

THE Geologic COLUMN OF MISSOURI

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Cass County Well

OIL AND GAS IN THE SHOW-ME STATE

The history of the Show-Me state's petroleum industry has been of limited production. However, some believe Missouri may possess significant untapped oil and gas resources with an estimated economic value of hundreds of billions of dollars. Rising oil prices and the uncertainty associated with foreign supplies have created rising interest in Missouri's oil and gas fortunes. Nearly all of Missouri's past and current production has been with conventional technology. However, energy resources once considered too costly to produce

are being re-evaluated for economic development. No one knows precisely, the quantity and value of the untapped oil and gas resources that lie underground, but the key to the state's energy future may lie with the development of its unconventional resources.



**MISSOURI DEPARTMENT
OF NATURAL RESOURCES**
Division of Geology and Land Survey

HISTORICAL PERSPECTIVE

Oil is an extremely complex mixture of hydrocarbons (carbon and hydrogen) with minor amounts of nitrogen, oxygen, sulfur and other minor impurities. "Natural gas," composed largely of methane (CH₄) is flammable and occurs by itself or with oil. Modern society uses oil and gas for needs as diverse as gasoline, kerosene, plastics, paints, medical supplies, lubricants, rubber, fabrics, cosmetics and foodstuffs. However, in early America, the driving force behind commercial oil and gas production was lighting. Coal oil or kerosene was originally developed from coal. After the first oil well was drilled in America in 1859, the world suddenly had an economical bright-light source because it was cheaper to extract kerosene from oil than coal. Natural gas was also preferred over other sources of lighting of the day because it burned without noticeable residue.

Shortly after the Civil War, oil and gas were discovered in Missouri when water wells were being drilled near Kansas City. By the early 1930s, gasoline was needed to fuel American expansion and the oil boom began. More than 2,500 wells dotted the state. Many wells were successful, resulting in additional drilling throughout the state. Most of the central, eastern and southern Missouri wells were "dry holes" because those exploring for oil and gas had little understanding of the science that determines where oil is located in recoverable amounts. Today, geologic mapping has better defined the location of potential oil and gas producing rock units and structures.

OIL AND GAS PRODUCTION METHODS

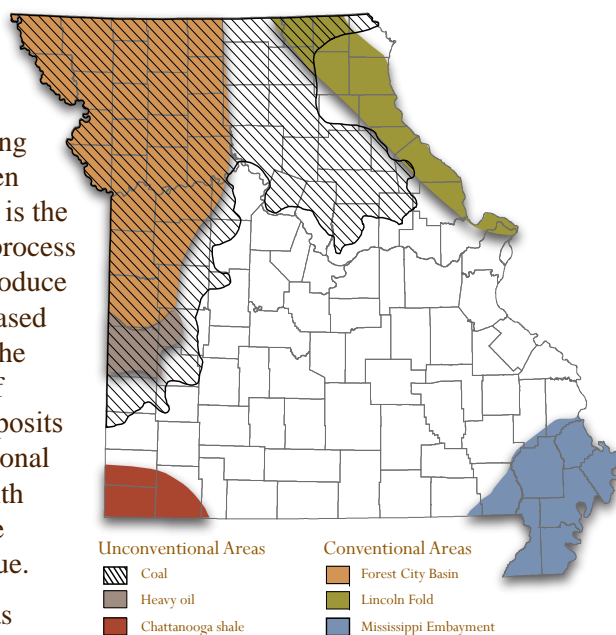
Both conventional and unconventional methods have been used to produce oil in Missouri. However, nearly all of Missouri's past and current production uses conventional technology. Typically, conventional oil wells produce by pumping liquid oil from a simple drill hole. Unconventional production techniques must be applied to oil and gas resources that are not responsive to conventional techniques. For example, injection of carbon dioxide or heated gases (to thin and mobilize the oil for extraction) may be used to

produce oil that is too thick and viscous for simple pumping methods. Even more difficult is the complicated process required to produce oil that is encased in oil shale. The state boasts of significant deposits of unconventional oil and gas with potential huge economic value.

For oil and gas to accumulate in economically recoverable quantities, three conditions must exist:

1. A significant source of hydrocarbons.
2. A porous host rock (reservoir) to store the petroleum.
3. A low permeability caprock to trap the oil and gas in the reservoir and prevent it from escaping.

OIL AND GAS PRODUCTION AREAS



Normally, the best place to accumulate oil and gas is where the bedrock layers are bent and contorted into what geologists call folds. Upward, folded rock layers are called domes and anticlines. Downward, folded rocks are called synclines and basins. Petroleum "reserves" are those deposits that have already been discovered but not yet produced.

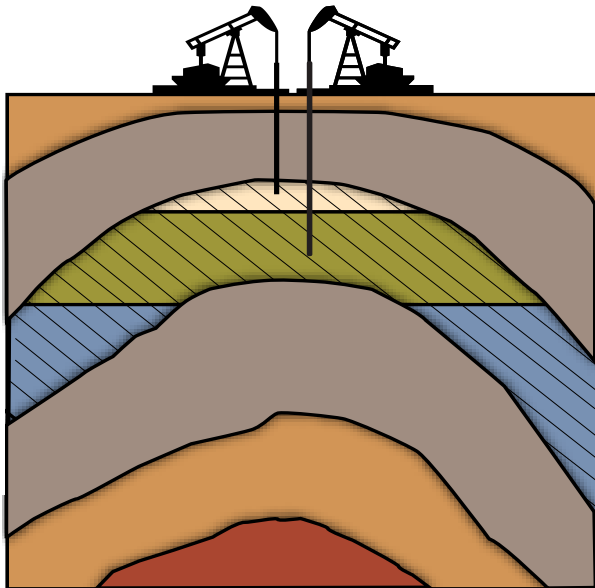
CONVENTIONAL RESOURCES

There are currently three areas with potential for conventional oil and gas production in different regions of the state: the Forest City basin, the Lincoln fold and the Mississippi embayment. Commercial oil production has increased slightly in recent years. There currently are 323 producing oil wells. While there is no commercial gas production in Missouri, 47 domestic gas wells are being used in private homes and small businesses to fuel heating appliances.

FOREST CITY BASIN

The Forest City basin is a bowl-like feature in the subsurface rock layers in northwest Missouri and adjacent portions of Iowa, Nebraska and Kansas where thick deposits of sediments have accumulated. Bedrock units, at or near the ground surface south of the Kansas City area, thicken to the north and are deeply buried in the center of the basin. Some of these units bear oil and gas. Geologic forces have created subtle folds in these rocks since their

OIL AND GAS PRODUCING ANTICLINE



deposition, creating traps for the petroleum resources. Atchison County has seen continuous oil production from north-south trending anticlines since 1943. There are several different producing zones at depths ranging up to 2,800 feet in Atchison County. Approximately 75,000 barrels of oil are produced in the region on an annual basis. Historically, natural gas also has been produced in Jackson, Cass, Clay, Clinton, Platte and Caldwell counties, from sandstone and black shales.

LINCOLN FOLD

The Lincoln fold is an upward fold or anticline that extends from northern St. Louis County northwest to Knox County. In 1952, exploration was underway in St. Louis County to determine the potential for storing gas in the St. Peter Sandstone (in the southeastern limit of the fold near Florissant). During exploratory drilling, oil was discovered in a limestone unit 1,000 feet below the surface about 400 feet above the targeted St. Peter Sandstone. Production from this region totals about 1.2 million barrels with a record high 76,000 barrels in 1954. Exploration continued along the fold, but resulted in a majority of dry holes. As a side note, Laclede Gas Company in St. Louis, has been successful in storing natural gas in a circular closed structure called the Florissant dome that developed on the Lincoln fold.

MISSISSIPPI EMBAYMENT

The Mississippi embayment is a large depressed area, extending north from the Gulf Coast to the southeast region of Missouri. It is characterized, on the surface, by a large alluvial plain interrupted by a line of low hills. This area is noted for its deep-seated faults or breaks in rock that have deformed the bedrock and overlying soil units alike. Roughly 2,000 feet or more of younger sediments bury the potential oil and gas producing rock units in this region. The area of greatest potential is thought to be in Pemiscot and Dunklin counties, within the northwest-southeast trending fold called the Pascola arch. The arch is a structural bedrock-high located deep beneath the ground, where oil and gas may be trapped. Bedrock in the arch correlates to oil and gas producing units found in Texas and Oklahoma. No commercial production and only limited exploration have occurred in the area. However, this region is experiencing renewed exploration interest.

A MOMENT IN TIME

Oil and gas have been known about and drilled for in Missouri since the 1860s. This photo was taken in 1922 on the William Heisser Farm west of Scott City in southeast Missouri and shows a wooden derrick sitting over a new oil well. While no commercial production has been developed to date, in the southeast part of the state, the potential reserves are still in question. The geology of the area resembles regions along the U.S. Gulf Coast that have had tremendous historic oil and/or gas production.

Photo courtesy of Missouri State Archives.



UNCONVENTIONAL RESOURCES

The potential for unconventional oil and gas resources in Missouri has an estimated economic value of hundreds of billions of dollars. Three potential resource areas include: the tar sands of western Missouri; the coalbed methane gas associated with deeply buried coal seams in northwest, north central and west central Missouri; and the oil shales in the northern and the extreme southwest part of the state.

TAR SAND

“Heavy oil,” also known as pitch or asphalt, is thick and does not flow easily. Heavy oil in sand or sandstone is called tar sand. Production of tar sand is difficult and requires special techniques to “thin” the oil for extraction. Most of Missouri’s tar sand is located in western Missouri near the Kansas border in a bedrock structure known as the Bourbon arch. Nearly 800,000 barrels of oil have been produced since 1960 in Vernon County with a record high of more than 163,000 barrels in 1984. Recent estimates of reserves in the Bourbon arch are 1.4 to 1.9 billion barrels of oil. Assuming oil prices of approximately \$55 to \$65 per barrel and current technology and recovery rates, the estimated value of Missouri’s heavy oil is \$35 to \$42 billion.

COALBED METHANE

As coal ages, it is altered by naturally-occurring bacteria. During this process, methane is produced and attaches to the coal. To produce methane from a well, a hole must be drilled into the coal bed and the groundwater pumped out. Once the coal is de-watered, the methane is released from the coal and can be produced from the well. In 2006, more than 3,200 coalbed methane wells in Kansas produced nearly 24 billion cubic feet of gas. Many of these wells reside in the same coal units that occur in western Missouri. While coalbed methane has not yet been produced economically in Missouri, it likely will be, given Missouri’s extensive coal deposits. The amount of potential methane remaining in Missouri coals could be valued as high as several hundred billion dollars.

OIL SHALE

Deposits of organic-rich clay beds that have been hardened into rock by heat and pressure are called oil shale. Oil shale is found overlying some coal beds in northern Missouri and in portions of the Chattanooga Shale formation of extreme southwest Missouri. Only the most preliminary analyses have been conducted on Missouri oil shale. Nevertheless, it is likely that significant amounts of oil are present, with a potential value of several hundred billion dollars. However, huge technical and economic issues remain in determining how, or if, the resource will be developed.

STATE OIL AND GAS COUNCIL

The State Oil and Gas Council, created in 1966, fosters and promotes the orderly development and production of Missouri’s oil and gas resources. The Council also works to ensure that wastes generated by oil and gas wells are managed properly to minimize the impact on the environment. In addition, the Council implements regulations to protect groundwater aquifers that may be affected by oil and gas well drilling. This group recently established well drilling spacing units in portions of a five county area in southeast Missouri.

Oil production in Missouri in 2006 was more than 86,000 barrels from 323 wells with an estimated value of \$4.7 million. In recent months, exploration has reached a higher level of interest because of the record high cost of oil. The number of new oil and gas well permits issued by the Council increased from 27 in 2005 to 39 in 2006 with most recent increases occurring in Cass County. Current production is in five counties (Cass, Jackson, Vernon, Atchison and St. Louis), with historic commercial production in Clay, Platte, Caldwell, Clinton, Bates and Holt counties.

Information about the Council’s meeting dates, meeting minutes, permitting and state oil and gas rules can be found at: www.dnr.mo.gov/geology/geosrv/ogc/.

FOR ADDITIONAL INFORMATION

For additional information you may contact the Geological Survey Program, at (573) 368-2100 or visit us on the Web at www.dnr.mo.gov/geology. For more information on oil and gas you may visit:

Missouri Department of Natural Resources	www.dnr.mo.gov
U.S. Geological Survey	www.usgs.gov
American Geological Institute	www.agiweb.org
American Association of Petroleum Geologists	www.aapg.org



**MISSOURI DEPARTMENT
OF NATURAL RESOURCES**
Division of Geology and Land Survey

PLUGGING OF ABANDONED WELLS

Seven abandoned oil wells near Garden City no longer pose public safety or environmental threats to Cass County residents because the division recently contracted to plug the wells using forfeited bond funds. A well is considered abandoned when it is no longer used to produce oil or natural gas. More than 9,900 oil and gas wells have been drilled in Missouri since the early 1900s. During the last century, many of those wells were taken out of service and properly plugged. Unfortunately, the division estimates that there are more than 2,000 abandoned oil or gas wells in the state that have not been properly closed. Abandoned or improperly constructed or maintained wells can act as conduits for contamination to enter groundwater or to rise to the surface. Proper plugging of oil and gas wells is necessary to protect public health and safety, conserve and protect our natural resources and to enable the oil and gas industry to efficiently develop Missouri's oil and gas resources.

Prior to drilling an oil or gas well, an owner or operator must file a bond with the state. The bond must be of sufficient amount to cover the cost of plugging the well and provide a guarantee that the state has money to properly close the well if abandoned. This bond is held by the state until plugging of the well is documented and approved by the state geologist. The owner or operator may then apply to have the bond returned. In the event the well is abandoned without being properly plugged, the bond is forfeited to the Oil and Gas Remedial Fund. The Remedial Fund can then be used to properly plug the well.



ED CLARK MUSEUM OF MISSOURI GEOLOGY



MINERALS, ROCKS, FOSSILS, MAMMOTH TUSKS, MAPS AND MORE!

The museum, named for Edward L. Clark, State Geologist from 1944 to 1955, is home to Missouri minerals, rocks and fossils. Also on display are mammoth tusks, maps and numerous historic items used throughout the long history of the Division of Geology and Land Survey since the agency was created in 1853. During Clark's term, much emphasis was placed on the state's mineral industry and developing water resources. Under Clark, the division published aeromagnetic maps showing variations in the distribution of magnetic minerals in the rocks that make up the upper part of the Earth's crust.

The museum provides a background for division staff to share with both adults and children, the importance of our state's natural resources and highlights the fossils, rocks and minerals that are found in our state. The museum also identifies the role that the division plays in the management and protection of these resources.

Self-guided tours are available to the public weekdays from 8-5. Located at the 111 Fairgrounds Road in Rolla. Our phone number is (573) 368-2100.



OIL AND GAS PUBLICATIONS

RI-21. **Northeast Missouri's Oil Possibilities Improve**, by Earl McCracken, 2 p., 3 figs., 1956. Discusses development of the Florissant oil field and oil and gas possibilities of northeast Missouri. Reprinted from Oil and Gas Journal, vol. 53, no. 35, p. 154-155, January 1955.

IC-27. **A Preliminary Evaluation of Shale-Oil Resources in Missouri**, by Laurence M. Nuelle and H. Scott Sumner, 28 p., 1 pl., 1981. Preliminary overview of Missouri's Pennsylvanian and Devonian shale-oil potential. Extensive review of adjoining states data pertaining to Missouri units.

V-27. **The Oil and Gas Resources of Cass and Jackson Counties Missouri**, by Joseph R. Clair, 208 p., 7 pls., 14 figs., 1 tbl., 1943. Discusses physiography, stratigraphy, structural and economic geology as a basis for describing oil and gas resources.

V-37. **Subsurface Geology of the Mississippi Embayment of Southeast Missouri**, by John G. Grohskopf, 133 p., 9 pls., 1955. A report on the stratigraphy, structural geology, and economic geology of the Mississippi Embayment area.

OFR-90-80-OG. **Heavy-Oil Resource Potential of Southwest Missouri**, by Bruce W. Netzler, 11 p., 1990. An overview of west-central Missouri's potential for heavy-oil production. Includes reserve estimates, stratigraphy and recovery methods.

OFR-01-99-GS. **Coalbed Methane Potential of Harrison County, Missouri**, by David C. Smith, 27 p., 2001. A report on the natural gas production possibilities of a number of coal beds, including the Cainsville and Princeton in Harrison County of northwestern Missouri.

OFM-82-94-OG. **Missouri Oil and Gas Wells of Record/Belton 7½' Quadrangle**, by Bruce W. Netzler, 1982, 1:24,000. USGS topographic map with location of known oil and gas wells as of 1982.

OFM-85-224-OG. **Structural Contour Map on the Top of the Devonian (Hunton) in Northwestern Missouri**, by Kenneth L. Deason, 1985, 1:500,000. Structural map showing anticlines, domes and faults as interpreted from well log data.

These and other publications may be purchased through the Missouri Department of Natural Resources, Division of Geology and Land Survey. To order a copy, contact the publications desk at: (573) 368-2125 or 1-800-361-4827 or use our online form at: www.dnr.mo.gov/geology/adm/publications/MapsOrder.htm.



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