FIELD TRIP THROUGH THE GEOLOGY OF NORTHEASTERN KANSAS

by

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Kansas Geological Survey
Open-file Report 88-46

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THE 1988 SUMMER SOLSTICE FIELD TRIP: THE GEOLOGY OF NORTHEASTERN KANSAS

This trip is aimed at an explication of the geology of northeastern Kansas. It will cover approximately 300 million years of the state's geologic history, from Pennsylvanian stratigraphy near Lawrence to glacial deposition south of Wamego. It will cover some structural geology, including the spillway fault at Tuttle Creek Reservoir, the Nemaha uplift, and the Abilene anticline in northern Riley County. It will cover aspects of economic geology, by looking at a kimberlite in Riley County and the celebrated Poersch # 1 well in Washington County. And it will provide a couple of opportunities to collect fossils: Permian fossils at Buffalo Mound and Cretaceous fossils in the Greenhorn Limestone.

ROAD LOG

Begin at the Kansas Geological Survey, Lawrence. **Go south on Iowa Street (U.S. Highway 59), four miles west on 23rd Street, then one-half mile south to the Clinton Lake spillway.**

STOP 1. The CLINTON LAKE SPILLWAY provides a dramatic illustration of the cycles of deposition common during the Pennsylvanian Period of geologic history, about 300 million years ago. The interbedded limestone/shale sequence here, part of the Oread Formation, is common throughout eastern Kansas, and is probably the result of changing sea levels in the Pennsylvanian sea (copies of a measured cross section and discussion of the Clinton spillway, by Stephens and Watney, are available from Rex Buchanan). Where the water in that sea was deep (tens of feet, say), it deposited limestone. Where it was shallower, it left behind these gray shales. Beginning in the early 20th century, geologists began to discern the pattern to this limestone/shale deposition; a typical limestone/shale sequence was called a "cyclothem." R.C. Moore was one of the early proponents of the notion of cyclothems, and the concept is still strongly identified with him today. While the cyclicity of these deposits is obvious, the theory of cyclothems has sparked undying geologic arguments, which include disagreement over the environment when the rocks were deposited (dark black shales are a common component of a cyclothem, but people still argue about their significance. Moore said they were shallow-water deposits, but many people today think they represent deposition in the deepest part of the ocean) and the source of the sea level change (did the land move up and down, changing the sea level, or did the ice caps melt, releasing water into the oceans and raising the sea levels?). These arguments are important to current interpretation of geologic history, and may even have some economic importance, since a knowledge of stratigraphy helps geologists interpret well logs and search for oil.

The Oread Limestone is actually composed of four limestone beds and three intervening shale beds. This limestone/shale sequence is distinctly different from the shale beds that lie above and below. The Oread can be traced from far northeastern Kansas, south to Oklahoma. The three criteria used in defining geologic formations are a distinctive rock type or rock sequence, an observed separation from adjacent rock units, and traceability or mapability from one exposure to another.

The alternating limestone and shale sequence of Upper Pennsylvanian and Lower Permian rocks is reflected in the landscape of the eastern third of Kansas. These rocks dip at a slight angle to the west and northwest away from the Ozark Dome, an uplift in southeastern Missouri. Limestones are more resistant than shales to erosion and tend to cap hills and ridges, while gentle slopes are developed on the shales. The result is a series of escarpments or cuestas (Spanish for slope) that trend in a parallel north-south pattern across this end of the state. Each escarpment is capped by a limestone. Pilot Knob (which overlooks Leavenworth), the hills west of Tonganoxie, Mount Oread, and the high ground around Pleasant Grove south of Lawrence are all capped by the Oread Limestone and form part of the Oread escarpment, which, like the other escarpments in eastern Kansas, has a steep east-facing slope and a gentle west-facing slope that reflects the gentle westerly dip of the rocks away from the Ozark Dome. The entire sequence of Pennsylvanian and Permian rocks are arrayed like giant stairsteps across eastern Kansas. In traveling east to west across eastern Kansas, as we will on this trip, we continually climb up the steps or escarpments. In the process, we travel through geologic time by passing over and through rocks that are younger to the west.

Go 2.5 miles north from Clinton spillway. Here at the junction with U.S. Highway 40, the surrounding hills are capped by the Lecompton Limestone, the next limestone formation above the Oread. **Turn east and drive 4 miles to Rockledge Road in Lawrence.** In this stretch of highway, we will travel briefly on the Lecompton Limestone escarpment and descend its steep east face shortly before passing the office of Rural Water District # 1. From that point to Rockledge Road, we will travel on the gentle back slope of the Oread escarpment. **Proceed a mile north to the Turnpike** (Interstate 70) and descend the Oread escarpment. **Proceed west on I-70** through more Pennsylvanian formations, the city of Topeka, and western Shawnee County (for a detailed description of the geology and other fascinating information about this drive, see Buchanan and McCauley, 1987). In this drive you will see several more limestone/shale sequences that resemble the Oread Limestone. Cross into Wabaunsee County and, eight miles west of the county line, **take the exit at about milepost 338.2. Turn south, under the interstate, then back east for about 3/4**

mile, then go back north, under the interstate, and then east again. Stop at the top of Buffalo Mound.

STOP 2. BUFFALO MOUND. This hill, elevation 1,273 feet, is about 300 feet above Mill Creek valley to the north. The name reportedly came from its resemblance to a buffalo's back, but you have to have good eyes and a vivid imagination to see it. Buffalo Mound represents a line of demarcation between Pennsylvanian rocks, to the east, and Permian rocks, to the west; thus, the Mound is something of a landmark on the east edge of the Flint Hills, which are formed on Permian limestones, shales, and cherts. The contact between Pennsylvanian and Permian rocks is visible in the roadcut about a mile east of here. This contact is the location where Permian rocks are immediately above, or in contact with, Pennsylvanian rocks. This Pennsylvanian/Permian contact is conformable; that is, there is no drastic change in rocks above or below, no apparent interruption in the deposition from one geologic period to the next, and no obvious change in the fossils.

Buffalo Mound is formed on the Janesville Shale, overlain by the Foraker Limestone, which is an excellent source of fossils here. The hill is capped by the Grenola Limestone. Fossils here weather out of the limestone and shale, and are easily collected on the ground's surface. Probably the most common fossils are fusulinids, one-celled ocean-dwellers that resemble grains of wheat, but the hillside is also full of brachiopods (shelled, clam-like animals), crinoids (also known as sea lilies; you'll probably only find the disks that made up the stalks of these animals), bryozoans (colonial organisms, also known as "moss animals," whose fossils may resemble corals or may be net-like), corals, and maybe even a trilobite. In some locations the limestone is so full of fossils that it might better be called a coquina.

For non-geologists, paleontology usually evokes images of skeletons of dinosaurs, mastodons, and sabre-toothed cats haunting the halls of natural history museums. However, other forms of life, the invertebrates and their fossilized remains, are more useful to geologists in determining the ages of rocks and in correlating rock units from two separate areas (the Greenhorn Limestone, which we'll see later in the day, is characterized by profuse remains of a clam called *Inoceramus*. When you see a limestone with fossils of that species of *Inoceramus*, odds are good that it is the same age as the Greenhorn, no matter where you find it. Some fossils only show up in rocks of certain ages. Trilobites, for example, were extinct by the end of Permian Period, so that any rocks containing trilobites must be about 250 million years old or older. Also, because they lived at different times, you wouldn't expect to find fossilized trilobites and dinosaurs in the same rock, any more than you'd expect to see George Washington and Franklin Roosevelt in the same photograph). Invertebrates are especially important in older rocks formed before vertebrates evolved.

Even in later geologic periods, after the arrival of vertebrates, invertebrates are usually much more abundant in any given environment.

This abundance, together with the shorter life spans of invertebrates, creates many more potential fossils in any given span of time. Invertebrates must have hard parts in order to be preserved as fossils, so that animals with shells, spines, bony plates, or simple skeletons are the most likely to be fossilized. These hard parts, in turn, have to be deposited and buried in an environment that is conducive to their preservation.

Fossils are useful not only for correlating rocks and determining their age. They also record the evolutionary changes that organisms undergo in geologic time, and they reflect environmental changes. Most of the animals you'll find here at Buffalo Mound lived in shallow water. If that water was rocked by heavy waves, the fossils get broken into tiny fragments, indicative of what geologists call a "high-energy" environment. If conditions are more quiescent, or "low energy," the fossils are better preserved. Ask Chris Maples which kind of environment this is.

Return to I-70, then drive west 11 miles to the Kansas Highway 99 exit. Turn north and go 4.5 miles, parking on county road to the west.

STOP 3. The hill to the east is covered with GLACIAL BOULDERS. These boulders are a metamorphic rock called Sioux quartzite; this is rock that was previously sandstone but has been metamorphosed into quartzite, a much harder rock than sandstone. Some of these boulders show thin lines that probably represent billion-year-old evidence of seasonal, shallow water deposition where these sandstones were originally formed. Geologists call these rocks erratics because they aren't found originally in place in Kansas, but were probably hauled in by glaciers from the South Dakota/Minnesota/Iowa area where they crop out. The Kansan glaciation occurred several hundred thousand years ago. Because of the amount of time that has elapsed since the glaciers moved into Kansas, most other evidence of the glaciation has since been eroded away, unlike other areas, such as Wisconsin, where more recent glaciation still shows in the landscape in such features as drumlins or moraines. Geologists have long known about and commented on these glacial erratics in Kansas. The first state geologist of Kansas, Benjamin Franklin Mudge, thought they floated into Kansas on the backs of ice bergs, and fell to the sea floor when the bergs melted. Today's geologists think these erratics represent the southern edge of the glacier's advance into Kansas; no erratics are found south of here, meaning that we're very near the glacier's terminus. However, geologists are uncertain why so many quartzite boulders wound up on the same hilltop. Some geologists propose topographic reversal as an explanation. That is, this ridge may have been a valley floor in the past that filled up with boulders. The boulders may have made the valley more resistant to erosion than the surrounding rock, so that erosion broke down the valley walls until they were lower than the valley, leaving the boulder-chocked valley standing as a ridge. Other geologists believe that large crevasses opened in the thin glacial ice here near the terminus, and boulders fell into the cracks and were concentrated in this location (for a longer discussion of glaciation, and a picture of this hillside with the grass burnt off, see Dort, 1987; copies available from Rex). Geologists call this area a felsenmeer, German for "sea of rocks," and it's not hard to see why. While the erratics here are numerous, they're not particularly large. Much bigger boulders--the size of a pickup, say--are also found throughout this vicinity.

From the felsenmeer, take the dirt road west 3 miles. At the crest of a small hill looking southeast, we can see a notch in the line of hills that form the horizon. This notch is a wind gap, which had a former life as a water gap. In this location, the Kansas glaciation at one time dammed the Kansas River northeast of here, backing up the water into "Kaw Lake." The wind gap southeast of here was an outlet for this lake and thus served as a water gap at that time. Eventually the ice dam gave way, allowing the Kansas River to reoccupy its valley and leaving the water gap high and dry. The Rock Island railroad later used this pass through the hills for a branch from McFarland to Manhattan, taking advantage of the lower grade.

A half mile west, in a small valley, the road cuts through a weathered exposure of the Tarkio Limestone Member of the Emporia Limestone. The same limestone forms the rim rock in the pasture to the north and is full of fusulininds (probably *Triticites*). This limestone is exposed in the bank of Deep Creek above the waterfall at Pillsbury Crossing, where we're headed next. This limestone is Pennsylvanian in age, as are the other formations here and in Tabor valley to the west. We passed an outcrop of the Tarkio limestone 24 miles east of here along I-70. If it followed the general westerly dip of rocks in eastern Kansas, which averages about 25 feet per mile, the Tarkio should be 600 feet deep in the subsurface, rather than being exposed at the surface, as it is here. The explanation is the Nemaha Uplift, a large faulted anticline that runs from southeastern Nebraska, south to southern Oklahoma. An anticline is an upward fold of rocks that has older rocks at its center. Most of this uplift occurred before the rocks were deposited. But the fact that the rocks were lifted above their normal position indicates that uplift has occurred since these rocks were deposited. Anticlines often form traps where oil and gas can accumulate. No such fields are found along the Nemaha in this area, but oil was discovered farther south in southern Kansas and Oklahoma. In fact, the El Dorado field, the largest oil producer in Kansas history, sits astride the Nemaha uplift in Butler County.

The Nemaha is steeper on its east side and appears to be faulted along this flank throughout most of its length. At this point it is less than 1,100 feet down to the ancient Precambrian basement rocks. However, a few miles east, near the boulder field we just visited, the same basement rocks are 3,300 feet deep. This offset is at least partially caused by fault movement along the Humboldt Fault Zone, named after a town in southeastern Nebraska. Faulting along the Humboldt is also responsible for many of the small earthquakes in eastern Kansas.

Turn south at the next corner, then go 1.5 miles and turn back west again. For the next three miles, the road passes by Tabor hill and through Tabor Valley, named after pioneer A. W. Tabor, who later moved to Colorado and discovered gold. The school house at the end of this road is called Tabor School, and a stone marker on the school grounds is dedicated to Tabor's wife. **From the Tabor School, go north 0.5 mile, then back west about 0.75 miles, then north to Pillsbury Crossing.** We'll stop briefly to look at the waterfall, which is formed on a ledge of the Elmont limestone. **From here, proceed across Deep Creek, turn north 0.1 mile, then west for 2.5 miles to an intersection with a black-topped road headed north.** Here we pass back into Permian rocks. **Follow that road 4.0 miles to the intersection with Kansas Highway 177** and climb up through Permian rocks, reaching the Wreford limestone at the crest of the hill. This is one of the flinty or cherty limestones that gives the Flint Hills their name. **Take K-177 over the Kansas River, into Manhattan, to intersection with U.S. Highway 24. Take U.S. 24 through Manhattan to the intersection with K-13. Turn northeast on K-13 and cross the Tuttle Creek Lake dam. Park in the lot at the east end of the dam on the southeast side of the road.**

STOP 4. Spillway fault. See the attached discussion of the spillway fault by Underwood and Polson, 1988.

Return to U.S. 24, turn west for about 5.5 miles, then turn north on a county road. Go 4 miles north, one west, then 0.5 miles north.

STOP 5. The Stockdale kimberlite is in the pasture about 0.25 mile to the west (see Brookins, 1970a; copies available from Rex). Kimberlites are long, volcano-like pipes of igneous rock that moved to the surface in this location during the Cretaceous, about 100 million years ago. Kimberlite is a soft, greenish rock that contains pieces of more deeply buried rock that were broken off underground and moved to the surface along with the kimberlite. Kimberlite also contains other minerals, such as serpentine, ilmenite, and garnets. Kimberlites are the source of diamonds in other locations in the world, such as South Africa. The Kansas kimberlites have produced no diamonds, although the Survey drilled into a kimberlite near Leonardville in the early 1970s, and, at one point, the barrel of a drill bit was grooved by something that could have been a diamond.

The Stockdale is one of at least eight or nine kimberlites that have been discovered in Riley County. Most are near the surface although not as well exposed as the Stockdale. In the early 1980s, Cominco, a mining company, leased several of the kimberlites and dug trenches through them--the trench at Stockdale runs up the hillside east of the kimberlite--hauling the material out to sift through it for diamonds or rare-earth minerals. The company also used geophysical surveys to locate several previously unknown kimberlites. Additional kimberlites may be near the surface in other locations in the county. We'll drive past another one at the Winkler crater, northwest of here.

From this stop, **go north 0.5 mile, then west 2.0 miles and intersect with U.S. Highway 77. Proceed north**, passing through the town of Randolph and about two miles west of the K-16 bridge over Tuttle Creek Lake, the longest bridge in Kansas. **At 9.5 miles north of the turn onto U.S. 77, turn west 3.5 miles.** We'll stop briefly here. The Winkler Crater (see the attached photo and discussion in Brookins, 1970b) is in the pasture to the north. The Winkler--named after a nearby town and because geologists originally thought this location was a meteorite crater--was also trenched by Cominco, but because the trench has been filled in, there is no exposure of kimberlite and nothing much to see. More noticeable here is the structural geology exposed in the roadcut. In Kansas, most rock layers dip slightly to the west. The limestones (in this case, the Barneston) exposed in this roadcut dip to the east, evidence of an uplift called the Abilene anticline (see Underwood and Polson for a figure showing the anticline's location). An anticline is a fold of rocks shaped something like the arch at St. Louis. These rocks have been pushed up, so that older rocks are at the center of the anticline. This anticline may reflect the eastern edge of the Midcontinent rift. This is also another good fossil-collecting location.

From the Winkler crater, **proceed west 4.5 miles to the small town of Mayday, and turn north. Go 5.2 miles north, then turn west about 0.3 mile.** At the top of this hill is the location of the Poersch # 1 well (named after landowner, Noel Poersch), drilled by Texaco in 1984. The hole went 11,300 feet deep, penetrating more than a half-mile deeper than any previous well in Kansas, and more than 8,000 feet into the Precambrian. Drillers generally stop when they encounter rocks from the Precambrian, partly because Precambrian rocks are usually metamorphic and igneous, rather than the sedimentary rocks in which nearly all oil accumulations occur. Also Precambrian rocks are 570 million years old or older, which means they may have been around before most of the types of life had evolved that could serve as a source of oil or gas. The antiquity of the Precambrian also means that there's been plenty of time for any oil that might have formed to migrate away or be cooked off.

Texaco drilled into the Precambrian based on the postulated existence of a thick block of Precambrian sediments that were indicated by seismic surveys in the late 1970s. Those sediments were related to the midcontinent rift, a split in the earth's crust that developed about a billion years ago and ran from the Lake Superior region, through Iowa and Nebraska, and into Kansas. Texaco found no oil in the Poersch well, and the well cuttings and logs were kept confidential until this spring. From studying those records, Survey geologists have recreated the geology encountered by the well (see Berendsen and others, 1988). The well hit Precambrian volcanic rocks at about 3,000 feet. These were mostly basalts that flowed out onto the land's surface, each creating new layers of rock 40 to 260 feet thick, toward the end of the Precambrian. Those basalt flows probably lit up the night sky, glowing in the dark if anyone had been around to see. Going deeper, at about 7,500 feet, the well struck the suspected sediments. Those sediments were probably created when faulting occurred along the rift, building an ancient mountain ridge. Rivers flowed out of those mountains, depositing coarse sediments in valley floors and along the flanks of the rift. The brown sediments probably contrasted markedly with the pink of the surrounding granites. The well also churned up rocks with coatings of hematite, which may indicate that a hot, dry environment, such as the Nevada desert, formed the landscape at the time, about 900 million years ago. The Survey study showed no traces of organic material in the cuttings, and the rocks had little pore space, or room for oil to accumulate. Still, the lack of oil in the Texaco well doesn't condemn drilling throughout the rift. In 1987, Amoco drilled a 17,000-foot-deep well along the rift in Iowa, although the results haven't been made public. What's more, major oil-producing areas have often required extensive drilling before their potential was discovered. Stay tuned.

From the Texaco well location, **drive about 1.0 mile east, turn north three miles, then turn west and drive 12 miles to Kansas highways 9/15. Turn north, drive 1.5 miles to the K-115 and turn west, driving a mile to the town of Palmer. Then turn north 0.5 mile, then back west 1.5 miles. Stop at the roadcut through the Dakota sandstone.**

STOP 6. DAKOTA FORMATION. From the 250 million-year-old limestones of the Permian at the last stop, we've come to the Dakota Formation, deposited about 100 million years ago, during the Cretaceous. The Dakota contact with underlying Permian rocks, although not obvious in the last leg of the trip except perhaps by a slight change of soil color, nevertheless represents a major break in geologic history. Following the Permian, there were two geologic periods, the Jurassic and Triassic, that are not present here due to erosion or non-deposition. This is a gap in the geologic record of more than 100 million years. A contact between rocks of drastically different ages, representing a gap in the geologic record, is called an unconformity.

The western half of Kansas was covered by an extensive sea during the Cretaceous, with a sandy beach and deltaic deposits along its edge. The Dakota Formation is made up of sandstones, shales, and clays that were deposited by rivers and along the edge of that ocean. While shale makes up the majority of the Dakota, the sandstone is more noticeable at the surface. It crops out from Stanton County in far southwestern Kansas, north of Dodge City in Ford County, and on a line from Ellsworth County up to Washington County. Here the Dakota shows evidence of cross-bedding, the angular lines in the lower part of the sandstone, probably indicating that it was deposited by running water. The sandstone is also heavily cemented, in places, by iron stone, which stains the rock reddish brown and produces some unusual rounded structures within the rock. Ask Frank Wilson how it got that way.

From here, proceed 6.5 miles west. Turn north and drive 12 miles to U.S. Highway 36. Turn east and proceed to the roadcut east of the intersection. Park along the highway. WATCH OUT FOR TRAFFIC.

STOP 7. The Graneros Shale is at the base of this roadcut, and is overlain by the Greenhorn Limestone. Like the Dakota, the Greenhorn is from the Cretaceous, although probably deposited in shallow sea water. The uppermost bed in this unit (which is not exposed here) was quarried in north-central Kansas for use as a building stone and for fenceposts. It is known locally as the fencepost limestone (see Muilenburg and Swineford,1975, for a discussion of its formation and uses). Of particular note here are the large numbers of fossil clams (*Inoceramus*). The Greenhorn is characterized by the profusion of these clam fossils, and by the noticeable lack of other fossils. Ask Chris Maples why that is.

From here, proceed east on U.S. 36. Again, see Buchanan and McCauley, 1987, for a description of the geology and other sights along the highway. For those who don't have a copy (God forbid), you'll note that the most prominent rock is again the Dakota Formation. **Take U.S. 36 east through Washington and Marysville, then turn south on K-99**. Of note along K-99 are a silver-coated glacial erratic, on the east side of the road north of Frankfort, and the newly dedicated hand-dug well on the north edge of Westmoreland. According to the sign by the well, this is the second largest-hand-dug well in the world, smaller only than the world's largest hand-dug well at Greensburg, which means, amazingly enough, that Kansas has the two largest hand-dug wells in the world. **Proceed through Wamego--note the Marsh arch bridge over the Kansas River south of town--back to I-70 and then back to Lawrence.**

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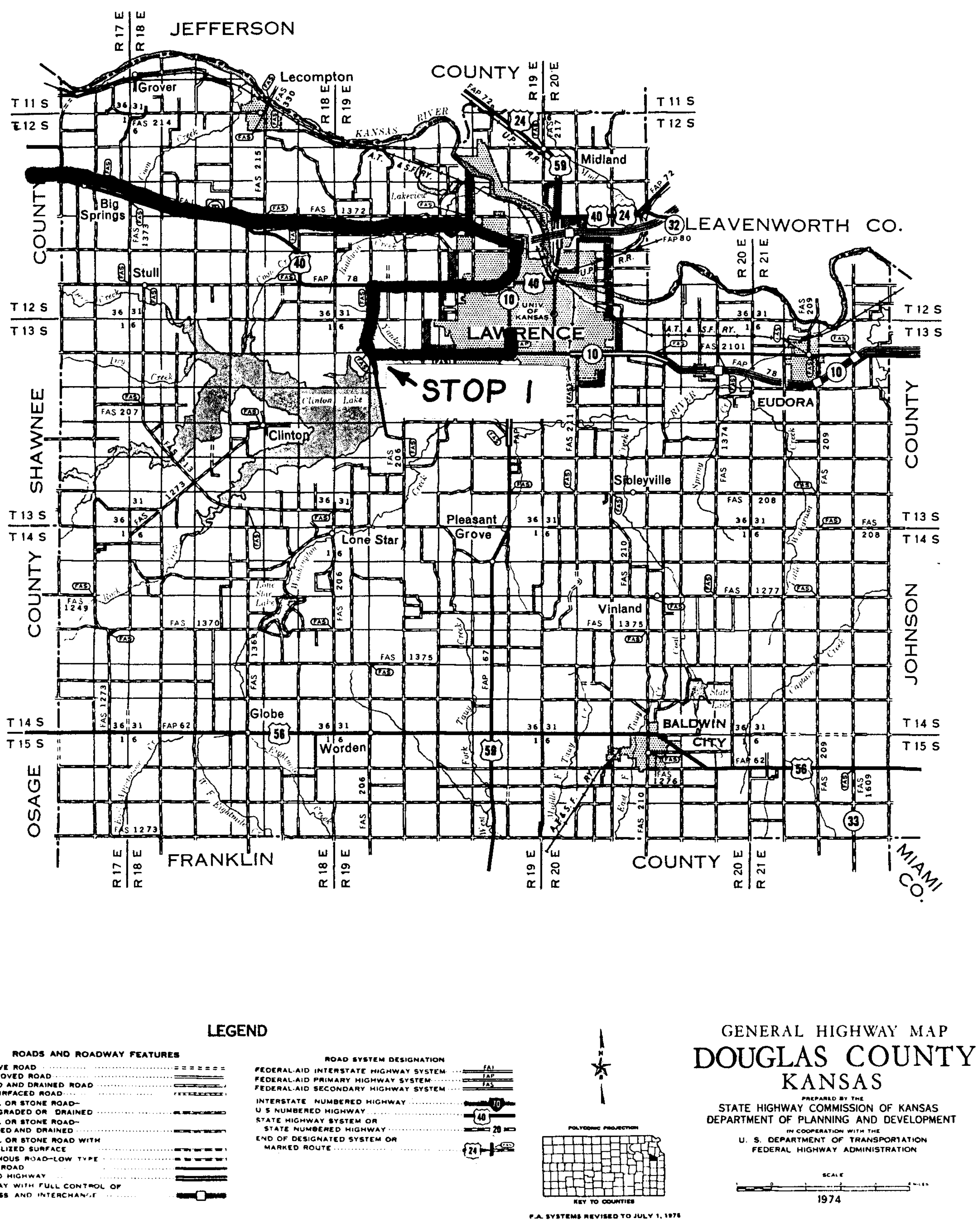
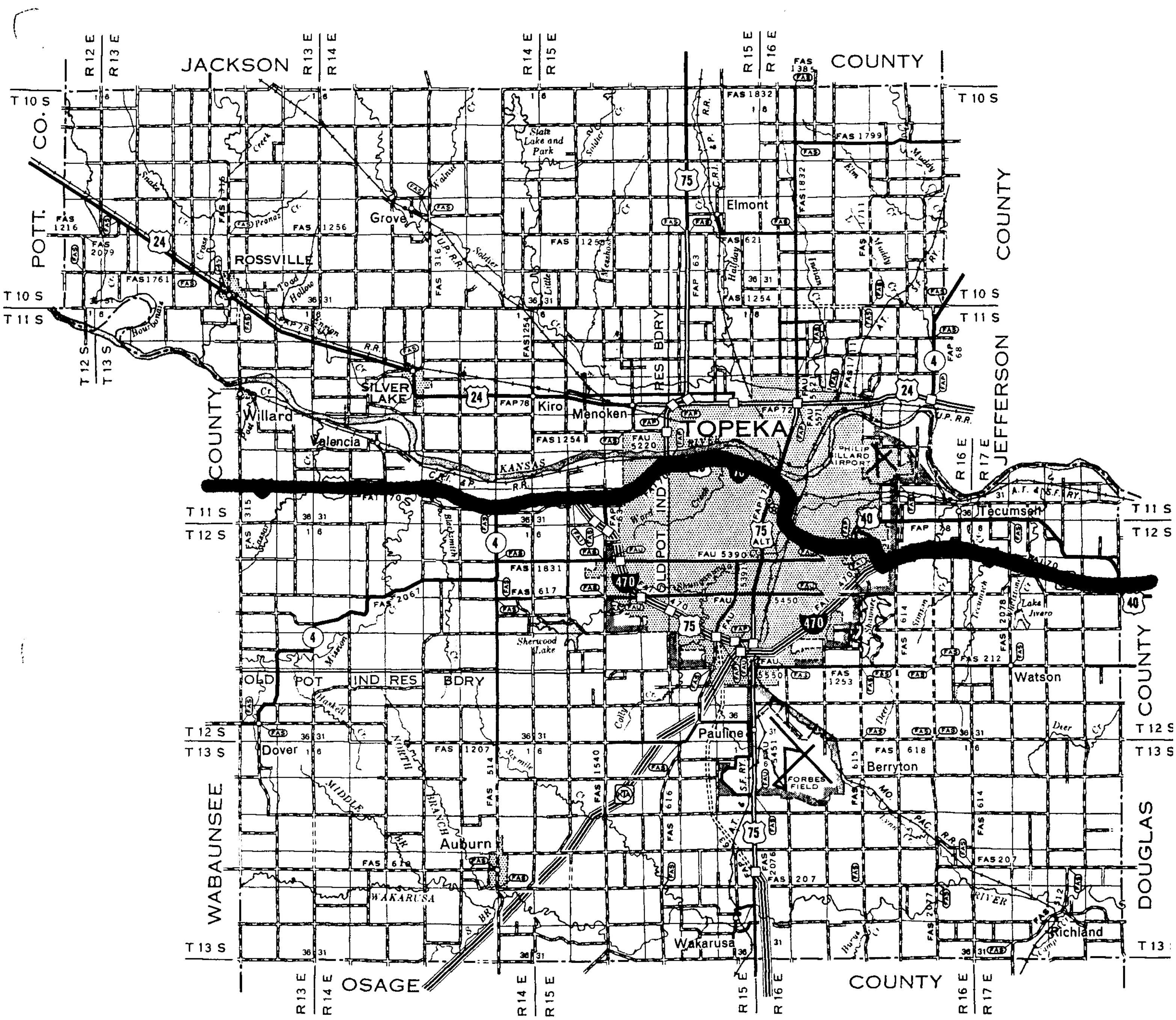

JEFFERSON
COUNTY
LEAVENWORTH CO.
JOHNSON COUNTY
MIAMI CO.
FRANKLIN
COUNTY
OSAGE COUNTY
SHAWNEE COUNTY
Lecompton
Grover
Big Springs
Stull
Midland
LAWRENCE
UNIV. OF KANSAS
STOP 1
EUDORA
Clinton
Clinton Lake
Sibleyville
Lone Star
Pleasant Grove
Vinland
Globe
Worden
BALDWIN CITY
KANSAS RIVER
LEGEND
ROADS AND ROADWAY FEATURES
ROAD SYSTEM DESIGNATION
GENERAL HIGHWAY MAP
DOUGLAS COUNTY
KANSAS
PREPARED BY THE
STATE HIGHWAY COMMISSION OF KANSAS
DEPARTMENT OF PLANNING AND DEVELOPMENT
IN COOPERATION WITH THE
U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
1974
KEY TO COUNTIES
F.A. SYSTEMS REVISED TO JULY 1, 1975



LEGEND

ROADS AND ROADWAY FEATURES

- PRIMITIVE ROAD
- UNIMPROVED ROAD
- GRADED AND DRAINED ROAD
- SOIL SURFACED ROAD
- GRAVEL OR STONE ROAD— NOT GRADED OR DRAINED
- GRAVEL OR STONE ROAD— GRADED AND DRAINED
- … OR STONE ROAD WITH … IZED SURFACE
- … OUS ROAD—LOW TYPE
- … ROAD
- DIVIDED HIGHWAY
- HIGHWAY WITH FULL CONTROL OF ACCESS AND INTERCHANGE

ROAD SYSTEM DESIGNATION

- FEDERAL-AID INTERSTATE HIGHWAY SYSTEM — FAI
- FEDERAL-AID PRIMARY HIGHWAY SYSTEM — FAP
- FEDERAL-AID SECONDARY HIGHWAY SYSTEM — FAS
- INTERSTATE NUMBERED HIGHWAY — 70
- U S NUMBERED HIGHWAY — 40
- STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY — 20
- END OF DESIGNATED SYSTEM OR MARKED ROUTE — 24 FAS

POLYCONIC PROJECTION

KEY TO COUNTIES

FA SYSTEMS REVISED TO MAY 1, 1979

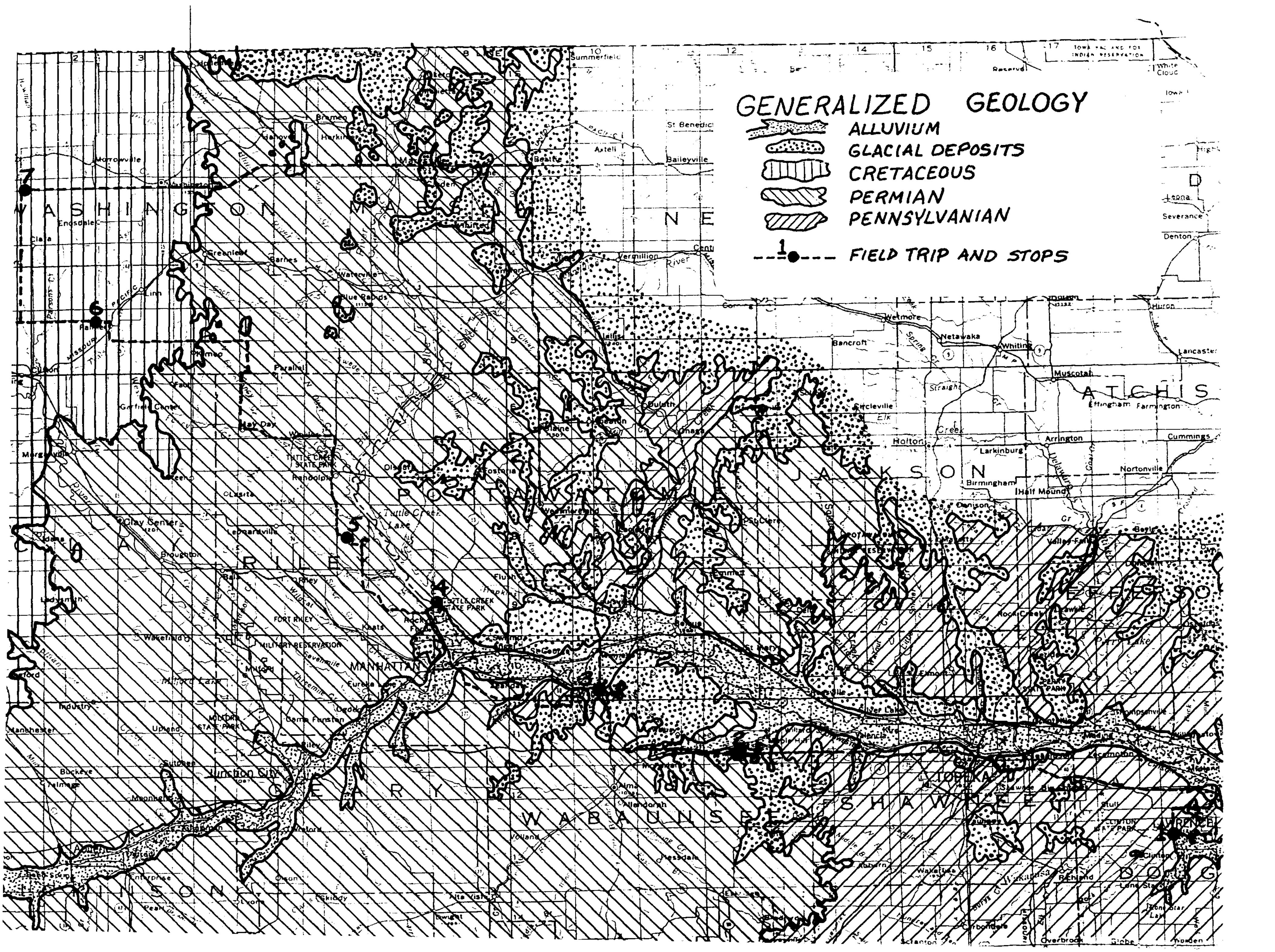
GENERAL HIGHWAY MAP

SHAWNEE COUNTY
KANSAS

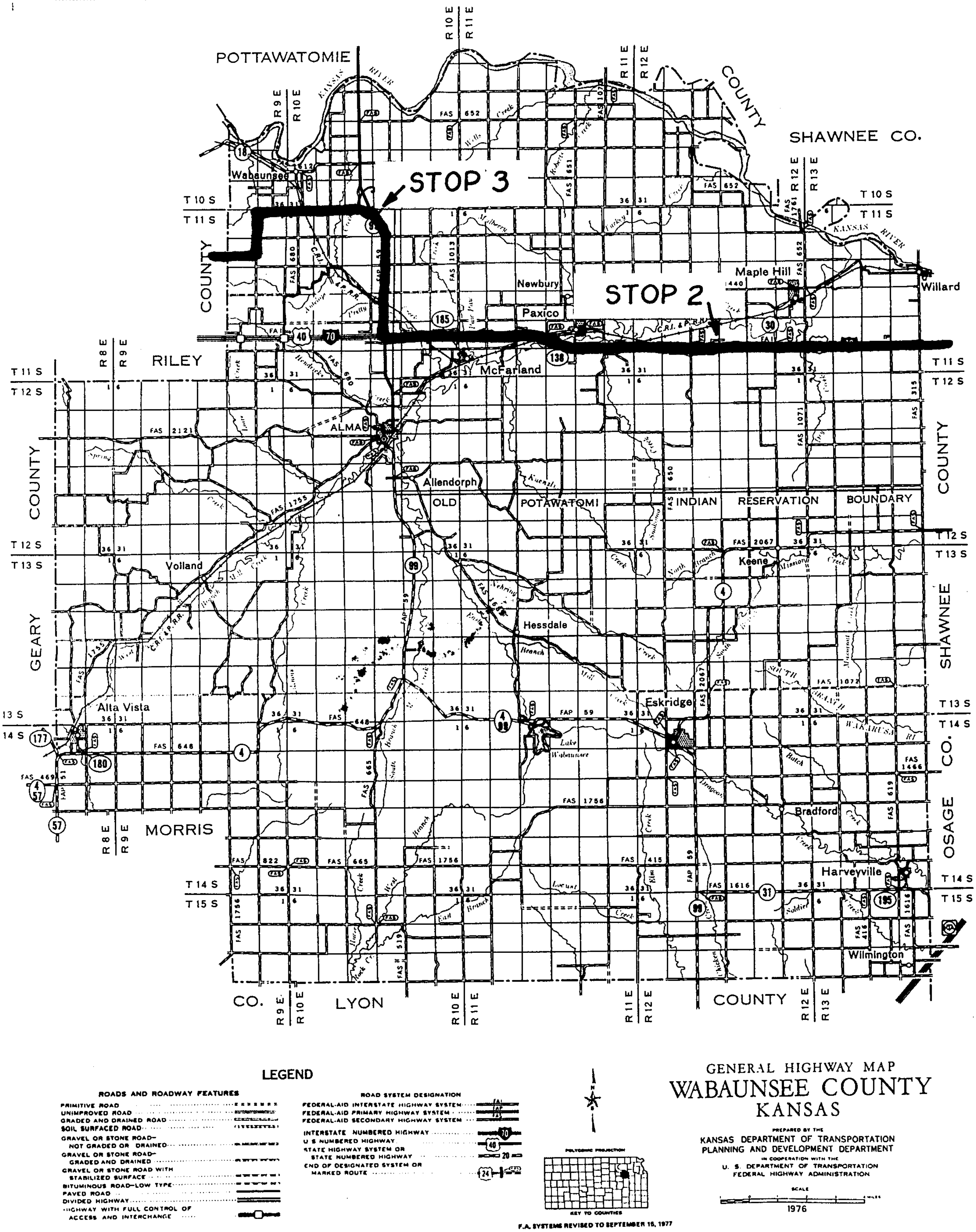
PREPARED BY THE
KANSAS DEPARTMENT OF TRANSPORTATION
PLANNING AND DEVELOPMENT DEPARTMENT
IN COOPERATION WITH THE
U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

SCALE

1977



GENERALIZED GEOLOGY
ALLUVIUM
GLACIAL DEPOSITS
CRETACEOUS
PERMIAN
PENNSYLVANIAN
FIELD TRIP AND STOPS
WASHINGTON
MARSHALL
NEMAHA
POTTAWATOMIE
JACKSON
ATCHISON
JEFFERSON
CLAY
RILEY
GEARY
WABAUNSEE
SHAWNEE
DOUGLAS
MANHATTAN
Junction City
TOPEKA
LAWRENCE
Clay Center
Holton
Tuttle Creek Lake
Milford Lake
Marysville
Washington
Abilene
FORT RILEY
MILITARY RESERVATION


STOP 3
STOP 2
POTTAWATOMIE
COUNTY
SHAWNEE CO.
RILEY
COUNTY
GEARY
COUNTY
SHAWNEE
CO.
OSAGE
MORRIS
CO.
LYON
COUNTY
Wabaunsee
Maple Hill
Willard
Newbury
Paxico
McFarland
ALMA
Allendorph
OLD POTAWATOMI INDIAN RESERVATION BOUNDARY
Volland
Keene
Hessdale
Eskridge
Alta Vista
Lake Wabaunsee
Bradford
Harveyville
Wilmington
T 10 S
T 11 S
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T 13 S
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R 8 E
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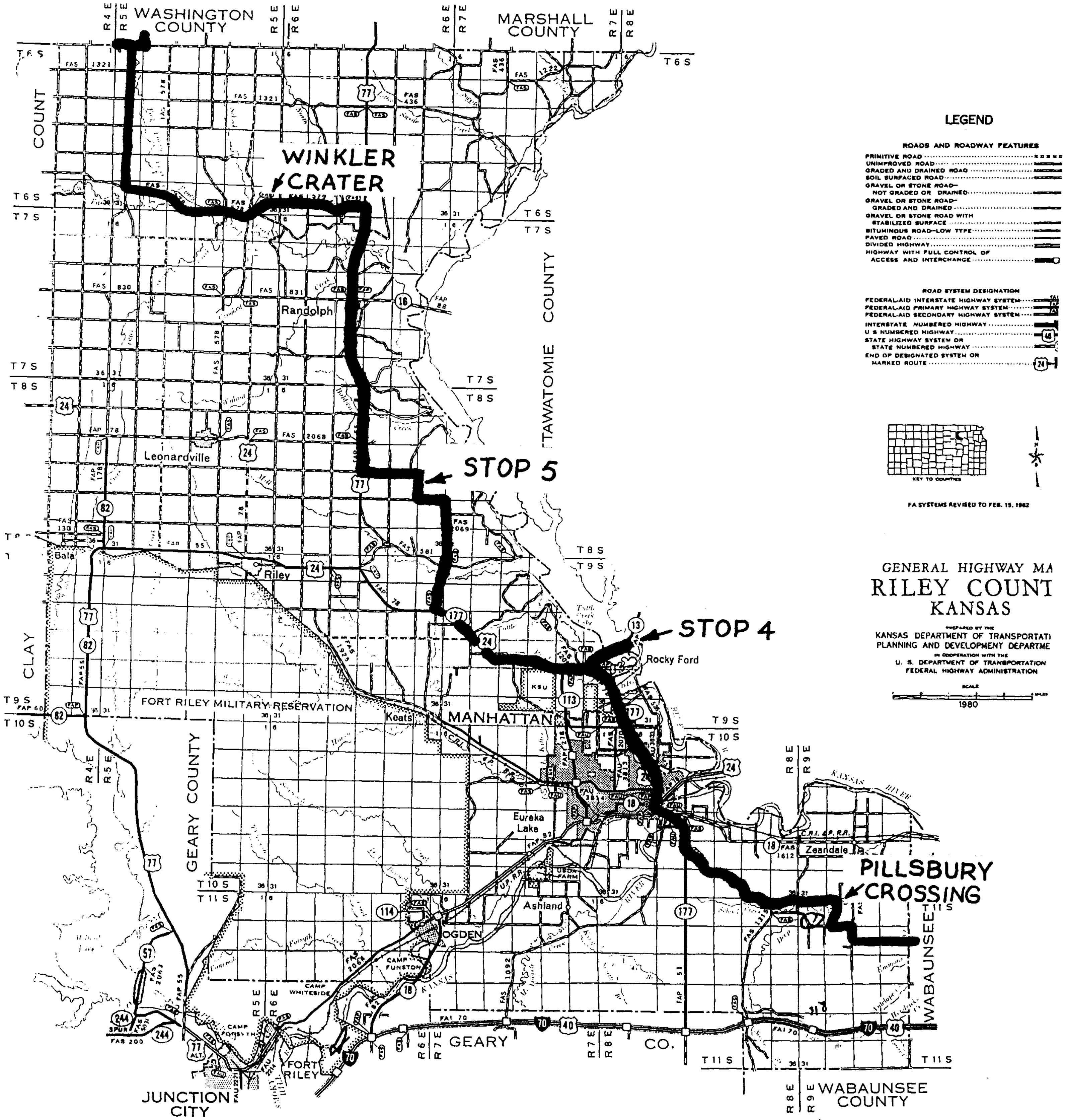
R 10 E
R 11 E
R 12 E
R 13 E
LEGEND
ROADS AND ROADWAY FEATURES
PRIMITIVE ROAD
UNIMPROVED ROAD
GRADED AND DRAINED ROAD
SOIL SURFACED ROAD
GRAVEL OR STONE ROAD— NOT GRADED OR DRAINED
GRAVEL OR STONE ROAD— GRADED AND DRAINED
GRAVEL OR STONE ROAD WITH STABILIZED SURFACE
BITUMINOUS ROAD—LOW TYPE
PAVED ROAD
DIVIDED HIGHWAY
HIGHWAY WITH FULL CONTROL OF ACCESS AND INTERCHANGE
ROAD SYSTEM DESIGNATION
FEDERAL-AID INTERSTATE HIGHWAY SYSTEM
FEDERAL-AID PRIMARY HIGHWAY SYSTEM
FEDERAL-AID SECONDARY HIGHWAY SYSTEM
INTERSTATE NUMBERED HIGHWAY
U S NUMBERED HIGHWAY
STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY
END OF DESIGNATED SYSTEM OR MARKED ROUTE
POLYCONIC PROJECTION
KEY TO COUNTIES
F.A. SYSTEMS REVISED TO SEPTEMBER 15, 1977
GENERAL HIGHWAY MAP
WABAUNSEE COUNTY
KANSAS
PREPARED BY THE
KANSAS DEPARTMENT OF TRANSPORTATION
PLANNING AND DEVELOPMENT DEPARTMENT
IN COOPERATION WITH THE
U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
SCALE
1976


WASHINGTON COUNTY
MARSHALL COUNTY
WINKLER CRATER
STOP 5
STOP 4
PILLSBURY CROSSING
Randolph
Leonardville
Riley
Rocky Ford
MANHATTAN
FORT RILEY MILITARY RESERVATION
Keats
Eureka Lake
Ashland
Zeandale
OGDEN
CAMP FUNSTON
CAMP WHITESIDE
CAMP FORSYTH
FORT RILEY
JUNCTION CITY
GEARY COUNTY
GEARY CO.
CLAY
WABAUNSEE COUNTY
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ROADS AND ROADWAY FEATURES
ROAD SYSTEM DESIGNATION
KEY TO COUNTIES
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GENERAL HIGHWAY MA
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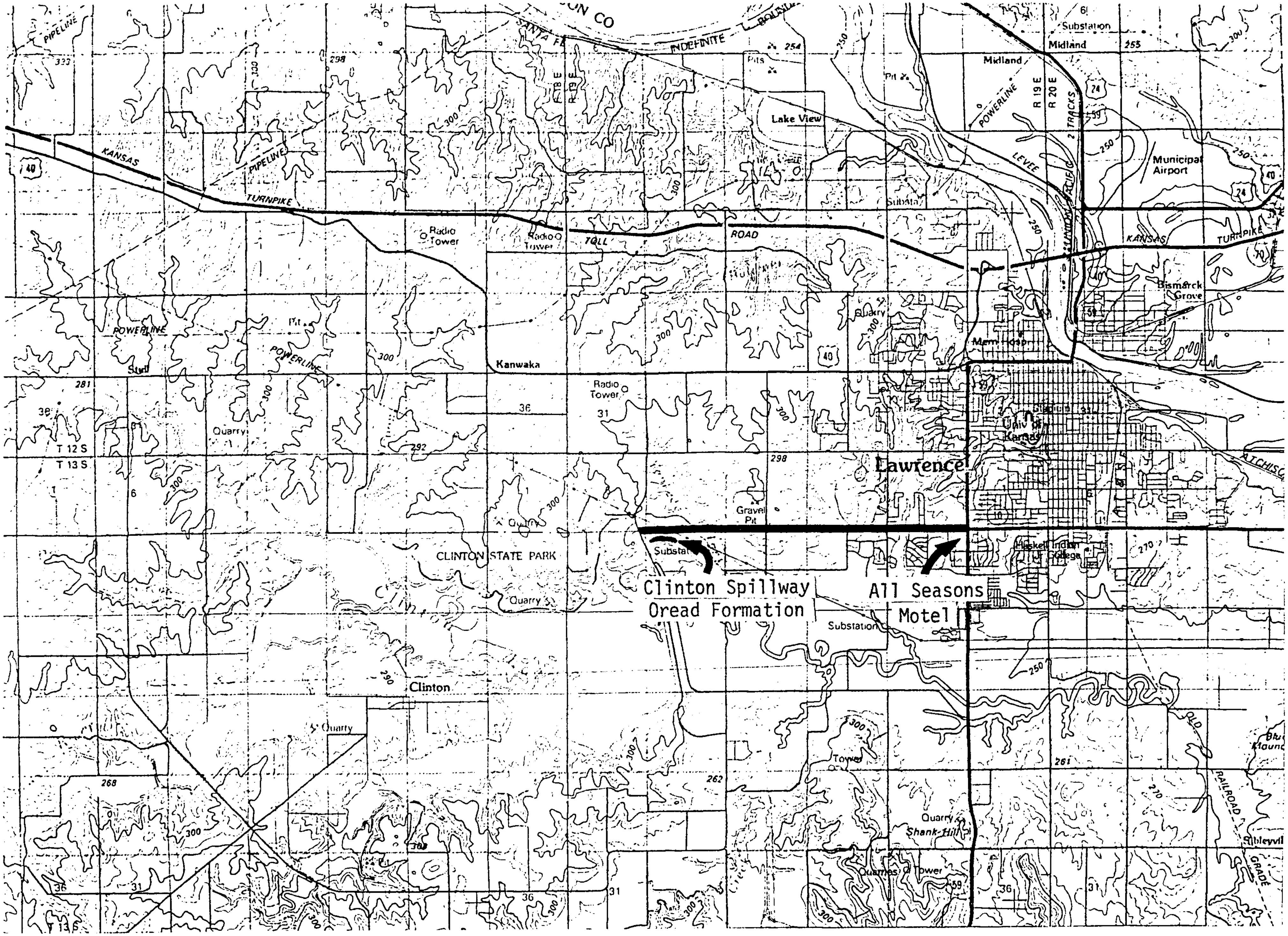
FEDERAL HIGHWAY ADMINISTRATION
1980


Clinton Spillway
Oread Formation
All Seasons
Motel
Lawrence
CLINTON STATE PARK
Clinton
Kanwaka
Lake View
Midland
Municipal Airport
Bismarck Grove
Haskell Indian Jr College
KANSAS TURNPIKE
TOLL ROAD
Shank Hill
Quarry
Substation
Radio Tower
Gravel Pit
POWERLINE
PIPELINE
LEVEE
R 19 E
R 20 E
T 12 S
T 13 S

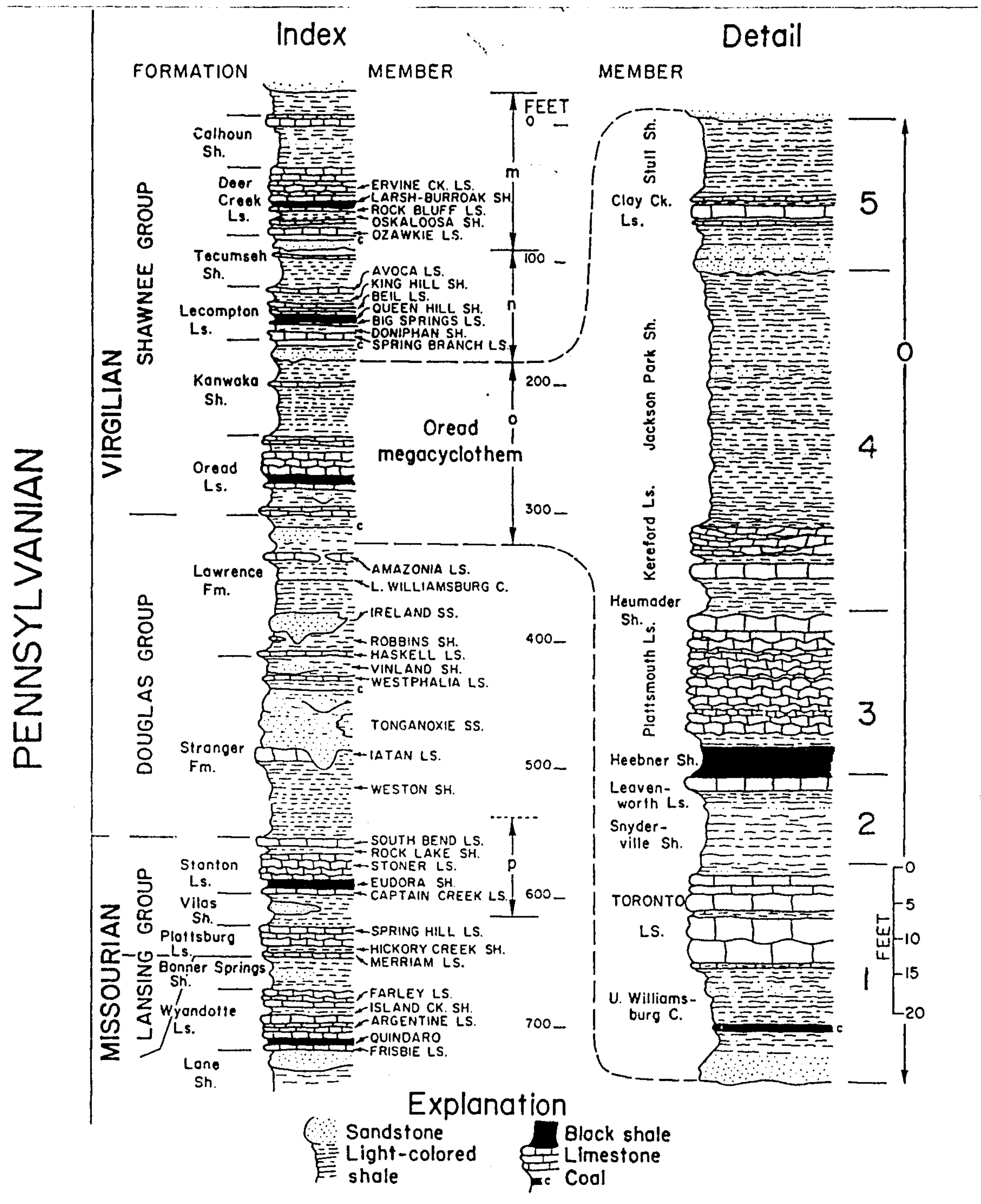


Figure 2.—Stratigraphic position of Oread Limestone and Oread megacyclothem. Section at left shows general relationship of Oread Limestone to other rock units [letters *m*, *n*, *o*, and *p* are four megacyclothems recognized by Moore (1950)]. Oread megacyclothem (O) on right [arabic numerals on far right refer to cyclothems recognized by Moore (1950) within Oread megacyclothem]. Stratigraphic concepts of Douglas Group after Ball (1964). Lansing and Shawnee interpretation after Jewett, O'Connor, and Zeller (1968). (from Troell, 1969)

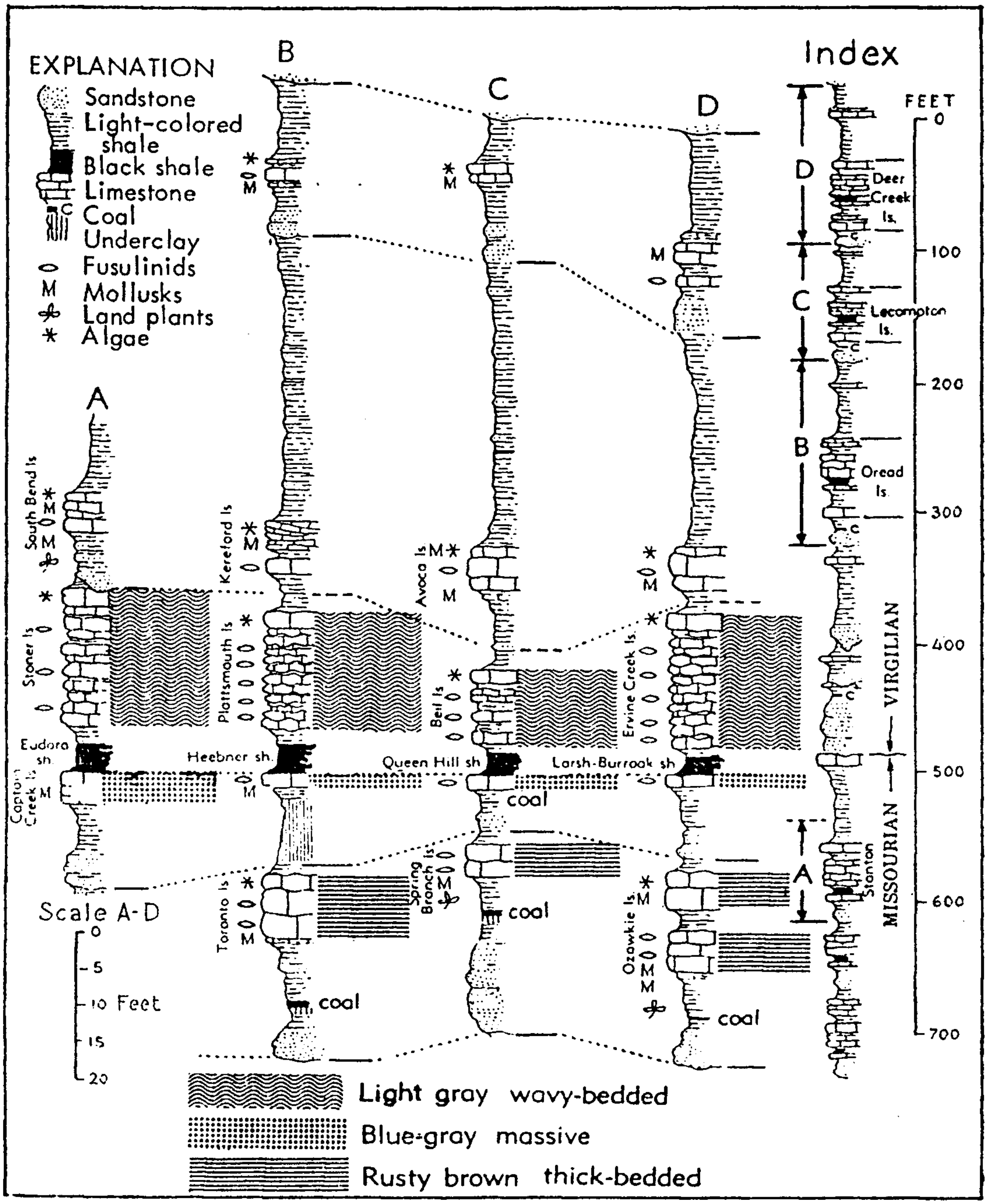


Figure 3.—Cyclothems grouped in megacyclothems, as observed in late Missourian and early Virgilian deposits of central Kansas. Diagram emphasizes repetition of strikingly dissimilar cyclothems in constant sequence. (from Moore, 1964)

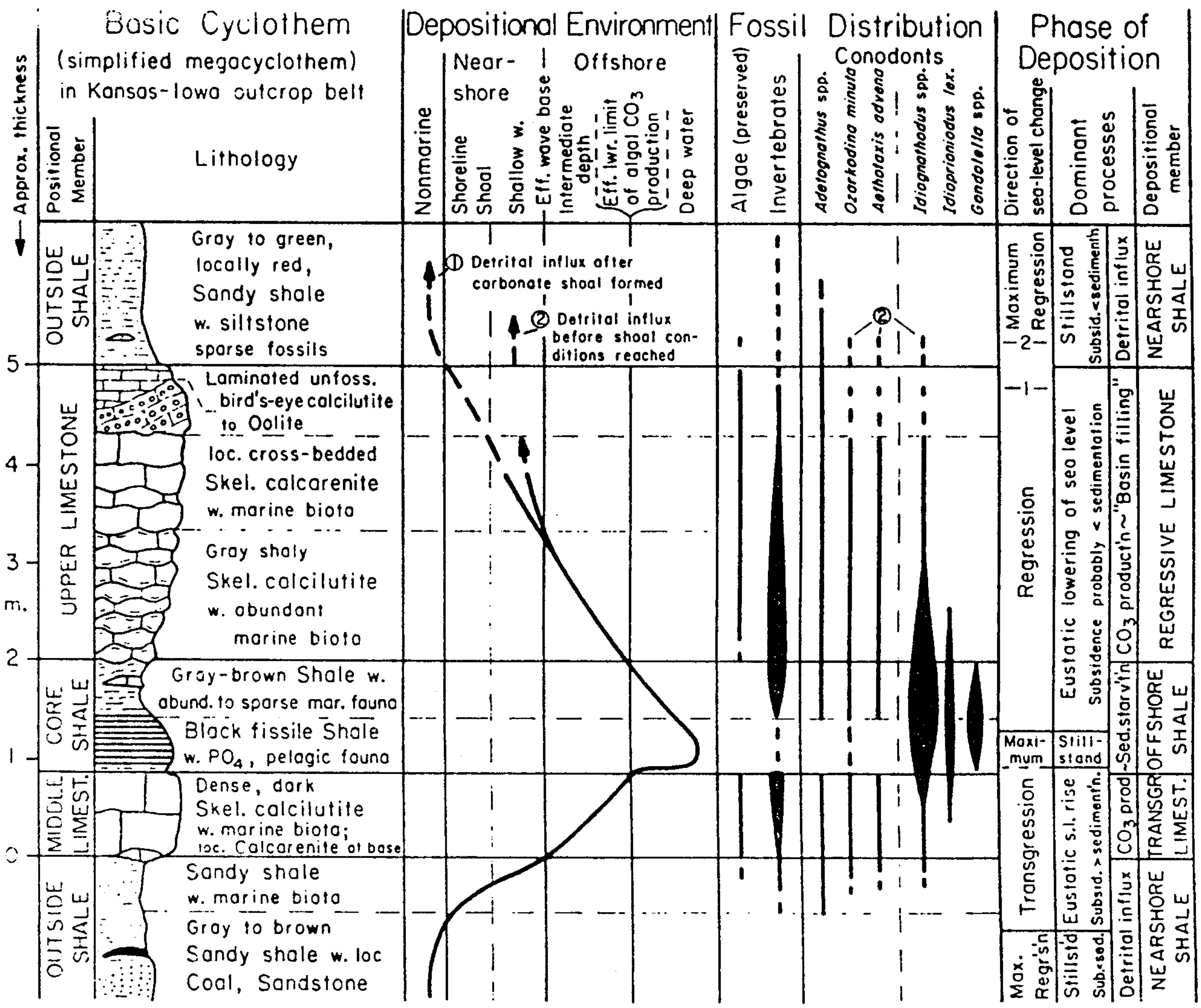
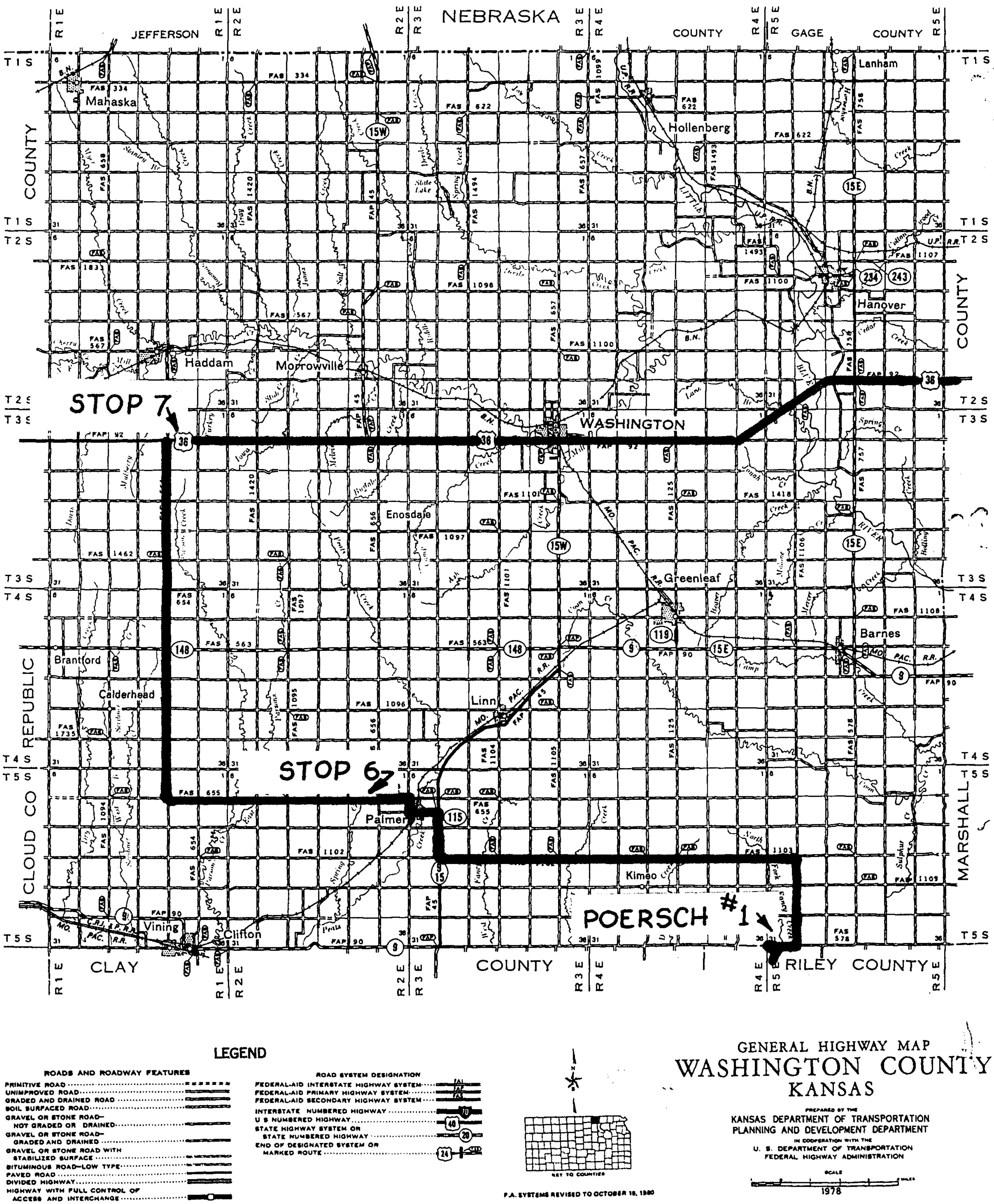


Figure 4.—Basic Upper Pennsylvanian individual Kansas cyclothem sequence (simplified megacyclothem). Environmental interpretations are based mainly on lithology and gross biotic distribution. Algae and invertebrate distributions are derived from personal observations, and data collected by R. K. Pabian, M. A. Senich, and M. D. Brondos; thickness of invertebrate line reflects relative diversity. Conodont distribution generalized from Heckel and Baesemann (1975, p. 492-493) and later data collected by R. H. Wood; thickness of lines reflects relative abundance.

Terms describing depositional phase of lithologic members (transgressive, offshore, regressive, nearshore) may be preferable to positional terms in cyclothem (middle, core, upper, outside) when depositional environment can be reasonably well established. Basic transgressive-regressive nature of certain cyclic sequences was discussed by Moore (1936), Elias (1937) and Weller (1958); black shales were recognized as representing maximum transgression when present, by Payton (1966), Evans (1967), Schenk (1967), Troell (1969), James (1970), Johnson (1971), Heckel and Baesemann (1975), Heckel (1975a), and Wilson (1975, p. 213). (from Heckel, 1977)


NEBRASKA
JEFFERSON
COUNTY
GAGE
COUNTY
REPUBLIC CO
CLOUD CO
MARSHALL COUNTY
CLAY
COUNTY
RILEY COUNTY
STOP 7
STOP 6
POERSCH #1
WASHINGTON
Mahaska
Lanham
Hollenberg
Hanover
Haddam
Morrowville
Enosdale
Greenleaf
Barnes
Brantford
Calderhead
Linn
Palmer
Kimeo
Vining
Clifton
LEGEND
ROADS AND ROADWAY FEATURES
PRIMITIVE ROAD
UNIMPROVED ROAD
GRADED AND DRAINED ROAD
SOIL SURFACED ROAD
GRAVEL OR STONE ROAD— NOT GRADED OR DRAINED
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U S NUMBERED HIGHWAY
STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY
END OF DESIGNATED SYSTEM OR MARKED ROUTE
KEY TO COUNTIES
F.A. SYSTEMS REVISED TO OCTOBER 15, 1980
GENERAL HIGHWAY MAP
WASHINGTON COUNTY
KANSAS
PREPARED BY THE
KANSAS DEPARTMENT OF TRANSPORTATION
PLANNING AND DEVELOPMENT DEPARTMENT
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U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
SCALE
1978

OREAD LIMESTONE

at

CLINTON SPILLWAY

by Bryan Stephens and Lynn Watney

The gentle eastward-sloping upland surface in the vicinity of Lawrence is interrupted by several parallel northeasterly trending hills or cuestas resulting from differential erosion of slightly westward-dipping Pennsylvanian limestones and shales. Although local anticlines, synclines, and small faults may disrupt this shallow westerly dip, it provides for broad exposures of strata along valleys carved by rivers flowing east down the regional slope.

Mount Oread, the hill on which the University of Kansas rests, is capped by the Upper Pennsylvanian (Virgilian) Oread Formation. The same strata are exposed here on the north face of the spillway near Clinton Lake dam on the Wakarusa River, 5.5 kilometers (3.5 mi) west of Lawrence (Fig. 1). The interval from the Plattsmouth Limestone down to the Amazonia Limestone Member of the Lawrence Shale is well exposed on the spillway wall (Fig. 2). The measured section at this locality is attached.

The Oread Limestone, originally described by Haworth (1894), consists, from base to top, of the Toronto Limestone, Snyderville Shale, the thin Leavenworth Limestone, the black fissile Heebner Shale, the thick Plattsmouth Limestone, Heumader Shale, and Kereford Limestone (Fig. 3). The Oread Limestone, according to Moore (1936), is part of a **megacyclothem**, a sequence of distinctive shale-limestone couplets repeated in several successive formations. Moore identified five limestone members in the idealized megacyclothem. The **lower limestone** is the Toronto, followed upward by the **middle limestone** (Leavenworth), the **upper limestone** (Plattsmouth), **super limestone** (Kereford), and finally the **fifth limestone** (Clay Creek) at the top of the cycle (Fig. 3). The **inside** or **core shale** is the Heebner Shale. Moore suggested that a marine transgression peaked during accumulation of the Plattsmouth Limestone based its abundance of fusulinids. The **lower**, **super**, and **fifth** limestones are not always present in a single megacyclothem, but are compositely expressed in the four late Missourian and early Virgilian megacyclothem sequences seen in Figure 3.

Heckel (1977) describes a simpler cyclothem consisting of four components: the **middle limestone**, **core shale**, **upper limestone**, and **outside shale** (Fig. 4). Maximum regression is associated with the outside shale (i.e., Kanwaka) and **maximum transgression is recorded by the core shale** (i.e., Heebner).

The **Toronto Limestone** of the Oread Formation (the **lower limestone** in Moore's megacyclothem classification) may represent an intermediate marine inundation separate from the transgression accounting for the Oread cyclothem (Troell, 1969). The black **Heebner Shale** Member of the Oread cyclothem is attributed to maximum inundation when anoxic bottom-water conditions prevailed during deposition. The Oread Limestone is a wide-spread unit in the Midcontinent. It is exposed on outcrops in Kansas, Missouri, Nebraska, and Iowa, and in the subsurface to at least western Kansas where the Heebner Shale serves as an important stratigraphic marker.

We would like you to begin the examination of the exposure with the **Amazonia Limestone** near the base of the slope and work your way up to the upper portion of the **Plattsmouth Limestone** at the crest of the exposure. The stratigraphic relationships are identified for you in the attached measured section. Take time to look at the rocks and section and ask Bryan and Lynn questions about what you observe.

References Cited

Haworth, E., 1894, Resume of the stratigraphy of eastern Kansas: Kansas Univ. Quart., v. 2, pp. 126-129.

Heckel, P.H., 1977, Origin of phosphatic black shale facies in Pennsylvanian cyclothems of Mid-Continent North America: Amer. Assoc. Petroleum Geol. Bull., v. 61, p. 1045-1068.

Moore, R.C., 1936, Stratigraphic classification of the Pennsylvanian rocks of Kansas: Kansas Geol. Survey Bull. 22, 256 p.

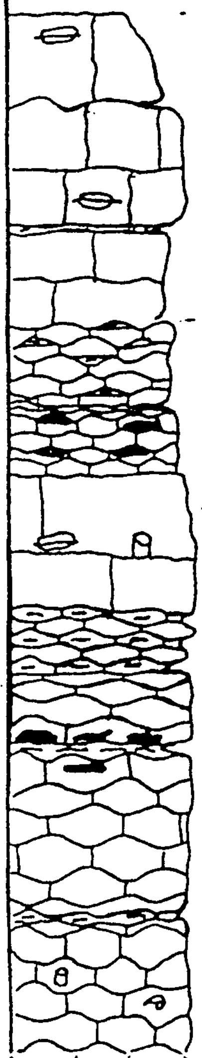
Moore, R.C., 1964, Paleontological aspects of Kansas Pennsylvanian and Permian cyclothems, in D.F. Merriam, ed., Symposium on cyclic sedimentation: Kansas Geol. Survey Bull. 169, v. 1, p. 287-380.

Troell, A.R., 1969, Depositional facies of Toronto Limestone Member (Oread Limestone, Pennsylanian), subsurface marker unit in Kansas: Kansas Geol. Survey Bull. 197, 29 p.

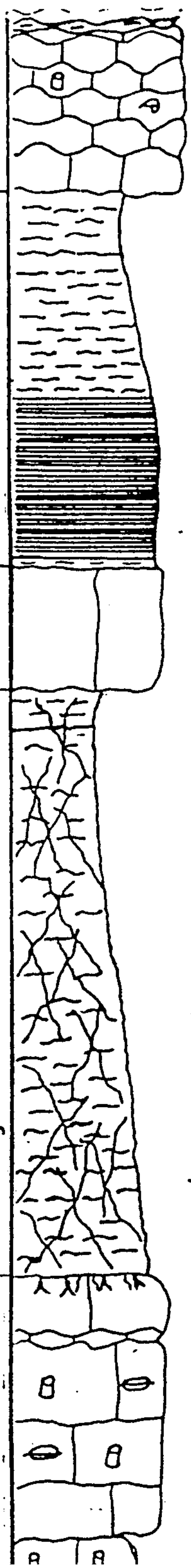
Zeller, D.E., 1968, The stratigraphic succession in Kansas: Kansas Geol. Survey Bull. 189, 81 p.

Measured Section of Clinton Spillway
Douglas Co., Kansas

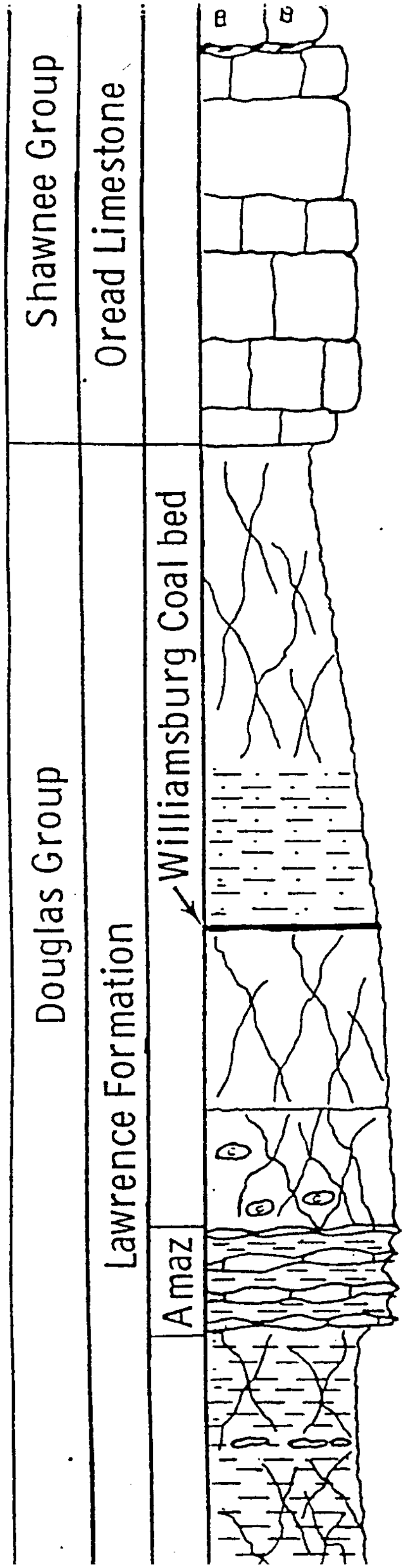
Vertical Scale : 1 m



Group	Formation	Member	Lithology and Weathering Profile	Sed. Struct.	Rock Name	Fossils Particles	Color Fresh/ Weathered	Grain Size	Diagenetic Features	Remarks
Shawnee Group	Oread Limestone	Plattsmouth Ls. Mbr.			fusulinid packstone					
					fusulinid packstone		brown-rusty orange			
					skeletal packstone		gray			
					algal packstone-wackestone		tan			thin wavy bedding shale interbeds
					cherty wackestone		gray		chert	
					fusulinid/crinoid packstone		gray-orange yellow			
					wackestone/ packstone		rusty orange			rugose coral common
					skeletal packst.-wackestone		gray		(chert)	chert concentrated on bottom of bed
					skeletal packstone/ wackestone		gray			whispy shale laminations
					skeletal packstone/ wackestone		gray			whispy shale laminations



Shawnee Group	Oread Limestone					
		Heebner Sh. Mbr.	clay shale	greenish yellow / dark gray brown	clay	softer and less platy than shale below
		Heebner Sh. Mbr.	black shale	black		hard platy phosphate nodules conodonts, sulfides 3 cm. soft shale at base
		Leav	Leavenworth Ls. wackestone	dark gray-brown		
		Snyderville Sh. Mbr.	clay shale	dark gry-brn		
		Snyderville Sh. Mbr.	clay shale	dark gray	clay	
		oronto Ls. Mbr.	micrite	tan		tube-like structures at top of bed filled with shale, Weather to tubes. pyrite
		oronto Ls. Mbr.	crinoid/ fusulinid packstone/ wackestone	light gray		algal oncolites coated grains glauconite
		oronto Ls. Mbr.	crinoidal	greenish		



Lithology	Color	Remarks
crinoidal packstone/ wackestone	light greenish gray	whispy shale laminations
skeletal packstone	light gray -orange yellow	iron stains
skeletal wackestone	light gray	iron stains
wackestone	light gray	
mudstone/ clay shale	gray	thin (1 cm.) silty laminations weathering to yellow color
coal smut	black	
mudstone	greenish gray greenish gray with maroon mottling	clayey light brown calcareous nodules cylindrical and branching
Amazonia Ls. Mbr. micrite, silty Ls, & clay shale	greenish gray/orange yellow	solution breccia sheet cracks fitted clasts
slightly silty clay shale	greenish gray lt. gray	maroon lenses around iron rich nodules soft. thinly laminated