KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 96-41

Field Trip To
The Kanopolis Lake Area

Kansas Earth Science Teachers Association
Fifth Annual Fall Field Trip
October 5, 1996

by

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Jim McCauley
Bob Sawin

KANSAS GEOLOGICAL SURVEY
1930 Constant Avenue
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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. 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 Western Interior Seaway (fig. 2) was continuous from the Gulf of Mexico to the Arctic Ocean (Williams and Stelck, 1975).

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 (Bayne, et al., 1971).

Description. Shale, fissile, medium to dark gray, and black. Contains thin sandstone bodies throughout and a persistent, thick, light-colored sandstone at the top. Beds of cone-in-cone, "quartzitic" sandstone, siltstone, and thin limestone are common (Bayne, et al., 1971). Pyrite, marcasite, gypsum crystals, ironstone concretions, lignitized wood fragments and logs, and marine invertebrates (mainly bivalves and gastropods) are found in the shales. A marine molluscan fauna occurs in the limestone.

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 hematitic (iron) stain and cement color it reddish brown. Barite rosettes, ripple marks, and cross-bedding can be seen in the sandstones.

Environment of Deposition. 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, and onto the gently dipping western flank of the Nemaha anticline in central Kansas (Franks, 1979). The climate was probably warm and humid (Franks, 1975). 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 (Bayne, et al., 1971).

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 non-marine Dakota Formation (Bayne, et al., 1971).

Cone-in-cone. Cone-in-cone structure forms oval-shaped concretions and discontinuous lenses in the Kiowa Formation in many parts of Ellsworth County. Formation of cone-in-cone is attributed to precipitation and growth of fibrous crystals of calcite soon after the sediments were deposited. A unique set of physicochemical 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

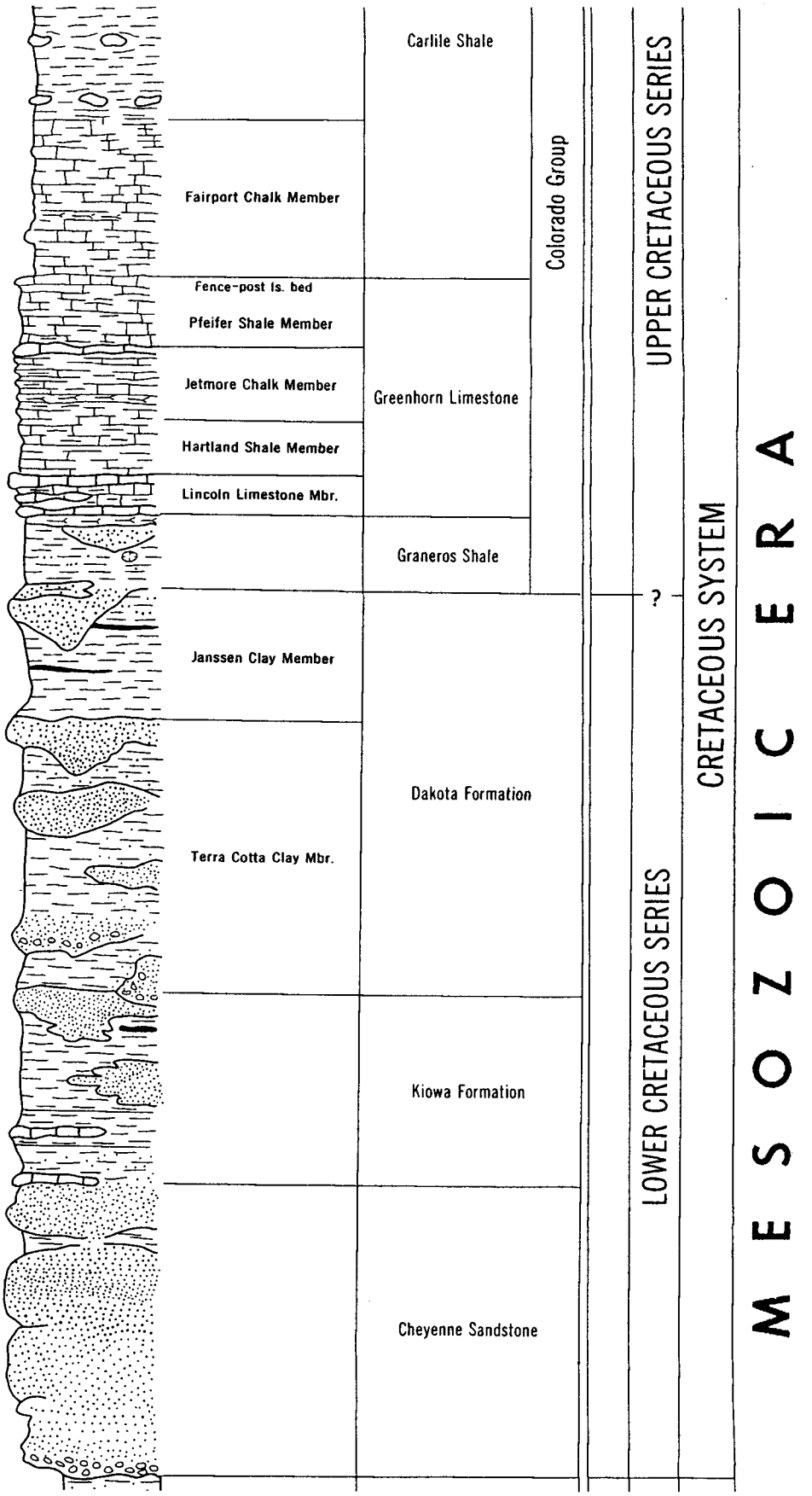


Figure 1. Stratigraphic classification of Lower Cretaceous rocks in Kansas (from Zeller, 1968).

Figure 2. Paleogeographic map of North America during Lower Cretaceous times (from Williams and Stelck, 1975).

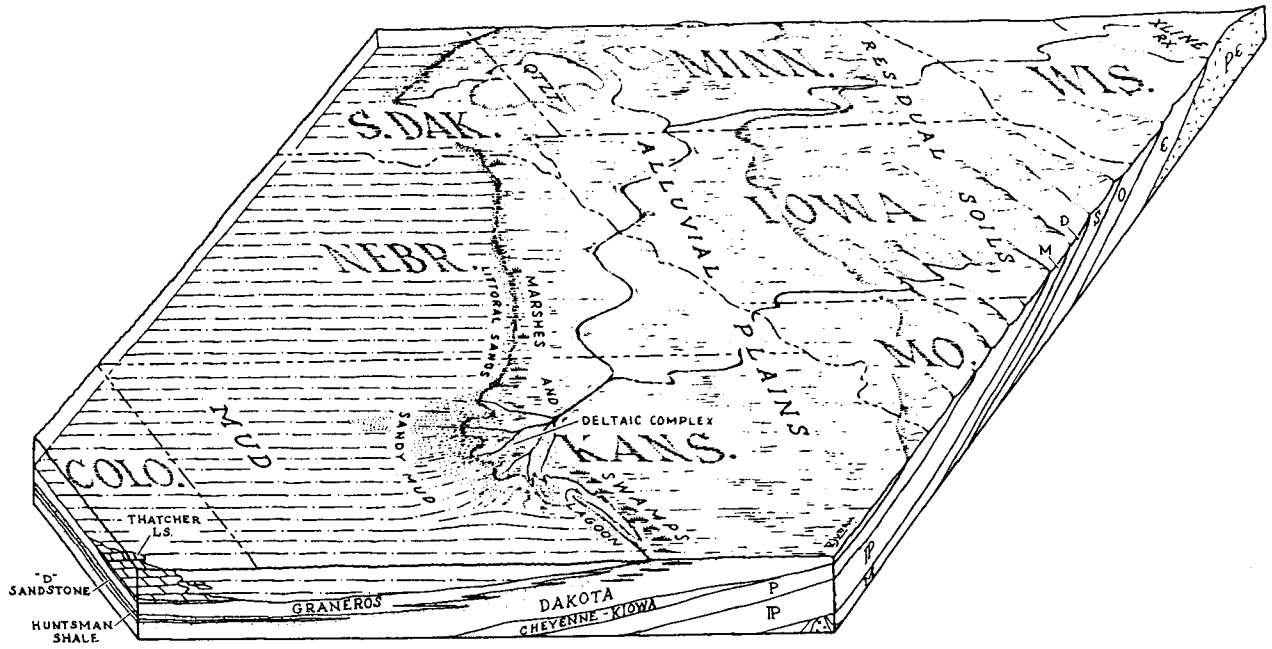


Figure 3. Paleogeographic reconstruction of central Kansas during deposition of the Dakota and Graneros Shale formations (from Hattin, et al., 1978).

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 (Franks, 1969).

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 abundant euhedral crystals of gypsum (selenite) measuring up to 7 inches in the long dimension. Radial aggregates (sunbursts) of gypsum may also 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 (Bayne, et al., 1971).

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. Although the Dakota is thought of as primarily sandstone, the dominate lithology is light-gray to light-greenish-gray siltstone or clay dappled with abundant red to reddish-brown mottles. Clay and siltstone are estimated to compose as much as 70 percent of the thickness of the Dakota Formation in many areas. In Ellsworth County, the Dakota Formation ranges from 190 to 250 feet thick (Bayne, et al., 1971).

The Dakota Formation has been divided into two members in central Kansas (Plummer and Romary, 1942). In general, gray and dark-gray beds of siltstone and clay, and beds of lignite, are confined mostly to the upper third of the Dakota. Red-mottled siltstone and clay are found mainly in the lower two-thirds. The usefulness of these member names lies mainly in their gross lithologic differences and in the economic utility of the contained clays (Bayne, et al., 1971).

Description. Clay, silt, shale, sandstone, and siltstone, locally cemented with hematite and limonite. Contains lignite and locally, beds of "quartzitic" sandstone (light-gray, hard, calcite cemented). Colors are white, red, gray, brown, and tan (Bayne, et al., 1971). Cross-bedding is a prominent feature in most sandstones in the Dakota.

Environment of Deposition. The Dakota Formation is generally thought to have been deposited during the retreat of the Kiowa sea under nonmarine conditions in a low-lying coastal or deltaic plain bordering the Cretaceous sea (fig. 3). 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 (swampy conditions). Sandstones in the Dakota Formation were deposited mainly by streams and rivers. Imprints of oak, willow, walnut, sycamore, magnolia, laurel, and sassafras leaves indicate the climate was mild (Bayne, et al., 1971).

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.

Cross-bedding. Cross-bedding 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, cross-bedding is found in dune, stream channel, or delta deposits. The direction in which the beds are inclined is usually indicative of the direction the current of water or air was flowing at the time of deposition.

KIOWA-DAKOTA CONTACT

The upper part of the Kiowa and the lower part of the Dakota formations can be difficult to tell apart and the exact boundary between the two is based on interpretation.

Sandstones in the upper Kiowa are interpreted as (marine) delta-front sands, barrier bars, offshore bars, and tidal-current bars deposited near the margin of the Kiowa sea (Franks, 1975). Recent work by Hamilton (1989) interprets the sandstones in the upper part of the Kiowa Formation as being deposited by streams within incised valleys (fluvial, nonmarine deposits) and should therefore be part of the Dakota Formation. The basal Dakota Formation boundary is an erosional surface (according to Hamilton, 1989) that separates the underlying marine to deltaic deposits of the Kiowa Formation from the terrestrial facies of the Dakota Formation, although the exact nature (and position) of the boundary is under some dispute (Feldman, 1994). Because of the interfingering nature of the deposits, distinguishing marine from nonmarine deposits where a fluvial system (rivers, deltas) enters the ocean is problematic. However, for the most part, the Kiowa was deposited in a shallow marine environment and the Dakota in a fluvial nonmarine environment.

The "quartzite" concretions often occur near this disputed boundary, and have been described in both the Kiowa and Dakota Formations. More than one bed of concretions have been observed (Bayne, et al., 1971 and Fent, 1950); they may, in reality, occur in both units.

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 groundwater level declines in the Ogallala Formation of western Kansas, underlying Cretaceous rocks may be an important source of water. For the sake of that discussion, water specialists often refer to the Dakota, Kiowa, and underlying Cheyenne Sandstone formations as one unit -- the Dakota aquifer. Their research has shown that because this aquifer varies greatly from place to place, it will probably never be as important as the Ogallala Formation, but with careful management could produce significant amounts of water.

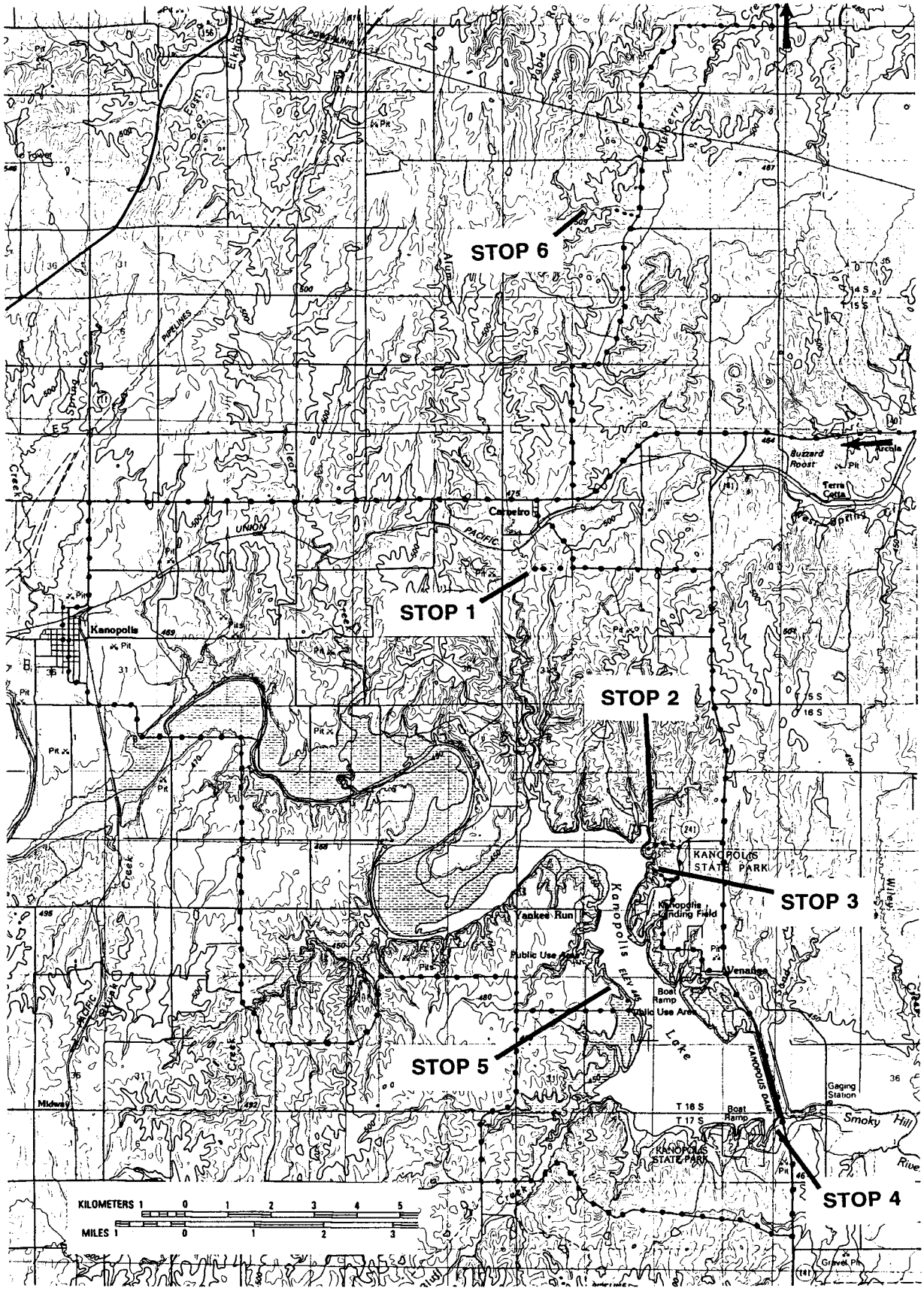


Figure 4. Kanopolis Lake Area field trip route.

ROAD LOG

See Figure 4, Kanopolis Lake Area Field Trip Route. The following field trip guide begins in Salina, makes several stops around Kanopolis Lake in the Dakota and Kiowa formations, then returns to Salina. Total elapsed mileage 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.

Miles

0.0 From the College Center at **Kansas State University-Salina**, proceed east to Centennial Avenue and turn north. KSU-Salina is located at the former Schilling Air Force Base, once part of the Strategic Air Command. The base was closed in the 1960s and made into an industrial park and the local municipal airport. The main north-south runway is 2.7 miles long and can be used as an emergency landing site for the Space Shuttle.

(1.0)

1.0 Pass under **Interstate 135** overpass.

(0.1)

1.1 **Dry Creek** has its source in the Dakota-capped hills west of Lindsborg in northern McPherson County. Dry Creek is a Yazoo-type stream flowing along the edge of the floodplain of the Smoky Hill River for 20 miles, much in the manner of the Yazoo River in Mississippi, which shares the floodplain of the Mississippi River but is separated by natural levees.

(0.9)

2.0 **Crawford Street**. Turn west.

(0.1)

2.1 **Dry Creek** (elevation 1220 feet). This creek empties into Mulberry Creek on the north edge of Salina, which in turn flows into the Saline River just north of Interstate 70.

(0.2)

2.3 Pass over **I-135** and continue west over a broad alluvial valley carved in the soft shales of late Permian age.

(3.0)

5.3 **Kansas Highway 140**. Turn southwest (left). This state highway was once federal highway U.S. 40. The nation's first coast-to-coast highway, it was also known as the "National Road," stretching from Atlantic City to the west coast. K-140 (known locally as "old highway 40) 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.

(3.7)

9.0 **Bavaria**. This small town was originally named Honek, for its postmaster, but the name was later changed to reflect the German background of many early settlers.

(0.4)

9.4 **Spring Creek**. This is the most common stream name in Kansas. Spring Creek flows into Mulberry Creek four miles to the northeast.

(2.4)

11.8 The road south leads to the **Smoky Hill Air National Guard Bombing Range**, the northern boundary of which is 1.7 miles south. This range, used primarily for bombing practice by pilots from Wichita's McConnell Air Force Base, covers nearly 50 square miles of Smoky Hills pastures. The prominent hill four miles to the south is Soldier Cap Mound, named for its likeness to Civil War headgear. Its elevation is 1578 feet, 370 feet higher than the elevation at this point.

(0.9)
12.7 The road curves to the west, ascending the **valley of West Spring Creek**.

(3.0)
15.7 **Brookville**, home of the Brookville Hotel and its famous chicken dinners.

(2.4)
18.1 The prominent hill just north of the highway is capped with sandstone in the **Dakota Formation**. The lower slopes are formed on the Kiowa Formation.

(1.2)
19.3 **Saline County/Ellsworth County line**. This is also the entrance to the C-K Ranch. The railroad curves to the south here and just to the south is the railroad siding and former station with the Italian name of Arcola, which was once named Rock Springs. Elevation is 1420 feet. Ellsworth County was named after Fort Ellsworth, which was probably named for Civil War soldier Allen Ellsworth.

(0.8)
20.1 Just south of the road are Dakota Formation **concretions** similar to those at Rock City, south of Minneapolis in Ottawa County. This stretch of highway appears in the 1985 bicycling movie "American Flyers" that starred Kevin Costner and Rae Dawn Chong.

(0.7)
20.8 **Dakota sandstone** crops out just to the south. The Dakota-Kiowa contact is at about road level. To the west we climb into the Dakota Formation and will remain in it until we approach Kanopolis State Park and Stop 2.

(0.1)
20.9 The **spring** just south of the highway issues from the base of the Dakota Formation.

(0.5)
21.4 The sandstone-capped butte to the south is **Buzzard Roost**. Just over the hill is another 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 member 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.

(0.5)
21.9 **Kansas Highway 141** leads south to Kanopolis Lake. Continue west. Elevation 1530 feet.

(0.2)
22.1 Road cut in the **Dakota Formation**.

(3.2)
25.3 Turn south at the abandoned canopy-style gas station and enter **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.

(0.4)
25.7 **Road forks**, bear left.

(1.0)
26.7 **T**, turn west.

(0.5)
27.2 **STOP 1. Mushroom Rock State Park.** 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 colored sandstones are locally termed "quartzite." This "quartzite" sandstone is mined in a quarry south of Lincoln (Buchanan, personal communication), and has been mined locally and at other locations in central Kansas. Because it is hard, it is a valuable construction material and was used for rip rap on the Kanopolis Dam. In the portion of the park south of the road is Pulpit Rock, a concretion that stands on a softer sandstone pedestal. Turn around and backtrack to the east following our visit.

(2.7)
29.9 **K-141**, turn south.

(0.7)
30.6 The elevation is 1675 feet, the highest elevation on this trip. These **uplands** are in the Dakota Formation.

(3.3)
33.9 Here the highway drops from the Dakota Formation into the **Kiowa Formation**.

(2.1)
36.0 Turn west on **Venango Road** named for the Venango Post Office, once located in this area. It was named for Venango County, Pennsylvania.

(0.3)
36.3 **Turn north.**

(0.4)
36.7 **Turn west.**

(0.1)
36.8 **State Park Office**. Stop here for vehicle permits and guides for Buffalo Track Canyon Nature Trail.

(0.5)
37.3 **Turn north.**

(1.0)
38.3 **Turn east.**

(0.6)
38.9 Make sharp turn to southwest. This hilltop is capped by the **Dakota**. Follow signs for Horsethief Canyon.

(0.6)
39.5 **STOP 2. Horsethief Canyon.**
Go north along the gravel road to the trailheads for hiking in Horsethief Canyon or hike along the lakeshore to the south and collect barite roses from the Kiowa Formation. Sand-barite rosettes (barium sulfate) are not scattered uniformly throughout the sandstone, but are arranged in clusters or groups. Their relative insolubility causes them to protrude above the weathered surface of the sandstone.

The thick sandstone body that outcrops along the shoreline of Kanopolis Lake in this area has been interpreted as an offshore marine barrier bar in the upper Kiowa Formation (Franks, 1975) or as a fluvial sandstone within the lower Dakota Formation (Hamilton, 1989). This sandstone outcrop is characteristic in thickness and lateral extent of sandstone bodies in the subsurface that are major conduits of groundwater.

(0.2)
39.7 **Trailheads** for Buffalo Track Canyon Nature Trail and the Horsethief Canyon Trail. Markers along the Buffalo Track Canyon Trail correspond to stops in the trail guide.

(1.4)
41.1 Backtrack 1.4 miles to **turnoff for Corral Group Shelter**, and turn right.

(0.4)

41.5 **STOP 3. Lunch - Corral Group Shelter.**
After lunch return by the same route to K-141. The Kiowa Formation is exposed along the shore of Kanopolis Lake below the shelter house. This outcrop exposes marine Kiowa Formation in the lower part and a cross-bedded sandstone (either upper Kiowa or lower Dakota) in the upper part (fig. 5). Shallow marine conditions in the lower sandstone are suggested by ripple marks, which are very visible here, and burrows. The contact with the cross-bedded sandstone is sharp and erosional. The lowest meter of the cross-bedded sandstone contains shale clasts and large blocks of lignitic sandstone, and lacks fossils and burrows (Feldman, 1994). The upper sandstone is interpreted as an offshore barrier bar (Franks, 1975) or as fluvial channel deposits (Hamilton, 1989).

(2.8)

44.3 **K-141**. Turn south and proceed across Kanopolis Dam. This reservoir was built in 1948 by the U.S. Army Corps of Engineers, making it the oldest of the major Corps reservoirs in the state. The dam is three miles long and 131 feet above the stream bed. The outlet tunnel is 14 feet in diameter and 2443 feet long. Normal pool elevation is 1459 feet.

(2.6)

46.9 **STOP 4. Dam Control Tower Outcrop -- Kiowa Formation.**
Turn west at the south end of the dam on the road to Kanopolis State Park. Park near the gravel road leading to the outlet structure and hike northwest to the outcrops near lake level, south of the outlet control tower.

The base of this exposure is approximately 20 feet above the Cretaceous-Permian unconformity. The outcrop consists of a shallowing upward succession from open marine deposition at the base to a possible beach deposit at the top (fig. 6) (Feldman, 1994). The 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 (Scott, 1970). The coquina shell-beds (gastropods and bivalves) probably formed from the winnowing of mud by storm-generated currents (Scott, 1967). Upward in the section, the proportion of sandstone increases, the abundance of marine fossils decreases, and the abundance of plant fossils increases. An increase in energy is indicated by the upward succession from shale, to thin sandstone beds, to thick, cross-bedded sandstones (possible beach deposit) (Feldman, 1994).

Pyritized gastropods (*Turritella* sp.), cone-in-cone structures, 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 laminations.

After collecting here and visiting the control tower, return to K-141 and proceed south.

(0.8)

47.7 **Post Rock Rural Water District** on east side of highway.

(0.5)

48.2 This small creek can act as the **outlet for Kanopolis Lake** when it reaches high levels and flows through the emergency floodway one mile west. This creek ultimately flows into the Smoky Hill River two miles to the northeast. This creek cuts down into the Ninnescah Shale of Permian age just west of the highway. Rocks of Triassic and Jurassic ages are missing between the Ninnescah and the overlying Kiowa Shale. The Ninnescah Shale is the oldest rock exposed in Ellsworth County.

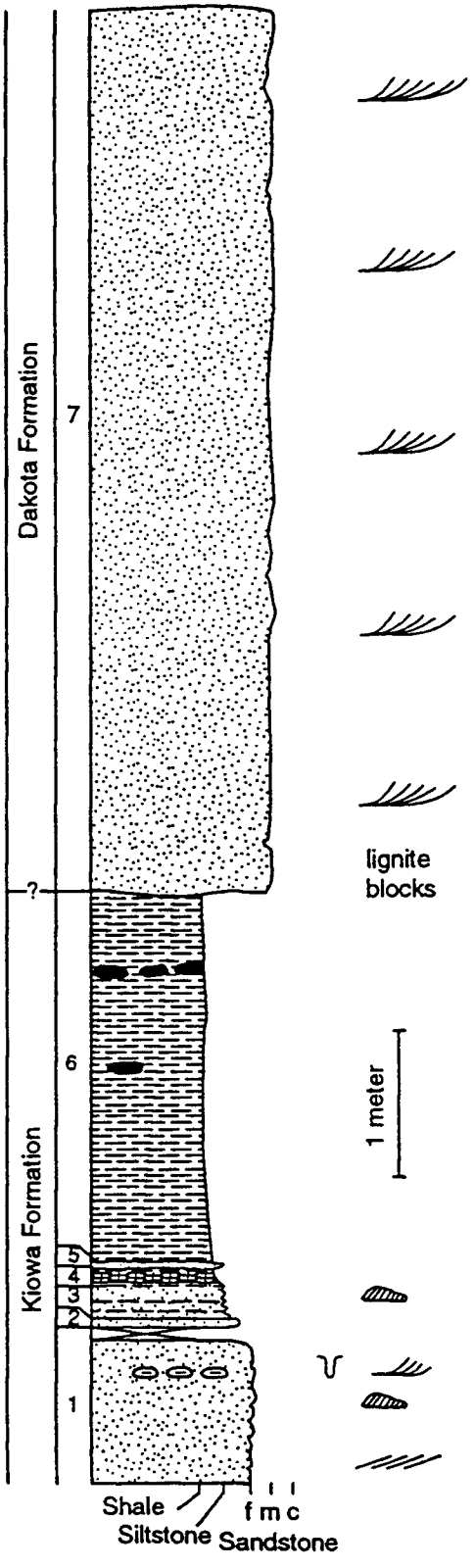
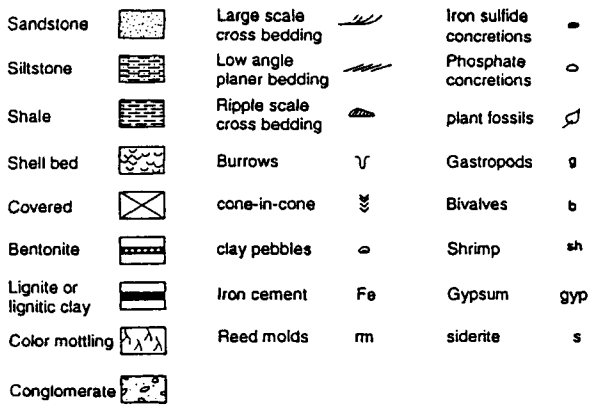


Figure 5. Graphic section at Stop 3 (from Feldman, 1994).



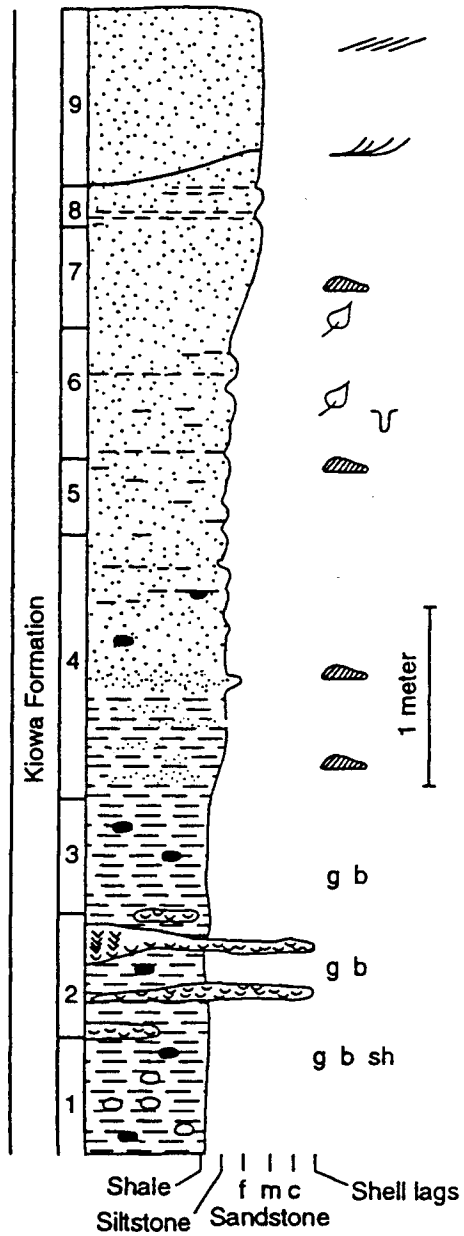


Figure 6. Graphic section at Stop 4 (from Feldman, 1994).

(0.2)
48.4 **Turn west** on gravel road.

(1.3)
49.7 To the north is the **emergency floodway** for Kanopolis Lake. At high levels water can flow out of the lake here rather overtopping and possibly destroying the dam.

(1.3)
51.0 The road drops down through sandstone outcrops near the **base of the Dakota Formation**.

(0.3)
51.3 Gray shale in the **Kiowa Formation**.

(0.2)
51.5 **Kiowa Formation**.

(0.2)
51.7 The road climbs back up into sandstone in the **Dakota**.

(0.4)
52.1 **Sherman Ranch**. Established in 1897, this became one of the largest ranches in Kansas, reaching 40,000 acres in area.

(0.2)
52.3 Sandstone in the **Kiowa Formation**.

(0.4)
52.7 **Bluff Creek**.

(0.8)
53.5 **Crossroads**. Turn north toward Yankee Run.

(2.1)
55.6 Sandstone and shale in the **Kiowa Formation**.

(0.7)
56.3 Turn east. This corner is near the **base of the Dakota**. Much of this upland is covered by river terrace deposits from the time of Kansan glaciation, about 350,000 years ago. The road descends to the east into the Kiowa Formation.

(1.7)
58.0 **STOP 5. Boldt Bluff .**
Park in the camping area and follow the off-road vehicle trail north to the collecting site in Kiowa shale at the end of the point. The Kiowa Formation here is similar to the exposures at Stops 2, 3, and 4. Notice the channels in the sandstone. Collect marcasite, lignitized wood, and gypsum (selenite) crystals. After Stop 5 backtrack 1.7 miles to T-intersection.

(1.7)
59.7 **T**, turn north.

(0.6)
60.3 Turn west, traveling across upland composed of **Kansas terrace material** covering the Kiowa.

(1.2)
61.5 **Clay pits** south of the road.

(0.8)
62.3 **Road curves to the south**.

(1.0)
63.3 Curve to the west traveling over the **Dakota Formation**.

(0.9)
64.2 Road drops down into the valley carved into the **Kiowa Formation**.

(0.5)
64.7 Curve to the north dropping down into the **Kiowa Formation** once again.

(0.7)
65.4 **Thompson Creek**, named for Smoky Hill Thompson who established a hunting ranch in this area in 1859. Legend has it that Thompson plowed his ground with a team of buffalo.

(0.5)
65.9 Pass a **slump** in the upper part of the Kiowa Formation and climb up in the Dakota. These slumps are common in Smoky Hills pastures when layers of shale in the Kiowa or Dakota formations

become saturated with water, then slide down the hillside. Such slumps were particularly common after the wet summer of 1993.

(0.1)
66.0 Geologists have mapped a small **fault** crossing the road in this location.

(1.1)
67.1 **Buckeye Cemetery**. The tombstones in this cemetery include one made of petrified wood, one made from Dakota sandstone, and another consisting of a plaque attached to a large piece of Sioux quartzite. Several graves from the Sternberg family are also found here. Charles Sternberg was a native New Yorker who moved to Kansas in the 1860s and settled on his brother's ranch in Ellsworth County, where he found a large, fossilized semi-tropical leaf in the Dakota. Because of that discovery, he later wrote, "I made up my mind what part I should play in life, and determined that whatever it might cost me in privation, danger, and solitude, I would make it my business to collect facts from the crusts of the earth." (Rogers, 1991). Sternberg spent most of his life searching for fossils, often collecting for paleontologists at museums and universities. His son George later joined him in the enterprise and they became famous for their finds from the Cretaceous chalks of western Kansas. The Sternberg Museum at Fort Hays State University is named for the Sternberg family. From here, continue north, dropping down from the Dakota onto Pleistocene terrace deposits that mantle underlying Kiowa Formation.

(2.6)
69.7 Turn west. Visible to the north across the Smoky Hill River is **Fremont's Knob**, a Dakota-capped butte named for John C. Fremont who passed through here following his first California Expedition.

(1.0)
70.7 **Smoky Hill River**. Elevation 1500 feet.

(0.5)
71.2 **Turn north**.

(0.5)
71.7 **Turn west**.

(0.6)
72.3 **Turn north**.

(0.3)
72.6 **Turn west**.

(0.3)
72.9 **Turn north**.

(0.6)
73.5 Turn west, go one block to the Main Street in **Kanopolis** and turn north. Two stone buildings to the east are remnants of Fort Harker. In addition, the guard house is preserved on the west edge of town as a museum. Fort Harker was established here in 1866 and was named for Civil War General Charles G. Harker, who had been killed at the battle of Kennesaw Mountain in 1864. During its operation, Fort Harker played host to generals Grant, Sherman, Custer, and Philip Sheridan, who operated from Fort Harker during his 1868-69 campaign against the Plains tribes. The fort was abandoned in April, 1872. The town's name comes from the combination of Kansas and the Greek word "polis," meaning city. Because of its central location in the state, Kanopolis was once promoted as the capital of Kansas and several city lots in the center of town were reserved for that purpose. In spite of support for the move from the Populist party in the 1890s, the capital has remained in Topeka.

(0.6)
74.1 North edge of **Kanopolis**. Turn east. Just to the north is one of the few surviving, still-operating drive-in theaters in Kansas.

(0.4)

74.5 Turn north on **Kansas Highway 111**. To the south is the Acme Brick Company, which uses clay from the Dakota Formation. To the east 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. The railroad to the south of here is the Union Pacific. This stretch of the railroad was constructed across Kansas in the 1860s--it reached Hays in 1867--and was known as the Kansas Pacific. To publicize its progress, the railroad hired Alexander Gardner to photograph scenes along the way. Gardner was a well-known Civil War photographer and took the last portrait of Abraham Lincoln before his assassination. In accompanying the railroad across Kansas, Gardner took many of the first photographs of Kansas towns, such as Hays and Ellsworth, and the earliest photographs of this area's geologic features, such as Mushroom Rocks, the petroglyphs at Horsethief Canyon, and Palmer's Cave. Most of Gardner's stereographs (or stereo photographs) are in a collection at the Kansas State Historical Society; KGS photographer John Charlton has attempted to rephotograph many of those same locations to compare changes in the landscape since Gardner's trip in 1867.

(1.5)

76.0 **K-140**. Turn east.

(1.2)

77.2 **Kanopolis Salt Mine** is one mile south.

(1.5)

78.7 Sandstone in the **Dakota Formation**.

(0.3)

79.0 **Clear Creek**.

(2.6)

81.6 Sandstone in **Dakota Formation**.

(0.5)

82.1 **Alum Creek**. Alum is a hydrated metallic sulfate, especially aluminum potassium sulfate.

(0.5)

82.6 **Carniero**. This small town was originally known as Alum Creek Station.

(0.5)

83.1 Turn north on **26th Road** following a tributary of Alum Creek.

(1.8)

84.9 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. This is shown in the accompanying topographic map (fig. 7). Similar piracy appears to have taken place to the west in East Elkhorn Creek. 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 is in this area.

(0.3)

85.2 **Turn east.**

(0.3)

85.5 **Mulberry Creek.**

(0.1)

85.6 Curve north descending **Mulberry Creek Valley**.

(1.0)

86.6 Cross **Mulberry Creek** again (elevation 1563 feet).

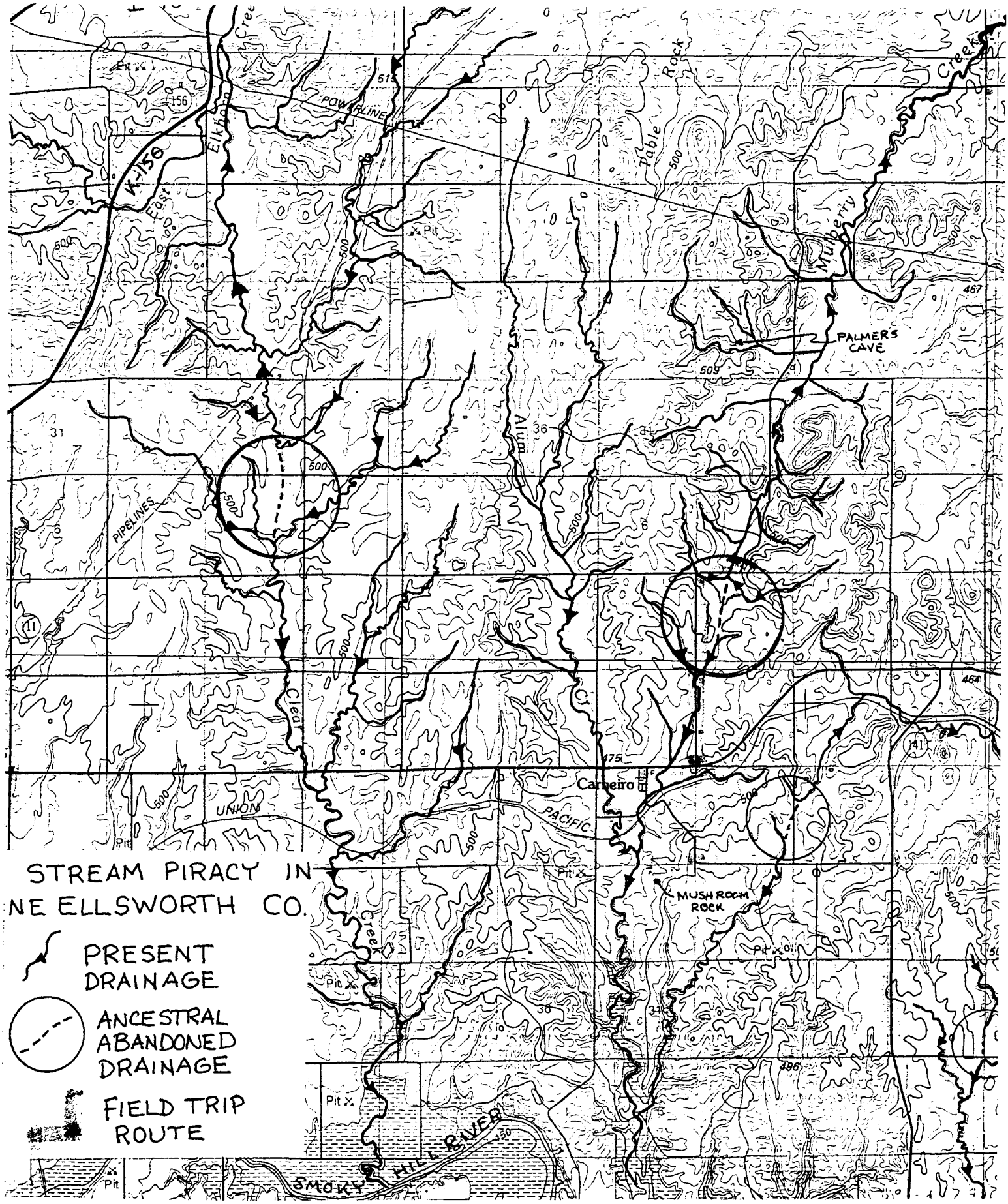


Figure 7. Stream piracy in northeast Ellsworth County.

(1.2)

87.8 **STOP 6. Palmer's Cave .** This driveway leads toward Palmer's Cave, 0.6 mile west-northwest of the road. 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 Dakota 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. After visiting the cave, continue north on the gravel road.

(0.6)

88.4 **Dakota sandstone** in road cut west of the road.

(0.7)

89.1 **Mulberry Pass**, a wind gap carved in the Dakota Formation.

(2.0)

91.1 **Curve to the east**.

(1.0)

92.1 **Mulberry Creek** (elevation 1458 feet).

(0.4)

92.5 Turn north at the **crossroads**.

(0.6)

93.1 **Mulberry Creek**. The creek flows into the Saline River just north of Salina, about 20 miles east of here.

(1.4)

94.5 **Table Rock Creek** (elevation 1440 feet). To the west four miles is a prominent escarpment formed by the Greenhorn Limestone.

(0.5)

95.0 **I-70**. Head east on I-70 and return to KSU-Salina/College Center via I-135 to Crawford Street, east to Centennial Avenue then south to College Center.

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