GEOLOGY OF THE KANOPOLIS LAKE AREA

Public Field Trip

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Kansas Geological Survey

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Kanopolis Lake

Kansas Geological Survey
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Ellsworth County, Kansas

Introduction

Ellsworth County lies within the Smoky Hills physiographic province and is drained by the Smoky Hill River and its tributaries, and tributaries of the Saline and Arkansas rivers. The Smoky Hills are mature dissected hills, often capped by sandstones of the Cretaceous Dakota Formation. The hills and the river that drains them got their name form the smoky haze that often hangs in the valleys in the morning. Kanopolis Dam is on the Smoky Hill River about 25 miles southwest of Salina, Kansas.

Rocks exposed in the Kanopolis Lake area, mainly the Kiowa and Dakota formations (fig. 1), are Cretaceous in age (about 100 million years old). The Cretaceous was a time of high global sea level, and much of the Western Interior of North America was periodically flooded. During times of highest sea level, the Cretaceous Interior Seaway (fig. 2) was continuous from the Gulf of Mexico to the Arctic Ocean.

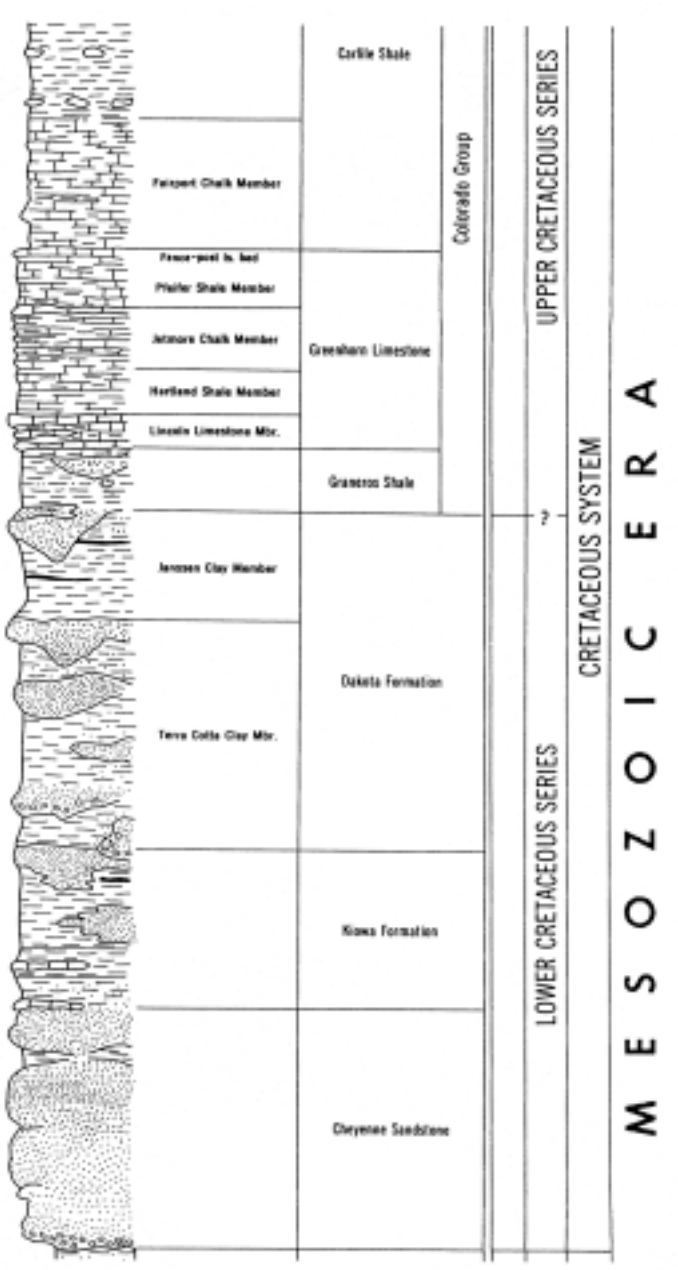

Fig. 1—Stratigraphic column of rocks encountered on this field trip.

Kiowa Formation

The Kiowa Formation is exposed in several places around Kanopolis Lake. The Kiowa is a heterogeneous unit made up of shale, siltstone, sandstone, and coquina limestone ("shell-beds"). The thickness of the Kiowa Formation in Ellsworth County ranges from 110 to 150 feet.

The lower part of the Kiowa Formation consists of medium-gray, dark-gray, and black shales that split easily. Thin sandstone bodies are common throughout the unit, and a persistent, thick, light-colored sandstone occurs at the top. Beds of cone-in-cone, "quartzitic"

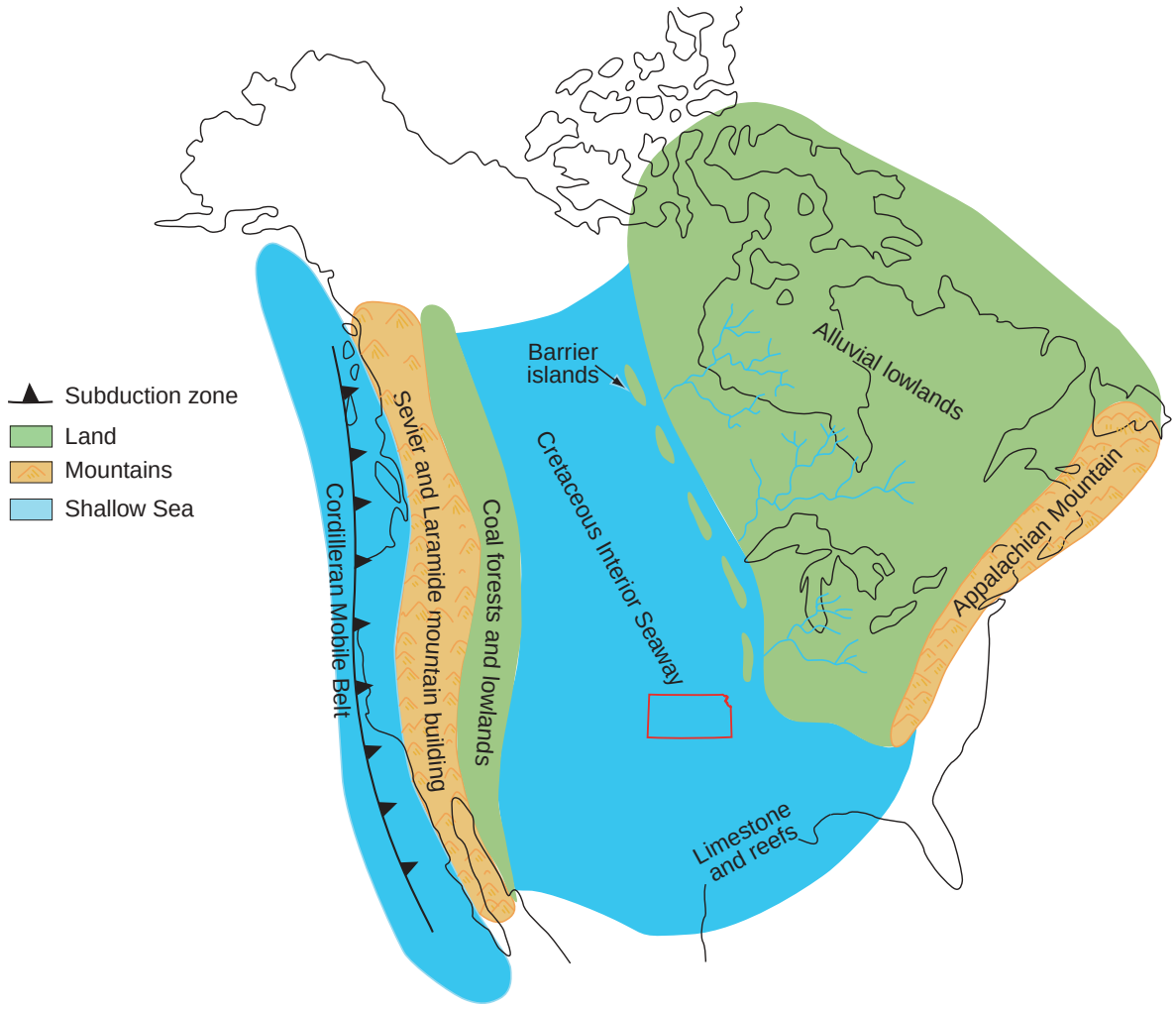

Fig. 2—Geography of North America during the Cretaceous Period, about 100 million years ago. Present-day Kansas is outlined in red (from Wicander and Monroe, 1989).

sandstone, siltstone, and thin limestone are common. Pyrite, marcasite, gypsum crystals, ironstone concretions, lignitized wood fragments and logs, and marine invertebrates (mainly bivalves and gastropods) are found in the shales. Marine mollusks occur in the limestone. Many of these features are described in more detail on page 3.

Sandstone is a major component of the Kiowa Formation in the Kanopolis Lake area. The sandstones are very light gray to pale grayish orange, but in places they are colored reddish brown by hematitic (iron) stain and cement. Barite rosettes, ripple marks, and crossbedding can be seen in the sandstones.

These rocks formed from sediments that were deposited in nearshore to coastal environments as the early Cretaceous sea spread northeastward across gentle terrain developed mainly on Permian rocks. The climate was probably warm and humid. The shales were deposited in relatively quiet water where the bottom was only occasionally disturbed by currents and waves. Bottom-dwelling marine life inhabited bays or other places where salinity and current or wave activity were favorable. Stronger currents, waves, or storms destroyed and reworked some of these areas to form the coquina shell-beds.

The abundance of sandstone and associated carbonaceous material in the upper part of the Kiowa Formation is evidence that the seas were starting to recede and marked the beginning of deposition of the overlying, mostly nonmarine Dakota Formation.

Cone-in-cone. Cone-in-cone structure forms oval-shaped concretions and discontinuous lenses in the Kiowa Formation in many parts of Ellsworth County (see fig. 8). Cone-in-cone is thought to have formed from precipitation and growth of fibrous crystals of calcite soon after the sediments were deposited. A unique set of physical and chemical conditions was essential to the formation of cone structures in the sediment. Decaying organic matter in the sediments underlying the cone-in-cone may have lowered the pH in the sediments sufficiently to cause recrystallization of the calcite. Gravity-induced stresses during compaction of the sediment may have been partly responsible for the near vertical orientation of the calcite fibers and the cone structures. Contortion of the shale beds around the cone-in-cone structures indicates that the cone-in-cone developed before the enclosing sediments were firm and were still quite plastic.

Marcasite. Common in the dark-gray shales of the Kiowa, marcasite (iron sulfide) is distinguished from pyrite by its pale bronze color and flat or bladed crystals. Pyrite is darker in color and has cubic crystals.

Gypsum crystals. Weathered shale slopes are littered with crystals of gypsum (selenite) measuring up to 7 inches long. Radial aggregates (sunbursts) of gypsum also may be found. The gypsum (calcium sulfate) is a secondary product derived from the weathering of iron sulfide (mainly marcasite) in the shale.

Clay-ironstone concretions. Composed mainly of very fine grained siderite (iron carbonate) and some clay, these concretions occur in thin discontinuous zones parallel to the bedding of the enclosing shale. On weathering, the concretions break into angular fragments.

Dakota Formation

The resistant, conspicuous beds of the Dakota Formation are the dark-brown sandstones cemented with iron oxide that cap the hills and produce the irregular topography so common in the Smoky Hills. The Dakota Formation is a thick, heterogeneous sequence of clay, siltstone, and sandstone. The sandstones are locally cemented with hematite and limonite. The Dakota contains lignite (a low-grade form of coal that was deposited in swampy conditions) and, locally, beds of “quartzitic” sandstone. “Quartzite” concretions have been described in both the Kiowa and Dakota Formations (see discussion for Stop 2, Mushroom Rock State Park). More than one bed of concretions have been observed, and they may, in reality, occur in both units. Crossbedding (see below) is prominent in most sandstones in the Dakota.

Although the Dakota is thought of as primarily sandstone, the most common rocks in the formation are light-gray to light-greenish-gray siltstones or clays abundantly dappled with red to reddish-brown. Clay and siltstone compose as much as 70 percent of the thickness of the Dakota Formation in many areas. In Ellsworth County, the Dakota Formation is 190 to 250 feet thick.

The Dakota Formation is generally thought to have been deposited under nonmarine conditions during a time of retreating seas in a low-lying coastal or deltaic plain bordering the Cretaceous sea. The terrestrial nature of Dakota sedimentation can be inferred from the general absence of marine fossils, the abundance of leaf fossils, and the occurrence of lignitic beds. Sandstones in the Dakota Formation were deposited mainly by streams and rivers. Fossils of oak, willow, walnut, sycamore, magnolia, laurel, and sassafras leaves indicate the climate was mild.

Marine fossils in the upper part of the Dakota and the deposition of marine sediments of the overlying Graneros Shale Formation mark the return of higher sea levels in central Kansas.

Crossbedding. Crossbedding is a series of thin, inclined layers in a larger bed of rock (usually sandstone) that form a distinct angle to the principal horizontal bedding plane. Formed by currents of water or wind, crossbedding is found in dune, stream-channel, or delta deposits. The direction in which the beds are inclined usually indicates the direction that the current of water or air was flowing at the time of deposition.

The Dakota Aquifer

In recent years these geologic units have been the subject of particular interest because of their potential as a water source. With ground-water-level declines in the High Plains aquifer of western Kansas, underlying Cretaceous rocks may be an important source of water. Water specialists often refer to the Dakota, Kiowa, and underlying Cheyenne Sandstone formations as one unit—the Dakota aquifer. Their research has shown this aquifer is not capable of producing water in amounts as large as the High Plains aquifer, and water quality varies greatly from place to place. As a result, the Dakota aquifer will probably never be as important as the High Plains aquifer, but with careful management it could produce significant amounts of water.

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ROAD LOG

Kanopolis Lake Area Field Trip Route (fig. 3). This road log begins and ends at the Langley Point Group Shelter in Kanopolis State Park, elevation 1500 feet. Total elapsed mileage between stops is shown for each entry on the road log. The distance from one feature to the next is shown by the mileage figure in parenthesis.

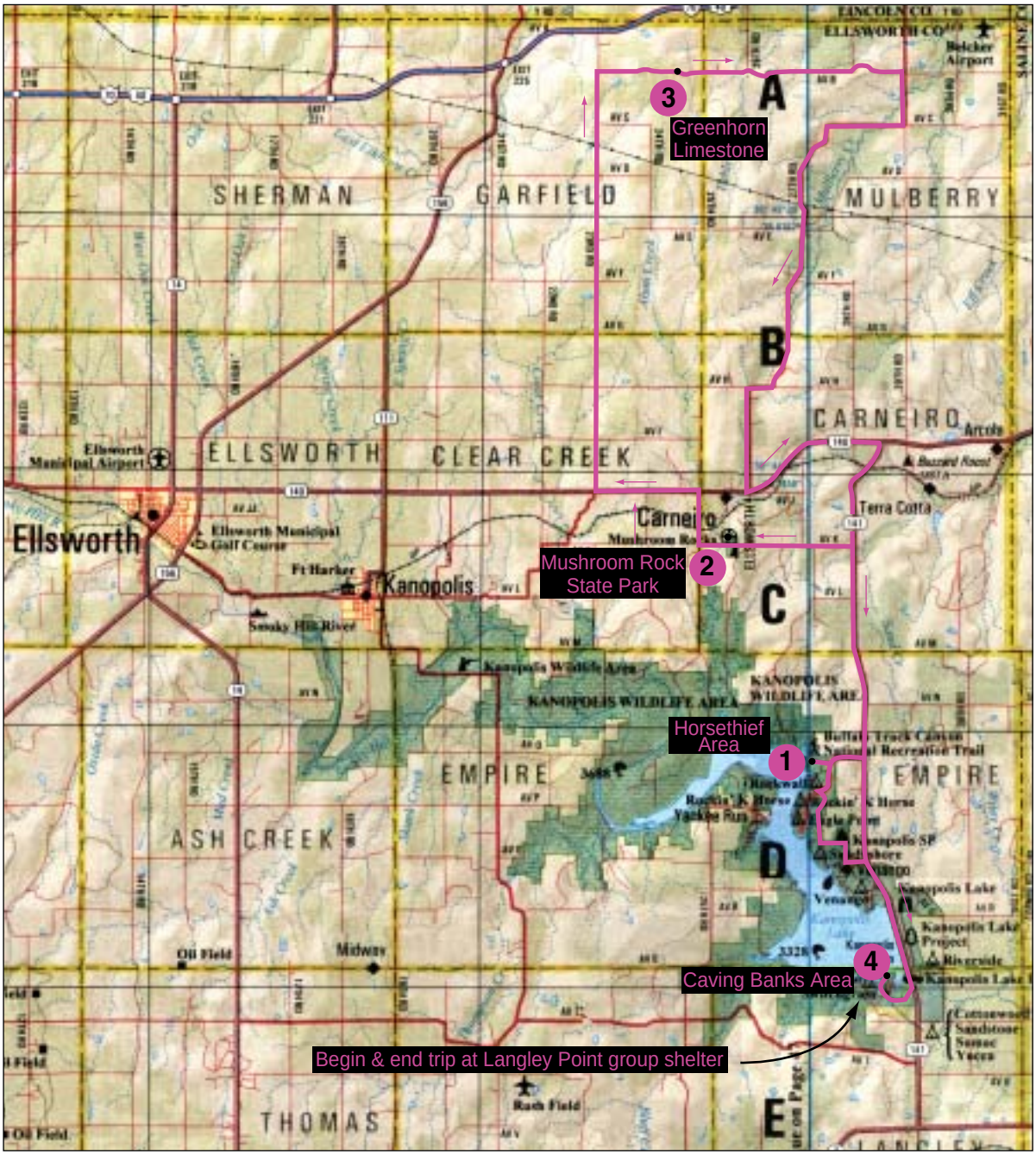

Fig. 3—Map of the October 11, 2003, field-trip route.

Total Mileage		Point-to-Point Mileage
0.0	Reset trip odometers to zero and proceed south.	(0.1)
0.1	Concretionary sandstone in the Kiowa Formation protrudes from the ground on both sides of the road.	(0.2)
0.3	Langley Point Road. Turn left (east) and pass pay station.	(0.4)
0.7	Pass over southern extension of Kanopolis Dam.	(0.3)
1.0	Junction of Langley Point Road and Kansas Highway 141. Turn left (north) on K-141 and proceed along the top of Kanopolis Dam. Normal lake elevation is 1459 feet and the elevation of the Smoky Hill River below the dam is 1410 feet. Kanopolis Lake was built in 1948 on the Smoky Hill River by the U.S. Army Corps of Engineers, making it the oldest of the major Corps reservoirs in the state. The dam is 3 miles long and 131 feet above the streambed. The outlet tunnel is 14 feet in diameter and 2443 feet long. The dam and lake are named for the small town of Kanopolis to the northwest. The name Kanopolis comes from combining the Greek word for city ("polis") with the "Kan" of Kansas. Kanopolis formed around Fort Harker in the 1860's.	(2.5)
3.5	Venango Road. Turn left (west).	(0.3)
3.8	Curve right onto Horsethief Road.	(0.4)
4.2	Pass pay station for Kanopolis State Park.	(0.1)
4.3	Kanopolis State Park office.	(0.5)
4.8	Curve to north.	(1.0)
5.8	"T" intersection in middle of prairie dog town, turn right (east).	(0.6)
6.4	Turn left (west) at sign for Horsethief Canyon. This hill is capped by the Dakota Formation. The elevation is 1595 feet.	(0.2)
6.6	Sandstone in the Kiowa Formation is exposed in this draw and a small cave is visible up the draw to the right.	(0.2)
6.8	Turn right at the restroom and enter parking lot.	

STOP 1. Horsethief Area. From here we will hike south along the shore and look at shale and sandstone in the Kiowa Formation. The thick sandstone body that crops out along the shoreline of Kanopolis Lake in this area has been interpreted as an offshore marine barrier bar. Shallow marine conditions are suggested by ripple marks, which are visible here, and burrows from

invertebrate animals that lived in these shallow waters. This sandstone outcrop is characteristic in thickness and lateral extent of sandstone bodies in the subsurface that are major conduits of ground water.

Where our hike ends, barite roses have weathered out of the sandstone and can be collected at the water's edge. Sand-barite rosettes (barium sulfate) are not scattered uniformly throughout the sandstone, but form in clusters or groups. Their resistance to erosion causes them to protrude above the weathered surface of the sandstone.

Native American petroglyphs have been carved into the sandstone that forms the bluff across the lake to the northwest. Because these sandstones are soft and easily eroded, the area, called Inscription Rock, is now off-limits to most visitation.

Trailheads to Buffalo Track Canyon Nature Trail and the Horsethief Canyon Trail are 0.2 mile north along the gravel road. Markers along the Buffalo Track Canyon Trail correspond to stops in a trail guide provided by the Kansas Department of Wildlife and Parks. Fragments of leaf fossils can be found in some of the tightly cemented sandstone that weathers out of slopes along the trail.

Total Mileage		**Point-to-Point Mileage**
0.0	After STOP 1, zero out odometers and backtrack to K-141.	(1.3)
1.3	Beavers have built a series of dams in the small stream on the right (west).	(2.0)
3.3	K-141. Turn left (north) passing over sand and gravel deposits (known as a terrace) left by the Smoky Hill River when it flowed at a higher level during the Ice Ages, about 250,000 years ago.	(0.2)
3.5	To the left (west) are sand and gravel pits in Smoky Hill River terrace deposits.	(1.1)
4.6	Climb through hills formed in the Kiowa Formation.	(0.7)
5.3	These uplands are formed in the Dakota Formation.	(4.0)
9.3	Avenue K. Turn left (west) following a sign pointing the way to Mushroom Rock State Park.	(0.5)
9.8	The big blue water storage tank to the north belongs to the Post Rock Rural Water District.	(1.5)
11.3	Continue west. The road to the north leads 1 mile to Carneiro. This town bears the Spanish name for "sheep" and was once a important shipping point for sheep on the Union Pacific. Carneiro is the site of Alum Creek Station on the Smoky Hill Trail, an early road to the Colorado gold strikes and later a stage route between Kansas City and Denver. This stretch of the trail was also a military trail connecting Fort Riley with Fort Harker in Kanopolis and Fort Larned on the Santa Fe Trail.	(0.5)

11.8 **STOP 2. Mushroom Rock State Park.** This will be our lunch stop. At about 5 acres, this also is the smallest state park in Kansas. Numerous sandstone concretions are found here on both sides of the road. These sandstone concretions occur in the lower part of the Dakota Formation or upper Kiowa Formation. The concretions represent local features within the sandstone where the sand grains have been cemented together by lime (calcium carbonate) carried in solution and deposited by circulating ground water sometime after the sandstone was deposited. The lime cement was deposited concentrically and grew outward from a nucleus. During the process of weathering and erosion, the softer sandstone has been removed, leaving behind the firmly cemented concretions. These hard, dense, light-gray sandstones are locally termed "quartzite." This "quartzite" is a sedimentary rock. The term "quartzite" also is given to a metamorphic rock that was originally composed of sandstone, but, through heat and pressure, was changed into a much harder, denser rock. The pink boulders that dot the landscape of northeastern Kansas are called Sioux quartzite and are the metamorphic form of the rock. This sedimentary "quartzite" sandstone is mined today in a quarry south of Lincoln, and has been mined in the past at other locations in central Kansas. Because it is hard, it is a valuable construction material and was used for rip rap on Kanopolis Dam. In the portion of the park south of the road is Pulpit Rock, a concretion that stands on a softer sandstone pedestal (fig. 4).

Fig. 4—Pulpit Rock at Mushroom Rock State Park.

Total Mileage		Point-to-Point Mileage
0.0	After STOP 2, zero out odometers and continue west.	(0.1)
0.1	Alum Creek.	(0.4)
0.5	"T" intersection. Turn right (north) on 25th Road. A large clay pit is visible to the southwest. This is one of many clay pits in Ellsworth County in the Dakota Formation that supply the raw material for the Acme Brick Company plant in nearby Kanopolis.	(0.3)
0.8	Union Pacific Railroad crossing. **WARNING! This crossing has no warning equipment. STOP, LOOK, AND LISTEN.** This is the main line between Kansas City and Denver and is a busy railroad.	(0.7)
1.5	Kansas Highway 140. Turn left (west). This state highway was once U.S. Highway 40. The nation's first coast-to-coast highway, it also was known as the "National Road," stretching from Atlantic City to the west coast. Known locally as "old highway 40," K–140 parallels the Union Pacific Railroad just to the south. Once known as the Kansas Pacific, this branch of the Union Pacific was built in 1867 and was the key link in opening up the cowtowns of Abilene, Salina, Ellsworth, and Hays as destinations and shipping centers for Texas cattle being driven north on trail drives.	(0.6)
2.1	At the crest of this hill we pass through a Dakota Formation road cut.	(1.4)
3.5	Turn right (north) on 23rd Road. We will be traveling across the Dakota Formation for the next 4.2 miles. Three miles to the southwest is the Kanopolis Salt Mine. Salt was discovered in Ellsworth County in 1887 and has been produced in Kanopolis since 1891. The shaft for this mine was sunk in 1914 to a depth of 850 feet, producing from a 10-foot interval of the Permian-age Hutchinson Salt Member of the Wellington Formation. It is the oldest, continually operated salt mine in the state. In 2000, an abandoned salt mine shaft next to the Acme Brick Company plant exploded and shot discarded bricks and other debris into the air, damaging nearby buildings and cars. The old shaft had been used as a dump and then capped over. Engineers think that pressure generated from the buildup of water in the old mine workings increased to the point where the surface cap failed, and the released air caused the "eruption."	(4.5)
8.0	This ridge is capped by the Graneros Shale, the formation above the Dakota. The elevation is 1720 feet.	(1.0)
9.0	To the right (east) is another clay pit in the Dakota Formation.	(0.8)
9.8	This ridge is capped by the Greenhorn Limestone.	(1.0)
10.8	This tributary of East Elkhorn Creek flows south-southwest 3 miles and then makes a U-turn and flows almost due north into East Elkhorn Creek. Its drainage	

Total Mileage		Point-to-Point Mileage

has been captured by a rapidly eroding north-flowing stream in a process known as stream piracy (fig. 5). From here we climb through the Graneros Shale up into the Greenhorn Limestone. (0.7)

11.5 Avenue B. Turn right (east). The next 6.3 miles is an ungraveled, fair weather road, and is extremely muddy during and after rain. The Carlile Shale (the formation above the Greenhorn Limestone) caps this hilltop. (0.6)

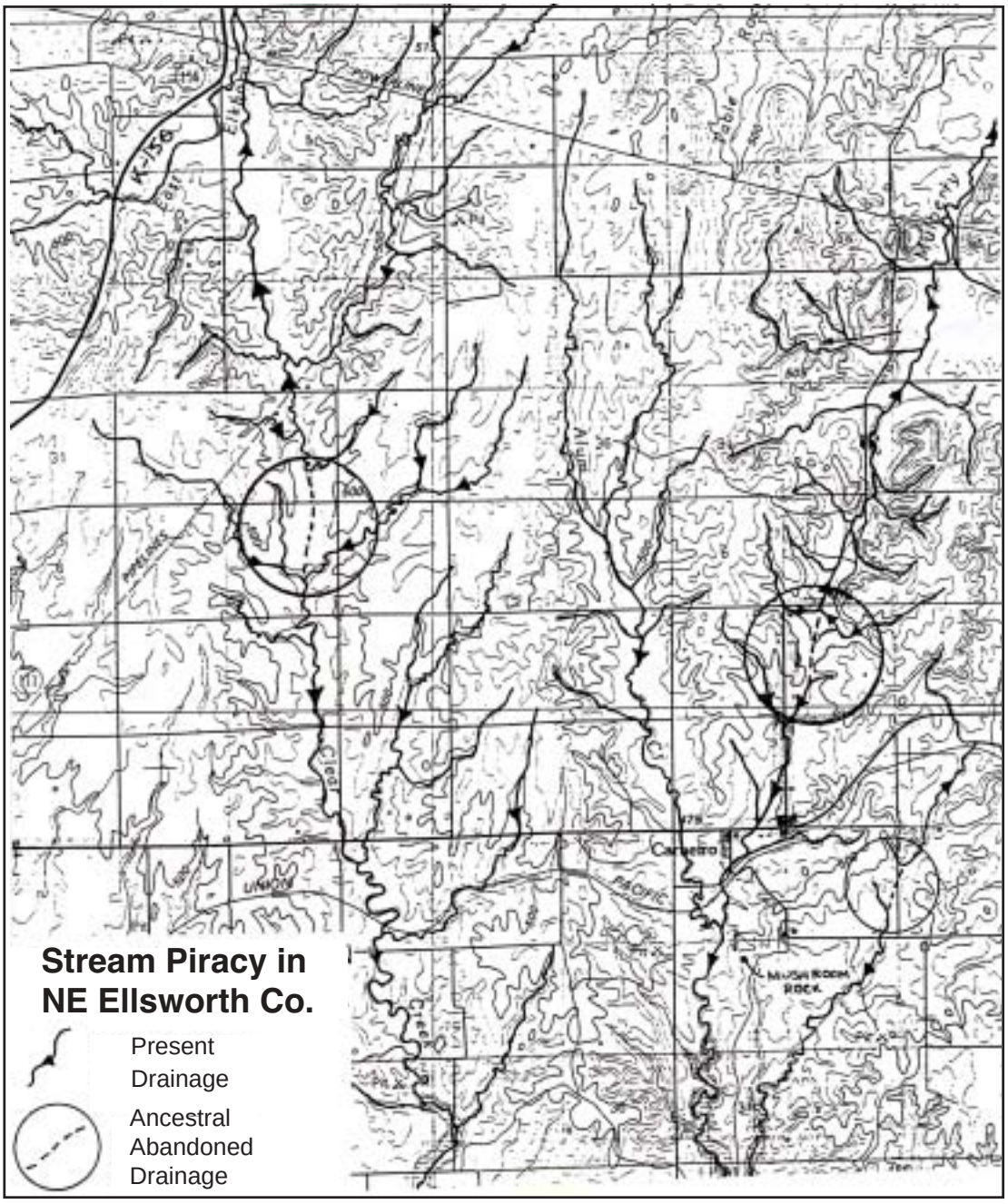

Fig. 5—Stream piracy in northeast Ellsworth County.

Total Mileage		Point-to-Point Mileage
12.1	The small barn on the right (south) side of the road is made from Fencepost limestone, a thin, 8–12-inch bed of limestone at the top of the Greenhorn Limestone. Although thin, it occurs over a wide area of central and western Kansas and has been extensively quarried for fenceposts, building stone, and more recently, for decorating, landscaping, and signs.	(0.4)
12.5	The fence line on the left (north) side of the road is made from Fencepost limestone (fig. 6).	(0.5)

Fig. 6—Greenhorn Limestone fenceposts.

13.0 **STOP 3. Greenhorn Limestone.** Park on the top of the hill as far to the right as is safe so that other vehicles can pass. The elevation here is 1810 feet, 400 feet above the Smoky Hill River below Kanopolis Dam. Thin beds of sandstone in the Carlile Shale are found at the top of the hill. Down the hill are fossiliferous outcrops of Greenhorn Limestone, and below the Greenhorn, the gray Graneros Shale is exposed.

The Greenhorn Limestone consists of several thin limestone beds, 3 to 12 inches thick, separated by somewhat thicker chalky shale beds. The limestone beds contain numerous inoceramid clams (fig. 7) and smell like natural gas or crude oil when freshly broken.

The Graneros Shale was deposited in deeper, offshore marine waters of normal salinity. The gray, silty shale characteristically weathers into brittle, small flakes. Although fossils are not obvious at first glance, they do occur throughout the formation, mainly as casts and in thin limestone beds.

Fig. 7—Inoceramid clam from the Greenhorn Limestone.

Total Mileage		Point-to-Point Mileage
0.0	After STOP 3, zero out odometers and continue east.	(1.0)
1.0	In the pasture to the right is a small landslide in the Dakota Formation.	(0.5)
1.5	26th Road. Continue east.	(0.1)
1.6	Cross Table Rock Creek and then bear to the right. The elevation is 1530 feet.	(1.1)
2.7	The flat-topped hills to the right (south) are capped by a thin, 3-feet-thick siltstone in the Dakota Formation. Siltstone is a very fine grained sedimentary rock composed of particles that are smaller than those that make up sandstone.	(0.9)
3.6	28th Road. Continue east and curve around a prominent Dakota-capped mesa.	(1.2)
4.8	29th Road. Turn right (south).	(0.4)
5.2	Mulberry Creek. The elevation is 1435 feet. This creek flows into the Saline River just north of Salina, about 20 miles east of here.	(0.2)
5.4	Crossbedded sandstone in the Dakota is exposed in a road cut.	(0.3)
5.7	Curve to the right (west) on Avenue C.	(0.4)
6.1	Mulberry Creek.	(1.1)
7.2	Curve south at entrance to the Rolling Hills Ranch.	(1.8)
9.0	Mulberry Pass, a wind gap carved in the Dakota Formation, exposing sandstone on both sides of the road. The elevation is 1630 feet.	(0.8)
9.8	Dakota sandstone on right (west) side of road.	(0.4)
10.2	Palmer's Cave is west of the road on private property. Palmer's Cave is an erosional feature in an outcrop of Dakota sandstone. The cave itself is a passage about 15 feet long, created by the seepage of water from a spring that issues here. The cave is probably most notable for the Indian petroglyphs that were carved into this soft sandstone, including tally marks and geometric designs. Probably the best-known petroglyph here was a long, reclining figure, with large rays radiating from its head, that was carved onto the south face of the bluff that formed the cave. Unfortunately, a large section of rock spalled off the bluff in September 1995, shortening the cave and destroying the reclining figure and several other petroglyphs. A series of smaller cave salso are found in a bluff of Dakota sandstone along the creek.	(1.2)

Total Mileage		Point-to-Point Mileage
11.4	The barns on the left (east) are made from sandstone from the Dakota Formation.	(0.1)
11.5	Mulberry Creek. The elevation is 1560 feet.	(1.0)
12.5	Curve to the west on Avenue H.	(0.2)
12.7	Mulberry Creek.	(0.3)
13.0	Curve to the south on 26th Road.	(0.3)
13.3	Cross a ridge (elevation 1675 feet) marking the present-day drainage divide between Alum Creek and the Smoky Hill River to the south and Mulberry Creek and the Saline River to the north. The upper part of the Alum Creek drainage appears to have been captured by stream piracy perpetrated by rapid headward erosion in the present-day Mulberry drainage basin, similar to the piracy that appears to have taken place to the west in East Elkhorn Creek (see fig. 5). The U-turns that creeks make near their mouths—sometimes called barbed drainage—are tell-tale signs of stream piracy. The Saline River has cut a valley that is 140 feet deeper than the Smoky Hill River valley in this area. A much more dramatic example of stream priacy occurred on the Smoky Hill River during the Ice Age. Previously the Smoky Hill flowed south into the Arkansas River. But south of here in northern McPherson County, a tributary of the Kansas River eroded headward late in the Ice Age and captured the flow from the Smoky Hill. As a result, today's Smoky Hill River makes an abrupt turn in McPherson County and flows north to Salina before joining the Republican River at Junction City and becoming the Kansas River.	(1.7)
15.0	K-140. Turn left (east). The elevation is 1530 feet.	(2.8)
17.8	Junction with K-141. Turn right (south). After making the turn, Buzzard Roost is on the left (east).	(0.6)
18.4	Union Pacific Railroad overpass. About 1.5 miles east along the railroad is a siding and former town named Terra Cotta. Terra Cotta is Italian for "baked earth" and is the name of the type of ceramic material used in making common flower pots, roofing tiles, and other products. The Dakota in outcrop is often the brownish-red color of terra cotta and the lower portion is named the Terra Cotta Member for exposures in this area. Numerous clay pits can be found in this region that supply the Acme Brick plant in nearby Kanopolis with raw materials. Terra Cotta was a major cattle shipping center around the turn of the century. Today a siding and a cemetery are all that remain.	(0.2)

Total Mileage		Point-to-Point Mileage
18.6	On the left (east) is a butte capped by a massive sandstone in the Dakota Formation known as Castle Rock. Its elevation is 1660 feet.	(1.4)
20.0	Avenue K, which runs west to Mushroom Rock State Park. Continue south on K-141 and backtrack to Langley Point Group Shelter in Kanopolis State Park south of the dam, where the field trip began.	(9.5)
29.5	Langley Point Group Shelter. Turn right (east) and go a short distance to the end of the road.	

STOP 4. Caving Banks Area—Kiowa Formation. The base of this exposure is approximately 20 feet above the contact between rocks of Cretaceous and Permian age. The outcrop probably represents a lowering of sea level from open marine deposition at the base (the dark-gray shale) to a possible beach deposit (the sandstone) at the top. The dark-gray shale at the base of the exposure contains marine invertebrates (mostly bivalves and gastropods) that lived on or just beneath the sediment-water interface. The shells are not abraded nor concentrated by currents and are thought to have accumulated where they died. The coquina shell-beds (gastropods and bivalves) probably formed from the winnowing of mud by storm-generated currents. Upward in the section, the proportion of sandstone increases, the abundance of marine fossils decreases, and the abundance of plant fossils increases.

Snail shells (*Turritella* sp.) that have largely been replaced by pyrite, cone-in-cone structures (fig. 8), crustaceans, and several bivalves can be found at this locality. Fish scales, teeth, imprints of small bivalves, and rarely, a small lobster can be found by carefully splitting the shale along its layers.

Fig. 8— Cone-in-cone structure from the Kiowa Formation.