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BULLETIN 101

GEOLOGY AND GROUND-WATER RESOURCES OF JACKSON COUNTY, KANSAS

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Prepared by the State Geological Survey of Kansas and the United States Geological Survey, with the co-operation of the Division of Sanitation of the Kansas State Board of Health and the Division of Water Resources of the Kansas State Board of Agriculture

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GEOLOGY AND GROUND-WATER RESOURCES OF JACKSON COUNTY, KANSAS

By Kenneth L. Walters

ABSTRACT

This report describes the geography, geology, and ground-water resources of Jackson County in northeastern Kansas. The county has an area of 658 square miles and had a population of 11,087 in 1946. It consists predominantly of rolling hills and has an intricate drainage system. Near the largest streams the surface is deeply dissected and the relief is pronounced. The climate is humid, the average annual precipitation being about 32 inches. General farming and livestock raising are the principal occupations in the county.

The rocks that crop out in this area range in age from Pennsylvanian to Recent. The oldest formation cropping out in the county is the Cedar Vale shale which is exposed in eastern Jackson County. Pleistocene glacial drift comprises the surface material in a large area in central and northern Jackson County and yields moderate quantities of water to wells. The alluvium is the youngest deposit in the county and also yields moderate quantities of water to wells.

This report contains a map showing the areas of outcrop of the rock formations, a map showing the location of test holes and wells for which records are given, and cross sections of the area showing the character and thickness of the formations overlying the Pennsylvanian and Permian bedrock.

The ground-water reservoir is recharged from precipitation that falls within the area, by percolation from streams, and by underflow from adjacent areas. Ground water is discharged from the ground-water reservoir by seepage into streams, by transpiration and evaporation, by movement into adjacent areas, and by wells and springs.

Most of the wells in the county are drilled or dug. No irrigation is practiced in Jackson County.

Ground water in Jackson County is generally hard, but except for individual wells that are contaminated by surface seepage—the water is suitable for most uses.

The field data upon which this report is based are given in tables. They include records of 255 wells, chemical analyses of water from 24 representative wells, and logs of 47 test holes.

INTRODUCTION

Location and Size of the Area

Jackson County is in the northeastern part of Kansas, in the second tier of counties south of Nebraska and in the second and third rows of counties west of Missouri. The county has an area of about 421,-

120 acres, or 658 square miles. Its location with respect to other counties is shown in Figure 1.

Purpose and Scope of the Investigation

An investigation of the geology and ground-water resources of Jackson County was begun in the fall of 1949 by the United States Geological Survey and the State Geological Survey of Kansas, with the co-operation of the Division of Sanitation of the Kansas State Board of Health and the Division of Water Resources of the Kansas State Board of Agriculture.

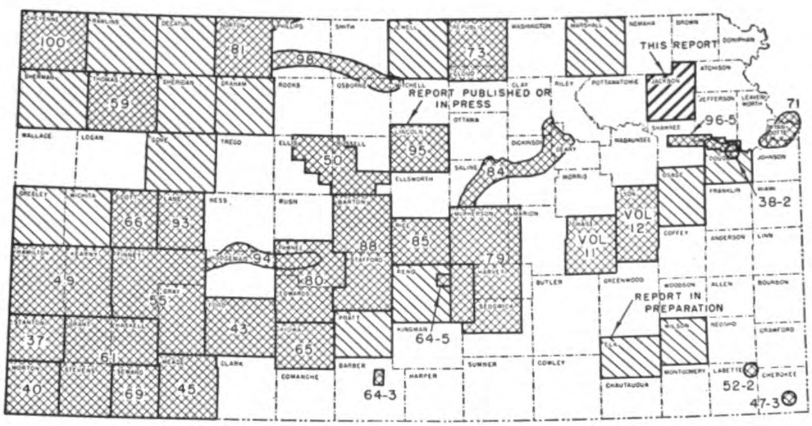

Fig. 1.—Index map of Kansas showing area covered by this report and areas for which co-operative ground-water reports have been published or are in preparation.

Ground water is one of the most important natural resources of Jackson County. Nearly the entire population of Jackson County depends upon wells for water supply. The increased availability of electricity and modern sanitary facilities in rural areas and the demand for larger quantities of water in municipalities already supplied with water have materially increased the withdrawal of ground water. An understanding of the occurrence of ground water in Jackson County is necessary if this resource is to be developed to the extent needed to meet present and future demands.

The investigation was made under the general direction of A. N. Sayre, chief of the Ground Water Branch of the United States Geological Survey; and under the immediate supervision of V. C. Fishel, district engineer of the Ground Water Branch in charge of the co-operative ground-water studies in Kansas.

Previous Geologic and Hydrologic Work

Although a detailed study of the geology and ground-water resources of Jackson County has not been previously undertaken, this area is referred to briefly in several earlier reports. Haworth (1913), in a special report on well waters in Kansas, discussed the complexities of the glacial drift of northeastern Kansas and remarked upon the reliability of valley fill as an aquifer in that area. Moore and others (1940) summarized the occurrence of ground water in northeastern Kansas. The report of a reconnaissance investigation by Frye (1941) on the ground-water resources of Atchison County described the aquifers of the area adjacent to Jackson County on the east. Schoewe (1946) summarized the coal resources of Jackson County and discussed the Pennsylvanian stratigraphy of the eastern part of the county. The geology of the county in relation to oil and gas was discussed by Jewett and Abernathy (1945) and by Jewett (1949).

Methods of Investigation

Field work was begun in Jackson County in the fall of 1949 and was continued during the summer of 1950. During the investigation 255 wells were measured with a steel tape to determine the depth of the well and the depth to the water level.

Data were obtained from well owners and well drillers concerning the yield of wells and the water-bearing materials. A total of 47 test holes were drilled in the county with a portable hydraulic-rotary drilling machine owned by the State Geological Survey and operated by W. T. Connor, Lawrence Gnagy, and Max Yazza. The drill cuttings were studied in the field and later examined in the office with a microscope. The altitude of the land surface at each test hole was determined by W. W. Wilson and C. K. Bayne using a spirit level.

Samples of water from 24 wells in the county were collected and chemical analyses of them were made by Howard Stoltenberg, chemist in the Water and Sewage laboratory of the Kansas State Board of Health.

Field observations were recorded on aerial photographs and were later plotted on a base map modified from a map prepared by the Soil Conservation Service, United States Department of Agriculture. The illustrations were drafted by W. W. Wilson of the U. S. Geological Survey.

Well-Numbering System

In this report, wells and test holes are numbered according to their location as given by the General Land Office system of land classification. The component parts of a well number are the township number, the range number, the section number, and the two lower-case letters which indicate, respectively, the quarter section and the quarter-quarter section in which the well is located. The lower case letters are assigned in counterclockwise order be-

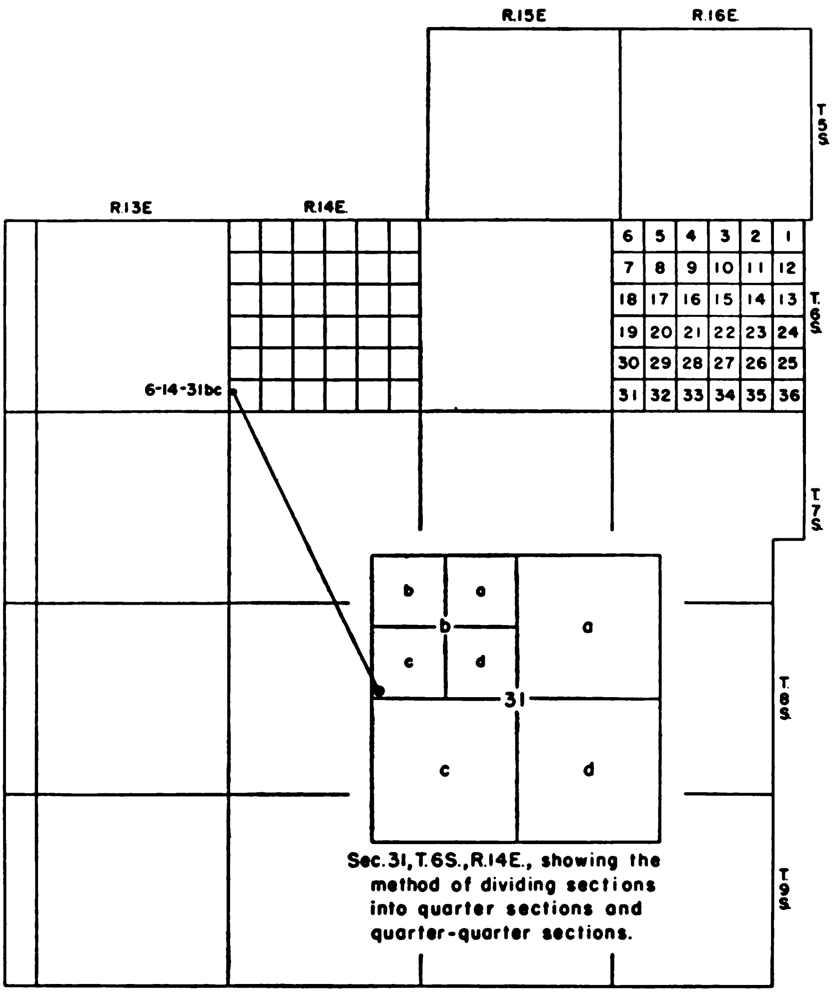

Fig. 2.—Map of Jackson County illustrating the well-numbering system used in this report.

ginning with the letter a, in the northeast quarter or quarter-quarter section. For example, well 6-14-31bc (Fig. 2) is in the SW¼ NW¼ sec. 31, T. 6 S., R. 14 E.

ACKNOWLEDGMENTS

Appreciation is expressed to the many residents of Jackson County who supplied information and gave permission for their wells to be measured. Special thanks are due Ralph J. Bell, superintendent of Holton Water Department, and to the several water-well drillers operating in the area, for much valuable information. J. M. Jewett and Howard O'Connor spent several days in the field with me in the fall of 1950.

The manuscript of this report has been reviewed critically by several members of the Federal and State Geological Surveys; by Dwight Metzler, Director and Chief Engineer, and Willard O. Hilton, Geologist, Division of Sanitation, Kansas State Board of Health, and by R. V. Smrha, Chief Engineer, and George S. Knapp, Engineer, Division of Water Resources, Kansas State Board of Agriculture.

GEOGRAPHY

TOPOGRAPHY

Jackson County lies in the Dissected Till Plains section of the Central Lowlands physiographic province (Schoewe, 1949). The county has three principal types of topography (Fig. 3) which are discussed below.

Thick drift Region.—More than one-third of the area of Jackson County consists of an erosion surface on thick glacial drift (Pl. 4A). In this region the surface topography is not affected by the bedrock. The divide areas are smooth or gently undulating. Near the streams, dissection is more pronounced and the hills slope uniformly to wide rounded valleys. The average local relief of this area does not exceed 40 feet.

Alluvial valleys.—The numerous alluvial valleys of Jackson County have an average width of about half a mile, and they constitute about 13 percent of the area of the county.

Erosional bedrock area.—The bedrock crops out in the western, southern, and eastern parts of the county. Although glaciated, this area is sparsely covered with isolated patches of till, outwash, and erratic boulders. Parts of this area are extensions of the Attenuated Drift Border section of the Central Lowlands province. The relief

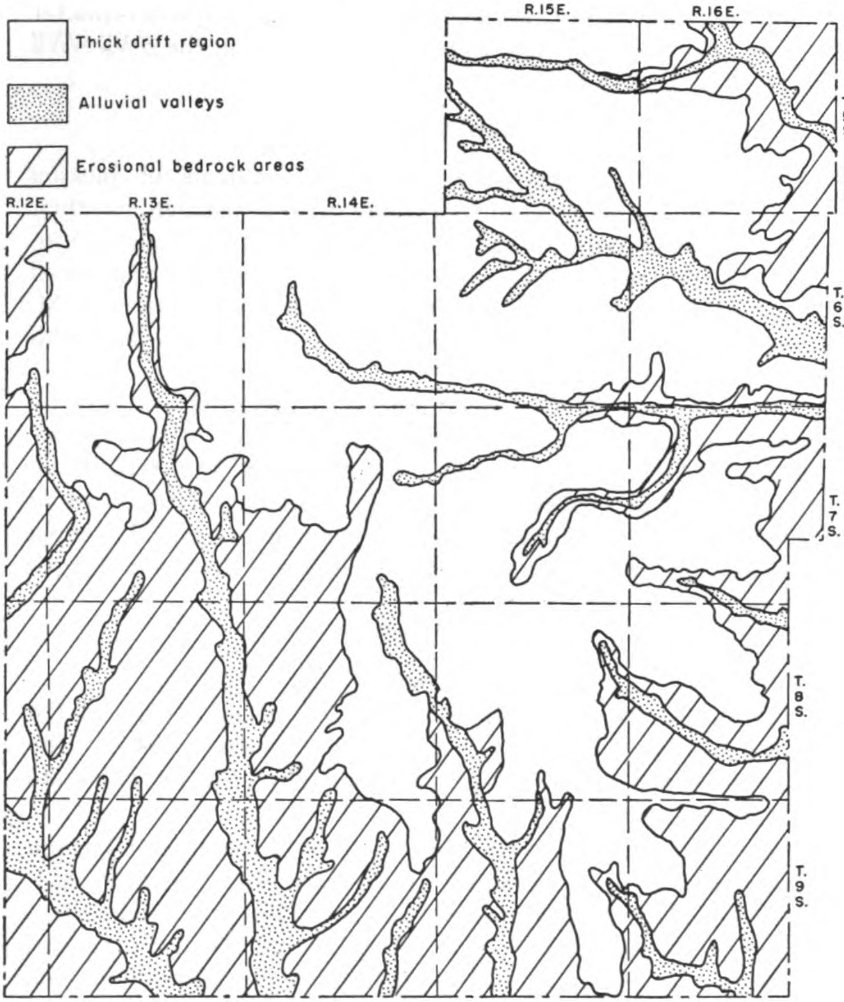

FIG. 3.—Map of Jackson County showing topographic divisions.

of the erosional bedrock area is more pronounced than that of the thick drift region (Pl. 4B). The hills have flattened tops and steep sides similar to those of the Flint Hills region farther south.

DRAINAGE

The surface of Jackson County slopes gently to the southeast. The larger streams in the eastern part of the county flow in a general direction slightly south of east, whereas those in the western and southern parts of the county flow nearly straight south.

Big Soldier Creek is the longest stream in Jackson County. The stream enters the county 4 miles east of the northwest corner and leaves the county 8 miles east of the southwest corner. Cross Creek

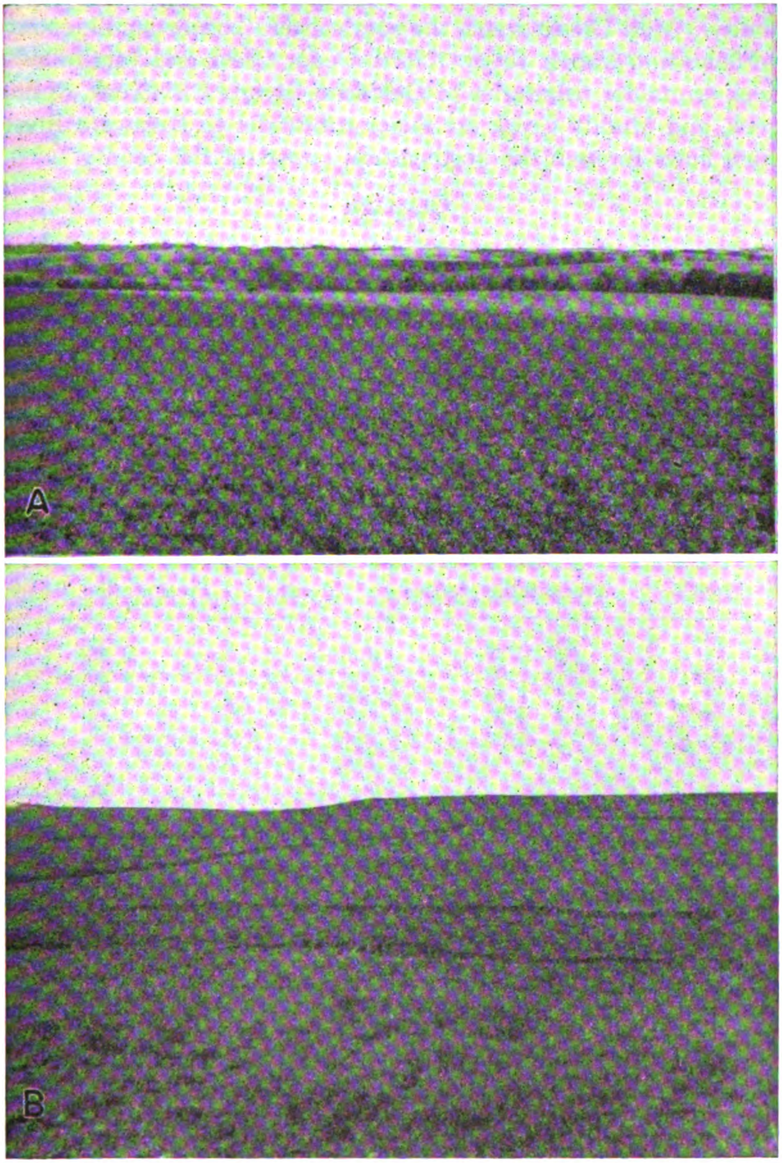

PLATE 4. A, Glacial topography of northern Jackson County. B, Bedrock topography in the NW¼ sec. 15, T. 9 S., R. 14 E.

drains the extreme southwestern part of the county, its course roughly paralleling the Jackson-Pottawatomie County line. Walnut Creek and Little Soldier Creek have their headwaters in the Pottawatomie Indian Reservation and join Big Soldier Creek in Shawnee County. Mud Creek drains the southeastern corner of the county and flows into Kansas River. North Cedar Creek and South Cedar Creek are minor tributaries to Delaware River. Elk Creek, Spring Creek, and Muddy Creek are major tributaries to Delaware River, which flows through the northeastern corner of the county.

Climate

According to the 1948 report of the Kansas State Board of Agriculture, Jackson County has an average growing season of 183 days. The average date of the first killing frost in the fall is October 17, and the average date of the last killing frost in the spring is April 23. The normal monthly precipitation for the period 1898 through 1945 is shown in Table 1. The normal annual precipitation at Holton is 32.01 inches.

Table 1. *The normal monthly precipitation for the period 1898 through 1945 at Holton, Kansas*

Month	Precipitation, inches	Month	Precipitation, inches
Jan.	0.87	July	3.18
Feb.	1.03	Aug.	4.20
Mar.	1.76	Sept.	4.01
Apr.	2.75	Oct.	2.45
May	4.46	Nov.	1.85
June	4.40	Dec.	1.05

The annual precipitation and the cumulative departure from normal precipitation at Holton for the period 1902 through 1950 are shown in Figure 4. The normal annual mean temperature of Jackson County is 54.9 degrees. The ground is covered with snow an average of 30 days per year.

Agriculture

Jackson County is primarily an agricultural county. In 1945 there were 1,985 farms in the county. In 1948 these farms had livestock valued at $5,815,800 and produced crops valued at $6,512,170. The total assessed valuation of farm land in 1946 was $14,965,755, ranking the county twenty-first in Kansas.

The approximate land area of Jackson County is 419,840 acres. In 1948 158,000 acres were in tame and prairie grass pasture. The chief pasture area is in the southwestern part of the county where topographic relief and pronounced bedrock outcrops make tilling of the soil impractical. No irrigation is practiced in Jackson County. The comparative value of the agricultural products of Jackson County for 1948 is shown in Table 2.

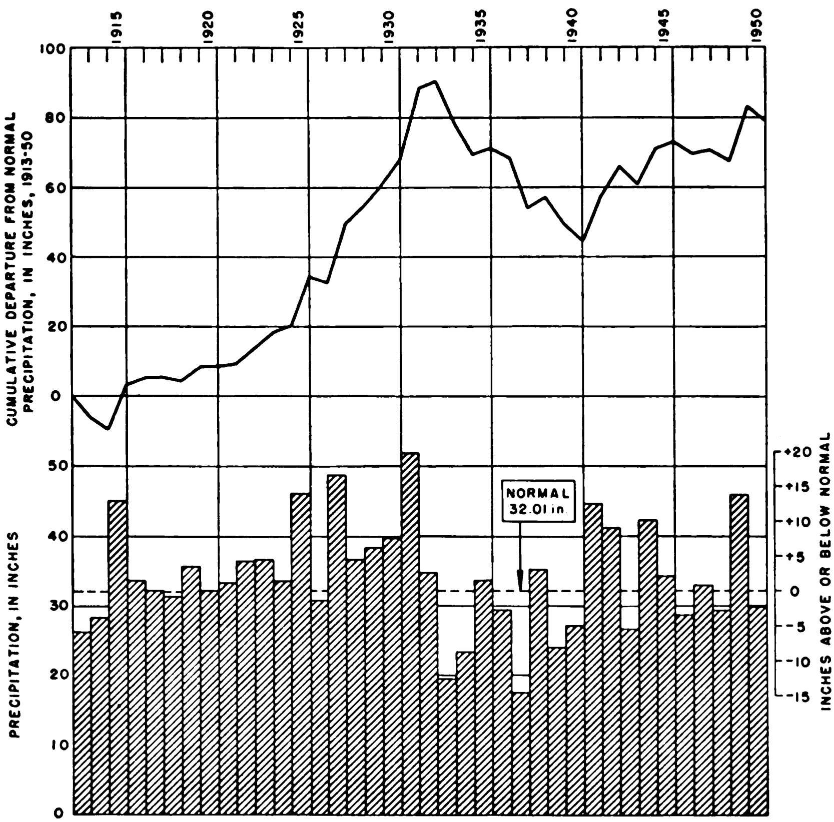

Fig. 4.—Annual precipitation and the cumulative departure from normal precipitation at Holton, Kansas.

TABLE 2. *Comparative values of the agricultural products of Jackson County for 1948*

Crops produced in 1948			Livestock on farms 1948		
Crop	Acres	Value	Livestock	Number	Value
Corn	59,300	$2,741,400	Cattle (other than milk cows)	24,600	$2,545,000
Wheat	47,700	2,141,000	Milk cows	11,000	1,804,000
Oats	20,980	395,620	Swine	21,300	888,300
Hay	40,760	950,110	Chickens	233,800	280,600
Sorghum	7,500	213,060	Horses & mules	5,250	220,500
Others	1,393	70,980	Sheep & lambs	5,010	76,700
Total	....	$6,512,170	Total	....	$5,815,800

TRANSPORTATION

The Union Pacific Railway Company line between Topeka and Marysville crosses through the southwestern corner of Jackson County, passing through Delia. The Chicago, Rock Island, and Pacific Railroad passes through Hoyt, Mayetta, Holton, and Whiting, connecting Topeka with St. Joseph, Missouri. A branch of the Missouri Pacific Railroad passes through the northern tier of townships in the county, serving Whiting and Netawaka.

The county is served by five State highways, K9, K16, K116, K62, and K79, as well as by U. S. highway 75; all are surfaced with black top. Most mail route roads, which are maintained by the county, are graded and surfaced with gravel or crushed limestone. Some of the least-used roads in areas of greatest topographic relief have been abandoned.

POPULATION

Jackson County had a population of 11,098 in 1950 and an average density of population of 16.9 to the square mile. The population of Jackson County increased rather rapidly from 1860 to 1900, then declined gradually to the present figure. The population of the cities, as reported by the 1950 census, are as follows: Holton 2,705; Whiting 267; Mayetta 247; Hoyt 246; Netawaka 213; Soldier 193; Circleville 169; Denison 166; and Delia 164.

NATURAL RESOURCES

The natural resources of Jackson County have been utilized for more than 60 years. The eighth biennial report of the Kansas State Board of Agriculture, 1891-92, devoted a paragraph to the discussion of the availability of building stone in Jackson County.

The known mineral resources of Jackson County consist of limestone, sand and gravel, and coal. Neither gas nor oil is produced in Jackson County.

Limestone.—Jackson County has limestone suitable for nearly every use. The Cottonwood, Neva, Americus, Tarkio, Reading, and Wakarusa limestones have been quarried in Jackson County for building stone but no building-stone quarries are now being operated in the county. The above-mentioned units, as well as the Burlingame limestone, have been quarried and crushed for use as road-building material or agricultural lime. Several large quarries and crushing plants now operate in Jackson County (Pl. 5.).

Sand and gravel.—Two sand and gravel pits in northwestern Jackson County are being operated as a source of road surfacing material. These deposits are of glacial origin and consist of unsorted sand and gravel mixed with clay and boulders. A gravel deposit in northeastern Jackson County consists principally of coarse brown chert gravel mixed with sand and clay. This deposit, which is no longer worked, probably is of pre-Kansan age.

Coal.—Very little coal has been mined in Jackson County. Only three small drift mines 1½ miles south and half a mile west of Larkinburg have been operated. Schoewe (1946) states that an area of about 2.5 square miles is underlain by a 14-inch coal bed containing about 2,800,000 tons of Elmo coal. He estimates the potential coal reserve in the county as approximately 191,500,000 tons. The coal averages about 12 inches in thickness and underlies an area of about 200 square miles.

GEOLOGY

Summary of Stratigraphy *

The geologic formations that crop out in Jackson County are of sedimentary origin and range in age from Pennsylvanian to Quaternary (Table 3). The areal distribution of the formations is shown on Plate 1. The Cedar Vale shale, which is Pennsylvanian in age, is the oldest formation exposed in the county. The Wreford limestone crops out in a small area along the extreme western edge of the county and is the youngest outcropping Paleozoic formation in the county. Much of the Paleozoic bedrock is mantled by deposits of Pleistocene glacial drift and Recent alluvium.

* The geologic classification and nomenclature of this report follow the usage of the State Geological Survey of Kansas (Moore, and others, 1951) and do not conform in all respects to the usage of the U. S. Geological Survey.

TABLE 3.—*Generalized section of the geologic formations of Jackson County, Kansas*[a]

System	Series	Group	Formation	Members	Thickness, feet	Physical character	Water supply
Quaternary	Pleistocene		Alluvium		0–50	Silt and clay, with minor quantities of sand in the upper part. Sand and gravel with thin beds of clay in the lower part.	Yields large quantities of water to wells along the major streams of the county. Alluvium of minor tributary streams yields supplies adequate for domestic or stock needs.
			Sanborn formation	Peoria silt	0–3	Tan, massive silt.	Does not furnish water to wells in Jackson County.
			Kansas till and associated deposits.		0–150	Unconsolidated clay and boulders, with incorporated deposits of sand and gravel.	Supplies small to moderate quantities of water to many domestic and stock wells where a sufficient thickness lies below the water table.
			Atchison formation		0–110	Silt and very fine sand in the upper part, coarse sand and fine gravel in the lower part.	Yields moderate supplies of water to wells in eastern and northern Jackson County.
			Pre-Kansan gravel		0–12	Medium to coarse chert gravel with a minor amount of quartzite gravel.	Yields moderate supplies of water to a few wells in the county.
		Chase	Wreford limestone	Threemile limestone.	0–5	Cherty limestone beds, with thin beds of shale.	Not known to yield water to wells in Jackson County due to its unfavorable topographic position.
			Speiser shale		15–18	Varicolored shale and a thin but persistent limestone bed.	Yields no water to wells in Jackson County.
			Funston limestone		4–7	Massive gray limestone, and light colored shale.	Yields very little water to wells in Jackson County.
			Blue Rapids shale		22?	Blocky gray shale, contains some green, red, and black.	Yields no water to wells in Jackson County.
			Crouse limestone		3–5	Massive and platy limestone, contains some shale.	Yields small quantities of water to a few wells.
			Easly Creek shale		15–20	Light colored and red shale.	Yields no water to wells in Jackson County.

TABLE 3.—*Generalized section of the geologic formations of Jackson County, Kansas*[a]—*Continued*

SYSTEM	Series	Group	Formation	Members	Thickness, feet	Physical character	Water supply
Permian	Wolfcampian	Council Grove	Bader limestone	Middleburg limestone Hooser shale Eiss limestone	13–18	Massive limestone beds, alternating with shale.	Yields small quantities of water to wells.
			Stearns shale		20	Gray or green calcareous shale.	Yields no water to wells in Jackson County.
			Beattie limestone	Morrill limestone Florena shale Cottonwood limestone	15–19	Gray to black shale and impure limestone in the upper part, massive limestone in the lower part.	Yields moderate supplies of water to wells in Jackson County.
			Eskridge shale		34	Varicolored shale and impure limestone.	Not known to yield water to wells in Jackson County.
			Grenola limestone	Neva limestone Salem Point shale Burr limestone Legion shale Sallyards limestone	25–35	Alternating beds of massive limestone and gray shale.	Yields moderate supplies of water to wells.
			Roca shale		18	Composed chiefly of gray-green, calcareous shale, contains some red shale.	Does not furnish water to wells in Jackson County.
			Red Eagle limestone	Howe limestone Bennett shale Glenrock limestone	9–15	Massive limestone beds and gray or black shale.	Yields small to moderate quantities of water to wells in Jackson County.
			Johnson shale		12–18	Consists chiefly of gray shale, contains several impure limestone beds.	Does not furnish water to wells in Jackson County.

TABLE 3.—*Generalized section of the geologic formations of Jackson County, Kansas**—*Continued*

System	Series	Group	Formation	Members	Thickness, feet	Physical character	Water supply
			Foraker limestone	Long Creek limestone Hughes Creek shale Americus limestone	34–48	Impure limestone and limy shale in the upper part; hard, massive limestone in the lower part.	Furnishes moderate supplies of water to wells in Jackson County.
		Admire	Hamlin shale	Oaks shale Houchen Creek limestone Stine shale	35–45	Alternating beds of shale and limestone with minor amounts of sandstone.	Yields small quantities of water to wells.
			Five Point limestone		1–2	Hard, massive, fossiliferous limestone.	Yields little or no water to wells in Jackson County.
			West Branch shale		17–23	Consists chiefly of gray shale and shaly sandstone.	Yields little or no water to wells in Jackson County.
			Falls City limestone		5–9	Massive, coquina-like limestone in the upper part, shale and impure limestone in the lower part.	Yields little or no water to wells in Jackson County.
			Hawxby shale		15–20	Blocky, gray shale; and minor amounts of impure limestone.	Does not furnish water to wells in Jackson County.
			Aspinwall limestone		1–2	Gray to white, non-resistant limestone.	Yields small quantities of water to wells in Jackson County.
			Towle shale		12–18	Red and gray silty to sandy shale.	Yields little or no water to wells in Jackson County.
			Brownville limestone		1–3	One or two beds of soft impure limestone.	Not known to yield water to wells in Jackson County.
			Pony Creek shale		14–20	Red silty shale, and soft massive sandstone.	Yields small quantities of water to wells in Jackson County.

TABLE 3.—*Generalized section of the geologic formations of Jackson County, Kansas*[a]—*Continued*

System	Series	Group	Formation	Members	Thickness, feet	Physical character	Water supply
			Caneyville limestone	Grayhorse limestone (not recognized in Jackson Co.) Nebraska City limestone	1–2	Soft, impure, fossiliferous limestone.	Yields no water to wells in Jackson County.
			French Creek shale		18–22	Gray to yellow sandy shale, coal and sandstone.	Yields small quantities of water to wells in Jackson County.
			Jim Creek limestone		0–1	Dark, fossiliferous limestone.	Does not yield water to wells in Jackson County.
			Dry-Friedrich shale		35–45	Sandy and micaceous yellow shale, and crossbedded sandstone. The intervening Grandhaven limestone was not recognized in Jackson County.	Yields small to moderate quantities of water to wells in Jackson County.
			Dover limestone		3–6	Massive, brown, fossiliferous limestone.	Supplies very small quantities of water to a few wells in Jackson County.
			Langdon shale		35–45	Light-brown and gray shale, and soft sandstone.	Yields small supplies of water to a few wells in Jackson County.
			Maple Hill limestone		1–2	Medium-hard gray limestone.	Yields small supplies of water to a few wells in Jackson County.
			Pierson Point shale		13–25	Yellow to dark gray shale with minor amounts of impure limestone and shaly sandstone.	Yields little or no water to wells in Jackson County.
Pennsylvanian	Virgilian	Wabaunsee	Tarkio limestone		3–5	Consists of one or two beds of massive brown limestone.	Does not yield water to wells in Jackson County.
			Willard shale		30–40	Dark gray to brown shale and crossbedded sandstone.	Yields little or no water to wells in Jackson County.
			Elmont limestone		3–4	Alternating beds of massive limestone and calcareous gray shale.	Yields small quantities of water to a few wells in Jackson County.

TABLE 3.—*Generalized section of the geologic formations of Jackson County, Kansas*[a]*—Concluded*

SYSTEM	Series	Group	Formation	Members	Thickness, feet	Physical character	Water supply
			Harveyville shale		9–15	Calcareous, blocky, greenish-gray shale.	Does not yield water to wells in Jackson County.
			Reading limestone		2–3	Hard, massive, dark blue limestone.	Yields small quantities of water to a few wells in Jackson County.
			Auburn shale		25–50	Consists chiefly of gray shale with minor amounts of sandstone and limestone.	Does not yield water to wells in Jackson County.
			Wakarusa limestone		2–4	Massive, hard, crystalline limestone.	Yields small quantities of water to a few wells in Jackson County
			Soldier Creek shale		7–9	Bluish-gray, clayey to sandy shale.	Does not yield water to wells in Jackson County.
			Burlingame limestone		6–10	Thick-bedded, brown brecciated limestone.	Yields small quantities of water to wells in Jackson County.
			Silver Lake shale		25–35?	Alternating beds of bluish to brown, sandy shale, and sandy to massive sandstone.	Furnishes small quantities of water to a few wells in Jackson County.
			Rulo limestone		1–2	Dark colored, fossiliferous limestone.	Does not furnish water to wells in Jackson County.
			Cedar Vale shale			Bluish to brown sandy shale, contains persistent Elmo coal near top. (Entire formation not exposed in Jackson County.)	Furnishes small quantities of water to a few wells in Jackson County.

[a] **Classification of the State Geological Survey of Kansas.**

The character and ground-water supplies of the geologic formations are discussed in the section on geologic formations and their water-bearing characteristics.

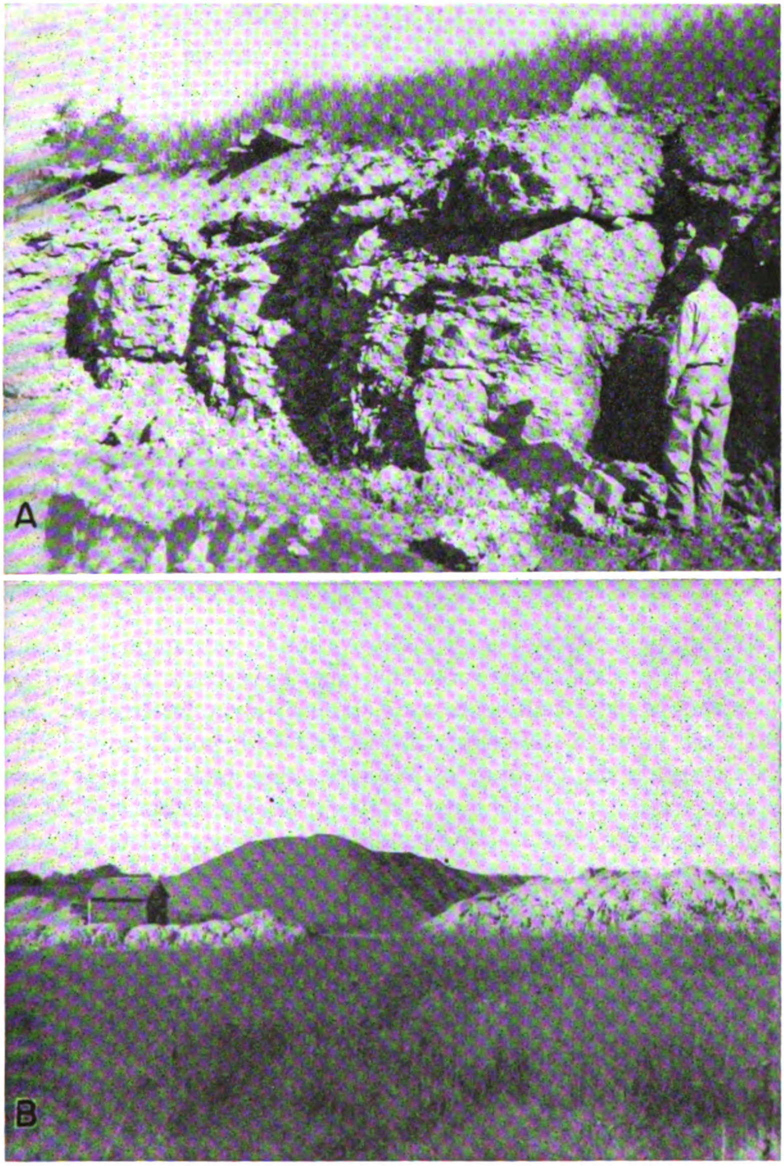

PLATE 5. **A,** Quarry in Burlingame limestone near Mayetta. **B,** Stockpile of agricultural lime and road material at quarry near Mayetta.

Geologic History

PALEOZOIC ERA

The Paleozoic geologic history of the area is known because of the studies that have been reported in several publications. Lee (1943) shows that the area was subjected both to erosion and deposition during the Paleozoic Era. Jackson County is on the east flank of the Nemaha anticline and in the west part of the Forest City basin. Both of these structural features were developed mainly after Mississippian time. Logs of several oil-test wells in the county indicate that as much as 3,300 feet of sediment overlies Pre-Cambrian granite. All the Paleozoic systems are represented in either the subsurface or on the surface. Geologic conditions along the northern side of the county are shown in cross section by Jewett and Abernathy (1945, pl. 1), and along the eastern side of the county by Jewett (1949, pl. 2).

MESOZOIC ERA

After the retreat of Permian seas, erosion was the predominant geologic process until Quaternary time. No rocks of Mesozoic age occur in Jackson County, but possibly Cretaceous rocks were deposited and later removed by erosion.

CENOZOIC ERA

During the Tertiary Period Jackson County was again an area of erosion. Any Cretaceous rocks that may have been deposited and many feet of older sediments were stripped away by erosion. Several small areas in the county are strewn with poorly sorted chert gravel resting on Permian or Pennsylvanian beds. These gravel deposits may be remnants of Tertiary stream deposits. At the beginning of the Quaternary Period, continental ice sheets advanced toward the central United States. The first Pleistocene ice sheet, the Nebraskan, probably did not extend into Jackson County. The only known glacial deposits of Nebraskan age in Kansas are found at a considerable distance to the north and east of Jackson County (Frye and Leonard, 1952). Gravel classified as pre-Kansan in this report may have been deposited as a result of Nebraskan glaciation, or it may have been deposited as earliest Kansan outwash and would be comparable to the basal part of the Atchison formation.

An east-trending low area in the bedrock surface of northern Jackson County is probably a post-Nebraskan pre-Kansan valley eroded in a position marginal to the Nebraskan ice front (Frye and Walters, 1950). Deposits, locally as much as 100 feet thick, consisting of sand and silt in the upper part and sand and gravel at the base fill the lower part of this area. These deposits are pro-Kansan outwash and have been named the Atchison formation from exposures in Atchison County. Glacial deposits overlying the Atchison formation in this area are lithologically similar to Kansan deposits overlying the remainder of the county and are judged as being of Kansan age. The Kansan glacier, which was the second and last to invade Kansas, extended approximately as far south as Kansas River and as far west as Big Blue River. The surface developed in Jackson County and surrounding areas after the close of the Permian Period was mantled by thick deposits of glacial drift. Immediately after the retreat of the ice sheet the area probably was relatively flat, but many of the filled valleys were reopened by streams carrying meltwater from the retreating glacier. The Grand Island sand and gravel member of the Meade formation was deposited along these streams and is of late Kansan age. Thin veneers of eolian silt or loess were deposited over the flat uplands during later Pleistocene time, but at no place in Jackson County are these deposits thick enough to be an important source of ground water, and therefore they are not shown on the geological map.

Since the close of the Kansan Stage, streams have eroded their valleys to their present levels and have deposited alluvium and terrace deposits along their courses.

SUBSURFACE WATER

All water present below the surface of the earth is called subsurface water to distinguish it from surface water in ponds, lakes, and streams.

Suspended Water

Above a certain level the voids or pore spaces in the earth are filled partly with air or other gases and partly with water. This zone is called the zone of aeration and the water in this zone is called suspended water (Fig. 5). This water may be percolating downward or it may be held in suspension by molecular attraction. Although this water is not available to springs and wells, it is of great importance because the portion of it near the surface is the chief source of moisture for plants.

Ground Water

All voids below the zone of aeration are filled with water and this zone is called the zone of saturation. The upper surface of the zone of saturation is known as the water table. The walls of a pit or well may be moist at various levels above the water table, but water will

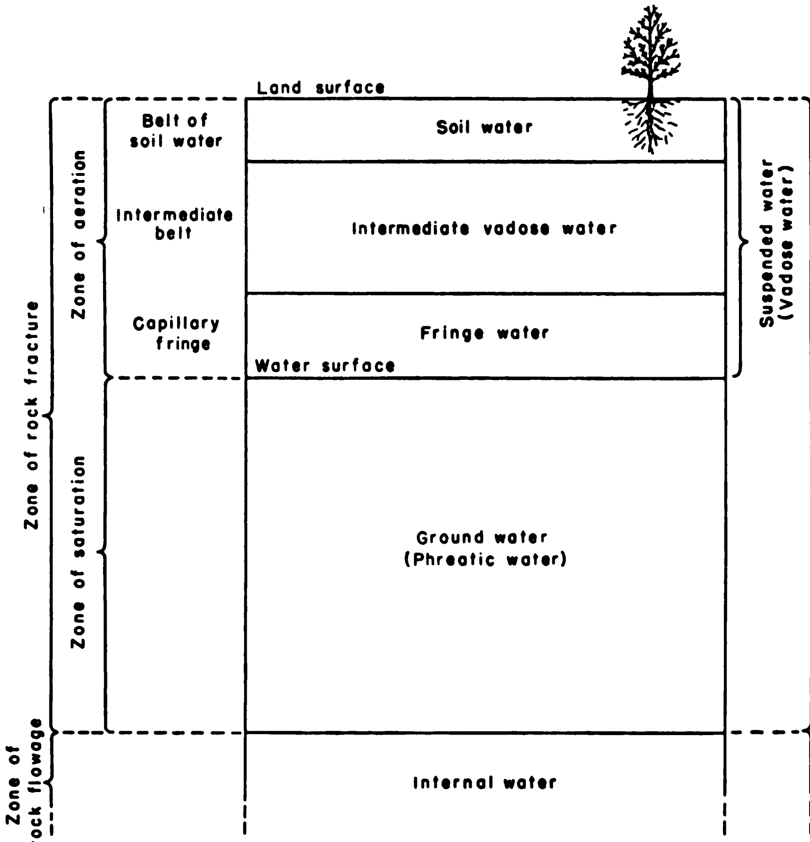

Fig. 5.—Diagram showing divisions of subsurface water (from O. E. Meinzer).

not flow into a well until the zone of saturation is reached. All water below the water table is designated ground water. The zone of saturation extends downward to the greatest depth at which interconnected voids occur.

PRINCIPLES OF OCCURRENCE

This discussion on the principles of occurrence of ground water is based on a discussion by Meinzer (1923), to which the reader is referred for more complete information.

The porosity of a rock is its property of containing interstices. Porosity is expressed quantitatively as the percent of the total volume that is occupied by interstices or voids. Pore spaces fall into two general classes: (1) the open spaces between component particles (primary interstices) and (2) joints, crevices, openings along bedding planes, and solution cavities that have developed since deposition (secondary interstices). The amount of water that can be stored in a material depends upon its porosity. Several common types of open spaces or interstices, and the relation of texture to porosity are shown in Figure 6.

Not all the water in the zone of saturation is available for recovery through wells. A part of the water will drain into wells by gravity, and a part will remain in the interstices of the rock formation, held by molecular attraction. The water-yielding capacity of a saturated rock is called its specific yield. The specific yield is the ratio of the volume of water yielded to the total volume of rock and is expressed as a percentage. Thus if 100 cubic feet of saturated rock yields 10 cubic feet of water by gravity the specific yield is 10 percent. If 15 cubic feet of water remained in the interstices the specific retention of the rock would be 15 percent. The sum of the specific yield and the specific retention is equal to the porosity, in this case 25 percent. A saturated rock having a specific yield of zero will yield no water. A rock formation that will yield water in sufficient quantity to be of consequence is called an aquifer.

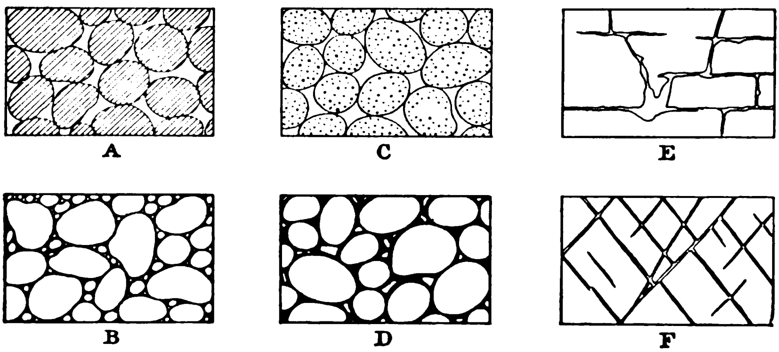

Fig. 6.—Diagram showing several types of rock interstices and the relation of rock texture to porosity. **A**, Well-sorted sedimentary deposit having a high porosity; **B**, poorly sorted sedimentary deposit having low porosity; **C**, well-sorted sedimentary deposit consisting of pebbles that are themselves porous so that the deposit as a whole has a very high porosity; **D**, well-sorted sedimentary deposit whose porosity has been diminished by the deposition of mineral matter in the interstices; **E**, rock rendered porous by solution; **F**, rock rendered porous by fracturing. (From O. E. Meinzer.)

SOURCE

In Jackson County essentially all ground water is derived from precipitation in the form of rain or snow. Part of the moisture that falls as rain or snow is carried away by surface runoff to streams. Part of it may evaporate or be absorbed by vegetation and transpired into the atmosphere. The part that escapes discharge by these means percolates slowly downward to the water table and becomes ground water. The amount of water discharged by runoff depends upon several factors: (1) the slope of the land surface, (2) the permeability of the surficial materials, (3) amount of moisture already held in the zone of aeration, and (4) whether the surface material is frozen. The amount discharged by evaporation and transpiration depends primarily upon the temperature, humidity, and kind of vegetation.

ARTESIAN CONDITIONS

Ground water, under normal atmospheric pressure, will rise only as high as the water table. Where ground water is confined below an impermeable stratum and will rise above the bed in which it is contained, the water is said to be under artesian pressure. A well that flows at the land surface is a flowing artesian well.

Although no flowing wells are known in Jackson County at the present time, the water in many wells in the area is under artesian pressure.

THE WATER TABLE

The water table is the upper boundary of the zone of saturation in ordinary permeable material. If this boundary is formed by an impermeable bed, the water table is absent. In some places the downward percolation of water within the zone of aeration may be impeded by an impermeable bed. The accumulation of water above the impermeable bed forms a local zone of saturation within the zone of aeration, known as a perched water body. The water table is not a plane surface; it differs from place to place in shape and depth below the land surface. In general the slope of the water table is similar to the slope of the land surface, except that changes in elevation are not so abrupt. In areas where the saturated material has a low permeability, the slope of the water table is much steeper than in areas of high permeability, other conditions being equal. Heavy pumping of wells will temporarily cause a local lowering of the water table, whereas recharge from a stream will cause the water table to be higher along the stream. The water table is nearer the surface during and immediately following periods of heavy rainfall (Fig. 7).

As shown by the geologic cross sections (Pl. 3), the bedrock floor of the area overlain by thick glacial deposits slopes in the same general direction as the land surface. The direction of general movement of ground water in this area is eastward. South of Straight Creek the ground water moves northeast, and north of Straight Creek it moves southeast. In areas where the bedrock is exposed, or is covered with a thin mantle of unsaturated material, a water table does not exist, any ground water present being in the form of confined or artesian water. Although there is no water table, there is an imaginary surface, the piezometric surface, which coincides with the level to which water will rise in artesian wells and which, like the water table, shows the direction of movement of ground water and the effects of recharge and discharge.

GROUND-WATER RECHARGE

Recharge is the addition of water to the zone of saturation. The sources of recharge in Jackson County are precipitation, streams, and subsurface flow.

Recharge by precipitation.—Most of the ground water available to wells and springs in Jackson County falls on the area as rain or snow. The zone of aeration must absorb more water than can be held up by capillary forces before the zone of saturation receives recharge from precipitation; thus, if the soil moisture is nearly depleted, a moderate amount of precipitation may not recharge the ground-water reservoir. Conditions for ground-water recharge by precipitation are unfavorable over large areas of Jackson County where glacial till is the predominant surficial material. Because of the low permeability of the till much of the water of a heavy rainfall is lost by surface runoff. Thick deposits of sand and gravel at or near the surface are often found incorporated with glacial drift. Such deposits offer ideal conditions for recharge but are not nearly as extensive as the till. Recharge by precipitation in bedrock areas takes place at the outcrop of permeable beds of dipping limestone or sandstone.

Recharge by streams.—The recharge of ground water by streams is not important in Jackson County. An intermittent or ephemeral stream is one that flows only during periods of heavy rainfall. The channel of such a stream is not cut down to the water table, and when the stream is flowing some water seeps into the stream bed and percolates downward to the water table. A stream that loses

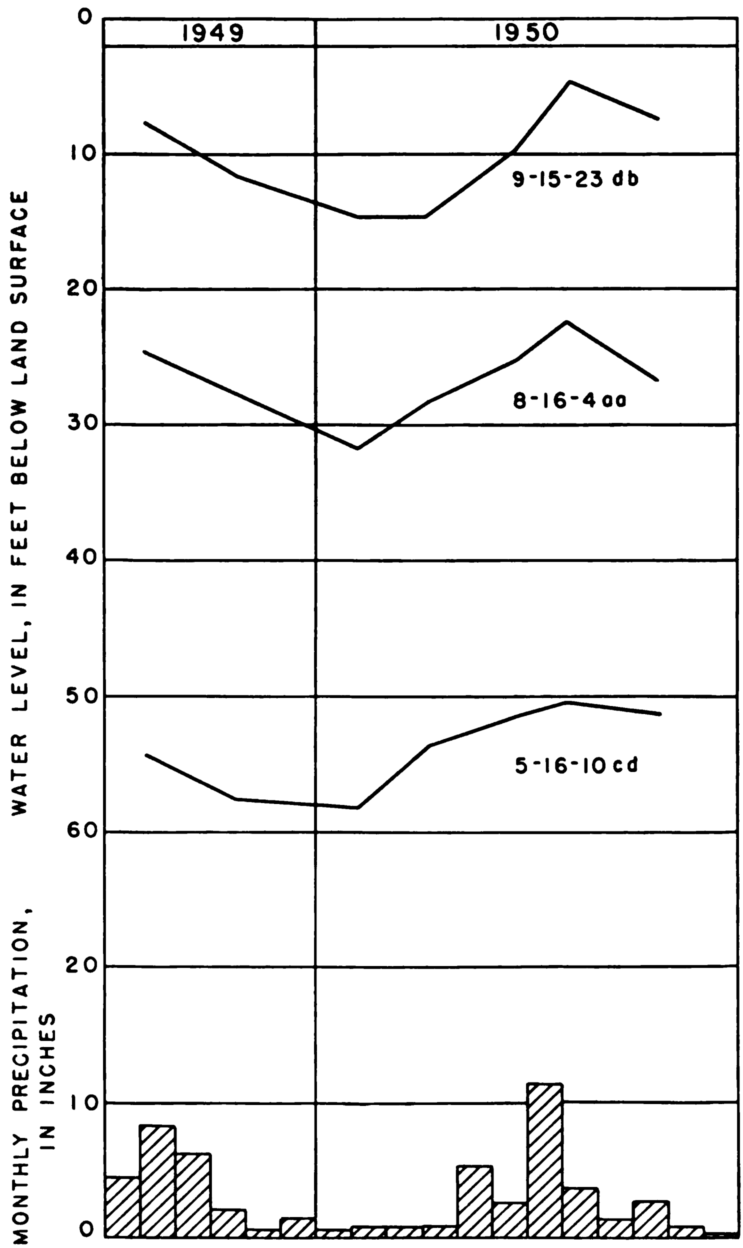

Fig. 7.—Hydrographs showing the fluctuation of water level in three wells in Jackson County.

water to the zone of saturation is called an influent stream, and a stream that gains water from the zone of saturation is called an effluent stream. Influent and effluent streams are illustrated by the diagrammatic sections in Figure 8.

Recharge by subsurface flow.—The movement of ground water in northern Jackson County is to the east; hence, some ground water moves into Jackson County from the area to the west by subsurface flow. Water confined in a permeable bed by an overlying impermeable bed moves generally in the direction of regional dip; hence, some water is derived from areas outside Jackson County in this manner.

DISCHARGE OF GROUND WATER

Ground-water discharge is the removal of water from the zone of saturation, and may take place by transpiration and evaporation, by discharge from springs and seeps, by subsurface flow into an adjoining area, and by pumping from wells.

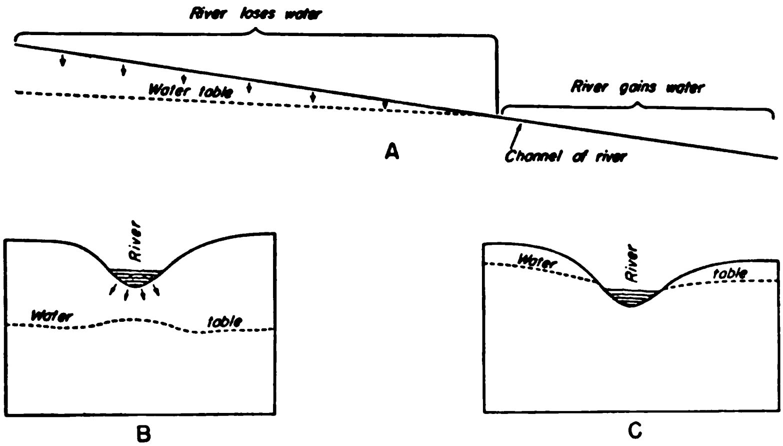

FIG. 8.—Diagrammatic sections showing influent (b) and effluent streams (c).

Discharge by transpiration and evaporation.—The roots of plants may extend down to the water table or capillary fringe and discharge the water into the atmosphere by transpiration. In areas where the water table is far below the surface, only the deep-rooted plants known as phreatophytes are able to withdraw water from the zone of saturation. However, where the water table is near the surface, as in the valleys of Jackson County, the ordinary grasses and field crops can withdraw ground water by transpiration.

Water is lost directly by evaporation in places where the water table is at the surface, such as streams, ponds, and swampy areas.

Discharge by springs and seeps.—A stream whose channel has cut below the water table will receive ground water from springs and seeps and is said to be a gaining or effluent stream. The perennial streams of Jackson County are of the effluent type, except possibly during long periods of drought when the water table is lower. Seeps may be noted along the banks of many creeks and ditches in Jackson County, generally where the downward percolation of water has been interrupted by an impermeable formation. Several of the larger springs in Jackson County are listed in Table 10.

Discharge by subsurface flow.—The discharge of ground water from Jackson County by subsurface flow is into the area to the east and is probably about equal to the amount entering the county from the west.

Discharge by wells.—Practically all the domestic and stock supplies of water in Jackson County are derived from wells. Although wells are the most obvious method of discharge, the amount of water withdrawn by wells is relatively small.

RECOVERY

Principles of recovery.—When water is removed from a well the water table or piezometric surface is lowered in an area encircling the well, resulting in an inverted cone-shaped depression. This depressed area is known as the cone of depression. The amount of lowering of the water table at the well is called the drawdown. As the pumping rate of the well is increased, the drawdown becomes greater. When a well is first pumped the water level falls very rapidly, but as pumping is continued the drawdown increases at a diminishing rate. When pumping is stopped the recovery is rapid at first, but gradually tapers off and may continue for many hours or days after pumping is stopped.

The specific capacity of a well is the rate of yield per unit of drawdown and is generally expressed in gallons a minute per foot of drawdown. In testing the specific capacity of a well, pumping is continued until the water level remains approximately stationary, or for some arbitrary period such as 24 hours.

Construction of wells.—In much of the area of Jackson County where shallow wells obtain water from consolidated rocks, dug wells are the most common type. This type of well is simply a pit dug into the water-bearing rocks and walled up with rock, brick, or concrete. The advantage of this type of well is the large infiltration area and storage reservoir provided by the large diameter. Dug wells are more subject to contamination and failure during dry weather than deeper drilled wells.

In some of the valleys containing alluvium, a few driven wells supply stock and domestic needs. Driven wells can be used only where the water table is near the surface, and where the material is soft enough to permit a pipe to be driven to the water table. A driven well consists of a length of 1¼ or 1½ inch pipe having a drive-point screen on the lower end. They are usually pumped by a pitcher pump. The aquifer must be quite permeable for a satisfactory driven well because the intake area of the drive point is small.

Most of the wells in the thick drift area of the county, as well as many of the deeper wells in other parts of the county, are of the drilled type. Wells may be drilled either by the percussion method or by hydraulic-rotary machines. The drilled wells for stock and domestic use are usually 6 inches in diameter and are cased with galvanized-steel or wrought-iron casing. Wells obtaining water from unconsolidated material are cased to the bottom. The portions of the casing that are in the water-bearing beds are perforated, or a specially designed screen is used to allow intake of water. Many drilled wells obtaining water from consolidated beds that will not cave are left uncased in the lower part. Some municipal and industrial wells in unconsolidated material are gravel-packed. In this type of construction a large-diameter hole is first made and cased. A smaller casing containing sections of well screen spaced to correspond with the water-bearing beds is then centered in the hole and the annular space between the large casing and the smaller casing is filled with carefully selected gravel. The larger casing is then withdrawn to permit the water to flow into the well. This type of construction increases the effective diameter of the well and helps to prevent fine sand from entering the well.

Several of the wells visited in Jackson County were bored by means of a well auger and are fitted with bell-top clay-tile casing about 14 inches in diameter. They are generally shallow and are more subject to contamination than drilled wells.

Utilization of Water

Domestic and stock supplies.—Practically all the domestic and stock supplies of water in the county are derived from wells or springs. In areas where relatively large supplies of water of good quality are not available, many farms have shallow wells near the house for domestic use and a deeper well some distance from the house for stock supplies. Many of the stock farms have ponds for stock water formed by damming natural drainageways.

Public supplies.—Holton is the only city in Jackson County having a public water-supply system. Until 1950 the water supply of Holton was derived from four wells and nine springs. Two of the wells are east of the city in the alluvium of Elk Creek. One of these wells (6-15-35dd) is 48 feet deep, is cased with 6-inch iron casing, and yields about 20 gallons per minute. The other well (6-15-36dd) is 38 feet deep, is cased with 6-inch iron casing, and yields 48 gallons per minute.

The springs and other wells are about a mile north of well 6-15-36dd and derive their water from glacial sand and gravel. They yield 12 to 55 gallons per minute each. Vertical-turbine pumps powered by small electric motors pump the water from the springs into a central sump. The system has storage facilities totaling 750,000 gallons. The average daily consumption is about 200,000 gallons, of which 35,000 gallons is used by the Chicago, Rock Island, and Pacific Railroad. Since 1950 the city has depended on impounded surface water for its water supply.

Irrigation and industrial supplies.—No irrigation is practiced in Jackson County, and no industries have their own water supply.

Quality of Water

The chemical character of the ground water in Jackson County is indicated by the analyses in Table 4 and Figure 9. The analyses were made by H. A. Stoltenberg in the Water and Sewage Laboratory of the Kansas State Board of Health. Twenty-four samples of water were collected from wells distributed fairly uniformly over the area, deriving water from the principal aquifers within the county.

CHEMICAL CONSTITUENTS IN RELATION TO USE

The following discussion of the chemical constituents of ground water in relation to use has been adapted in part from publications of the U. S. Geological Survey and the State Geological Survey of Kansas.

Dissolved solids.—The residue left after a natural water has evaporated consists of rock materials and may include some organic material and some water of crystallization. Waters containing less than 500 parts per million of dissolved solids are generally satisfactory for domestic use, except for the difficulties resulting from their hardness and, in some areas, excessive iron content and corrosiveness.

TABLE 4.—Analyses of water from typical wells in Jackson County

Analyzed by H. A. Stoltenberg. Dissolved constituents given in parts per million[a]

Well number	Depth (feet)	Geologic source	Date of collection	Temperature (°F.)	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$ Total	Carbonate	Noncarbonate
5-15-16bb	219	Glacial sand and gravel	4-2-51	54	1,660	31	2.2	170	67	307	400	567	316	0.5	2.4	700	328	372
5-15-31cd	102	do.	3-27-51	56	1,280	26	.24	203	58	137	405	380	157	.3	115	745	332	413
5-16-15cd	20	Dry-Friedrich shale	4-2-51	55	536	10	.18	109	25	29	271	31	39	.2	159	375	222	153
5-16-20dd	44	Glacial sand and gravel	4-2-51	54	486	22	.20	75	24	69	420	16	23	.7	49	286	286	0
6-12-1aa	20	Beattie limestone	3-27-51	......	392	6.2	.21	88	11	32	256	42	16	.3	71	264	210	54
6-13-8cc	38	Glacial sand and gravel	4-2-51	54	791	24	.71	117	42	95	464	15	93	.3	177	464	380	84
6-13-18aa	85	Beattie limestone	4-2-51	55	678	15	.42	126	52	29	390	210	15	.4	39	528	320	208
6-14-27bb	47	Foraker limestone	3-28-51	54	649	14	.48	113	31	65	364	154	27	.4	66	410	298	112
6-15-8ad	51	Glacial sand and gravel	4-2-51	55	331	15	.97	82	13	12	239	25	13	.3	53	258	196	62
6-15-22cd	96	do.	3-28-51	56	535	12	.13	93	33	54	376	123	32	.4	2.5	368	308	60
6-16-36cb	40	Burlingame and Wakarusa limestones	4-3-51	56	911	9.2	.42	118	51	71	183	27	67	.1	478	504	150	354
7-13-10bb	75	Foraker limestone	3-27-51	......	549	12	.29	118	33	28	381	133	14	.3	23	430	312	118
7-13-23aa	57	Red Eagle limestone	4-2-51	56	383	8.2	.86	97	23	11	354	35	10	.4	24	336	290	46
7-13-33ad	46	Grenola limestone	3-27-51	56	467	9.8	.25	87	42	23	420	33	12	.3	53	390	344	46
7-14-11aa	69	Glacial sand and gravel	3-28-51	57	319	18	.43	74	20	12	290	22	12	.3	18	266	238	28
7-14-27cc	98	Red Eagle and Grenola limestones	3-28-51	55	422	11	.18	84	23	35	354	13	16	.2	66	304	290	14
7-14-29dd	67	Red Eagle limestone	3-28-51	55	431	9.0	.23	98	27	20	368	52	12	.3	32	356	302	54
7-15-11cc	70	Dry-Friedrich shale	3-28-51	52	329	15	.70	80	12	21	290	16	9.0	.2	33	249	238	11
7-15-29bb	51	Glacial sand and gravel	4-2-51	55	640	24	.91	99	41	63	386	192	18	.7	12	416	316	100
8-14-10ad	60	West Branch and Hamlin shales	4-3-51	55	482	27	.24	82	30	50	420	49	18	.4	19	328	328	0
8-16-9dd	50	Glacial sand and gravel	4-3-51	56	758	21	.25	119	47	84	393	155	128	.6	9.7	490	322	168
9-13-27da	30	French Creek shale	3-27-51	......	397	6.6	.17	80	35	19	378	41	12	.4	17	344	310	34
9-13-28ad	31	Terrace Deposits	3-27-51	57	1,090	15	.25	162	34	185	446	102	290	.1	80	544	366	178
9-16-30dc	115	Cedar Vale and Silver Lake shales	4-2-51	55	520	8.2	.64	18	9.6	174	499	77	9.0	.4	2.8	84	84	0

a. One part per million is equivalent to one pound of substance per million pounds of water or 8.33 pounds per million gallons of water.

An equivalent per million is a unit chemical equivalent weight of solute per million unit weights of solution. Concentration in equivalents per million is calculated by dividing the concentration in parts per million by the chemical combining weight of the substance or ion.

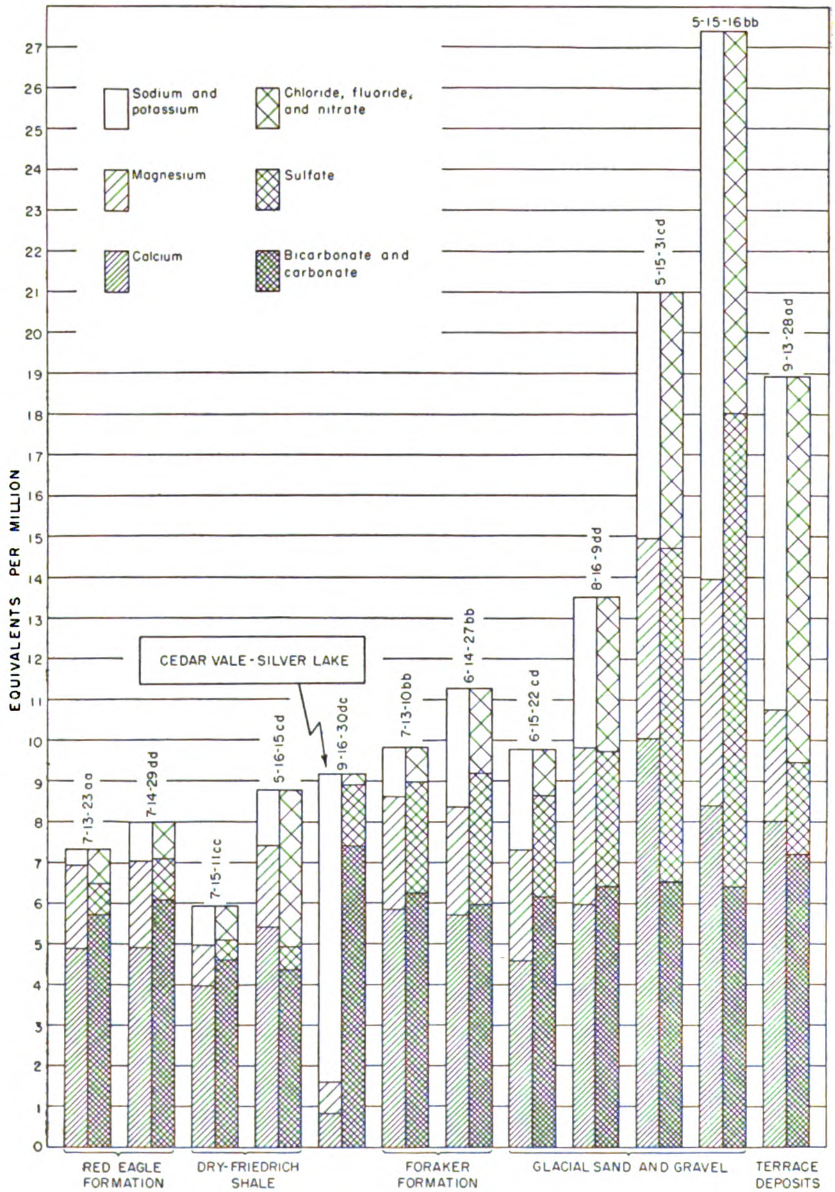

FIG. 9.—Analyses of water from some of the principal water-bearing formations in Jackson County.

Waters having more than 1,000 parts per million of dissolved solids are generally not satisfactory for domestic use, for they are likely to contain enough of certain constituents to produce a noticeable taste or to make the water unsuitable in some other respects.

The dissolved solids in samples of water from Jackson County ranged from 319 to 1,660 parts per million. A little less than half the samples contained less than 500 parts per million and about two-fifths contained between 500 and 1,000 parts per million (Table 5). Only three of the samples contained more than 1,000 parts per million. The samples having the greatest amount of dissolved solids were from deep wells deriving water from glacial sand and gravel.

TABLE 5. *Dissolved solids in samples of water from wells in Jackson County*

Dissolved solids, parts per million	Number of samples
Less than 300	0
301—400	6
401—500	5
501—600	4
601—700	3
701—800	2
801—900	0
901—1,000	1
More than 1,000	3
Total	24

Hardness.—The hardness of water, which is the property that generally receives the most attention, is recognized most commonly by its effects when soap is used with the water. Calcium and magnesium cause almost all the hardness of ordinary water. These constituents are also the active agents in the formation of the greater part of the scale formed in steam boilers and other vessels used to heat or evaporate water.

In addition to the total hardness, the table of analyses shows the carbonate hardness and the noncarbonate hardness. The carbonate hardness is due to the presence of calcium and magnesium bicarbonates and can be almost completely removed by boiling. In some reports this type of hardness is called temporary hardness. The permanent or noncarbonate hardness is due to the presence of sulfates or chlorides of calcium and magnesium and cannot be removed by boiling. With reference to use with soap, the carbonate hardness and noncarbonate hardness do not differ. In general, the noncarbonate hardness forms harder scale in steam boilers.

Water having a hardness of less than about 50 parts per million is generally rated as soft, and treatment for the removal of hardness is not necessary under ordinary circumstances. Hardness between 50 and 150 parts per million does not seriously interfere with the use of water for most purposes, but the hardness does slightly increase the amount of soap used and removal by a softening process is profitable for laundries or other industries using large quantities of soap. Water having a hardness in the upper part of this range will cause considerable scale on steam boilers. Hardness above 150 parts per million is very noticeable, and if the hardness is more than about 200 parts per million water for household use is commonly softened. Where municipal water supplies are softened an attempt is made generally to reduce the hardness to about 80 to 90 parts per million. The additional improvement from further softening of a public supply generally is not deemed worth the increase in cost.

Water samples collected in Jackson County ranged in total hardness from 84 to 745 parts per million. Only 1 sample contained less than 200 parts per million (Table 6), 21 samples contained 200 to 600 parts per million, and 2 samples contained more than 600 parts per million total hardness.

TABLE 6. *Hardness of samples of water from wells in Jackson County*

Hardness, parts per million	Number of samples
Less than 100	1
101—200	0
201—300	5
301—400	8
401—500	5
501—600	3
601—700	1
701—800	1
Total	24

Iron.—Next to hardness, iron is the constituent of natural water that generally receives the most attention. The quantity of iron in ground water may differ greatly from place to place, even though the water may be derived from the same formation. If a water contains more than a few tenths of a part per million of iron, the excess may settle out as a reddish precipitate. Iron, present in sufficient quantity to give a disagreeable taste and to stain cooking utensils and plumbing, may be removed from most water by simple aeration and filtration, but some water requires the addition of lime or some other substance. "Zeolite-type" filters also can be used.

The iron content of the water samples from wells in Jackson County ranged from 0.17 to 13 parts per million. Twenty of the samples contained less than 1 part per million of iron; two samples contained more than 2 parts per million (Table 7).

TABLE 7. *Iron content of samples of water from wells in Jackson County*

Iron, parts per million	Number of samples
0.0 —0.10	0
0.11—0.30	12
0.31—0.50	4
0.51—0.70	2
0.71—1.00	4
1.1 —2.0	0
2.1 —3.0	1
More than 3.0	1
Total	24

Fluoride.—The fluoride content of waters likely to be used by children should be known because fluoride in water is associated with the dental defect known as mottled enamel, which may appear on the teeth of children who drink water containing excessive amounts of fluoride during the period of formation of the permanent teeth. Waters containing more than about 1.5 parts per million of fluoride are likely to produce mottled enamel. If the water contains as much as 4 parts per million of fluoride, 90 percent of the children are likely to have mottled enamel, and 35 percent or more of the cases will be classified as moderate or worse (Dean, 1936). However, contents of fluoride up to 1 part per million are believed by many health authorities to be beneficial in inhibiting tooth decay.

None of the samples of water from wells in Jackson County contained as much as 1 part per million of fluoride.

Nitrate.—The use of water containing an excessive amount of nitrate in the preparation of a baby's formula can cause cyanosis or oxygen starvation ("blue babies"). Some authorities advocate that water containing over 45 parts per million of nitrate (as NO_3) should not be used in formula preparation (Metzler and Stoltenberg, 1950). Water containing 90 parts per million of nitrate is generally considered very dangerous to infants, and water containing

150 parts per million may cause severe cyanosis. Cyanosis is not produced in adults and older children by the concentrations of nitrate found in drinking water. Boiling water high in nitrate content does not render it safe for use by infants; therefore, only water that is known to be low in nitrate content should be used for this purpose.

The nitrate content of the water from a well may be somewhat seasonal, being highest in the winter and lowest in the summer (Metzler and Stoltenberg, 1950, p. 201). In general, water from wells that are susceptible to surface contamination is likely to be high in nitrate concentration.

The nitrate content of the water from wells sampled in Jackson County ranged from 2.4 to 478 parts per million. Thirteen of the samples contained less than 40 parts per million of nitrate, 7 contained 40 to 80 parts per million, and 4 contained more than 80 parts per million of nitrate (Table 8). In general, water from the deeper drilled wells deriving water from glacial sand and gravel had the lowest nitrate content.

TABLE 8. *Nitrate content of samples of water from wells in Jackson County*

Nitrate, parts per million	Number of samples
0— 10.0	4
10.1— 20.0	4
20.1— 30.0	2
30.1— 40.0	3
40.1— 60.0	3
60.1— 80.0	4
80.1—100.0	0
100.1—200	3
More than 200	1
Total	24

Sulfate.—Sulfate (SO_4) in ground water is derived principally from gypsum or anhydrite (calcium sulfate), and from the oxidation of pyrite (iron disulfide). Magnesium sulfate (Epsom salt) and sodium sulfate (Glauber's salt), if present in sufficient quantity, will impart a bitter taste to the water and may act as a laxative for people not accustomed to drinking it.

The sulfate content of the water from wells sampled in Jackson County ranged from 13 to 567 parts per million (Table 9). Of the samples, 15 contained less than 100 parts per million, 6 contained

100 to 200 parts per million, 2 contained 200 to 400 parts per million, and 1 contained 567 parts per million of sulfate.

TABLE 9. *Sulfate content of samples of water from wells in Jackson County*

Sulfate, parts per million	Number of samples
0—25	6
25—50	7
50—100	2
100—200	6
200—400	2
More than 400	1
Total	24

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING CHARACTERISTICS

PENNSYLVANIAN SYSTEM

WABAUNSEE GROUP

Cedar Vale Shale, Rulo Limestone, and Silver Lake Shale

The Cedar Vale shale, Rulo limestone, and Silver Lake shale, which will be considered as a single unit in this report, crop out in a few of the deepest valleys in eastern Jackson County. The greatest combined thickness of these formations exposed in Jackson County is near the center of sec. 32, T. 9 S., R. 16 E., where nearly 50 feet is exposed. The Elmo coal of the Cedar Vale shale and the Rulo limestone are covered at this location. The predominant materials here are bluish- to yellowish-brown sandy shale and shaly to massive sandstone.

The Elmo coal crops out and has been mined along a creek bank about 1 mile south of Larkinburg. The coal is about 14 inches thick and is separated from the overlying Rulo limestone by 4 inches of shale. The Rulo limestone at this outcrop is nearly black, very fossiliferous, and badly weathered; its thickness is slightly less than 1 foot.

Small quantities of water may be available from sandstone within the Cedar Vale shale and Silver Lake shale, but few wells are known to obtain significant quantities of potable water from these formations.

Burlingame Limestone, Soldier Creek Shale, and Wakarusa Limestone

These formations are well exposed over much of eastern Jackson County, but in many places where the Soldier Creek shale is thin it is difficult to distinguish between the Burlingame limestone and the Wakarusa limestone.

The Burlingame limestone is deep brown and thick-bedded. In many exposures it has an unusual mottled and brecciated appearance, being composed of light-brown limestone fragments in a rusty-brown matrix. Small calcite veinlets are common throughout the formation. Algal remains are abundant in the upper part. The Burlingame limestone ranges from 6 to 10 feet in thickness.

The lithology of the Soldier Creek shale is variable. Dark tan, green, gray, and streaks of red are the most common colors. Fossils are not numerous, but in some places crinoids are found just below the Wakarusa limestone. The maximum thickness of the Soldier Creek shale in Jackson County is 9 feet.

The Wakarusa limestone is a hard blue-gray massive crystalline limestone about 2.5 feet thick. Fusulinids, large algae, brachiopods, and other fossils are present in the limestone. After prolonged weathering the outcrop becomes brown, and large rectangular blocks break off.

The Burlingame limestone and the Wakarusa limestone are not major sources of water in Jackson County; however, limited supplies of water suitable for domestic use can be obtained by wells penetrating the formations. The Soldier Creek shale does not yield water to wells in Jackson County.

Auburn Shale

The Auburn shale consists largely of gray shale which contains small amounts of impure sandstone and limestone. Nearly all exposures show a few inches to several feet of black platy shale near the center of the formation. The Auburn shale ranges from 25 to 50 feet in thickness. It does not yield appreciable amounts of water to wells in Jackson County.

Reading Limestone

The Reading limestone is a dark-blue hard limestone in three massive beds. Crinoid stems and a few pelecypods are the only conspicuous fossils. The characteristic thickness of the Reading limestone is about 2 feet.

The Reading limestone is known to yield water only to a few shallow dug wells where the limestone is near the surface.

Harveyville Shale

The Harveyville shale is a calcareous greenish-gray blocky shale ranging in thickness from 9 to 15 feet. No wells are known to obtain water from the Harveyville shale in Jackson County.

Elmont Limestone

The Elmont limestone comprises three or four limestone beds separated by shale layers. The lower limestone bed is massive and has prominent vertical joints. The shale beds are calcareous and greenish gray. In many exposures the two upper limestone beds have a conglomeratic appearance and contain numerous fusulinids. The average thickness of the Elmont limestone is about 3 feet. It supplies a small amount of water where it is not too deeply buried under younger rocks.

Willard Shale

Shale is the predominant material of the Willard shale but impure cross-bedded sandstone is common in the upper part. The shale is dark gray to brown and is not generally fossiliferous. Locally, a coaly streak occurs near the top of the formation. The average thickness of the formation in Jackson County is 35 feet.

The Willard shale is not a significant aquifer in Jackson County.

Tarkio Limestone

The Tarkio limestone is well exposed along its entire outcrop area and is one of the most easily recognized formations in Jackson County. The Tarkio limestone is a massive brown limestone in one or two beds. A multitude of large fusulinids stand out on a weathered surface and impart a very rough appearance. The Tarkio limestone ranges in thickness from 3 to 5 feet in Jackson County.

The Tarkio limestone does not yield appreciable amounts of water in Jackson County.

Pierson Point Shale

The Pierson Point shale is generally yellow in the lower part and dark gray to black in the upper part. Impure limestone and shaly sandstone are common in the upper one-half of the formation. The thickness ranges from 13 to 25 feet in Jackson County.

The Pierson Point shale is of little consequence as an aquifer.

Maple Hill Limestone

The Maple Hill limestone is generally a single bed of medium-hard gray limestone. Vertical jointing is prominent and in the outcrop the limestone usually weathers to a deep red. Slender fusulinids are numerous in most exposures. The thickness of the Maple Hill limestone is 1 to 2 feet.

The Maple Hill limestone supplies small quantities of water to a few wells in Jackson County.

Langdon Shale

The Langdon shale is light brown and light blue-gray and has thin irregular sandstone beds throughout. The upper part in a few outcrops is a soft massive brown sandstone. The formation ranges in thickness from 35 to 45 feet.

The sandstone beds of the Langdon shale yield small supplies of water where not deeply buried in eastern and southern Jackson County.

Dover Limestone

The Dover limestone in Jackson County generally consists of a single massive bed of brown limestone containing large fusulinids and many algal remains. At a few exposures in Jackson County an upper bed of conglomeratic limestone is separated from the main bed by 2 to 3 feet of tan shale. The average thickness of the formation is about 3 feet.

The Dover limestone supplies only very small quantities of water to a few shallow dug wells in Jackson County.

Dry-Friedrich Shale

In Jackson County the Grandhaven limestone is absent or very inconspicuous, and the two shale formations which the limestone normally separates will be considered as a single unit called the Dry-Friedrich shale. Because the Dry-Friedrich shale is poorly exposed the total thickness could not be determined accurately but it is approximately 35 to 45 feet. The lower half of the unit is a sandy and micaceous yellow shale, the upper half of the unit is chiefly massive and cross-bedded sandstone and some sandy shale.

The sandstones of the upper part of the Dry-Friedrich shale yield small to moderate supplies of water to many wells in Jackson County.

Jim Creek Limestone

The Jim Creek limestone is exposed in only a few places in Jackson County. In every place the formation is a single bed of dark fossiliferous limestone about half a foot thick. Upon weathering the rock breaks down into small shelly chips.

The Jim Creek limestone is not an aquifer in Jackson County.

French Creek Shale and Pony Creek Shale

In Jackson County the Nebraska City limestone member is the only recognizable part of the Caneyville limestone.

The French Creek shale and the Pony Creek shale, being similar in water-bearing characteristics, are considered in this report as a single unit. The Nebraska City limestone member is included in this unit.

The French Creek shale averages about 20 feet in thickness. Gray to brownish-yellow sandy shale is the predominant material. Two thin but persistent coal beds occur near the top of the formation. Locally the lower coal bed is underlain by several feet of soft tan sandstone.

The Nebraska City limestone member is a soft impure tan limestone bed containing many shell fragments. The average thickness is slightly more than 1 foot.

The Pony Creek shale is distinguished chiefly by the presence of red shale in the lower part. Locally a soft massive sandstone occurs in the middle part and the upper part is a sandy and micaceous tan shale. The Pony Creek shale ranges from 14 to 20 feet in thickness.

Where local sandstones of considerable thickness are penetrated the French Creek and Pony Creek formations yield small quantities of water to a few domestic and stock wells in Jackson County.

Brownville Limestone

The Brownville limestone, the uppermost formation of the Pennsylvanian System in Kansas, is well exposed along most of its outcrop area in Jackson County. The Brownville occurs as one or two beds of soft rather impure tan to yellow limestone containing many well-preserved brachiopod shells. The formation ranges in thickness from 1 to 3 feet.

The Brownville limestone is of little consequence as an aquifer in Jackson County.

Permian System

ADMIRE GROUP

Towle Shale

In Jackson County, the base of the Towle shale is not marked by a prominent unconformity as it is reported to be in many places in Kansas. The Indian Cave sandstone member was not recognized anywhere in the county. The average thickness of the Towle shale is about 15 feet. The lower half is typically red shale and the upper half, gray to tan shale.

The Towle shale supplies little or no water to wells in Jackson County.

Aspinwall Limestone

The Aspinwall limestone is a medium-hard gray limestone that becomes white upon weathering. Fossils are not commonly found in this formation and exposures have a tendency to weather into small chips. The thickness of the Aspinwall limestone is about 1 foot.

When not too deeply buried the Aspinwall limestone may yield very small quantities of water to wells.

Hawxby Shale

The Hawxby shale consists chiefly of gray blocky shale. Thin beds of lenticular impure limestone are present near the middle of the formation. The average thickness of the Hawxby shale is about 18 feet.

The Hawxby shale yields little or no water to wells in Jackson County.

Falls City Limestone

In Jackson County the Falls City limestone is the most distinctive formation of the Admire group. The exact thickness is not known, but the main limestone bed is about 3 feet thick. A thin bed of impure yellow limestone is found in some places about 4 feet below the main bed. The main bed is quite massive, and the many small shell fragments of which it consists gives it a very rough or coquina-like appearance. On weathered outcrops the vertical joints become greatly enlarged by solution (Pl. 6A), and large blocks of limestone are strewn down the slope from the outcrop (Pl. 6B). Small pelecypods are the most numerous fossils.

The Falls City limestone yields little or no water to wells in Jackson County.

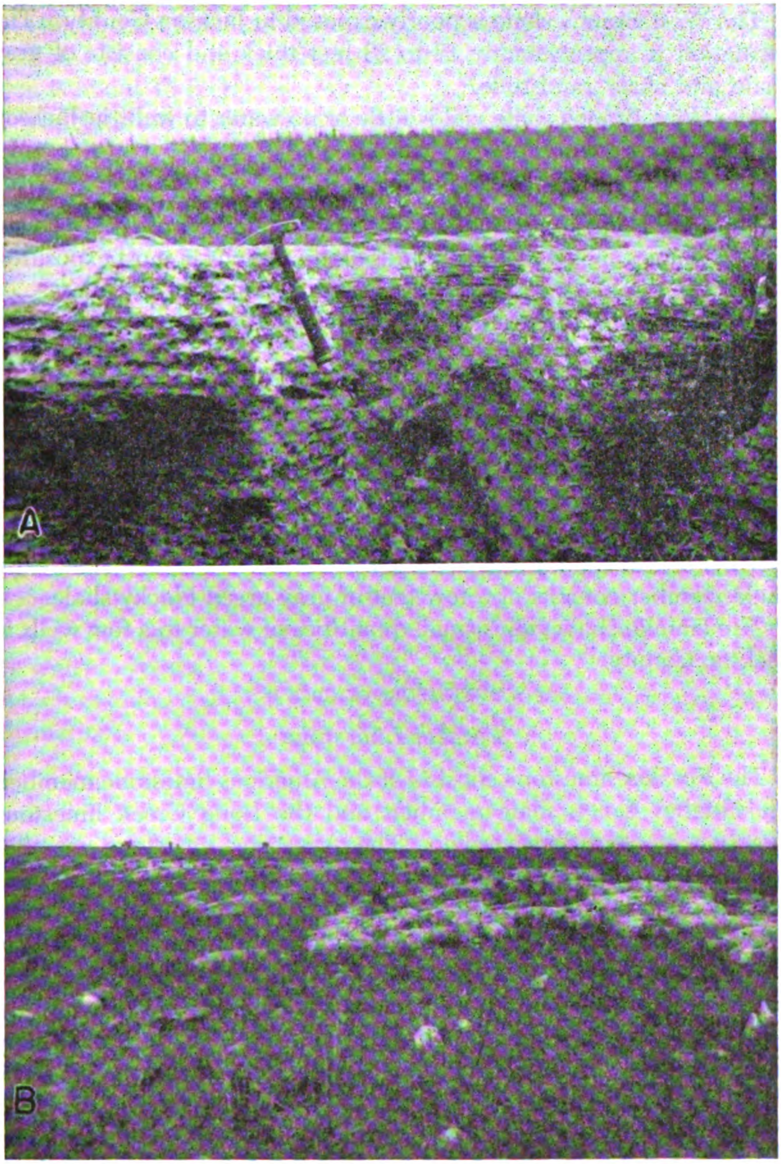

PLATE 6. Outcrops of the Falls City limestone. **A**, Outcrop in sec. 13, T. 9 S., R. 13 E. showing enlarged vertical joints. **B**, Typical outcrop of Falls City limestone; sec. 10, T. 9 S., R. 14 E.

West Branch Shale

The West Branch shale is poorly exposed in Jackson County. The formation is approximately 17 to 23 feet thick and consists of gray shale and shaly sandstone.

The West Branch shale yields little or no water to wells in Jackson County.

Five Point Limestone

The Five Point limestone consists of a single bed of hard brownish-gray limestone. Small fusulinids are numerous in most exposures. The formation is consistently just less than 1 foot in thickness.

The Five Point limestone yields little or no water to wells in Jackson County.

Hamlin Shale

The Hamlin shale consists of three members in ascending order: the Stine shale, Houchen Creek limestone, and Oaks shale. A massive sandstone bed occurs locally near the top of the Stine shale member. The poorly developed Houchen Creek limestone member consists of less than a foot of impure nodular limestone. The Oaks shale member consists of a few feet of gray-green blocky shale.

The Hamlin shale yields small quantities of water to a few wells in Jackson County.

COUNCIL GROVE GROUP

Foraker Limestone

The Foraker limestone consists of the Americus limestone member, the Hughes Creek shale member, and the Long Creek limestone member, in ascending order. The Americus limestone member is a single bed of very hard blue limestone just less than 1 foot thick. Large crinoid stems are weathered in relief on many old exposures. The Hughes Creek shale member consists of 30 to 40 feet of yellow and dark-gray shale and impure yellow limestone. In a few exposures in Jackson County a great many fusulinids are present. In lithology the Long Creek limestone member ranges from hard limy shale to a series of cellular or honeycombed beds of limestone. The Long Creek limestone member ranges in thickness from 3 to 7 feet.

The Long Creek limestone member of the Foraker formation yields moderate amounts of water to domestic and stock wells in Jackson County.

Johnson Shale

The Johnson shale consists chiefly of gray shale, but the formation contains several impure limestone beds. The thickness of the formation is about 15 feet.

The Johnson shale is not an aquifer in Jackson County.

Red Eagle Limestone

The Red Eagle limestone, like most limestone formations of the Council Grove group, is composed of two limestone members and an intervening shale member. The lower limestone member, the Glenrock, is a fairly hard brown massive fusulinid-bearing limestone. The thickness ranges from 1 to 2 feet.

The Bennett shale member consists of 6 to 9 feet of shale and impure limestone. The lower part of the member, which contains numerous *Orbiculoidea,* is predominantly black in color. The upper part of the member is gray or light green.

The Howe limestone member is a massive bed of fine-grained limestone or siltstone. In a fresh exposure it generally has a splintered or fractured appearance. It is dark gray and fossils are rare. The member ranges in thickness from 2 to 4 feet.

The Red Eagle limestone yields a considerable amount of water to wells in western Jackson County. The Howe limestone member, which contains water in cracks, is the most important aquifer in the formation.

Roca Shale

In Jackson County the Roca shale is about 18 feet thick and is composed chiefly of gray-green limy shale. Generally about 4 feet of red shale lies just below the center of the formation (Pl. 7A).

The Roca shale is not an aquifer in Jackson County.

Grenola Limestone

The members of the Grenola limestone, in ascending order, are the Sallyards limestone, Legion shale, Burr limestone, Salem Point shale, and Neva limestone.

The Sallyards limestone member is a hard, rather brecciated-appearing bed generally less than 2 feet thick. The Legion shale member consists of 4 to 6 feet of gray and black fissile shale. The Burr limestone member is a single bed of medium-hard gray fossiliferous limestone about 4 feet thick, or, locally, two beds of limestone separated by about 4 feet of black shale. The Salem Point shale

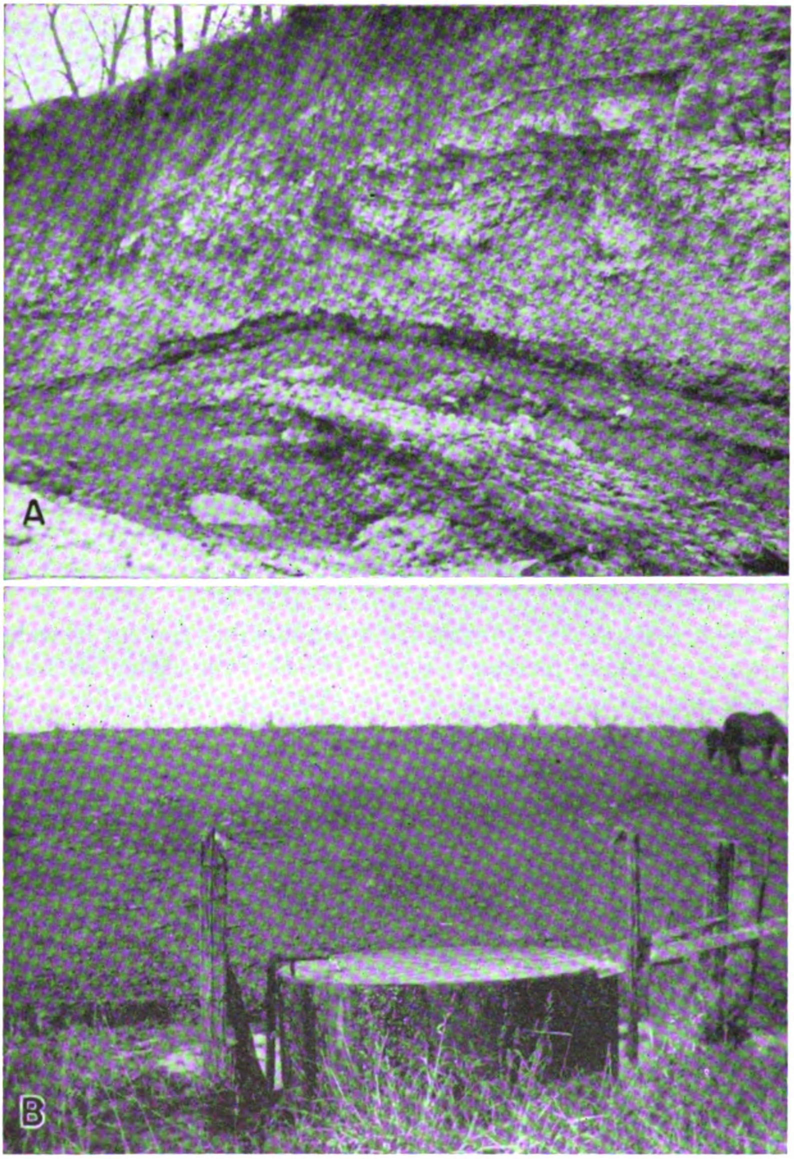

PLATE 7. **A**, Exposure of Roca shale, NE¼ NW¼ sec. 16, T. 7 S., R. 13 E. **B**, Flow of water from spring issuing from the Neva limestone member of the Grenola limestone; SW¼ SE¼ sec. 28, T. 7 S., R. 14 E.

member ranges in thickness from 7 to 9 feet, and is composed chiefly of gray nonfossiliferous shale.

The Neva limestone member is a bench-forming unit composed of three to five limestone beds separated by shale beds. The main limestone bed, about 7 feet thick, weathers pitted or cavernous. The limestone beds are fossiliferous and ashy gray. The shale beds are gray but locally black in the lower part.

The Grenola limestone is one of the most important aquifers in Jackson County. The Neva limestone member, being somewhat cavernous, supplies relatively large quantities of water to many wells and springs in northwestern Jackson County (Pl. 7B).

Eskridge Shale

The Eskridge shale is red or pink in the lower part and pale green or gray in the upper part. A zone of impure limestone beds separates the upper and lower parts of the formation (Pl. 8A). Fossils are not common in the Eskridge shale. The thickness is uniformly about 34 feet.

The Eskridge shale yields little or no water to wells in Jackson County.

Beattie Limestone

The members of the Beattie limestone, in ascending order, are the Cottonwood limestone, Florena shale, and Morrill limestone.

The Cottonwood limestone member forms a prominent bench in outcrops and caps many of the higher ridges in western Jackson County. The thickness is uniformly about 6 feet (Pl. 8B). The member is a hard massive buff limestone that weathers almost white. Fusulinids are plentiful, and elongated nodules of brown chert weathering in relief impart a very distinctive appearance. Springs and seeps issuing at the base of the limestone support heavy growths of vegetation along the outcrop.

The Florena shale member consists chiefly of gray shale, but small amounts of black shale are not uncommon. Thin shell beds of the brachiopod *Chonetes granulifer* are interspersed through the lower part; they are the only conspicuous fossils present. The Florena shale member ranges in thickness from 6 to 10 feet.

The Morrill limestone member is a nonresistant brown limestone containing much crystalline calcite. On weathered exposures the limestone is almost entirely weathered away, and only large masses of calcite or calcite-lined cavities remain. The Morrill limestone member is about 3 feet thick.

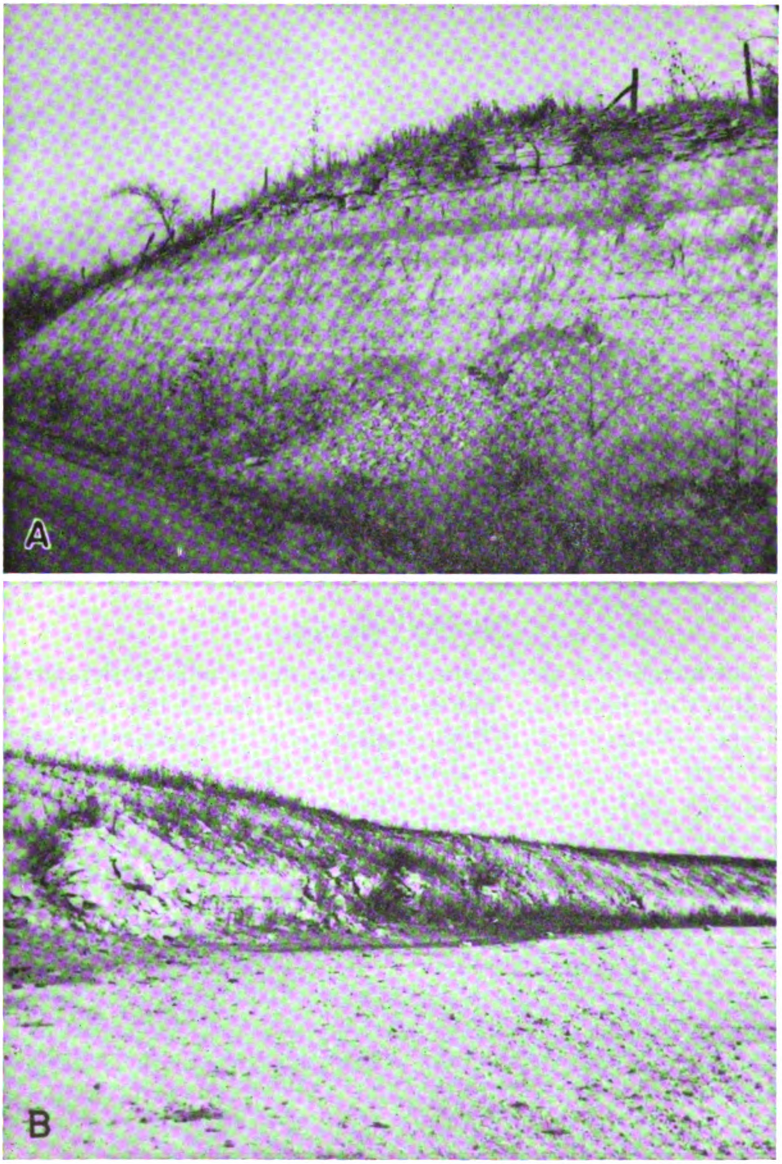

PLATE 8. **A**, Eskridge shale and Cottonwood limestone members of the Beattie formation; in road cut, SE¼ SE¼ sec. 34, T. 6 S., R. 13 E. **B**, Upper part of Cottonwood limestone member; in quarry, SE¼ SW¼ sec. 27, T. 7 S., R. 13 E.

The Beattie limestone is probably the best aquifer in Jackson County where it has a favorable topographic position. The Cottonwood limestone member is the chief water bearer, the water being contained in joints and solution channels. In general, even extended droughts have little effect upon wells deriving their water from the Cottonwood. In many wells the Morrill limestone member is probably an aquifer supplementing the Cottonwood. The Florena shale member is not significant as an aquifer.

Stearns Shale

The Stearns shale consists of about 20 feet of gray or pale-green calcareous shale. One or two white chalky limestone beds less than 1 foot thick are present in most exposures.

The Stearns shale yields little or no water to wells in Jackson County.

Bader Limestone

The Bader limestone is composed of the Eiss limestone member, Hooser shale member, and Middleburg limestone member. The Eiss limestone member is the first resistant bed above the Cottonwood limestone and forms a prominent bench. The Eiss is a massive limestone which weathers slightly platy and pitted. It is creamy tan and contains very few fossils. The thickness ranges from 3 to 4 feet.

The Hooser shale member consists of 9 to 12 feet of moderately fossiliferous shale. A large part of the shale is tan but the lower third is locally mottled with streaks of red. The Middleburg limestone member is not as resistant as the Eiss limestone member and generally does not form a prominent bench. The Middleburg limestone member is a yellowish-tan platy-weathering fossiliferous limestone. The upper few inches are generally almost black. The average thickness of the Middleburg is 1½ feet.

The Eiss and Middleburg limestone members of the Bader limestone yield small amounts of water to wells. The Hooser shale member is not significant as an aquifer.

Easly Creek Shale

In Jackson County the Easly Creek shale is predominantly light colored, except for a red zone in the center. The Easly Creek shale ranges in thickness from 15 to 20 feet.

It does not yield water to wells in Jackson County.

Crouse Limestone

The Crouse limestone consists of a massive lower bed of gray limestone and upper beds of platy darker limestone. Fossil fragments that weather in relief impart a somewhat rough appearance to the outcrop. The greatest thickness of the Crouse limestone observed in Jackson County was 4½ feet, but this thickness probably was reduced considerably by solution.

The Crouse limestone yields small quantities of water to a few shallow dug wells in Jackson County.

Blue Rapids Shale

The Blue Rapids shale is not well exposed anywhere in Jackson County. The interval between the top of the Crouse limestone and what was judged to be the base of the Funston limestone is about 22 feet. Several impure limestone beds occur near the top of the interval; however, they may belong to the lower part of the overlying Funston limestone.

The Blue Rapids shale yields little or no water to wells in Jackson County.

Funston Limestone

In Jackson County the Funston limestone consists of 5 feet of limestone and shale. The upper bed is 2 feet of hard massive blue-gray limestone. The remaining lower 3 feet is light-colored shale and impure platy limestone. The massive upper limestone bed breaks off in large blocks that slip down the hillsides and cover the lower part of the formation.

The Funston limestone, owing to its high topographic position and limited areal distribution, yields very little water to wells in Jackson County.

Speiser Shale

The lower 12 to 14 feet of the Speiser shale consists of varicolored shale, dark at the base, red, pink, and green in the center, and gray near the top. Above the varicolored shale is about 1 foot of hard crystalline gray limestone overlain by 3 feet of gray fissile shale.

The Speiser shale yields little or no water to wells in Jackson County.

CHASE GROUP

Wreford Limestone

The Threemile limestone member is the only member of the Wreford limestone present in Jackson County. The Threemile limestone member occurs in only a few small areas in the extreme western part of the county. In these areas the limestone is weathered away and only a bed of irregular chert nodules remain.

The Threemile limestone member, which is a good aquifer in other parts of Kansas, does not yield water to wells in Jackson County owing to its unfavorable topographic position.

Quaternary System

PLEISTOCENE SERIES

Pre-Kansan Gravel

Deposits of gravel composed largely of chert but containing a small amount of quartzite and quartz rest directly on Paleozoic bedrock and are overlain by the Atchison formation or by till at many places in northern Jackson County. These gravel deposits are considered to be of Pleistocene age because of the quartzite they contain; they can be distinguished from the Atchison formation by the larger percentage of chert they contain. In Jackson County the average thickness of these gravel deposits, which in this report are classified as pre-Kansan, is about 6 feet. The pre-Kansan gravel deposits are highly permeable, but owing to their patchy occurrence and relative thinness they do not furnish large quantities of water to wells in Jackson County.

Atchison Formation

The Atchison formation, which was deposited as pro-Kansan outwash, overlies the bedrock or pre-Kansan gravels and underlies Kansas till in much of northern Jackson County. The basal part of this formation consists of 1 to 20 feet of coarse sand and fine to medium quartz, quartzite, and chert gravel. The basal part of the Atchison formation yields adequate supplies of water to many stock and domestic wells in Jackson County.

The upper part of the Atchison formation consists of as much as 100 feet of very fine quartz sand and silt. The upper part of the formation is often called quicksand by water-well drillers because of the difficulty experienced with caving of the sand.

Kansas Till and Associated Deposits

Glacial deposits consisting of till and material deposited by glacial meltwater are the most widespread geologic formations in Jackson County. The greatest thickness of these materials is found in the northern part of the county, where more than 150 feet was penetrated in one test hole.

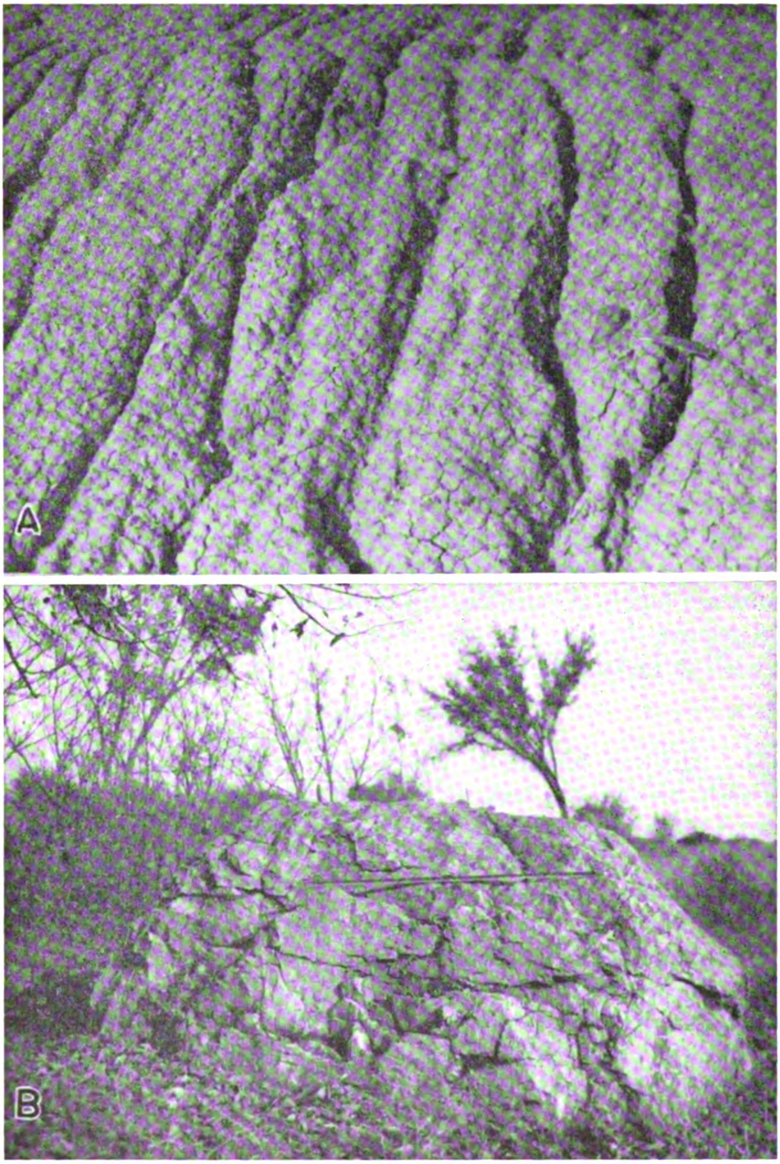

PLATE 9. A, Glacial till in road cut, SE¼ NE¼ sec. 9, T. 6 S., R. 14 E. B, Glacial erratic in the SW¼ NW¼ sec. 6, T. 6 S., R. 13 E.

Till is the predominant material of the glacial deposits (Pl. 9A). The till is in three intergradational zones caused by different degrees of weathering. The upper zone, which averages about 12 feet in thickness, is noncalcareous and is tan or gray in color. In this zone the till is oxidized and leached of its calcareous material. The second zone is slightly darker than the first zone and the material is calcareous. Here the till is oxidized but is not leached. The base of this zone generally lies at a depth of 40 to 60 feet. The lower till zone contains fresh or unaltered till. The fresh till is dark blue when damp and is very calcareous. Fresh till is rarely found in a natural exposure. The till consists largely of clay and varying amounts of sand, gravel, and boulders (Pl. 9B). The coarser materials consist mainly of limestone, sandstone, granite, and quartzite. Till, because of its low permeability, is a very poor aquifer.

The glacial meltwater or glacioaqueous deposits are predominantly sand and gravel containing varying proportions of silt and clay (Pl. 10). The glacioaqueous deposits are irregular bodies or lenses which may occur at any position within the till. Some of the glacioaqueous deposits are good aquifers, especially deposits composed of coarse sand and gravel containing a minimum of silt and clay. A small glacioaqueous deposit surrounded by relatively impermeable till and not connected to other extensive glacioaqueous deposits may fail as an aquifer because of insufficient recharge. The presence or absence of glacioaqueous deposits cannot be determined except by drilling; however, most wells or test holes drilled in an area of thick glacial drift will penetrate one or more such deposits. Although the permeability and thickness of glacioaqueous deposits differs greatly, most farm and domestic wells penetrating these deposits have adequate yields. It is unlikely that industrial or municipal wells could be developed in any of the deposits.

Alluvium

The alluvium of the streams in Jackson County is of late Pleistocene (Recent) age and consists of sand, gravel, silt, and clay. The upper part of the alluvium consists of silt and clay containing a small amount of sand. The lower part of the alluvium is composed of sand and gravel and thin beds of clay. The alluvium of the major streams in Jackson County yields moderately large quantities of water to wells, and the alluvium of many of the minor tributary streams yields supplies adequate for domestic or stock needs.

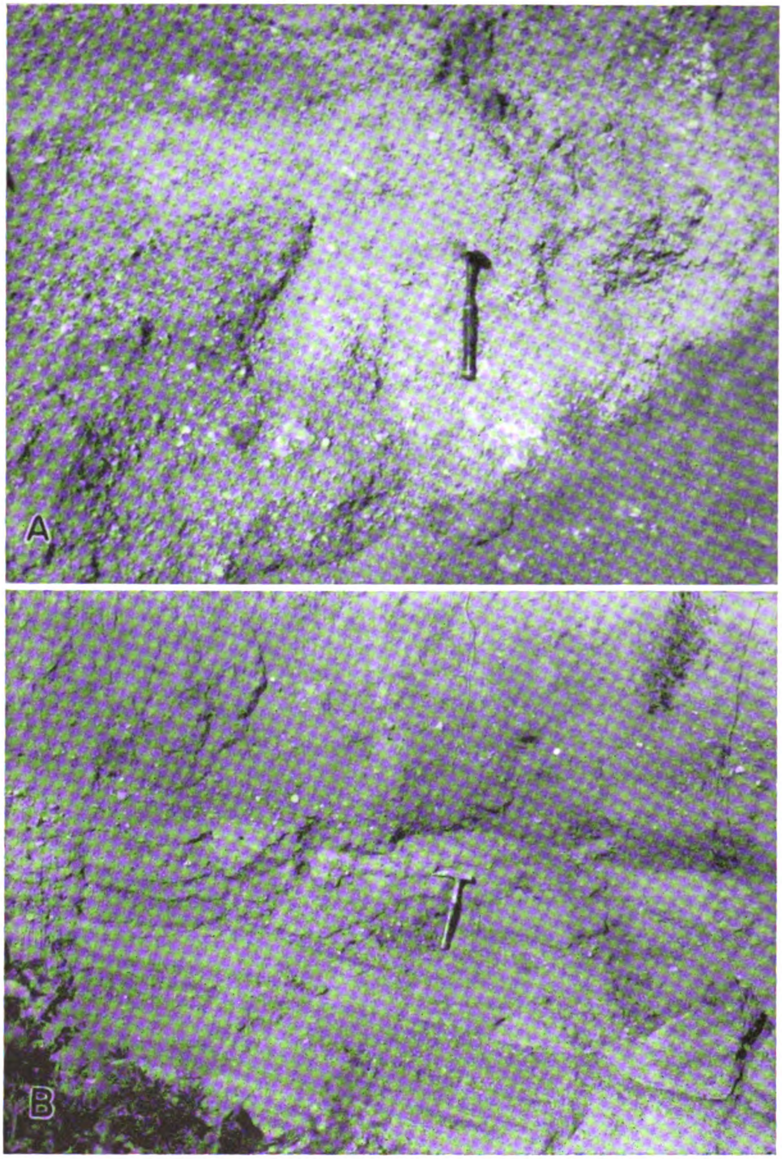

PLATE 10. A, Deposit of glacial sand and gravel, SE¼ sec. 29, T. 6 S., R. 14 E. B, Sand and gravel interstratified with Kansas till; SW¼ NW¼ sec. 27, T. 6 S., R. 14 E. (Photo by A. R. Leonard, June 1949.)

GROUND-WATER REGIONS

In the following paragraphs the ground-water conditions in Jackson County are discussed briefly by regions that are established on the basis of the chief aquifer or group of aquifers within the regions. The boundaries of the regions, shown on Plate 2, are generalized, and it should be understood that the following discussion does not apply to every individual well within a given region.

Within the region designated A, most wells derive water from alluvial deposits. Wells deriving water from alluvium generally are relatively shallow and have moderately large yields of water of good quality. In nearly every place in Jackson County where alluvium is present it is exploited in preference to other aquifers.

Glacial till and associated deposits are the chief aquifers in the regions designated B. The depth to water, as well as the quality and quantity of water availale, is extremely variable in these regions. In nearly every place within these regions, however, it is possible to develop an adequate domestic or stock supply of satisfactory quality. Many wells in these areas extend a few feet into the underlying bedrock but derive their water from gravel deposits which rest directly upon the bedrock.

Permian rocks of the Grenola limestone and all overlying Permian rocks up to the Wreford limestone are the aquifers in the regions designated C. In these regions the Grenola and Beattie limestones yield moderate to large quantities of water of good quality. The Permian formations overlying the Beattie limestone in Jackson County yield only small amounts of water to wells. The depth to water in these regions, and to some extent the quality of water available, depends on the topographic position.

Permian rocks of the Council Grove group underlying the Grenola limestone are the chief aquifers in the regions designated D. In these regions wells do not, in general, yield large quantities of water, but the quality of the water available is satisfactory for domestic and stock supplies. In these regions the depth to water and the quality of water depend on the topographic position.

Pennsylvanian rocks and Permian rocks of the Admire group are the aquifers in the regions designated E. In many parts of these regions, water supplies are very meager and large-diameter dug wells are used to provide a greater infiltration area and also to serve as a reservoir. In general, the quality of water from shallow wells in these regions is satisfactory, but water from many of the deeper wells is highly mineralized.

RECORDS OF WELLS AND SPRINGS

Descriptions of 255 wells and springs visited in Jackson County are given in Table 10. All information classed as "reported" was obtained from the owner, tenant, or driller. Depths of wells not classed as "reported" are measured and are given to the nearest tenth of a foot below the measuring point described in the tables, and depths to water level not classed as "reported" are measured and are given to the nearest hundredth of a foot.

TABLE 10.—*Records of wells and springs in Jackson County, Kansas*

Well No. (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 5 S., R. 15 E.														
5-15-2bc	SW¼NW¼ sec. 2	Ross Amon	B	50	12	Ct	Sand and gravel	Glacial deposits	Cy, H	D,S	Land surface	0	30	....	Never goes completely dry.
5-15-6dd	SE¼SE¼ sec. 6	L. H. Defforest	Dr	69.6	6	OW	do	do	Cy, E	D,S	Top of casing, east side	0.9	46.40	9-11-50	
5-15-12bb	NW¼NW¼ sec. 12	School District	Dr	24.4	6	GI	do	do	Cy, H	P	Top of platform	0.7	15.28	8-18-50	
5-15-15ad	SE¼NE¼ sec. 15	Chas. Atwater	Dr	56	6	GI	Sand	do	Cy, E	D,S	Land surface	0	18	....	
5-15-16bb	NW¼NW¼ sec. 16	H. W. Jones	Dr	219	6	GI	Gravel	do	Cy, E	D,S	do	0	100	....	Analysis of water is given in Table 4.
5-15-22db	NW¼SE¼ sec. 22	F. Bergman Estate	B	31.8	12	Ct	do	do	Cy, H	D	Top of tile	1.2	19.47	10-23-50	
5-15-25aa	NE¼NE¼ sec. 25	Minnie Dieckmann	Du	35.0	42	R	Sand and gravel	do	Cy, W	D,S	Top of platform	0.4	30.60	8-18-50	
5-15-30cb	NW¼SW¼ sec. 30	W. J. Hayden	B	54.6	14	Ct	do	do	Cy, W	N	Base of pump	0.6	13.55	9-11-50	Abandoned; formerly a domestic well.
5-15-31cd	SE¼SW¼ sec. 31	Howard Gunn	Dr	102.0	6	GI	do	do	Cy, W	D,S	Top of casing	2.2	60.60	9-11-50	Analysis of water is given in table 4.
5-15-34cc	SW¼SW¼ sec. 34	School District	Dr	37.2	6	GI	do	do	Cy, H	P	do	0.3	11.87	10-23-50	
5-15-36cc	SW¼SW¼ sec. 36	School District	B	39.1	12	Ct	Sand	do	Cy, H	P	Top of board platform	0.3	4.99	7-16-49	
	T. 5 S., R. 16 E.														
5-16-1aa	NE¼NE¼ sec. 1	Juel Johannes	Dr	31.7	6	GI	do	do	Cy, H	D	Top of casing	0.9	10.64	8-16-50	
5-16-3dc	SW¼SE¼ sec. 3	D. Wenger	Du	39.0	36	R	do	do	Cy, H	D	Top of platform	0.5	21.25	8-21-50	
5-16-5da	NE¼SE¼ sec. 5	R. Pendlebury	B	50	14	Ct	Sandstone	Dry-Friedrich	J,E	D,S	Top of casing	0	38	....	
5-16-6aa	NE¼NE¼ sec. 6	R. D. Bartlow	Du	42.0	28	R	Gravel	Glacial deposits	J,E	D,S	Land surface	0	16.00	10-3-50	
5-16-8bb	NW¼NW¼ sec. 8	S. Smith	Dr	260	6	GI	Limestone	Burlingame, Wakarusa	Cy, E	D	do	0	160	....	Very low yield.
5-16-8dd	SE¼SE¼ sec. 8	H. Ham	Dr	183.3	6	GI	Limestone	Willard-Tarkio	Cy, W	S	Top of casing	1.1	90.20	8-18-50	do.
5-16-10cd	SE¼SW¼ sec. 10	E. Patterson	Dr	67.9	6	GI	Sandstone	Dry-Friedrich	Cy, H	D	do	0.7	51.90	10-23-50	
5-16-13ad	SE¼NE¼ sec. 13	Wm. Lockwood	Du	65	48	R	?	Langdon?	Cy, W	D,S	Top of platform	0.4	17	....	
5-16-13bb	NW¼NW¼ sec. 13	School District	Dr	71.0	6	GI	?	Willard?	Cy, H	P	Top of casing	0.9	43.91	8-16-50	
5-16-15cd	SE¼SW¼ sec. 15	Ferd. Niehouse	Du	20	36	R	Sandstone	Dry-Friedrich	Cy, H	D,S	Land surface	0	10	....	Analysis of water is given in Table 4.
5-16-18bc	SW¼NW¼ sec. 18	E. McQueen	Dr	50	6	GI	Gravel	Glacial deposits	Cy, H	S	Top of casing	0.7	20	....	
5-16-20dd	SE¼SE¼ sec. 20	E. Love	Du	44.5	42	R	do	do	Cy, E	D,S	Top of platform	0.6	36.15	8-18-50	Analysis of water is given in Table 4.

5-16-20aa	NE¼NE¼ sec. 20	Fred Olsen	B	48	12	Ct	Sand and gravel	do	Cy, W	D,S	Land surface	0	30	....	
5-16-21bb	NW¼NW¼ sec. 21	P. W. Louden	Du	39.5	36	R	do	do	Cy, W	N	Top of platform	0.4	17.20	8-21-50	
5-16-23ad	SE¼NE¼ sec. 23	....	Du	32.4	150	R	Sand	Alluvium	Cy, H	N	NE. corner of square hole in cover	2.4	18.26	2-10-50	K.E.R.C. well.
5-16-24ab	NW¼NE¼ sec. 24	Wm. Lockwood	Dr	33.1	6	GI	Sandy shale	Willard	Cy, H	D	Base of pump	0.4	12.70	8-16-50	Very low yield.
5-16-25ac	SW¼NE¼ sec. 25	Frank Banaka	Du	32	40	R	Limestone	Maple Hill?	Cy, H	D,S	Land surface	0	14	....	
5-16-25cb	NW¼SW¼ sec. 25	Fred May	Du,B	40	42-14	R,Ct	Gravel	Glacial deposits	Cy, W	S	do	0	8	....	
5-16-25cc	SW¼SW¼ sec. 25	E. Hollenbeck	Du	40	36	R	Sand and gravel	do	Cy, H	D	do	0	34	....	
5-16-27ca	NE¼SW¼ sec. 27	City of Whiting	B	25.5	14	Ct	Clay	do	Cy, H	P	Top of platform	0.7	7.25	8-21-50	Very low yield.
5-16-28dc	SW¼SE¼ sec. 28	Mrs. J. E. Higby	Dr	90	6	GI	Sandstone	Dry-Friedrich	Cy, W	D,S	Land surface	0	35	....	
5-16-30ab	NW¼NE¼ sec. 30	School District	B	18.2	14	Ct	Sand and gravel	Glacial deposits	Cy, H	P	Top of tile	0.3	4.45	8-18-50	
5-16-33da	NE¼SE¼ sec. 33	Robt. Love	Du	48	36	R	do	do	Cy, W	S	Land surface	0	22	....	
5-16-35cd	SE¼SW¼ sec. 35	School District	Dr	77.6	6	GI	?	Pierson Point-Langdon	Cy, H	P	Top of casing	0.5	8.89	8-11-50	
5-16-36bc	SW¼NW¼ sec. 36	Fred Sheid	Dr	67.1	6	GI	?	Willard-Pierson Point	Cy, H	N	do	1.0	38.75	8-16-50	Very low yield.
	T. 6 S., R. 12 E.														
6-12-1aa	NE¼NE¼ sec. 1	Ralph Forgy	Du	20	40	R	Limestone	Beattie	Cy, H	D,S	Land surface	0	15	....	Analysis of water is given in Table 4.
6-12-13bb	NW¼NW¼ sec. 13	I. A. Godlove	Du	17.9	48	R	do	do	Cy, H	D	Top of platform	0.9	10.80	9-14-50	
6-12-13cb	NW¼SW¼ sec. 13	School District	Dr	61.1	6	GI	do	Bader	N	N	Top of casing	0.7	46.85	9-14-50	Abandoned.
6-12-24ab	NW¼NE¼ sec. 24	C. R. Osterchamp	Du	51.6	40	R	do	Crouse	Cy, H	N	Land surface	0	10.20	9-14-50	
6-12-25dc	SW¼SE¼ sec. 25	M. McKinsey	Dr	117	6	GI	do	Beattie	Cy, W	D,S	do	0	65	....	
6-12-36bb	NW¼NW¼ sec. 36	J. S. Coverdale	Dr	80	6	GI	Sand and gravel	Glacial deposits	Cy, E	D,S	do	0	65	....	
	T. 6 S., R. 13 E.														
6-13-1aa	NE¼NE¼ sec. 1	R. Swindale	Dr	115	6	GI	Limestone	Grenola	Cy, W	D,S	do	0	77	....	
6-13-7cd	SE¼SW¼ sec. 7	E. Smith	Dr	120	6	GI	do	Beattie	Cy, H	D,S	do	0	75	....	
6-13-8bb	NW¼NW¼ sec. 8	A. Wassenberg	Dr	37.5	6	GI	Sand and gravel	Glacial deposits	Cy, W	S	Top of casing	1.0	10.90	9-12-50	Analysis of water is given in Table 4.
6-13-11ab	NW¼NE¼ sec. 11	L. B. Tolin Estate	Dr	136.0	6	GI	Limestone	Grenola	Cy, W	S	do	0.6	78.30	9-8-50	
6-13-12cd	SE¼SW¼ sec. 12	Herman Myer	Dr	60	6	GI	do	do	Cy, W	S	Land surface	0	40	....	
6-13-14bb	NW¼NW¼ sec. 14	Asa Freel	Dr	145	6	GI	do	Red Eagle	Cy, G	S	do	0	40	....	
6-13-18aa	NE¼NE¼ sec. 18	C. A. White	Dr	85	6	GI	do	Beattie	Cy, W	D,S	do	0	78	....	Analysis of water is given in Table 4.
6-13-18dd	SE¼SE¼ sec. 18	Mrs. N. A. Casebeer	Dr	84	6	GI	do	do	Cy, H	D,S	do	0	30	....	
6-13-22cc	SW¼SW¼ sec. 22	N. Rasmus	Du	22.9	36	R	do	Grenola	Cy, H	N	Top of platform	0.8	15.20	8-10-49	Abandoned; formerly a stock well.
6-13-22dc	SW¼SE¼ sec. 22	C. H. Hance	Dr	107.4	6	GI	do	Red Eagle	Cy, W	D,S	Top of casing	0.9	70.39	9-22-50	
6-13-27dc	SW¼SE¼ sec. 27	School District	Dr	18.4	6	GI	do	Grenola	N	N	do	1.1	17.00	9-22-50	Abandoned; formerly a school well.
6-13-28bb	NW¼NW¼ sec. 28	....	Dr	116.5	6	GI	do	Red Eagle	Cy, W	N	do	0.2	43.00	9-12-50	Abandoned; formerly a domestic and stock well.
6-13-29aa	NE¼NE¼ sec. 29	W. C. Holliday	Dr	102.0	6	GI	do	do	Cy, W	N	do	1.1	60.20	9-13-50	Abandoned; formerly a domestic and stock well.
6-13-30ad	SE¼NE¼ sec. 30	Evan Lewelling	Dr	65	6	GI	do	Grenola	Cy, W	D,S	Land surface	0	20	....	

TABLE 10.—*Records of wells and springs in Jackson County, Kansas—Continued*

Well No. (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 6 S., R. 14 E.														
6-14-2dc	SW¼SE¼ sec. 2	L. Hutchinson	B	65.0	12	Ct	Sand and gravel	Glacial deposits	Cy, H	S	Top of tile	0.4	21.20	8-23-50	
6-14-3cc	SW¼SW¼ sec. 3	C. M. Geis	Dr	140	6	GI	do	do	Cy, W	D,S	Land surface	0	90		
6-14-6ba	NE¼NW¼ sec. 6	E. T. Allen	Dr	112	6	GI	do	do	Cy, E	D,S	do	0	60		
6-14-11cd	SE¼SW¼ sec. 11	H. M. Heffner	B	44.8	14	Ct	do	do	Cy, W	D,S	Top of tile	1.1	11.70	9-11-50	
6-14-12cd	SE¼SW¼ sec. 12	J. C. Albright	B	28.9	14	Ct	do	do	N	N	do	0.7	3.80	8-23-50	Abandoned; formerly a domestic well.
6-14-21cd	SE¼SW¼ sec. 21	City of Circleville	Dr	96	6	GI	Sand	do	Cy, H	P	Land surface	0	35		Pumped dry in 15 minutes at 8 gpm.
6-14-24bb	NW¼NW¼ sec. 24	G. E. Glick	B	38.9	14	Ct	Sand and gravel	do	Cy, W	D,S	Base of pump	2.3	20.00	8-23-50	
6-14-24cc	SW¼SW¼ sec. 24	Wayne Glick	Dr	49.4	6	GI	do	do	Cy, H	N	Top west side of casing	1.2	8.18	8-31-49	Abandoned; formerly a domestic and stock well.
6-14-25ab	NW¼NE¼ sec. 25	Cecil Riley	DD	40	36–6	R,GI	do	do	Cy, H	D	Top of platform	0.6	22		
6-14-27bb	NW¼NW¼ sec. 27	Henry Albin	Dr	47	6	GI	Limestone	Foraker	Cy, E	D,S	Land surface	0	38		Analysis of water is given in Table 4.
6-14-29bc	SW¼NW¼ sec. 29	Mina Simmons	Dr	110.0	6	GI	Sand and gravel	Glacial deposits	Cy, W	D,S	Top of casing	0.7	68.70	8-23-50	
6-14-34bc	SW¼NW¼ sec. 34	J. Coulson	Sp				do	do	F	S				8-23-50	Flows 2½ gpm.
6-14-34db	NW¼SE¼ sec. 34		Sp				do	do	F	N				8-23-50	Discharges into ditch reported to flow 28 gpm.
6-14-34dd	SE¼SE¼ sec. 34	School District	Dr	28.1	6	GI	do	do	N	N	Top of casing	0.7	13.95	8-23-50	Abandoned school well.
	T. 6 S., R. 15 E.														
6-15-1aa	NE¼NE¼ sec. 1	F. Klahr	B	31.6	14	Ct	do	do	Cy, W	N	Top of tile	1.0	10.20	9-13-50	Abandoned; formerly a domestic and stock well.
6-15-3bb	NW¼NW¼ sec. 3	J. Dachenhausen	B	49.9	14	Ct	do	do	Cy, W	N	do	0.5	36.91	9-13-50	do.
6-15-7aa	NE¼NE¼ sec. 7	School District	Dr	33.0	6	GI	do	do	Cy, H	P	Top of casing	2.0	20.05	8-22-50	
6-15-8ad	SE¼NE¼ sec. 8	Joe Wallisch	B	51.1	12	Ct	do	do	Cy, E	D,S	Top of tile	0.8	41.84	8-31-49	Analysis of water is given in Table 4.

6-15-14ba	NE¼NW¼ sec. 14	School District	Dr	21.0	6	GI	do	do	Cy, H	P	do	0.6	16.30	7-25-49	Barely adequate for school.
6-15-15bd	SE¼NW¼ sec. 15	P. D. Haag	Dr	42.2	6	GI	do	do	Cy, W	S	do	1.3	29.29	2-10-50	
6-15-17bc	SW¼NW¼ sec. 17		B	115.0	14	Ct	do	do	Cy, H	N	do	2.3	44.35	8-22-50	Unused domestic and stock well.
6-15-19ad	SE¼NE¼ sec. 19	Craig Bros.	Dr	40	8	GI	do	do	Cy, W	D,S	Land surface	0	8		
6-15-22cd	SE¼SW¼ sec. 22	School District	Dr	96.0	6	OW	do	do	Cy, H	P	Top of casing	0.7	69.99	8-18-50	Analysis of water is given in Table 4.
6-15-28cc	SW¼SW¼ sec. 28	School District	Du	20.9	60	Br	do	do	N	N	Land surface	0	14.38	8-22-50	Abandoned school well.
6-15-34cc	SW¼SW¼ sec. 34	Bert Walters	Du	24.5	36	R	do	do	Cy, H	D	Top of platform	0.7	20.50	10-2-50	
6-15-35dd	SE¼SE¼ sec. 35	City of Holton	Dr	48	6	I	do	Terrace and glacial deposits	T, E	P	Land surface	0	28		Yields 20 gpm.
6-15-36dd	SE¼SE¼ sec. 36	do	Dr	38	6	I	do	do	T, E	P	Top of casing	2	26		Yields 48 gpm.
6-15-36ab	NW¼NE¼ sec. 36	do	Sp			C	do	Glacial deposits	T, E	P				7-27-49	Developed by City of Holton. Yields 42 gpm.
6-15-36ab	do	do	Sp			C	do	do	T, E	P					Developed by City of Holton. Yields 55 gpm.
6-15-36ac	SW¼NE¼ sec. 36	do	Sp			C	do	do	T, E	P					Developed by City of Holton. Yields 12 gpm.
	T. 6 S., R. 16 E.														
6-16-4cc	SW¼SW¼ sec. 4	School District	Dr	80.0	5	OW	do	do	Cy, H	P	Top of casing	0.7	34.80	8-11-50	
6-16-6cd	SE¼SW¼ sec. 6	Ella Grannell	Dr	88.6	6	OW	do	do	Cy, W	D,S	do	0.9	54.20	9-22-50	
6-16-9ba	NE¼NW¼ sec. 9	Gerhard Hahn	Dr	160	6	GI	do	do	Cy, E	D,S	Top of platform	0.4	60.20	8-29-50	
6-16-10dd	SE¼SE¼ sec. 10	J. Oliver	Du	15.8	36	R	do	do	Cy, W	N	Top of curb	0.5	5.57	8-11-50	Abandoned; formerly a stock well.
6-16-13aa	NE¼NE¼ sec. 13	A. J. Shonecker	Du	28.5	40	R	do	do	N	N	do	0.6	24.15	8-10-50	do.
6-16-14bc	SW¼NW¼ sec. 14	C. Shrader	Du	18.8	48	R	Sand	Alluvium	N	N	do	2.7	9.80	9-22-50	Unused stock well.
6-16-20cc	SW¼SW¼ sec. 20	J. A. Rawlins	Dr	101	6	OW	Gravel	Glacial deposits	Cy, W	S	Land surface	0	76		
6-16-24ba	NE¼NW¼ sec. 24	Eva Ryan	Dr	125	6	OW	do	do	Cy, E	D,S	do	0	70		
6-16-28aa	NE¼NE¼ sec. 28	School District	Dr	95.7	6	GI	Sand and gravel	do	Cy, H	P	Top of casing	0.3	85.85	8-11-50	
6-16-29aa	NE¼NE¼ sec. 29	Mrs. Wagonblast	B	62.7	16	Ct	do	do	Cy, W	S	Top of platform	0.9	30.20	8-29-50	
6-16-32dd	SE¼SE¼ sec. 32	C. Clinkenbeard	Du	55	48	R	do	do	Cy, E	D,S	do	1.9	45		
6-16-35bb	NW¼NW¼ sec. 35	Fred Krans	Dr	190	6	GI	do	do	Cy, W	D,S	Land surface	0	60		
6-16-36cb	NW¼SW¼ sec. 36	E. J. Doyle	Du	40	48	R	Limestone	Burlingame-Wakarusa	Cy, H	D	Top of curb	0.9	30		Analysis of water is given in Table 4.
	T. 7 S., R. 12 E.														
7-12-12cd	SE¼SW¼ sec. 12	Paul Venneberg	Du	41.6	36	R	do	Funston	Cy, W	D,S	Top of platform	0.9	36.97	9-16-50	
7-12-13da	NE¼SE¼ sec. 13	A. Marcouy	Du	11.6	14	Ct	?	Blue Rapids	N	N	Top of tile	0.9	6.12	8-16-49	Abandoned; formerly a stock well.
7-12-25aa	NE¼NE¼ sec. 25	F. Segrist	Dr	49.6	6	GI	Limestone	Beattie	Cy, W	N	Base of pump	1.0	44.19	8-16-49	Unused domestic and stock well.

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TABLE 10.—*Records of wells and springs in Jackson County, Kansas—Continued*

Well No. (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed		Method of lift (5)	Use of water (6)	Measuring point		Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
							Character of material	Geologic source			Description	Distance above land surface (feet)			
	T. 7 S., R. 13 E.														
7-13-3bb	NW¼NW¼ sec. 3	M. Brown	Dr	104	6	GI	Limestone	Red Eagle-Grenola	J, E	D,S	Land surface	0	80	....	
7-13-3cc	SW¼SW¼ sec. 3	Marvin Starr	Dr	95	6	GI	do	Red Eagle	Cy, E	D,S	do	0	70	....	
7-13-5ad	SE¼NE¼ sec. 5	R. Chrisman	Dr	67.3	6	GI	do	Grenola	Cy, W	N	Top of casing	1.1	59.95	9-13-50	
7-13-5dc	SW¼SE¼ sec. 5	J. W. Prickett	Dr	61.5	6	GI	do	do	Cy, H	N	do	0.9	19.20	10-23-50	Unused domestic well.
7-13-5bc	SW¼NW¼ sec. 5	Tom Bottom	Dr	132	6	OW	Gravel	Glacial deposits	J, E	D,S	Land surface	0	78	....	
7-13-10bb	NW¼NW¼ sec. 10	Chas. Starr	Dr	75	6	GI	Limestone	Foraker	Cy, E	D,S	do	0	60	....	Analysis of water is given in Table 4.
7-13-10bc	SW¼NW¼ sec. 10	School District	Dr	104.0	6	GI	do	do	Cy, H	P	Top of casing	1.1	75.70	7-22-49	
7-13-11ca	NE¼SW¼ sec. 11	E. Nott	Du	38.6	36	R	do	Beattie	N	N	Top of wall	0.4	18.40	7-28-49	Abandoned; formerly a domestic and stock well.
7-13-14ad	SE¼NE¼ sec. 14	....	B	74.4	14	Ct	do	Grenola	Cy, W	N	Top of tile	0.6	51.48	9-1-50	
7-13-23aa	NE¼NE¼ sec. 23	School District	Dr	57.4	6	GI	do	Red Eagle	Cy, H	P	Land surface	0	47.10	9-1-50	Analysis of water is given in Table 4.
7-13-31dd	SE¼SE¼ sec. 31	Federal Land Bank	Dr	54.2	6	GI	do	Beattie	Cy, W	D,S	Top of pump	3.5	43.85	9-7-50	
7-13-33ad	SE¼NE¼ sec. 33	School District	Dr	46.2	6	GI	do	Grenola	Cy, H	P	Top of casing	0.3	30.15	8-15-50	Analysis of water is given in Table 4.
7-13-36dd	SE¼SE¼ sec. 36	School District	Dr	43.2	6	GI	do	do	Cy, H	P	do	0.6	32.68	11-7-49	
	T. 7 S., R. 14 E.														
7-14-3cd	SE¼SW¼ sec. 3	....	Sp	....	....	....	Sand and gravel	Glacial deposits	F	N	....	....	....	8-23-50	Flows 1 gpm.
7-14-4cc	SW¼SW¼ sec. 4	School District	Dr	38.8	6	GI	do	do	Cy, H	P	Top of casing	0.6	33.58	8-25-50	
7-14-4cc	SW¼SW¼ sec. 4	Lizzie Askren	Dr	65	6	GI	do	do	Cy, E	D,S	Land surface	0	60	....	
7-14-5dd	SE¼SE¼ sec. 5	Earl Askren	Dr	104	7	OW	Limestone	Red Eagle-Grenola	Cy, E	D,S	do	0	80	....	
7-14-6aa	NE¼NE¼ sec. 6	A. F. Stauffer	Du	49.8	36	R	Sand and gravel	Glacial deposits	Cy, H	D,S	Top of platform	1.0	33.10	8-23-50	
7-14-6cc	SW¼SW¼ sec. 6	John Fisher	Dr	120.0	6	GI	Limestone	Grenola	Cy, E	D	Top of casing	0.4	98.70	8-25-50	
7-14-8dc	SW¼SE¼ sec. 8	Chas. Mannell	Dr	59.0	6	GI	Shale	Eskridge	Cy, H	N	do	0.7	7.10	7-25-49	Unused domestic well.
7-14-11aa	NE¼NE¼ sec. 11	Glen Doss	Dr	69	6	GI	Gravel	Glacial deposits	Cy, W	D,S	do	0	50	....	Analysis of water is given in Table 4.
7-14-14ca	NE¼SW¼ sec. 14	Ed Townsend	Dr	106	6	GI	?	Hawxby-Hamlin	Cy, H	D	Land surface	0	20	....	

7-14-17ad	SE¼NE¼ sec. 17	Fred Adams	Du	12	36	R	Sand	Alluvium	Cy, W	D,S	do	0	2		
7-14-19bc	SW¼NW¼ sec. 19		Dr	50.5	6	GI	Limestone	Red Eagle	Cy, H	N	Top of casing	0.6	40.08	10-5-50	
7-14-20ab	NW¼NE¼ sec. 20	School District	Dr	29.7	6	GI	do	Grenola	Cy, H	P	do	0.1	13.24	8-31-50	
7-14-22da	NE¼SE¼ sec. 22	Raymond Riley	Dr	79	6	GI	Sand	Glacial deposits	Cy, E	D,S	Land surface	0	30		
7-14-24cb	NW¼SW¼ sec. 24	A. Bryant	B, Dr	50	14, 6	Ct, GI	Sand and gravel	do	Cy, E	D,S	do	0	23		
7-14-26da	NE¼SE¼ sec. 26	Geo. Taylor	Du	31.1	40	R	do	do	Cy, H	D	Top of platform	0.7	28.90	8-24-50	Very low yield.
7-14-27dd	SE¼SE¼ sec. 27	School District	Dr	36.0	6	GI	do	do	Cy, H	P	Top of casing	0.6	10.95	8-24-50	
7-14-27cc	SW¼SW¼ sec. 27	Wm. Stoll	Dr	98	6	GI	Limestone ?	Red Eagle-Grenola?	Cy, E	S	Land surface	0	30		Analysis of water is given in Table 4.
7-14-29dd	SE¼SE¼ sec. 29	B. Kennedy	Dr	67.7	6	GI	Limestone	Red Eagle	Cy, G	D,S	do	0	46.64	8-20-50	Analysis of water is given in Table 4.
7-14-31ad	SE¼NE¼ sec. 31	Joe Kennedy	Dr	52.7	6	GI	do	do	Cy, H	D	Top of casing	1.9	36.50	10-5-50	
	T. 7 S., R. 15 E.														
7-15-7aa	NE¼NE¼ sec. 7	R. Sacher	Dr	38	6	GI	Sand and gravel	Glacial deposits	Cy, E	S	Land surface	0	9		
7-15-7ab	NW¼NE¼ sec. 7	School District	Du	29.3	36	B	do	do	Cy, H	P	Top of curb	0.5	8.50	8-23-50	
7-15-11cc	SW¼SW¼ sec. 11	Fred Koch	Dr	69.7	6	GI	Sandstone	Dry-Friedrich	Cy, W	D,S	Base of pump	0.5	66.15	8-31-50	Analysis of water is given in Table 4.
7-15-13aa	NE¼NE¼ sec. 13	J. Pitsch	Du	39.3	36	R	do	Langdon	Cy, W	D,S	do	0.6	28.15	6-28-50	
7-15-15dc	SW¼SE¼ sec. 15	Karl Schumacher	Du	18	36	R	Sand	Glacial deposits	Cy, H	D	Land surface	0	6		
7-15-22cb	NW¼SW¼ sec. 22	J. M. Biddison	Dr	64.4	6	GI	Sand and gravel	do	N	N	Top of casing	1.3	42.95	8-14-50	Unused domestic well.
7-15-23dc	SW¼SE¼ sec. 23	School District	Dr	69.1	6	GI	Sandstone	Langdon-(Dry-Friedrich)	Cy, H	P	do	0.2	40.06	8-31-50	
7-15-27cc	SW¼SW¼ sec. 27	do	Dr	56.6	6	GI	do	Dry-Friedrich	Cy, H	P	do	0.4	37.47	8-14-50	
7-15-29bb	NW¼NW¼ sec. 29	Hal Ham	B	50.8	14	Ct	Sand and gravel	Glacial deposits	Cy, W	D	Top of platform	1.0	17.81	8-22-50	Analysis of water is given in Table 4.
7-15-31dd	SE¼SE¼ sec. 31	School District	Dr	25.0	6	GI	do	do	Cy, H	P	Top of casing	0.6	7.90	8-22-50	
7-15-33dd	SE¼SE¼ sec. 33	F. Carson	Dr	127	6	GI	?	Dry-Friedrich	N		do	1.0	30.00	6-21-50	Yields 9 gpm. Pump installation not completed 6-21-50. To be a domestic well.
	T. 7 S., R. 16 E.														
7-16-2cd	SE¼SW¼ sec. 2		Du	33.3	40	R	Limestone	Elmont	Cy, W	N	Top of curb	1.9	6.37	8-10-50	
7-16-10aa	NE¼NE¼ sec. 10	W. A. Ridge	Du	32.1	36	R	?	Auburn-Reading	Cy, H	N	Base of pump	1.8	13.70	6-24-50	Abandoned; formerly a domestic well.
7-16-20cc	SW¼SW¼ sec. 20	J. H. Chorn	Dr	72	6	GI	Gravel	Glacial deposits	Cy, E	D,S	do	0	40		
7-16-21cd	SE¼SW¼ sec. 21	do	Du	61.6	36	R	Sand and gravel	do	Cy, W	N	do	0.3	16.23	6-23-50	Abandoned; formerly a domestic and stock well.
7-16-21da	NE¼SE¼ sec. 21	Perkins	DD	80	36, 6	R, GI	do	do	Cy, E	D,S	Land surface	0	55		
7-16-22ab	NW¼NE¼ sec. 22	School District	Dr	84.7	6	GI	?	Auburn-Elmont	Cy, H	P	Top of casing	0.4	73.93	6-23-50	
7-16-23ab	NW¼NE¼ sec. 23		Du	29.6	48	R	Limestone	Elmont	Cy, W	N	Top of platform	3.0	25.73	6-23-50	Abandoned; formerly a domestic well.
7-16-27bc	SW¼NW¼ sec. 27	J. Dodson	Du	45.1	36	R	Sand and gravel	Glacial deposits	Cy, H	N	Top of curb	0.3	29.46	6-23-50	

TABLE 10.—*Records of wells and springs in Jackson County, Kansas—Continued*

Well No. (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 7 S., R. 16 E.														
7-16-27dd	SE¼SE¼ sec. 27	Blanch Gardner	DD	67.6	36, 6	R, GI	Sand	Glacial deposits	Cy, E	S	Top of curb	2.0	27.40	6-22-50	
7-16-28bc	SW¼NW¼ sec. 28	Rose Ramey	Du	49.5	48	R	Shale	Willard	Cy, W	N	Land surface	0	19.82	6-23-50	Unused stock well.
7-16-29cd	SE¼SW¼ sec. 29	John Lytle	Du	30	36	R	do	Pierson Point	Cy, E	D,S	do	0	20		
7-16-32aa	NE¼NE¼ sec. 32	J. F. Ramey	Du	45	48	R	Limestone	Elmont	Cy, W	D,S	do	0	23		
7-16-33aa	NE¼NE¼ sec. 33		Du	28.2	48	R	do	Tarkio	Cy, H	N	Top of platform	1.6	10.42	6-22-50	Abandoned; formerly a domestic well.
7-16-33aac	SW¼NE¼NE¼ s. 33	L. R. Twombly	Du	24	42	R	Sand	Glacial deposits	Cy, H	D	Land surface	0	18		
7-16-35cd	SE¼SW¼ sec. 35	Ralph Eubanks	Du	42.2	36	R	do	do	J, E	D,S	Top of platform	1.0	30.60	6-22-50	
	T. 8 S., R. 12 E.														
8-12-24bb	NW¼NW¼ sec. 24	School District	Dr	55.4	6	GI	do	do	Cy, H	N	do	0	44.10	9-16-50	Abandoned; formerly a school well.
	T. 8 S., R. 13 E.														
8-13-6aa	NE¼NE¼ sec. 6		Du	17.2	40	R	Limestone	Grenola	N	N	Land surface	0	7.40	9-7-50	Abandoned; formerly a domestic and stock well.
8-13-16da	NE¼SE¼ sec. 16	Oren Bond	Dr	78	6	GI	do	Red Eagle	Cy, W	D,S	do	0	60		
8-13-20cb	NW¼SW¼ sec. 20	F. Berlin	Dr	49.6	6	GI	?	West Branch	N	N	Top of casing	0.9	39.30	9-7-50	Abandoned; formerly a domestic well.
8-13-21dd	SE¼SE¼ sec. 21	School District	Dr	43.0	6	GI	Limestone	Long Creek	Cy, H	P	Land surface	0	38.92	8-15-50	
8-13-22bc	SW¼NW¼ sec. 22	Lester Cooper	Dr	50	6	GI	do	Grenola	Cy, W	D,S	do	0	40		
8-13-23dd	SE¼SE¼ sec. 23	Indian Land	Du	19.5	40	R	?	West Branch-Hamlin	N	N	do	0	12.07	10-5-50	Unused domestic well.
8-13-27dd	SE¼SE¼ sec. 27	James Chaney	Dr	59.2	6	GI	Limestone	Long Creek	Cy, H	S	Top of casing	1.0	41.45	10-5-50	
8-13-35aa	NE¼NE¼ sec. 35	School District	Dr	28.5	6	GI	?	Towle-Aspinwall	Cy, H	P	do	0.3	11.64	9-20-50	
	T. 8 S., R. 14 E.														
8-14-1ad	SE¼NE¼ sec. 1		B	16.0	14	Ct	Sand and gravel	Glacial deposits	N	N	Top of tile	0.9	13.70	8-24-50	Abandoned; formerly a stock well.
8-14-2aa	NE¼NE¼ sec. 2	Tweedy	Du	18.5	36	R	do	do	Cy, H	N	Top of platform	0.3	4.90	8-24-50	do.

8-14-8bc	SW¼NW¼ sec. 8	C. M. Baker	Dr	54.4	6	GI	?	West Branch-Hamlin	Cy, H	N	Top of casing	0.3	8.05	9-1-50	
8-14-9cc	SW¼SW¼ sec. 9	School District	Dr	54.8	6	GI	?	do.	Cy, H	P	do.	0.1	7.10	8-31-50	
8-14-9dd	SE¼SE¼ sec. 9	Frank Zibell	Dr	68.0	6	GI	?	do.	Cy, H	N	do.	0.8	49.00	8-30-50	Unused stock well.
8-14-10ad	SE¼NE¼ sec. 10	L. W. Summer	DD	60.0	6	GI	?	do.	Cy, E	D,S	Land surface	0	38	....	Analysis of water is given in Table 4.
8-14-11cd	SE¼SW¼ sec. 11	....	B	35.8	8	Ct	Sand and gravel	Glacial deposits	Cy, H	N	Top of tile	0.7	17.25	8-24-50	
8-14-12ad	SE¼NE¼ sec. 12	Paul Jacobs	DD	121	27, 6	W, GI	Sandstone	French Creek-Pony Creek	Cy, G	S	Land surface	0	16	....	
8-14-19dd	SE¼SE¼ sec. 19	School District	Du	22.8	36	R	?	Aspinwall-Hawxby	Cy, H	P	Top of wall	0.8	4.38	9-1-50	
8-14-26da	NE¼SE¼ sec. 26	C. R. Tayler	Dr	37.4	6	GI	Sand and gravel	Glacial deposits	Cy, H	N	Top of casing	0.5	11.20	9-5-50	Unused domestic well.
8-14-33aa	NE¼NE¼ sec. 33	....	Dr	118.0	6	GI	Sandstone	Dry-Friedrich	Cy, W	S	Top of platform	0.6	29.90	9-15-50	
8-14-33ad	SE¼NE¼ sec. 33	Leo Hards	Dr	88.7	6	GI	?	(Dry-Friedrich)-French Creek	Cy, H	S	Top of casing	1.1	11.75	10-2-50	
	T. 8 S., R. 15 E.														
8-15-2aa	NE¼NE¼ sec. 2	School District	Dr	65.5	6	GI	Sand and gravel	Glacial deposits	Cy, H	P	do.	0	11.34	8-19-50	
8-15-3ba	NE¼NW¼ sec. 3	W. H. Snyder	Dr	90	6	GI	do.	do.	Cy, W	D,S	Land surface	0	75	....	
8-15-3ab	NW¼NE¼ sec. 3	E. J. Dykeman	Dr	80	6	GI	do.	do.	Cy, H	D	do.	0	70	....	
8-15-10da	NE¼SE¼ sec. 10	School District	Dr	99.3	6	GI	Limestone	Maple Hill-Dover	Cy, H	P	Top of casing	0.2	33.10	8-31-49	
8-15-12bb	NW¼NW¼ sec. 12	A. P. Kientz	Du	30	36	R	Sand and gravel	Glacial deposits	Cy, H	D	Land surface	0	17	....	
8-15-18dd	SE¼SE¼ sec. 18	C. Cozad	Dr	71.5	6	GI	?	French Creek-Pony Creek	Cy, H	S	Top of casing	0.4	49.65	8-22-50	Very low yield.
8-15-21ad	SE¼NE¼ sec. 21	Pottawatomie Indian Agency	Du	51.3	96	R	Sand and gravel	Glacial deposits	J, E	P	Top of curb	2.0	6.00	8-14-50	This well is in a battery of 2 identical wells.
8-15-22cc	SW¼SW¼ sec. 22	M. Fitzgerald	Du	34	60	R	do.	do.	Cy, W	S	do.	1.5	6	....	
8-15-22da	NE¼SE¼ sec. 22	A. Renolds	Dr	33.6	6	GI	do.	do.	Cy, H	P	Base of pump	0.4	4.92	8-15-50	Supplies water for Mayetta grade school.
8-15-22bb	NW¼NW¼ sec. 22	J. Fitzgerald	Du	60	36	R	do.	do.	Cy, H	D	Land surface	0	32.85	8-17-50	
8-15-24cd	SE¼SW¼ sec. 24	W. Mathews	Du	17.3	48	R	do.	do.	Cy, H	D,S	Top of platform	0.8	2.65	8-19-50	
8-15-28bc	SW¼NW¼ sec. 28	J. G. Wiruth	Dr	136.5	6	GI	?	Dry-Friedrich	Cy, W	N	Top of casing	0.8	32.65	9-2-50	Unused domestic well.
8-15-34cd	SE¼SW¼ sec. 34	F. W. Lehman	Dr	91.6	6	GI	?	Pierson Point-Langdon	Cy, W	D,S	do.	1.1	82.20	8-31-49	
	T. 8 S., R. 16 E.														
8-16-2dd	SE¼SE¼ sec. 2	W. Blumburg	Du	29.3	54	C	Sand and gravel	Terrace deposits	Cy, W	D,S	Top of platform	1.0	4.04	6-22-50	
8-16-2aa	NE¼NE¼ sec. 2	J. T. Williamson	Dr	39.8	6	GI	Limestone	Burlingame-Wakarusa	Cy, H	N	Top of casing	0	31.85	11-22-49	Unused domestic well.
8-16-3ba	NE¼NW¼ sec. 3	R. Rawlings	Du	23.6	36	R	do.	Reading	Cy, H	S	Top of platform	2.5	15.90	6-22-50	Very low yield.
8-16-4aa	NE¼NE¼ sec. 4	City of Denison	Du	43.6	120	R	Gravel	Terrace deposits or alluvium	Cy, E	P	do.	1.8	28.93	10-23-50	
8-16-7ad	SE¼NE¼ sec. 7	C. F. Wing	DD	80	36, 6	R,GI	Sand and gravel	Glacial deposits	Cy, W	D,S	do.	1.4	59.10	6-29-50	
8-16-7da	NE¼SE¼ sec. 7	Paul McCrory	DD	37.5	......	......	do.	do.	Cy, W	D,S	do.	0.6	35.50	6-29-50	

TABLE 10.—*Records of wells and springs in Jackson County, Kansas—Continued*

Well No. (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed		Method of lift (5)	Use of water (6)	Measuring point		Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
							Character of material	Geologic source			Description	Distance above land surface (feet)			
	T. 8 S., R. 16 E.														
8-16-8ad	SE¼NE¼ sec. 8	Gilliland	Du	45.6	36	R	Sand and gravel	Glacial deposits	Cy, H	D	Land surface	0	32.50	6-25-50	
8-16-9dd	SE¼SE¼ sec. 9	J. D. Braum	Dr	50.0	6	GI	do	do	J, E	D	Base of pump	1.4	36.41	11-22-49	Analysis of water is given in Table 4.
8-16-10ab	NW¼NE¼ sec. 10	C. F. Jones	Dr	38	6	GI	do	do	Cy, H	D	Land surface	0	20	....	
8-16-17bb	NW¼NW¼ sec. 17	A. N. Porter	B	45	28	B	do	do	Cy, E	D	do	0	23	....	
8-16-17cc	SW¼SW¼ sec. 17	M. Porter	Dr	115.0	6	GI	Sandstone	Cedar Vale-Silver Lake	N	N	do	0	18	....	Reported to be too salty for stock.
8-16-19bb	NW¼NW¼ sec. 19	J. L. Reynolds	B	17.1	12	Ct	Sand and gravel	Glacial deposits	Cy, H	N	Base of pump	0.3	10.40	8-31-49	
8-16-19cc	SW¼SW¼ sec. 19	B. Whittington	Du	24.5	36	R	do	do	Cy, H	D	Top of platform	1.0	20.30	6-30-50	
8-16-22cc	SW¼SW¼ sec. 22	John Luscomb	Du	35.0	36	R	Shale?	Auburn-Harveyville	Cy, H	D	do	0.4	26.97	6-29-50	
8-16-26db	NW¼SE¼ sec. 26	E. H. Voight	Du	15.7	29	R	Limestone	Reading	N	N	do	1.3	13.90	11-22-49	Abandoned; formerly a domestic and stock well.
8-16-27ab	NW¼NE¼ sec. 27	School District	Du	20.9	36	R	do	Burlingame-Wakarusa	Cy, H	P	do	0.8	6.50	6-29-50	
8-16-32cd	SE¼SW¼ sec. 32	A. F. Allen	B	47.3	24	Ct	Sand	Glacial deposits	....	D	Land surface	0	16.10	7-14-50	Pump installation not completed 7-14-50.
8-16-35cd	SE¼SW¼ sec. 35	School District	Du	34.2	72	R	do	do	Cy, H	P	do	0	15.99	11-22-49	
	T. 9 S., R. 12 E.														
9-12-25aa	NE¼NE¼ sec. 25	do	Du	23.6	36	R	do	do	Cy, H	P	Top of platform	0.7	7.65	10-6-50	
	T. 9 S., R. 13 E.														
9-13-3da	NE¼SE¼ sec. 3	F. Heath	Du	46.3	48	R	do	do	Cy, H	D	Land surface	0	11.50	10-5-50	
9-13-5aa	NE¼NE¼ sec. 5	School District	Dr	66.8	6	GI	?	West Branch-Hamlin	N	N	Top of casing	0.4	10.80	9-21-50	Abandoned; formerly a school well.
9-13-14cb	NW¼SW¼ sec. 14	J. A. Murry	Du	60	62	R	?	Pony Creek-Towle	Cy, E	D,S	Land surface	0	45	....	
9-13-27da	NE¼SE¼ sec. 27	Ignac Horak	Du	30	48	R	Sandstone	French Creek	Cy, H	D,S	do	0	15	....	Analysis of water is given in Table 4.

9-13-28ad	SE¼NE¼ sec. 28	Union Pacific R.R.	Dr	31	6	GI	Sand and gravel	Terrace deposits	Cy, H	......	Top of casing	1.0	19.80	3-27-51	Analysis of water is given in Table 4.
9-13-29bb	NW¼NW¼ sec. 29	Robt. Burgett	Du	54.4	36	R	Sandstone	French Creek-Pony Creek	Cy, H	S	Top of platform	1.2	16.20	10-6-50	
9-13-33bb	NW¼NW¼ sec. 33	Sophia Taylor	Du	75	48	R	do	Dry-Friedrich-French Creek	Cy, W	D	Land surface	0	35	....	
9-13-35aa	NE¼NE¼ sec. 35	School District	Du	35.6	36	R	?	Alluvium?	Cy, H	N	do	0	7.80	10-5-50	Abandoned; formerly a school well.
9-13-36cc	SW¼SW¼ sec. 36	A. Macha	Du	50	62	R	Sandstone	Dry-Friedrich	Cy, H	D,S	do	0	45	....	
	T. 9 S., R. 14 E.														
9-14-4cc	SW¼SW¼ sec. 4	School District	Dr	29.7	6	GI	Sand and gravel	Glacial deposits	Cy, H	N	do	0	10.15	9-16-50	
9-14-21cb	NW¼SW¼ sec. 21	C. A. Moss	Dr	100	6	GI	?	Willard-Tarkio	Cy, E	S	do	0	18	....	
9-14-23cc	SW¼SW¼ sec. 23	School District	Dr	35.1	6	GI	Sandstone	French Creek-Pony Creek	Cy, H	P	Top of casing	0.5	3.57	8-15-50	
9-14-23dc	SW¼SE¼ sec. 23	....	Du	24.7	96	R	Sand	Alluvium	Cy, H	P	Top of platform	4.0	9.55	10-25-49	K.E.R.C. well.
9-14-24aa	NE¼NE¼ sec. 24	....	Dr	84.4	6	GI	Sandstone	Dry-Friedrich	N	N	do	1.3	42.10	10-4-50	Abandoned; formerly a domestic and stock well.
9-14-27ab	NW¼NE¼ sec. 27	C. Palhman	Dr	176	6	GI	do	do	Cy, W	S	Land surface	0	100	....	
	T. 9 S., R. 15 E.														
9-15-3cb	NW¼SW¼ sec. 3	E. Stanley	B	28	36	B	Sand	Glacial deposits	Cy, H	D,S	do	0	17	....	
9-15-3cb	NW¼SW¼ sec. 3	do	Du	30	48	R	Limestone	Dover	Cy, H	S	do	0	20	....	
9-15-3cc	SW¼SW¼ sec. 3	School District	Du	16.8	48	R	Sand and gravel	Glacial de osi s	Cy, H	N	Base of pump	0.8	8.72	8-17-50	
9-15-11ad	SE¼NE¼ sec. 11	J. A. Ehrhart	Du	34.2	72	R	do	do	Cy, H	S	do	0.9	20.31	8-19-50	
9-15-14dd	SE¼SE¼ sec. 14	H. V. Hallaron	Du	32	108	R	Shale	Langdon	Cy, H	D	Top of platform	0.8	17	....	
9-15-23db	NW¼SE¼ sec. 23	Rock Island R. R.	Du	28.8	36	R	Sand	Glacial deposits	Cy, H	D	Top of curb	0.45	7.85	10-24-50	
9-15-26bb	NW¼NW¼ sec. 26	R. W. Burns	Du	33.1	60	R	Sandstone	Dry-Friedrich	Cy, H	D,S	Base of pump	1.0	23.58	8-15-50	
9-15-27cb	NW¼SW¼ sec. 27	K. R. Moravek	Du	17	48	R	Limestone	Elmont	Cy, H	D	Top of platform	1.0	14.50	8-17-50	
9-15-29ca	NE¼SW¼ sec. 29	Edward Bausch	Du	19.5	48	R	do	Tarkio	Cy, H	S	Base of pump	1.3	8.22	8-15-50	Very low yield.
9-15-30ab	NW¼NE¼ sec. 30	L. H. Pensky	Dr	77	6	GI	Sand and gravel	Glacial deposits	Cy, H	D	Land surface	0	32	....	
9-15-34da	NE¼SE¼ sec. 34	Chas. Shaw	Dr	67	6	GI	?	Elmont-Willard	Cy, G	S	do	0	50	....	
	T. 9 S., R. 16 E.														
9-16-3bb	NW¼NW¼ sec. 3	....	Du	54.9	36	R	Limestone	Burlingame-Wakarusa	N	N	do	0	14.14	6-30-50	Reported to be too salty for stock.
9-16-3cc	SW¼SW¼ sec. 3	J. A. Steinmeyer	Du	29.7	36	R	Sand and gravel	Glacial deposits	Cy, H	S	Top of curb	1.3	8.42	11-22-49	
9-16-6bc	SW¼NW¼ sec. 6	Russell Kinkade	Du	60	36	R	do	do	Cy, E	D	Land surface	0	20	....	
9-16-6aa	NE¼NE¼ sec. 6	C. E. Vaught	B	45	28	B	do	do	Cy, H	D	do	0	30	....	
9-16-7bb	NW¼NW¼ sec. 7	....	Du	27.7	120	R	do	do	Cy, H	P	Base of pump	1.9	9.18	6-30-50	K.E.R.C. well.
9-16-7cc	SW¼SW¼ sec. 7	W. C. Sell	Du	23.8	48	R	do	do	Cy, H	D	Top of curb	0.8	18.95	8-8-49	
9-16-9aa	NE¼NE¼ sec. 9	School District	Du	57.8	48	R	Limestone	Elmont	N	N	do	0	7.10	6-30-50	Abandoned; formerly a school well.
9-16-11ba	NE¼NW¼ sec. 11	L. S. Burbank	Du	36.4	30	R	Shale	Auburn	Cy, H	D	Base of pump	0.6	25.40	6-30-50	Very low yield.

TABLE 10.—*Records of wells and springs in Jackson County, Kansas—Concluded*

Well No. (1)	Location	Owner or tenant	Type of well (2)	Depth of well (feet) (3)	Diameter of well (in.)	Type of casing (4)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (5)	Use of water (6)	Measuring point: Description	Measuring point: Distance above land surface (feet)	Depth to water level below measuring point (feet) (7)	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
	T. 9 S., R. 16 E.														
9-16-14db	NW¼SE¼ sec. 14	Finis Colhover	Du	33.0	48	R	Limestone?	Reading?	Cy, H	D,S	Top of curb	0.7	12.37	11-22-50	
9-16-17a	SW¼NE¼ sec. 17	School District	Du	30.0	48	R	Sand and gravel	Glacial deposits	Cy, H	P	do	1.0	8.15	8-8-49	
9-16-19aa	NE¼NE¼ sec. 19	Glenn Mann	Du	37.6	60	R	Limestone	Elmont	Cy, E	D,S	do	2.0	21.55	8-8-49	
9-16-20ca	NE¼SW¼ sec. 20	Louis Long	Du	37	48	R	do	do	Cy, E	D,S	Land surface	0	29	....	
9-16-24cb	NW¼SW¼ sec. 24	....	Du	32.1	192	R	Sand	Alluvium	Cy, H	D,S	Top of curb	3.1	13.25	8-8-49	K.E.R.C. well.
9-16-27dd	SE¼SE¼ sec. 27	School District	Dr	45.9	6	GI	do	do	Cy, H	P	Land surface	0	6.84	6-30-50	
9-16-30dc	SW¼SE¼ sec. 30	K. M. Martin	Dr	115	6	OW	Sandstone	Cedar Vale-Silver Lake	Cy, E	D,S	do	0	50	....	Analysis of water is given in Table 4.
9-16-32bd	SE¼NW¼ sec. 32	H. J. Meggison	Dr	124.0	6	GI	do	do	Cy, H	D	Top of casing	0.7	99.80	8-8-49	

1. Well numbering system described in text.
2. B, bored well; DD, dug and drilled well; Dr, drilled well; Du, dug well; Sp, spring.
3. Reported depths are given in feet; measured depths are given in feet and tenths below measuring points.
4. C, concrete; GI, galvanized sheet iron; OW, oil-well casing; R, rock; W, wood; Ct, clay tile; B, brick.
5. Method of lift: Cy, cylinder; F, natural flow; N, none; T, turbine; J, jet.
   Type of power: E, electric; G, gas engine; H, hand operated; W, windmill.
6. D, domestic; N, not being used; P, public supply; S, stock.
7. Measured depths to water level are given in feet, tenths, and hundredths; reported depths to water level are given in feet.

LOGS OF TEST HOLES

On the pages that follow are listed the logs of 47 test holes drilled in Jackson County and adjoining areas (Pl. 2). The test drilling was localized in areas of thick glacial or alluvial deposits to obtain detailed information on the thickness and character of the unconsolidated sediments overlying the bedrock. The geologic cross sections shown on Plate 3 are based largely on data obtained from this test drilling. The test holes were drilled by the State Geological Survey. The samples were collected and studied in the field, and later examined microscopically in the laboratory by me.

4-15-35cd (Brown County).—Sample log of test hole in the SE¼ SW¼ sec. 35, T. 4 S., R. 15 E., 0.05 mile west of the Cen. S. line sec. 35, drilled November 1948. Surface altitude, 1,160.6 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, noncalcareous, dark-gray	4	4
Till, clay, noncalcareous, sandy, tan	2	6
Till, clay, slightly calcareous, gray	5	11
Till, clay, calcareous, sandy, tan and gray	62.5	73.5
Sand, medium to coarse, and fine gravel; contains clay in the upper part	21.5	95
Till, clay, calcareous, sandy, blue-gray	11	106
Sand, medium to coarse, quartz; contains a little fine gravel	9	115
PERMIAN—Wolfcampian		
Hawxby shale (?)		
Shale, calcareous, light-gray; contains thin soft limestone zones	5	120

4-16-31dd (Brown County).—Sample log of test hole in the SE cor. sec. 31, T. 4 S., R. 16 E., drilled November 1948. Surface altitude, 1,124.1 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, compact, light-brown	4	4
Till, clay, noncalcareous, reddish-tan	4	8
Till, clay, calcareous, light-tan; contains a few caliche pebbles and medium gravel	19	27
Till, clay, calcareous, sandy, light-tan	5	32
Gravel, fine to medium, predominantly quartz	5	37
Till, clay, tan; contains much medium gravel	3	40
Sand, medium to coarse; contains a little clay	10	50
Till, clay, calcareous, tan	14	64
PERMIAN—Wolfcampian		
Towle shale		
Shale, calcareous, tan	4	68
Shale, calcareous, red	8	76
Limestone, light-tan	1	77

4-16-35cd (Brown County).—Sample log of test hole in the SE¼ SW¼ sec. 35, T. 4 S., R. 16 E., 0.35 mile east of the SW cor. sec. 35, drilled November 1948. Surface altitude, 1,125.8 feet.

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, black	2	5
Kansan glacial deposits		
Till, clay, calcareous, sandy, tan	4	9
Sand, medium to coarse; a few gravel	6	15
Till, clay, sandy, tan	2	17
PENNSYLVANIAN—Virgilian		
Brownville limestone		
Limestone, fossiliferous, light-tan	3	20

5-15-18cb.—Sample log of test hole in the NW¼ SW¼ sec. 18, T. 5 S., R. 15 E., 0.15 mile south of the Cen. W. line sec. 18, drilled July 1950. Surface altitude, 1,142.1 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, noncalcareous, gravelly, tan	6	6
Till, clay, calcareous, tan; contains a small amount of sand and gravel	35	41
Till, clay, calcareous, sandy, blue	100	141
Atchison formation		
Sand, very fine	65	206
Pre-Kansan deposits		
Gravel, fine to medium, angular, chert	4	210
PENNSYLVANIAN—Virgilian		
Jim Creek limestone (?)		
Limestone	2	212

5-15-25aa.—Sample log of test hole in the NE¼ NE¼ sec. 25, T. 5 S., R. 15 E., 200 feet south of NE cor. sec. 25, drilled July 1949. Surface altitude, 1,131.4 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, noncalcareous, gray	3	3
Clay, noncalcareous, tan and gray	15	18
Till, clay, noncalcareous, sandy, light-gray	2	20
Sand, medium to coarse, quartz	1	21
Till, clay, noncalcareous, gravelly, light-gray	2	23
Sand, coarse, and fine gravel	3	26
Till, clay, calcareous, tan; contains a little gravel	14	40
Till, clay, blue; contains a little fine gravel	80	120
Atchison formation		
Sand, very fine	43	163

	Thickness, feet	Depth, feet
PENNSYLVANIAN—Virgilian		
Langdon shale		
Shale, calcareous, sandy, gray; contains a trace of red shale	7	170

5-15-31cb.—Sample log of test hole in the NW¼ SW¼ sec. 31, T. 5 S., R. 15 E., 30 feet south of the Cen. W. line sec. 31, drilled July 1950. Surface altitude, 1,167.6 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, slightly calcareous, gravelly, brown	3	3
Till, clay, calcareous, gravelly, tan	37	40
Sand, coarse, and fine gravel	17	57
Till, clay, calcareous, gravelly, blue	8	65
Till, clay, calcareous, very sandy, blue	41	106
Sand, coarse, quartz and feldspar	14	120
Till, clay, calcareous, sandy, blue	25	145
PERMIAN—Wolfcampian		
Falls City limestone(?)		
Limestone, hard	1	146

5-15-36aa.—Sample log of test hole in the NE¼ NE¼ sec. 36, T. 5 S., R. 15 E., 0.2 mile south of NE cor. sec. 36, drilled August 1950. Surface altitude, 1,106.7 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, noncalcareous, tan and brown	3	3
Till, clay, noncalcareous, tan	4	7
Till, clay, calcareous, tan	13	20
Till, clay, calcareous, sandy and gravelly, tan	19	39
Till, clay, calcareous, blue	48	87
Atchison formation		
Sand, very fine	31	118
PENNSYLVANIAN—Virgilian		
Langdon shale		
Shale, calcareous, gray; contains a little hard limestone	8	126

5-16-7cc.—Sample log of test hole in the SW¼ SW¼ sec. 7, T. 5 S., R. 16 E., 90 feet north of the SW cor. sec. 7, drilled August 1950. Surface altitude, 1,014.1 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, noncalcareous, sandy, black	6	6
Silt and clay, noncalcareous, tan	4	10
Silt and clay, noncalcareous, very sandy, dark-gray	14	24
Sand, coarse, quartz	6	30
Sand, coarse, quartz; and fine chert gravel	10	40
PENNSYLVANIAN—Virgilian		
Dry-Friedrich shale		
Shale, noncalcareous, dark-gray to black	10	50

5-16-19bb.—Sample log of test hole in the NW¼ NW¼ sec. 19, T. 5 S., R. 16 E., 130 feet south of the NW cor. sec. 19, drilled August 1950. Surface altitude, 1,120.7 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt, noncalcareous, sandy, black	3	3
Silt and clay, noncalcareous, sandy, reddish-brown	5	8
Till, clay, noncalcareous, sandy, tan	8	16
Till, clay, calcareous, gravelly, tan	14	30
Till, clay, calcareous, very sandy and gravelly, tan	10	40
Till, clay, calcareous, gravelly, blue	30	70
Till, clay, calcareous, very sandy, blue	30	100
Pre-Kansan deposits		
Gravel, coarse and medium, chert	3	103
PENNSYLVANIAN—Virgilian		
French Creek shale		
Shale, noncalcareous, dark-gray to black	12	115
Jim Creek limestone		
Limestone, hard, gray	0.5	115.5

5-16-20aa.—Sample log of test hole in the NE¼ NE¼ sec. 20, T. 5 S., R. 16 E., 0.15 mile south of NE cor. sec. 20, drilled August 1950. Surface altitude, 1,151.0 feet.

	Thickness, feet	Depth, feet
Soil, black	3	3
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, noncalcareous, tan	3	6
Till, clay, noncalcareous, sticky, gray	19	25
Till, clay, noncalcareous, sticky, blue-gray	19	44
Till, clay, calcareous, gravelly, tan	6	50
Till, clay, calcareous, sandy, tan	46	96
PENNSYLVANIAN—Virgilian		
Dry-Friedrich shale		
Shale, calcareous, blue or greenish-gray; limestone at base	4	100

5-16-23aaa.—Sample log of test hole in the NE¼ NE¼ sec. 23, T. 5 S., R. 16 E., a quarter of a mile north of the Delaware River bridge, drilled August 1950. Surface altitude, 987.3 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Terrace deposits (Recent)		
Clay, noncalcareous, tan	15	15
Sand, coarse, and fine quartz gravel	4	19
PENNSYLVANIAN—Virgilian		
Willard shale		
Shale, calcareous, blue	6	25

5-16-23aa.—Sample log of test hole in the NE¼ NE¼ sec. 23, T. 5 S., R. 16 E., 840 feet north of the Delaware River bridge, drilled August 1950. Surface altitude, 976.8 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, noncalcareous, black	6	6
Silt and clay, noncalcareous, tan	3	9
Sand, fine to coarse, and fine to medium gravel	6	15
PENNSYLVANIAN—Virgilian		
Willard shale		
Limestone, very hard	1	16

5-16-23ad.—Sample log of test hole in the SE¼ NE¼ sec. 23, T. 5 S., R. 16 E., 90 feet south of the south end of the Delaware River bridge, drilled August 1950. Surface altitude, 973.9 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, noncalcareous, sandy, black	4	4
Silt and clay, noncalcareous, black	6	10
Silt, noncalcareous, very soft, black	10	20
Silt, noncalcareous, gravelly, greenish-black	11	31
PENNSYLVANIAN—Virgilian		
Willard shale		
Shale, sandy, micaceous, tan, and weathered sandy limestone	5	36
Shale, calcareous, blue	2	38

5-16-29dd.—Sample log of test hole in the SE¼ SE¼ sec. 29, T. 5 S., R. 16 E., 200 feet north of SE cor. sec. 29, drilled August 1950. Surface altitude, 1,114.9 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, noncalcareous, tan	5	5
Clay, noncalcareous, reddish-tan	9	14
Till, clay, calcareous, sandy and gravelly, tan	26	40
Till, clay, calcareous, sandy and gravelly, reddish-tan,	13	53
PENNSYLVANIAN—Virgilian		
Dry-Friedrich		
Limestone or limy shale, red	2	55
Shale, calcareous, micaceous, red and green	5	60
Shale, slightly calcareous, sandy, micaceous, greenish-tan	6	66

6-13-1ab.—Sample log of test hole in the NW¼ NE¼ sec. 1, T. 6 S., R. 13 E., 200 feet east of the Cen. N. line sec. 1, drilled July 1950. Surface altitude, 1,285.5 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Clay, noncalcareous, gravelly, tan	6	6
Sand and gravel, much calcareous material	4	10
Till, clay, calcareous, gray and tan	17	27

	Thickness, feet	Depth, feet
Till, clay, calcareous, gravelly, blue	23	50
Boulder, limestone	1	51
Till, clay, calcareous, gravelly, blue	9	60
PERMIAN—Wolfcampian		
Beattie limestone (?)		
Shale, calcareous, green	4	64
Limestone, hard, white	1	65

6-13-13cd.—Sample log of test hole in the SE¼ SW¼ sec. 13, T. 6 S., R. 13 E., 500 feet west of the Cen. S. line sec. 13, drilled July 1950. Surface altitude, 1,270.8 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Clay and silt, noncalcareous, brown	3	3
Till, clay, clacareous, gravelly, tan	14	17
Till, clay, calcareous, sandy, gray	9	26
Till, clay, calcareous, gravelly, tan	15	41
Gravel, fine	8	49
Till, clay, calcareous, sandy, blue	41	90
Till, clay, calcareous, green	6	96
Till, clay, calcareous, sandy, blue	42	138
Pre-Kansan deposits		
Gravel, fine to medium, chiefly angular limestone	12	150
PERMIAN—Wolfcampian		
Grenola limestone		
Limestone, hard, gray	1	151

6-13-31aa.—Sample log of test hole in NE¼ NE¼ sec. 31, T. 6 S., R. 13 E., 575 feet south of NE cor. sec. 31, drilled July 1950. Surface altitude, 1,333.4 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, noncalcareous, brown	5	5
Till, clay, calcareous, gravelly, tan and gray	31	36
Sand and gravel; a few thin clay beds	3	39
PERMIAN—Wolfcampian		
Easly Creek shale		
Shale, calcareous, red and gray	10	49
Limestone, gray	1	50

6-14-9dd.—Sample log of test hole in the SE¼ SE¼ sec. 9, T. 6 S., R. 14 E., 0.2 mile north of the SE cor. sec. 9, drilled June 1949. Surface altitude, 1,260.0 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, noncalcareous, tan	4	4
Till, clay, calcareous, tan; contains much caliche and a little fine gravel	9	13
Till, clay, calcareous, gravelly, tan	48	61
Till, clay, calcareous, gravelly, blue	38	99

	Thickness, feet	Depth, feet
Gravel, fine to medium	4	103
Till, clay, calcareous, blue	5	108
Gravel, fine, and coarse sand	12	120
Sand, coarse, and blue calcareous clay	4	124
Till, clay, calcareous, blue	5	129
Gravel, fine, chiefly limestone and chert	1	130
Till, clay, calcareous, sandy, blue	21	151
PERMIAN—Wolfcampian		
Grenola limestone		
Limestone, hard, gray	0.5	151.5

6-14-22bb.—Sample log of test hole in the NW¼ NW¼ sec. 22, T. 6 S., R. 14 E., 0.15 mile east of NW cor. sec. 22, drilled July 1950. Surface altitude, 1,198.7 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, calcareous, gravelly, brown	4	4
Till, clay, calcareous, gravelly, tan and gray	14	18
Till, clay, calcareous, sandy, tan and gray	20	38
Till, clay, calcareous, gravelly, tan and gray	2	40
Till, clay, calcareous, sandy, blue	30	70
Gravel, fine to medium, and blue clay	13	83
Till, clay, calcareous, sandy, blue	13	96
Sand, medium to coarse, quartz	5	101
Till, clay, calcareous, very sandy, blue	16	117
PERMIAN—Wolfcampian		
Foraker limestone		
Limestone, yellow	1	118
Shale, calcareous, gray	2	120
Limestone, dark-gray to blue	1.5	121.5

6-15-1aa.—Sample log of test hole in the NE¼ NE¼ sec. 1, T. 6 S., R. 15 E., 10 feet north of the SE cor. NE¼ NE¼ sec. 1, drilled June 1949. Surface altitude, 1,084.5 feet.

	Thickness, feet	Depth, feet
Soil, noncalcareous, black	2.5	2.5
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Till, clay, noncalcareous, gravelly, tan	3.5	6
Till, clay, calcareous, gravelly, gray	2	8
Till, clay, calcareous, gravelly, tan	39	47
Till, clay, calcareous, sandy, blue	26	73
Atchison formation		
Sand, very fine	82	155
Gravel, fine, chert and quartzite	1.5	156.5
PENNSYLVANIAN—Virgilian		
Elmont limestone		
Limestone, gray	0.5	157

6-15-19bc.—Sample log of test hole in the SW¼ NW¼ sec. 19, T. 6 S., R. 15 E., 0.3 mile south of the NW cor. sec. 19, drilled July 1950. Surface altitude, 1,182.1 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, noncalcareous, brown	3	3
Till, clay, moderately calcareous, tan	7	10
Till, clay, calcareous, gravelly, tan	44	54
Till, clay, sandy, blue-gray	6	60
Sand, very coarse, and blue clay	5	65
Till, clay, calcareous, blue	9	74
Sand, very coarse, quartz	23	97
Till, clay, calcareous, sandy, blue	33	130
PERMIAN—Wolfcampian		
West Branch-Hamlin Shale		
Shale, calcareous, gray with trace of pink	5	135

6-15-21aa.—Sample log of test hole in the NE¼ NE¼ sec. 21, T. 6 S., R. 15 E., 200 feet south of the NE cor. sec. 21, drilled August 1950. Surface altitude, 1,141.7 feet.

	Thickness, feet	Depth, feet
Soil, black	3	3
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Till, clay, noncalcareous, tan	3	6
Till, clay, calcareous, tan	4	10
Till, clay, calcareous, gravelly	28	38
Till, clay, calcareous, sandy, blue	32	70
Gravel, fine to medium, and blue clay	17	87
Sand, coarse, and fine gravel	6	93
Gravel, medium, and coarse sand	24	117
PENNSYLVANIAN—Virgilian		
French Creek shale		
Shale, fossiliferous, dark-gray, and hard gray limestone	3	120

6-15-25dd.—Sample log of test hole in the SE¼ SE¼ sec. 25, T. 6 S., R. 15 E., 0.2 mile north of the SE cor. sec. 25, drilled June 1949. Surface altitude, 1,098.9 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Clay, noncalcareous, sandy, reddish-tan	5	5
Till, clay, calcareous, tan; contains a little gravel and caliche	15	20
Till, calcareous, tan; contains a little gravel and fine sand	5	25
Till, calcareous, gravelly, tan	5	30
Till, calcareous, sandy, blue-gray	7	37
Till, calcareous, sandy, reddish-tan	4	41

	Thickness, feet	Depth, feet
Gravel, fine to medium	9	50
Sand, coarse; contains a little fine gravel	10	60
Gravel, fine to coarse, quartz	8	68
PENNSYLVANIAN—Virgilian		
Dry-Friedrich shale		
Shale, slightly calcareous, micaceous, blue-gray	7	75

6-16-7bb.—Sample log of test hole in the NW¼ NW¼ sec. 7, T. 6 S., R. 16 E., 40 feet south of the NW cor. sec. 7, drilled August 1950. Surface altitude, 993.0 feet.

	Thickness, feet	Depth, feet
Soil	5	5
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt and clay, noncalcareous, gray	10	15
Clay, noncalcareous, blue-gray	11	26
Sand, medium to coarse, and medium gravel	14	40
Atchison formation		
Sand, very fine, quartz	18	58
Sand, medium to coarse, and fine gravel	9	67
PENNSYLVANIAN—Virgilian		
Willard shale		
Shale, calcareous, gray	8	75

6-16-7bc.—Sample log of test hole in the SW¼ NW¼ sec. 7, T. 6 S., R. 16 E., 130 feet north of the Cen. W. line sec. 7, drilled August 1950. Surface altitude, 991.4 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, noncalcareous, sandy, black	6	6
Clay, noncalcareous, gray	9	15
Sand, medium, quartz	11	26
Sand, coarse, quartz; and fine gravel	12	38
Atchison formation		
Sand, very fine	12	50
Sand, coarse, and fine to medium gravel	13	63
PENNSYLVANIAN—Virgilian		
Willard shale		
Shale, calcareous, gray-green	7	70

6-16-7cc.—Sample log of test hole in the SW¼ SW¼ sec. 7, T. 6 S., R. 16 E., 0.15 mile north of the SW cor. sec. 7, drilled August 1950. Surface altitude, 993.0 feet.

	Thickness, feet	Depth, feet
Soil, black	4	4
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Clay, noncalcareous, black	6	10
Clay, noncalcareous, tan	8	18

	Thickness, feet	Depth, feet
Clay, slightly calcareous, tan	7	25
Sand, medium, quartz; and fine gravel	15	40
Sand, coarse, and fine to medium gravel	20	60
Atchison formation		
Sand, very fine	14	74
Gravel, medium, quartz and chert	3	77
PENNSYLVANIAN—Virgilian		
Willard shale		
Shale, calcareous, gray-green	3	80

6-16-11bb.—Sample log of test hole in the NW¼ NW¼ sec. 11, T. 6 S., R. 16 E., 200 feet east of the NW cor. sec. 11, drilled August 1950. Surface altitude, 1,092.4 feet.

	Thickness, feet	Depth, feet
Soil, noncalcareous, black	3	3
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Till, clay, noncalcareous, gray and tan	15	18
Till, clay, calcareous, sandy, tan	24	42
Sand, medium to coarse, and medium quartz gravel	8	50
Till, clay, calcareous, gravelly, blue	25	75
PENNSYLVANIAN—Virgilian		
Maple Hill limestone		
Limestone, hard, brown	1	76

6-16-19bb.—Sample log of test hole in the NW¼ NW¼ sec. 19, T. 6 S., R. 16 E., 400 feet south of the NW cor. sec. 19, drilled August 1950. Surface altitude, 1,092.5 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt, noncalcareous, brown	2	2
Till, clay, calcareous, gravelly, tan	34	36
Till, clay, calcareous, gravelly, blue	24	60
Till, clay, calcareous, sandy, blue	17	77
Gravel, fine to medium, chert and quartz	5	82
Till, clay, calcareous, very sandy, blue	18	100
Atchison formation		
Sand, very fine	28	128
Gravel, fine to medium, mostly limestone	12	140
PENNSYLVANIAN—Virgilian		
Willard shale		
Shale, calcareous, blue-gray	20	160

6-16-21aa.—Sample log of test hole in the NE¼ NE¼ sec. 21, T. 6 S., R. 16 E., 0.2 mile south of the NE cor. sec. 21, drilled August 1950. Surface altitude, 1,074.2 feet.

	Thickness, feet	Depth, feet
Soil, noncalcareous, sandy, black	2	2
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Till, clay, calcareous, sandy, tan	3	5
Till, clay, calcareous, tan	8	13
Sand, medium to coarse, and fine gravel	3	16
Till, clay, calcareous, sandy, tan	9	25
Till, clay, calcareous, tan	28	53
Till, clay, calcareous, sandy, blue	17	70
Atchison formation		
Sand, very fine	86	156
Gravel, fine, limestone and quartz	19	175
PENNSYLVANIAN—Virgilian		
Shale, calcareous, blue	4	179

6-16-31cc.—Sample log of test hole in the SW¼ SW¼ sec. 31, T. 6 S., R. 16 E., midway between the 3rd and 4th power poles north of the SW cor. sec. 31, drilled July 1950. Surface altitude, 990.1 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, noncalcareous, black	4	4
Silt and clay, noncalcareous, gray	8	12
Clay, noncalcareous, gray-green	14	26
Silt and clay, noncalcareous, black	11	37
Sand, medium to coarse, quartz; and fine gravel	8	45
PENNSYLVANIAN—Virgilian		
Elmont limestone		
Limestone, dark-gray	1	46

6-16-31ccc.—Sample log of test hole in the SW¼ SW¼ sec. 31, T. 6 S., R. 16 E., 35 feet east of the SW cor. sec. 31, drilled July 1950. Surface altitude, 985.6 feet.

	Thickness, feet	Depth, feet
Road fill	4	4
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt and clay, noncalcareous, gray	11	15
Clay, noncalcareous, sandy, greenish-gray	5	20
Sand, medium and coarse; contains numerous snail shells	10	30
Sand, coarse, quartz, and fine gravel	8	38
PENNSYLVANIAN—Virgilian		
Elmont limestone		
Limestone, dark-blue	.5	38.5
Shale, dark-gray	1.5	40

6-16-36aa.—Sample log of test hole in the NE¼ NE¼ sec. 36, T. 6 S., R. 16 E., 0.2 mile south of the NE cor. sec. 36, drilled August 1950. Surface altitude, 1,031.2 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt, noncalcareous, gravelly, brown	2	2
Till, clay, noncalcareous, gravelly, tan	18	20
Till, clay, calcareous, gravelly, tan	16	36
Till, clay, calcareous, gravelly, blue	34	70
Atchison formation		
Sand, very fine	31	101
Silt, calcareous, blue and very fine sand	6	107
Sand, very fine	25	132
Pre-Kansan deposits		
Gravel, fine to medium, chert and limestone	7	139
PENNSYLVANIAN—Virgilian		
Cedar Vale shale		
Shale, calcareous, sandy, blue-gray	7	146

7-14-3bb.—Sample log of test hole in the NW¼ NW¼ sec. 3, T. 7 S., R. 14 E., 0.2 mile south of the NW cor. sec. 3, drilled June 1949. Surface altitude, 1,256.3 feet.

	Thickness, feet	Depth, feet
Soil, black	1	1
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Till, clay, calcareous, sandy, tan	9	10
Till, clay, calcareous, gravelly, tan	39	49
Till, clay, calcareous, gravelly, blue	2	51
Till, clay, calcareous, blue	56	107
Gravel, fine to medium, limestone and quartz	13	120
Till, clay, calcareous, blue	4	124
PERMIAN—Wolfcampian		
Roca shale(?)		
Shale, calcareous, yellow and gray	3	127

7-14-36dd.—Sample log of test hole in the SE¼ SE¼ sec. 36, T. 7 S., R. 14 E., 300 feet north of the SE cor. sec. 36, drilled August 1950. Surface altitude, 1,257.7 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Till, clay, gravelly, brown	4	4
Till, clay, gravelly, gray	6	10
Till, clay, tan and yellow	10	20
Till, clay, calcareous, gravelly, tan	20	40
Till, clay, calcareous, sandy, gray	17	57
Sand, very fine	6	63

	Thickness, feet	Depth, feet
Till clay, calcareous, sandy, tan	27	90
Till, clay, calcareous, sandy, blue	6	96
PERMIAN—Wolfcampian		
Hughes Creek shale(?)		
Shale, calcareous, blue-black	14	110

7-15-1aa.—Sample log of test hole in the NE¼ NE¼ sec. 1, T. 7 S., R. 15 E., 65 feet south of south end of Elk Creek bridge, drilled July 1950. Surface altitude, 986.9 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, noncalcareous, black	4	4
Silt, very loose, brown	13	17
Sand, coarse, and fine quartz gravel	9	26
Clay, calcareous, sandy, gray-green	5	31
Sand, coarse, and coarse quartz and chert gravel	14	45
PENNSYLVANIAN—Virgilian		
Harveyville shale		
Shale, calcareous, gray	5	50

7-15-6bb.—Sample log of test hole in the NW¼ NW¼ sec. 6, T. 7 S., R. 15 E., 400 feet south of the NW cor. of sec. 6, drilled July 1950. Surface altitude, 1,137.7 feet.

	Thickness, feet	Depth, feet
Soil	2	2
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt, and clay, noncalcareous, brown	4	6
Till, clay, calcareous, sandy, tan	37	43
Till, clay, calcareous, sandy, blue	77	120
Gravel, fine, and blue calcareous clay	9	129
PENNSYLVANIAN—Virgilian		
Pony Creek shale		
Shale, red	3	132
Limestone, gray	2	134
Shale, calcareous, gray-green	1	135

7-15-19bb.—Sample log of test hole in the NW¼ NW¼ sec. 19, T. 7 S., R. 15 E., 0.15 mile east of the NW cor. sec. 19, drilled July 1950. Surface altitude, 1,170.5 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Till, clay, noncalcareous, gravelly, tan	17	17
Till, clay, noncalcareous, very sandy, tan	7	24
Till, clay, calcareous, blue	3.5	27.5
Sand, medium to coarse	2.5	30

	Thickness, feet	Depth, feet
Till, calcareous, blue	8	38
Sand and clay, calcareous, tan	2	40
Till, clay, calcareous	24	64
PERMIAN—Wolfcampian		
Hamlin shale		
Shale, calcareous, blue-gray	9	73

8-15-7dd.—Sample log of test hole in the SE¼ SE¼ sec. 7, T. 8 S., R. 15 E., 386 feet west of the SE cor. sec. 7, drilled July 1950. Surface altitude, 1,219.0 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Silt and clay, noncalcareous, gravelly, tan	4	4
Till, clay, calcareous, sandy, tan	21	25
Till, clay, calcareous, gravelly, tan	20	45
Till, clay, calcareous, gray and tan	2	47
Till, clay, calcareous, sandy and gravelly, blue	18	65
PERMIAN—Wolfcampian		
Hamlin shale		
Shale, calcareous, blue-gray	13	78

8-15-22bb.—Sample log of test hole in the NW¼ NW¼ sec. 22, T. 8 S., R. 15 E., 20 feet east of the NW cor. sec. 22, drilled July 1950. Surface altitude, 1,181.3 feet.

	Thickness, feet	Depth, feet
Road fill	4	4
QUATERNARY—Pleistocene		
Kansan glacial deposits		
Till, clay, noncalcareous, sandy, gray	6	10
Till, clay, noncalcareous, gravelly, tan	17	27
Till, clay, calcareous, sandy, blue	13	40
Till, clay, calcareous, sandy, tan	7	47
Till, clay, calcareous, sandy, blue	32.5	79.5
PERMIAN—Wolfcampian		
Towle shale		
Shale, blue-gray	8.5	88
PENNSYLVANIAN—Virgilian		
Brownville limestone		
Limestone, gray	2	90
Pony Creek shale		
Shale, light-gray	7	97

9-13-19aa.—Sample log of test hole in the NE¼ NE¼ sec. 19, T. 9 S., R. 13 E., on the south road shoulder 120 feet west of the Union Pacific Railroad track, drilled July 1950. Surface altitude, 979.0 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, gray-black	3	3
Silt, noncalcareous, black	4	7
Silt and clay, noncalcareous, tan	13	20
Silt and clay, calcareous, black; contains many snail shells	22	42
Sand, medium to coarse, quartz and limestone; contains a little green calcareous shale, and medium to coarse gravel	5	47
PENNSYLVANIAN—Virgilian		
French Creek shale		
Shale, gray and bluish-gray	3	50

9-13-19ab.—Sample log of test hole in the NW¼ NE¼ sec. 19, T. 9 S., R. 13 E., 25 feet south of the 4th power pole east of Cross Creek, drilled July 1950. Surface altitude, 981.1 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, black	7	7
Silt and clay, brown	3	10
Clay, calcareous, brown	20	30
Silt and clay, calcareous, black	7	37
Clay, calcareous, greenish-gray	7.5	44.5
Sand, coarse, and fine to medium gravel	3.5	48
PENNSYLVANIAN—Virgilian		
French Creek shale		
Shale, gray; trace of red shale and coal near top	9	57

9-13-19ba.—Sample log of test hole in the NE¼ NW¼ sec. 19, T. 9 S., R. 13 E., 210 feet west of the west end of Cross Creek bridge, drilled July 1950. Surface altitude, 976.8 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, black	6	6
Silt and clay, calcareous, sandy, tan	10	16
Silt, calcareous, black	10	26
Sand, medium to coarse, green, and fine gravel	13.5	39.5
PENNSYLVANIAN—Virgilian		
French Creek shale		
Shale, red	3.5	43
Shale, blue-gray, and soft impure limestone	3	46

9-13-19bb.—Sample log of test hole in the NW¼ NW¼ sec. 19, T. 9 S., R. 13 E., 600 feet east of the NW cor. sec. 19, drilled July 1950. Surface altitude, 989.0 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, black	3	3
Silt and clay, gray-black	4	7
Clay, calcareous, tan	15.5	22.5
Silt and clay, calcareous	23	45.5
PENNSYLVANIAN—Virgilian		
French Creek shale		
Shale, calcareous, hard, greenish-gray	1.5	47

9-14-29bd.—Sample log of test hole in the SE¼ NW¼ sec. 29, T. 9 S., R. 14 E., 250 feet west of the Cen. sec. 29, drilled July 1950. Surface altitude, 990.0 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, black	3	3
Clay, gray	4	7
Clay, calcareous, tan to buff	16.5	23.5
Sand, fine to medium, quartz	5	28.5
PENNSYLVANIAN—Virgilian		
Maple Hill limestone		
Limestone, yellow	1.5	30

9-14-29bc.—Sample log of test hole in the SW¼ NW¼ sec. 29, T. 9 S., R. 14 E., 0.15 mile east of the Cen. W. line sec. 29, drilled July 1950. Surface altitude, 971.8 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, black	4	4
Clay, gray	10	14
Clay, brown	6	20
Clay, calcareous, sandy, tan	5	25
Sand, fine to medium, and fine gravel	4.5	29.5
PENNSYLVANIAN—Virgilian		
Willard shale		
Shale, calcareous, hard, gray	6.5	36

9-14-30ac.—Sample log of test hole in the SW¼ NE¼ sec. 30, T. 9 S., R. 14 E., 0.15 mile east of the Cen. sec. 30, drilled July 1950. Surface altitude, 967.9 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, black	3	3
Clay, brown	16	19
Clay, sandy, brown	6	25
Silt, black	13	38
Clay, calcareous, greenish	7	45
Sand, medium, and fine to medium gravel	4	49
PENNSYLVANIAN—Virgilian		
Willard shale		
Shale, gray	4	53

9-14-30ad.—Sample log of test hole in the SE¼ NE¼ sec. 30, T. 9 S., R. 14 E., 0.2 mile west of the Cen. E. line sec. 30, drilled July 1950. Surface altitude, 966.8 feet.

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium (Recent)		
Silt, black	10	10
Silt and clay, brown	11	21
Sand and silt, black	18.5	39.5
Silt and clay, sandy, tan	7.5	47
Sand, medium to coarse; contains a little fine gravel	3	50
PENNSYLVANIAN—Virgilian		
Willard shale		
Shale, calcareous, blue-black	3	53

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AREAL GEOLOGY OF JACKSON COUNTY, KANSAS

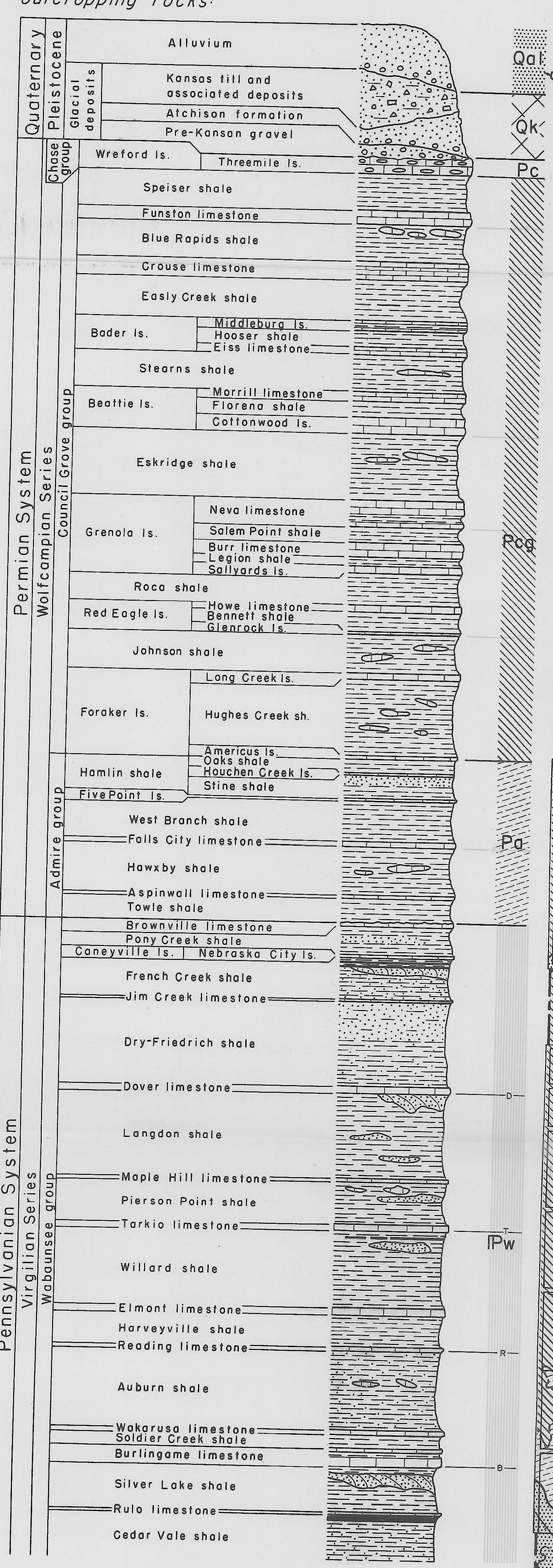
By Kenneth L. Walters
1950

State Geological Survey of Kansas

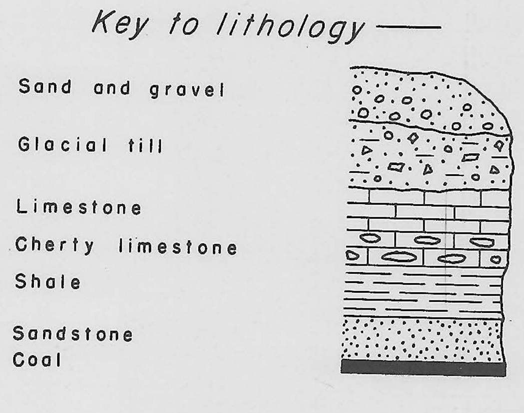
Bulletin 101
Plate 1

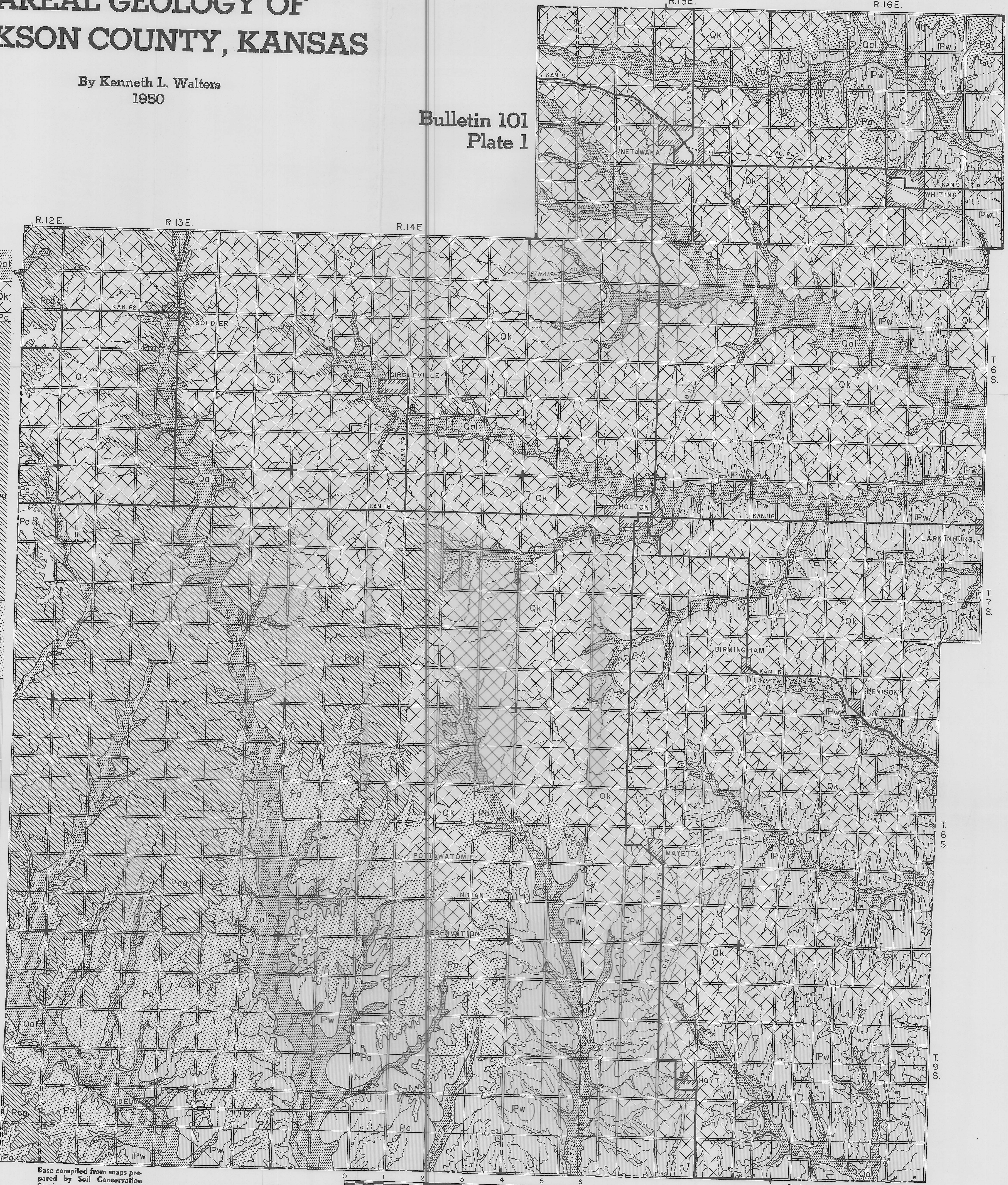
EXPLANATION

Generalized stratigraphic column of outcropping rocks:



Key to lithology —





Base compiled from maps prepared by Soil Conservation Service

0 1 2 3 4 5 6
SCALE IN MILES

Drainage from map prepared by U. S. Dept. of Agriculture

MAP OF JACKSON COUNTY, KANSAS

Showing the Location of Wells and Test Holes for which Records are given, and Ground-Water Regions

By Kenneth L. Walters
1950

State Geological Survey of Kansas

Bulletin 101
Plate 2

EXPLANATION

- Domestic and stock wells
- Public supply well
- Observation well
- Spring
- Test hole

[69/95]

Upper number is the depth to water level below land surface, in feet. Lower number is the depth of well below land surface, in feet.

Brackets indicate that water analysis is given.

- Federal or State Highway
- Graded road
- Ungraded road
- Section line (no road)
- Township line (no road)
- County line (no road)
- Railroad
- Perennial stream
- Intermittent stream

Ground-Water Regions

A — The principal aquifers are sand and gravel deposited as alluvial fill. Wells range in depth from 15 to 50 feet, and yield moderate to large quantities of water. The water is of a good quality.

B — Glacial till and associated deposits are the principal aquifers in these regions. The depth of wells and the quantity and quality of water available are extremely variable.

C — Permian rocks from the base of the Wreford limestone to the Grenola limestone are the principal aquifers in these regions. Wells yield moderate to large quantities of water which is, in general, of a good quality.

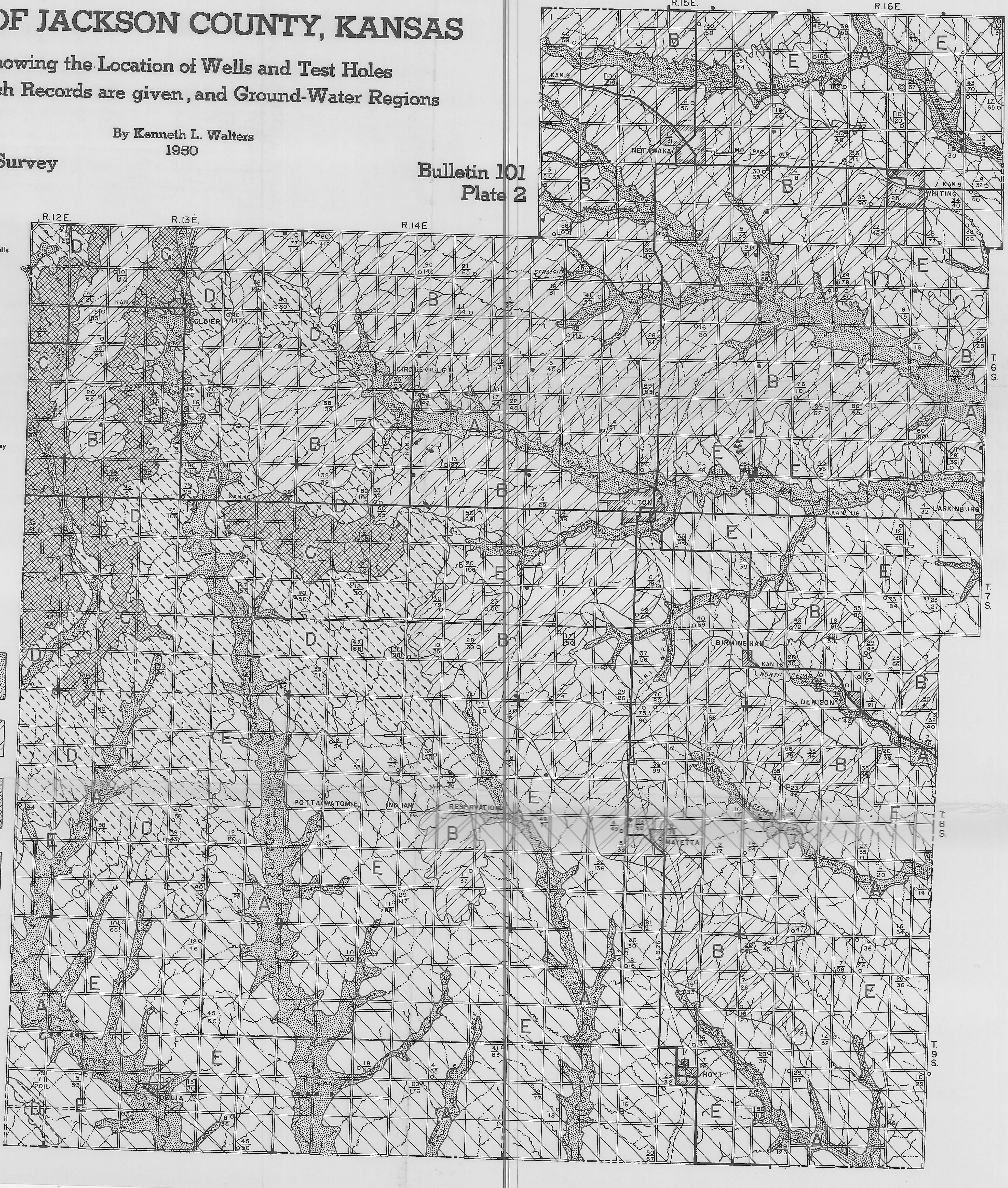
D — Permian rocks of the Council Grove group underlying the Grenola limestone are the chief aquifers in these regions. Wells yield only moderate quantities of water.

E — Pennsylvanian rocks and Permian rocks of the Admire group yield small quantities of water to wells in these regions. The quality of water depends largely on the depth of the wells.

Base compiled from maps prepared by Soil Conservation Service

Drainage from map prepared by U. S. Dept. of Agriculture

0 1 2 3 4
SCALE IN MILES



GEOLOGIC CROSS SECTIONS IN JACKSON COUNTY, KANSAS

by Kenneth L. Walters
1950

State Geological Survey of Kansas

Bulletin 101, Plate 3