Generalized Geologic Time Scale



The story told by rocks

by James R. Chaplin

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Мул	Eon	ERA	PERIOD	Еросн	LIFE AND FOSSIL FORMS		SOME GEOLOGICAL AND BIOLOGICAL EVENTS	
×				HOLOCENE	Paleoindian	Geological Events The Holocene Epoch, also called Recent or postglacial time, began as the Great Ice Age ended. It is the current epoch.	One or more earthquakes in the Lawton area produced the Meers Fault, which is visible as a 3-meter-high escarpment. It is the only	"fault scarp" known to have formed in the Midcontinent area (Oklahoma and surrounding states) within the past 1,200–1,500 years.
0.01-		OZOIC (recent life)	QUATERNARY	PLEISTOCENE	Saber-toothed cat Columbian mammoth White pelican Camelops Oak	 Geological Events This was the epoch of the Great Ice Age. Ice sheets never extended into Oklahoma, although some advanced into northeastern Kansas, about 130 miles north of the border. The climate was cooler and wetter than it is today. The storage in glaciers of ocean water lowered sea level and led to significant erosion worldwide. Winds carried dust from glacial outwash plains (broad sheets of sediment left by glacial meltwater) and deposited it over parts of northern Oklahoma in thicknesses of 1–5 feet. Today, these deposits of windblown dust (loess) make good soil for crops. Rivers fed by meltwater from glaciers in the Rocky Mountains initiated the State's major drainage systems. The early positions of these rivers are marked by Pleistocene (and Holocene) alluvial deposits left as terraces above present-day flood plains. Groundwater in Quaternary alluvium and terrace deposits associated with the Cimarron River in northwestern Oklahoma is used extensively for irrigation and for municipal, stock, and domestic supplies. It is the major source of water for the city of Enid, the 	largest single user of groundwater in Oklahoma. In the Panhandle, the dissolution of subsurface Permian salt is believed to be one of the important causes for the formation of local subsidence basins filled with wind-blown deposits. Volcanic ash, blown into the air from volcanic eruptions in some parts of the Rocky Mountains during the Pleistocene and deposited in Oklahoma, is used for radiometric dating of deposits and events. Ash also is mined as an industrial mineral. Alabaster Caverns, Woodward County, began to develop. Plant Life A mixture of prairie grasslands and pine and oak woodlands covered western and central Oklahoma. Northeastern and southeastern Oklahoma were densely forested. Animal Life There is evidence from northeastern Oklahoma near Afton, Delaware County, that extinct forms of beaver, camel, horse, woodland	 musk-ox, stag moose, and ancient elephants (mammoths and mastodons) inhabited Oklahoma about 12,000–14,000 years ago. Pleistocene fossils of mammoths and mastodons have been found throughout Oklahoma. The Columbian mammoth (<i>Mammuthus columbi</i>) was the most common; one of the earliest documented Oklahoma discoveries was in Jackson County in the 1930s. One of the few fossil sites in North America that demonstrates that the mammoth and the early mastodon coexisted is in southwestern Oklahoma near Frederick, Tillman County. Based on skeletal and artifact evidence, Paleoindians (the earliest people in North America) lived in Oklahoma about 11,000–12,000 years ago and killed and butchered Columbian mammoths. Stone tools, as well as mammoth bones and artifacts, have been recovered from the Cooperton site in Kiowa County and the Domebo site in Caddo County. Many large North American mammals became extinct about 11,000 years ago—including mastodons and mammoths, sabertoothed cats, horses, camels, and ground sloths, all of which lived in Oklahoma.
1.6 -		CEN	ERTIARY NEOGENE (subperiod)	PLIOCENE	Glyptodon Gomphotherium	 Geological Events Basaltic lava flowed from fissures and vents in New Mexico and in the Oklahoma Panhandle area during the Pliocene. Today, the flattopped erosional remnants can be seen in Black Mesa State Park. Sand, clay, and gravel that eroded from the Rocky Mountains were deposited by flowing water and wind in western Oklahoma, 	principally as the Ogallala Formation. Today, the Ogallala Formation is a major groundwater aquifer throughout western Oklahoma. *Plant Life* • Fossil leaf impressions from angiosperms (including prairie types) and conifers have been found in western Oklahoma.	 Animal Life Fossils recovered from the Ogallala Formation in Ellis and Roger Mills Counties include horse teeth and mastodon, camel, rhinoceros, fox, and skunk bones.
23- 36.5- 53- 65-			TER PALEOGENE (subperiod)	MIOCENE OLIGOCENE EOCENE PALEOCENE	Ground sloth Teleoceras	 Geological Events The Rocky Mountains formed in the Late Cretaceous—Early Tertiary and caused uplifting in the western United States and Oklahoma. The broad, gentle uplift and southeastward tilt of the land caused the last withdrawal of the seas from Oklahoma. 	 No early Cenozoic deposits are preserved in Oklahoma because of erosion or nondeposition. Animal Life The oldest (6–7 million years old) evidence in Oklahoma for fossil 	elephants (proboscideans) is reported from Ellis and Texas Counties. • About 50 localities in Oklahoma have yielded fossils of proboscideans that inhabited the State from about 7 million years ago to 11,000 years ago.
205-		ZOIC (middle life)	CRETACEOUS	Acrocanthosan	Primitive mammal Arus Enallaster Oxytropidoceras	 Geological Events The Gulf of Mexico began extending farther northward, and the Arctic Ocean began to extend southward into the Western Interior of North America and Oklahoma. Limestones, formed in shallow inland seas covering southern and western Oklahoma, and sands and gravels deposited primarily by rivers entering these seas, are preserved now as outliers (isolated exposed areas surrounded by older rocks). Oklahoma was a land area for at least part of the Cretaceous. In southern and southeastern Oklahoma, younger Cretaceous rocks rest on rocks ranging in age from Precambrian through Permian—intervening rock layers are missing, indicating non- 	deposition or erosion of exposed land areas. In contrast, Cretaceous rocks in northern Texas rest on Triassic and Jurassic rocks in a conformable pattern, due to continuous deposition by sea water. **Plant Life** Algae, tropical ferns, cycads, conifers, and angiosperms (flowering plants) form part of the Dakota Group in western Oklahoma and the Woodbine Formation of the southern part of the State; some of the flora included magnolia, willow, oak, sycamore, and varnish trees. The tropical ferns and cycad fossils suggest that the Cretaceous climate in Oklahoma was relatively warm and humid.	 Animal Life First reported finds of Mesozoic mammals in Oklahoma were shrewlike insect eaters from the Antlers Formation (Early Cretaceous) in southeastern Oklahoma. Meat-eating dinosaurs Acrocanthosaurus and Deinonychus, and their presumed prey Tenontosaurus (a plant eater), also have been found in the Antlers Formation. Cretaceous marine reptiles in southeastern Oklahoma include mosasaurs, plesiosaurs, and ichthyosaurs. Marine invertebrate fossils include ammonoid-type cephalopods (common in the Lake Texoma area), primitive oyster-type pelecypods, and spatangoid-type echinoids ("heart urchins").
			JURASSIC	Stegosaurus	Cycad Apatosaurus	 Geological Events Most of Oklahoma was above sea level during the Jurassic. Continental deposits, as much as 500 ft thick, crop out only in the Panhandle because either they were not deposited elsewhere in the State, or they were deposited and then eroded. In contrast, a seaway covered much of Texas. In northeastern Texas, Early Jurassic marine deposits are several thousand feet thick. Extensive volcanic activity led to the accumulation of uranium in 	the Panhandle in the Morrison Formation, which is Late Jurassic in age (150 million years old). **Plant Life* * Algae and unidentified silicified wood fragments have been reported from the Morrison Formation in the Panhandle . * Ferns, cycads, and conifers were the dominant vegetation in the Jurassic.	 Animal Life Fossils of Jurassic dinosaurs—including the sauropods Apatosaurus, Camarasaurus, and Diplodocus, as well as Stegosaurus and Camptosaurus—have been found in Oklahoma. They have been recovered mainly from the Panhandle in the Morrison Formation. Other fossils include crocodiles, turtles, and fish. A spectacular dinosaur trackway is preserved in the Morrison Formation near Kenton, Cimarron County.
		TRIASSIC		Metopo	osaurus Conifer Rutiodon	 Geological Events Oklahoma was a land area during the Triassic. Continental deposits exposed in the Panhandle of Oklahoma are only about 500 feet thick. However, in northern Texas, Late Triassic continental deposits are about 8,000 feet thick—indicating major subsidence (sink- 	 ing) took place south of Oklahoma. Plant Life While no Triassic plant fossils have been found in Oklahoma, plants undoubtedly were present during this period and probably 	 included conifers, ferns, and cycads. Animal Life Fragments of fossil reptiles and amphibians have been reported from the Dockum Group, a red-bed sequence, in the Panhandle.
290-	PHANEROZOIC		PERMIAN	Cotylorhy	Cordaites Xenacanthus Captorhinus Diplocaulus Dimetrodon	 Geological Events Red beds—sandstones, mudstones, and shales that get their color from oxidized iron minerals—were deposited widely and are broadly exposed today in north-central, central, and western Oklahoma. "Badlands" topography formed in the Glass Mountains in north-central Major County. Gypsum beds, anhydrite, and salt were deposited, largely in western Oklahoma. Today, thick salt deposits occur in the subsurface. The Arbuckle Mountains were eroded and slowly buried beneath their own clastic detritus (older rock debris), preserving a former or older (fossil) landscape containing a fossil cave system. The Garber-Wellington, one of the State's major groundwater aquifers, was deposited as a delta in north-central and central Oklahoma. Sand-barite rosettes (rose rocks) formed in central Oklahoma in the Garber Sandstone. Chert from some Permian limestones was used more than 250 million years later (during the Pleistocene) by Paleoindians to make 	 spear points, knives, axes, and scrapers. Paleozoic rocks, down to and including the Cambrian-age Carlton Rhyolite in south-central Oklahoma, were deeply dissected by streams. Oil and gas is produced today from Permian rocks in southwestern and western Oklahoma. Abundant red beds and salt and gypsum deposits are evidence that the climate was warm and dry, and possibly of a desert type, except along shorelines, where fossil plants indicate warm, humid, and rainy conditions. After the Permian, Oklahoma geology is characterized by shallow burial of sediments and/or subaerial (surface) exposure accompanied by weathering—little tectonic activity has occurred since the end of the Permian, and mountains and basins are leveling. Plant Life Fossils of algae, lycopods, ferns, sphenopsids, pteridosperms, conifers, and Cordaites have been discovered in Oklahoma, 	 mostly in the Oklahoma City area as well as northward toward Kansas. Animal Life In marine strata, fossil fusulinids are useful in dating Permian rocks. Marine invertebrate fossils include primarily bryozoans, brachiopods, pelecypods, gastropods, and crinoids. Vertebrate fossils include diverse fishes, four-footed amphibians, and large, fin-backed, primitive reptiles (such as Dimetrodon). Amphibians were common. Permian reptile fossils and trackways have been reported from Kay and Noble Counties in north-central Oklahoma. The Dolese Brothers limestone quarry at Richards Spur, near Fort Sill, is one of the richest deposits of Permian reptile and amphibian fossils in the world. The fossils—mostly small reptiles called captorhinids—occur in solution cavities in the Ordovician Arbuckle Limestone that are filled with Permian sediments.
			RBONIFEROUS PENNSYLVANIAN (U.S.)	Calami	AGE OF COAL SWAMPS Prouddenites Dragonfly Sigillaria Lepidodendron	 Geological Events The Pennsylvanian was the period of greatest mountain building in Oklahoma. Folding, faulting, and uplift produced the Wichita Mountains in the southeast, the Arbuckle Mountains, southcentral, and the Ouachita Mountains, southeast. Major movement occurred along the Nemaha uplift in central and north-central Oklahoma. Deformation (bending and breaking of rock layers) produced a series of northwest-trending basins (e.g., the Anadarko, Hollis, and Ardmore basins) and uplifts (e.g., Wichita Mountains, Arbuckle Mountains, and Criner Hills). Because of uplift and erosion, Precambrian granites were exposed at the surface (exhumed) for the first time during the Early Pennsylvanian in south-central Oklahoma. 	 Several conglomerates derived from nearby uplifts are preserved; they record the beginning of tectonic (mountain-building) activity in southern Oklahoma. Streams continued to dissect the Ozark plateau in northeastern Oklahoma. Today, Pennsylvanian rocks crop out extensively across the eastern half of the State. Pennsylvanian rocks are the major producers of oil and gas throughout Oklahoma. Abundant organic material, primarily decaying trees and other plant material that accumulated in swamps and lakes, contributed to vast resources of bituminous coal in eastern Oklahoma. Plant Life Pennsylvanian plant fossils are abundant in Oklahoma and include 	algae, lycopods (such as Lepidodendron and Sigillaria), sphenopsids (such as Calamites), gymnosperms (such as Cordaites), pteridosperms (such as Pecopteris and Neuropteris), and true ferns. • Fossil wood indicates a relatively hot, humid climate. **Animal Life** • Marine invertebrate fossils include brachiopods, pelecypods, cephalopods, gastropods, bryozoans, corals, and crinoids. • Some of the world's oldest fossil mollusks (primarily nautiloids) with original shell iridescence preserved occur in asphalt-impregnated limestone (Deese Group) near Sulfur, Murray County. • Insects were common. • Fusulinids (one-celled marine animals with tiny shells; also called "wheat fossils") were abundant in the Pennsylvanian and are used to date rocks of this age.
325-		OZOIC (early life)	CARE MISSISSIPPIAN (U.S.)	Fern	AGE OF CRINOIDS Bryozoan Crinoid Stethacanthus	 Geological Events The initial major subsidence (sinking) of the Anadarko and Arkoma sedimentary basins occurred. Carbonates became the most abundant and widespread kind of sediment in the epeiric (inland) seas of the Early Mississippian; they formed extensive beds of cherty limestone in northern and northeastern Oklahoma. More than 320 million years later, during the Pleistocene, Paleoindians in Oklahoma used Mississippian chert to make spear points, knives, axes, and scrapers. In Late Mississippian time, streams began to dissect the 	Ozark plateau in northeastern Oklahoma. Streams deposited large quantities of clastic (fragments from older rocks) sediments, forming sandstones and shales in northeastern and southern Oklahoma. Oil and gas are produced from Mississippian rocks in northcentral Oklahoma. Plant Life Mississippian plant fossils include algae, spores from terrestrial (land) plants, lycopods (club mosses), sphenopsids (scouring	rushes), pteridosperms ("seed ferns"), primitive gymnosperms (conifers), and ferns. Animal Life • Mississippian fossils of primitive fishes have been found in Craig and Pontotoc Counties. • Marine invertebrate fossils include primarily brachiopods, pelecypods (primitive oysters), bryozoans (coral-like organisms), corals, stalked echinoderms (blastoids, sometimes called "fossil acorns," and crinoids, sometimes called "sea lilies"), and cephalopods.
355 -		PALE	DEVONIAN	Dicranurus	AGE OF FISHES Cladoselache Archaeopteris Honeycomb coral AGE OF CORALS	 Geological Events Organic-rich, black Woodford Shale (Late Devonian–Early Mississippian)—today Oklahoma's major source rock for hydrocarbons—was deposited widely (except in the Ouachita basin). An estimated 70% of the oil discovered in southern and central Oklahoma was derived (sourced) from the Woodford Shale. Plant Life In Oklahoma, the first documented terrestrial (land) plants, includ- 	 ing Archaeopteris (formerly called Callixylon whiteanum), appeared during the Devonian. These trees formed an extensive Devonian forest in the Ada vicinity. The State's oldest fossil tree—which is also the world's largest Archaeopteris specimen—stands at the entrance to East Central State University in Ada. Fossil algae, ferns, and spores (Tasmanites) have been found in Oklahoma. 	 Animal Life In Oklahoma, the earliest fossils of primitive fishes have been documented in the Bois d'Arc Limestone in Murray County. Marine invertebrate fossils include primarily brachiopods, corals, nautiloids, crinoids, and trilobites. White Mound in southeastern Murray County is a world-famous collecting locality for Early Devonian fossils from the Hunton Group.
438-			SILURIAN	Calymene	Horn coral Graptolite Dalmanites	 Geological Events Much of Oklahoma remained covered by sea water during the Silurian. Shallow-marine-shelf deposition resulted in the formation of limestone and dolomite. In the Late Silurian, the sea withdrew from part of Oklahoma, and there was clastic as well as carbonate deposition. Uplifts at the close of the Silurian and beginning of the Devonian 	exposed Silurian rocks to widespread erosion throughout Oklahoma. • Today, major oil and gas production comes from the Hunton Group (Silurian and Early Devonian age) throughout Oklahoma. **Plant Life** • Fossil algae from the Silurian have been found in Oklahoma.	 Animal Life Marine invertebrate fossils primarily include brachiopods, graptolites, gastropods (snails and snail-like animals), corals, and trilobites. Shales containing fossil graptolites are used to date Ordovician and Silurian rocks in the Arbuckle Mountains and southeastern Oklahoma.
430			PRDOVICIAN	Sowerbyella	OF STRAIGHT NAUTILOIDS Straight nautiloid	 Geological Events Sea water covered much of Oklahoma, and shallow-water carbonates such as limestone and dolomite formed thick layers on the marine shelf. Limestone, dolomite, and high-purity silica sand in the Arbuckle Mountains are quarried today as mineral resources. Sandstones in the Middle Ordovician Simpson Group are an important source of oil and gas in southern, central, and eastern Oklahoma 	 A meteorite struck Major County during the late Early Ordovician, creating the Ames impact crater. Now deeply buried by sediments, the Ames structure has been explored for hydrocarbons. Because of plate (Pangea) migration during the Ordovician, southwestern Oklahoma was located around latitude 25°S. (about the latitude of Rio de Janeiro, Brazil, today), giving it a hot climate ranging from arid to humid. 	 Animal Life Marine invertebrate fossils include graptolites (extinct colonial marine invertebrates), trilobites, brachiopods, nautiloids (squidlike cephalopods with shells), crinoids, and corals. The Middle Ordovician Bromide Formation of southern Oklahoma contains perhaps the largest and most diverse echinoderm fossils ever collected from a single formation. Some examples include crinoids, sea urchins, and starfish.

PROTEROZOIC

ARCHEAN

510-

AGE OF TRILOBITES

Geological Events

Igneous "basement" rocks formed in southwestern and south-

Wichita Mountains (granites, rhyolites, and gabbros) and in the

Geological Events

Proterozoic igneous rocks underlie most of Oklahoma and, together

younger Paleozoic rocks later were deposited. Proterozoic igneous

rocks include the Tishomingo Granite (1.37 billion years old), Troy

with Cambrian igneous rocks, form the "basement" upon which

Granite (1.39 billion years old), and rhyolites.

central Oklahoma. They are exposed today primarily in the

The Viola Limestone is an important source of oil in central and

southern Oklahoma.

Arbuckle Mountains (rhyolites).

Plant Life

• Fossil stromatolites, structures formed by cyanobacteria (blue-green

• During the Late Cambrian and Early Ordovician, all but southeast-

day evidence of these events includes sandstones and great

• The Cambrian–Ordovician Arbuckle Group is an important source

• The oldest rocks at the surface in Oklahoma include metamorphic

rocks such as the Blue River Gneiss (1.39 billion years old) and

In northeastern Oklahoma, basement rocks commonly are less

granite exposed in northeastern Oklahoma near the town of

granites that are exposed in the **Arbuckle Mountains**, as well as

of oil and gas in southern, central, and north-central Oklahoma.

thicknesses of limestone and dolomite.

Spavinaw, Mayes County.

ern Oklahoma subsided (sank), and a sea filled the area. Present-

algae), have been found in Ordovician rocks in Oklahoma.

parts of western and southern Oklahoma.

Arbuckle Mountains.

• The earliest record of vertebrate life in Oklahoma occurs in the

form of small fish scales and plates in the Viola Limestone in the

Plant Life

Animal Life

• Marine invertebrate fossils include trilobites (animals with hard, segmented shells) and brachiopods (clamlike animals).

than 1 mile below the surface, but they are 5 or 6 miles deep in

Plant and Animal Life

No fossils have been found in the Proterozoic rocks of Oklahoma

because only igneous and metamorphic rocks are exposed.

• Fossil stromatolites have been found in Cambrian rocks in Oklahoma.