonian Chert and Carbonate

The Devonian chert and carbonate play consists of gas and local oil trapped in Devonian tripolitic chert and fractured cherty limestone reservoirs by basement-controlled fault blocks. This play covers all of the Black Warrior basin except for its northeasternmost part in Alabama and northernmost part in Mississippi where the Devonian chert and limestone sequence has been truncated by Late Devonian uplift and erosion. Secondary porosity in the tripolitic chert is usually highest where the chert has been exposed to subaerial processes during Late Devonian uplift and erosion. The source of the gas and oil probably is the overlying Upper Devonian Chattanooga Shale and (or) Mississippian and Pennsylvanian shale beds juxtaposed against Devonian strata by adjoining fault blocks.

Province 66. Cincinnati Arch

Play 6601 Cambrian and Lower Ordovician Carbonate

The Cambrian and Lower Ordovician Carbonate play consists of oil and associated gas trapped in Cambrian and Lower Ordovician platform dolomite by erosional outliers beneath the widespread Knox unconformity and by small anticlines probably controlled by basement faults. This play covers the entire Cincinnati arch. Prospective reservoirs of vuggy dolomite, with porosity enhanced by fractures and (or) karst processes, are located in the Cambrian and Lower Ordovician Knox Group. The Middle and upper Ordovician Utica Shale and Maquoketa Shale are the source of the oil and gas north of the Lexington dome of Kentucky, whereas the Upper Devonian Chattanooga Shale is the source south of the Lexington dome.

Play 6602 Middle and Upper Ordovician Carbonate

The Middle and Upper Ordovician carbonate play consists of oil and associated gas trapped in Middle and Upper Ordovician platform limestone and dolomite by a variety of facies-change stratigraphic traps, dolomitized fracture zones, and small anticlines probably controlled by

basement faults. This play covers the entire Cincinnati arch except for local parts of the Lexington (KY) and Nashville (TN) domes where the Middle and Upper Ordovician sequence is exposed. Dolomite and limestone having varying amounts of vuggy, intergranular, and biomoldic porosity--commonly enhanced by fractures--make the best reservoirs. Most of the reservoirs are situated in the Middle Ordovician and Middle to Upper Ordovician Trenton Limestone, Black River Limestone, Lexington Limestone, High Bridge Group, Nashville Group, and Sunnybrook limestone. The Middle and Upper Ordovician Utica Shale and Maquoketa Shale are the source of the oil and gas north of the Lexington dome, whereas the Upper Devonian Chattanooga Shale is the source south of the Lexington dome.

Play 6603 Silurian/Devonian (Hunton) Carbonate

The Silurian/Devonian (Hunton) Carbonate play consists of oil and associated gas trapped in Silurian and Devonian platform carbonates by a variety of facies-change and unconformity traps. This play is located primarily in the Cumberland saddle of Kentucky and Tennessee and along the flanks of the Lexington and Nashville domes. Prospective reservoirs of vuggy dolomite and limestone, commonly enhanced by fractures and(or) karst processes, are located in the Silurian and Devonian Hunton Group, Silurian and Devonian "Corniferous" limestone, Silurian Louisville Limestone, Middle Silurian Laurel Dolomite, and the Middle Devonian Jeffersonville (Boyle) Limestone. The Upper Devonian Chattanooga Shale and New Albany Shale are the source of the oil and gas.

Play 6604 Devonian Black Shale

The Devonian Black Shale play consists of gas trapped in fractured black shale of the Upper Devonian Chattanooga Shale and New Albany Shale. This play is located mainly in the Cumberland saddle of Kentucky and Tennessee and along the flanks of the Nashville dome. The fractured reservoirs of the Upper Devonian Chattanooga and New Albany Shales are self-sourced.

Play 6605 Mississippian Carbonate

The Mississippian Carbonate play consists of oil and gas trapped in Mississippian bioherms and platform carbonates by facies-change and unconformity traps. This play is located mainly in the Cumberland saddle of Kentucky and Tennessee and locally along the flanks of the Lexington and Nashville domes. Prospective limestone reservoirs with vuggy and intergranular porosity are located in the Lower Mississippian Fort Payne Formation and the Upper Mississippian Warsaw, St. Louis, Salem, and Monteagle Limestones. The Upper

Devonian Chattanooga Shale and New Albany Shale are the source of the oil and gas.

Province 67. Appalachian Basin

Play 6701. Rome Trough

The Rome trough is a narrow northeast trending rift basin that underlies the Appalachian basin in Pennsylvania, West Virginia, and Kentucky. Approximately 2 to 3 km of Lower and Middle Cambrian shallow-marine to peritidal carbonate, sandstone, and shale fill the rift. The Rome trough play consists of gas and locally oil possibly trapped in anticlinal structures controlled by basement faults of the rift system. Prospective reservoir units are carbonate and sandstone, with intergranular, vuggy, and fracture porosity, in the Conasauga Group and Rome Formation. Dark gray to black shale beds in the Conasauga Group are the proposed source of the gas and oil.

Play 6702 Upper Cambrian, Ordovician, and Lower-Middle Silurian Thrust Belt

The eastern part of the Appalachian basin has been deformed into a fold and thrust belt that extends from New York to Alabama. The Upper Cambrian, Ordovician, and Lower-Middle Silurian Thrust Belt play is situated in the most complexly deformed part of the fold and thrust belt between, approximately, the Allegheny structural front on the west and the Blue Ridge structural province on the east. Commercial gas may be trapped in ramp anticlines above zones of bedding-plane detachment in Cambrian and (or) Ordovician shale. Prospective reservoirs are dolomite in the Upper Cambrian to Lower Ordovician Knox and Beekmantown Groups, limestone in the Middle Ordovician Black River and Trenton Limestones, and sandstone in the Upper Ordovician Bald Eagle (Oswego) Sandstone, Lower Silurian Tuscarora (Clinch) Sandstone, and Middle Silurian Keefer Sandstone. Many of these proposed reservoirs depend on fracture porosity. Middle Ordovician dark gray to black shale of the Utica (Antes) Shale, Liberty Hall Shale, Blockhouse Shale, and Athens Shale is the proposed source of the gas.

Play 6703 Beekmantown/Knox Carbonate Oil/Gas

The Beekmantown/Knox Carbonate Oil/Gas play extends from approximately the Allegheny structural front in Pennsylvania and West Virginia to the west side of the Appalachian basin in New York, Ohio, and Kentucky. Lengthwise, the play extends from New York to Alabama. The play consists of oil and gas trapped in erosional outliers and truncated strata beneath the widespread Knox unconformity and

possibly in broad anticlines controlled by basement faults. Vuggy dolomite in the Upper Cambrian and Lower Ordovician Knox and Beekmantown Groups is the primary reservoir. Prospective dolomite reservoirs are likely to be enhanced by fracture porosity in areas of recurrent basement faulting. Dark gray to black shale of the Middle Ordovician Utica (Antes) Shale is the proposed source of the oil and gas in the Ohio, Pennsylvania, and New York parts of the play. The source of the oil and gas is less certain in the southern part of the play (WV, VA, KY, TN, AL) but it could be the Upper Devonian Chattanooga Shale or the Middle Ordovician Liberty Hall, Blockhouse, and Athens Shales.

Play 6704 Rose Run/Gatesburg/Theresa Sandstone Gas

The Rose Run/Gatesburg/Theresa Sandstone Gasplay extends from approximately the Allegheny structural front in Pennsylvania and West Virginia to the truncation limit of the Rose Run Sandstone in eastern Ohio and northwestern Pennsylvania. Also, the play includes the western part of New York and the eastern part of Kentucky where reservoir-quality sandstone of Late Cambrian-Early Ordovician (?) age is present. The play consists of gas trapped in erosional outliers and truncated strata beneath the widespread Knox unconformity and possibly in broad anticlines controlled by basement faults. Quartzose sandstone of the Rose Run Sandstone, Gatesburg Formation, and Theresa Formation--with primary and secondary intergranular porosity--constitutes the reservoir. Sandstone reservoirs are likely to be enhanced by fracture porosity in areas of recurrent basement faulting. Dark gray to black shale of the Middle Ordovician Utica (Antes) Shale is the proposed source of the gas.

Play 6706 Trenton/Black River Carbonate Oil/Gas

The Trenton/Black River Carbonate Oil/Gas play extends from approximately the Allegheny structural front in Pennsylvania and West Virginia to the west side of the Appalachian basin in New York, Ohio, and Kentucky. Lengthwise, the play extends from New York to Alabama. The play consists of oil and gas trapped in dolomitized fracture zones, fractured limestone intercalated with black shale, and broad anticlines controlled with basement faults. Prospective reservoirs are located in the Middle Ordovician Trenton and Black River Limestones. Dark gray to black shale of the Middle Ordovician Utica (Antes) Shale is the proposed source of the oil and gas in the Ohio, Pennsylvania, and New York parts of the play. The source of the oil and gas is less certain in the southern part of the play (WV, VA, KY, TN, AL) but it may be the Upper Devonian Chattanooga Shale or the Middle Ordovician Liberty Hall, Blockhouse, and Athens Shales.

Play 6708 Queenston/Bald Eagle Sandstone Gas

The Queenston/Bald Eagle Sandstone Gas play extends from approximately the Allegheny structural front in Pennsylvania and West Virginia to the depositional limit of the Upper Ordovician Bald Eagle (Oswego) Sandstone and the sandy facies of the Upper Ordovician Queenston Formation in central West Virginia, western Pennsylvania, and western New York. The northeast limit of the play is defined in east-central New York where the Upper Ordovician sandstone units are truncated. The play consists of gas trapped in broad anticlines controlled by basement faults and in truncated strata (possibly accompanied by facies changes) beneath the widespread Taconic unconformity. Prospective reservoirs are sandstone beds, with intergranular and(or) fracture porosity, in the Upper Ordovician Bald Eagle (Oswego) Sandstone and the Upper Ordovician Queenston Formation. The Middle Ordovician Utica (Antes) Shale is the proposed source of the gas.

Play 6710 Tuscarora Sandstone Gas (See Play 6712)

Play 6711 Clinton/Medina Sandstone Gas (See Play 6712)

Play 6712 Clinton/Medina Sandstone Oil/Gas

The Tuscarora Sandstone Gas play, Clinton/Medina Sandstone Gas play, and Clinton/Medina Sandstone Oil/Gas play are contiguous plays that occupy progressively westward parts of the Lower Silurian sandstone depositional (fluvial to deltaic) system. This group of plays extends westward from near the Allegheny structural front in Pennsylvania and West Virginia, where the sandstone beds are thickest and have minor shale interbeds (Tuscarora Sandstone), to the depositional limit of the lower Silurian Clinton sandstones in central Ohio and eastern Kentucky, where the sandstone beds are thinner and intercalated with abundant shale and siltstone.

The Clinton/Medina Sandstone Oil/Gas play and the Clinton/Medina Sandstone Gas play consist of oil and gas trapped in facies-change stratigraphic traps. These plays occupy a belt of oil and gas fields that has been producing in Ohio, western Pennsylvania, and western New York since the late 1800's. The eastern limit of oil production in eastern Ohio and north westernmost Pennsylvania defines the boundary between the Clinton/Medina Sandstone Oil/Gas play. Primary inter-granular porosity in the Lower Silurian Clinton/Medina sandstone reservoirs diminishes eastward due to increased depth of burial. Consequently, the sandstone reservoirs in the Clinton/Medina

Sandstone Gas play commonly have much lower porosity and permeability values than the sandstone reservoirs in the Clinton/Medina Sandstone Oil/Gas play. These tight sandstone reservoirs produce gas only after they have been hydraulically fractured.

The Tuscarora Sandstone Gas play, the most easterly of the three plays, extends across central West Virginia and central Pennsylvania. This play consists of gas trapped in broad anticlines that may be controlled by basement faults. Prospective quartzose sandstone reservoirs generally have low primary intergranular porosity and, thus, depend on secondary intergranular porosity and fracture porosity to improve their quality.

The source of the oil and gas in these plays is uncertain but most probably is the Middle Ordovician Utica (Antes) Shale.

Play 6714 Keefer/Big Six Sandstone Gas (See Play 6715)

Play 6715 Big Six Sandstone Oil/Gas

The Keefer/Big Six Sandstone Gas play and the Big Six Sandstone Oil/Gas play are contiguous plays in the Middle Silurian shallow-marine sandstone depositional system. The Keefer/Big Six Sandstone Gas play, occupying most of West Virginia and adjoining eastern Kentucky between the Allegheny structural front and the depositional limit of the Keefer Sandstone, is the largest of the two plays. Also, the Keefer/Big Six Sandstone Gas play includes part of northeastern Pennsylvania and adjoining New York that is detached--because of the depositional geometry of the sandstone--from the main part of the play. The Keefer/Big Six Sandstone Gas play consists of gas possibly trapped in stratigraphic traps and broad anticlines. The reservoir quality of the Keefer and Big Six Sandstones is poor to moderate.

The Big Six Sandstone Oil/Gas play occupies a small part of east-central Kentucky where oil and gas is trapped in erosionally truncated strata of the Big Six sandstone and overlying Middle and Upper Silurian carbonate units commonly referred to by drillers as the "Corniferous" limestone.

Gas in the northern West Virginia, Pennsylvania, and New York part of the Keefer/Big Six Sandstone Gas play was probably derived from the Middle Ordovician Utica (Antes) Shale, whereas gas in the southern West Virginia and Kentucky part of the play was probably derived from the Upper Devonian Chattanooga Shale. The Upper

Devonian Chattanooga Shale that rests unconformably on the Big Six sandstone and "Corniferous" limestone in east-central Kentucky was the source of the oil and gas in the Big Six sandstone Oil/Gas play.

Play 6716 Upper Silurian Sandstone Gas

Gas produced from updip pinchouts of the Upper Silurian Williamsport Sandstone ("Newberg" sand) in West Virginia constitutes the Upper Silurian Sandstone Gas play. The Williamsport Sandstone is characterized by good intergranular porosity. Although stratigraphic traps are the most common traps in this play, broad anticlines controlled by basement faults and ramp anticlines above a zone of detachment in salt beds of the Upper Silurian Salina Group may be possible targets. The source of the gas is unknown; perhaps, it was derived from shale units in the Salina Group.

Play 6717 Silurian Carbonate

The Silurian Carbonate play consists of oil and(or) gas trapped in stratigraphic traps and broad anticlines probably controlled by basement faults. This play covers a large part of the Appalachian basin that includes central and western New York, western Pennsylvania, Ohio, western West Virginia, and eastern Kentucky. The eastern boundary of the play coincides approximately with the western limit of bedding plane detachment in salt beds of the Upper Silurian Salina Group. Vuggy carbonate, commonly enhanced by karst processes, characterizes the reservoirs in the Middle Silurian Lockport Dolomite, Middle Silurian Newberg Dolomite, and Upper Silurian Salina Group. The reservoir in the Kentucky part of the play is located in a carbonate unit that is commonly referred to by drillers as the "Corniferous" limestone (Lockport Dolomite and Salina Group combined). The source of the oil and gas in the play is probably Middle and Upper Devonian black shale. Shale beds in the Salina Group may have been a local source.

Play 6718 Silurian and Devonian Carbonate Thrust Belt

The Silurian and Devonian Carbonate Thrust Belt play is characterized by gas that may be trapped in thrust-faulted ramp anticlines above zones of detachment in salt beds of the Upper Silurian Salina Group and Cambrian and Ordovician shale. Broad anticlines controlled by basement faults may also be important traps. The play extends from south-central New York, through central Pennsylvania, to west-central New York, through central Pennsylvania, to west-central West Virginia. A narrow zone of imbricate faults that cuts Upper Silurian and Lower Devonian carbonates in western New York, although isolated from the main part of the thrust belt, is included with this play.

The prospective reservoir units in the play are characterized by vuggy and fracture porosity that possibly has been enhanced by karst processes. These reservoirs may be present in the Middle Silurian Lockport Dolomite, Upper Silurian Salina Group, Upper Silurian Bass Islands Dolomite, Lower Devonian Helderberg Limestone, and Middle Devonian Onondaga Limestone. The gas and local oil proposed in the play may be derived from the Salina Group, Utica (Antes) Shale, Middle Devonian Marcellus Shale, and Upper Devonian black shale.

Play 6719 Devonian Carbonate Gas

The Devonian Carbonate Gas play consists of gas trapped in pinnacle reefs and possibly in fractured carbonate and dolomitized fracture zones. The play covers a large area that includes central and western New York, western Pennsylvania, Ohio, western West Virginia, and eastern Kentucky. The eastern border of the play coincides approximately with the western limit of bedding plane detachment in the salt beds of the Salina Group. In addition to pinnacle reefs in the Middle Devonian Onondaga Limestone, prospective reservoirs may be found in the Lower Devonian Helderberg Limestone, Middle Devonian Columbus Limestone, and Upper Devonian Boyle Dolomite. Source beds for the gas in this play are located in the Middle Devonian Marcellus Shale and Upper Devonian black shale.

Play 6720 Oriskany Sandstone Gas/Faulted Anticlines (See Play 6721)

Play 6721 Oriskany Sandstone Gas

The Oriskany Sandstone Gas/Faulted Anticlines play and the Oriskany Sandstone Gas play are contiguous plays in the Middle Devonian Oriskany Sandstone depositional system. The Oriskany Sandstone Gas/Faulted Anticlines play, the easternmost of the two plays, consists of gas trapped in ramp anticlines above zones of bedding plane detachment in salt beds of the Salina Group and(or) Cambrian and Ordovician shale. Calcite-cemented quartzose sandstone, with intergranular (primary and secondary) and fracture porosity, constitutes the Oriskany Sandstone reservoir in the Faulted Anticlines play. Gas-bearing fractured chert in the Middle Devonian Huntersville Chert, that overlies the Oriskany Sandstone, is included with the Faulted Anticlines play. The Oriskany Sandstone Gas/Faulted Anticlines play extends southward from south-central West Virginia.

The Oriskany Sandstone Gas play consists of gas and local oil trapped in pinchouts, truncated strata, combination traps, and broad anticlines. This play covers most of eastern Ohio, western West Virginia, and

northwestern Pennsylvania, but there are several large patches within the region where the Oriskany Sandstone is absent due to erosion and(or) nondeposition. The eastern boundary of the Oriskany Sandstone Gas play coincides approximately with the western limit of bedding plane detachment in salt beds of the Salina Group. The Oriskany Sandstone reservoir in this play consists of friable, calcite-cemented sandstone with primary intergranular porosity.

The gas and local oil in the Oriskany Sandstone plays was derived from the overlying Middle Devonian Marcellus Shale and Upper Devonian black shale.

Play 6722 Upper Devonian Sandstone Gas (See Play 6723)

Play 6723 Upper Devonian Sandstone Oil/Gas

The Upper Devonian Sandstone Gas play and the Upper Devonian Sandstone Oil/Gas play are contiguous plays in the sandstone depositional system of the Upper Devonian Catskill delta. The Upper Devonian Sandstone Oil/Gas play, located in western Pennsylvania, western New York, and north-central West Virginia, consists of oil and gas trapped in a variety of stratigraphic traps and combination traps with low-amplitude anticlines and domes. Many of the oil and gas fields in the play contributed to the beginning of the American petroleum industry in the middle to late 1800's. Numerous sandstone and pebbly sandstone beds, with moderate to high primary intergranular porosity, provided the oil and gas reservoirs in the play. In ascending order, the reservoir sandstones are subdivided into the Elk, Bradford, and Venango Groups.

The Upper Devonian Sandstone Gas play borders the east side of the Upper Devonian Sandstone Oil/Gas play. The boundary between the two plays is defined as the eastern limit of oil production. Eastward, the Upper Devonian Sandstone Gas play extends to and slightly beyond the Allegheny structural front and southward the gas play extends into southern West Virginia. Approximately the same reservoir units and traps are present in the two plays; however, many of the sandstone reservoirs in the gas play are characterized by low porosity and permeability values. Commonly, gas is produced from these tight sandstone reservoirs only after they have been hydraulically fractured. Local areas of secondary intergranular porosity and natural fracturing greatly enhance the reservoir quality of the sandstone.

The oil and gas in these plays was derived from the Middle Devonian Marcellus Shale that underlies the sandstone reservoirs and from

Upper Devonian black shale that intertongues with the sandstone reservoirs.

Play 6724 Devonian Black Shale

Black gas shales of Devonian and Mississippian age occur over much of the Appalachian basin, extending from eastern Tennessee north and northeastward into Ohio and New York. In general, these shales were deposited along the distal margin of the Acadian Catskill delta in response to episodes of tectonic subsidence and regional transgression during the Acadian orogeny. A major trend of high organic carbon content in the black shales extends along the western side of the Catskill delta, from southwestern Virginia to the southern shores of Lake Erie. The high content of organic detritus in these Devonian and Mississippian black shale source beds is probably related to high organic productivity in combination with moderate sedimentation rates along the distal margins of the Catskill delta rather than to the widespread establishment of a pycnocline and preservation in anoxic environments. In general, organic matter in the black shales is more marine and oil prone on the western side of the basin, away from the major sources of siliciclastic input, than it is to the east. Thermal maturity trends follow depositional strike and isopachs of the Catskill delta and, thus, are related to depth of burial. Fracture porosity within the black shale sequence appears to have been affected mostly by regional decollement within discrete stratigraphic units that were, perhaps, overpressured during deformation.

These shales are most productive in the south-central part of the Appalachian basin, where they are thermally mature and are abundantly fractured. Shale gas is produced from relatively large fields in southwestern Virginia, eastern Kentucky, southwestern West Virginia, and southernmost Ohio. To the north, the strata rich in organic matter are thermally immature and fields along the southern shores of Lake Erie in Ohio and Pennsylvania are marginally productive. To the east in northwestern West Virginia, the organic content of the shales is diluted by increased amounts of siliciclastics, organic matter is not sufficient to sustain long-term gas production, and shale gas wells are short lived.

Play 6725 Mississippian and Pennsylvanian Sandstone/Carbonate

The Mississippian and Pennsylvanian Sandstone/Carbonate play consists of oil and gas trapped in a variety of structural traps and combination traps with low-amplitude anticlines and domes. Locally, gas is trapped in anticlines formed by basement faults or bedding plane detachment in Silurian and(or) Devonian strata. This play extends

from approximately the Allegheny structural front in central Pennsylvania and eastern West Virginia to the western margin of the basin in Ohio, Kentucky, and Tennessee. Lengthwise, the play extends from north-central Pennsylvania to Alabama. Numerous oil and gas fields have been discovered in the play over the past 100 years. Sandstone and carbonate reservoirs in the play occur at shallow depths and exhibit good intragranular porosity. Among the important reservoirs are the Lower Mississippi Berea Sandstone (OH, WV), Lower Mississippian Fort Payne Formation (TN), Upper Mississippian Big Injun sandstone (WV, OH), Upper Mississippian Maxton sandstone (WV), Upper Mississippian Grenbrier/Newman Limestone (WV, KY), and the Upper Pennsylvanian Cow Run Sandstone. Upper Devonian and Lower Mississippian black shale is the source of the oil and gas in the play.

Province 68. Blue Ridge Thrust Belt

Play 6801 Southern Appalachian Sub-Crystalline Thrust Sheets

This play involves structure in fractured carbonates beneath the Blue Ridge overthrust sheet. This is a highly speculative play because of the high thermal maturity and lack of drilling data.

Play 6802 Champlain Valley/Sub-Taconic Allochthon, New York, Vermont

The Blue Ridge play includes the northern part of the Appalachian Region in the U. S. to the east of the Adirondack Mountains in New York and adjacent New England, and includes the Lower Paleozoic strata that occur in the Champlain Valley and beneath crystalline thrust sheets a little farther to the east. The region is considered to have some hydrocarbon potential because it is geologically similar to the gas-producing region of the Quebec Lowlands nearby in Canada. Drilling targets are in Cambrian and Ordovician carbonate and siliciclastic rocks that lie unconformably on 1.1 billion-year old Grenvillian basement. Six wells drilled in the region are dry and abandoned. One of these, however contained shows of oil and gas. Drilling depths generally have ranged from 3,000 to almost 7,000 feet.

Because of the high levels of thermal maturation in the region, the potential for hydrocarbon production is expected to be for dry gas. Porosity is likely to be related to fractures associated with major subhorizontal thrust faults in the region and potential reservoirs would be local zones of great fracture porosity that are sealed by permeability barriers (Source, USGS OFR 88-450-A.)

Province 69. Piedmont

Play 6901 Eastern Mesozoic Basins

The onshore eastern Mesozoic Basins occur in a relatively wide band in the Piedmont and Coastal Plain Provinces from Florida to New England. Basins in the Piedmont Province are exposed at the surface and their distribution is well established. Basins beneath the Coastal Plain are known either from drilling or from seismic exploration. Depending upon the availability of drill hole data, the nature of the strata in the buried basins is only poorly to moderately well known, but basin fill, in general, consists mostly of siliciclastic sediments that were deposited in alluvial fan, fluvial, and lake environments. Thermal maturation values range widely because of the local effects of abundant diabase intrusions. Organic matter is, in general, terrestrially derived and the source rocks tend to be gas prone.

Ten of the larger basins were selected for a preliminary evaluation to determine if they had suitable source beds, thermal maturation, and geologic traps to warrant an evaluation for hydrocarbon potential. Of these, only one was omitted because of a lack of information concerning potential source beds.

Province 70. Atlantic Coastal Plain

Play 7001 Eastern Mesozoic basins

See Play 6901

Province 71 Adirondack Uplift

Play 7101. Champlain Valley/Sub-Taconic Allochthon, New York,
Vermont

See Play 6802.

Province 72 New England

Play 7201 Champlain Valley/Sub-Taconic Allochthon, New York,
Vermont

See Play 6802.