GEOLOGY AND EARTH RESOURCES OF OKLAHOMA

An Atlas of Maps and Cross Sections

KENNETH S. JOHNSON, CARL C. BRANSON, NEVILLE M. CURTIS, JR., WILLIAM E. HAM
WILLIAM E. HARRISON, MELVIN V. MARCHER, AND JOHN F. ROBERTS

INTRODUCTION TO THE GEOLOGY OF OKLAHOMA

KENNETH S. JOHNSON

Geologic History

Rocks of every geologic period crop out in Oklahoma. Although most of these rocks are of sedimentary origin, consolidated from sediments deposited during the Paleozoic Era, the oldest are Precambrian granites and rhyolites formed 1.05 to 1.35 billion years ago. Much later, during the early and middle parts of the Cambrian Period, a different group of granites, rhyolites, gabbros, and basalts formed in southwestern and south-central Oklahoma. Heat and fluids given off by the Cambrian magmas changed an older group of sedimentary rocks into metamorphic rocks. Precambrian and Cambrian igneous and metamorphic rocks underlie all of the State and are the floor or "basement" upon which all younger rocks rest.

At many times in the past, forces within the earth caused portions of Oklahoma and surrounding states to alternately sink below and rise above sea level. When the region sank, large areas were covered by shallow seas, and thick layers of marine mud, sand, and calcareous skeletal debris were deposited. Other sands and muds were laid down at the same time, as alluvial and deltaic deposits near the ancient seas. After burial beneath later sediments, the muds, sands, and calcareous layers were changed to shale, sandstone, and limestone by compaction and cementing together of the granular material. When certain areas were later raised out of the seas, earlier deposited sediments and rocks were exposed and eroded, just as they are being eroded today. Uplift was accomplished either by gentle arching of broad areas or by the formation of mountains where rocks were intensely folded and faulted and thrust upward.

The three principal mountain belts of Oklahoma—the Ouachitas, Arbuckles, and Wichitas—occur in the southern third of the State and were formed by folding, faulting, and uplift during the Pennsylvanian Period. North of the mountain uplifts are two deep basins (Anadarko and Arkoma), and north of these basins are the relatively undisturbed shelf areas of northern Oklahoma.

Shallow seas covered all of Oklahoma during various parts of the Cambrian, Ordovician, Silurian, and Devonian Periods. Thick limestones and dolomites are the most common rocks of these periods, although several formations of sandstone and shale also occur. Fossils are common in many of the limestones, with brachiopods, trilobites, corals, and crinoids being most numerous. In seas of the present Ouachita Mountain area, however, shale, sandstone, and chert were the principal deposits.

During the Mississippian and Pennsylvanian Periods, the sedimentary basins of Oklahoma sank much deeper and more rapidly than before. Thick sequences of shale with interbedded sandstone and limestone were formed in these basins and also in a deep basin that existed in the area of the present Ouachita Mountains. Plants growing in swamps near the edge of Pennsylvanian seas were buried and have since decomposed to form coal.

The greatest period of mountain building in Oklahoma was in Pennsylvanian time. Flat-lying sedimentary rock layers in the southern half of the State were sharply folded, tilted, and faulted; earlier formed igneous rock masses were pushed upward; and the three mountain chains (Ouachita, Arbuckle, and Wichita) were thrust high above surrounding seas. Gravel and boulders eroded from the rising mountains were deposited to form conglomerates at the foot of the mountains and in the nearby seas.

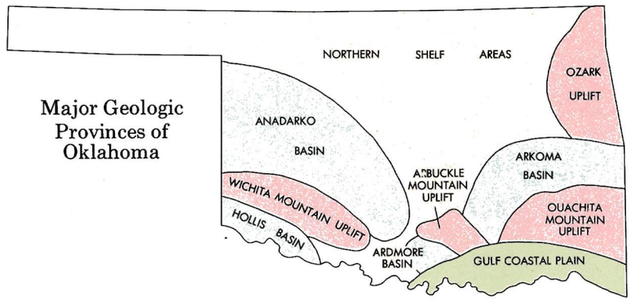
Following the period of mountain building, a shallow Permian sea covered western Oklahoma. The mountains were largely worn down, and sand and mud eroded from land in the eastern half of the State were carried in rivers to the sea. The red color of these Permian sandstones and shales comes from red iron oxide compounds deposited with the sand and mud. The climate was warm and dry, and thick layers of gypsum and salt were deposited from evaporating sea water.

Nonmarine shales and sandstones characterize the Triassic, Jurassic, and Cretaceous sedimentary rocks of Oklahoma. Shallow seas covered southern and western Oklahoma during some of the Cretaceous Period, and marine deposits resulted in limestone and shale.

Since the broad gentle raising of Oklahoma and surrounding areas above sea level at the beginning of the Tertiary Period, no part of the State has been covered by sea water. Oklahoma's land surface sloped down to the east and southeast, and extensive deposits of Tertiary sand and gravel were washed in by large rivers flowing from the newly formed Rocky Mountains.

The Quaternary Period, up through the present, is characterized as a time of erosion. Rocks and loose sediment at the surface are being weathered to soil, and the soil particles are then carried away to streams and rivers. In this way hills and mountain areas are being worn down, and sediment is carried to the sea or is temporarily deposited on the banks and in the bottoms of rivers and lakes.

Present-day topography and landforms are largely controlled by the kinds of rocks at the surface. Resistant rocks, such as granite, sandstone, and limestone, generally form high ridges, hills, and mountain peaks, whereas nearby outcrops of shale and other easily eroded rocks form valleys and lowland areas.



Geologic Time Scale Compared to a Calendar Year

GEOLOGIC ERA	GEOLOGIC PERIOD	BEGINNING (MILLION YEARS AGO)	COMPARATIVE DATE[1]	DAY	HR	MIN
Cenozoic ("Recent life")	Quaternary	1	December	31	22	03
	Tertiary	70	December	26	7	44
Mesozoic ("Middle life")	Cretaceous	135	December	21	1	12
	Jurassic	180	December	17	9	36
	Triassic	220	December	14	3	44
Paleozoic ("Ancient life")	Permian	270	December	10	2	24
	Pennsylvanian	320	December	6	1	04
	Mississippian	350	December	3	14	40
	Devonian	400	November	29	13	20
	Silurian	430	November	27	2	56
	Ordovician	490	November	22	4	37
	Cambrian	600	November	13	16	00
Precambrian		4,500	January	1	0	00

[1]Determined by A. J. Myers.

Glossary of Selected Geologic Terms

Alluvium—flat-surfaced deposits of sand, silt, clay, and gravel in stream beds and on flood plains of present-day rivers and streams.
Aquifer—a permeable rock or deposit that is water bearing.
Asphalt—a solid or semisolid oil residue remaining in rocks after escape of the gaseous and more liquid components.

Basalt—a dark-colored fine-grained igneous rock (lava) formed from magma that flowed onto the surface of the earth. Oklahoma basalts are dark gray or black.
Basin—a large area that sank faster than surrounding areas during much of geologic time and in which a great thickness of sediments was deposited.
Bentonite—an absorbent clay formed by decomposition of volcanic ash.

Caliche—a porous sedimentary rock consisting of sand or gravel cemented by calcium carbonate.
Chat—the crushed chert, limestone, and dolomite that is left as a by-product of milling lead-zinc ores.
Chert—a dense sedimentary rock or mineral consisting of microscopic particles of silica (quartz). Occurs in layers and as isolated masses. Flint and novaculite are varieties of chert.
Coal—a combustible black sedimentary rock consisting mostly of partly decomposed and carbonized plant matter.
Conglomerate—a sedimentary rock consisting largely of rounded gravel or pebbles cemented together in a finer matrix.
Cuesta—a ridge with a long, gentle slope capped by a hard layer of rock and terminated by a steep slope.

Dimension stone—any stone suitable for cutting and shaping into blocks and slabs for building or ornamental purposes.
Dolomite—a sedimentary rock consisting mostly of the mineral dolomite, $CaMg(CO_3)_2$, formed from dolomite muds and fossil fragments or, more commonly, by alteration of limestone.

Era—a large division of geologic time consisting of two or more geologic periods.
Erosion—the natural processes of weathering, disintegration, dissolving, and removal of rock and earth material, mainly by water and wind.

Fossil—remains or traces of a prehistoric animal or plant.

Gabbro—a dark-colored, coarse-grained igneous rock formed from magma that cooled beneath the earth's surface. Oklahoma gabbros are dark gray or black.
Geology—the study of the earth, including its structure, history, landforms, and resources.
Geomorphic province—a large region of similar landforms resulting from erosion of rocks and/or deposition of sediments that are somewhat uniform in nature and structure.
Glass sand—high-purity quartz sand suitable as a raw material in manufacturing glass.
Granite—a light-colored, coarse-grained igneous rock formed from magma that cooled beneath the earth's surface. Oklahoma granites are mostly light gray, pink, red, and brown.
Gypsum—a sedimentary rock consisting of the mineral gypsum, $CaSO_4 \cdot 2H_2O$, formed by chemical precipitation from evaporating sea water.

Hogback—a sharp ridge formed by layers of hard rock that dip steeply downward.

Igneous rock—rock formed by cooling and solidification of hot molten material called magma. Magma that flows onto the surface of the earth (lava) cools rapidly to form fine-grained rocks, whereas magma that solidifies several miles beneath the surface cools slowly to form coarse-grained rocks.

Lignite—a brownish-black, low-grade coal.
Limestone—a sedimentary rock consisting mostly of the mineral calcite, $CaCO_3$, formed mainly from lime muds and fossil fragments.

Magma—molten rock material generated within the earth.
Marine—refers to sediments deposited in sea water.
Metamorphic rock—rock that has been changed through intense heat, high pressures, or contact with chemically active fluids from magma.

Nonmarine—refers to sediments deposited on land or in lakes, streams, swamps, or deltas.

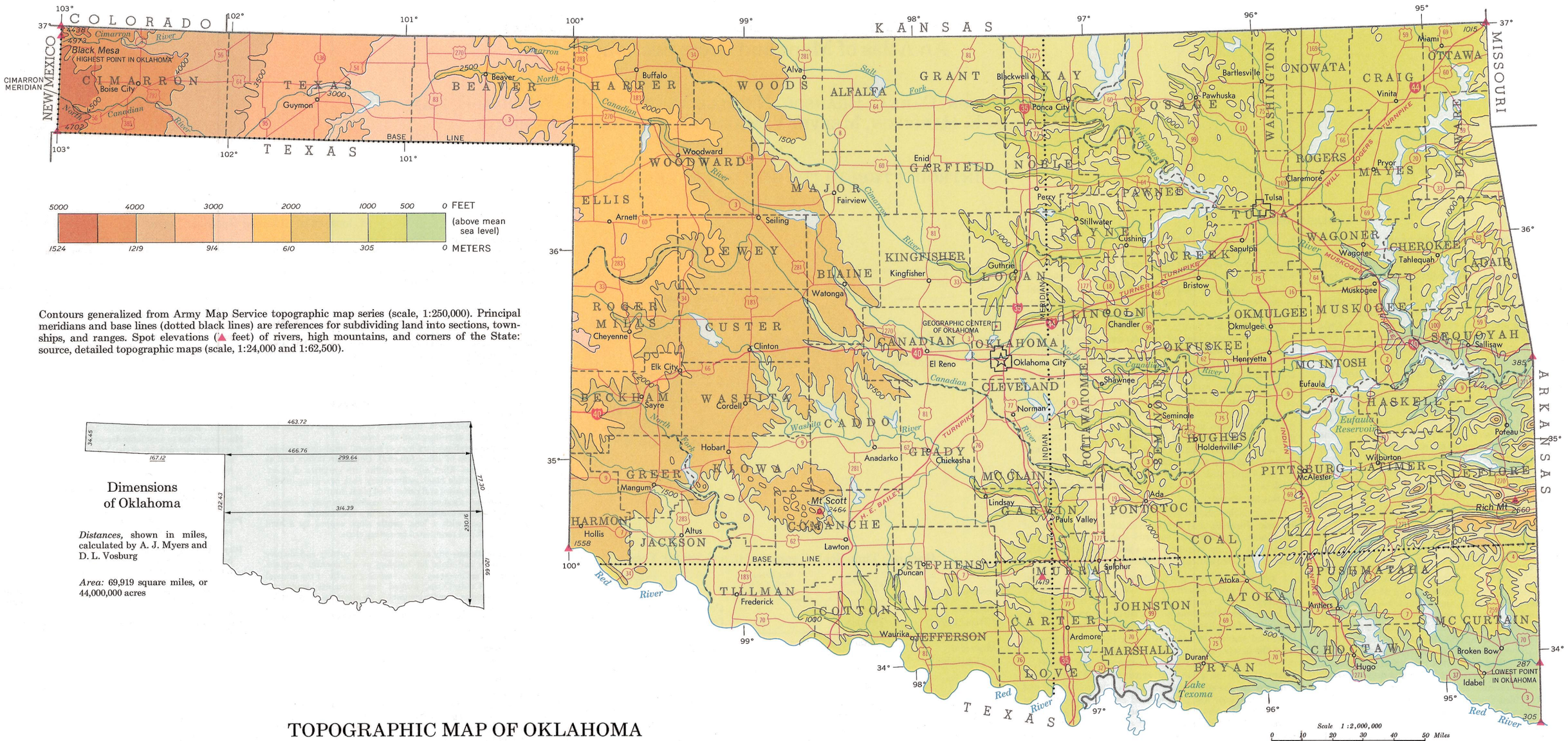
Period—one of the fundamental units of geologic time into which earth history is divided. A period is a subdivision of an era.

Rhyolite—a light-colored, fine-grained igneous rock(lava) formed from magma that flowed onto the surface of the earth. Oklahoma rhyolites are pink, red, or brown.

Salt—a sedimentary rock consisting of the mineral halite, NaCl, formed by chemical precipitation from evaporating sea water.
Sandstone—a sedimentary rock consisting of sand grains (mostly quartz) cemented together.
Sedimentary rock—rock formed by the compaction and cementing of sediments deposited in water or from air. Sediments may consist of rock or mineral fragments of various sizes (mud, sand, gravel), the remains of animals or plants, the products of chemical action or evaporation, or mixtures of these materials. Sedimentary rocks typically have a layered structure known as bedding or stratification.
Shale—a sedimentary rock formed from muds and clays.

Terrace deposit—an old alluvial deposit near to, but above, the present-day flood plain of a river.
Tripoli—a lightweight form of silica rock used for its abrasive and absorbent properties.

Volcanic ash—accumulations of glasslike dust ejected from volcanoes. The sources of Oklahoma volcanic ash were once-active volcanoes in New Mexico.



Contours generalized from Army Map Service topographic map series (scale, 1:250,000). Principal meridians and base lines (dotted black lines) are references for subdividing land into sections, townships, and ranges. Spot elevations (▲ feet) of rivers, high mountains, and corners of the State: source, detailed topographic maps (scale, 1:24,000 and 1:62,500).

Dimensions of Oklahoma

Distances, shown in miles, calculated by A. J. Myers and D. L. Vosburg

Area: 69,919 square miles, or 44,000,000 acres

TOPOGRAPHIC MAP OF OKLAHOMA

Compiled by
KENNETH S. JOHNSON

(Updated 1979)

Arbuckle Mountain Province

Arbuckle Hills—Low to moderate hills chiefly of Cambrian to Mississippian limestones. Steeply dipping strata are complexly folded and faulted.

Arbuckle Plains—Gently rolling hills and plains developed on granites of Precambrian age and gently dipping limestones chiefly of Ordovician age.

Ouachita Mountain Province

Beavers Bend Hills—Moderate to high hills and ridges formed by tightly folded Ordovician through Mississippian sedimentary rocks.

Ridge and Valley Belt—Long and sinuous mountain ridges of broadly folded Mississippian and Pennsylvanian sandstones towering above subparallel shale valleys.

Hogback Frontal Belt—Thrust blocks of steeply dipping Pennsylvanian sandstones and limestones in hogback ridges rising 500 to 1,700 feet above adjacent valleys.

Wichita Mountain Province

Granite Mountain Region—Peaks of Cambrian granite and related igneous rocks towering 500 to 1,200 feet above surrounding redbed plains.

Limestone Hills—Low to moderate hills of steeply dipping Ordovician limestones rising above redbed plains.

Other Provinces

Ardmore Basin—Lowland of folded Mississippian and Pennsylvanian shales and sandstones between Arbuckles and Dissected Coastal Plain.

Arkansas Hill and Valley Belt—Broad, gently rolling plains and valleys with scattered hills 100 to 300 feet high capped by Pennsylvanian sandstones.

Black Mesa—Flat-topped erosional remnant of Tertiary basaltic lava flow extruded from volcano in Colorado. Highest point in State

Boston Mountains—Deeply dissected plateau capped by gently dipping Pennsylvanian sandstones.

Central Redbed Plains—Red Permian shales and sandstones forming gently rolling hills and broad, flat plains.

Cimarron Gypsum Hills—Escarpments and badlands developed on Permian sequence of interbedded gypsum and shale.

Claremore Cuesta Plains—Resistant Pennsylvanian sandstones and limestones dipping gently westward, forming cuestas between broad shale plains.

Dissected Coastal Plain—Soft, south-dipping Cretaceous sands, gravels, and clays of Gulf Coastal Plain, slightly dissected by streams.

Eastern Sandstone Cuesta Plains—West-dipping Pennsylvanian sandstones forming cuestas that overlook broad shale plains.

High Plains—Featureless flat upland surface on Tertiary and Pleistocene alluvial sands. Deeply dissected along rivers and major streams.

Mangum Gypsum Hills—Gently rolling hills to steep bluffs and badlands developed on Permian sequence of interbedded gypsum and shale.

McAlester Marginal Hills Belt—Resistant Pennsylvanian sandstones capping broad hills and mountains that rise 300 to 2,000 feet above wide, hilly plains.

Neosho Lowland—Gently rolling shale lowlands with a few low escarpments and buttes capped by Pennsylvanian sandstones and Mississippian limestones.

Northern Limestone Cuesta Plains—Thin Permian limestones capping west-dipping cuestas that rise above broad shale plains.

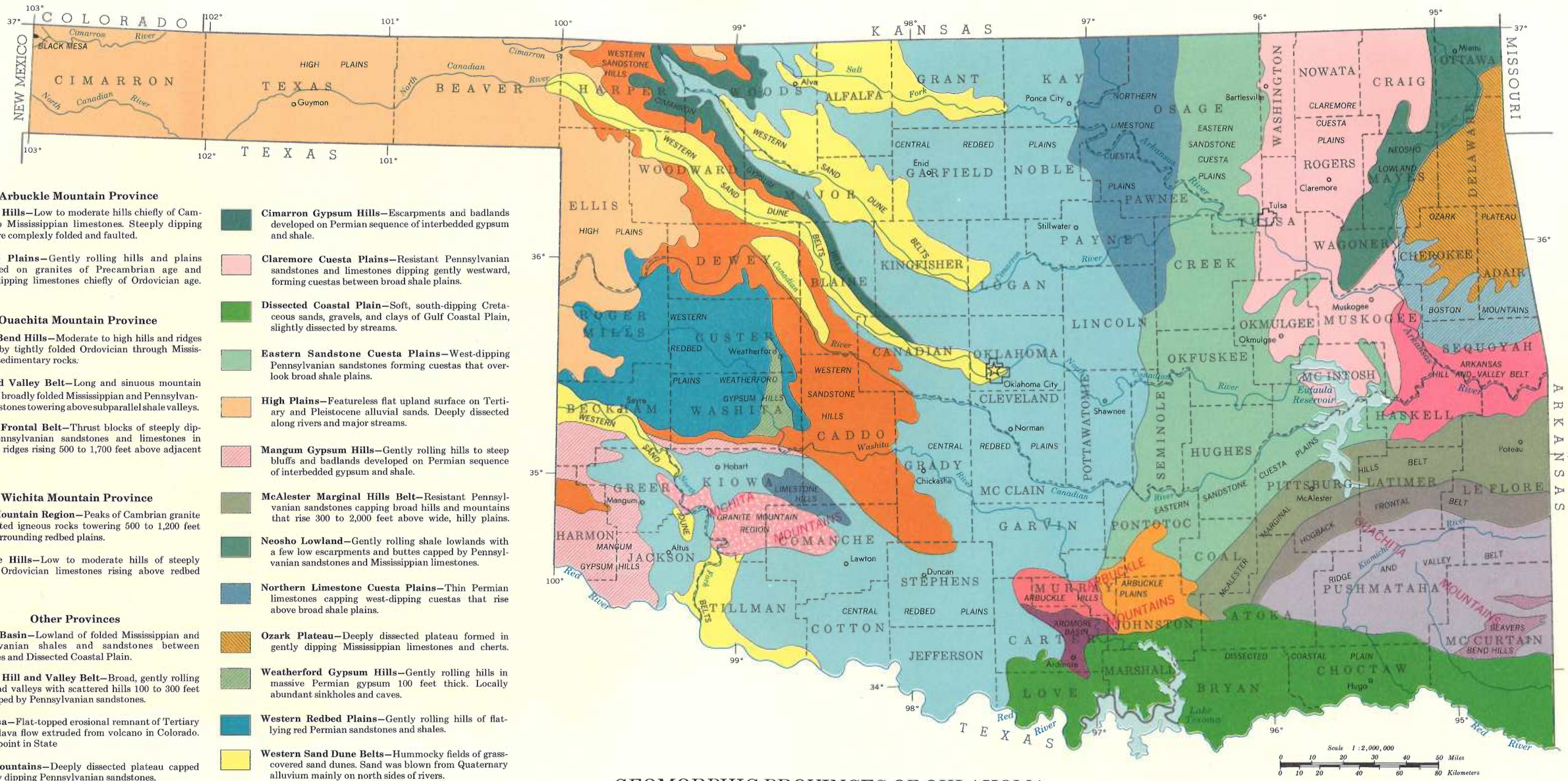
Ozark Plateau—Deeply dissected plateau formed in gently dipping Mississippian limestones and cherts.

Weatherford Gypsum Hills—Gently rolling hills in massive Permian gypsum 100 feet thick. Locally abundant sinkholes and caves.

Western Redbed Plains—Gently rolling hills of flat-lying red Permian sandstones and shales.

Western Sand Dune Belts—Hummocky fields of grass-covered sand dunes. Sand was blown from Quaternary alluvium mainly on north sides of rivers.

Western Sandstone Hills—Soft, flat-lying red Permian sandstones forming gently rolling hills cut by steep-walled canyons.

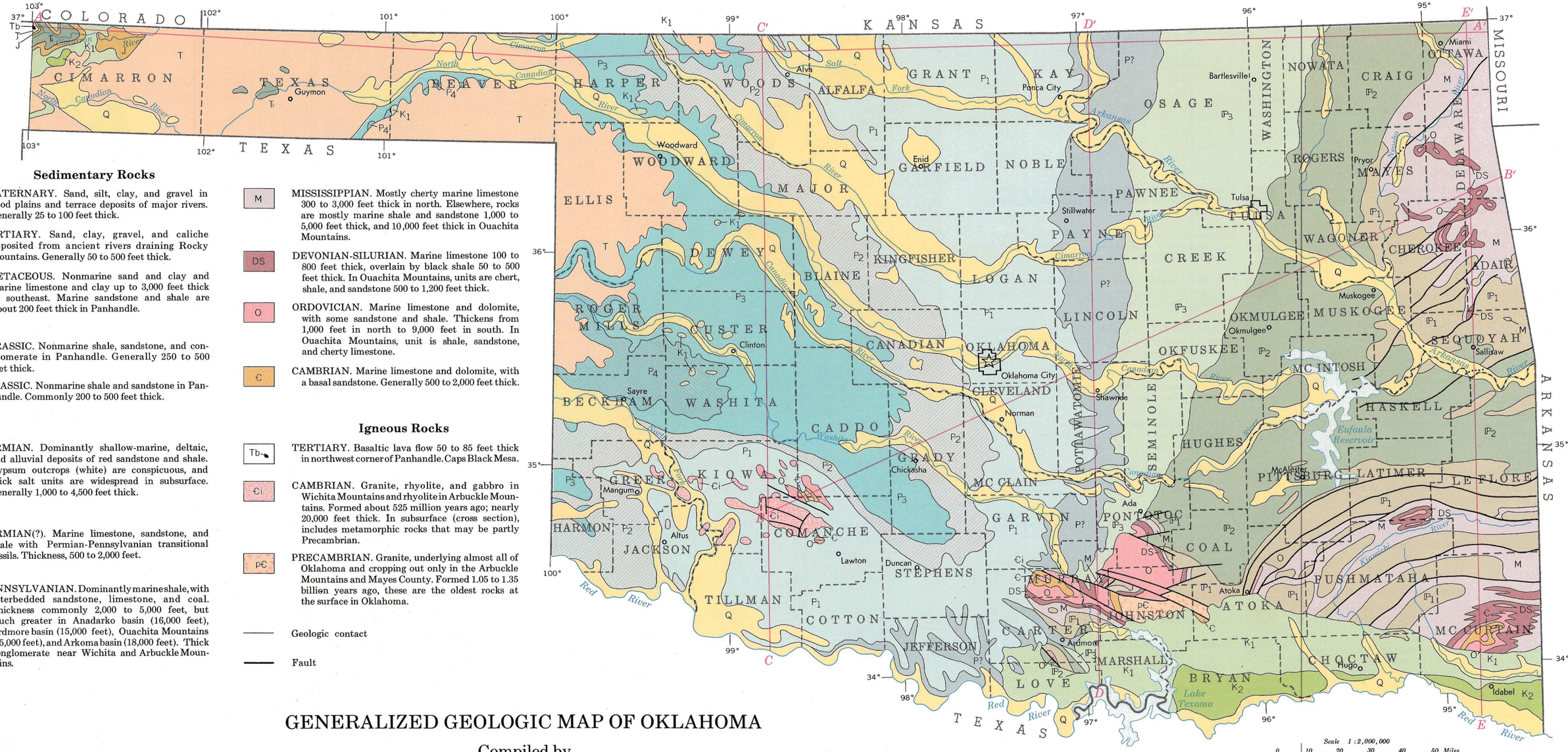


GEOMORPHIC PROVINCES OF OKLAHOMA

By

NEVILLE M. CURTIS, JR., AND WILLIAM E. HAM

Cartographer: David M. Deering



Sedimentary Rocks

Q — QUATERNARY. Sand, silt, clay, and gravel in flood plains and terrace deposits of major rivers. Generally 25 to 100 feet thick.

T — TERTIARY. Sand, clay, gravel, and caliche deposited from ancient rivers draining Rocky Mountains. Generally 50 to 500 feet thick.

K_2 — CRETACEOUS. Nonmarine sand and clay and marine limestone and clay up to 3,000 feet thick in southeast. Marine sandstone and shale are about 200 feet thick in Panhandle.

K_1

J — JURASSIC. Nonmarine shale, sandstone, and conglomerate in Panhandle. Generally 250 to 500 feet thick.

T_R — TRIASSIC. Nonmarine shale and sandstone in Panhandle. Commonly 200 to 500 feet thick.

P_4, **P_3** — PERMIAN. Dominantly shallow-marine, deltaic, and alluvial deposits of red sandstone and shale. Gypsum outcrops (white) are conspicuous, and thick salt units are widespread in subsurface. Generally 1,000 to 4,500 feet thick.

P_2, **P_1**

P? — PERMIAN(?). Marine limestone, sandstone, and shale with Permian-Pennsylvanian transitional fossils. Thickness, 500 to 2,000 feet.

IP_3 — PENNSYLVANIAN. Dominantly marine shale, with interbedded sandstone, limestone, and coal. Thickness commonly 2,000 to 5,000 feet, but much greater in Anadarko basin (16,000 feet), Ardmore basin (15,000 feet), Ouachita Mountains (15,000 feet), and Arkoma basin (18,000 feet). Thick conglomerate near Wichita and Arbuckle Mountains.

IP_2

IP_1

M — MISSISSIPPIAN. Mostly cherty marine limestone 300 to 3,000 feet thick in north. Elsewhere, rocks are mostly marine shale and sandstone 1,000 to 5,000 feet thick, and 10,000 feet thick in Ouachita Mountains.

DS — DEVONIAN-SILURIAN. Marine limestone 100 to 800 feet thick, overlain by black shale 50 to 500 feet thick. In Ouachita Mountains, units are chert, shale, and sandstone 500 to 1,200 feet thick.

O — ORDOVICIAN. Marine limestone and dolomite, with some sandstone and shale. Thickens from 1,000 feet in north to 9,000 feet in south. In Ouachita Mountains, unit is shale, sandstone, and cherty limestone.

ϵ — CAMBRIAN. Marine limestone and dolomite, with a basal sandstone. Generally 500 to 2,000 feet thick.

Igneous Rocks

Tb — TERTIARY. Basaltic lava flow 50 to 85 feet thick in northwest corner of Panhandle. Caps Black Mesa.

ϵi — CAMBRIAN. Granite, rhyolite, and gabbro in Wichita Mountains and rhyolite in Arbuckle Mountains. Formed about 525 million years ago; nearly 20,000 feet thick. In subsurface (cross section), includes metamorphic rocks that may be partly Precambrian.

pϵ — PRECAMBRIAN. Granite, underlying almost all of Oklahoma and cropping out only in the Arbuckle Mountains and Mayes County. Formed 1.05 to 1.35 billion years ago, these are the oldest rocks at the surface in Oklahoma.

Geologic contact

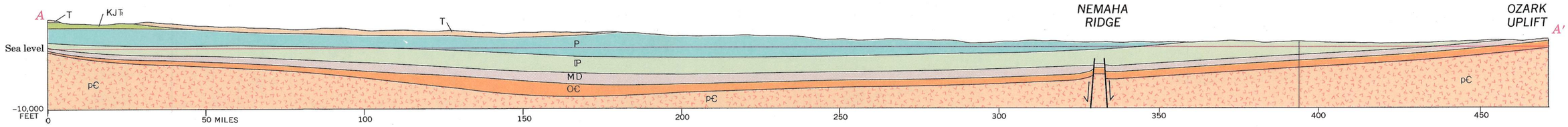
Fault

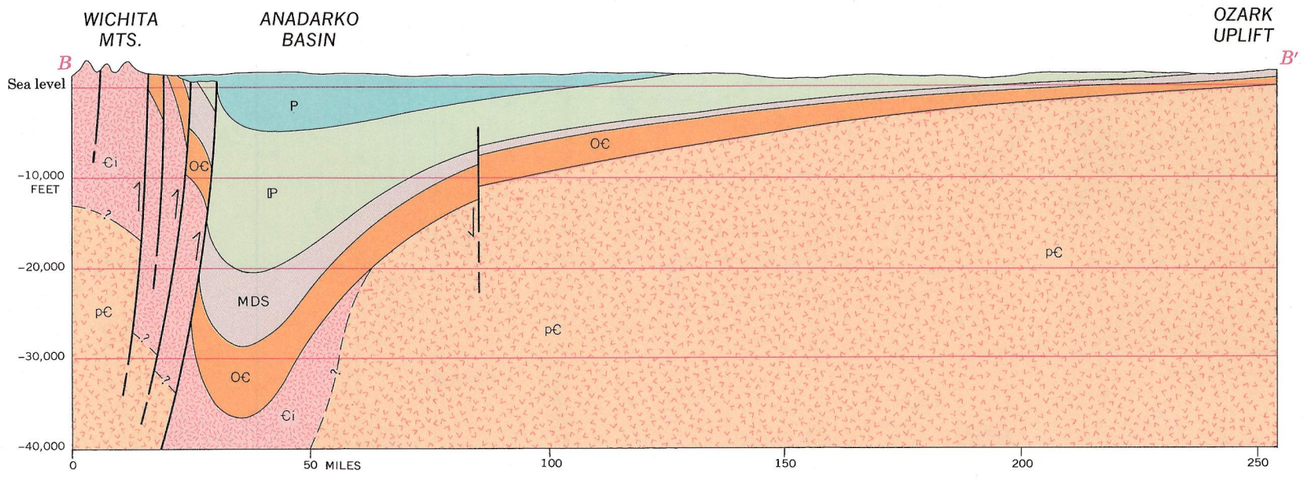
GENERALIZED GEOLOGIC MAP OF OKLAHOMA

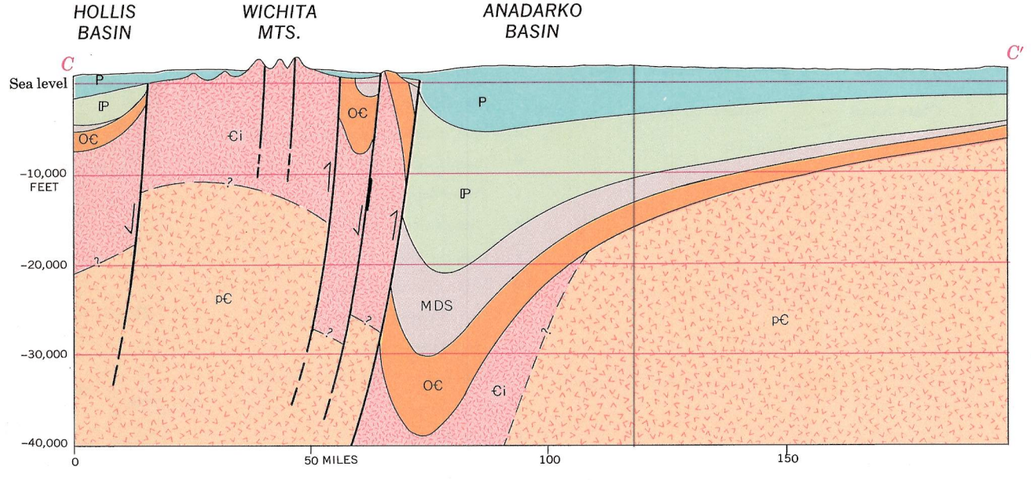
Compiled by

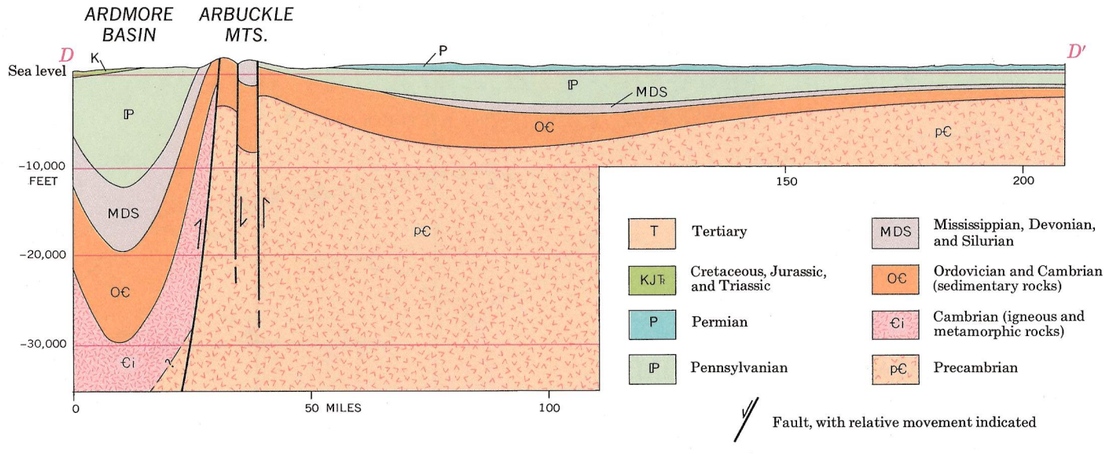
CARL C. BRANSON AND KENNETH S. JOHNSON

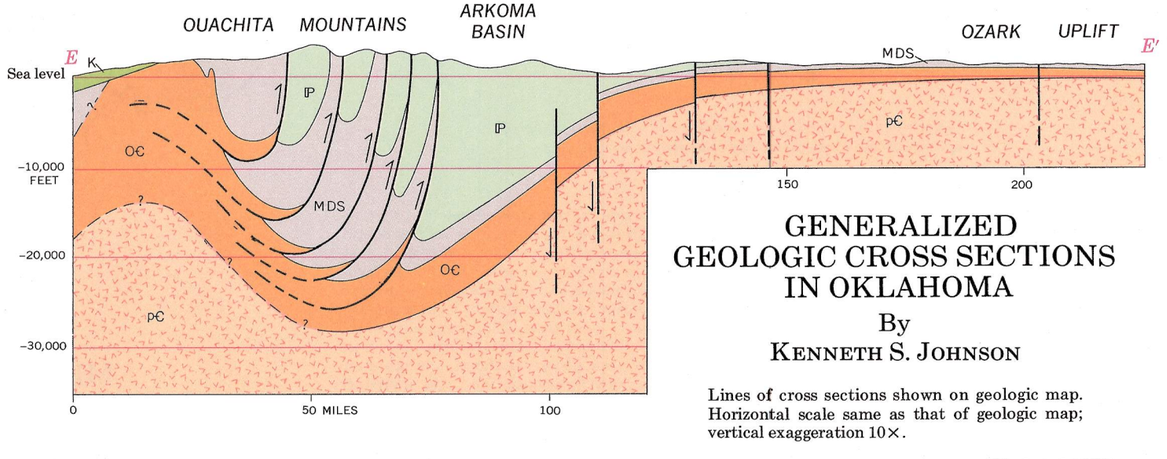
(Updated 1979)











T	Tertiary	MDS	Mississippian, Devonian, and Silurian
KJT	Cretaceous, Jurassic, and Triassic	O€	Ordovician and Cambrian (sedimentary rocks)
P	Permian	€i	Cambrian (igneous and metamorphic rocks)
IP	Pennsylvanian	p€	Precambrian

Fault, with relative movement indicated

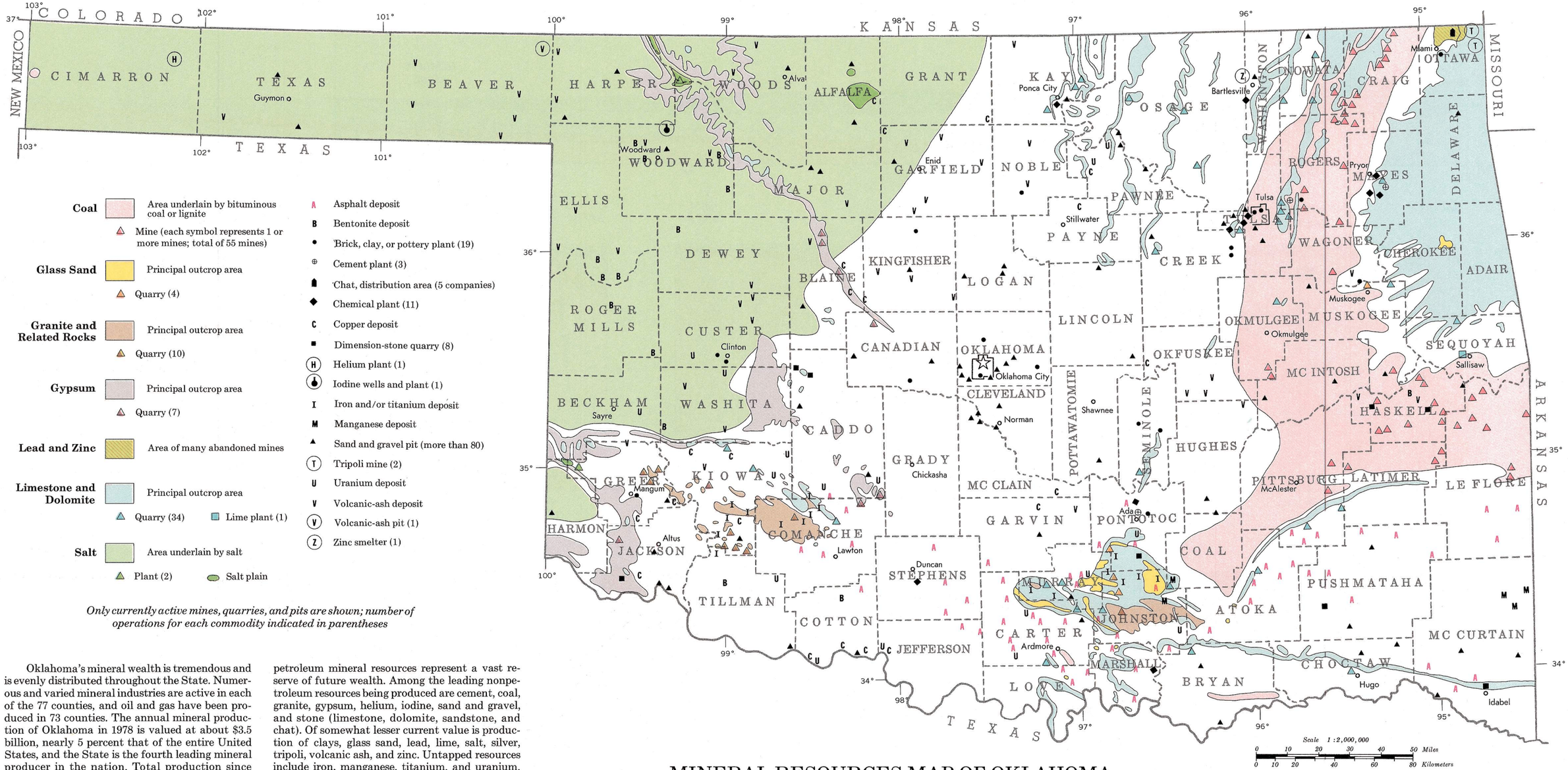
GENERALIZED GEOLOGIC CROSS SECTIONS IN OKLAHOMA

By

KENNETH S. JOHNSON

Lines of cross sections shown on geologic map. Horizontal scale same as that of geologic map; vertical exaggeration 10×.

(Updated 1979)



Coal — Area underlain by bituminous coal or lignite

Mine (each symbol represents 1 or more mines; total of 55 mines)

Glass Sand — Principal outcrop area

Quarry (4)

Granite and Related Rocks — Principal outcrop area

Quarry (10)

Gypsum — Principal outcrop area

Quarry (7)

Lead and Zinc — Area of many abandoned mines

Limestone and Dolomite — Principal outcrop area

Quarry (34) Lime plant (1)

Salt — Area underlain by salt

Plant (2) Salt plain

A Asphalt deposit

B Bentonite deposit

Brick, clay, or pottery plant (19)

⊕ Cement plant (3)

Chat, distribution area (5 companies)

◆ Chemical plant (11)

C Copper deposit

Dimension-stone quarry (8)

(H) Helium plant (1)

Iodine wells and plant (1)

I Iron and/or titanium deposit

M Manganese deposit

Sand and gravel pit (more than 80)

(T) Tripoli mine (2)

U Uranium deposit

V Volcanic-ash deposit

(V) Volcanic-ash pit (1)

(Z) Zinc smelter (1)

Only currently active mines, quarries, and pits are shown; number of operations for each commodity indicated in parentheses

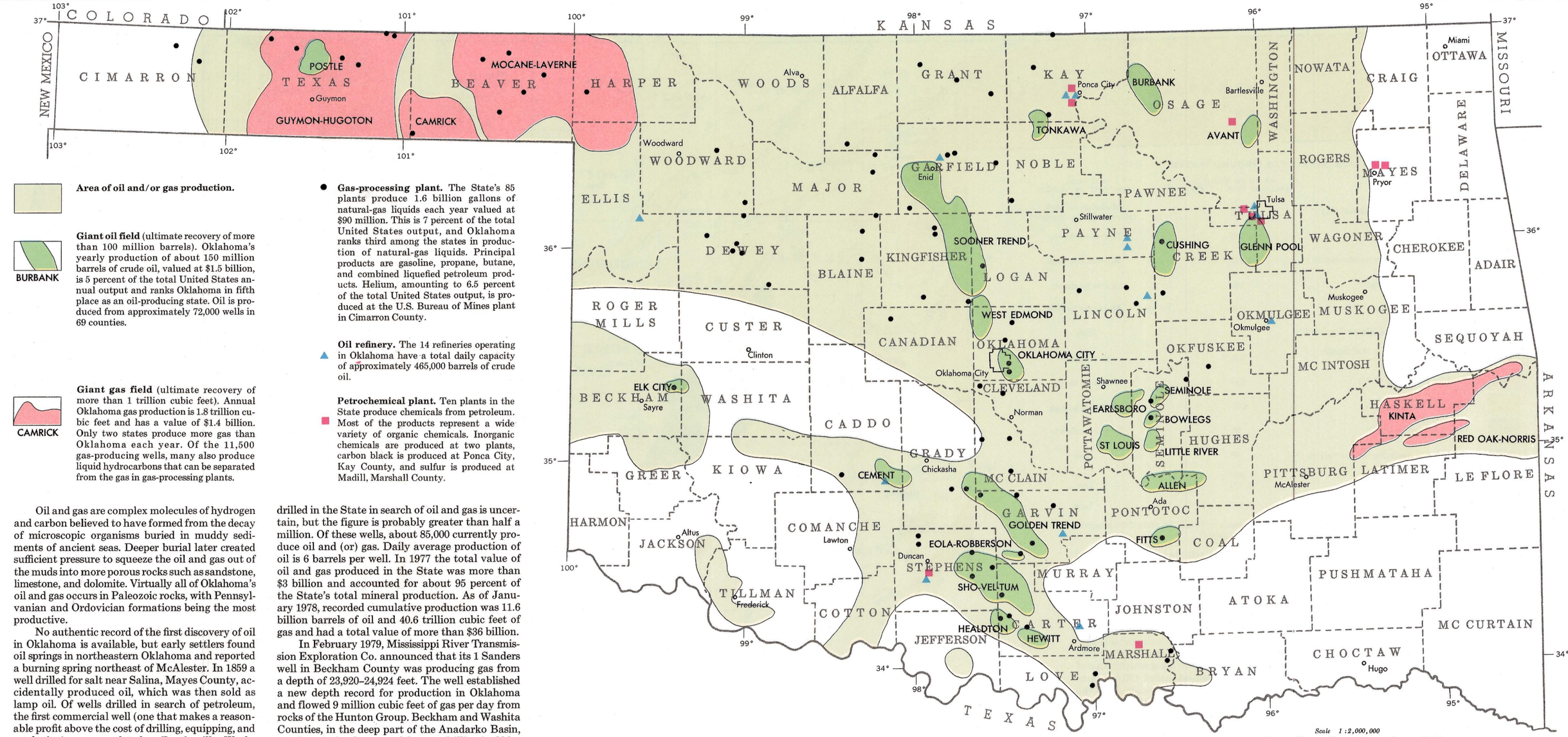
Oklahoma's mineral wealth is tremendous and is evenly distributed throughout the State. Numerous and varied mineral industries are active in each of the 77 counties, and oil and gas have been produced in 73 counties. The annual mineral production of Oklahoma in 1978 is valued at about $3.5 billion, nearly 5 percent that of the entire United States, and the State is the fourth leading mineral producer in the nation. Total production since statehood (1907) is valued in excess of $47 billion. Oklahoma is well known as an oil state, and petroleum (including crude oil, natural gas, and natural-gas liquids) accounts for about 94 percent of the State's yearly mineral output. However, nonpetroleum mineral resources represent a vast reserve of future wealth. Among the leading nonpetroleum resources being produced are cement, coal, granite, gypsum, helium, iodine, sand and gravel, and stone (limestone, dolomite, sandstone, and chat). Of somewhat lesser current value is production of clays, glass sand, lead, lime, salt, silver, tripoli, volcanic ash, and zinc. Untapped resources include iron, manganese, titanium, and uranium. Oklahoma ranks first among the states in production of iodine, second in helium and tripoli, third in liquefied petroleum gas and natural gas, and fifth in crude oil and gypsum.

MINERAL RESOURCES MAP OF OKLAHOMA

EXCLUSIVE OF OIL AND GAS FIELDS

Compiled by
KENNETH S. JOHNSON

(Updated 1979)



Area of oil and/or gas production.

Giant oil field (ultimate recovery of more than 100 million barrels). Oklahoma's yearly production of about 150 million barrels of crude oil, valued at $1.5 billion, is 5 percent of the total United States annual output and ranks Oklahoma in fifth place as an oil-producing state. Oil is produced from approximately 72,000 wells in 69 counties.

BURBANK

Giant gas field (ultimate recovery of more than 1 trillion cubic feet). Annual Oklahoma gas production is 1.8 trillion cubic feet and has a value of $1.4 billion. Only two states produce more gas than Oklahoma each year. Of the 11,500 gas-producing wells, many also produce liquid hydrocarbons that can be separated from the gas in gas-processing plants.

CAMRICK

Gas-processing plant. The State's 85 plants produce 1.6 billion gallons of natural-gas liquids each year valued at $90 million. This is 7 percent of the total United States output, and Oklahoma ranks third among the states in production of natural-gas liquids. Principal products are gasoline, propane, butane, and combined liquefied petroleum products. Helium, amounting to 6.5 percent of the total United States output, is produced at the U.S. Bureau of Mines plant in Cimarron County.

Oil refinery. The 14 refineries operating in Oklahoma have a total daily capacity of approximately 465,000 barrels of crude oil.

Petrochemical plant. Ten plants in the State produce chemicals from petroleum. Most of the products represent a wide variety of organic chemicals. Inorganic chemicals are produced at two plants, carbon black is produced at Ponca City, Kay County, and sulfur is produced at Madill, Marshall County.

Oil and gas are complex molecules of hydrogen and carbon believed to have formed from the decay of microscopic organisms buried in muddy sediments of ancient seas. Deeper burial later created sufficient pressure to squeeze the oil and gas out of the muds into more porous rocks such as sandstone, limestone, and dolomite. Virtually all of Oklahoma's oil and gas occurs in Paleozoic rocks, with Pennsylvanian and Ordovician formations being the most productive.

No authentic record of the first discovery of oil in Oklahoma is available, but early settlers found oil springs in northeastern Oklahoma and reported a burning spring northeast of McAlester. In 1859 a well drilled for salt near Salina, Mayes County, accidentally produced oil, which was then sold as lamp oil. Of wells drilled in search of petroleum, the first commercial well (one that makes a reasonable profit above the cost of drilling, equipping, and producing) was completed at Bartlesville, Washington County, in about 1896. The earliest recorded production of oil in Oklahoma was 30 barrels in the year 1901.

Detailed data are available on oil and gas exploration in Oklahoma since 1933, but unfortunately records on the number of wells drilled during the boom years prior to that time are incomplete. Therefore, the total number of wells drilled in the State in search of oil and gas is uncertain, but the figure is probably greater than half a million. Of these wells, about 85,000 currently produce oil and (or) gas. Daily average production of oil is 6 barrels per well. In 1977 the total value of oil and gas produced in the State was more than $3 billion and accounted for about 95 percent of the State's total mineral production. As of January 1978, recorded cumulative production was 11.6 billion barrels of oil and 40.6 trillion cubic feet of gas and had a total value of more than $36 billion.

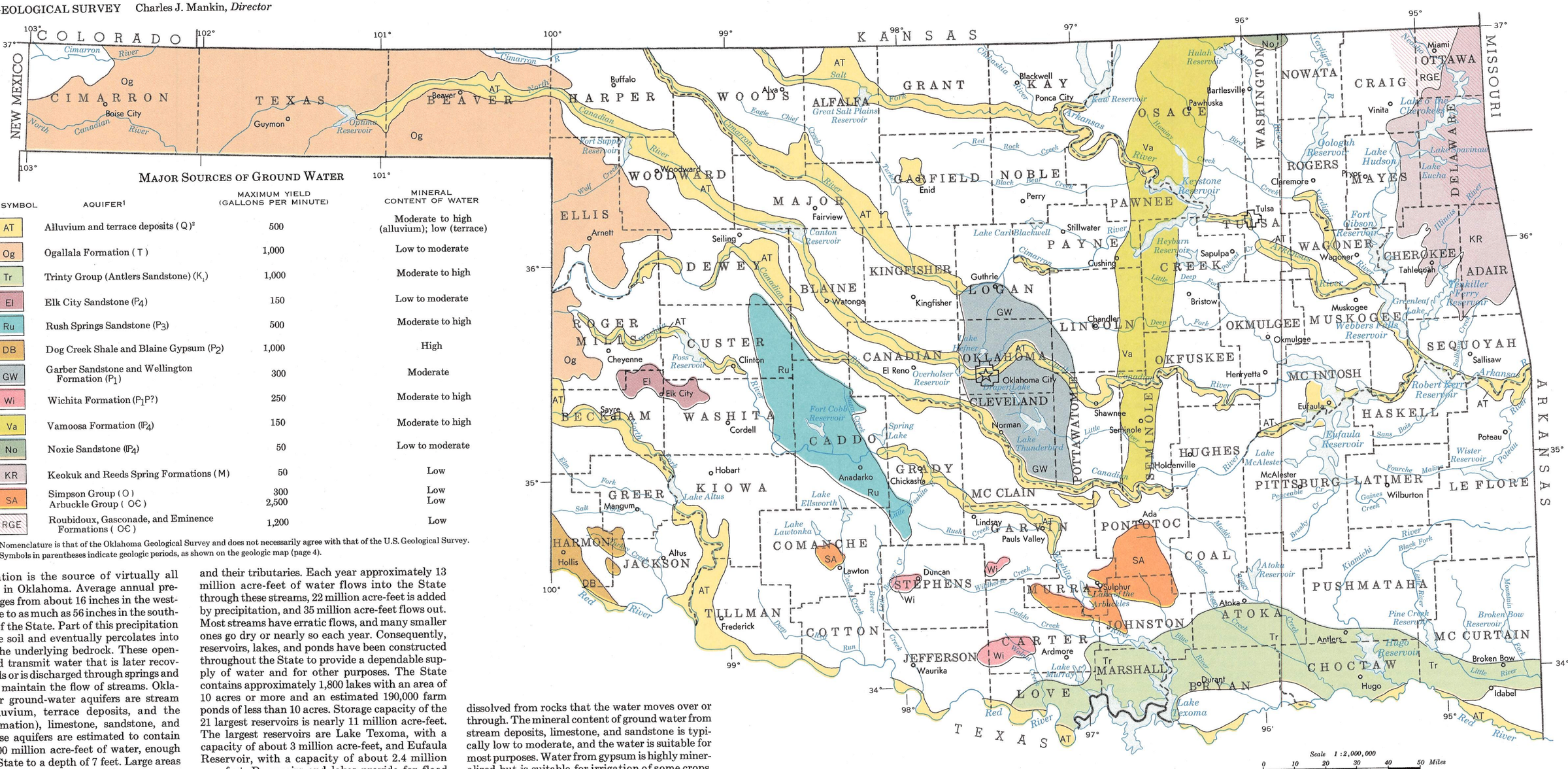
In February 1979, Mississippi River Transmission Exploration Co. announced that its 1 Sanders well in Beckham County was producing gas from a depth of 23,920–24,924 feet. The well established a new depth record for production in Oklahoma and flowed 9 million cubic feet of gas per day from rocks of the Hunton Group. Beckham and Washita Counties, in the deep part of the Anadarko Basin, continue to be the area of deepest drilling in Oklahoma, and other wells will probably be productive at depths greater than the current State record of 24,924 feet. Beckham County is also the location of the world's deepest borehole. In 1974 the Lone Star 1 Rogers was drilled to a total depth of 31,441 feet and thus claimed the depth record from a Washita County well, the Lone Star 1 Baden, which had been drilled to a total depth of 30,050 feet in 1972.

GENERALIZED OIL AND GAS MAP OF OKLAHOMA

Compiled by

JOHN F. ROBERTS AND WILLIAM E. HARRISON

(Updated 1979)



Major Sources of Ground Water

Map Symbol	Aquifer[1]	Maximum Yield (Gallons per Minute)	Mineral Content of Water
AT	Alluvium and terrace deposits (Q)[2]	500	Moderate to high (alluvium); low (terrace)
Og	Ogallala Formation (T)	1,000	Low to moderate
Tr	Trinty Group (Antlers Sandstone) (K_1)	1,000	Moderate to high
El	Elk City Sandstone (P_4)	150	Low to moderate
Ru	Rush Springs Sandstone (P_3)	500	Moderate to high
DB	Dog Creek Shale and Blaine Gypsum (P_2)	1,000	High
GW	Garber Sandstone and Wellington Formation (P_1)	300	Moderate
Wi	Wichita Formation ($P_1P?$)	250	Moderate to high
Va	Vamoosa Formation ($\mathbb{P}_4$)	150	Moderate to high
No	Noxie Sandstone ($\mathbb{P}_4$)	50	Low to moderate
KR	Keokuk and Reeds Spring Formations (M)	50	Low
SA	Simpson Group (O)	300	Low
	Arbuckle Group (OC)	2,500	Low
RGE	Roubidoux, Gasconade, and Eminence Formations (OC)	1,200	Low

[1]Nomenclature is that of the Oklahoma Geological Survey and does not necessarily agree with that of the U.S. Geological Survey.
[2]Symbols in parentheses indicate geologic periods, as shown on the geologic map (page 4).

Precipitation is the source of virtually all ground water in Oklahoma. Average annual precipitation ranges from about 16 inches in the western Panhandle to as much as 56 inches in the southeastern part of the State. Part of this precipitation soaks into the soil and eventually percolates into openings in the underlying bedrock. These openings store and transmit water that is later recovered from wells or is discharged through springs and seeps to help maintain the flow of streams. Oklahoma's major ground-water aquifers are stream deposits (alluvium, terrace deposits, and the Ogallala Formation), limestone, sandstone, and gypsum. These aquifers are estimated to contain more than 300 million acre-feet of water, enough to cover the State to a depth of 7 feet. Large areas of the State, shown uncolored on the map, are underlain mainly by shale that yields only enough water for household use. Ground water provides about 80 percent of the water used for irrigation.

Part of the precipitation falling on the land surface runs off to form streams and rivers. Runoff ranges from about 0.2 inch per year in the Panhandle to nearly 20 inches in the southeast. The entire State is drained by the Arkansas and Red Rivers and their tributaries. Each year approximately 13 million acre-feet of water flows into the State through these streams, 22 million acre-feet is added by precipitation, and 35 million acre-feet flows out. Most streams have erratic flows, and many smaller ones go dry or nearly so each year. Consequently, reservoirs, lakes, and ponds have been constructed throughout the State to provide a dependable supply of water and for other purposes. The State contains approximately 1,800 lakes with an area of 10 acres or more and an estimated 190,000 farm ponds of less than 10 acres. Storage capacity of the 21 largest reservoirs is nearly 11 million acre-feet. The largest reservoirs are Lake Texoma, with a capacity of about 3 million acre-feet, and Eufaula Reservoir, with a capacity of about 2.4 million acre-feet. Reservoirs and lakes provide for flood control, generation of electricity, recreation, and water supply. About 80 percent of all water used by cities and industries is taken from surface-water sources. Completion of a series of locks and dams on the Arkansas and Verdigris Rivers provide for barge navigation from the Mississippi River to the Tulsa area.

All natural waters contain various minerals dissolved from rocks that the water moves over or through. The mineral content of ground water from stream deposits, limestone, and sandstone is typically low to moderate, and the water is suitable for most purposes. Water from gypsum is highly mineralized but is suitable for irrigation of some crops. Water in streams in western Oklahoma is generally highly mineralized and in many places is unfit for most uses. The mineral content of water in streams draining the eastern part of the State is generally low. Highly mineralized water, unfit for nearly any use, is present beneath fresh water in all parts of the State at depths ranging from less than 100 feet locally to as much as 3,000 feet in the Arbuckle Mountains.

MAJOR SOURCES OF WATER IN OKLAHOMA

Compiled by

MELVIN V. MARCHER
(U.S. Geological Survey)

(Updated 1979)