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## MINERAL RESOURCES OF EASTERN KANSAS IN THE MISSOURI RIVER BASIN

by

W.L. Heidenreich
W.L. DeCarbonel

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Kansas Geological Survey
1930 Constant Avenue
University of Kansas
Lawrence, KS 66047-3726

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by W. Lee Heidenreich[1/] and W. L. de Carbonel[2/]

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1/ Mining Engineer, U. S. Bureau of Mines, Rolla, Mo.
2/ Former Mining Engineer, U. S. Bureau of Mines, Rolla, Mo.

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## INTRODUCTION

This is one of two reports on the mineral resources of Kansas in the Missouri River Basin prepared by mining engineers of the Minerals Technology Division, Region VI, U. S. Bureau of Mines, for the purpose of providing information to agencies of the Department of the Interior and others concerned with the planning of Federal power developments in the Basin.

The 36 counties in northwest Kansas are reported in "Mineral Resources of Western Kansas in the Missouri River Basin."

This report covers the 29 counties including Marshall, Riley, Geary, Dickinson and part of Marion and all counties to the east which lie in Kansas within the Basin.

Information in this report was gathered from all available reliable sources, from maps and publications, and from detailed field work by the authors between July and December 1949, and between November 1950 and March 1951.

The report deals lightly with petroleum, natural gas resources, and power developments as these subjects are covered by other agencies. It presents only enough data to complete mineral statistics and power developments in the various counties.

## ACKNOWLEDGMENTS

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The maps in this report were prepared by James D. Cooper and his staff in the U. S. Bureau of Mines at Rolla, Mo.

## SUMMARY

Eastern Kansas, within the Missouri River Basin, is mainly a grazing and agricultural region, with few large industries based on natural resources. It has no known deposits of metallic minerals. The major mineral industries are sand-gravel, limestone, cement, gypsum, coal, petroleum, natural gas, and a minimum of low-fusion ceramic products. In 1949, production totaled about 2,682,000 tons of sand-gravel, 3,432,000 tons of crushed limestone, 900,000 tons of coal, 1,777,400 barrels of oil, and 288,600 thousand cubic feet of natural gas. Portland cement output was important, and all from a single plant. One plant manufactured a relatively small tonnage of hydraulic cement.

The area has unlimited reserves of alluvial sand-gravel in the valleys of its major streams, the Republican, Solomon, Big Blue, Kansas, and Missouri Rivers, and large reserves of glacial gravel and stream gravels older than the present drainage system.

Limestone suitable for road metal, riprap, concrete aggregate, agricultural limestone, or building stone occurs abundantly in most counties.

Limestone and shale, source materials suitable for the manufacture of portland cement, are plentiful in many eastern Kansas counties. Portland cement is produced by one large plant in Wyandotte County, and hydraulic cement by a small plant in Bourbon County.

Illite shale, suitable for the manufacture of common red brick, calcined lightweight or dense aggregate, and other low-fusion ceramic products, is abundant. Bourbon County has a pottery plant for manufacture of flower pots.

Gypsum is mined and processed to plaster by one company in Marshall County.

Source materials for the manufacture of mineral wool are widespread but there are no mineral wool industries.

Loess, suitable as mineral filler and for the manufacture of dense or lightweight ceramic aggregate and soil-cement brick, is plentiful in most northern and eastern counties.

Coal reserves of the Basin area are only a small part of the reserves of southeastern Kansas and the recoverable reserves are limited. The 1950 production was 900,198 tons, most of which was mined in Linn County.

Oil production in 1950 from eastern Kansas within the Basin area totaled 2,252,212 barrels, an increase of about 475,000 barrels over the 1949 production. The new Davis Ranch Pool in Wabaunsee County produced 356,015 barrels in 1950 from an Ordovician horizon; all the rest of the production, with the exception of a small amount in Nemaha and Brown Counties, was from lower Pennsylvanian horizons, from fields which have passed the flush production stage and now are being rejuvenated by water-flooding projects.

Natural gas production is of minor importance, being only about a tenth of one percent of the total production in Kansas.

Eastern Kansas has a network of pipelines for collection of gas and oil from the fields and for distribution to market and refineries. The only refinery in the area is that of Phillips Petroleum Co. at Kansas City, Kans.

Kansas Power & Light Co. and Kansas City Power & Light Co. generate and distribute power over a transmission network of 154,000, 115,000, 66,000, 33,000-volt and lesser voltage lines. They have or can have tie-ins with other large power systems outside the Basin area. In addition, there are 16 municipally-owned electric generating stations in eastern Kansas. Eastern Kansas Utilities, Inc., and Kansas Gas & Electric Co. furnish power to counties in southeastern Kansas.

The alluvials of the principal rivers furnish abundant supplies of water for industrial and domestic use. Crawford County has an abundant fresh water supply in deep wells to Ordovician and Cambrian aquifers. Away from the rivers, areas of eastern Kansas get water from wells sunk to porous alluvials in minor water courses, to limestones near the surface or to porous sandstones, and from lakes and collecting ponds dependent upon rainfall. Rainfall varies from 30 inches a year in the western part to 40 inches in the eastern part.

## GEOLOGY OF NORTHEASTERN KANSAS

The geology herein described is based on the geological map of Kansas prepared by the State Geological Survey of Kansas (28), and the nomenclature is from Bulletin 89 (25) also prepared by the State Geological Survey of Kansas.

The Cherokee group, the lowest of the Pennsylvanian system, outcrops in Crawford County in southeast Kansas (figs. 1, 2, 3, and 4). It strikes about 30° east of north and dips 10 to 15 feet per mile 30° north of west. Superimposed on this base lies the rest of the Desmoinesian and the Missourian and Virgilian series (table 1) constituting the Pennsylvanian system. The Pennsylvanian is about 2,320 feet thick and consists of shales with intercalated limestone beds and occasional sandstone beds, all striking north 30° east in parallel bands and dipping gently westward.

At the top of the Pennsylvanian system (Brownville limestone) (fig. 2) is an erosion interval, not too well marked. The Pennsylvanian rocks are overlain by the Wolfcampian and Leonardian series of the Permian system (table 1). The Permian rocks within the Basin are about 1,485 feet thick and consist of shales with intercalated limestones (fig. 3), the limestones being thinner and softer than the Pennsylvanian limestones. The beds and formations strike and dip approximately parallel to those in the Pennsylvanian system.

At the top of the Permian is a major erosion interval followed by overlying Cretaceous beds striking northeasterly and dipping gently westward. The contact between the Cretaceous and

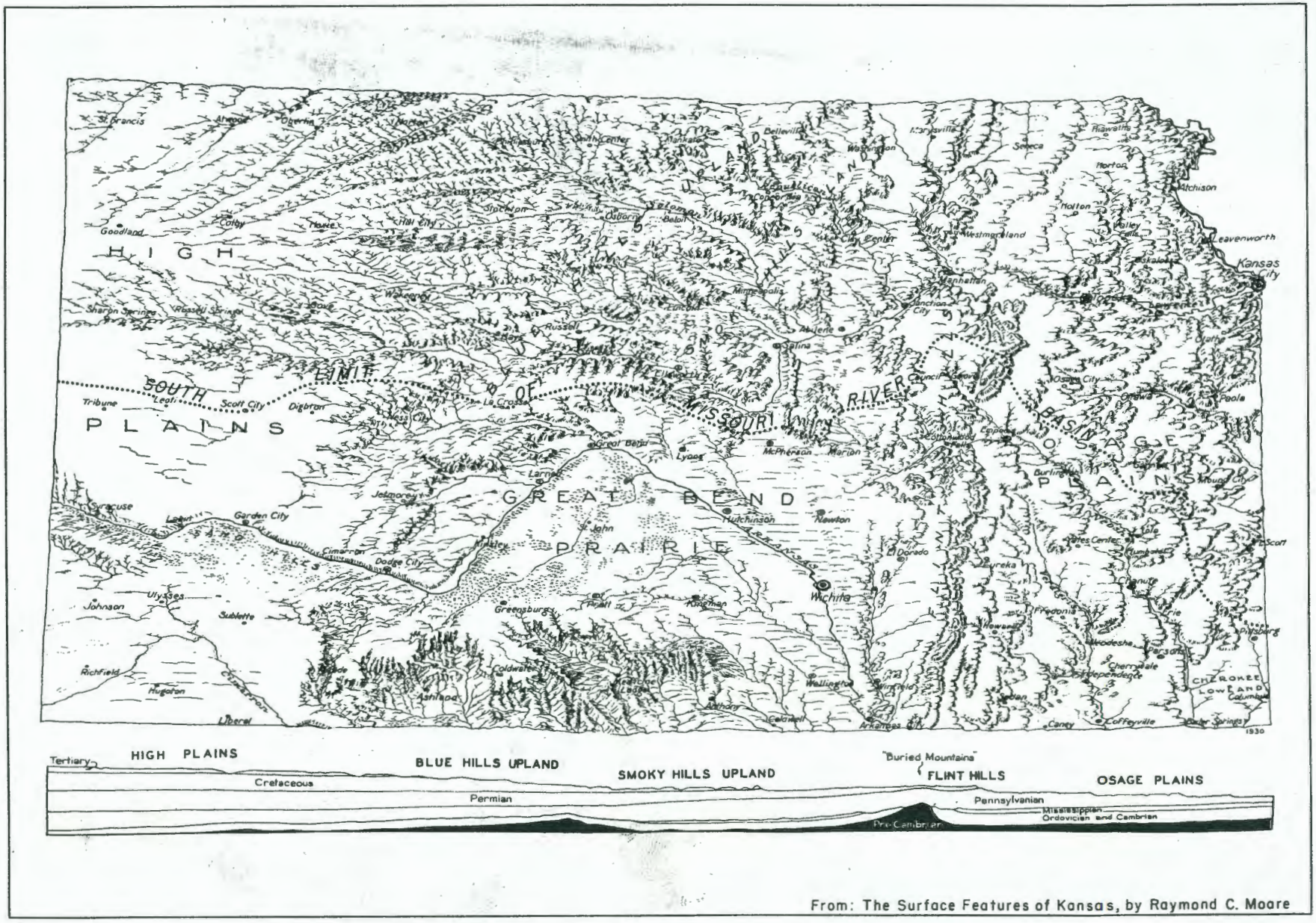



Figure I.- Surface relief map of Kansas

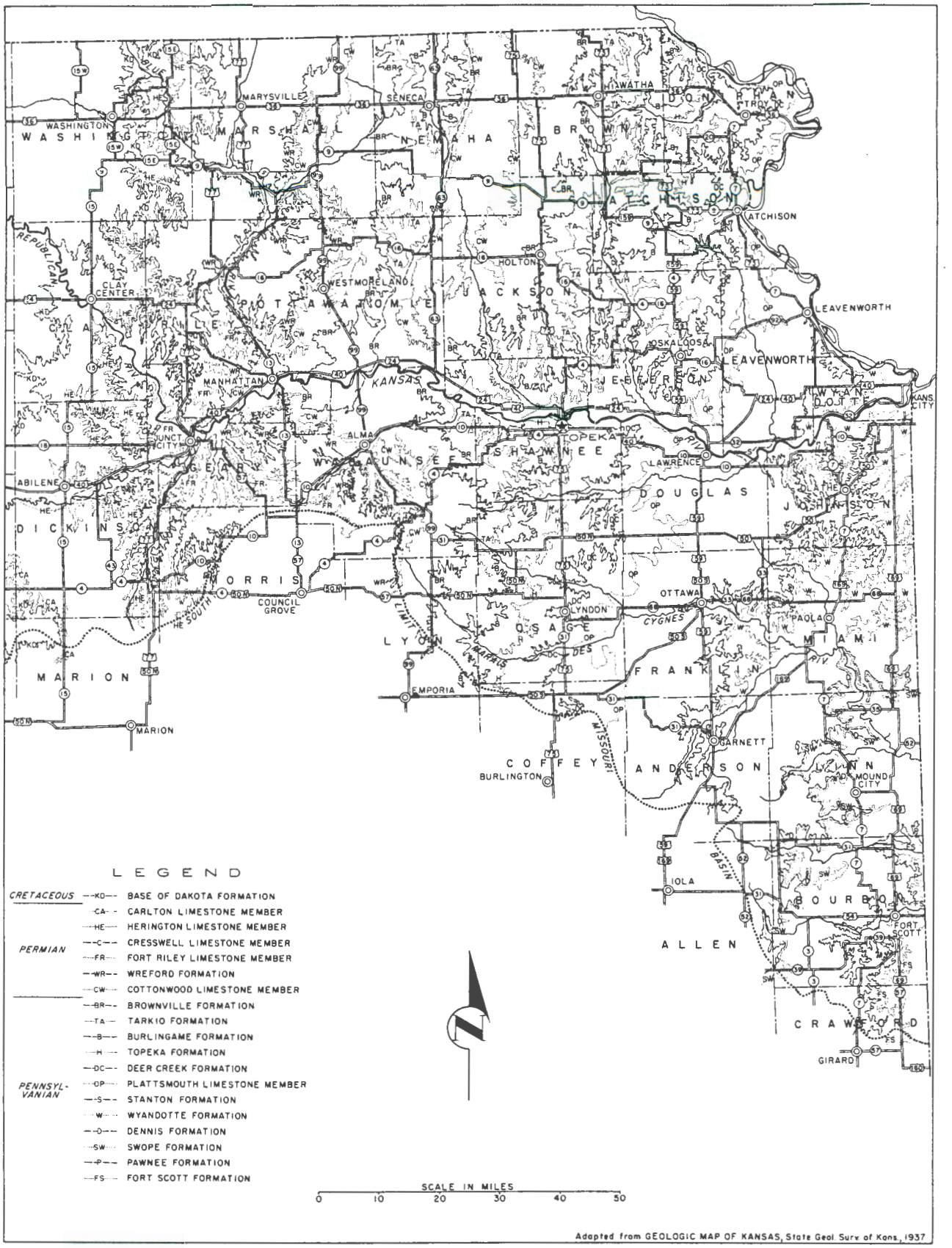



Figure 2.- Major limestone outcrops of the Missouri Basin in eastern Kansas

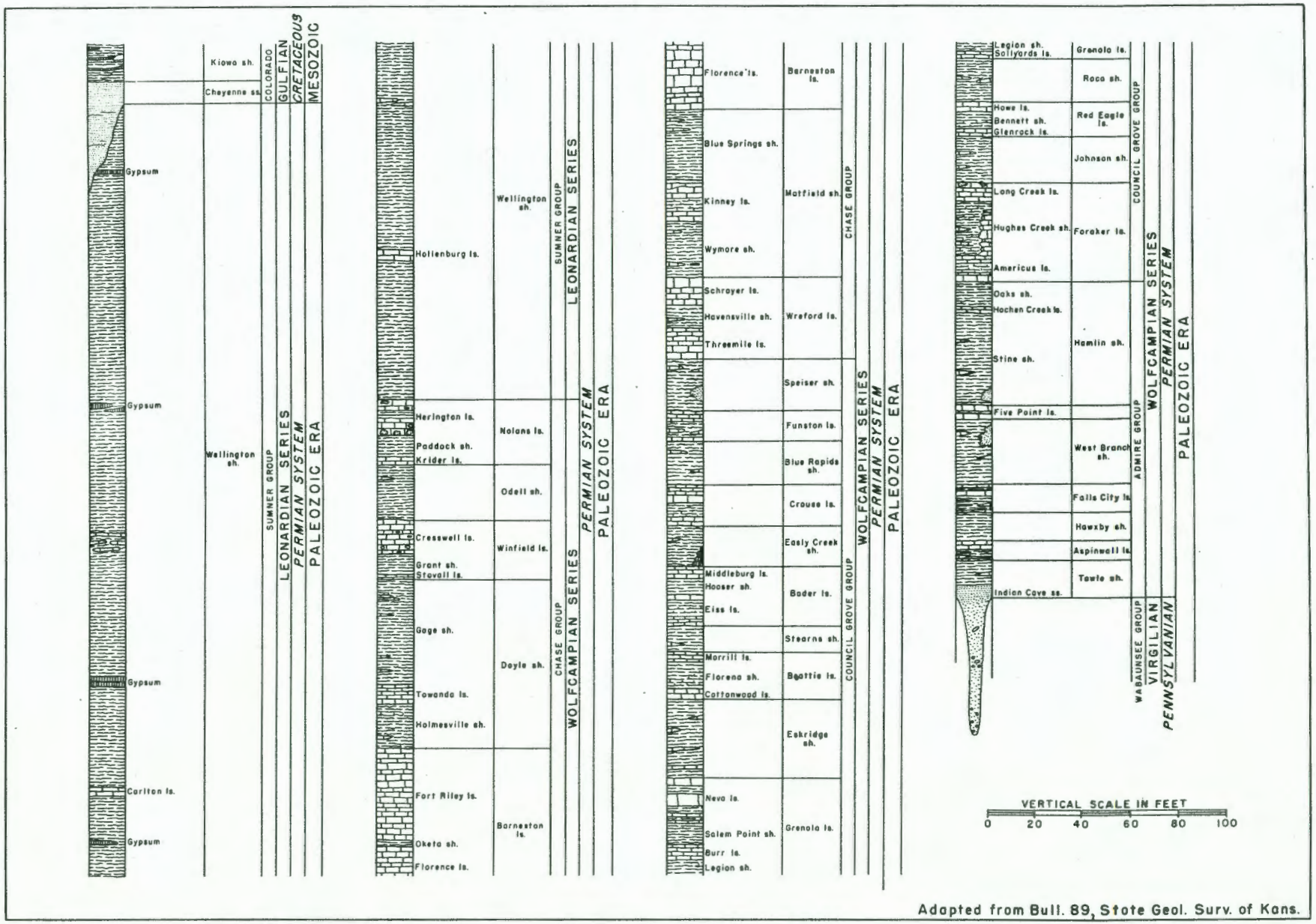



Figure 3.- Geologic column of the Cretaceous and Permian rocks outcropping in eastern Kansas

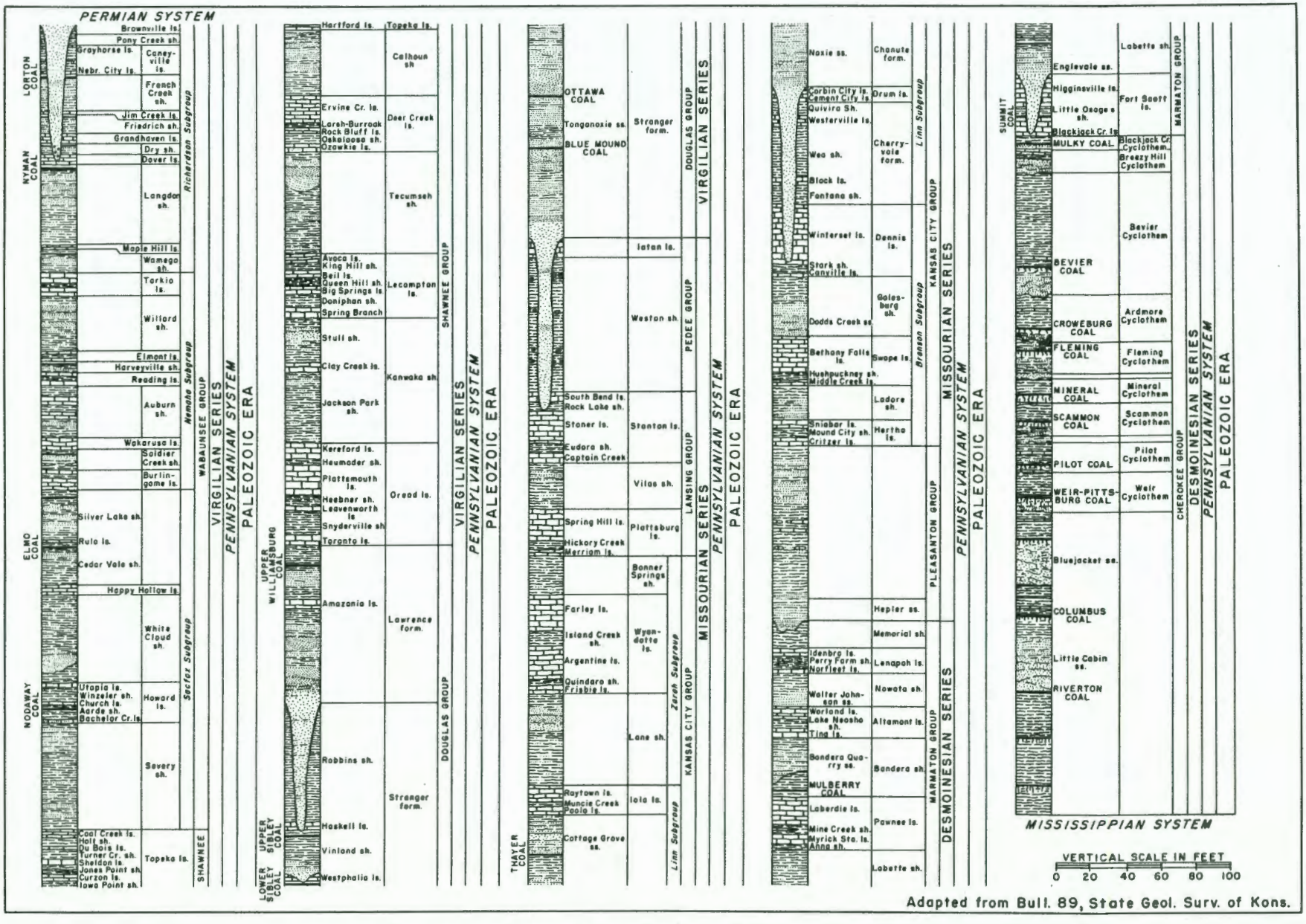



Figure 4.- Geologic column of the Pennsylvanian rocks outcropping in Kansas

Table 1.- Stratigraphic column of outcropping rocks of Kansas within the Missouri Basin

| SYSTEM | SERIES | GROUP | THICKNESS (FEET) | | TOTAL THICKNESS(FT) |
|---|---|---|---|---|---|
| Quaternary | Pleistocene | Sanborn | 30 | | 30 |
| Tertiary | Pliocene | Ogallala | 200 | | 200 |
| Cretaceous | Gulfian | Montana | 700 | | |
| | | Colorado | 1000 | | |
| | | Dakota sandstone | 200 | 1900 | |
| | Comanchean | Kiowa shale | 100 | 100 | 2000 |
| Permian | Leonardian | Quartermaster | | | |
| | | Nippewalla | | | |
| | | Sumner | 700 | 700 | |
| | Wolfcampian | Chase | 335 | | |
| | | Council Grove | 320 | | |
| | | Admire | 130 | 785 | 1485 |
| Pennsylvanian | Virgilian | Wabaunsee | 470 | | |
| | | Shawnee | 325 | | |
| | | Douglas | 250 | 1045 | |
| | Missourian | Pedee | 90 | | |
| | | Lansing | 85 | | |
| | | Kansas City | 350 | | |
| | | Pleasanton | 100 | 625 | |
| | Desmoinesian | Marmaton | 250 | | |
| | | Cherokee | 400 | 650 | 2320 |
| | | | | | 6035 |
| Mississippian | | | | | |

References: State Geol. Surv. of Kans., Bulls. 52 & 89

the Permian is an overlapping one, with younger members overlapping the older members towards the northeast.

The only major tectonic structure in eastern Kansas is the Nemaha anticline which strikes about north 30° east from the center of the south border of Morris County through western Wabaunsee, central and northeastern Pottawatomie, and central Nemaha Counties (1),[3/] (fig. 7). Along its crest in the northern counties, Pennsylvanian rocks are exposed, flanked on both sides by Permian rocks. On the east flank 10° reverse dips (east) occur for distances of about half a mile. Along the crest, pre-Cambrian rocks are found several thousand feet closer to the surface than their normal occurrence.

In western Kansas is another major tectonic structure, the central Kansas uplift, which had a marked influence on western oil productivity. The uplift is not evident on the surface.

The northern counties are covered heavily by glacial drift and outwash sands lying on the older consolidated geological formations. This cover extends southward, in decreasing thickness, to the Kansas River. South of the river the drift extends into Wabaunsee and Lyon Counties and into the northern half of the other counties bordering the river.

The Sanborn formation (fig. 3), a blanket of loess for the most part 10 to 30 feet thick, lies on the glacial drift and covers northern Marshall and Nemaha Counties, northern and eastern

3/ Numbers in parentheses refer to items in the bibliography at the end of this report.

Brown County, all of Doniphan County, the eastern half of Atchison County, the northeastern half of Leavenworth County, and most of Wyandotte County. The loess is as much as 200 feet thick near the Missouri River in Doniphan County, and is prominent along the Missouri River in Leavenworth, Atchison, and Wyandotte Counties and on the north bank of the Kansas River in Wyandotte County.

Loess is probably a windborn formation, supplemented by water sedimentation and concentration, very fine in texture, most of it passing through a 200-mesh screen. Near the surface it contains some calcium carbonate and organic matter. Loess usually is uniform in composition and is composed of quartz, feldspar, altered feldspar, mica, altered mica, altered and unaltered volcanic glass, some calcite, some ferromagnesium minerals, and varying amounts of clay of the illite type.

## MINERAL RESOURCES

### Loess

Loess occurs in abundance but little use has been made of it. Analyses of the material range as follows (2):

| | Percent |
|---|---|
| $SiO_2$ | 65 to 79 |
| $Al_2O_3$ | 9 to 15 |
| $Fe_2O_3$ | 15 to 4 |
| $CaO$ | 1 to 6 |
| $MgO + K_2O$ | Under 5 |

In its natural state, intimately mixed with 10 to 12 percent cement an equal amount of water and compressed to 1,000 p.s.i., it forms an excellent soil-cement block, pleasing in

appearance and as weather-resistant as most limestones. Soil--cement blocks are not in commercial production but have been used in a few houses in Shawnee County. The Economy Building Block Machine Co. of Topeka builds a machine for the manufacture of the block.

Loess is suitable for the manufacture of coarse, low-cost brick or hollow tile, as a substitute for shale, with the advantage of low-mining costs and low-firing temperatures.

Experiments at the University of Kansas have shown loess to be suitable for the manufacture of ceramic aggregates in rotary kilns with minimum heat requirements--ceramic aggregates such as lightweight concrete aggregate like haydite or dense aggregates for road metal, railroad ballast, or riprap (2). High clay content loess is preferable for lightweight aggregate and low clay content for dense products.

### Sand-gravel

Eastern Kansas within the Basin area had approximately the following production of sand-gravel in 1949:

| | Tons |
|---|---|
| Alkali-reactive alluvial sand-gravel ..... | 1,982,000 |
| Non-reactive alluvial sand-gravel ..... | 360,000 |
| Lime-gravels and glacial-gravels ..... | 340,000 |
| Total ..... | 2,682,000 |

Alluvial sand-gravels, reserves of which are unlimited as the supply is constantly replenished by sedimentation, are pumped from the Kansas, Republican, Solomon, Missouri, and Big Blue Rivers and are screened, classified, and graded according to

specifications for use as road metal and concrete aggregates. All except those from the alluvials of the Big Blue River are alkali-reactive, when used as concrete aggregates and should have an admixture of 30 to 40 percent coarse neutral aggregate.

The lime-gravels and clay-bearing or cherty, glacial gravels are not suitable for concrete aggregates. Large deposits occur principally in Lyon, Wabaunsee, Pottawatomie, Marshall, Nemaha, Brown, and Johnson Counties.

## Limestone

Limestone occurs in abundance in most counties but is least available in the northern counties which are covered by glacial till and loess. The Permian limestones are suitable for road metal, riprap, agricultural limestone, and structural stone. The Pennsylvanian limestones have an additional use as concrete aggregate. The annual crushed limestone production is approximately as follows:

| | Tons |
|---|---|
| Crushed limestone ..... | 2,848,500 |
| Agricultural limestone ..... | 527,500 |
| Structural stone ..... | 56,000 |
| Total ..... | 3,432,000 |

The Permian limestones usually are not acceptable as concrete aggregate due to lack of hardness and to frequent cherty inclusions. The Fort Riley, Cottonwood, and Neva limestones have been quarried extensively in the past for building stone in Geary, Riley, Marshall and Pottawatomie Counties, and used in building

construction at Junction City, Fort Riley, Manhattan, Kansas State College, Westmoreland, St. Marys and Marysville. The depth of overburden in relation to the quarry thickness of the limestones places the quarrying of Permian limestones at a disadvantage when competing with the thicker limestones of the Pennsylvanian rocks.

Analyses of limestones of eastern Kansas are shown in table 2.

TABLE 2. -Analyses of Eastern Kansas limestone (3)

| Member | County | Thickness, feet | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | Calculated $CaCO_3$ | Calculated $MgCO_3$ |
|---|---|---|---|---|---|---|---|---|---|
| Curzon ..... | Osage | 4.0 | 0.74 | 0.24 | 0.53 | 54.37 | 0.51 | 96.81 | 1.07 |
| Curzon ..... | Osage | 4.0 | 0.82 | 0.25 | 0.67 | 54.56 | 0.53 | 97.11 | 1.11 |
| Curzon ..... | Osage | 4.0 | 3.45 | 0.75 | 0.66 | 51.84 | 0.96 | 92.39 | 2.01 |
| Ervine Creek ... | Douglas | 8.0 | 2.70 | 0.55 | 1.69 | 53.92 | 0.54 | 96.15 | 1.16 |
| Ozawkie ..... | Douglas | 5.0 | 2.11 | 0.71 | 0.89 | 53.27 | | 95.00 | |
| Spring Branch .. | Douglas | Upper bed | 5.73 | 1.59 | 5.65 | 40.11 | | 70.19 | |
| Plattsmouth .... | Douglas | 8.0 | 2.35 | 0.17 | 0.41 | 53.95 | 0.23 | 96.18 | 0.47 |
| Stoner ..... | Miami | 12.0 | 2.90 | 0.62 | 1.37 | 52.38 | 0.83 | 93.40 | 1.74 |
| Stoner ..... | Johnson | 7.0 | 2.78 | 0.81 | 0.82 | 52.65 | 1.26 | 93.56 | 2.64 |
| Stoner ..... | Miami | 12.0 | 1.72 | 0.39 | 0.50 | 53.97 | 0.51 | 96.24 | 1.07 |
| Stoner ..... | Miami | 10.0 | 3.43 | 0.91 | 1.38 | 49.58 | 2.45 | 88.00 | 5.12 |
| Spring Hill .... | Leavenworth | 18.0 | 5.16 | 0.55 | 0.53 | 52.11 | 0.58 | 92.92 | 1.00 |
| Spring Hill .... | Anderson | 19.0 | 0.68 | 0.64 | | 55.06 | 0.43 | 98.18 | 0.89 |
| Farley ..... | Leavenworth | 22.0 | 1.30 | 0.30 | 0.39 | 54.04 | 0.98 | 96.36 | 2.05 |
| Farley ..... | Leavenworth | 5.0 | 2.13 | 0.38 | 0.47 | 52.58 | 1.56 | 93.76 | 3.26 |
| Argentine ..... | Wyandotte | 13.0 | 2.98 | 1.61 | 0.48 | 52.69 | 0.08 | 93.96 | 0.17 |
| Argentine ..... | Leavenworth | Upper 20.0 | 10.29 | 1.03 | 0.84 | 47.66 | 1.76 | 84.98 | 3.68 |
| Argentine ..... | Leavenworth | Lower 20.0 | 18.94 | 1.63 | 0.91 | 42.58 | 0.31 | 75.98 | 2.47 |
| Argentine ..... | Loring Quarry Leavenworth | Upper 20.0 | 16.00 | 0.84 | 0.61 | 45.39 | 0.80 | 80.94 | 1.67 |
| Argentine ..... | Loring Quarry Leavenworth | Lower 8.0 | 34.08 | 4.37 | 2.09 | 27.26 | 3.72 | 47.47 | 7.78 |
| Sniabar ..... | Linn | 5.0 | 2.54 | 0.72 | 0.53 | 53.33 | 0.27 | 95.10 | 0.58 |

## Shale

Much of eastern Kansas is underlain by Pennsylvanian rocks which comprise a series of alternating shales and limestones with shale predominating. The relative ratio of limestone to shale increases towards the base of the system. The shales are illite type, of low-fusion temperatures (about 2000° F.), and, when comparatively free of impurities such as sand, lime, sulfur or gypsum, are suitable for the manufacture of common red brick, calcined aggregates and other illite-shale ceramic products. In the past, there have been several brick and tile plants in the area; at present, use of the shale is made in a large modern portland cement plant in Wyandotte County, a small hydraulic cement plant in Bourbon County, and a flower pot industry in Bourbon County. Common red brick is being replaced by concrete as construction material.

Plans have been made to start a brick and tile plant and a lightweight calcined aggregate plant (haydite), south of Ottawa in Franklin County, using Weston shale as source material.

## Gypsum

In an area about 8 miles in diameter with Blue Rapids, Marshall County, as a center, gypsum mining has been continuous since 1870. At present, one company is mining gypsum and producing plaster. The area has substantial gypsum reserves. It occurs as an 8-foot bed of pure gypsum.

Gypsum industries have existed in Clay and Dickinson Counties but mining has long been discontinued and the calcining mills have been dismantled.

### Cement

Limestone and shale, source materials for the manufacture of portland cement, are abundant in eastern Kansas, but the area has only one portland cement plant in Wyandotte County. In Bourbon County, a small hydraulic cement plant is operating, one of the few plants in the United States making hydraulic cement.

### Mineral wool

Singly or in combination, limestone, sandstone or shale can be used to manufacture mineral wool if the mixture contains equal proportion of lime and silica. Alumina or magnesia may be present but are not essential; however, the technical know-how is of utmost importance. Source materials for manufacture of mineral wool are abundant in most counties in eastern Kansas. The ceramic division's experimental plant of the State Geological Survey of Kansas, has made many successful tests of rock in various areas (24). Mineral wool plants have existed in southeastern Kansas but none is now operating. Source materials, cheap fuel, and transportation are available for a market to be created.

### Coal
(figs. 20, 32, 35, 37, 38, 39, and 40)

The 1950 coal production in the State of Kansas totaled 2,116,378 tons of which 95 percent was produced by strip mines.

The coal production originating within the Missouri River Basin was 900,198 tons, most of which was mined in Linn County.

The 1950 production for the State is shown in table 3.

TABLE 3. - Kansas coal production in tons (1950)(4)

| | Missouri River Basin | | | Arkansas River Basin | | | |
|---|---|---|---|---|---|---|---|
| | Deep | Strip | Total | Deep | Strip | Total | Total |
| Bourbon ..... | | 103,104 | 103,104 | | | | 103,104 |
| Cherokee ..... | | | | 9,795 | 505,044 | 514,829 | 514,839 |
| Crawford ..... | 22,729 | 18,849 | 41,578 | 50,000 | 648,181 | 698,181 | 739,759 |
| Franklin ..... | 2,501 | 423 | 2,924 | | | | 2,924 |
| Labette ..... | | | | | 3,160 | 3,160 | 3,160 |
| Linn ..... | 2,486 | 714,525 | 717,011 | | | | 717,011 |
| Osage ..... | 19,390 | 16,191 | 35,581 | | | | 35,581 |
| Total ..... | 47,106 | 853,092 | 900,198 | 59,795 | 1,156,385 | 1,216,180 | 2,116,378 |

Most of the economic recoverable coal reserves in Kansas lie in the Arkansas River Basin. The reserves lying within the Missouri River Basin and recoverable under present economic conditions and technology are estimated to be as follows:

| County | Bed | Thickness (inches) | Tonnage recoverable |
|---|---|---|---|
| Bourbon | Bevier | 14 to 16 | 4,000,000 |
| Crawford | Miscellaneous | 10 to 36 | 3,000,000 |
| Franklin | Upper Williamsburg | 18 | 2,500,000 |
| Osage | Nodaway | 15 to 20 | 4,000,000 |
| Linn | Mulberry | 26 | 8,000,000 |
| | Total ..... | | 21,500,000 |

The coal from Linn and Bourbon Counties is mostly washed coal and most of it is produced by two operators. The rest of the production and that from Crawford County is not washed and is sold locally and is not competitive on the open market. Southeastern Kansas coal in 1950 sold at the tipple for an average price of about $4 a ton. It is grade C high-volatile bituminous coal averaging 12,300 B.t.u. as received.

The Nodaway coal is mined mostly as lump coal, which sold for $6.50 to $7 a ton at the tipple. It is subject to decrepitation and spontaneous combustion and does not store well. It averages about 10,800 B.t.u. as received.

## Oil (fig. 6)

Oil production in eastern Kansas within the Basin area was 1,777,413 barrels in 1949. The incomplete production figure for the same area in 1950 was 2,252,212 barrels. The increase

was due to secondary oil produced by water-flooding projects in Anderson and Miami Counties and to the new production in the Davis Ranch Pool discovered in April 1949 in Wabaunsee County.

TABLE 4. - Oil production in the Missouri River Basin in eastern Kansas

| County | Barrels | |
|---|---|---|
| | 1949(6) | 1950(5) |
| Allen | 89,640 | 85,130 |
| Anderson | 380,978 | 527,946 |
| Bourbon | 15,374 | 11,048 |
| Brown | 5,540 | No report |
| Dickinson | 202,070 | 162,132 |
| Douglas | 4,000 | No report |
| Franklin | 255,767 | 278,204 |
| Jefferson | 75,458 | 50,532 |
| Leavenworth | 11,718 | 10,722 |
| Linn | 47,290 | 53,177 |
| Marion | 274,223 | 244,384 |
| Miami | 365,384 | 459,729 |
| Nemaha | 3,312 | 13,193 |
| Wabaunsee | 46,659 | 356,015 |
| Total | 1,777,413 | 2,252,212 |

The oil production in the State of Kansas in 1949 was 100,164,092 barrels (6). The production from the entire Missouri River Basin in Kansas in 1949 was 43,109,842 barrels; in 1950 the same area produced 47,062,174 barrels.

Most of the oil produced in eastern Kansas, within the Basin area, is from lower Pennsylvanian horizons, viz., the Peru, Squirrel, Prue, and Bartlesville, located respectively in the lower Marmaton and the upper, middle, and lower Cherokee groups (table 1). Dickinson County production is from the Mississippian

system, and the Wabaunsee County production is from the Viola of the Ordovician system (fig. 5). The small Brown and Nemaha County production is from the Hunton horizon of the Devonian-Silurian system.

Oil was discovered in Kansas at shallow depths south of Paola, Miami County, in 1860. Development of oil and gas fields was slow at first but started to accelerate in the 1890's in Miami and Allen Counties. In the 1900's, oil was found in important quantities in Chautauqua, Montgomery, and Neosho Counties in the Arkansas River Basin. In 1915, oil and gas were discovered in Butler County on the Nemaha anticline structure, at first at shallow depths (660 feet). Later, gushers were opened in the Viola and Arbuckle horizons (fig. 5) in the Ordovician-Cambrian systems. In 1918, Butler County produced 36,069,000 barrels of oil while the production for the State of Kansas that year totaled 45,451,017 barrels. The occurrence of oil on anticlined structures and in porous lenses was better understood and interest in exploration moved towards the west. In the 1920's oil was discovered in western Kansas on the Central Kansas uplift (fig. 7).

The old oil-producing areas in eastern Kansas were pretty well outlined by 1920 and in that year reached a peak production of 2,283,000 barrels. The flush production was off and stripper wells were being abandoned. Before 1920, vacuum or

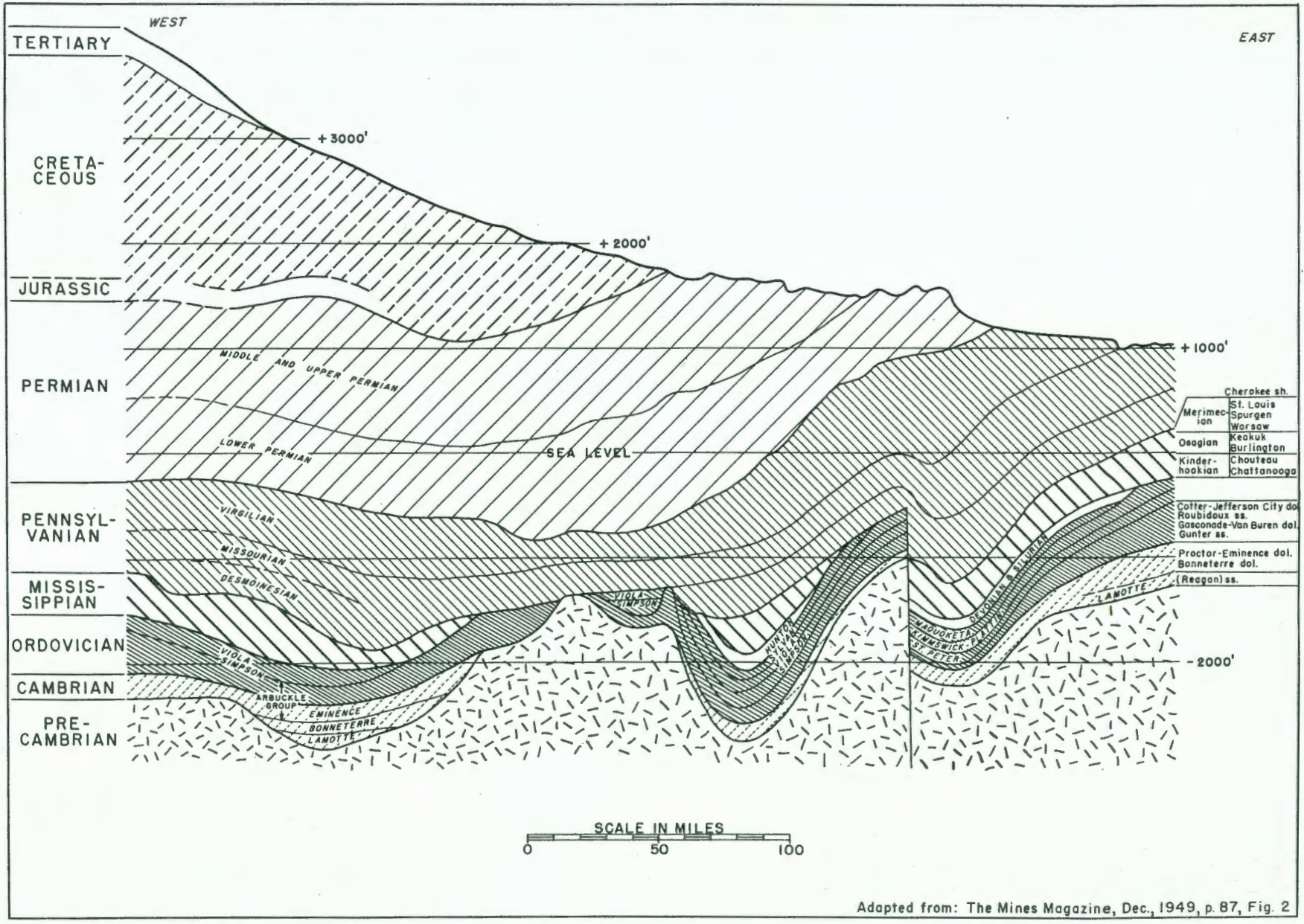



Figure 5.- East-west geologic cross section through central Kansas

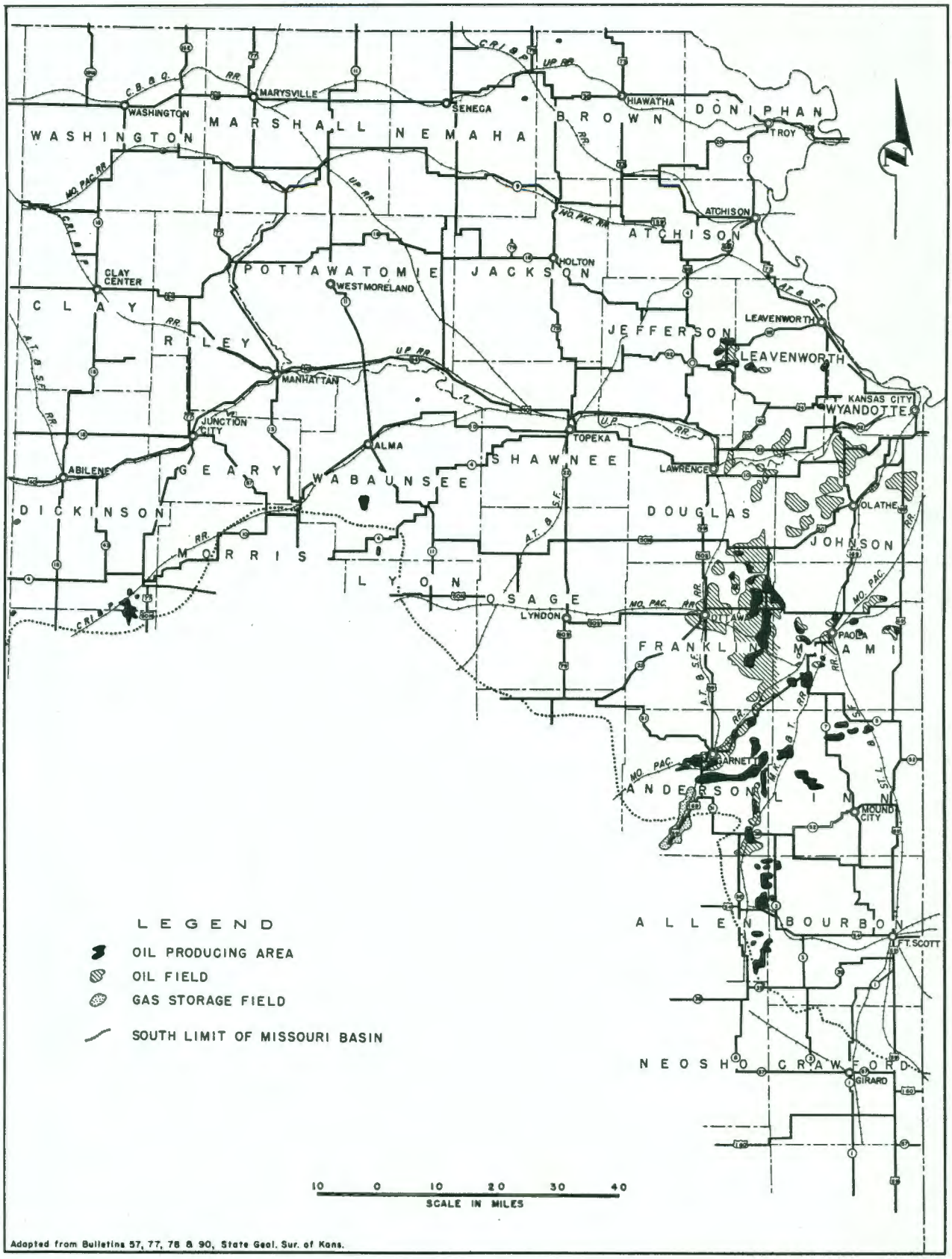
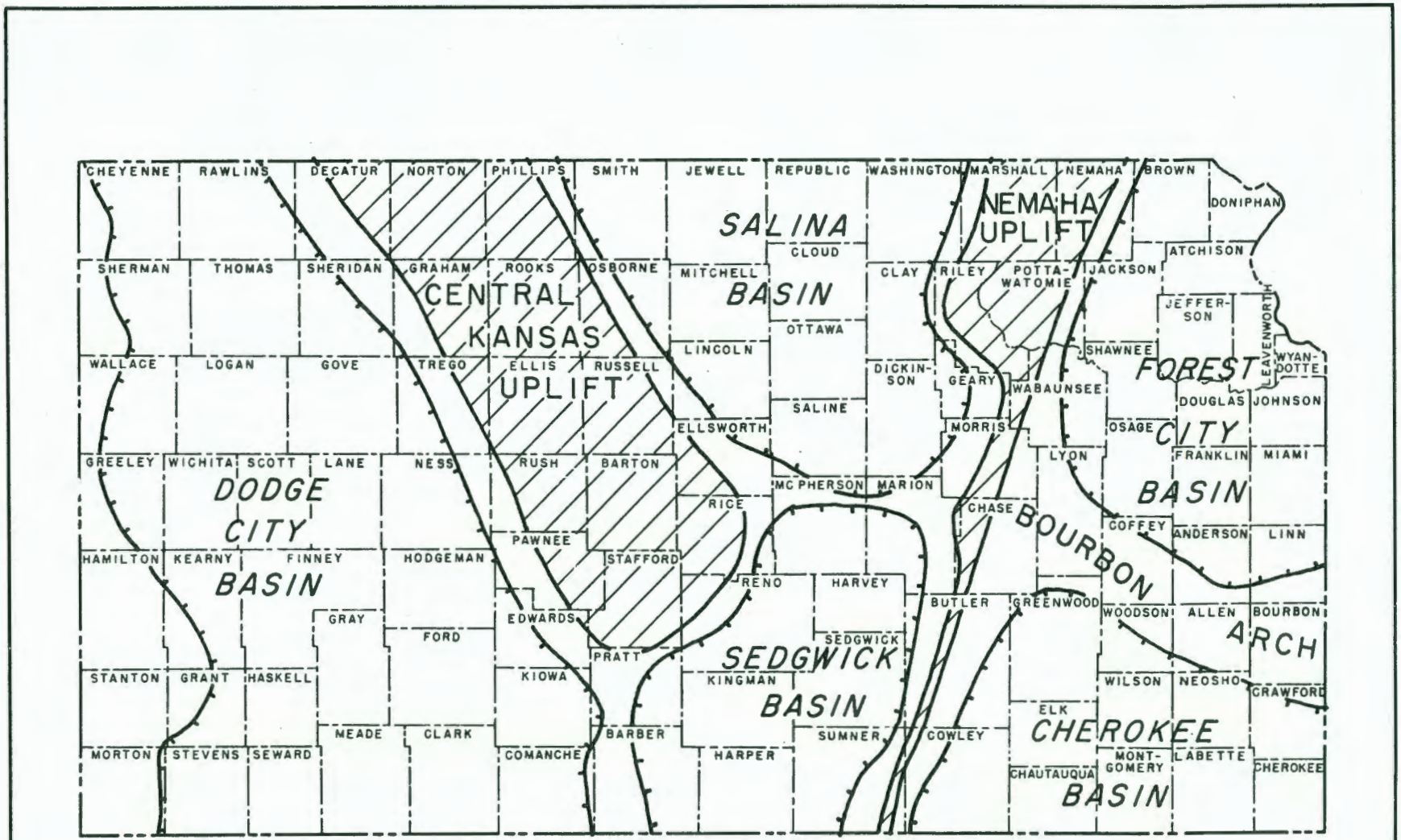



Figure 6.- Oil producing areas within the Missouri Basin in eastern Kansas




Adopted from Bull. 77, State Geol. Sur. of Kans.

Figure 7.- Structural features of Kansas

pressurized air or gas was applied to some fields with varying degrees of success in increasing production. Later, water under pressure was introduced into the oil sands, though not legalized until 1935, and gradually as knowledge was acquired, the old fields were being rejuvenated. At present, this secondary oil is a very important part of eastern Kansas oil production and its extraction will increase as water-flooding projects are introduced, until the fields become exhausted. So far as can be estimated, water-flooding approximately doubles the normal yield of an oil field.

## Gas (6)

TABLE 5. - Gas production in eastern Kansas within the Missouri River Basin

| County | 1949<br>M cubic feet |
|---|---|
| Anderson | 11,000 |
| Bourbon | 15,356 |
| Jefferson | 81,827 |
| Johnson | 4,341 |
| Leavenworth | 6,827 |
| Linn | 11,969 |
| Miami | 120,000 |
| Wyandotte | 37,303 |
| Total | 288,623 |

The 1949 gas production from the Hugoton field in southwest Kansas was 247,868,876 M cubic feet, while that from the rest of the State was 40,675,860 M cubic feet, making the total for the State in that year, 288,544,473 M cubic feet (14.65 p.s.i. absolute) (6). The production of eastern Kansas within the Missouri Basin area was only one-tenth of one percent of this total.

All gas produced in eastern Kansas is not reported as many farm homes use gas from private wells in quantity, probably exceeding the gas connected to commercial lines.

### Oil and gas pipelines

The numerous oil companies operating in eastern Kansas have networks of collecting pipelines throughout the oil and gas fields. These lines lead to central pumping and compressing stations which deliver the oil and gas through large multiple lines to refineries or to market. The oil refinery of the Phillips Petroleum Co. at Kansas City, Kans. is the only one in eastern Kansas.

A large gas-compressing station will use 16,000 to 20,000 hp.; a central oil boosting station requires 4,000 to 5,000 hp. The products of the line supply the source of power. The main oil and gas lines are shown on figure 8.

### Metals

Crystals of lead and zinc sulfides have been found in many counties in southeastern Kansas within the Basin area. The most important occurrence was galena in a shattered shale area 50 feet in diameter about 1½ miles southeast of Pleasanton, Linn County. Mined at intervals between 1866 and 1902, 35 tons of galena ore was shipped to the old Argentine smelter. The possibilities of commercial production of lead or zinc from the Pennsylvanian shales of eastern Kansas are slight.




Figure 8.- Oil and gas pipelines in the Missouri Basin in eastern Kansas

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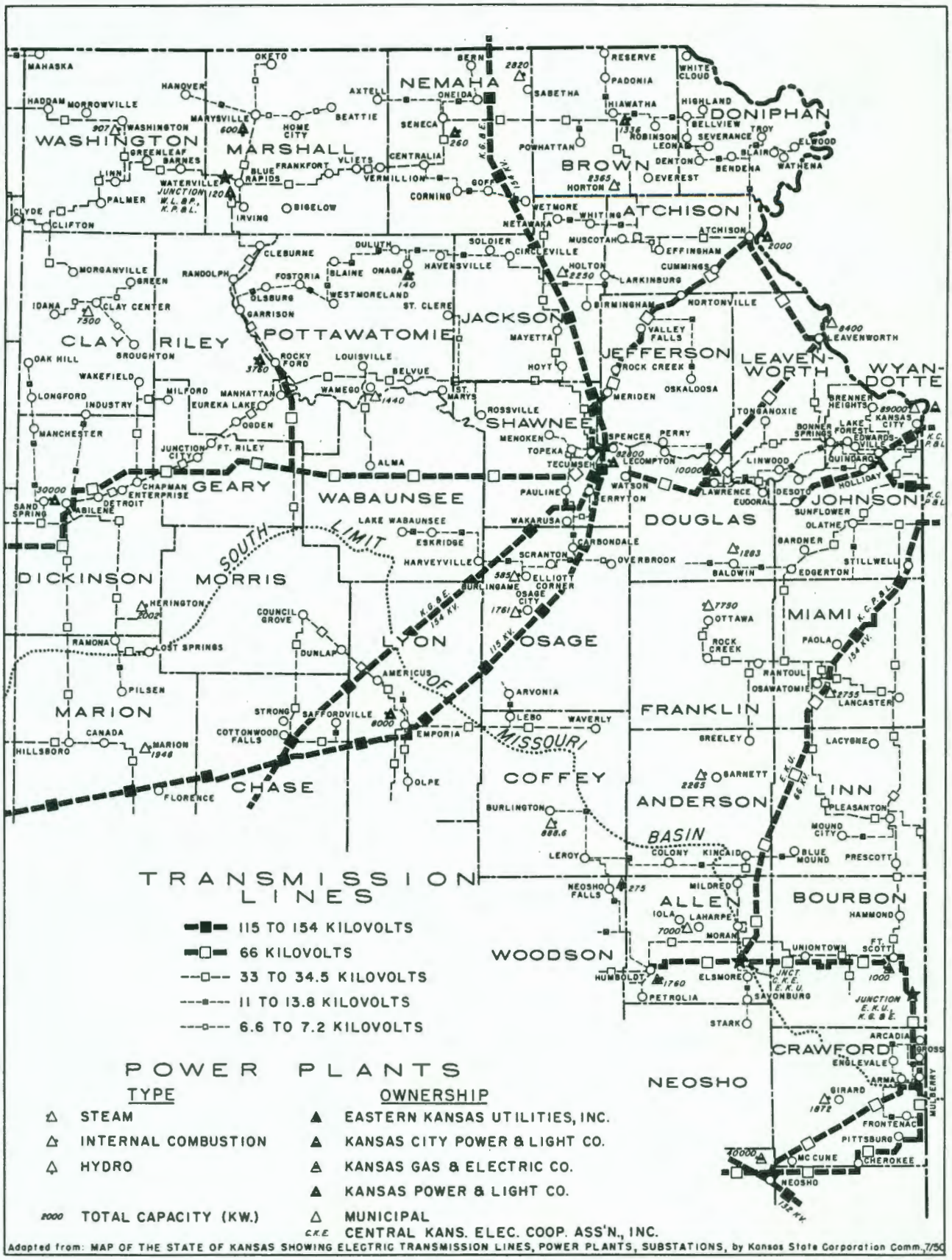
## ELECTRIC POWER

Kansas Power & Light Co. distributes power in most of the counties in eastern Kansas and within the Basin area and has 12 generating units with an installed capacity of 146,616-kw. (fig. 9), exclusive of the 30,000-kw. unit under construction at Lawrence and of the large generating units at Hutchison. Most of the units are internal combustion-type but the larger units are steam-generating plants using gas under boilers, with coal or oil stand-by for the winter months. The company ties in with the Western Light & Telephone Co. system of western Kansas in Marshall, Rice and Barton Counties and with Eastern Kansas Utilities, Inc., in Miami and Allen Counties.

Eastern Kansas Utilities, Inc., has three generating units developing 3,035-kw., and purchases power from the Kansas City Power & Light Co. and distributes power in Crawford, Bourbon, Allen, Linn, Woodson, Coffey, Anderson, and Miami Counties.

Bowersock Power & Milling Co. has 1,850-kv.-a. hydroelectric plant at Lawrence, Douglas County, and supplies power to Lawrence industries.

Kansas City Power & Light Co. distributes power to parts of Wyandotte, Johnson, Miami, Franklin, Linn, Allen, and Bourbon Counties. It generates no power in Kansas. In the Kansas City, Mo. area, the company has two generating units of about 311,000-kw. capacity and is building a third unit of about 180,000-kw. capacity.




Adapted from: MAP OF THE STATE OF KANSAS SHOWING ELECTRIC TRANSMISSION LINES, POWER PLANTS, SUBSTATIONS, by Kansas State Corporation Comm., 7/50

Figure 9.- Power plants and transmission lines in the Missouri Basin in eastern Kansas

Rural Electrification Administration generates no electricity in eastern Kansas, but purchases it from power companies or municipal plants in most of the counties for distribution to small consumers in rural districts.

In many of the counties there are municipally-owned generating plants servicing towns. There are 16 such plants in the Basin area of eastern Kansas with a total installed capacity of 137,897-kw., including a 99,000-kw. plant at Kansas City, Kans.

Kansas Gas & Electric Co. generates no power within the Basin but has a 154,000-volt line from Midian, Butler County, to Omaha, Neb., passing through Tecumseh, Shawnee County. In Bourbon County the company ties in to the Eastern Kansas Utilities, Inc., and also furnishes power throughout Crawford County. In Sedgwick County, the company has two gas-fired, steam-generating electric plants generating 104,000-kw., and in Labette County it has a 40,000-kw. coal steam generating plant.

Electric power requirements

It may be assumed that in most consumer classifications power requirements will increase in proportion to the increase in population, but that assumption is not entirely true of the mineral industry. The depletion of known reserves and the probability of discovering new reserves are factors not controlled by market demand. In eastern Kansas the present use and future demand for power in the mineral industry is far less than in other classifications such as farm, residential, commercial, and industrial.

The minerals produced in northeastern Kansas are oil, coal, limestone, sand-gravel, and cement. The oil production is largely secondary oil from fields which have been outlined fairly definitely. Oil fields can produce their own power but in the larger fields some electrical power is used. Secondary oil production will increase for a few years and then must decline. New production may keep pace with the decline, but the probability is that the oil fields will not have any increased demand for electrical power.

The coal reserves of eastern Kansas are limited. About 2,000 hp. will take care of the present coal industry and the outlook for future demands is that it will decrease.

About 4,500-kw. takes care of the present cement industry; in the next 20 years the demand may increase about 250 percent.

Only permanent installations in the limestone and sand-gravel industries are electrified. Temporary or portable equipment is powered by gasoline or diesel oil and the industry will continue to use that power. The limestone industry uses little electric power, about 1 hp. per 1,000 tons annual output. About 3,500 hp. would take care of the present limestone industry if it were 100 percent electrified. Probably not more than 50 percent will be electrified. The industry may increase about 250 percent over the next 20 years.

The sand-gravel industry, using heavy duty pumps, consumes about 2 hp. per 1,000 tons annual output and probably not over 60 percent will be electrified. About 5,400 hp. takes care of the present industry, if fully electrified, and the industry may increase 250 percent by 1970.

## WATER*

The average annual rainfall in Kansas ranges progressively from 15 inches at the Colorado border to 30 inches at the west border of eastern Kansas and to 40 inches at the east border and southeastern Kansas. The amount of rainfall is important in areas which have neither water-filled alluvials in running streams nor deep well water resources in pre-Pennsylvanian formations.

Abundance of water means wells yielding 1,000,000 or more gallons a day. Moderate water supply means wells yielding 200,000 to 1,000,000 gallons a day. Small amounts of water mean wells yielding less (usually much less) than 200,000 gallons a day.

The alluvials of the Smoky Hill and Republican Rivers in Dickinson and Geary Counties carry an abundance of water. The water is hard, 300 to 900 parts dissolved solids per million, but most of it is carbonate hardness (not sulfate hardness), and is easily treated. The alluvials of the Kansas River in Riley, Pottawatomie, Wabaunsee, Shawnee, Jefferson, Douglas, Leavenworth, Wyandotte, and Johnson Counties have an abundance of hard water.

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* Many bulletins on water resources by the State Geological Survey of Kansas are listed in bibliography at end of this report.

The alluvials of the Missouri River in Doniphan, Atchison, Leavenworth, and Wyandotte Counties contain abundant hard water. The Big Blue River alluvials in Marshall, Riley, and Pottawatomie Counties have an abundance of water with 400 to 500 parts per million hardness, mostly carbonate. The Little Blue River alluvials in Washington and Marshall Counties carry moderate supplies of water with hardness of about 400 parts per million.

The alluvials of the Delaware River carry small amounts of water in Brown County and moderate amounts in Atchison and Jefferson Counties. Soldiers Creek in Jackson County, Nemaha River in Nemaha County and Vermillion River in Pottawatomie County have alluvials carrying from small to moderate quantities of water.

The Marias des Cygnes River has alluvials carrying moderate to abundant supplies of water except close to its headwaters, and furnishes water to towns along its course. The Cottonwood and Neosho Rivers in Lyon, Coffey, and Allen Counties have alluvials with moderate amounts of hard water. Emporia, Lyons County, prefers to obtain softer water from lakes about 28 miles distant.

Almost all deep wells in eastern Kansas encounter saline waters except in Crawford County. In Crawford County, abundant non-flowing artesian fresh water is found in wells 600 to 1,700 feet deep, depending on the geological horizon sought. The hardness is usually less than 400 parts per million, mostly carbonate.

In ascending order the water-bearing formations encountered are the LaMotte sandstone, (Cambrian); Roubidoux sandstone, (lower Ordovician); Jefferson City-Cotter dolomites, (lower Ordovician); and Mississippian limestone (fig. 5). These formations which dip to the west, outcrop in south central Missouri and obtain their water from rainfall in that area.

Areas in eastern Kansas located at a distance from river alluvials are usually short of water. Small supplies are obtained from sand-gravel lenses in minor water courses, glacial sand-gravels, fractured limestones lying near surface, or from lakes and collecting ponds which entrain run-off waters. The loess blanket of northeastern Kansas is impervious to water. Permian shales carry no water and the limestones carry water in fractured zones only. Cherty limestones carry more water than the more pure limestones. Irregular sandstones at the base of the Admire group, in the Wabaunsee and Shawnee groups, and in the Pennsylvanian system, occasionally are water carriers; shallow wells often run dry during prolonged periods of drought.

## DICKINSON COUNTY

### PHYSICAL FEATURES

Dickinson County lies in the valley of the Smoky Hill River between the Smoky Hills Upland and the Flint Hills (fig. 1). All of the County drains into the Smoky Hill River, which flows eastward and crosses the County just north of the central part at elevations of 1,170 to 1,100 feet above sea level. Maximum relief in the County is not more than 150 feet (fig. 10).

Four railroad systems serve the County. A main line of the Union Pacific crosses east to west through Chapman, Abilene (the county seat), and Solomon. A main line of the Missouri Pacific Railroad crosses the southern part east to west through Herington and Carlton. The Atchison, Topeka & Santa Fe Railroad traverses the County diagonally from the southeast, passing through Hope, Enterprise, and Abilene and continuing northwest up Abilene Creek. The Chicago, Rock Island & Pacific Railroad runs south and east from its terminal at Abilene through Enterprise and Woodbine to Herington where it branches---one line continuing south and another going southwest.

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 10.

### GEOLOGY

Loess deposits in Dickinson County are thin and occur only in scattered areas. The valley of the Smoky Hill River is

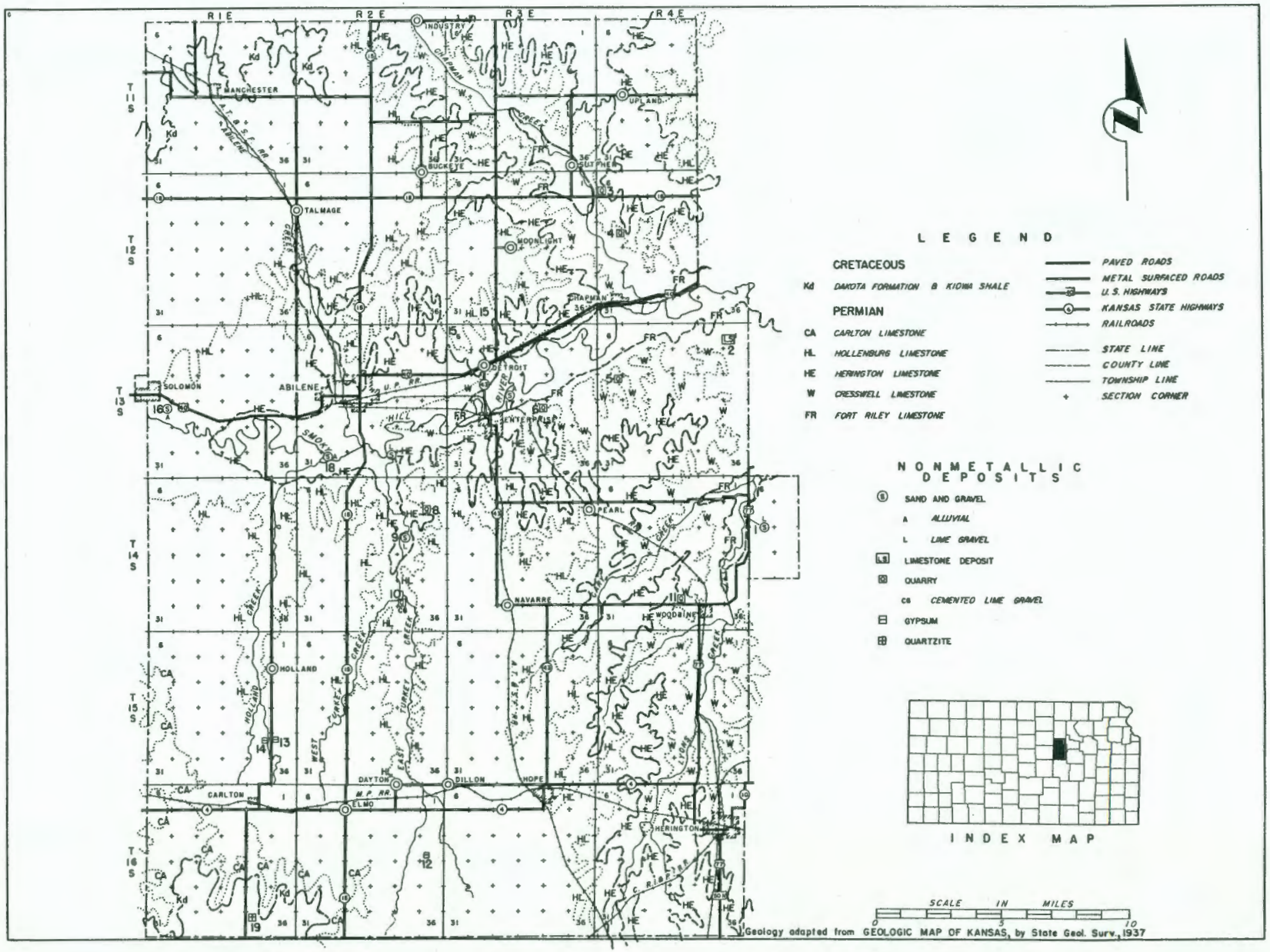



Figure 10.- Dickinson County, Kansas

covered by a belt of alluvial 1 to 3 miles wide. Heavy dune sand deposits of Pleistocene age are found north of Detroit (15, fig. 10).

The consolidated geological formations outcropping in the County, named in order of age, the youngest first (figs. 3 and 10), are: the Kiowa shale, an illite-type less than 100 feet thick, the occasional sandstone lenses near the top; the lower part of the Wellington shale, 100 to 150 feet thick, a green and red illite shale containing two thin impure limestone members (Carlton and Hollenburg) near its base; and formations of the Chase group, an illite shale group 325 feet thick, only part of which is found in eastern Dickinson County and includes the following limestones in descending order: the Nolans formation, Herington member; the Winfield formation, Cresswell member; and the Barneston formation, Fort Riley member. The most conspicuous stratum of the Fort Riley limestone is a massive 60-inch bed near the base, which forms typical "rim rock outcrops".

## MINERAL RESOURCES

In 1949, three sand-gravel plants on the Smoky Hill River produced about 172,000 tons of coarse sand-gravel for road metal and concrete aggregates. Oil production for the same year was 202,070 barrels (6). In 1950, oil production decreased to 162,132 barrels (5). The County has some upper Permian limestones

that have supplied limestone for road metal and a little structural stone, but quarries on them are not now active.

Two gypsum plants that operated about 1890 have long since been dismantled and the remaining gypsum reserves are of little consequence.

### Loess and dune sand

Loess deposits in the County occur only in scattered areas and have little depth.

Large deposits of fine dune sand are found in secs. 31, and 32, T. 12 S., R. 3 E., and in sec. 6, T. 13 S., R. 3 E. (15, fig. 10). They might serve as mortar sand but have not been exploited.

### Sand-gravel

Alluvial sand-gravel, replenished by sedimentation, occurs in abundance. It is all alkali-reactive and when used as concrete aggregate, should have an admixture of 30 to 40 percent neutral coarse aggregate.

The Schofner Sand & Gravel Co. is operating a sand-gravel plant in sec. 19, T. 13 S., R. 1 E. (16, fig. 10), on the north side of the Smoky Hill River. The sand-gravel has a gradation factor of 400 plus and is used primarily as road metal. Railroad facilities are available.

The C. Smith Sand & Gravel Co. operates a sand-gravel plant in the SW¼ sec. 16, T. 13 S., R. 3 E. (17, fig. 10), pumping directly from the Smoky Hill River. The gradation factor is above 400.

The Gowling Bros. Sand & Gravel Co. operates a sand-gravel plant in the NW¼ of sec. 32, T. 13 S., R. 2 E. (18, fig. 10), on the north side of the Smoky Hill River. The plant pumps directly from the river and produces sand-gravel of the following grades:

| Material | Gradation factor |
|---|---|
| Road gravel | 400 plus |
| Concrete sand | 350-375 |
| Mortar sand | 250 |

## Lime-gravel

Lime-gravel deposits or quarries occur in the following places:

| Sec. | T(S) | R(E) | No. on fig. 10 |
|---|---|---|---|
| E½ 12 | 14 | 4 | 1 |
| NE¼ 34 | 13 | 2 | 7 |
| NW¼ 14 | 14 | 2 | 9 |
| SW¼ 26 | 14 | 2 | 10 |

## Limestone

Several small quarries have been opened to furnish limestone for road metal and structural stone, but none is in regular operation and no permanent equipment has been installed.

The Carlton limestone member—a thin bedded, white, fossiliferous stone about 3 feet thick—is suitable for road metal but is not exploited. The Hollenberg limestone member, a tan-colored, honeycombed stone about a foot thick, has no commercial value.

The Herington limestone member (fig. 3) is developed best in the southeast corner of the County, north and south of the town of Herington. The limestone is 10 feet thick and has been used as road metal and as rough structural stone. There is a quarry in the W½ of sec. 12, T. 14 S., R. 2 E. (8, fig. 10).

The Cresswell limestone member, exposed in several small quarries throughout the County, is 15 feet thick and has a massive 3-foot base suitable for structural stone. Idle Cresswell quarries are found in the following locations:

| Sec. | T(S) | R(E) | No. on fig. 10 |
|---|---|---|---|
| SW¼ 6 | 12 | 4 | 3 |
| S½ 18 | 12 | 4 | 4 |
| NE¼ 18 | 13 | 4 | 5 |
| SE¼ 22 | 13 | 3 | 6 |
| SW¼ 27 | 14 | 4 | 11 |

The Towanda limestone member, 5 to 7 feet thick, is poorly exposed but is suitable for raw material or railroad ballast.

The Fort Riley limestone member, 35 to 40 feet thick, a good road metal, outcrops near the flood plain of the Smoky Hill River and in a few places in eastern Dickinson County north of Woodbine. Its most useful stratum is a 60-inch, massive bed that saws easily into dimension stone. An outcrop occurs in the SW¼ of sec. 1, T. 13 S., R. 4 E. (2, fig. 10).

## Gypsum

A plant at Dillon dismantled many years ago, once calcined gypsum from a now abandoned pit in the SW¼ of sec. 13, T.

16 S., R. 2 E. (12, fig. 10). The gypsum bed, 12 to 15 feet thick, outcrops between secs. 13 and 14. The gypsum was calcined at Dillon.

A 9-foot bed of gypsum is found in the NW¼ of sec. 25, T. 15 S., R. 1 E. (13, fig. 10); the bed outcrops also in the road between secs. 24 and 25. Some gypsum was mined in sec. 24 and gypsite is reported in the NE¼ of sec. 26, T. 15 S., R. 1 E. (14, fig. 10). A gypsum mill was built on the Missouri Pacific Railroad at Carlton but was moved to Gypsum, Saline County, more than 60 years ago. The gypsum reserves in the County are of no present economic importance.

### Quartzite

Kiowa shale occurs in the southwest and northwest parts of the County. Considerable sandstone is in evidence in the NW¼ of sec. 35, T. 16 S., R. 1 E. (19, fig. 10), and quartzite may occur in this vicinity and to the east.

### Oil and gas (6) (fig. 6)

In 1949, Dickinson County produced 202,070 barrels of oil from 28 wells in four active pools totaling 2,900 acres. The production fell off in 1950 to 162,132 barrels. The greater part of the production is from the Mississippian horizon at 2,300 feet in the Lost Springs Pool in the southeast corner of the County. The Socony-Vacuum Oil Co., Inc. has an oil-collecting line into the Lost Springs Pool (fig. 8).

Kansas Power & Light Co. has a main 16-inch gas line crossing the County, and a compressing station at Abilene. Eight-inch gas lines service the County and tie in with Central West Utilities Co. in the southern part.

## ELECTRIC POWER (fig. 9)

Kansas Power & Light Co. has a 115,000-volt transmission line from Tecumseh (Shawnee County) through Abilene to Hutchinson (Reno County). The company services Dickinson County over 33,000-volt lines; in addition, an 11,000-volt line goes to Industry and an 11,000-volt line leads to Manchester and on into Clay County. The company has a steam generating electric plant of 30,000-kw. capacity at Abilene.

Herington has a municipal, internal combustion, electric plant of 2,000-kw. capacity.

## WATER

Water is abundant in the alluvials of the Smoky Hill River. Elsewhere in the County, water is scarce and is supplied by runoff waters to collecting ponds.

## MARION COUNTY

### PHYSICAL FEATURES

Only the northern 4- or 5-mile strip of Marion County is within the Missouri River Basin. This part of the County, its highest altitude about 1,200 feet above sea level, lies on the south border of the Basin area between the Smoky Hill Upland and the Flint Hills. The topography is flat, dips gently eastward, and is broken slightly by young drainage systems progressing north and south from the divide marking the south border of the Basin area (figs. 1 and 11).

Two railroad systems serve the County. A branch of the Chicago, Rock Island & Pacific Railroad runs northeast across the northern part through Durham and Ramona. Another branch of the Rock Island enters the County from the south and crosses it in a northeasterly direction through Peabody, Marion (the county seat), and Lincolnville (fig. 11). The Atchison, Topeka & Santa Fe Railroad enters the County from the east and branches at Florence. One line goes north and west through Marion and Lehigh; the other runs southwest through Peabody. Still another line of the Santa Fe crosses the northeast corner of the County, passing through Lost Springs.

Secondary roads checkerboard the County, at intervals of 1 and 2 miles. The main paved roads are shown on figure 11.

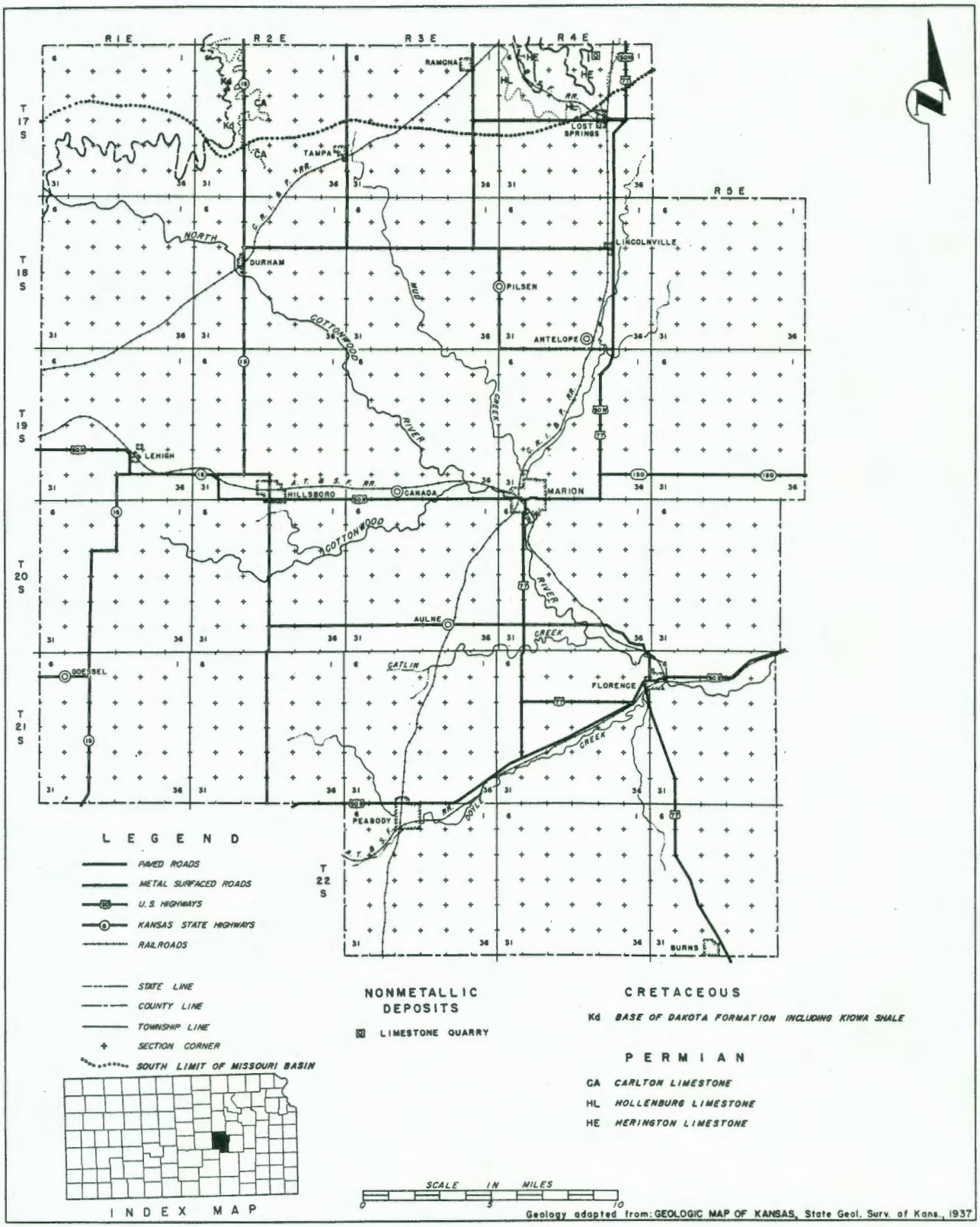



Figure II.- Marion County, Kansas

## GEOLOGY

The surface soil in Marion County is mostly residual. The consolidated geological formations outcropping in the County, named in order of age, the youngest first (figs. 2, 3, and 11), are: the Kiowa shale, an illite shale 50 to 100 feet thick with occasional sandstone or silt beds near its top; the basal part of the Wellington shale with its two thin and unimportant limestone beds, the Carlton member (3 feet thick) and the Hollenberg member (1 to 3 feet thick); and the Nolans formation, of which the Herington limestone is the principal member and the only limestone of any importance outcropping in northern Marion County.

## MINERAL RESOURCES

The part of Marion County within the Missouri River Basin produced 254,676 barrels of oil in 1949 (6). In 1950, this production declined to 244,384 barrels (5).

This area has no mineral commodity except some limestone in the vicinity of Herington. The limestone is suitable for road metal, but there is no recorded production.

### Sand-gravel

No deposits of sand-gravel occur in northern Marion County within the Missouri River Basin.

### Shale

Wellington shale is abundant and is a potential source of material for the manufacture of common red brick.

## Limestone

The Herington limestone member, 4 to 8 feet thick and useful as road metal, is the only limestone of any importance outcropping within the Basin area in the County. An idle quarry is located at an outcrop north of Lost Springs, in the NE¼ of sec. 3, T. 17 S., R. 4 E. (1, fig. 11).

## Oil and gas (6) (fig. 6)

Marion County produced 688,967 barrels of oil and 213,014 M cubic feet of gas in 1949. The part of Marion County within the Missouri River Basin produced 274,223 barrels of oil from 141 wells in 5,500 acres. In 1950, the production from the same area decreased to 244,384 barrels (5). Production is from the Mississippian horizon at a depth of 2,365 feet in the Lost Springs Pool in northeastern Marion County.

Socony Vacuum Oil Co., Inc., has oil lines into the oil pools and has pumping stations in the Lost Springs and Florence Pools. Sinclair Prairie Oil Co. also has collecting lines into the pools. Standish Pipe Line Co. has a multiple crude oil line passing through the County (fig. 8).

Central West Utilities Co. supplies gas from its Dickinson County lines to Tampa, Hillsboro, Marion, Peabody, and Florence.

## ELECTRIC POWER (fig. 9)

The 115,000-volt line of the Kansas Power & Light Co. from Tecumseh passes through southern Marion County. The

company also furnishes power to the County over 33,000-volt transmission lines and has a tie-in with the Kansas Gas & Electric Co. system east of Peabody.

Rural Electrification Administration purchases power from the Kansas Power & Light Co. and distributes it in rural areas.

Hillsboro has a municipal internal combustion, electric plant of 895-kw. capacity, and Marion has a similar type municipal plant of 1,946-kw. capacity.

## WATER

Water is scarce in northern Marion County, and collecting ponds are the most reliable sources. Some water is available in shallow wells sunk to tap shattered Winfield and Fort Riley limestones.

## MORRIS COUNTY

### PHYSICAL FEATURES

Only the northwest quarter and the northern border of Morris County are within the Missouri River Basin. The County lies on the western edge of the Flint Hills and on the south border of the Basin area (fig. 1). The topography on the Missouri-Arkansas divide, flat and dipping gently eastward with altitudes of 1,100 to 1,200 feet above sea level, is dissected by Clarks Creek flowing northeastward into the Flint Hills and the Kansas River.

Four railroads serve the County. A main line of the Missouri Pacific Railroad crosses east to west, passing through Council Grove, the county seat, and Dalavan. The Chicago, Rock Island & Pacific Railroad crosses the northwestern part of the County in a northeast direction through White City and Dwight. The Missouri, Kansas & Texas Railroad traverses the County diagonally in a northwest course through Council Grove and White City. The Atchison, Topeka & Santa Fe Railroad cuts the southwest corner, passing through Diamond Springs and Burdick.

Secondary roads checkerboard the County at intervals of 1 to 5 miles. The main paved highways are shown on figure 12.

### GEOLOGY

The top soil in Morris County is mostly residual. The consolidated geological formations outcropping in the County named

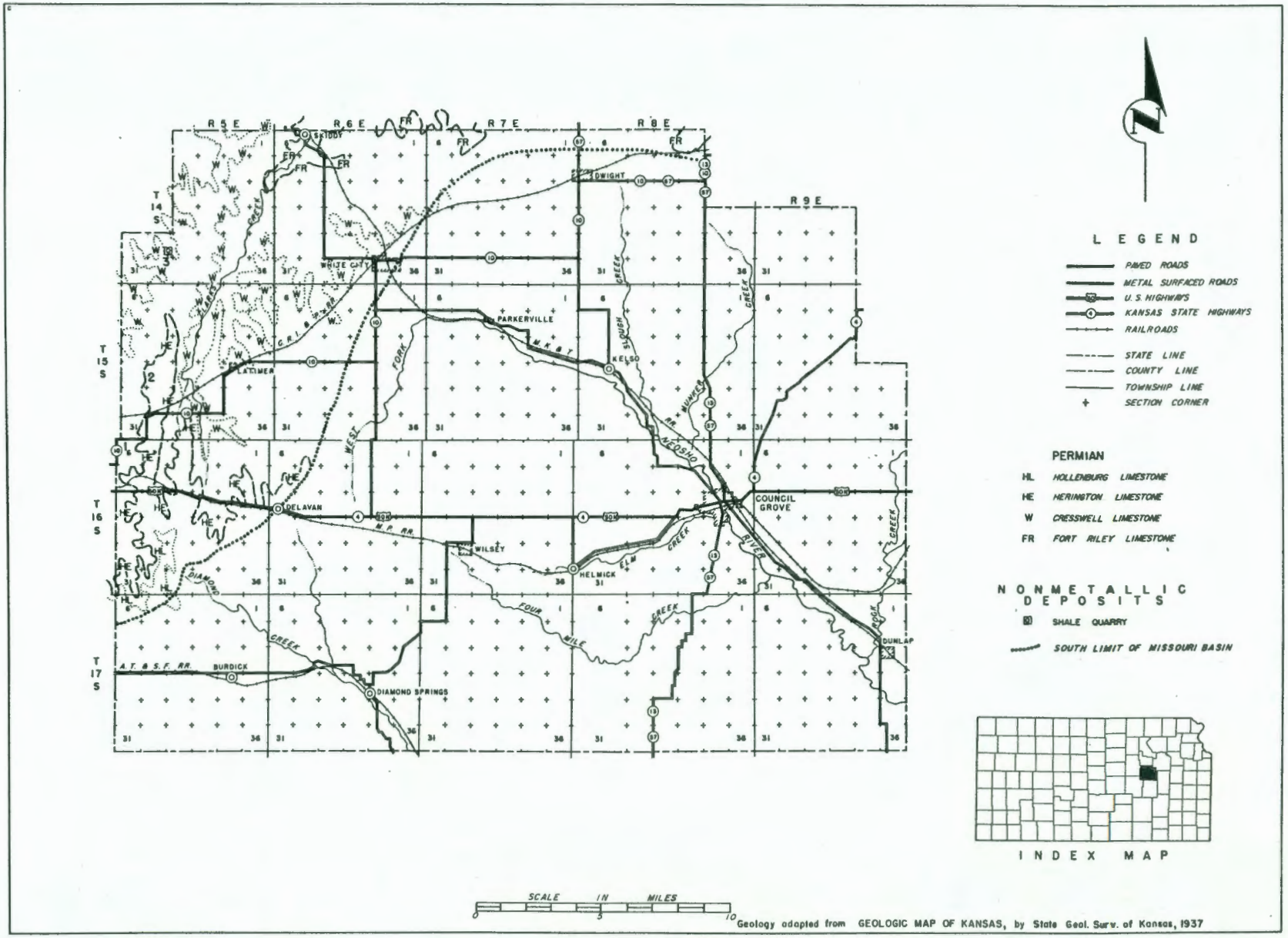



Figure 12.- Morris County, Kansas

in order of age, the youngest first (figs. 3 and 12), are: the Wellington shale with its lowest member, the Hollenburg limestone, 1 to 3 feet thick and soft in quality; Nolans limestone (Herington member); Winfield limestone (Cresswell member); Doyle shale (Towanda limestone member); and Barneston limestone (Fort Riley member). All members, except the Towanda limestone which is seldom available, are mapped on figure 12.

## MINERAL RESOURCES

Morris County, within the Missouri Basin, produces no mineral commodity. Limestones are available as road metal, and a small amount of Fort Riley limestone is available as structural stone.

The County, outside the Missouri Basin, produced 1,301 barrels of oil and 65,984 M cubic feet of gas in 1949 (6).

### Sand-gravel

There are no sand-gravel deposits in Morris County within the Basin area. Sand-gravel is available along the Smoky Hill and Republican Rivers farther north in Geary County.

### Shale

Illite shales are abundant but they are not utilized in this area.

### Limestone

The most important limestone in the area is a 60-inch massive bed of the Fort Riley member, available but not exploited

along the north border near Skiddy and in the northeast corner of the County (fig. 12).

The Cresswell limestone member, outcropping both to the north and south in the vicinity of Latimer, and also in the northwest corner of the County, is available for road metal. An idle shale quarry, consisting of Cresswell limestone and Grant shale, and formerly supplying road metal, is in the SE¼ of sec. 29, T. 14 S., R. 5 E. (3, fig. 12).

The Herington limestone member, available as road metal but not exploited, outcrops in many places along the west County line in sec. 6, T. 16 S., R. 5 E. (1, fig. 12) and in secs. 19, 30 and 31, T. 15 S., R. 5 E. (2, fig. 12).

Oil and gas (6)

The Basin area in Morris County has no oil production but the County is being explored actively. The Burdick field, in sec. 15, T. 15 S., R. 5 E., was discovered in 1949 and during that year yielded 1,296 barrels of oil from the Mississippi "chat" at a depth of 2,220 feet. A nearby field, discovered in 1928, produced 85 barrels in 1949. Miscellaneous gas fields in the County, but outside the Missouri Basin area, produced 65,984 M cubic feet of gas during 1949.

The Central West Utilities Co. has a 4-inch gas line from Dickinson County furnishing gas to Wilsey, White City, and Council Grove (fig. 8).

## ELECTRIC POWER (fig. 9)

Kansas Power & Light Co. furnishes power to Dunlap and Council Grove over a 34,500-volt transmission line from Emporia, Lyon County.

Rural Electrification Administration purchases power from the Company for distribution into rural areas.

## WATER

Water is scarce in northern Morris County and is obtained from run-off waters in collecting ponds or shallow wells to water-bearing limestones.

## GEARY COUNTY

### PHYSICAL FEATURES

Geary County is in the Flint Hills of Kansas (fig. 1). The Smoky Hill River from the southwest and the Republican River from the northwest join near the center of the County to form the Kansas River, which continues northeastward. The altitude at the junction is 1,075 feet above sea level. The three main streams, as well as the numerous, steep-walled, north-flowing tributaries (all of which point toward the Smoky Hill River), have cut a relief of more than 300 feet below the uplands to the south. The topography of northwest Geary County is not as rugged as that of the south part (figs. 2 and 13).

Two railroad systems serve the County. A main line of the Union Pacific Railroad crosses east to west in the valleys of the Kansas and Smoky Hill Rivers, passing through Junction City, the county seat. A branch line runs northwest from Junction City and follows the Republican River Valley through Milford. A branch line of the Missouri, Kansas & Texas Railroad enters the County from the south and terminates at Junction City.

Secondary roads checkerboard the northwest corner of the County at intervals of 1 to 2 miles. South of the Kansas and Smoky Hill Rivers, the County is so rugged that north-south roads must follow the courses of the northwest-flowing creeks; the east-west roads are irregularly spaced at 2- to 4-mile intervals. The main paved highways are shown on figure 13.

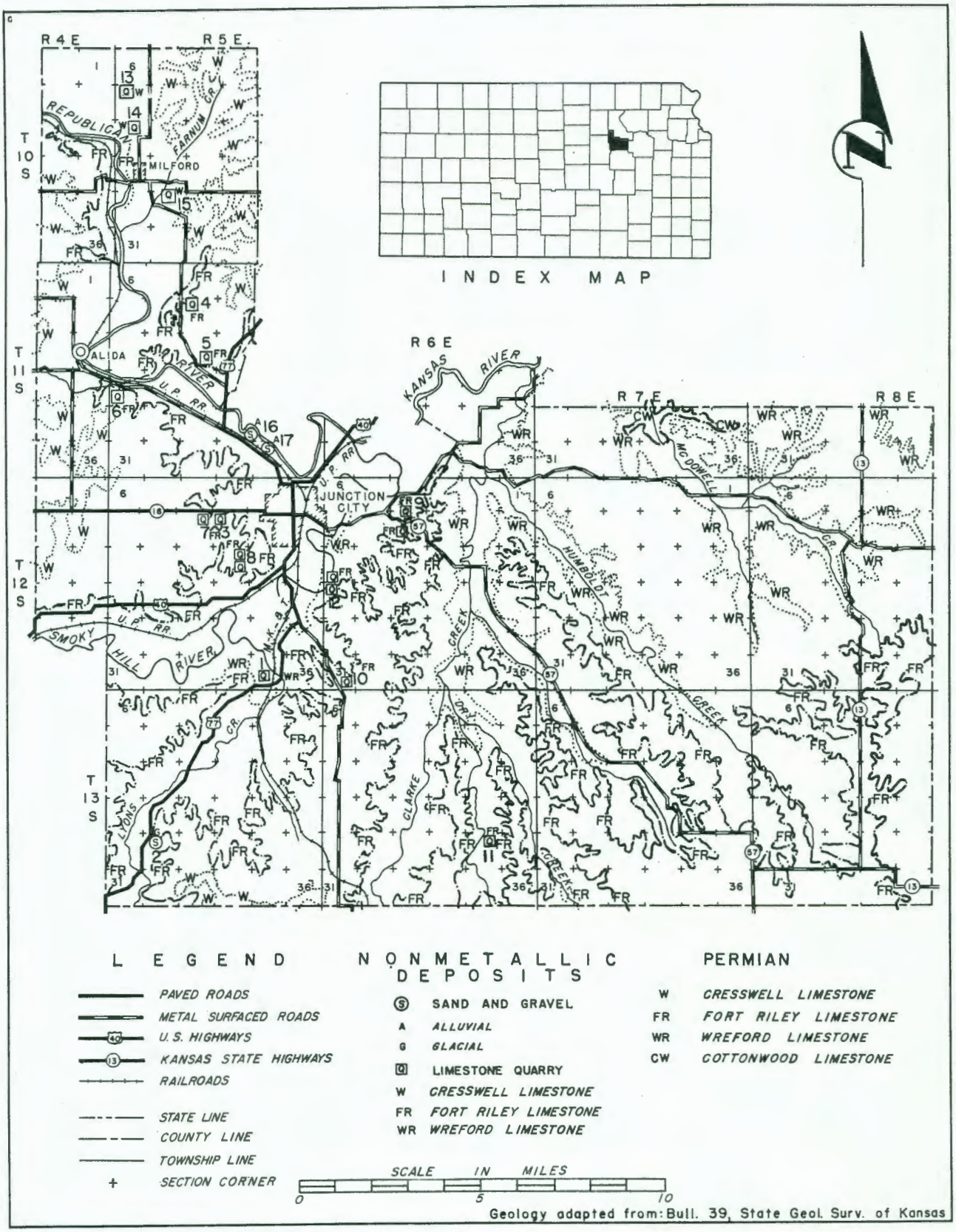



Figure 13.- Geary County, Kansas

## GEOLOGY (9)

Loess deposits in Geary County are thin and occur only in scattered areas, principally to the north of the Kansas River. The range of the geological formations exposed in the County is from the top of the Winfield limestone formation of the Chase group (a shale group averaging 335 feet thick and containing 10 limestone members, 1 to 40 feet thick, most of them less than 10 feet) down to and including the Beattie limestone formation of the Council Grove group (a shale group averaging 320 feet thick and containing 13 limestone members, 3 to 20 feet thick, most of them under 8 feet) (figs. 3, 13, and table 1).

The limestone members of importance outcropping in the County, named in order of age, the youngest first (figs. 3 and 13), are: Cresswell, Towanda, Fort Riley, Florence, Schroyer, Threemile, and Cottonwood. The Towanda and Florence members are not mapped on figure 13, whereas the Schroyer and Threemile members are mapped as the Wreford formation.

## MINERAL RESOURCES

Geary County has an abundance of alkali-reactive sand-gravel; about 160,000 tons is produced annually. The County also has an abundance of limestone for road metal, cut stone, and riprap. Only one quarry is active, however; it was producing cut stone in 1949. The limestones have been used as concrete aggregate but not in competition with eastern limestone.

The beds have objectionable features; they are either too soft, too thin, or contain excessive flint. The County annual production is estimated to be 10,000 tons which is used as road metal. Limestone suitable for the manufacture of mineral wool is likewise available in quantity.

### Loess

Geary County has some loess and glacial drift north of the Kansas River.

### Sand-gravel

Alluvial sand-gravel deposits, constantly replenished by sedimentation, occur in unlimited quantities in the Smoky Hill and Republican Rivers. All the sand-gravels are alkali-reactive and, when used as concrete aggregates, should have an admixture of neutral coarse aggregate.

The Junction City Sand & Gravel Co. has a sand-gravel plant north of Highway 77 in the SW¼ of sec. 26, T. 11 S., R. 5 E. (16, fig. 13), pumping out of the Republican River. The plant produces mortar sand, concrete sand, and road sand.

The More Sand Co. has a sand-gravel plant in the NW¼ of sec. 35, T. 11 S., R. 5 E. (17, fig. 13). The product consists of mortar sand (gradation factor 275), concrete sand (gradation factor 375), and road sand (gradation factor 400 plus).

## Limestone

The Cresswell limestone, 10 to 14 feet thick and mostly thin-bedded except for a massive 3-foot basal bed, is used chiefly for road metal. The massive bed, qualifying for structural stone use, occurs in northwestern Geary County and at some places in the southwest quarter. Idle Cresswell limestone quarries appear as follows:

| Sec. | T(S) | R(E) | No. on fig. 13 |
|---|---|---|---|
| NW¼ 7 | 10 | 5 | 13 |
| NW¼ 18 | 10 | 5 | 14 |
| NW¼ 29 | 10 | 5 | 15 |

The Towanda limestone 4 to 7 feet thick has been used as road metal and, in some other counties, as railroad ballast. Two small idle quarries are located in the SW¼ of sec. 18 and in the NW¼ of sec. 19, T. 12 S., R. 6 E. (12, fig. 13).

The Fort Riley limestone, 30 to 35 feet, occurs in abundance. The member's most useful bed is a massive 5-foot stratum near the base, used extensively as dimension stone, riprap, and road metal. The Walker Cut Stone Co. operates a quarry in the NW¼ of sec. 10, T. 12 S., R. 5 E. (3, fig. 13), and was producing only cut stone in 1949. The stone breaks naturally along vertical northeast seams and northwest seams dipping northward 75 degrees. Black powder breaks out 10- to 14-ton blocks that are sawed by gang saws and diamond saws and are shaped by planers and by hand. The company expects to add a crusher to

produce road material, agricultural limestone, and perhaps concrete aggregates from the present waste rock. The company reported that the rock averaged 93 percent $CaCO_3$.

Idle Fort Riley limestone quarries are located as follows:

| Sec. | T(S) | R(E) | No. on fig. 13 | |
|---|---|---|---|---|
| NW¼ 9 | 11 | 5 | 4 | |
| SE¼ 16 | 11 | 5 | 5 | |
| SW¼ 19 | 11 | 5 | 6 | |
| NE¼ 19 | 12 | 5 | 7 | |
| E½ 15 | 12 | 5 | 8 | (2 quarries) |
| N½ 9 | 12 | 6 | 9 | (2 quarries) |
| SE¼ 31 | 12 | 6 | 10 | |
| NE¼ 26 | 13 | 6 | 11 | |

The Florence limestone, 40 feet thick, occurs in abundance but is flinty and is not exploited. Crushing causes sharp edges that cut rubber tires. An idle, Florence, coarse lime-gravel quarry, in the NW¼ of sec. 29, T. 13 S., R. 5 E. (2, fig. 13), once supplied road material, the sharp edges having been worn smooth.

The Schroyer, 15 feet, and Threemile, 10 feet thick, limestones (Wreford formation), usually flinty and breaking with sharp edges, are used sparingly. Once the edges are worn smooth, the limestones become excellent road metal, being harder and freer from dust than nearby purer limestone. Although the limestones are in abundance, no operating quarries are found. An idle quarry, once used to furnish stone for a lime kiln, is in the SE¼ of sec. 35, T. 12 S., R. 5 E. (1, fig. 13).

The Cottonwood member, a white limestone 6 feet thick, has been used extensively as cut stone, riprap, road material, and concrete aggregate. It occurs along the north border of northeast Geary County in an area too small to permit much quarrying in the County.

In the experimental plant at the University of Kansas, the Kansas State Geological Survey has made a coarse mineral wool using only Florence limestone and it has made a high-grade wool with a minimum of shot, using a mixture of Fort Riley limestone, Oketa shale, Florence limestone, and alluvial clay. Geary County has an abundance of source material for mineral wool but no mineral wool industry.

## Oil and gas (6)

Potential oil and gas strata underlie Geary County but no discovery of either commodity has been made. Twelve deep test wells scattered over the County have been dry. The floor of the pre-Cambrian rocks is very irregular because of the Nemaha Uplift which passes through the County (fig. 7). In sec. 28, T. 10 S., R. 9 E. (Riley County), the floor is 928 feet below the surface; in sec. 14, T. 9 S., R. 4 E. (Clay County), the floor is 2,760 feet below the surface. In some places the Pennsylvanian rocks rest on the pre-Cambrian while in other places the Ordovician and Cambrian lie under the Pennsylvanian.

Kansas Power & Light Co. has two gas lines, an 8-inch and a 10-inch, servicing Junction City from the west and continuing eastward (fig. 8).

## ELECTRIC POWER

Kansas Power & Light Co. services Geary County through 33,000-volt transmission lines with sub-stations at Junction City and Milford. The company's 66,000-volt line from Tecumseh (Shawnee County) to Hutchinson (Reno County) ties in with Junction City (fig. 9).

Rural Electrification Administration purchases power from Kansas Power & Light Co. for distribution to rural areas.

## WATER

The alluvials of the Smoky Hill, Kansas, and Republican Rivers have an abundance of water. Smaller supplies are available in shallow wells to alluvials of minor streams or to fractured zones in the Fort Riley and Cottonwood limestones.

## RILEY COUNTY

### PHYSICAL FEATURES

Riley County lies in the Flint Hills of Kansas (fig. 1). The Big Blue River from the north, forming the eastern border of the County, joins the Kansas River, coming up from the southwest, at Manhattan, the county seat. The uplands are drained by an intricate system of smaller streams tributary to these main streams. The altitude at Manhattan, the lowest point in the County, is 1,010 feet above sea level. The topography is rugged and steep within 6 miles of either side of the two main streams. The maximum relief in the County is about 300 feet (figs. 2 and 14).

Two railroad systems serve Riley County. A main line of the Union Pacific Railroad enters from the east, passes through Manhattan, and follows the Kansas River Valley. A branch line of the same system runs north from Manhattan up the Big Blue River Valley into Marshall County. The Chicago, Rock Island & Pacific Railroad crosses the County somewhat diagonally, southeast to west of north, through Zeandale and Riley.

In areas within 6 miles of the Kansas and Big Blue Rivers, rugged and steep topography causes secondary roads to follow drainage courses and contours. The flat Flint Hills of southeastern Riley County are accessible but have few roads. The western part of the County is checkerboarded by secondary roads at intervals of 1 to 2 miles. The main paved highways are shown on figure 14.

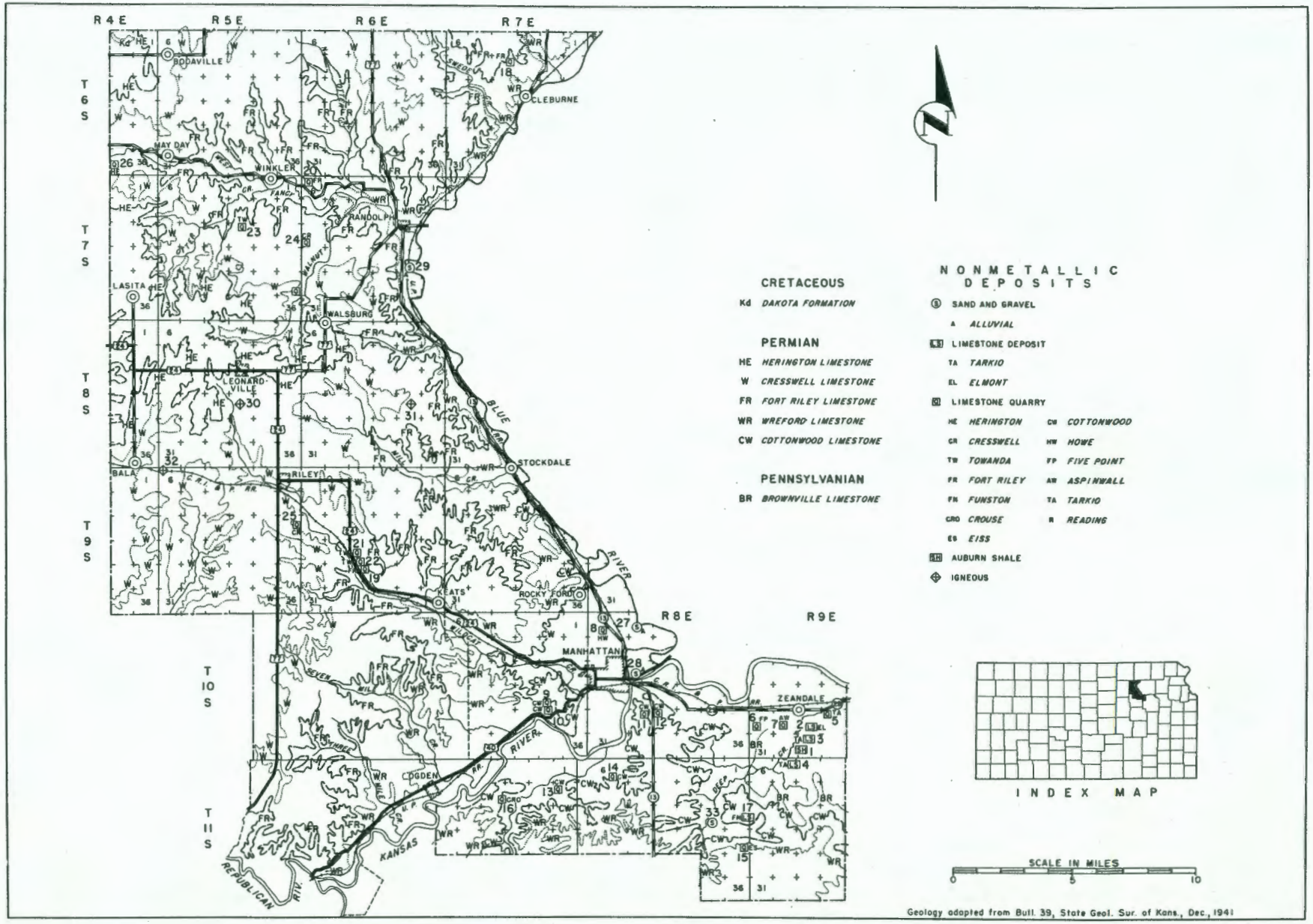



Figure 14.- Riley County, Kansas

## GEOLOGY (9)

Loess, 20 to 50 feet deep, occurs in a number of places in Riley County, north of the Kansas River. The largest area is on the Fort Riley Military Reservation (fig. 14). The consolidated geological groups outcropping in the County, named in order of age, the youngest first (figs. 3, 4, and 14), are: the Colorado, of which a remnant of the Dakota formation lies on an area of basal Wellington shale (Sumner group) in the northwest corner of the County; the Chase, a series of limestones and illite shales about 335 feet thick, occupying most of the northern and southwestern parts of the County; Council Grove, a series of limestones and illite shales about 320 feet thick, along the lower Big Blue River near Manhattan and in southeastern parts of the County; the Admire, an illite shale about 130 feet thick and two thin unimportant limestone members, in the southeast part of the County; and the Wabaunsee, from the Brownville limestone member down to the Auburn shale member, outcropping in a small area in the extreme southeast corner.

The Nemaha anticline, passing through this area, explains the outcropping of the Pennsylvanian rocks. The top of the Pennsylvanian system, the Brownsville limestone, is mapped on figure 14.

Three small basic intrusions of fine-grained, serpentinized peridotite, probably of Cretaceous age, are found in the north-central part of the County.

## MINERAL RESOURCES

Riley County produces annually about 90,000 tons of alkali-reactive sand-gravels, nonalkali-reactive sand-gravels, and water-worn flint and lime-gravels used as road metal.

From 30,000 to 50,000 tons of Cottonwood and Neva limestones are quarried annually for structural stone.

Other Permian and Pennsylvanian limestone beds occur in abundance and some have been quarried. The local Pennsylvanian limestones are harder than the Permian and are more suitable for concrete aggregate but they outcrop in only a small area.

Source materials for mineral wool and for cement are plentiful in the County and although they are not now exploited, portland cement was at one time made at Manhattan.

### Sand-gravel

Riley County has two types of alluvial sand-gravel, unlimited in quantity and replenished by sedimentation. Sand-gravel in the Big Blue River is nonalkali-reactive and may be used as concrete aggregate. Sand-gravel in the Kansas River is alkali-reactive and when used as concrete aggregate, should have an admixture of 30 to 40 percent neutral coarse aggregate.

The Walters Sand Co. has a sand-gravel plant in the center of sec. 5, T. 10 S., R. 8 E. (27, fig. 14), on the west bank of the Big Blue River. It produces nonalkali-reactive road gravel, concrete sand-gravel, and mortar sand. The plant lacks rail facilities.

The same company has a sand-gravel plant in Manhattan on the west bank of the Kansas River, just north of the Kansas River bridge, in the S½ of sec. 17, T. 10 S., R. 8 E. (28, fig. 14). This plant produces alkali-reactive concrete sand and mason sand. At this location the company has a ready-mix concrete installation that uses, as an admixture, about 30 percent Argentine limestone, shipped from Leavenworth County. Rail facilities are nearby.

A small sand-gravel plant, on the Big Blue River and a few miles south of Randolph, operates intermittently and produces nonalkali-reactive sand-gravel (29, fig. 14).

Water-worn flint gravels and lime-gravels, possibly Tertiary in age, occur along Deep Creek in southeastern Riley County and supply gravel for use as road metal. In 1949, the County was operating a temporary plant in the SW¼ of sec. 14, T. 11 S., R. 8 E. (33, fig. 14).

### Limestone (figs. 3, 4, and 14)

Limestones occur in abundance and in many beds in Riley County and have been quarried, some extensively, for road metal, riprap, railroad ballast, structural stone, and concrete aggregate. The several limestones will be discussed in order of age, the youngest first.

The Herington limestone member, 2 to 7 feet thick, has been used as road metal but is not important in the County.

An idle quarry is reported (10) in the NW¼SE¼ of sec. 35, T. 6 S., R. 4 E. (26, fig. 14).

The Cresswell limestone member, 7 to 17 feet thick, with a massive 3-foot basal bed suitable for building stone, has been used chiefly as road metal. Idle quarries are reported (10) in the SW¼SW¼ of sec. 18, T. 7 S., R. 6 E. (24, fig. 14) and in the SE¼NE¼ of sec. 13, T. 9 S., R. 5 E. (25, fig. 14).

The Towanda limestone member, thin-bedded and 5 to 11 feet thick, is still available and has been quarried extensively as railroad ballast by the Chicago, Rock Island & Pacific Railroad. Idle quarries are found in the following places (10):

| Sec. | T(S) | R(E) | No. on fig. 14 |
|---|---|---|---|
| 21 | 9 | 6 | 21 |
| 28 | 9 | 6 | 22 |
| NW¼NE¼ 15 | 7 | 5 | 23 |

The Fort Riley limestone member, about 30 feet thick with a massive 60-inch bed usually found near its base, is available in unlimited quantities. All of the member can be used as road metal but its most useful stratum is the massive bed. In most specifications, the Fort Riley limestone is too soft for use as concrete aggregate. It hardens upon exposure and the outcrops usually show as rimrock contours. The limestone has been extensively quarried for dimension stone, foundation rock, riprap, and road metal; and has been used in

many of the buildings in Fort Riley and Manhattan. The stone was not quarried in 1949. Some of the idle quarries are located in the following places:

| Sec. | T(S) | R(E) | No. on fig. 14 |
|---|---|---|---|
| NE¼ 9 | 6 | 7 | 18 |
| N½ 28 | 9 | 6 | 19 |
| SE¼NW¼ 6 | 7 | 6 | 20 |

The Florence limestone member, flinty and about 30 to 40 feet thick also occurs in unlimited quantities and is the most common outcrop in the Flint Hills. It is a potential source material for mineral wool if used with the nearby Fort Riley limestone and Oketa shale (fig. 3). The Florence member is also suitable as road metal, if not too coarse; coarse material has sharp edges which cut tires.

The Schroyer limestone member, 14 to 18 feet thick, and the Threemile limestone member, usually about 9 feet thick, the two constituting the Wreford limestone formation, are both flinty but have important sections which are non-flinty and, hence, more weather resistant. The flinty sections have the same potentials as the Florence limestone; the non-flinty sections can be used as building stone. The Wreford formation occurs in abundance in Riley County but is not being quarried.

The Funston limestone formation, 5 feet thick, often massive and with a Los Angeles test loss of about 45 percent, is not quarried but is a potential road metal. It outcrops

conspicuously in secs. 9 and 16, T. 11 S., R. 7 E., in sec. 13, T. 11 S., R. 8 E., and in sec. 18, T. 11 S., R. 9 E. (17, fig. 14).

The Crouse limestone formation, 8 to 10 feet thick, usually thin-bedded and platy with a massive base, is serviceable as road metal. An idle quarry is located in the center of the SE¼ of sec. 9, T. 11 S., R. 7 E. (16, fig. 14).

The Kiss limestone member, about 8 feet thick including some shale, can be quarried in blocks about 20 inches thick which have been used as building stone or riprap. It has a Los Angeles test loss of 35 to 42 percent and is not now being quarried. An idle quarry is found in the SE¼ SE¼ of sec. 24, T. 11 S., R. 8 E. (15, fig. 14).

The Cottonwood limestone member, 6 feet thick, is white and massive with many fusuline fossils. It is mined extensively, together with the Neva limestone 37 feet below, as structural stone, foundation rock, riprap, road metal, and if mined free of flint, for use as concrete aggregate.

The Neva limestone member, 10 to 17 feet thick but with a quarry thickness of 6 to 7 feet, is a white, flaggy limestone, free of fusuline fossils, and hence more popular as structural stone than the Cottonwood limestone. It is quarried extensively and used for the same purposes as the latter. Most of the buildings of the Kansas State College are built of Neva or Cottonwood limestones.

The Manhattan Stone Co. of Manhattan was quarrying Cottonwood and Neva limestones in 1949. Most of the stone was shipped to cutting plants in Nebraska but the company operated a small stone-cutting plant in Manhattan, using a single 22-inch diamond saw. The Manhattan Cut Stone Co. was building a stone-cutting plant in Manhattan in 1949, which will be equipped with two gang saws, two 48-inch diamond saws, three planers, and a rock splitter. The stone will come from the quarries of the Manhattan Stone Co. at the following locations:

| Sec. | T(S) | R(E) | No. on fig. 14 |
|---|---|---|---|
| SW¼ 23 | 10 | 7 | 9 |
| NW¼ 26 | 10 | 7 | 10 |
| E½NE¼ 29 | 10 | 8 | 11 |
| W½NW¼ 28 | 10 | 8 | 12 |
| NW¼ 12 | 11 | 7 | 13 |
| SE¼ 6 | 11 | 8 | 14 |

Neva and Cottonwood limestones are plentiful in Riley County.

The Burr limestone member, 2 to 3 feet thick, is poorly exposed in the County and is not an acceptable building stone.

The Howe limestone member, a massive bed about 2½ feet thick and the lowest bed of the Council Grove group exploited in the County, has been used as road metal. An idle quarry is found in the NE¼SW¼ of sec. 6, T. 10 S., R. 8 E. (8, fig. 14).

The Five Point limestone member was quarried several years ago at a location (now idle) in the SW¼ of sec. 30, T. 10 S., R. 9 E. (6, fig. 14), producing 10,000 tons of limestone used as riprap near Manhattan.

An idle quarry on the Aspinwall limestone formation, a 2-foot bed of ornamental limestone, is located on a hilltop in the center of the S½ of sec. 29, T. 10 S., R. 9 E. (7, fig. 14). The stone was used for the pier abutments of the Kansas River bridge at St. George (Pottawatomie County) and for a church in Ziondale. Neither the Five Point nor the Aspinwall limestone is important.

The Brownville limestone formation, 2 to 5 feet thick, is mapped on figure 14 but has no economic value (fig. 4).

The Dover limestone formation, 2 to 4 feet thick, outcrops in southeastern Riley County but is not of commercial importance (fig. 4).

The Tarkio limestone formation, 6 to 11 feet thick but available only in small quantities in Riley County, has a Los Angeles test loss of under 40 percent and is suitable for riprap, foundation stone, road metal, and concrete aggregate. Tarkio limestone can be quarried in secs. 28, 29, 32, and 33, T. 10 S., R. 9 E. (2 and 3, fig. 14) and in secs. 4 and 5, T. 11 S., R. 9 E. (4, fig. 14). An old quarry is found in the SW¼NW¼ of sec. 27, T. 10 S., R. 9 E. (5, fig. 14).

The Elmont limestone formation, about 2 feet thick, is a hard limestone suitable for structural stone and concrete aggregate. A small deposit is available in sec. 28, T. 10 S., R. 9 E. (2, fig. 14).

The Reading limestone formation, 2 to 4 feet thick, is a good structural stone or concrete aggregate but its area of occurrence in the County is very limited. It outcrops in the NE¼ of sec. 32, T. 10 S., R. 9 E. (1, fig. 14) and is not of economic importance.

Igneous rock

Three small igneous intrusions, probably Cretaceous, occur in the County. They are similar in appearance, are inconspicuous and, except for a little local contact metamorphism, have scarcely disturbed the surrounding rock. Surface outcrops are 100 to 200 feet in diameter and are located as follows:

| Sec. | T(S) | R(E) | No. on fig. 14 |
|---|---|---|---|
| NE¼ 22 | 8 | 5 | 30 |
| Center 23 | 8 | 6 | 31 |
| NW 6 | 9 | 5 | 32 |

The intrusions are partially serpentinized peridotites containing minute calcite-filled cracks and small xenoliths of the enclosing rocks. They have a Los Angeles test loss of 29 percent and appear to be good concrete aggregate. They have failed tests for soundness made by the Kansas State Highway Commission, probably due to minute cracks in the rock. The intrusion (32, fig. 14) near Bala has been drilled to a depth of

150 feet by Prof. H. H. Munger of the Kansas State College and by the Kansas State Highway Commission. A magnetic survey indicated that its areal dimensions are about 400 by 1,000 feet, with its eastern extension covered by shales and Cresswell limestone.

### Mineral wool

Riley County has unlimited source material for the manufacture of mineral wool but has no mineral wool industry.

### Cement

The County has abundant source material for a cement industry, from the Cottonwood limestone down to the Johnson shale (fig. 3). Cement was made at Manhattan at one time.

### Oil and gas (fig. 6)

Potential oil and gas strata underlie the County but test holes to date (at least 12) have been dry.

The Kansas Power & Light Co. has a 10-inch line from its principal main in Dickinson County, passing through Fort Riley, Ogden, Manhattan, and continuing eastward (fig. 8).

### ELECTRIC POWER (fig. 9)

The Kansas Power & Light Co. has an electric plant at Rocky Ford with a capacity of 3,760-kw.; 600-kw. is hydro-electric and the rest is steam-generated. A 33,000-volt line traverses northward in eastern Riley County and continues into Marshall County. Another 33,000-volt line runs south to Manhattan, thence westward into Geary County.

## WATER

Alluvials of the Big Blue and Kansas Rivers contain abundant supplies of water. Areas away from the rivers depend on wells to fractured zones in the Fort Riley and Cottonwood limestones, porous lenses in minor water courses, and upon collecting ponds.

## MARSHALL COUNTY

### PHYSICAL FEATURES

Marshall County is in the Flint Hills of Kansas. Its highest altitude is about 1,550 feet above sea level (fig. 1); the lowest altitude, about 1,200 feet, is in the river bottoms at the south border of the County (figs. 2 and 15). The flat upland of the western half of the County is dissected sharply by the Big Blue River flowing southward, joining the Little Blue River from the west at Blue Rapids, and continuing southward to the Riley-Pottawatomie County line. The upland of the eastern half of the County is dissected and drained by Vermillion Creek and Black Vermillion River which flow south and southwest to a junction with the Big Blue River near the south border.

Marshall County is served by two railroad systems. A branch line of the Union Pacific comes up from the main line at Manhattan (Riley County), follows the valley of the Big Blue River through Blue Rapids and Marysville, the county seat, and continues northward into Nebraska. Another line of the Union Pacific (St. Joseph & Grand Island) enters the northeastern corner of the County, and passes through Axtell, Marysville, and Bremen. Still another branch of the same system enters near the southeast corner, passes through Lillis and Winifred, and joins other Union Pacific lines at Marysville. A line of the Missouri Pacific enters the County from the east and traverses

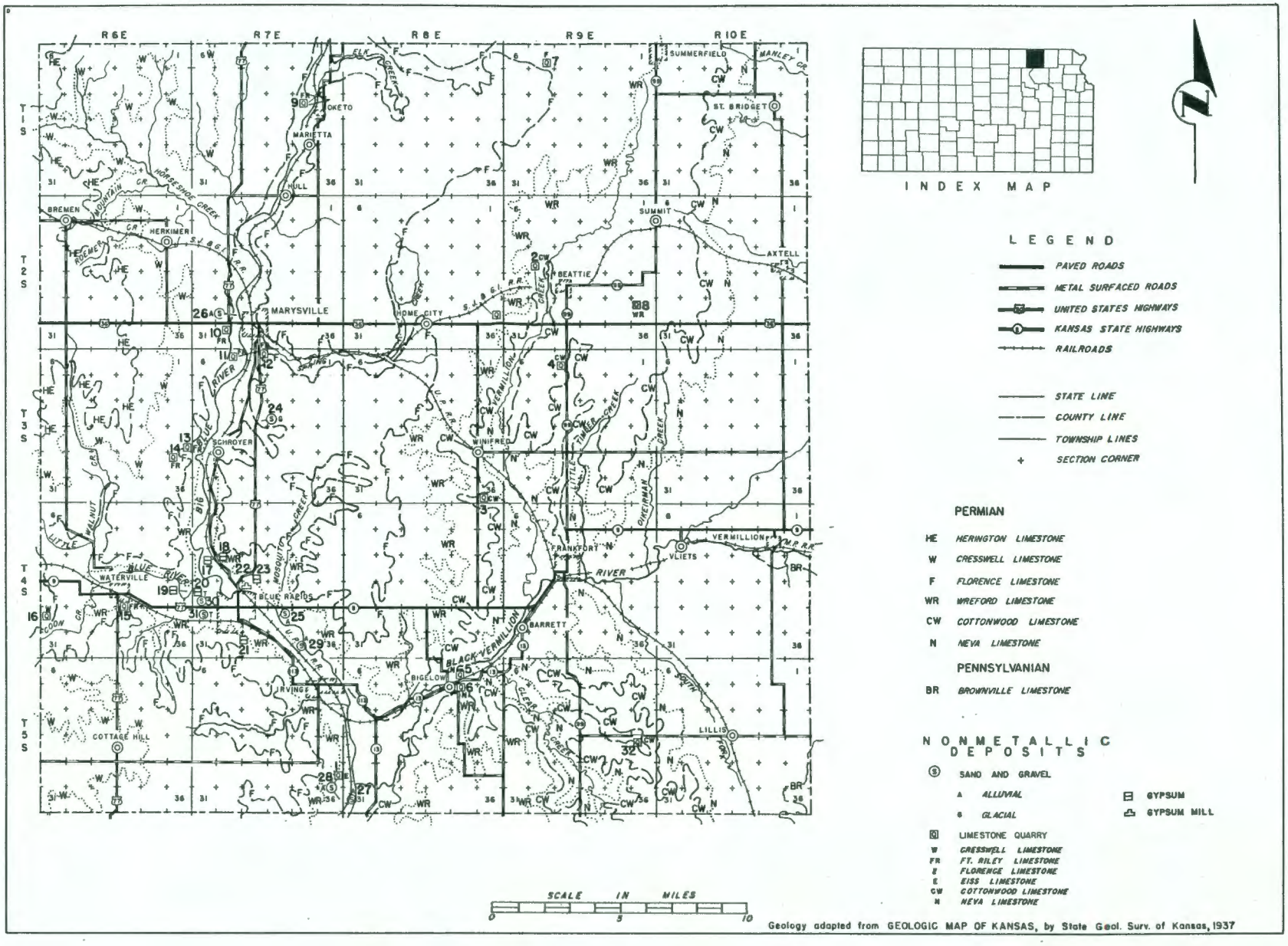



Figure 15.- Marshall County, Kansas

the southern part, through Vermillion, Frankfort, Irving, and Waterville (fig. 15).

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 15.

## GEOLOGY

Save for areas of erosion in valleys of the principal streams, Marshall County is heavily covered by loess (Pleistocene Sanborn formation) and glacial till and gravel (fig. 3).

The consolidated geological formations exposed in the County include the entire Chase, Council Grove, and Admire Groups of Permian rocks from the Herington limestone, outcropping in the northwest, down to the Brownville limestone (top of Pennsylvanian System) outcropping under the glacial till in the southwest (table 1, and figs. 2, 3, and 15). The truncated outcrops of the various members of these groups strike east of north and dip from 10 feet a mile towards the west. Each of the groups is a series of illite shales and intercalated limestone beds. The total thickness of the shales exceeds that of the limestones. The average thickness of each group is given in table 1.

The important outcropping limestone beds, named in descending order, the youngest first, are: Herington, Cresswell, Fort Riley, Florence, Wreford, Cottonwood, Neva, and Brownville. All, except the Fort Riley limestone, are mapped on figure 15.

## MINERAL RESOURCES

The greater part of Marshall County is buried under a heavy cover of loess and glacial drift, effectively preventing the exploitation of many of its limestone and shale members. The County produces annually about 10,000 tons of glacial gravels for road purposes and over 300,000 tons of nonalkali-reactive sand-gravels, most of which is shipped outside its borders. Its sand-gravel deposits are unlimited in extent. Gypsum has been mined for about 50 years; its reserves are not definitely known but are believed to be adequate. One company produces plaster by calcining gypsum.

A few thousand tons of road metal are mined each year from two quarries of shattered flinty limestone. Structural stone, riprap, and road metal have been produced in the past from the County's numerous limestone beds but no quarries are operating at present.

### Loess

In many parts of Marshall County, thick loess lies on the glacial till. It is a potential source of material for mineral filler for bituminous road mats, soil-cement blocks for structural purposes, and calcined light or dense aggregates.

### Sand-gravel

Coarse glacial gravels, containing clay binder, are plentiful on the upland between Marysville and Blue Rapids, and

about 10,000 tons is quarried annually for road metal. A pit was operated during 1949 in the SE¼ of sec. 16, T. 3 S., R. 7 E. (24, fig. 15).

Two large inactive glacial sand-gravel pits are located west of Blue Rapids in the SW¼ of sec. 19, T. 4 S., R. 7 E. (30, fig. 15) and in the NW¼ of sec. 30, T. 4 S., R. 7 E. (31, fig. 15). These sand-gravels are alkali-reactive and, when used as concrete aggregates, should have an admixture of 30 to 40 percent neutral coarse aggregate.

Sand-gravels from the alluvials of the Big Blue River are not alkali-reactive and may be used as aggregate in concrete. Near Marysville, in the NE¼NE¼ of sec. 32 and the SE¼SE¼ of sec. 29, T. 2 S., R. 7 E. (26, fig. 15), Hill Bros. are producing sand-gravel, mostly for use in their construction contracting business.

The McHugh Sand & Gravel Co. has a plant on the east bank of the Big Blue River in the NE¼NW¼ of sec. 27, T. 4 S., R. 7 E. (25, fig. 15). No rail facilities are on the property.

The Blue River Sand & Gravel Co. has two plants on the west bank of the Big Blue River south of Irving. One plant is in sec. 31, T. 5 S., R. 8 E. (27, fig. 15) and the other is in the E½ of sec. 36, T. 5 S., R. 7 E. (28, fig. 15). One plant pumps directly from the river and the other from the alluvial banks. Both have railroad facilities.

The company has a third plant north of Irving on the west side of the Big Blue River in the W½NW¼ of sec. 35, T. 4 S., R. 7 E. (29, fig. 15), which produces road sand, concrete sand, and mortar sand.

## Gypsum

The gypsum industry in the vicinity of Blue Rapids started as early as 1871. An abandoned gypsum mine and evidences of a gypsum plant are found in the NE¼ of sec. 18, T. 4 S., R. 7 E. (17, fig. 15) and in the NW¼ of sec. 17, T. 4 S., R. 7 E. (18, fig. 15) near the flood plain level of the Big Blue River northwest of Blue Rapids. Another abandoned mine and ruins of a gypsum plant are located in the E½ of sec. 24, T. 4 S., R. 6 E. (19, fig. 15) and in the W½ of sec. 19, T. 4 S., R. 7 E. (20, fig. 15) on the south side of the Little Blue River west of Blue Rapids. A third abandoned gypsum mine and plant is south of Blue Rapids in the NW¼ of sec. 33 and in the NE¼ of sec. 32, T. 4 S., R. 7 E. (21, fig. 15). The first two of these plants were operated from the 1870's to the 1890's and the third was operated by the U. S. Gypsum Co. between 1917 and 1941. A part of section 33, east of the mine portal, has been drilled and contains 8 feet of gypsum still unmined.

The Certainteed Products Corp. of Ardmore, Pa., has been operating a gypsum plant about 50 years in the NW¼ of sec. 21, T. 4 S., R. 7 E. (22, fig. 15). The mine, on adjoining sec. 16, T. 4 S., R. 7 E. (23, fig. 15), is on an 8- to 9-foot bed of

gypsum. The impure product is marketed to cement plants and the clean gypsum is milled, calcined, and marketed as plaster.

The area within 4 miles of Blue Rapids is favorable for the occurrence of gypsum, which is found in the Easly Creek shale and directly on the Middleburg limestone (Council Grove group, fig. 3). All mines have been opened by adit tunnels. The extent that the area has been prospected is not known but no doubt substantial gypsum reserves can be proved by drilling. The presently operating company can probably supply the demand of the market area, which is limited by existing freight rates.

## Limestone

Limestone has been quarried for structural stone and road metal but no quarries are now in operation. The limestones outcropping in the County, named in order of age, the youngest first (figs. 3 and 15), are:

The Herington limestone member, about 6 feet thick, and its associate member of the Nolans formation, the 3-foot, flinty Krider limestone, are poorly exposed. The Herington limestone outcrops in the northwest corner near the Washington County line (fig. 15), and has been used for road metal.

The Cresswell limestone member, 7 feet thick, is thin-bedded and platy on top with a massive 3-foot basal section. This member, along with its associate member of the Winfield formation, the 1-foot flinty Stovall limestone, outcrops occasionally in

western Marshall County from Herkimer southward about 6 miles but usually is covered by glacial till (fig. 15). An outcrop occurs in the SW¼SW¼ of sec. 12, T. 3 S., R. 6 E. and in a small area south of Blue Rapids near the County line. A small quarry, once used to produce road metal, is located near the Washington County line in the W½ of sec. 30, T. 4 S., R. 6 E. (16, fig. 15). The massive, 3-foot basal section is structural stone but heavy glacial till overburden allows only limited exploitation.

The Fort Riley limestone member, with its massive, 5-foot basal bed, is abundant in central Marshall County on both sides of the Little Blue and Big Blue Rivers and is the most important limestone bed in the County. It is not mapped on figure 15 because it lies only a few feet above the Florence limestone which is mapped. Although the Fort Riley limestone now has no active quarries, it has been quarried extensively as building stone, rip-rap, and road metal. It is a little soft for use as concrete aggregate but has been used as such when flint-free. Idle quarries are found in the following places;

| Sec. | T(S) | R(E) | No. on fig. 15 |
|---|---|---|---|
| SW¼ 12 | 1 | 7 | 9 |
| NW¼ 13 | 1 | 7 | 9 |
| NW¼ 32 | 2 | 7 | 10 |
| NE¼ 4 | 3 | 7 | 11 and 12 (2 quarries) |
| SE¼ 24 | 3 | 6 | 13 |
| NW¼ 25 | 3 | 6 | 14 |
| SW¼ 22 | 4 | 6 | 15 |

The Florence limestone member, flinty and about 30 feet thick, is abundant in the County on both sides of the Little Blue and Big Blue Rivers and on the upland between Blue Rapids and the Nebraska border where much of it is buried under glacial till. It has a potential use as road metal, railroad ballast, and as source material for mineral wool. Road metal has been obtained from a quarry of shattered Florence limestone in the SE¼ of sec. 5, T. 1 S., R. 9 E. (7, fig. 15).

The Wreford limestone formation, with two flinty members (Schroyer and Threemile), each about 10 feet thick, shows as terraces 50 to 75 feet above the Big Blue River south of Blue Rapids and along the north branch of the Black Vermillion River below Frankfort. The formation is well exposed along Highway 66, 2½ to 3 miles west of Highway 99. In other parts of the County, it is covered by loess and glacial till. A quarry of shattered, flinty limestone, probably the Wreford formation but very similar to the Florence quarry (7, fig. 15), is located in the NW¼ of sec. 25, T. 2 S., R. 9 E. (8, fig. 15).

The Funston, Crouse, Middleburg, and Eiss limestone beds are exposed in the valley of the Big Blue River below Blue Rapids and Irving, and have potential use as road metal. An idle Eiss limestone quarry, with a 10-foot face showing 4 feet of limestone, 2 feet of shale, and another 4 feet of limestone, and used for road material, is found in the E½ of sec. 25, T. 5 S., R. 7 E. (1, fig. 15).

The Cottonwood limestone member, 6 feet thick, and the Neva limestone member, 6 to 10 feet thick, are available in the County and share in importance with the Fort Riley limestone. No quarries are active (1950) but both beds have been quarried in the past for structural stone, riprap, and road metal. They are best exposed south of Beattie on both sides of Highway 99. In the rest of the County, the outcrops usually lie under heavy cover of loess and glacial till. Idle quarries of Cottonwood or Neva limestones are located in the following places:

| Sec. | T(S) | R(E) | No. on fig. 15 | Formation |
|---|---|---|---|---|
| SE¼ 20 | 2 | 9 | 2 | Cottonwood |
| SW¼ 36 | 3 | 8 | 3 | Do. |
| W½ 4 | 3 | 9 | 4 | Do. |
| SW¼ 2 | 5 | 8 | 5 | Neva |
| NW¼ 11 | 5 | 8 | 6 | Do. |
| NW¼ 24 | 5 | 9 | 32 | Cottonwood |

The limestones and shales of the lower Council Grove group (fig. 3), which could be useful in a potential cement industry, together with the Neva and Cottonwood limestones are not available in Marshall County due to a heavy cover of loess and glacial till which also cover the limestones of the Admire group and the Brownville limestone, uppermost of the Wabaunsee group, occurring in the eastern part of the County.

## Oil and gas (fig. 8)

Potential oil and gas strata underlie Marshall County but no discovery of either commodity has been made.

Cities Service Gas Co. supplies gas to the principal towns of the County through 4- and 6-inch lines from the multiple gas mains of the Northern Natural Gas Co. in Washington County. The City Service line continues eastward into Nemaha County.

## ELECTRIC POWER (fig. 9)

Kansas Power & Light Co. furnishes power to all the larger towns of the County over 33,000-volt transmission lines from Nemaha and Riley Counties. Oketa, Howe City, Beattie, and Bigelow are serviced over 6,600-volt lines. The company has a 120-kw. hydroelectric plant at Blue Rapids, and a 600-kw. hydroelectric plant at Marysville.

Rural Electrification Administration purchases power from the company and distributes it into rural areas.

## WATER

The alluvials of the Little Blue and Big Blue Rivers carry an abundance of water. In other parts of the County, water is obtained by shallow wells sunk to the Fort Riley or Cottonwood limestones, to porous lenses in the glacial drift or along minor water courses, and by entraining run-off water.

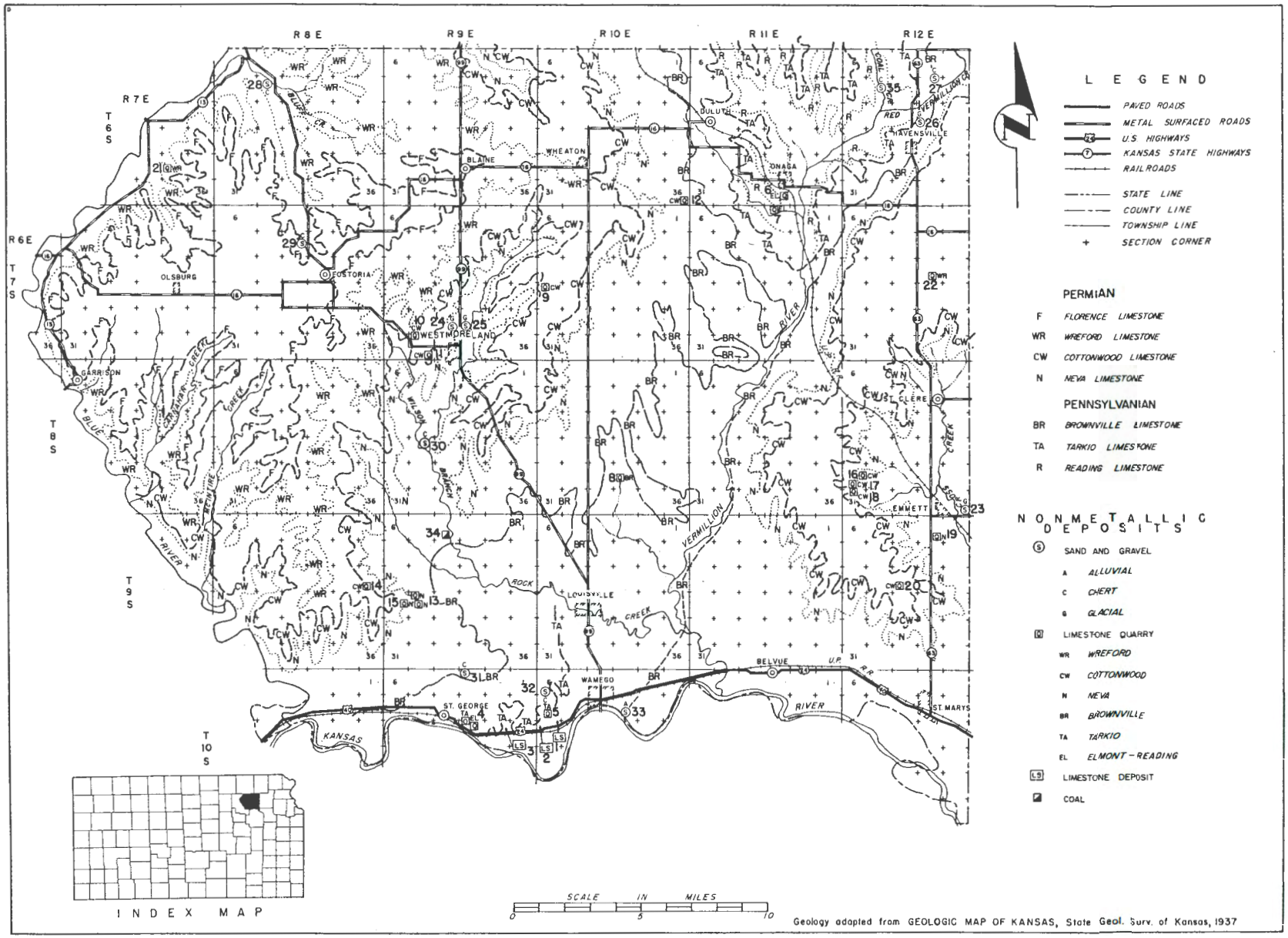
## POTTAWATOMIE COUNTY

### PHYSICAL FEATURES

Pottawatomie County lies on the eastern slope of the Flint Hills of Kansas (fig. 1). The Big Blue River flows southward along the west border of the County and joins the Kansas River near Manhattan (Riley County). The Kansas River flows eastward along the south border. The drainage is west into the Big Blue River and south and southeast into the Kansas River. The altitude ranges from a maximum of about 1,350 feet above sea level in the Flint Hills in the western half to 987 feet at Wamego on the Kansas River (figs. 2 and 16). The topography of the County, flat and rolling, steepens abruptly upon approaching the Big Blue and Kansas Rivers and slopes gently eastward toward the Vermillion River.

Pottawatomie County is served by the Union Pacific Railroad system. The main Kansas City to Denver line crosses near the south border in the valley of the Kansas River, through St. Marys and St. George. The Topeka to Marysville branch cuts the northeastern corner of the County in a northwest direction passing through Emmett and Onago. Westmoreland, the county seat, has no rail connections.

The rugged topography of the area, adjacent to and 5 miles east of the Big Blue River, has caused secondary roads to be built along drainage courses. Eastern Pottawatomie County, between Emmett and St. Clere and the Vermillion River, has discouraged



Geology adapted from GEOLOGIC MAP OF KANSAS, State Geol. Surv. of Kansas, 1937

Figure 16.- Pottawatomie County, Kansas

the usual checkerboarding by secondary roads. In all other parts of the County, secondary roads checkerboard at 1- and 2-mile intervals. The main paved highways are shown on figure 16.

## GEOLOGY

Pottawatomie County has a heavy cover of loess, the Pleistocene Sanborn formation, and of glacial till and outwash. Glacial outwash sands are especially heavy along the southern border west of Wamego.

The Nemaha uplift passes through the County, the crest of the anticline striking northeastward from a few miles west of Wamego, through Onaga and the northeast corner. The uplift has exposed Pennsylvanian members along the crest with overlying Permian members both to the west and to the east of the crest (fig. 7). The beds to the west have a normal westerly dip of 10 to 12 feet a mile. To the east of the crest, reverse east dips of as much as 10 degrees occur for short distances; then the beds resume their normal north of west dip.

The important limestone beds outcropping in Pottawatomie County, named in order of age, the youngest first (figs. 3, 4, and 16), are: Fort Riley, Florence, Wreford, Cottonwood, Neva, Brownville, Tarkio, Elmont, Reading, and Burlingame. All are mapped on figure 16 except the Fort Riley, Elmont, and Burlingame. The Fort Riley limestone lies about 5 feet above the top of the Florence limestone and the Elmont limestone lies 10 to 15 feet above the Reading bed. The Burlingame is a useful limestone but its occurrence is very limited in the County.

## MINERAL RESOURCES

Pottawatomie County has large reserves of alkali-reactive and nonalkali-reactive sand-gravels, the annual production of which is estimated to be 40,000 tons.

Limestones occur in abundance and have been quarried for structural stone, riprap, and road metal, and are potential sources of agricultural limestone. Quarries are now inactive. The Neva and Cottonwood members with associated shales can furnish source materials for a potential cement industry. The Wreford and Florence flinty limestones and adjacent members are source materials for a mineral wool industry.

### Sand-gravel

The Big Blue and Kansas Rivers have unlimited quantities of alluvial sand-gravels. Those of the Big Blue River are nonalkali-reactive but are not exploited on the Pottawatomie County side of the river. The sand-gravels of the Kansas River are alkali-reactive when used as concrete-aggregate and should have an admixture of 30 to 40 percent of neutral coarse aggregate. The Wamego Sand Co. pumps sand from the Kansas River at Wamego to a plant on the north bank in the NE¼ SW¼ of sec. 10, T. 10 S., R. 10 E. (33, fig. 16). The company has been operating since January 1946 and produces concrete and road sand, the latter having a gradation factor of 420 to 435.

In the sand-covered area between St. George and Wamego, a number of small waterworn, stream chat deposits are found, generally at high spots and free of overburden. A small, idle

pit is located in the SE¼ NE¼ of sec. 3, T. 10 S., R. 9 E. (31, fig. 16). Another deposit is in the SE¼ SW¼ of sec. 6, T. 10 S., R. 10 E. (32, fig. 16).

Creek gravels, largely chert washed down from the Florence and Wreford beds, are plentiful and are used intermittently (5,000 to 10,000 tons annually) as road metal. A creek northwest of Fostoria has furnished gravel in the W½ of sec. 9, T. 7 S., R. 8 E. (29, fig. 16). Gravel has also been obtained from the following places:

| Creek | Sec. | T(S) | R(E) | No. on fig. 16 |
|---|---|---|---|---|
| Red Vermillion | 10 | 6 | 12 | 27 |
| Bluff | 8 | 6 | 8 | 28 |
| Wilson | 20 | 8 | 9 | 30 |
| Coal | 8 | 6 | 12 | 35 |

Deposits of coarse, glacial gravel with clay occur throughout the County and have been used as road metals. These gravels should be crushed to pass a 2-inch mesh screen. No quarries were active in 1949, but pits are found in the following localities:

| Sec. | T(S) | R(E) | No. on fig. 16 |
|---|---|---|---|
| SE¼ 35 | 8 | 12 | 23 |
| SE¼ 28 | 7 | 9 | 24 |
| SW¼ 27 | 7 | 9 | 25 |
| SW¼ 15 | 6 | 12 | 26 |

## Limestone

The Fort Riley limestone member, with its massive 5-foot basal bed good for structural stone and riprap, is found in a small area about 2 miles west of Olsburg.

The Florence limestone member, a cherty limestone 30 feet thick and abundant, is a potential source of mineral wool and road metal.

The Wreford limestone formation, consisting of two flinty members (Schroyer and Threemile limestones), likewise is plentiful. Both members have non-flinty massive tops or bases available for structural stone and road metal, and both are potential sources of mineral wool. A Schroyer quarry is located in the NE¼ SW¼ of sec. 26, T. 6 S., R. 7 E. (21, fig. 16), and a Threemile quarry is in the SW¼ SE¼ of sec. 15, T. 7 S., R. 12 E. (22, fig. 16). The flint free base in the latter quarry resembles Cottonwood limestone but is softer.

The Cottonwood and Neva limestone members are extensive in the County, and can be quarried in unlimited quantities with 5- to 7-foot quarry faces. They have a potential use as structural stone, riprap and road metal, and with the lower Council Grove limestones and shales, could furnish source material for a cement industry. Quarries in these beds are no longer active. The two limestones outcrop as two belts, an east and a west (figs. 2 and 16).

The northern and southern ends of the east belt are covered by glacial till. The outcrops in the central area near Westmoreland are available and small, idle quarries are found in the following localities:

| Sec. | T(S) | R(E) | No. on fig. 16 | Limestone member |
|---|---|---|---|---|
| NE¼NW¼ 19 | 7 | 10 | 9 | Cottonwood |
| NW¼NW¼ 32 | 7 | 9 | 10 | Do. |
| SE¼SE¼ 32 | 7 | 9 | 11 | Do. |
| SE¼SE¼ 36 | 6 | 10 | 12 | Do. |
| NW¼ 20 | 9 | 9 | 13* | Neva |
| SW¼ 13 | 9 | 8 | 14 | Cottonwood |
| SE¼NE¼ 19 | 9 | 9 | 15 | Neva |

* Two quarries

The northern end of the west belt is covered by glacial till but vast quantities of stone are available in the central section and in the south, north of St. Marys. Small, idle quarries are found in the following places:

| Sec. | T(S) | R(E) | No. on fig. 16 | Limestone member |
|---|---|---|---|---|
| NE¼SE¼ 30 | 8 | 12 | 16 | Cottonwood* |
| SE¼SW¼ 30 | 8 | 12 | 17 | Do. |
| N½NW¼ 31 | 8 | 12 | 18 | Do. |
| SW¼SE¼ 3 | 9 | 12 | 19 | Neva |
| SW¼SW¼ 16 | 9 | 12 | 20 | Cottonwood |

* Equipped with crusher and operated in 1948.

The Five Point and Aspinwall limestone beds, 1 to 3 feet thick, are usually buried under glacial till but, when available, make good limestone for structural purposes and for riprap. Some terraces are available in a 10- to 12-mile stretch

between Wamego and St. Marys, above and parallel to the alluvial flood plains of the Kansas River.

The Brownville limestone formation generally is not a useful stone. An old quarry, believed to be Brownville limestone and located in the NE¼ SW¼ of sec. 27, T. 8 S., R. 10 E. (8, fig. 16), still contains rock broken from a 4-foot bed of hard, massive dark brown fossiliferous limestone suitable for structural use, riprap, or road metal.

The Tarkio limestone formation, 4 to 5 feet thick, is usually brown with large, conspicuous fusuline fossils. Buried under glacial till in most of the County, the formation is exposed in the northeast corner in the vicinity of Onaga but is not quarried (figs. 4 and 16). It is also exposed in the south, a little east of St. George. Two large abandoned quarries are located in this area; one is in the NW¼ of sec. 15, T. 10 S., R. 9 E. (4, fig. 16, upper quarry) and the other is in the SE¼ SW¼ of sec. 7, T. 10 S., R. 10 E. (5, fig. 16). Stone from those quarries was used as riprap and railroad ballast. Tarkio limestone is also suitable as concrete aggregate. It is still available between St. George and Wamego about 40 feet above Highway 40 and in the Onaga area (fig. 16).

The Elmont and Reading limestone formations, separated by 8 to 15 feet of shale, also are generally buried in the County but are exposed in the same general areas as the Tarkio limestone.

Along Highway 40 east of St. George, Elmont limestone is 6 feet thick, an unusual thickness, and outcrops prominently in secs. 13 and 14, T. 10 S., R. 9 E. (3, fig. 16). Ordinarily, Elmont and Reading limestones are 2 to 4 feet thick. An abandoned Elmont quarry is found in the NW¼ of sec. 15, T. 10 S., R. 9 E. (4, fig. 16), adjoining a Tarkio quarry but 40 feet lower. Reading limestone outcrops along Highway 40 in the NW¼ of sec. 18, T. 10 S., R. 10 E. (2, fig. 16), but usually is too well protected in this area by the overlying Elmont bed to be available for exploitation.

Elmont and Reading limestones are available in many places in the Onaga area at normal thicknesses of 2 to 4 feet and have been quarried recently as building stone. An idle quarry is found in the NE¼ SE¼ of sec. 34, T. 6 S., R. 11 E. (6, fig. 16) and another quarry, recently operated, is in the NE¼ NW¼ of sec. 3, T. 7 S., R. 11 E. (7, fig. 16). In this area many of the Reading limestone outcrops are close to creek levels.

The Wakarusa limestone formation, about 2 feet thick, outcrops west of Wamego on Highway 40, near flood plain level, in the NE¼ of sec. 18, T. 10 S., R. 10 E. (1, fig. 16). The bed also outcrops north and east of Onaga.

The Burlingame limestone formation is exposed along the north border of the County but its outcropping within the County is of no importance.

### Mineral wool

The Florence and Wreford limestones, outcropping in the northwest part of the County, together with nearby limestones and shales, contain large quantities of source material for a potential mineral wool industry.

### Cement

The Cottonwood and Neva limestone outcrops in the southeastern part of the County, together with nearby limestones and shales, are abundant source materials for a cement industry.

### Coal

No coal is produced in Pottawatomie County. About 100 tons of coal was produced from the Lorton seam, a Wabaunsee coal (fig. 4) in the SE¼ of sec. 4, T. 9 S., R. 9 E. (34, fig. 16). The coal at this point was 10 inches thick, under heavy overburden, and below creek level (12). The Lorton seam is 20 to 30 feet below the Brownville limestone.

The Elmo coal seam, 8 inches thick and about 25 feet below the Burlingame limestone, outcrops in the County only on the Nemaha-Pottawatomie County line, 4 miles west of the northeast corner of the County.

### Oil and gas (fig. 8)

Potential oil and gas strata underlie the County, but 15 test wells, one to the pre-Cambrian system at 3,486 feet, have failed to find any production.

The Service Pipe Line Co. has a multiple crude oil line from Wyoming crossing the County.

Kansas Power & Light Co. has a 4-inch gas line from Manhattan (Riley County), servicing St. George, Wamego, Belvue and St. Marys, with a branch northward to Westmoreland, Blaine, Wheaton, and Onaga.

## ELECTRIC POWER

Kansas Power & Light Co. has a 33,000-volt transmission line from its 3,760-kw. plant at Rocky Ford (Riley County), traversing eastward along the southern border of the County, and supplying Louisville, Wamego, Belvue, and St. Marys. A 33,000-volt line runs north from Rocky Ford in the valley of the Big Blue River and, above Garrison, feeds an 11,000-volt line to Olsburg, Fostoria, Westmoreland, Blaine, Duluth, Onaga, and Havensville, continuing eastward into Jackson County. The company has an internal combustion plant of 120-kw. capacity at Onaga.

Wamego has a municipal, internal combustion, electric plant of 1,440-kw. capacity.

Rural Electrification Administration purchases power from the Kansas Power & Light Co. for distribution in rural areas.

## WATER

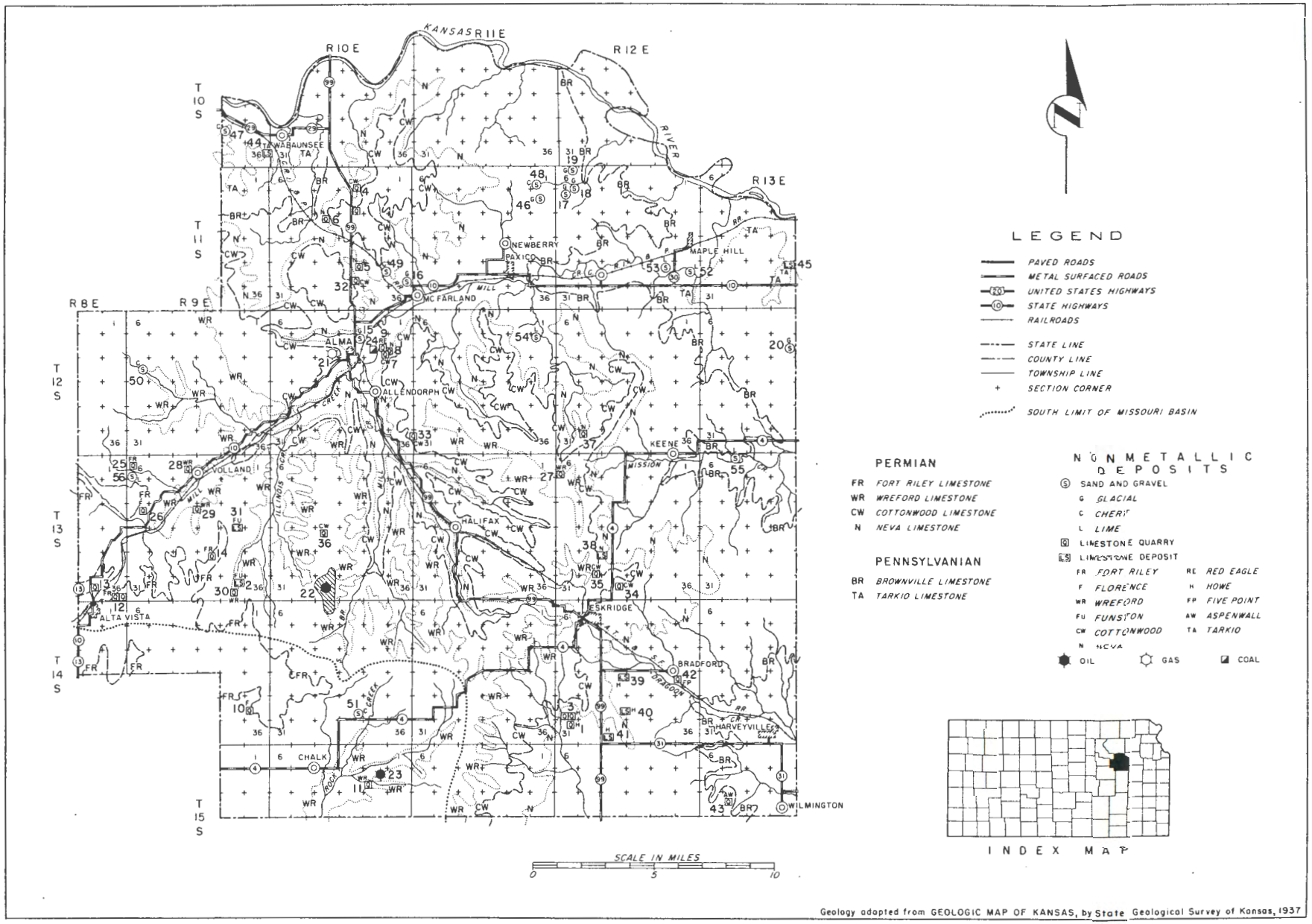
The alluvials of the Big Blue and Kansas Rivers carry an abundant water supply. Vermillion River and smaller water courses carry moderate amounts of water. Water in smaller amounts is available in wells sunk to the Cottonwood limestone or in collecting ponds.

## WABAUNSEE COUNTY

### PHYSICAL FEATURES

Wabaunsee County lies on the eastern edge of the Flint Hills upland of Kansas (fig. 1). The Kansas River flows eastward along the northern edge of the County at altitudes of 1,011 to 956 feet above sea level. The south border of the Missouri River Basin crosses the uplands of the Flint Hills in the southwest quarter of the County at an altitude of about 1,400 feet (figs. 2 and 17). Mill Creek flows diagonally across the County from the southwest corner, joining the Kansas River near the northeast corner. Most of the County, save the southeastern part, drains into Mill Creek. The southeastern part drains east and southeast into the Marias des Cygnes Basin, a part of the Missouri River Basin. The topography on the uplands of southwestern Wabaunsee County is flat; Mill Creek and its numerous tributaries, however, sharply dissect the terrain and give most of it a rugged topography. The lowland of the eastern part of the County is rolling with a maximum relief of 100 to 150 feet.

Wabaunsee County is served by two railroad systems. The Chicago, Rock Island & Pacific enters the northeast corner, follows Mill Creek southwest, and branches at McFarland. One branch swings northeast through Wabaunsee to the Kansas River; the other continues southwest up Mill Creek through Alma, the county seat, and passes through Alta Vista near the southwest corner. A branch of the




Geology adapted from GEOLOGIC MAP OF KANSAS, by State Geological Survey of Kansas, 1937

Figure 17.- Wabaunsee County, Kansas

Atchison, Topeka & Santa Fe Railroad enters the southeast corner of the County and runs northwest through Eskridge to its terminal at Alma.

Secondary roads checkerboard the borders of Wabaunsee County at intervals of 1 to 3 miles. The rugged topography of the central part has forced all roads to follow drainage courses allowing few east-west connecting roads. The main paved highways are shown on figure 17.

## GEOLOGY

Loess occurs in scattered areas in Wabaunsee County. Glacial till and gravel are abundant in the northern half of the County.

The crest of the Nemaha anticline strikes northeastward in the western part of the County from Alta Vista, in the southwest corner, through or to the west of Wabaunsee, and on into Pottawatomie County, creating reverse east dips on the east side of the crest and exposing the top Pennsylvanian members in the northwest corner of the County (figs. 7 and 17).

The consolidated geological members exposed in the County range from the shales above the Permian Fort Riley limestone in the southwest to the Pennsylvanian Elmont limestone in the northwest (figs. 3, 4, and 17). The principal limestones outcropping in the County, named in order of age, the youngest first, are: Fort Riley, Florence, Wreford, Cottonwood, Neva,

Brownville, Tarkio, and Elmont. All are mapped on figure 17, except the Florence member, which lies about 5 feet below the Fort Riley bed, and the Elmont formation whose limited exposures within the County are too low for exploitation.

## MINERAL RESOURCES

Wabaunsee County has an abundance of alkali-reactive sand-gravel in the alluvials of the Kansas River but no plants are located on the south side of the river. The County also has plentiful coarse glacial gravels, waterworn chert gravels, and sharp flint creek gravels. About 75,000 tons are produced annually for use as road metal.

Quarrying of limestone was once an active industry, but in 1949 only one small quarry was in operation, producing crushed flinty limestone for use as road metal. The County has an abundance of limestone formerly quarried for structural stone, riprap, road metal, railroad ballast, agricultural limestone, and cement manufacturing. Plentiful source material is also available for mineral wool.

Oil was discovered in the southern part of the County in April 1949 and production for that year was 46,659 barrels. The 1950 production was 356,215 barrels.

### Sand-gravel

Alluvial sand-gravel deposits are extensive in the Kansas River but are not exploited from the Wabaunsee County side.

They are alkali-reactive and, when used as concrete aggregate, should have an admixture of 30 to 40 percent of neutral coarse aggregate. Concrete sand-gravels used in the County are trucked in from Wamego, Pottawatomie County.

Coarse glacial gravel, generally mixed with clay, is abundant in the northern half of the County and makes excellent road metal for secondary roads if crushed to pass through a 2-inch screen. In 1949, a pit was operating in the NE¼ SE¼ of sec. 10, T. 12 S., R. 13 E. (20, fig. 17). Portable equipment was used and all gravel was crushed to pass through a 2-inch screen. Similar deposits occur north of McFarland, Paxico, and Vera. The U. S. Geological Survey (30) reports another coarse-gravel pit in the NE¼ NW¼ of sec. 7, T. 11 S., R. 12 E. (46, fig. 17).

North of Mill Creek a belt of water-worn, chert river gravel, 8 to 10 feet thick, extends northeast from a point 2 miles southwest of Alma, passing north of Paxico and extending to the Kansas River alluvials south of St. Marys in Pottawatomie County. A number of gravel pits, intermittently operated, are located on this belt in the following places:

| Sec. | T(S) | R(E) | No. on fig. 17 |
|---|---|---|---|
| NE¼ 10 | 12 | 10 | 15 |
| SE¼SE¼ 25 | 11 | 10 | 16 |
| NW¼NE¼ 7 | 11 | 12 | 17 |
| SE¼SE¼ 6 | 11 | 12 | 18 |
| NW¼NE¼ 6 | 11 | 12 | 19 |

The U. S. Geological Survey (30) reports other small (3,000- to 18,000- cubic yards) chert-gravel deposits in the following localities:

| Sec. | T(S) | R(E) | No. on fig. 17 |
|---|---|---|---|
| NW¼SW¼ 26 | 10 | 9 | 47 |
| SW¼SW¼ 1 | 11 | 11 | 48 |
| SE¼NE¼ 26 | 11 | 10 | 49 |
| NW¼SE¼ 18 | 12 | 9 | 50 |
| SE¼SE¼ 27 | 14 | 10 | 51 |

Creek gravels, largely washed down from Wreford and Florence limestone beds, are abundant in Rock Creek in southwestern Wabaunsee County. The U. S. Geological Survey (30) reports lime-gravel deposits of 2,000- to 15,000- cubic yards in the following places:

| Sec. | T(S) | R(E) | No. on fig. 17 |
|---|---|---|---|
| SW¼NE¼ 25 | 11 | 12 | 52 |
| SE¼NE¼ 26 | 11 | 12 | 53 |
| NW¼NW¼ 12 | 12 | 11 | 54 |
| NE¼NW¼ 5 | 13 | 13 | 55 |
| SW¼SW¼ 6 | 13 | 9 | 56 |

An estimated 75,000 tons of glacial sand-gravels are produced annually for road metal by portable equipment. These sand-gravels are not suitable for concrete aggregate.

## Limestone (fig. 3)

The massive 5-foot bed of the Fort Riley limestone member has been mined extensively for structural stone, road metal, and railroad ballast. Soft and frequently containing flint

inclusions, it is not a good aggregate for concrete. The stone apparently hardens upon continuous exposure to air. Idle quarries on this bed are in the following places in southwestern Wabaunsee County:

| Sec. | T(S) | R(E) | No. on fig. 17 |
|---|---|---|---|
| SW¼SE¼ 36 | 13 | 8 | 12 |
| SE¼SE¼ 36 | 13 | 8 | 12 |
| NW¼SE¼ 35 | 13 | 8 | 13 |
| NW¼NE¼ 27 | 13 | 9 | 14 |

The U. S. Geological Survey (30) reports a deposit of hard, massive Fort Riley limestone in the SE¼ NW¼ of sec. 6, T. 13 S., R. 9 E. (25, fig. 17). The stone is porous and has a specific gravity of 1.92.

The Florence limestone member, about 30 feet thick, flinty, and suitable for road metal and railroad ballast, is abundant in the southeast part of the County. A quarry was operated in 1949 in the NW¼ SW¼ of sec. 25, T. 14 S., R. 9 E. (10, fig. 17). The rock, crushed to pass through a 2-inch screen and screened over a ¼-inch screen, was used as road metal. A sample of Florence limestone, analyzed by the U. S. Bureau of Mines, contained too little $CaCO_3$ and too much silica to permit classification as agricultural limestone.

The U. S. Geological Survey (30) reports a Florence limestone quarry in the SE¼ NE¼ of sec. 18, T. 13 S., R. 9 E. (26, fig. 17). The stone is medium-hard and cherty and has a specific gravity of 2.20.

The Wreford limestone formation, with its two flinty limestone members (Schroyer and Threemile), each 10 to 14 feet thick, is abundant in the County. It is suitable for road metal and railroad ballast when crushed, and its flint-free, massive 3- to 4-foot beds can be used as structural stone. One idle quarry, which supplies road metal, is in the NW¼ SW¼ of sec. 11, T. 15 S., R. 10 E. (11, fig. 17).

The U. S. Geological Survey (30) reports small (5,000 to 50,000 cubic yards) deposits or quarries of Wreford limestone in the following localities:

| Sec. | T(S) | R(E) | No. on fig. 17 |
|---|---|---|---|
| SW¼SW¼ 6 | 13 | 12 | 27 |
| NE¼SE¼ 4 | 13 | 9 | 28 |
| NE¼NE¼ 16 | 13 | 9 | 29 |
| NW¼NE¼ 35 | 13 | 9 | 30 |

The first three deposits are medium-hard, cherty limestone with specific gravities ranging from 2.08 to 2.22 and are acceptable as road metal. The specific gravity of deposit No. 30 is 1.94.

The Funston limestone formation, usually a 5-foot bed of little importance lying about 25 feet below the Wreford formation, outcrops in the NW¼NE¼ of sec. 35, T. 13 S., R. 9 E. (2, fig. 17) as a massive bed, 10 to 12 feet thick. It has not been used in this area but is probably sufficiently resistant to weathering to be suitable as a building stone. This unusual development of the Funston formation is found in a creek bottom and very likely is of limited extent.

The U. S. Geological Survey (30) reports a small deposit of Funston limestone, 22 feet thick, in the NW¼ NE¼ of sec. 24, T. 13 S., R. 9 E. (31, fig. 17). It is a massive, soft limestone with a specific gravity of 1.88 and a Los Angeles test loss of 63.2 percent.

The Cottonwood limestone member, a massive white 6-foot bed with conspicuous fusuline fossils, is abundant and has been quarried extensively throughout Wabaunsee County for structural stone, riprap, and road metal. The Neva limestone member, a flaggy, white, non-fusuline bed with quarry faces 6 to 7 feet thick, and about 35 feet below the Cottonwood member, is also abundant and has been quarried likewise extensively for riprap, structural stone, and road metal. Both limestones were used in a cement plant once located near Alma. No attempt has been made to list all the Cottonwood-Neva quarries. A few of them are located in the following places:

| Sec. | T(S) | R(E) | No. on fig. 17 |
|---|---|---|---|
| SW¼SE¼ 3 | 11 | 10 | 4 (Cottonwood member) |
| NE¼NE¼ 27 | 11 | 10 | 5 ( Do. Do. ) |
| SE¼NW¼ 16 | 11 | 10 | 6 (Neva Do. ) |
| SE¼ 11 | 12 | 10 | 7 (Cottonwood Do. ) |
| SE¼ 11 | 12 | 10 | 8 (Neva Do. ) |

The U. S. Geological Survey (30) reports deposits or quarry pits of Cottonwood limestone ranging in size from 7,000 to 64,500 cubic yards, in the following localities:

| Sec. | T(S) | R(E) | No. on fig. 17 |
|---|---|---|---|
| NE¼SE¼ 27 | 11 | 10 | 32 |
| SE¼NE¼ 36 | 12 | 10 | 33 |
| SW¼SE¼ 28 | 13 | 12 | 34 |
| SE¼SE¼ 29 | 13 | 12 | 35 |
| SW¼NW¼ 23 | 13 | 10 | 36 |

The specific gravity ranges from 2.15 to 2.32 with a Los Angeles test loss usually more than 45 percent.

The U. S. Geological Survey (30) reports small quarries or deposits of Neva limestone in the following places:

| Sec. | T(S) | R(E) | No. on fig. 17 |
|---|---|---|---|
| NE¼NE¼ 31 | 12 | 12 | 37 |
| NW¼NW¼ 28 | 13 | 12 | 38 |

The specific gravity ranges from 2.25 to 2.43. The harder and denser limestones have a Los Angeles test loss as low as 32 percent.

The Howe limestone member, ordinarily a small 3-foot bed, is 6 to 7 feet thick, 4 miles wide south of Eskridge. One quarry was opened in the NE¼ of sec. 31, T. 14 S., R. 12 E. (1, fig. 17), and two quarries were opened in the S½ of sec. 30, T. 14 S., R. 12 E. (3, fig. 17). The stone was used as road metal but was too soft and was unsatisfactory for that purpose. The fines were sold as agricultural limestone.

The U. S. Geological Survey (30) reports small Howe limestone deposits or quarries in the following localities:

| Sec. | T(S) | R(E) | No. on fig. 17 |
|---|---|---|---|
| NE¼NE¼ 21 | 14 | 12 | 39 |
| SE¼NE¼ 28 | 14 | 12 | 40 |
| SW¼SW¼ 33 | 14 | 12 | 41 |

The specific gravity ranges from 2.33 to 2.39.

The Red Eagle limestone formation and the underlying Johnson shale formation were used in a quarry in the SE¼ of sec. 11, T. 12 S., R. 10 E. (9, fig. 17) to furnish the shale component in a now idle cement plant near Alma. Quarries 7 and 8 in the same section furnished the lime component.

The Five Point limestone member and the Aspinwall limestone formation, each 1 to 3 feet thick, are available along the southern border of the Kansas River flood plain eastward from Highway 99 to within 5 miles of the east border of the County. They are also available in an irregular area southward from Maple Hill to Harveyville and outcrop to the west of the Brownville limestone (fig. 17). These thin limestones can be used as structural stone or as riprap.

The U. S. Geological Survey (30) reports a small Five Point limestone quarry in the NW¼NW¼ of sec. 24, T. 14 S., R. 12 E. (42, fig. 17) and a small Aspinwall limestone quarry in the SW¼SW¼ of sec. 8, T. 15 S., R. 13 E. (43, fig. 17). The Five

Point limestone has a specific gravity of 2.27 and a Los Angeles test loss of 41.9 percent, whereas the Aspinwall limestone has a specific gravity of 2.66 and a Los Angeles test loss of 29.4 percent.

Rock outcrops of the Pennsylvanian system in the County are confined to the northeast corner and a small area on the Nemaha anticline in the northwest corner. The thin Dover and Maple Hill limestones, 2 to 4 feet thick, are available in limited quantities but are not considered commercially important.

The Tarkio limestone formation, 4 to 5 feet thick, with a brown outcrop conspicuous with fusuline fossils, is suitable for concrete aggregate, riprap, and road metal. Available in the northwest and northeast, the stone has not been quarried. The U. S. Geological Survey (30) reports Tarkio limestone deposits in the following localities:

| Sec. | T(S) | R(E) | No. on fig. 17 |
|---|---|---|---|
| NE¼NE¼ 36 | 10 | 9 | 44 |
| NE¼NE¼ 27 | 11 | 13 | 45 |

The specific gravity ranges from 2.39 to 2.58 and the Los Angeles test loss ranges from 32 to 35 percent.

The Elmont limestone formation, a hard blue-gray stone 2 to 4 feet thick, occurs in the northeast under the Tarkio limestone. The formation is not readily available as outcrops are close to flood plain levels.

## Cement

A lime kiln and a cement plant were located a mile east of Alma in 1890 in the SE¼ of sec. 11, T. 12 S., R. 10 E. The plants operated but a short time although a good grade of portland cement was produced. Cottonwood and Neva limestones supplied the lime component and the Red Eagle and Johnson formations furnished the shale component from quarries Nos. 7, 8, and 9 (fig. 17) in the same quarter section. An abundance of these outcrops occur throughout the County, sufficient for a revived cement industry.

## Mineral wool

Florence and Wreford flinty limestones, together with nearby limestones and shales, are extensive throughout the County and, although they have not been utilized, are suitable for the manufacture of mineral wool.

## Salt

Alma was a small salt center about 1890. Salt was produced by evaporating brine waters which seeped into shallow wells. The industry ceased when the brine wells of Reno County began production.

## Agricultural limestone

Agricultural limestone is imported into Wabaunsee County from the east. The County has, however, an abundance of limestone suitable for grinding into agricultural limestone.

## Coal

Coal was produced about 1890 for a limited time from a 700-foot shaft in the SE¼ SW¼ of sec. 11, T. 12 S., R. 10 E.

(24, fig. 17). The coal probably came from the Nodaway horizon—a seam usually less than 2 feet thick (fig. 4).

The Lorton seam, 2 to 9 inches thick, extends throughout the County and a little has been mined for local consumption. The Lorton seam is 20 to 30 feet below the Brownville limestone which is mapped on figure 17.

Thin seams of Permian coal are reported in the Hawxby shale (fig. 3).

The coals are high-volatile grade C bituminous and are not commercial at this time.

Oil and gas (6 and 29)

Oil was discovered in 1949 in the Davis Ranch Pool in sec. 33, T. 13 S., R. 10 E. (22, fig. 17), and 46,659 barrels of oil was produced during the year. Initial production was 2,580 barrels a day from the Viola limestone at a depth of 3,200 feet. The tops of the wells are in the Wreford horizon.

In 1950, the Woodbury Pool was discovered in sec. 11, T. 15 S., R. 10 E. (23, fig. 17). Oil production in Wabaunsee County in 1950 was 356,615 barrels (5).

A capped well in the SE¼ of sec. 9, T. 12 S., R. 10 E. (21, fig. 17), near Alma, contains some helium gas.

There were no oil or gas lines in Wabaunsee County in the summer of 1949.

## ELECTRIC POWER (fig. 9)

Kansas Power & Light Co. has a 33,000-volt transmission line from Wamego to Alma. A 13,200-volt line from Osage County services Harveyville, Eskridge, and Lake Wabaunsee.

The 66,000-volt transmission line from the Tecumseh power plant in Shawnee County crosses westward through the center of Wabaunsee County. No power is produced within the County.

Rural Electrification Administration purchases power for distribution into rural areas.

## WATER

The alluvials of the Kansas River have an abundance of water. Water is obtainable in Mill Creek and from wells sunk to the Cottonwood limestone and to porous lenses in glacial deposits. Collecting ponds for entrained run-off waters are used when necessary.

## LYON COUNTY

### PHYSICAL FEATURES

Lyon County lies on the Osage Plains of Kansas with its northwest corner bordering in the Flint Hills, (fig. 1). Only the northeast corner is within the Missouri River Basin. Altitudes along the Missouri-Arkansas drainage divide range from 1,200 to 1,350 feet above sea level. The country is rolling, dissected moderately by young drainage systems flowing intermittently northward toward the Missouri Basin and southward toward the Arkansas Basin. The Neosho River, a tributary of the Arkansas Basin, flows southeastward past Emporia and the center of the County at altitudes of 1,100 to 1,050 feet (fig. 18).

Three railroad systems serve Lyon County. A main line of the Atchison, Topeka & Santa Fe Railroad enters from the west and branches at Emporia, the county seat. One line continues east in the Neosho River Valley and the other traverses northeast through Reading. A main line of the Missouri Pacific Railroad crosses the northern part east to west through Admire and Bushong. The Missouri, Kansas & Texas crosses the County diagonally running northwest up the valley of the Neosho River, passing through Emporia.

Secondary roads checkerboard the County at intervals of 1 and 2 miles with larger intervals in the northwest and southwest due to a more rugged topography. The main paved highways are shown on figure 18.

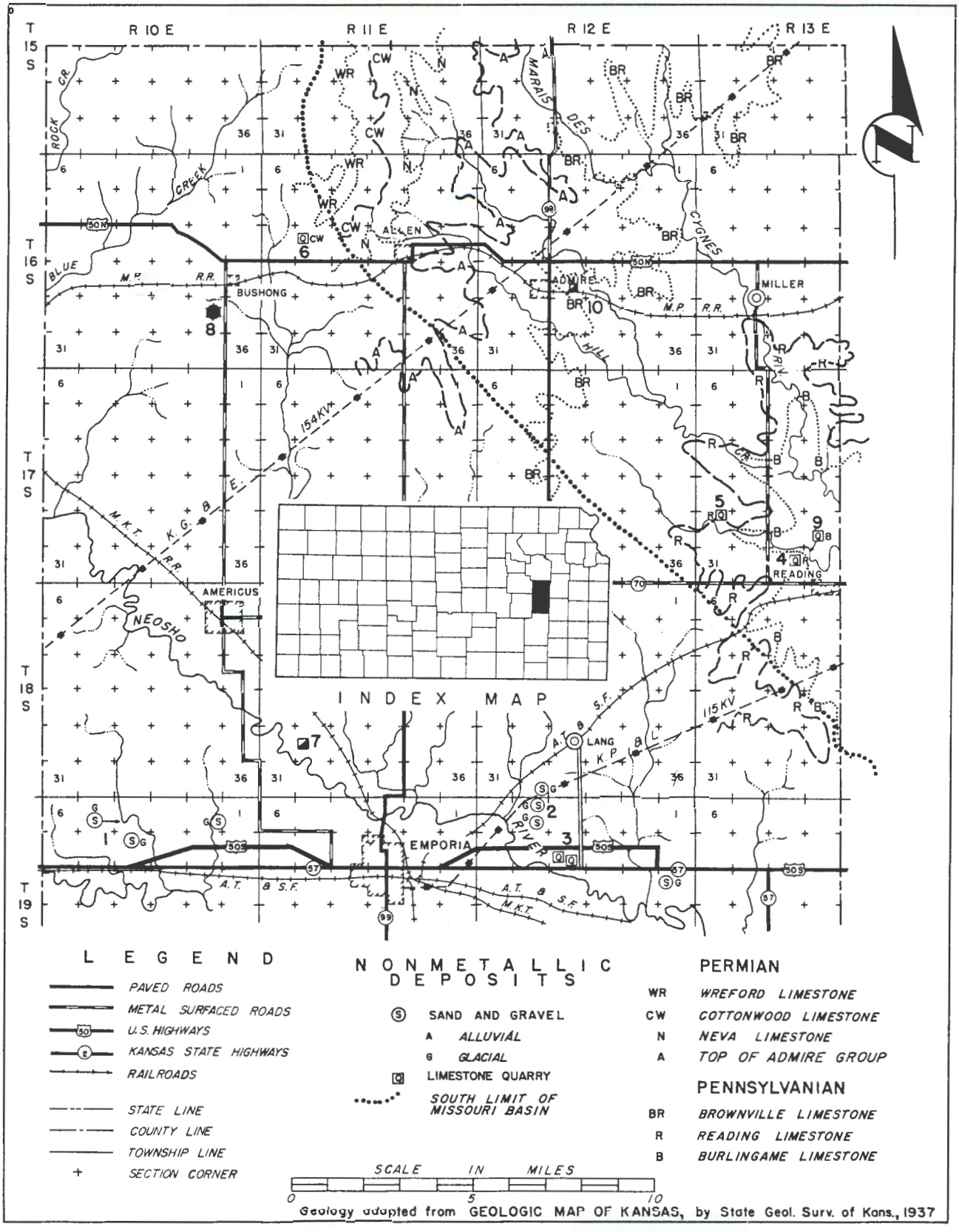



Figure 18.- Lyon County, Kansas

F3-K161-R

## GEOLOGY

Lyon County is covered by glacial till, residual soil, and areas of chert stream gravel.

The consolidated geological formations outcropping in the County range from the Wreford in the northwest down to the Topeka in the southeast (figs. 3 and 4). The major limestones outcropping in the Missouri Basin, named in order of age, the youngest first (figs. 3 and 18), are: Wreford, Cottonwood, Neva, Brownville, Tarkio, Elmont, Reading, and Burlingame. All are mapped on figure 18 except the Elmont limestone which lies a short distance above the Reading limestone and is poorly exposed in the County.

## MINERAL RESOURCES

The northeastern part of Lyon County, the only part within the Missouri Basin area (fig. 18), has no alluvial sand-gravel deposits. There are many available sites for limestone quarries and a number of idle quarries but the 1950 production of limestone was less than 5,000 tons.

The County produced, in the area south of the Missouri Basin, about 75,000 tons of stream gravel for use as road metal on secondary roads and has one fully equipped limestone quarry which was idle in the winter of 1950-51.

The County produced 423,608 barrels of oil in 1949, of which 90 percent was from the Atylo Pool in the southwest corner. Secondary production by salt water-flooding methods accounted for 90 percent of the oil.

## Sand-gravel

No alluvial sand-gravels are produced in Lyon County, though they may occur, highly silt-diluted, in the Neosho River. A belt of stream gravel, 12 to 14 miles long and about 10 feet thick and containing well-rounded, flint-like pebbles and some clay, occurs north of Highway 50, extending from sec. 8, T. 19 S., R. 10 E. (1, fig. 18) to sec. 4, T. 19 S., R. 12 E. (2, fig. 18), interrupted by the Neosho River and recent drainage courses. Little or no overburden exists and neither screening nor washing is necessary. Many gravel pits are located on this belt but none were in operation in January 1951. These gravels are used for road metal on many of the secondary roads and their easy availability discourages the operation of limestone quarries for that purpose.

The hills of southwestern Lyon County are covered by large quantities of rounded limestone gravel, up to 3 inches in diameter, which is used locally for road metal. There are no regularly operated pits.

## Limestone (figs. 3, 4, and 18)

The Wreford limestone formation, containing two flinty limestone members (Schroyer and Threemile), each about 10 feet thick, is very plentiful in the northwest part of the County but has been used very little. When crushed to 1½-inch and finer, the members make good road metal and railroad ballast but the material has sharp edges.

The Cottonwood and Neva limestone members, 4 to 5 feet and 6 to 7 feet thick, respectively, outcrop conspicuously and abundantly in the southwest and northwest quarters. Either can be used as building stone, cut stone, riprap, and road metal. Neither limestone is recommended as concrete aggregate and neither has been quarried, except in one instance, when an abandoned Cottonwood quarry in the SE¼ NW¼ of sec. 17, T. 16 S., R. 11 E. (6, fig. 18) supplied stone for building a stretch of Highway 50N.

The Five Point and Aspinwall limestone beds, under glacial till, are not available for exploitation.

The Brownville limestone formation, not a useful bed, is mapped on figure 18, because it marks the top of the Pennsylvanian system and is close to the outcrop of the Lorton coal seam.

The Elmont limestone formation, poorly exposed, is not mapped.

The Reading limestone formation, 2 to 4 feet thick and outcropping in northeast Lyon County, is mapped on figure 18. The stone is suitable for concrete aggregate, building stone, riprap, and road metal. A few thousand tons of rock lie broken in a quarry in the NE¼ of sec. 30, T. 17 S., R. 13 E. (5, fig. 18), and a portable crusher occasionally is brought to crush a batch of stone for concrete aggregate. An abandoned water-filled quarry is found in the SW¼NE¼ sec. 33, T. 17 S., R. 13 E. (4, fig. 18).

The Burlingame limestone formation outcrops continuously from north to south in the eastern part of the County but often under a cover of glacial till. Where available, it consists of 5 to 7 feet of rust-colored limestone with some shale parting. Two quarries, one abandoned and the other inactive but fully equipped for operation, are found about 5 miles east of Emporia in the S½ of sec. 9, T. 19 S., R. 12 E. (3, fig. 18). North of Reading in the NW¼ of sec. 34, T. 17 S., R. 13 E. (9, fig. 18), an abandoned quarry shows about 6 feet of Burlingame limestone.

Coal (12)

The Norton coal seam, usually less than 12 inches thick, is 17 inches thick in one locality in the W½ of sec. 29, T. 18 S., R. 11 E. (7, fig. 18). An old Norton coal shaft is located near the center of sec. 21, T. 16 S., R. 12 E. (10, fig. 18).

Nodaway coal, under the Church limestone member (fig. 4), is 4 to 12 inches thick in southeastern Lyon County. Both Nodaway and Norton coals are high-volatile class C bituminous coals and have been mined for local use in the past but are no longer economical to produce.

Oil and gas (6)

A small discovery-well, brought in near Bushong in the NE¼ of sec. 26, T. 16 S., R. 10 E. (8, fig. 18) early in 1950, produced 4,334 barrels of oil that year (5). This well is not

within the Missouri Basin but its production may be related to the new discoveries a few miles north within the Basin in Wabaunsee County.

Oil production of Lyon County was 423,608 barrels in 1949 from pools near the south border and outside the Missouri Basin. Of this total, 393,249 barrels was secondary production by salt-water flooding methods. Production is from the Bartlesville sand at depths of about 1,925 feet.

The multiple gas line (24 and 26-inch) of the Panhandle Eastern Pipe Line Co. crosses the southern part of the County. The company has a compressing station 8 miles south of Emporia, consisting of ten 800-h.p., six 1300-h.p., and two 1600-h.p. units, representing a total of 18 units and 19,000-h.p. The plant has an electrical unit for pumping water purchased from the city of Emporia.

Cities Service Gas Co. has two principal gas mains crossing the County and supplies gas to Emporia (fig. 8).

Socony-Vacuum Oil Co. has a 6-inch oil products line traversing the County and a pumping station north of Emporia.

## ELECTRIC POWER

The Kansas Gas & Electric Co., 154,000-volt transmission line from the Midian substation in Butler County to Omaha, Nebr. crosses northwest Lyon County.

The Kansas Power & Light Co. has a 115,000-volt transmission line from Tecumseh (Shawnee County), passing through Emporia. The company services the County through 34,500-volt lines and sells power to the Rural Electrification Administration for distribution into rural areas. The company also operates a steam-generating, electric plant of 8,000-kw. capacity at Emporia (fig. 9).

## WATER

The alluvials of the Neosho and Cottonwood Rivers carry an abundance of water, but the city of Emporia prefers to obtain softer water from a lake 28 miles northwest of the city. Water is obtainable in northern Lyon County from wells to the Cottonwood limestone and Marais des Cygnes alluvials and from collecting ponds.

# COFFEY COUNTY

## PHYSICAL FEATURES

Coffey County lies in the Osage Plains of Kansas (fig. 1). Only the northern border and the northeastern section of the County are within the Missouri River Basin. The terrain on the Missouri-Arkansas divide, flat and about 1,200 feet above sea level, slopes gently northward and is moderately dissected by the young northward, intermittently-flowing creeks which, at the north border, have reliefs of about 100 feet and minimum altitudes of 1,000 feet.

Three railroad systems serve Coffey County. A main line of the Atchison, Topeka & Santa Fe cuts the northwest corner, passing through Lebo. A branch line of the Santa Fe, entering the northeast corner, runs southwest through Waverly and Burlington, the county seat, and terminates at Gridley. The Missouri, Kansas & Texas Railroad enters from the south and runs northwest in the Neosho River Valley through Burlington and Strawn. The Missouri Pacific Railroad cuts the southeast corner, passing through LeRoy (fig. 19).

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 19.

## GEOLOGY

The soil of Coffey County, within the Missouri Basin, is mostly residual with some glacial till.

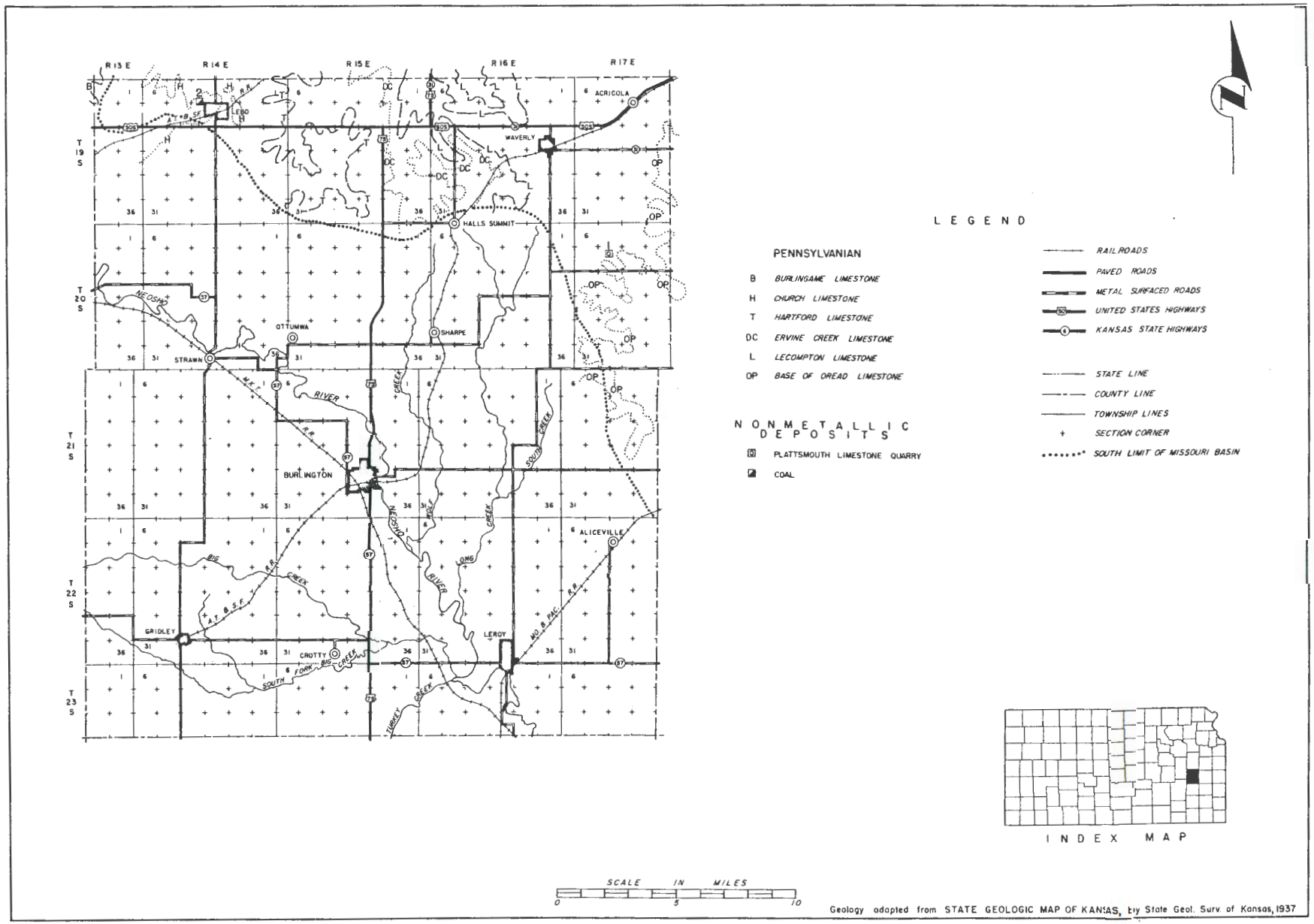



Figure 19.- Coffey County, Kansas

The consolidated geological members outcropping range from the Burlingame limestone in the northwest corner to the Douglas shales in the northeast. The important limestone beds exposed in the Basin area of the County, named in order of age, the youngest first (figs. 4 and 19), are: Burlingame, Church, Topeka, Deer Creek, Lecompton, and Plattsmouth.

## MINERAL RESOURCES

The Missouri Basin area of Coffey County has no sand-gravel deposits. Limestone is abundant in the eastern part but no quarries were active. A small coal-stripping operation was started near Lebo in the fall of 1950. The County produced 107,394 barrels of oil in 1950, but none of it originated in the Basin area.

### Limestone

The Burlingame limestone formation outcrops only in the extreme northwest corner of the County and is not quarried. The bed, about 6 feet thick, is useful for concrete aggregate (if not discolored), road metal, riprap, and agricultural limestone.

The Church limestone member, about 2 feet thick, serves only as a marker for the Nodaway coal.

The Topeka limestone formation, with its principal members (the 8-foot Curzon and 4-foot Hartford limestones), is abundant and suitable for road metal but is not quarried in the Basin area of the County.

The Deer Creek limestone formation, with its 15-foot Ervine Creek limestone as the useful member, is also abundant but not quarried in the Basin area. It is suitable for concrete aggregate, riprap, road metal, and agricultural limestone.

The Lecompton limestone formation is plentiful but never used because of nearby occurrences of thicker limestones.

The Plattsmouth limestone member, usually 16 to 20 feet thick, is the most valuable and plentiful limestone in the County. The stone is used for concrete aggregate, riprap, road metal, and agricultural limestone. An idle quarry is located in sec. 8, T. 20 S., R. 17 E. (1, fig. 19). The Plattsmouth limestone ordinarily makes prominent east-facing escarpments.

## Coal

The upper Williamsburg coal seam (fig. 4) is found in eastern Coffey County close to the base of the Oread limestone formation, but is of no economic importance. Many years ago a few thousand tons were mined for local use. The seam was seldom over 6 inches thick.

The Nodaway coal seam lies under the Church limestone member (fig. 4) and outcrops in northwestern Coffey County (fig. 19). The seam is 13 to 15 inches thick and of the same quality as that described in the Osage County report. About 155,000 tons of coal were mined prior to 1900, but very little has been mined since (12). H. A. Rogers Coal Co., formerly operating in Osage County, began, in the fall of 1950, a small stripping operation north of Lebo in sec. 4, T. 19 S., R. 14 E. (2, fig. 19).

### Oil and gas (6)

Coffey County produced 25,551 barrels of oil in 1949 from five fields in the southern and southwestern parts. Production increased in 1950 to 107,394 barrels (5). None of the production originated within the Missouri Basin area. Production was from the Bartlesville (near the base of the Pennsylvanian), the Burgess (near the top of the Mississippian), and lower Mississippian horizons at depths of 1,585 to 1,878 feet. The fields were discovered from 1917 to 1922. Sub-Mississippian rocks (Arbuckle and Bonneterre dolomites and Lamotte sandstone) are present in Coffey County but have not proved to be productive.

Standish Pipe Line Co. has an 8-inch crude oil line and Phillips Petroleum Co. an 8-inch oil-products line crossing the County.

Union Gas Co. brings gas to Burlington and other towns in the County through a 6-5/8-inch line from the south (fig. 8).

## ELECTRIC POWER

Kansas Power & Light Co. supplies northern Coffey County over a 34,500-volt transmission line from Emporia (Lyon County) (fig. 9).

## WATER

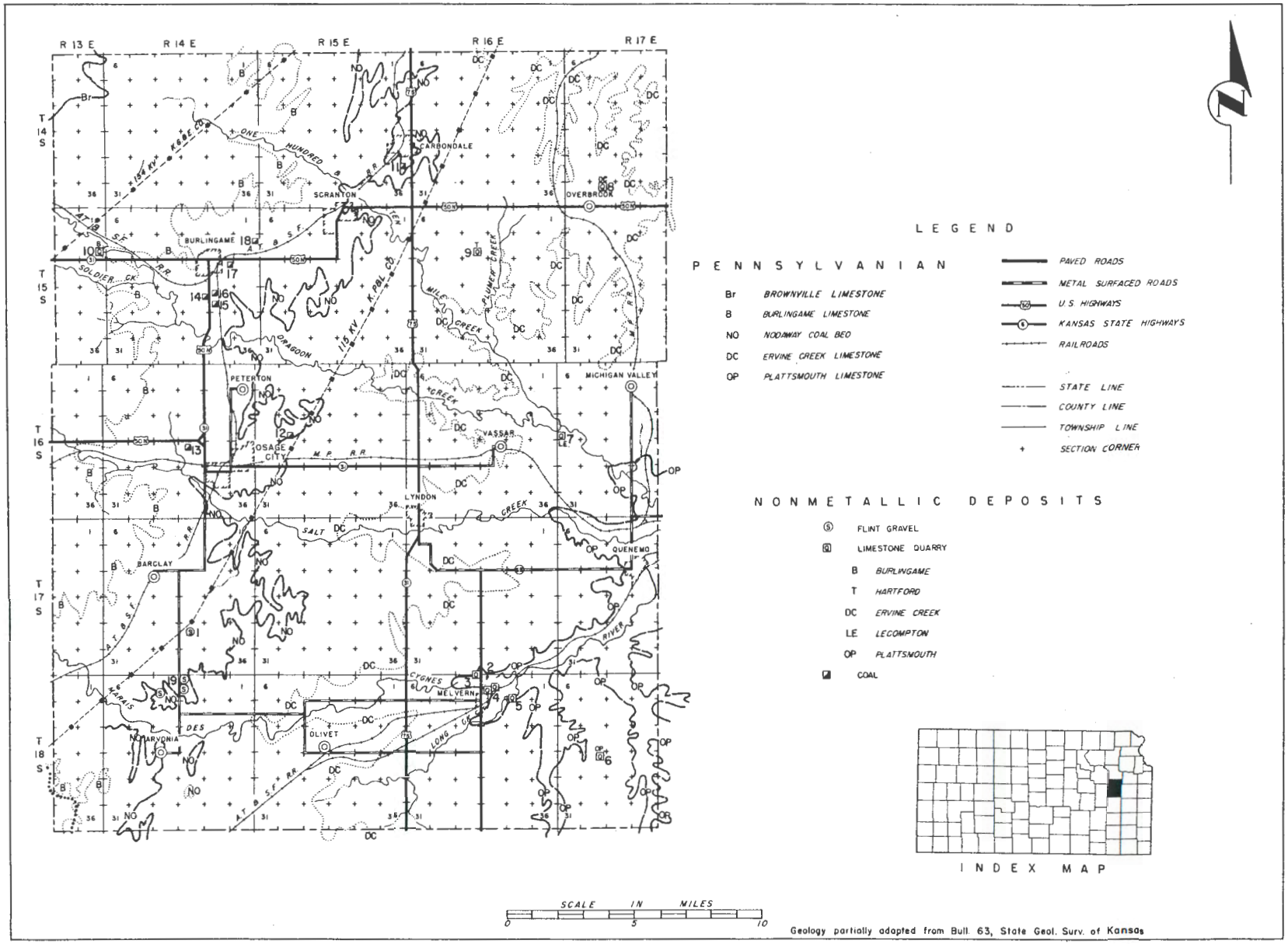
The water-bearing alluvials of the Neosho River traverse the center of the County diagonally in a southeast direction. The Missouri Basin area of the County, short of water, depends on collecting ponds and shallow wells to the Topeka and Oread limestones.

## OSAGE COUNTY

### PHYSICAL FEATURES

Osage County lies in the Osage Plains of Kansas (fig. 1). The Marias des Cygnes River flows eastward across the southern part and, with its three main tributaries from the northwest, drains all of the County except the northeast and north border (fig. 20). Altitudes on the divide near the north border are 1,200 to 1,250 feet above sea level. The river and its tributaries sharply dissect the terrain. River-level altitude on the east border is about 950 feet. The escarpments of the Oread limestone, outcropping in the southeast, are prominent features.

Two railroad systems serve Osage County. The main line of the Atchison, Topeka & Santa Fe Railroad from Emporia (Lyons County) cuts the southeast corner diagonally, passing through Olivet and Quenemo. The Topeka branch of the Santa Fe from Emporia crosses western Osage County in a northeast direction, through Osage City, Burlingame, and Carbondale. Another branch of the Santa Fe runs northwest from Burlingame to Alma in Wabaunsee County. The Missouri Pacific Railroad crosses westward through the center, passing through Osage City. From this line near Quenemo, a branch of the Missouri Pacific runs northward along the east border of the County to Pacific runs northward along the east border of the County to Topeka (Shawnee County). Lyndon, the county seat, is not on a railroad.




Geology partially adapted from Bull. 63, State Geol. Surv. of Kansas

Figure 20.- Osage County, Kansas

Secondary roads checkerboard Osage County at intervals of 1 and 2 miles. Cross roads are irregular in rugged areas such as the basin of the Marais des Cygnes River and the lower reaches of its chief tributaries. The main paved highways are shown on figure 20.

## GEOLOGY

Glacial till and residual soil cover most of Osage County. In the southwest part, many hilltops are covered by a thin blanket of glacial stream gravel.

The consolidated geological formations outcropping in the County range from the Admire shales in the northwest corner down to the upper Douglas shales in the southeast. The major outcropping limestone beds, named in order of age, the youngest first (figs. 3, 4, and 20), are: Brownville, Tarkio, Elmont, Reading, Burlingame, Church, Curzon, Hartford, Ervins Creek, Lecompton, and Plattsmouth (fig. 20). The Tarkio, Elmont, and Reading limestones are not mapped on figure 20, as they are available only in a small area in T. 15 S., R. 13 E., between the west border and the Burlingame limestone outcrops. The Church limestone bed is mapped since it is in the Nodaway coal horizon. The Curzon and Hartford beds are not mapped; they outcrop in many places but are not important in Osage County.

## MINERAL RESOURCES

Osage County has no alluvial sand-gravel deposits. Sand-gravels for concrete aggregates are shipped in from the Kansas River at Topeka. The southwest part of the County has large

quantities of flinty, glacial gravels. Quarries produce annually about 10,000 tons for road metal on secondary roads.

Limestone occurs in abundance. A commercial quarry in southeast Osage County produces crushed limestone in moderate quantity of which 15 percent is agricultural limestone. Two idle and dismantled quarries have produced over 100,000 tons of crushed limestone for road metal during the past three years.

About 12,000,000 tons of coal have been mined from the Nodaway seam since 1869 with a maximum annual production of 453,000 tons in 1890. The 1950 production was 36,000 tons. The seam, 12 to 20 inches thick, is high-volatile grade C bituminous coal.

### Sand-gravel

Glacial stream gravel deposits, 3 to 5 feet thick and ordinarily without overburden, occur on many hilltops in the southwest part of the County. Contractors for Barclay Township and Osage County were excavating gravel in early 1951 for secondary roads from the SW¼NE¼ of sec. 27, T. 17 S., R. 14 E. (1, fig. 20). The gravel contains rounded flint pebbles, less than 2 inches in diameter, and sufficient clay as binding material. No screening is necessary. It is not suitable for concrete aggregate. Other flint gravel deposits occur in secs. 3 and 4, T. 18 S., R. 14 E. (19, fig. 20).

## Limestone

The Brownville limestone formation, not commercial, is mapped on figure 20 since it marks the top of the Pennsylvanian series.

The Tarkio, Elmont, and Reading formations, the first 4 to 5 feet thick and each of the others 2 to 3 feet thick, outcrop in a small area in T. 15 S., R. 13 E., west of the Burlingame limestone outcrop. None of them is an important limestone in Osage County.

The Burlingame limestone formation outcrops in the western part of the County. Although the bed is frequently buried under glacial till, the limestone is available in many places. Perry Jones of Lawrence, Kans., recently quarried, in the SE¼ of sec. 12, T. 15 S., R. 13 E. (10, fig. 30), light-rust-colored limestone for use as road metal. Two idle pits show 4 to 6 feet of limestone.

The Church limestone member, about 2 feet thick and not commercial, is mapped on figure 20 as a marker for the Nodaway coal seam which lies 5 to 12 feet beneath and outcrops to the east.

The Topeka limestone formation, used very little, outcrops conspicuously in eastern Osage County and usually shows 4 feet of rusty Hartford limestone and less than 6 feet of Curzon limestone separated by a thin shale. A small quarry, used locally to supply stone for the construction of fences and farm building foundations, is found in the SW¼SE¼ of sec. 9, T. 15 S., R. 16 E. (9, fig. 20).

The Deer Creek limestone formation, of which the 16-foot Ervine Creek limestone is the principal member, outcrops conspicuously and abundantly in northeastern Osage County. Although ocurring also in southeastern and southern parts, it is generally buried under glacial till. A quarry in the NW¼NE¼ of sec. 32, T. 14 S., R. 17 E. (8, fig. 20), has produced crushed rock for use as road material and concrete aggregate.

The Lecompton limestone formation, with 4 to 5 feet of limestone outcrops conspicuously east of Lyndon. The stone is not commercially important because of abundant thicker beds nearby. An abandoned quarry, used to supply road metal, is found in the SW¼ of sec. 18, T. 16 S., R. 17 E. (7, fig. 20).

The Plattsmouth limestone member, 21 feet thick and the most important limestone bed in the County, outcrops abundantly in the southeast part, south and east of Quenemo and Melvern. It is suitable for concrete aggregate, riprap, road metal, railroad ballast, and agricultural limestone.

Dusenburg Concrete & Material Co., operating a quarry and crushing plant in the SW¼ of sec. 3, T. 18 S., R. 16 E. (2, fig. 20), produces crushed limestone. Agricultural limestone constitutes 15 percent of the production and road metal most of the remainder.

Idle Plattsmouth quarries are found in the following places:

| Sec. | T(S) | R(E) | No. on fig. 20 |
|---|---|---|---|
| NE¼NE¼ 4 | 18 | 16 | 3 |
| Center 3 | 18 | 16 | 4 |
| SW¼SW¼ 2 | 18 | 16 | 5 |
| NE¼ 20 | 18 | 17 | 6 |

Coal (12)

The Hodaway coal seam, 12 to 20 inches thick and 4½ to 12 feet below the Church limestone, outcrops in a northeast-southwest direction through the center of Osage County. The coal has been mined by stripping methods and by shallow shafts in which longwall mining methods were used. Coal mining has been active more than 80 years and, in early days, industry centered in areas where the coal seam was thickest. In 1950, five shaft mines and two strip mines produced 36,000 tons of the coal.

The coal is high-volatile, grade C bituminous with low fusion ash. It decrepitates on standing, is subject to spontaneous combustion and, therefore, does not store well. Analyses of two samples are submitted (21):

| | Oxbow Coal Co. R/M as received, percent | Linville & Son R/M as received, percent |
|---|---|---|
| Moisture | 8.20 | 10.36 |
| Volatile matter | 47.98 | 38.03 |
| Fixed carbon | 37.18 | 45.64 |
| Ash | 6.64 | 5.97 |
| | 100.00 | 100.00 |
| Sulfur | 5.08 | 2.83 |
| B.t.u. | 10,776 | 11,982 |

Coal operators from southeast Kansas have test drilled part of Osage County and have decided that large-scale operations are not justified. Undoubtedly, one of the reasons may be the previously-mentioned difficulty involved in storage.

The commercially recoverable reserve of strip-minable coal within the County is about 3,000,000 tons. The recoverable deep mine coal within 2 or 3 miles of the outcrop is about 25,000,000 tons. The shaft mines produce lump coal only, which sells for $7 a ton at the tipple. For industrial use it is not competitive with coal in southeast Kansas, which averages $4 a ton at the tipple.

Linville & Son, at Carbondale in the E½ of sec. 25, T. 14 S., R. 15 E. (11, fig. 20), use a bulldozer to remove about 15 feet of overburden from a coal seam 15 inches thick/

Oxbow Coal Co., in Osage City in the S½ of sec. 17, T. 16 S., R. 15 E. (12, fig. 10), use a 2W Monighan dragline and a Link Belt Coal loader. The overburden, 20 feet thick, includes the 2-foot Church limestone 12 feet above the coal.

Parre Bros. operate a coal mine, with a 116-foot shaft, west of Osage City in the NE¼NW¼ of sec. 22, T. 16 S., R. 14 E. (13, fig. 20), producing from a 14- to 15-inch seam.

Central Coal Co. has two shafts south of Burlingame. No. 2 shaft, not operating in 1950, is in the SE¼ NE¼ of sec. 22, T. 15 S., R. 14 E. (14, fig. 20). No. 3 shaft, 110 feet deep and in the SW¼ of sec. 23, T. 15 S., R. 14 E. (15, fig. 20), produced in 1950 from a seam 18 inches thick.

W. I. Isaacs, operating Bell No. 4 with a 120-foot shaft, south of Burlingame in the NW¼ of sec. 23, T. 15 S., R. 14 E. (16, fig. 20), produces from a bed 15 to 18 inches thick.

J. C. Coal Co. (James Curley of Osage City), operating through a 114-foot shaft, east of Burlingame in the NE¼ of sec. 14, T. 15 S., R. 14 E. (17, fig. 20), produces from a seam 18 inches thick.

Kansas Coal & Mining Co., operating the 130-foot shaft of the Alcorn mine, northeast of Burlingame in the NE¼ of sec. 12, T. 15 S., R. 14 E. (18, fig. 20), produces from a seam 18 to 20 inches thick.

### Oil and gas (11)

Potential oil and gas-bearing strata underlie Osage County. About 40 test wells, most of which did not go below the Pennsylvanian-Mississippian contact, have been drilled without encountering commercial production.

Cities Service Gas Co. has a multiple gas line through southern Osage County and a service line supplying gas to Lyndon (fig. 8).

## ELECTRIC POWER

The 154,000-volt transmission line of the Kansas Gas & Electric Co., from Midian (Butler County) to Omaha, Nebr., crosses the northwest corner of the County (fig. 9). The 115,000-volt transmission line of the Kansas Power & Light Co., from Tecumseh

(Shawnee County) to Emporia (Lyon County), crosses the County diagonally northeast to southwest.

Northern Osage County is serviced by the Kansas Power & Light Co. through 13,200-volt lines from Shawnee County with a 6,800-volt line to Overbrook.

Burlingame has a municipal, internal combustion electric plant of 585-kw. capacity, and Osage City has a similar type municipal plant of 1,671-kw. capacity.

Rural Electrification Administration purchases power from the Kansas Power & Light Co. and distributes it into rural areas.

## WATER

Water is obtained from the alluvials in the Marais des Cygnes River. The remainder of the County depends on collecting ponds and upon shallow wells to porous lenses in minor water courses usually without water in dry seasons.

## SHAWNEE COUNTY

### PHYSICAL FEATURES

Shawnee County lies in the Osage Plains of Kansas (fig. 1). The Kansas River flows eastward through the center at altitudes ranging from 900 to 850 feet above sea level and, with its tributaries, drains most of the County. The Wakarusa River flows east near the southern border and joins the Kansas River in Douglas County. The highest points in the County are along the north and south borders where altitudes range from 1,250 feet in the southwest to 1,050 feet in the northeast. The topography is typical of rolling country, dissected by tributary creeks, and is steep and rugged bordering the flood plains of the Kansas River (fig. 21). The major limestone outcrops form gentle east-facing escarpments.

Four railroad systems serve Shawnee County. A main line of the Union Pacific crosses east to west on the north side of the Kansas River, passing through Topeka, the State Capitol. A few miles west of Topeka, a branch line leads off to the northwest. The Atchison, Topeka & Santa Fe, entering the County from the east and on the south side of the Kansas River, runs to Topeka where the main line swings south to Emporia and a branch line goes north to Atchison. The Chicago, Rock Island & Pacific enters from the north and at Topeka swings west on the south bank of the Kansas River. A branch line of the Missouri Pacific comes in at the southeast corner and runs northward to its terminal at Topeka.

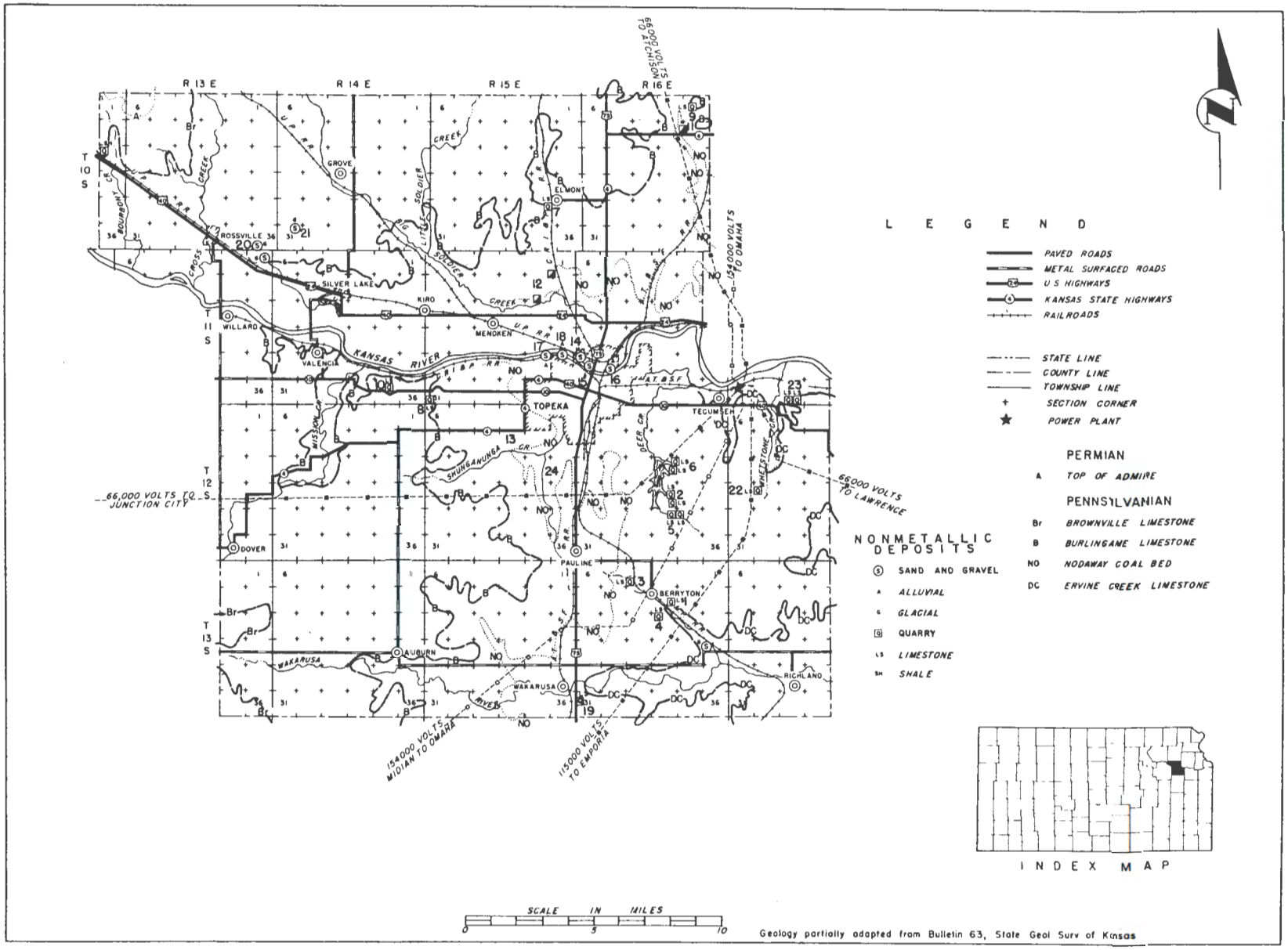



Figure 21.- Shawnee County, Kansas

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved roads are shown on figure 21.

## GEOLOGY

Glacial till and loess cover most of Shawnee County, the loess being heaviest on the north bank of the Kansas River.

The consolidated geological members outcropping in the County, range from the Permian, Admire group, in the northwest and southwest corners down to the Pennsylvanian, Plattsmouth limestone, the top of which outcrops at the east border near the Kansas River (fig. 21). The major limestone beds exposed, named in order of age, the youngest first (figs. 2, 3, 4, and 21), are: Brownville, Dover, Tarkio, Elmont-Reading, Burlingame, Church, Topeka, Ervine Creek, Lecompton, and Plattsmouth.

## MINERAL RESOURCES

The Kansas River contains an abundance of sand-gravel, and five plants in or near Topeka produce about 360,000 tons annually. Limestone also occurs in abundance in Shawnee County and is quarried for road metal, concrete aggregate, building stone, and agricultural limestone. Production for 1950 amounted to about 170,000 tons of concrete aggregate and road metal, 8,000 tons of agricultural limestone, and 1,500 tons of foundation rock or building stone. The County produces no coal or oil, and its common red brick industry terminated long ago.

## Loess

Loess deposits occur in areas close to the Kansas River and are a potential source material for soil-cement blocks, mineral filler for road mats, and lightweight or dense calcined aggregates. The Economy Building Block Machine Co. of Topeka makes a soil-cement block machine that intimately mixes 10 or 12 percent of cement with loess and compresses the mixture to 1,000 p.s.i. to form blocks resembling sandstone.

## Sand-gravel

Glacial till, found near the Kansas River, contains buried glacial stream gravel formerly used as road metal on secondary roads. Idle gravel pits are located in the NE¼ of sec. 1, T. 11 S., R. 13 E. and in the SW¼ of sec. 36, T. 10 S., R. 13 E. (20, fig. 21), and in the NE¼ of sec. 31, T. 10 S., R. 14 E. (21, fig. 21).

Sand-gravel deposits in the Kansas River are constantly replenished by sedimentation. All sand-gravels in the County are alkali-reactive when used as concrete aggregate and should have an admixture of 30 to 40 percent neutral, coarse aggregate.

Consumers Sand Co. has a sand plant on the north side of the Kansas River in the NW¼ of sec. 30, T. 11 S., R. 16 E. (14, fig. 21). The plant employs a suction dredge with a 55-foot ladder with cutting chain.

Kansas Sand Co. operates two plants on the north side of the Kansas River, one in the NW¼ of sec. 30, T. 11 S., R. 16 E. (15, fig. 21) and the other in the center of sec. 29, T. 11 S., R. 16 E. (16, fig. 21). Both plants are electrically operated and use suction sand pumps on pontoons. Dried engine sand and standard grades of sand are produced.

River Sand Co. has a plant on the south side of the Kansas River in the NE¼ of sec. 26, T. 11 S., R. 15 E. (17, fig. 21), using an electrically-operated suction pump mounted on pontoons.

Victory Sand & Stone Co. operates a plant on the south side of the river in the NE¼ of sec. 25, T. 11 S., R. 15 E. (18, fig. 21). A steel barge supports a suction pump and a 35-foot ladder with cutter chain.

All the above plants have rail and truck facilities.

## Limestone

The Brownville limestone formation, 2 to 3 feet thick and not commercial, is mapped (fig. 21) because it marks the top of the Pennsylvanian system.

The Dover limestone formation, about 3 feet thick and not a useful stone, outcrops in the western part of the County.

The Tarkio limestone formation, 5 feet thick, also outcrops in the western part and, although not used in the County, is suitable for concrete aggregate and road metal.

The Elmont and Reading limestone formations, each 2 to 4 feet thick, likewise outcrop in the western area and, although not used in the County, are suitable for building stone.

Auburn reef, a local limestone bed 4 to 5 feet thick, lies below the Reading limestone. The Shawnee Limestone Co. was equipping a small quarry in November 1950 in the N½ of sec. 35, T. 11 S., R. 14 E. (10, fig. 21).

The Burlingame limestone formation (fig. 21), 4 to 7 feet thick and suitable for concrete aggregate if not iron-stained due to surface weathering, is abundant in the County. P. H. Netherland of Elmont, Kans., operates a quarry in the NE¼ of sec. 26, T. 10 S., R. 15 E. (7, fig. 21). The plant produces crushed stone for use as road metal because of its limonitic stain.

Henry C. Luttjohan produces crushed limestone from a quarry in the SW¼ of sec. 31, T. 11 S., R. 15 E. (8, fig. 21). About 8 percent of the product is agricultural limestone and the remainder is evenly divided as concrete aggregate and road metal. No washing is necessary.

An abandoned Burlingame quarry is found in sec. 2, T. 10 S., R. 16 E. (9, fig. 21).

The Church limestone member, 2 feet thick and not a commercial stone, outcrops diagonally across Shawnee County in an east of north general direction. It is mapped (fig. 21) as a tracer for the Nodaway coal seam, a few feet below.

The Topeka limestone formation, consisting of the 6- or 7-foot Curzon limestone and the 4-foot, massive, yellow, Hartford limestone separated by a foot or two of shale, outcrops abundantly in the County and has been used as building stone and road metal. F. E. Fritts was producing rectangular building blocks in the fall of 1950 from the Hartford bed in the NE¼ of sec. 22, T. 12 S., R. 16 E. (2, fig. 21), the only active quarry in the Topeka formation.

The Concrete Materials Co. of Topeka operated a quarry earlier in the year in Curzon and Hartford limestone in the SW¼ of sec. 4, T. 13 S., R. 16 E. (3, fig. 21). The crushed stone was used as road metal. Abandoned or idle Topeka quarries are found in the following places:

| Sec. | | T(S) | R(E) | No. on fig. 21 |
|---|---|---|---|---|
| NW¼ | 15 | 13 | 16 | 4 |
| SE¼ | 22 | 12 | 16 | 2 |
| NW¼ | 26 | 12 | 16 | 5 |
| NE¼ | 27 | 12 | 16 | 5 |
| E½ | 15 | 12 | 16 | 6* |
| NW¼ | 20 | 12 | 17 | 22 |
| SW¼NW¼ | 31 | 13 | 16 | 19 |

* Two quarries

The Ervine Creek limestone member ranges from a feather edge to 15 feet thick, depending on the amount of erosion. The stone is suitable for concrete aggregate, road metal, and agricultural limestone. A quarry, operated earlier in 1950 but idle in the fall, is found in the SE¼ of sec. 10, T. 13 S., R. 16 E. (1, fig. 21). Two abandoned quarries are found in the S½ of sec. 33, T. 11 S., R. 17 E. (23, fig. 21).

The Lecompton limestone formation, 4 to 6 feet thick, is not used because of the abundance of more desirable limestone beds. The Plattsmouth limestone member is an excellent stone but its limited occurrence in the County precludes its being an important stone.

## Coal (12)

Shawnee County has produced about 73,000 tons of coal, of which approximately 65,000 tons is from the Nodaway seam. The greatest annual production, 9,547 tons, was in 1889 (12). No coal has been mined in the County in recent years.

The Nodaway seam, 2 to 12 inches thick, lies 1½ to 6 feet below the Church limestone which can be traced across the County (figs. 4 and 21). Twelve-inch coal has been mined in the northeast corner of the County in the NE¼ of sec. 10, T. 10 S., R. 16 E. (11, fig. 21). Coal has also been mined northeast of Menoken in secs. 11 and 12, T. 11 S., R. 15 E. (12, fig. 21), and southwest of Topeka in sec. 10, T. 12 S., R. 15 E. (13, fig. 21). Some coal has been mined south of Topeka in sec. 13, T. 12 S., R. 15 E. (24, fig. 21).

Nodaway coal is high-volatile grade C bituminous with the following analysis (12):

| | As received |
|---|---|
| Constituent | Percent |
| Moisture ..... | 8.20 |
| Volatile matter ..... | 47.98 |
| Fixed carbon ..... | 37.18 |
| Ash ..... | 6.64 |
| | 100.00 |
| Sulfur ..... | 5.08 |
| B.t.u. ..... | 10,776 |

Nodaway coal decrepitates rapidly, is subject to spontaneous combustion, and consequently does not store well.

The Elmo coal seam, 2 to 16 inches thick likes above the Nodaway seam and 11 to 25 feet below the Burlingame limestone formation. It was mined in former years in a few places west of Topeka but neither seam is now economic.

Oil and gas (6)

Potential oil and gas strata underlie Shawnee County but 25 or more test wells have not found any commercial production.

Socony-Vacuum Oil Co. has oil product lines traversing the County and a pumping station near Tecumseh (fig. 8).

The Service Pipe Line Co. has a multiple crude oil line from Wyoming crossing the County. A plant at Washington (Washington County) pumps oil through two 12-inch lines into two 55,000-barrel open storage tanks at Elmont. A plant at Elmont, in turn, pumps the oil to Freeman, Mo., through three 10-inch lines. The Elmont station consists of two 7½ by 24-inch Triplex pumps and one 5½ by 24-inch Duplex pump driven by one 700-h.p. diesel, one 600-h.p. diesel, one 600-h.p. diesel, and one 250-h.p. diesel motors. The pumps operate under pressures up to 800 p.s.i. and have a daily capacity of 92,000 barrels.

Cities Service Gas Co. supplies gas to Topeka.

## ELECTRIC POWER

Kansas Power & Light Co. has a power plant on the Kansas River at Tecumseh, consisting of two 6,000-kw., one 15,000-kw., one 25,000-kw., and one 30,000-kw. units, a total installed capacity of 82,000-kw.

Transmission lines of 66,000 volts each extend from the plant to Atchison, Lawrence, and Junction City, and a 115,000-volt line extends from the plant to Hutchinson by way of Emporia.

Gas is the principal fuel. Some stoker and pulverized coal is used throughout the year and, during a few winter months, coal is used exclusively. Oil storage is provided. About 10 days are required to change from stoker coal to gas, or to reverse; gas, pulverized coal, or oil can be used under the boiler at the same time. The plant operates on a basis of approximately 14,000 B.t.u. a kilowatt hour.

Kansas Power & Light Co. furnishes power to the County over 33,000-volt, 13,200-volt, and 6,600-volt transmission lines.

Rural Electrification Administration purchases power for distribution into rural areas.

Kansas Gas & Electric Co. has a 154,000-volt transmission line from Midian to Omaha, Nebr., passing close to the power plant at Tecumseh. During World War II, the line tied in with the plant but is not now connected (1951) (fig. 9).

## WATER

The alluvials of the Kansas River have an abundance of water. Moderate amounts of water are available in the Wakarusa River and other tributaries to the Kansas River. Other parts of Shawnee County are dependent on collecting ponds or shallow wells to porous strata in minor water courses. These wells usually go dry during periods of little rainfall.

## JACKSON COUNTY

### PHYSICAL FEATURES

Jackson County lies east of the Flint Hills in the Osage Plains of Kansas (fig. 1). The western half drains south through Soldier Creek; the eastern half drains east into the Delaware River which flows southeast across the northeast corner. The terrain is rolling with altitudes of 1,050 to 1,200 feet along the south border, gradually rising to 1,400 to 1,500 feet above sea level in the northwest (fig. 22).

Soldier Creek cuts deeply into the uplands of the western part of the County, and numerous creeks in the southeast sector give that area a rugged topography.

Three railroads serve Jackson County. The Chicago, Rock Island & Pacific Railroad from Topeka runs north through the eastern half, passing through Mayetta, Holton (the county seat), and Whiting. The Missouri Pacific Railroad cuts the northeast corner in a westward direction through Whiting and Netawaka. The Union Pacific Railroad from Topeka crosses the southwest corner through Delia.

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 22.

### GEOLOGY

Jackson County has a heavy cover of glacial till and loess.

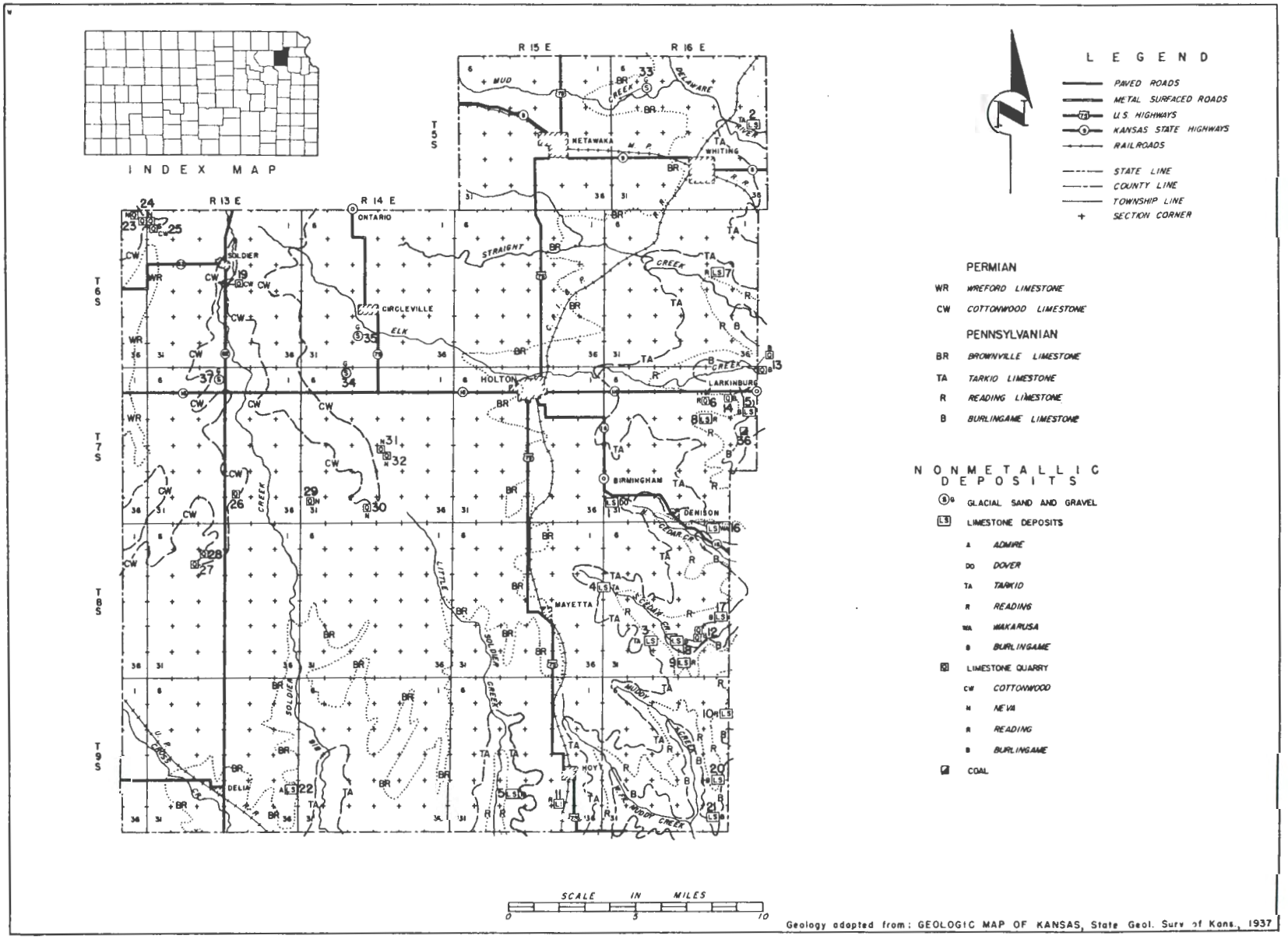



Figure 22.- Jackson County, Kansas

The consolidated geological members exposed in the County range from the Wreford limestone formation in the northwest to the shales below the Burlingame limestone formation appearing in a few places along the east border (figs. 2 and 22). The Brownville limestone, the top of the Pennsylvanian system, outcrops in a general east of north direction through the center of the County (figs. 3 and 4). The principal limestone beds outcropping, named in order of age, the youngest first (figs. 3, 4, and 22) are: Wreford, Cottonwood, Neva, Five Point, Aspinwall, Brownville, Dover, Tarkio, Elmont, Reading, and Burlingame.

## MINERAL RESOURCES

Jackson County has no alluvial sand-gravel deposits. Sand-gravels for concrete aggregate are shipped in from the Kansas River at Topeka or from the Blue River in Washington County. Some glacial gravel deposits occur but are no longer quarried. Limestone is found in abundance although many outcrops are buried under heavy glacial till. Two limestone quarries were active in the summer of 1949; other quarries were operated periodically. Annual production in the County is estimated as 120,000 tons of crushed stone and 20,000 tons of agricultural limestone. The County produces no oil or coal.

### Sand-gravel

Jackson County has no large rivers; consequently, no deposits of alluvial sand-gravel. Sand-gravel deposits of glacial origin are found in the northern part but none was operated in 1949. A shallow deposit has been worked in the NW¼ SW¼ of sec. 7,

T. 5 S., R. 16 E. (33, fig. 22). Glacial gravel occurs in the following places:

| Sec. | T(S) | R(E) | No. on fig. 22 |
|---|---|---|---|
| NE¼ 5 | 7 | 14 | 34 |
| SW¼ 28 | 6 | 14 | 35 |
| SE¼NE¼ 4 | 7 | 13 | 37 |

## Limestone

The Wreford limestone formation, consisting chiefly of the cherty Threemile limestone member about 10 feet thick, extends from Pottawatomie County into northwestern Jackson County. The formation covers the W½ of sec. 1, T. 7 S., R. 12 E. and the W½ of sec. 36, W½ of sec. 25, and sec. 24, T. 6 S., R. 12 E., and extends north to the southwest corner of sec. 6, T. 6 S., R. 13 E. (fig. 22). It is easily available and, when crushed, is suitable as road metal and railroad ballast.

The Cottonwood member is a massive 5-foot limestone. The Neva member, approximately 37 feet below, is much thicker but only about 7 feet of blocky and flaggy limestone is quarried. The beds occur in abundance but usually are buried under glacial till and are therefore available in comparatively few places. They are available, however, in northwestern Jackson County, on both sides of Soldier Creek south of Soldier, in the northern part of T. 8 S., R. 13 E. near the Pottawatomie County line, and in the central part of T. 7 S., R. 14 E.

Anderson & Oxendale of Horton are operating a Permian limestone quarry in the County in the SE¼NW¼ of sec. 22, T. 7 S., R. 14 E. (32, fig. 22), using a portable crushing plant to make road metal and agricultural limestone.

Idle Cottonwood and Neva quarries are found in the following places:

| Sec. | T(S) | R(E) | No. on fig. 22 | Member |
|---|---|---|---|---|
| NE¼NW¼ 1 | 6 | 12 | 23 | Neva |
| SE¼NE¼ 1 | 6 | 12 | 24 | Do. |
| SW¼NW¼ 6 | 6 | 13 | 24 | Do. |
| NW¼SW¼ 6 | 6 | 13 | 25 | Cottonwood |
| NE¼SE¼ 1 | 6 | 12 | 25 | Do. |
| NE¼SE¼ 16 | 6 | 13 | 19 | Do. |
| SE¼SW¼ 27 | 7 | 13 | 26 | Do. |
| NE¼SE¼ 8 | 8 | 13 | 27 | Neva |
| NW¼NW¼ 9 | 8 | 13 | 28 | Cottonwood |
| NE¼NW¼ 31 | 7 | 14 | 29 | Neva |
| SW¼NE¼ 33 | 7 | 14 | 30 | Do. |
| NW¼NW¼ 22 | 7 | 14 | 31 | Do. |

The Five Point and Aspinwall limestone beds, each only a foot or two thick, are suitable as building stone or riprap. They outcrop west of the Brownville formation (fig. 22) but usually under glacial till. Outcrops can be seen along Mud Creek in the northern part of the County and in T. 8 S., R. 14 E., west of conspicuous Brownville outcrops. They are also visible east of Delia in sec. 25, T. 9 S., R. 13 E. (22, fig. 22).

The Brownville limestone formation, 1 to 3 feet thick, is not a commercial stone but is mapped to show the top of the Pennsylvanian system.

Outcrops of the Dover limestone formation ordinarily are buried under glacial till. However, a conspicuous outcrop is found in the SW¼ NW¼ of sec. 31, T. 7 S., R. 16 E. (1, fig. 22). A hard rock, 2½ feet thick, it resembles Tarkio limestone with long fusuline fossils.

The Tarkio limestone formation, 5 feet thick and suitable for concrete aggregates, road metal and riprap, has not been quarried in the County but is available in places. The bed outcrops conspicuously in secs. 13, 23, and 24, T. 5 S., R. 16 E. (2, fig. 22). Tarkio limestone is available east of Mayetta in the E½ of sec. 29, T. 8 S., R. 16 E. (3, fig. 22) and along a creek from sec. 13, T. 8 S., R. 15 E. to sec. 18, T. 8 S., R. 16 E. (4, fig. 22). Other outcrops occur in sec. 8, T. 9 S., R. 16 E. and west of Hoyt in secs. 21, 28, 29, and 33, T. 9 S., R. 15 E. (5, fig. 22).

The Elmont and Reading limestone formation, each 2 to 3 feet thick, and separated by 3 to 10 feet of shale, are suitable for building stone and concrete aggregate. A quarry, once operating on Reading limestone in the SW¼ of sec. 2, T. 7 S., R. 16 E. (6, fig. 22), averaged 28 inches of quarry face. Reading or Elmont limestones, available in many places in the County, outcrop conspicuously in the N½ of sec. 14, T. 6 S., R. 16 E. (7, fig. 22) and in secs. 10, 11, 14, 23, and 24, T. 7 S., R. 16 E. (8, fig. 22). The formations are also available east of Mayetta in sec. 34, T. 8 S., R. 16 E. (9, fig. 22) and in bordering sections.

Farther south, Reading limestone outcrops in secs. 11, 14, and 23, T. 9 S., R. 16 E. (10, fig. 22) and in secs. 25, 26, 35, and 36, T. 9 S., R. 15 E. (11, fig. 22).

The Wakarusa limestone formation, a hard, brown stone 2½ feet thick, outcrops southeast of Denison on Highway 16 in sec. 3, T. 8 S., R. 16 E. (16, fig. 22).

The Burlingame limestone formation, the oldest Pennsylvanian limestone in the County, is found in abundance. George W. Baker of Halton has a portable crushing plant with primary and secondary crushers and screening units. The crushed rock is used as road metal and the finer is stored as agricultural lime. The quarry face, 6 to 8 feet of limestone, is hard and tan-colored but becomes lighter at a distance from the outcrop. Two contiguous quarries are operated in the NE¼ of sec. 27, T. 8 S., R. 16 E. (12, fig. 22).

An abandoned quarry, possibly Wakarusa limestone, is found in the NE¼ NE¼ of sec. 1, T. 7 S., R. 16 E. (13, fig. 22) with 2 feet of hard, tan-colored limestone and another abandoned quarry on the same bed is located in the SE¼ of sec. 1, T. 7 S., R. 16 E. (14, fig. 22).

The Burlingame limestone formation outcrops in secs. 12 and 13, T. 7 S., R. 16 E. (15, fig. 22), in sec. 23, T. 8 S., R. 16 E. (17, fig. 22), and in secs. 27 and 28, T. 8 S., R. 16 E. (18, fig. 22). The formation outcrops conspicuously in the southeast corner of the County, usually along slopes of major creeks,

and along the County line in secs. 14 and 23, T. 9 S., R. 16 E. (20, fig. 22) and in secs. 9, 15, 16, 22, 23, 26, 27, 29, 30, 34, and 35, T. 9 S., R. 16 E. (21, fig. 22).

### Coal (12)

The Elmo coal horizon, 12 to 14 inches thick in Jackson County, is about 20 feet below the Burlingame limestone. A little coal was mined many years ago south of Larkinburg in the center of sec. 13, T. 7 S., R. 16 E. (36, fig. 22) and some may have been mined along Cedar and Muddy Creeks in the southeast corner of the County. No coal is mined at present.

### Oil and gas (6)

Potential oil and gas strata underlie Jackson County but testing has not produced oil. A test well in sec. 27, T. 7 S., R. 15 E. is reported to have shown oil in the Hunton limestone (Silurian-Devonian) (fig. 5).

The Nemaha anticline passes near the northwest corner of the County (fig. 7). Oil companies were active in 1949 in a structural survey of the east side of the anticline.

Service Pipe Line Co. has a multiple crude oil line from Wyoming crossing the southwest corner of the County. A Socony-Vacuum Oil Co. oil products line crosses northward into Nebraska.

Cities Service Gas Co. furnishes gas to Holton through a 4-inch line from Brown County (fig. 8).

## ELECTRIC POWER

Kansas Power & Light Co. services Jackson County over 33,000- and 13,200-volt transmission lines.

The 154,000-volt line of Kansas Gas & Electric Co. from Midian (Butler County) to Omaha, Nebr., passes through the County.

Holton has a municipal, internal-combustion plant of 2,250-kw. capacity (fig. 9).

Rural Electrification Administration purchases power from Kansas Power & Light Co. and distributes it into rural areas.

## WATER

Moderate water supply is available in the alluvials of Soldier and Elk Creeks. Wells to the Cottonwood limestone or to minor porous lenses in the glacial till yield small water supplies. Entrained run-off waters in collecting ponds are used in many places.

## NEMAHA COUNTY

### PHYSICAL FEATURES

Nemaha County lies in the Osage Plains of Kansas (fig. 1). The topography is hilly and rolling. The central part, with altitudes of almost 1,500 feet above sea level, is the highest point in the County. The central and northern sectors drain north through the Nemaha River and the western part drains west through the Black Vermillion River. The southern part drains south through Red Vermillion and Soldier Creeks, and the eastern sector southeast through numerous creeks (fig. 23). Fine sand of the glacial outwash is the predominant feature of central Nemaha County.

Three railroads serve the County. A line of the Union Pacific (Grand Island & St. Joseph) traverses westward across the northern part through Sabetha, Seneca (the county seat), and Baileyville. The Missouri Pacific Railroad runs westward across the southern part through Wetmore, Corning, and Centralia. The Chicago, Rock Island & Pacific Railroad cuts the northeastern corner, passing through Sabetha and Bern.

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 23.

### GEOLOGY

Nemaha County is covered by glacial till and outwash to depths of a few feet to over 400 feet. Glacial streams have cut

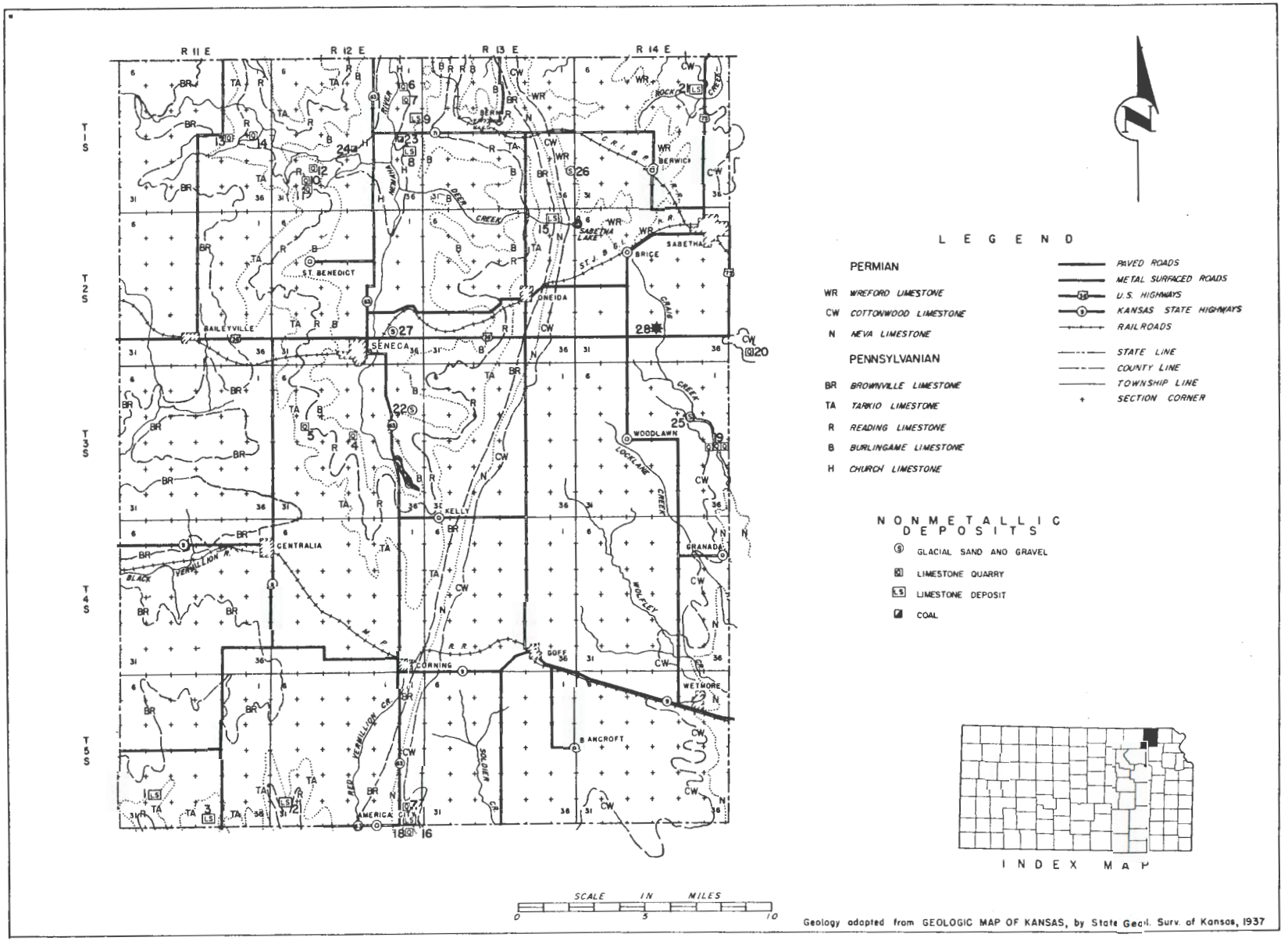



Figure 23.- Nemaha County, Kansas

channels through the till, leaving deposits of stream gravel whose continuity has been broken by recent erosion. Deposits of wind-blown loess have spotted the County, covering both till and glacial gravels.

The consolidated geological formations outcropping in the County (mostly under heavy cover of till) range from the Wreford limestone formation (Permian system), which outcrops in the northeast, to the Severy shale formation (Pennsylvanian system) appearing on the Nemaha River in north-central Nemaha County.

The Nemaha anticline enters the south border of the County west of America City, passes close to Kelly and Oneida, and goes into Nebraska north of Bern near the north County line (figure 7). The eastern flank of the anticline is the steeper, and the crest and the eastern flank are associated with minor rolling and reversal of dips and minor thrust faulting. At Seneca, near the crest, the pre-Cambrian granite is only about 800 feet below the surface, whereas, along the flanks, it is three times as deep. The Nemaha uplift is responsible for raising the Wabaunsee group and erosion has exposed the group's members. The Wabaunsee group is flanked on both sides by the overlying Admire group. On the west flank, where dips are normal and to the west, the Admire group outcrop is 4 to 8 miles wide; on the east flank, where reverse dips of 5 to 10 degrees are prevalent, the outcrop is often less than ½-mile wide.

This flank is best exposed west of Sabetha Lake along a creek bottom in sec. 1, T. 2 S., R. 13 E. (15, fig. 23).

The principal limestone beds in Nemaha County, named in order of age, the youngest first (3, 4, and 23), are: Wreford, Cottonwood, Neva, Fine Point, Aspinwall, Brownville, Tarkio, Elmont, Reading, Burlingame, and Church.

The Brownville limestone formation outcrops in two bands, more or less parallel in strike (east of north), one band on the west flank and the other on the east flank of the Nemaha anticline (fig. 23). Between the two Brownville outcrops, the Pennsylvanian limestones outcrop, horseshoe fashion on both sides of the Nemaha River. The Permian Cottonwood and Neva limestones also outcrop in two parallel bands, both on the east flank of the Nemaha anticline and striking east of north. The outcrops near the east border of the County have normal flat westward dips. Those near the center are very close to the crest and are in the area of reverse east dips and minor thrust faulting.

## MINERAL RESOURCES

Nemaha County has an abundance of fine sand on glacial outwash and also plentiful glacial sand-gravel deposits in eroded segments of glacial streams. No pits are in regular operation but annual production for road metal is estimated to be 20,000 tons.

Limestone likewise is found in abundance but the outcrops usually are buried under a heavy cover of glacial till. About

20,000 tons of Church and Reading limestones was quarried in the early part of 1949, and used as road metal and building stone. No quarries were active during the latter part of that year.

Oil was discovered in Nemaha County in 1947. Production was 3,312 barrels in 1949 and 13,193 barrels in 1950.

Some Hodaway coal has been mined locally in the past but no coal is mined now.

## Loess

The Pleistocene cover in Nemaha County is chiefly glacial till and glacial outwash, fine sands in depth up to 400 feet and covered in places by shallow wind-blown loess deposits.

## Sand-gravel

Throughout the cover of wind-blown loess, remnants of numerous gravel-filled channels occur, some of which are large deposits of excellent secondary road metal. One such deposit, 200 feet in width and over 50 feet in depth, is found in the SW¼ SE¼ of sec. 12, T. 3 S., R. 12 E. (22, fig. 23). This pit was idle in the summer of 1949 and sand-gravel for road metal was imported from Marshall County. Similar deposits may occur in adjoining secs. 7, 13, and 18. Some of the gravel is cemented and requires crushing. Glacial gravel is not suitable for concrete aggregate but can be made satisfactory by washing. Water is available. Washed gravel is alkali-reactive and, when used as concrete aggregate, should have an admixture of 30 to 40 percent neutral, coarse aggregate.

A large, idle, sand-gravel pit is near Seneca in the SE¼ of sec. 26, T. 2 S., R. 12 E. (27, fig. 23). Other deposits are in the N½ of sec. 14, T. 3 S., R. 14 E. (25, fig. 23) and in the E½ of sec. 25, T. 1 S., R. 13 E. (26, fig. 23).

Limestone (figs. 3, 4, and 23)

The Threemile limestone member, a cherty bed about 10 feet thick, the base of the Wreford formation, occurs in a small area in northeastern Nemaha County. It is largely covered by glacial till but its outcrop edges in places are available as road metal and, for that purpose, should be crushed to pass a 1½-inch screen.

The Eiss limestone member (fig. 3) has been salvaged from fields and creeks north of Sabetha and hand-trimmed and used locally as foundation and structural stone.

The Cottonwood and Neva limestone members outcrop in two belts, one through the central part of the County near the crest of the Nemaha uplift and the other near the east border of the County. The Cottonwood member is a massive 5-foot limestone, and the Neva member, lying 37 feet beneath, is a blocky, flaggy limestone with a quarry face of 6 to 7 feet. Both furnish good structural stone, road metal, and agricultural limestone. The eastern belt ordinarily is not available due to a cover of glacial till. It outcrops conspicuously, however near Sabetha Lake in

sec. 1, T. 2 S., R. 13 E. (15, fig. 23) and also near the south border of the County. An idle Neva quarry is located in the SE¼ NW¼ of sec. 36, T. 5 S., R. 12 E. (17, fig. 23) and an abandoned one across the County line in sec. 1, T. 6 S., R. 12 E. (18, fig. 23). Cottonwood limestone is available in sec. 36, T. 5 S., R. 12 E. and in sec. 31, T. 5 S., R. 13 E. (16, fig. 23). Cottonwood limestone is exposed near Craig Creek in sec. 13, T. 3 S., R. 14 E. (19, fig. 23), and was quarried in three small quarries which ceased operations when overburden became excessive. Some Cottonwood limestone is available in a small area in sec. 11, T. 1 S., R. 14 E. (21, fig. 23). Cottonwood limestone was quarried and crushed for use as road metal on Nemaha County roads in 1949 from a deposit in Brown County, near the Nemaha-Brown County line, in the NE¼ SE¼ of sec. 31, T. 2 S., R. 15 E. (20, fig. 23).

Five Point and Aspinwall limestone beds of the Admire group, each a foot or two thick, show up occasionally in creeks and along hillsides in northwestern Nemaha County, and enough has been picked up to build a few local barns and houses. They show up in the east, in a creek west of Sabetha Lake in the W½ of sec. 1, T. 2 S., R. 13 E. (15, fig. 23).

The Brownville limestone formation, 2 to 3 feet thick and not a commercial stone, is mapped to show the top of the Pennsylvanian system.

The Tarkio limestone formation is usually about 5 feet thick. An idle quarry, with 8 to 9 feet of stone and 5 to 10 feet of overburden, is in the NE¼ NW¼ of sec. 23, T. 1 S., R. 11 E. (13, fig. 23). Tarkio outcrops occur in the east half of T. 1 S., R. 11 E. and in the west half of T. 1 S., R. 12 E. and sites are available for small quarries. Tarkio limestone, 5 to 6 feet thick, also is available in southwest Nemaha County and can be quarried in secs. 29, 31, and 32, T. 5 S., R. 11 E. (1, fig. 23). It has a potential use as concrete aggregate, road metal, and agricultural limestone.

The Elmont and Reading limestone formations, each 2 to 4 feet thick and separated by 4 to 10 feet of shale, are used as structural stone or concrete aggregate. An idle quarry, which supplied the stone for construction of the church at St. Benedict in 1891, is found in the S½ of sec. 29, T. 1 S., R. 12 E. (10, fig. 23). Here, the Reading formation is 3 feet, the Elmont 4 feet, and the interbedded shale 10 feet thick. A similar idle quarry is found south of this quarry in the NW¼ NE¼ of sec. 32, T. 1 S., R. 12 E. (11, fig. 23).

Another Elmont-Reading quarry, recently operated, is in the SW¼ NE¼ of sec. 29, T. 1 S., R. 12 E. (12, fig. 23). The limestone beds are each 2 feet thick, and the parting shale (Harveyville) is 4 feet thick. An idle Elmont quarry is located in the NW¼ of sec. 24, T. 1 S., R. 11 E. (14, fig. 23).

Some Elmont, Reading, and Wakarusa limestones are available southwest of Seneca in secs. 8, 9, 16, and 17, T. 3 S., R. 12 E.

An abandoned water-filled quarry on a hilltop in the SW¼SW¼ of sec. 15, T. 3 S., R. 12 E. (4, fig. 23) furnished Reading limestone for the Lake Seneca dam, a few miles to the east. Elmont, Reading, and Wakarusa limestone outcroppings, each about 2 feet thick, have been quarried or remnants from them picked up in stream beds in the W½ NE¼ of sec. 17, T. 3 S., R. 12 E. (5, fig. 23).

Elmont and Reading limestones, each 2 to 4 feet thick, are available also in southwest Nemaha County in secs. 29, 30, 31, and 32, T. 5 S., R. 12 E. (2, fig. 23) and in secs. 31, 32, 34, 35, and 36, T. 5 S., R. 11 E. (3, fig. 23).

The Burlingame limestone formation, ordinarily buried under a heavy cover of glacial till, is about 4 feet thick in the E½ of sec. 13, T. 1 S., R. 13 E. (9, fig. 23), and is available to a limited extent east, north, and west of Bern.

The Church limestone member, generally 2 feet thick, is the oldest limestone outcropping in the County. Anderson and Oxendale of Holton, Kans., using portable crushing and screening units, opened up a quarry in the spring of 1949 in 6 feet of Church limestone in the NW¼ of sec. 12, T. 1 S., R. 12 E. (6, fig. 23). The stone was used for road metal and, if kept clean of overburden, was suitable for concrete aggregate or agricultural limestone. By midsummer, the equipment had been moved to a Cottonwood quarry in Brown County. An idle Church limestone quarry is found in the SW¼ of sec. 12, T. 1 S., R. 12 E. (7, fig. 23). The stone is also

available in the section to the east. The thickness of the limestone in section 13 and southward is not known, but, in sec. 24, T. 1 S., R. 12 E. (8, fig. 23), the bed is only 2 feet thick and is no longer commercial. On the west side of the Nemaha River, the Church limestone is buried under glacial till.

### Brick

A brick plant, with a capacity of about 20,000 bricks a day, was started in 1911 near the Nemaha River east of Seneca. It operated for many years on an illite-type shale of the lower Wabaunsee group but has since been dismantled.

### Coal (12)

The Nodaway coal seam, high-volatile grade C bituminous and 12 to 14 inches thick, lies about a foot below the Church limestone (fig. 4). Approximately 30,000 tons has been mined since 1875, but not more than 3,000 tons was mined in any year. Some strip mining was done in 1940 but no coal is now produced. Mining was done by longwall methods through adits or vertical shafts or by stripping. Most mining was conducted east of the Nemaha River in sec. 24, T. 1 S., R. 12 E. (23, fig. 23); however, some was done west of the river in sec. 22, T. 1 S., R. 12 E. (24, fig. 23). Prof. W. H. Schoewe (12) gives a proved Nodaway coal reserve, in the County, of 5,760,000 tons and an inferred reserve of 268,800,000 tons of 12-inch coal. The seam is not commercial at present.

Oil and gas (6)

More than 20 dry holes have been drilled in Nemaha County in search of oil. A well was drilled in 1948 in the Strahm Field, in the SW¼ SW¼ of sec. 27, T. 2 S., R. 14 E. (28, fig. 23), to the Hunton horizon (Silurian Devonian) at a depth of 2,889 feet (figs. 5 and 6). The well came in at 54 barrels a day, producing 1,000 barrels in 1948 and 3,312 barrels in 1949. The field produced 13,193 barrels in 1950 (5). The Nemaha anticline passes through the County, and granite has been found 571 feet below the anticline's crest.

Cities Service Gas Co. supplies gas to Sabetha through a 4-inch line from Brown County. Kansas Power & Light Co. furnishes gas to Seneca through a 4-inch line from Marshall County (fig. 8).

ELECTRIC POWER (fig. 9)

Kansas Power & Light Co. has a 33,000-volt transmission line crossing the County through Seneca and Centralia. The company has an internal combustion electric plant of 260-kw. capacity at Seneca. A 13,200-volt line from Centralia services Corning, Goff, and Wetmore. A 13,200-volt line from Seneca supplies Beattie in Marshall County, and Oneida and Bern.

Rural Electrification Administration purchases power from Kansas Power & Light Co. at Seneca for distribution to rural areas.

Sabetha has a municipal internal combustion electric plant of 2,820-kilowatt capacity.

The Kansas Gas & Electric Co. has a 154,000-volt line passing through the County from Midian in Butler County to Omaha, Nebr.

## WATER

The Nemaha River alluvials carry moderate amounts of water. Water is obtained from wells sunk to porous strata in the glacial till or to limestone aquifers. The larger towns depend on lakes or collecting ponds supplied by run-off waters.

## BROWN COUNTY

### PHYSICAL FEATURES

Brown County is in the Osage Plains of Kansas (fig. 1). The northern half drains northward through Pony, Walnut, and Roy's Creeks; the southern half drains southward through the Delaware River and eastward through Wolf Creek and its tributaries. The upland topography is rolling with altitudes of 1,300 to 1,400 feet above sea level. In the vicinity of the main streams and tributaries, the topography is rugged with a maximum relief of about 200 feet.

Brown County is served by three railroads. The Union Pacific (St. Joseph & Grand Island), entering a little south of midway of the east County line, crosses the County northwestward through Robinson, Hiawatha (the county seat), and Morrill. The Missouri Pacific, coming in near the southeast corner, twists west and north through Everest, Hiawatha, and Reserve. The Chicago, Rock Island & Pacific, also entering the County near the southeast corner, runs west and north through Horton, Powhattan, and Fairview (fig. 24).

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown onfigure 24.

### GEOLOGY

Brown County is covered heavily with glacial till, gravels, moraines, and loess. Loess attains depths of 200 feet in the northeast sector along the east border.

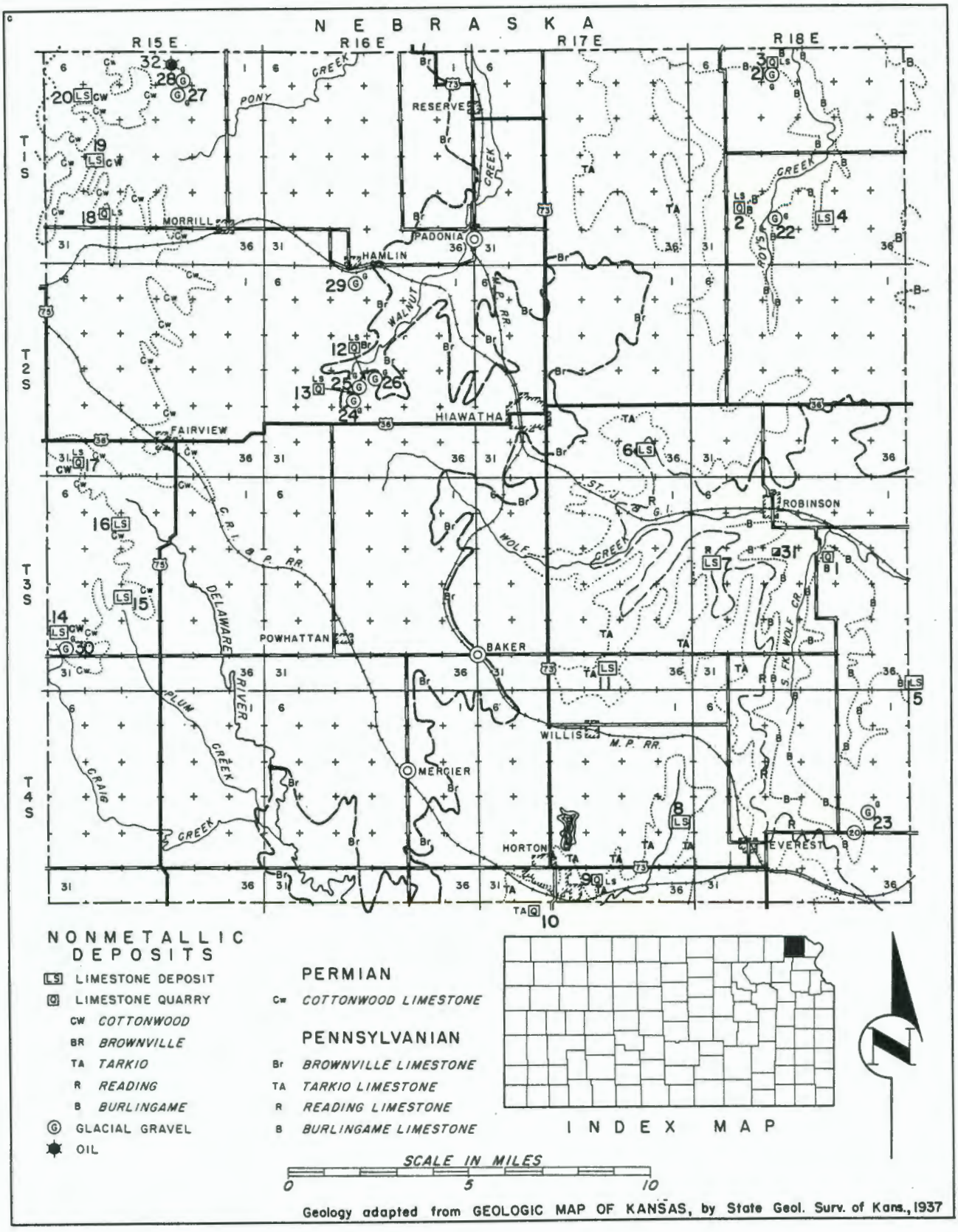



Figure 24.- Brown County, Kansas

The consolidated geological members outcropping in the County range from the Hiss limestone (Permian) in the northwest down to Church limestone (Pennsylvanian), which appears in Wolf Creek at the east border (figs. 3, 4, and 24). The principal limestones outcropping, named in order of age, the youngest first, are: Cottonwood, Neva, Five Point, Aspinwall, Brownville, Tarkio, Elmont, Reading, and Burlingame. The outcrops of the members follow meandering courses because of rugged topography but the strike of all is east of north and all dip gently about 10 feet a mile north of west. Outcrops are usually buried; in the north half of the County there are no rock exposures above road level, and in the south half, exposures are infrequent.

## MINERAL RESOURCES

Brown County has no large streams and, hence, has no deposits of alluvial sand-gravels. Throughout the County occur eroded segments of ancient stream gravels containing rounded chert and glacial moraines with coarse gravel and clay which make excellent secondary road metal if crushed to pass through 1½- to 2-inch screens. About 50,000 tons of gravel is produced annually and is used as road metal without preliminary crushing.

Limestone is abundant but, due to a heavy cover of glacial till and loess, very little is available for quarrying. In the summer of 1949, a portable crushing plant was operating on Cottonwood limestone and a quarry on Burlingame limestone was

starting operations but had not reached production. Limestone production in 1949, estimated at 35,000 tons, was used as road metal and agricultural limestone.

The Lorton and Elmo coal seams, each about 1 foot thick, are found in the County. The Elmo seam has been mined but is not commercial at present.

The only oil pool in the County produced 5,540 barrels of oil in 1949.

### Loess

Brown County has an abundance of loess, especially in the eastern part, which is a potential source of material for mineral filler for road mats, soil-cement blocks for structural use, and dense or lightweight calcined aggregate.

### Sand-gravel

The glacial gravels of Brown County generally contain too much clay or chert to be suitable for concrete aggregate. A gravel pit, lying on the Burlingame limestone, in the SW¼ of sec. 4, T. 1 S., R. 18 E. (21, fig. 24), was producing glacial gravel in the summer of 1949 for use on Brown and Doniphan County roads. A large gravel pit in the SW¼ of sec. 28, T. 1 S., R. 18 E. (22, fig. 24) was used occasionally. An active gravel pit is located near Everest in the southeast corner in the NE¼ of sec. 23, T. 4 S., R. 18 E. (23, fig. 24).

A pit is in operation south of Hamlin in the SE¼ of sec. 21, T. 2 S., R. 16 E. (24, fig. 24). Half a mile north, an extension of the deposit occurs in the center of sec. 21 (25, fig. 24), and a further extension is found in an old pit in the NW¼NW¼ of sec. 22, T. 2 S., R. 16 E. (26, fig. 24). A gravel pit is located in the center of sec. 4, T. 2 S., R. 16 E. (29, fig. 24). A small gravel pit is found on the Cottonwood limestone in the SE¼SW¼ of sec. 30, T. 3 S., R. 15 E. (30, fig. 24).

Gravel deposits, 12 to 15 feet thick, occur in northwest Brown County, often with overburden of glacial till or loess as much as 15 feet thick. An active pit is located in the NE¼ of sec. 10, T. 1 S., R. 15 E. (27, fig. 24). An idle pit is found in the SE¼ of sec. 3, T. 1 S., R. 15 E. (28, fig. 24). These deposits have waterworn chert pebbles with clay binding.

## Limestone

The Kiss limestone member (fig. 3), occupying many of the high places in northwest Brown County, has been picked up in fields and used locally for farm buildings and foundations.

The Cottonwood limestone member, a massive 5-foot bed, and the Neva limestone member, 37 feet below and with a quarry face 6 to 7 feet thick, occur near the west boundary of the County. Both are useful as building stone, riprap, road material, and agricultural limestone. The outcrops usually are buried under heavy glacial till and are available in but few places.

Some Cottonwood limestone is available in secs. 30 and 31, T. 3 S., R. 15 E. (14, fig. 24). Farther north in secs. 20 and 21, T. 3 S., R. 15 E. (15, fig. 24) and in secs. 8 and 9, T. 3 S., R. 15 E. (16, fig. 24), both Cottonwood and Neva limestones are available.

Anderson and Oxendale, Holton, Kans., operated (summer of 1949) a portable crushing and screening plant on 5 to 6 feet of Cottonwood limestone in the NE¼ SE¼ of sec. 31, T. 2 S., R. 15 E. (17, fig. 24), making road material and agricultural limestone.

An old idle Cottonwood quarry is found in the SE¼ of sec. 29, T. 1 S., R. 15 E. (18, fig. 24). Cottonwood limestone is also available in secs. 20 and 21, T. 1 S., R. 15 E. (19, fig. 24), and both limestone members occur with constant overburden in secs. 6, 7, and 8, T. 1 S., R. 15 E. (20, fig. 24).

The Five Point and Aspinwall limestone outcrops are ordinarily buried under glacial till. During the days of WPA, two small quarries were opened on Five Point limestone on the banks of Walnut Creek where overburden was the least. The quarries were located in the NE¼ NE¼ of sec. 21, T. 2 S., R. 16 E. (12, fig. 24) and in the SW¼ NE¼ of sec. 21, T. 2 S., R. 16 E. (13, fig. 24). The limestone, 2 feet thick, was used as building stone and riprap, but the quarries were abandoned years ago.

The Brownville limestone formation, not a commercial rock, is mapped on figure 24 to mark the top of the Pennsylvanian members.

The Tarkio limestone formation, 4 to 5 feet thick, is suitable for concrete aggregate and road metal. It outcrops conspicuously in the vicinity of Horton and along a creek in the SE¼ of sec. 23, T. 4 S., R. 17 E. (8, fig. 24). Abandoned Tarkio quarries are found in the SW¼ NW¼ of sec. 34, T. 4 S., R. 17 E. (9, fig. 24) and in the NW¼ NE¼ of sec. 5, T. 5 S., R. 17 E. (10, fig. 24). Tarkio limestone is also available in sec. 34, T. 3 S., R. 17 E. (11, fig. 24). The formation is exposed occasionally along creek bottoms northeast of Hiawatha.

Elmont and Reading limestone formations, each 2 to 3 feet thick and separated by 6 to 10 feet of shale, are useful as building stone, particularly the Reading bed. Neither has been quarried in the County because both outcrops are usually buried under glacial till. Reading limestone is available in a creek in the E½ of sec. 35, T. 2 S., R. 17 E. (6, fig. 24) and for 3 or 4 miles to the south of that section, in eastern T. 3 S., R. 17 E. and western T. 3 S., R. 18 E. (7, fig. 24). North and south of this area, Elmont or Reading limestones are seldom seen, except in occasional creek bottoms and, hence, are only partly mapped.

The Burlingame limestone formation also has been quarried in Brown County. An abandoned quarry, with a 10-foot face consisting of 2 feet of limestone at the top and 6 feet at

the bottom with a 2- to 24-inch interlying shale layer, is found southeast of Robinson in the NW¼ NE¼ of sec. 15, T. 3 S., R. 18 E. (1, fig. 24). The rock is suitable for concrete aggregate, if mined clean, and for road metal and agricultural limestone. The Burlingame formation is occasionally available, without too much overburden, on both sides of Roy's Creek north to the Nebraska line. Davies Bros. of Hiawatha were opening a quarry and setting up a small portable crushing unit in August 1949 in the SE¼ NW¼ of sec. 29, T. 1 S., R. 18 E. (2, fig. 24) on a tributary to Roy's Creek. The formation at this point is 12 to 15 feet thick with two shale partings.

Four feet of Burlingame limestone is exposed in another tributary to Roy's Creek in the S½ of sec. 27, T. 1 S., R. 18 E. (4, fig. 24). The 4-foot bed appears again under a gravel deposit in an old quarry in the NE¼ SW¼ of sec. 4, T. 1 S., R. 18 E. (3, fig. 24). The limestone is also available in sec. 36, T. 3 S., R. 18 E. and in the NE¼ of sec. 1, T. 4 S., R. 18 E. (5, fig. 24). The top of the Burlingame limestone in outcrop No. 5 has an algal crust with sponge-like masses.

## Coal (12)

Brown County has four coal horizons--Lorton, Nyman, Elmo, and a 3-inch, unnamed seam beneath the Maple Hill limestone formation. The Lorton seam, ranging in thickness from a few inches to 12 inches, is found about 22 feet below the Brownville limestone.

The Nyman seam, approximately 3 inches thick, lies in the shale under the Dover limestone. The Elmo bed, 12 to 15 inches thick, is about 20 feet below the Burlingame limestone.

The Elmo seam is the only one that has been mined, but it is no longer commercial. Probably about 100,000 tons has been mined, most of it prior to 1900, and largely by stripping, adit, or shaft along the South Fork of Wolf Creek, southeast of Robinson. A 12-inch outcrop of Elmo Coal can be seen in the shale bluff near a creek crossing one mile south of Robinson in the NE¼ NW¼ of sec. 16, T. 3 S., R. 18 E. (31, fig. 24).

Oil and gas (6)

The Livenwood Pool, discovered in 1944 in sec. 3, T. 1 S., R. 15 E. (32, fig. 24), produced 5,540 barrels of oil in 1949 from the Hunton horizon at 2,580 feet (Silurian-Devonian, fig. 5). This is the only oil pool in the County and no activity is reported.

Cities Service Gas Co. has an 8-inch gas line from Atchison County to Lorton. The company also has a 6-inch line running north through Hiawatha to Nebraska with a 4-inch line branching west to Sabetha in Nemaha County, and service lines to Fairview and Hamlin (fig. 8).

A Socony-Vacuum oil products line runs northward through Brown and Nemaha Counties and into Nebraska (fig. 8).

ELECTRIC POWER

Kansas Power & Light Co. supplies Brown County with a 33,000-volt transmission line from Atchison County through Hiawatha

and westward into Nemaha County; 13,200-volt lines service Padonia and Reserve in the north and Robinson and Doniphan County in the east. Powhattan and Everest are also furnished power. The company has an internal combustion electric plant of 1,356-kilowatt capacity at Hiawatha.

Horton has a municipal, internal combustion plant of 2,365-kilowatt capacity. Rural Electrification Administration purchases power from this plant and from Kansas Power & Light Co. for distribution into rural areas.

## WATER

Well water is not plentiful in Brown County. Some is available in porous strata in the glacial till and some in limestone aquifers such as the Cottonwood and Burlingame beds. The larger towns depend on lakes and collecting ponds supplied by run-off waters.

## DONIPHAN COUNTY

### PHYSICAL FEATURES

Doniphan County is in the northeast corner of Kansas. The Missouri River flows southeastward along the north and east borders at an average altitude of about 1,000 feet above sea level. The highest altitude is approximately 1,400 feet near the southwest corner. The terrain is rolling country, sharply dissected by the principal drainage systems. Loess bluffs, 150 to 200 feet high, parallel the bottom lands of the Missouri River. Northwest Doniphan County drains north through Wolf and Cedar Creeks; the eastern part drains east through Walnut and Peter Creeks, and the southern part through Rock and Independence Creeks (fig. 25).

Doniphan County is served by two railroad systems. The Union Pacific (St. Joseph & Grand Island) from St. Joseph, Mo., runs west through the center, passing through Elwood, Troy (the county seat), and Severance. A branch line of the St. Joseph & Grand Island swings north, a short distance east of Severance to Highland. The Chicago, Rock Island & Pacific, also from St. Joseph, runs west and south across the County, through Elwood, Troy, and Purcell (fig. 25).

Secondary roads checkerboard most of the County at intervals of 1 to 3 miles. The rugged topography of the bluffs bordering the Missouri River disturbs the regularity of the pattern. The principal paved highways are shown on figure 25.

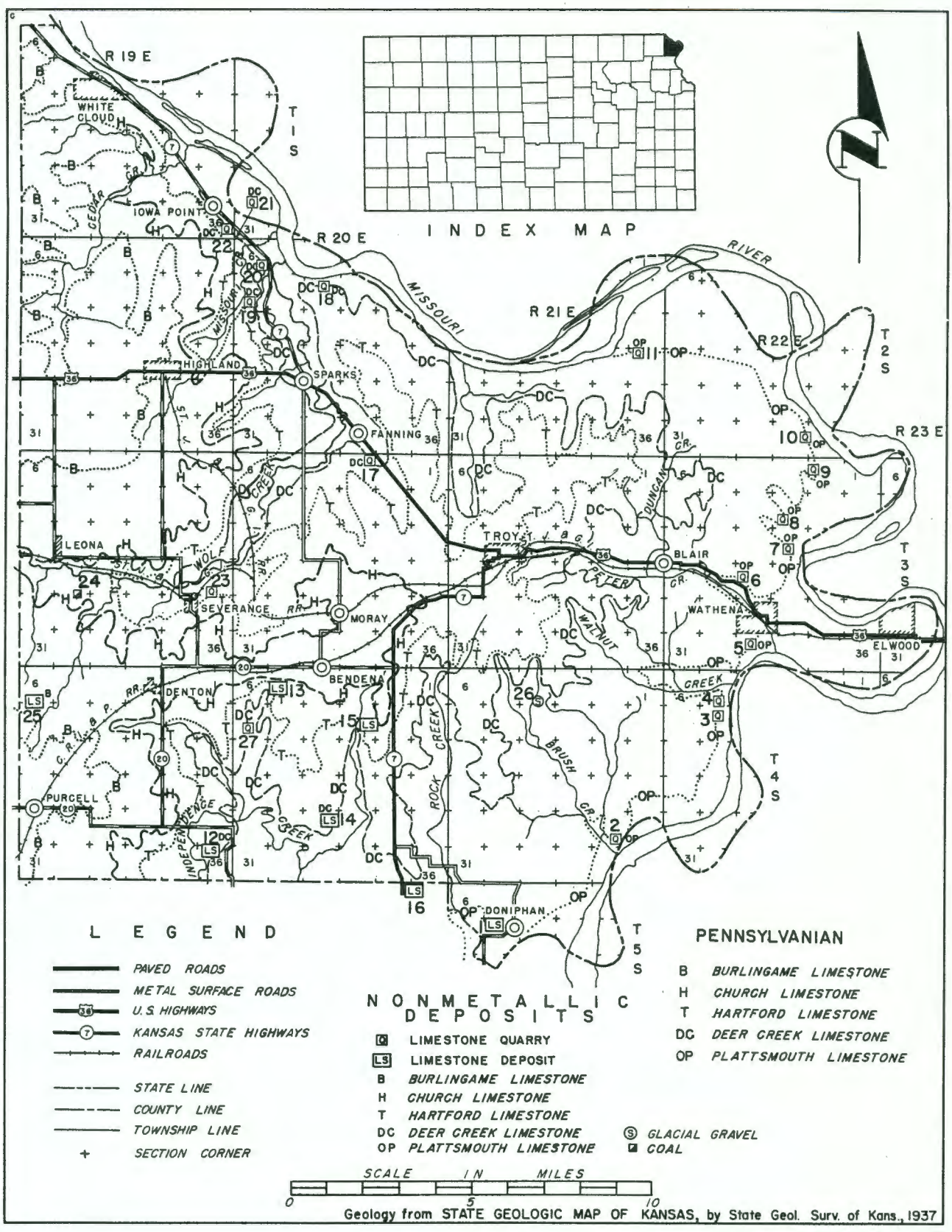



Figure 25.- Doniphan County, Kansas

## GEOLOGY

Doniphan County is heavily covered with glacial till and overlying loess, the latter being prominent in a belt 5 miles wide along the Missouri River. The loess, in places, is 200 feet thick.

The consolidated geological beds outcropping in the County range from the Soldier Creek shale and Burlingame limestone formations of the Wabaunsee Group down to the upper 60 feet of the Douglas Group shales (fig. 4 and table 1). The principal limestone beds outcropping, named in order of age, the youngest first, are: Burlingame, Church, Topeka, Deer Creek, Lecompton, Plattsmouth, and Toronto (fig. 25).

## MINERAL RESOURCES

Doniphan County has no known commercial deposits of glacial sand-gravel. It has an unlimited supply of alluvial sand-gravel in the Missouri River but none is produced within the County. Concrete aggregates are imported from Missouri.

The County has large reserves of limestone that have been quarried extensively for riprap and river dikes. Production for 1949 is estimated to have been 25,000 tons of riprap and dike rock and 50,000 tons of crushed limestone for road metal and concrete aggregate.

### Loess

Doniphan County has an abundance of loess available for soil-cement blocks for structural use, as mineral filler in road mats, and as dense or lightweight calcined aggregates.

## Sand-gravel

Sand-gravel deposits are scarce in the County. An edge of a glacial sand-gravel channel, under 10 feet of loess, is exposed in a road cut in the SE¼ SW¼ of sec. 4, T. 4 S., R. 21 E. (26, fig. 25).

The alluvials of the Missouri River contain abundant sand-gravel but no sand plants are operating on the Kansas side in Doniphan County, where the high banks of the river are difficulty accessible. These sand-gravels are alkali-reactive and, when used as concrete aggregate, should have an admixture of 30 to 40 percent neutral, coarse aggregate.

## Limestone (fig. 4)

The Burlingame limestone formation outcrops under heavy cover in western Doniphan County and at no place is it exposed sufficiently for favorable quarry sites. The best exposures are in secs. 6 and 7, T. 4 S., R. 19 E. (25, fig. 25).

The Church limestone member, about 2 feet thick, and not a commercial stone, is mapped (fig. 25) as a horizon of the Nodaway coal seam. It is best exposed in the valley of Wolf Creek south and east of Leona.

The Topeka limestone formation is generally under a heavy cover of glacial till and loess. Its most useful limestone members are the 6- to 8-foot Curzon and the 4-foot Hartford beds, separated by 2 to 4 feet of shale. A Topeka quarry, used for road metal, is located in the SE¼ SW¼ of sec. 24, T. 3 S., R. 19 E. (23, fig. 25).

The Deer Creek limestone formation, 40 feet thick, consists of three limestones and two shales. The Ervine Creek limestone, its principal member, is 16 feet thick and, in Doniphan County, is only 10 feet below the Hartford limestone of the Topeka formation. The Ervine Creek bed appears on the banks of Independence Creek in the southern part of the County in secs. 35 and 36, T. 4 S., R. 19 E. (12, fig. 25) and can be followed northward up a tributary of Independence Creek to secs. 5 and 6, T. 4 S., R. 20 E. (13, fig. 25). A small quarry is in sec. 7, T. 4 S., R. 20 E. (27, fig. 25). The Ervine Creek limestone leaves Independence Creek in sec. 28, T. 4 S., R. 20 E. (14, fig. 25) and follows north, up the west bank of a tributary, to sec. 10, T. 4 S., R. 20 E. (15, fig. 25). From that point the bed outcrops in a southerly direction along the east bank of the same tributary and reaches Atchison County in secs. 35 and 36, T. 4 S., R. 20 E. (16, fig. 25), east of Highway 7.

More important areas of available Ervine Creek limestone are northward along the east bank of Wolf Creek, south of Farming, in sec. 2, T. 3 S., R. 20 E., to the Missouri River, and along the west bank of Wolf Creek south of Sparks, northwestward along Highway 7 to Iowa Point. A quarry with a portable crushing and screening plant was opened in 1949 in the NE¼ of sec. 3, T. 3 S., R. 20 E. (17, fig. 25). The Ervine Creek bed in the quarry has an overburden of 10 feet of Calhoun shale and some Hartford limestone.

An idle Ervine Creek quarry, once used by the Corps of Engineers for building dikes on the Missouri River, is found in the N½ of sec. 9, T. 2 S., R. 20 E. (18, fig. 25). The quarry, 3/4-mile long and about 60 feet above the river, has heavy overburden consisting of 10 feet of Calhoun shale, 35 feet of Topeka limestone, and 10 to 20 feet of loess. Two and one-half acres at the eastern end is stripped of overburden.

An abandoned Ervine Creek-Topeka limestone quarry is found in the SE¼ of sec. 7, T. 2 S., R. 20 E. (19, fig. 25). The Corps of Engineers is operating two small dike rock quarries (1949) in sec. 6, T. 2 S., R. 20 E. on Highway 7 (20, fig. 25). Idle quarries also were found in the SW¼ of sec. 31, T. 1 S., R. 20 E. (21, fig. 25) and in the SE¼ of sec. 36, T. 1 S., R. 19 E. (22, fig. 25), both of which have an overburden of 10 feet of Calhoun shale and some Topeka limestone. The Deer Creek formation at Iowa Point dips below road level and the outcrop crosses the Missouri River.

The Lecompton limestone formation, consisting of four limestone members, each 2 to 7 feet thick and separated by three shale members, is 35 feet thick. The outcrop usually is buried and its thin limestone members are not commercial because thicker and better limestones are available nearby.

The Plattsmouth limestone member, about 21 feet thick, and the underlying Toronto limestone member, 10 feet thick, are separated by about 20 feet of shale and limestone. Both have been

used extensively by the Corps of Engineers for riprap and dike purposes. Plattsmouth limestone breaks into large slabs and is preferred to the finer-breaking Toronto limestone, a dense, white stone. The two limestone beds appear in southern Doniphan County in sec. 8, T. 5 S., R. 21 E. (1, fig. 25). The Roundy quarry in sec. 26, T. 4 S., R. 21 E. (2, fig. 25) has been operated extensively for dike rock and was active in 1949.

An abandoned Toronto limestone quarry is found on the same property. Another Toronto quarry, once operated by the Corps of Engineers, is in the NE¼ of sec. 8, T. 4 S., R. 22 E. (3, fig. 25). Abandoned WPA Toronto quarries are found in the SE¼ of sec. 5, T. 4 S., R. 22 E. (4, fig. 25) and in the NW¼ of sec. 33, T. 3 S., R. 22 E. (5, fig. 25).

Idle Plattsmouth quarries, some very large, are north of Wathena in the following places:

| Sec. | T(S) | R(E) | No. on fig. 25 |
|---|---|---|---|
| NW¼ 21 | 3 | 22 | 6 |
| Center 15 | 3 | 22 | 7 |
| SW¼ 10 | 3 | 22 | 8 |
| NW¼ 2 | 3 | 22 | 9 |

An abandoned Toronto limestone quarry is found in the NE¼ of sec. 34, T. 2 S., R. 22 E. (10, fig. 25).

The Plattsmouth member has dipped in the N½ of sec. 24, T. 2 S., R. 21 E. (11, fig. 26) to about the level of the river

bottom lands. An idle quarry, 3/4-mile long and handicapped by heavy overburden (although well-located for underground mining), is located here. Upstream from this point, the Plattsmouth bed dips under the Missouri River.

Outcrops of the Amazonia limestone member, 5 feet thick and not of commercial value in Doniphan County, are exposed occasionally in the Douglas shales about 30 feet below the Toronto limestone.

### Coal

The Elmo coal seam, 20 to 25 feet under the Burlingame limestone, is deeply buried under glacial till and loess.

The Nodaway coal seam, 5 to 12 inches thick and about 2 feet under the Church limestone, outcrops visibly along the slopes of Wolf Creek, west of Severance in sec. 29, T. 3 S., R. 19 E. (24, fig. 25) and along Highway 7 south of White Cloud. The seam, formerly mined for local consumption, is not now mined.

### Oil and gas (6)

Potential oil and gas strata underlie Doniphan County but eight test wells have been unsuccessful.

The County is not serviced for gas facilities.

## ELECTRIC POWER

Kansas Power & Light Co. furnishes electric power to Doniphan County through 13,200-volt transmission lines tied to the main 44,000-volt system in Atchison and Brown Counties. Rural Electrification Administration purchases power from the company for rural distribution.

Blair, Wathena, and Elwood are supplied by the Doniphan County Light & Power Co. (fig. 9).

## WATER

The alluvials of the Missouri River carry an abundance of water. Peter and Wolf Creeks carry smaller amounts. Some water is obtainable in wells sunk to porous strata in glacial till or to limestone aquifers.

## ATCHISON COUNTY

### PHYSICAL FEATURES

Atchison County is in the northeastern part of Kansas. The Missouri River flows southward along its eastern border at an average altitude of 950 feet above sea level. Along the river, bluffs rise steeply for 150 to 200 feet and the altitude of the rolling terrain to the west increases gradually to a maximum of about 1,350 feet in the northwest uplands. The western part of the County is drained by the southward-flowing Delaware River and its tributaries (fig. 26). The northeast sector is drained by Independence and Deer Creeks which flow eastward to the Missouri River. The southeast sector drains into southeasterly-flowing Stranger Creek. The escarpment of Oread limestone along the Missouri River (figs. 4 and 26) is the most pronounced physiographical feature in the County.

Atchison County is served by two railroad systems. The Missouri Pacific Railroad from the south, follows the west bank of the Missouri River to Atchison, the county seat, where a branch runs west and north through Shannon and Huron. Another branch from Atchison goes south to Parnell, thence westward through Effingham and Muscotah. The Topeka branch of the Atchison, Topeka, & Santa Fe runs southwest from Atchison through Parnell and Cummings and on into Jefferson County. South of Parnell, a branch of the Santa Fe swings southeast through Potter to Leavenworth.

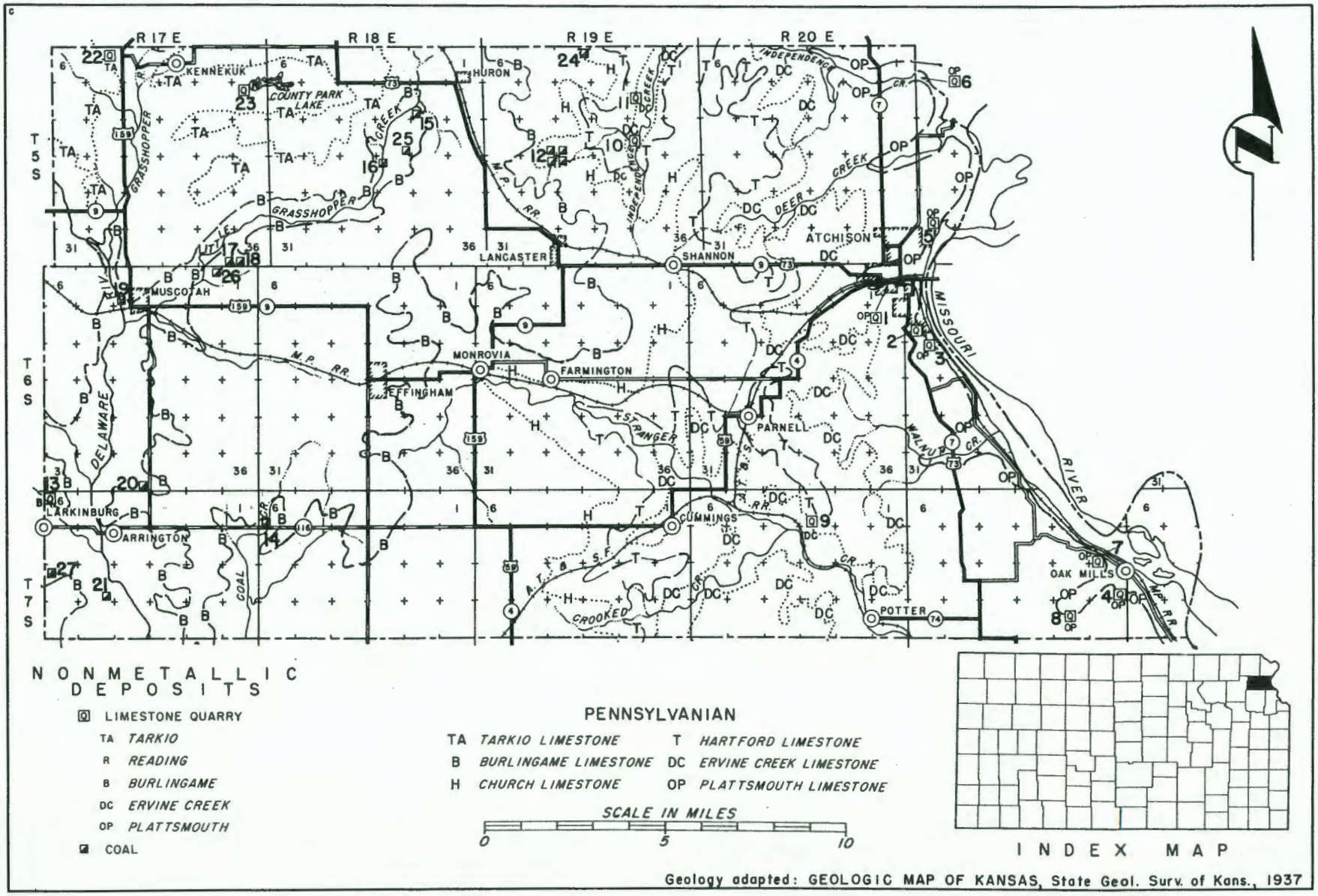



Figure 26.- Atchison County, Kansas

The County is checkerboarded by secondary roads at intervals of 1 and 2 miles. The checkerboard pattern is disturbed by the rugged topography of the bluffs on the west branch of the Missouri River. The principal paved highways are shown on figure 26.

## GEOLOGY

Atchison County is covered by glacial till and loess, the loess cover increasing in depth in areas close to the Missouri River. Underlying formations are exposed only in areas of erosional activity such as along the Missouri River and its tributaries from the west, and along the Delaware and Grasshopper Rivers and their tributaries.

The consolidated geological formations outcropping in the County range from the Tarkio limestone of the Wabaunsee group in the northwest sector down to the Lawrence shales of the Douglas Group along the Missouri River (table 1 and fig. 4).

The major limestone beds outcropping, in order of age, the youngest first (figs. 4 and 26), are: Tarkio, Elmont, Reading, Burlingame, Church, Topeka (Hartford), Deer Creek, Lecompton, Plattsmouth, and Toronto.

## MINERAL RESOURCES

Atchison County has an abundance of limestone and an estimated annual production of 530,000 tons of crushed limestone for road metal and concrete aggregate, quarry rock for dikes and

riprap in the Missouri River, and agricultural limestone. Alluvial sand-gravels are plentiful in the Missouri River, but very little is produced. Coal has been mined but coal reserves are not now economic.

## Loess

Loess, abundant on the hills bordering the Missouri River, is a potential source of material for soil-cement blocks for structural use, for mineral fillers in road mats, and for dense or lightweight calcined aggregate.

## Sand-gravel

No deposits of glacial gravel are known except occasional shallow blankets a foot or two thick. The Missouri River alluvials have an unlimited supply of sand-gravel but they are not exploited except for the intermittent operations of a small plant in the northeast corner of the city of Atchison. Sand-gravel is imported from plants on the Kansas River. The alluvial sand-gravel is alkali-reactive and, when used as concrete aggregate, should have an admixture of 30 to 40 percent coarse neutral aggregate.

## Limestone

Limestone is abundant in Atchison County and is extensively quarried in the eastern part (fig. 4).

The Tarkio limestone formation, 5 feet thick and suitable for concrete aggregate and road metal, is available in the northwest

part but is not now quarried. A small idle quarry is in sec. 5, T. 5 S., R. 17 E. (22, fig. 26). Tarkio outcrops are exposed south of Kennekuk in secs. 9, 10, 11, 15, 19, and 20, T. 5 S., R. 17 E.

Elmont and Reading limestone formations, each 2 to 4 feet thick and separated by 3 feet of shale, are suitable for building stone, riprap, and, when mined clean, for concrete aggregate. They are available in the valleys of Delaware and Grasshopper Rivers between Muscotah and the north border of the County. An idle quarry in the NE¼NW¼ of sec. 12, T. 5 S., R. 17 E. (23, fig. 26), shows 3 feet each of Elmont and Reading limestones. The stone was used as riprap for the dam in the County Park immediately to the east.

The Burlingame limestone formation, when quarried, usually has a 6- to 7-foot quarry face suitable for road metal and, if not stained, for concrete aggregate. Although used very little in Atchison County, the formation is available in the hills south of Arrington, on both sides of the Delaware River. A small abandoned quarry on a 20-inch limestone bed is found in the NW¼ NW¼ of sec. 6, T. 7 S., R. 17 E. (13, fig. 26). This may be the Wakarusa limestone which lies 12 to 15 feet above the Burlingame formation. The stone was used as road material. Burlingame limestone is exposed on Coal Creek east of Arrington, in sec. 6, T. 7 S., R. 18 E. (14, fig. 26), where it serves as a marker for the Elmo coal seam about 20 feet below. The formation is also available in the valley

of the Delaware River at Muscotah and on Little Grasshopper Creek northeast of Muscotah in sec. 35, T. 5 S., R. 17 E. (17, fig. 26) and in sec. 15, T. 5 S., R. 18 E.

The Church limestone member, about 2 feet thick and not a commercial limestone, is mapped as a marker for the Nodaway coal seam a foot or two below. It is exposed best near the headwaters of Independence Creek, about 2 miles north of Lancaster, in secs. 16, 17, and 20, T. 5 S., R. 19 E. (12, fig. 26).

The Topeka limestone formation, approximately 35 feet thick, is generally buried beneath till in Atchison County. The formation's two lower limestone members, the 8-foot Curzon and the 5-foot Hartford (separated by 2 to 4 feet of shale), are useful as road metal when available. The best exposures are near Independence Creek in secs. 9, 12, and 13, T. 5 S., R. 19 E. Topeka limestone is not used in the County.

The Deer Creek limestone formation has three limestone and two shale members. The 15-foot Ervine Creek limestone, the topmost and most important member, is useful as road metal or concrete aggregate. The bed is exposed along the slopes of Crooked Creek and an idle quarry is found near the creek's junction with Stranger Creek in the SW¼ of sec. 3, T. 7 S., R. 20 E. (9, fig. 26). Ervine Creek limestone is available in the north along Independence Creek in secs. 1, 2, 11, and 14, T. 5 S., R. 19 E. Abandoned quarries are found in the NW¼ SW¼ of sec. 14, T. 5 S., R. 19 E. (10, fig. 26) and near the center of sec. 11, T. 5 S., R. 19 E. (11,

fig. 26). These quarries supplied road metal and encountered excessive overburden. Atchison County has no active quarries in the Ervine Creek limestone.

The Lecompton limestone formation, approximately 35 feet thick, has four limestone members and three shale members. The thickest limestone member is only 6 feet thick, and even where free of overburden (which is seldom), is not used because of the availability of nearby thicker limestones.

The Hereford limestone member, 2 to 6 feet thick and 4 to 6 feet above the Plattsmouth limestone member, is an excellent rock and is used where found of sufficient thickness and close to Plattsmouth operations.

The Plattsmouth limestone member, 20 feet thick with wavy 3- to 6-inch bedding planes, is the most useful limestone in Atchison County. It outcrops along the bluffs above the Missouri River and underlies all of the County. The stone can be safely mined by underground methods, using adits or vertical shafts, thereby avoiding the problem of overburden. The bed has a natural parting 6 feet below the top that can be used as a roof, and a parting 1½ feet above the bottom that can be used as a floor, leaving rooms 12 to 13 feet high. The roof stands well but must be barred after air-slacking sets in.

Ralph Bromley operated a small quarry in the city of Atchison in about the center of sec. 1, T. 6 S., R. 20 E. (1, fig. 26).

The quarry, with semiportable equipment, was producing crushed limestone in the fall of 1949. The Corps of Engineers were opening up a new quarry at that time for river dike rock in the SE¼ SE¼ of sec. 13, T. 7 S., R. 21 E. (4, fig. 26).

George W. Kerford Quarry Co. had an underground quarry in the SE¼ of sec. 7, T. 6 S., R. 21 E. (2, fig. 26) and another in the NE¼ of sec. 18, T. 6 S., R. 21 E. (3, fig. 26). The two quarries were producing a large tonnage of screened crushed limestone and agricultural limestone in 1949. Room-and-pillar system of mining with mechanized equipment was used.

The Kerford Quarry Co. has an open quarry on the same property, producing quarry rock for rock dikes on the Missouri River.

A worked-out portion of the underground quarry, totaling 16½ acres and separated from the operating quarries by a 200-foot pillar, is being used by the Production and Marketing Administration for cold storage.

Idle Plattsmouth quarries are located in the following places:

| Sec. | T(S) | R(E) | No. on fig. 26 |
|---|---|---|---|
| SE¼SW¼ 30 | 5 | 21 | 5 |
| SW¼SW¼ 6 | 5 | 21 | 6 |
| SE¼SW¼ 12 | 7 | 21 | 7 |
| SE¼NW¼ 23 | 7 | 21 | 8 |

No. 7 is a large quarry recently operated by the Corps of Engineers for river riprap and dike rock.

The Toronto limestone member, 7 to 8 feet thick and about 20 feet below the Plattsmouth limestone, is a good commercial stone but is not used.

## Coal

The Atchison Brick, Tile & Coal Mining Co., now in receivership, has a 1,300-foot shaft on the property of the George W. Kerford Quarry Co. in the SE¼ of sec. 7, T. 6 S., R. 21 E. (2, fig. 26). A 30-inch seam of Bevier coal in the Cherokee shale (fig. 4) was mined from this shaft but the shaft was abandoned long ago. The collar of the shaft is about the Snyderville shale horizon (fig. 4).

The Nodaway coal seam, about 2 feet below the Church limestone, is 7 to 14 inches thick in the SW¼ of sec. 16, SE¼ of sec. 17, NE¼ of sec. 20, and the NW¼ of sec. 21, T. 5 S., R. 19 E. (12, fig. 26). Coal was once mined from this area from a 30-foot shaft mine and two drift mines in the NW¼ of sec. 21 (12). Nodaway coal was also mined in the NE¼ of sec. 4, T. 5 S., R. 19 E. (24, fig. 26). The coal is now occasionally mined by farmers for local use. The outcrop is buried under glacial till everywhere in the County, except in T. 5 S., R. 19 E.

The Elmo coal seam, 7 to 15 inches thick and about 20 feet below the Burlingame limestone, was mined many years ago in divers places to a limited extent. The seam was mined in the following places (12):

| Sec. | T(S) | R(E) | No. on fig. 26 |
|---|---|---|---|
| SW¼ 11 | 5 | 18 | 15 |
| SE¼ 15 | 5 | 18 | 25 |
| NW¼ 22 | 5 | 18 | 16 |
| SE¼ 35 | 5 | 17 | 17 |
| SW¼ 36 | 5 | 17 | 18 |
| SW¼ 4 | 6 | 17 | 19 |
| NE¼ 2 | 6 | 17 | 26 |
| SE¼ 33 | 6 | 17 | 20 |
| NW¼ 18 | 7 | 17 | 27 |
| SE¼ 17 | 7 | 17 | 21 |

The coal reserves of Atchison County are not now commercial. Prof. W. H. Schoewe of the University of Kansas estimates that the County has a proved reserve of 940 acres of 12-inch Hodaway coal and 4,907 acres of 12-inch Elmo coal (12).

Oil and gas (6)

Potential oil and gas strata underlie the County. The seven or eight tests made to date (1951) have not been productive.

Cities Service Gas Co. has a 10-inch gas line from Leavenworth County to the city of Atchison and an 8-inch line from Atchison northwestward to Brown County (fig. 8).

ELECTRIC POWER

Kansas Power & Light Co. has two 66,000-volt transmission lines to Atchison, one from Tecumseh (Shawnee County) and one from Lawrence (Douglas County) via the city of Leavenworth. Central and western Atchison County are serviced by a 33,000-volt line from Atchison and a 13,200-volt line from Effingham to Muscotah. Larkinburg is serviced by a 13,200-volt line from Jackson County. The company has a 2,000-kilowatt steam generating electric plant at Atchison (fig. 9).

Rural Electrification Administration purchases power from the company for distribution into rural areas.

## WATER

The alluvials of the Missouri River carry an abundance of water. Water is also obtainable from alluvials in the Delaware River and its larger tributaries, from Stranger and Independence Creeks, and from many east-flowing tributaries of the Missouri River.

## JEFFERSON COUNTY

### PHYSICAL FEATURES

Jefferson County is in the Osage Plains of eastern Kansas (fig. 1). The Kansas River flows eastward along the southern border at an average altitude of 800 feet above sea level. The terrain rises gradually toward the north to a maximum altitude of 1,200 feet in the northeast and 1,300 feet in the northwest. The Delaware River and its tributaries, flowing southward, cut deeply into the general relief and drain the County with the aid of tributaries direct to the Kansas River. Escarpments of the Burlingame limestone in the northwest, of the Deer Creek limestone in the northeast and central parts, and especially of the Oread limestone in the southeast are marked physiographical features (fig. 27). The northeast sector drains northward.

Jefferson County is served by two railroads. A main line of the Union Pacific Railroad crosses east to west near the north bank of the Kansas River. The Atchison branch of the Atchison, Topeka & Santa Fe Railroad cuts the northwest corner, passing through Meriden, Valley Falls, and Nortonville; Oskaloosa, the county seat, is not on a railroad.

Secondary roads checkerboard the County at intervals of 1 and 2 miles. Rugged topography near streams frequently interrupts the pattern. The main paved highways are shown on figure 27.

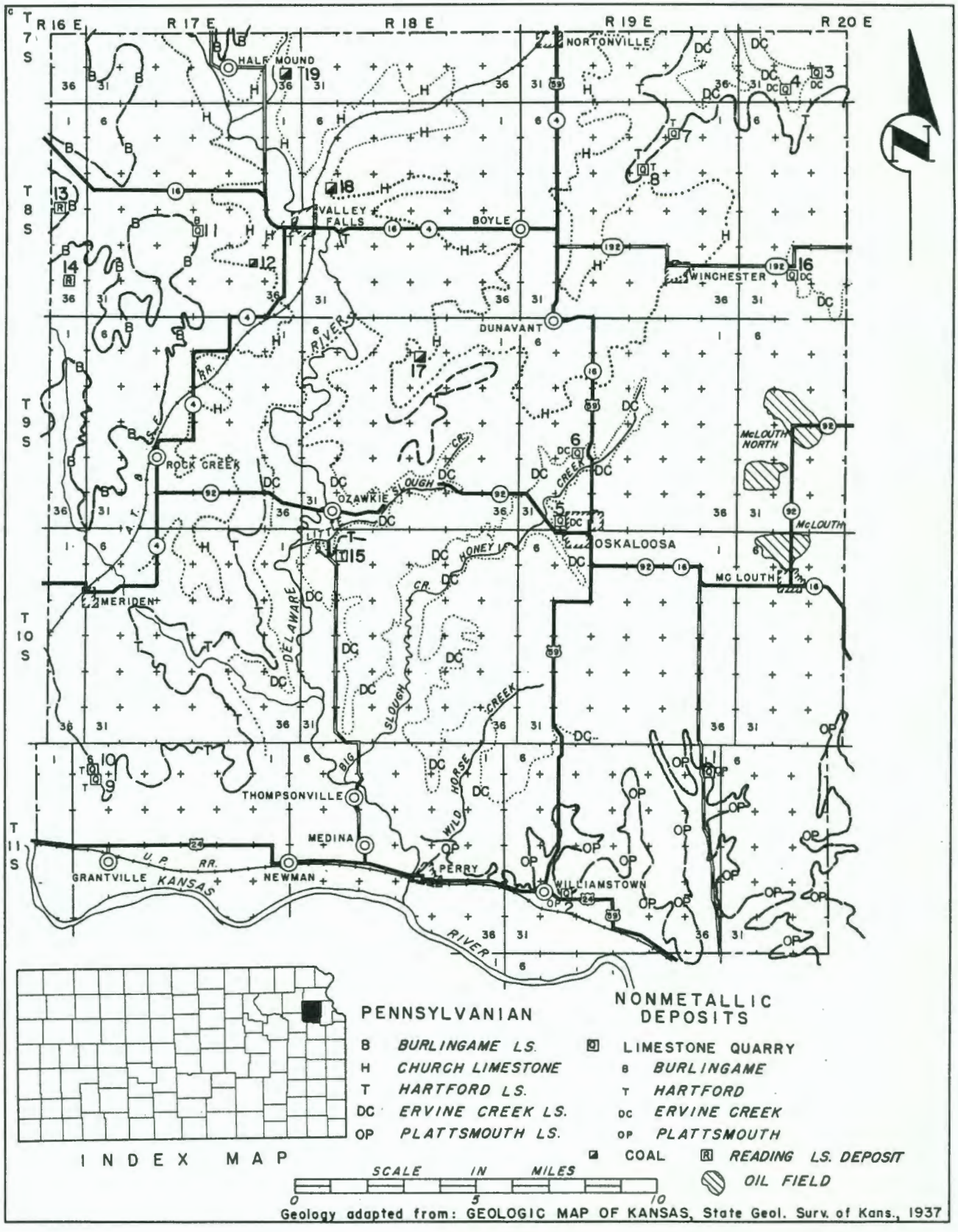



Figure 27.- Jefferson County, Kansas

## GEOLOGY

Jefferson County is heavily covered by glacial drift except along drainage courses. Loess is conspicuous near the north edge of the Kansas River bottom lands which extend a mile or two north of the present river.

The consolidated geological formations outcropping in the County range from the Elmont limestone of the Wabaunsee Group, exposed in small areas in the northwest sector, down to the upper shales of the Douglas group, appearing in the southeast (fig. 4). The principal limestone beds outcropping, in order of age, the youngest first (figs. 2, 4, and 27) are: Elmont, Reading, Burlingame, Church, Topeka (Hartford), Deer Creek, Lecompton, Plattsmouth, and Toronto.

## MINERAL RESOURCES

Jefferson County has an abundance of limestone, one permanent limestone quarry with crushing plant, and several quarries operated intermittently with portable equipment. The County produced in 1949 about 140,000 tons of crushed limestone, for road metal, concrete aggregate, and agricultural limestone. In the same year, 75,458 barrels of oil and 81,827 M cubic feet of gas were produced. Oil production in 1950 declined to 50,532 barrels. The County has an abundance of sand-gravel in the Kansas River but no production. Two thin coal seams, neither of which is now economic, outcrop in the County.

### Loess

Loess is available near the Kansas River as source material for soil-cement blocks for structural purposes, mineral filler for road mats, and calcined aggregate.

### Sand-gravel

Sand-gravel is abundant in the Kansas River but is not exploited in the County. It is alkali-reactive and, when used as concrete aggregate, should have an admixture of 30 to 40 percent neutral coarse aggregate.

### Limestone

Elmont and Reading limestone formations, each 2 to 4 feet thick and separated by 6 to 10 feet of shale, are available in the northwest sector, west of the Burlingame limestone outcrops. Either formation is useful as structural stone. One or the other is available in secs. 13 and 24, T. 8 S., R. 16 E. (13, fig. 27) and in secs. 25 and 36, T. 8 S., R. 16 E. (14, fig. 27).

The Burlingame limestone formation, used to a limited extent as road metal, is available in some places in northwestern Jefferson County. A 5- to 8-foot quarry face can be developed. A small abandoned quarry is found in the NW¼ SW¼ of sec. 22, T. 8 S., R. 17 E. (11, fig. 27).

The Church limestone member, only 2 feet thick and not a commercial stone, is mapped as a tracer for the underlying Nodaway coal.

Of the five limestone and four shale members comprising the Topeka limestone formation, only the lower two limestones (Curzon and Hartford) are of economic interest. The Curzon bed is 7 to 8 feet thick and the Hartford about 4 feet; the beds are separated by 1½ to 2 feet of shale. The outcrops in Jefferson County usually are covered by glacial drift. However, outcrops are exposed on both banks of Crooked Creek and small abandoned quarries, formerly used to supply road metal, are located in the SW¼ SW¼ of sec. 2, T. 8 S., R. 19 E. (7, fig. 27) and in the SE¼ SW¼ of sec. 10, T. 8 S., R. 19 E. (8, fig. 27).

Topeka limestone is available south of Ozawkie in secs. 5 and 6, T. 10 S., R. 18 E. (15, fig. 27). The stone is also available near the west border in secs. 24, 25, and 36, T. 10 S., R. 16 E. and in secs. 6 and 7, T. 11 S., R. 17 E. A small recently-operated quarry is located in the NW¼ NE¼ of sec. 7, T. 11 S., R. 17 E. (9, fig. 27) and a larger abandoned quarry is found across the road in the SW¼ SE¼ of sec. 6, T. 11 S., R. 17 E. (10, fig. 27). The quarry had a 9-foot face, including the 2-foot Iowa shale parting, and supplied stone for road metal.

The Deer Creek limestone formation consists of three limestone and two shale members, of which only the top member, the 15- to 16-foot Ervine Creek limestone, is commercial. Used as road metal in Jefferson County, the stone is also suitable as concrete aggregate and agricultural limestone. Grossman & Peterson

opened a quarry in 1949 in the E½ SW¼ of sec. 32, T. 7 S., R. 20 E. (4, fig. 27), on a contract for surfacing Norton Township roads. They use a portable, diesel-powered plant. An abandoned quarry is found in the NW¼ NW¼ of sec. 33, T. 7 S., R. 20 E. (3, fig. 27). A large reserve of Ervine Creek limestone is available in this northeast sector.

Large tonnages of Ervine Creek limestone are also available in central Jefferson County near Ozawkie and Oskaloosa in the valleys of the Delaware River, Big and Little Slough Creeks, and Honey and Wild Horse Creeks where mapped on figure 27. The extensions of the outcrop are not mapped as they become hopelessly buried under glacial drift. Idle quarries are found in the SW¼ of sec. 32, T. 9 S., R. 19 E. (5, fig. 27) and in the SW¼ SE¼ of sec. 20, T. 9 S., R. 19 E. (6, fig. 27). A small abandoned Ervine Creek quarry is found in the NW¼ SE¼ of sec. 29, T. 8 S., R. 20 E. (16, fig. 27), east of Winchester.

The Lecompton limestone formation, usually buried, has no limestone members over 6 or 7 feet thick and is not used.

The Plattsmouth limestone, a 21-foot member of the Oread limestone formation, is the best commercial limestone in the County, and outcrops conspicuously in the southeastern corner. The stone is used as road metal, concrete aggregate, and agricultural lime. N. R. Hamm has a quarry and permanent crushing and screening plant with washing facilities, using 270-hp. connected load, in the W½ NE¼ of sec. 29, T. 11 S., R. 19 E. (2, fig. 27). The plant produces

crushed stone and agricultural limestone. A small abandoned Plattsmouth quarry is located in the center of the line between secs. 1 and 12, T. 11 S., R. 19 E. (1, fig. 27).

The Toronto limestone member, 8 feet thick and only about 20 feet below the thicker and more available Plattsmouth limestone, is not used.

Coal (12)

The Elmo coal seam, 7 to 14 inches thick, lies approximately 40 feet under the Burlingame limestone. The outcrop in the northwest usually is buried and there is no record of its having been mined.

The Nodaway coal seam, 9 to 14 inches thick, lies a few feet under the Church limestone. The coal was mined for local use from 1856 to 1944, but at no time did the annual production exceed 2,000 tons. Nodaway coal outcrops on the highway through sec. 26, T. 8 S., R. 17 E. (12, fig. 27). Coal was mined as recent as 1944 in the NW¼ of sec. 10, T. 9 S., R. 18 E. (17, fig. 27). Mining has also been done in the E½ of sec. 18, T. 8 S., R. 18 E. (18, fig. 27) and in the SW¼ NE¼ of sec. 36, T. 7 S., R. 17 E. (19, fig. 27) near Half Mound.

Oil and gas (6)

Oil was discovered in Jefferson County in 1940. The County produced 75,458 barrels of oil in 1949 from 22 wells in the McLouth and McLouth North Fields (figs. 6 and 27). Production

declined in 1950 to 50,532 barrels (5). Production is from the Mississippian and the McLouth sand (Cherokee, near base, fig. 5) at depths of about 1,500 feet.

The same fields produced 81,827 M cubic feet of gas in 1949.

Cities Service Gas Co. supplies gas to Valley Falls and Oskaloosa through an 8-inch line (fig. 8).

## ELECTRIC POWER

Kansas Power & Light Co. has a 66,000-volt transmission line through Meriden, Rock Creek, Valley Falls, and Nortonville. The company services Oskaloosa through an 11,500-volt line (fig. 9) and Perry through a 13,500-volt line from Lawrence.

Rural Electrification Administration purchases power from the company and distributes it into rural areas.

## WATER

Water occurs in abundance in the alluvials of the Kansas and the Delaware Rivers. Water can also be obtained in tributaries of the Delaware River and in collecting ponds.

## LEAVENWORTH COUNTY

### PHYSICAL FEATURES

Leavenworth County is in the Osage Plains of eastern Kansas (fig. 1). The Missouri River flows southward along the northeast border, and the Kansas River east along the south border. River altitudes are about 800 feet above sea level. Steep bluffs stand 150 to 200 feet above the river bottom lands, and the terrain rises toward the west and north to a maximum of about 1,250 feet.

Stranger Creek, flowing southward through the center, cuts deeply into the uplands and drains most of the County. Short, deep, direct tributaries to the Kansas and Missouri Rivers drain the remainder of the County. The topography is rugged in the vicinity of the drainage system, and the escarpments of the Plattsmouth limestone, meandering from the northeast corner to the southwest corner, are very marked physiographic features (fig. 28).

Leavenworth County is served by four railroad systems. The Missouri Pacific Railroad follows the west bank of the Missouri River through Leavenworth. The Atchison, Topeka & Santa Fe Railroad enters the County slightly above the southeast corner and traverses north and west through Leavenworth and Lowemont. The main line of the Union Pacific between Kansas City and Denver runs westward near the north bank of the Kansas River. The Chicago,

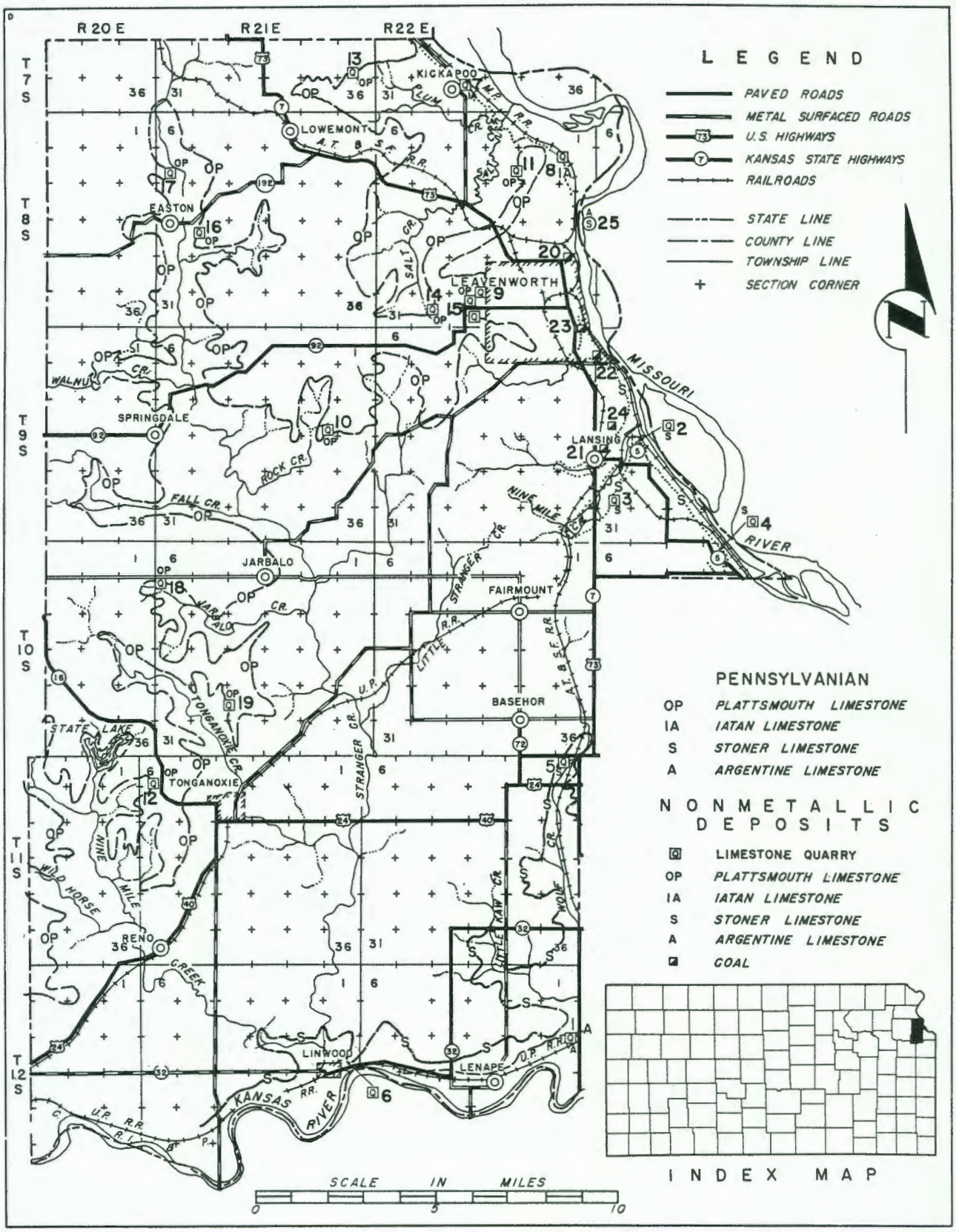



Figure 28.- Leavenworth County, Kansas

Rock Island & Pacific Railroad parallels the Union Pacific Railroad, entering the County slightly above the southwest corner, runs northeast through Tonganoxie to Leavenworth, the county seat (fig. 28).

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The checkerboard pattern is interrupted along the rugged topography of the bluffs of the Missouri and Kansas Rivers and along the escarpments near Stranger Creek. The main paved highways are shown on figure 28.

## GEOLOGY

Leavenworth County is covered with glacial till and loess, the latter being most pronounced along the west bank of the Missouri River and the north bank of the Kansas River.

The consolidated geological formations outcropping in the County range from the Deer Creek limestone of the Shawnee group, buried in the northwest corner, to the Wyandotte limestone (Argentine limestone member) of the Kansas City group, appearing in the southeast corner above the Union Pacific Railroad tracks. The principal limestone beds outcropping, in order of age, the youngest first (figs. 4 and 28), are: Deer Creek, Lecompton, Plattsmouth, Toronto, Iatan, Stoner, Plattsburg, and Argentine.

## MINERAL RESOURCES

Leavenworth County has an abundance of limestone. Production in 1949 was about 440,000 tons of crushed limestone for road metal, concrete aggregate, and agricultural limestone. Only

one small sand-gravel plant was active in 1949. The County produced 11,718 barrels of oil and 6,827 M cubic feet of gas in that year. Oil production declined in 1950 to 10,722 barrels.

### Loess

Eastern Leavenworth County, within a few miles of the Missouri River, is covered heavily with loess, a potential source of material for soil-cement blocks for structural purposes, mineral filler for road mats, and light or dense calcined aggregates.

### Sand-gravel

The Kansas and Missouri Rivers have an unlimited supply of alluvial sand-gravels, which are alkali-reactive and, when used as concrete aggregate, should have an admixture of 30 to 40 percent of neutral coarse aggregate.

The Dresser Sand Co. of Leavenworth operates a small pumping and screening plant on a barge on the Missouri River near Leavenworth (25, fig. 28).

### Limestone (figs. 4 and 28)

Deer Creek and Lecompton limestone formations, outcropping in northwestern Leavenworth County but usually under a heavy cover of glacial till, are of no commercial value in view of the abundance of available limestone nearby.

The Plattsmouth limestone member, 21 feet thick, is used as road metal, concrete aggregate, riprap, and agricultural limestone. Its outcrop, the most abundant and most pronounced of any in the County, first appears in the northeast corner about 200 feet

above the Missouri River bottoms. From Fort Leavenworth, the Plattsmouth escarpment, swings southwest and passes into Douglas County near the southwest corner. Stranger Creek and its tributaries have cut into the outcrop, resulting in a meandering course and countless opportunities for open quarries. Four quarries with crushing plants were active in the fall of 1949 in the following localities: City of Leavenworth, SE¼ sec. 28, T. 8 S., R. 22 E. (9, fig. 28); Myron Gilman, SE¼ sec. 14, T. 9 S., R. 21 E. (10, fig. 28); Corps of Engineers, SE¼ sec. 10, T. 8 S., R. 22 E. (11, fig. 28); and J. C. Haigwood, SE¼ SW¼ sec. 6, T. 11 S., R. 21 E. (12, fig. 28).

Idle or abandoned Plattsmouth quarries are found in the following places:

| Sec. | T(S) | R(E) | No. on fig. 28 |
|---|---|---|---|
| SW¼ 25 | 7 | 21 | 13 |
| Center 32 | 8 | 22 | 14 |
| SE¼ NE¼ 33 | 8 | 22 | 15 |
| NW¼ 20 | 8 | 21 | 16 |
| NE¼ SW¼ 7 | 8 | 21 | 17 |
| NW¼ 7 | 10 | 21 | 18 |
| SW¼ 28 | 10 | 21 | 19 |

The Toronto limestone member, approximately 8 feet thick and 20 feet below the Plattsmouth member, is not used because of the proximity of the Plattsmouth limestone.

The Iatan limestone formation, the top of the Pedee group and about 200 feet below the Plattsmouth limestone, is a white limestone about 10 feet thick and outcrops in northeastern

Leavenworth County, about level with the Missouri Pacific Railroad tracks in secs. 28 and 29, T. 7 S., R. 22 E. An idle quarry, once used by the Corps of Engineers, is found in sec. 33, T. 7 S., R. 22 E. (7, fig. 28). The limestone appears also in the hills of the Fort Leavenworth military reservation in sec. 12, T. 8 S., R. 22 E. (8, fig. 28) where some quarrying has been done. South of the city of Leavenworth, the formation disappears and in its place is found the soft Tonganoxie sandstone (fig. 4).

The Stoner limestone member of the Lansing group (fig. 4) is about 80 feet below the Iatan limestone, and, in the County, has an average thickness of approximately 12 feet. It appears at river level under the bridge of Highway 92 at Leavenworth, and outcrops conspicuously southward along the Missouri River and above the Missouri Pacific Railroad tracks, past the city of Leavenworth and to the Wyandotte County line (fig. 28). The bed appears again on the Leavenworth Wyandotte County line near Highway 24, and is conspicuous southward along Wolf Creek to the bluffs above the Loring quarries in the southeast corner of the County. Here, the outcrop swings westward, and west of Linwood dips under the Kansas River.

Stoner limestone, quarried extensively in the past, is suitable for riprap, concrete aggregate, road metal, and agricultural limestone. The only active Stoner quarry in the fall of 1949 was a small hand-operated one in the NW¼ of sec. 20, T. 9 S., R. 23 E. (2, fig. 28), by the Kansas State Penitentiary at Lansing, using convict labor.

An old idle Stoner quarry is found in the SE¼ SW¼ of sec. 30, T. 9 S., R. 23 E. (3, fig. 28), and another one, once operated by the Corps of Engineers, is located in the NE¼ of sec. 3, T. 10 S., R. 23 E. (4, fig. 28). A large idle quarry, formerly equipped with a spur track from the Santa Fe Railroad, occurs in the NW¼ NE¼ of sec. 1, T. 11 S., R. 22 E. (5, fig. 28). A small idle Stoner quarry is found in the SW¼ SE¼ of sec. 13, T. 12 S., R. 21 E. (6, dig. 28).

The Argentine limestone member of the Wyandotte formation (fig. 4) outcrops only in the southwest corner of the County in secs. 13, 14, 15, and 16, T. 12 S., R. 22 E. The Loring quarry in sec. 13, T. 12 S., R. 22 E. (1, fig. 28) is operated by Loring Quarries, Inc. The quarry face is 85 feet by vertical measurement and includes, in descending order, the following members: Spring Hill limestone, Hickory Creek shale, Merriam limestone, Bonner Springs shale, Farley limestone, Island Creek shale, and Argentine limestone. The shales in the quarry have pinched to thicknesses of 6 inches to 2 feet, and formerly the entire face was quarried for limestone. In recent years, underground mining has been begun and only the upper part of the Argentine limestone is mined. A room-and-pillar mining system is used, with 25-foot pillars and 35-foot rooms, 18 to 21 feet high. A crushing plant produces crushed limestone and agricultural limestone on a relatively large scale.

## Brick

The State of Kansas has operated at times a small shale quarry, probably Vilas shale, and has made common red brick in beehive--type ovens located within the prison walls at Lansing.

## Coal

No coal is being produced in Leavenworth County at present. From 1854 to about 1900, a little coal was produced from shallow operations in Plum Creek, Salt Creek, and along Stranger Creek from the Upper Sibley coal seam. This seam, 9 to 20 inches thick, lies 6 to 33 feet below the Haskell limestone member of the Stranger formation (Douglas group) (fig. 4). Total production was under 15,000 tons (13).

A shaft, sunk in 1870 in the northeast edge of the city of Leavenworth in the SW¼ of sec. 24, T. 8 S., R. 22 E. (20, fig. 28), encountered 21 inches of coal at 713 feet. The shaft was sunk later to 1,100 feet. A 26-inch seam was encountered at 998 feet and a 28-inch one at 1,030 feet. The top seam, the Bevier coal of the Cherokee shale (fig. 4), was the only coal extensively mined. Operation was suspended long ago and the site is now occupied by a furniture factory.

In 1881, a shaft was sunk inside the walls of the prison at Lansing to the Bevier seam, 20 inches thick at this point. A force of 350 to 400 convicts was used until the mine was closed by an act of legislation in 1947 (21, fig. 28). In 1886, a shaft was sunk to the Bevier coal in the southeast corner of the city of

Leavenworth in the SW¼ of sec. 6, T. 9 S., R. 23 E. (22, fig. 28) near the river. About the same time or a little later, another shaft was sunk near the river in the SE¼ SW¼ of sec. 36, T. 8 S., R. 22 E. (23, fig. 28). In 1904, a fifth shaft was sunk a mile north of Lansing in the SW¼ of sec. 18, T. 9 S., R. 23 E. (24, fig. 28).

The four mines outside the prison operated on a 22-inch bed of Bevier coal at an average depth of 720 feet and employed 1,000 to 1,200 men for many years. However, all these mines were shut down and dismantled many years ago, the prison mine outlasting the others. Coal production from the Leavenworth field, including some from across the river in Missouri, reached a peak of 250,000 tons a year.

Oil and gas (6)

Leavenworth County reported an oil production in 1949 of 11,718 barrels from 11 producing wells in the Ackerman and Bankers Life Pools in the western part of the County. Production declined in 1950 to 10,722 barrels (5). Production is from the McClouth sand (basal Cherokee shale) at a depth of about 1,400 feet. The pools were discovered in 1941 (figs. 4, 6, and 28).

Gas production in 1949 was 6,827 M cubic feet from the Squirrel sand (upper Cherokee shale) in the Linwood Pool in southern Leavenworth County.

Gas lines of the Cities Service Gas Co. from southern gas fields extend through Leavenworth County, supplying gas to the larger towns, and continue northward into the northeastern counties.

## ELECTRIC POWER

Kansas Power & Light Co. has a 66,000-volt transmission line from Lawrence (Douglas County) through the city of Leavenworth to Atchison (Atchison County). The company has a steam generating electric plant of 8,400-kw. capacity at Leavenworth, and services eastern and southern Leavenworth County through 33,000- and 13,800-volt lines.

Rural Electrification Administration purchases power from the company at Tonganoxie for distribution into rural areas.

## WATER

Water occurs in abundance in the alluvials of the Missouri and Kansas Rivers. Stranger Creek and the many tributaries to the Kansas River and the Missouri River are water carriers. Water is also obtainable in shallow wells to the Tonganoxie sandstone of the Douglas group which lies over the Stanton limestone between Leavenworth and Linwood.

## WYANDOTTE COUNTY

### PHYSICAL FEATURES

Wyandotte County is in the Osage Plains of eastern Kansas. The Missouri River flows east and south along most of the northern and eastern border. The Kansas River flows eastward along the southern border and, near a midway point, swings northeast to join the Missouri River at Kansas City, Kans. River elevations are about 750 feet above sea level. Bordering the bottom lands of the two principal rivers, the terrain rises steeply for about 200 feet and then increases gradually to a maximum altitude of approximately 1,100 feet at the west border (fig. 29). The County drains directly into the Missouri and Kansas Rivers through short creeks which have cut deeply into the highlands.

Wyandotte County is served by five railroad systems, all leading out of Kansas City, Mo. The Union Pacific Railroad follows the north bank of the Kansas River westward. The Chicago, Rock Island & Pacific parallels the Union Pacific on the north bank. The Atchison, Topeka & Santa Fe, running west out of Kansas City, follows roughly the south bank of the Kansas River. At Bonner Springs, a branch of the Santa Fe runs northwest to Leavenworth. The Missouri Pacific Railroad follows the west bank of the Missouri River. The St. Louis & San Francisco dissects the southeast corner of the County. The county seat is Kansas City, Kans. (fig. 29).

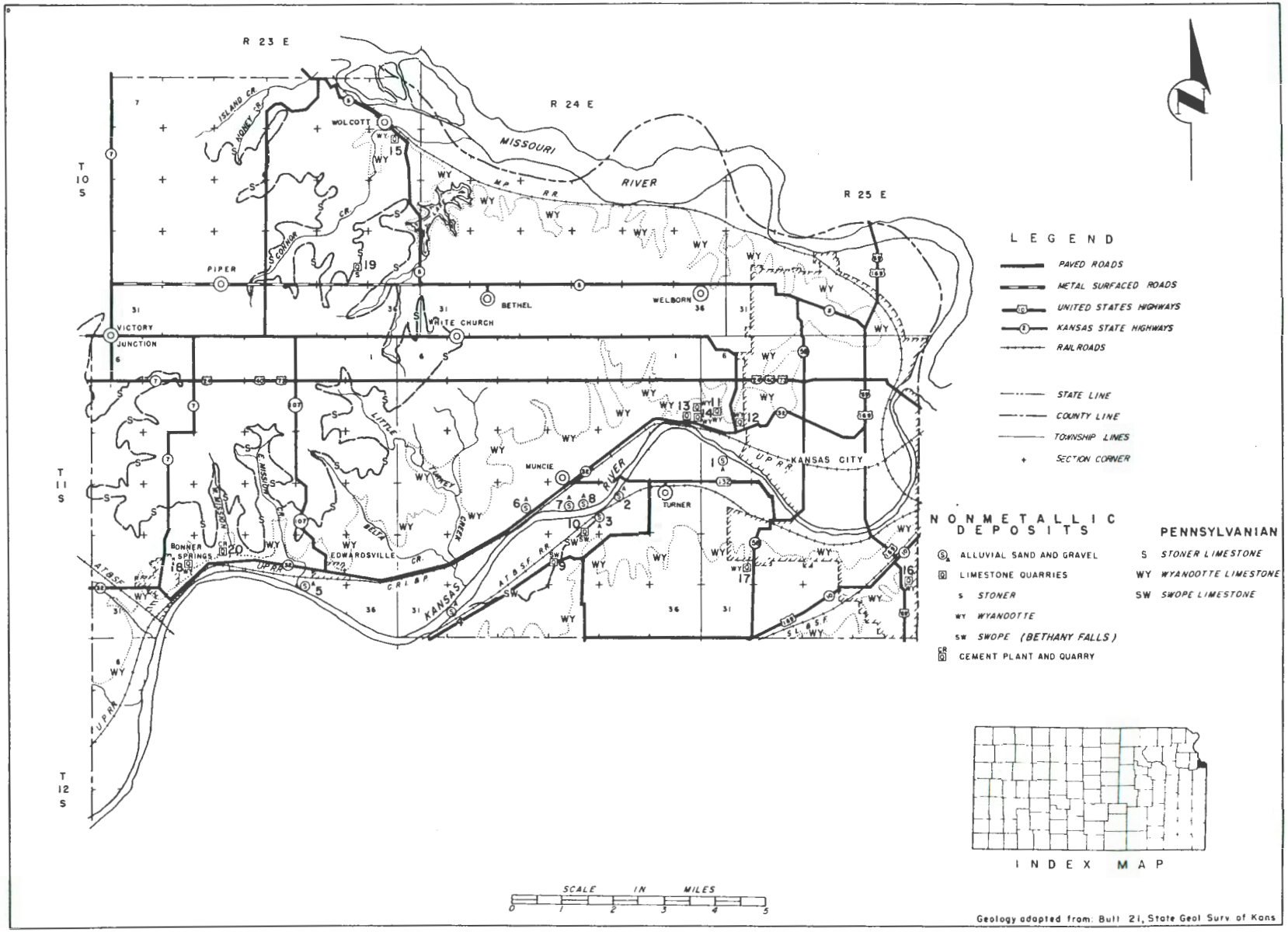



Figure 29.- Wyandotte County, Kansas

Secondary roads, most of them black top, checkerboard the County at 1-mile intervals except along the bluffs of the principal rivers where the steep and rugged topography interrupts the pattern. The main paved highways are shown on figure 29.

## GEOLOGY

Wyandotte County is covered by glacial till and loess, the latter being especially heavy along the Missouri River and in Kansas City, Kans. The consolidated geological members that outcrop in the County, often under a heavy cover of till or loess, range from the Tonganoxie sandstone (Douglas group) in the northwest down to the Bethany Falls limestone and Hushpuckney shale (Kansas City group) on the south bank of the Kansas River (figs. 4 and 29). The principal sandstone and limestone beds outcropping in the County, in order of age, the youngest first, are: Tonganoxie, Stoner, Captain Creek, Spring Hill, Merriam, Farley, Argentine, Iola, Drum, Westerville, Winterset, and Bethany Falls.

## MINERAL RESOURCES

Wyandotte County has an abundance of sand-gravel and limestone. It produced in 1949 about 1,075,000 tons of sand-gravel, 750,000 tons of crushed limestone used as riprap, road metal, and concrete aggregate, 160,000 tons of agricultural limestone, a little oolitic limestone structural stone, and over a million barrels of portland cement. The County also produced 37,303 M cubic feet of natural gas.

## Loess

Wyandotte County has an abundance of loess on the bluffs above the Missouri River and near its junction with the Kansas River. The deposit is a potential source of material for mineral filler and stabilizer, for soil-cement blocks for structural use, and for dense or lightweight calcined aggregates.

## Sand-gravel

Eight sand plants are located on the Kansas River and none on the Missouri River.

Kaw Valley Sand Co. has a plant in the SE¼ NW¼ of sec. 18, T. 11 S., R. 25 E. (1, fig. 29) on the south side of the Kansas River. Alluvials, raised by an electrically-powered 8-inch suction pump with cutter, are screened and classified, the overflow water being returned to the river. A gasoline-powered clamshell is used for loading trucks for delivering sand to market.

Stewart Sand & Material Co. has a sand plant on the south side of the Kansas River in the SE¼ NW¼ of sec. 23, T. 11 S., R. 24 E. (2, fig. 29). A 10-inch suction pump delivers alluvial material to a steel structured plant with trommels and screw type classifiers and an elevated conveyor, belt for stock-piling. A gasoline-driven clamshell is used for loading trucks and cars. The electrical connected load is 600-hp. The depth of sand in the river is 25 to 45 feet. Both truck and rail facilities are available.

American Sand & Material Co. has a sand plant on the south side of the Kansas River in the NE¼ SE¼ of sec. 22, T. 11 S., R. 24 E. (3, fig. 29). An 8-inch suction pump with a 300-hp. motor pumps to a steel structured plant with coarse grizzlies, vibrating screens, and plus 16-mesh fine screens. The products are loaded directly into railroad cars and shipped to consumers or unloaded to stock piles. A 60-hp., 3/4-yard clamshell loader and a 75-hp., 1-yard clamshell loader, gasoline powered, are used at the stock piles.

Chamber Sand Co. has a plant on the south bank of the Kansas River in the NW¼ SW¼ of sec. 32, T. 11 S., R. 24 E. (4, fig. 29) with truck and rail facilities. A 6-inch centrifugal suction pump driven by a 144-hp. diesel engine pumps to the screening and classifying plant. A stationary dragline and two 3/4-yard portable clamshell loaders, gasoline or diesel oil powered, are used on the stock pile.

Holiday Sand & Gravel Co. has a plant on the north side of the Kansas River in the SW¼ SW¼ of sec. 26, T. 11 S., R. 23 E. (5, fig. 29). A 10-inch suction pump with a 250-hp. motor pumps to a steel tipple with a 1¼-inch grizzly, the undersize from which is screened and classified. A 3/4-yard (60-hp.) clamshell loader, a 1-yard (90-hp.) clamshell, and a 2-yard (120-hp.) clamshell, all gasoline or diesel powered, are used on the stock pile. Truck and rail facilities are available.

Peck-Woolf Sand & Material Co. operates a sand plant on the north side of the Kansas River in the NW¼ SE¼ of sec. 21, T. 11 S., R. 24 E. (6, fig. 29). A 10-inch centrifugal suction pump with a 300-hp. motor pumps to two steel tipples with coarse and fine screens and cone classifiers. Three electrically-driven stationary draglines (20-hp., 75-hp., and 100-hp.) are used for loading and stock-piling. Two electric-powered, 60-hp. clamshell loaders and two gasoline-powered, 1-yard clamshell loaders also are used. Truck and rail facilities are available.

Hoppe Sand Co. produces sand from a plant on the north side of the Kansas River in the SE¼ NW¼ of sec. 22, T. 11 S., R. 24 E. (7, fig. 29). A 200-hp. diesel-powered, 8-inch centrifugal suction pump pumps to a sand plant with a 3/4-inch grizzly and ½-inch coarse screen and over 20-mesh screens. For loading and stock-piling, one stationary dragline and three 75-hp. portable, 1-yard clamshells are used. All are gasoline-powered. Rail and truck facilities are available.

Dreyer Sand Co. operates a sand plant on the north side of the Kansas River in the SW¼ NE¼ of sec. 22, T. 11 S., R. 24 E. (8, fig. 29). A diesel-driven, 8-inch suction pump pumps to the sand plant, through a 5/16-inch screen and over 16-mesh screens and a cone classifier. A gasoline-powered clamshell loader is used. There are no rail facilities. A concrete truck tunnel extends under the stock pile.

## Limestone (figs. 2, 4, and 29)

Outcropping limestone beds are numerous in Wyandotte County, and three limestone plants are operating.

The Stoner limestone member, a massive white stone 10 to 12 feet thick and once quarried extensively in adjoining counties, has not been used much in Wyandotte County. The bed outcrops prominently in the southwest near the west border and also in the highlands of the northwest, but usually under glacial till or loess. An abandoned quarry is found in the NW¼ SE¼ of sec. 26, T. 10 S., R. 23 E. (19, fig. 29).

The Captain Creek limestone member, about 6 feet thick and separated from the overlying Stoner limestone by 5 to 8 feet of Eudora shale, is not used in Wyandotte County but is utilized farther south where it is thicker.

The Spring Hill limestone member of the Plattsburg formation, outcropping in the western part of the County and usually under heavy cover, is a good limestone 10 to 20 feet thick but is not used in the County.

The Merriam limestone member of the Plattsburg formation is separated from the overlying Spring Hill limestone by the Hickory Creek shale, a few inches to 8 feet thick. The bed, approximately 10 feet thick, is a good limestone suitable for building stone, riprap, cement, or road metal. The bed outcrops in the western part of the County, generally under heavy cover, and is used only at the Lone Star cement plant where it occurs as overburden.

The Farley limestone member of the Wyandotte formation is separated from the overlying Plattsburg formation by the Bonner Springs shale, a few feet to 25 feet thick. Farley stone is not abundant in the County. It is 25 feet thick at the Lone Star cement quarry and is part of the lime component used in the cement plant.

The Argentine limestone member, 30 to 35 feet thick, lies 8 to 12 feet below the Farley limestone. The basal beds are frequently siliceous. The stone is one of the most important in the County and is used extensively as building stone, road metal, concrete aggregate, and agricultural limestone. The bed outcrops prominently along both sides of the Kansas River and along the bank of the Missouri River.

American Rock Crusher Co., Inc., Kansas City, Kans., operates an underground quarry in Argentine limestone in the N½ SE¼ of sec. 30, T. 11 S., R. 25 E. (17, fig. 29); producing crushed stone and agricultural limestone. The room-and-pillar system of mining is used, with 25-foot pillars and rooms 30 feet x 13½ feet high. Four feet of limestone and calcareous shale is left in the floor. The roof pillar is 14 feet thick, the lower 2 feet being hard calcareous shale which forms a good roof but is unsatisfactory as crushed stone. The broken rock is loaded mechanically into trucks which haul the stone to a crushing and screening plant. Screens are adjusted to suit specifications.

A large abandoned quarry, from which great quantities of Argentine limestone and the underlying shale have been removed, is found in southeastern Wyandotte County in the SW¼ SW¼ of sec. 26, T. 11 S., R. 25 E. (16, fig. 29). Other abandoned quarries are in the NW¼ NE¼ of sec. 13, T. 10 S., R. 23 E. (15, fig. 29) and in the NE¼ SW¼ of sec. 29, T. 11 S., R. 23 E. (18, fig. 29).

The Iola limestone formation is separated from the overlying Argentine limestone by about 35 feet of shale. The Raytown limestone, the formation's principal member, is less than 5 feet thick in the County and is not used. Another member, directly under the Raytown bed, is the Muncie Creek shale, 2 to 3 feet thick. which contains nodules of phosphate (17). A sample of the shale, taken from an outcrop on Highway 32 in sec. 7. T. 11 S., R. 25 E. and submitted to the Bureau of Mines' laboratory at Rolla, Mo., analyzed 0.63 percent $P_2O_5$. A radiometric analysis showed approximately 0.003 percent uranium equivalent. The Iola formation outcrops most prominently along Highway 32 and along the Missouri River from Kansas City, Kans. to Wolcott.

The Drum limestone formation, about 10 feet thick, is separated from the overlying Iola formation by approximately 12 feet of Chanute formation shale. Drum stone outcrops on both sides of the Kansas River and along the west bank of the Missouri River northeast of Kansas City, Kans. A large abandoned quarry is found in the SE¼ SE¼ of sec. 7, T. 11 S., R. 25 E. (12, fig. 29) near

Highway 32. Drum limestone and the underlying Westerville limestone were quarried for road metal and building stone. In the Mike & Joe Quarry in the W½ SE¼ of sec. 12, T. 11 S., R. 24 E. (13, fig. 29), two men are quarrying Drum limestone and Westerville limestone for building stone. The two limestones are separated by 5 feet of Quivira shale which is wasted.

The Westerville limestone member is being quarried on a small scale on the "Jenkins 400", with one small quarry in the SW¼ of sec. 7, T. 11 S., R. 25 E. (11, fig. 29), two small quarries in the SE¼ of sec. 12, T. 11 S., R. 24 E. (14, fig. 29), and the Mike & Joe Quarry in the E½ SW¼ of sec. 12, T. 11 S., R. 24 E. (13, fig. 29). The Westerville limestone member, 16 feet thick, has a 2½- to 3-foot flinty, ferruginous top layer which is wasted because it decrepitates rapidly upon weathering. Below this capping is 5 to 10 feet of oolitic limestone that is quarried on a small scale for structural stone, hand-shaped in the quarry. The bottom part of the Westerville member is siliceous and is not quarried. The Drum limestone is removed as overburden when necessary and sold as foundation rock. The Westerville limestone is not continuous over the State. Averaging about 8 feet in thickness, the bed does not extend much beyond Wyandotte and Johnson Counties.

The Winterset limestone member, a flinty stone averaging 36 feet in thickness, lies a short distance below the Westerville limestone but is not used in the County.

The Bethany Falls limestone member, 16 to 26 feet thick, is the most important and the most extensively used limestone in Wyandotte County, although its available outcrop extends but a short distance along the south bank of the Kansas River.

Thompson Crushed Rock Co. operates an underground mine on Bethany limestone and has a reinforced concrete crushing and screening plant in the NW¼ SW¼ of sec. 27, T. 11 S., R. 24 E. (9 fig. 29). The company employs a room-and-pillar method of mining with 22-foot pillars and 40-foot rooms, 12 feet high. The floor is Hushpuckney shale and a 4-foot limestone pillar is left in the roof. The broken limestone is loaded by Highloaders into 10-ton trucks, hauled to a pan loader or coarse shaking grizzly, and fed to a primary crusher. The stone is crushed and screened to meet specifications. None of the crushed stone is washed. Truck or rail facilities are available.

Peerless Quarries, Inc., Turner, Kans., has an underground mine, with rail and truck facilities, in the Bethany Falls limestone and a steel and wood crushing and screening plant on the south side of the Kansas River in the SW¼ SE¼ of sec. 22, T. 11 S., R. 24 E. (10, fig. 29). The crushed stone is used as riprap, road metal, and concrete aggregate. Agricultural limestone is produced also. A room-and-pillar system of mining, with 20-foot pillars and 40-foot rooms, 12½ feet high is employed. A shale floor is utilized and a 4-foot limestone pillar is left in the roof. Highloaders load the broken rock into trucks for delivery to the crushing and screening plant.

## Sandstone

The Tonganoxie sandstone of the Douglas group overlies the Stoner limestone of the Lansing group in the northwest part of the County. The two members are separated by approximately 10 feet of limestone and shale. The Tonganoxie bed is a soft, porous sandstone which serves only as an aquifer.

## Cement

Wyandotte County has one cement plant, operated by the Lone Star Cement Corp. of Bonner Springs, Kans. Annual capacity is over a million barrels. The plant and open quarry are in the W½ and the W½ E½ of sec. 28, T. 11 S., R. 23 E. (20, fig. 29), on the north side of Highway 32. A 40-foot face is quarried and consists, in descending order, of 25 feet of Farley limestone, 3 feet of Island Creek shale, and 12 feet of Argentine limestone.

The lower part of the Argentine limestone, which is 30 to 35 feet thick, is too siliceous to be used. Overlying the Farley limestone is 20 to 25 feet of Bonner Springs shale (which is stripped and wasted) and 10 feet of Merriam limestone (which is used at the cement plant). Four wagon-drills, operated by compressed air, are used to drill limestone and shale overburden for blasting; an electric shovel loads the broken rock into trucks for disposal. Some shale overburden may be removed by carryalls. Vertical holes, 6-inches in diameter, are drilled in the quarry bench by electric churn drills for blasting. An electric shovel loads the broken rock

into trucks which haul to the cement mill, which is electrically operated. The resulting clinker from the kilns is ground in eight 36-inch Griffens and then to two 7 feet by 24 feet and one 7 feet by 26 feet tube mills. The product from the tube mills is stored in the cement stock house.

### Coal

The Thayer coal seam in the County is only a streak an inch or less in thickness. It outcrops in the Chanute shale formation a short distance below the Iola limestone.

### Oil and gas (6)

Potential oil and gas strata underlie Wyandotte County but it has no commercial production of oil. A total of 37,303 M cubic feet of gas was produced in 1949 from the Roberts-Maywood area in the western part of the County in T. 11 S., R. 23 E.

Phillips Petroleum Co. has a large refinery on the Missouri River bottoms in northeast Kansas City, Kans. (fig. 8).

## ELECTRIC POWER

The 115,000-volt transmission line from the power plants of the Kansas City Power & Light Co. in Kansas City, Mo., to the Sunflower Ordinance Plant in Douglas County, crosses southeastern Wyandotte County. The company services the eastern part of the County over 33,000-volt lines (fig. 9).

Kansas Power & Light Co. supplies the western part of the County over 13,800-volt lines.

The Board of Public Utilities of Kansas City, Kans., has a municipally-owned, steam-generating, electric plant of 99,000-kw. capacity in Kansas City, Kans.

## WATER

The alluvials of the Kansas River and the Missouri River contain an abundant supply of water. Interior Wyandotte County depends on entrained runoff waters or shallow wells to the porous Tonganoxie sandstone or other porous strata of the Douglas group.

## DOUGLAS COUNTY

### PHYSICAL FEATURES

Douglas County is in the Osage Plains of eastern Kansas (fig. 1). The Kansas River flows south of east along the north border at altitudes of 825 to 800 feet above sea level. The Wakarusa River flows eastward across the County and joins the Kansas River near the northeast corner. The terrain rises gradually toward the south and west to a maximum altitude of 1,200 feet. The Plattsmouth limestone forms pronounced escarpments beginning at the Kansas River on the north border and meandering southward through the middle of the County to cross the south border (fig. 30).

Douglas County is served by three railroad systems. A main line of the Union Pacific Railroad runs west along the north bank of the Kansas River, through Lawrence, the county seat. The Chicago, Rock Island & Pacific Railroad uses the same right of way. The Atchison, Topeka & Santa Fe Railroad traverses east to west along the south bank of the Kansas River. A branch of the Santa Fe leads south from Lawrence, passing through Vinland and Baldwin into Franklin County (fig. 30).

Secondary roads checkerboard Douglas County at intervals of 1 and 2 miles. The pattern is disturbed by the rugged topography in the vicinity of outcrops of the Plattsmouth limestone.

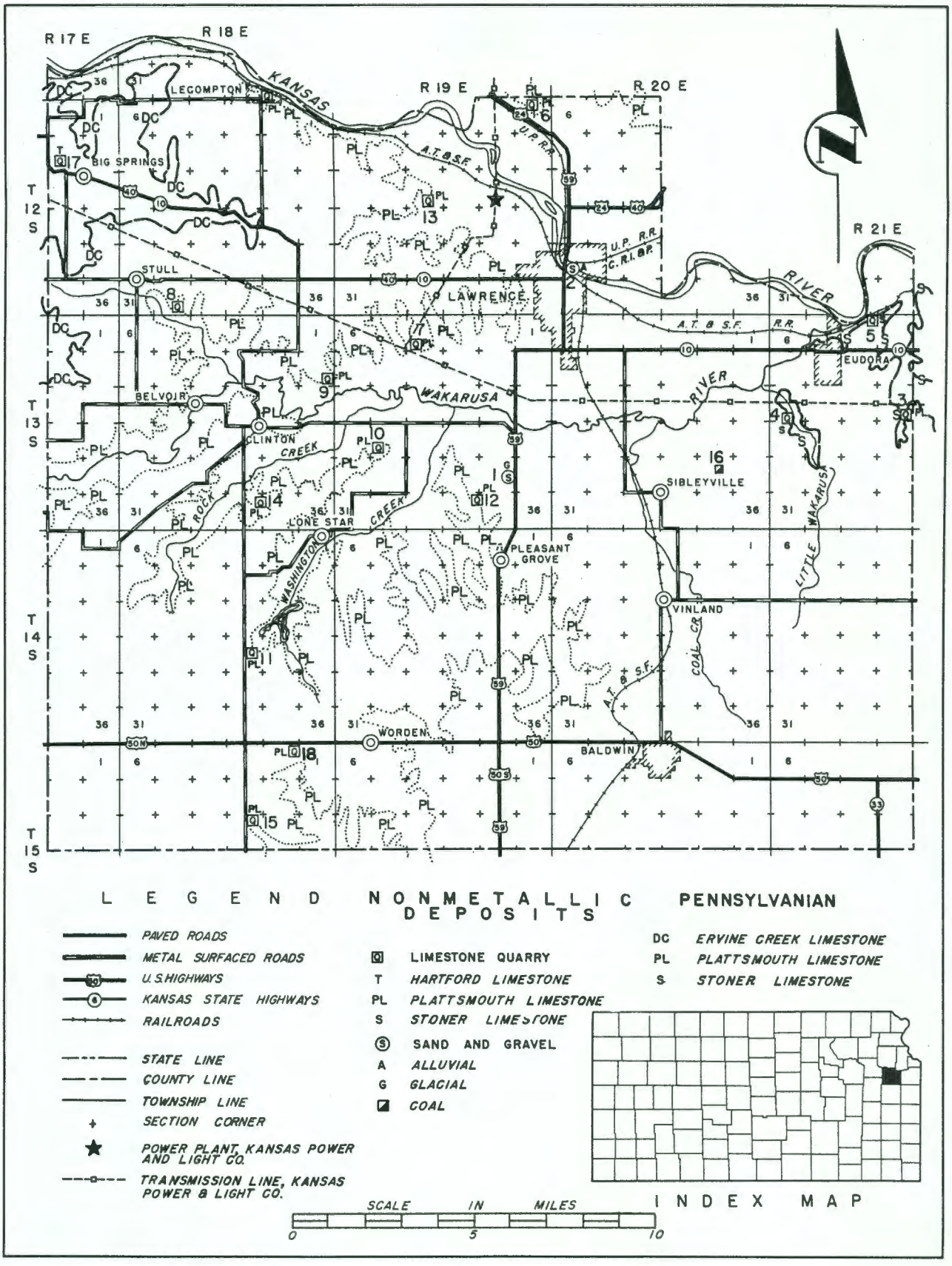



Figure 30.- Douglas County, Kansas

## GEOLOGY

The northern part of Douglas County is covered by glacial drift. Quantities of loess are found near the Kansas River.

The consolidated geological formations outcropping in the County range from the Topeka limestone in a small area in the northwest down to the Stanton limestone (Stoner member) in the northeast (fig. 4). The principal limestones, in order of age, the youngest first, are: Hartford, Ervine Creek, Lecompton, Plattsmouth, Toronto, Stoner, and Captain Creek.

## MINERAL RESOURCES

Douglas County has an abundance of sand-gravel and one regularly-operated sand plant, at Lawrence. The County also has large reserves of limestone but most of the quarries use portable equipment and production varies from year to year. Three limestone quarries were in operation in 1951 at an annual rate of 75,000 tons of crushed and screened rock and agricultural limestone. The County produced 4,000 barrels of oil in 1949 with no marked change in 1950. One small strip mine was producing a few hundred tons of coal a year.

### Sand-gravel

A big deposit of glacial gravel of the moraine-type with boulders up to 18 inches in diameter is located within 4 miles of Lawrence on Highway 59. A large quarry was formerly operated in this deposit in the SE¼ of sec. 26, T. 13 S., R. 19 E. (1, fig. 30). The gravel was crushed for use as road metal.

The alluvials of the Kansas River have unlimited quantities of sand-gravel. The Bowersock Mill & Power Co. operates a sand-gravel plant at Lawrence in the SW¼ of sec. 30, T. 12 S., R. 20 E. (2, fig. 30). The sand-gravel is alkali-reactive and, when used as concrete aggregate, should have an admixture of 30 to 40 percent of neutral coarse aggregate.

Limestone (fig. 4)

The Hartford limestone member, the base of the Topeka limestone formation, is 4 to 5 feet thick and outcrops in limited quantities in western Douglas County. A small idle quarry is in the SE¼ SW¼ of sec. 11, T. 12 S., R. 17 E. (17, fig. 30). The stone was used as road metal.

The Ervine Creek limestone member of the Deer Creek formation, up to 15 feet thick, outcrops abundantly in the northwest and southwest corners of the County. It is suitable for concrete aggregate and road metal, but is not quarried in the County.

The Lecompton limestone formation outcrops below the Deer Creek limestone, but no member is more than 6 feet thick. The stone is not quarried.

The Plattsmouth limestone member, Oread formation, with a thickness up to 16 feet, outcrops extensively and prominently throughout the western half of Douglas County at many inactive quarries. 10,000 to 20,000 tons of limestone has been crushed and stock-piled, and the equipment removed.

The following Plattsmouth quarries were inactive in the spring of 1951:

| Quarry | Sec. | T(S) | R(E) | No. on fig. 30 |
|---|---|---|---|---|
| Alford | NW¼ 1 | 12 | 19 | 6 |
| Mitchel | SW¼ 4 | 13 | 19 | 7 |
| Walters | SW¼SE¼ 32 | 12 | 18 | 8 |
| Clough | SE¼SE¼ 12 | 13 | 18 | 9 |
| Banning | SW¼ 20 | 13 | 19 | 10 |
| | NW¼SE¼ 22 | 14 | 18 | 11 |
| | NW¼NW¼ 35 | 13 | 19 | 12 |
| | NE¼NE¼ 2 | 15 | 18 | 18 |

The following are active Plattsmouth quarries:

| Quarry | Sec. | T(S) | R(E) | No. on fig. 30 |
|---|---|---|---|---|
| Unfred | SE¼SW¼ 16 | 12 | 19 | 13 |
| Howard | SE¼NE¼ 34 | 13 | 18 | 14 |
| Clark | NW¼NE¼ 15 | 15 | 18 | 15 |

The three quarries have an annual production of about 75,000 tons of crushed limestone, used as road metal, riprap, and agricultural limestone.

The Toronto limestone member, approximately 8 feet thick and not quarried, lies about 20 feet below the Plattsmouth limestone.

The Stoner limestone member outcrops in the northeast corner of the County. An abandoned quarry, with a 12-foot quarry face, is found in the SE¼SE¼ of sec. 15, T. 13 S., R. 21 E. (3, fig. 30). Small quarries are located in the SE¼SW¼ of sec. 18, (4, fig. 30) and in the SE¼ SW¼ of sec. 18, T. 13 S., R. 21 E. (4,

fig. 30). The Lothhols quarry in the NE¼ NE¼ of sec. 4, T. 13 S., R. 21 E. (5, fig. 30) was inactive in the spring of 1951. The Stoner limestone, 14 feet thick, is suitable for riprap, road metal, and concrete aggregate.

The Captain Creek limestone member lying 6 to 8 feet below the Stoner limestone is not quarried in the County.

### Shale

Considerable Weston shale is available in southeast Douglas County between the Tonganoxie sandstone member, and the Stanton limestone formation. The shale is a potential source of material for brick or lightweight calcined aggregate (haydite).

### Metals

Crystals of galena and spalerite have been found in many places in northern Douglas County but no commercially exploitable deposits are known. The minerals generally occur in calcareous concretions in shale.

### Coal (13)

The Douglas group, consisting of shale, sandstone and thin limestones, occupies the eastern half of the County. This group contains a number of thin, noncontinuous coal seams which, from 1870 to 1910, were mined by many small operators. In thickness the seams ranged from a few inches to 22 inches and, where mined, averaged 8 to 14 inches. The Ottawa and Blue Mound seams are near the bottom of the Douglas group, a short distance above the Weston

shale. The upper and lower Sibley seams are in the lower half of the Douglas group, and the upper and lower Williamsburg seams lie near the top of the group and close to the overlying Oread limestone formation (fig. 4).

The Gordon strip pit produced a little coal in 1951 for local consumption from the 11-inch Blue Mound seam in the SW¼ NE¼ of sec. 26, T. 13 S., R. 20 E. (16, fig. 30). When mined clean, the coal is good high-volatile C bituminous with a heating value of 12,000 to 13,000 B.t.u., dry basis.

### Oil and gas (6)

Oil production in Douglas County in 1949 totaled 4,000 barrels from the Squirrel sand (near the top of the Cherokee shale), in the Baldwin Pool. This is an old pool discovered in 1919 about 2 miles east-southeast of Baldwin. A small amount of gas is produced from the Eudora area.

The crude-oil line of the Service Pipe Line Co., from the Elmont pumping plant in Shawnee County, crosses Douglas County south of Lawrence. An oil products line of the Socony-Vacuum Oil Co., Inc., crosses the northwest corner (fig. 8).

Two lines from the Cities Service Gas Co. compressing plant near Ottawa cross the County northward and northeastward to furnish gas to the larger towns.

## ELECTRIC POWER

Kansas Power & Light Co. has a generating station on the Kansas River near Lawrence, consisting in 1950, of a single unit of 10,000-kw. capacity. The company is increasing this capacity

to 40,000 kilowatts. Gas is used for fuel with oil as a stand-by. A 66,000-volt line extends westward to Tecumseh. Another 66,000-volt line goes northeast to Leavenworth and a 66,000-volt line is replacing a 33,000-volt line extending eastward to the Sunflower Ordinance Plant in Johnson County. Kansas Power & Light Co. has distributing lines throughout the County and furnishes power to the Lawrence water department.

Bowersock Mill & Power Co. has a dam and hydraulic power plant on the Kansas River at Lawrence. The plant has five 250-kv.-a. and two 300-kv.-a. units, a total of 1,850-kv.-a., driven by Leffel hydraulic turbines with a 34-foot head. The plant furnishes power to industries in Lawrence and ties in with the Kansas Power & Light Co.

Rural Electrification Administration purchases power from Kansas Power & Light Co. for distribution to rural areas.

Baldwin has an internal combustion electric plant of 1,283-kilowatt capacity.

## WATER

Water is abundant in the alluvials of the Kansas River, and wells in those alluvials supply Lawrence with water. Water is also obtainable in shallow wells into the Tonganoxie sandstone, to porous alluvials along minor water courses, and in collecting ponds.

## JOHNSON COUNTY

### PHYSICAL FEATURES

Johnson County is in the Osage Plains of eastern Kansas (fig. 1). The Kansas River flows north of east from the northwest corner of the County at an altitude of about 800 feet above sea level and, about midway of the north border, enters Wyandotte County. The terrain rises southward from the river to maximum altitudes of approximately 1,200 feet. Most of the drainage is to the north and east through deep cutting creeks. In the southwest the drainage is southward into the Marais des Cygnes River Basin (fig. 31).

Johnson County is served by four railroads (fig. 31). The Atchison, Topeka & Santa Fe runs westward along the south branch of the Kansas River. A branch of the Santa Fe enters the northeast corner of the County and crosses diagonally passing through Olathe, the county seat, and Edgerton. The St. Louis & San Francisco Railroad traverses in a north-south direction through the middle, touching Holliday, Olathe, and Spring Hill. The Missouri Pacific Railroad cuts the southeast corner, passing through Kenneth and Stillwell.

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 31.

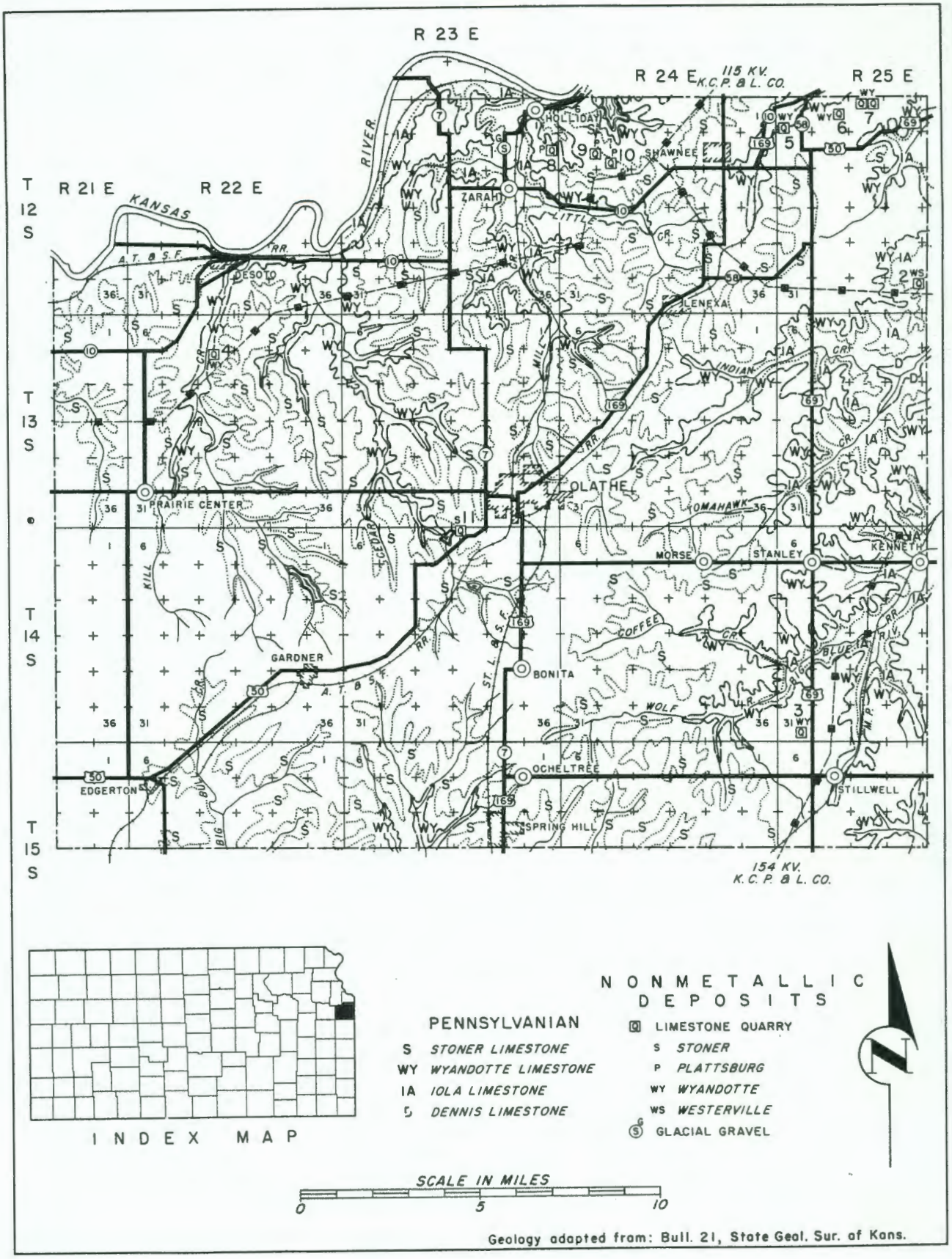



Figure 31.- Johnson County, Kansas

### Geology

Both glacial till and residual soil are found in Johnson County. The northern part near the Kansas River has loess deposits up to 15 feet thick.

The consolidated geological members outcropping in Johnson County range from the Tonganoxie sandstone (Douglas group) in the southwest down to the Bethany Falls limestone (Kansas City group) which outcrops to a limited extent in creek beds near the Missouri border (figs. 2, 4, and 31). The principal limestones, in order of age, the youngest first, are: Stoner, Captain Creek, Spring Hill, Merriam, Farley, Argentine, Raytown, Drum, Westerville, Winterset, and Bethany Falls.

## MINERAL RESOURCES

Johnson County produces sand-gravel from a single glacial gravel deposit. The Kansas River has vast reserves of alluvial sand-gravel but they are not exploited. The County has an abundance of limestone for road metal or concrete aggregate and produces annually about 100,000 tons of crushed rock, agricultural limestone, and rough building stone.

### Sand-gravel

Alluvial sand-gravels occur in abundance in the Kansas River in the County but are not exploited. They are alkali-reactive.

A large deposit of alkali-reactive glacial gravel occurs in sec. 11, T. 12 S., R. 23 E. (1, fig. 31). The deposit, at least

50 feet thick, lying on the Iola formation, has been mined for more than 40 years. The Holiday Sand & Gravel Co. is, at present, mining and screening the material for use as concrete aggregate.

## Limestone

The Stanton limestone formation outcrops extensively and conspicuously in the western half of Johnson County. It also outcrops in the west half of the east half of the County, but the major part of the formation has been eroded and the remnants are inconspicuous. The formation has two limestone members of importance, the Stoner, 8 to 15 feet thick, and the lower lying Captain Creek, 5 to 16 feet thick, separated by 6 to 10 feet of shale. Johnson County is operating a Stanton quarry in the NW¼ sec. 3, T. 14 S., R. 23 E. (11, fig. 31), producing crushed rock, mostly from the Captain Creek limestone which, at this location, is 12 to 16 feet thick. Stoner limestone is used largely for foundation rock.

The Plattsburg limestone formation is not mapped on figure 31. Consisting of two limestone members, the Spring Hill and the underlying Merriam, separated by a foot or two of shale, the formation, 10 to 28 feet thick, is between the Stoner and Wyandotte outcrops. Throughout the County, many small abandoned Plattsburg quarries were opened to obtain rough-shaped foundation rock. In northern Johnson County, three quarries were operating in 1951, each using three or four men and hand tools. The quarries are situated as follows:

| Sec. | T(S) | R(E) | No. on fig. 31 |
|---|---|---|---|
| 12 | 12 | 23 | 8 |
| 7 | 12 | 24 | 9 |
| 8 | 12 | 24 | 10 |

The Wyandotte limestone formation has two limestone members, Farley and Argentine, usually separated by 8 to 10 feet of shale; however, near the Kansas River and in southern Johnson County, the shale thins and the two members appear as one, 20 to 60 feet thick. Wyandotte limestone outcrops extensively, generally along the walls of stream valleys. Reno Construction Co. has a quarry in the SE¼ sec. 31, T. 14 S., R. 25 E. (3, fig. 31), producing crushed stone and agricultural limestone from a 60-foot face of Wyandotte limestone. A large idle Wyandotte quarry, opened to furnish stone for the 10,000-acre Sunflower Ordinance Plant south of De Soto, is in the NW¼ sec. 9, T. 13 S., R. 22 E. (4, fig. 31). The quarry has 10 feet of Farley limestone and 25 to 30 feet of Argentine limestone separated by 2 feet of Island Creek shale.

In the northeast corner of the County, several large Wyandotte quarries, abandoned because of residential encroachment, are located as follows:

| Sec. | T(S) | R(E) | No. on fig. 31 |
|---|---|---|---|
| SW¼ 6 | 12 | 25 | 5 |
| NE¼ 6 | 12 | 25 | 5 |
| NE¼ 5 | 12 | 25 | 6 |
| NW¼ 4 | 12 | 25 | 7 |
| NE¼ 4 | 12 | 25 | 7 |

The Raytown limestone member of the Iola formation averages but 6 feet thick in Johnson County and, hence, has not been used. It outcrops along the banks of the Kansas River up to Cedar Creek, along Mill Creek, and along the east-flowing creeks near the Missouri boundary.

The Drum limestone formation outcrops under the Iola limestone formation along the Kansas River and in eastern Johnson County. The stone is often cherty and has been quarried only in the Southwest Quarry, in the NW¼ sec. 35, T. 12 S., R. 25 E. (2, fig. 31). This quarry was once a large producer but due to residential encroachment, now produces only a small tonnage of crushed stone and a little building stone. The quarry shows 10 feet of Drum limestone at the surface and 20 feet of oolitic Westerville limestone in the pit, separated by about 5 feet of shale.

Winterset and Bethany Falls limestones outcrop in creek bottoms in eastern Johnson County but the occurrences are too near water level to be of interest.

## Coal (13)

There is no commercial coal in the County. The Thayer seam outcrops in the Chanute shale and is but an inch or less thick in the two exposures near Kenneth.

Oil and gas (6)

Very little oil has been produced in Johnson County. A few barrels were produced in wells near Gardner but none in 1949. A total of 4,341 M cubic feet of gas was reported from the Olathe area. A well was drilled in the NE¼ sec. 13, T. 13 S., R. 24 E. but apparently without significant results.

Phillips Petroleum Co. has a pumping station on a 6-inch oil products line in the SE¼ SE¼ sec. 28, T. 13 S., R. 24 E. The plant has one 175-hp. Sterling unit and one 225-hp. Clark unit. Natural gas from Cities Service Gas Co. is used for power with a butane stand-by unit using butane from a nearby 8-inch Phillips line which is not connected to the pumping plant. The oil-products line runs north through Johnson County to the refinery in Kansas City, Kans.

A Sinclair boosting station, in the SE¼ SW¼ sec. 10, T. 14 S., R. 25 E., has two incoming 8-inch oil products lines and one outgoing 6-inch line. The station has two 400-hp. and one 200-hp. units, using electrical power from the Kansas City Power & Light Co. The products lines run northeast into Missouri.

The Sinclair Refining Co. has a boosting station at Ridel, in the SE¼ sec. 16, T. 14 S., R. 25 E., on a multiple crude-oil line consisting of three 12-inch and two 18-inch incoming lines and one 18-inch and two 8-inch outgoing lines. The plant

consists of three Bush-Sulzer 750-hp. diesel units, two Snow 600-hp. diesel units, and two 450-hp. diesel units--a total of 4,350-hp. Crude oil is used as fuel. The oil is pumped northeast into Missouri.

Cities Service Gas Co. has a compressing station, in the NW¼ sec. 36, T. 12 S., R. 23 E., on a 16-inch gas line from the Craig field in T. 12 S., R. 23 E., which is used as an underground gas reservoir. The gas is pumped to the Glavin station in Kansas City. The 16-inch line joins the three 16-inch lines crossing Johnson County southwest to northeast.

## ELECTRIC POWER

Kansas Power & Light Co. distributes power to Olathe and Spring Hill and intermediate areas over a 33,000-volt line from Tecumseh and Lawrence.

Kansas City Power & Light Co. operates a 115,000-volt line from Kansas City, Mo. Near Shawnee it branches--one line runs to the Sunflower Ordinance Plant and the other goes eastward to the Pratt-Whitney plant in Jackson County, Mo.

Kansas City Power & Light Co. also has a 154,000-volt line from Kansas City, Mo., to Paoli, Kans., which crosses southeastern Johnson County. The voltage is cut to 33,000 and 11,000 volts for distribution in Johnson County. The company has no present tie-in with Kansas Power & Light Co.

Neither Rural Electrification Administration nor Eastern Kansas Utilities, Inc., operate in Johnson County.

## WATER

Water is scarce and expensive in Johnson County except in the alluvials of the Kansas River. Towns to which Kansas River water is not available must depend on runoff water stored in ponds or lakes.

## FRANKLIN COUNTY

### PHYSICAL FEATURES

Franklin County is in the Osage Plains of eastern Kansas (fig. 1). The Marais des Cygnes River flows eastward through the center at an average altitude of about 800 feet above sea level. The terrain in general rises from the river to the north and south to a maximum altitude of approximately 1,150 feet at the southwest corner. Tributaries to the river cut deeply into the topography. Pottawatomie Creek, in the southeast corner and a tributary of the Marais des Cygnes River, has an altitude of about 850 feet. The escarpments of the Plattsmouth limestone in the west and of the Stoner and Wyandotte limestones farther east are prominent physiographical features (fig. 32).

Franklin County is served by two railroad systems. A branch of the Missouri Pacific Railroad enters from the east in the valley of the Marais des Cygnes River, crosses the County westward, passing through Ottawa, the county seat. Another branch of the Missouri Pacific Railroad cuts the southeast corner along the valley of Pottawatomie Creek. A main line of the Atchison, Topeka & Santa Fe Railroad enters the County near the northeast corner, passes through Ottawa, and continues westward in the valley of the Marais des Cygnes River. From Ottawa a branch of the Santa Fe leads southwest through Williamsburg. Another branch of the Santa Fe from Lawrence (Douglas County) enters Franklin County midway of the north border and runs due south through Norwood, Ottawa, and Richmond (fig. 32).

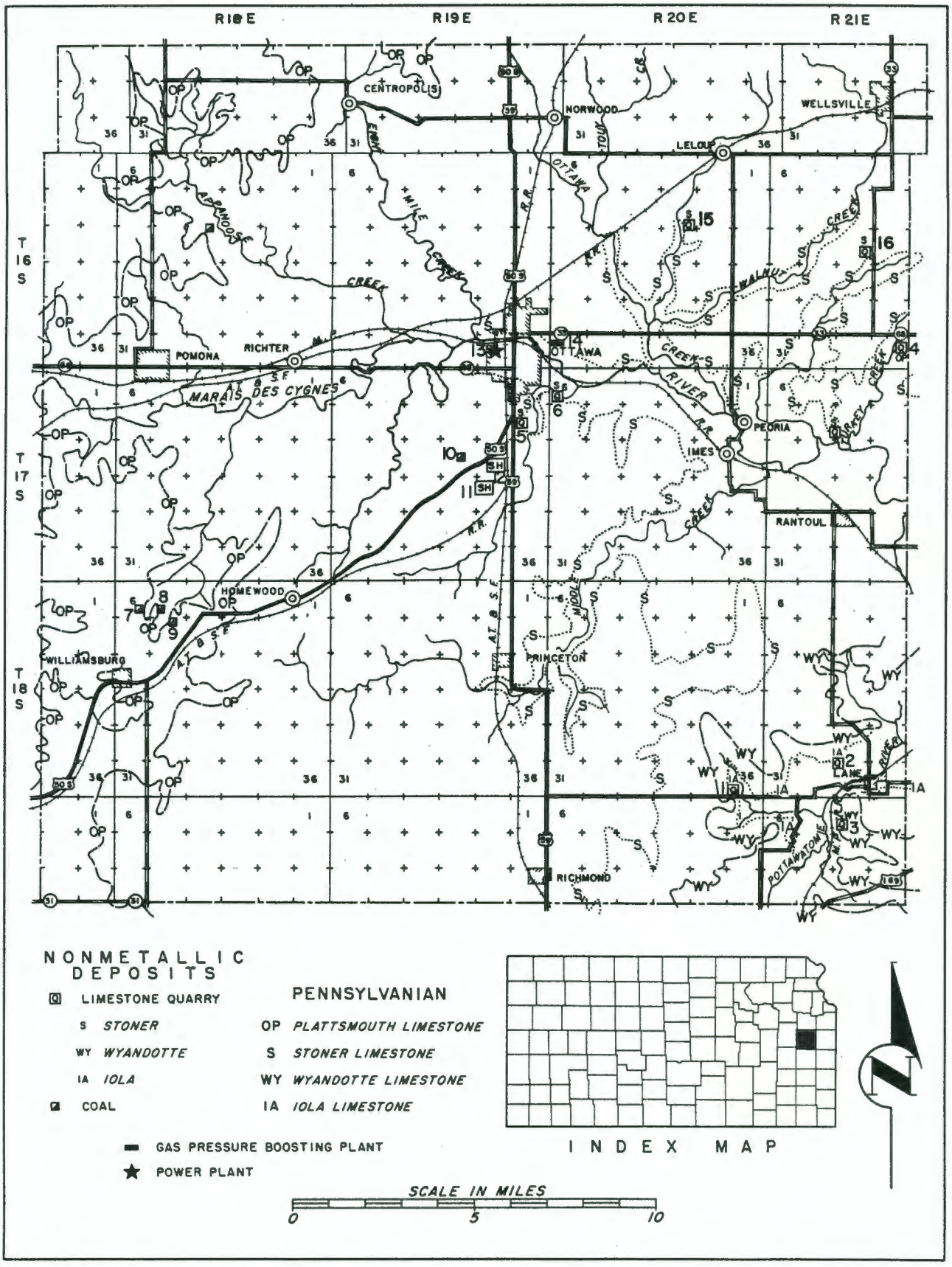



Figure 32.- Franklin County, Kansas

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 32.

## GEOLOGY

Only occasional patches of glacial till occur in Franklin County. The outcropping consolidated geological formations range from the Lecompton limestone of the Shawnee group in the northwest down to the Iola limestone of the Kansas City group in the southeast. The principal outcropping limestones, in order of age, the youngest first (figs. 2, 4, and 32), are: Lecompton, Plattsmouth, Toronto, Stoner, Captain Creek, Spring Hill, Merriam, Farley, Argentine, and Raytown.

## MINERAL RESOURCES

Franklin County produces no sand-gravel. It has an abundance of available limestone and in 1950 produced approximately 100,000 tons of crushed limestone and 20,000 tons of agricultural limestone. The County obtains about 3,000 tons of coal annually from the Upper Williamsburg seam. In 1949, Franklin County produced 255,767 barrels of oil; production increased in 1950 to 278,504 barrels.

### Sand-gravel

The County has no commercial deposits of sand-gravel.

### Limestone (figs. 4 and 32)

The Lecompton limestone formation, with one member 5 feet thick, outcrops to a limited extent in the northwest corner of the County but has no commercial importance.

The Plattsmouth limestone member (Oread limestone formation), 16 feet thick and outcropping conspicuously along the west border of the County, is an excellent stone for road metal or concrete aggregate but has not been quarried in the County.

The Toronto limestone member, 5 to 8 feet thick, outcrops about 20 feet below the Plattsmouth limestone but is not used.

The Stoner and Captain Creek limestone formations, usually separated by about 8 feet of shale, outcrops abundantly and conspicuously from Ottawa eastward in the valley of the Marais des Cygnes River. South of Ottawa, the outcrops usually are buried. The Fagle quarry, in the SE¼ NW¼ sec. 12, T. 17 S., R. 19 E. (5, fig. 32), has 22 feet of Stoner limestone and produces crushed stone for road metal and agricultural limestone. Nearby, in the SW¼ SW¼ sec. 6, T. 17 S., R. 20 E. (6, fig. 32), Bert Ross operates a quarry with a 48-foot face ranging from the Stoner limestone down through the Merriam limestone. In 1951, he was producing crushed stone for road metal, concrete aggregate, and agricultural limestone, mainly from the Captain Creek limestone. The agricultural limestone averaged plus 90-percent $CaCO_3$ equivalent. The analyses, reported by the Geological Survey of Kansas, were as follows:

| | Percent | |
|---|---|---|
| Constituent | Stoner 12 feet | Captain Creek 10 feet |
| $SiO_2$ ..... | 1.72 | 3.43 |
| $Al_2O_3$..... | 0.39 | 0.91 |
| $Fe_2O_3$ ..... | 0.50 | 1.38 |
| CaO ..... | 53.97 | 49.58 |
| MgO ..... | 0.51 | 2.45 |
| Calculated $CaCO_3$.. | 96.24 | 88.00 |
| Calculated $MgCO_3$.. | 1.07 | 5.12 |

Idle Stoner quarries are located in the SE¼ sec. 10, T. 16 S., R. 20 E. (15, fig. 32) and in the SE¼ sec. 16, T. 16 S., R. 21 E. (16, fig. 32).

The Plattsburg and Wyandotte limestone formations outcrop conspicuously below the Stoner limestone in eastern Franklin County and south of Highway 68. No quarries are active in these formations. A large abandoned Wyandotte quarry is in the SW¼ sec. 4, T. 19 S., R. 21 E. (3, fig. 32), which has 8 feet of Farley limestone and 25 to 30 feet of Argentine limestone separated by 5 feet of Island Creek shale. Two abandoned Plattsburg quarries are located close to the east County line in the NE¼ sec. 34, T. 16 S., R. 21 E. (4, fig. 32). The Wyandotte limestone formation gradually thins and disappears southwest of Lane.

Raytown limestone, 20 feet thick in Franklin County, is the most important member of the Iola formation. It outcrops near Lane on both sides of Pottawatomie Creek. Two abandoned Raytown quarries are in the SW¼ sec. 36, T. 18 S., R. 20 E. (1, fig. 32). Franklin County quarried 50,000 tons of Raytown limestone for use as road metal from a pit in the NW¼ NW¼ sec. 33, T. 18 S., R. 21 E. (2, fig. 32).

## Shale

A narrow strip of Weston shale, up to 80 feet thick, outcrops in a northeast-southwest direction throughout Franklin County. Some years ago a shale pit was operated south of Ottawa in sec. 14, T. 17 S., R. 19 E. (12, fig. 32), as material for a

common red brick plant at Ottawa. Recently, coal operators from Pittsburg, Kans., purchased 160 acres in the NW¼ sec. 23, T. 17 S., R. 19 E. (11, fig. 32) and about 60 acres along the Santa Fe track in the SE¼ sec. 14, T. 17 S., R. 19 E. (12, fig. 32). They expect to operate a shale pit in section 23, and plan to build a brick plant and a plant to manufacture lightweight aggregate (haydite) in section 14.

## Coal (13)

The Douglas geologic group occupies a belt 2 to 10 miles wide, extending from the southwest corner to the northeast corner of Franklin County. On figure 32, the belt lies between the Plattsmouth limestone and the Stoner limestone outcrops. About 2 miles northeast of Williamsburg, a bay of Lawrence shale is exposed. In this shale, and 10 to 20 feet below the Toronto limestone, outcrops the upper Williamsburg coal seam, 14 to 22 inches thick. For many years, this 1½-square mile area has been producing and still is producing a few thousand tons of coal a year. The operating coal mines are located in the following places:

| Sec. | T(S) | R(E) | No. on fig. 32 |
|---|---|---|---|
| 6 | 18 | 18 | 7 |
| 5 | 18 | 18 | 8 |
| 8 | 18 | 18 | 9 |

Although there have been many small operations on the Upper Williamsburg coal seam along and below the outcrop of the Oread formation, the three mines mentioned above are the only ones now active.

The coal reserves of Upper Williamsburg coal northeast of Williamsburg are estimated to be 1,350,000 tons with the following dry basis analysis (13):

| Constituent | Percent |
|---|---|
| Volatile matter ..... | 36.5 |
| Fixed carbon ..... | 54.0 |
| Ash ..... | 9.5 |
| Total ..... | 100.0 |
| Sulfur ..... | 1.0 |
| Moisture ..... | 10.0 |
| B.t.u. (dry) ..... | 13,500 |

Ottawa coal, 6 to 10 inches thick, outcrops about 2 miles south of Ottawa on Highway 50S9. Approximately ½-mile west of the outcrop in sec. 14, T. 17 S., R. 19 E., an adit mine (10, fig. 32) extracted some coal 20 to 40 years ago. The Ottawa seam, of local occurrence only, is near the bottom of the Douglas group (fig. 4). The reserves in this area are estimated to be 1,000,000 tons with the following dry basis analysis (13):

| Constituent | Percent |
|---|---|
| Volatile matter ..... | 31.5 |
| Fixed carbon ..... | 61.5 |
| Ash ..... | 7.0 |
| Total ..... | 100.0 |
| Moisture ..... | 13.1 |
| B.t.u. (dry) ..... | 12,300 |

Oil and gas (6)

Franklin County produced 255,767 barrels of oil in 1949, of which 163,753 barrels was secondary oil produced by water-flooding methods in five operating projects. Production increased

in 1950 to 278,504 barrels (5). The oil fields are within 5 miles of the east County line and the main producer (Paola-Rantoul No. 3), which produces 90 percent of the oil, extends into Miami County. All production is Pennsylvanian, mainly from the Squirrel sand (upper Cherokee shale, fig. 4) at a depth of 700 feet. The first oil discovery in Franklin County was in 1860.

A multiple crude-oil line of the Sinclair Prairie Oil Co. and an 8-inch oil products line of the Phillips Petroleum Co. cuts the southeastern corner of the County (fig. 8).

A multiple gas line of the Panhandle Eastern Pipe Line Co. crosses the County south of Ottawa.

Cities Service Gas Co. has a gas compressing station, in sec. 32, T. 16 S., R. 20 E. (14, fig. 32), with seven units, each driven by a 1,000-hp. Cooper-type 22 gas engine. There are four lines on the suction end under 250 pounds pressure and five outgoing lines, 16, 18, and 20-inch, under approximately 360 pounds pressure. The gas comes from Pampa, Tex., and various Oklahoma and Kansas fields (not Hugoton) and is distributed to Kansas City, Kans., and Kansas City, Sedalia, Springfield, and St. Joseph, Mo., and Falls City, Nebr. The 26-inch line of the Cities Service Gas Co. from Hugoton to Kansas City passes within a mile of the compressing station but is not connected with it.

## ELECTRIC POWER

The municipal plant of Ottawa (13, fig. 32) is the only electric power generating plant in Franklin County. Oil is used

for fuel under boilers in winter; at other times, gas is used. The plant has two boilers, each supplying 45,000 pounds of steam an hour at 450 p.s.i. The generating plant consists of three turbine-driven units, 2,500-kw., 1,250-kw., and 4,000-kw., a total of 7,750-kw. It furnishes power to Ottawa and about 20 small nearby towns. Kansas City Power & Light Co. has a maximum stand-by demand on the municipal plant and takes power at 33,000 volts and distributes it throughout Franklin County.

## WATER

Towns near the Marais des Cygnes River obtain water from wells sunk in its alluvial. Water is also collected in lakes or ponds which entrain runoff waters.

# MIAMI COUNTY

## PHYSICAL FEATURES

Miami County is in the Osage Plains of eastern Kansas (fig. 1). The Marais des Cygnes River flows southeastward in a meandering course across the southwest quarter at an altitude of less than 800 feet above sea level. Its valley widens toward the southeast and is marked by the escarpments of the Dennis and Swope formations (figs. 4 and 33).

Pottawatomie Creek joins the Marais des Cygnes River near Osawatomie; Bull Creek and Wea Creek join it south of Paola. These tributary valleys are marked by escarpments of the Iola formation. Beyond the river system of the County, the terrain rises, due to additional escarpments of overlying formations, to altitudes of 1,100 to 1,200 feet.

Miami County is served by four railroad systems. The Missouri Pacific enters near Bucyrus in the northeast corner, passes through Paola, the county seat, and branches at Osawatomie. One branch bears west up the Marais des Cygnes Valley; the other continues southwest up Pottawatomie Creek. The St. Louis & San Francisco Railroad, entering Midway on the north border, traverses south through the center of the County, touching Hillsdale, Paola, and Fontana. The Missouri, Kansas & Texas Railroad enters the east border near Louisburg, passes through Paola, and swings south through Beagle. The Atchison, Topeka & Santa Fe barely cuts the extreme northwest corner.

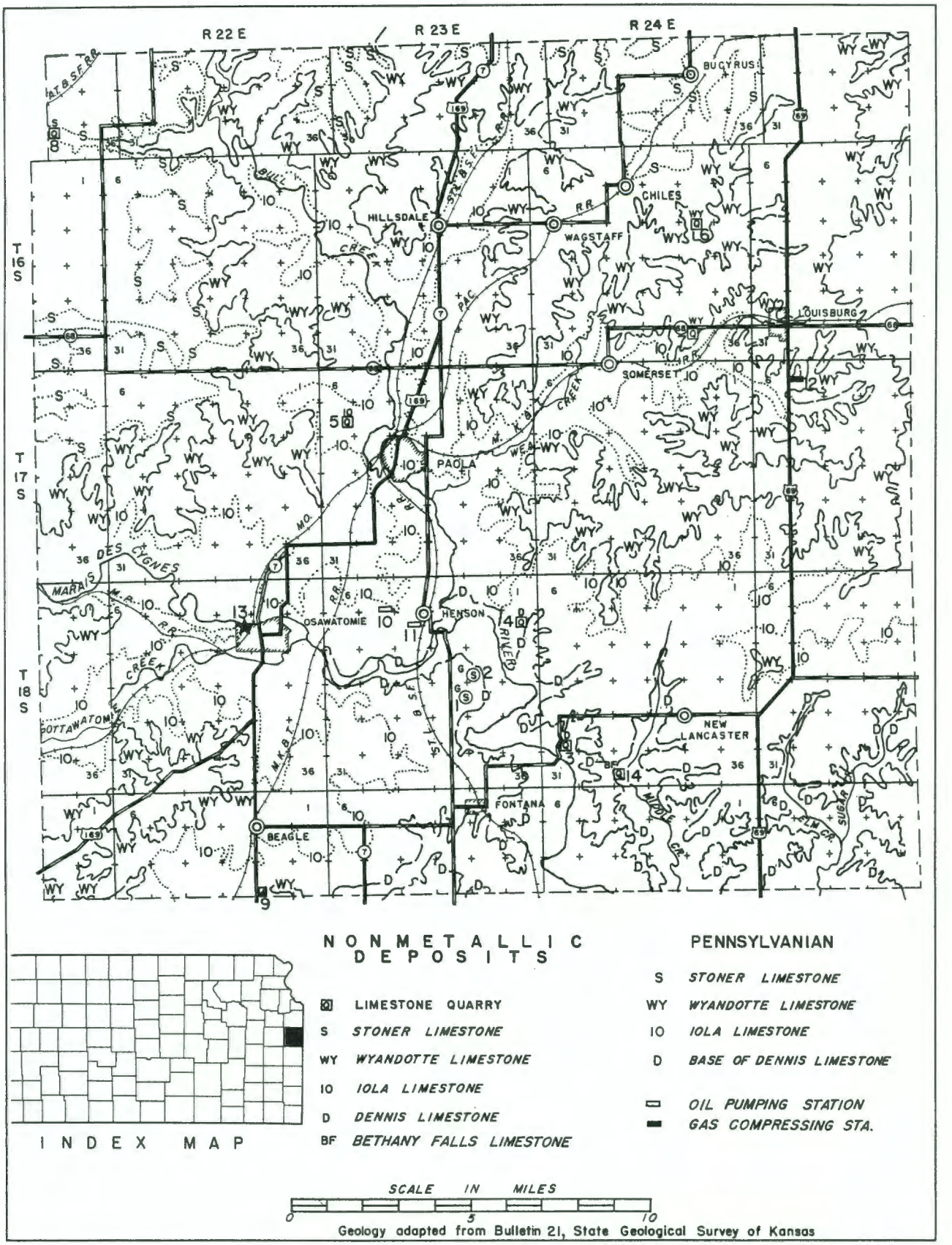



Figure 33.- Miami County, Kansas

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 33.

## GEOLOGY

Miami County is covered mostly with residual soil, and there is evidence of thin layers of loess and glacial till. The consolidated geological formations outcropping in the County range from the Stanton limestone (Lansing group) in the northwest part down to the Hertha limestone (Pleasanton group) in creek and river bottoms of the southeast corner (figs. 4 and 33).

The principal outcropping limestones, in order of age, the youngest first, are: Stoner, Captain Creek, Spring Hill, Merriam, Farley, Argentine, Raytown, Drum, Block, Winterset, Bethany Falls, and Sniabar.

## MINERAL RESOURCES

Miami County has no sand-gravel deposits of importance. It has, however, an abundance of available limestone. The County produced in 1950 approximately 183,000 tons of crushed limestone suitable for road metal and, when washed, suitable for concrete aggregate. It also produced about 43,000 tons of agricultural limestone. County production of oil in 1949 was 365,384 barrels and of gas 120,000 M cubic feet. In 1950, oil production increased to 459,729 barrels.

## Sand-gravel

Two small pits show a glacial gravel blanket about 5 feet thick in secs. 22 and 23, T. 18 S., R. 23 E. (1, fig. 33) and in secs. 14 and 15, R. 18 S., R. 23 E. (2, fig. 33).

## Limestone

The Stanton limestone formation, containing two important limestone members, the Stoner (10 to 18 feet thick) and Captain Creek (5 to 14 feet thick), separated by 5 to 10 feet of shale, outcrops conspicuously in the northwest quarter of Miami County. The Killough Quarry, in the NW¼ sec. 35, T. 15 S., R. 21 E. (8, fig. 33), produces crushed limestone, used as road material, and agricultural limestone. Production is from an 18-foot face of Stoner limestone. Fourteen feet of Captain Creek limestone is available in the floor of the quarry, separated from the Stoner limestone by 5 feet of shale. Many small abandoned Stanton quarries can be found throughout the County.

The Plattsburg limestone formation, separated from the Stanton formation by the Vilas shale formation, and containing two limestone members, the Spring Hill and Merriam (separated by a foot of shale), is approximately 11 feet thick in Miami County. Outcrops are abundant in western and northern parts of the County; however, there are no commercial quarries and many small quarries have been abandoned. Plattsburg limestone would be most serviceable as foundation stone.

The Wyandotte limestone formation contains two limestone members, Farley and Argentine, separated by Island Creek shale. The shale is usually missing in Miami County, and the Wyandotte formation appears as one limestone, 12 to 30 feet thick, outcropping abundantly from the northeast corner to the southwest corner. The County quarries crushed stone for use as road metal from a Wyandotte quarry in the NE¼ NW¼ sec. 14, T. 16 S., R. 24 E. (6, fig. 33). The Forrester Construction Co. of Paola quarried road metal in 1951 from a Wyandotte quarry in the NW¼ sec. 35, T. 16 S., R. 24 E. (7, fig. 33). Many small abandoned Wyandotte quarries occur throughout the County.

The Raytown limestone member (Iola limestone formation), 10 to 18 feet thick, outcrops throughout central Miami County along the slopes of all prominent rivers and creeks. T. W. Hayes, Inc., of Paola is producing agricultural limestone, crushed rock for use as road metal, and material for concrete aggregate from a quarry in the SE¼ sec. 7, T. 17 S., R. 23 E. (5, fig. 33).

The Drum limestone formation, 2 to 6 feet thick, and the Block limestone member, 3 to 7 feet thick, are of no importance in view of the prevalence of thicker overlying limestones.

The Winterset limestone member (Dennis limestone formation), about 30 feet thick, and the Bethany Falls limestone member (Swope limestone formation), a very good limestone and 10 to 20 feet thick, are separated by about 5 feet of shale. Both limestones

outcrop in southeastern Miami County along the Marais des Cygnes River and along creek beds farther east; however, neither outcrops advantageously for large quarry operations within the County. Road rock was quarried recently from Winterset limestone in the SW¼ SE¼ sec. 30, T. 18 S., R. 24 E. (3, fig. 33), and the Forrester Construction Co. quarried road metal from the same member in the SW¼ NE¼ sec. 12, T. 18 S., R. 23 E. (4, fig. 33). Both quarries are now idle. Another small idle quarry is in Bethany Falls limestone in the SW¼ sec. 33, T. 18 S., R. 24 E. (14, fig. 33).

The Hertha limestone formation outcrops in some of the creek beds of southeastern Miami County but is of no commercial importance.

## Coal (14 and 15)

The Thayer coal seam, in the Chanute shale formation, outcrops from Kansas City to the Oklahoma border. The Chanute shale, 16 to 36 feet thick in Miami County, includes all strata from the base of the Iola formation to the top of the Drum limestone. The coal seam is about midway in the shale, but the thinner the shale the closer the seam lies to the Iola formation.

Mining of Thayer coal has been limited to counties south of Miami. In Miami County, the coal seam ranges from a few inches to 8½ inches thick. Eight inches of Thayer coal shows up in a road cut on the Linn County line in the SW¼ SW¼ sec. 14, T. 19 S., R. 22 E. (9, fig. 33).

An analysis of Thayer coal from sec. 25, T. 18 S., R. 22 E. follows (14):

| Constituent | Percent |
|---|---|
| Moisture | 5.21 |
| Volatile matter | 36.95 |
| Fixed carbon | 47.03 |
| Ash | 10.81 |
| Total | 100.00 |

| | |
|---|---|
| Thickness of seam | 3 inches |
| B.t.u. (as received) | 12,810 |
| Sulphur (percent) | 5.15 |

Oil (6 and 1)

Oil production of Miami County in 1949 was 365,384 barrels of which 262,891 barrels was secondary oil produced by water-flooding methods. Production increased in 1950 to 459,629 barrels, the increase being due to water-flooding projects (5). All the oil comes from lower Pennsylvanian horizons ranging from lower Cherokee shales up through the Pleasanton group. There have been no successful tests below the Pennsylvanian (fig. 5).

Oil was first produced in Miami County in 1860, and most of the producing fields are more than 25 years old. The producing sand ranges from 300 feet to 700 feet below the surface. Formerly, producing oil sands occurred under most of Miami County, but the present important producing areas are the Stanton-Osawatomie area in the southwest, the Big Lake area northeast of Paola, and the Prestonville area (including Paola "shoestring" sands) in northwest Miami County. Water-flooding projects have rejuvenated many of the old fields and, in 1949, ten such projects were active in the County.

The Paola "shoestring", 10 miles long and 400 feet wide, is controlled by one company which has divided it into three water-flood projects. The first is completed and produces 399 barrels daily. The second, partially completed, produces 113 barrels daily. The third project is still under natural production, producing 13 barrels daily (February 1951).

The water-flooding procedure in this field is to drill a series of water wells 175 feet apart across the "shoestring" at intervals of 600 feet. The depth to the oil sand is approximately 700 feet. Water is obtained from several 1,800-foot, salt-water wells. All old oil wells are plugged and salt water is pumped into the new wells under pressure which is increased gradually to 725 p.s.i. Then oil wells are drilled in a series halfway between the water well series, and the oil is allowed to flow to tanks naturally. Old oil wells may be reopened if they happen to be on pattern. About 15 barrels of salt water is used for each barrel of oil produced.

### Oil lines

A multiple oil line (three 8-inch lines and three 12-inch lines) of the Sinclair Prairie Oil Co. runs northeast through the center of the County (fig. 8).

An 8-inch oil products line of the Phillips Petroleum Co. enters Miami County from the west, going to a booster station in the SE¼ SE¼ sec. 5, T. 18 S., R. 23 E. (10, fig. 33). A 6-inch and an 8-inch line run north from the booster station to the refinery

in Kansas City, Kans. Another 8-inch line runs northeast into Missouri. The booster station has six 300-hp. units.

A multiple products line of the Great Lakes Pipe Line Co., consisting of three 8-inch lines, enters Miami County from the southwest, going to a booster station in the NW¼ NE¼ sec. 9, T. 18 S., R. 23 E. (11, fig. 33). A multiple line of the two 12-inch lines continues northward to Kansas City, Kans., Chicago, and Minneapolis. The booster station has three 810-hp. American Locomotive (MacIntosh-Seymour type) engines driving the pumps. Two 1,080-hp. units are being installed (February 1951).

## Gas

Gas production of Miami County, delivered into commercial lines, was 120,000 M cubic feet in 1949 (6). Many farmers have drilled gas wells for personal use and this production, much larger than the commercial production, is not included in gas production figures for Miami County. Lack of gathering lines and market is responsible for this small output, rather than any exhaustion of the gas fields. Natural gas was first brought into Paola in 1886.

## Gas lines

The multiple gas line of Panhandle Eastern Pipe Line Co. (one 24-inch and one 26-inch), from the compressing station at Emporia, crosses the northern half of Miami County to a Louisburg compressing station in the NW¼ SW¼ sec. 5, T. 17 S., R. 25 E. (12, fig. 33). This station increases the pressure from about 450 p.s.i.

to 800 p.s.i., and the line continues eastward to Houstonia, Mo. The Louisburg plant has sixteen 1,000-hp. Bessemer-Cooper units. Water is obtained from a nearby lake fed by runoff waters.

ELECTRIC POWER (figs. 9 and 33)

The municipal power plant of Osawatomie, in sec. 10, T. 18 S., R. 22 E. (13, fig. 33), is the only power generating station in Miami County. The plant furnishes power to the town of Osawatomie and sells some power to the Rural Electrification Administration under a contract soon to be terminated. The plant has an installed capacity of 2,755-kw. with the following installed units:

| Unit | Kilowatts |
|---|---|
| 1 gas or diesel-powered Nordberg ..... | 1,235 |
| 1 diesel-powered Worthington ..... | 560 |
| 1 diesel-powered McIntosh-Seymour ..... | 560 |
| 1 diesel-powered McIntosh-Seymour ..... | 400 |

A 154,000-volt line, operated by the Kansas City Power & Light Co., originally a pool line, enters the County from the north. The line ties in with generating plants at Kansas City and St. Joseph, Mo., and Des Moines, Ia., thence goes to a switching station a few miles south of Paola. From this station, 33,000-volt lines go west to Ottawa in Franklin County, south to Greeley in Anderson County, and north to Olathe in Johnson County. Another 33,000-volt lines goes east to Highway 169, thence north to Olathe and south to Pleasanton in Linn County.

Eastern Kansas Utilities, Inc., purchases power from Kansas City Power & Light Co. at the Paola switching station and distributes it throughout Miami County. Eastern Kansas Utilities, Inc., carries a 66,000-volt line south to Moran in Allen County.

Rural Electrification Administration purchases power from Eastern Kansas Utilities, Inc., and from the Osawatomie municipal plant for distribution into rural areas.

## WATER

Water is obtained from wells sunk to alluvials in the Marais des Cygnes River and from lakes or ponds supplied by runoff waters.

## ANDERSON COUNTY

### PHYSICAL FEATURES

Anderson County lies in the Osage Plains region of eastern Kansas (fig. 1). The divide between the Missouri River Basin and the Arkansas River Basin crosses the southwest part of the County at an altitude of about 1,100 feet above sea level. Most of the drainage is to the northeast through tributaries of Pottawatomie Creek which exits at the northeast corner near Greeley at an altitude of approximately 850 feet. Southeastern Anderson County drains toward the east. The most prominent physiographical features are the escarpments of Stanton and Plattsburg limestones, which extend in a general north-south direction through the central and east central part of the County (fig. 34).

Anderson County is served by three railroads. The Atchison, Topeka & Santa Fe enters near the middle of the north border, traverses south through Garnett, the County seat, Welda, and Colony. The Missouri Pacific Railroad comes in the northeast corner near Greeley, passes through Garnett, and swings south of west through Mt. Ida and Westphalia. The Missouri, Kansas & Texas cuts the extreme southeast corner, going through Selma and Kincaid.

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 34.

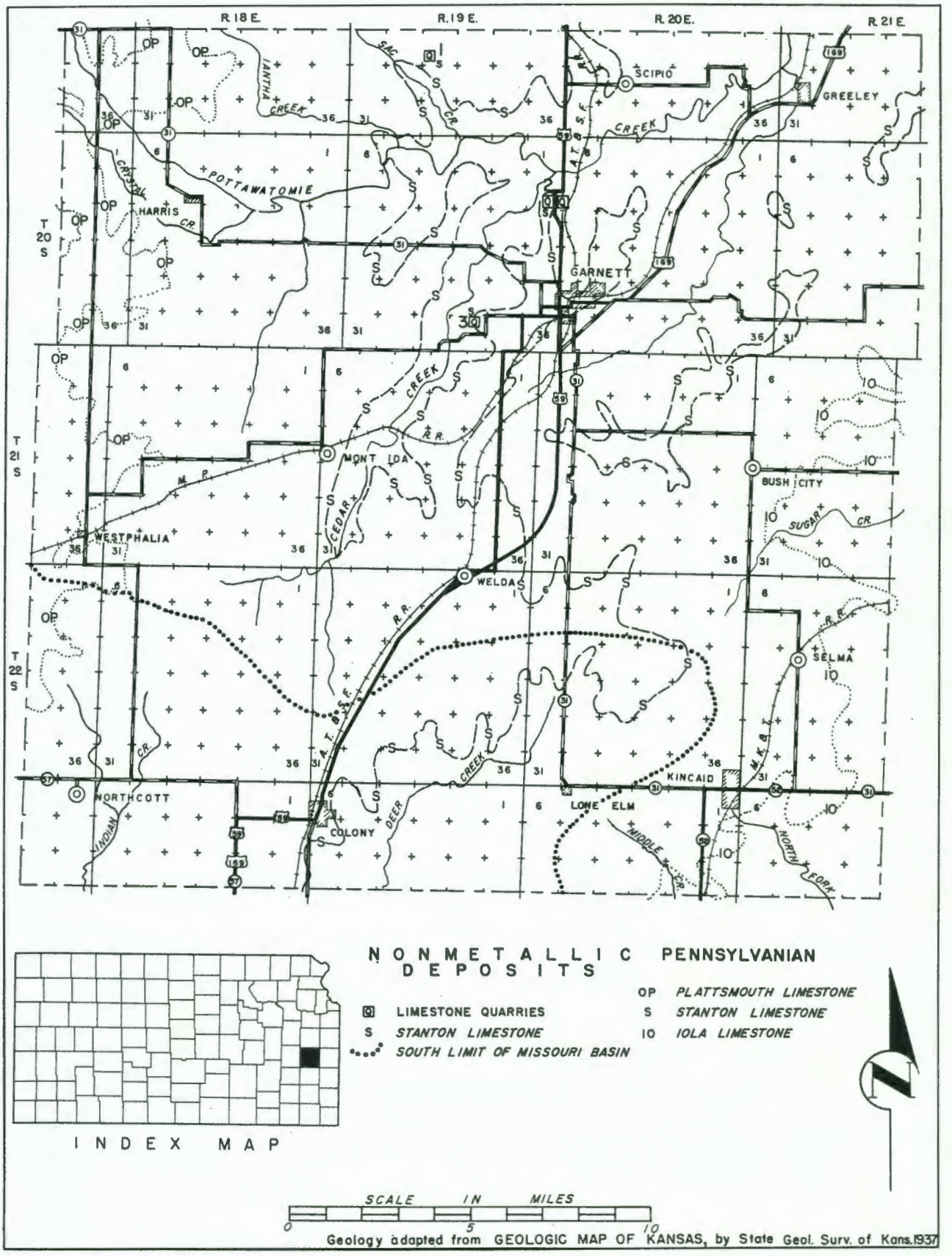



Figure 34.- Anderson County, Kansas

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## GEOLOGY (fig. 4)

Soil and Pleistocene or Pliocene terrace deposits form a mantle up to 20 feet thick on many hilltops and ridges. The underlying consolidated formations consist of alternating beds of shales, sandstones, and limestones with a gentle regional dip towards the northwest. The formations, outcropping in bands, have a general northeast-southwest strike. Prominent east-facing limestone escarpments extend up the valley sides; the valleys show outcrops of the underlying shales. The geological formations range from the Oread limestone (Plattsmouth limestone member) in the northwest down to the Dennis limestone and top of the Bethany Falls limestone member on the southeast border. The principle limestones outcropping in the County, in order of age, the youngest first, are: Plattsmouth, Stoner, Captain Creek, Plattsburg, Raytown and Winterset (figs. 2, 4, and 34).

## MINERAL RESOURCES

Anderson County has no commercial sand-gravel deposits. It produced, in 1950, about 78,000 tons of crushed limestone and 26,000 tons of agricultural limestone. Oil production in 1949 was 402,420 barrels, most of which was secondary from water-flooding projects. Production of oil increased in 1950 to 543,875 barrels. The County also produced 17,589 M cubic feet of natural gas.

## Limestone

The Oread limestone formation, of which the Plattsmouth limestone is the principal member, prominently caps the hills in the northwestern part of Anderson County but is not exploited.

The Stanton limestone formation, of which the Stoner and Captain Creek limestone are the principal members, outcrops as prominent, north-south escarpments in the central part of the County. Three quarries in the Stanton limestone produced 78,000 tons of crushed limestone and 26,000 tons of agricultural limestone in 1950. The Nelson quarry, in 12 feet of Stoner limestone in sec. 21, T. 19 S., R. 19 E. (1, fig. 34), was abandoned early in 1951. The quarry of the Garnett Rock Co., in sec. 12, T. 20 S., R. 19 E. and sec. 7, T. 20 S., R. 20 E. (2, fig. 34), produces both Stoner and Captain Creek limestone from a 30-foot face, with a shale separating the two limestones. Captain Creek limestone is mined by underground room-and-pillar system. Anderson County operates a quarry in sec. 34, T. 20 S., R. 19 E. (3, fig. 34), producing road metal from a 24-foot quarry face of Stoner limestones, Eudora shale, and Captain Creek limestone.

The Plattsburg limestone formation outcrops prominently as cliffs and escarpments east of the Stanton formation but is not exploited in the County.

The Wyandotte formation in Anderson County is represented by calcareous shales or thin limestones.

The Iola limestone formation, of which the principal member is the Raytown limestone, outcrops prominently as escarpments near the east-central border but has not been exploited.

Outcrops of the Winterset and Bethany Falls limestone members are too limited to be of importance.

## Coal

A 6- to 9-inch seam of upper Williamsburg coal, once mined for local consumption but not now mined, outcrops in places in northwest Anderson County below the Oread limestone outcrop.

## Oil (6)

Oil production of Anderson County in 1949 was 402,420 barrels from seven active fields totaling 17,700 acres. Six of the fields were water-flooding projects and were responsible for 78 percent of the production. Of the total production 380,978 barrels originated within the Missouri River Basin. Total County production increased to 543,875 barrels (5) in 1950, of which 527,946 barrels originated in the Basin area. Water-flooding projects were responsible for the increase.

Production came from the Squirrel sand (Upper Cherokee shale) and the Bartlesville sand (lower Cherokee shale, fig. 4), at depths of 600 to 800 feet.

An 8-inch oil products line of Phillips Petroleum Co. crosses northwest Anderson County. Three 8-inch oil products lines of Great Lakes Pipe Line Co. pass through the southeast corner.

Service Pipe Line Co. and Sinclair Prairie Oil Co. have gathering lines to the oil fields and multiple pipelines for transportation of oil to the refineries.

### Gas

Anderson County produced 17,589 M cubic feet of gas in 1949 from many fields (6). Cities Service Gas Co. is using the Colony-Welda field in the center of the County to store gas by repressuring for service to the Kansas City area.

## ELECTRIC POWER (fig. 9)

Garnett has a municipal, internal combustion, electric plant of 2,265-kw. installed capacity. Kansas City Power & Light Co. serves northern Anderson County through a 33,000-volt line from Franklin County. Southern Anderson County is serviced by Eastern Kansas Utilities, Inc., through a 13,800-volt transmission line.

## WATER

Water supply in the County is not good. Water is obtained by shallow wells or cisterns to alluvials of streams south of Pottawatomie Creek or from collecting ponds. Garnett has a deep well pump to pre-Pennsylvanian aquifers.

## LINN COUNTY

### PHYSICAL FEATURES

Linn County lies in the Osage Plains of eastern Kansas (fig. 1). The highest altitude, 1,050 to 1,100 feet above sea level, is along the west border. The Marais des Cygnes River meanders southwest across the northeastern part through a wide flood-plain valley bordered by steep limestone-capped escarpments 100 to 200 feet high (fig. 35). The river, at an elevation of approximately 750 feet, and its eastward-flowing tributaries drain most of the County. The south border area drains southward. The large streams have flat bottomed, alluvial-filled valleys, 1 to 8 miles wide, bordered by high, steep bluffs. Small, isolated hills or mounds, erosional remnants of limestone-capped hills, are common in the bottom lands (11 and 16).

Linn County is served by three railroads. The St. Louis & San Francisco traverses the east side, going through La Cygne, Pleasanton, and Prescott. A branch of the Missouri Pacific Railroad enters from the east and terminates at Mound City, the county seat. The Missouri, Kansas & Texas runs south and west across the northwest part, passing through Parker and Centerville (fig. 35).

Secondary roads checkerboard the County at intervals of 1 to 3 miles with irregular patterns in the eastern bottom lands. The main paved highways are shown on figure 35.

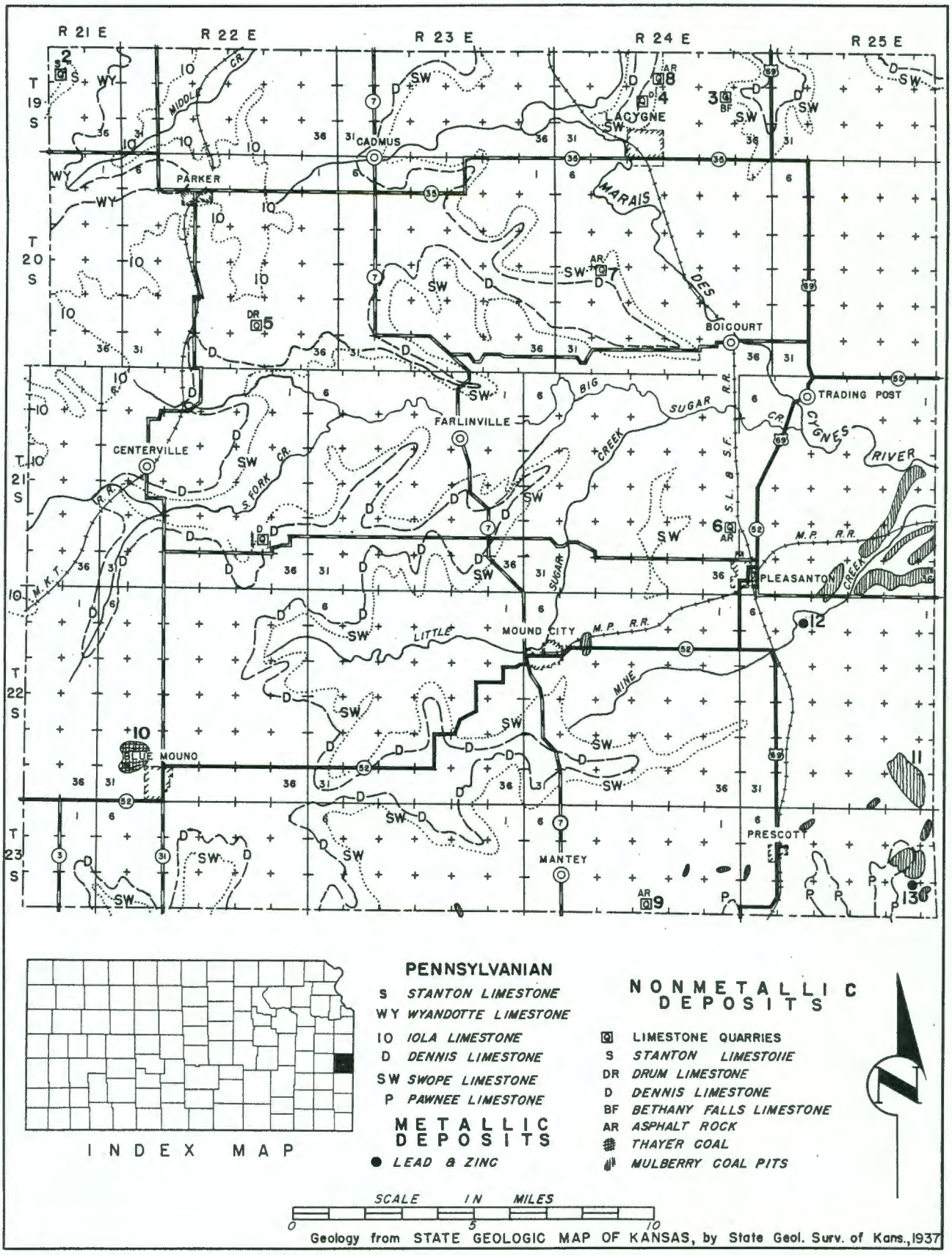



Figure 35.- Linn County, Kansas

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## GEOLOGY

Linn County is covered by a few feet of residual unconsolidated sand or gravel. The outcropping consolidated geological formations range from the Stanton limestone (Stoner member) of the Lansing group in the northwest corner down to the Pawnee limestone of the Marmaton group in the southeast corner (figs. 2, 4, and 35). They consist of alternating limestones, shales, and sandstones with a gentle regional dip towards the west and north. In crossing the County southeastward, the lower or older members outcrop progressively in irregular bands with a general northeast-southwest trend. The principal limestones and sandstones, in order of age, the youngest first, are: Stanton and Plattsburg, limestone formations of the Lansing group; Wyandotte, Iola, Drum, Dennis (Winterset), and Swope (Bethany Falls) limestone formations of the Kansas City group; Hepler sandstone fromation of the Pleasanton group; and Altamont and Pawnee limestone formations of the Marmaton group (fig. 4).

## MINERAL RESOURCES

Linn County has few sand-gravel deposits but has abundant limestone. County production in 1950 was about 96,000 tons of crushed limestone for concrete aggregate and road metal and approximately 31,000 tons of agricultural limestone. It also produced in that year 717,011 tons of coal and 53,177 barrels of oil. The output of oil in 1949 was 47,290 barrels; that of natural gas was 11,969 M cubic feet.

## Sand-gravel

Sand-gravel deposits are scarce and poor in quality. Near Centerville, small stream-gravel deposits supply material for secondary roads. The material, contaminated with clay and shale, is unsuitable for concrete aggregate.

## Limestone

Murray Limestone Products Co., the County's largest operator, has a quarry with 24 feet of Winterset limestone in the SE¼ sec. 26, T. 21 S., R. 22 E. (1, fig. 35). Below the quarry floor, 18 feet of Bethany Falls limestone is available.

Giles Quarry, the next largest operator, has a quarry with a 28-foot face of Stanton limestone in the northwest corner of the County in the SW¼ sec. 23, T. 19 S., R. 21 E. (2, fig. 35).

Cornelius Limestone Quarry conducted a small operation with 8 feet of Bethany Falls limestone in sec. 26, T. 19 S., R. 24 E. (3, fig. 35).

The Hays Quarry had a small operation with 10 feet of Winterset limestone in the W½ sec. 28, T. 19 S., R. 24 E. (4, fig. 35).

McKee Quarries, Inc., operated a small quarry with 8 feet of presumably Drum limestone in the SE¼ sec. 27, T. 20 S., R. 22 E. (5, fig. 35). Operations were abandoned early in 1951.

Crushed rock sold for about $1 a ton and agricultural limestone for $1.35 a ton at the quarries.

The occurrence of the Stanton limestone formation is limited to the extreme northwest corner of the County. Plattsburg and Wyandotte limestone formations, below it, have begun to thin out. Outcrops of the Iola limestone formation are not prominent in western Linn County. The underlying Drum limestone formation, usually about 6 feet thick, is quarried at the McKee Quarries. Dennis and Swope limestone formations, each 10 to 20 feet thick and a good limestone, occur in abundance. The Hepler sandstone formation, the base of the Pleasanton group, is quarried occasionally for "flagstone" in eastern Linn County. The Altamont limestone formation is not used. The Pawnee limestone formation, a good commercial rock, has a limited occurrence in southeast Linn County.

Asphalt rock (18)

Asphalt rock is a porous petroliferous sandstone or limestone which has lost the lighter constituents of the crude oil. Running 3.5 to 12.0 percent hydrocarbons, the rock is found in the Pawnee limestone in southeast Linn County, in the Hepler sandstone near Pleasanton, and in the Bethany Falls limestone.

The most important operations were those of the Kansas Asphalt Rock Co. in the Hepler sandstone in sec. 25, T. 21 S., R. 24 E. (6, fig. 35). Bethany Falls asphalt rock occurrs in sec. 20, T. 20 S., R. 24 E. (7, fig. 35) and in sec. 21, T. 19 S., R. 24 E. (8, fig. 35). The occurrence in Pawnee limestone is in sec. 15, T. 23 S., R. 24 E. (9, fig. 35).

Local asphalt rock, added to other crushed rock, has been used for road making, but no asphalt rock quarries or asphalt plant operations were active in Linn County in 1950.

## Flagstone

Large dimension flagstone was once quarried from Kepler sandstone in sec. 25, T. 21 S., R. 24 E. (6, fig. 35) and used for sidewalks in Pleasanton and Mound City, but operations were discontinued years ago.

## Coal

The Thayer coal seam, 2½ to 14 inches thick and outcropping across the west part of Linn County, is in the Chanute shale formation under the Iola limestone. The seam was mined some years ago by means of adits, slopes and shafts, and about 32,000 tons of coal were extracted (14). It is 6 to 12 inches thick west of Blue Mound (12, fig. 35). The analysis of the coal at this place is as follows (14):

| Constituent | Percent |
|---|---|
| Moisture | 2.40 |
| Volatile matter | 35.49 |
| Fixed carbon | 52.49 |
| Ash | 9.62 |
| Total | 100.00 |
| Sulfur | 0.69 |
| B.t.u. (as received) | 13,325 |
| B.t.u. (moisture free) | 13,653 |
| B.t.u. (moisture and ash free) | 15,102 |

The important coal reserve in Linn County is the Mulberry seam, now mined on a large scale by Hume Sinclair Coal Co. by strip-mining methods. The operations are in the southeast corner of Linn County in sec. 26, T. 22 S., R. 25 E. (11, fig. 35), and the coal is washed at a washing plant in Bates County, Mo., near the Kansas line. The thickness of the seam varies greatly; it is 14 to 40 inches thick and, where strip-mined in the fall of 1950, was 18 inches thick. The Mulberry seam occurs in the lower part of the Bandera shale formation of the Marmaton group and a little above the Pawnee limestone formation (fig. 4).

The analysis of the Mulberry coal follows (19):

| Constituent | Percent |
|---|---|
| Moisture | 9.4 |
| Volatile matter | 32.2 |
| Fixed carbon | 43.8 |
| Ash | 14.6 |
| Total | 100.0 |
| Sulfur | 2.9 |
| B.t.u. (as received) | 11,180 |
| B.t.u. (moisture free) | 12,150 |

There are many small strip and deep mines, most of which have been abandoned, on the Mulberry seam. Linn County production was 158,349 tons in 1949 (4) and 717,011 tons in 1950 (4).

The total proved reserves of Mulberry coal in Linn County was estimated in 1947 by Abernathy, Jewett, and Schoewe (20) as 54,691,000 tons, but it is not known how much of this is recoverable. The economically recoverable reserve in southeast Linn County is believed to be about 8,000,000 tons (1950). Farther north, between

Pleasanton and La Cygne, is a reserve but the area is low and subject to overflow by the Marais des Cygnes River and its tributaries; consequently, the proportion recoverable under present conditions is not known. Deep mining as standard practice is not economic in the County.

## Oil (6)

Linn County produced 47,290 barrels of oil in 1949 from four reporting fields—the Blue Mound, Centerville, Goodrich-Parker, and Cadmus-La Cygne. The reported production from Blue Mound (2,524 barrels) is questionable, as the field has been abandoned. Of the total production, 39,475 barrels was produced by water-flooding methods. Production from three fields (including Blue Mound) in 1950 was 53,177 barrels (5), most of it from water-flooding projects. There are many nonproducing fields in the County, which might be rejuvenated by water-flooding projects.

All production is Pennsylvanian. The La Cygne-Cadmus production is from sands in the Bandera and Labette shales at depths of about 200 feet. The Centerville and Goodrich-Parker production is from the Squirrel and the Bartlesville sands in the Cherokee shale group at depths of 500 to 700 feet (fig. 4). The original Blue Mound production was from the top of the Mississippian system (fig. 5).

Service Pipe Line Co. serves the fields and has a multiple oil pipeline traversing the County.

Great Lakes Pipe Line Co. has a multiple oil-products line crossing the County (fig. 8).

### Gas

Linn County reported a gas production in 1949 of 11,969 M cubic feet (6), which was collected by the Commercial Gas Pipeline Co. for distribution. Individually-owned wells produce considerable gas that is used locally and not reported.

### Metals

Lead, as the mineral galena, occurs a mile and a half southeast of Pleasanton in the SE¼ sec. 5, T. 22 S., R. 25 E. (12, fig. 35). It was originally discovered in the bed of Mine Creek about 1866. Sporadic exploration by adit and shaft in 1866, 1873, 1900, and later, produced about 35 tons of galena ore which was shipped to a smelter then operating at Argentine, Kans.

The lead, deposit, in a shattered zone about 50 feet in diameter in the Pleasanton shale, has been developed to depths of 100 to 250 feet. Gas explosions, caused by gases issuing from the shales, made development extremely hazardous. The site of the workings is now an open, water-filled pit.

Other minor galena occurrences have been reported in a well ½-mile east of Mound City and in a coal pit in sec. 11, T. 23 S., R. 25 E. (13, fig. 35).

## ELECTRIC POWER (fig. 9)

Kansas City Power & Light Co. has a 66,000-volt line traversing western Linn County, also a 34,500-volt line from the

Paola switching station (Miami County) to Pleasanton and south into Bourbon County. Rural Electrification Administration purchases power from the company for distribution into rural areas.

Eastern Kansas Utilities, Inc., ties in with Kansas City Power & Light Co. and services Pleasanton and Mound City. This company has a 13,800-volt line from Anderson County to serve the Blue Mound area.

WATER

The alluvials of the Marais des Cygnes River carry moderate supplies of water and are adequate for the larger towns. The river is subject to heavy seasonal floods. Most of the County gets water from shallow wells and cisterns to alluvials fed by the seasonal rains.

## ALLEN COUNTY

### PHYSICAL FEATURES

Allen County is in the Osage Plains of eastern Kansas (fig. 1). Only a small, wedge-shaped area along the eastern border lies within the Missouri River Basin. The divide, on the south border of the Basin area, crosses the north border of Allen County about 9 miles west of the northeast corner and runs southeastward to the southeast corner at altitudes of about 1,100 feet above sea level. The drainage in the north segment of the Basin area in the County is eastward through Little Osage River, which crosses the County's east border at an altitude of approximately 850 feet. Drainage in the south is through the Marmaton River, which crosses the east border at an altitude of about 800 feet (fig. 36). The chief topographical features are rolling plains dissected by the two eastward-flowing rivers with prominent east-facing escarpments formed by limestone outcrops.

Allen County is served by three railroad systems. The Missouri Pacific Railroad crosses east to west near the middle, through Moran and Iola, the county seat. The Atchison, Topeka & Santa Fe traverses the western half north to south, passing through Carlyle, Iola, and Humboldt. The Missouri, Kansas & Texas Railroad traverses the eastern half, in a north-south direction through Mildred, Moran, and Savonburg, and a branch of that line runs from Moran to Iola, paralleling the Missouri Pacific. Another branch of the same system cuts the southwest corner, passing through Humboldt and Petrolia.

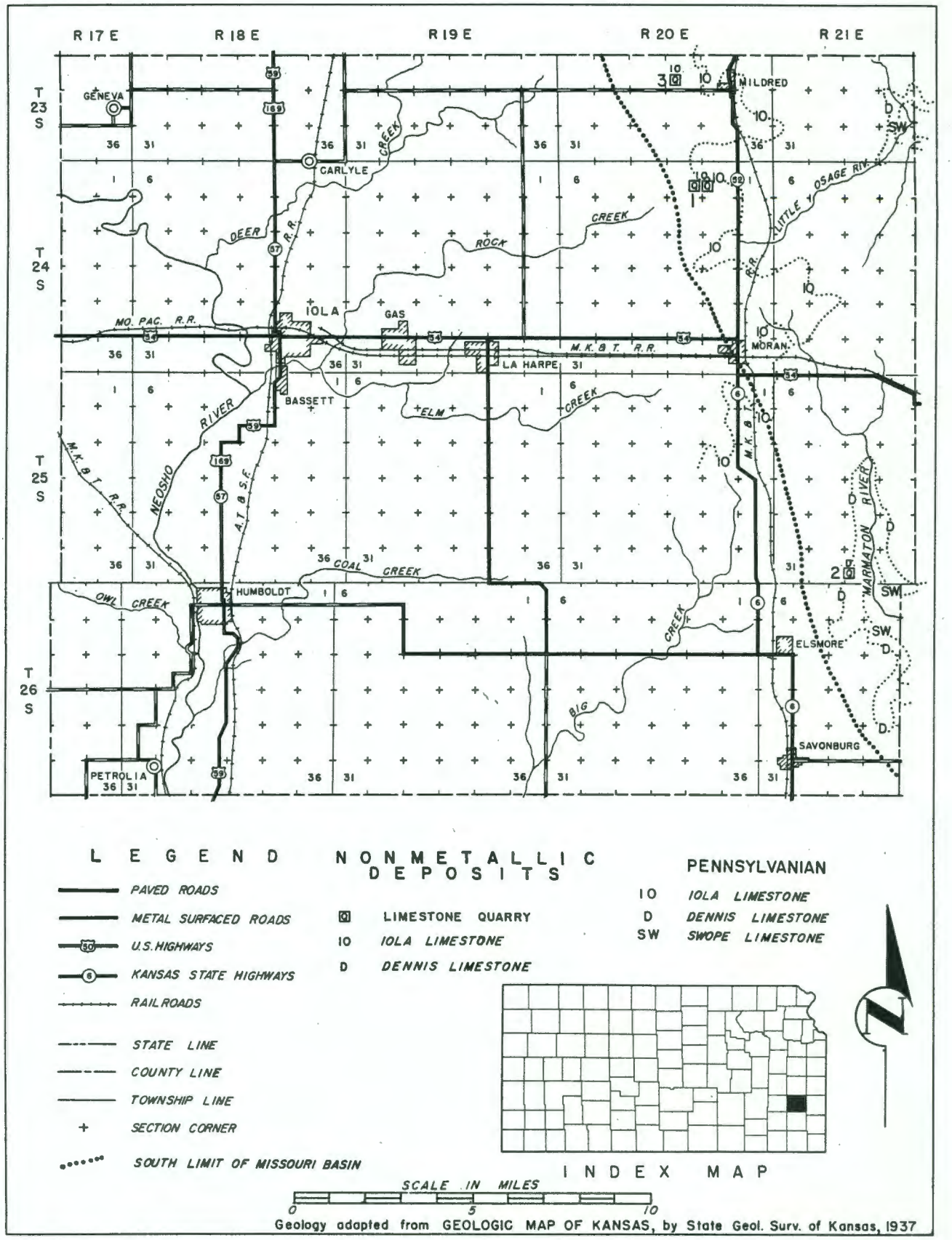



Figure 36.- Allen County, Kansas

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Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 36.

## GEOLOGY

The exposed consolidated geological formations of eastern Allen County (within the Basin area) consist of alternating beds of shale and limestone with occasional sandstone. The formations range from the Lane-Bonner Springs shales, overlying the Iola limestone formation west of Mildred down to the top of the Pleasanton shale in the valley of Marmaton River in the southeast (figs. 4 and 36). All formations strike east of north and dip 10 to 15 feet a mile north of west.

The main limestones outcropping in the Basin area, in order of age, the youngest first, are: Raytown, Winterset, and Bethany Falls.

## MINERAL RESOURCES

The Missouri Basin area of Allen County has no sand-gravel deposits but has large reserves of limestone suitable for agricultural limestone and construction purposes. The area also has a large reserve of source material for the manufacture of portland cement and mineral wool. In 1950 it produced moderate quantities of crushed and agricultural limestone. Production of oil in 1950 was 85,130 barrels.

### Sand-gravel

The Basin area of Allen County has no sand-gravel deposits; however, the western part of the County has chert-gravels several feet thick in terraces along the Neosho River.

## Limestone

Limestone, suitable for construction purposes or agricultural limestone, is abundant throughout the County as well as within the Basin area. No limestone quarries were active in the Basin area in 1951, but there were 15 inactive or abandoned ones. In 1950, two small quarries produced agricultural and crushed limestone. The agricultural limestone was removed from a stock pile of the Reading Limestone Quarry, operating on Iola limestone, in secs. 2 and 3, T. 24 S., R. 20 E. (1, fig. 36). The County quarry active in 1950 and operating on Winterset limestone, is in the SW¼ sec. 33, T. 25 S., R. 21 E. (2, fig. 36). Both quarries use portable equipment.

## Cement

The Basin area, and the County in general, has an abundance of limestone and shale for the manufacture of cement. Portland cement was once manufactured in a plant, now dismantled, at Mildred. Raw materials came from the Iola limestone formation and nearby shale in a quarry in the SW¼ sec. 22, T. 23 S., R. 20 E. (3, fig. 36). Several cement plants are now operating south and west of Iola.

## Rock wool (22)

Iola limestone, from the old cement quarry at Milford (3, fig. 36), has been tested by the State Geological Survey of Kansas and found satisfactory for the manufacture of rock wool. Lack of a supply of cheap fuel has been the principal deterrent to the establishment of a rock wool industry in the area. The

Colony Gas Field in the County has been proposed as an underground storage for gas from Oklahoma and Kansas fields farther west to supply the Kansas City area. The proposal, if carried out, might give some impetus to rock wool manufacture.

## Coal

The Thayer coal seam, 3 to 6 inches thick within the County and not mined, outcrops under the Iola limestone in the northeastern part and continues southward across the County into Neosho County.

## Oil (6)

Oil was discovered at Iola in 1873. Within a short time several wells were drilled in the vicinity and a gas field was developed large enough to supply the town. Most of the oil fields passed peak production years ago and many were abandoned, or nearly so, before the campaign of secondary recovery, by water-flooding projects, began in 1937. Allen County in 1949 produced 278,368 barrels of oil in 11 fields with a total acreage of 28,400 acres. Of this production, 89,723 barrels originated in four fields within the Basin area. Oil production in 1950, within the Basin area, was 85,130 barrels.

The four fields in the Basin area are the Bronson-Zenia, Davis-Bronson, Elsmore Shoestring, and Elsmore-West. All are under water-flooding projects and produce from the Bartlesville sand (lower Cherokee group, fig. 4) at depths of 650 to 775 feet.

Great Lakes Pipe Line Co. has a pumping station in south central Allen County and a multiple oil products line crossing the County northeastward. Main crude oil lines of the Texas Empire Pipe Line Co., Service Pipe Line Co., and Sinclair Prairie Oil Co. also traverse the County. Texas Empire Pipe Line Co. has a pumping station near Humboldt. Collecting lines service the oil field (fig. 8).

## ELECTRIC POWER

Iola has a municipal, steam-generating, electric plant of 7,000-kw. capacity. Rural Electrification Administration purchases power from it for distribution into rural areas.

Kansas City Power & Light Co. has a 66,000-volt line from its switching station at Paola (Miami County) to a switching station south of Moran, where Eastern Kansas Utilities, Inc., ties in and distributes power throughout Allen County over 66,000-volt, 34,500-volt and smaller lines (fig. 9). Eastern Kansas Utilities, Inc., has an internal combustion electric plant of 1,760-kw. capacity at Humboldt, tied into its general system.

## WATER

Western Allen County obtains water from alluvials of the Neosho River. Eastern Kansas depends on shallow wells in the basins of the Little Osage and Marmaton Rivers, and upon collecting ponds for runoff water.

## BOURBON COUNTY

### PHYSICAL FEATURES

Bourbon County is in the Osage Plains of eastern Kansas (fig. 1). The south limit of the Missouri River Basin crosses the southwest corner at an altitude of about 1,100 feet above sea level. The County is drained by east-flowing rivers, the Little Osage and Marmaton and their tributaries. Total relief is about 400 feet, from 1,100 to 700 feet above sea level. The lowest altitudes are at the Marmaton and Little Osage Rivers in eastern Bourbon County; the highest points are in the more rugged western area. Several low, southeast-facing escarpments are formed by beds of resistant limestones (fig. 37).

Bourbon County is served by three railroad systems. The St. Louis & San Francisco Railroad comes in from the north near Fulton and branches at Fort Scott, the county seat. One branch runs southeast through Garland; the other leads southwest through Pawnee. The Missouri Pacific Railroad crosses east to west, passing through Fort Scott, Redfield, and Bronson. A branch at Fort Scott, turns south into Crawford County. The Missouri, Kansas & Texas Railroad enters the County from the east, passes through Fort Scott, and swings southwest into Crawford County (fig. 37).

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 37.

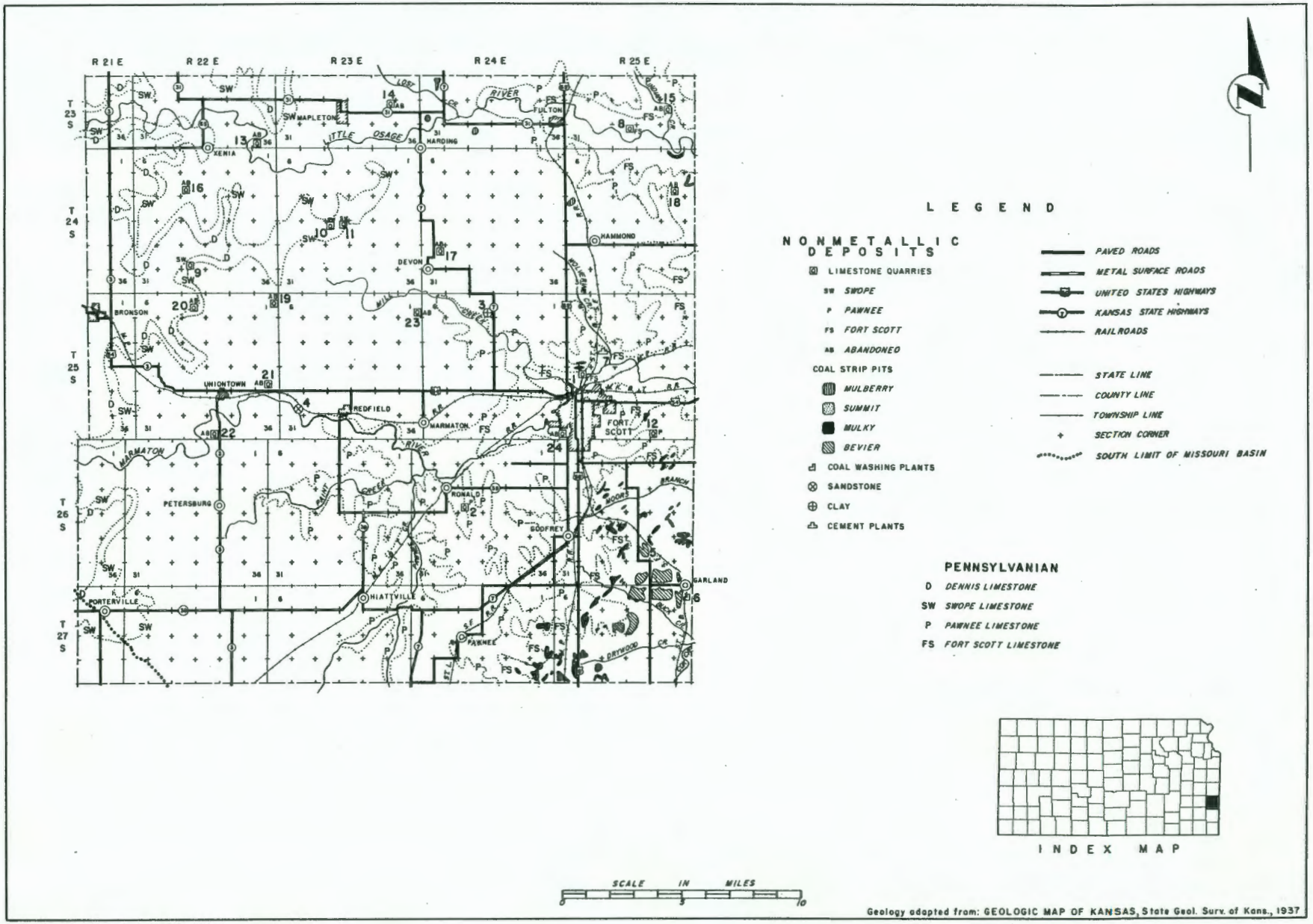



Figure 37.- Bourbon County, Kansas

## GEOLOGY

The consolidated surface geological formations of Bourbon County consist of alternating layers of shales, limestones, and occasional sandstones ranging from the Chanute shale formation of the Kansas City group, outcropping in the northwestern part, down to and including the upper 250 feet of the Cherokee shale group, outcropping in the eastern and southeastern parts of the County. The parallel beds strike east of north and dip 10 to 15 feet a mile toward the west (figs. 4 and 37).

The Dennis (Winterset limestone) and the Swope (Bethany Falls limestone) formations of the Kansas City group (Bronson sub-group) outcrop in a narrow strip along the west border and on the uplands of northwest Bourbon County between the Marmaton and Little Osage Rivers along a winding escarpment. The thickness of the Bronson sub-group is about 110 feet.

The Pleasanton group, underlying the Bronson sub-group and about 150 feet thick in the County, consists of shales, thin limestones and the basal Hepler sandstone.

The Marmaton group, underlying the Pleasanton group and approximately 180 feet thick in the County, has two principal limestone formations--the Pawnee and the basal Fort Scott. A thin bed of Mulberry coal lies a few feet above the Pawnee limestone. The Marmaton group is exposed along the Marmaton River between Fort Scott and Uniontown and along streams in eastern Bourbon County.

The Cherokee shale group, underlying the Marmaton group, is 350 feet thick but the lower 100-foot section does not outcrop within the County. Essentially a shale group with some sandstones, thin limestones and numerous coal beds, it outcrops in the eastern part of the County in the valleys of Little Osage and Marmaton Rivers and in the southeast along Cox and Drywood Creeks.

The subsurface Mississippian formations are 300 to 350 feet thick (fig. 5). The Ordovician formations are about 660 feet thick and the Cambrian approximately 300 feet thick.

## MINERAL RESOURCES

Bourbon County produces no sand-gravel. It has abundant reserves of limestone, and produced in 1949 an estimated 150,000 tons of crushed stone and cement rock for manufacture of hydraulic cement. Coal production in 1949 was 137,670 tons; in 1950 it was 103,104 tons. The County produced 15,374 barrels of oil and 15,356 M cubic feet of gas in 1949. Oil production decreased to 11,048 barrels in 1950. Fort Scott has a small pottery plant manufacturing flower pots.

### Limestone

Bourbon County has an abundance of limestone in the Dennis, Swope, Pawnee, and Fort Scott formations. Limestone is used as road metal and concrete aggregate and some for the manufacture of hydraulic cement. The Cement Quarry is in sec. 19, T. 25 S., R. 25 E. (1, fig. 37). The Bourbon County Quarry is in sec. 16, T. 26 S., R. 24 E. (2, fig. 37). The Cement Quarry has a permanent installation but other quarries use portable equipment.

The following quarries are operated occasionally:

| Sec. | T(S) | R(E) | Formation | No. on fig. 37 |
|---|---|---|---|---|
| NE¼ 33 | 23 | 25 | Fort Scott | 8 |
| SW¼ 28 | 24 | 22 | Swope | 9 |
| NW¼ 21 | 24 | 23 | Do. | 10 |
| NE¼ 21 | 24 | 23 | Do. | 11 |
| SW¼SE¼ 34 | 25 | 25 | Pawnee | 12 |

The following quarries apparently have been abandoned:

| Sec. | T(S) | R(E) | No. on fig. 37 |
|---|---|---|---|
| SW¼ 36 | 23 | 22 | 13 |
| NE¼ 26 | 23 | 23 | 14 |
| SE¼NW¼ 26 | 23 | 25 | 15 |
| SW¼ 9 | 24 | 22 | 16 |
| NE¼ 30 | 24 | 24 | 17 |
| SW¼SE¼ 11 | 24 | 25 | 18 |
| SE¼NE¼ 1 | 25 | 22 | 19 |
| SE¼NW¼ 4 | 25 | 22 | 20 |
| SW¼SE¼ 24 | 25 | 22 | 21 |
| SE¼SW¼ 34 | 25 | 22 | 22 |
| SE¼ 1 | 25 | 23 | 23 |
| SE¼ 36 | 25 | 24 | 24 |

## Hydraulic cement

Hydraulic cement is a natural cement made by grinding calcined argillaceous limestone of such composition that unground calcines will not slack upon addition of water. It will set under water and is used for underwater jobs requiring rapid setting.

The Fort Scott Hydraulic Cement Co. operates a cement plant in sec. 17, T. 25 S., R. 25 E. (7, fig. 37)—one of the few plants in the United States producing hydraulic cement. The limestone is mined at a quarry on the basal member of the Fort Scott limestone in sec. 19, T. 25 S., R. 25 E. (1, fig. 37). About a fifth of the relatively small quarry product is converted to

hydraulic cement; the rest is used as road metal, riprap, agricultural lime, and chicken feed lime.

A bed of Mulky coal, lying a few feet below the Fort Scott limestone in the quarry, is used as fuel in the cement plant.

### Shales

Brick and pottery industries, represented at one time by several plants in Fort Scott, were active during early days of Kansas history. A pottery clay of the Marmaton group is now being mined for the manufacture of flower pots in Fort Scott. The clay comes from the top part of the Bandera shale (fig. 4) in the Leslie clay pit near Devon in the SE¼ sec. 4, T. 25 S., R. 24 E. (3, fig. 37). The production, used exclusively by the Fort Scott Pottery Works, is small.

### Sandstone

Some flagstone has been mined from a sandstone quarry, now idle, in Bandera shale in the SE¼ sec. 30, T. 25 S., R. 23 E. (4, fig. 37). Flagstone from this quarry was used for the Will Rogers Memorial at Claremore, Okla.

### Coal

The first coal mine of commercial importance in the State was started near Fort Scott in 1865. Bourbon County has five coal seams that have been mined. They are, in descending order, the Mulberry, Summit, Mulky, Bevier, and Croweburg (fig. 4).

The Mulberry bed lies a short distance above the Pawnee limestone of the Marmaton group. Thinner in Bourbon County than in Linn County (to the north), the bed gradually plays out southward from Linn County. It has minable reserves in Bourbon County but is not exploited.

The Summit coal locally overlies the lower limestone member of the Fort Scott limestone (fig. 4). From a few inches to 2 feet thick, the seam was formerly mined in northeastern Bourbon County.

The Mulky bed, 8 to 12 inches thick and near the top of the Cherokee group, has been mined extensively in the Fort Scott area. It was strip-mined by two companies in 1950. The 1949 production was 6,472 tons; production in 1950 was 8,391 tons. The Mulky coal production, incidental to the mining of cement rock and used in the manufacture of hydraulic cement, is not included in production totals, because data on it are not available.

The average proximate analysis of Mulky coal is as follows (24):

| Constituent | Percent (as received) | Percent (moisture and ash free) |
|---|---|---|
| Moisture ..... | 2.8 | — |
| Volatile matter .... | 40.3 | 46.0 |
| Fixed carbon ..... | 47.4 | 54.0 |
| Ash ..... | 9.3 | — |
| Sulfur ..... | 3.9 | 4.5 |
| B.t.u. ..... | 13,286 | 15,130 |

The Bevier seam, about 75 feet below the top of the Cherokee shale, is the principal coal mined in Bourbon County. The seam averages 15 inches thick, increasing in places to 20 inches. Production in 1949 was 137,670 tons (4); production decreased to 103,104 tons in 1950.

Kelley Carter Coal Co. is the principal operator, producing 117,479 tons in 1949 and 75,258 tons in 1950 (4). The company strip mines the Bevier bed in sec. 27, T. 26 S., R. 25 E. (5, fig. 37), and washes the coal in its modern, 250-tons-an-hour, washing plant in sec. 1, T. 27 S., R. 25 E. (6, fig. 37).

The Croweburg coal seam is in the Cherokee shale about 35 feet below the Bevier bed. The coal is available for a short distance near the southeast corner of the County but is not mined.

The average proximate analyses of Mulky and Bevier coals are (24):

| Constituent | Percent (as received) | | Percent (moisture and ash free) | |
|---|---|---|---|---|
| | Mulky | Bevier | Mulky | Bevier |
| Moisture ..... | 2.8 | 3.8 | — | — |
| Volatile matter ..... | 40.3 | 37.8 | 46.0 | 43.7 |
| Fixed carbon ..... | 47.4 | 48.6 | 54.0 | 56.3 |
| Ash ..... | 9.3 | 9.8 | — | — |
| Sulfur* ..... | 3.9 | 2.6 | 4.5 | 3.1 |
| B.t.u. ..... | 13,286 | 13,026 | 15,130 | 15,077 |

* From ultimate analyses

The Bourbon County coal production in tons (4) for 1949 and 1950 follow:

| Company | 1949 | 1950 |
|---|---|---|
| Brooks Coal Co. ..... | 2,111 | 6,035 |
| Double Eagle Coal Co. ..... | 3,242 | 2,801 |
| Garrett Coal Co. ..... | 7,117 | 5,294 |
| Jones Coal Co. ..... | 4,491 | 8,126 |
| Kelly Carter Coal Co. ..... | 117,479 | 75,258 |
| Pellett Coal Co. ..... | 746 | — |
| Thornhill Coal Co. ..... | 2,484 | 5,590 |
| Total ..... | 137,670 | 103,104 |

The estimated coal reserves (20) in Bourbon County in 1947 were as follows:

| Coal bed | Coal reserves in thousands of tons | |
|---|---|---|
| | Proved | Potential |
| Mulberry ..... | 8,320 | 317,000 |
| Milky ..... | 5,760 | 216,000 |
| Bevier ..... | 7,920 | 216,000 |
| Croweburg ..... | — | 15,000 |
| Total ..... | 22,000 | 764,000 |

Future technology, such as burning coal in place, may make total coal reserves available but only a portion of the estimated total is available at present. Deep mining is not economic. An estimate of about 4,000,000 tons of proved economically-recoverable coal in the County seems more appropriate.

## Oil (6 and 11)

Oil production is confined to five fields in the western part of Bourbon County: the Bronson-Zenia, Davis-Bronson, Elsmore Shoestring, Hepler, and Savonburg. Oil production of the County in 1949 was 15,374 barrels. The production in 1950 for the first two fields was 11,048 barrels; production from the Hepler and Savonburg fields is not available and that from the Elsmore Shoestring is included in Allen County production figures.

All production is from the Bartlesville sand in the Cherokee shale at depths of 550 to 650 feet. Flush production passed years ago, and water-flooding projects have been established in the Bronson-Zenia and Hepler fields in Bourbon County.

The main producing sands of the Cherokee shale are the Squirrel sand, about 20 feet thick, located a few feet below the top of the Cherokee shale, the Bartlesville sand, 5 to 40 feet thick, occurring about 180 feet below the top of the Cherokee shale; and the Burgess sand, approximately 10 feet thick, located near the base of the Cherokee shale.

Service Pipe Line Co. collects oil from the fields. Texas Empire Pipe Line Co. has a 10-inch oil line crossing southern Bourbon County, and a pumping station at Hiattville (fig. 8).

### Gas

Bourbon County produced 15,356 M cubic feet of gas in 1949 from various fields, the youngest of which was opened up in 1943.

Cities Service Gas Co. has an 8-inch gas line from Humboldt across southern Bourbon County to the Fort Scott area, connecting with the gathering lines of the Commercial Gas Pipeline Co. which extends into the gas fields (fig. 8).

## ELECTRIC POWER

Eastern Kansas Utilities, Inc., has a steam-generating electric plant of 1,000-kw. capacity at Fort Scott, distributing power to the County. The plant is tied into a 66,000-volt line

from the Kansas City Power & Light Co. switching station at Moran in Allen County and to the power lines of Kansas Gas & Electric Co. south of Fort Scott (fig. 9).

Rural Electrification Administration purchases power from Eastern Kansas Utilities, Inc., and distributes it to rural areas.

## WATER

Water is available in the alluvials of the Little Osage and Marmaton Rivers. Small amounts of water are usually available in shallow wells to limestones if they lie near the surface and have sufficient catchment area to the east. Deep wells to Mississippian limestones or Ordovician dolomites and sandstones find abundant water, but it may be too highly mineralized for domestic use.

## CRAWFORD COUNTY

### PHYSICAL FEATURES

Crawford County is in the Osage Plains of eastern Kansas (fig. 1). Only the northeastern part of the County lies within the Missouri River Basin (fig. 38). The highest point in the Basin area, 1,060 feet above sea level, is on the divide in the vicinity of Farlington, and the lowest point is 800 feet, in the northeast corner of the County. Drainage is northeastward through several creeks, all tributaries of the Marmaton River. Several low, southeast-facing escarpments have been formed by the more resistant limestones. The streams have broad meandering valleys.

Crawford County is served by six railroad systems. A line of the Missouri Pacific Railroad enters the north border about 6 miles west of the northeast corner, goes south through Arma, and swings southeast across the east border. Another line of the Missouri Pacific comes in from the east and cuts the southeast corner, passing through Pittsburg and Cherokee (fig. 38).

The St. Louis & San Francisco Railroad, enters the County from the north above Farlington and branches at Girard, the county seat. One branch continues south through Beulah and Cherokee; the other swings southeast through Pittsburg. Another line of the St. Louis & San Francisco enters from the east, passes through Pittsburg, and continues westward through Cherokee and McCune along the extreme southern part of the County. Still another branch of the same system traverses the extreme northeast corner, touching Mulberry and Arcadia.

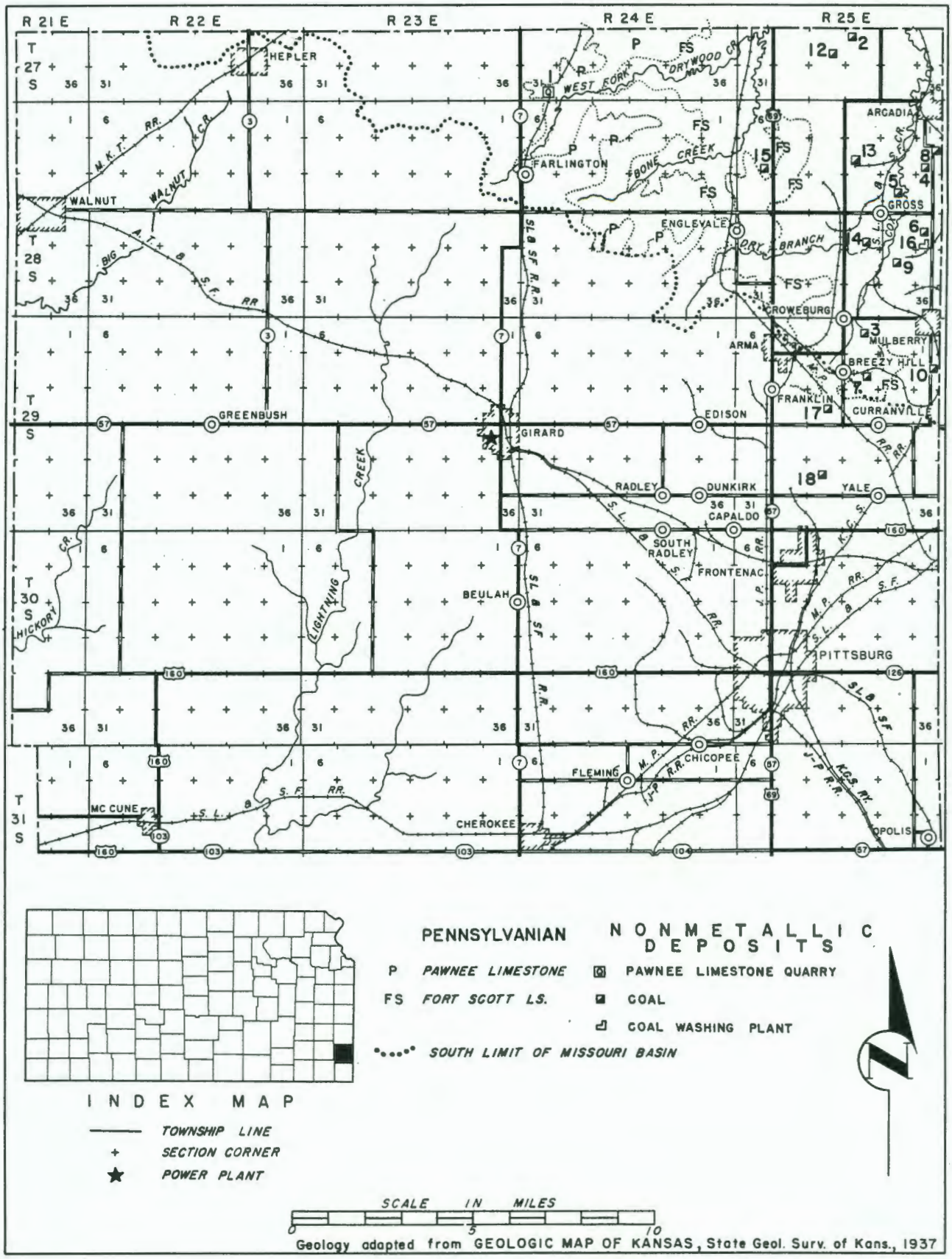



Figure 38.- Crawford County, Kansas

The Atchison, Topeka & Santa Fe comes in from the east and, in a north of west direction, goes through Frontenac, Girard, and Walnut.

The Kansas City-Southern Railroad cuts the southeast corner arc-wise, serving Curranville and Pittsburg.

The Joplin-Pittsburg line enters near the southeast corner of the County and runs to the coal mining areas around Pittsburg and Cherokee.

The Missouri, Kansas & Texas cuts the extreme northwest corner, going through Hepler and Walnut.

Secondary roads checkerboard the County at intervals of 1 and 2 miles. The main paved highways are shown on figure 38.

## GEOLOGY

The consolidated geological formations, outcropping in the Missouri River Basin in Crawford County, consist of alternating beds of shales, limestone, sandstone, and coal. They range from the lower half of the Pleasanton shale group in the northwest corner down through the upper half of the Cherokee shale group at the center of the east border (figs. 4 and 38). The three groups (Pleasanton, Marmaton, and Cherokee) occur as bands striking northeasterly across the County and dipping gently, 10 to 15 feet a mile, towards the northwest. The two limestone formations of importance are the Pawnee and Fort Scott in the Marmaton group.

The Pleasanton shale group, about 75 feet thick, has a thin basal sandstone (Hepler), 3 or 4 feet thick. The Marmaton group, lying under the Pleasanton group and about 250 feet thick, contains the Pawnee limestone and the basal Fort Scott limestone. The Mulberry coal bed lies a short distance above the Pawnee limestone. The Cherokee group, beneath the Marmaton group, ranges from 316 to 455 feet in thickness, but only the upper half outcrops in the Basin area. The group, in its entirety, contains about 15 coal beds (fig. 4).

Subsurface, under the Cherokee shale, in descending order, lie 300 to 400 feet of Mississippian limestones, 685 to 800 feet of Ordovician dolomites and sandstones, and 340 to 430 feet of Cambrian dolomites and sandstones (fig. 5).

## MINERAL RESOURCES

No sand-gravel is produced within the Missouri River Basin area. Limestone is plentiful but none was quarried in 1950. Crawford County produced 739,759 tons of coal in 1950, but only 41,578 tons originated within the Basin area. The Basin, in 1949, produced 44,695 tons of coal. The County produced 61,324 barrels of oil in 1949, but none of the production originated within the Missouri Basin area.

### Limestone

The Fort Scott and Pawnee limestones outcrop profusely in the Basin area, but were not quarried in 1950. A large amount

of hard, block shale from old deep mine dumps has been used as road metal. The Stork quarry, in sec. 31, T. 27 S., R. 24 E. (1, fig. 38), is an abandoned Pawnee limestone quarry. The product was used as road metal but did not meet requirements of agricultural limestone. The Fort Scott limestone usually is not acceptable as road metal.

## Oil and gas

Crawford County produced 61,324 barrels of oil in 1949 from six active fields in the western part. None of the production originated within the Basin area. Oil production is from the Bartlesville sand (Cherokee group) at depths of about 400 feet.

There was no gas production in 1949. Girard, Pittsburg, and Chicopee are supplied with gas by the Cities Service Gas Co. through a 10-inch pipe from Cherokee County.

## Coal (figs. 39 and 40)

Crawford County produced 739,759 tons of coal in 1950 (4), of which 90 percent was from strip mine operations. The production originating within the Missouri River Basin was only 41,578 tons, of which 22,729 tons or 55 percent was produced in deep mines on the Weir-Pittsburg seam. The rest was from strip mines in thinner, overlying coal seams. Areas mined in the Basin area of Crawford County by strip mines and underground mines are shown on figures 39 and 40. Coal production in Crawford County, within the Basin area, from 1946 to 1950, inclusive, is given in the following table:

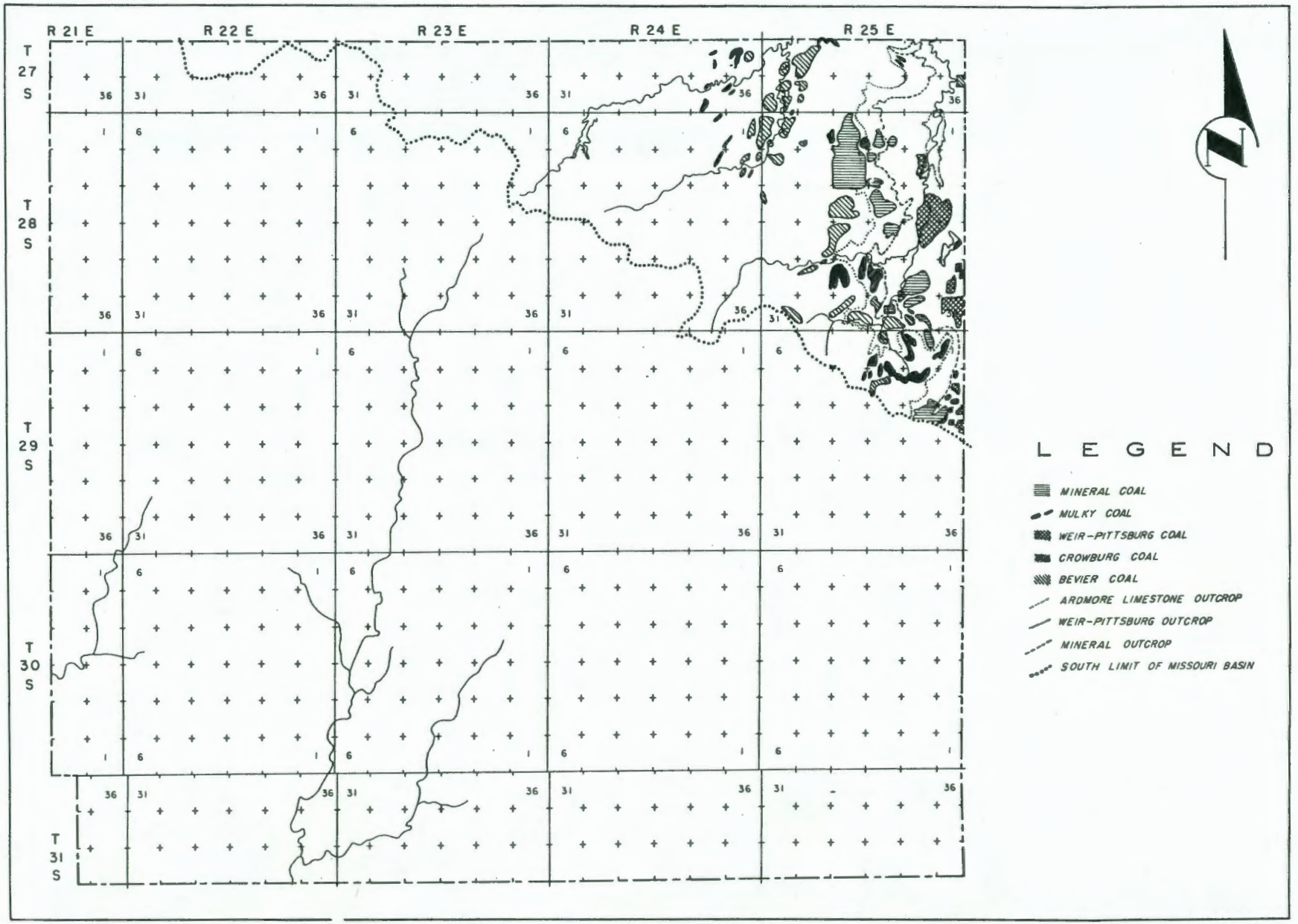



Figure39.-Coal strip mines in the Missouri Basin in Crawford County, Kansas

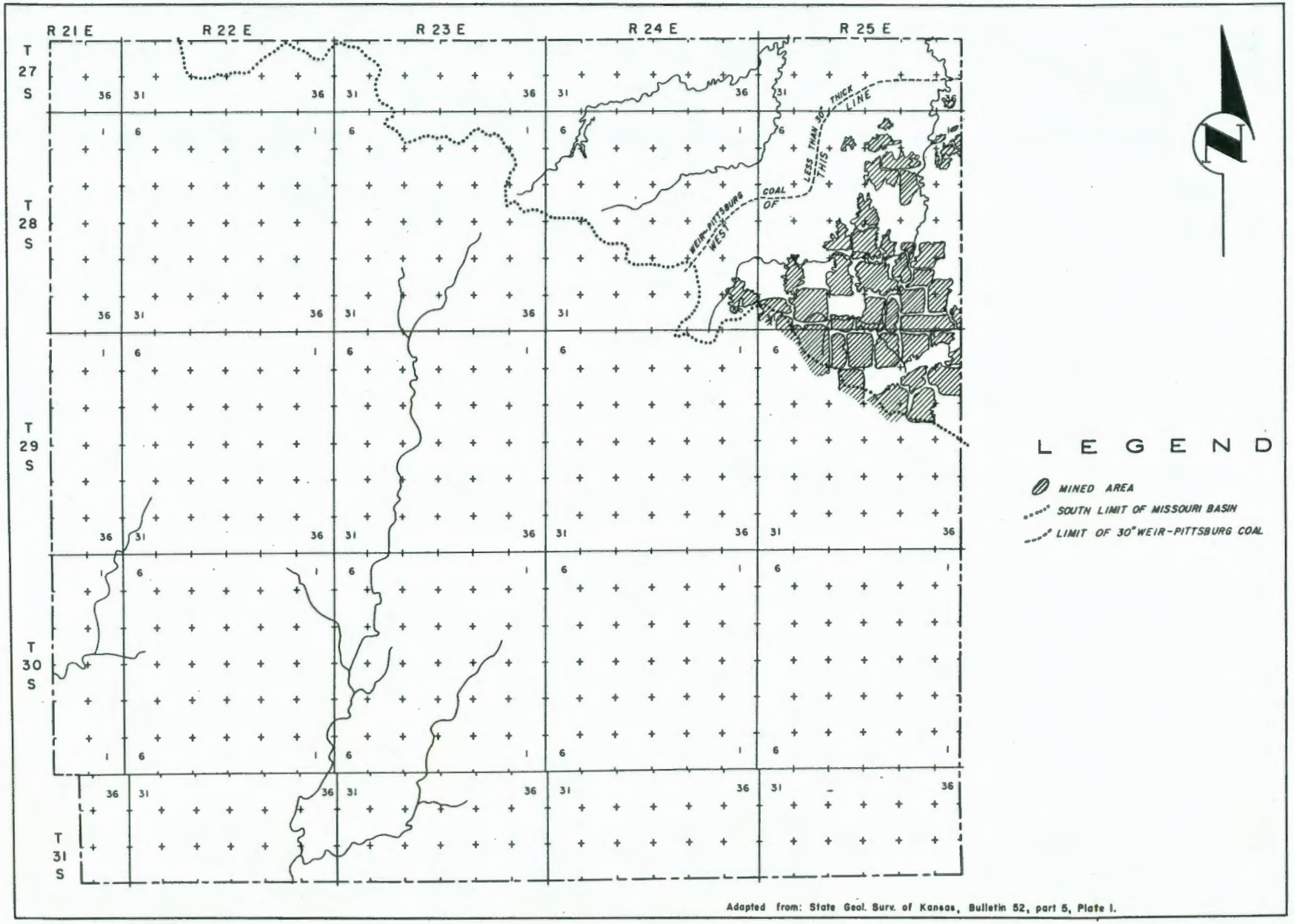



Figure 40.–Underground mined areas of Weir-Pittsburg coal in the Missouri Basin in Crawford County, Kansas

Crawford County (Missouri River Basin)
coal production, 1946 through 1950 (4)

| No. on fig. 38 | Company | Kind | Tons 1946 | 1947 | 1948 | 1949 | 1950 |
|---|---|---|---|---|---|---|---|
| 2 | ABC Coal Co. .... | Strip | — | 724 | 865 | 218 | 596 |
| 3 | Carr Coal Co. ... | Do. | 4,184 | 7,647 | 2,437 | 1,579 | 1,511 |
| 4 | Dee Umbria Coal Co. ..... | Deep | 11,471 | 8,009 | 10,451 | 8,399 | 3,350 |
| 5 | Cross Coal Co. .. | Do. | 653 | 575 | 1,198 | 286 | 323 |
| 6 | Kennedy Coal Co.. | Do. | 4,653 | 10,908 | 8,977 | 4,216 | 8,250 |
| 7 | Mark Coal Co..... | Strip | — | — | 100 | 298 | 210 |
| 8 | Pal Coal Co. .... | Slope | 113 | 389 | 264 | — | — |
| 9 | Target Coal Co. . | Strip | — | — | 1,075 | 2,000 | 1,581 |
| 10 | True Cherokee Coal Co. ..... | Deep | — | — | 2,304 | 9,250 | 10,064 |
| 12) 13) | Wholesale Lumber & Coal Co. .... | Strip | 13,062 | 11,070 | 21,699 | 12,795 | 14,140 |
| 14 | Wyatt Coal Co. .. | Deep | 9,846 | 14,755 | 9,534 | 5,489 | 742 |
| 15 | Prairie Coal Co.. | Strip | — | — | 880 | 165 | 99 |
| 15 | Hill Coal Co. ... | Do. | — | — | — | — | 712 |
| | Total ..... | | 43,982 | 54,077 | 59,784 | 44,695 | 41,578 |

Coal mining in Kansas dates from 1860. Railroads entered southeastern Kansas in 1870 and eventually consumed the greater part of production. The recent trend to diesel power by the railroads and the increasing use of gas and oil as fuel for domestic and industrial consumption have greatly reduced the demand for coal, and, hence, its production. Early production was largely from strip and deep mines on the Weir-Pittsburg bed. At present, the strippable Weir-Pittsburg coal is almost exhausted, and production in southeast Kansas is dependent upon large stripping operations on the thinner overlying beds. Deep mines are unable to meet this competition and most of them have shut down. The few that are operating are unable to pay the union scale of wages and are therefore worked on a contract or cooperative basis, usually during the

winter season only. The selling price of coal in 1950 averaged about $4 a ton at the tipple in southeastern Kansas. Deep mines in the area would need approximately $1.50 a ton more to meet strip-mine competition.

Coal reserves in Crawford County (within the Missouri River Basin), which can be economically recovered under present conditions and technology, are believed to be not over 3,000,000 tons, although the actual proved underground reserve is many times that figure. The coal beds in Crawford County, within the Basin area, in order of age, the oldest first (fig. 4), are: Weir-Pittsburg, Pilot, Scammon, Mineral, Fleming, Croweburg, Bevier, and Mulky.

Weir-Pittsburg coal, near the middle of the Cherokee group, is 175 to 200 feet below the Fort Scott limestone. Within the Basin area, the seam is 32 to 38 inches thick, increasing toward the southwest to 46 inches in Labette County. It decreases in thickness toward the west and north, and the present known limit of 30-inch coal is shown on figure 40. Several thin coal beds, less than 16 inches, lie below the Weir-Pittsburg seam but do not outcrop within the Basin area and are not mined. Horsebacks (barren areas) often occur in the Weir-Pittsburg bed. Weir-Pittsburg coal is being mined as follows:

Target Coal Co.--Strip mining in the SE¼ NW¼ of sec. 26, T. 28 S., R. 25 E. (9, fig. 38).

Cross Coal Co.—Slope mining in the NE¼ SW¼ of sec. 14, T. 28 S., R. 25 E. (5, fig. 38).

Pal Coal Co.—Slope mining in the SE¼ NE¼ of sec. 12, T. 28 S., R. 25 E. (8, fig. 38).

Doe Umbria Coal Co.—Shaft mining in the S½ of sec. 12, T. 28 S., R. 25 E. (4, fig. 38).

Kennedy Coal Co.—Shaft mining in the SW¼ NE¼ of sec. 24, T. 28 S., R. 25 E. (6, fig. 38).

True Cherokee Coal Co.—Shaft mining in the SE¼ NE¼ of sec. 12, T. 29 S., R. 25 E. (10, fig. 38).

Wyatt Coal Co.—Shaft mining in the SW¼ SE¼ of sec. 22, T. 28 S., R. 25 E. (14, fig. 38).

The Pilot coal seam, 3 to 7 inches thick and lying 20 to 27 feet above the Weir-Pittsburg coal, is not mined.

The Scammon coal seam, 3 to 12 inches thick and lying 30 to 40 feet below the Weir-Pittsburg coal, also is not mined.

The Mineral coal seam (also known as Baxter) is 65 to 80 feet above the Weir-Pittsburg bed. The seam, 17 to 24 inches and averaging 19½ inches thick, is mined extensively by the Mackie Clemens Coal Co. just south of the Missouri River Basin area (17 and 18, fig. 38).

The Fleming coal seam, 1 to 10 inches thick, lies 10 to 20 feet above the mineral bed. The seam is not continuous in the area but, when of sufficient thickness, is mined with the Mineral coal bed.

The Crowsburg coal seam, averaging 12 inches thick and 17 to 35 feet above the Mineral coal, is mined occasionally.

The Bevier coal seam, averaging 18 inches in thickness, is one of the important coal seams. Overlying the Ardmore limestone, the bed is 80 to 100 feet below the Fort Scott limestone formation, the base of the Marmaton group. Bevier coal is being mined as follows:

ABC Coal Co.—Strip mining in the NW¼ NW¼ of sec. 27, T. 27 S., R. 25 E. (2, fig. 38).

Carr Coal Co.—Strip mining in the SW¼ NE¼ of sec. 3, T. 29 S., R. 25 E. (3, fig. 38).

Wholesale Lumber & Coal Co.—Strip mining in the SE¼ of sec. 28, T. 27 S., R. 25 E. (12, fig. 39) and in the SW¼ of sec. 10, T. 28 S., R. 25 E. (13, fig. 38).

The Mulky coal seam, 8 to 12 inches thick and 3 to 5 feet below the Fort Scott limestone, is mined for local use. Mulky coal is being mined as follows:

Mark Coal Co.—Strip mining in the NW¼ SE¼ of sec. 10, T. 29 S., R. 25 E. (7, fig. 38).

Prairie Coal Co.—Strip mining in the SE¼ SE¼ of sec. 7, T. 28 S., R. 25 E. (15, fig. 38).

Analyses of the important coal beds in Crawford County are shown as follows:

Analyses of Crawford County Coals (24)

| Coal bed | Condition* | Percent: Moisture | Volatile matter | Fixed carbon | Ash | Sulfur | B.t.u. content |
|---|---|---|---|---|---|---|---|
| Mulky | 1 | 2.8 | 40.3 | 47.5 | 9.4 | 3.9 | 13,287 |
| | 2 | | 41.5 | 48.9 | 9.6 | 4.0 | 13,337 |
| | 3 | | 46.0 | 54.0 | — | 4.5 | 15,130 |
| Bevier | 1 | 4.1 | 36.7 | 48.5 | 10.7 | 2.5 | 12,823 |
| | 2 | | 38.2 | 50.6 | 11.2 | 2.6 | 13,340 |
| | 3 | | 43.0 | 57.0 | — | 2.9 | 15,060 |
| Mineral | 1 | 4.6 | 34.3 | 48.7 | 12.4 | 4.1 | 12,435 |
| | 2 | | 35.9 | 51.2 | 12.9 | 4.4 | 13,040 |
| | 3 | | 41.5 | 58.7 | — | 5.0 | 14,970 |
| Weir-Pittsburg | 1 | 5.7 | 32.9 | 49.7 | 10.7 | 4.2 | 12,421 |
| | 2 | | 35.3 | 53.4 | 11.3 | 4.4 | 13,214 |
| | 3 | | 39.9 | 60.1 | — | 5.1 | 14,902 |

* (1) as received; (2) moisture free; (3) moisture and ash free

Clemens Coal Co. operates a modern McNally-type washing plant in the SW¼ sec. 24, T. 28 S., R. 25 E. (16, fig. 38). The source of coal for the washer is the operations of the Mackie Clemens Coal Co. in secs. 16 and 28, T. 29 S., R. 25 E. (17 and 18, fig. 38), which are outside the Basin area, and an operation in the NE¼ sec. 13, T. 28 S., R. 25 E. (11, fig. 38) in Missouri. Some coal is purchased from Kennedy Coal Co. and other small operators nearby.

## ELECTRIC POWER

Girard has a municipally-owned, internal combustion, electric plant of 1,872-kw. capacity. Kansas Gas & Electric Co. furnishes power to the rest of the County over 66,000-volt lines from power sources outside the Missouri River Basin.

Rural Electrification Administration purchases power from Kansas Gas & Electric Co. for distribution to rural areas.

## WATER

Crawford County has an abundant supply of water from deep wells into aquiferous dolomites and sandstones or Ordovician and Cambrian age. Small quantities of water are available in shallow wells to limestones lying close to the surface or to porous alluvials in the numerous drainage courses. Sandstones in the Cherokee shale, close to their outcrops, contain small amounts of water.

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