

OKLAHOMA GEOLOGICAL SURVEY

A State Agency for research and public service

GEOLOGY AND MINERAL RESOURCES OF OKLAHOMA¹

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INTRODUCTION

Oklahoma is a region of complex geology where several major sedimentary basins are set amongst mountain ranges and uplifts. The State contains many classic areas where fundamental concepts of geology, petroleum exploration, and minerals production have been formulated through the years. Because of its geologic history, Oklahoma has abundant mineral resources that include petroleum (crude oil and natural gas), coal, nonfuel minerals (lead, zinc, gypsum, limestone, sand and gravel), and water. The value of petroleum, coal, and nonfuel minerals reached a high of \$11 billion in 1983, and was about \$6 billion in 1997, making the mineral industry the greatest source of revenue in the State in recent years.

GEOLOGY

Geologic forces deep within the earth's crust hundreds of millions of years ago caused portions of Oklahoma to subside as major sedimentary basins, while adjacent areas were folded and thrust upward as major mountain uplifts (Fig. 1). Most of the outcropping rocks in Oklahoma are of sedimentary origin, and they consist mainly of shale, sandstone, limestone, and gypsum. These sedimentary rocks typically are 2,000–10,000 ft thick in the northern shelf areas, and they increase sharply

to 30,000–40,000 ft thick in the deep basins of the south. These sedimentary rocks contain most of the State's mineral resources, including petroleum, coal, water, and most of the nonfuel minerals. Sedimentary rocks rest upon a "basement" of igneous and metamorphic rocks that underlie all parts of the State (Fig. 1).

Exposed in the southern Oklahoma mountain belts are a great variety of sedimentary and igneous rock units seen at few other places in the entire Midcontinent region.

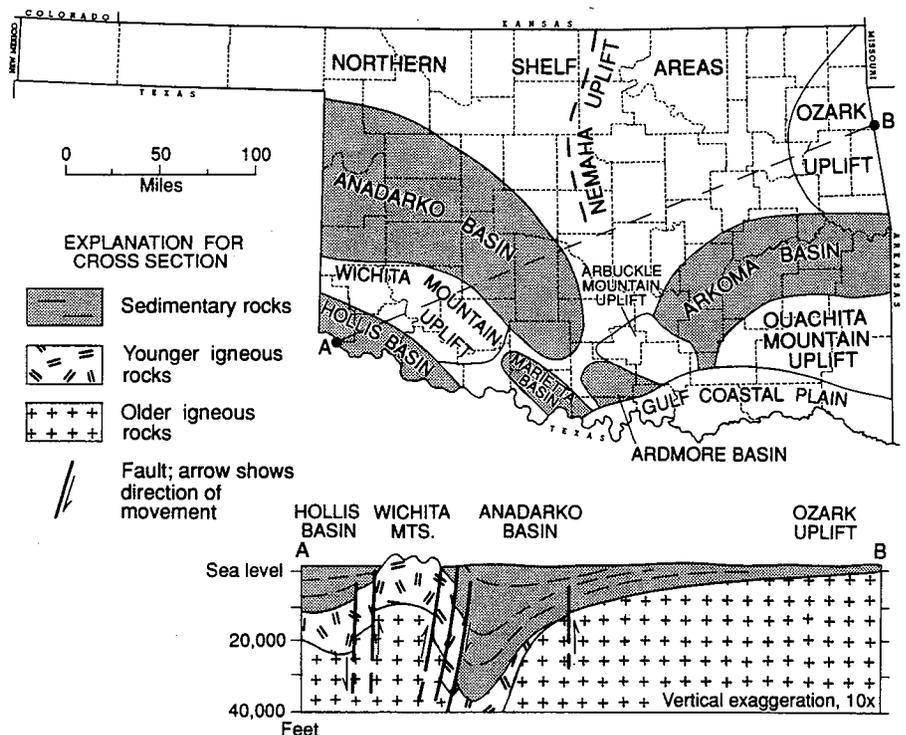


Figure 1. Major geologic provinces of Oklahoma.

¹Updated from: *Directory of Oklahoma, 1991–1992*, Oklahoma Department of Libraries, p. 620–623.

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Steeply dipping strata, such as those exposed along Interstate 35 through the Arbuckle Mountains, attest the strong geologic forces that folded and raised the mountain blocks. Outcropping rocks outside the mountain regions are essentially horizontal, with dips of less than one degree being most common. These strata typically form gently rolling hills and plains: thick shale units form broad, flat plains and valleys, whereas resistant layers of sandstone and limestone cap mesas, cuestas, and hills 100–500 ft high. Rocks and soils of western Oklahoma typically are red in color, due to iron oxides present in the bedrock, whereas rocks and soils elsewhere are shades of brown, gray, and black.

PETROLEUM RESOURCES

Oil and gas are a mixture of complex molecules of hydrogen and carbon formed from the decomposition of microscopic animals and plant material buried in muddy sediments of ancient seas that once covered Oklahoma. Deep burial of these muds created sufficient heat and pressure on the organic remains to transform them into oil and gas that could be squeezed out of the muds into more-porous sedimentary rocks, such as sandstone, limestone, and dolomite. Oil and gas therefore occupy the small spaces between grains or crystals that constitute a porous rock; they do not exist in large open cavities, or pools, as is sometimes believed, due to use of the term “oil pool.”

There is no reliable account of the first discovery of oil

in the State, but Native Americans used oil and tar from natural seeps for medicinal purposes, and early settlers found oil springs in northeastern Oklahoma. A well drilled for salt near Salina, Mayes County, in 1859 accidentally struck oil, which was then sold for lamp oil. Although the first recorded production in the State was 30 barrels of oil in 1891, the first commercial oil well (one that makes a reasonable profit above the cost of drilling, equipping, and producing) was completed at Bartlesville, Washington County, in 1897. Since then, oil and/or gas production has been established in 74 of the 77 counties in the State (Fig. 2).

Oklahoma has long been one of the main petroleum-producing states in the United States. Its reputation as an “oil state” was well established in the early 1900s by the discovery of such famous major oil fields as Glennpool, Cushing, Healdton, Sho-Vel-Tum, Burbank, Seminole, and Oklahoma City between 1905 and 1928 (Fig. 2). Early-day major gas fields discovered between 1912 and 1926 are the Red Oak–Norris, Guymon–Hugoton, and Kinta fields. Many more major oil and gas fields have been discovered through continued exploration of new frontiers since the late 1920s. Oklahoma was the leading producer of petroleum in the Nation from 1907 through 1923: at present it is the fifth leading producer of oil, behind Texas, Alaska, Louisiana, and California; and is second in production of natural gas, behind Texas.

Through the end of 1997, more than 500,000 wells had been drilled in Oklahoma in search of oil and gas, and about 120,000 of them are still producing. Total cumula-

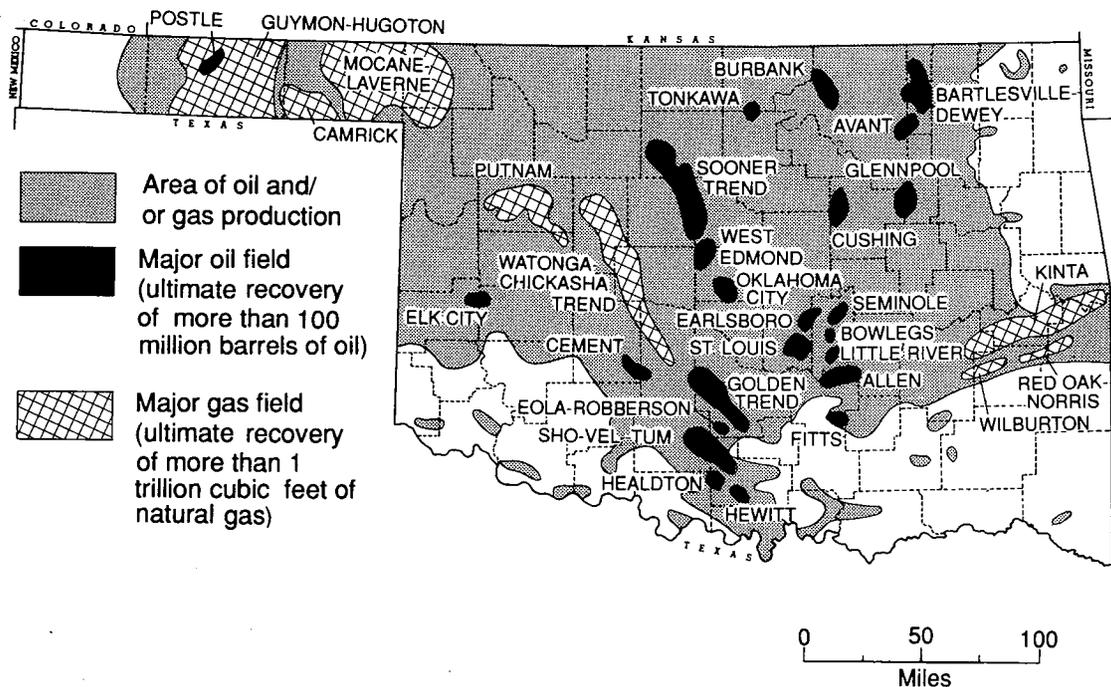


Figure 2. Oil and gas fields of Oklahoma.

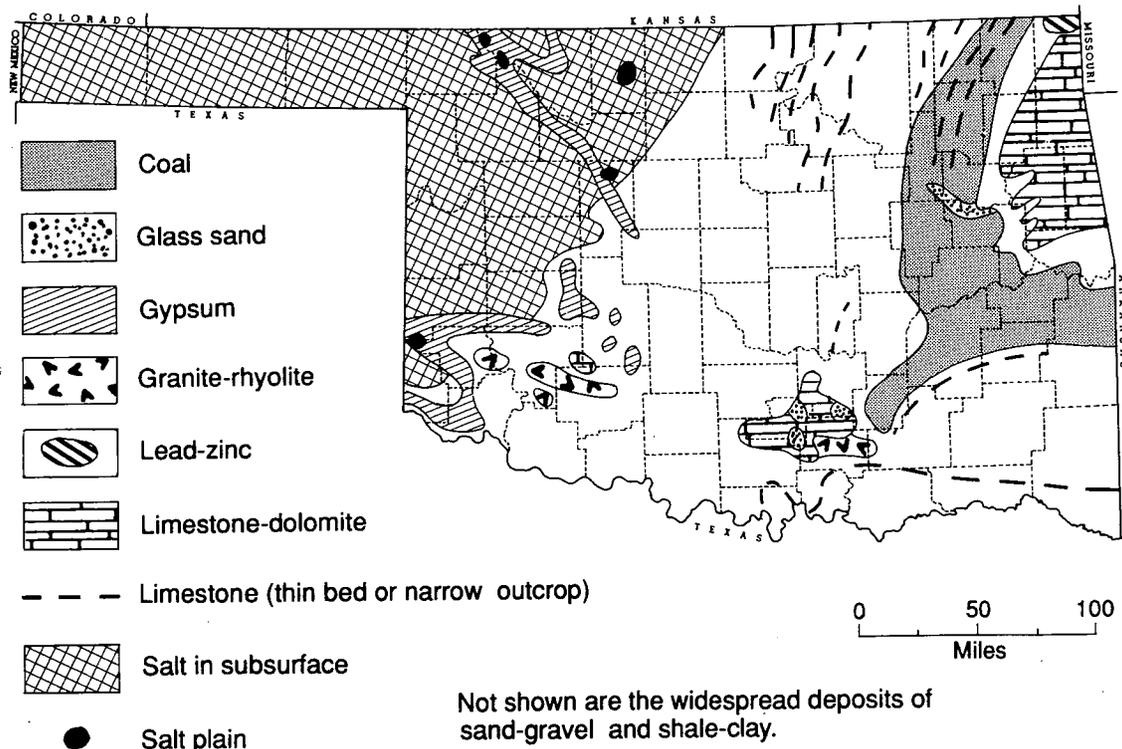


Figure 3. Nonpetroleum mineral resources of Oklahoma.

tive production from 1891 through 1997 was about 14 billion barrels of oil (valued at \$78 billion, cumulative value for each year, not adjusted to today's dollars) and 81 trillion cubic feet of natural gas (valued at \$85 billion). Production during 1997 was 83 million barrels of oil and 1.7 trillion cubic feet of natural gas; these had a total value of about \$5.6 billion.

COAL RESOURCES

Vast resources of bituminous coal are present in an area of about 8,000 square miles of eastern Oklahoma (Fig. 3). More than 200 million tons of coal have been produced from hundreds of mines since mining began in 1873. In recent years, most of the coal mined in Oklahoma has been used in generating electricity or in making coke for steel manufacture. Oklahoma coal production reached a peak of about 5.7 million tons in 1981. Production was about 1.62 million tons in 1997, and it was valued at about \$42 million.

Oklahoma coal beds are 0.8–10 ft thick, have 0.4–6.5% sulfur, and contain 11,500–14,500 Btu per pound. Early mining was mainly by underground methods, but since the late 1950s almost all Oklahoma coal has been mined by surface methods. In comparison to underground mining, surface mining is safer, recovers a higher percentage of coal, and is less costly per ton; also, current state regulations require restoration of the land after mining is completed. Surface mining, however, is restricted to shallow mining depths, where the coal beds are no more than 50–100 ft deep; thus only a portion of the State's total coal resources can be recovered by this mining method.

NONFUEL MINERAL RESOURCES

Nonfuel minerals include both metals (lead, zinc, and copper) and nonmetals (limestone, gypsum, salt, clays, and sand and gravel). Oklahoma has an important history in metals production, although there is no mining of metallic resources at this time. Underground mining in the Miami-Picher field of northeastern Oklahoma (Fig. 3) yielded approximately 1.3 million tons of lead and 5.2 million tons of zinc between 1891 and 1970 (when the mines closed). Oklahoma led the United States in zinc production almost every year from 1918 through 1945. About 1.9 million tons of copper-shale ore were mined southwest of Altus, in Jackson County, between 1964 and 1975. Principal metallogenic provinces of Oklahoma are in the northeast corner of the State and in the Ouachita, Arbuckle, and Wichita Mountains (Fig. 1).

Nonmetallic minerals are widely distributed in Oklahoma (Fig. 3), and many of them are being mined for local, regional, and national markets. Crushed-stone and building-stone resources include the limestone, dolomite, and granite deposits; other major construction resources are cement (made from limestone and shale) and the extensive sand and gravel deposits along the modern and ancient riverways. Glass sand, a high-purity silica sand present in the Arbuckle Mountains and in the Arkansas River at Muskogee, is used for glass making, foundry sands, ceramics, and abrasives. Enormous reserves of gypsum in the western part of the State are mined for wallboard, for plaster, as a retarder in portland cement, and as a soil conditioner. Thick layers of rock salt underlie most of west-

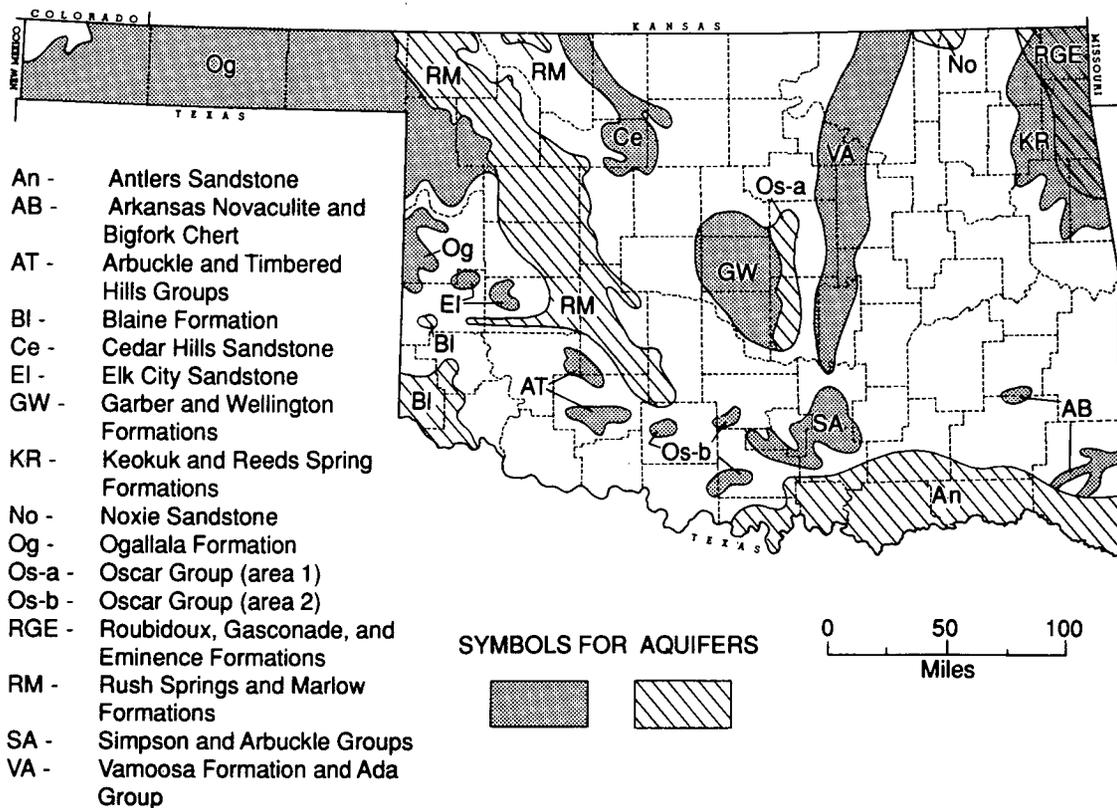


Figure 4. Bedrock aquifers in Oklahoma.

ern Oklahoma at depths of 30–3,000 ft, and natural springs of salt water emit brine to the several salt plains in the region (Fig. 3). Iodine is produced from deep oil-field brines (7,000–10,000 ft deep) by three companies in the Woodward–Vici–Dover area of northwestern Oklahoma. Oklahoma is the sole domestic producer of iodine; the State’s production of about 3 million pounds in 1997 was nearly 40 percent of the United States’ needs. Other important nonmetallic minerals in Oklahoma include clays and shales (to make brick and tile) and tripoli and volcanic ash (abrasive and/or absorbent materials).

The total estimated value of nonfuel mineral production in Oklahoma during 1997 was \$411 million, and the State ranked 34th in the Nation. Leading nonfuel producers during 1997 were crushed stone (\$134 million), portland and masonry cement (\$131 million), sand and gravel (\$33 million), glass sand (\$27 million), iodine (\$24 million), and gypsum (\$18 million).

WATER RESOURCES

Water is a natural resource that is critical to all life and activities in Oklahoma, and precipitation is the source of virtually all surface water and ground water in the State. Average annual precipitation ranges from about 16 inches in the western Panhandle to as much as 56 inches in the Ouachita Mountains of the southeast. Part of the precipitation falling on the land surface runs off to form streams and rivers. The entire State is drained by the Arkansas

and Red Rivers and their tributaries. A large number of reservoirs, lakes, and ponds have been constructed on rivers and streams for flood control and to provide a dependable supply of surface water for municipalities, irrigation, recreation, and generation of electricity. About 80% of all water used by cities and industries is taken from surface-water sources. The State reservoirs with the largest volume of water are Texoma, Eufaula, Grand, Broken Bow, Tenkiller, and Keystone Lakes.

Part of the precipitation soaks into the soil and percolates down to become ground water that is stored in small openings or pores in underlying sediments and bedrock. Oklahoma’s principal ground-water aquifers are widespread and consist of stream and river deposits (alluvium and terraces), limestones, sandstones, gypsums, and fractured cherts (Fig. 4). These aquifers commonly yield 50–1,000 gallons per minute of good-quality water for irrigation, municipal, domestic, and industrial use. Ground water provides about 80% of the water used for irrigation, chiefly in the drier, western one-third of the State. Areas not underlain by principal aquifers consist mainly of shales, siltstones, and sandstones that commonly yield only enough water for household use.

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