NSF Science Teachers Institute 1960

KANSAS STATE TEACHERS COLLEGE
EMPORIA, KANSAS

Fourth Geologic Field Conference

SATURDAY, JUNE 11, 1960

Wilson's Springs

ON TRIBUTARY OF BRUSH CREEK
SOUTHWEST OF COYVILLE,
NORTHWESTERN WILSON CO., KANSAS

in the

Flint Hills – Osage Cuestas

of Lyon, Chase, Butler, Greenwood, Wilson, Woodson, and Allen Counties, Kansas

State Geological Survey of Kansas
THE UNIVERSITY OF KANSAS, LAWRENCE, KANSAS
JUNE 1960

FOURTH GEOLOGIC FIELD CONFERENCE
in
the FLINT HILLS and OSAGE CUESTAS
of Lyon, Chase, Butler, Greenwood, Wilson, Woodson, and Allen Counties

11 June 1960

For
National Science Foundation SUMMER SCIENCE INSTITUTE 1960
KANSAS STATE TEACHERS COLLEGE OF EMPORIA
Director of Institute..........Otto M. Smith

FIELD CONFERENCE DIRECTORS..........J. M. Jewett, KGS
C. F. Gladfelter, KSTC

LEADERS...........Paul C. Franks, KGS
A. L. Hornbaker, KGS
Paul Johnston, KSTC
Ada Swineford, KGS

PRE-CONFERENCE SESSIONS

Thursday June 9..........

7:00 - 10:00 p.m.....Stratigraphy of Kansas, Paul Johnston
The Rise of Mammals, C. F. Gladfelter

Friday June 10..........

7:00 - 10:00 p.m.....History of the Earth, Frank C. Foley
Kansas Through the Ages, Ada Swineford

Interrelations, Paul C. Franks
Along the Route, J. M. Jewett

GUIDEBOOK........ Grace Muilenburg and Roberta Gerhard
Division of Public Information
STATE GEOLOGICAL SURVEY OF KANSAS

State Geological Survey, The University of Kansas, Lawrence, Kansas
Frank C. Foley, Director
William W. Hambleton, Associate Director

June 1960

ACKNOWLEDGMENTS for preparation of Guidebook..........

Illustrations...Geological Survey Drafting Room, under supervision of Ruth Vaill

Typing........Barbara McKnight

Reproduction..Carrie Badsky
Barbara McKnight

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INTRODUCTION

Geologists have two kinds of things with which to work. One is the rocks themselves, which are the only documents of earth history. There is almost no end to the ways in which these rocks can be investigated. The tools are numerous and some are extremely complicated. The other kind of thing is processes that can be seen or that rationally can be postulated as taking place. These too the geologist must study; for can one believe otherwise than that unchanging natural laws have operated for a long time in the same ways they are working now?

One can see limy mud on the floor of a present sea and even measure the rate of accumulation. Little imagination is needed to believe that limestones now high in mountains were once on sea floors. One can see silt carried seaward by streams and can reasonably explain some other rocks. Now and then people have seen a mountain built by volcanic action, and rather ancient volcanic mountains are definitely identified. One cannot see, however, molten material deep in the earth freeze into solid rock, but a reasonable theory to explain the making of granite can be formulated.

To facilitate study and discussion, rocks are classified and reclassified and placed in smaller and smaller "pigeon holes." Rocks are classed not only as to what they are but as individual units, either layers or other masses, within the crust of the earth. Processes too are classified; rocks are then reclassified not only in accordance with what they are but according to how they may have been made and what processes are believed to have affected them.

When rocks are studied, then, it ought to be realized two things are available: the rocks and an accumulation of ideas.

J. M. J.

FIELD CONFERENCE . . Saturday, June 11, 1960. Start 7:30 a.m. KSTC.

Route: Emporia--Strong City via US 50; Strong City-Cottonwood Falls-Matfield Green-Cassoday via K 13; Cassoday-Rosalia via country road; Rosalia-Eureka-Lake Eureka via US 54 and country road; Lake Eureka-Eureka-Coyville-Buffalo via US 54 and country road; Buffalo-Yates Center-Iola via US 75, 54; Iola-Lake Bassola via US 169-59.

Stop 1................. Exposure of Florena Shale and Cottonwood Limestone (Beattie formation), about 3 miles east of Strong City, Chase County. Brachiopods abundant in Florena.

Stop 2................. Quarry exposure of the Wreford Limestone showing reef development of Threemile Limestone (lowermost member), about 3 miles south of Matfield Green on K 13. Study of Permian stratigraphy.

Stop 3................. Road cut exposure of the Wreford Limestone and the Matfield Shale on US 54 about 5 miles east of Rosalia, Butler County. Stratigraphic study of Threemile Limestone as compared with exposure at Stop 2.

Stop 4................. LUNCH. Study of upper Pennsylvanian rocks at Lake Eureka. Burlingame Limestone and Silver Lake Shale exposed in waterfall below the dam. Abundant plant and coral fossils; ripple marks.

Stop 5................. Exposure of channel sandstone (Ireland member of the Lawrence Shale) at Wilson's Springs, about 1 mile east of Greenwood-Wilson County line.

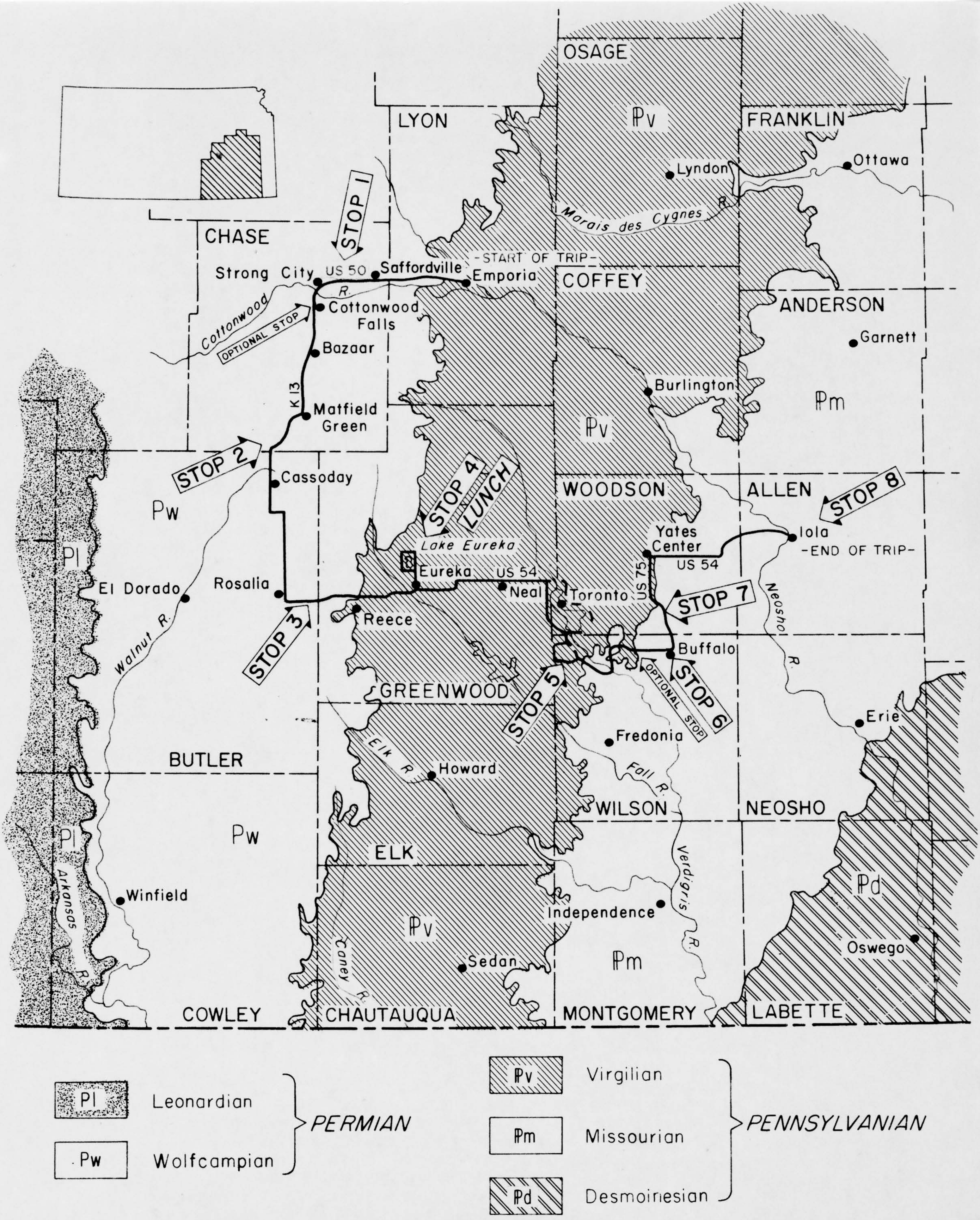
Stop 6 .... Acme Brick Company plant, 1 mile west of Buffalo, Wilson County.

Stop 7................. Rose Dome, anticlinal structure about 5 miles north of Buffalo in Woodson County. Several "granite" boulders to be seen near US 75.

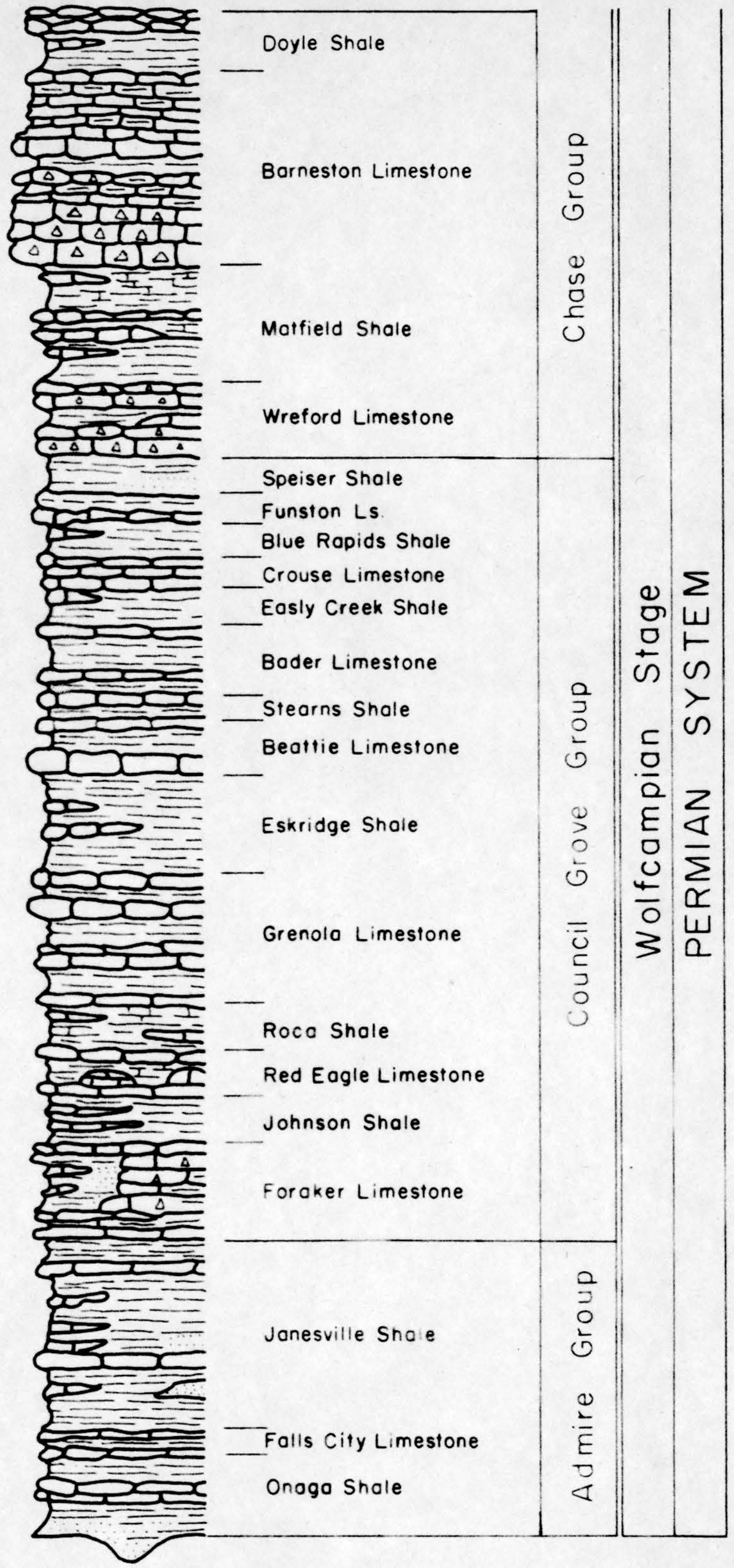
Stop 8 .... Lake Bassola. Old brick plant quarry in Lane-Bonner Springs Shale, about 1 mile south of Iola, Allen County.

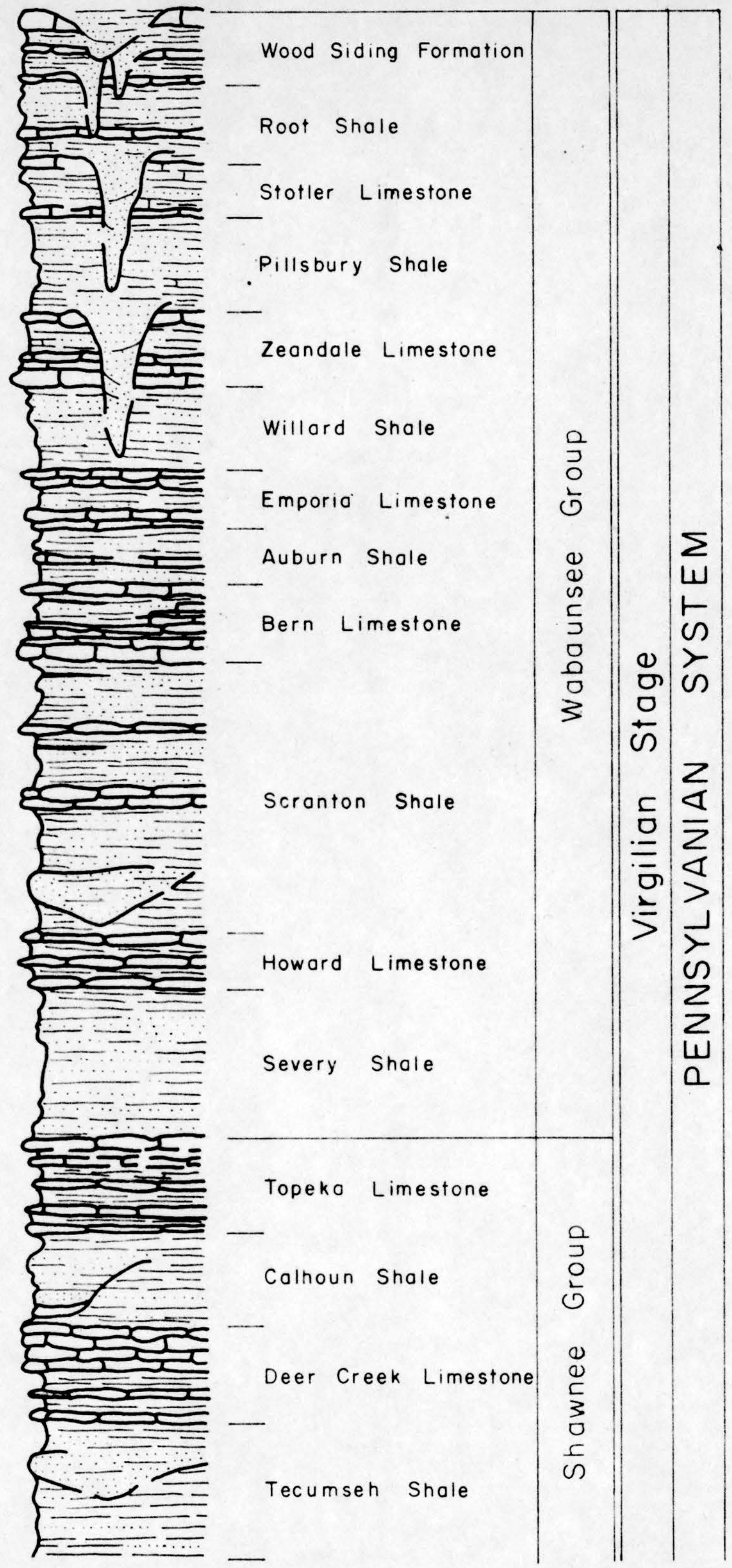
Pre-conference sessions on geology scheduled for Thursday evening, June 9, and Friday evening, June 10.

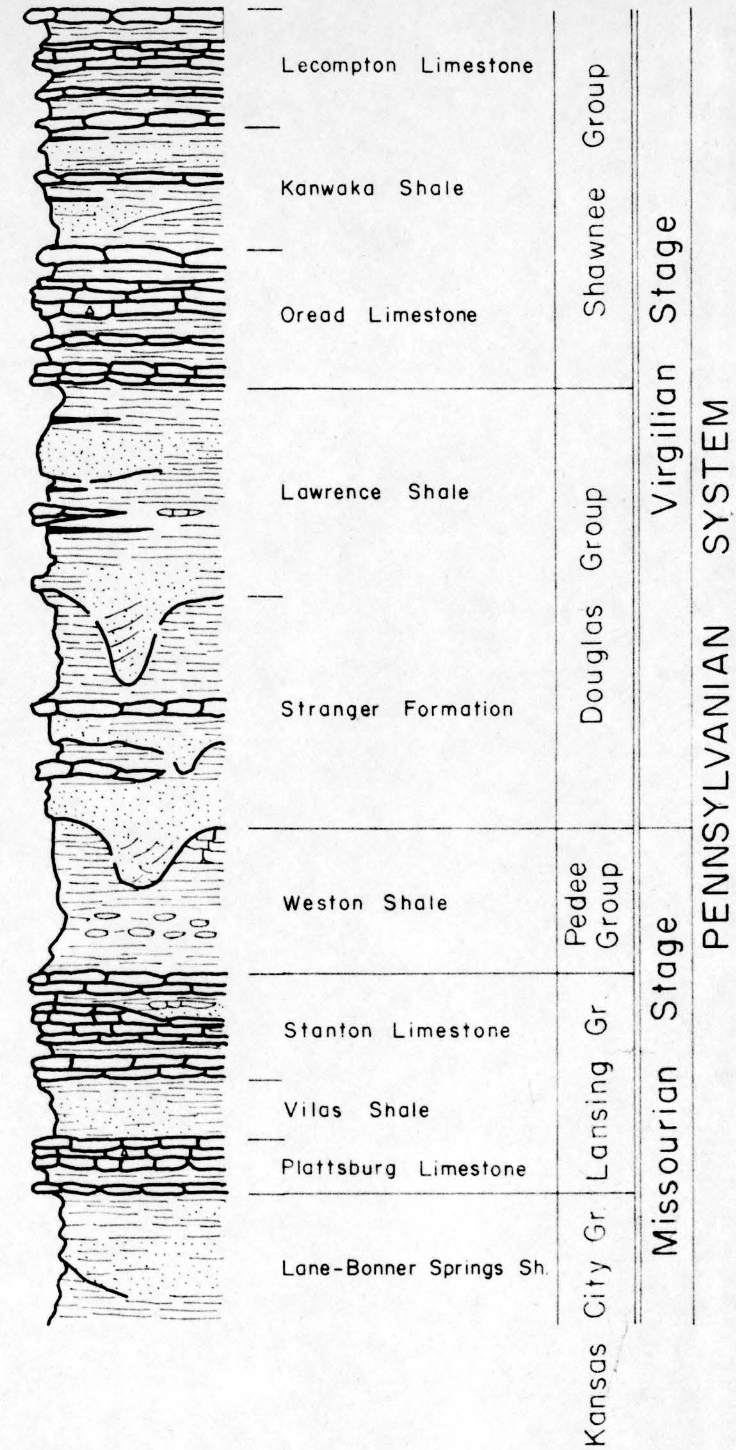
We wish to thank Phillips Petroleum Company for making available their recreation building at Lake Eureka, I. H. Wilson of Fall River for granting permission to visit Wilson's Springs, Acme Brick Company for their hospitality at the Buffalo plant.



Map showing conference route and generalized geology of field-trip area.

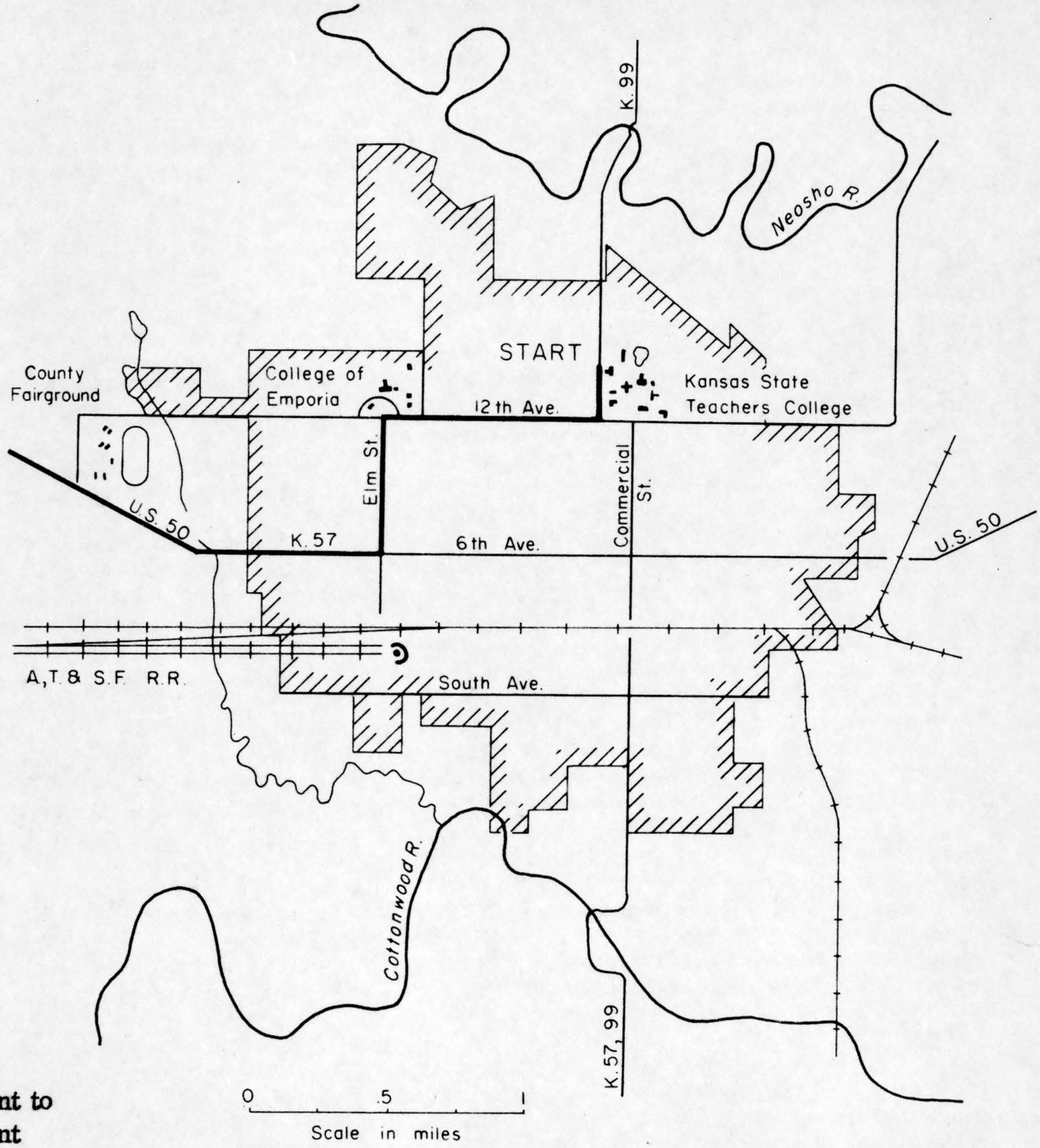






Graphic column of outcropping rocks in field trip area. (Detailed classification given on page 45.)

ROAD LOG... GEOLOGIC CONFERENCE IN FLINT HILLS--OSAGE CUESTA REGION
of Lyon, Chase, Butler, Greenwood, Wilson, Woodson, Allen Counties



Mileage	
cumu-lative	point to point
0.0	0.0

Assemble in parking lot at west entrance of New Science Hall, KSTC. Be ready to leave parking lot at 7:00 a.m.

Emporia is one of the state's oldest cultural and educational centers. Kansas State Teachers College of Emporia, which currently has an enrollment of about 3,200, was founded as the State Normal School in 1865, at a time when educational institutions dedicated to the training of teachers were almost nonexistent in this part of the United States.

The county seat of Lyon County, Emporia has a population that exceeds 15,000. The altitude near the center of the city is about 1140 feet above sea level.

Mileage cumu-lative	point to point	
		Incorporated as Emporia Town Company in 1857, Emporia has defended its name (from the Greek emporion meaning merchant) by maintaining status as an important trading and shipping center. Because of its location near the eastern edge of the Flint Hills bluestem pastures, the merchant city has an economy closely allied with cattle raising and shipping.
0.0	0.0	Turn left (south) on Merchant Street (K 99).
0.2	0.2	Turn right (west) on West 12th Avenue, at stop light. Go west 12 blocks.
0.9	0.7	College of Emporia on right.
		Founded by the Presbyterian Synod of Kansas in October 1882, College of Emporia was opened formally in November 1883. Attendance the first year was 17; the second year, 80. Present enrollment exceeds 200.
		Anderson Memorial Library at C. of E. (note stone building with dome), which was dedicated June 4, 1902, is believed to be the first Carnegie library on an American college campus. It was erected as a memorial to John Byars Anderson, a former trustee of the college, who lent books to Andrew Carnegie when Carnegie was a miner boy in Pennsylvania.
1.0	0.1	Turn left (south) on Elm Street.
1.4	0.4	Turn right (west) on West 6th Avenue (also US 50 and K 57).
1.8	0.4	Leave Emporia. Stockyards on left.
		Most of the city of Emporia is built on the extensive Emporia Terrace, developed during the Kansan Stage of the Great Ice Age (Pleistocene time). Bedrock, late Pennsylvanian in age, is exposed north and west of KSTC campus. We shall be on the Emporia Terrace, which rises about 20 feet above the alluvial floodplain of Cottonwood River, until we reach the vicinity of Plymouth. To the north are higher terraces developed earlier in the Pleistocene period, and south across the river are lower terraces, developed later in the Pleistocene period.

Straparolus gladfelteri Tasch
Identified and named by Paul Tasch, University of Wichita.

Sidelight...C. F. Gladfelter's fossil namesake, the gastropod Straparolus gladfelteri, has been found by the professor and others in the Dry Shale (Pennsylvanian age) at several localities where the Dry Shale is exposed in Lyon County. (The type locality of the Dry Shale is on Dry Creek in sec. 5, T. 20 S., R. 11 E., about 5 miles south of the western edge of Emporia, or about 1.5 miles west of Emporia Airport.)

In 1875, center of population in Kansas was about 17 miles northeast of Emporia.

3.2 1.4 Kansas Highway Patrol on right. Santa Fe railroad crossing.

3.7 0.5 Kansas Turnpike entrance. Elevation 1146 feet above sea level.

3.9 0.2 Turnpike underpass.

4.2 0.3 Crossroads; drive-in theater; elevation 1133 feet above sea level; sign to Bluestem Hall (Flint Hills recreation parlor on property of the finder of that little gastropod Straparolus gladfelteri).

5.1 0.9 Crossroads. Elevation 1156 feet above sea level.

5.3 0.2 Bridge. Moon Creek.

5.6 0.3 Cottonwood Friends Church; cemetery on left. Cedar tree.

6.0 0.4 Roadside park: picnic table and fireplace.

6.1 0.1 Cottonwood School. J. M. Jewett, director of this field trip, and J. C. Frye, a former state geologist of Kansas, slept here, once. (Accustomed to the Hickory Branch, they found it hard.)

7.1 1.0 Crossroads.

7.2 0.1 Bridge. Linck Creek.

We have descended from Emporia Terrace and are now on the floodplain of Cottonwood River.

Sands and gravels of the alluvium and terrace deposits along Cottonwood and Neosho Rivers are important sources of ground water. Pits where terrace gravels and alluvial sand and gravel are obtained, chiefly for use as road metal, may be observed at several places. Some silts in the deposits are potential ceramic raw materials. Volcanic ash in the Emporia Terrace at a locality between 6th and 7th Avenues just east of Garfield Street, Emporia, was mined for use as an abrasive around 1910. (This is one of the easternmost occurrences of volcanic ash in the state; ask Ada Swineford or one of the other field trip leaders how and when ash came to Kansas, a land of no volcanoes.)

8.1 0.9 Crossroads. Elevation 1135 feet above sea level. Emporia Sand and Gravel Company pits to right. C. E. Schultz, University of Nebraska, has identified mammoth bones from the pits.

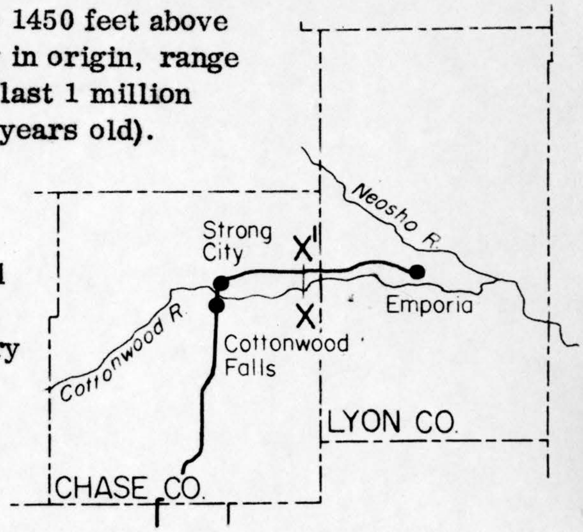
8.6 0.5 Bridge. Beaver Creek. Plymouth ahead and to right.

In July 1925 Lyon County cattlemen protested to the Kansas City Airways Transportation Company that their planes were frightening cattle and causing them to lose weight. Pilots were instructed to "fly high."

Lyon County, organized in 1858, has an approximate land area of 852 square miles and a population of 26,759 (preliminary 1960 census count). Principal industries are cattle raising, shipping, and farming. Industrial minerals include oil, sand and gravel, and stone.

Physiographically, approximately the eastern two-thirds of Lyon County is in the Osage Cuestas and the western one-third in the Flint Hills. Surface elevations range from about 1050 to 1450 feet above sea level. Outcropping rocks, sedimentary in origin, range in age from Pleistocene (approximately the last 1 million years) to Pennsylvanian (210 to 235 million years old).

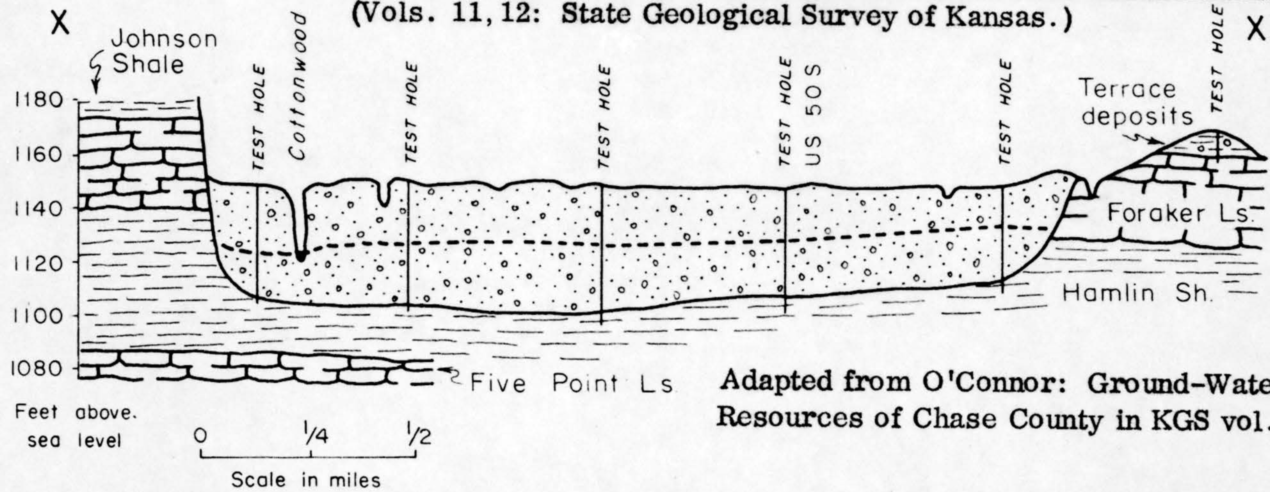
10.1 1.5 Leave Lyon County; enter Chase County.



Chase county, organized in 1859, has a land area of about 774 square miles and a population of about 4,000. The principal industry is cattle raising--about 70 percent of the county's area is unplowed grassland. Oil, gas, sand and gravel, and stone are among the industrial minerals.

Chase County is in the physiographic province known as the Flint Hills; escarpments and upland, dissected by Cottonwood River and tributaries, are dominant features. Range in elevation is from about 1100 feet to about 1600 feet above sea level. Outcropping bedrock is Permian in age (a geologic period existing between 185 million and 210 million years ago), and surficial deposits are Pleistocene and Tertiary in age.

References: Geology, Mineral Resources, and Ground-Water Resources of Chase County, Kansas and Geology, Mineral Resources, and Ground-Water Resources of Lyon County, Kansas. (Vols. 11, 12: State Geological Survey of Kansas.)



Adapted from O'Connor: Ground-Water Resources of Chase County in KGS vol. 11.

The alluvial floodplain deposits of Cottonwood River contain large quantities of hard but otherwise good water. The municipal supplies of Strong City and Cottonwood Falls are obtained from wells in the alluvium of Cottonwood Valley. The above cross section (X - X' on above map inset) shows geologic conditions in Cottonwood River valley in the vicinity of Saffordville.

The F. B. and Rena G. Ross Natural History Reservation of Kansas State Teachers College of Emporia is located immediately to the north. This 1040-acre tract (960 acres in Lyon County, 80 acres in Chase County), made available to KSTC on November 17, 1958, is described by Emily L. Hartman in the Emporia State Research Series Studies for June 1960 (vol. 8, no. 4).

11.2	1.1	Dunlap road to right.
11.9	0.7	Bridge. Buckeye Creek.
12.2	0.3	Saffordville to south.
12.9	0.7	We are leaving the floodplain at elevation of approximately 1150 feet above sea level and traveling onto a high terrace.

Some of the high terraces north of Cottonwood River in eastern Chase County are 50 to 100 feet above the present floodplain; the tops of terraces are remnants of former floodplains.

13.3	0.4	Crossroads. Elevation 1170 feet above sea level.
14.0	0.7	Cross Bull Creek.
14.4	0.4	Note chert gravels.

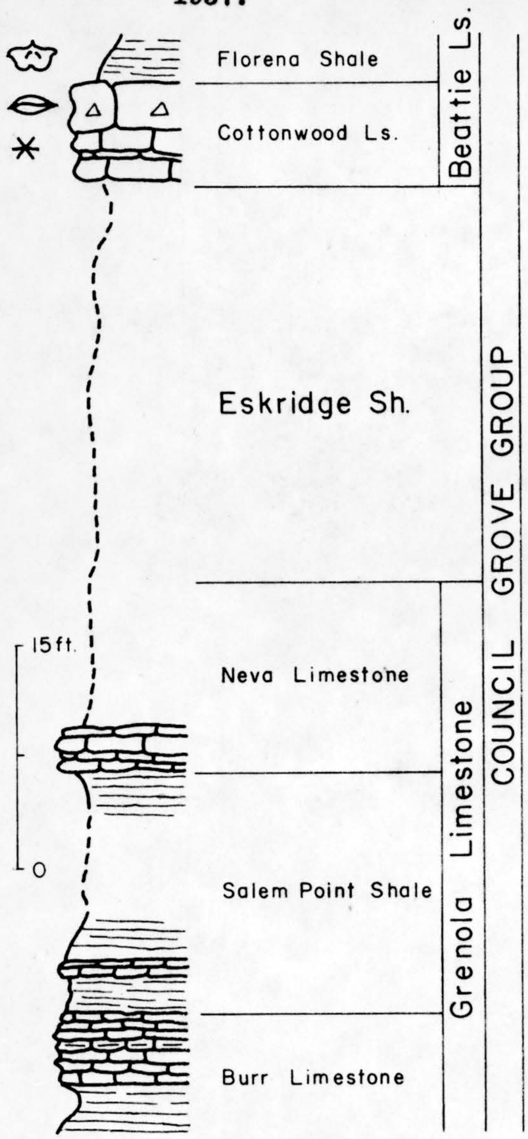
Accumulations of chert gravels, along with chert and quartz sand, are extensive in the terrace deposits and alluvium of Cottonwood River valley and tributary stream valleys.

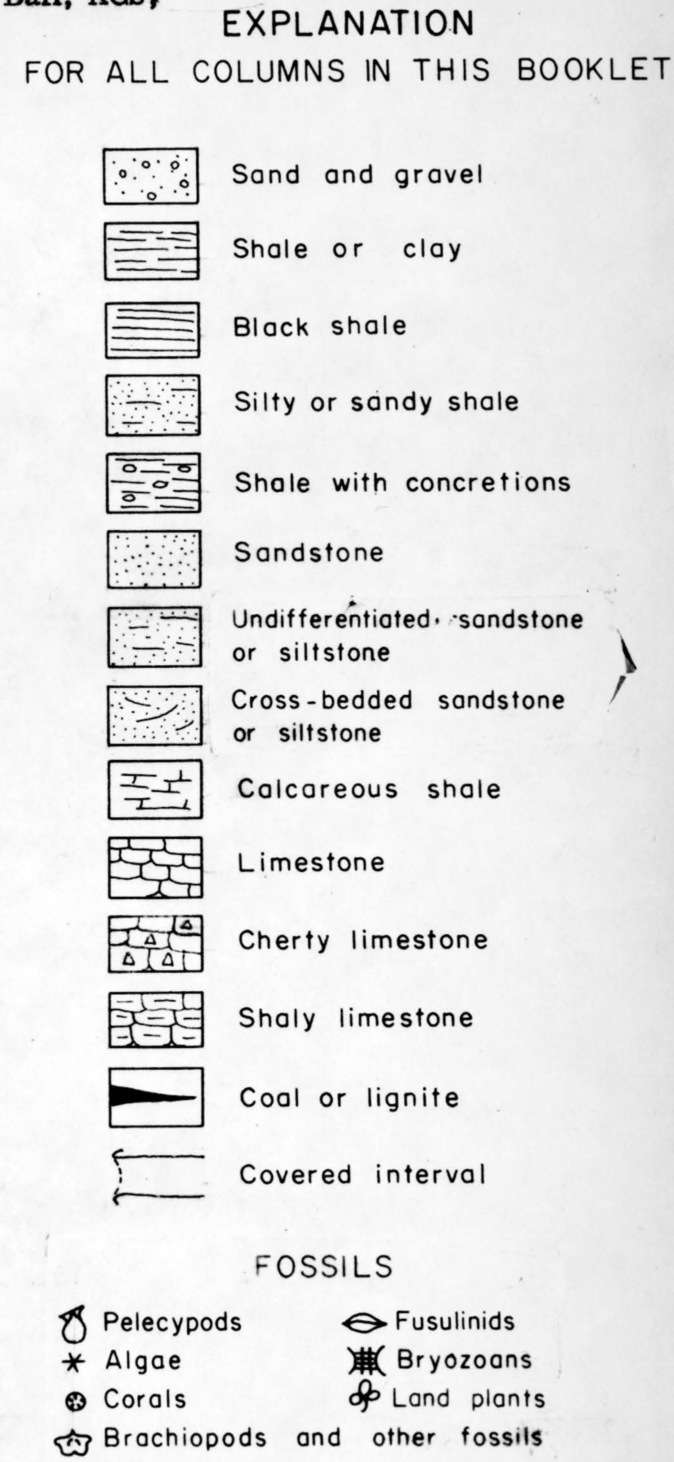
14.8	0.4	View. Flint Hills escarpments and uplands from elevation 1217 feet above sea level.

14.9	0.1	Lower part of Grenola Limestone, Permian age, exposed in roadcut. This is the first noticeable exposure of bedrock along US 50 west of Emporia. We shall see occasional outcrops of the Grenola Limestone and Eskridge Shale formations during the next mile.
15.3	0.4	Grenola Limestone; the Neva Limestone is the uppermost member.
15.4	0.1	Grenola Limestone.
16.1	0.7	Bridge, Peyton Creek. Grenola Limestone and adjacent rocks.
16.4	0.3	Picnic area on left. Elevation about 1210 feet above sea level. Park for STOP 1 (next page).

STOP 1. **Fossil-collecting locality in Permian rocks east of Strong City, Chase County. (SE 1/4 sec. 12, T. 29 S., R. 8 E.)**

Section measured by S. M. Ball, KGS, 1957.





Several types of fossils may be found in the Florena Shale exposed near a road-side park on US 50 about 3 miles east of Strong City. The brachiopod Chonetes is especially abundant.

Fusulinids and algae may be seen in the Cottonwood Limestone, which occurs below the Florena Shale.

Annals of Kansas 1885-1925, published by the Kansas State Historical Society: Sept. 7, 1913--Tons of clam shells from Cottonwood River were being shipped to button factories.

Continue west on US 50.

17.4 1.0 Crossroads. Benchmark (BM △): 1229 feet above sea level.

Benchmarks are permanent or semi-permanent markers of latitude, longitude, and elevation of points on the land surface. Used as controls in topographic mapping, benchmarks insure accurate positions and elevations for features to be shown on the maps. Determined by control surveys, these points generally are marked by small metal tablets cast with standard inscriptions and stamped with code numbers, dates, and other information.

17.6 0.2 Grenola Limestone on both sides of road. From here to Strong City, outcropping rocks are younger than Beattie Limestone. Most of the rocks belong to the Council Grove Group, but high on the hills rocks of the Chase Group may be seen. (Refer to graphic section, page 6.)

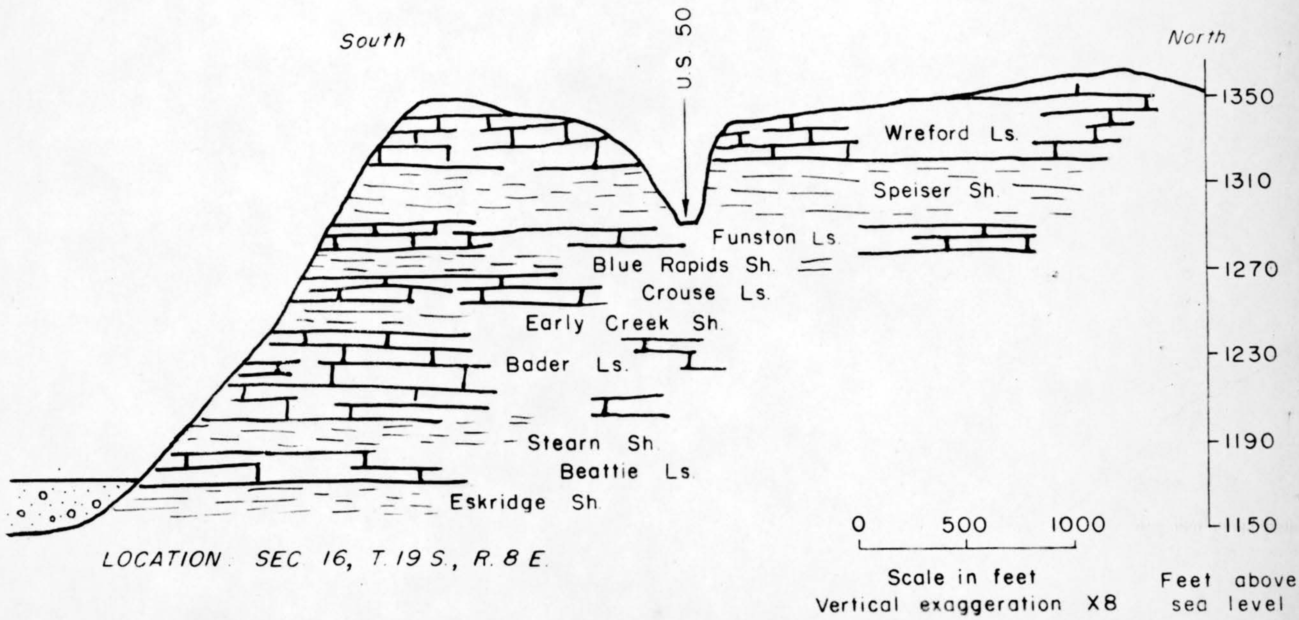
17.9 0.3 Cottonwood Limestone on left.

18.5 0.6 Crossroads.

19.6 1.1 Cemetery on left. Elevation 1250 feet above sea level.

19.8 0.2 Old quarry in Threemile Limestone to left (south). Elevation of hill to left (south) 1349 feet; to right (north) 1370 feet.

Note roadcuts, both sides of road. From near base of hill to top, rocks exposed include: Blue Rapids Shale, Funston Limestone, Speiser Shale, Wreford Limestone (Threemile member at very top). Study sketch below.



20.2 0.4 City limits, Strong City, city of the annual event of the <u>Flint Hills Rodeo</u>. Ask Professor Gladfelter for further details.

20.6	0.4	Turn left (south) on K 13 (Cottonwood Street). Go through business district of Strong City.
20.8	0.2	On floodplain of Cottonwood River in heart of Strong City, which has a population of about 650. Elevation is about 1180 feet above sea level.

Settled in 1871 and 1872, on the mainline of Atchison, Topeka, and Santa Fe Railroad about 1.5 miles north of Cottonwood Falls, Strong City was known as Cottonwood Station until 1881. In that year the name was changed to Strong City in honor of W. B. Strong, then president of Santa Fe Railroad. (You thought it got its name from something else, didn't you?)

The cattle-feeding operations west of town, where several thousand steers commonly are being fattened at one time, indicate the prominence of the cattle industry in this Flint Hills community. In the past Strong City has been one of the country's major rock-products centers. From nearby quarries large quantities of building stone have been shipped and many tons of crushed rock utilized by the railroads. Limestones that have been quarried include Neva, Cottonwood, Morrill, Eiss, Crouse, Funston, and Threemile. (Refer to pages 6 and 45 for stratigraphic positions of these rock units.)

21.5	0.7	Leave Strong City.

Oxbow lake on left; oxbows are crescent-shaped lakes in abandoned meander bends that have been cut off from the main stream channel by a change in the stream's course.

22.0	0.5	City limits, Cottonwood Falls, county seat of Chase County. Population about 950. Elevation about 1200 feet above sea level.
22.2	0.2	Bridge over Cottonwood River. Water falls; dam and old mill site to right.

Cottonwood Falls was incorporated as a town in 1858 (third-class city in 1872). Early in its history, Cottonwood Falls became noted for the excellent quality building stones obtained from quarries in the neighborhood. The most famous is the Cottonwood Limestone, which throughout the years has remained one of the most popular of the state's building stones. The stone has been used extensively over a wide area. Most of the stone in the Statehouse at Topeka is Cottonwood Limestone from Chase County.

W. A. Morgan established Chase County Leader on March 6, 1871. On April 1, 1889, the wife of the newspaper editor, Minnie D. Morgan, became mayor of Cottonwood Falls; she was one of three women elected mayors of Kansas towns that year.

22.5	0.3	Chase County Courthouse. Jog left, then right at courthouse.

Built of Cottonwood Limestone in 1870, the Chase County Courthouse is an excellent example of Victorian architecture, and it exhibits the attractiveness and durability of this Permian-age building stone.

OPTIONAL STOP. Roniger Museum, south side of courthouse block.

Roniger Memorial Museum was built in 1959 of Cottonwood Limestone from the relatively new Elmdale Quarry located northwest of Cottonwood Falls. Indian arrowheads collected in the Flint Hills by the Ronigers, ranchers from near Bazaar, are on display in the museum. The exhibit is one proof that the Indian knew what to do with the cherty (flinty) rock of the Flint Hills long before his paler-skinned brother came along to claim and tame the region.

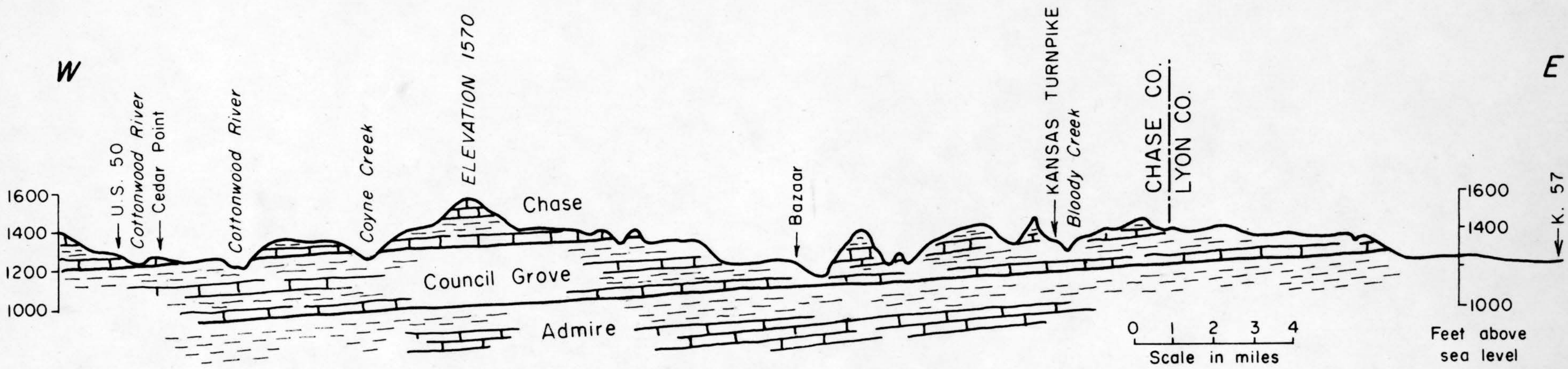
22.6	0.1	From southeast corner of courthouse block, turn left (east).
22.7	0.1	Turn right (south).
23.2	0.5	City limits, Cottonwood Falls. Continue south on K 13.

From Annals of Kansas: May 15, 1912--Heavy shipments of cattle arrived at Cottonwood Falls from Texas, New Mexico, and other states. It is estimated that Chase County grazed 75,000 head a season.

24.3	1.1	Bridge. Buckeye Creek.
25.1	0.8	Onto Wreford Limestone escarpment. Up from Funston Limestone.
25.6	0.5	South Fork Valley to left.
25.8	0.2	Characteristic outcrop of Wreford Limestone on either side of road.
26.2	0.4	In Matfield Shale.
26.6	0.4	Hills to right capped by Florence Limestone. Road at approximate level of Kinney Limestone.
26.8	0.2	Riding on Kinney Limestone.
27.0	0.2	View of beautiful South Fork Valley.
27.1	0.1	Down from Wreford Limestone.
27.5	0.4	Funston Limestone on right.
27.7	0.2	Jordan Ranch.
28.1	0.4	Wreford Limestone on hills to right.
28.8	0.7	Road curves in Funston Limestone.

We are near the northwest corner of the bluestem grassland area (of almost 30,000 acres) proposed in 1958 as a national park site.

29.3	0.5	Road to Bazaar (to left). Bazaar Cemetery; Bazaar School (on right). On gravel terrace; old chert gravel pits in vicinity.
		The little village of Bazaar, in the heart of Chase County, recently had a centennial celebration. Its post office was established in 1860, it is the girlhood home of Peggy Green (Peggy of the Flint Hills of the Topeka Daily Capital), and it was once the world's leading cattle shipping center.
		From Annals of Kansas : . April 30, 1921--Six trainloads of cattle were being unloaded at Bazaar, distributing point for Flint Hills pastures. Already 17,000 head had been received. Feb. 17, 1924--Bazaar, population 100, has shipped over 1,000 carloads of cattle the past six months.
		The chert gravels in the vicinity of Bazaar are characteristic of high level gravels seen farther east. They represent former filling of valleys. Many tons of gravel have been taken from the Bazaar pits and screened for use as road metal and other rock aggregate.
		(Turn to the next page to study a cross section showing arrangement of rock layers in relation to surface relief west-east from Cedar Point, Chase County, to Kansas 57, Lyon County.)
29.5	0.2	Indian cemetery marker on hill to left.
29.6	0.1	Bridge. Rock Creek. Neva Limestone in creek bed.
29.7	0.1	Knute Rockne Memorial on hill to west. (Base of native limestone; top of imported granite.)
32.5	2.8	Hills on left capped by Wreford Limestone.
32.8	0.3	Railroad overpass (Santa Fe).
34.0	1.2	Old Orient Railroad grade--reminder of a railway venture that had a stormy and long construction history but was never completed. Born as a promoter's idea of the shortest rail route from Kansas City to Pacific salt water (Kansas City to Topolobampo, Mexico), the Kansas City, Mexico and Orient Railway was incorporated in 1900 and the first rail laid at Emporia on July 4, 1901. (Continued at the next Orient grade encounter.)
35.3	1.3	Wayne Rogler Ranch.
35.4	0.1	Wreford Limestone is exposed at top of railroad cut to right.
35.8	0.4	Crocker Creek.
36.0	0.2	Pioneer Bluffs Ranch.
36.2	0.2	Wreford Limestone near top of cut, right.



Generalized cross section of the Flint Hills escarpment in Chase and Lyon Counties

At a vertical exaggeration of more than 52 times the horizontal scale, this cross section shows the relationship of westward-dipping bedrock to eastward-sloping topography in a part of eastern Kansas. We are reminded that the hills and valleys have resulted from erosional carving, not localization of accumulations or upthrusting of individual segments of the earth's crust. Long ago the nearly parallel rock layers, pictured here, extended uninterrupted far to the east, possibly a thousand miles. Uplifted and tilted almost uniformly through a vast area, hard limestone and softer shale were beveled, and their edges lay in a plain-like expanse.

The Flint Hills (note the 1570 foot elevation), it is believed, were a divide between two large drainage areas on the ancient terrain. Height above sea level and erosive force of streams being what they were, the rocks could then be worn no lower. Comparatively recently all Kansas was tilted to the east. Streams, whose history still is quite vague, have cut their present valleys, have filled and partly reexcavated them, and have produced the present landscape. Only small parts of the old surface remain as present hill tops and even they must have been slightly reduced in height.

--J. M. Jewett, KGS

On March 1, 1885, Chase County had 817 dogs. Some of these dogs killed livestock and cattlemen were unhappy.

36.6	0.4	Curve right.
37.2	0.6	City limits, Matfield Green.
37.4	0.2	Post office, Matfield Green.

Matfield Green is a cattle-shipping point in southern Chase County, in the valley of South Fork Cottonwood River. Wreford Limestone caps hills in immediate vicinity at about 1450 feet above sea level. About 7 miles to east, elevation of a hill capped by Fort Riley Limestone exceeds 1600 feet above sea level.

From Annals of Kansas: Sept. 10, 1925--1,500 head of cattle received at Matfield Green from Texas Panhandle for pasturage and fall feeding.

37.8	0.4	Curve.
38.2	0.4	Railroad cut (on right) in Wreford Limestone.
39.2	1.0	Old Orient Railroad grade again. By 1908 about 730 miles of track had been put down and an additonal 240 miles graded, but by 1912 financial difficulties resulted in receivership. (Concluded below at Orient grade crossing.)
39.5	0.3	Wreford Limestone crops out.
39.9	0.4	Cross old railroad track that never was (the Orient Railroad grade, which looks like an esker but isn't).

On the verge of abandonment, the project was revived in 1923, when oil was discovered in West Texas and the completed part of the Orient line from Alpine, Texas, to Wichita, Kansas, became a major medium of oil transport. But oil alone could not keep the venture alive. Besides, a poorly constructed roadbed characterized sections that had gotten beyond the grading stage; ties were untreated and bridges light, ballast had been disregarded and geologic conditions probably ignored. The road was doomed. In 1928 the Santa Fe Railway Company purchased the Orient.

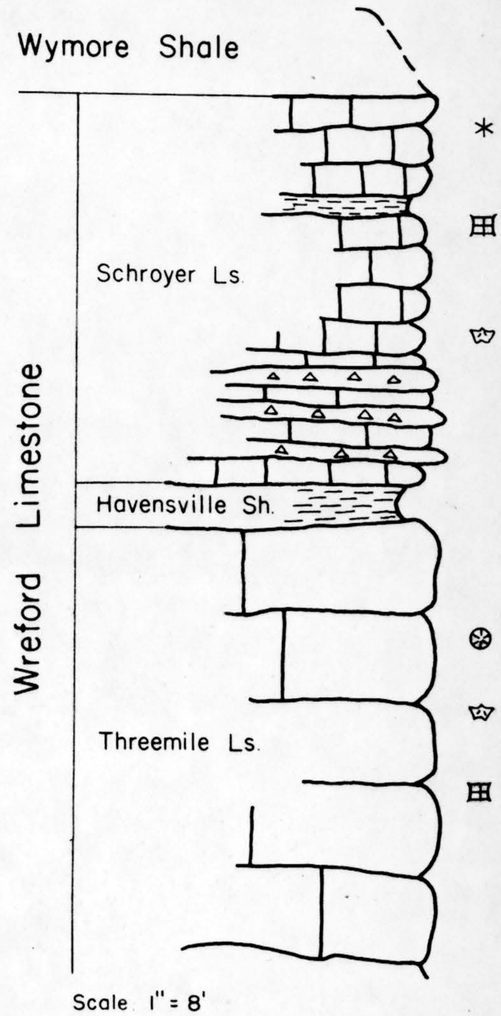
40.4	0.5	Entrance to quarry in Wreford formation. Note reeflike appearance (thickening) in Threemile (lower limestone) and folding in Schroyer (upper limestone). (A. L. Hornbaker will be delighted to talk about the whys of this thickening and folding.)

STOP 2 (next page).

STOP 2. Quarry in Wreford Limestone, about 3 miles southwest of Matfield Green, Chase County. (West of K 13 in sec. 19, T. 22 S., R. 8 E.)

Section measured by A. L. Hornbaker and R. O. Kulstad, KGS, 1960.

STOP 2 and STOP 3 offer a good opportunity to study facies change within a formation. Here in the Wreford formation we see normal development of the Schroyer Limestone, a very thin Havensville Shale, and an unusually thick development of the upper part of the Threemile Limestone, which is a reef deposit. (See page 21 for discussion of reefs.) Formation of the reef took place in clear, warm, relatively shallow water—during maximum advance of the sea. * Fragmentation of crinoid and delicate bryozoan remains suggests moderate wave action. Thin sections of the rock, studied microscopically, reveal thin, tubular thread-like structures, which are remains of lime-secreting algae. A large proportion of the limestone is attributed to these lime-secreting plants.

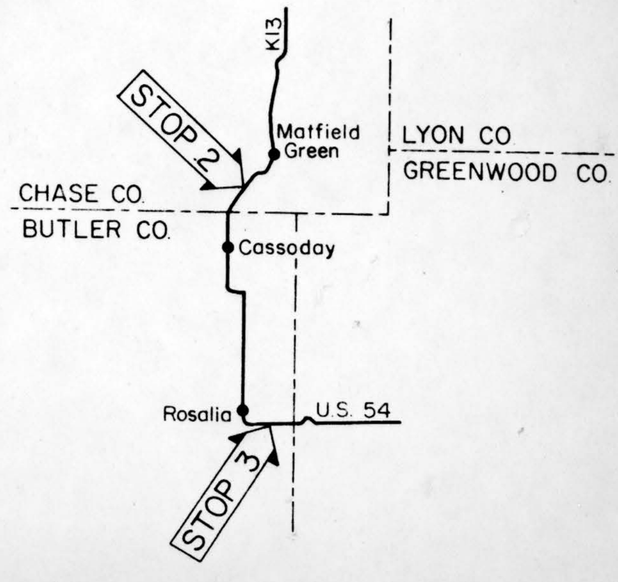


At the next stop, the Threemile Limestone is normally developed and consists of cherty limestone. Above it the Havensville Shale is thicker and represents a more normal thickness of that unit.

*(For a more detailed discussion of the type of deposition resulting from the rhythmic incoming and outgoing of the seas—cyclic deposition—refer to page 50.)

— A. L. Hornbaker, KGS

Heed signal to leave.



40.6	**0.2**	**Railroad underpass (Santa Fe).**
40.9	**0.3**	**Florence Limestone.**

41.1	0.2	Matfield Green Turnpike Service area to left.
41.8	0.7	In Barneston formation (on or near top). Fort Riley Limestone exposed.
42.9	1.1	Top of Fort Riley Limestone.
43.5	0.6	Leave Chase County; enter Butler County. On top of Flint Hills.

Organized in 1855, Butler County has an approximate land area of 1,445 square miles. The largest county in the state, it is also one of the more populous; its rank, based on the preliminary 1960 census report of 38,452, is eleventh. Cattle raising and the oil industry are major contributions to the county's economy. (According to the State Board of Agriculture, Butler County was the top county in number of cattle and calves on Kansas farms in 1959--a total of 100,000. It ranked 4th in barrels of oil produced--7,929,366.)

Butler County is in Flint Hills physiographic region. Some of the highest of the region's uplands are in eastern Butler County; the altitude in several spots exceeds 1600 feet. All bedrock exposed in the county is Permian in age, and surficial deposits are Pleistocene and Tertiary.

44.5	1.0	Signal tower to left. On Florence Limestone at Chase-Butler County line.
47.1	2.6	Turnpike overpass.
47.5	0.4	Cassoday. Elevation about 1500 feet above sea level.

Fifty years ago (1910) Cassoday was described as a town of considerable commercial importance, although a great distance (12 miles) from a railroad. A town of 300, it had telephone connections with surrounding towns and a daily stage line to El Dorado.

47.8	0.3	Straight ahead. Leave K 13.
47.9	0.1	Caution! Railroad track. (The A. T. & S. F. finally made it!)
48.1	0.2	Leave Cassoday.

We shall be traveling high on the Flint Hills upland--at an average elevation of 1500 feet above sea level--for the next 15 or 16 miles, as we go almost due south to Rosalia. The surface in this stretch is developed on the weather-resistant limestones of the Barneston formation (the Fort Riley and Florence members), outcrops of which may be noted occasionally in road ditches.

48.9	0.8	Fort Riley Limestone in ditches.
49.5	0.6	Used-to-be windmill to left.
50.6	1.1	Florence Limestone.

52.4 1.8 Turn left.

53.4 1.0 Turn right. Phillips Booster Station to left; one of a number of such stations along pipelines carrying oil and gas from producing areas to distributing points.

Butler County is one of the state's top ranking oil-producing counties. The El Dorado Field, discovered in 1915, has been the state's most prolific oil producer (241,182,846 barrels), was once the country's top producer, and still produces about 4,400,000 barrels annually.

54.2 0.8 Caution! Narrow bridge.

56.5 2.3 Little bridge. (There are several more little bridges ahead; we'll cross them as we get to them.)

57.6 1.1 Florence Limestone, commonly referred to as Florence flint.

Butler County had a terrible prairie fire on October 20, 1872.

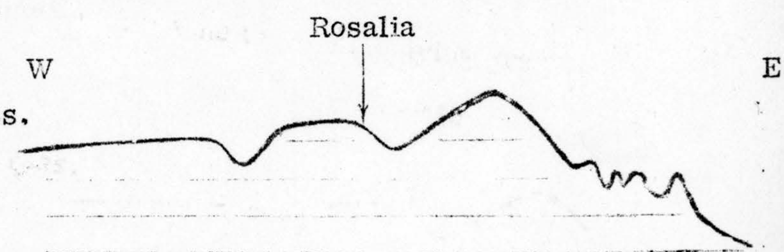
59.8 2.2 Florence flint.

62.4 2.6 Bridge. Florence outcrop in ravine to right. Flying gravel.

63.3 0.9 Crossroads.

63.8 0.5 Railroad (Mo. P.) Cross. Rosalia.

In the 1870s Rosalia had a broom factory.



Flint Hills escarpment in maximum development. Elevation rise, 1200 feet to 1600 feet above sea level. Horizontal distance, about 15 miles. (Profile generalized from U. S. Geological Survey topographic map of El Dorado Quadrangle, 30-minute series.)

64.3 0.5 Stop. Caution! Turn left on US 54.

65.5 1.2 Bridge. Windmill and stock tank to left.

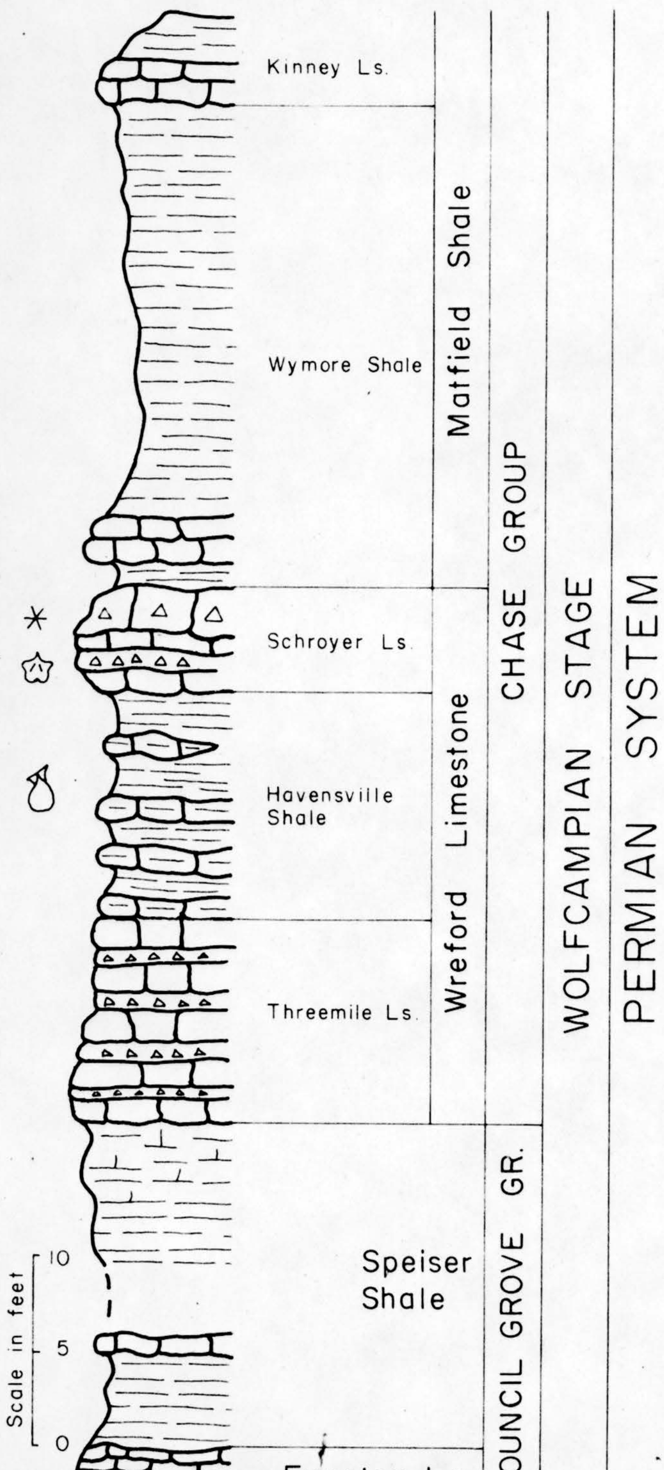
68.3 2.8 Thick deposits of chert gravels in roadcuts.

68.5 0.2 Pond to left. Drive onto new road.

68.7 0.2 STOP 3 (next page).

STOP 3. Exposure in roadcut along US 54, Butler County, near the Butler-Greenwood County line. (Near South line sec. 4, T. 26 S., R. 8 E.) Section measured by A. L. Hornbaker and R. O. Kulstad, KGS, 1960.

Complete Wreford formation. Kinney Limestone (under fenceposts) and Wymore Shale members of Matfield Shale exposed above.



This roadcut exposes a section of rock different from the section at the last stop, although the same three members of the Wreford formation are represented in both areas.

Here the Threemile Limestone is much thinner and the Havensville Shale considerably thicker. Wherever the reeflike chalky limestone of the Threemile developed as a thick unit (as seen at the last stop), the Havensville Shale is correspondingly thin. It is possible that reef growth continued during deposition of the lower Havensville Shale. Thus the calcareous shale--locally limestone--of the lower Havensville Shale may be in part equivalent in age to the chalky limestone of the Threemile as seen at the previous stop.

Structurally, a reef consists of a rigid calcareous framework (core) made up mainly of the interlocked and encrusted skeletons of reef-building organisms, especially corals and algae. The core is flanked by sediments derived from organic and physical degradation of the frame and organism of the reef builders. The flanking debris constitutes the major part of the reef, usually 90 percent or more of the total reef.

In limestone units, a reef is surrounded laterally by normal marine limestones. Some ancient reefs attained thicknesses up to 2,000 feet (Permian reefs in West Texas and New Mexico). Growth of most reefs probably started in fairly shallow water. The great thicknesses attained by some of the ancient reefs indicate that these structures grew upward as sea level rose. Rising of the sea level must have been slow to prevent drowning of the reef organisms. Modern reefs are capable of growing one foot in approximately 10 years.

--A. L. Hornbaker, KGS

68.8	0.1	Leave improvement area. Speiser Shale (red in ditch to right).
69.4	0.6	Leave Butler County; enter Greenwood County. Pump jacks in area.

Greenwood County was organized in 1862; approximate land area is 1,150 square miles. Population is about 13,000. Major source of farm income is livestock. Leading mineral products are oil and stone.

Physiographically, Greenwood County is in the Flint Hills (extreme western part) and the Osage Cuestas. Elevations are lowest, 1000 feet above sea level and lower, in the Fall River and Verdigris River valleys in the southeastern part of the county; they are highest, 1500 feet and higher, along the Flint Hills escarpment at the western border of the county. Permian rocks are exposed in the westernmost part and Pennsylvanian rocks elsewhere in the county. Thick deposits of Pleistocene-age sands and gravels are found in valley areas.

69.6	0.2	Neva Limestone on right.
69.8	0.2	Neva on left.

As we descend the eastern escarpment of the Flint Hills, note the topographic expression of the hills and valleys.

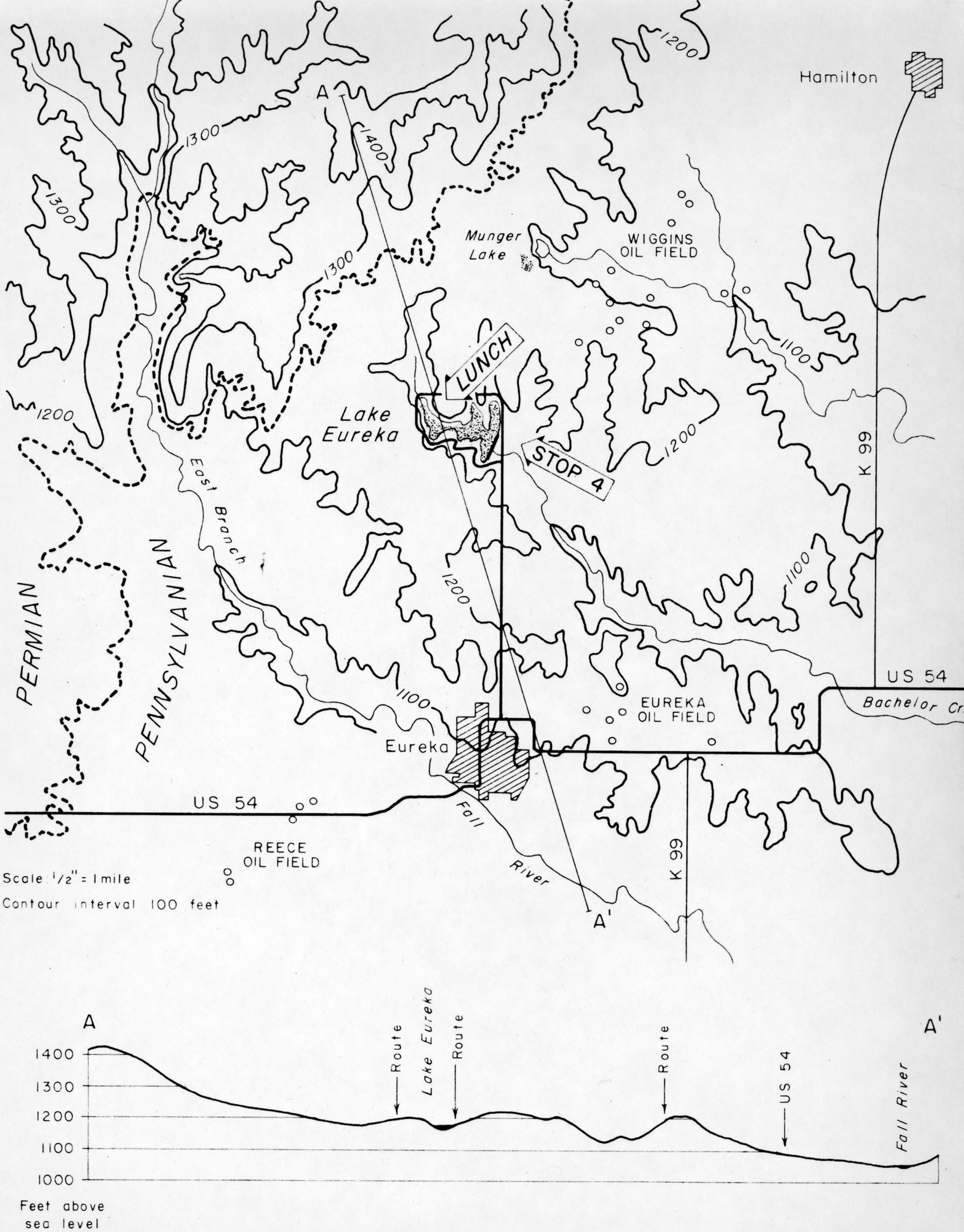
70.1	0.3	Sallyards Oil Field. This elongated oil field, a part of the Golden Lanes,* was opened in 1917. Production is from the "Bartlesville sand" at an average depth of 2,400 feet. Production during 1959 was 762,137 barrels of oil. Waterflooding is practiced in this field.

One of the three initial waterflood projects in Kansas oil fields (in 1935) was in Greenwood County. The county currently ranks first among the state's counties in oil production by secondary recovery.

*(For a discussion of the Greenwood County "shoestring sands," refer to "Mineral Resources of the Flint Hills-Osage Cuesta Region," page 52.)

70.4	0.3	Lower part of Grenola formation exposed. Also Roca Shale and upper part of Red Eagle Limestone.
71.1	0.7	Howe Limestone member of the Red Eagle; Roca above.
71.6	0.5	Underpass (Missouri Pacific).
72.0	0.4	Red Eagle Limestone.
72.3	0.3	Hughes Creek member of Foraker Limestone. Fossils--fusulinids, crinoid stems, brachiopods, bryozoans--are plentiful in Hughes Creek.
72.5	0.2	Americus Limestone in creek bed by elm tree. (Botany and geology are on speaking terms.)

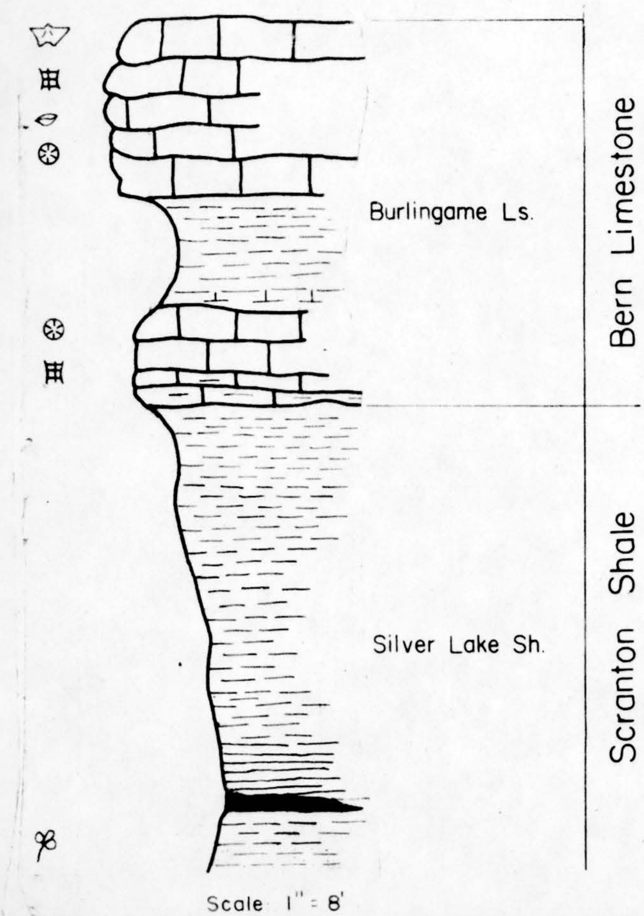
72.9	0.4	Bridge.
73.8	0.9	Bridge. Lower part of Admire Group (Permian). Reece, 0.5 mile south.
74.5	0.7	The wooded area to the right illustrates how vegetation reflects the character of underlying bedrock. Trees are growing on sandstone deposits, whereas surrounding limestones and shales are not able to support as much vegetation.
75.0	0.5	We are now passing down the stratigraphic section from Permian to Pennsylvanian rocks; uppermost unit of the Pennsylvanian is Brownville Limestone.
79.1	4.1	Tank battery on right.
79.2	0.1	Reece Oil Field. The Reece produces from Kansas City rocks at about 1,380 feet and from Mississippian limestones at about 2,100 feet. Production in 1959 amounted to 17,900 barrels of oil.
80.1	0.9	Roadcut. Emporia Limestone and Auburn Shale.
80.4	0.3	Auburn Shale.
81.0	0.6	Burlingame Limestone and Silver Lake Shale.
81.3	0.3	Missouri Pacific underpass.
81.8	0.5	Bridge. Fall River. Howard Limestone in left bank.
81.8	0.0	Enter Eureka on River Street.
		Located on Fall River in 1857, Eureka—Greek for "I have found it"— became the county seat of Greenwood County. The first building was a schoolhouse built of short planks hewn from logs; the house served as a meeting place for all public gatherings. When the Santa Fe and Missouri Pacific Railroads reached the town, it developed into an important grain, livestock, and produce shipping point. It is now a progressive town of about 4,000 inhabitants.
82.1	0.3	At caution light turn left (north) on US 54 (Main Street).
82.4	0.3	Greenwood County courthouse on left.
82.6	0.2	Intersection, 7th Street and US 54. (Ford store and school at intersection.) Cross; continue north on Main Street.
82.8	0.2	Railroad tracks (3).
83.1	0.3	Turn right (east) on 13th Street.
83.4	0.3	Turn left (north). Continue north to Lake Eureka, lunch stop.
84.6	1.2	Eureka Municipal Airport on left.



Map and profile of the Lake Eureka area, Greenwood County. Surface features of the profile A-A' are interpreted from contoured topography in the map area A-A'.

86.0	1.4	Road to right. Continue north.
87.0	1.0	Road to left.
87.5	0.5	Entrance to Lake Eureka, left. Continue north across Bachelor Creek to park entrance on north side of bridge.
87.6	0.1	Bridge. Bachelor Creek. From bridge note dam and spillway of Lake Eureka.
88.1	0.5	Park entrance. Turn left into park and follow lead car to LUNCH STOP at the Phillips Petroleum Company Recreation Building.
		After LUNCH, board your bus. Proceed around lake; bear left.
89.7	1.6	Bridge of inlet to Lake Eureka.
92.3	2.6	Park behind lead car near dam and spillway.

STOP 4. **Dam and spillway of Lake Eureka, Greenwood County.**
(NE 1/4 sec. 10, T. 25 S., R. 10 E.)
Section measured by A. L. Hornbaker and R. O. Kulstad, KGS, June 1960.



The Burlingame Limestone is well exposed below the dam and in the roadcut. It is brown, fine-grained, hard, thick-bedded and brecciated in some exposures. Shale separates the limestone members at this locality but is commonly absent. Algal deposits are abundant in the upper Burlingame. Cross sections of horn corals can be found on the surface of the massive bedded limestones. Brachiopods, bryozoan fragments, and crinoid stems are disseminated throughout most of the limestone. Fusulinids are abundant in the morepersistent thin beds.

Below the Burlingame at the waterfall is the Silver Lake Shale. Locally a thin coal bed is found underlying a dark gray to black shale about three feet above the water level at the foot of the falls. Fragments of land plants, particularly Calamites, a relative of the modern Equisetum, are abundant in the sandy shales below the coal.

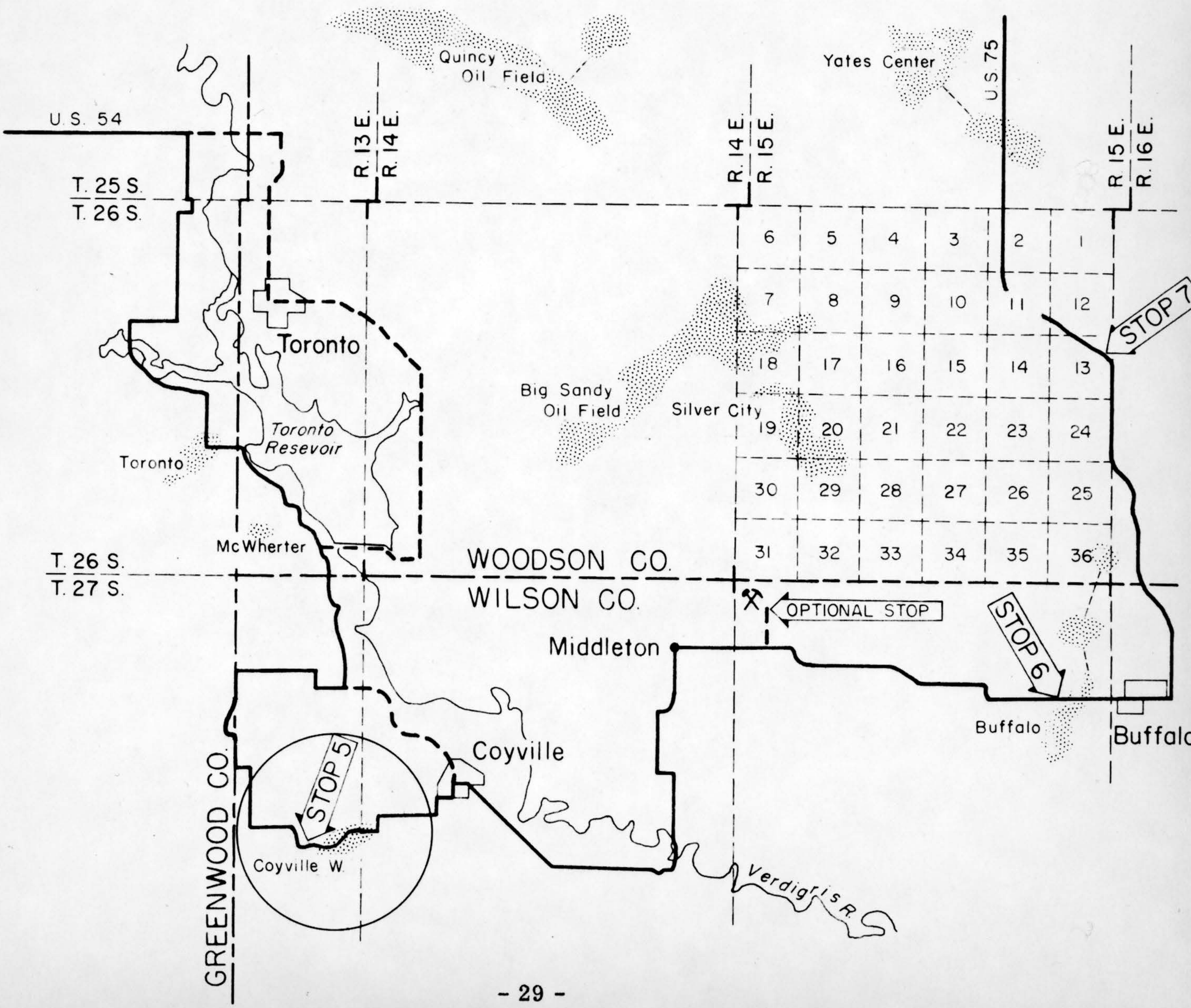
--A. L. Hornbaker, KGS

All aboard for points east: Wilson's Springs, Acme Brick Company, Rose Dome, Lake Bassola! Follow lead car.

92.4	0.1	Leave Lake Eureka by south entrance. Turn right (south) on road. Return to Eureka.
96.4	4.0	Outskirts of Eureka. Turn left.
96.9	0.5	Turn right. We are in the Eureka Oil Field.
		The Eureka has been a producer for at least 30 years. Production during 1959 was 41,249 barrels of oil from the Fort Scott and Mississippian limesones at depths of 1,750 and 2,000 feet.
97.1	0.2	Railroad tracks (Missouri Pacific; Atchison, Topeka, Santa Fe).
97.4	0.3	Arrive at US 54. Turn left (east) on US 54. Leave Eureka.
97.7	0.3	Cemetery on right. Oil well on right is in the Eureka Oil Field.
99.7	2.0	Junction US 54 and K 99. Continue east on US 54 and K 99.
100.8	1.1	Road to right.
100.9	0.1	Road to left.
101.4	0.5	Church Limestone member of Howard formation.
101.8	0.4	Turn left (north) on US 54 and K 99.
102.8	1.0	Turn right on US 54 and K 99.
103.1	0.3	Caution! Narrow bridge. Bachelor Creek Limestone on both sides. Bachelor Creek takes care of the overflow from Lake Eureka, about 6 miles upstream from here (as the crow flies).
103.7	0.6	Caution! Junction K 99 and US 54. Continue east on US 54.
105.2	1.5	Topeka Limestone on right (south).
105.4	0.2	Railroad underpass (Missouri Pacific).
105.8	0.4	Crossroads. Continue on US 54.
106.3	0.5	Topeka Limestone.
107.3	1.0	Cottonwood tree to right.
107.7	0.4	Channel sandstone in Stull Shale. Observe sandstone cutting out other rocks. Contact (about 8 feet exposed) between sandstone and Stull Shale was once an erosional surface--millions of years ago. After a channel was eroded in the shale, sands were deposited which are now consolidated and known as channel sandstone.

107.9	0.2	Bridge. Homer Creek. Homer and Bachelor join here to become Walnut Creek.
109.1	1.2	Neal. Population in 1910 was 150.
109.4	0.3	Road to right.
109.8	0.4	Crossroads. Continue ahead on US 54.
110.7	0.9	Road to right.
111.4	0.7	Kanwaka Shale, which is stratigraphically below the Lecompton Limestone. (Incidentally, the specimens of horn corals that Professors Gladfelter and Johnston collected for you came from the Beil Limestone member of the Lecompton formation where it crops out along the Verdigris River about 2 miles southwest of Virgil.)
111.7	0.3	Marvin E. Boyer Oil Storage Tanks, left.
114.0	2.3	Roadside park, right. Day facilities.
114.7	0.7	Road to Quincy and Virgil, left. Turn right, off US 54.
		(ALTERNATE ROUTE via Toronto, page 43; yellow sheet.)
115.2	0.5	Junction in road.
115.6	0.4	Curve to left.
115.7	0.1	Curve right.
116.0	0.3	Curve right.
116.2	0.2	Turn left.
116.5	0.3	Radio tower on right.
116.9	0.4	Road to right. Continue straight ahead (south).
117.2	0.3	Railroad crossing (Missouri Pacific).
117.4	0.2	Toronto Limestone exposed in road cut on right. Limestone is fossiliferous, bedding uneven. We are near the type locality of Toronto Limestone, named for Toronto, Woodson County, 1.5 miles to the east.
117.5	0.1	Quarry in Toronto Limestone, on left. Williamsburg coal at base of limestone.

117.9	0.4	**Crossroads. Sign: Toronto Dam. Foundation on right: former place of learning. Turn right.**
118.2	0.25	**Toronto Limestone.**
118.7	0.5	**Crossroads. Turn left (south).**
118.8	0.1	**Toronto Limestone, basal member of the Oread Limestone, which can be traced southwest-northeast across Kansas, from Chautauqua County to Doniphan County.**
119.1	0.3	**Bridge. Walnut Creek. Westernmost extension of Toronto Reservoir, completed recently.**
119.2	0.1	**Curve left.**
119.3	0.1	**Toronto Limestone--extended exposure.**
119.9	0.6	**Curve left.**



120.3 0.4 Curve left (east).

120.5 0.2 Toronto Limestone.

120.7 0.2 Turn right (south).

121.2 0.5 Toronto Oil Field. The Toronto, discovered in 1913, extends into Woodson County. Producing sands are the "Peru" and "Bartlesville" at depths of 1,000 and 1,700 feet.

121.5 0.3 Turn left (east) at crossroads. Sign: Toronto Dam Site. (N line sec. 27.)

121.9 0.4 Leave Greenwood County; enter Woodson County.

Woodson County was organized in 1855 and has an approximate land area of 504 square miles. Its population is about 5,750. Farmers harvest a variety of crops, including wild hay, and livestock contributes to the rural income. Mineral commodities include oil, gas, and stone.

Physiographically in the Osage Cuestas, the county has a general elevation of slightly more than a 1000 feet above sea level. Sedimentary bedrock exposed is Pennsylvanian in age and alluvial sands and gravels are Pleistocene. The state's only known "granite" (igneous) outcrop, Rose Dome, and the peridotite (also igneous) exposure, Silver City, are probably Cretaceous in age.

122.0 0.1 Road curves right. Sign: Toronto Dam Site.

122.7 0.7 Sandstone exposure. Curve right, pass road to left to Toronto Reservoir.

123.2 0.5 Turn left toward Toronto Reservoir. Reservoir dam visible to far right.

123.6 0.4 Lake--turn right--or swim.

124.0 0.4 Six-way crossroads. Straight ahead! Carlisle Cemetery on left.

124.5 0.4 Old iron bridge. Cross.

124.8 0.3 Leave Woodson County; enter Wilson County. Elevation about 903 feet above sea level. Continue south on winding road for about 2 miles.

Organized in 1865, Wilson County originally extended to south line of the state. It now has an approximate land area of 504 square miles and the population has increased from 27 in 1860 to more than 14,000 a century later. Among crops raised on the farms are wheat and a variety of grains and hay; chickens and other livestock are also raised. Mineral resources include cement, oil, stone, clay, gas, and sand and gravel.

General elevation for this county in the south Osage Cuestas is about 900 feet above sea level. Chief topographic features are escarpments formed by resistant beds of Pennsylvanian-age limestones and shales. Pleistocene-age sands and gravels may be found in the valleys of Verdigris and Fall Rivers and other streams.

Roadside exposures for most part in Stranger Formation, except for the higher elevation about 1.5 miles ahead.

126.7 1.9 Turn right (west) at crossroads. Elevation 919 feet above sea level. In rocks of the Stranger Formation.

127.2 0.5 Turn right, then left. "Roller Coaster" country.

127.6 0.4 Liberty School on right. Rural schools are a Kansas heritage; Wilson County had 100 of them 75 years ago.

In that day, the mid 1880s, according to an article in the Fifth Biennial Report of the State Board of Agriculture, average salary for male teachers in Kansas was $42.02 a month; for female teachers, $ 33.85. Some salaries, for men even, were as low as $20.00 a month and few exceeded $60.00. (Wilson County teachers averaged $39.31 and $ 33.78 a month respectively)

Teachers were trained at the (1) State Normal School at Emporia-- the only state institution devoted exclusively to the training of teachers; (2) Chair of Pedagogies, State University (Lawrence); and (3) County Normal Institutes.

127.7 0.1 Road to right (north). Continue west. Elevation 935 feet above sea level.

128.0 0.3 Rising in stratigraphic section; from rocks of Stranger Limestone to rocks of Lawrence Shale.

128.7 0.7 Turn left at crossroads. (Now heading south on W line sec. 11, Greenwood-Wilson County line.)

128.8 0.1 Low-water bridge. Cross.

129.2 0.4 Curve right (into Greenwood County). Cemetery to left. Elevation 977 feet above sea level.

129.7 0.5 Turn left (southeast) at cylindrical sheds. Cross low-water bridge. Road curves right. (Now on county line again.)

130.3. 0.6 Turn left(east). Elevation 984 feet above sea level.

130.5 0.2 Turn right at No Hunting sign on pole with can. (Now heading south in sec. 23). Look out for flying gravel! (These gravels do get around!)

131.3 0.8 Cattle guard on right (maybe cattle too). Hill is capped by Plattsmouth Limestone member of the Oread formation (exposed on roadsides).

131.5 0.2 Turn left; crooked telephone pole. (Ask Roberta Gerhard, recently from New York, to discuss topography vs. telephone poles.)

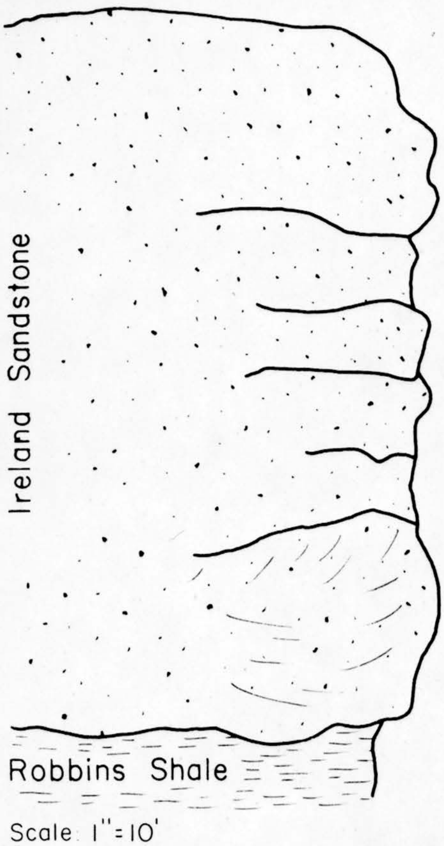
132.3 0.8 Turn right (south). Elevation 1018 feet above sea level.

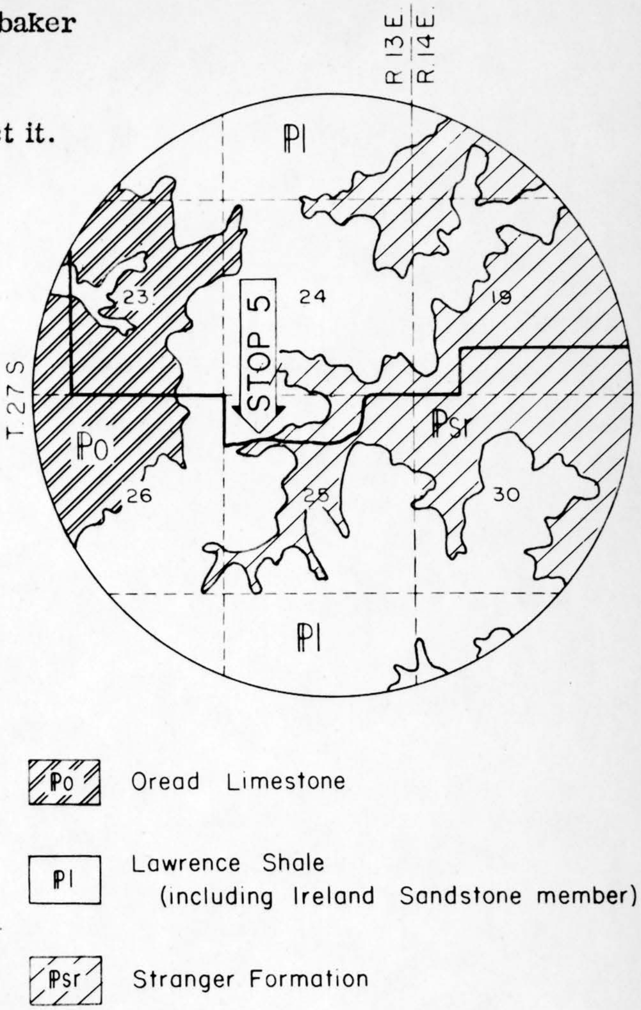
132.5 0.2 Turn left (east).

STOP 5. Wilson's Springs. (NW 1/4 sec. 25, T. 27 S., R. 13 E.)

Section measured by A. L. Hornbaker and R. O. Kulstad, June 1960.

We are on private property. Please protect it. Mr. and Mrs. I. H. Wilson, owners, are developing the area.





(See also page 29.)

V-shaped canyons cut in the Ireland Sandstone member of the Lawrence Shale (Douglas Group, Pennsylvanian age) afford a cool, refreshing stop. Small bubbling (?) springs issue from the Ireland Sandstone to form intermittent streams, picturesque waterfalls, moist shaded sandstone cliffs supporting an abundance of vegetation that includes several types of delicate ferns.

As we approached this stop, did you notice the distinct change in vegetation? The grasslands and cultivated fields to the west are in the outcrop area of the Oread formation. The forested area we are now in--the outcrop area of the Ireland Sandstone--became distinguishable as we came over the crest of the hill about one-half mile to the west. Oak trees are the characteristic vegetation in a belt across the state where the Ireland Sandstone crops out. It is easy to map sandstones of this type simply by following the wooded areas in which oak is predominant.

The Ireland is a massive, in part cross-bedded sandstone grading upward into sandy shale and thin-bedded sandstones of the upper part of the Lawrence Shale. The Ireland Sandstone rests unconformably on the Robbins Shale of the Stranger Formation. It is overlain conformably by the Oread formation, which crops out to the west.

-- A. L. Hornbaker, KGS

At STOP 5 and vicinity we are in the Coyville West Oil Field. Production for 1959 was 1,609 barrels of oil from Cherokee rocks.

133.2	0.6	Pump jack on right.
133.4	0.2	Road to north and to east. Turn right (east). Ireland Sandstone hills to left and right; Douglas Group rocks.
133.9	0.5	Turn left (north).
134.2	0.3	Turn right (east).
134.7	0.5	The Westphalia Limestone member of the Stranger Formation, an important marker bed for stratigraphic and structural studies of middle Pennsylvanian strata, crops out in this vicinity.
135.0	0.3	Sharp turn left (north).
135.3	0.3	Coyville. Turn right for 1 block; left 1 block; right 2 blocks; left 3 blocks.
		Coyville is home to about 100 people and is a trading area for the Verdigris Valley rural area of northwestern Wilson County. Elevation, 876 feet above sea level. Bedrock in area belongs to Stranger Formation of Douglas Group, Pennsylvanian age.
135.8	0.5	Turn right (east).
136.1	0.3	Curve to right and leave Coyville via road to southeast.
136.2	0.1	Caution! Narrow bridge. Brush Creek.
		We are on the fertile floodplain of Verdigris River. The Verdigris, because of its low gradient (about 850 feet above sea level in this vicinity and slightly below 700 feet above sea level near Coffeyville where it leaves Kansas some 50 miles to the south) is a sluggish, meandering stream. It is easy to understand that the valley has been subject to frequent flooding; Toronto Reservoir, recently completed upstream, should check some of this flooding activity.
137.5	1.3	Caution! Narrow bridge. Greathouse Creek.
137.9	0.4	Curve left (east).
		The escarpment to the west and south marks the edge of the Verdigris floodplain.
138.8	0.9	Crossroads. Elevation 862 feet above sea level.
139.8	1.0	Road to left and to right. Turn left (north).
139.9	0.1	Moss Bridge. Verdigris River. Note meandering course of river; road curve conforms to meander bend.

140.6	0.7	Crossroads. Elevation 863 feet above sea level. Continue north
140.9	0.3	Weston Shale in roadcuts to right. Floodplain on left.
141.3	0.4	Curve left.
141.4	0.1	Bridge. Little Sandy Creek. Road to left. Road to right. Turn right (north). Elevation 864 feet above sea level.
141.8	0.4	Leave floodplain; go up in stratigraphic section in next half mile from Weston Shale to Stranger Formation.
142.4	0.6	Road to left and road to right. Turn right (east).
142.6	0.2	Turn left (north). Winding road for next quarter mile.
143.6	1.0	Middletown. Elevation 963 feet above sea level. Turn right (east). The Westphalia Limestone, which here crops out at the approximate altitude of 960 feet, can be traced around Middletown.
144.5	0.9	Bridge. Sandy Creek.
144.6	0.1	Road to left (north) Elevation 926 feet. Near the base of the Stranger Formation. Continue east.
145.1	0.5	Road to left (north) leads to intermittently operated quarry in Stoner Limestone (member of Stanton Formation), about three quarters of a mile from here. (SE 1/4 NW 1/4 sec. 6, T. 27 S., R. 15 E.) OPTIONAL STOP. Stoner Limestone is quarried here for use as crushed rock aggregate. The nearly white limestone is wavy bedded and fine grained. Crystalline calcite replaces a few large brachiopods and other fossils. Geodes lined with calcite sprinkled with some pyrite crystals may be found. Thin beds contain an abundance of fusulinids.
145.6	0.5	Curve to right (south). Elevation 1003 feet above sea level.
145.9	0.3	Curve to left (east).
146.7	0.8	Road to right (south). Elevation 1014 feet. Continue east.
146.8	0.1	Road to Ecco Ranch headquarters to left (north). Elevation 1042 feet above sea level. Continue east. In roadcuts ahead note ripple marks in sandstone. (Ask one of the field trip leaders to tell the whys of these ripple marks.)
147.1	0.3	Mound to left has an altitude exceeding 1100 feet, is capped by Lawrence Shale.

147.3	0.2	Curve right (southeast). Elevation 1025 feet.
147.7	0.4	Curve left (east). Going downhill out of Douglas Group rocks into Weston Shale.
147.9	0.2	Road to left. Elevation 920 feet above sea level.
148.0	0.1	At elevation of about 900 feet above sea level enter alluvial valley of West Buffalo Creek.
148.2	0.2	Road to right (south). Continue east.
148.6	0.4	Bridge. West Buffalo Creek.
148.7	0.1	Little red (brick) schoolhouse. (Make mental note of the use of brick; recall at next stop.)

Speaking of the past of the rural schools again, the average school term in Kansas was 23.8 weeks in 1886. In two counties average length of school year was 8 weeks and in only a few did the term average more than 30 weeks. Bourbon County, having an average term of 39.3 weeks, and Crawford County of 36 weeks, were way out front. (Average length of school term in Wilson County was 30 weeks.)

148.8	0.1	Curve to right (south) at intersection of north-south road.
149.0	0.2	Curve to left (east).
149.2	0.2	Mound to right is capped by limestone of the Stranger Formation. This is a typical topographic feature of the area--an erosional remnant protected by a resistant limestone cap.
150.0	0.8	Road to left (north). Continue east.

We are in the Buffalo Oil Field, discovered in 1924. The field extends into Woodson County, and producing zones are the "Bartlesville" at depths of 950 and 1025 feet and Cherokee at 1,150 feet. During 1959 the yield from the pools of this field was 87,705 barrels of oil.

150.3	0.3	Bridge. East Buffalo Creek.

Sidelight... On April 24, 1867, an earthquake shock was felt at 2:45 p.m. in eastern Kansas and western Missouri. A second shock soon followed. Some chimneys fell. (A geophysicist on this trip, J. A. Peoples of the K. U. geology faculty and operator of the K. U. seismograph, may be willing to tell you something about earthquakes.)

150.4	0.1	Turn left at entrance to Acme Brick Company plant. STOP 6 (next page).

Follow lead car to parking area.

STOP 6. Plant and shale pit of Acme Brick Company at Buffalo, Kansas. Located about 1 mile west of Buffalo, Wilson County, Kansas (SW 1/4 sec. 12, T. 27 S., R 15 E.)

Your host at STOP 6 will be Mr. Melvin Sperry, superintendent of Acme Brick Company, Buffalo plant.

The Buffalo plant of the Acme Brick Company manufactures brick from the Weston Shale obtained at a nearby pit. The chief product is face brick, although some drain tile and other products are also made. Brick from the Buffalo plant have been sold as far away as Cuba and South America, and many have been shipped to distant points in the United States; Kansas, however, is the chief market area.

A brick plant has been operating at this site since 1903, although the ownership has changed hands several times.* During the years when paving brick were in great demand this Buffalo plant was one of the important suppliers. The brick house we saw along the road a little more than a mile west of the plant is made of the rounded-off paving brick that were put through the "rattler" test.

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* During the first decade of the 20th century, natural gas was being found and produced in many eastern Kansas localities. The availability of abundant cheap gas for fuel brought many industries to this part of Kansas in the early 1900s. The availability of raw materials for use in manufacture of such mineral products as brick, tile, and portland cement was an added encouragement to the establishment of certain types of industries.

--Norman Plummer, KGS

Resume route of field trip. Follow lead car.

151.0 0.6 At exit to plant property turn left (east).

151.6 0.6 Buffalo. Elevation about 950 feet above sea level. Cross railroad track (Missouri Pacific) and continue east through Buffalo.

Founded in 1867 and incorporated as a third class city in 1898, Buffalo was named for the bison that roamed the county in bygone days. Early in 1906 mastodon remains found near the town were sold to the American Museum, New York.

152.5 0.9 Intersection US 75. Turn left (north) on US 75.

153.3 0.8 Road to right (east). Continue north on US 75.

154.1 0.8 Bridge. East Buffalo Creek.

154.4	0.3	Leave Wilson County; enter Woodson County. (This is our second and last entrance into Woodson County on this trip.)
154.7	0.3	On hill, elevation 1000 feet above sea level.
155.5	0.8	Several broad curves in next mile.
156.3	0.8	Railroad overpass (Missouri Pacific). Benchmark at railroad level: 981.051 feet above sea level.
156.8	0.5	Bridge.
157.7	0.9	Cemetery on right.
157.8	0.1	Crossroads. Schoolhouse on right.
158.2	0.4	Left curve in highway.
158.5	0.3	Parking for STOP 7 is on north-south country road. Follow the leader.

STOP 7. Rose Dome. (Sec. 13, T. 26 S., R. 15 E.)

Rose Dome is a gently arched anticlinal structure that is somewhat elliptical in plan. The long axis of the structure (about 6 miles long) trends slightly north of east. The dome is about 3 miles wide and reaches its highest point in sec. 13, T. 26 S., R. 15 E., where sedimentary rocks of the Lansing and Pedee Groups are exposed. An escarpment held up by Ireland Sandstone rims the dome and imparts topographic expression.

Residual boulders best described as "granite" rest on the shale near the center of the dome. The boulders have a mineralogic composition near that of true granite; however, they contain abundant chalcedonic quartz and have a microscopic texture not typical of granite.

Igneous rock, intruded into Pennsylvanian sedimentary rocks, has been penetrated by oil wells drilled on Rose Dome. This rock, found at depths ranging from 600 to more than 1600 feet, is nearly black in color and seems to be peridotitic rather than granitic. No definite genetic relationships have yet been established between the "granite" and the peridotitic igneous rock; their respective ages (that is, times of formation) are unknown; and the genetic relationship between the upwarping of the dome and the emplacement of igneous rock has not been determined.

--Paul Franks, KGS

On signal let the caravan roll. Northward through sediments to the hay capital of the world.

159.1	0.6	Crossroads.
159.5	0.4	Crossroads.
160.2	0.7	Right curve in highway.
160.6	0.4	Road to left.
161.1	0.5	Bridge.
161.6	0.5	Crossroads.
162.1	0.5	Oil wells are in the Yates Center Oil Field. Production during 1959 was 15,139 barrels of oil from the Mississippian at 1,480 feet.
162.6	0.5	Crossroads.
163.7	1.1	Crossroads.
164.6	0.9	Bridge. South Owl Creek. Yates Center City Reservoir (to left) on this stream.
165.2	0.6	City limits, Yates Center, prairie hay capital of the world. Approximate elevation, 1100 feet.
		Yates Center became the county seat in 1876, about 9 years after it was founded for the purpose. Laid out in the geographical center of the county by Abner Yates, the town began to prosper when the nearby towns of Defiance and Kalida "moved in."
165.7	0.5	Junction US 75 and US 54 in Yates Center. Turn right (east) on US 54.
166.5	0.8	Leave Yates Center.
		In December 1865, a large force was at work on the Verdigris Valley road in this vicinity.
167.4	0.9	Approximate base of Douglas Group rocks.
167.5	0.1	Crossroads.
168.1	0.6	Railroad overpass (Missouri Pacific).
168.3	0.2	Durand to left.
168.5	0.2	County road, right.
169.5	1.0	Crossroads.

169.6	0.1	Bridges (3).
170.3	0.7	Iron pump for pumping iron water, left.
170.6	0.3	Crossroads.
171.5	0.9	Road to right.
171.6	0.1	Bridges (2).
172.0	0.4	Road to left.
172.5	0.5	Crossroads.
173.5	1.0	Road to left. Cemetery on right.
173.7	0.2	Bridges. Bridges are a boon to mankind. Think how many streams we'd have to ford if it weren't for bridges.
174.4	0.7	Left turn on US 54. Stay on US 54.
175.3	0.9	Crossroads.
175.4	0.1	Bridges (2).
176.4	1.0	Crossroads.
176.9	0.5	Right turn in highway.
177.3	0.4	Bridge.
177.9	0.6	Neosho Falls to left. Some Kansas streams have waterfalls. Some towns are named after waterfalls. Ask Paul Franks for his opinion of waterfalls in Kansas.
178.9	1.0	Piqua. Sprung up in 1882, after the railroad came.
179.0	0.1	Railroad crossing.
180.1	1.1	Leave Woodson County; enter Allen County.

Organized in 1855, Allen County covers about 505 square miles. Named in honor of William Allen, U. S. Senator and governor of Ohio who favored the doctrine of popular sovereignty on the opening of Kansas Territory to settlement, the county now has more than 17,000 persons on its land. Corn is one of the leading crops grown and dairy farming is an important part of the agricultural economy. Mineral products include cement, oil, stone, clay, and gas.

Allen County is in the Osage Cuestas, the rolling plain country of eastern Kansas dominated by east-facing escarpments. The elevation is about 1000 feet above sea level, except in the stream valleys. The Neosho River is the most important river in the county. Outcropping bedrock is Pennsylvanian in age, and the alluvial fill of the broad stream valleys is Pleistocene.

181.0	0.9	Plattsburg Limestone on left.
181.9	0.9	Quarry in Plattsburg Limestone on left. Roadcut on left; also in Plattsburg.
182.1	0.2	Crossroads.
183.1	1.0	Crossroads.
184.0	0.9	Crossroads.

The Iola Oil Field, a producer for many years, is scattered about Iola. In 1959 production, from the "Bartlesville" at depth of 850 feet, approximated 186,000 barrels of oil.

184.2	0.2	Bridge.
184.4	0.2	Bridge.
184.7	0.3	Bridge. Some practical geologist, Paul Johnston for instance, might explain to those interested how engineers use geology in building bridges.
185.2	0.5	Bridge. Neosho River.

The Neosho has a bad record in overflowing its banks.

From Annals of Kansas: June 3, 1904--Rivers were overflowing. The Neosho Valley was flooded, and hundreds were homeless...The Cottonwood reached from bluff to bluff. A torrential rain at Emporia forced farmers to move out of valleys. The lower section of Iola was flooded. Rain, hail, and wind continued over the state.

185.6	0.4	Bridge.
185.9	0.3	Cemetery on left.
186.0	0.1	City limits, Iola.

Iola was born in 1859, at a meeting called to locate a new town with a view to making it the county seat of Allen County. In 1860 several stores were located at the town site, and soon after the Civil War the town began to develop. The first newspaper, The Neosho Valley Register, started publication in 1866. Incorporated in 1870, Iola is now a town of almost 7,000 persons.

Iola through the years has catered to mineral industries--cement plants, brick and tile works, zinc smelters. Nearness to some of the state's earliest natural gas wells was an advantage.* In 1907 the town experimented with oiled streets, and early in the century the city had a good waterworks, electric lights, and gas for heating and illuminating. It still supports a brick plant (The Iola Brick and Tile Company east of town) and a cement plant (The Lehigh Portland Cement Company, south of town near STOP 8).

* One of the earliest and most notable of these was the Acres Well, developed by the Iola Mining Company in 1873.

186.1 0.1 Caution! Railroad crossing (Atchison, Topeka, and Santa Fe).

186.3 0.2 Junction US 54 and US 59, US 169, K 57. Turn right on US 59-169, K 57.

186.9 0.6 Leave Iola.

In 1906 the Kansas Natural Gas Company completed a 900-mile pipeline that served nearly 300 Kansas towns. The main wells were near Petrolia south of Iola.

187.2 0.3 Bridge. Have you counted the bridges? (The field trip bridge counters probably missed a few.)

187.3 0.1 Picnic table.

Sidelight...Well-kept roadside parks are becoming a trademark of Kansas highways.

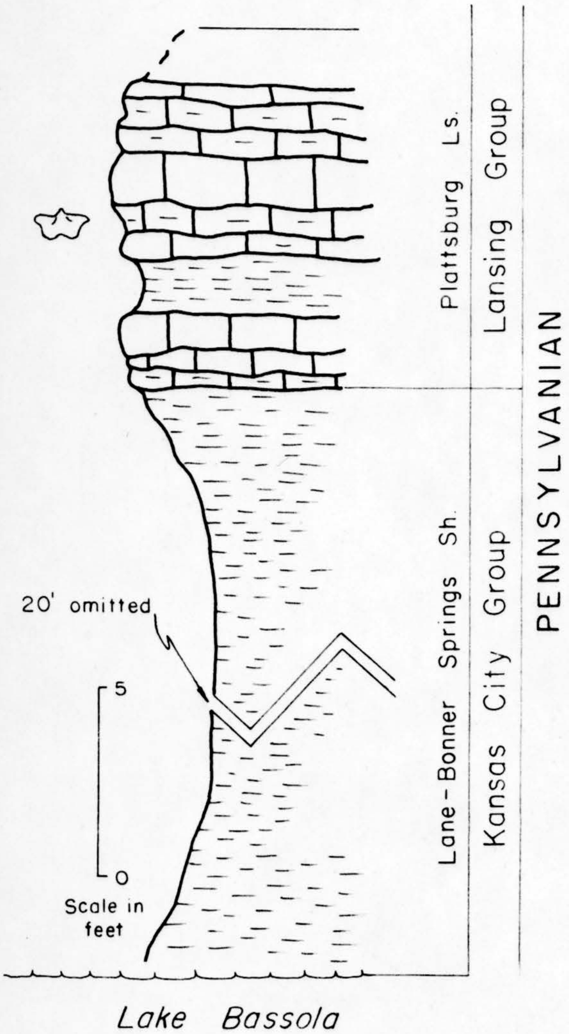
Another sidelight...Teachers looking for material on the out of doors, animals and plants and rocks and streams and all natural phenomena, should ask how to get on the mailing list to receive issues of the periodical The Kansas Naturalist, prepared by the Department of Biology, with cooperation of the Division of Education at KSTC....A selected list of Kansas Geological Survey publications of general interest with special reference to today's field-trip area is given on page 55....

Prepare to turn off highway to STOP 8 (next page).

187.5 0.2 Turn left to **STOP 8**. Park.

STOP 8. Section at Lake Bassola, site of old brick plant quarry south of Iola, Allen County. (Near center West line sec. 2, T. 18 S., R. 25 E.)

Section measured by A. L. Hornbaker and R. O. Kulstad, KGS, June 1960.



Lake Bassola now occupies the quarry in Lane-Bonner Springs Shale, utilized in manufacture of brick by the I. B. Kirk Gas and Smelting Company plant that operated at this site from 1908 to 1925 and for a time in the mid 1930s. Early in the century several brick and tile plants operated in the Iola vicinity. At that time many industries were attracted to eastern Kansas because of the abundant gas available as cheap fuel.

From the hill (near the remains of an old water tower) we can see Lehigh Portland Cement Company plant and quarry across Lake Bassola. Fossils can be found here in the basal part of the Plattsburg Limestone (at the top of the quarry).

This is the last scheduled stop. Return to US 169-59, K 57.

Turn right (north). Follow K 57 for Emporia or US 59-169 for Lawrence.

THE FIELD TRIP IS OVER!

ALTERNATE ROUTE (From road to Quincy at junction with US 54 in Greenwood County to Wilson's Springs in Wilson County.)

0.0	0.0	At intersection of US 54 and road to Quincy. Continue east on US 54.
0.6	0.6	Bridge. Verdigris River. In flood area of Toronto Reservoir.
1.0	0.4	Leave Greenwood County; enter Woodson County. Toronto Limestone; coal under.
1.5	0.5	Turn right on K 105 to Toronto.
2.3	0.8	Toronto Limestone on right. Type locality of Toronto Limestone is in vicinity of Toronto.
3.7	1.4	Toronto water tower, left.
3.9	0.2	Toronto.
4.2	0.3	Railroad crossing.
4.3	0.1	Turn left on Main street to Toronto Dam.
4.4	0.1	Caution light.
4.8	0.4	Toronto Point to right. Continue east.
7.3	2.5	Curve right.
10.4	3.1	Turn right.
11.2	0.8	Drive on dam of Toronto Reservoir.
11.8	0.6	Off dam.
12.1	0.3	Curve left.
12.3	0.2	Turn left.
12.6	0.3	Bridge.
12.9	0.3	Leave Woodson County; enter Wilson County. Elevation about 903 feet above sea level. Continue south on winding road for about 2 miles. Roadside exposures for most part in Stranger Formation, except for the higher elevation about 1.5 miles ahead.
14.8	1.9	Turn left (west). Elevation 919 feet above sea level. In rocks of Stranger Formation.

15.3	0.5	Curve right.
16.0	0.7	Curve left.
17.5	1.5	Coyville.
17.6	0.1	Turn left for one block.
17.7	0.1	Turn right; proceed 4 blocks, through Coyville.
18.0	0.3	Turn right; leave Coyville on winding road.
18.3	0.3	Sharp turn right (west).
19.1	0.8	Turn left (south).
19.3	0.2	Turn right (west).
19.8	0.5	Road to north and south. Turn left (south).
20.6	0.8	Turn in gate to Wilson's Springs. STOP 5. (Page 32).

After STOP 5 pick up REGULAR SCHEDULED ROUTE.

CLASSIFICATION OF OUTCROPPING ROCKS IN ALLEN, CHASE, GREENWOOD, LYON, WILSON, AND WOODSON COUNTIES, KANSAS

CENOZOIC ROCKS

<u>NEOGENE SYSTEM</u>

<u>Pleistocene Series</u>

<u>Pliocene Series</u>

(older Cenozoic and all Mesozoic rocks seemingly not represented)

PALEOZOIC ROCKS

<u>PERMIAN SYSTEM</u>

Wolfcampian Stage
- Chase Group
- Council Grove Group
- Admire Group

<u>PENNSYLVANIAN SYSTEM</u>

Virgilian Stage
- Wabaunsee Group
- Shawnee Group
- Douglas Group

Missourian Stage
- Pedee Group
- Lansing Group
- Kansas City Group
- Pleasanton Group

Exposed bedrock in:

<u>Allen County</u> includes section (in ascending order) from upper part of Pleasanton Group to Stanton Limestone of the Lansing Group--all Pennsylvanian in age.

<u>Chase County</u> includes section from West Branch Shale of the Admire Group to rocks in the lower part of the Sumner Group-- all Permian in age.

<u>Greenwood County</u> includes section from Stranger Formation (Douglas Group--Pennsylvanian age) to lower part of Barneston Limestone of the Chase Group (Permian age).

<u>Lyon County</u> includes section from Calhoun Shale in the upper part of the Shawnee Group (Pennsylvanian age) to Barneston Limestone of the Chase Group (Permian age).

<u>Wilson County</u> includes section from the top of Drum Limestone of the Kansas City Group to Oread Limestone of the Shawnee Group--all Pennsylvanian in age.

<u>Woodson County</u> includes section from Plattsburg Limestone of the Lansing Group to the Topeka Limestone of the Shawnee Group--all Pennsylvanian in age.

<u>Butler County</u> includes section from Grenola Limestone of the Council Grove Group to the Wellington Formation of the Sumner Group--all Permian in age.

Named units exposed in the field trip area are listed on this and the following pages. Units are listed in the order in which they are generally found; youngest at the top, oldest at the bottom. In general the uppermost (youngest) bedrock in any county occurs on hills in the western part of the county; the lowermost (oldest) in valleys in the eastern part. However, recent surficial deposits are generally found in the reverse arrangement. Remains of deposits laid down before the present topography was formed are now found on hill tops. Stream alluvium in valleys is more or less contemporaneous with the making of the present topography, as it was deposited after rivers cut, at least in part, their present valleys.

NEOGENE SYSTEM

*Pleistocene Series

Recent and Wisconsinan Stages.
- Alluvium

Illinoian Stage
- Wiggam Terrace deposits

Kansan Stage
- Emporia Terrace deposits

Pliocene Series
- Chert gravels

PERMIAN SYSTEM

Wolfcampian Stage

Chase Group
- Doyle Shale (formation)
- Barneston Limestone (formation)
  - **Fort Riley Limestone
  - Oketo Shale
  - Florence Limestone
- Matfield Shale (formation)
  - Blue Springs Shale
  - Kinney Limestone
  - Wymore Shale
- Wreford Limestone (formation)
  - Schroyer Limestone
  - Havensville Shale
  - Threemile Limestone

Council Grove Group
- Speiser Shale (formation)
- Funston Limestone (formation)
- Blue Rapids Shale (formation)
- Crouse Limestone (formation)
- Easly Creek Shale (formation)
- Bader Limestone (formation)
  - Middleburg Limestone
  - Hooser Shale
  - Eiss Limestone
- Stearns Shale (formation)
- Beattie Limestone (formation)
  - Morrill Limestone
  - Florena Shale
  - Cottonwood Limestone
- Eskridge Shale (formation)
- Grenola Limestone (formation)
  - Neva Limestone
  - Salem Point Shale
  - Burr Limestone

(Grenola Limestone formation cont'd.)
  - Legion Shale
  - Sallyards Limestone
- Roca Shale (formation)
- Red Eagle Limestone (formation)
  - Howe Limestone
  - Bennett Shale
  - Glenrock Limestone
- Johnson Shale (forma tion)
- Foraker Limestone (formation)
  - Long Creek Limestone
  - Hughes Creek Shale
  - Americus Limestone

Admire Group
- Janesville Shale (formation)
  - Hamlin Shale
  - Five Point Limestone
  - West Branch Shale
- Falls City Limestone (formation)
- Onaga Shale (formation)
  - Hawxby Shale
  - Aspinwall Limestone
  - Towle Shale

PENNSYLVANIAN SYSTEM

Virgilian Stage

Wabaunsee Group

Richardson Subgroup
- Wood Siding Formation
  - Brownville Limestone
  - Pony Creek Shale
  - Grayhorse Limestone
  - Plumb Shale
  - Nebraska City Limestone
- Root Shale (formation)
  - French Creek Shale
  - Jim Creek Limestone
  - Friedrich Shale
- Stotler Limestone (formation)
  - Grandhaven Limestone
  - Dry Shale
  - Dover Limestone
- Pillsbury Shale (formation)
- Zeandale Limestone (formation)
  - Maple Hill Limestone
  - Wamego Shale

Nemaha Subgroup
- Willard Shale (formation)

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*Chert gravels are present from all stages of the Pleistocene.

**All units listed under formations have the status of members

(Nemaha Subgroup cont'd.)
- Emporia Limestone (formation)
  - Elmont Limestone
  - Harveyville Shale
  - Reading Limestone
- Auburn Shale (formation)
- Bern Limestone (formation)
  - Wakarusa Limestone
  - Soldier Creek Shale
  - Burlingame Limestone

Sacfox Subgroup
- Scranton Shale (formation)
  - Silver Lake Shale
  - Rulo Limestone
  - Cedar Vale Shale
  - Happy Hollow Limestone
  - White Cloud Shale
- Howard Limestone (formation)
  - Utopia Limestone
  - Winzeler Shale
  - Church Limestone
  - Aarde Shale
  - Bachelor Creek Limestone
- Severy Shale (formation)

Shawnee Group
- Topeka Limestone (formation)
  - Coal Creek Limestone
  - Holt Shale
  - Du Bois Limestone
  - Turner Creek Shale
  - Sheldon Limestone
  - Jones Point Shale
  - Curzon Limestone
  - Iowa Point Shale
  - Hartford Limestone
- Calhoun Shale (formation)
- Deer Creek Limestone (formation)
  - Ervine Creek Limestone
  - Larsh-Burroak Shale
  - Rock Bluff Limestone
  - Oskaloosa Shale
  - Ozawkie Limestone
- Tecumseh Shale (formation)
- Lecompton Limestone (formation)
  - Avoca Limestone
  - King Hill Shale
  - Beil Limestone

(Lecompton Formation cont'd.)
  - Queen Hill Shale
  - Big Springs Limestone
  - Doniphan Shale
  - Spring Branch Limestone
- Kanwaka Shale (formation)
  - Stull Shale
  - Clay Creek Limestone
  - Jackson Park Shale
- Oread Limestone (formation)
  - Kereford Limestone
  - Heumader Shale
  - Plattsmouth Limestone
  - Heebner Shale
  - Leavenworth Limestone
  - Snyderville Shale
  - Toronto Limestone

Douglas Group
- Lawrence Shale (formation)
  - Amazonia Limestone
  - Ireland Sandstone
- Stranger Formation
  - Robbins Shale
  - Haskell Limestone
  - Vinland Shale
  - Westphalia Limestone
  - Tonganoxie Sandstone

Missourian Stage

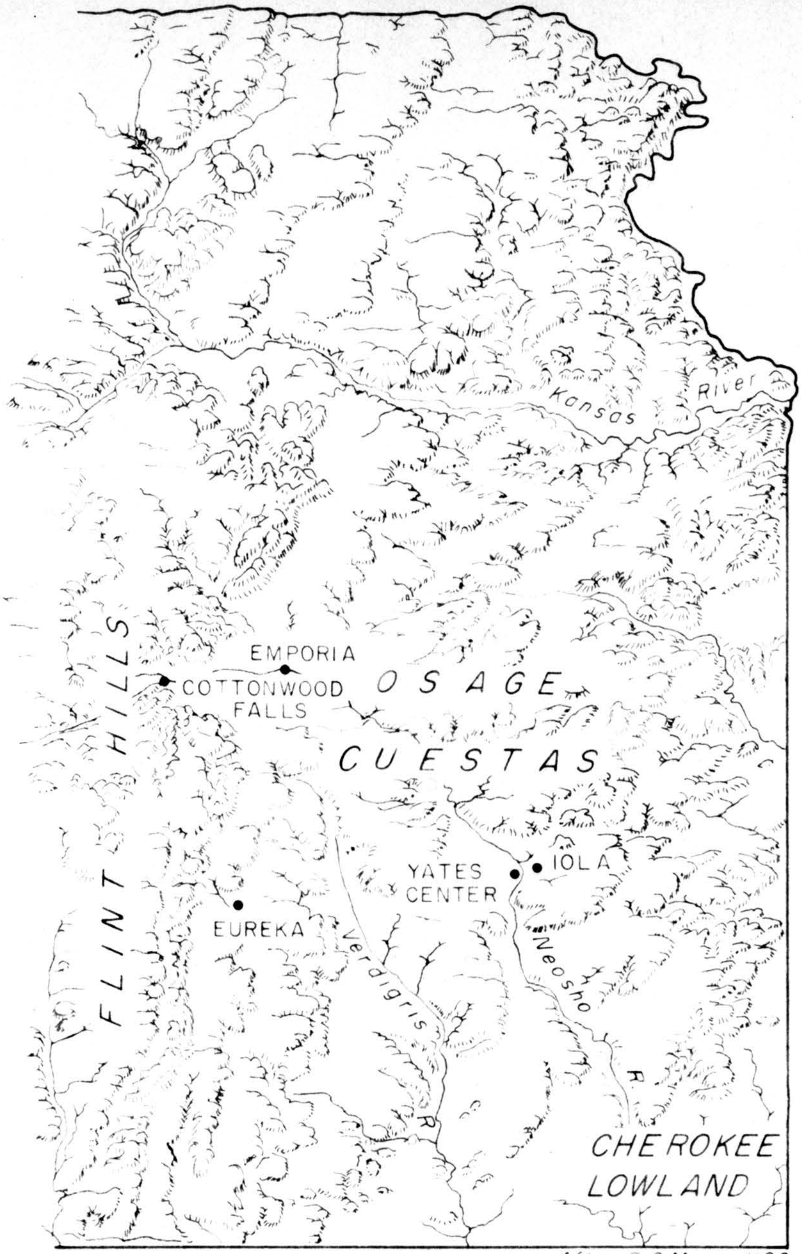
Pedee Group
- Weston Shale (formation)

Lansing Group
- Stanton Limestone (formation)
  - South Bend Limestone
  - Rock Lake Shale
  - Stoner Limestone
  - Eudora Shale
  - Captain Creek Limestone
- Vilas Shale (formation)
- Plattsburg Limestone (formation)
  - Spring Hill Limestone
  - Hickory Creek Shale
  - Merriam Limestone

Kansas City Group

Zarah Subgroup
- ' Lane-Bonner Springs Shale (formations)

' Lane Shale and Bonner Springs Shale formations; separated elsewhere by Wyandotte Limestone formation but not differentiated here because the absence of the Wyandotte.



After R.C. Moore, KGS

THE LANDSCAPE

J. M. Jewett, State Geological Survey of Kansas

Everywhere the land surface is a document of earth history, and except in extremely flat countries the revelations may touch much more than recent geological time. The landscape is a composite recording events that reach far into the past. Hence, partly understood, landscape takes on added beauty

Flint Hills and less rugged land to the east (Osage Cuestas) exemplify most of the character of eastern Kansas topography and land forms that in general are more or less common in many parts of the world. Systems of stream valleys are cut below an ancient, nearly flat surface whose position is recorded by the nearly accordant hilltops.

The Flint Hills, however, are unique. It is doubtful that one can find anywhere else the same kind of rock-terraced hills and the same kind of wood-fringed valleys cut from bluestem-covered slopes. Crenulated bands of contrasted vegetation form a life-sized geologic map of the whole countryside. These "Permian Mountains" stretch north-south beyond the borders of the state, although they are somewhat subdued across the northern border into Nebraska and are less angular in Oklahoma, where they merge into Osage Hills.

In all eastern Kansas, and farther west under younger rock cover, upper Paleozoic beds in the outer part of the earth's crust slant gently westward or slightly north of west. This inclination of strata--but not of land surface-- is away from the Ozark region. Erosion, working for along time, has removed a great amount of rock; layer after layer farther and farther to the west has been eroded. The present surface across the beveled beds of rock is, therefore, like a fallen deck of cards, or overlapping shingles on a roof.

Today's field trip enters the Flint Hills country not far west of Emporia, and a place not far west of STOP 3 is in the highest part, where Fort Riley Limestone lies next below shallow soil. At Stops 1, 2, and 3 and at scores of intervening roadside exposures one sees lower Permian rocks from which the hills are etched. The rocks are almost entirely shales and limestones. Two of the limestone formations, the Wreford (Stops 2 and 3) and the slightly younger (and higher) Barneston contain large quantities of chert or flint embedded as nodules in limestone. This material may be regarded either as rock or mineral; it is cryptocrystalline silica (silica dioxide) and may be thought of as a noncrystalline variety of quartz. Chalcedony also is noncrystalline silica, but commonly the name is used for material that is more translucent than flint or chert.

In both limestone members of the Wreford formation, the Threemile and the Schroyer, flint is abundant, as it is in the Florence Limestone, lowermost member of the Barneston formation. Flint is present in almost all Pennsylvanian and Permian limestone formations in Kansas but its abundance is not so great as in these three limestones (Threemile, Schroyer, and Florence). The flint, partly that embedded in the rock but more especially that weathered free and strewn as debris along the hillsides, gives these hills their name.

Whereas the westernmost occurrence of Fort Riley Limestone as the bedrock next below the soil cover may be regarded as the western boundary of the Flint Hills, the line of outcrop of the Brownville Limestone (pages 6, 45) may be designated as marking the eastern extent of the Hills. This is, obviously, fixing a boundary entirely arbitrarily, and it may be mentioned that nearly all geological classification is based on artificial divisions. This field trip crosses the Brownville Limestone east of Reece at about mileage 75.0 and hence leaves the Flint Hills country, entering a region of similar but lower east-facing escarpments.

Pennsylvanian rocks in the country east of the Flint Hills are not greatly different from those of lower Permian age in which the Hills are carved. There is more sandstone in the Pennsylvanian section, however, and STOP 5 is in the Chautauqua Hills where topography differs from that in the Flint Hills chiefly because of the difference in kind of rock. Here the hills are carved in the escarpment of the Ireland Sandstone (page 32).

Most of the bedrock layers in eastern Kansas are marine deposits. In late Pennsylvanian and early Permian time, sea waters covered this part of North America. Evidence for this is in the rocks containing the remains of animals that could not have lived on land and, it is reasonable to believe, did not live in fresh water. The presence of marine conditions was interrupted now and then, however, by withdrawals of sea water. It is believed that red shales, characteristic of some of the Permian shale formations and some older ones, are composed of material that accumulated in a position slightly above sea level, and that green shales, also characteristic of lower Permian rocks, were deposited in a near-shore but marine environment.

In any discussion of the rocks in eastern Kansas one must note that the layered rocks are made of material that was derived from formerly existing rocks. Some shales and sandstones, for example, are mechanically accumulated debris; others, as limestones, are deposits organically secreted from sea water. It would be remiss here not to say that the origin of flint is not certainly understood. Possibly a large percent of flint in Kansas rocks is due to the presence in Paleozoic seas of sponges that formed spicules of silica secreted from sea water by the organisms. Our knowledge of the actual environments under which these rocks were formed is almost entirely nonexistent. It ought to be emphasized that each formation and each member of each formation had its own environmental conditions, for no two rock layers are alike.

That our ignorance of geologic history revealed by these sediments is profound may be explained further. For a long time it has been recognized that in this and other parts of the world Pennsylvanian and Permian rocks were deposited in cycles and that there were cycles within cycles. Deposition under cyclic conditions is indicated by regular sequences of rock types occurring over and over again. Seemingly the rock types or phases of cyclothems, as the sediments of a single cycle are called, were controlled by marine conditions, nonmarine conditions, regression of sea water, transgression of sea water (and hence salinity), depth of water, and nature of the biota (which must have been controlled by the foregoing and other factors) and perhaps other conditions. There has been a considerable amount of speculation as to the cause of the changing conditions and their repeated reoccurrences in the same order. Some geologists have postulated the periodic storing of water on the land as glaciers and its subsequent release into the sea. Others think that the causes must have been extraterrestrial, but perhaps not with glaciation as a modus operandi.

At STOP 7, small amounts of a kind of rock that is almost unknown as a native of Kansas at the land surface are seen. This is granitic rock of igneous origin, similar to granite, well known in the cores of mountain ranges, as in the Front Range of the Colorado Rockies, and known to occur somewhat abundantly deep in the earth in many places, including Kansas. The presence of granite at Rose Dome, Woodson County, is then quite anomalous. When first found, the granite was believed to be in the form of boulders brought from the north by glaciers. The attitude of sedimentary beds in the same area, which justifies its designation as "dome," indicates differential movements that accompanied intrusion of igneous material. Slight alteration of sediments also indicates igneous action there. We have no knowledge of the hypothetical "pipe" that connects the outcropping "granite" with a deeper igneous body.

A few things have been said about the consolidated rocks in the field-trip area. It has been mentioned that valleys have been filled, reexcavated, and refilled. The valley fill material now below fertile "bottom land" on floodplains, and in somewhat higher terraces, may be regarded as unconsolidated rock, for it too is a geologic accumulation as is the agricultural productive soil.

The beauty of eastern Kansas, including the Flint Hills country and other lower ranges, is not so much in the rather abrupt relief of hill top above river valley as in the slopes that combine angles with convex curves in the upper reaches and concave ones below in accordance with sculpturing in delicate balance between erosive power and resistance of rock protected by tough sod. The shape of the landscape is not fixed by character of bedrock alone. Thick accumulations of unconsolidated rock debris make up terraces along stream valleys and partly fill valleys, tempering the ruggedness of the terrain and adding to its charm.

It ought to be understood, too, that landscapes everywhere are but temporary things.

MINERAL RESOURCES OF THE FLINT HILLS AND OSAGE CUESTA REGIONS

A. L. Hornbaker, State Geological Survey of Kansas

The road log on this field conference traverses parts of seven counties. In these counties we see a wide variety of geologic phenomena. Most of the economic resources of the area--the oil and gas fields, limestone quarries, gravel pits, shales and limestones used in the manufacture of brick and tile products, ground-water resources, yes, even the soil--are geologically controlled. The topography and soil types are closely related and each is controlled by geologic conditions.

Soils

The soils in the seven-county area vary, depending on their origin and topographic control. Upland soils are for the most part derived from sedimentary rocks in the immediate area. These are called residual soils and their fertility depends largely on the rock type from which they were formed. Relatively pure limestone soils are usually quite fertile where they have developed sufficient thickness. Cherty limestones, on the other hand, decompose and the chert is left as residual material to form a thin rocky soil impossible to cultivate. Hence the name "Flint Hills," a grassland area used largely for grazing purposes.

Soils in the valleys are formed from mud and silt deposited when streams overflowed onto the floodplains (alluvial soil) or from mud and silt washed from slopes (colluvial soil). These form the fertile "bottom land" soils in the area.

Oil and Gas

Oil and gas are the most important economic resources, except for soil, of this seven-county area. The El Dorado field, discovered in 1915, for years was the largest oil-producing field in Kansas and in 1918 had the distinction of being the leading producer in the nation. In 1956, after having been outproduced by a few of the new western Kansas pools for a number of years, the El Dorado climbed back to the number one position in the state, largely because of secondary recovery. Since 1956 it has held the number two position.

Greenwood County has long been of interest to the petroleum geologist because of its famous "shoestring oil sands," which extend into Butler and adjacent counties. These sandstone bodies within the Cherokee Shale are elongated, flat-bottomed lenses with convex tops. They range in thickness from 50 to more than 100 feet, in width from 1/2 to 1 1/2 miles, and in length from 1 to 7 miles. In systems 25 to 45 or more miles long, they lie approximately end to end in er echelon arrangements. The sands represent offshore bars that accumulated in a bay on the western and northwestern shores of the ancient Cherokee sea (early Pennsylvanian time).

The following table showing oil and gas production for 1959 is based on figures compiled by E. D. Goebel of the Geological Survey's Oil and Gas Division:

County	Total Barrels of Oil	Barrels of Oil from Secondary Recovery	Gas Production (Thousands of Cu. Ft.
Allen	979,234	785,653	109,967
Butler	7,929,366	4,318,555	
Chase	112,839	24,700	29,685
Greenwood	5,844,543	4,131,383	
Lyon	182,007	90,332	
Wilson	206,834	126,490	125,486
Woodson	815,355	616,200	13,201

Most of the crude oil produced in the seven-county area is shipped by trucks or pipeline to local refineries. The following table lists the refineries, pertinent data for each.

	Daily Crude Capacity bbls	Gasoline bbls	Lubricants bbls	Coke tons	Asphalt bbls
American Petrofina Co. of Texas, El Dorado	20,000	250			1,900
Mid America Refining Co., Inc., Chanute	2,625				350
Mobil Oil Co. Augusta	42,000	1,700			7,000
Skelly Oil Co. El Dorado	48,000	4,900		500	3,000
Standard Oil Co. (Ind.) Neodesha	24,300	1,300		90	

Limestone, Sand and Gravel

Limestone in this area not only controls topographic features but is important economically; it is used in the manufacture of cement, for building stone, for concrete aggregate, for road metal, and for agricultural limestone. In recent years large portable rock crushers have increased greatly the use of crushed rock for road bases, road metal, and concrete aggregate. Wherever a new road is under construction in the area, portable crushers move in to local accessible limestone outcrops and reopen old quarries or open new quarries. Many limestone beds too thin for permanent stationary quarries are thus usable for local road projects because of portable crushing units.

Sand and gravel, especially high-terrace gravels, are of local importance in the area. Gravels of this type cover thousands of acres in Eastern Kansas and are used for road metal, fill material, and concrete aggregate.

Shale

The brick industry has been important in Allen and Wilson Counties for many years. According to Mr. Norman Plummer, head of the Ceramics Division of the Geological Survey, the Pennsylvanian shales of Kansas are one of the best sources in the country for red firing brick and heavy tile products.

In early days, when paving bricks were used for city streets and highway construction, the brick industry boomed in many southeastern Kansas counties. At one time 67 brick plants were operating in Kansas; Allen County and Wilson County each had six plants.

There are now two plants in each of these counties, at Humboldt and Iola in Allen County and at Fredonia and Buffalo in Wilson County.

SELECTED PUBLICATIONS OF THE STATE GEOLOGICAL SURVEY
THE UNIVERSITY OF KANSAS

(With Special Reference to Reports and Maps Applicable to Area of Field Conference.)

Some High-Calcium Limestones in Kansas (Bull. 90, Part 5), by Russel T. Runnels. 25 cents.

Geologic Structures in Kansas (Bull. 90, Part 6), by J. M. Jewett. 75 cents.

The Red Eagle Formation in Kansas (Bull. 96, Part 8), by Howard G. O'Connor and J. M. Jewett. 25 cents.

Pleistocene Geology of Kansas (Bull. 99), by John C. Frye and A. Byron Leonard. $1.00

Oil and Gas in Eastern Kansas (Bull. 104), by J. M. Jewett. $1.50

Depositional Environment of the Wreford Megacyclothem (Lower Permian) of Kansas (Bull. 124) by Donald E. Hattin. $1.00.

The Precambrian Rocks of Kansas (Bull. 127, Part 3), by O. C. Farquhar. 75 cents.

Cement Raw Materials in Kansas (Bull. 134, Part 2), by Russell T. Runnels. 25 cents.

The Mineral Industry in Kansas in 1958 (Bull. 134, Part 7), by Walter H. Schoewe. 50 cents.

Symposium on Geophysics in Kansas (Bull. 137), by William W. Hambleton. $2.00

Ground-Water Levels in Observation Wells in Kansas, 1959 (Bull. 146), by V. C. Fishel and Margaret Broeker. In Press.

Oil and Gas Developments in Kansas During 1959 (Bull. 147), by E. D. Goebel, P. L. Hilpman, D. L. Beene, and R. J. Noever. In Press.

Cross Sections in Eastern Kansas (Oil and Gas Investigations No. 12), by Wallace Lee and Daniel F. Merriam. 50 cents.

Geology, Mineral Resources, and Ground-Water Resources of Chase County, Kansas (Vol. 11), by R. C. Moore, J. M. Jewett, H. G. O'Connor, and R. K. Smith. 75 cents.

Kansas Rocks and Minerals, by Laura Lu Tolsted and Ada Swineford. Mailing charge 5 cents.

The Kansas Scene, by Grace Muilenburg.

Graphic Column and Classification of Rocks in Kansas (chart), by J. M. Jewett. Mailing charge 10 cents.

The Geography of Kansas. Part IV, Economic Geography: Mineral Resources, by Walter H. Schoewe. Reprinted from Kansas Academy of Science Transactions, Vol. 61, No. 4, 1958. 75 cents.

Research and Activities of the State Geological Survey of Kansas: fiscal year ending June 30, 1959, by Grace Muilenburg

MAPS

Geological Map of Kansas (scale approximately 8 miles equals 1 inch). 50 cents; by mail 75 cents.

Surface Features of Kansas (map and text), by R. C. Moore. Mailing charge 10 cents.

The Petroleum Industry in Kansas, by Edwin D. Goebel. 50 cents; by mail 75 cents.

Stat igraphy of the Outcropping Pennsylvanian Rocks in the Fredonia Quadrangle, Kansas, by Holly C. Wagner and L. D. Harris. 50 cents.

Geology of the Fredonia Quadrangle, Kansas, by Holly C. Wagner. $1.00

Topographic Maps - 30 cents a quadrangle sheet, unless otherwise noted:
- 7 1/2-minute series: Emporia, Plymouth, Saffordville, Strong City, Buffalo.
- 15-minute series: Severy, Fredonia.
- 30-minute series: Coverage of the field trip area; 1884-1895 map series. Non-detailed reconnaissance type for most part; Cottonwood Falls sheet most detailed of these maps.

Quadrangle Maps of areas between 2 degrees of longitude and 1 degree of latitude (scale 1:250,000, or about 1 inch equals 4 miles): Hutchinson, Wichita, Joplin. 50 cents a quadrangle sheet.

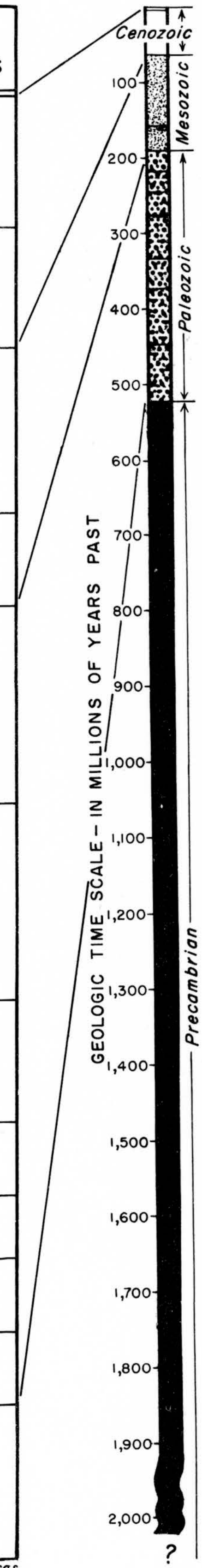
Map Index of available sheets free on request.

GEOLOGIC TIMETABLE AND KANSAS ROCK CHART

ERAS	PERIODS	ESTIMATED LENGTH IN YEARS*	TYPE OF ROCK IN KANSAS	PRINCIPAL MINERAL RESOURCES
CENOZOIC	QUATERNARY (PLEISTOCENE)	1,000,000	*Glacial drift; river silt, sand, and gravel; dune sand; wind-blown silt (loess); volcanic ash.*	Water, agricultural soils, sand and gravel, volcanic ash.
CENOZOIC	TERTIARY	59,000,000	*River silt, sand, and gravel; fresh-water limestone; volcanic ash; bentonite; diatomaceous marl; opaline sandstone.*	Water, sand and gravel, volcanic ash, diatomaceous marl.
MESOZOIC	CRETACEOUS	70,000,000	*Chalk, chalky shale, dark shale, vari-colored clay, sandstone, conglomerate. Outcropping igneous rock.*	Ceramic materials; building stone, concrete aggregate, and other construction rock; water.
MESOZOIC	JURASSIC	25,000,000	*Sandstones and shales, chiefly subsurface.*	
MESOZOIC	TRIASSIC	30,000,000		
PALEOZOIC	PERMIAN	25,000,000	*Limestone; shale; evaporites (salt, gypsum, anhydrite); red sandstone and siltstone; chert; some dolomite.*	Natural gas; salt; gypsum; building stone, concrete aggregate, and other construction materials; water.
PALEOZOIC	PENNSYLVANIAN	25,000,000	*Alternating marine and non-marine shale, limestone, and sandstone; coal; chert.*	Oil, coal, limestone and shale for cement manufacture, ceramic materials, construction rock, agricultural lime, gas, water.
PALEOZOIC	MISSISSIPPIAN	30,000,000	*Mostly limestone, predominantly cherty.*	Oil, zinc, lead, gas, chat and other construction materials.
PALEOZOIC	DEVONIAN	55,000,000	*Subsurface only. Limestone, black shale.*	Oil
PALEOZOIC	SILURIAN	40,000,000	*Subsurface only. Limestone.*	Oil
PALEOZOIC	ORDOVICIAN	80,000,000	*Subsurface only. Limestone, dolomite, sandstone, shale.*	Oil, gas, water.
PALEOZOIC	CAMBRIAN	80,000,000	*Subsurface only. Dolomite, sandstone.*	Oil
PRE-CAMBRIAN	(Including PROTEROZOIC and ARCHEOZOIC ERAS)	1,600,000,000 +	*Subsurface only. Granite, other igneous rocks, and metamorphic rocks.*	Oil and gas.

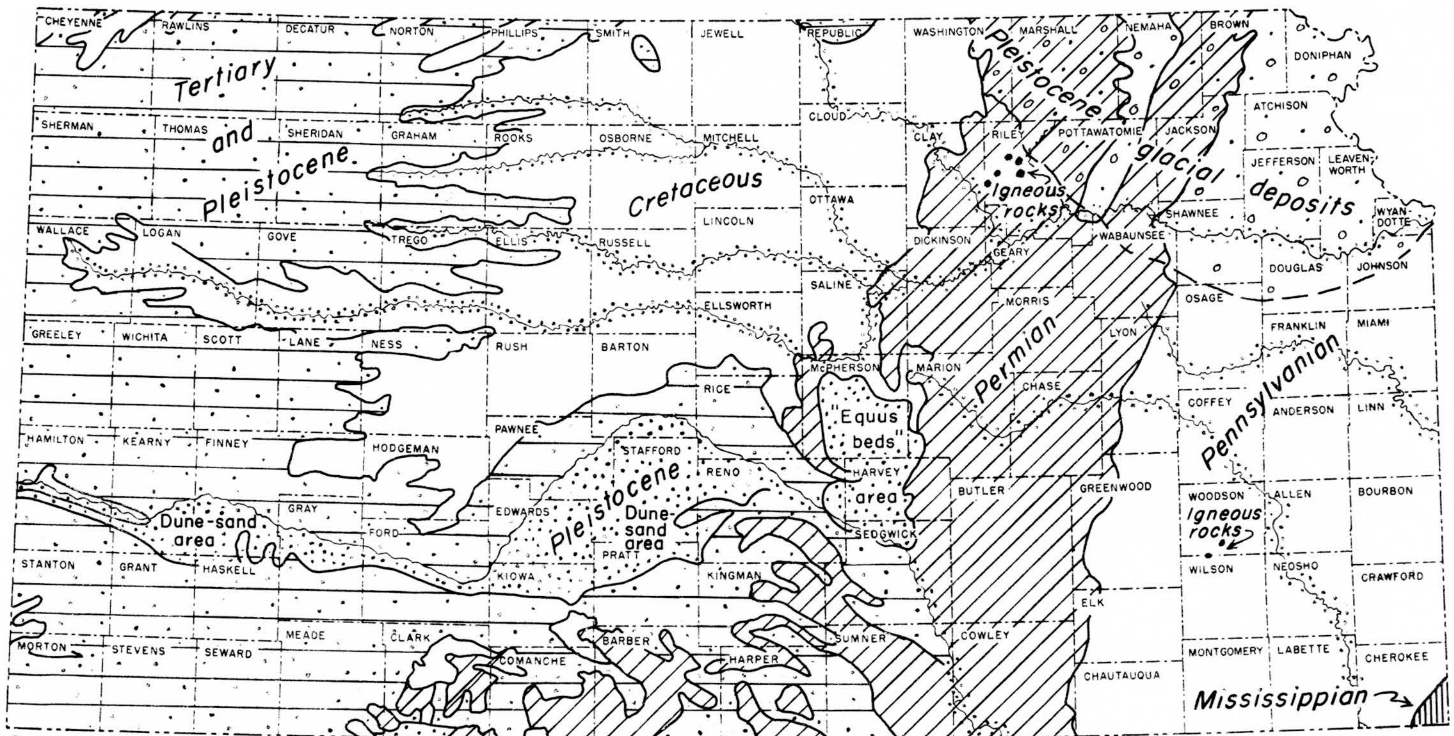
(Not scaled for geologic time or thickness of deposits)

*Committee on Measurement of Geologic Time, National Research Council

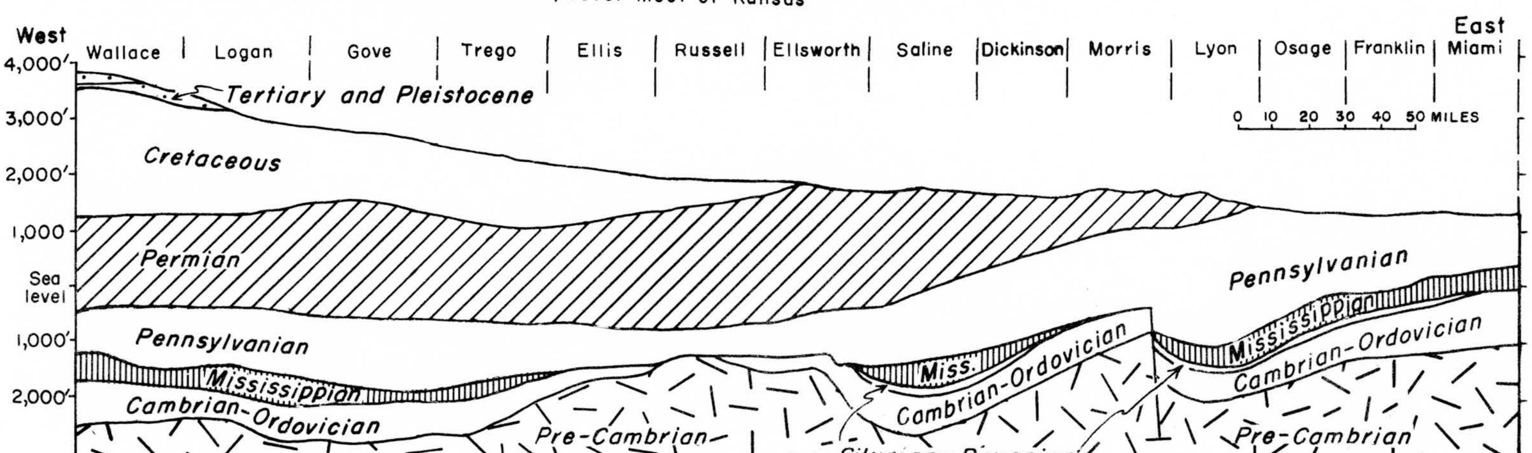


State Geological Survey of Kansas

Generalized geologic map of Kansas

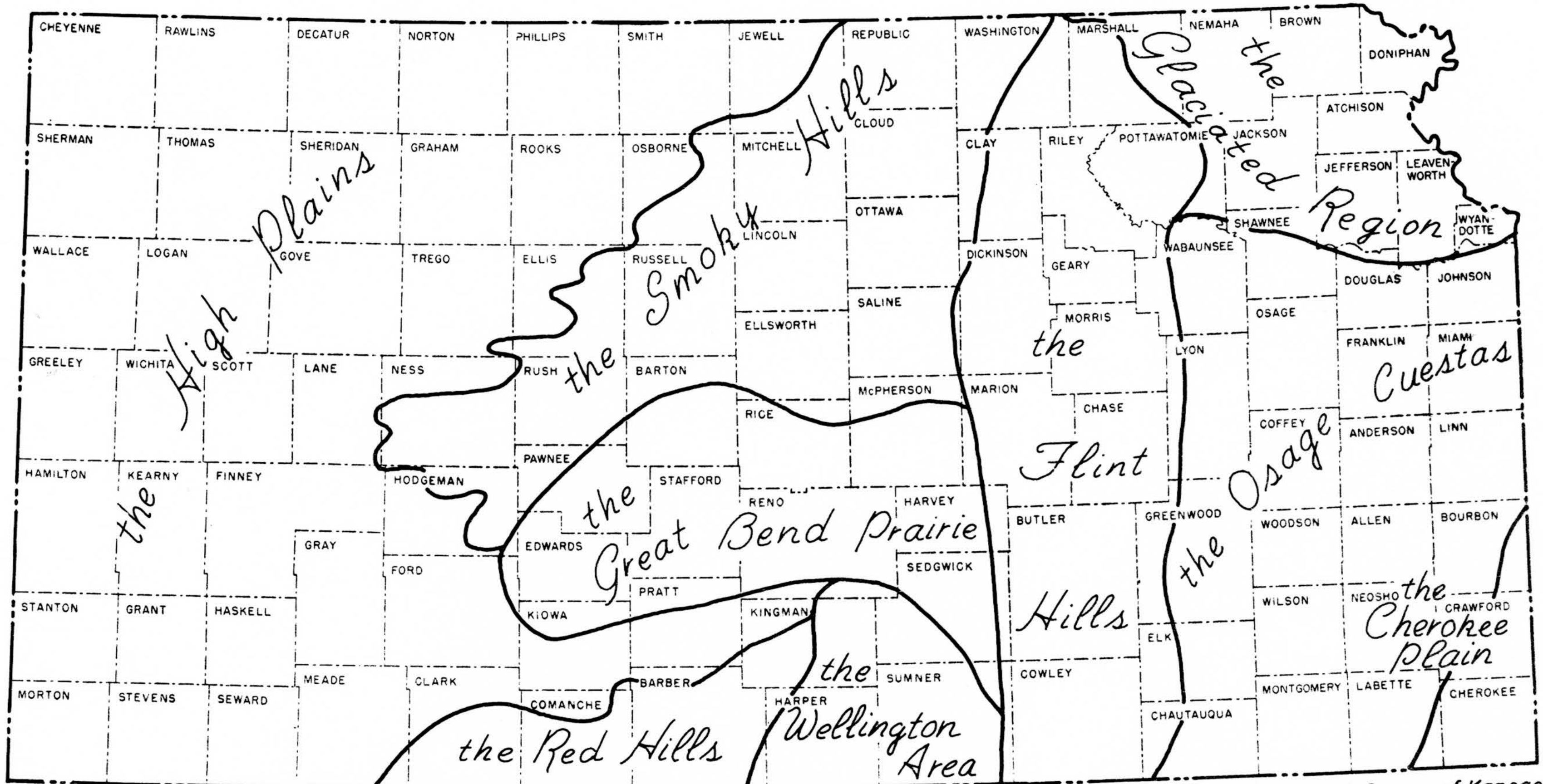


Pleistocene deposits, including present soils, cover most of Kansas



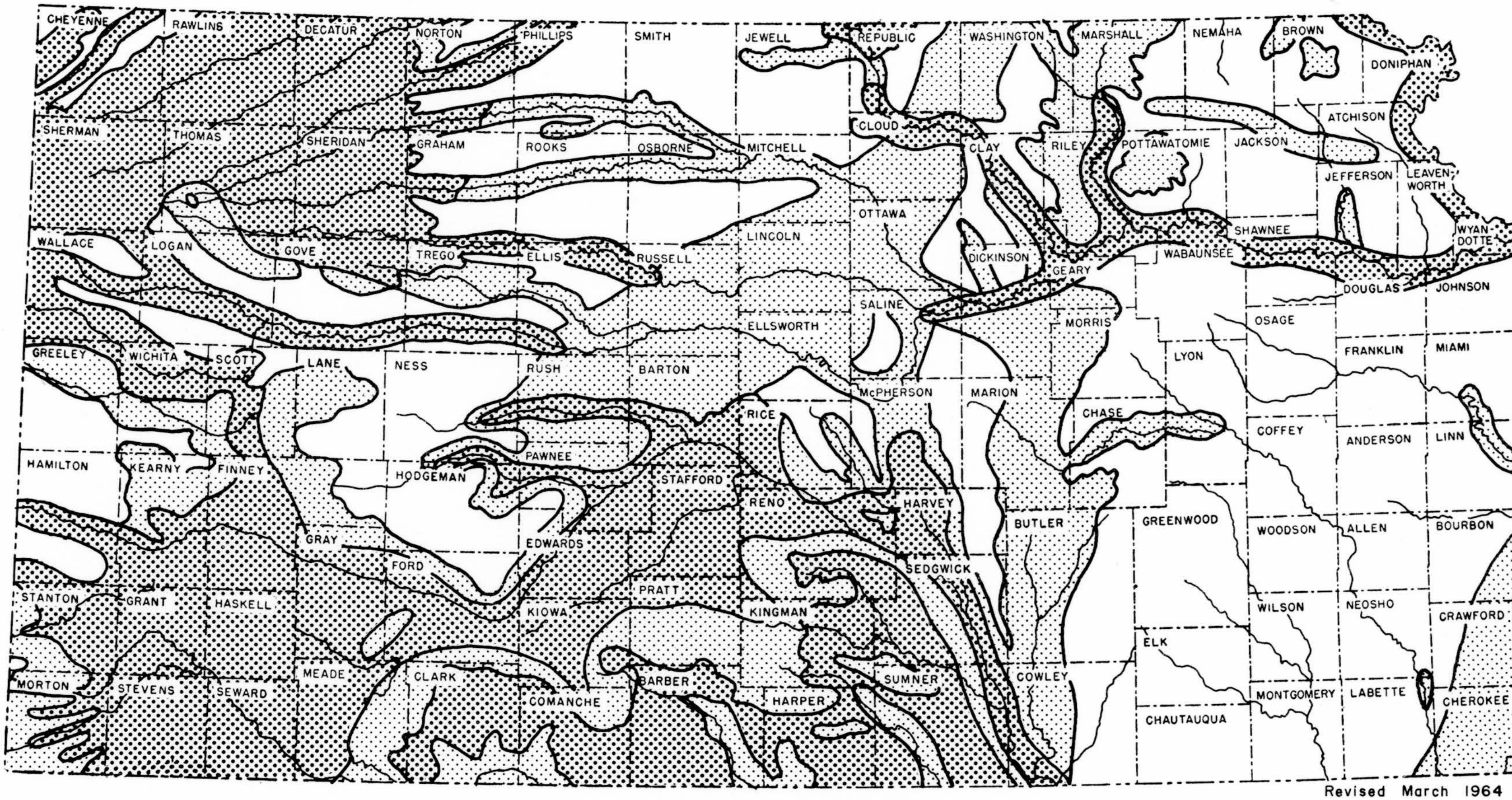
Generalized cross section of Kansas rocks

—State Geological Survey of Kansas



State Geological Survey of Kansas

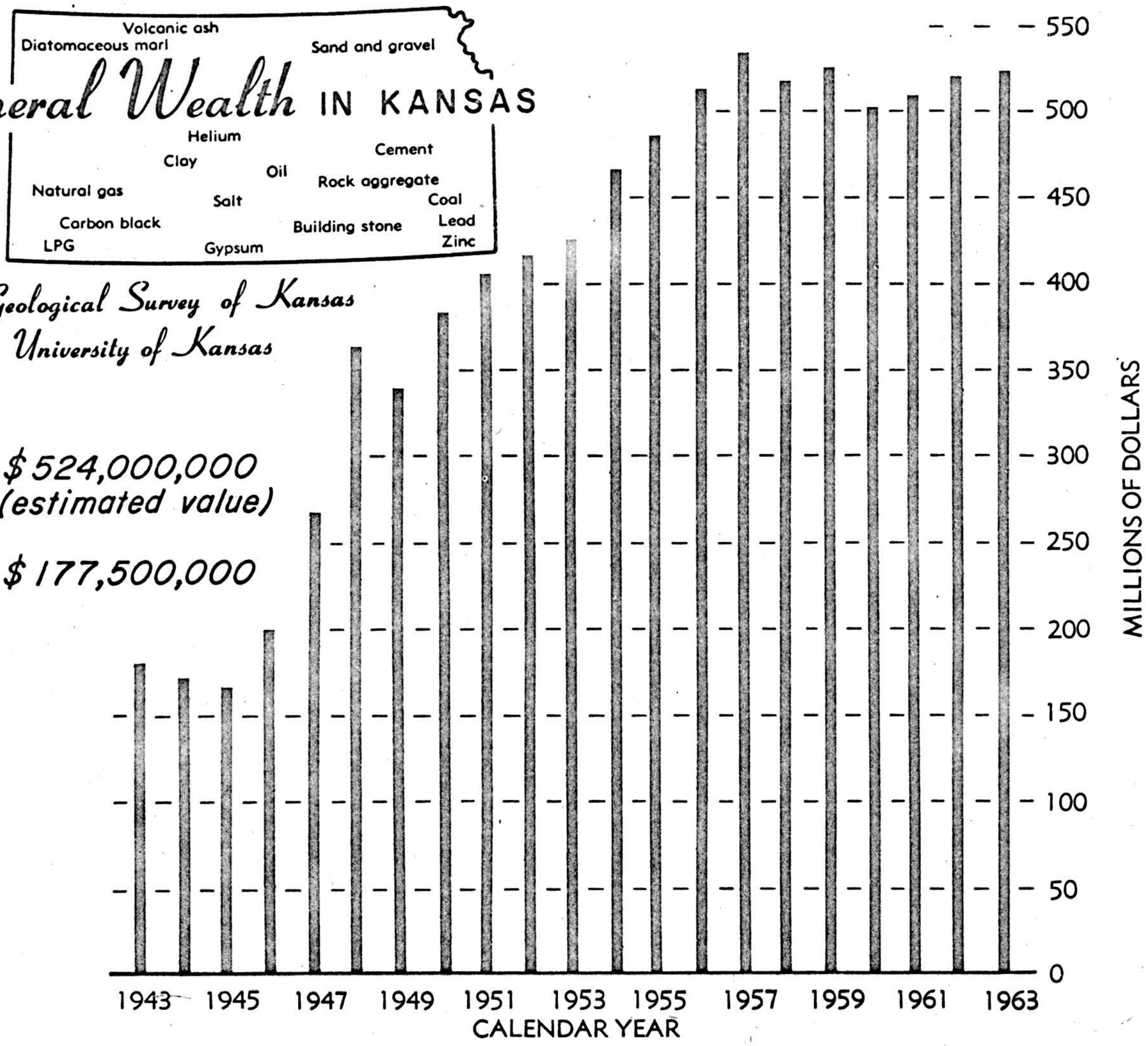
GENERALIZED GROUND-WATER REGIONS IN KANSAS



(dense dot pattern)	Areas in which yields of 500 gallons of water a minute are generally available.
(light dot pattern)	Areas in which yields of from 50 to 500 gallons of water a minute are generally available.
(blank)	Areas in which yields of less than 50 gallons of water a minute are generally available.

Map prepared by the United States and Kansas Geological Surveys, in cooperation with the State Board of Agriculture and Department of Health.

Mineral Wealth IN KANSAS



State Geological Survey of Kansas
The University of Kansas

1963.. *$524,000,000*
(estimated value)

1943.. *$177,500,000*

ESTIMATED VALUE OF

MINERAL PRODUCTION IN KANSAS 1963

	Percent of total	
Petroleum, crude	61.8	$ 324,000,000
Natural gas	15.1	79,000,000
Cement (portland and masonry)	4.9	26,000,000
Stone (building stone, crushed rock, etc.)	3.3	17,500,000
Natural gasoline and LPG	2.7	14,000,000
Salt	2.4	12,400,000
Helium	2.2	11,350,000
Clay and clay products	2.1	10,900,000
Sand and gravel	1.6	8,250,000
Coal	.97	5,100,000
Zinc	.18	960,000
Lead	.05	240,000
Misc. (carbon black, diatomaceous marl, gypsum, natural cement, salt brine, volcanic ash)	2.7	14,300,000
		$ 524,000,000

Each January the State Geological Survey makes mineral-production estimates to cover the year just ended. These estimates are based on figures and trends obtained from producers and other sources: trade journals, State Mine Inspector, State Corporation Commission, and U.S. Bureau of Mines, with which agency the Geological Survey has a cooperative agreement in getting statistical information other than for petroleum, coal, and metals.