Geology of South-central Kansas Field Trip

Public Field Trip, April 20, 2002

Jim McCauley
Liz Brosius
Rex Buchanan
Bob Sawin

Kansas Geological Survey
Open-file Report 2001-41

Geology of South-central Kansas Field Trip

Jim McCauley, Liz Brosius, Rex Buchanan, and Bob Sawin
Kansas Geological Survey

Introduction

This field trip focuses on the rocks and fossils of south-central Kansas, specifically those that crop out in several locations in Butler, Greenwood, Woodson, and Wilson counties (see map, p. 14). Most of the rocks we will see at our stops were deposited during the Pennsylvanian Period of geologic time, about 300 million years ago. Although we will be in the Osage Cuestas physiographic region for most of our stops, on Stop 3 we will be in the Chautauqua Hills region (see factsheets).

This field trip is part of the Kansas Geological Survey's participation in Earth Science Week (October 7–13), a national celebration of the earth sciences, established in 1998 by the American Geophysical Institute, based in Alexandria, Virginia. Earth Science Week is a time to increase public awareness and understanding of the earth sciences. For more information about Earth Science Week, visit their web site at **www.earthsciweek.org.**

From El Dorado to Stop 1

We begin our field trip in El Dorado in East Park, just east of the Kansas Oil Museum, which is operated by the Butler County Historical Society. East Park is just west of the Walnut River, and it was the Walnut River valley that inspired an early settler to exclaim, "El Dorado!" when he saw the area. El Dorado is Spanish for "land of gold" and was the legendary quest of many early explorers in the New World.

It wasn't until many years later that this region, in fact, did become the land of gold—black gold. In 1915 oil was discovered about 3 miles northwest of East Park on the Stapleton lease (in two sandstones 590 and 670 feet below the surface). The El Dorado field was born.

However, the story begins about three years earlier when Erasmus Haworth, an early director of the Kansas Geological Survey, and his son did detailed mapping of the surface rocks in the area around El Dorado. Oil and gas had previously been discovered in the Augusta area, in association with what geologists call an anticline (an upward bulge in the earth's strata). Haworth discovered a large anticline near El Dorado and recommended it as a site for oil exploration. On October 6, 1915, Haworth's prediction became a reality when a well belonging to Cities Service struck oil. This was the first discovery of a major oil field using scientific methods—namely, detailed geologic mapping of the surface rocks.

In a short time, El Dorado became the largest oil field in Kansas, a distinction it held until just a few years ago. By 1918 oil from the El Dorado field accounted for 12.8% of the nation's production and 9% of the world's production. This field helped fuel our entry into World War I and thus was a factor in the Allied victory.

From East Park we travel east along U.S. Highway 54 (Central Ave), crossing the Walnut River. The elevation here is about 1,260 feet above sea level. As we continue east, we will slowly gain elevation as we climb the gentle western slope of the escarpment formed on the limestones of the Barneston Limestone. Like most of the rocks in eastern Kansas, the Barneston dips very slightly to the west. It also caps the highest ridges of the Flint Hills, the physiographic region in which El Dorado and most of Butler County lie (see factsheet). However, it is not until we reach the edge of the Barneston escarpment that the scenery takes on the rugged appearance we associate with the Flint Hills.

For the first 12 miles of the route, until we get close to the small town of Rosalia, the limestone that we see at the surface is the Fort Riley Limestone Member, the uppermost unit of the Barneston Limestone. The Fort Riley is an important limestone resource, and there are several quarries in the El Dorado area where it is quarried for aggregate and rip-rap. The Fort Riley has also been used as a building stone; part of the state capitol in Topeka is built from Fort Riley limestone quarried near Junction City. In Cowley County, to the south, the Fort Riley is known locally as the Silverdale limestone because of large quarries near the small town of that name.

From Rosalia, we continue eastward through an area in which the Florence Limestone Member is at the surface. The Florence is the lowermost unit in the Barneston and is one of the limestones containing large amounts of the chert, or flint, that give this region its name. Chert is chemically similar to quartz, but lacks quartz's crystalline properties and has water as part of its chemical make-up. Flint Hills chert is usually white, gray, pale blue, or brown. Because chert is more resistant to weathering than the surrounding limestone, it remains after the limestone has been worn or dissolved away and litters much of the countryside where it crops out.

Near mile marker 269, U.S. Highway 54 crosses the crest of the Flint Hills escarpment; the elevation here is 1,610 feet, 350 feet above the Walnut River in El Dorado. To the south, the gentle western dip of the rocks is reflected in the dipping horizon formed by the hills.

As we continue east on Highway 54, we cross into Greenwood County and leave the Flint Hills behind, entering the physiographic region called the Osage Cuestas, characterized by limestones and shales that form small, eastward-facing escarpments, or cuestas (see factsheet). When we crossed into Greenwood County, we also crossed a time boundary, leaving behind rocks formed during the Permian Period (less than 290 million years ago) and entering a region where the surface rocks were formed during the Pennsylvanian Period (more than 290 million years ago). Because the deposition of alternating limestones and shales was almost continuous in this area 290 million years ago, geologists debate just where to put the boundary between the two periods. In fact, this boundary has been moved a number of times.

At about mile marker 281, the highway drops off a small escarpment formed on the Bern Limestone (fig. 1). We will see this formation exposed at Stop 1.

As the route continues through Eureka, it crosses Fall River, where the elevation is 1,010 feet, or 250 feet below the Walnut River in El Dorado and 600 feet below the crest of the Flint Hills in Butler County. Eureka is the county seat of Greenwood County.

In Eureka, turn left (north) on Main Street and go 1 mile to 13th Street, passing the Greenwood County courthouse. Turn right (east) on 13th Street and go 0.4 mile to North State Street and turn left (north). Continue north 4.5 miles to the entrance of a park-like area near the north end of the dam at Eureka City Lake. We will park here and walk a short distance south to the spillway (Stop 1).

STOP 1—Eureka City Lake Spillway

The spillway at Eureka City Lake is a good place to learn about the basic bedrock geology in south-central Kansas. Eureka City Lake was built in the 1930's as a Works Progress Administration (WPA) project and is a water supply lake for Eureka, about 5 miles to the south. The spillway is a means by which water can move out of the lake during times of extremely high water levels.

Several distinctive rock layers are visible at the spillway; in fact, this site has exposures of limestone, shale, and sandstone, the three common rock types in Kansas (fig. 2). These rocks were deposited during the Pennsylvanian Period of geologic history (also known as the Coal Age), from about 323 to 290 million years ago. During that time, Kansas was near the equator, the climate was warmer, and a shallow sea advanced and retreated repeatedly across eastern Kansas (figs. 3, 4).

At times the sea left behind minerals that eventually became limestone, the brown and tan rocks in the spillway. Limestone is made up of calcium carbonate, debris composed of sea shells and other marine life, and minerals that were deposited onto the shallow ocean floor. Some of those limestones contain fossils of the invertebrate animals that were common during the Pennsylvanian—corals, clams, brachiopods, and crinoids. These creatures secreted calcium carbonate to form shells and other hard body parts that make up these limestones.

At other times, rivers deposited mud into the oceans; these muds eventually formed shales, the softer, thinly layered, gray rocks in between the limestones. Occasionally, this area was at or slightly above sea level and sandstone was deposited by rivers flowing into estuaries and deltas, and coal was deposited in marshes. Limestone, shale, and sandstone are sedimentary rocks—that is, they are made up of fragments of rock or shells that were deposited by wind or water. Except for rare exceptions (one of which we will see at Stop 2), rocks at the surface in Kansas are exclusively sedimentary in origin.

In order to identify different rock layers, geologists have given each of them a name, based on the location where it was first described (see factsheet for more information about how rocks are named). Here at the spillway, overflow from Eureka City Lake has formed a waterfall over two layers in the formation called the Bern Limestone. The uppermost layer is the Wakarusa Limestone Member; the

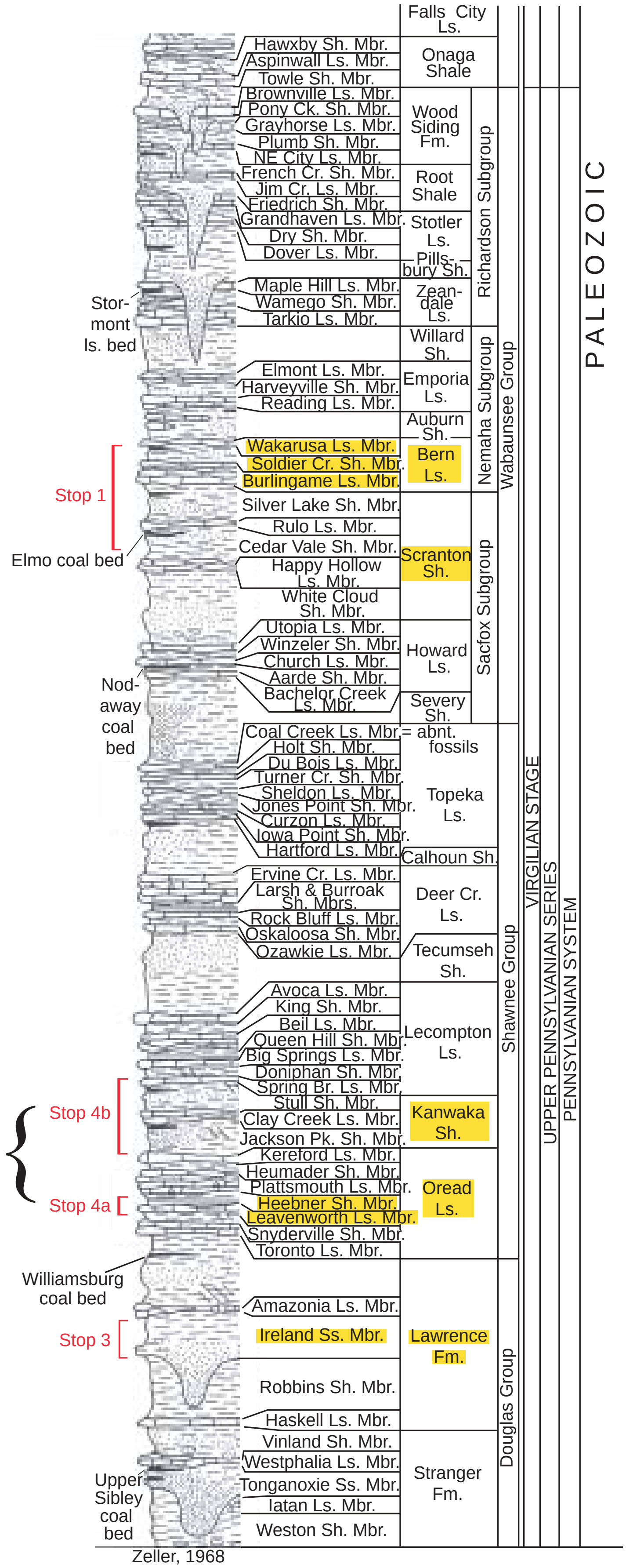


Fig. 1—Stratigraphic classification of Upper Pennsylvanian rocks in Kansas (from Zeller, 1968).

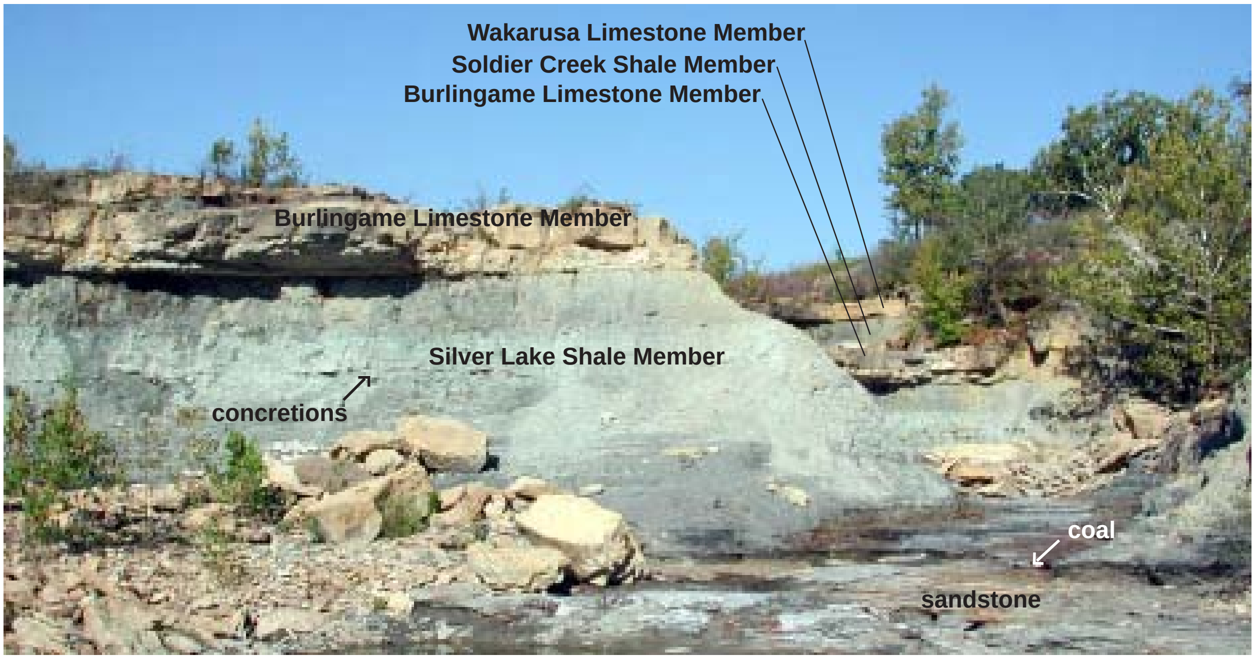


Fig. 2—Spillway at Eureka City Lake and the different rock units that are exposed there.

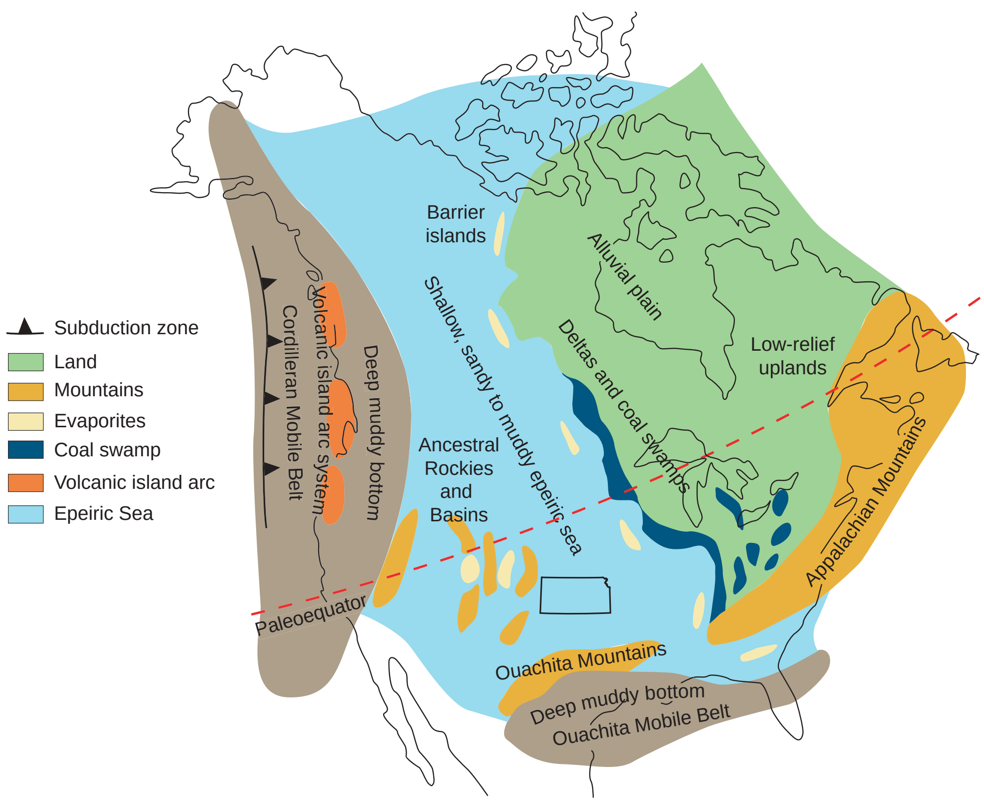


Fig. 3—Geography of North America during the Pennsylvanian Period, about 300 million years ago. Present-day Kansas was near the shore of the shallow sea (from Wicander and Monroe, 1989).

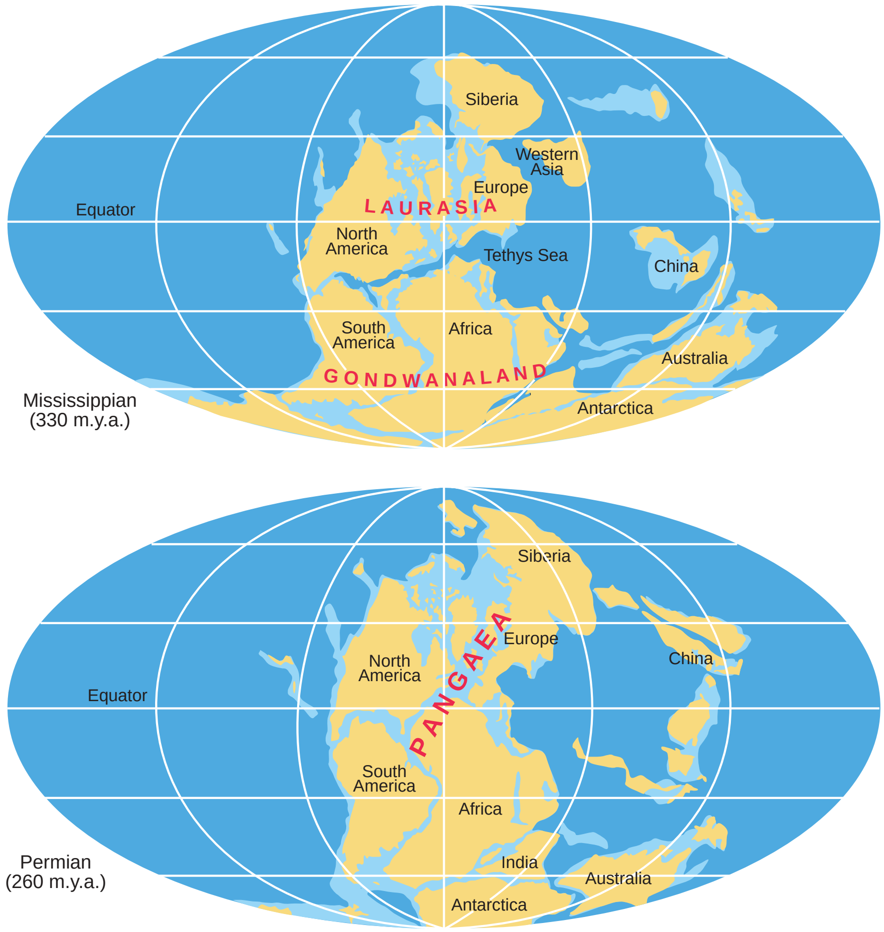


Fig. 4—Positions of the plates during the Mississippian and Permian periods, the two periods bracketting the Pennsylvanian Period. During the Pennsylvanian, Kansas lay near the equator (from Tarbuck and Lutgens, 2000).

lower one is the Burlingame Limestone Member. Both members are named for outcrops near towns south of Topeka. These limestones are separated by the Soldier Creek Shale Member.

Below the Burlingame is a thick sequence of gray shale and sandstone in the upper part of the Scranton Shale, the Silver Lake Shale Member. Below the Silver Lake is a sandstone layer, which is also part of the Scranton Shale. The sandstone contains mica flakes and woody fragments and also displays various sedimentary structures, including ripple marks (fig. 5). A thin coal layer can also be found in the Scranton.

The different sedimentary rocks in this sequence indicate changing environments of deposition. The coal and ripple-marked sandstone were formed slightly above sea-level, perhaps in a swampy delta. The shale most likely was deposited as sea level rose slightly. As water got deeper and the shoreline was farther away, the influx of sediment decreases. The water cleared up enough for shell-secreting

Fig. 5—Ripple marks in sandstone at Eureka City Lake.

invertebrates to flourish. The calcium carbonate shells they formed are the raw materials making up the limestones we see at the top of the sequence. This sequence recurred hundreds of times here in Kansas during the Pennsylvanian and early Permian (from about 323 to 275 million years ago), creating the repetitive sequence of limestones and shales that make up the Flint Hills and Osage Cuestas.

STOP 1 to STOP 2

From Stop 1, we backtrack south on North State Street to Eureka and turn left (east) on 7th Street. We take 7th Street for 0.4 miles to Jefferson Street and turn right (south) for one-half mile to U.S. Highway 54 or River Street. We turn left (east) on Highway 54 and continue east for 31 miles to Yates Center and the junction with U.S. Highway 75. We take Highway 75 to the south for about 13 miles until we reach the small town of Buffalo.

As we travel east through Greenwood and Woodson counties to Yates Center, we remain in the Osage Cuestas physiographic region. On the way to Buffalo, the highway makes a jog and passes over Rose Dome—a broad, gentle uplift formed by igneous intrusion below the surface. This has brought limestone in the Stanton Formation to the surface, and it is quarried near the highway. The Stanton can be traced northward to the Kansas City area. In this quarry, gentle dips can be seen in the limestone beds, reflecting the arching of the bedrock.

When we reach Buffalo, we turn right (west) at the Micro-Lite sign and proceed through town on Micro-Lite Street. The Micro-Lite plant is located on the west edge of town, along the railroad tracks.

From the Micro-Lite plant, we head west, passing clay pits in the Weston Shale Member of the Stranger Formation, which provided raw material for a brick plant that once operated in Buffalo. After about 4 miles, we turn right (north), passing the Wildcat Ranch. Proceed 1.25 miles and then turn left (west) and go 0.5 mile and turn right (north) at the entrance to the mine and proceed about 0.75 miles to the loading area, where we will park the bus and then walk into the quarry area (Stop 2).

STOP 2—Micro-Lite Quarry/ Silver City Dome

Most of the rocks at the surface of Kansas are sedimentary in nature—that is, they are made up of sediments usually deposited at the bottom of an ocean or by a stream. In general, you have to drill hundreds or thousands of feet below the land's surface in Kansas to find igneous rocks, those once-molten rocks, such as granite. In a few places, however, you can see igneous rocks at the surface, and two of those locations are in Woodson County.

The igneous rocks here are called lamproites. About 90 million years ago, these igneous rocks rose from great depth and exploded to the surface, producing volcano-like features. Lamproites are pipes of igneous rock, which was highly charged with gas and pushed its way up through faults, fractures, and zones of crustal weakness (fig. 6). They are similar to kimberlites, another type of igneous rock in Kansas, found at 13 locations in Riley and Marshall counties, west of Tuttle Creek Lake. Lamproites have a different chemical composition than kimberlites, but both have produced diamonds (although not in Kansas). In fact, the world's largest diamond mine is in a lamproite at Argyle in northwestern Australia.

Because the landscape has endured millions of years of erosion since the lamproites here erupted, relatively little evidence of these features is visible at the land's surface. At Rose Dome, about five miles south of Yates Center, the intrusion of the lamproite created a broad dome that is apparent at the land's surface and on topographic maps. In addition to the pipe of molten rock that blew to the surface, other lamproite intruded itself into the underground rock (because lamproite and kimberlite

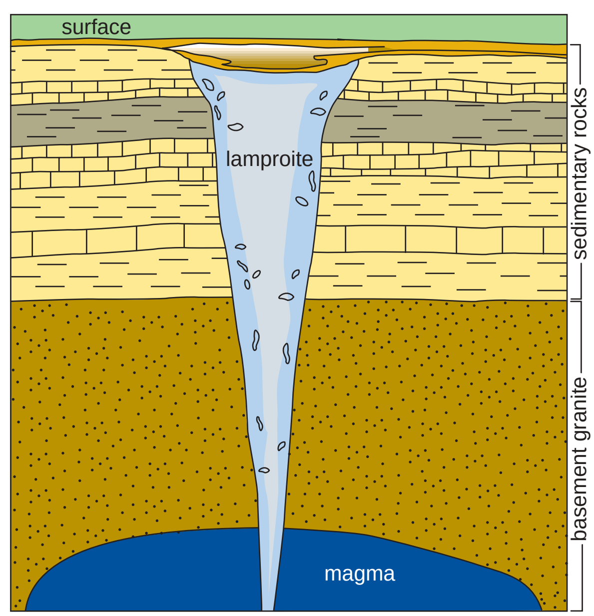


Fig. 6—Generalized diagram of a lamproite pipe.

intrude themselves into rock that is already in place, they are sometimes referred to as “intrusives”). Horizontal sheets of lamproite branch off the main pipe. These layers, or sills, extend away from the main pipe and have been encountered at depths of about 1,300 feet during core drilling, and drilling for oil and gas, in the area around the dome.

The lamproite itself is not visible at the surface of Rose Dome, but a number of granite boulders litter a pasture west of U.S. Highway 75. These granite boulders, which are generally surrounded by trees that have grown up around them, probably came along for the ride with the lamproite when it exploded to the surface. The granite was probably originally part of the crystalline basement rock that is about 2,500 feet deep here, and lies beneath the overlying sedimentary rocks. These granites are about 1.2 billion years old, formed during ancient Precambrian times. Geologists use the term “xenolith” for rock fragments, such as these chunks of granite, that are “foreign rocks,” or not part of the intrusive but mixed in with the lamproite, like chocolate chips in cookie dough. These granites seem so out-of-place here that early geologists thought they might have been carried in by glaciers, though we now know that glaciers did not extend this far south in Kansas.

The lamproite we will visit today is at the Silver City dome, southwest of Rose Dome. The Silver City lamproite is very similar to the Rose Dome. The actual topographic dome at Silver City is more subtle and a little more difficult to visualize than at Rose Dome; however, the lamproite itself is exposed at Silver City. The lamproite contains shiny flakes of mica; that led to early reports that the rock contained silver and a short burst of mining in the 1870’s that produced a settlement called Silver City. While there is no silver here, the lamproite has been mined intermittently since then, and steadily since 1982 when Micro-Lite began quarrying one of the lamproite sills. The lamproite is quarried and hauled to the nearby town of Buffalo, where it is bagged and eventually used as a mineral supplement for cattle feed. The rock contains small amounts of the essential minerals magnesium, potassium, and iron. In 1996, Micro-Lite mined about 70,000 tons of lamproite.

While much igneous rock is very hard, the lamproite exposed at the surface here is soft and powdery, weathering to an olive brown. The rock itself is called peridotite (pronounced pah-RID-oh-tight); it is coarse grained and high in the minerals olivine and pyroxene. Surrounding the lamproite are sedimentary rocks that were deposited in Pennsylvanian times, about 300 million years ago, before the lamproite came to the surface. When the lamproite exploded to the surface, it was extremely hot, as much as 800 degrees Celsius, cooking the limestones and shales that it contacted. This process is called “contact metamorphism”—the high heat of the molten rock cooks and changes the existing sedimentary rocks (these previously in-place sedimentary rocks are sometimes referred to as “country rock” a term that, in this context, has nothing to do with music). Thus, some of these sedimentary rocks (such as the Weston Shale Member and the Tonganoxie Sandstone Member of the Stranger Formation) are now extremely hard and have a far different character than the much softer rocks that we have seen in the other stops on this field trip.

STOP 2 to STOP 3

From the Micro-Lite Quarry, we backtrack about 0.75 mile to the east-west gravel road, where we turn right (west) for 1 mile, and then left (south) for another mile, passing a quarry in the Stanton Limestone on the south flank of the Silver City Dome. At the T-intersection, we turn right (west) for 1.5 miles until we come to Middletown. The hills along this stretch mark the southwest rim of the Silver City Dome. At Middletown, we turn left (south) again for 1 mile. At the T-intersection, we turn right (west) and travel 2 miles to the crossroads, where we turn left (south) and curve to the right (west), crossing the Verdigris River. The elevation of the river is about 845 feet—the lowest point on the trip. We’ll continue west for about 1.5 miles to the junction with a blacktop road, where we turn right (north) and travel 3 miles to the junction with Kansas Highway 105.

On K-105 we continue north and eventually west for about 5.3 miles, passing along the east side of Toronto Lake. On the east edge of the town of Toronto, we turn left (south) on Point Road and continue for a little less than 2 miles to the Toronto Point area of Toronto Lake State Park (Stop 3).

STOP 3—Toronto Lake

Toronto Lake was completed in 1960 and occupies approximately 2,800 acres. The park encompasses an additional 1,075 acres and offers visitors recreational activities such as swimming, fishing, water skiing, camping, hiking, picnicking, and wildlife observation.

Located in the gently rolling terrain of the Verdigris River valley, Toronto Lake marks the northernmost reaches of the Chautauqua Hills physiographic region, a region of sandstone hills formed on thick sandstones in the Lawrence and Stranger Formations. These sandstones were deposited in deep, alluvial valleys during the Pennsylvanian Period, at a time when the area was above sea level. A patchwork of oak woodlands and tallgrass prairie cover the hills in this region; as a result, they are sometimes known as the Cross Timbers, a vegetative complex that extends southward into Oklahoma and central Texas.

This stop gives us a chance to see one of the sandstones that characterizes this region, the Ireland Sandstone Member of the Lawrence Formation. The Ireland Sandstone was deposited in an ancient river valley that existed in eastern Kansas during the Pennsylvanian Period. At that time this part of Kansas was above sea level, and the seashore was southwest of here. This stream flowed in a south-southwest direction and deposited sand in a broad deep valley several miles in width that can be traced north-northeastward into the Leavenworth area. This stream valley was filled with sand up to at least 160 feet in depth, which has since been cemented into sandstone.

Where this sandstone is at or close to the surface, rain and runoff have soaked into the pores between the sand grains and created a freshwater aquifer that supplies water to farms and some small towns in its vicinity. This sandstone contains structures such as ripple marks and cross-bedding which are indicative of deposition by running water. Usually limestone and shale have horizontal bedding planes, but high-energy streams create dunelike structures on their streambeds. Sandstones deposited under these conditions have bedding planes in a confusing array of angles and directions.

STOP 3 to STOP 4a (optional)

[Note: In case of bad weather, we'll proceed directly to Stop 4b. If the weather is good, we'll go to Stop 4a and then Stop 4b.]

From Toronto Lake, we'll backtrack north to K-105 and turn left (west), following the highway west and north through Toronto, until we meet U.S. Highway 54. We take Highway 54 west for about 5.5 miles, and then we turn off on a gravel road to the left (south), which continues south for 1 mile and then makes a short jog to the right (west). We turn left (south) at the next road and continue about one-half mile to Stop 3a, Rocky Ford, a natural crossing of the Walnut Creek.

STOP 4a—Rocky Ford (optional)

The rock forming Rocky Ford is the Leavenworth Limestone Member of the Oread Limestone. The black platy Heebner Shale Member can be found in the north bank of the creek. Where it crops out in eastern Kansas and southeastern Nebraska, the Leavenworth Limestone Member maintains a uniform thickness of about one foot or so; this indicates that the environment in the ancient sea that covered this area at that time was the same over a wide area and the ocean depth was also widely uniform. The Leavenworth shows a slight southerly dip in this area, and its upper surface is scarred by numerous joints that run in various directions. Some of these joints are more prominent than others and may have preferred orientations. These are essentially fractures in the rock that are the result of various geologic strains exerted in this area during millions of years when the North American Plate was drifting over the globe (see fig. 2).

Note: The road across Rocky Ford is a public road, but the land on either side is private property. To visit this site, you must have permission from the owners.

STOP 4a to STOP 4b

After visiting Rocky Ford, the route continues south from Walnut Creek about one-half mile. At the Rocky Ford Cemetery, we turn right (west) and go a short distance to the roadcut on the prominent hill just ahead, which is Round Mound, Stop 4b.

[From Toronto Lake to Stop 4b.—After reaching the junction of U.S. Highway 54 and K-105 north of Toronto, we turn left (west) on Highway 54 and travel 7 miles to the gravel road on the east side of the small town of Neal. We turn left on the gravel road and follow it south and east in a stairstep fashion to the roadcut in the prominent hill just south of the road. This is Round Mound (Stop 4b).

STOP 4b—Round Mound

The rocks that crop out in the roadcut at Round Mound are in the Kanwaka Shale. The type locality of the Kanwaka Shale is just west of the community of Kanwaka, which is a little west of Lawrence. Numerous fossils of invertebrate marine animals have weathered out of the shale and thin limestones and can be collected here.

Fossils are the ancient remains or evidence of once-living plants and animals, and invertebrates are animals without backbones. In Kansas, invertebrate fossils are much more common than vertebrate fossils. Even so, these fossils represent only a tiny sampling of the animals that once inhabited this part of the earth, most of which lived and died leaving no visible trace. The fossils here give an idea of the variety of animals that lived in the Pennsylvanian seas, roughly 300 million years ago. Among the fossils found at this site are bryozoans, brachiopods, bivalves (oysters, clams, scallops), corals, and trilobites.

Bryozoans are some of the most abundant fossils found in sedimentary rocks, and they are also widespread today, both in marine and freshwater environments. Bryozoans are small animals (just large enough to be seen with the naked eye) that live exclusively in colonies. Bryozoans are sometimes called moss animals—the name comes from two Greek words, *bryon* (moss) and *zoon* (animal)—because some bryozoans form colonies of bushy tufts that resemble mosses. Bryozoan colonies can also resemble colonies of some corals. Like corals, most bryozoans secrete external skeletons made of calcium carbonate, but unlike corals, bryozoans generally don't build reefs. Each bryozoan colony starts out with a single individual, called a zooid. Each zooid is essentially cylindrical and has a ring of tentacles that it uses to feed, drawing tiny plants and animals towards its mouth. As the first zooid begins feeding, it buds to form additional zooids, each of which has its own feeding tentacles. The new zooids also bud, forming the colony. Large colonies may consist of hundreds of thousands or even millions of zooids. Fossil bryozoan colonies come in a variety of shapes (figs. 7, 8). Some bryozoans built colonies that grew from the seafloor in branching structures; these fossils look like something like twigs. Other species erected netlike frameworks, while still other spread like a crust on shells, rocks, plants, and even other bryozoan colonies.

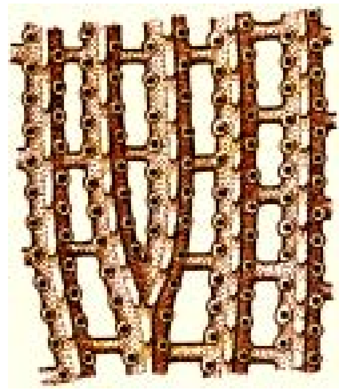


Fig. 7—*Fenestella* is one bryozoan found in Kansas rocks; its colonies had a netlike structure.

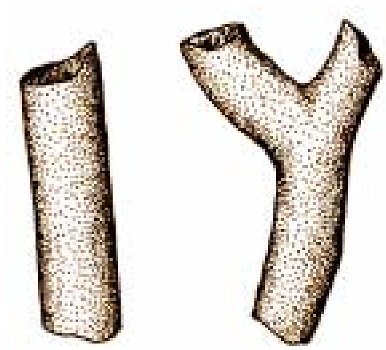


Fig. 8—This bryozoan, *Rhombopora*, is also common in Kansas rocks. It is characterized by upright, branching stems that resemble small twigs.

Brachiopods have a shell consisting of two parts called valves. Their fossils are common in the Pennsylvanian and Permian limestones of eastern Kansas. Brachiopods have an extensive fossil record. They first appear in rocks dating back to the early part of the Cambrian Period, about 545 million years ago, and were extremely abundant until the end of the Permian Period, about 250 million years ago, when they were decimated in the mass extinc-

Fig. 9—Fossil brachiopods common in Kansas rocks.

tion that killed more than 90 percent of all living species and was the largest of all extinction events (larger than the major extinction at the end of the Cretaceous that killed off the dinosaurs). A distinctive feature of all brachiopods is that their valves are bilaterally symmetrical—that is, the right half is a mirror image of the left half. (Humans are also bilaterally symmetrical.) The bilateral symmetry of the individual valves differentiates brachiopods from clams and other bivalved mollusks, with which they are sometimes confused. Unlike brachiopods, clam valves are not bilaterally symmetrical; instead, the right and left valves are mirror images of each other. Brachiopod shells come in a variety of shapes and sizes (fig. 10). The outer surface of the valves may be marked by concentric wrinkles or radial ribs. Some brachiopods have prominent spines, but these are generally broken off and incorporated separately in the sediment.

Clams and other bivalves are generally easy to recognize because they look a lot like the shells scattered along modern seashores. Clams and their relatives (oysters, scallops, mussels) are often called bivalves (or bivalved mollusks) because their shell is composed of two parts called valves. Like their living relatives, fossil bivalves come in many different shapes and sizes. Typically, the right and left valves are symmetrical, in contrast to the bilateral symmetry of individual brachiopod valves (fig. 10). Some bivalves, however, such as oysters, have valves that are not symmetrical. In western Kansas, fossil clams found in younger rocks from the Cretaceous Period are even more common. Some of these—the inoceramid clams from western Kansas—are huge, as much as 6 feet in diameter.

Corals are close relatives of sea anemones and jellyfish and are the main reef builders in modern oceans. Corals can be either colonial or solitary. As fossils, corals are found worldwide in sedimentary rocks; the oldest are from rocks deposited during the Middle Cambrian, over 525 million years ago. Corals are among the simplest multicellular animals and are characterized by their radial symmetry and lack of well-developed organs. Corals live attached to the seafloor and feed by trapping small animals with their tentacles. They reproduce both sexually and asexually. Budding, a kind of asexual reproduction, occurs when the parent polyp splits off new polyps. Evidence of budding can be seen in fossil

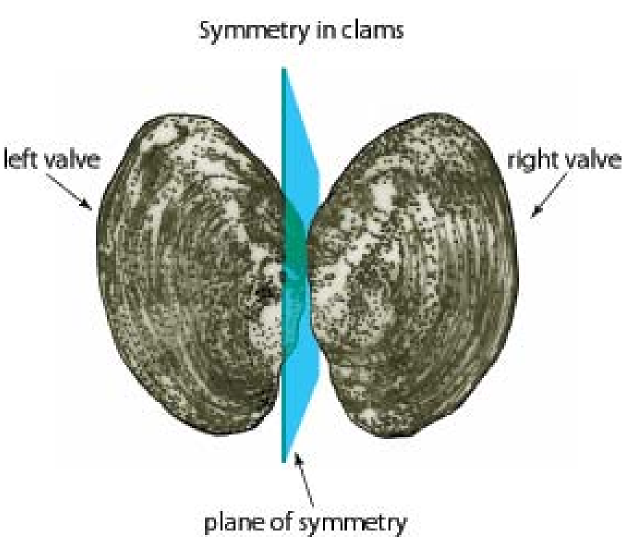


Fig. 10—Symmetry in clams.

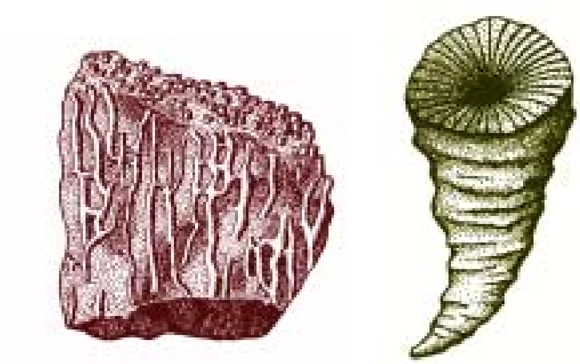


Fig. 11—The colonial tabulate coral *Syringopora* (on the left) shows the structure of the hard parts that protected the polyps and formed the framework of the colony. Note the pores on the surface of the colony, from which the polyps extended their tentacles to feed. The solitary rugose coral *Caninia* (on the right) is common in eastern Kansas.

corals. Two groups of corals were important inhabitants of the Pennsylvanian and Permian seas—tabulate and rugose corals (fig. 11). Tabulate corals were exclusively colonial and produced calcium carbonate skeletons in a variety of shapes (moundlike, sheetlike, chainlike, or branching). Tabulate corals get their name from horizontal internal partitions known as tabulae. Some tabulate corals were probably reef builders (but not in Kansas). A common characteristic of rugose corals, from which they get their name, is the wrinkled appearance of their outer surface. (Rugose comes from the Latin word for wrinkled.) Rugose corals may be either solitary or colonial. Because solitary rugose corals are commonly shaped like a horn, these fossils are sometimes called horn corals. Both tabulate and rugose corals died out in the major extinction that occurred at the end of the Permian Period, roughly 250 million years ago. This extinction marked the end of the Paleozoic Era.

The corals that inhabited the post-Paleozoic seas differ significantly from the earlier corals. Because of this, many specialists argue that these later corals may not be closely related to the Paleozoic corals.

Trilobites are an extinct group of arthropods, relatives of insects, spiders, ticks, crabs, shrimp, lobsters, and numerous other organisms. They were exclusively marine organisms. Trilobites first appear in the fossil record in rocks deposited during the Lower Cambrian, about 540 million years ago. Although they were extremely abundant during their first 100 million years or so, by the Pennsylvanian and Permian Periods (when the surface rocks in eastern Kansas were deposited), trilobites were much less dominant. They became extinct, along with many other species, at the end of the Permian. The bodies of trilobites, like insects, have three parts: the head (or cephalon), the thorax, and the tail (or pygidium). Leg-like appendages attached to all three parts, but these are rarely preserved. Because of this, and the fact that trilobites have no living counterpart, paleontologists are hesitant to speculate about how trilobites lived. Trilobite pygidia are sometimes found in eastern Kansas (fig. 12).

Fig. 12—This tail, or pygidium, of the trilobite *Ameura,* came from the Pennsylvanian Drum Limestone, near Independence, Kansas. Most Kansas trilobites belong to the genus *Ameura* or *Ditomopyge.*

STOP 5 to El Dorado

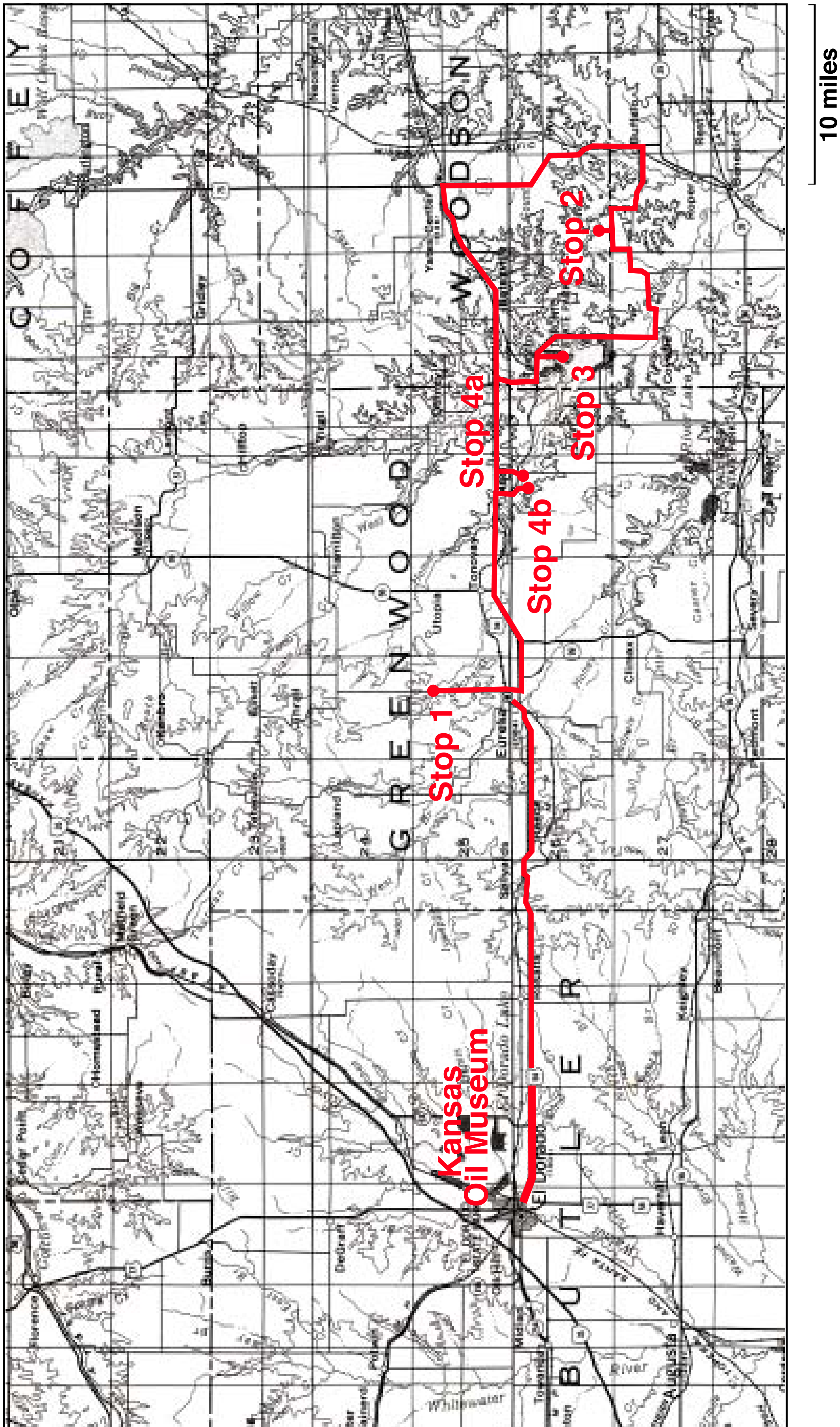
As we leave Round Mound, we'll travel west and north along the major gravel road 3 miles to the town of Neal and U.S. Highway 54, which will take us back to El Dorado, about 43 miles to the west. The Kansas Oil Museum, located next to our rendezvous point in East Park, will be open when we return. It is considered the best oil museum in the state and has exhibits that explain the various means of petroleum exploration and production and the ways they've changed over the years. In addition, the museum has exhibits that show what life was like in El Dorado and the company towns that sprang up during the oil boom that followed the discovery of the El Dorado field.

References

Tarbuck, Edward J., and Lutgens, Frederick K., 2000, Earth Science (9th Edition): Upper Saddle River, New Jersey, Prentice Hall, 672 p.

Wicander, R., and Monroe, J. S., 1989, Historical Geology—Evolution of the Earth and Life through Time: St. Paul, Minnesota, West Publishing Company, 578 p.

Zeller, Doris, ed., 1968, The Stratigraphic Succession in Kansas: Kansas Geological Survey, Bulletin 189, 81 p.


COFFEY
WOODSON
GREENWOOD
BUTLER
Kansas Oil Museum
El Dorado
Eureka
Stop 1
Stop 2
Stop 3
Stop 4a
Stop 4b
10 miles