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BULLETIN 100

GEOLOGY AND GROUND-WATER RESOURCES OF CHEYENNE COUNTY, KANSAS

By GLENN C. PRESCOTT, JR.
(U. S. Geological Survey)

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

Printed by authority of the State of Kansas
Distributed from Lawrence

UNIVERSITY OF KANSAS PUBLICATION
APRIL, 1953

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1953

24-5034

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GEOLOGY AND GROUND-WATER RESOURCES OF CHEYENNE COUNTY, KANSAS

By Glenn C. Prescott, Jr.

ABSTRACT

This report describes the geography, geology, and ground-water resources of Cheyenne County in the northwestern corner of Kansas. The county has an area of about 1,027 square miles and in 1950 had 5,668 inhabitants. Cheyenne County lies within the High Plains section of the Great Plains physiographic province and consists of flat to rolling upland plains with the exception of the northern part of the county and the area adjacent to South Fork Republican River, which are deeply dissected. South Fork runs northeastward nearly through the center of the county and into Dundy County, Nebraska. South Fork and its tributaries drain much of Cheyenne County but an area in the vicinity of Bird City has no surface drainage outlet. The climate is semiarid, the normal annual precipitation being about 18 inches and the average annual temperature being about 52° F. Farming and livestock raising are the principal occupations in the county. A small acreage is under irrigation.

The outcropping rocks in Cheyenne County are sedimentary and range in age from late Cretaceous to Recent. The report contains a map showing the surficial geology and cross sections showing subsurface relations. Much of the county is underlain by the Tertiary Ogallala formation, which is generally covered by wind-blown silts of the Sanborn formation. The Pierre shale of late Cretaceous age, the oldest outcropping formation in the county, is exposed in several areas. The Ogallala is the principal water-bearing formation in the county but the alluvium of South Fork and other streams also yields water to wells.

The report contains a map showing the location of wells for which records were obtained and showing by means of shading the depths to water level. The depth to the water table ranges from less than 10 feet to nearly 275 feet. Included in the report is a contour map showing the shape and slope of the water table. The configuration of the Pierre shale also is shown by contours, and a map showing the thickness of water-bearing materials is included.

The ground-water reservoir is recharged principally by precipitation that falls within the county or in adjacent areas to the west, southwest, and south. Ground water is discharged through transpiration and evaporation, by springs, by discharge into streams, by subsurface movement into adjacent areas, and by wells. Most of the domestic, stock, public, and irrigation supplies are obtained from wells.

Irrigation is practiced to a limited extent in Cheyenne County along South Fork and in the uplands south of Bird City. Yields of wells in the alluvium of South Fork generally are small because of the thinness of the water-bearing materials. Yields of upland wells tapping the Ogallala formation are larger, but depths to water level are much greater in the uplands, increasing the cost of irrigating.

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Analyses of 20 samples of ground water are given, together with a discussion of the principal chemical constituents in relation to use. The analyses indicate that waters from the Ogallala formation and alluvial deposits are suitable for most purposes although moderately hard. Water from alluvial deposits is generally higher in dissolved solids than water from the Ogallala formation. The field data upon which this report is based are given in tables. They include records of 361 wells and 1 spring, chemical analyses of 20 water samples from representative wells, and logs of 44 test holes and 2 irrigation wells.

INTRODUCTION

Purpose and Scope of the Investigation

The study of the geology and ground-water resources of Cheyenne County, Kansas, is one of a series begun in Kansas in 1937 by the United States Geological Survey and the State Geological Survey of Kansas with the cooperation of the Division of Sanitation of the State Board of Health and the Division of Water Resources of the State Board of Agriculture.

These detailed surveys of county areas or major stream valleys are made to evaluate both the quantity and quality of ground water and the possibilities of increasing the use of available ground water.

Ground water is a principal natural resource of Cheyenne County. Nearly all public, domestic, and stock water supplies are obtained from wells. Ground water is used to some extent for irrigation, a use which probably will increase in the future. Although the danger of seriously depleting the supply of ground water is slight at the present rate of pumping, there is a definite need for an adequate understanding of the quality and quantity of the available supply, of where additional supplies can be obtained, and of what may be necessary to safeguard them from depletion.

The field work upon which this report is based was done during the summer and fall of 1950. During this period test holes were drilled, private and municipal wells were measured, water samples were collected, and the surface and subsurface geology of the county were studied and mapped.

The investigation was made under the general administration 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 in charge of ground-water studies in Kansas.

Location and Extent of the Area

Cheyenne County is in the High Plains section of the Great Plains physiographic province. The county is in the northwest

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corner of the State and is bounded on the north by Dundy County, Nebraska, on the east by Rawlins County, Kansas, on the south by Sherman County, Kansas, and on the west by Yuma County, Colorado (Fig. 1). Cheyenne County contains all or part of 30 townships (from T. 1 S. to T. 5 S. and from R. 37 W. to R. 42 W.) having an area of approximately 1,027 square miles.

Methods of Investigation

The data upon which this report is based were obtained during about 5 months in the summer and fall of 1950. In the spring of 1946 Delmar W. Berry made an inventory of wells in the valley of the South Fork Republican River, which is referred to in this report for brevity as South Fork. Most of the irrigation wells in the valley at that time were included in the inventory. He also established 22 observation wells in and near the valley, and semimonthly measurements of most of these wells have been made since 1946.

Data have been obtained on 361 wells and 1 spring, most of the wells being measured with a steel tape to determine their depth and the depth to water level. Well owners and drillers were interviewed concerning yield of wells and type of water-bearing materials. A pumping test was made on an irrigation well to determine the yield of the well and the permeability of the water-bearing materials. Samples of water were collected from 17 wells and 1 spring; the samples were analyzed in the Water and Sewage Labora-

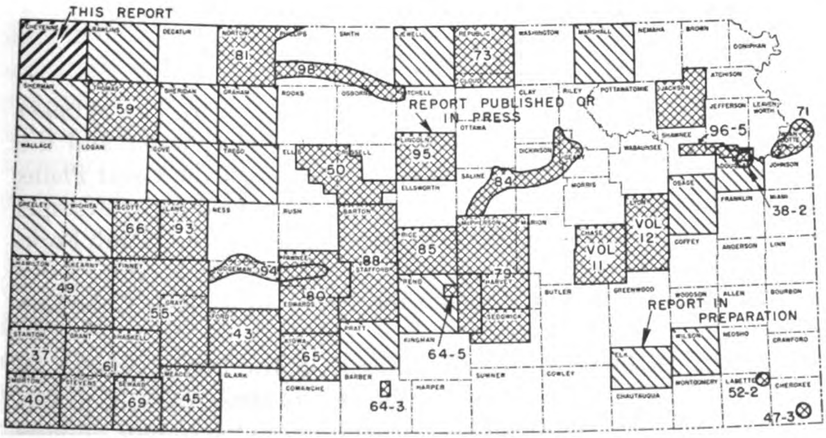

Fig. 1.—Index map of Kansas showing area covered by this report and other areas for which cooperative ground-water reports have been published or are in preparation.

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tory of the State Board of Health at Lawrence by Howard A. Stoltenberg, chemist.

During the investigation the surficial geology was studied and the geologic map (Pl. 1) was prepared. The character of the material beneath the land surface was determined by drilling 41 test holes through the entire thickness of water-bearing materials into the underlying Cretaceous Pierre shale. These test holes were drilled with the portable hydraulic-rotary drilling machine owned by the State Geological Survey of Kansas and operated by William T. Connor and Earl L. Gorman. Laurence E. Gnagy collected and studied samples of the well cuttings in the field and prepared logs of the test holes. The altitude of the ground surface at the test holes and of the measuring points of the wells inventoried in 1950 were determined by level parties headed by Woodrow W. Wilson and Charles K. Bayne. Altitudes of measuring points of wells inventoried in 1946 were determined by personnel of the U. S. Bureau of Reclamation.

The wells shown on Plates 1 and 2 were located within the sections by the use of an odometer. The base map used in these plates was prepared by Woodrow W. Wilson from a county map compiled by the Soil Conservation Service, U. S. Department of Agriculture. The locations of the roads were corrected, where necessary, from observations in the field and from topographic maps of the U. S. Geological Survey. The geologic mapping was done on a map obtained from the Soil Conservation Service, and drainage was adapted from maps issued by the Soil Conservation Service.

Previous Investigations

The earliest reference to Cheyenne County is by Hay (1895) who discussed the source and quantity of ground water and the geology and water-bearing formations of a part of the Great Plains along the Kansas-Colorado State line and mentioned early attempts to irrigate in the county with water from wells and from South Fork. Several geologic cross sections were included in the report. A report by Newell (1896) contained records of 43 wells in Cheyenne County.

Three papers by Haworth in 1897 (1897, 1897a, 1897b) mentioned South Fork in Cheyenne County, and one of these (1897b, p. 99) noted the diversity of ground-water conditions in the county. Logan (1897) discussed the Pierre shale in Cheyenne County, and included a geologic cross section from St. Francis to Arikaree River. Johnson

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(1901, 1902) made special reference to the source, availability, and use of ground water in western Kansas, and Darton (1905, p. 292) briefly discussed geologic and hydrologic conditions in Cheyenne County. Parker (1911) included an analysis of water from a well at St. Francis, and Wolff (1911) made a detailed study of ground-water conditions along South Fork near St. Francis. Haworth (1913) also discussed the South Fork.

Elias's (1931) report on the geology of Wallace County described in detail several geologic formations that crop out in Cheyenne County. A report on the geology of Rawlins and Decatur Counties (Elias, 1937) devoted a section to deep-well irrigation south of Bird City in Cheyenne County and Landes (1937) mentioned briefly the water supplies. In 1940 Moore and others (1940) prepared a generalized report on the ground-water resources of the State. A report on the geology and ground-water resources of Sherman County, which borders Cheyenne County on the south, is now in press (Prescott, in press).

Well-Numbering System

The well and test-hole numbers used in this report give the location of wells according to General Land Office surveys. The well number is composed of township, range, and section numbers, followed by lower-case letters to indicate the subdivision of the section in which the well is located. The first letter denotes the quarter section, the second letter denotes the 40-acre tract, and the third letter indicates the 10-acre tract. The 160-acre, 40-acre, and 10-acre tracts are designated a, b, c, or d in a counterclockwise direction, beginning in the northeast quarter. When two or more wells are located within a 10-acre tract, the wells are numbered serially according to the order in which they were inventoried. An example of the well-numbering system is given in Figure 2.

Acknowledgments

I am indebted to many residents of Cheyenne County who assisted in this investigation by granting permission to measure their wells and who supplied data on local geology and ground water. Special thanks are extended to owners of irrigation wells who permitted pumping tests to be made, and to Ralph A. Crawford, well driller from St. Francis, who furnished information. Thanks are also extended to Grover Rogers of Bird City and Harold Miller of St.

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Francis, who gave information about the Bird City and St. Francis municipal supplies.

The manuscript for this report has been reviewed by several members of the Federal and State Geological Surveys; Robert Smrha, Chief Engineer, and George S. Knapp, Engineer, of the Division of Water Resources of the Kansas State Board of Agriculture; and Dwight F. Metzler, Director, and Willard O. Hilton, Geologist, of the Division of Sanitation of the Kansas State Board of Health. The illustrations were drafted by Woodrow W. Wilson.

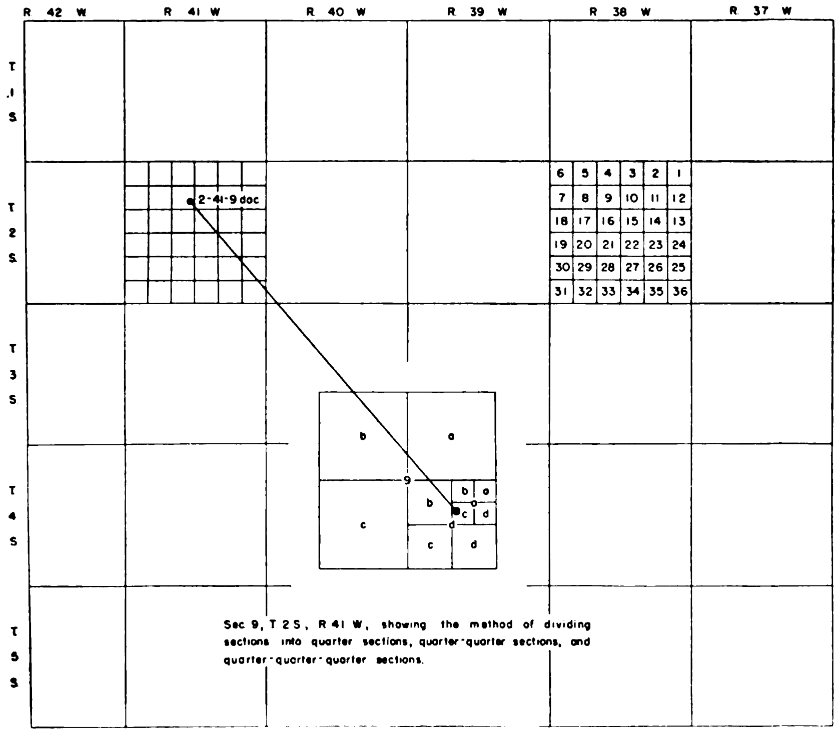

FIG. 2.—Map of Cheyenne County illustrating the well-numbering system used in this report.

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GEOGRAPHY

Topography and Drainage

Cheyenne County has two distinct types of topography: the flat to gently undulating upland plain in the areas east, northeast, south, and southwest of Bird City (Pl. 3A), and the rugged, deeply dissected uplands along the northern border of the county (Pls. 3B, 3C, and 4A) and along the valley of South Fork. On Plate 1 the topography in the Bird City area is indicated by the absence of drainage lines and the presence of numerous undrained depressions; the development of the drainage indicates to some extent the degree of dissection of the northern part of the county and the area just south of South Fork. The surface of the plains slopes gradually eastward at the rate of about 10 feet to the mile. The lowest point in the county has an altitude of approximately 3,000 feet where South Fork enters Dundy County, Nebraska. Several localities along the southern border of T. 5 S., R. 42 W. have altitudes of more than 3,800 feet. The maximum relief, therefore, is about 800 feet. The local relief ranges from about 10 feet in the Bird City vicinity to more than 300 feet in the deeply dissected area in the northern part of the county. The local relief along South Fork is as much as 200 feet.

South Fork, which with its tributaries drains most of Cheyenne County, rises in eastern Colorado and enters Cheyenne County about 6 miles north of the Sherman County border. It flows northeastward across the county and enters Nebraska about 8 miles west of the Rawlins County line. The valley floor of South Fork in Cheyenne County ranges in width from about 1 to 1.5 miles (Pl. 4B). Arikaree River, which rises in eastern Colorado, flows across the extreme northwest corner of Kansas, drains a small area in northwest Cheyenne County, and joins North Fork Republican River near Haigler, Nebraska, to form Republican River. From this confluence the Republican flows eastward and is joined by South Fork near Benkelman, Nebraska. Some of the major tributaries to South Fork in Cheyenne County are Hackberry, Cherry, Big Timber, and Sand Creeks.

Little Beaver Creek is an ephemeral stream—that is, it flows only during and after heavy rains. The creek enters the county about 7 miles east of the Colorado border, runs roughly parallel to the Sherman County line for several miles, and flows northeastward

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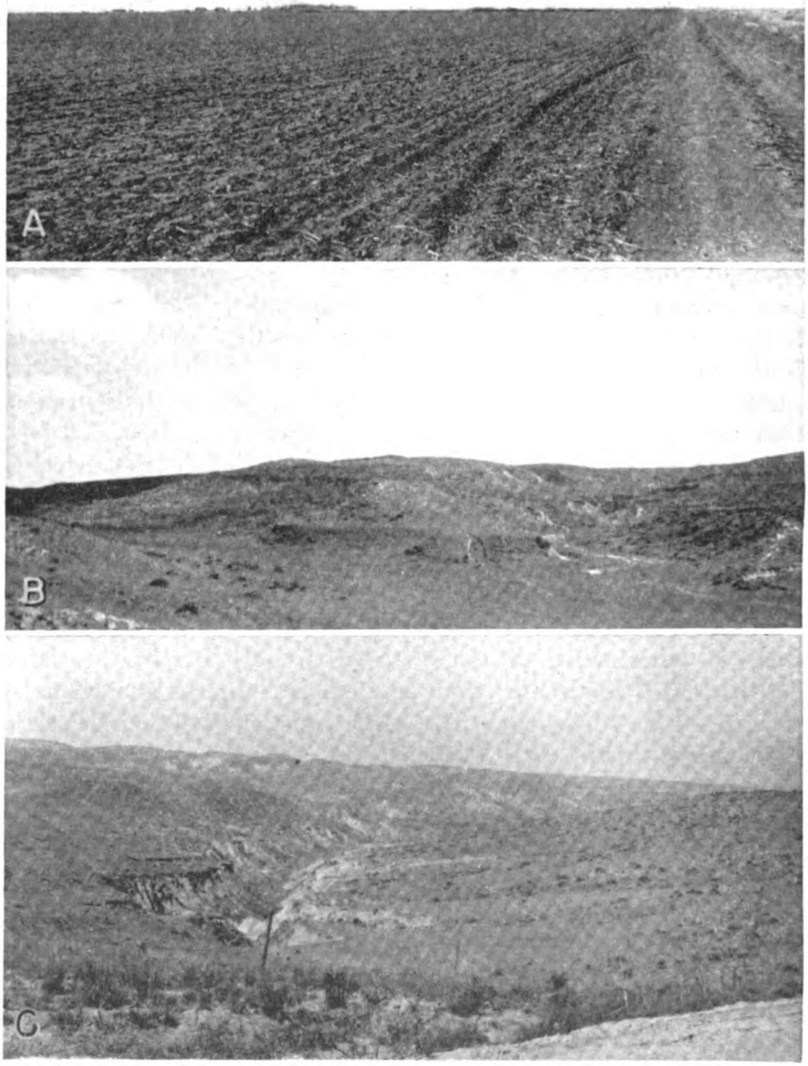

PLATE 3. A, Flat upland-plains topography looking west toward Bird City along road between secs. 28 and 33, T. 3 S., R. 37 W. **B,** Valley eroded in loess of the Sanborn formation in SW¼ sec. 6, T. 1 S., R. 39 W. Pierre shale topped by thin Ogallala formation crops out at base of some of the bluffs. **C,** Loess hills of the Sanborn formation in northern Cheyenne County. View is northwest from SW¼ sec. 11, T. 1 S., R. 40 W.

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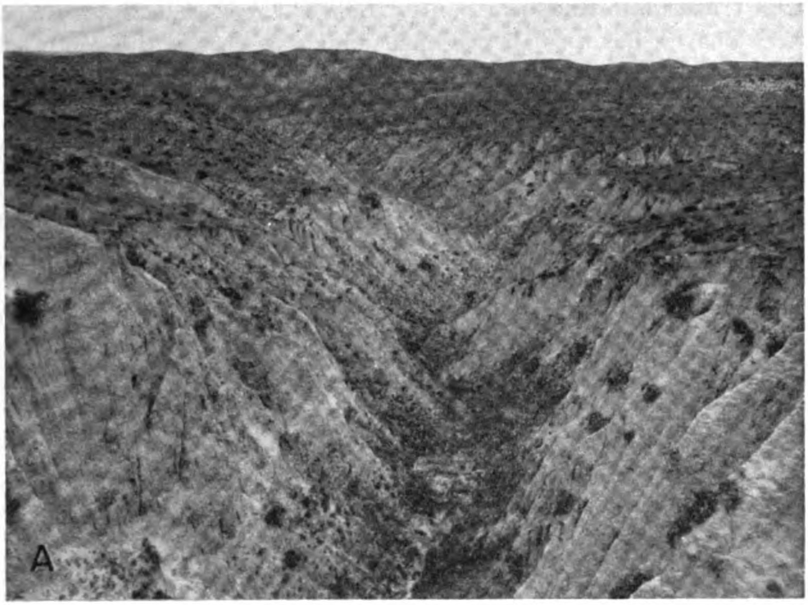

PLATE 4. **A,** Deeply dissected valley in loess of the Sanborn formation in northern Cheyenne County. Pierre shale crops out at bottom of cut. View northeast from SW¼ sec. 11, T. 1 S., R. 40 W. **B,** Channel of South Fork in southwestern Cheyenne County. View is east from bridge in sec. 34, T. 4 S., R. 42 W.

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as it crosses into Rawlins County. Beaver Creek, sometimes called Wet Beaver, has a small perennial flow as it crosses the southeast corner of the county.

Climate

The climate of Cheyenne County is semiarid, being characterized by light to moderate precipitation, abundant sunshine, and a high rate of evaporation. The heat of the summer days is relieved to some extent by good wind movement and low relative humidity. Summer nights are generally cool. The normal annual mean temperature at St. Francis is 52.1° F. The highest normal monthly mean temperature is 77.3° F. in July, and the lowest normal monthly mean temperature is 28.0° F. in January. The highest temperature on record is 111° F., which was first recorded on July 24, 1936. The lowest temperature recorded at St. Francis is —28° F., which occurred on January 12, 1912. The growing season averages 160 days, ranging from 194 to 132 days. Killing frosts have occurred as late as May 29 and as early as September 21.

The normal annual precipitation at St. Francis, determined by the U. S. Weather Bureau, is 17.86 inches; the average annual precipitation during the period 1908 to 1950 is 20.30 inches. The precipitation has ranged from a low of 11.69 inches in 1910 to a high of 33.20 inches in 1923. More than half the precipitation falls during the growing season from May through September, when moisture is needed most. The annual precipitation and the cumulative departure from normal precipitation at St. Francis are shown in Figure 3, and the normal monthly precipitation is shown in Figure 4.

Population

According to the 1950 Federal census the population of Cheyenne County was 5,668. The average density of population was 5.5, as compared with 23.2 for the entire State. In 1890 the population was 4,401 but by 1900 it had dropped to 2,640. In 1930 the population was up to 6,942, the greatest number ever officially recorded by the Census Bureau. In 1940 the population was 6,221.

St. Francis, the county seat, had a population of 1,041 in 1940 and 1,892 in 1950. Bird City had 694 inhabitants in 1940 and 784 in 1950. Cheyenne County ranks 83d in population within the State.

Transportation

Cheyenne County is served by a branch line of the Chicago, Burlington and Quincy Railroad, which leaves the main line at Orleans, Nebraska, parallels Beaver Creek to Atwood in Rawlins County,

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continues west to Cheyenne County passing through Bird City and Wheeler, and terminates at St. Francis. The north part of the county is served also by the main line of the Chicago, Burlington and Quincy Railroad, which runs across the southern part of Dundy County, Nebraska.

U. S. Highway 36 passes through the center of Cheyenne County from east to west. State Highway 27 runs north from Sherman County and joins U. S. Highway 36 half a mile south of Wheeler. The highways are concurrent from this point to about a mile west of St. Francis, where Highway 27 turns northward toward Haigler, Nebraska. This northern reach of Highway 27 is not paved but is well graveled. Many of the county roads are graveled and are kept in good condition throughout the year. Most of the township roads have been graded.

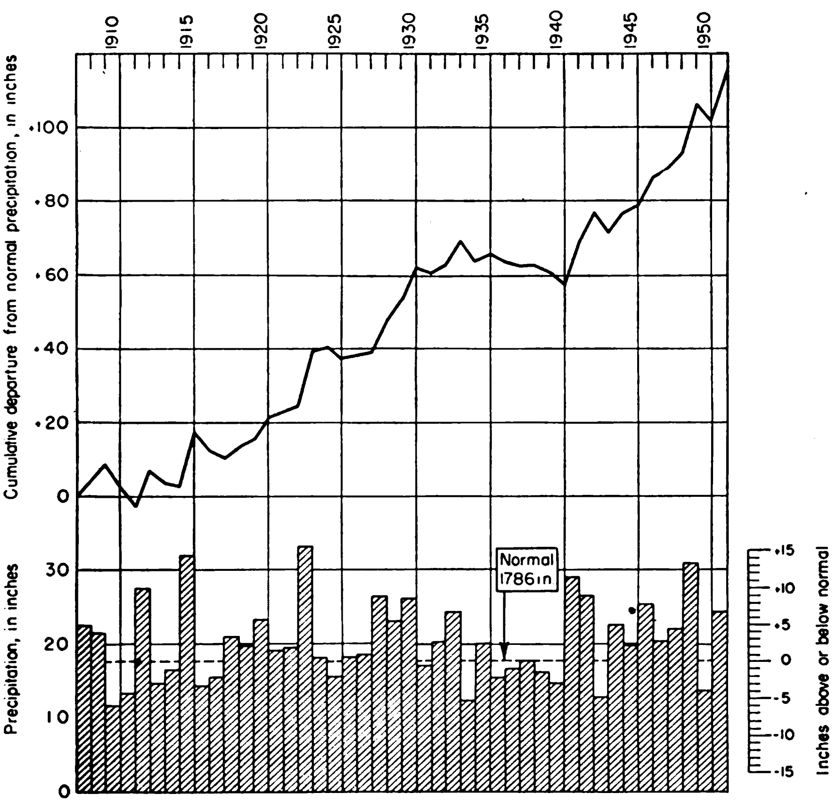

FIG. 3.—Graphs showing annual precipitation and cumulative departure from normal precipitation at St. Francis.

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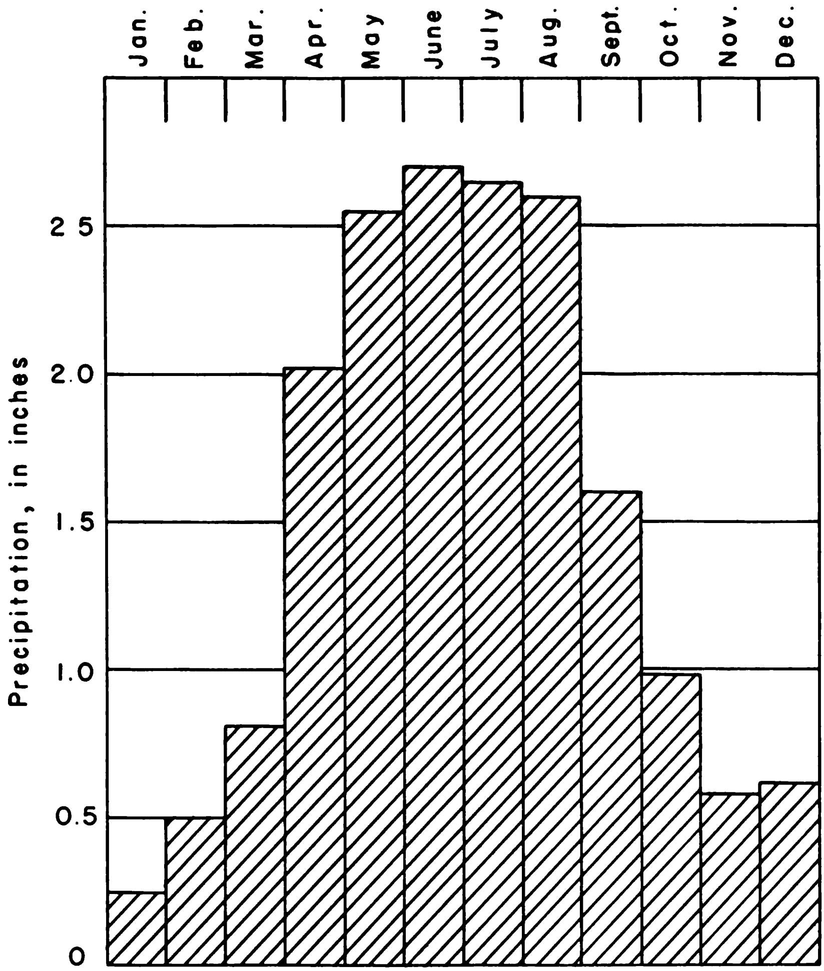

FIG. 4.—Graph showing the normal monthly precipitation at St. Francis computed from records covering the period 1908-42.

AGRICULTURE

Agriculture is the chief occupation in Cheyenne County. According to the census of 1950 there were 817 farms in 1950 and 218,760 acres of major crops were harvested. About 72 percent of the cultivated acreage in 1950 was used for the production of wheat. Much of the land area is in pasture, and cattle raising is a major occupation. The acreage of principal crops grown in 1950 is shown in Table 1.

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Mineral Resources

In 1951 two wildcat oil test wells were drilled in Cheyenne County. One of these wells in the SE¼ SE¼ NW¼ sec. 26, T. 1 S., R. 39 W. found oil in what may prove to be commercial amounts. This oil pool, which is known as the Judy pool, is temporarily abandoned. The results of the 1951 prospecting were apparently encouraging because several test wells have been drilled in 1952.

With the possible exception of oil and gas, Cheyenne County has no mineral resources of great economic importance other than ground water and the fertile soil. A small amount of sand and gravel from the alluvium of South Fork is used for road surfacing material. Samples of the Pierre shale have been analyzed for oil and gas content as potential oil-shale reserves in the geochemistry laboratory of the State Geological Survey at Lawrence, but no oil was found and there was only a minute quantity of gas.

Table 1.—*Acreage of principal crops grown in Cheyenne County, Kansas in 1950*

Crop	Acres
Wheat	158,000
Corn	17,900
Oats	680
Barley	3,070
Rye	420
Sorghum	
For grain	12,600
For forage	20,430
For silage	1,020
Irish potatoes	10
All hay	4,630

GENERAL GEOLOGY

Summary of Stratigraphy*

The rocks cropping out in Cheyenne County are sedimentary and range in age from late Cretaceous to Recent. The areal distribution of their outcrops is shown on Plate 1.

The Pierre shale of late Cretaceous age is the oldest geologic formation cropping out in Cheyenne County. The formation underlies the entire county and crops out along South Fork and Arikaree River and along valleys tributary to these streams. The Ogallala

* The stratigraphic nomenclature used in this report is that of the State Geological Survey of Kansas and differs in some respects from that of the U. S. Geological Survey.

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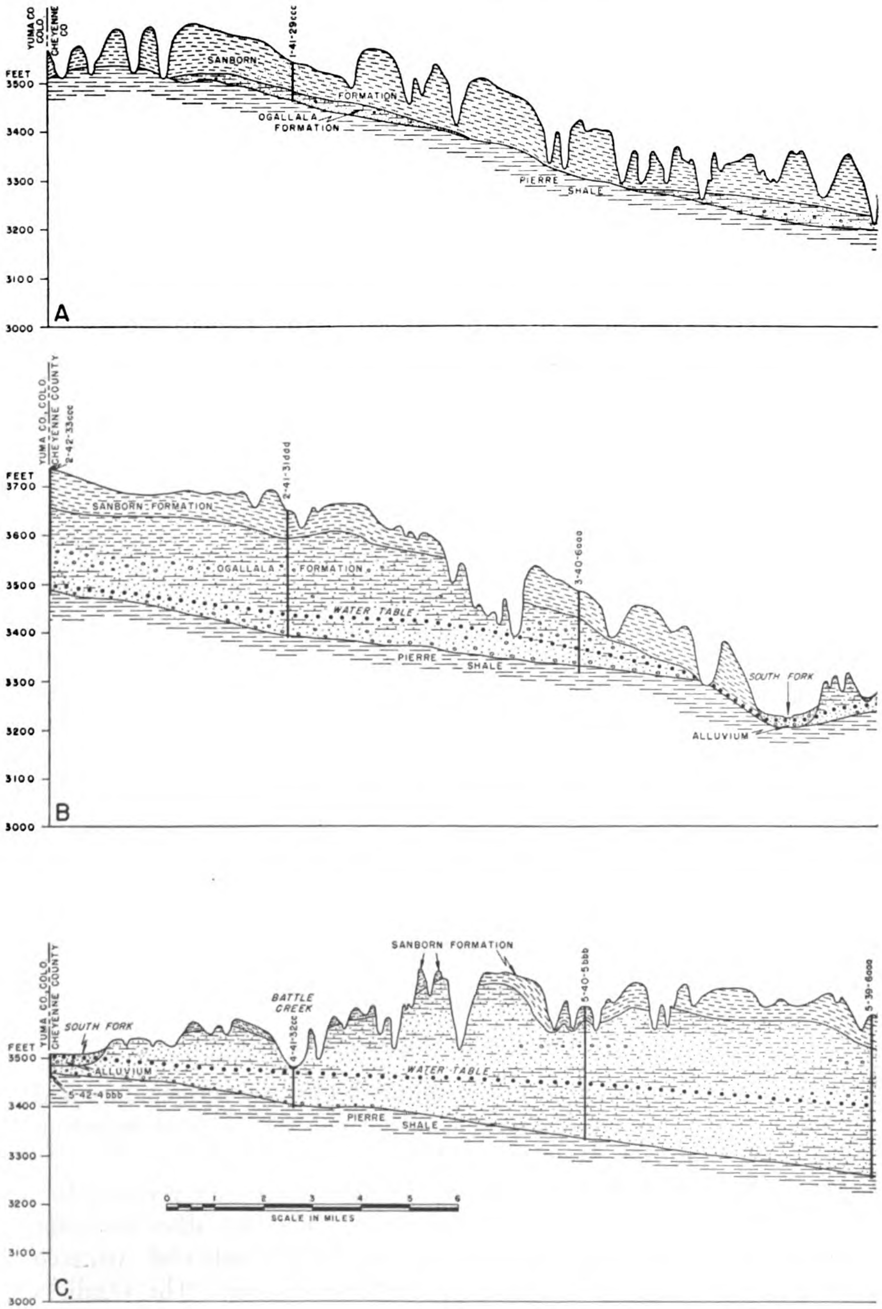
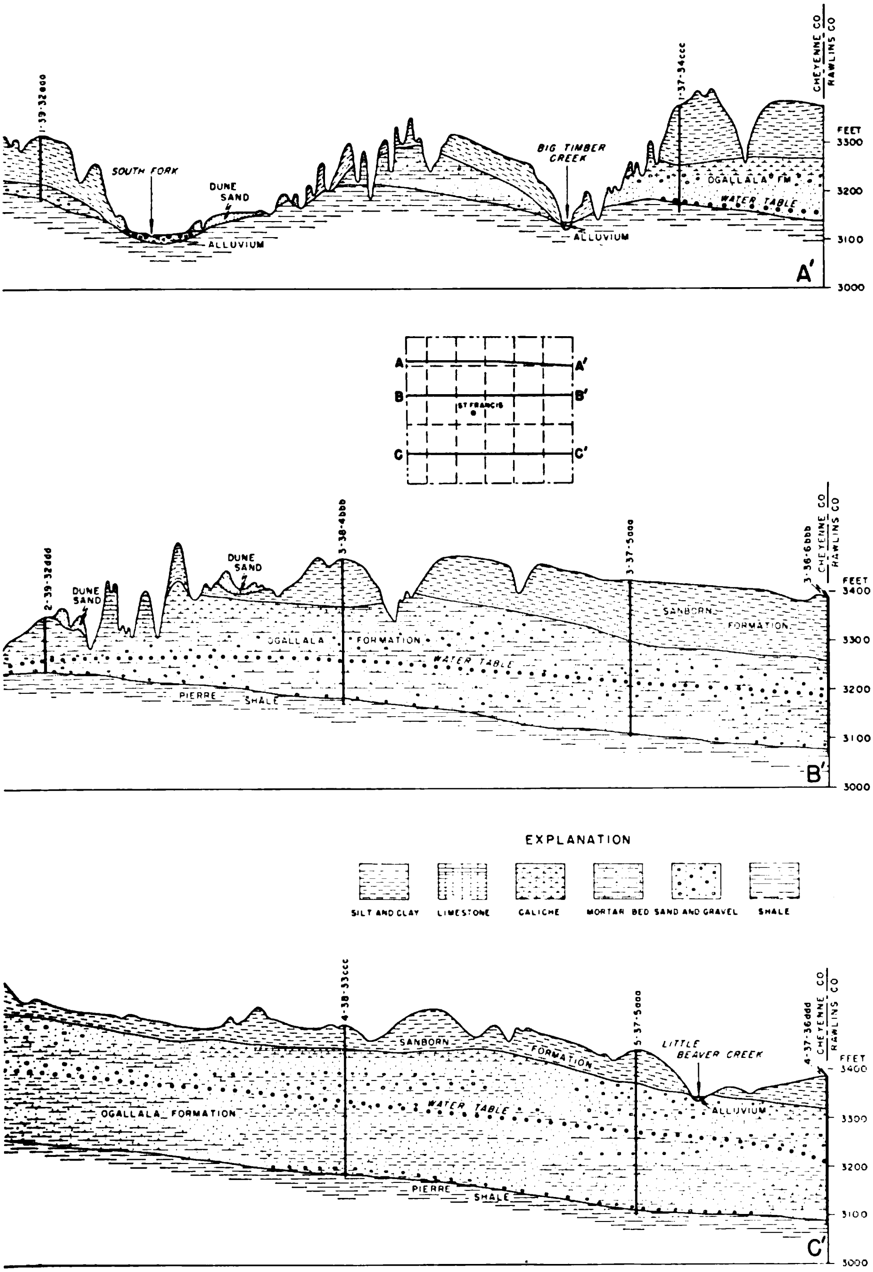


Fig. 5.—Geologic cross sections in Cheyenne



County along lines A-A′, B-B′, and C-C′.

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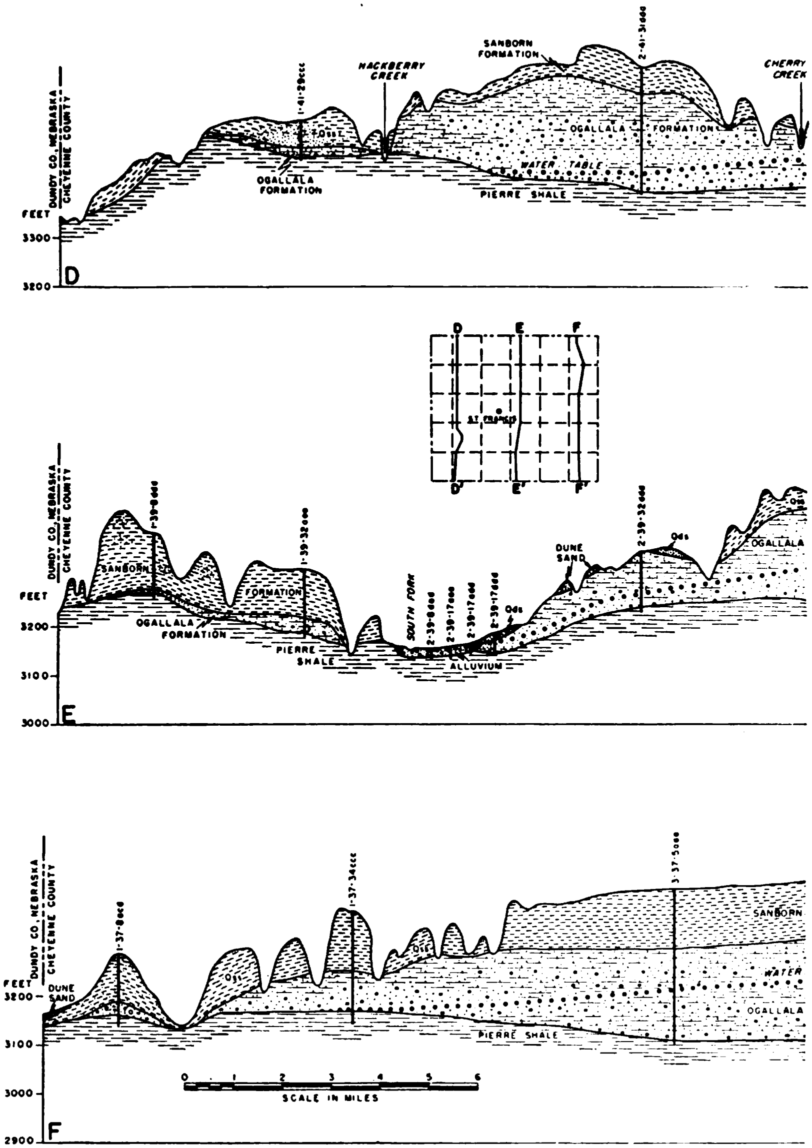

FIG. 6.—Geologic cross sections in Cheyenne

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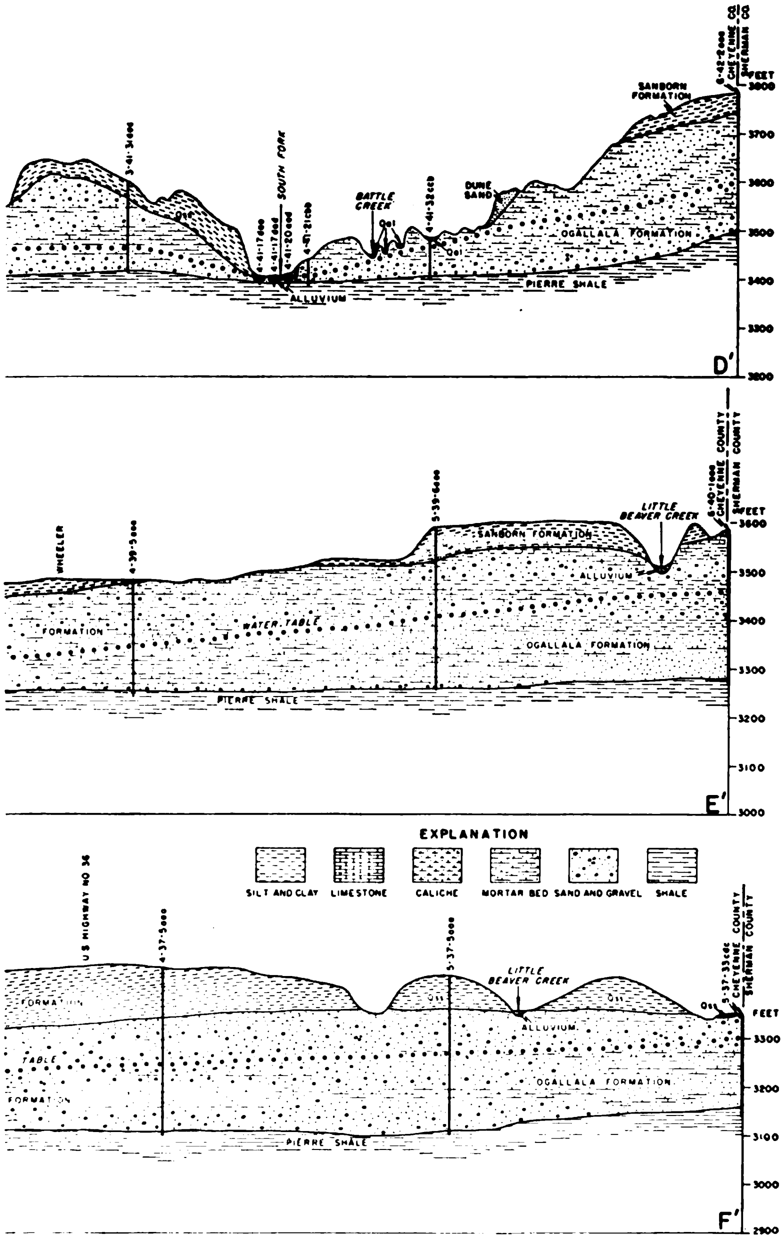

County along lines D-D′, E-E′, and F-F′.

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formation of Tertiary (Pliocene) age lies above the Pierre shale in much of the county, but in places the Ogallala is very thin or has been removed by erosion. The Ogallala crops out along many stream valleys, but in the uplands it generally is mantled by a thick deposit of wind-blown silt (loess), the Quaternary (Pleistocene) Sanborn formation. Dune sand of late Pleistocene age covers an area south of South Fork, and alluvial deposits along most of the streams constitute the most recent deposits in the area. Table 2 summarizes the character and ground-water supply of the geologic formations. The stratigraphic relationships of the formations are shown in the geologic cross sections (Figs. 5 and 6).

Geomorphology

The development of the present topography in Cheyenne County is a result of events in Pliocene and Pleistocene times. During early Tertiary time the Rocky Mountains were uplifted extensively and streams flowed eastward from the mountains across the Great Plains. While deposition was occurring further north, the western Kansas area was being eroded. By Pliocene time conditions were reversed, possibly owing to differential uplift of the land, and streams from the Rocky Mountains laid down thick deposits of sand, gravel, silt, and clay over the High Plains of Kansas. By the end of the depositional period the erosional plain in the Rocky Mountain region merged with the aggradational plain in the Great Plains. Near the end of Ogallala time, when stream gradients were low and stream channels became choked with sediments, probably several small lakes were formed. A fresh-water limestone, the "Algal limestone," was deposited in the waters of these shallow lakes.

Early in Pleistocene time the existing streams (probably South Fork and Arikaree River in Cheyenne County) were rejuvenated and began to cut through the Pliocene deposits and where the Ogallala was thin, into the Pierre shale. Later, presumably by Illinoian time, the valleys were alluviated with deposits of the Crete sand and gravel member of the Sanborn formation. Another period of erosion followed and most of the Crete, except a few remnants along South Fork and Arikaree Valleys, were removed. Alluviation followed this period of erosion and South Fork and Arikaree River continue to deposit small amounts of sediment at the present time.

During Illinoian and early Sangamonian time silt was carried in and deposited on the uplands and slopes by winds, forming the Loveland silt member of the Sanborn formation. In late Sanga-

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TABLE 2.—*Generalized section of the geologic formations in Cheyenne County, Kansas*

System	Series	Formation	Thickness (feet)	Character	Water Supply
Quaternary	Pleistocene*	Alluvium	0–40	Sand, gravel, and silt comprising stream deposits along South Fork and most of the smaller streams. Deposits along South Fork generally coarser than along small streams.	Yields moderate supplies of water to wells along South Fork and small amounts in smaller stream valleys, except where deposits are above water table; some irrigation wells in South Fork Valley obtain water from alluvium.
		Dune sand	0–20	Sand, fine to coarse; in places contains very coarse sand.	Generally lies above the water table and yields no water to wells but it is important as a catchment area for ground-water recharge to adjacent and underlying formations.
		Sanborn	0–180	Silt, tan to light-brown; in places is very sandy and in places contains sand and gravel at the base.	Generally lies above the water table but in places may yield a small amount of water probably from Crete sand and gravel member at the base of the formation.
Tertiary	Pliocene	Ogallala	0–290	Sand, gravel, and silt, predominately calcareous; may be consolidated or unconsolidated; contains caliche beds and a limestone bed.	Yields moderate to large supplies of water to wells in much of the county; supports a few irrigation wells; formation is thin to absent in northern third of county and there yields small amounts of water or no water.
Cretaceous	Gulfian*	Pierre shale	900–1400	Shale, tan, and light- to dark-gray.	Not known to yield water to wells in Cheyenne Co.

* Classification of the State Geological Survey of Kansas.

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monian time the Loveland silt member was weathered to form the Sangamon (formerly called Loveland) soil. The Loveland silt member is not widespread in Cheyenne County. After the close of the Sangamon weathering period the Peoria silt member of the Sanborn formation was deposited in a thick nearly continuous blanket over the county. Overlying the Peoria are a few scattered patches of the Bignell silt member of the Sanborn formation. These deposits, and dune sand south of South Fork, attest to the recurrence of eolian deposition during late Pleistocene time.

During Recent time the county has undergone considerable erosion, which has formed much of its present topography. Several of the small streams have cut deeply into the Ogallala formation, and some of the tributaries to the Arikaree and South Fork have cut into the Pierre shale. Vertical downcutting has been particularly active on the north border of the county. In this area the Sanborn formation is more than a hundred feet thick, and because of its inability to resist erosion it has been very greatly dissected (Pls. 3B, 3C, and 4A). The Ogallala formation, being very thin or absent, in this area, has offered very little resistance to erosion, and deep canyons have been cut through the loess into the Pierre shale. In other areas the loess cover has been modified by the action of sheet and rill wash and soil creep. Some slopes are covered by deposits that have moved from the uplands by these processes.

During Recent time many shallow depressions, ranging in diameter from a few tens of feet to more than a quarter of a mile, have developed on the uplands, particularly in the Bird City area. Most of the depressions collect water during periods of heavy rainfall and hold the water until it has evaporated or percolated into the ground.

GROUND WATER

Source

Portions of the following paragraphs on the source and occurrence of ground water have been adapted from Meinzer (1923, pp. 2-102). The reader is referred to his report for a more detailed treatment of the subject.

Water that exists beneath the surface of the earth is termed subsurface water. The part of subsurface water that is in the zone of saturation is termed ground water or phreatic water; subsurface water above the zone of saturation—that is, in the zone of aeration—is called suspended subsurface water or vadose water. Ground water is the water that supplies wells and springs.

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Ground water that is available to wells in Cheyenne County is derived from precipitation falling as rain or snow within the area or within near-by areas to the west. Part of the water that falls as rain or snow is carried away as surface runoff into streams, part of the water may evaporate, and part is absorbed by plants and returned to the atmosphere as water vapor by the process known as transpiration. Water that escapes runoff, evaporation, and transpiration percolates slowly downward through the soil and underlying strata and eventually reaches the water table where it joins the body of ground water in the zone of saturation.

The ground water percolates slowly through the rocks in directions determined by the shape and slope of the water table. The shape and slope of the water table are controlled by topography, local variations in the quantity of recharge or discharge, and the stratigraphy and structure of the rocks. The ground water is discharged through springs or wells, by seepage into streams, or by transpiration and evaporation in bottom lands adjacent to the streams.

Occurrence

The rocks that form the crust of the earth generally are not entirely solid but contain numerous open spaces called voids or interstices. These interstices may contain either liquid or gas, such as water, oil, natural gas, and air. Different kinds of rocks vary greatly in the number, size, shape, and arrangement of their interstices, and hence in their water-bearing properties. The occurrence of ground water in any region is determined therefore by the geology of the region.

The interstices in rocks range from microscopic openings to large caverns found in some limestones and lava rocks. In most rocks the interstices are connected and water can move by percolation from one to another. In some rocks the interstices are largely isolated and water has little opportunity to percolate. The porosity of a rock is its property of containing interstices. Porosity is expressed quantitatively as the percentage of the total volume of the rock that is occupied by interstices.

Porosity determines only how much water a given rock can hold, not how much it can yield to wells. A rock is said to be saturated when its interstices are filled with water. Not all the water in a saturated rock is available to wells, because part of the water is held against the force of gravity by molecular attraction. In a fine-grained rock the molecular attraction is very great and only a small

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part of the water, or none at all, can be drained out by the force of gravity, whereas in a coarse sand or gravel having the same porosity only a small part is retained by molecular attraction and the remainder, acted on by gravity, becomes available to wells. Thus, for a given porosity and a given degree of assortment, a coarse-grained rock will yield more water to wells than a fine-grained rock. The amount of water that a rock will yield when saturated is known as the specific yield; the specific yield of a water-bearing formation is defined as the ratio of the volume of water that the saturated formation will yield by gravity, to its own volume. This ratio is often expressed as a percentage.

The permeability of a water-bearing material is its capacity for transmitting water under a hydraulic gradient and is measured by the rate at which the material will transmit water through a given cross section under a given difference of pressure per unit of distance. A bed of silt, clay, or shale may have as high a porosity as a deposit of coarse sand or gravel, but because of the small size of its interstices it may be almost impermeable.

In summary, the rate of movement of ground water is determined by the size, shape, quantity, and degree of connection of the interstices, and by the hydraulic gradient.

The coefficient of permeability, commonly expressed in Meinzer's units, is the rate of flow in gallons a day through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent (loss of 1 foot of head for each foot the water travels) at a temperature of 60° F. The field coefficient of permeability is the same, except that it is measured at the prevailing temperature rather than at 60° F. The coefficient of transmissibility is defined as the number of gallons of water a day transmitted through each vertical 1 foot strip extending the saturated thickness of the aquifer under a unit gradient, at the prevailing temperature. The coefficient of transmissibility is equal to the field coefficient of permeability multiplied by the saturated thickness of the aquifer. Both permeability and transmissibility can be conveniently expressed, for field use, as the flow across a section 1 mile instead of 1 foot wide, under a gradient of 1 foot per mile instead of 1 foot per foot.

A pumping test was made on well 4-42-26bad to determine the permeability and transmissibility of water-bearing materials in Cheyenne County. The coefficient of transmissibility, based on this test, is about 175,000 gallons per day per foot and the field coefficient of permeability is about 5,500 gallons per day per square foot. These are high values, indicating a permeable and productive aquifer. This

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well had a yield of 560 gallons a minute with a drawdown of 27 feet after 6.5 hours of pumping.

The Water Table and Movement of Ground Water

The permeable rocks that lie beneath a certain level in Cheyenne County are generally saturated with water. These saturated rocks are said to be in the zone of saturation, and the upper surface of the zone of saturation when it is overlain by unsaturated permeable material is called the water table. The permeable rocks lying above the water table are said to be in the zone of aeration. Some of the water that enters the soil at the surface moves slowly by gravity down through the zone of aeration to the zone of saturation. The remainder of the water that enters the soil is used by transpiration and evaporation or is retained in the zone of aeration by molecular attraction. In fine-grained material the earth is always moist several feet above the water table, owing to capillarity, and this belt is called the capillary fringe. Water in the capillary fringe or in transit or storage in the zone of aeration is not available to wells.

SHAPE AND SLOPE

The shape and slope of the water table in Cheyenne County are shown on Plate 1 by contour lines drawn on the water table. Water-table contour lines connect points of equal altitude and these lines show the configuration of the water surface just as topographic maps show the shape of the land surface. Ground water moves in the direction of maximum downward slope, which is at right angles to the contours.

The shape and slope of the water table are controlled by several factors. The causes for the irregularities of the shape and slope of the water table in Cheyenne County are: the configuration of the Cretaceous bedrock floor, discharge of ground water into streams, local differences in the permeability of water-bearing formations, and recharge of ground water by ephemeral streams.

Ground water is moving through Cheyenne County in a general northeasterly or easterly direction (Pl. 1). The direction of movement of ground water in the county is determined to a considerable extent by the shape of the bedrock floor which, in general, slopes northeastward or eastward as does the water table (Fig. 7). Not all irregularities in the bedrock surface, however, are reflected in the shape of the water table.

The discharge of ground water into streams influences the shape and slope of the water table in Cheyenne County mainly along South Fork. The prominent upstream flexure of the water-table

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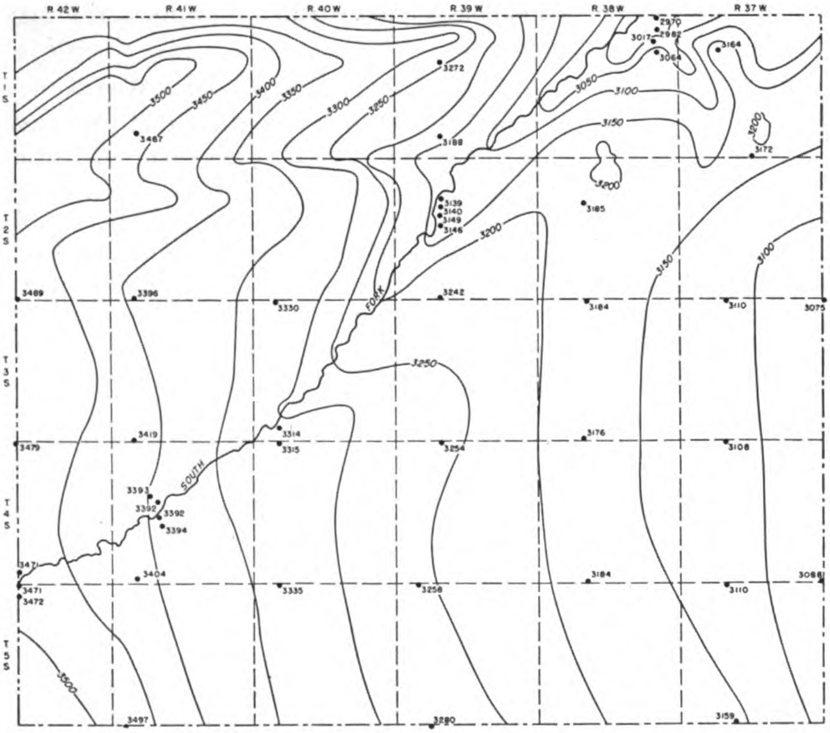

FIG. 7.—Map showing the location of test holes and the configuration of the top of the Pierre shale by means of contours.

contours along the river is due largely to the effluent seepage (Fig. 8).

The transmissibility of the water-bearing materials affects the slope of the water table. In general, the slope of the water table varies inversely with the transmissibility of the water-bearing materials. In areas where the water-bearing beds have a low transmissibility the slope of the water table steepens, but in areas of thicker or more permeable water-bearing beds the water table has a gentler slope and the contours are more widely spaced.

Recharge of ground water by ephemeral streams probably is not a significant factor in the formation of any permanent features in the water table of Cheyenne County. Ephemeral (intermittent) streams flow only after rains. Their channels lie above the water table and are dry most of the time. During periods of flow much water seeps into stream beds and moves downward to the water table, especially along Little Beaver Creek, where the alluvial de-

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posits contain much sand and gravel. Such recharge causes a temporary mound or ridge to form in the water table, but such an irregularity is not permanent and is not shown on a small-scale map such as Plate 1. The movement of ground water from losing streams and to gaining streams is shown by the diagrammatic sections in Figure 8.

Water-table contours are not shown for the northern part of the county, where loess deposits are thick and outcrops of the Pierre shale are numerous. In this area the principal water-bearing formation in Cheyenne County, the Ogallala formation, is thin or absent. Both the loess and the Pierre shale have a very low permeability, and few wells drilled entirely in one or the other yield water. However, water can be obtained locally in this area, especially in draws containing alluvial or colluvial (slope-wash) deposits, but the water table is generally discontinuous.

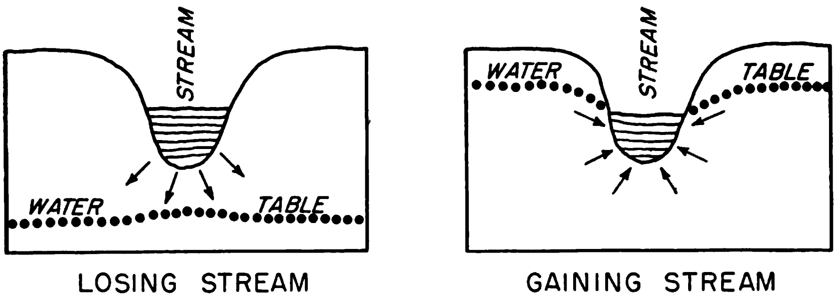

Fig. 8.—Diagrammatic sections showing losing and gaining streams.

FLUCTUATIONS OF THE WATER TABLE

The water table does not remain stationary but fluctuates owing to variations in discharge and recharge and to a minor extent to such factors as changes in atmospheric pressure. The water table rises when the amount of recharge exceeds the amount of discharge and declines when discharge exceeds recharge.

Factors controlling the rise of the water table in Cheyenne County are the amount of water entering the county beneath the surface from areas to the west, the amount of precipitation that penetrates the ground and reaches the zone of saturation, and the amount of seepage that reaches the water table from surface streams. All these factors depend upon precipitation either in this county or in counties immediately adjacent to the west, southwest, and south.

Factors controlling the decline of the water table are the movement of ground water from the county to adjacent areas on the

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north and east, seepage into streams, loss of water through transpiration and evaporation where the water table is shallow, and pumping from wells.

Periodic water-level measurements were begun in Cheyenne County along South Fork in 1946 to obtain information concerning the fluctuations of the water table. The water-level measurements are published in annual water-supply papers of the U. S. Geological Survey (1128, 1158, and ensuing reports).

Ground-Water Recharge

Recharge is the addition of water to the ground-water reservoir and may be accomplished in several ways. All ground water available to wells in Cheyenne County is derived from precipitation falling as rain or snow within the county or within adjacent areas to the west, southwest, and south. Part of the water that falls as precipitation is carried away as surface runoff and is lost to streams, part evaporates, and some is absorbed by plants and returned to the atmosphere as water vapor by transpiration.

The remainder percolates slowly down through the soil and underlying strata and part of it eventually reaches the water table. Once the water becomes part of the body of ground water, it moves in the direction of the slope of the water table to be discharged later in any of several ways described elsewhere.

The quantity of water that is carried away by surface runoff depends upon several factors: the duration and intensity of rainfall, the slope of the land, the type and condition of the soil, and the vegetation. Runoff resulting from torrential rains is much greater than that resulting from gentle rains, and steep slopes permit greater runoff than gentle slopes. In general, runoff is greater in places of tightly compacted fine-grained soil than in places of loose sandy soil. Runoff is also greater during winter rains that occur at times when the ground is frozen and is impervious to infiltration. The velocity of surface runoff is reduced by a suitable vegetative cover and water has a better chance to seep into the soil. Modern methods of land terracing and contour farming tend not only to reduce the erosion of valuable soil but also to reduce runoff and therefore increase the infiltration of water into the soil and, when more than sufficient water is available to replenish soil moisture, to the water table.

The amount of water that leaves Cheyenne County as surface runoff is not large. In the water year 1946-47, which includes the period October, 1946, through September, 1947, the amount of water

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that passed the stream-gaging station on South Fork near the Kansas-Colorado State line was 36,660 acre-feet (U. S. Geol. Survey, 1950, pp. 559-560). During the same period, 61,750 acre-feet of water passed the gaging station just north of the Kansas-Nebraska State line. Therefore, 25,090 acre-feet was added to South Fork in Cheyenne County. The drainage area contributing to the runoff of 25,090 acre-feet is 690 square miles. Converted to inches per square mile, the runoff is 0.68 or about 2.5 percent of 27.08 inches, the precipitation in Cheyenne County during this period. These computations are made for the area drained by South Fork but comparable values would be obtained for the other major streams in Cheyenne County were data available. Very little of the water that reaches the surface as precipitation in Cheyenne County is lost to direct surface runoff.

Much of the water that reaches the surface as precipitation is lost by evaporation and transpiration and never reaches the water table. A large percentage of the precipitation falls during the period from May through September when temperatures are high, humidity is low, winds are relatively high, and consequently the rate of evaporation is high. No figures regarding the annual rate of evaporation in Cheyenne County are available, but the average rates of evaporation from a free water surface (U. S. Department of Agriculture, Bureau of Plant Industry type pan) for the months of the growing season based on a 38-year record from 1913 to 1951 at Colby, Thomas County, experiment station are: April, 4.93 inches; May, 6.28 inches; June, 7.72 inches; July, 9.29 inches; August, 8.23 inches; and September, 6.30 inches.

During the growing season, absorption and transpiration by vegetation consume a large percentage of the rainfall during this period. The quantity of water lost by transpiration varies widely with different species of plants. The use of water by plants may be shown by stating the quantity of water consumed to produce a unit weight of dry plant matter. This quantity is designated as the transpiration ratio. The transpiration ratios in pounds of water per pound of dry matter for several plants common in Cheyenne County are as follows: wheat, 375; corn, 345; alfalfa, 829; buffalo grass, 308; and sunflower, 577 (Foster, 1948, p. 286).

The water that escapes runoff, evaporation, and transpiration percolates into the soil. When the soil contains enough water to satisfy the soil-moisture requirement, any excess water may move downward to the zone of saturation. Although a considerable amount of rain may fall during the summer months, the increased

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evaporation and transpiration may use most of the water that enters the soil, and soil moisture may be nearly depleted at the end of the growing season. During the fall and winter, when evaporation and transpiration are at a minimum, the soil may again become sufficiently saturated to permit recharge if precipitation is adequate.

UPLAND AREAS

Ground-water recharge in the upland areas of Cheyenne County is probably very slight. The uplands are covered by a mantle of wind-blown silt or loess (Sanborn formation) which reaches a maximum of 180 feet in thickness in the northern part of the county. In certain areas the Sanborn formation contains a large amount of fine to medium sand and may permit a larger amount of infiltration of precipitation than areas where it is composed mainly of silt. An opportunity for recharge is offered also in the area of dune sand in places on the slopes south of South Fork. Rodent burrows and sod cracks developed during dry seasons may also be avenues of additional recharge. Generally, the loess is rather porous but nearly impermeable.

Some of the upland areas, particularly the area northeast and southwest of Bird City, have many shallow undrained depressions which collect water and form temporary ponds after heavy rains (Pl. 1). The water in some of these ponds disappears quickly, but in others, water may remain for weeks or months. Probably a certain amount of recharge takes place by seepage from these ponds.

STREAMS

Ground-water recharge is derived more from water in the stream channels than from the infiltration of water through the upland deposits of Cheyenne County. Many of the smaller streams, particularly Little Beaver Creek and most of the southern tributaries to South Fork, lie above the water table and flow only for short periods after heavy rainfall. Most of the small streams contain sandy alluvial deposits through which water may travel as it moves downward to the water table. Recharge from these stream channels takes place only during and after heavy rains when the streams contain water. Although South Fork generally receives water from the ground-water reservoir, the river recharges the ground water occasionally.

SUBSURFACE INFLOW

Much ground-water recharge in Cheyenne County results from subsurface inflow. Plate 1 indicates that ground water enters the county from the west, southwest, and south, and some of the water

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that reaches the water table in counties adjacent to the west and southwest eventually moves into Cheyenne County. The cross sections in Figures 5 and 6 and the map showing the thickness of water-bearing materials (Fig. 9) indicate that little or no recharge occurs along the northwest border of the county by subsurface inflow except in the alluvium of Arikaree River.

The thickness of water-bearing materials ranges from about 90 to 175 feet along the southern border of the county and from about 35 to 90 feet on the southwestern edge of the county. Considerable recharge from subsurface inflow occurs in these areas.

IRRIGATION

In areas of extensive irrigation ground-water recharge may occur by seepage from ditches and by downward percolation after water has been spread on the fields. In the vicinity of a pumped well the water table may decline, and in the area where the water returns to the ground-water body the water table may rise. In Cheyenne

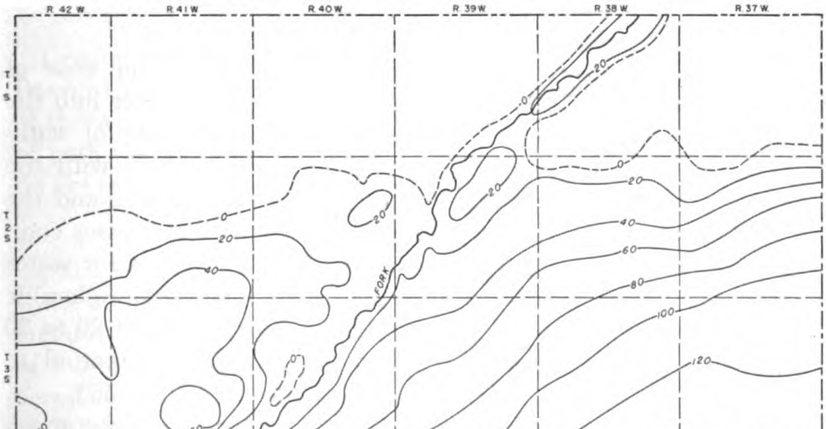

Fig. 9.—Map showing the saturated thickness of the Tertiary and Quaternary deposits in Cheyenne County.

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County little irrigation is practiced and the amount of recharge from this source is negligible. Should the amount of irrigation in the vicinity of South Fork be increased significantly, the water table in the alluvium along the river probably would rise.

Ground-Water Discharge

Discharge of subsurface water is divided into vadose-water discharge or discharge of soil water not derived from the zone of saturation, and ground-water discharge or discharge from the saturated zone (Meinzer, 1923a, p. 48). Discharge of soil water is accomplished by the direct evaporation of water contained in the soil and by discharge of water from growing plants by transpiration. This consumption of water reduces ground-water recharge because the deficiency of soil moisture must be replenished before recharge can take place. Ground-water discharge may take place through evaporation and transpiration, by discharge from wells and springs, by seepage into streams, and by underground movement to adjacent areas.

TRANSPIRATION AND EVAPORATION

The roots of plants may draw water directly from the zone of saturation or the capillary fringe and discharge the water into the atmosphere by the process of transpiration. The rate of withdrawal of ground water by transpiration varies mainly with the type of plants, the depth to the water table, the climate, and the season of the year. The roots of ordinary plants and grasses commonly do not extend to depths of more than a few feet for water but certain plants are known to extend their roots to considerable depths. Alfalfa may obtain ground water from depths of 20 to 30 feet below the surface, and alfalfa roots have been reported to extend 66 to 129 feet in extreme cases (Meinzer, 1927, p. 55).

The loss of ground water through direct evaporation and transpiration from the water table is high in certain areas, particularly in the valleys of South Fork and Arikaree River and their tributaries and in Beaver Creek Valley. In areas where the depth to water exceeds 20 feet the amount of evaporation and transpiration from the water table probably is small.

SPRINGS

In Cheyenne County some ground water is discharged from springs. Many small springs are found in the county, especially in some of the small valleys tributary to South Fork at the contact

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between the Pierre shale and the Ogallala formation. Water moving laterally at the base of the Ogallala formation on the top of the impermeable Pierre shale flows or seeps out at the surface where the top of the Pierre shale is exposed. In 1950 parts of Big Timber, Spring, Plum, Cherry, and Hackberry Creeks contained small spring-fed streams. These streams and the springs that feed them are locally important sources of water for stock.

Springs occur along South Fork where the water table intersects the ground surface. Water at two farmhouses in sec. 16, T. 4 S., R. 41 W. is supplied by such springs, and other springs in the same section supply abundant water for stock.

Springs in the SW¼ sec. 10, T. 3 S., R. 40 W. issue from cracks in the Pierre shale a few feet above river level on the north bank of South Fork. The water probably enters the shale a short distance upstream where the shale is beneath the surface of the water in the river. The water moves in the shale through cracks and along bedding planes and emerges at the surface as seeps or springs.

SEEPAGE INTO STREAMS

Ground water adds to the flow of South Fork, Arikaree River, and Beaver Creek where the stream levels are generally below the level of the water table. Little Beaver Creek and most of the tributaries of both the Arikaree and South Fork are above the water table and do not receive water from the zone of saturation.

WELLS

Most of the domestic, municipal, stock, railroad, and irrigation water supplies in Cheyenne County are derived from wells, but the amount of ground water discharged by pumping is a small fraction of the total amount of ground water discharged. About 700 to 800 acre-feet of ground water is discharged annually by pumping from wells in Cheyenne County.

SUBSURFACE OUTFLOW

The water-table contours on Plate 1 indicate that water is moving out of the county beneath the surface to the east and northeast. The saturated thickness of water-bearing materials is more than 100 feet along much of the eastern border of the county, and hence a large amount of ground-water discharge takes place as subsurface outflow. Data on permeability and transmissibility are not adequate to permit estimating either subsurface inflow into or subsurface outflow from the county.

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Recovery of Ground Water

PRINCIPLES OF RECOVERY

When water is pumped from a well the water table in the vicinity of the well is lowered to form a depression resembling an inverted cone. This depression of the water table is called the cone of depression or cone of influence, and the vertical distance that the water table is lowered is called the drawdown. The cone of depression expands and deepens as water travels toward the well from successively greater distances, until it intercepts sufficient recharge to balance the pumping. In any given well, the greater the pumping rate the greater the drawdown; the water level drops rapidly at first, then more slowly. When pumping ceases the water level rises rapidly at first, then more slowly for some time, until its original level is approached or reached.

DUG WELLS

Dug wells are wells that have been excavated, usually by hand with pick and shovel. Dug wells in Cheyenne County are most common in areas where ground-water supplies are limited. In such areas wells of large diameter are dug to provide a reservoir for water. In Cheyenne County most dug wells extend through the water-bearing beds and a few feet into the Pierre shale. They are cased with concrete, iron, galvanized iron, or rock. Several dug wells in Cheyenne County are uncased because they are dug mainly in loess, which stands in vertical walls without caving. As most of the dug wells tap poor water-bearing material they have a small yield. Several irrigation wells and the St. Francis municipal wells were dug to the water table, then drilled deeper.

BORED WELLS

Bored wells are made by post-hole diggers or hand augers. They are common in South Fork Valley where the water table is shallow. Bored wells are usually cased with 5- or 6-inch galvanized-iron casing.

DRILLED WELLS

Most of the domestic and stock wells were drilled by cable-tool drills. The cable-tool or percussion method uses a heavy bit which is lifted and dropped at regular intervals to produce a cutting action at the bottom of the hole. The crushed material in the well is mixed with water added during the drilling and is removed by means of a bailer. The hydraulic-rotary method also is used for the drilling of domestic and stock wells. In this method cutting is done by rotating

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in the hole a cutting bit at the end of a hollow drill pipe. Cuttings are removed by circulating muddy water under high pressure down through the drill pipe and up through the annular space between the pipe and the hole. The cuttings are brought to the surface as fragments suspended in the mud. The drilling mud prevents caving of the hole by plastering the walls.

The hydraulic-rotary method and the reverse-rotary method are used in the construction of wells of large capacity. In the reverse-rotary method the direction of flow of water is reversed, the cuttings being carried up through the drill pipe. In Cheyenne County the most common method of constructing wells of large diameter and large capacity is to dig down to the water table by hand and to deepen the well beneath the water table by drilling or by means of a sand pump. In the sand-pumping method, casing is placed in the dug part of the well and forced downward as sand and water are removed from the bottom of the well with a bailer. This method is most effective in deposits of uncemented sand and gravel such as in the alluvium of South Fork. The municipal wells at St. Francis were constructed in this manner.

Most of the drilled wells in Cheyenne County obtain water from unconsolidated or partially consolidated deposits of Pleistocene or Pliocene age. Wells in these deposits are ordinarily cased from top to bottom with steel, iron, or galvanized-iron casing to prevent caving. The casing below the water table is perforated or a well screen is used to allow the free passage of water into the well. The size of the openings in the screen or perforated casing is an important factor in the construction of a well. If the openings are too large, the fine material may filter through and fill the well; if the openings are too small, they may become clogged so that water is prevented from entering the well freely. A common practice is to select an opening size that will pass 30 to 60 percent of the particles of the sizes making up the finer-grained water-bearing material. The coarser particles that remain around the screen form a natural gravel packing which increases the effective diameter and thus the specific capacity (yield per foot of drawdown) of the well.

Gravel-packed wells are generally effective for increasing yields of wells penetrating mainly fine sand, and the gravel packing of wells has been practiced to some extent in the construction of irrigation wells in Cheyenne County. In drilling a well of this type in this area a hole of large diameter is first drilled and cased with unperforated casing. A smaller well screen or perforated casing is centered in the hole opposite the water-bearing beds, and enough

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unperforated casing to reach the surface is added. The space between the two casings is filled with sorted gravel, preferably of a grain size just slightly larger than the openings in the screen or perforated casing, and also just slightly larger than the particles of water-bearing material. The outer casing is then withdrawn, uncovering the screen and allowing water to flow from the water-bearing material through the gravel packing. The envelope of gravel placed around the screen increases the effective diameter of the well, prevents the movement of fine sand into the well, and increases the production of sand-free water. The drawdown is generally reduced appreciably because the friction of water entering the well is reduced. The character of the water-bearing material usually determines whether construction of gravel-packed wells is advisable. If the material is coarse and well sorted, as is generally the case in the alluvium of South Fork Valley, gravel-walled wells are not necessary. Where wells are to be drilled in the poorly sorted fine-grained materials of the Ogallala formation in the upland areas of Cheyenne County, gravel packing may be beneficial. For a more detailed discussion of well construction and development the reader is referred to publications by Rohwer (1940), McCall and Davison (1939), and Bennison (1947).

METHODS OF LIFT AND TYPES OF PUMPS

Most domestic and stock wells in Cheyenne County are equipped with cylinder pumps. Many use windmills for power, but some are operated by hand and some are equipped with pump jacks operated by gasoline engines or electric motors. A few wells are equipped with electrically driven jet pumps. The spread of rural electrification in the county has increased the number of electric pumps in use. Some wells are equipped with the force type of cylinder pump which is used to pump water for considerable distances or to considerable heights. Most of the cylinder pumps are of the lift type, which discharge water at the surface or in near-by storage tanks or cisterns.

Irrigation wells in Cheyenne County are equipped with either horizontal centrifugal or deep-well turbine pumps operated by stationary gasoline, butane, or diesel engines, or by tractors. Horizontal centrifugal pumps can be used only where the depth to water plus the drawdown does not exceed the working suction limit. These pumps are usually set in pits dug nearly to the water table. A common type of irrigation pumping plant in South Fork Valley consists of two or more wells connected to a centrifugal pump by a

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suction pipe laid in the ground just above the water table. An installation of this type is called a battery of wells. Deep-well turbine pumps are used in the irrigation wells in the uplands and in some of the wells in South Fork Valley.

Several types of electrically operated pumps are used in the municipal wells at St. Francis and Bird City. St. Francis has two deep-well turbine pumps, one centrifugal pump, and a piston-type suction pump. Bird City has two turbine pumps and a plunger-type cylinder pump. The railroad well at St. Francis has a piston-type suction pump.

Utilization of Ground Water

During this investigation information on 361 wells and 1 spring was obtained. Only a small percentage of the domestic and stock wells was visited, but records were made for all public-supply wells and for the railroad well at St. Francis. Most of the irrigation wells were visited also. Records of wells are listed in Table 6 and the principal uses of water are described below.

Domestic and Stock Supplies

Nearly all the domestic water supplies of Cheyenne County are from wells. Springs supply a small amount of water for domestic use. In parts of Cheyenne County ground-water supplies are lacking or contain excessive amounts of minerals and water for cooking, drinking, and washing must be hauled. In general, ground water in Cheyenne County, although moderately hard, is suitable for most domestic uses.

Most stock-water supplies are also from wells but water from springs, streams, stock ponds, and undrained depressions is used to some extent, especially in areas where wells are difficult to obtain.

Public Supplies

Public water supplies at Bird City and St. Francis are obtained from wells. Data on the Bird City and St. Francis municipal wells are given in Table 6.

Bird City.—Bird City obtains its water from three wells in the city park which penetrate the Ogallala formation. These wells are reported to range from about 230 to 260 feet in depth and individual yields are estimated to range from 55 to 125 gallons a minute. The wells pump directly into the mains and the excess is stored in an elevated tank holding 50,000 gallons. The maximum daily consumption in 1950 was 228,000 gallons on June 12. On some days the consumption was as low as 30,000 gallons. The average daily

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consumption is about 80,000 gallons. The quality of water used in Bird City is indicated on Table 3 (well 3-38-36 bad).

St. Francis.—St. Francis, the county seat of Cheyenne County, obtains its water supply from four wells deriving water from the alluvium of South Fork. The wells range in depth from about 25 to 30 feet and all are drilled through the entire thickness of the alluvium into the Pierre shale. They are near the power plant and pump directly into the mains, the excess going to an elevated water tank in the southern part of town. The capacity of the tank is 225,000 gallons. The maximum yield of each well is about 300 gallons a minute. The average daily consumption is about 500,000 gallons, but during dry periods when gardens and lawns are irrigated the daily consumption is much greater. An analysis of a composite sample of water from the St. Francis municipal supply is included in Table 3 (well 3-40-21dcd). The water is not treated.

INDUSTRIAL SUPPLIES

The Chicago, Burlington and Quincy Railroad at St. Francis has one well used principally for filling locomotive boilers. No data concerning the yield of the well and the amount of water used by the railroad are available.

IRRIGATION SUPPLIES

Irrigation, both from South Fork and from wells, was practiced on a small scale in Cheyenne County many years ago (Hay, 1895, p. 586; Wolff, 1911) and is still practiced to a small extent. Although 27 of the wells visited were classified as irrigation wells, very few pumped an appreciable amount of water in 1950. Some of the wells had not been used for several years. The main crops irrigated in 1950 were corn, alfalfa, and milo maize, the total acreage being a few hundred acres. The amount of water used for irrigation in Cheyenne County is small. A few wells equipped with windmills are used to pump small amounts of water for irrigating gardens. Yields of irrigation wells tested ranged from 150 to 900 gallons a minute. A typical irrigation well and an irrigation sprinkling system in Cheyenne County are shown on Plate 5.

POSSIBILITIES OF FURTHER DEVELOPMENT OF IRRIGATION SUPPLIES

Further development of irrigation supplies from wells in Cheyenne County depends upon the thickness of the water-bearing materials and their permeability, and the amount of recharge to the ground-water reservoir. Figure 9 indicates that, in general, there is little saturated material north of South Fork and the chances of

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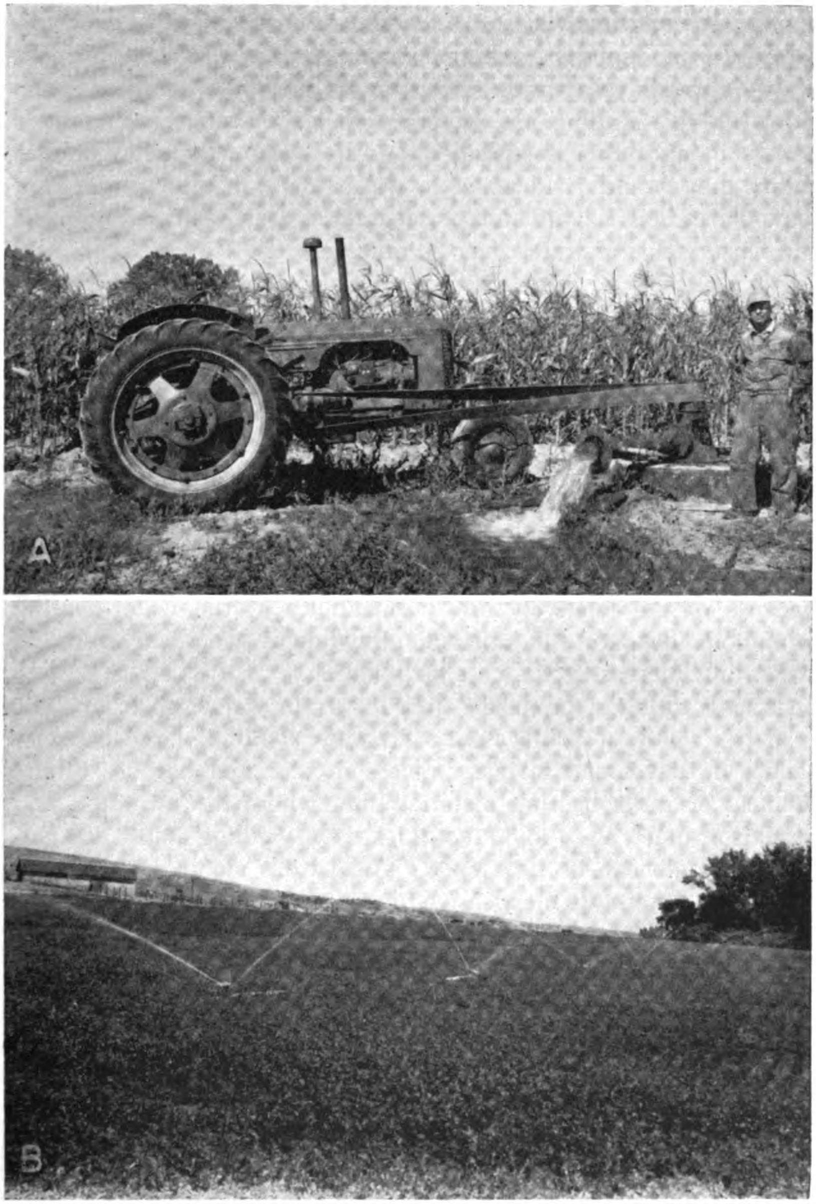

PLATE 5. **A, Irrigation well 1-38-19adc in South Fork Valley, pumping 400 gallons a minute. B, Irrigation sprinkling system irrigating alfalfa in South Fork Valley, sec. 29, T. 3 S., R. 40 W.**

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developing irrigation wells north of the river, except in the immediate vicinity of the river, are very poor. South of the valley the water-bearing deposits reach a maximum of nearly 180 feet in thickness and possibly irrigation wells can be developed in some areas. However, test drilling has indicated that the water-bearing beds are commonly rather fine-grained, and because of their low permeability they would yield water to wells slowly in most places. In some places beds having high permeabilities are penetrated by wells and large yields of water may be obtained.

The feasibility of further development of irrigation supplies from wells depends upon the availability of ground water as discussed in the preceding paragraph, the cost of drilling and pumping, the types of soil, the topography, the kinds of crops raised, the market and price conditions, and other factors beyond the scope of this report. The cost of drilling and pumping is determined to some extent by the depth to water level. Depths to water level in areas in Cheyenne County where an adequate supply of ground water for irrigation might be obtained range from less than 10 feet in areas along South Fork to more than 200 feet in the vicinity of Bird City. Because of the relatively low permeability of the water-bearing formations beneath the uplands, drawdowns would tend to be large, thus increasing the cost of pumping.

Perhaps the most promising area for future irrigation from wells is in the valley of South Fork. Probably wells of large capacity cannot be developed in many places in this area because of the thinness of water-bearing materials, but where the saturated material is as much as 20 to 30 feet thick wells yielding 300 to 400 gallons a minute can be developed. Also, wells along the river are shallow and therefore inexpensive to drill and economical to operate. Large yields from wells probably can be obtained in many areas in Cheyenne County where the aquifer is thick, although in these areas the water table is generally 100 feet or more below the surface. More wells may be drilled in such areas if future economic conditions are suitable.

Chemical Character of the Ground Water

The chemical character of the ground water in Cheyenne County is indicated by the analyses of water from 19 wells and 1 spring (Tables 3 and 4). Table 3 includes analyses of water from the Bird City and St. Francis municipal water supplies. Figure 10 shows graphically the chemical character of water from the principal

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water-bearing formations. The water samples were analyzed by Howard A. Stoltenberg, chemist, in the Water and Sewage Laboratory of the Kansas State Board of Health at Lawrence. The analyses show only the dissolved mineral content and do not indicate the sanitary conditions of the water.

CHEMICAL CONSTITUENTS IN RELATION TO USE

The following discussion of the chemical constituents of ground water has been adapted in part from publications of the Federal Geological Survey and the State Geological Survey of Kansas.

Dissolved solids.—When water is evaporated, the residue consists of rock materials, a little water of crystallization, and sometimes a small amount of organic material. The most important of these rock materials are listed in Table 3. The kind and quantity of these soluble rock materials in the water determine its suitability for use. Water with less than 500 parts per million of dissolved solids generally is satisfactory for domestic use, except for hardness or occasional excessive iron content. Water containing more than 1,000 parts per million is likely to contain enough of certain constituents to produce a noticeable taste or to make the water unsuitable in some other respect.

The dissolved solids in samples of water from Cheyenne County ranged from 239 to 905 parts per million. Six samples contained more than 500 parts per million.

Hardness.—Hardness of water is commonly recognized by its effects when soap is used with the water in washing. Calcium and magnesium cause practically all the hardness of ordinary waters and are also the active agents in the formation of the greater part of the scale formed in steam boilers and in other vessels in which water is heated or evaporated.

Hardness is of two types, carbonate hardness and noncarbonate hardness. Carbonate hardness, often called temporary hardness because it can be removed almost entirely by boiling, is caused by calcium and magnesium bicarbonate. Noncarbonate or permanent hardness is caused mainly by sulfates and chlorides of calcium and magnesium and to a lesser degree by nitrates and fluorides of calcium and magnesium. Carbonate and noncarbonate hardness are the same with respect to consumption of soap. In general, however, noncarbonate hardness forms the hardest scale in steam boilers.

Water having a hardness of less than 50 parts per million is rated as soft and is seldom treated to remove hardness. Hardness between 50 and 100 parts per million increases the consumption of soap and

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TABLE 3.—*Analyses of water from typical wells in Cheyenne County*

Analyzed by H. A. Stoltenberg. Dissolved constituents given n parts per million,[a] and in equivalents per million [b] (in italics)

Well number	Depth (feet)	Geologic source	Date of collection	Temperature (°F)	Dissolved solids	Silica (SiO₂)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO₃)	Sulfate (SO₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO₃)	Hardness as CaCO₃ Total	Carbonate	Noncarbonate
T. 1 S., R. 37 W.																		
1-37-20bcc	39.0	Alluvium	Dec. 5, 1950	53	648	44	0.16	87 *4.34*	33 *2.71*	93 *4.05*	439 *7.20*	112 *2.33*	41 *1.16*	1.7 *.09*	20 *.32*	352	352	0
T. 1 S., R. 39 W.																		
1-39-21bcc	45.0	Ogallala	Dec. 5, 1950	......	591	46	2.4	88 *4.39*	25 *2.06*	73 *3.17*	322 *5.28*	177 *3.68*	21 *.59*	.9 *.05*	1.1 *.02*	322	264	258
1-39-25bbc	28.1	Alluvium	Dec. 4, 1950	56	841	38	.20	102 *5.09*	39 *3.21*	120 *5.20*	307 *5.03*	341 *7.09*	43 *1.21*	1.5 *.08*	5.8 *.09*	415	252	163
T. 1 S., R. 41 W.																		
1-41-7abd	38.0	Colluvium, alluvium	Dec. 2, 1950	57	905	37	.19	132 *6.59*	49 *4.03*	80 *3.50*	222 *3.64*	475 *9.88*	16 *.45*	1.0 *.05*	6.2 *.10*	531	182	439
1-41-29dba	93.0	Ogallala	Dec. 2, 1950	57	470	27	.19	59 *2.94*	18 *1.48*	72 *3.11*	200 *3.28*	158 *3.29*	27 *.76*	1.2 *.06*	8.8 *.14*	221	164	57
T. 2 S., R. 37 W.																		
2-37-20ddd	220.0	do.	Dec. 5, 1950	58	298	60	.45	37 *1.85*	18 *1.48*	28 *1.22*	207 *3.39*	24 *.50*	11 *.31*	1.8 *.09*	16 *.26*	166	166	0
T. 2 S., R. 39 W.																		
2-39-17adc	15.1	Alluvium	Dec. 5, 1950	56	381	31	.30	61 *3.04*	16 *1.32*	51 *2.23*	295 *4.84*	60 *1.25*	15 *.42*	1.4 *.07*	.93 *.01*	218	218	0
T. 2 S., R. 40 W.																		
2-40-12bbc	130.6	Ogallala	Dec. 5, 1950	......	559	59	.35	64 *3.19*	34 *2.79*	51 *2.21*	205 *3.36*	44 *.92*	45 *1.27*	1.6 *.08*	159 *2.56*	299	168	131
T. 3 S., R. 38 W.																		
3-38-36bad	(c)	do.	Feb. 3, 1950	......	298	51	.04	32 *1.60*	14 *1.15*	37 *1.62*	209 *3.43*	19 *.40*	9 *.25*	1.5 *.08*	13 *.08*	138	138	0
T. 3 S., R. 40 W.																		
3-40-21dcd	(d)	Alluvium	Nov. 15, 1950	......	606	44	.03	80 *3.99*	28 *2.30*	76 *3.31*	324 *5.31*	143 *2.97*	32 *.90*	1.5 *.08*	21 *.34*	314	266	48
T. 3 S., R. 41 W.																		
3-41-2ccc	182.0	do.	Dec. 2, 1950	57	283	49	.10	37 *1.85*	19 *1.56*	25 *1.09*	205 *3.36*	20 *.42*	12 *.34*	1.3 *.07*	19 *.31*	170	168	2
T. 3 S., R. 42 W.																		
3-42-28dda	159.0	Ogallala	Dec. 2, 1950	60	244	51	.14	32 *1.60*	14 *1.15*	23 *1.02*	185 *3.03*	13 *.27*	9.3 *.15*	1.4 *.07*	9.3 *.15*	138	138	0

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TABLE 3.—*Analyses of water from typical wells in Cheyenne County*—(Concluded)

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
T. 4 S., R. 37 W. 4-37-23bcc	129.0	Ogallala	Nov. 25, 1950	58	283	49	.58	42 *2.10*	17 *1.40*	25 *1.07*	220 *3.61*	21 *.44*	11 *.31*	1.1 *.06*	9.3 *.15*	175	175	0
T. 4 S., R. 38 W. 4-38-4bbb	220.0	do	Nov. 25, 1950	......	293	50	.24	39 *1.95*	18 *1.48*	28 *1.24*	217 *3.56*	26 *.54*	10 *.28*	1.4 *.07*	14 *.23*	172	172	0
T. 4 S., R. 40 W. 4-40-2aad	91.0	do	Nov. 25, 1950	58	277	51	.14	38 *1.90*	14 *1.15*	29 *1.28*	200 *3.28*	24 *.50*	11 *.31*	1.7 *.09*	9.3 *.15*	152	152	0
T. 4 S., R. 41 W. 4-41-16bcc	....	do	Dec. 2, 1950	......	264	45	.06	40 *2.00*	14 *1.15*	26 *1.12*	210 *3.44*	15 *.31*	11 *.31*	1.3 *.07*	8.8 *.14*	158	158	0
T. 4 S., R. 42 W. 4-42-24dad	24.3	Alluvium	Dec. 2, 1950	......	239	46	.08	37 *1.85*	12 *.99*	22 *.95*	193 *3.16*	11 *.23*	8 *.23*	1.1 *.06*	7.1 *.11*	142	142	0
T. 5 S., R. 38 W. 5-38-23cbc	66.0	Ogallala	Nov. 25, 1950	56	239	33	.16	51 *2.54*	11 *.90*	12 *.53*	200 *3.28*	7 *.14*	9 *.25*	.7 *.04*	16 *.26*	172	164	8
T. 5 S., R. 39 W. 5-39-2bbb	140.0	do	Nov. 25, 1950	58	422	43	.36	73 *3.64*	25 *2.06*	17 *.74*	207 *3.39*	10 *.21*	31 *.87*	.8 *.04*	120 *1.93*	285	170	115
T. 5 S., R. 41 W. 5-41-16ccc	179.0	do	Dec. 2, 1950	58	255	47	.08	36 *1.80*	15 *1.23*	24 *1.04*	198 *3.25*	19 *.40*	8 *.23*	1.7 *.09*	6.2 *.10*	152	152	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.
b. 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.
c. Composite sample from Bird City water supply.
d. Composite sample from St. Francis water supply.

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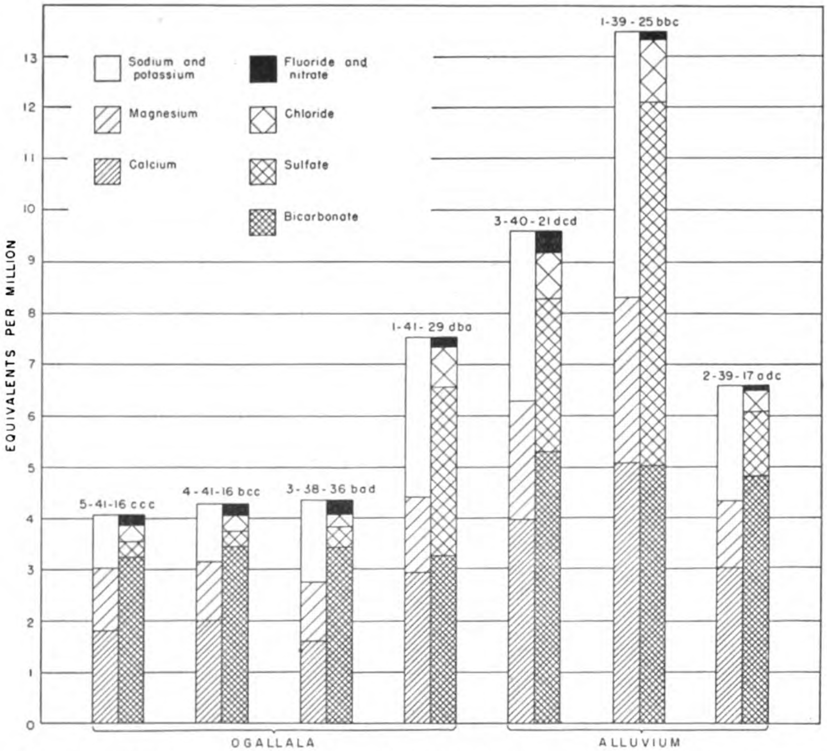

Fig. 10.—Analyses of water from the principal water-bearing formations in Cheyenne County.

the removal of hardness by a softening process may be profitable by laundries or other industries using large amounts of soap. Hardness of more than 150 parts per million is easily noticeable and where hardness exceeds 200 parts per million water for household use is sometimes softened or rain water is stored in cisterns for washing. Where municipal water supplies are softened the hardness is reduced generally to about 100 parts per million.

The hardness of samples of water collected in Cheyenne County ranged from 138 to 531 parts per million. Nine samples had a hardness of more than 200 parts per million and 11 samples, less than 200.

Silica.—Silica is a common rock material in solution in ground water. The silica in water may be deposited with other scale-forming constituents in steam boilers, but otherwise it has no effect on the use of water for most purposes.

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TABLE 4.—*Summary of the chemical character of the samples of water from typical wells in Cheyenne County*

Range in parts per million	Number of samples	
	Ogallala formation	Alluvium
Dissolved solids		
200–250	3	0
251–300	7	1
301–400	0	1
401–500	2	0
501–600	2	0
601–700	0	2
701–1000	0	2
Total hardness		
100–150	2	1
151–200	8	0
201–250	1	1
251–300	2	0
301–400	1	2
401–600	0	2
Fluoride		
0.5–1.0	3	1
1.1–1.5	7	4
1.6–2.0	4	1
Nitrate (NO_3)		
Less than 10	7	4
11–20	5	1
21–30	0	1
31–160	2	0

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Iron.—The quantity of iron in ground water may differ greatly from place to place, even in water from the same formation. If a water contains much more than 0.1 part per million of iron the excess, after exposure to the air, may settle as a reddish precipitate. Iron stains cooking utensils, bathroom fixtures, and clothing and may give a disagreeable taste if present in sufficient quantity. Iron content in water can generally be reduced by simple aeration and filtration, but for certain industrial uses iron must be completely removed by other methods.

In water samples from Cheyenne County the iron content ranged from 0.03 to 2.4 parts per million. All but five samples contained 0.1 part per million or more of iron.

Sulfate.—According to the U. S. Public Health Service (1946) a maximum of 250 parts per million of sulfate is recommended in water supplies used on interstate carriers. Waters containing excessive amounts of sodium sulfate (Glauber's salt) or magnesium sulfate (Epsom salt) may have an adverse effect on the human system. Only two samples from Cheyenne County contained more than 250 parts per million of sulfate and most samples contained considerably less than this amount.

Fluoride.—Although fluoride is usually present only in small quantities in ground water, the amount of fluoride in water consumed by children should be known. Fluoride in water is associated with the dental defect known as mottled enamel, which may appear on the teeth of children, who, during the formation of the permanent teeth, drink water containing too much fluoride. Teeth affected with mottled enamel have white chalky spots on them and in more severe cases may have brown stains or may be pitted.

According to Dean (1936) mild cases of mottled enamel may develop in a small percentage of children whose supply of drinking water contains about 1 part per million of fluoride. Mild cases of mottled enamel were reported in about 40 or 50 percent of children who drank water containing 1.7 to 1.8 parts per million. Drinking water containing 4 parts per million of fluoride resulted in mottled enamel in 90 percent of the children, 35 percent of the cases being classified as moderate or worse. The Public Health Service (1946) recommends that the content not be in excess of 1.5 parts per million.

Recent studies indicate that water containing small amounts of fluoride is beneficial in preventing tooth decay. At the present time fluoride is being added to public water supplies in many areas in the United States where the water is deficient in fluoride. In most such places the fluoride content is brought up to about 1.0 part per mil-

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lion, or about 0.5 part less than the maxium specified by the Public Health Service.

The fluoride content of water samples from Cheyenne County ranged from 0.7 part to 1.8 parts per million. Most of the samples were within the safe limits suggested by the Public Health Service, and only 5 samples contained more than 1.5 parts per million of fluoride.

Nitrate.—Some of the nitrate in ground water is derived from nitrate-bearing rocks and minerals in the water-bearing formations, but high concentrations of nitrate probably are due to direct flow of surface water into the well or to percolation of nitrate-bearing water into the well through the top few feet of the well. In Kansas probably much of the nitrate in well waters is derived from soils, which are rich in highly soluble organic nitrogen. Other sources of nitrate are barnyards, cesspools, and privies which may also contribute dangerous bacteria to the ground water.

The amount of nitrate in water should be known, not only because high nitrate may indicate pollution but because nitrate itself may be dangerous. A large amount of nitrate in water used in the preparation of a baby's formula can cause cyanosis of infants. If the water supply is not changed, eventual death may result.

According to Metzler and Stoltenberg (1950, p. 194): The nitrates are converted to nitrites and absorbed by the blood, where they destroy its oxygen-carrying properties. The blood becomes chocolate brown, the skin develops a blue color, and death may result from oxygen starvation.

Nitrate-bearing water does not cause cyanosis in adults but it may have other adverse effects.

The Kansas State Board of Health considers that concentrations of nitrate as NO_3 exceeding 45 to 90 parts per million are unsafe and should not be used for infant-formula preparation. All water samples collected in Cheyenne County contained nitrate, but only two samples, which contained 159 and 120 parts per million, respectively, were considered unsafe for drinking.

SANITARY CONSIDERATIONS

The analyses of water given in Table 3 show only the amounts of dissolved mineral matter in the water and do not indicate the sanitary quality of the water. The water in a well may contain mineral matter that imparts an objectionable taste or odor, yet may be free from harmful bacteria and be safe for drinking. On the other hand, the water in a well may be clear, palatable, and seemingly pure, yet may contain harmful bacteria. An abnormal amount of certain

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mineral constituents such as nitrate or chloride sometimes indicates pollution.

The entire population of Cheyenne County is dependent upon ground-water supplies and every precaution should be taken to protect these supplies from pollution. Wells should not be located near possible sources of pollution or where surface water can enter the ground at or near the well; every well should be constructed to seal off all surface water. As a rule, dug wells are more subject to contamination than drilled wells. They generally are not effectively sealed at the top, or the depth to water may be so shallow that bacteria may not be filtered out effectively as the water descends to the water table, even if the well is constructed properly.

WATER FOR IRRIGATION

The suitability of a water for irrigation is dependent mainly on the concentration of dissolved solids and on the percentage of sodium. The quantity of chloride is sometimes large enough to affect use of water for irrigation, and boron is sometimes present in sufficient amounts to be harmful to plants. The total concentration of dissolved constituents may be expressed in terms of total equivalents per million of anions or cations, parts per million of dissolved solids, or electrical conductivity. Electrical conductivity is the measure of the ability of the inorganic salts in solution to conduct an electric current, the current being dependent upon the number and kinds of dissolved solids. Electrical-conductivity measurements are not shown in analyses of water from Cheyenne County, but an approximate value can be obtained by multiplying total equivalents of anions or cations by 100, or by dividing dissolved solids in parts per million by 0.7 (Wilcox, 1948, pp. 4-5). To find the percentage of sodium, the results of the analysis must be reported in equivalents per million. The equivalents per million of sodium is divided by the sum of the equivalents per million of calcium, magnesium, sodium, and potassium, and the result is expressed as a percentage.

The classification of water for irrigation use is shown in Table 5 (Wilcox, 1948a). The classification is empirical only and, as in any method for interpretation of analyses, it is assumed that the water will be used under average conditions as related to soil, permeability, quantity of water used, climate, and crops. In general, water containing more than 60 percent of sodium or having an electrical conductance of more than 2,000 is unsuitable for irrigation. All samples of water from Cheyenne County analyzed are within the permissible limits suggested by Wilcox.

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TABLE 5.—*Permissible limits for electrical conductivity and percentage of sodium in several classes of irrigation water* (From Wilcox, 1948a, p. 27)

Classes of Water		Electrical conductivity (micromhos at 25° C.)	Percent sodium
Rating	Grade		
1	Excellent	less than 250	less than 20
2	Good	250–750	20–40
3	Permissible	750–2,000	40–60
4	Doubtful	2,000–3,000	60–80
5	Unsuitable	more than 3,000	more than 80

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

CRETACEOUS SYSTEM

GULFIAN SERIES

Pierre Shale

The oldest formation that crops out in Cheyenne County is the Pierre shale of late Cretaceous (Gulfian) age. The Pierre shale in northwestern Kansas has been studied and described by Elias (1931). He separated the Pierre into six members; only two, the Beecher Island shale member and an unnamed and unstudied shale member, are thought to crop out in Cheyenne County. The Pierre in Cheyenne County consists mainly of brown to yellow-brown shale. Dark-gray to black shale is not common in outcrops but was noted at several localities and was penetrated in several test holes. The shale contains many thin layers of gypsum and a few thin beds of brown limestone. The Pierre shale crops out at many localities in the north half of Cheyenne County, particularly along tributaries to Arikaree River and South Fork. The entire county is underlain by the Pierre, which ranges in thickness from about 900 feet in the southern part of the county to 1,100 feet in the north-central and northeastern parts and to 1,400 feet in the northwestern part. In an oil test well drilled in 1951 in the SE¼ SE¼ NW¼ sec. 26, T. 1 S., R. 39 W., the Pierre had a thickness of about 1,050 feet.

The Pierre shale is of no consequence as an aquifer in Cheyenne County; however, the formation serves as an impervious floor below the water-bearing sediments, and retards or prevents the downward percolation of water in much the same manner as the floor of a tank; to a large extent the configuration of the Pierre shale determines the shape and slope of the water table. Contours show-

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ing the configuration of the surface of the Pierre shale are shown on Figure 7. No wells are known to derive water from the Pierre in Cheyenne County, but the quality of water in wells extended into the shale is affected by its contact with the shale. Typically, water in such wells contains more dissolved solids, is harder, has a larger percentage of permanent hardness, and is much higher in sulfate content than average (Table 3 and Fig. 10, wells 1-39-25bbc, 1-41-29dba, 3-40-21dcd, and others).

TERTIARY SYSTEM

PLIOCENE SERIES

Ogallala Formation

The Ogallala formation was named by Darton in 1899 (pp. 732, 734) for a locality in southwestern Nebraska. In 1920 Darton (p. 6) referred to the type locality as near Ogallala Station in southwestern Nebraska. Elias (1931) made an intensive study of the Ogallala formation in Wallace County and in 1937 he briefly described the formation with special reference to ground water in Rawlins County. Other studies of the Ogallala in northwestern Kansas have been made in Thomas County by Frye (1945) and in Norton and Phillips Counties by Frye and Leonard (1949).

Character.—The Ogallala formation in Cheyenne County consists chiefly of sand, gravel, and silt; beds of bentonitic clay, caliche and sandy limestone; and zones of opal and chert. In areas outside Cheyenne County the Ogallala contains also beds of volcanic ash, diatomaceous marl, and "quartzite." The character of the Ogallala is given by the logs of test holes at the end of the report and in the following measured section.

Section measured in a road cut in the NE¼ sec. 19, T. 3 S., R. 40 W., Cheyenne County. Measured by A. I. Johnson and Mervin Klug.

	Thickness, feet
TERTIARY—Pliocene	
Ogallala formation	
5. Mortar bed, gray-white to pinkish-white	12.0
4. Sand, fine to medium, silty, partially cemented, reddish-brown	4.6
3. Sand, very fine to medium, silty, light pinkish-gray; contains abundant *Biorbia fossilia* fruits	7.4
2. Clay, shaly, olive-green; contains many calcareous nodules	10.5
CRETACEOUS—Gulfian	
Pierre shale	
1. Shale, unctuous, fissile, black	5.0
Total measured	39.5

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Sand is the most common constituent of the Ogallala formation and is found at nearly all stratigraphic positions; in some places the sand is in uniform well-sorted beds, but it generally is poorly sorted and mixed with silt, clay, or gravel. Gravel beds containing large amounts of sand and silt occur at many stratigraphic positions, but thick beds of uniform gravel are uncommon. Silt and clay, either mixed with deposits of sand and gravel or in layers, are common in the Ogallala. The silt layers may be reddish brown, tan, buff, gray, or white, generally contain nodules or stringers of caliche (calcium carbonate), and may be partially cemented with calcium carbonate. Many of the beds in the Ogallala are cemented or partially cemented, generally with calcium carbonate. Where sand and gravel deposits are cemented with calcium carbonate they may form rough benches or scarps and are called "mortar beds" because of the resemblance to old mortar. Plate 6A shows a type of mortar bed that crops out in several localities in Cheyenne County. The mortar bed is composed mainly of light-tan silt and fine sand, is well cemented, and is very hard. Plate 6B is a photograph of another type of mortar bed. It is less firmly cemented than that described above.

The Ogallala contains calcium carbonate, not only as cementing material and nodules, but also in beds or lenses (called "caliche"). The thickness of bedded caliche ranges from a few inches to 31 feet (test hole 1-37-34ccc).

Beds in the Ogallala are characteristically lenticular and discontinuous but the "Algal limestone," the uppermost bed, has been found in outcrops in Kansas from northwest Cheyenne County as far east as Lincoln County. This limestone has a peculiar concentrically banded structure and was thought by Elias (1931, pp. 136-141) to have been precipitated in quiet water at least in part by the alga *Chlorellopsis*. The "Algal limestone" has a maximum thickness of about 4 feet in Cheyenne County, is generally reddish, and weathers to a knobby, irregular surface. Outcrops of the "Algal limestone" are fairly common in Cheyenne County and have been found in several different localities—for example, in the SW¼ sec. 22, T. 1 S., R. 42 W.; in the NW¼ sec. 31, T. 5 S., R. 40 W., and in the SW¼ sec. 27, T. 1 S., R. 37 W.

Distribution and thickness.—The Ogallala underlies most of Cheyenne County except in areas along South Fork and its tributaries where it has been removed by erosion. Also, the formation is very thin or absent in much of T. 1 S., which borders Nebraska (Figs. 5, 6). The Ogallala is overlain in most of the county by Pleistocene deposits but it crops out along many of the streams in places where

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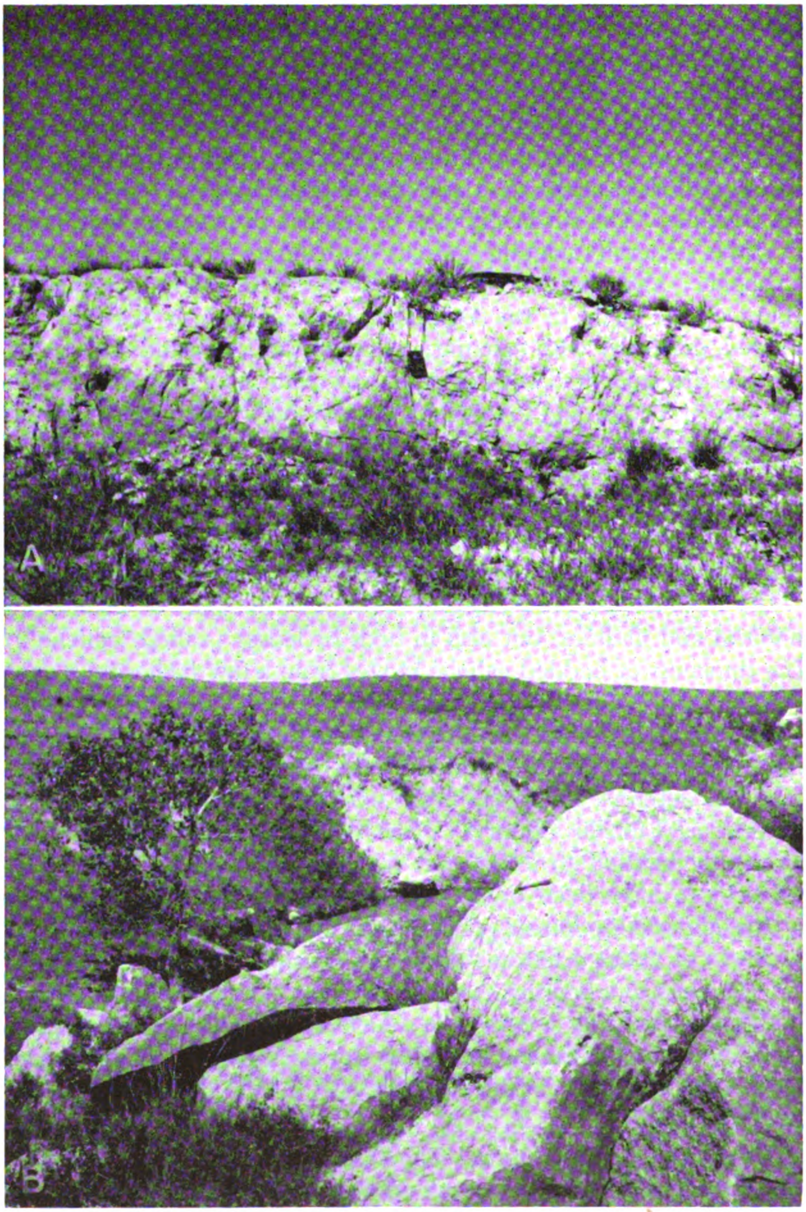

PLATE 6. **A**, Very hard variety of mortar bed in Ogallala formation, SW¼ sec. 21, T. 2 S., R. 39 W. **B**, Large broken and slumped blocks of mortar bed, NE¼ sec. 4, T. 2 S., R. 38 W.

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it has been exposed by stream or wind erosion (Pl. 1). The thickness of the Ogallala in test holes ranged from 289 feet in test hole 6-40-1aaa, drilled on the Sherman County border, to the vanishing point in several holes drilled along South Fork. The thickness of the formation is shown in the cross sections (Figs. 5 and 6) and in the logs of test holes given in this report.

Age and correlation.—In 1899 Darton (pp. 732, 734) applied the name Ogallala formation to deposits formerly called "Tertiary grit" and considered of Miocene age by Hay (1895, p. 570). Darton considered these deposits to be of Pliocene age and the formation is now generally considered to be of Pliocene age, on the basis of paleontological evidence.

The State Geological Survey of Kansas recognizes three members in the Ogallala formation. These members, which range from early Pliocene (or possibly late Miocene) to late Pliocene, are: Valentine, Ash Hollow, and Kimball. Their recognition is based primarily on plant fossils and a few distinctive lithologic types. Elias (1942) considers *Stipidium commune* to be the most common grass seed in the Valentine member. *Krynitzkia coroniformis* is generally indicative of the lower Ash Hollow or upper Valentine, and *Biorbia fossilia* is characteristic of the remainder of the Ash Hollow. *Prolithospernum johnstoni* is the most diagnostic form in the Kimball member and the "Algal limestone" at the top of this member simplifies its identification.

The Kimball member of the Ogallala has been identified in several areas in Cheyenne County by outcrops of the "Algal limestone." The abundance of *Biorbia fossilia* in beds in the NE¼ sec. 19, T. 3 S., R. 40 W., the NW¼ sec. 9, T. 4 S., R. 40 W., the NE¼ sec. 13, T. 5 S., R. 38 W., and the SW¼ sec. 4, T. 4 S., R. 40 W. are indicative of the Ash Hollow member. The Valentine member has not been identified in Cheyenne County. However, Elias found exposures of the Valentine on the south side of Arikaree River east of Wray, Colorado (Elias, 1942), and probably the Valentine is present in Cheyenne County.

Water supply.—The Ogallala formation is the most important source of ground water in Cheyenne County. In the uplands most of the wells, including several irrigation wells, the Bird City municipal wells, and many domestic and stock wells obtain water from this formation. In addition, the Ogallala yields water to several springs in the county. The yields of wells range from a few gallons a minute in small domestic and stock wells to more than 900

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gallons a minute in one irrigation well. Coarse sand and gravel where below the water table generally yield large supplies of water. Fine-grained or cemented materials may be very porous and may contain much water but may not be sufficiently permeable to yield water freely. The geologic cross sections (Figs. 5 and 6) and the map showing thickness of saturated materials (Fig. 9) indicate that, in certain areas in Cheyenne County, a large amount of water is available from the Ogallala.

Water samples were collected from 13 wells and 1 spring that obtain water from the Ogallala formation. Analyses of the samples are listed in Table 3 and analyses of typical water from the Ogallala are shown graphically in Figure 10. Chemical analyses indicate that the water is moderately to very hard but, in general, is of good quality both for domestic use and for irrigation.

Quaternary System

PLEISTOCENE SERIES

Sanborn Formation

In 1931 Elias (pp. 163-181) described unconsolidated Pleistocene deposits, consisting mainly of silt, in northwestern Cheyenne County and named these deposits the Sanborn formation, for the town of Sanborn, Nebraska, just north of the type locality. In 1937 (p. 7) he briefly described this formation in Rawlins and Decatur Counties. More recent studies of the Sanborn formation in northwestern Kansas have been made and are reported by Leonard and Frye (1943), Hibbard, Frye, and Leonard (1944), Frye (1945; 1946), and Frye and Leonard (1949). This report uses the classification and correlations of the Sanborn formation as described by Frye and Fent (1947) in central Kansas.

Character.—In Cheyenne County four members of the Sanborn formation—the Crete sand and gravel member, the Loveland silt member, the Peoria silt member, and the Bignell silt member—have been recognized. Outcrops of the Crete sand and gravel member are uncommon in Cheyenne County, but stream deposits of sand and gravel (Crete) representing the major channel fills of basal Sanborn have been observed in terraces along Arikaree River in the NE¼ NW¼ sec. 10, T. 1 S., R. 42 W., and along South Fork in the NW¼ SW¼ sec. 4, T. 2 S., R. 39 W. Test holes 1-38-11aaa and 1-38-12bcc, drilled south of South Fork, penetrated sand and gravel which was probably Crete. These deposits were masked by loess, and probably the Crete occurs in other areas along South Fork but is obscured by

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loess or dune sand. In some localities in northwest Cheyenne County the basal part of the Sanborn contains sand and gravel that was eroded from the Ogallala, moved down the slopes by sheet or rill wash, probably for only short distances, deposited, and covered by the loess of the Sanborn. These deposits, which may be considered Crete were later exposed by the deep erosion of the Sanborn formation in this area.

Three silt members, the Loveland, the Peoria, and the Bignell, lie above the Crete sand and gravel member of the Sanborn formation. The Loveland is thin and occurs only locally in Cheyenne County. The Loveland was penetrated in test hole 6-42-2aaa on the Sherman County line and it crops out in the SW¼ SE¼ sec. 17, T. 1 S., R. 41 W.; SW¼ sec. 6, T. 1 S., R. 39 W.; and NW¼ NW¼ sec. 35, T. 1 S., R. 40 W.

A soil profile (the Sangamon soil) separates the Loveland silt member from the Peoria silt member (Pl. 7A). This soil profile was developed during a period of subaerial erosion between the times of deposition of the two members. It is generally not well developed in Cheyenne County but in areas farther south and east the profile is colored dark reddish brown by oxidation and organic matter. The upper part of the soil zone has been leached of calcium carbonate, which has been deposited below as stringers and nodules of caliche.

The Peoria silt member is the most widespread member of the Sanborn in Cheyenne County. The Peoria consists mainly of tan to light-brown silt and very fine sand (Pl. 7B). Locally, however, it contains large amounts of fine to coarse sand, as in test holes 1-37-8acd and 5-39-6aaa. The sandy deposits are continuous with the silt, no definite boundary existing between them. Therefore, this sand is probably a sandy phase of the Peoria representing periods of high wind during Sanborn rather than more recent time.

Plate 8A shows a deposit of fine to coarse sand in the Peoria. This sand deposit has been protected from erosion by a sod cover and a thick black soil and now has the appearance of a small isolated butte.

The Bignell silt member, the youngest member of the Sanborn formation, has been identified in only a few places in Cheyenne County. The silt is exposed at one locality in the SE cor. sec. 28, T. 3 S., R. 39 W., in a road cut along U. S. Highway 36, where it overlies the Brady soil, which is developed on the Peoria silt. Other exposures of the Bignell silt member are in the NW¼ sec. 11, T. 1 S.,

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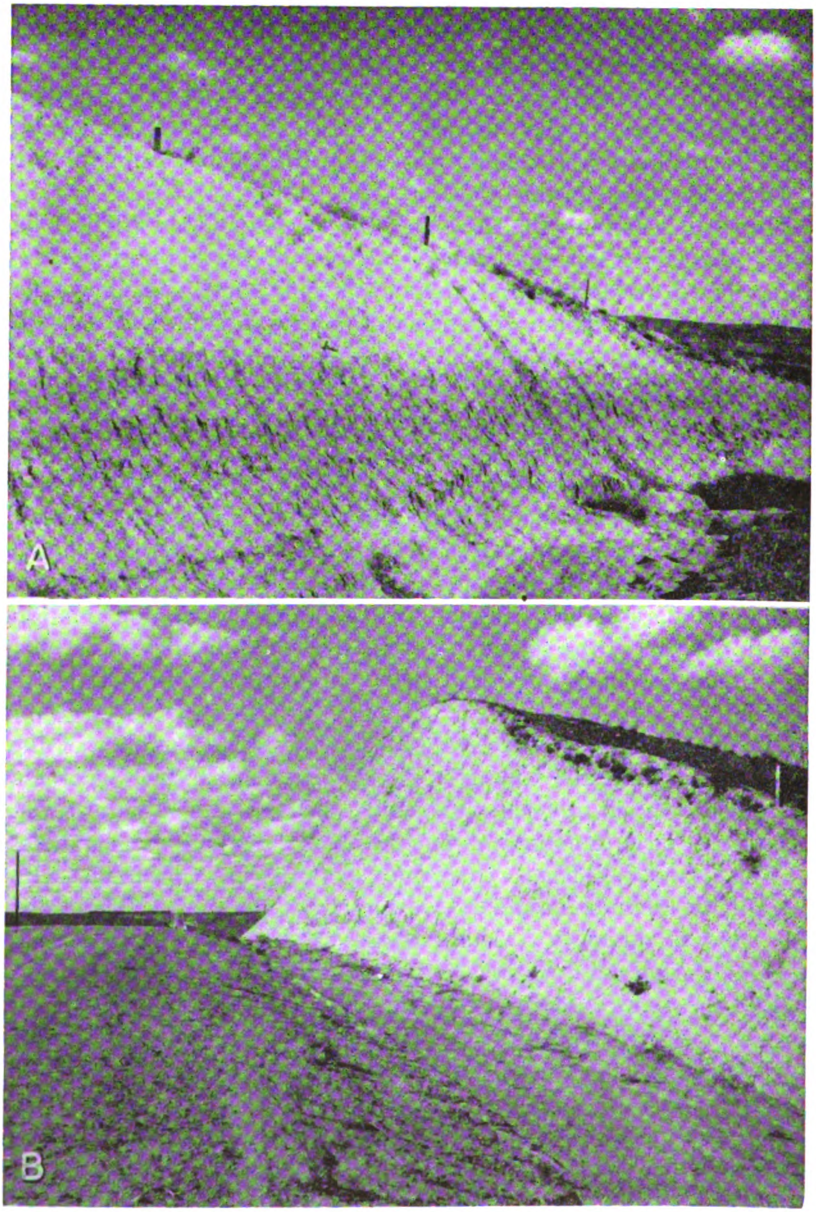

PLATE 7. **A**, Tan Peoria silt member of Sanborn formation above reddish-brown Sangamon soil; NW¼ NW¼ sec. 35, T. 1 S., R. 40 W. **B**, Peoria silt member of Sanborn formation, NW¼ NW¼ sec. 2, T. 2 S., R. 40 W., looking north.

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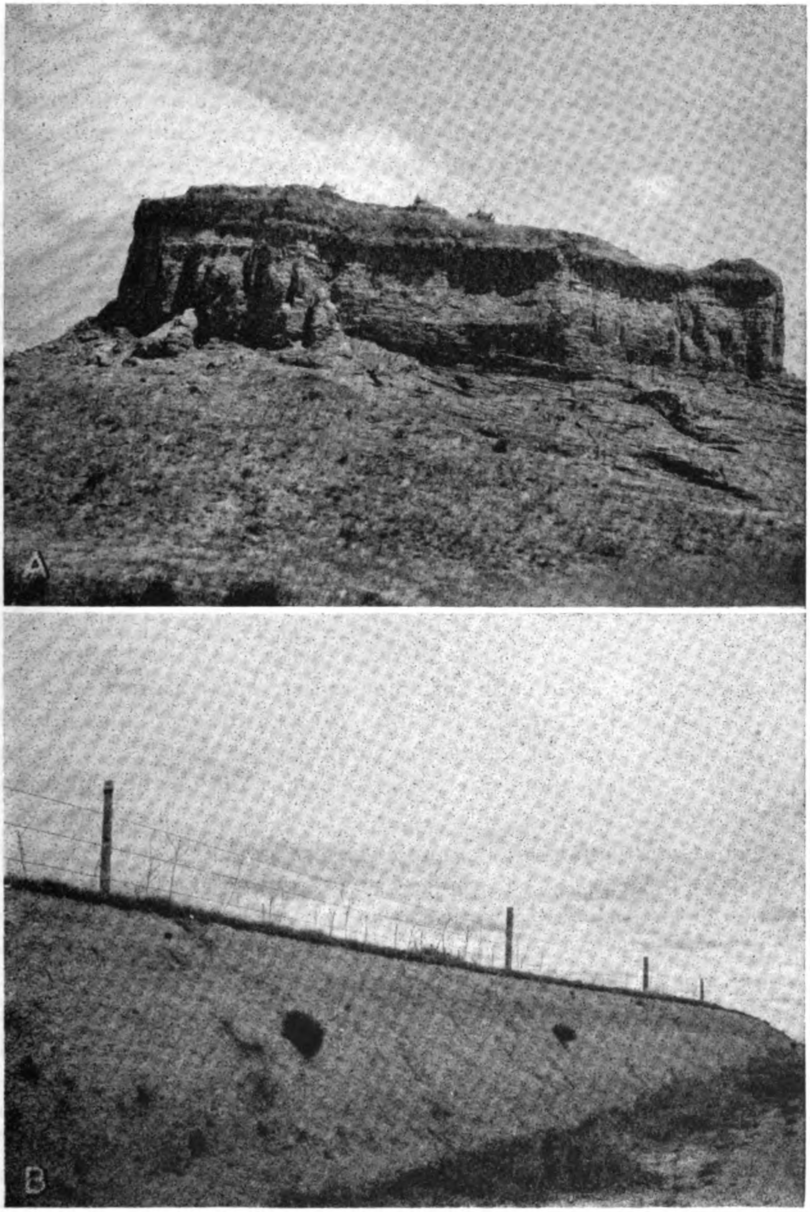

Plate 8. **A,** Butte of a sandy phase of the Peoria silt member of the Sanborn formation. Butte is protected from erosion by sod cover and soil. NW¼ sec. 17, T. 1 S., R. 37 W. **B,** Peoria silt member of the Sanborn formation overlain by thin Brady soil and thin Bignell silt member. NW¼ sec. 11, T. 1 S., R. 40 W.

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R. 40 W. (Pl. 8B), and in the NW¼ NW¼ sec. 23, T. 2 S., R. 40 W.

Included with the Sanborn formation on the geologic map (Pl. 1) are colluvial materials, which mantle some of the slopes. The colluvium or slope deposits consist mainly of silt of the Sanborn formation that has been redeposited during Recent time by the action of wind, surface water, and soil creep. Fragments of the Ogallala formation are included in some places in the lower part of the slope deposits. However, slope deposits are generally indistinguishable from the Sanborn formation and are mapped with it.

Distribution and thickness.—As indicated by Plate 1, the Sanborn formation and slope deposits underlie the surface of nearly all of Cheyenne County. According to Elias (1931, p. 163) 180 feet of loess is exposed in canyons in the NW¼ sec. 20, T. 1 S., R. 41 W., the type locality of the Sanborn. In sec. 17, T. 1 S., R. 41 W., just north of the type section designated by Elias, J. C. Frye and Norman Plummer (personal communication) measured 130 feet of Sanborn above the Pierre shale. Of this amount 90 feet is Peoria silt, 6 feet is Sangamon soil and Loveland silt, and 34 feet is Crete sand and gravel. The upper part of the section is covered and the Bignell silt member and Brady soil, if present, have not been identified. In the SE cor. sec. 28, T. 3 S., R. 39 W., 5 feet of the Bignell silt member is exposed. The Peoria silt member here is 8 feet thick, including 1.5 feet of Brady soil at the top. Most of the test holes drilled in the upland areas of Cheyenne County penetrated the Sanborn formation. In test hole 3-37-1bbb, 132 feet of silt, all thought to be Peoria, was penetrated.

Age and correlation.—The name Sanborn formation was first used by Elias (1931, p. 163) to replace such terms as "Tertiary marl" or "Plains marl" used by Hay (1895) and other early geologists in the central Great Plains region for deposits later recognized as consisting mainly of loess. Elias considered these deposits to be Pleistocene in age. Lugn (1935, p. 197) objected to the use of the term Sanborn formation because the terms Loveland formation and Peorian formation had already been used for several years in Nebraska for deposits in Nebraska that he considered equivalent to the Sanborn. Also, the term Sanborn was taken from the name of a small town in southwestern Nebraska where Peorian loess was recognized. In 1937 Elias (1937, p. 7) noted the occurrence of a dark-brownish ("red") loess that underlies the light yellowish-buff Sanborn loess in Decatur County. He classed this "red" loess as equivalent to the Loveland formation in Nebraska. The Loveland,

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Peoria, and Bignell silt members of the Sanborn formation are now correlated with the Loveland, Peorian, and Bignell loesses of Nebraska (Frye and Fent, 1947). The Crete sand and gravel member is considered Illinioan in age, the Loveland silt member is Illinoian and early Sangamonian, the Peoria silt member is Iowan and Tazwellian, and the Bignell silt member is Mankatoan and Caryan in age (Moore and others, 1951).

Water supply.—The Sanborn formation generally lies above the water table in Cheyenne County and does not yield water to wells. However, in the northern part of the county where the Sanborn is thick, the Ogallala thin, and the water table discontinuous, small quantities of highly mineralized water can be obtained in some of the canyons eroded in the loess. Several wells, for example 1-38-23cbb and 1-41-23acc, obtain water from the Sanborn formation, probably the Crete sand and gravel member, or from colluvial deposits. The Sanborn, because of its fine texture and low permeability, not only is unimportant as a water bearer but also generally retards greatly the recharge of ground water to aquifers below it.

Dune Sand

Deposits of dune sand lie south of South Fork for much of its extent across Cheyenne County. The dune sand is composed predominantly of fine to coarse sand which has been accumulated by the wind to form small hills. Most of the sand hills are vegetated, but in some spots, such as in road cuts, areas of bare sand are being subjected to renewed wind action. The dune sand probably was derived mainly from alluvial deposits along South Fork and to a lesser extent from sands in the Ogallala, and was blown a short distance to its present location during Recent time. The maximum thickness of the dune sand is not known but probably does not exceed 15 or 20 feet.

No wells in Cheyenne County are known to obtain water from the dune sand, but the dunes, because of their high permeability, are good intake areas for ground-water recharge from local precipitation.

Alluvium

General features.—Deposits of Recent alluvium lie along the valleys and underlie the flood plains of South Fork and Arikaree River and some of the small creeks. The alluvium along South Fork and Arikaree River consists mainly of sand and gravel with lesser amounts of silt and clay. Alluvial deposits along Little Beaver

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Creek contain a relatively large amount of sand and gravel derived from the Ogallala formation, but the valleys of Beaver, Hackberry, Big Timber, and other small creeks contain large amounts of silt and fine sand derived from the Sanborn formation and slope deposits. The major streams in Cheyenne County are not actively eroding at present but serve as transportation lines for the fine sediments carried into the streams from the upland areas by tributaries that flow after periods of heavy rain and do a small amount of erosive work.

The areal extent of the alluvial deposits is shown on Plate 1. Included with the alluvium along South Fork are scattered remnants of terrace deposits. These deposits of older alluvium are discontinuous and cannot be mapped as units in Cheyenne County. The thickness of the alluvium along South Fork where penetrated in test holes ranged from 14 to 37 feet. The thickness of alluvial deposits in the other valleys was not determined, but it probably is somewhat less than the maximum figure for South Fork, and its texture is, on the average, finer grained.

Water supply.—Next to the Ogallala formation the alluvium of South Fork is the most important water-bearing formation in Cheyenne County. The alluvium supplies water to the St. Francis municipal wells, to several irrigation wells, and to many domestic and stock wells. The yields of wells deriving water from the alluvium range from a few gallons a minute for domestic and stock wells to a few hundred gallons a minute for some of the irrigation wells. The alluvium along Arikaree River and Beaver Creek yields water to only a few wells in Cheyenne County because of its limited areal extent. Along some of the tributaries to Arikaree River and South Fork there is some water in alluvial and colluvial deposits, but the alluvium of Little Beaver Creek lies above the water table and does not yield water to wells. Water in alluvial deposits in Cheyenne County is of poorer quality than that in the Ogallala formation; it generally is considerably higher in dissolved solids and in hardness than is water from the Ogallala.

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RECORDS OF REPRESENTATIVE WELLS

Descriptions of 361 wells and 1 spring visited in Cheyenne County and near-by areas are described in Table 6. All information classed as reported was obtained from the owner or tenant. Reported depths of wells are given in feet; measured depths are in feet and tenths. Reported depths to water level are given in feet; measured depths to water level are given in feet, tenths, and hundredths. The well-numbering system used in this table is explained on page 11.

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TABLE 6.—*Records of wells in Cheyenne County*

Well number	Owner or tenant	Type of well (1)	Depth of well, feet	Diameter of well, inches	Type of casing (2)	Principal water-bearing bed		Method of lift (3)	Use of water (4)	Measuring point			Depth to water level below measuring point, feet	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
						Character of material	Geologic source			Description	Distance above land surface, feet	Height above mean sea level, feet (5)			
T. 1 N., R. 37 W.															
1-37-36dcc		Dr	13.5	6	GI	Sand, gravel	Alluvium	Cy,W	S	Top of iron cover	1.0	3,016.2	11.24	10- 2-50	Located in Dundy Co., Nebr.
T. 1 S., R. 36 W.															
1-36-7bbb	Chester Gerdes	Du	72.0	36	C,N	Sand	Ogallala	N,N	D,S	Top of concrete curb	.4	3,182.7	68.39	9-27-50	Not in use. Located in Rawlins Co., Kans.
T. 1 S., R. 37 W.															
1-37-5bac	Frances Calhoon	Dr	60.5	6	GI	do.	do.	Cy,H,W	D,S	Top of casing	1.0	3,105.3	54.55	7-21-50	
1-37-6bba	A. G. Shafer	Dr	87.5	6	GI	do.	do.	Cy,H,W	S	do.	.3	3,100.0	76.00	9-26-50	
1-37-7ccb	E. F. Ham	Dr	39.5	4	I	do.	Alluvium	Cy,H,W	S	do.	.7	3,050.0	28.06	7-21-50	
1-37-9aaa	G. A. David	Dr	22.0	5	GI	do.	do.	Cy,W	S	do.	2.1	3,111.1	19.78	9-26-50	
1-37-9caa	Hazel Ham	Du	33.5	48	C	Silt	Alluvium, Colluvium	Cy,H,W	S	Top of board cover	4.5	3,128.0	31.65	9-28-50	
1-37-12cdd	Chester Gerdes	Dr	142.0	5	GI	Sand	Ogallala	N,N	N	Top of casing	.7	3,308.1	128.54	9-27-50	Abandoned
1-37-20bcc	Oscar Gunther	Dr	39.0	5	GI	do.	Alluvium	Cy,H,W	S	do.	1.0	3,101.9	32.00	7-21-50	Chemical analysis
1-37-24ddc	Ogle Keenan	Dr	103.5	5	GI	do.	Ogallala	Cy,W	S	Top of concrete curb	1.8	3,286.3	102.26	9-20-50	
T. 1 S., R. 38 W.															
1-38-2cdc	Paul O'Brien	Dr	42.0	18	GI	Sand, gravel	Alluvium	T,T	I,O	Hole, base of pump	1.0	3,034.9	23.85	9-11-50	
1-38-4dcc	D. L. Ough	B	10.8	5	GI	do.	do.	Cy,W	S	Top of casing	.0	3,039.0	8.72	7-11-50	
1-38-7cba	Bertha Krug	Du	34.6	36	C,N	Sand, silt	Ogallala	Cy,W	S	Top of board platform	1.0	3,157.7	25.71	7-11-50	
1-38-8add	Clara Magnani	B	23.1	5	GI	Sand, gravel	Alluvium	Cy,W	D,S	do.	1.3	3,059.1	20.88	4-17-46	
1-38-8dcc	H. O. Haines	Dr	34.3	18	GI	do.	do.	T,T	I,O	Hole in pump base	1.0	3,058.1	13.73	9-11-50	
1-38-9cdd	J. W. Haines	Dr	29.0	24	GI	do.	do.	T,B	I	do.	1.2	3,050.6	12.30	9-25-50	
1-38-9ddc	do.	Dr	40.0	24	GI	do.	do.	T,B	I	do.	.8	3,055.1	21.46	9-25-50	
1-38-10acc	P. E. O'Brien, Sr.	Du	37.5	16	GI	do.	do.	HC,G	I	Top of concrete casing	1.5	3,042.6	22.37	7-11-50	
1-38-10ccb	Henry Yost	B	36.5	5	GI	Sand	do.	N,N	O	Top of concrete platform	.2	3,051.2	20.69	12-18-49	
1-38-12bad	Clyde Ketler	B	37.0	5	GI	do.	do.	Cy,W	S	Top of casing	.0	3,040.7	25.01	7-12-50	
1-38-17cdd	F. J. Ostick	B	22.2	5	GI	do.	do.	Cy,H	S,O	Top of concrete platform	.3	3,067.7	12.55	9-11-50	
1-38-18dcc	F. R. Walker	B	29.5	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	1.0	3,093.4	26.18	7-11-50	
1-38-19adc	Cecil Holliman	Dr	38.0	24	GI	Sand, gravel	do.	T,G	I	do.	1.0	3,088.0	17.86	9-24-50	Measured yield 400
1-38-19daa	L. A. Merklin	Du	45.0	72	C	do.	do.	HC,G	I	Top of concrete casing	.0	3,096.6	27.44	7-11-50	Not used
1-38-19daa2	do.	B	30.3	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	1.5	3,097.9	27.44	6-13-46	

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1-38-22bbc	Henry Yost	Dr	73.0	5	GI	do.	Ogallala	Cy,W	S	Top of casing	1.2	3,217.7	60.06	10- 2-50	
1-38-23cbb	T. Herring	Dr	45.5	5	GI	Silt	Sanborn	N,N	N	do.	1.0	3,105.4	29.73	9-25-50	
1-38-24ddb	Dan E. Owen	Dr	54.0	4	GI	Sand	Ogallala	Cy,H,W	S	do.	1.1	3,172.9	46.80	9-28-50	
1-38-25ccb	A. J. Schrader	Dr	52.0	5	GI	do.	do.	Cy,H,W	D,S	do.	1.2	3,207.3	42.66	9-26-50	
1-38-27bba	Edwin O'Leary	Dr	96.5	6	GI	do.	do.	N,N	N	do.	1.2	3,225.6	81.70	6-13-46	Abandoned
1-38-29bca	J. O. Bash	B	44.3	5	GI	Silt	Sanborn	Cy,W	D,S	Top of board platform	.8	3,126.2	40.09	6-13-46	Not in use
1-38-32cdd	Sam Brunswig	Du	19.7	5	GI	do.	Colluvium, Alluvium	Cy,W	D,S	do.	.2	3,170.1	14.83	6-13-46	
1-38-34aad	Russell Pearson	Du	50.0	24	I	Sand	Ogallala	Cy,H,W	D,S	Base of pump	1.7	3,218.9	44.57	7-21-50	
T. 1 S., R. 39 W.															
1-39-1aaa	A. G. Shafer	Dr	47.5	5	GI	Silt, fine sand	Ogallala and -or Sanborn	Cy,W	S	Top of iron plate	1.2	3,173.6	36.28	10- 2-50	
1-39-4dbb	Esther B. Bartlett	Du	44.0	24	?	Sand, silt	Colluvium	Cy,H,W	D,S	Top of board cover	1.1	3,258.3	38.37	10- 2-50	Not used
1-39-12baa	Aletha Stevens	Dr	92.0	4	GI	Sand	Ogallala	Cy,H	N	Top of concrete curb	.0	3,260.6	87.96	6-14-46	Abandoned
1-39-14bdc	John E. Morehouse	Du	35.0	48	C	Silt, fine sand	Colluvium, Alluvium	Cy,W	S	Top of plank cover	2.2	3,174.4	22.28	7-28-50	
1-39-18cbb	E. E. Hester	Du	102.0	36	GI	Sand	Ogallala	Cy,W	S	do.	1.6	3,398.0	96.53	10- 2-50	
1-39-21bcc	David S. Harvey	Du	45.0	48	C	Silt, fine sand	do.	Cy,H,W	D,S	Top of board cover	.7	3,260.6	42.37	7-28-50	Chemical analysis
1-39-25bbc	South Fork School	B	28.1	5	GI	Sand, gravel	Alluvium	Cy,H	D	Top of concrete curb	.8	3,106.7	16.30	7-10-50	Do.
1-39-25ccd	A. C. Clapp	B	36.3	5	GI	do.	do.	Cy,W,G	S	Top of casing	1.1	3,119.5	25.43	4-11-46	
1-39-26ccc	R. L. Harrison	B	17.8	5	GI	do.	do.	Cy,W	S	Top of concrete curb	1.0	3,115.3	13.13	7-12-50	
1-39-27ddc	do.	Du	20	16	S	do.	do.	HC,G	I			3,114.7	10		Abandoned—Battery of seven wells
1-39-30dbb	Harvey Barnhart	Du	26.3	34	C	Sand	Ogallala	Cy,W	D,S	Top of concrete curb	.8	3,242.0	21.77	6- 6-46	
1-39-33cdd	R. L. Queen	B	23.1	5	GI	Silt	Alluvium	Cy,W	S	do.	2.0	3,163.1	19.26	7-12-50	
T. 1 S., R. 40 W.															
1-40-3daa	Marvin Mills	Dr	31.0	5	GI	do.	do.	Cy,W	S	Top of tin cover	.0	3,258.2	23.96	9-29-50	
1-40-16cdd	Jacob Wall	Du	49.5	6	GI	Silt, fine sand	Ogallala	Cy,H,W	D,S	Top of board cover	8	3,378.8	41.93	9- 8-50	Originally dug—36 inches in diameter
1-40-23bba	Gertrude M. Barbour	Du Dr	43.0	5	GI	Sand	do.	Cy,W	S	do.	1.6	3,354.3	26.67	7-28-50	
1-40-27ddd	C. H. Ferguson	Dr	118.0	5	GI	do.	do.	Cy,W,G	S	Top of concrete curb	.7	3,355.1	111.77	8- 8-50	
1-40-28add	Jacob Keller	Du	28.0	48	C	do.	do.	Cy,W	S	Top of board cover	.7	3,326.6	25.48	7-28-50	
1-40-32cac	Marvin Mills	Du	34.5	24	?	Sand, silt	Alluvium	Cy,W	S	Top of concrete curb	1.6	3,322.1	31.33	8-14-50	
1-40-35dcd	Paul F. Rose	Dr	39.0	6	GI	do.	do.	Cy,W	S	Top of casing	.6	3,245.8	33.57	8- 3-50	
1-40-36acd	Fred Kamla	Dr	79.3	6	GI	Sand	Ogallala	Cy,W	D,S	Top of board platform	.0	3,283.6	78.35	6- 5-46	
T. 1 S., R. 41 W.															
1-41-7abd	W. E. Brown	Dr	38.0	5	GI	do.	Colluvium, Alluvium	Cy,W	S	Top of casing	2.7	3,360.1	26.50	12- 2-50	Chemical analysis
1-41-9bca	E. E. Workman	Du	18.5	48	N	Sand, silt	do.	Cy,W	S	Top of board cover	2.6	3,388.0	17.00	9- 7-50	
1-41-23acc	Louisa Rose	Du	39.5	48	C	Silt	Colluvium, Sanborn	N,N	N	Top of concrete cover	3.3	3,531.1	32.92	9- 8-50	Abandoned
1-41-24aab	W. R. Gregory	Du	75.0	36	N	Sand	Ogallala	Cy,H,W	D,S	Top of board cover	1.0	3,443.6	70.20	9- 8-50	
1-41-28daa	H. Roth	Dr	64.0	6	GI	do.	do.	Cy,W	S	Top of casing	1.0	3,482.6	51.63	9- 4-50	
1-41-29dba	A. J. Clark	Dr	93.0	5	GI	do.	do.	Cy,W	S	do.	1.5	3,540.8	85.13	10- 3-50	Chemical analysis
1-41-35abb	Anna Keller	Dr	37.0	6	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.3	3,413.8	28.30	9- 1-50	
1-41-36dbd	Alva Shull	Dr	29.2	6	GI	do.	Alluvium	Cy,H,W	D,S	Top of casing	1.0	3,353.2	24.23	9- 4-50	

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TABLE 6.—*Records of wells in Cheyenne County*—(Continued)

Well number	Owner or tenant	Type of well (1)	Depth of well, feet	Diameter of well, inches	Type of casing (2)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (3)	Use of water (4)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height above mean sea level, feet (5)	Depth to water level below measuring point, feet	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 1 S., R. 42 W.															
1-42-1ccc	A. J. McVey	Du	36.5	36	C	Silt	Alluvium	Cy,W	S	Top of board cover	3.0	3,366.7	28.70	7-22-50	
1-42-4daa	G. J. Puthoff	Dr	34.5	6	GI	Sand, silt	do.	Cy,W	S	Top of iron plate	1.6	3,319.0	17.94	12- 8-50	
1-42-10bda	Bill Newman	Dr	46.5	5	GI	Sand	do.	Cy,H	D,S	Top of concrete curb	.8	3,444.3	42.64	7-22-50	
1-42-15cab	Rex Daniels	Du	22.5	48	C	Sand, silt	do.	Cy,W	S	Top of board cover	2.0	3,377.5	19.49	8-11-50	
1-42-26dda	A. J. Clark	Dr	125	5	GI	Sand, gravel	Ogallala	Cy,H,W	D,S	....	....	3,626.1	120	8-31-50	
T. 2 S., R. 36 W.															
2-36-18bbb	Francis Hatch	Dr	248.0	5	GI	do.	do.	Cy,W	S	Top of concrete curb	1.0	3,376.2	215.37	8-15-50	Located in Rawlins Co.
T. 2 S., R. 37 W.															
2-37-1dda	do.	Dr	220.0	5	GI	do.	do.	Cy,W	S	Top of casing	1.0	3,376.9	219.50	9-28-50	
2-37-3cdd	T. G. Wilkens	Dr	233.0	5	GI	do.	do.	N,N	N	Top of concrete curb	.2	3,396.0	223.02	8-15-50	Abandoned
2-37-6add	Earl Loop	B	10.5	5	GI	Sand	Alluvium	Cy,H	S	Top of casing	.8	3,169.0	9.90	7-21-50	
2-37-16cdd	Buel E. Edie	Dr	218.0	5	GI	do.	Ogallala	Cy,W	D,S	Top of concrete curb	.7	3,403.1	215.25	9-20-50	
2-37-20ddd	Henry Kehlbeck	Dr	220.0	5	GI	Sand, gravel	do.	Cy,W	D,S	do.	.2	3,400.5	217.03	9-20-50	Chemical analysis
2-37-24ddd	E. Hilts	Dr	248.0	5	GI	do.	do.	Cy,W	D,S	do.	.5	3,384.6	217.79	8-15-50	
2-37-27aab	Fred A. Hilts	Dr	225.5	5	GI	do.	do.	Cy,H	N	Hole in casing	.2	3,404.1	220.41	8-15-50	Abandoned; domestic and stock well
2-37-31bba	A. H. Burr	Dr	212.0	5	GI	do.	do.	Cy,W	S	Top of iron plate	.9	3,419.7	197.27	9-13-50	
T. 2 S., R. 38 W.															
2-38-3bdd	Florence Elley	Dr	186.0	5	GI	do.	do.	Cy,H,W	S	Top of concrete curb	.5	3,384.8	179.10	11- 3-50	
2-38-7baa	Sarah J. Garner	Dr	60.0	5	GI	Sand	do.	Cy,H,W	N	Top of casing	1.2	3,254.8	46.63	9-25-50	Abandoned
2-38-11cba	R. W. Elley	Dr	29.0	5	GI	do.	do.	N,N	N	do.	.8	3,245.3	25.07	7-21-50	Do
2-38-12bdd	J. H. Donohue	Dr	58.5	5	GI	do.	do.	Cy,H,W	D,S	do.	.6	3,223.1	40.03	7-21-50	
2-38-13bac	J. Harwarth, Jr	Dr	76.0	5	GI	do.	do.	Cy,W	S	do.	.5	3,270.7	73.00	9-13-50	
2-38-15dbb	L. L. Hines	Dr	97.0	5	GI	Sand, gravel	do.	Cy,W	S	Top of casing	.5	3,302.1	86.23	7-20-50	
2-38-25bcc	J. M. Tressler	Dr	187.0	4	GI	do.	do.	Cy,H,W	D,S	Top of concrete curb	.7	3,408.3	184.24	9-26-50	
2-38-27ddd	W. A. Bartlett	Dr	237.0	5	GI	do.	do.	Cy,W	D	Top of casing	.4	3,465.3	229.98	7-20-50	
2-38-28bbb	A. J. Johnson	Dr	142.0	5	GI	do.	do.	Cy,W	S	do.	1.5	3,370.2	131.46	7-27-50	
2-38-30abb	Bruce Cole	Dr	224.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.3	3,441.8	195.23	7-27-50	
2-38-30dcd	do.	Dr	177.0	5	GI	do.	do.	Cy,N	N	do.	.3	3,427.9	168.24	11- 1-50	Abandoned
2-38-33aaa	R. Bandel	Dr	86.0	5	GI	do.	do.	Cy,W	S	do.	.6	3,323.2	74.05	8- 7-50	

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T. 2 S., R. 39 W.														
2-39-1aac	Arnold Munyon	Du	31.0	48	?	Sand, silt	Alluvium	Cy,W	D,S	Top of cover	1.3	3,161.4	19.79	7-11-50	
2-39-2cbb	Vera Gorthy	B	26.6	5	GI	do.	do.	N,N	O	Top of board platform	.8	3,160.21	13.17	9-11-50	
2-39-3bcd	J. A. Holliman	B	23.5	5	GI	Sand	do.	Cy,W	S	do.	2.0	3,145.4	15.25	7-10-50	
2-39-8aba	Harvey Barnhart	Dr	59.4	5	GI	do.	Ogallala	Cy,W,G	D,S	Land surface	.0	3,204.0	56.48	4- 2-46	
2-39-10bba	A. L. Pugh	Dr	39.0	5	GI	do.	do.	Cy,H	O	Top of casing	.5	3,166.7	26.28	9-11-50	
2-39-10ccb	Ray Pugh	B	45.8	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.4	3,173.2	24.40	4-11-46	
2-39-11cbb	School	Dr	70.5	5	GI	do.	do.	Cy,H	D	do.	.0	3,262.9	39.38	4-11-46	
2-39-16bba	G. Lewis	B	22.8	5	GI	do.	Alluvium	Cy,H	S	Top of casing	1.0	3,165.3	10.20	7-10-50	
2-39-17adc	P. E. Gaskill	B	15.1	6	GI	Sand, gravel	do.	Cy,H	D,S	Top of concrete curb	.3	3,167.4	7.22	3-28-46	Chemical analysis
2-39-17adc2	do.	Du	22.0	18	C,I	do.	do.	N,N	I	do.	1.0	....	10.00	12- 5-50	Battery of two wells: not in use
2-39-17baa	Myrtle E. Armstrong	Du	13.5	24	N	do.	do.	Cy,W	S,O	Top of board platform	.5	3,168.7	11.78	9-11-50	
2-39-19ccc	A. C. Keller	B	22.9	4	GI	do.	do.	Cy,H	O	Top of casing	.0	3,209.0	15.97	9-11-50	
2-39-20abd	F. Felzien	B	16.6	6	GI	do.	do.	Cy,H	S	Top of concrete curb	1.5	3,180.4	13.62	3-27-46	
2-39-20ddd	School	Dr	68.0	5	GI	do.	Ogallala	Cy,H	D	do.	.5	3,244.5	52.79	3-27-46	
2-39-23dda	Dora E. Warren	Dr	121.0	5	GI	do.	do.	Cy,W	D,S	do.	.0	3,356.7	115.42	7-27-50	Not in use
2-39-27bbb	G. W. Best	B	29.3	8	GI	Fine sand, silt	Alluvium	N,N	O	Top of board platform	1.3	3,236.5	18.12	9-11-50	
2-39-32adb	A. L. Pugh	Dr	50.0	6	GI	Sand	Ogallala	Cy,H,W	D,S	Top of concrete curb	1.0	3,299.9	37.55	7-10-50	
T. 2 S., R. 40 W.															
2-40-3dad	John Keller	Dr	113.0	5	GI	Sand, gravel	do.	Cy,W	S	do.	.6	3,416.9	107.29	8- 8-50	
2-40-7bca	Wendell Hill	Dr	87.0	6	GI	do.	do.	Cy,W	S	Top of casing	1.3	3,450.3	81.69	9- 1-50	
2-40-9adc	John Keller	Dr	169.0	5	GI	do.	do.	Cy,W	S	do.	1.2	3,499.2	161.90	8- 8-50	
2-40-12bbc	F. R. Douthit	Dr	130.6	5	GI	do.	do.	Cy,W	D,S	Top of concrete slab	.3	3,420.2	128.50	8-14-50	Chemical analysis
2-40-12dcc	Herbert Bandel	Dr	115.5	5	GI	do.	do.	Cy,W	D,S	do.	.5	3,394.4	83.71	6- 4-46	
2-40-15dad	Ansel Miller	Dr	52.3	5	GI	do.	do.	Cy,W	D	do.	.2	3,360.4	46.79	7- 8-50	
2-40-16bcb	Lawson Cook	Dr	193.5	5	GI	do.	do.	Cy,W	D,S	Top of concrete casing	2.5	3,528.8	174.72	8-14-50	
2-40-20bbc	John Indorf	Dr	199.0	6	GI	do.	do.	Cy,H,W	S	Top of casing	.5	3,555.3	185.90	9- 4-50	
2-40-25cdd	A. C. Keller	Du, Dr	33	18	B,I	do.	Alluvium	HC,G	I	....	......	3,219.6	14	12-16-50	Battery of three wells
2-40-26ccb	G. C. Rogers	Dr	88.6	5	GI	do.	Ogallala	Cy,W	D,S	Top of board platform	.3	3,387.6	79.34	12-13-46	
2-40-30add	E. Zimbelman	Dr	155.0	5	GI	do.	do.	Cy,W	D,S	Top of casing	.8	3,517.0	146.90	9- 8-50	Not in use
2-40-33bcc	William Gienger	Dr	116.5	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	1.0	3,456.9	109.05	7- 8-50	
2-40-36bbb	Robert Damerall est	B	21.6	5	GI	Sand	Alluvium	Cy,H	D	Top of casing	.0	3,236.8	17.70	7- 7-50	Not used
T. 2 S., R. 41 W.															
2-41-3cbb	O. M. Partlow	Du	15.7	48	N	Sand, silt	do.	Cy,H,G	D,S	Top of concrete curb	.5	3,401.2	10.69	9- 7-50	
2-41-6bba	J. A. Smith	Du	27.0	36	C	do.	do.	Cy,W	S	do.	2.0	3,485.2	23.31	9- 7-50	
2-41-8abb	Earl Bammes	Du	106.7	36	C	Sand	Ogallala	Cy,H,W	D,S	do.	.0	3,581.2	103.50	9- 7-50	
2-41-9dac	Harvey Ochsner	Dr	85.0	6	GI	do.	do.	Cy,W	S	Top of board platform	3.8	3,489.3	82.95	9- 7-50	
2-41-13dcd	Dan Rath, Jr.	Dr	219.0	5	GI	Sand, gravel	do.	Cy,H,W	S	Top of concrete curb	.5	3,590.3	203.40	9- 1-50	
2-41-17dcd	J. G. Northrup	Dr	192.0	5	GI	do.	do.	Cy,W	S	do.	.7	3,613.5	178.71	8-11-50	Reported drilled to shale
2-41-25daa	Peter Raile	Dr	147.0	5	GI	do.	do.	Cy,W	S	Top of concrete curb	.0	3,522.9	133.71	9- 1-50	
2-41-28daa	J. M. Zimbleman	Dr	203.0	5	GI	do.	do.	Cy,W	S	Top of casing	.9	3,612.9	190.38	8-17-50	
2-41-33ccc	Mathias Zimbleman	Dr	238.0	5	GI	do.	do.	N,N	N	do.	.3	3,667.1	236.78	8-17-50	Abandoned
2-41-34ddd	William Zweygardt	Dr	182.5	5	GI	do.	do.	Cy,W	S	Top of plate	.3	3,594.7	174.40	9- 7-50	

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TABLE 6.—*Records of wells in Cheyenne County*—(Continued)

Well number	Owner or tenant	Type of well (1)	Depth of well, feet	Diameter of well, inches	Type of casing (2)	Principal water-bearing bed		Method of lift (3)	Use of water (4)	Measuring point			Depth to water level below measuring point, feet	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
						Character of material	Geologic source			Description	Distance above land surface, feet	Height above mean sea level, feet (5)			
T. 2 S., R. 42 W.															
2-42-3cbc	Christian Samler	Du	71.5	36	N	Silt, fine sand	Ogallala	Cy,W	D,S	Top of board curb	2.9	3,604.2	67.44	8-11-50	
2-42-13aad	John Rieb	Dr	175.0	5	GI	Sand	do.	N,N	N	Top of concrete curb	1.0	3,622.0	162.16	8-31-50	Abandoned
2-42-14ddd	Jacob B. Hilt	Dr	249.0	6	GI	do.	do.	Cy,W	S	Top of casing	.6	3,693.2	233.38	8-11-50	
2-42-15ddd	Fred Wall	Dr	280	6	GI	do.	do.	Cy,W	D,S	Land surface	.0	3,742.0	275	10- 3-50	Reported drilled to shale
2-42-22ccc	R. L. Jones et al.	Dr	207.0	5	GI	do.	do.	Cy,W	S	Top of concrete curb	.0	3,671.8	194.82	7-17-50	Not in use
2-42-25bac	Perla E. Mundhenke	Dr	240.0	5	GI	do.	do.	Cy,H,W	N	Top of casing	1.0	3,683.8	232.74	7-22-50	Abandoned domestic and stock well
2-42-26cbc	L. W. Northrup	Dr	256.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.3	3,723.3	251.92	8-31-50	
2-42-33cbd	Fred Hilt	Dr	253.0	5	GI	do.	do.	Cy,W	S	do.	.2	3,741.3	243.22	8-31-50	
T. 3 S., R. 36 W.															
3-36-19baa	H. E. Archer	Dr	198.0	5	GI	Sand, gravel	do.	Cy,W	S	Top of casing	.4	3,382.6	191.79	8-15-50	Located in Rawlins Co.
T. 3 S., R. 37 W.															
3-37-2add	Eva Antholz	Dr	212.0	5	GI	do.	do.	N,N	N	do.	.6	3,397.0	208.25	9-20-50	Abandoned
3-37-3ccb	Harvey Dorsch	Dr	234.0	5	GI	do.	do.	Cy,W	S	Top of curb	.6	3,414.4	206.69	8- 7-50	
3-37-6baa	M. T. Wright	Dr	226.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.5	3,445.4	218.27	9-13-50	Not in use
3-37-17ccc	F. Beethe	Dr	202.0	4	GI	do.	do.	Cy,W	D,S	Top of casing	1.0	3,440.1	200.88	9-26-50	
3-37-22bcb	O. E. Smith	Dr	210.0	5	GI	do.	do.	Cy,H	D,S	Top of concrete curb	.6	3,422.6	201.63	8- 7-50	Abandoned
3-37-24cdc	Mary E. Phipps	Dr	203.5	5	GI	do.	do.	Cy,N	N	do.	.3	3,395.6	189.57	8-15-50	Do
3-37-30bab	Bird City cemetery	Dr	224.0	5	GI	do.	do.	Cy,W	P	Top of plate	.3	3,472.5	219.43	9-13-50	
3-37-31dcc	Amelie Carstens	Dr	225.0	5	GI	Sand	do.	Cy,W	D,S	do.	.5	3,481.6	218.32	9-19-50	
3-37-36dbc	E. H. Dankenbring	Dr	191.0	5	GI	do.	do.	Cy,W	S	Top of concrete curb	.4	3,382.3	175.86	8-15-50	
T. 3 S., R. 38 W.															
3-38-1dcd	Clarence Burr	Dr	232.0	5	GI	do.	do.	Cy,W	D,S	do.	.3	3,460.4	220.48	8- 7-50	
3-38-7cdc	L. D. Waters	Dr	213.0	5	GI	do.	do.	Cy,W	S	Top of casing	.4	3,489.5	207.70	9-13-50	
3-38-8bbb	H. Beeson	Dr	179.0	5	GI	do.	do.	N,N	N	do.	.8	3,442.3	168.34	7-27-50	Not in use
3-38-10aaa	J. W. Wright	Dr	215.0	5	GI	do.	do.	Cy,W	D,S	do.	.5	3,464.0	207.13	8- 7-50	
3-38-14cdd	A. L. Kehlbeck	Dr	231.0	5	GI	do.	do.	Cy,W	D,S	do.	.4	3,486.4	222.54	9-27-50	
3-38-17dad	Gladys & Lucille Beatty	Dr	243.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.7	3,511.8	234.05	8- 7-50	

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3-38-19ddd	A. E. Combs	Dr	245.0	5	GI	do.	do.	Cy,W	D,S	Top of casing	.8	3,523.6	230.33	8- 7-50	
3-38-27ada	B. L. Childers	Dr	230.0	5	GI	do.	do.	N,N	N	do.	.3	3,491.8	221.00	7-20-50	Abandoned
3-38-36bab	M. A. Hughs	Dr	272	16	S	Sand, gravel	do.	T,G	I	Hole, pump base	1.8	3,466.6	198.90	9-23-50	
3-38-36bad	Bird City	Dr	260	16	S	do.	do.	T,E	P			3,460.9	195	9-18-50	Estimated yield 125
3-38-36bad2	do.	Dr	240	12	S	do.	do.	T,E	P			3,460.9	195	9-18-50	Estimated yield 75
3-38-36bad3	do.	Dr	230	12	S	do.	do.	Cy,E	P			3,460.9	195	9-18-50	Estimated yield 55
T. 3 S., R. 39 W.															
3-39-2aca	Inland Mfg. Company	Dr	135.2	5	GI	do.	do.	Cy,W	S	Top of casing	.4	3,391.6	114.26	9-13-50	
3-39-3ccc	L. R. and Ella Hurtt	Dr	166.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.0	3,443.9	154.17	7-19-50	
3-39-4ccc	A. F. Magley	Dr	75.5	5	GI	do.	do.	Cy,H,W	D,S	Top of casing	.5	3,351.1	65.25	7-19-50	Not used
3-39-6aaa	Rosa F. Shoemaker	B	14.8	5	GI	Sand	Alluvium	Cy,H	N	Top of concrete slab	.7	3,251.3	7.14	3-26-46	Abandoned
3-39-8bad	A. F. Magley	B	32.5	5	GI	do.	do.	Cy,W	S	Top of board platform	1.6	3,309.6	24.63	7-10-50	
3-39-12ccd	Ruby E. Query	Dr	233.0	5	GI	do.	Ogallala	Cy,W	D,S	Top of casing	.8	3,513.7	227.32	7-27-50	
3-39-16bcc	R. J. Randall	Dr	182.0	5	GI	do.	do.	Cy,W	D,S	do.	.2	3,480.6	172.29	7-19-50	
3-39-19ccc	B. Stellet	Dr	66.0	5	GI	Sand, gravel	do.	Cy,H,W	D,S	Top of concrete curb	1.2	3,390.2	61.40	7-19-50	
3-39-22ddd	Roy Jackson	Dr	170.0	5	GI	do.	do.	Cy,W	D,S	Top of iron plate	.2	3,478.3	162.81	9-26-50	
3-39-23aaa	Henry Watt	Dr	206.0	5	I	do.	do.	Cy,W	D,S	Top of casing	2.2	3,499.4	210.50	7-19-50	
3-39-25ddc	R. O. Atkinson	Dr	186.0	5	GI	do.	do.	N,N	N	do.	.5	3,488.5	178.80	8-22-50	Abandoned
3-39-28cbb	L. W. Dean	Dr	168.0	5	GI	do.	do.	Cy,H,W	D,S	Top of board curb	.6	3,479.1	150.25	7-19-50	
3-39-30cdc	J. M. Roylston	Dr	84.5	6	GI	do.	do.	Cy,H,W	S	Top of casing	1.0	3,404.0	61.26	9-27-50	Not in use
3-39-34ddd	J. L. Northrup	Dr	204.0	5	GI	do.	do.	Cy,W	D,S	do.	.6	3,528.3	199.78	7-24-50	
T. 3 S., R. 40 W.															
3-40-1daa	Noble Dorsch	B	16.8	5	GI	Sand	Alluvium	Cy,H	D	Top of casing	1.0	3,264.4	10.72	7-10-50	
3-40-2acc	G. A. Briney	Dr	30.5	16	S	Sand, gravel	do.	T,G	I	Hole, base of pump	.4	3,245.9	14.22	10-17-50	
3-40-2cab	E. H. Felzien	B	32.0	5	GI	do.	do.	Cy,H	S	Top of concrete floor	.5	3,254.0	19.89	7- 7-50	
3-40-8bcc	Chreist Zimbelman	Dr	19.0	6	GI	Sand	Ogallala	Cy,H	D	Top of casing	.5	3,354.1	18.25	8-10-50	Abandoned
3-40-9baa	P. G. Walter	B	16.2	5	GI	do.	do.	Cy,H	O,S	do.	.0	3,344.4	12.53	9-11-50	
3-40-10daa	Lester Confer	Dr	17.0	8	GI	do.	Alluvium	HC,G	I	do.	.9	3,253.5	6.44	10-17-50	Battery of seven wells
3-40-11acc	C. F. Felzien	Du	17.0	6	GI	Sand, gravel	do.	Cy,W,H	S	Top of concrete curb	.4	3,253.0	9.99	7-10-50	
3-40-12dcd	A. C. Hancock	Dr	88.9	5	GI	do.	Ogallala	Cy,H	S	do.	.7	3,373.4	75.65	7-10-50	Abandoned
3-40-15bac	J. L. Finley	Du	14.2	22	I	do.	Alluvium	Cy,H	S	Top of board platform	.4	3,269.7	10.22	7- 8-50	
3-40-16bcc	P. Raile	B	14.0	6	GI	do.	do.	Cy,H	S	Top of casing	.4	3,312.8	11.09	9- 8-50	
3-40-16daa	J. L. Finley	B	14.3	6	GI	do.	do.	N,N	N	Top of concrete curb	1.0	3,278.1	11.20	12-18-49	Abandoned
3-40-21acb	Dr. E. J. Keller	B	18.3	6	GI	do.	do.	Cy,H	S	Top of concrete curb	.4	3,301.8	12.48	7-13-50	
3-40-21cbd	E. T. Sherlock	Du	23.0	12	GI	do.	do.	HC,G	I	Top of concrete casing	.3	3,296.4	12.88	7-31-50	Battery of three wells
3-40-21dad	Chicago, Burlington & Quincy Railroad	Du,Dr	17.0	10	S	do.	do.	P,G	R	Top of casing	—7.7	3,283.9	4.28	6- 1-51	
3-40-21dcd	City of St. Francis	Dr	30	24	GI	do.	do.	T,E	P			3,294.1	10	9-29-50	
3-40-21dcd2	do.	Du,Dr	26.0	18	GI	do.	do.	T,E	P	Top of concrete curb	3.3	3,295.2	13.26	9-29-50	
3-40-21dcd3	do.	Du,Dr	25	24	C, GI	do.	do.	HC,E	P			3,292.5	10	9-29-50	
3-40-21dcd4	do.	Du,Dr	25	24	C, GI	do.	do.	P,E	P			3,293.2	10	9-29-50	
3-40-22aba	T. Holliman et al	B	19.2	5	GI	do.	do.	N,N	O	Top of concrete curb	.2	3,286.3	12.35	9-11-50	
3-40-23caa	St. Francis cemetery	Dr	60.5	4	GI	Sand	Ogallala	Cy,W	P	do.	.0	3,370.6	48.88	7-19-50	
3-40-26bbb	C. Lloyd	B	36.8	5	GI	do.	do.	Cy,W	D,S	do.	.5	3,361.1	30.70	7- 7-50	

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TABLE 6.—*Records of wells in Cheyenne County*—(Continued)

Well number	Owner or tenant	Type of well (1)	Depth of well, feet	Diameter of well, inches	Type of casing (2)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (3)	Use of water (4)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height above mean sea level, feet (5)	Depth to water level below measuring point, feet	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 3 S., R. 40 W.															
3-40-28abc	Joe Cook	Du	24.0	8	GI	Sand, gravel	Alluvium	HC,G	I	Top of casing	0.3	3,297.1	10.22	7-29-50	
3-40-28add	John A. Ketter	B	25.3	8	GI	Sand	Ogallala	Cy,H	D	Top of concrete curb	.5	3,353.8	22.15	7- 6-50	Reported drilled to shale
3-40-28cbb	D. Danielson	B	25.5	5	GI	Sand, gravel	Alluvium	N,N	O	Land surface	.0	3,307.6	11.08	9-11-50	
3-40-29bcc	do.	Dr	22.0	16	GI	do.	do.	T,T	I	Top of casing	.7	3,314.0	9.33	8- 3-50	Yield 150 to 200
3-40-30dac	do.	Du	29.7	60	C	do.	do.	HC,G	I	Top of concrete casing	1.0	3,332.5	19.85	8- 9-50	Battery of two wells
3-40-30dcc	Coy L. DeGood	B	19.5	8	GI	do.	do.	Cy,W	S	Top of board platform	.2	3,330.0	11.97	3- 1-46	
3-40-32cad	Peter Sturm estate	Du, Dr	20.4	16	C, GI	do.	do.	Cy,G	I	Land surface	.0	3,341.5	8.80	7- 6-50	Battery of six wells; not in use
3-40-33dda	H. L. Harkins	Dr	27.4	6	GI	do.	Ogallala	Cy,H	O	Top of concrete curb	.0	3,370.3	12.81	9-11-50	
3-40-36bbb	W. R. Wilber	Dr	109.0	5	GI	do.	do.	Cy,W	S	do.	1.0	3,433.8	85.85	7- 7-50	
T. 3 S., R. 41 W.															
3-41-1aaa	H. J. Holzworth	Dr	155.5	6	GI	do.	do.	Cy,W	S	Top of casing	1.0	3,532.7	149.77	9- 1-50	
3-41-2ccc	Salem Lutheran Church	Dr	182.0	5	GI	do.	do.	Cy,W	D,S	do.	.0	3,591.4	171.50	7-17-50	Chemical analysis
3-41-6bab	Fred Walter	Dr	200	5	GI	do.	do.	Cy,W	D,S			3,651.5	199	8-10-50	
3-41-9cca	R. J. Walter	Dr	83.0	5	GI	do.	do.	Cy,H,W	S	Top of casing	1.3	3,519.1	79.21	8-10-50	
3-41-10cda	John Schauer	Dr	136.5	5	GI	do.	do.	Cy,H,W	D,S	do.	.8	3,559.3	126.95	8-10-50	
3-41-13ccd	F. Walz	B	15.1	5	GI	do.	Alluvium, Ogallala	Cy,H	O	do.	.0	3,388.2	8.13	9-11-50	
3-41-17dda	L. A. Schlepp	Dr	38.5	5	GI	do.	Ogallala	N,N	N	do.	.9	3,483.1	38.20	7-18-50	Abandoned
3-41-19ccd	Emil Lampe	Dr	182.0	5	GI	do.	do.	Cy,W	D,S	do.	.2	3,643.5	171.48	8-10-50	
3-41-20bba	George Holzworth	Dr	46.5	5	GI	do.	do.	Cy,W	S	Top of concrete curb	.6	3,499.3	40.15	9- 7-50	
3-41-26aaa	C. A. P. Falconer	Dr	143.0	5	GI	do.	do.	Cy,W	S	do.	.6	3,536.3	131.73	6-12-46	Abandoned
3-41-28bcc	L. A. Schlepp	Dr	215	5	GI	do.	do.	Cy,W	D,S			3,627.4	175	8-10-50	
3-41-29aba	Theo. Burr	Dr	135	5	GI	do.	do.	Cy,H,G	S			3,563.8	110	8-10-50	
3-41-34abd	Lyle Whitmore	Dr	104.5	6	GI	do.	do.	Cy,W	D,S	Top of concrete curb	1.0	3,548.8	101.72	6-12-46	
3-41-36aaa	John Zweygardt	B	29.8	8	GI	Sand	do.	Cy,W	S	do.	.8	3,381.3	26.55	7- 6-50	

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T. 3 S., R. 42 W.															
3-42-2dba	Edw. Schlepp et al	Dr	230.0	5	GI	Sand, gravel	do	Cy,W	S	do	.6	3,689.3	217.42	7-18-50	
3-42-10ccc	Albert Van Dike	Dr	214.5	5	GI	do	do	Cy,H	N	Top of casing	.8	3,717.7	206.32	7-17-50	Not in use
3-42-11ddd	Edw. Schlepp et al	Dr	177.0	5	GI	do	do	Cy,W	D,S	do	1.0	3,645.4	163.30	7-18-50	
3-42-21bcc	Andrew Rueb	Dr	209.0	5	GI	do	do	Cy,W,G	D,S	Top of concrete curb	.7	3,736.9	202.39	8- 9-50	
3-42-23ada	William Rueb, Jr.	Dr	106.0	5	GI	do	do	Cy,H,W	D,S	Top of casing	1.0	3,601.8	93.84	8- 9-50	
3-42-25ccc	School district	Dr	220.0	6	GI	do	do	Cy,E	D	do	—3.25	3,687.1	187.25	8- 1-50	
3-42-28dda	Clarence Raile	Dr	159.0	5	GI	do	do	Cy,W	D,S	Hole, base of pump	.3	3,679.5	151.62	8-31-50	Chemical analysis
T. 4 S., R. 36 W.															
4-36-19cbc	L. Briney	Dr	171.0	5	GI	do	do	Cy,W	D,S	Top of iron plate	.5	3,370.1	152.54	9-18-50	Located in Rawlins Co.
T. 4 S., R. 37 W.															
4-37-2cbb	Winifred Weaver	Dr	191.0	5	GI	do	do	Cy,H,W	D,S	Top of concrete curb	.2	3,409.0	181.19	9-19-50	Not in use
4-37-4bbc	C. E. Overturf	Dr	211.0	5	GI	do	do	Cy,W	D,S	do	.4	3,449.2	204.07	9-23-50	
4-37-14aba	E. L. Seymour et al	Dr	193.0	5	GI	do	do	Cy,W	D,S	do	.2	3,390.7	164.78	8-16-50	
4-37-16baa	Gladys M. Casford	Dr	210.0	5	GI	do	do	Cy,W.	D,S	Top of iron plate	.7	3,432.5	183.90	9-19-50	
4-37-18bbc	Elsie E. Skeen	Dr	202.0	5	GI	do	do	Cy,W	D,S	Top of curb	.8	3,467.3	198	7-24-50	Abandoned; unable to obtain measurement
4-37-23bcc	Clem Wahrman	Dr	129.0	5	GI	do	do	Cy,W	D,S	Top of concrete curb	.4	3,367.9	124.06	9-18-50	Chemical analysis
4-37-23ccb	do	Dr	128.0	8	I	do	do	T,G	I	Hole, base of pump	2.5	3,310.2	62.65	9-18-50	Measured yield 735
4-37-25bbb	A. E. Sheetz	Dr	83.0	5	GI	do	do	Cy,W	S	Top of concrete curb	.0	3,318.6	54.55	8-16-50	
4-37-29bbb	P. C. Gleason	Dr	130.0	5	GI	do	do	Cy,W	D,S	Top of casing	.5	3,389.7	123.27	8-22-50	
4-37-34baa	Gladys Rist	Dr	70.2	5	GI	do	do	N,N	N	do	.0	3,320.4	64.11	8-16-50	Abandoned
T. 4 S., R. 38 W.															
4-38-4bbb	Floyd E. Wright	Dr	220.0	5	GI	do	do	Cy,W	D,S	Top of concrete curb	.4	3,514.3	215.67	8- 7-50	Chemical analysis
4-38-15add	Herman and Herman	Dr	203.0	5	GI	do	do	N,N	N	Top of casing	.0	3,495.8	198.42	8-24-50	Abandoned
4-38-18bbb	A. C. Lillich	Dr	186.0	5	GI	do	do	Cy,W	D,S	do	1.0	3,511.5	179.41	8-24-50	
4-38-21add	L. A. Partch	Dr	187.0	5	GI	do	do	Cy,W	N	do	1.4	3,492.1	183.28	8-22-50	
4-38-26bca	Martin C. Busse	Dr	235.0	5	GI	do	do	Cy,W	D,S	do	.8	3,503.8	200.02	8-22-50	
4-38-29aaa	B. F. Nixon	Dr	190.0	5	GI	do	do	Cy,W	D,S	Top of concrete curb	1.0	3,509.8	186.80	9-23-50	
4-38-33ada	Glenn Bowers	Dr	250.0	10	S	do	do	Cy,W	D,S	Top of casing	1.1	3,512.9	198.10	8-23-50	
4-38-36aaa	John Murray	Dr	169.0	5	GI	do	do	Cy,H,W	D,S	Top of concrete curb	1.4	3,455.5	165.60	8-23-50	
T. 4 S., R. 39 W.															
4-39-1baa	H. O. Igou	Dr	230.0	5	GI	do	do	Cy,W	D,S	do	.6	3,543.3	223.87	8- 7-50	
4-39-5ddd	R. Witt	Dr	129.0	5	GI	do	do	Cy,W	D,S	do	.8	3,470.1	118.12	9-23-50	
4-39-7abb	J. W. Stermer	Dr	105.0	5	GI	do	do	Cy,H,W	D,S	Top of casing	.6	3,447.5	84.90	7-24-50	
4-39-10baa	M. S. Caldwell	Dr	157.5	5	GI	do	do	Cy,W	D,S	do	.9	3,492.3	150.74	7-24-50	
4-39-11ccd	P. A. McClure	Dr	142.5	6	GI	do	do	Cy,W	D,S	do	.6	3,476.5	136.79	7-20-50	Not in use
4-39-18bbb	Lyda Simeon	Dr	154.0	5	GI	do	do	Cy,W	D,S	Top of concrete curb	.5	3,517.6	144.55	8-21-50	
4-39-20bbb	John Kuhlman	Dr	143.5	5	GI	do	do	Cy,W	S	Top of casing	.8	3,508.7	135.40	7-24-50	
4-39-25aba	John Magley	Dr	160.0	5	GI	do	do	Cy,W	D,S	Top of concrete curb	1.1	3,499.0	157.65	8-22-50	
4-39-27dad	Chris Andrist	Dr	160	5	GI	do	do	Cy,W	D,S	do	1.2	3,496.3	134.20	8-22-50	
4-39-32abb	H. Lloyd	Dr	144.0	5	GI	do	do	Cy,W	S	do	.1	3,525.2	137.65	7-14-50	
4-39-36dba	Arnold Schield	Dr	163.0	5	I	do	do	Cy,W	D,S	Top of casing	3.0	3,510.3	152.24	8-22-50	

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T. 4 S., R. 40 W.															
4-40-2aad	Harold Bracelin	Dr	91.0	6	GI	Sand, gravel	Ogallala	Cy,W	S	Top of casing	0.4	3,438.1	77.83	8-23-50	Chemical analysis
4-40-3dba	Elmer M. Moberly	Dr	101.2	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.5	3,446.7	79.25	7- 6-50	
4-40-5adc	John W. Harkins	Dr	17.5	6	GI	do.	Alluvium	Cy,W	D	Top of casing	.3	3,371.4	12.72	7- 6-50	
4-40-5ccc	School	Dr	65.7	6	GI	do.	Ogallala	Cy,H	D	Top of concrete curb	.5	3,429.1	53.44	7- 6-50	
4-40-6abb	Peter Sturm estate	B	24.1	6	GI	do.	Alluvium	Cy,W	S	do.	.4	3,348.8	16.72	3- 8-46	
4-40-7bcb	T. O. Williams	Dr	58.8	5	GI	do.	Ogallala	Cy,W	D,S	do.	.3	3,431.5	53.94	3-20-46	
4-40-10ddd	Pearl B. Harkins	Dr	122.0	6	GI	do.	do.	Cy,W	S	do.	.7	3,488.2	112.47	8-12-50	
4-40-14ddd	School	Dr	123.5	5	GI	do.	do.	Cy,W	D	Top of casing	.2	3,492.0	109.88	7-14-50	
4-40-16bbb	Pearl B. Harkins	B	29.8	5	GI	do.	do.	Cy,W	S	Top of board platform	.7	3,410.2	24.88	6- 7-46	
4-40-18dac	J. L. Evins	Dr	82.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.7	3,454.2	60.00	6-10-46	
4-40-22bcb	L. C. Brown	Dr	114.0	5	GI	do.	do.	Cy,W	S	do.	.2	3,519.8	126.10	8-12-50	
4-40-26daa	R. Rogers	Dr	185.0	5	GI	do.	do.	Cy,W,G	S	Top of casing	.8	3,569.1	170.00	8-21-50	
4-40-29bba	P. W. Price	Dr	193.0	5	GI	do.	do.	N,N	N	Top of concrete curb	1.4	3,598.8	182.00	8-12-50	Abandoned
4-40-31dad	Marion Rogers	Dr	111.0	5	GI	do.	do.	Cy,W	D,S	do.	2.1	3,542.3	99.83	8-17-50	
4-40-35cbc	W. H. Smull, Jr.	Dr	223.0	4	GI	do.	do.	Cy,W	D,S	Top of casing	.0	3,634.1	213.84	8-21-50	
T. 4 S., R. 41 W.															
4-41-2aad	W. E. Johnson	B	29.9	6	GI	do.	Alluvium	Cy,H	S,O	Top of concrete curb	.7	3,370.8	26.36	9-11-50	
4-41-4bba	Fred Zweygardt	Dr	131.5	5	GI	do.	Ogallala	Cy,W	D,S	do.	1.2	3,568.5	119.72	6-12-46	
4-41-4dca	do.	Dr	96.0	5	GI	do.	do.	Cy,W	S	Top of board platform	1.0	3,518.8	91.10	7- 6-50	
4-41-6dcc	A. E. Zimbelman	Dr	126.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.7	3,574.1	113.02	7- 5-50	
4-41-8ddd	Fred Zweygardt	Dr	90.5	5	GI	do.	do.	Cy,H	D	do.	.0	3,505.1	88.64	3-11-46	Abandoned
4-41-12ccb	J. E. Cullum	Dr	57.4	5	GI	do.	do.	Cy,W	D,S	do.	.5	3,435.3	46.66	7- 7-50	
4-41-16bcc	K. D. Crumly	S	....	....	....	....	do.	....	D	....	....	3,414.6	....	12- 2-50	Chemical analysis
4-41-16daa	F. R. Douthit	B	26.3	5	GI	do.	Alluvium	Cy,W	S	Top of concrete curb	1.0	3,408.8	15.54	3- 8-46	
4-41-21cbb	do.	Dr	29.0	5	GI	do.	Ogallala	N,N	N	Top of casing	1.0	3,430.4	22.12	10- 4-50	Abandoned
4-41-23aab	Gus Schorzman	Dr	128.5	5	GI	do.	do.	Cy,W	S	Top of casing	.0	3,525.9	119.38	7- 7-50	
4-41-24ddd	George Williams	Dr	192.0	6	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.5	3,588.8	173.36	6-10-46	
4-41-26adc	D. E. Warner	Dr	167.5	5	GI	do.	do.	Cy,W	D,S	do.	.3	3,570.9	140.92	7- 6-50	
4-41-27dcc	T. J. Douthit	Dr	118.3	4	GI	do.	do.	Cy,W	S	do.	.5	3,552.2	110.82	7- 5-50	
4-41-31acb	Glenn Rogers	Dr	117.6	5	GI	do.	do.	Cy,W	D,S	do.	.8	3,553.1	95.52	7- 5-50	
4-41-32aba	Simon E. Matson	Dr	64.3	5	GI	do.	do.	Cy,W	D,S	do.	1.6	3,509.9	60.61	7- 5-50	
4-41-32ddb	do.	Dr	121.2	6	GI	do.	do.	N,N	O	Top of casing	.0	3,576.4	113.25	9-11-50	
4-41-36cdd	C. C. Harkins	Dr	231.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.1	3,676.6	221.18	8-12-50	

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T. 4 S., R. 42 W.															
4-42-2ccc	Henry Lampe	Dr	190.0	5	GI	do.	do.	N,N	N	Top of casing	.7	3,681.6	179.15	7-13-50	Abandoned; domestic and stock well
4-42-5aaa	W. E. Klie	Dr	223.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	1.2	3,737.2	192.12	8- 9-50	
4-42-9bcc	J. E. Slothard	Dr	87	5	GI	do.	do.	Cy,H,W,G	D,S			3,602.5	82	8- 9-50	
4-42-11ada	Wilmer Lampe	Dr	186.5	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	1.2	3,658.56	174.50	6-11-46	
4-42-13aad	Henry Lampe	Dr	145.5	5	GI	do.	do.	Cy,W	S	do.	1.0	3,593.4	139.89	6-11-46	
4-42-15bca	Wilmer Lampe	Dr	153.4	5	GI	do.	do.	Cy,W	S	do.	.5	3,642.0	136.93	6-11-46	
4-42-15ddd	School	Dr	149.0	5	GI	do.	do.	Cy,W	D	Top of board platform	.5	3,618.4	137.65	6-11-46	Abandoned school well
4-42-22cdd	F. F. Scheller	B	38.5	5	GI	do.	do.	Cy,G	D,S	Top of concrete curb	1.0	3,512.3	25.78	6- 5-50	
4-42-24cac	Jake Waltz	Dr	51.3	24	GI	do.	do.	T,T	I,O	Hole in base of pump	.8	3,474.1	25.82	9-11-50	
4-42-24dad	Harvey Ochsner	B	24.3	6	GI	do.	Alluvium	Cy,W	D,S	Top of casing	.7	3,449.9	16.06	7- 5-50	Chemical analysis
4-42-26bad	P. E. O'Brien, Jr.	Dr	51.1	24	GI	do.	Ogallala	T,D	I	Hole, base of pump	.8	3,486.6	22.28	9-15-50	Drawdown 27, yield 560 after 6½ hours of pumping
4-42-26bca	do.	Dr	57.0	18	I	do.	do.	T,G	I	do.	.7	3,488.5	18.85	7-13-50	Yield 316
4-42-28cbc	Mary O. West	Dr	23.0	5	GI	do.	do.	Cy,W	S	Top of casing	2.2	3,543.6	17.28	8- 9-50	
4-42-34dab	David Konkel	B	41.3	5	GI	do.	do.	Cy,H	D	do.	.2	3,512.6	30.11	7- 5-50	
4-42-34dbb	Grace B. Sheldon	B	14.8	5	GI	do.	Alluvium	N,N	N	Top of concrete curb	.1	3,494.1	9.99	12-18-49	Abandoned
4-42-36bcb	Bessie E. White	Dr	71.7	5	GI	do.	Ogallala	Cy,W	D,S	do.	1.0	3,538.2	71.52	7- 5-50	
T. 5 S., R. 37 W.															
5-37-1abb	G. L. Cooper	Dr	169.5	5	GI	do.	do.	Cy,W	S	Top of plate	.8	3,381.3	152.07	8-16-50	
5-37-7ccb	A. C. Nelson	Dr	75.0	6	GI	do.	do.	Cy,H,W	S	Top of concrete curb	1.0	3,374.2	65.83	7-25-50	
5-37-8aad	Fredrika Sorensen	Dr	81.5	5	GI	do.	do.	Cy,N	N	do.	1.3	3,346.7	69.60	8-16-50	Abandoned
5-37-9aad	L. Childers	Dr	67.0	5	GI	do.	do.	Cy,W,G	S	Top of casing	.1	3,329.2	59.78	9-18-50	
5-37-11bcb	Orange Fellows	Dr	140.0	5	GI	do.	do.	Cy,W	D,S	Top of plate	−4.6	3,384.5	125.23	8-24-50	
5-37-12abb	do.	Dr	155.0	5	GI	do.	do.	Cy,W	S	do.	.3	3,382.6	150.38	9-18-50	Not in use
5-37-14ccc	Christina Eggers et al.	Dr	134.0	5	GI	do.	do.	Cy,W	S	Top of concrete curb	.0	3,367.7	123.27	7-25-50	
5-37-15bdd	Walter Eggers	Du,Dr	225	18	C,S	do.	do.	T,B	I			3,388.1	134	7-25-50	
5-37-17cdc	R. J. Dunn	Dr	158.5	5	GI	do.	do.	Cy,W	D,S	Top of casing	.3	3,444.2	151.37	8-23-50	
5-37-22cbb	Harold Glasco	Dr	149.0	5	GI	do.	do.	Cy,W	D,S	Top of plate	1.0	3,400.8	141.10	8-24-50	
5-37-24cac	J. Eggers	Dr	44.0	5	GI	do.	do.	Cy,W	D,S	do.	.3	3,256.9	33.38	9-19-50	
5-37-26bcc	C. K. Fisher	Dr	24.5	5	GI	do.	do.	Cy,H	D	Top of casing	.0	3,265.2	18.62	9-19-50	Not in use
5-37-33bba	L. C. Hazen	Dr	42.0	5	GI	do.	do.	Cy,W	S	Hole in plate	.0	3,318.5	24.22	8-16-50	
T. 5 S., R. 38 W.															
5-38-8acc	J. L. Worley	Dr	179.5	5	GI	do.	do.	Cy,W	S	Top of casing	.3	3,509.3	151.92	7-24-50	
5-38-10aab	J. L. Kemp	Dr	161.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.5	3,480.3	149.61	8-24-50	
5-38-13bac	Paul Busse	Dr	120	16	GI	do.	do.	T,G	I			3,390.9	75	8-25-50	Not used in 1950
5-38-15cbb	Ralph W. Weaver	Dr	168	18	S	do.	do.	T,G	I			3,468.6	115	8-23-50	
5-38-19abb	E. Cress	Dr	106.0	5	GI	do.	do.	Cy,H,W	D,S	Top of casing	.3	3,477.2	98.72	7-26-50	Not in use
5-38-22bbb	R. W. Gilliland	Dr	251	16	C,S	do.	do.	T,D	I	Hole, base of pump	.6	3,451.8	102.92	7-26-50	Measured yield 912
5-38-23cbc	R. L. Henery	Dr	66.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.2	3,405.9	64.20	8-23-50	Chemical analysis
5-38-25ada	J. G. Wright	Dr	142.5	5	GI	do.	do.	Cy,N	N	do.	.4	3,446.6	130.29	8-16-50	Abandoned
5-38-28baa	A. Hendricks	Dr	109.0	5	GI	do.	do.	Cy,W	S	do.	.3	3,462.4	99.44	8-23-50	
5-38-31ccc	E. M. Brown	Dr	175.5	6	GI	do.	do.	Cy,W	N	Top of casing	1.0	3,560.6	162.74	7-15-49	Not in use
5-38-33dda	F. Kehlbeck	Dr	261	10	S	do.	do.	T,B	I			3,550.4	161	8-16-50	
5-38-36bab	Leslie A. Shahan	Dr	176.0	5	GI	do.	do.	N,N	N	Top of casing	.3	3,490.9	162.39	8-16-50	Abandoned
5-38-36cdc	M. B. Hanley	Dr	156.0	6	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.8	3,473.5	147.21	7- 8-49	

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TABLE 6.—*Records of wells in Cheyenne County*—(Concluded)

Well number	Owner or tenant	Type of well (1)	Depth of well, feet	Diameter of well, inches	Type of casing (2)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Method of lift (3)	Use of water (4)	Measuring point: Description	Measuring point: Distance above land surface, feet	Measuring point: Height above mean sea level, feet (5)	Depth to water level below measuring point, feet	Date of measurement	REMARKS (Yield given in gallons a minute; drawdown in feet)
T. 5 S., R. 39 W.															
5-39-1ddc	Ina P. Pfeifer	Dr	170.0	5	GI	Sand, gravel	Ogallala	Cy,W	N	Top of casing	0.3	3,528.6	162.20	7-24-50	Abandoned
5-39-2bbb	Chris Andrist	Dr	140.0	5	GI	do.	do.	Cy,H,W	D,S	do.	2.6	3,505.3	133.00	8-22-50	Chemical analysis
5-39-6cbc	L. E. Harrison	Dr	223.0	5	GI	do.	do.	Cy,W	N	do.	.2	3,626.7	210.20	7-24-50	Abandoned
5-39-9bcc	O. H. C. Felzien	Dr	192.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.4	3,590.6	184.46	7-26-50	
5-39-14dcd	C. L. Cress	Dr	106.0	5	GI	do.	do.	Cy,H,W	D,S	Top of casing	1.1	3,493.2	98.55	7-14-50	
5-39-15abb	E. W. Whisnant	Dr	171.0	5	GI	do.	do.	Cy,W	D,S	Top of plate	.5	3,650.1	164.30	8-23-50	
5-39-19ada	E. O. Bressler	Dr	184.0	3	GI	do.	do.	N,N	N	Top of concrete curb	.0	3,614.9	174.24	7-14-50	Abandoned
5-39-24ddd	Millie A. Powell et al.	Dr	83.5	5	GI	do.	do.	Cy,W	D,S	do.	.6	3,456.1	62.65	8-23-50	
5-39-26bba	Dale Moody	Dr	97.0	5	GI	do.	do.	Cy,W	D,S	Top of plate	.7	3,494.4	83.66	7-21-50	
5-39-32ccb	T. J. Ruder	Dr	108.0	5	GI	do.	do.	Cy,W	S	Top of casing	.7	3,560.3	102.05	10-26-49	
5-39-34bbc	Ralph F. Murray	Dr	144.0	5	GI	do.	do.	Cy,W	S	Top of concrete curb	1.4	3,575.0	142.78	7-26-50	
T. 5 S., R. 40 W.															
5-40-9daa	J. H. Zweygardt	Dr	197.5	4	GI	do.	do.	Cy,H,W	D,S	Top of casing	.3	3,651.8	195.68	7-14-50	Not in use
5-40-13cdd	C. Rogers	Dr	196.0	5	GI	do.	do.	Cy,W	S	Top of plate	.8	3,637.4	185.13	7-14-50	
5-40-18cbb	W. Stephenson	Dr	205.0	5	GI	do.	do.	N,N	N	Top of concrete curb	1.6	3,687.4	194.84	7-15-50	Abandoned
5-40-21ddd	Henry and Clarence Walters	Dr	196.5	5	GI	do.	do.	Cy,W	D,S	Top of casing	.2	3,664.2	179.94	7-14-50	Not in use
5-40-26ccb	Elizabeth Finegan	Dr	139.5	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.5	3,618.3	134.76	8-21-50	
5-40-30bdd	Pearl DeGood	Dr	172.0	5	GI	do.	do.	Cy,W	D,S	do.	1.0	3,679.4	168.68	7-15-50	Not in use
5-40-33ddb	Emma Vytlacil	Dr	101.0	5	GI	do.	do.	Cy,H,W	S	Top of casing	1.0	3,604.7	95.25	8-21-50	
5-40-36aca	V. E. Rogers	Dr	126.0	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.7	3,587.4	114.90	8-21-50	

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T. 5 S., R. 41 W.														
5-41-3dac	Everette Stasser	Dr	159.5	5	GI	do.	do.	Cy,H,W	S	Top of casing	.0	....	154.12	8-12-50	
5-41-6add	A. Angel et al.	Dr	47.5	5	GI	do.	do.	Cy,H	D	Top of concrete curb	.3	3,502.6	23.35	7- 5-50	
5-41-6ccd	A. C. Nelson	Dr	84.5	5	GI	do.	do.	Cy,H	D	do.	.4	3,575.3	78.00	8-17-50	
5-41-9dca	Benton & Hopkins Investment Co.	Dr	230.0	5	GI	do.	do.	Cy,W	S	do.	.7	3,720.4	219.09	8-12-50	
5-41-12bcb	R. A. Jeffries	Dr	202.0	5	GI	do.	do.	Cy,H,W	D,S	do.	1.0	3,665.1	187.37	8-17-50	
5-41-15cdd	A. Zielka	Dr	206.0	5	GI	do.	do.	Cy,H	N	Top of casing	.8	3,717.3	200.37	8-17-50	Abandoned
5-41-16ccc	Eleanor E. Robertson	Dr	179.0	5	GI	do.	do.	Cy,W	S	Top of plate	1.0	3,677.8	162.59	8-17-50	Chemical analysis
5-41-17cbc	Nellie Stuhlmiller	Dr	116.5	5	GI	do.	do.	Cy,W	D,S	Top of casing	1.1	3,637.7	108.87	8-17-50	
5-41-28ddd	E. C. Klinck, Jr.	Dr	194.0	5	GI	do.	do.	Cy,W	D	Top of plate	1.0	3,738.0	187.87	7-15-50	Not used often
5-41-29ddd	R. R. Brown	Dr	218.0	5	GI	do.	do.	N,N	N	Top of casing	.8	3,763.0	195.02	8-12-50	Abandoned
5-41-31baa	Justice Anderson	Dr	196.0	5	GI	do.	do.	Cy,W	D,S	do.	2.0	3,762.2	188.52	8-17-50	
5-41-35baa	Gottlieb Schlepp	Dr	169.5	5	GI	do.	do.	Cy,W	D,S	Top of concrete curb	.6	3,693.9	157.68	8-17-50	
T. 5 S., R. 42 W.															
5-42-2cda	John Rueb	Dr	87.8	5	GI	do.	do.	Cy,W	S	do.	.3	3,582.6	81.25	7- 5-50	
5-42-4aac	A. Carder	B	37.2	6	GI	do.	do.	Cy,W	O	do.	1.0	3,526.3	24.22	12- 2-50	
5-42-9bbb	W. Armknecht	Dr	95.0	6	GI	do.	do.	Cy,W	S	Top of casing	.9	3,610.0	85.76	9- 5-50	Not in use
5-42-13cbd	J. Schlepp	Dr	73.0	5	GI	do.	do.	Cy,W	S	Top of concrete curb	.7	3,589.1	56.22	7-15-50	
5-42-22add	School	Dr	105.0	5	GI	do.	do.	Cy,H	D	Top of casing	.7	3,653.6	95.05	7-15-50	
5-42-28bda	B. V. Kellner	Dr	118.0	5	GI	do.	do.	Cy,W	S	do.	.7	3,677.0	84.12	8-17-50	

1. B, bored; Dr, drilled; Du, dug; S, spring.
2. B, brick; C, concrete; GI, galvanized iron; I, iron; N, none; S, steel.
3. Type of pumps: Cy, cylindrical; HC, horizontal centrifugal; N, none; P, piston; T, turbine.
   Type of power: B, butane gas engine; D, diesel engine; E, electric motor; G, gasoline engine; H, hand; N, none; T, tractor; W, wind.
4. D, domestic; I, irrigation; N, none; O, observation; P, public supply; R, railroad; S, stock.
5. Where no measuring point is given, altitude is that of land surface at well.

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LOGS OF WELLS AND TEST HOLES

Listed on the following pages are logs of 44 test holes drilled by the State Geological Survey of Kansas and of 2 irrigation wells. The locations of test holes are shown on Figure 7. Logs entitled "sample log" were those drilled by the State Geological Survey and for which samples were collected. A "drillers log" is a written log obtained from a driller or from some other source. The logs of irrigation wells 5-38-15cbb and 5-37-15bdd were obtained by M. K. Elias and were originally published in a report on the geology of Rawlins and Decatur Counties (Elias, 1937, pp. 15, 16). Depth-to-water measurements obtained from test holes are included in the headings of the logs.

1-37-8acd. *Sample log of test hole in the SE¼ SW¼ NE¼ sec. 8, T. 1 S., R. 37 W., 75 feet due S of E granary, 40 feet E of W fence, drilled September, 1950. Surface altitude 3,289.3 feet; depth to water level 121.5 feet, October 30, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, brown	1	1
Silt, calcareous, brown	11	12
Sand, fine to medium, with some silt	41	53
Silt, with fine sand and some clay	41	94
TERTIARY—Pliocene		
Ogallala formation		
Silt with fine sand and caliche	6	100
Sand, fine to medium, with caliche, green clay, and a small amount of coarse to very coarse sand	10	110
Sand, medium to coarse, with a small amount of very coarse sand	5	115
Sand, coarse to very coarse; contains a small amount of clay	10	125
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to green	25	150

1-37-34ccc. *Sample log of test hole in the SW¼ SW¼ SW¼ sec. 34, T. 1 S., R. 37 W., 50 feet due E of largest tin granary; drilled September, 1950. Surface altitude 3,376.7 feet.*

	Thickness, feet	Depth, feet
Sanborn formation		
QUATERNARY—Pleistocene		
Silt, calcareous, brown	1	1
Silt, calcareous, clayey, tan	68	69
Silt and clay, tan; with some soft caliche	51	120

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	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala formation		
Caliche, soft, white; contains hard nodules	10	130
Caliche, white, with some medium sand, and a small amount of coarse to very coarse sand; contains a few opal fragments	14	144
Caliche, white, with some poorly cemented brown sand	7	151
Gravel, very fine, with very coarse sand and some caliche	9	160
Gravel, very fine, with very coarse sand and caliche, interbedded with gray silty clay	10	170
Sand, medium to very coarse; contains a small amount of very fine gravel; interbedded with clay	22	192
Sand, medium to coarse; contains a small amount of very coarse sand and very fine gravel	13	205
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow	15	220

1-38-1bbb. *Sample log of test hole in the NW¼ NW¼ NW¼ sec. 1, T. 1 S., R. 38 W., 75 feet E of center of N-S road, 200 feet south of center of E-W road (State line); drilled November, 1950. Surface altitude 3,006.5 feet; depth to water level 6.5 feet, November 10, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt and very fine sand, brown	8	8
Sand, medium to very coarse, and fine to coarse gravel	29	37
CRETACEOUS—Gulfian		
Pierre shale		
Shale, blue-gray	3	40

1-38-1cbb. *Sample log of test hole in the NW¼ NW¼ SW¼ sec. 1, T. 1 S., R. 38 W., 15 feet east of center of N-S road, 50 feet south of ½ section line fence; drilled November 1950. Surface altitude 3,014.7 feet; depth to water level 10.34 feet, November 10, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, tan to black	15	15
Sand, fine to very coarse	5	20
Sand, coarse to very coarse, with very fine to medium gravel	13	33
CRETACEOUS—Gulfian		
Pierre shale		
Shale, blue-black	2	35

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1-38-11aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 11, T. 1 S., R. 38 W., 25 feet west of center of road, 105 feet south of center of E-W road; drilled November 1950. Surface altitude 3,050.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, dark-brown to tan	18	18
Crete(?) member		
Sand, fine to medium; contains some coarse to very coarse sand and very fine gravel from 30 to 34 feet	16	34
CRETACEOUS—Gulfian		
Pierre shale		
Shale, soft, yellow-brown	14	48
Shale, blue-black	2	50

1-38-12bcc. *Sample log of test hole in the SW¼ SW¼ NW¼ sec. 12, T. 1 S., R. 38 W., 12 feet east of center of road, 0.45 mile south of intersection; drilled November 1950. Surface altitude 3,094.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, dark-brown to black	4	4
Silt, and very fine sand, tan	6	10
Sand, fine to very fine, and silt	15	25
Crete (?) member		
Sand, fine to coarse	5	30
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow-brown	10	40

1-39-8ddd. *Sample log of test hole in the SE¼ SE¼ SE¼ sec. 8, T. 1 S., R. 39 W., in old farmyard, 30 feet E of smallest door on east side of barn; drilled September 1950. Surface altitude 3, 391.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	2	2
Silt, clayey, tan, with a small amount of caliche	63	65
Silt and clay, tan, with a small amount of caliche	50	115
TERTIARY—Pliocene		
Ogallala formation		
Sand, fine to medium, with clay and caliche	4.5	119.5
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to greenish	10.5	130

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1-39-32aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 32, T. 1 S., R. 39 W., on road shoulder; 15 feet W of center of road; due W of south post of gate on east side of road; drilled September 1950. Surface altitude 3,319.4 feet.*

	Thickness, feet	Depth, feet
Road fill	3	3
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, compact, clayey, tan	81	84
Silt, clayey; contains a small amount of caliche	10.5	94.5
Clay, sandy	5.5	100
TERTIARY—Pliocene		
Ogallala formation		
Mortar bed, tan	20	120
Gravel, very fine to fine	4.5	124.5
Mortar bed, tan, with caliche zones; contains a hard limy zone at base	6.5	131
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to dark-gray	6	137

1-41-29ccc. *Sample log of test hole in the SW¼ SW¼ SW¼ sec. 29, T. 1 S., R. 41 W., in corner of field; 40 feet N of center of E-W road and 15 feet E of center of N-S farm road; drilled September 1950. Surface altitude 3,542.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, gray to tan	6	6
Sand, fine to medium	14	20
Sand, fine to medium, with some clay and silt	22	42
Sand, very fine to coarse	16	58
TERTIARY—Pliocene		
Ogallala formation		
Mortar bed, tan	17	75
Gravel, fine to very fine	1	76
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to green	3.5	79.5

2-38-8ddd. *Sample log of test hole in the SE¼ SE¼ SE¼ sec. 8, T. 2 S., R. 38 W., on E edge of wheat field, 40 feet W and 25 feet N of fence post on NE corner of intersection, drilled October 1950. Surface altitude 3,401.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, brown	2	2
Silt, clayey, calcareous, tan	4	6
Silt, clayey, calcareous, tan, with a few sand grains and some caliche	54	60
Silt, clayey, calcareous, tan	20	80

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	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala formation		
Clay, silty, sandy, tan	4	84
Gravel, fine to very fine, with some coarse sand and clay	12	96
Sand, fine to very coarse, with some clay, fine to very fine gravel, and caliche	28	124
Sand, medium to coarse, with some very fine gravel and zones of brown caliche	16	140
Sand, fine to medium, with some coarse sand and very fine gravel	11	151
Mortar bed, tan	6	157
Sand, medium to coarse, with clay	7	164
Clay, calcareous, tan	12	176
Clay, calcareous, sandy, tan	19	195
Sand, fine to medium, with clay and a little caliche	5	200
Sand, medium to coarse, with some caliche and very fine gravel	10	210
Gravel, very fine, with some very coarse sand	7	217
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to gray	12	229
Shale, dark-gray	1	230

2-39-8dad. *Sample log of test hole in the SE¼ NE¼ SE¼ sec. 8, T. 2 S., R. 39 W., 0.3 mile north of corner, 120 feet NW of small cottonwood tree; drilled November 1950. Surface altitude 3,157.3 feet; depth to water level 3.75 feet, November 9, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Sand, medium to very coarse, and some fine to very fine gravel	18.5	18.5
CRETACEOUS—Gulfian		
Pierre shale		
Shale, blue-gray	5.5	24

2-39-17aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 17, T. 2 S., R. 39 W., 30 feet south of REA line, 28 feet east of fence; drilled November 1950. Surface altitude 3,159.1 feet; depth to water level 3.35 feet, November 10, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Sand, medium to coarse	8	8
Sand, medium to very coarse, and very fine to fine gravel	11	19
CRETACEOUS—Gulfian		
Pierre shale		
Shale, blue-black	6	25

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2-39-17add. *Sample log of test hole in the SE¼ SE¼ NE¼ sec. 17, T. 2 S., R. 39 W., 18 feet west of center of road, 10 feet north of corner fence post; drilled November 1950. Surface altitude 3,167.1 feet; depth to water level 6.06 feet, November 10, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Dune sand		
Sand, fine to coarse	5	5
Alluvium		
Sand, coarse to very coarse	5	10
Sand, very coarse and very fine to fine gravel	8	18
CRETACEOUS—Gulfian		
Pierre shale		
Shale, blue-black	2	20

2-39-17ddd. *Sample log of test hole in the SE¼ SE¼ SE¼ sec. 17, T. 2 S., R. 39 W., 0.1 mile N of section line, 10 feet west of center of road; drilled November 1950. Surface altitude 3,187.3 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Dune sand		
Sand, very fine to medium	14	14
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to very coarse, and very fine to fine gravel; contains gray clay 30-41 feet	27	41
CRETACEOUS—Gulfian		
Pierre shale		
Shale, blue-gray	2	43

2-39-32ddd. *Sample log of test hole in the SE¼ SE¼ SE¼ sec. 32, T. 2 S., R. 39 W., in field, 50 feet N of center of E-W road and 80 feet W of center of N-S road; drilled September 1950. Surface altitude 3,355.1 feet.*

	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala formation		
Silt, sandy, brown	4	4
Sand, medium, with some caliche, red-tan	5	9
Mortar bed, red-tan	51	60
Mortar bed, tan	21	81
Gravel, very fine, and coarse to very coarse sand with some caliche	7	88
Mortar bed, tan, with some very fine gravel	8	96
Sand, fine to medium	9	105
Sand, medium to very coarse, with very fine gravel	8	113
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to green	9	122
Shale, dark-gray	2	124

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2-41-31ddd. *Sample log of test hole in the SE¼ SE¼ SE¼ sec. 31, T. 2 S., R. 41 W., in field; 25 feet W of fence and 90 feet N of center of county road; drilled September 1950. Surface altitude 3,650.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, calcareous, brown	3	3
Silt, gray to brown	23	26
Silt, clayey, light-tan, with a few caliche granules	17	43
Silt, clayey, tan, with some caliche	14	57
TERTIARY—Pliocene		
Ogallala formation		
Clay, sandy, white, with abundant lime	9	66
Mortar bed, tan	6.5	72.5
Sand, medium to fine, cemented with red-tan clay and lime	7.5	80
Mortar bed, tan	13	97
Sand, fine, with silt	6	103
Gravel, very fine, and coarse sand	12.5	115.5
Lime, dense	1	116.5
Mortar bed, tan-gray	9.5	126
Gravel, very fine and coarse to very coarse sand, with a few thin clay lenses	14.5	141.5
Mortar bed, tan	6.5	148
Clay, red, interbedded with medium to coarse sand	7	155
Sand, fine to medium, with some caliche	14	169
Sand, medium to coarse, with some very fine sand, interbedded with limy red clay	13	182
Mortar bed, tan	13	195
Gravel, very fine, and coarse to very coarse sand with a small amount of clay	5	200
Sand, medium to coarse, with some very fine gravel and a small amount of clay	13	213
Mortar bed, tan	4	217
Sand, medium to coarse, with a small amount of very fine gravel	5	222
Mortar bed, tan-gray	1.5	223.5
Gravel, very fine, with medium and coarse sand	15.5	239
Mortar bed, tan	4.5	243.5
Gravel, very fine, with some very coarse sand	10.5	254
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow	4	258
Shale, dark-gray	2	260

2-42-33ccc. *Sample log of test hole in the SW¼ SW¼ SW¼ sec. 33, T. 2 S., R. 42 W., on road shoulder, 20 feet W of fence, 10 feet N of fence post marked with tin square; drilled September 1950. Surface altitude 3,740.2 feet.*

	Thickness, feet	Depth, feet
Road fill	5	5

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	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, calcareous, light-tan	35	40
Silt, clayey, light-tan	23	63
Silt, tan; contains soft caliche and clay	17	80
TERTIARY—Pliocene		
Ogallala formation		
Silt, sticky, slightly sandy, light-tan; contains caliche	7	87
Clay, sandy, with much caliche	23	110
Gravel, very fine and very coarse sand	11	121
Mortar bed, tan	14	135
Gravel, very fine, and very coarse sand	15	150
Gravel, very fine to fine	10	160
Gravel, very fine to fine, and very coarse sand, with a very small amount of caliche	21	181
Mortar bed, tan	28	209
Sand, medium to coarse, with some very fine gravel; contains some caliche from 242-245 feet	42	251
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow	4	255

3-36-6bbb. *Sample log of test hole in the NW. cor. of sec. 6, T. 3 S., R. 36 W., in NW corner of field 25 feet E of center of N-S road, and 60 feet S of center of E-W road, Rawlins County; drilled September 1950. Surface altitude 3,386.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, black	2	2
Silt, clayey, calcareous, tan	88	90
Silt, clayey, tan, with zones of soft caliche	42	132
TERTIARY—Pliocene		
Ogallala formation		
Clay, white, with fine sand and caliche	13	145
Mortar bed, tan	13	157
Clay, sandy, white to tan; contains caliche	28	185
Gravel, very fine, with some medium to very coarse sand and caliche	7	192
Gravel, very fine, with coarse sand; contains sandy clay	37	229
Caliche, white	1	230
Mortar bed, tan	2.5	232.5
Sand, medium to coarse	6	238.5
Mortar bed, tan	58.5	297
Gravel, very fine, and coarse sand; contains thin beds of clay and caliche	15	312
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow	6	318
Shale, dark-gray	5	323

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3-37-5aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 5, T. 3 S., R. 37 W., in NE corner of field, 40 feet W of center of N-S road, and 50 feet S of center of E-W road; drilled September 1950. Surface altitude 3,423.2 feet; depth to water level 210.60 feet, September 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, black, calcareous	1	1
Silt, calcareous, clayey, tan	56	57
Silt, clayey, light-tan; contains caliche	68	125
TERTIARY—Pliocene		
Ogallala formation		
Mortar bed, tan	50	170
Gravel, very fine, with some medium and coarse sand	3	173
Mortar bed, tan	19	192
Gravel, very fine, with some medium and coarse sand	10	202
Clay, sandy, tan	3	205
Mortar bed, tan	23	228
Sand, coarse to very coarse, with some medium sand, very fine gravel and clay	17	245
Mortar bed, tan	13	258
Clay, sandy, white to tan	2	260
Mortar bed, tan	19	279
Gravel, very fine, and coarse to very coarse sand	11	290
Sand, fine to coarse, with some very fine gravel, clay, and caliche	19	309
Sand, fine, with some medium and coarse sand	3	312
Caliche, sandy, gray	1	313
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow	4	317
Shale, dark-gray	3	320

3-38-4bbb. *Sample log of test hole in the NW¼ NW¼ NW¼ sec. 4, T. 3 S., R. 38 W., 15 feet E and 3 feet S of REA pole; drilled October 1950. Surface altitude 3,472.6 feet; depth to water level 213.2 feet, October 6, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, brown	4	4
Silt and very fine to fine sand, brown	26	30
Silt, clayey, calcareous, tan	30	60
Silt, sandy brown	40	100
TERTIARY—Pliocene		
Ogallala formation		
"Algal limestone," red and tan	2	102
Caliche, white, with some opal fragments	13	115
Mortar bed, tan	12	127
Sand, medium to coarse, with some caliche	3	130
Mortar bed, tan	13	147
Sand, medium to coarse, with some caliche	12	159

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	Thickness, feet	Depth, feet
Gravel, very fine and very coarse to coarse sand, contains some caliche	4	163
Sand, medium to coarse, with some very fine gravel and caliche	9	172
Mortar bed, tan	17	189
Mortar bed, red-tan	8	197
Mortar bed, tan	17	214
Sand, medium to very coarse, with some very fine gravel and caliche	17	231
Mortar bed, red-tan	9	240
Sand, medium to very coarse, with a small amount of very fine gravel and caliche	25	260
Mortar bed, tan	8	268
Sand, very fine to medium	6	274
Clay, sandy, pink, with some very fine gravel	2	276
Sand, medium to coarse, with some very fine gravel, interbedded with clay	13	289
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to green	6	295
Shale, blue-green	5	300

3-38-32ddd. *Sample log of test hole in the SE¼ SE¼ SE¼ sec. 32, T. 3 S., R. 38 W., in SE corner of field, 40 feet W of center of N-S road, and 50 feet N of center of E-W road; drilled October 1950. Surface altitude 3,511.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, calcareous, brown	4	4
Silt, clayey, calcareous, tan; contains a few sand grains	101.5	105.5
TERTIARY—Pliocene		
Ogallala formation		
Caliche, soft, clayey, white	11.5	117
Silt and clay, sandy, calcareous, tan	10	127
Gravel, very fine, and coarse sand, with some caliche	11	138
Mortar bed, tan	32	170
Clay, tan to yellow, with some sand and caliche	5	175
Gravel, very fine, and coarse to very coarse sand, with some clay	25	200
Mortar bed, tan	8	208
Sand, medium to very coarse, with very coarse gravel,	9	217
Sand, fine to medium, with some coarse to very coarse sand, very fine gravel, and traces of caliche	30	247
Mortar bed, tan to tan-gray	28	275
Sand, fine to medium, greenish	8	283
Sand, fine to coarse, partially cemented	29	312

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	Thickness, feet	Depth, feet
Sand, medium to very coarse, and very fine gravel	8	320
Sand, medium to very coarse, and fine to very fine gravel; contains a small amount of medium gravel	15	335
CRETACEOUS—Gulfian		
Pierre shale		
Shale, clayey, yellow-brown	5	340
Shale, blue-black	6	346

3-40-6aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 6, T. 3 S., R. 40 W., in intersection triangle, 70 feet N of mail box and 25 feet W of N-S road; drilled September 1950. Surface altitude 3,484.3 feet; depth to water level 120.00 feet, September 30, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, tan-gray	3	3
Silt, calcareous, clayey, light-tan	49	52
TERTIARY—Pliocene		
Ogallala formation		
Clay with caliche, silt, and fine sand	34	86
Clay, pink-tan, with medium to fine sand, and a small amount of very fine gravel	5	91
Mortar bed, tan-gray	4	95
Gravel, very fine, with medium to very coarse sand	23	118
Clay, tan, with coarse sand and very fine gravel	4	122
Sand, medium to coarse, with very fine gravel and some clay	12	134
Sand, coarse, with some medium sand and very fine gravel	9	143
Sand, medium and very fine gravel with clay and caliche	5	148
Sand, very coarse, with some medium sand and very fine gravel	6	154
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to greenish-gray	13	167

3-40-32cbb. *Sample log of test hole in the NW cor. SW¼ sec. 32, T. 3 S., R. 40 W., 300 feet NE of N-S road on N side of diagonal road, 35 feet N of diagonal road; drilled October 1950. Surface altitude 3,329.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, black, and fine sand	2	2
Clay, brown	2	4
Clay, buff	3	7
Sand, coarse, with some very fine gravel	9	16
CRETACEOUS—Gulfian		
Pierre shale		
Shale, buff to tan and green	2	18
Shale, blue to dark-gray	2	20

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3-41-31ddd. *Sample log of test hole in the SE¼ SE¼ SE¼ sec. 31, T. 3 S., R. 41 W., in SE corner of pasture, 25 feet W of E fence, and 40 feet N of S fence; drilled September 1950. Surface altitude 3,603.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, calcareous, light-tan	4	4
Silt, clayey, light-tan, with some caliche	26	30
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to coarse, with some very fine gravel; cemented with some clay and caliche	18	48
Mortar bed, tan	2	50
Gravel, very fine, with coarse sand; contains some clay,	7	57
Sand, medium to coarse, with some very fine gravel	7	64
Mortar bed, red-tan	21	85
Gravel, very fine, with some very coarse sand	4	89
Mortar bed, red-tan	9	98
Sand, medium to coarse, interbedded with white and yellow clay	11	109
Sand, medium to coarse, with some caliche	2	111
Mortar bed, white to tan	42	153
Sand, medium to coarse, with some very fine gravel and some yellow clay	6	159
Sand, very coarse and very fine gravel; contains sandy clay and caliche	7	166
Sand, medium to coarse, with some clay and some very fine gravel	18	184
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow	5	189
Shale, dark-gray	1	190

4-37-5aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 5, T. 4 S., R. 37, W., 75 feet S of center of intersection, 45 feet W of center of N-S road; drilled October 1950. Surface altitude 3,446.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, tan	45	45
Silt and clay, calcareous, cream-colored	7	52
Silt and clay, light-tan	8	60
Silt and clay, tan to reddish-brown	44	104
TERTIARY—Pliocene		
Ogallala formation		
Caliche, white	11	115
Caliche, hard, white	5	120
Silt and very fine sand, calcareous, reddish-brown	10	130
Sand, coarse, to very coarse, and very fine to fine gravel	10	140

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	Thickness, feet	Depth, feet
Silt and very fine sand, compact, reddish-brown	20	160
Sand, fine to very coarse, and very fine gravel, partially cemented	20	180
Sand, medium to very fine, and silt	10	190
Sand, fine to medium, partially cemented	28	218
Sand, medium to very coarse	10	228
Mortar bed	12	240
Silt and very fine sand, reddish-brown; contains some fine to coarse sand	30	270
Sand, fine to coarse, partially cemented	20	290
Sand, fine to very coarse, and very fine gravel	10	300
Gravel, very fine, and very coarse sand	25	325
Sand, fine to very coarse, and very fine gravel	13	338
CRETACEOUS—Gulfian		
Pierre shale		
Shale, soft, yellow	4	342
Shale, dark-blue	8	350

4-37-36ddd. *Sample log of test hole in the SE¼ SE¼ SE¼ sec. 36, T. 4 S., R. 37 W., 30 feet N of E-W road, center of N-S road; drilled October 1950. Surface altitude 3,384.7 feet; depth to water level 171.4 feet, October 9, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	3	3
Silt, light-brown to tan	63	66
TERTIARY—Pliocene		
Ogallala formation		
Caliche, white; contains opal fragments	16	82
Silt, sandy, brown	6	98
Sand, coarse to very coarse, and very fine gravel	17	115
Clay and silt, sandy, brown	8	123
Sand, medium to very coarse, and very fine gravel	12	135
Sand	45	180
Clay and silt, sandy, brown	30	210
Mortar bed	35	245
Clay, soft, white	6	251
Mortar bed	11	262
Clay, sandy, white	3	265
Mortar bed	7	272
Caliche, white	10	282
Sand, fine	8	290
Sand, fine to very coarse; contains a small amount of very fine gravel	7	297
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, buff to tan	7	304
Shale, blue to dark-gray	2.5	306.5

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4-38-33ccc. *Sample log of test hole in the SW¼ SW¼ SW¼ sec. 33, T. 4 S., R. 38 W., in S. W. cor. of field, 30 feet E of center of N-S road and 50 feet N of center of E-W road; drilled September 1950. Surface altitude 3,491.0 feet; depth to water level 153 feet, September 10, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, brown	1	1
Silt, calcareous, tan	24	25
Sand, medium, with some coarse sand	6	31
Sand, medium, interbedded with soft brown clay	8	39
Silt, sandy	5	44
TERTIARY—Pliocene		
Ogallala formation		
"Algal limestone," white to reddish-brown	4	48
Caliche, sandy, white	14	62
Sand, medium, with some coarse sand, cemented with calcium carbonate	17	79
Sand, medium, with some coarse sand, weakly cemented	11	90
Gravel, very fine, with some very coarse sand	10	100
Clay, sandy, slightly calcareous, gray; contains some very fine gravel	8	108
Sand, medium, with some coarse sand, partially cemented	6	114
Gravel, very fine, with some coarse sand and a small amount of tan sandy clay	4.5	118.5
Sand, medium, and a small amount of coarse sand and very fine gravel	9.5	128
Clay, calcareous, tan, with some coarse sand and very fine gravel	4	132
Sand, medium, with some coarse sand and a small amount of fine sand and clay	8	140
Gravel, very fine, with some coarse sand	13	153
Clay, sandy, calcareous, tan; contains a small amount of very fine gravel	14	167
Sand, medium, with some fine sand	3	170
Sand, coarse, with a small quantity of medium sand; partially cemented	10	180
Clay, sandy, slightly calcareous, gray; contains some very fine gravel	3	183
Sand, medium, with some coarse sand, clay, and caliche,	3	186
Clay, sandy, white, with a moderate amount of caliche,	4	192
Sand, medium, with small amounts of coarse and fine sand, clay, and caliche	15	207
Clay, sandy, white to tan, with large quantities of caliche	3	210
Mortar bed	12	222
Sand, medium to fine, well-cemented with calcium carbonate	9	231

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	Thickness, feet	Depth, feet
Sand, medium to fine, interbedded with white clay	15	246
Sand, medium, with some coarse sand and gray clay	10	256
Clay, noncalcareous, yellow, with some fine sand	10.5	266.5
Clay, sandy, noncalcareous, tan	6.5	273
Clay, sandy, red-tan, with some hard yellow clay, and caliche zones at 273 ft. and 286 ft.	13	286
Sand, medium, with some coarse and fine sand and some clay	9	295
Sand, coarse, with very fine gravel	4	299
Clay, yellow and red-tan, fairly hard, slightly calcareous	8	307
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to blue-gray	3	310

4-39-5aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 5, T. 4 S., R. 39 W., in field, 30 feet S of fence and 50 feet W of center of Kansas Highway 27; drilled September 1950. Surface altitude 3,480.4 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, calcareous, brown	7	7
TERTIARY—Pliocene		
Ogallala formation		
Caliche, sandy, white	8	15
Sand, medium	3	18
Caliche, with coarse sand and very fine gravel	2	20
Mortar bed, tan	21	41
Clay, sandy, tan to brown, with caliche	7	48
Sand, medium, with some coarse sand and clay	7	55
Gravel, very fine, and very coarse sand	14	69
Mortar bed, tan	10	79
Coarse sand, with very fine gravel	7	86
Mortar bed, tan	19	105
Gravel, very fine, and very coarse sand	5	110
Sand, medium, with some caliche	10	120
Mortar bed, tan	20	140
Sand, medium, with some caliche	11	151
Mortar bed, light-tan	23	174
Clay, sandy, tan	3	177
Mortar bed, tan	28	205
Sand, medium to very coarse, grading to very fine gravel at depth	21	226
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to dark-gray	4	230

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4-40-5bbb. *Sample log of test hole in the NW¼ NW¼ NW¼ sec. 5, T. 4 S., R. 40 W., on road shoulder, 6 feet from center of road, and 10 feet south of section line fence; drilled September 1950. Surface altitude 3,357.2 feet; depth to water level 29.05 feet, September 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Dune sand		
Sand, fine to medium	8	8
TERTIARY—Pliocene		
Ogallala formation		
Clay, calcareous, tan	5	13
Sand, medium, with very fine gravel	4	17
Mortar bed, tan	16	33
Sand, coarse, with very fine gravel; contains yellow clay bed from 41½ to 42½	17.5	50.5
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow	7.5	58
Shale, dark-gray	2	60

4-41-17daa. *Sample log of test hole in the NE¼ NE¼ SE¼ sec. 17, T. 4 S., R. 41 W., 18 feet west of center of road, 45 feet south of gate post; drilled November 1950. Surface altitude 3,406.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Silt, brown	4	4
Sand, medium to coarse	4	8
Sand, very coarse, and very fine to medium gravel	6	14
CRETACEOUS—Gulfian		
Pierre shale		
Shale, blue-black	6	20

4-41-17dad. *Sample log of test hole in the SE¼ NE¼ SE¼ sec. 17, T. 4 S., R. 41 W., 300 feet west of center of N-S road, 200 feet south of E-W road; drilled October 1950. Surface altitude 3,406.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Sand, coarse to very coarse and very fine gravel; contains fine to medium gravel from 10-15 feet	15	15
CRETACEOUS—Gulfian		
Pierre shale		
Shale, gray	5	20

4-41-20aad. *Sample log of test hole in the SE¼ NE¼ NE¼ sec. 20, T. 4 S., R. 41 W., 60 feet west of center of road, 0.15 mi. south of road; drilled November 1950. Surface altitude 3,410.8 feet; depth to water level 6.95, November 10, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Sand, medium to very coarse, and very fine gravel; contains a small amount of fine to medium gravel	19	19

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	Thickness, feet	Depth, feet
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow-brown to tan	1	20
Shale, gray to blue-black	6	26

4-41-21cbb. *Sample log of test hole in the NW¼ NW¼ SW¼ sec. 21, T. 4 S., R. 41 W., 18 feet east of center of road, 12 feet west of fence; drilled November 1950. Surface altitude 3,439.5 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Dune sand		
Sand, medium to coarse, loose	2	2
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to coarse; contains brown silt and clay from 10-15 feet	19	21
Sand, medium to very coarse, and very fine gravel	12	33
Sand, coarse to very coarse, and very fine gravel; contains a small amount of fine to medium gravel	12	45
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow-brown to tan	6	51
Shale, gray	1	52
Shale, blue-black	1	53

4-41-32ccb. *Sample log of test hole in the NW¼ SW¼ SW¼ sec. 32, T. 4 S., R. 41 W., 3 feet E of center of road, 10 feet W and 2 feet N of post with tin marker; drilled August 1950. Surface altitude 3,482.8 feet.*

	Thickness, feet	Depth, feet
Road fill	2	2
QUATERNARY—Pleistocene		
Alluvium		
Sand, medium	3	5
TERTIARY—Pliocene		
Ogallala formation		
Mortar bed, tan	21	26
Clay, soft, gray, with some medium sand	6	32
Sand, fine to medium, with brown clay and silt	13	45
Sand, very coarse to coarse, with some yellow clay	6	51
Sand, coarse, with some yellow clay	17	68
Sand, fine to medium	6	74
Sand, very coarse, with coarse sand, very fine gravel, and yellow clay	5	79
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to dark-gray	6	85

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4-42-5aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 5, T. 4 S., R. 42 W., 45 feet south of center of E-W road, 30 feet west of center of N-S road; drilled November 1950. Surface altitude 3,735.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, dark-brown	2	2
Silt, tan	28	30
Silt, tan, and very fine sand	26	56
TERTIARY—Pliocene		
Ogallala formation		
Silt and clay, sandy, light-tan	18	74
Sand, medium to very coarse	5	79
Sand, medium to very coarse, with silt and clay	11	90
Sand, medium to very coarse, and very fine gravel	10	100
Sand, very coarse, and very fine gravel	9	109
Silt and clay, brown	11	120
Sand, very fine to medium, partially cemented, brown,	20	140
Sand, very fine to coarse, brown	10	150
Sand, fine to coarse, partially cemented, brown	12	162
Sand, fine to coarse, partially cemented, with some very fine gravel and very coarse sand; contains hard calcium carbonate layer from 177 to 179 feet	28	190
Sand, medium to coarse, and very fine gravel	14	204
Silt and clay, brown	6	210
Silt and clay, brown; contains some fine to medium sand	8	218
Silt and very fine sand, light-tan	15	233
Sand, medium to very coarse; contains very fine gravel from 250 to 256 feet	23	256
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow-brown	10	266
Shale, gray	4	270

4-42-33cbb. *Sample log of test hole in the NW¼ NW¼ SW¼ sec. 33, T. 4 S., R. 42 W., 30 feet S and 5 feet E of clump of cottonwood trees marked with tin square; drilled August 1950. Surface altitude 3,506.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Sand, medium	2	2
Sand, coarse, with very fine gravel	6	8
Sand, medium, with very fine gravel	18	26
Sand, coarse, with yellow clay and very fine gravel	4	30
Sand, coarse, with very fine gravel	6	36
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow, grading to dark-gray with depth	11	47

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5-37-5aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 5, T. 5 S., R. 37 W., in field, 75 feet S of E-W road, and 40 feet W of N-S road; drilled September 1950. Surface altitude 3,429.7 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, calcareous, dark-brown	1	1
Silt, calcareous, tan	9	10
Silt, calcareous, slightly clayey, tan, with some caliche,	46	56
Clay, silty, tan with caliche	12	68
TERTIARY—Pliocene		
Ogallala formation		
Clay, soft, sandy, calcareous, tan, with some caliche	20	88
Gravel, very fine with some coarse sand, interbedded with clay	4	92
Gravel, very fine, with some coarse sand, interbedded with sandy clay from 112-117 feet	28	120
Sand, coarse, with some very fine gravel and some medium sand; interbedded with sandy clay	18	138
Sand, coarse, with some very fine gravel and some medium sand; contains clay	29	167
Sand, medium, with some coarse sand and some very fine gravel	7.5	174.5
Mortar bed	4	178.5
Sand, medium, with some fine sand and a little coarse sand, cemented with clay and caliche; contains a small amount of very fine gravel from 189-191 feet and below 200 feet	39.5	218
Sand, fine, interbedded with clay	7	225
Mortar bed, tan	20	245
Sand, fine to very fine	6	251
Mortar bed, tan	7	258
Clay, green, with caliche, fine sand, and very fine gravel	7	265
Sand, fine, containing clay	12	277
Sand, fine interbedded with hard, brown, sandy clay	20	297
Sand, medium, with some fine sand	8	305
Sand, fine, with some medium sand	5	310
Gravel, very fine, with some coarse sand, cemented with clay	10	320
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow, grading to blue-gray with depth	10	330

5-37-15bdd. *Drillers log of irrigation well in the SE cor. NW¼, sec. 15, T. 5 S., R. 37 W. Surface altitude, 3,388.1 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, yellow	25	25

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	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala formation		
"Algal limestone," tough, pinkish	2	27
Limestone and silt, sandy, porous	23	50
Gravel and sand	30	80
Silt	6	86
Gravel	5	91
Silt and rock	6	97
Gravel and sand	7	104
Silt, yellow	6	110
Sand and gravel	8	118
Silt	4	122
Gravel and sand (first water)	6	128
Silt and gravel, with fossil bones	6	134
Rock, hard (second water)	2	136
Gravel, with fossil bones	12	148
Soft rock, sand, and gravel	79	227

5-37-33cdc. *Sample log of test hole in the SW¼ SE¼ SW¼ sec. 33, T. 5 S., R. 37 W., drilled August, 1949. Surface altitude, 3,350.7 feet; depth to water level, 50.0 feet, August 14, 1949.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, tan	1	1
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to coarse, and fine gravel	9	10
Sand, medium to coarse, and fine to coarse gravel; contains a large amount of coarse gravel	10	20
Gravel, coarse to fine; contains a small amount of coarse sand	11	31
Sand, medium to coarse, and fine gravel; contains greenish-brown clay	14	45
Sand, fine to coarse, and fine to medium gravel; contains some brownish silt and clay	15	60
Gravel, coarse to fine, and medium to coarse sand	17	77
Mortar bed	16	93
Silt and clay, brown	4	97
Mortar bed containing much calcium carbonate; contains less calcium carbonate and is softer from 128 to 130 feet	33	130
Sand, fine to medium; contains some calcium carbonate cement	12	142
Sand, fine to medium	8	150
Sand, fine to medium; contains some green clay	15	165
Mortar bed; containing much calcium carbonate cement	5	170
Sand, fine to medium; contains very little cement	22	192

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	Thickness, feet	Depth, feet
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, yellow-brown	5	197
Shale, blue-black	13	210

5-38-15cbb. *Drillers log of irrigation well in the NW cor. SW¼ sec. 15, T. 5 S., R. 38 W. Surface altitude, 3,468.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Dirt, yellow	50	50
TERTIARY—Pliocene		
Ogallala formation		
Sand and gravel, coarse, loose	10	60
Clay, sandy (first water)	55	115
Sand, coarse, and gravel	5	120
Clay (second water)	6	126
Sand, coarse	2	128
Clay	4	132
Rock, sandy limestone (third water)	1	133
Quicksand	5	138
Gravel	3	141
Clay and white "magnesia" (porous limestone)	10	151
Sand, coarse	4	155
Quicksand	8	163
Rock ("magnesia," a somewhat sandy limestone)	20	183

5-39-6aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 6, T. 5 S., R. 39 W., in field, 40 feet W of center of road and 15 feet S of center of driveway into field, driveway is 150 feet S of intersection; drilled August 1950. Surface altitude 3,590.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, calcareous, brown	5	5
Sand, medium, with some fine to coarse sand	30	35
Sand, medium, and some fine to coarse sand; contains a small amount of gray clay	10	45
Sand, medium, with some fine sand, silt, and gray clay,	5	50
Silt, calcareous, brown, with some very fine sand and gray clay	15	65
TERTIARY—Pliocene		
Ogallala formation		
Clay, white, with a small quantity of coarse sand	9	74
Clay, white and brown, with much coarse sand, some fine sand, and very fine gravel	6	80
Gravel, very fine, with some coarse sand and a small quantity of white clay	15	95
Clay, compact, brown, with some very fine gravel and coarse sand	3	98
Clay, compact brown, with some very fine gravel, fine sand and a small amount of fine to medium gravel	6	104

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	Thickness, feet	Depth, feet
Clay, white, with medium sand and some very fine gravel	10	114
Mortar bed, tan	43	157
Sand, very coarse, with some medium sand	5	162
Gravel, very fine, with some coarse sand	6	168
Gravel, very fine, with some coarse and medium sand and red sandy clay	6	174
Sand, medium, with some coarse and fine sand, cemented with clay	6	182
Clay, white, with some fine sand	4	186
Sand, coarse, with some medium sand and clay	7	193
Mortar bed, tan	27	220
Sand, fine, with some medium sand; contains a small amount of clay	4	224
Sand, fine, with some medium and coarse sand, well-cemented	8	232
Mortar bed, tan	39	271
Sand, fine, with some medium sand	4.5	275.5
Mortar bed, tan	14.5	290
Sand, fine, with very fine sand and silt	12	302
Mortar bed, tan	27	329
Sand, fine, with very fine sand and partially cemented clay	3	332
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow to blue	3	335

5-40-5bbb. *Sample log of test hole in the NW¼ NW¼ NW¼ sec. 5, T. 5 S., R. 40 W., in ditch, 10 feet E of center of road, 10 feet W of marked telephone pole; drilled August 1950. Surface altitude 3,606.6 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Silt, calcareous, light-brown	28	28
TERTIARY—Pliocene		
Ogallala formation		
Sand, coarse, with some very fine gravel and yellow clay	8	36
Sand, coarse, with a small amount of very fine gravel	2	38
Mortar bed, tan	20.5	58.5
Sand, coarse, with very coarse sand and very fine gravel	10.5	69
Clay, soft, yellow	1	70
Sand, medium to coarse with some white clay	7	77
Gravel, very fine with some fine to very coarse sand	5	82
Sand, fine, containing clay	18	100
Sand, fine, with some caliche	22	122
Mortar bed, tan	48	170
Sand, very fine, with small amounts of medium sand and clay	10	180

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	Thickness, feet	Depth, feet
Mortar bed, tan	68	248
Sand, fine, with red-brown clay and some medium sand	4	252
Sand, fine, with some medium sand and a small amount of clay	14	266
Sand, medium, with fine and coarse sand and some yellow clay	6	272
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow and dark-blue	2	274

5-42-4bbb. *Sample log of test hole in the NW¼ NW¼ NW¼ sec. 4, T. 5 S., R. 42 W., 35 feet E of fence; 6 feet W of center of road; drilled August 1950. Surface altitude 3,510.0 feet; depth to water level 5.1 feet, August 30, 1950.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Alluvium		
Sand, medium to coarse, contains a little very coarse sand	15	15
Gravel, very fine, containing fine to medium gravel	9	24
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium to coarse, cemented with yellow clay	10	34
Sand, medium to coarse; contains very coarse sand	5	39
CRETACEOUS—Gulfian		
Pierre shale		
Shale, yellow	7	46
Shale, blue	4	50

5-42-4bcc. *Sample log of test hole in the SW¼ SW¼ NW¼ sec. 4, T. 5 S., R. 42 W., 6 feet E of center of road; 0.45 mi. S of test hole 5-42-4bbb; drilled August 1950. Surface altitude 3,514.1 feet; depth to water level 3.5 feet, August 30, 1950.*

	Thickness, feet	Depth, feet
Road fill	4	4
QUATERNARY—Pleistocene		
Alluvium		
Sand, medium to coarse	13	17
Gravel, very fine, with some medium to very coarse sand and some gray clay	10	27
TERTIARY—Pliocene		
Ogallala formation		
Sand, medium, poorly cemented with calcium carbonate; contains some very fine gravel which may be lag	2	29
Gravel, very fine, with a small amount of fine to medium gravel	13.5	42.5

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	Thickness, feet	Depth, feet
CRETACEOUS—Gulfian		
Pierre shale		
Shale, soft, light-gray	1.5	44
Shale, blue-gray	6	50

6-40-1aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 1, T. 6 S., R. 40 W., Sherman County drilled September, 1949. Surface altitude, 3,584.1 feet; depth to water level 129 feet, September 6, 1949.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation—Peoria silt member		
Silt, dark-brown to tan	15	15
TERTIARY—Pliocene		
Ogallala formation		
Limestone, light-tan; "Algal" at the top	13	28
Clay and silt, sandy, red	3	31
Mortar bed	9	40
Silt and clay, sandy, reddish-brown	18	58
Sand, fine to coarse	10	68
Gravel, course	12	80
Sand, fine to coarse	10	90
Sand, very fine to medium	5	95
Silt, sandy, brown	5	100
Silt and very fine sand, brown	40	140
Sand, fine to coarse, and fine gravel	18	158
Silt and clay, sandy, light-tan	12	170
Sand, fine to coarse and fine gravel; contains silt and clay	20	190
Silt and very fine sand, brown	10	200
Silt and very fine to fine sand, light-brown	20	220
Sand, very fine to fine	15	235
Mortar bed	5	240
Sand, medium to coarse	64	304
CRETACEOUS—Gulfian		
Pierre shale		
Shale, weathered, greenish to yellowish-brown	6	310
Shale, dark-blue to black	5	315

6-42-2aaa. *Sample log of test hole in the NE¼ NE¼ NE¼ sec. 2, T. 6 S., R. 42 W., Sherman County, drilled September, 1949. Surface altitude 3,784.7 feet; depth to water level 184.82 feet, September 17, 1949.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene		
Sanborn formation		
Peoria silt member		
Silt, dark-brown	2	2
Silt, tan	38	40
Loveland silt member		
Silt, red-brown	4	44

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	Thickness, feet	Depth, feet
TERTIARY—Pliocene		
Ogallala formation		
Silt and clay, calcareous, cream-colored	11	55
Sand, fine to coarse, with silt and clay binder	5	60
Mortar bed	4	64
Sand, fine to coarse, and fine to coarse gravel	6	70
Sand, fine to coarse, and fine gravel	7	77
Sand, medium to coarse, and fine to coarse gravel; contains compact brown clay and silt	3	80
Sand, fine to coarse, reddish	6	86
Sand, fine to coarse, and a little fine to coarse gravel	14	100
Sand, fine to coarse, partially cemented	8	108
Sand, fine to coarse, and fine to coarse gravel	6	114
Silt and clay, gray to brown	6	120
Sand, fine to coarse, with brown silt and very fine sand	13	133
Sand, fine to coarse, and fine to coarse gravel; contains compact silt and very fine sand	7	140
Sand, fine to coarse, and fine gravel; contains very fine sand and silt	7	147
Sand, fine to coarse, and fine to coarse gravel	14	161
Sand, fine to coarse	3	164
Sand, fine to coarse, and fine to coarse gravel	6	170
Sand, fine to coarse; contains silt and very fine sand	6	176
Sand, fine to coarse, and fine to coarse gravel	8	184
Sand, fine to coarse, partially cemented; contains a little fine to coarse gravel	5	189
Mortar bed	18	207
Sand, fine to medium, brown	7	214
Mortar bed	4	218
Sand, fine to coarse, and fine to coarse gravel, partially cemented	6	224
Mortar bed	6	230
Sand, fine to coarse, and fine gravel	10	240
Sand, fine to coarse, and fine to coarse gravel; contains silt and very fine sand as binder	10	250
Sand, fine to coarse, and fine to coarse gravel, partially cemented	10	260
Sand, fine to coarse, and fine gravel; contains a small amount of medium to coarse gravel	15	275
Gravel, coarse to fine, and medium to coarse sand	5	280
Sand, coarse to medium, and a small amount of fine gravel	6	286
Gravel, coarse to fine, and coarse sand	2	288
CRETACEOUS—Gulfian		
Pierre shale		
Shale, clayey, yellow-brown to tan	12	300
Shale, blue-black	6	306

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Division of Ground Water

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Engineer in Charge

BULLETIN 101

GEOLOGY AND GROUND-WATER RESOURCES OF JACKSON COUNTY, KANSAS

By KENNETH L. WALTERS
(State Geological Survey of Kansas)

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

Printed by authority of the State of Kansas
Distributed from Lawrence

JUNE, 1953

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1953

24-7020

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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,-

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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.

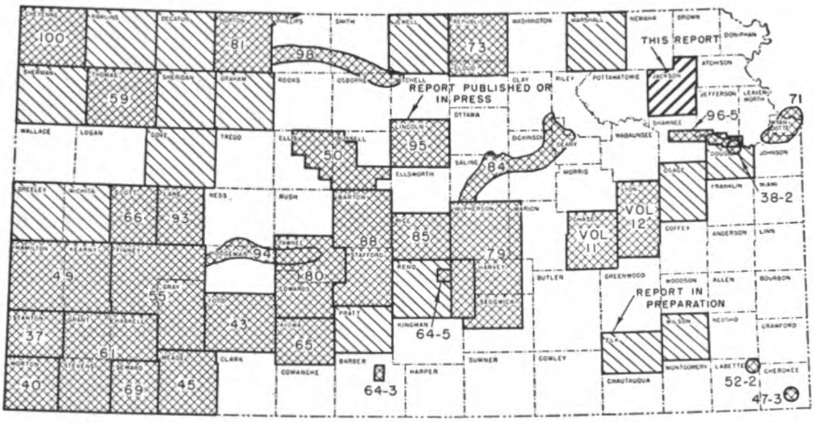

Fig. 1.—Index map of Kansas showing area covered by this report and areas for which co-operative ground-water reports have been published or are in preparation.

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.

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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.

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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-

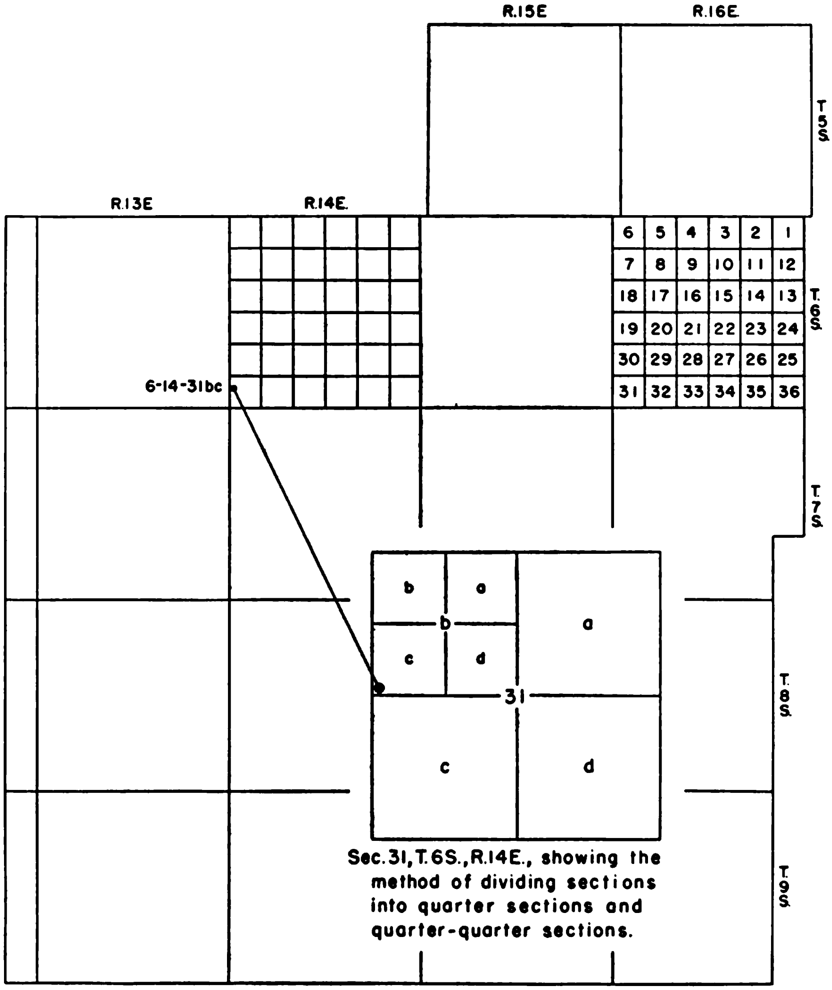

Fig. 2.—Map of Jackson County illustrating the well-numbering system used in this report.

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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

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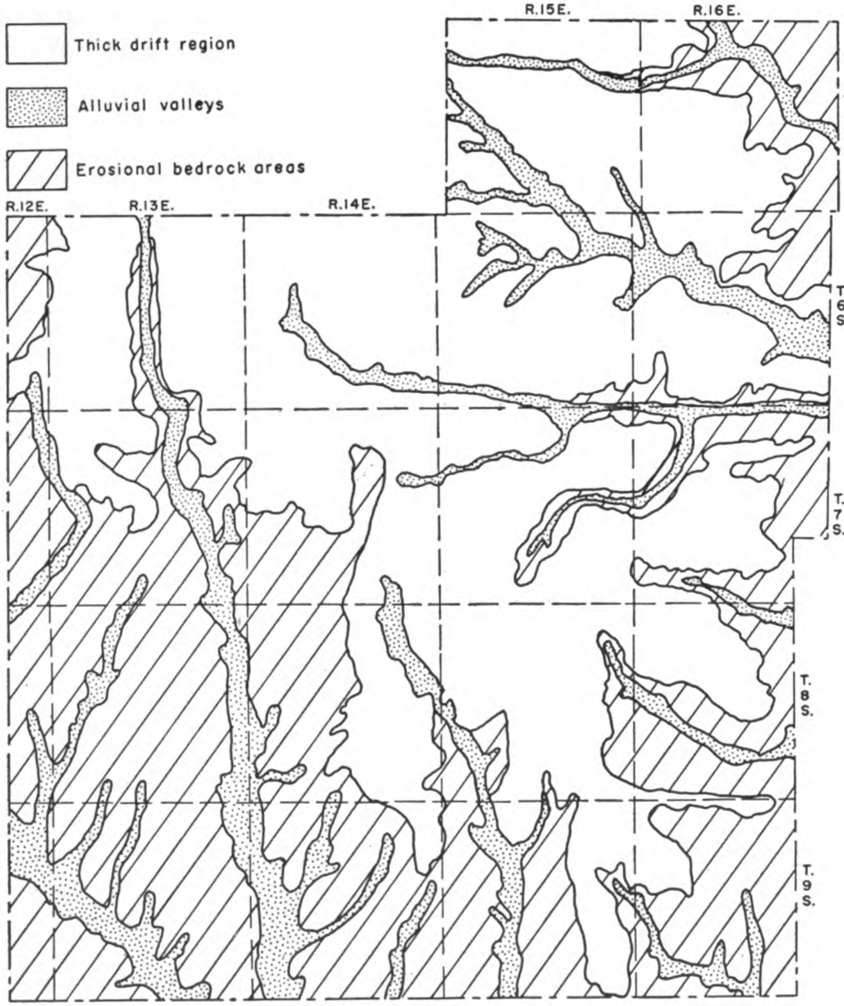

FIG. 3.—Map of Jackson County showing topographic divisions.

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.

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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

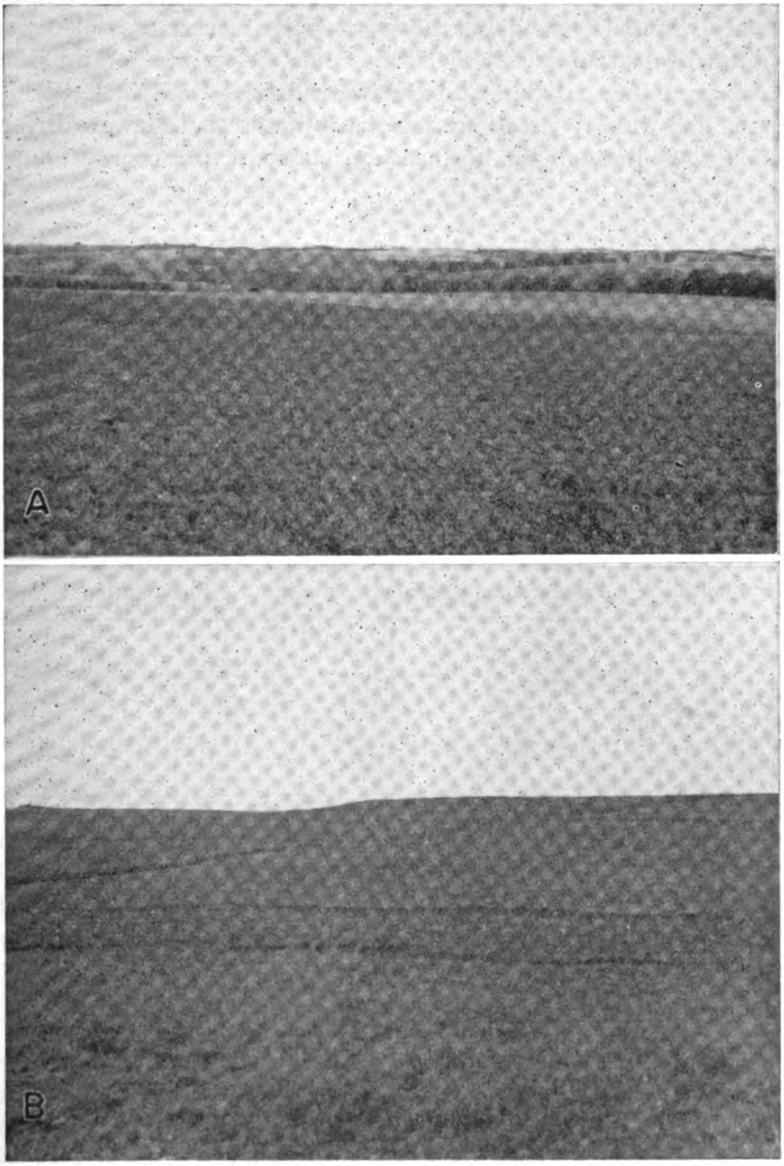

PLATE 4. A, Glacial topography of northern Jackson County. **B,** Bedrock topography in the NW¼ sec. 15, T. 9 S., R. 14 E.

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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.

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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.

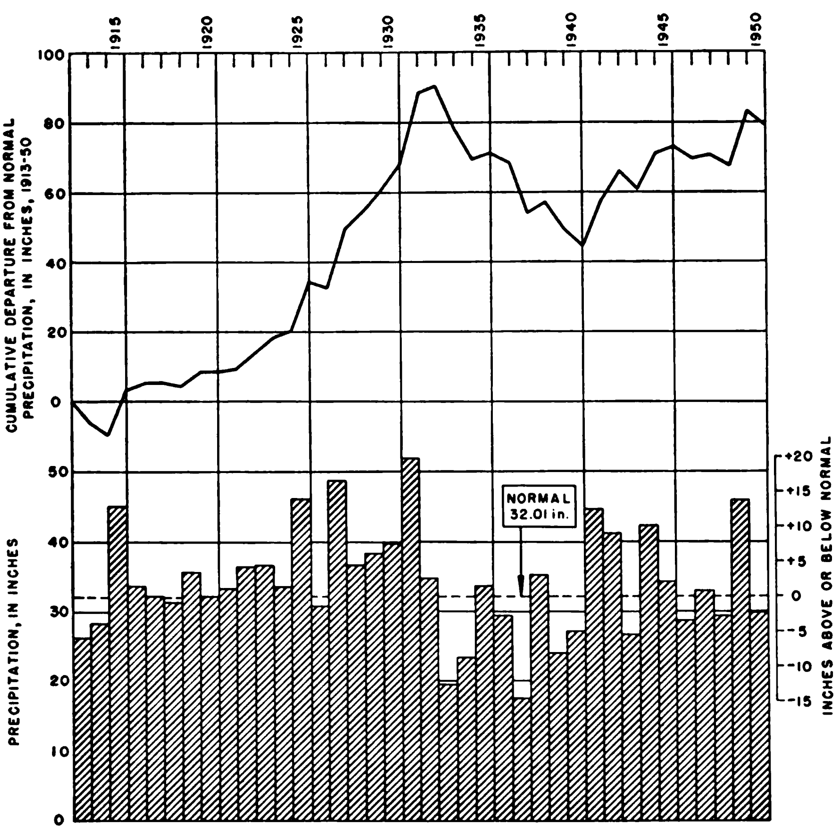

FIG. 4.—Annual precipitation and the cumulative departure from normal precipitation at Holton, Kansas.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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

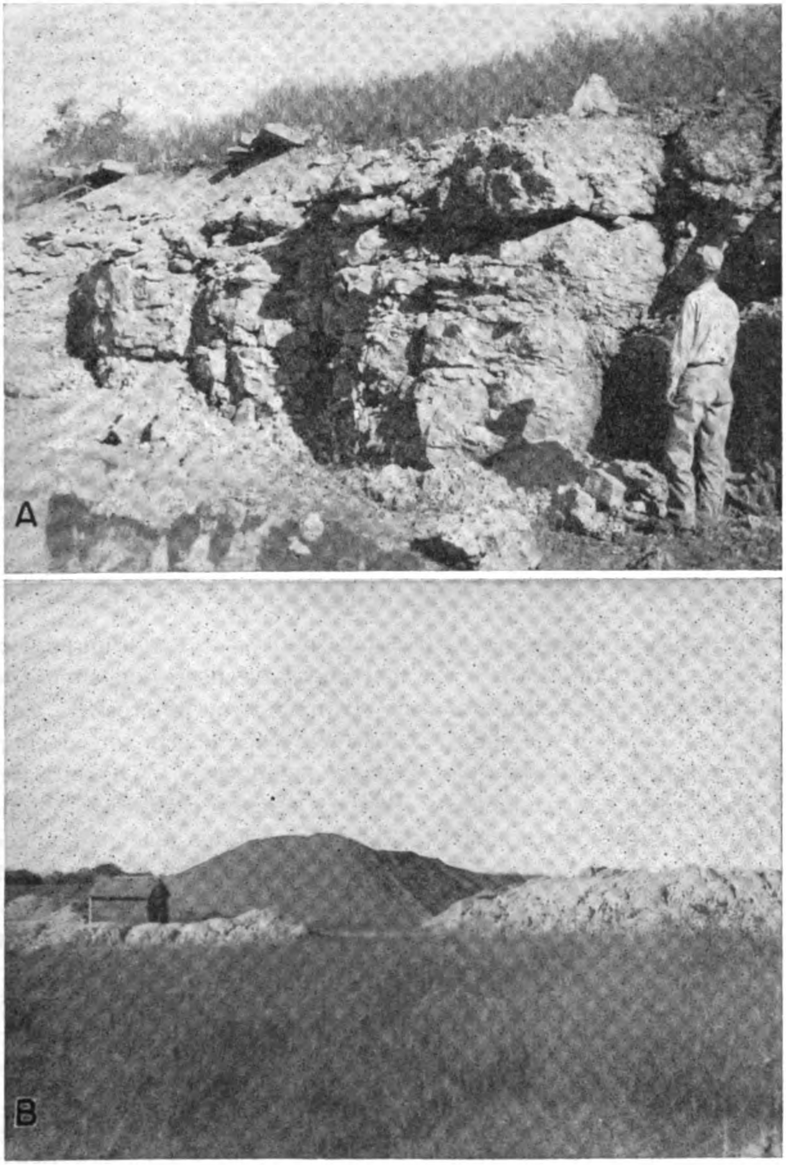

PLATE 5. **A,** Quarry in Burlingame limestone near Mayetta. **B,** Stockpile of agricultural lime and road material at quarry near Mayetta.

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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

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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.

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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

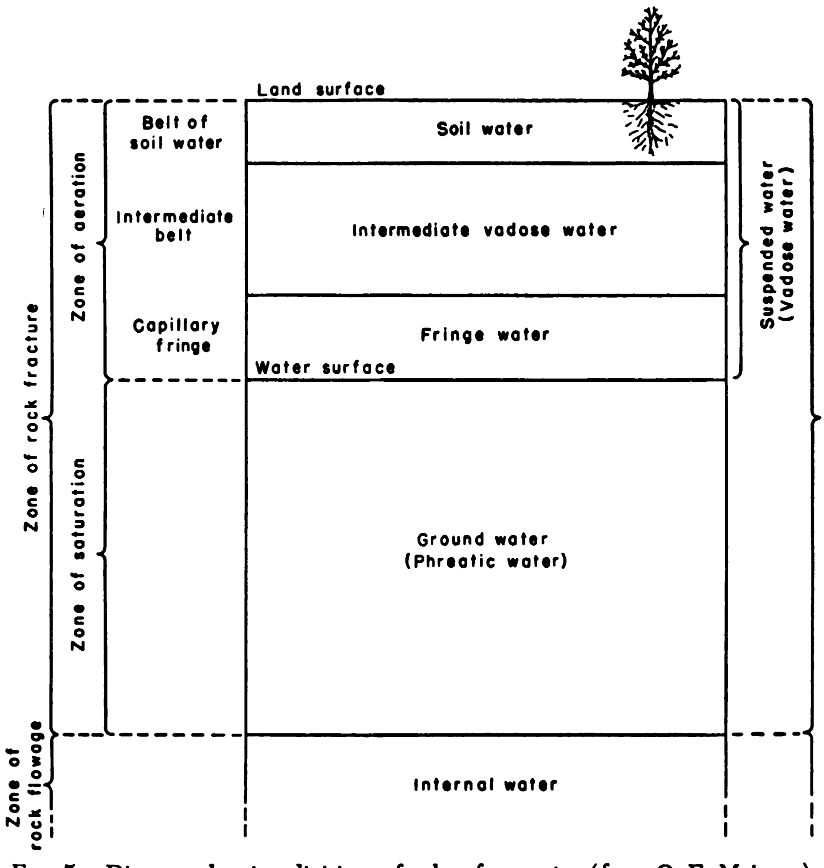

Fig. 5.—Diagram showing divisions of subsurface water (from O. E. Meinzer).

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.

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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.

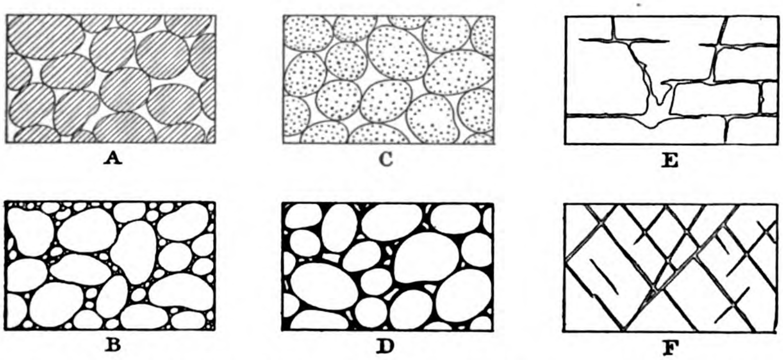

FIG. 6.—Diagram showing several types of rock interstices and the relation of rock texture to porosity. **A**, Well-sorted sedimentary deposit having a high porosity; **B**, poorly sorted sedimentary deposit having low porosity; **C**, well-sorted sedimentary deposit consisting of pebbles that are themselves 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.)

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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

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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

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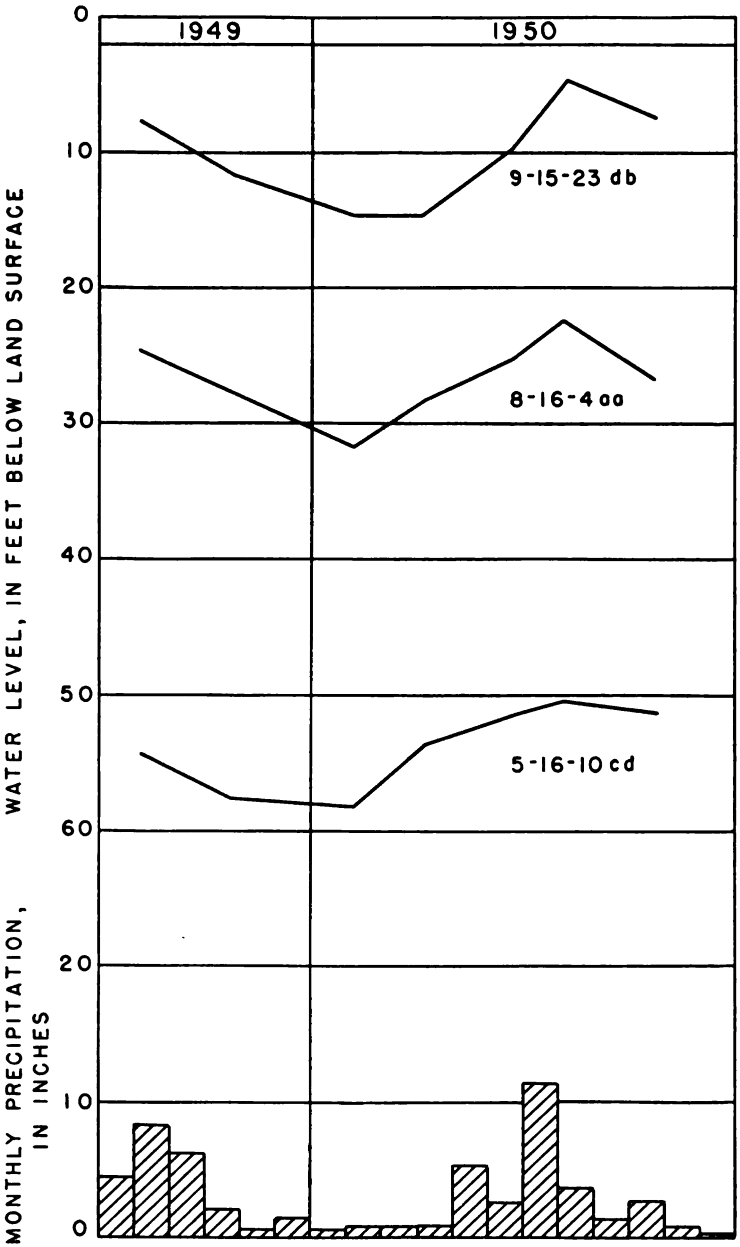

Fig. 7.—Hydrographs showing the fluctuation of water level in three wells in Jackson County.

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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.

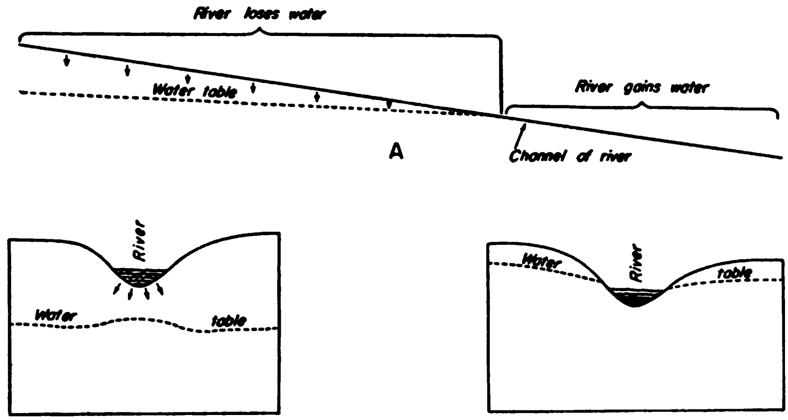

Fig. 8.—Diagrammatic sections showing influent (b) and effluent streams (c).

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.

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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

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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

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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.

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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.

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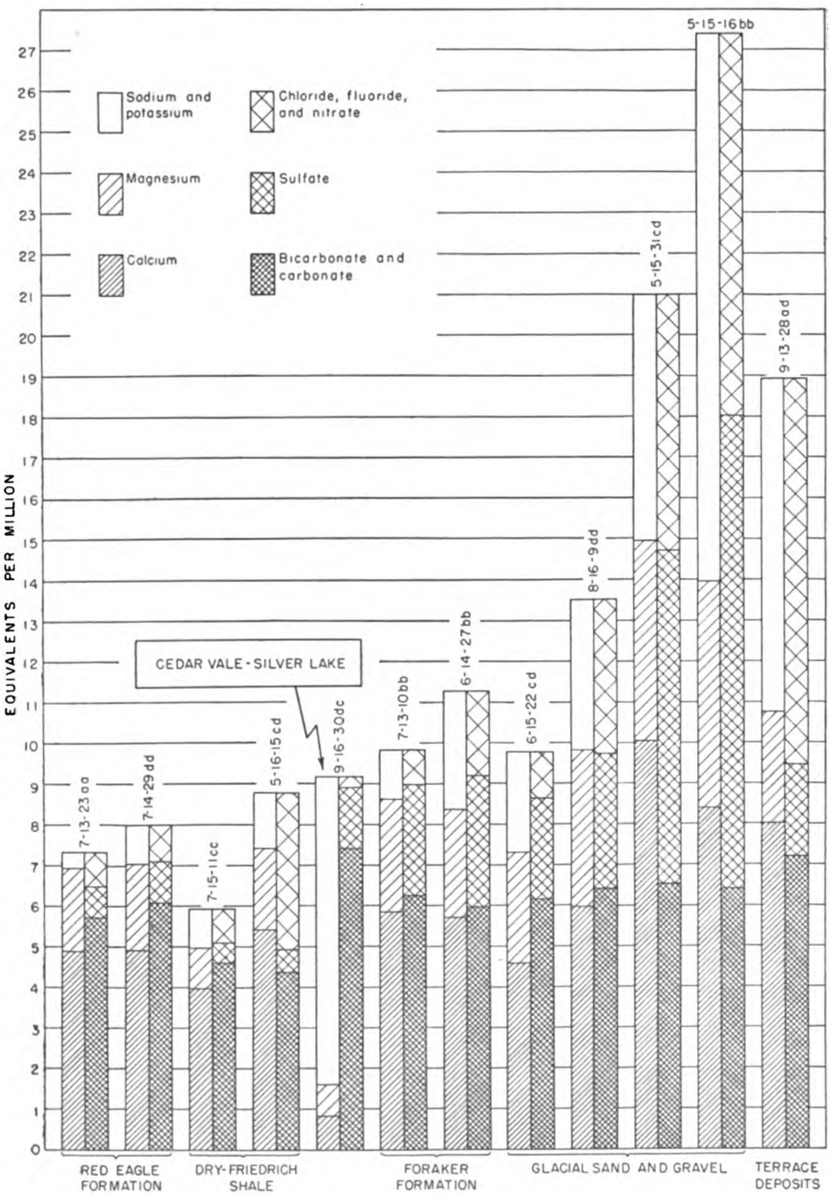

Fig. 9.—Analyses of water from some of the principal water-bearing formations in Jackson County.

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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.

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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 plumb-

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ing, 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

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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

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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.

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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.

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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.

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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.

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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.

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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.

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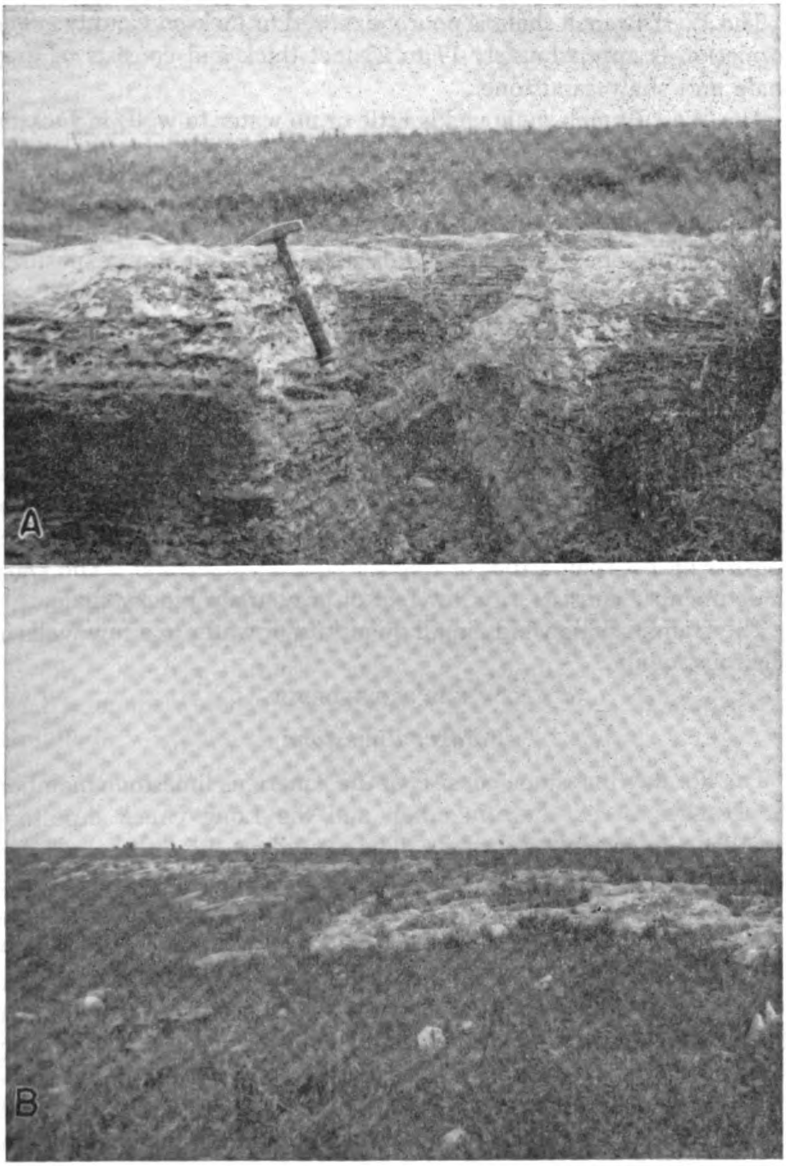

PLATE 6. Outcrops of the Falls City limestone. **A**, Outcrop in sec. 13, T. 9 S., R. 13 E. showing enlarged vertical joints. **B**, Typical outcrop of Falls City limestone; sec. 10, T. 9 S., R. 14 E.

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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.

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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

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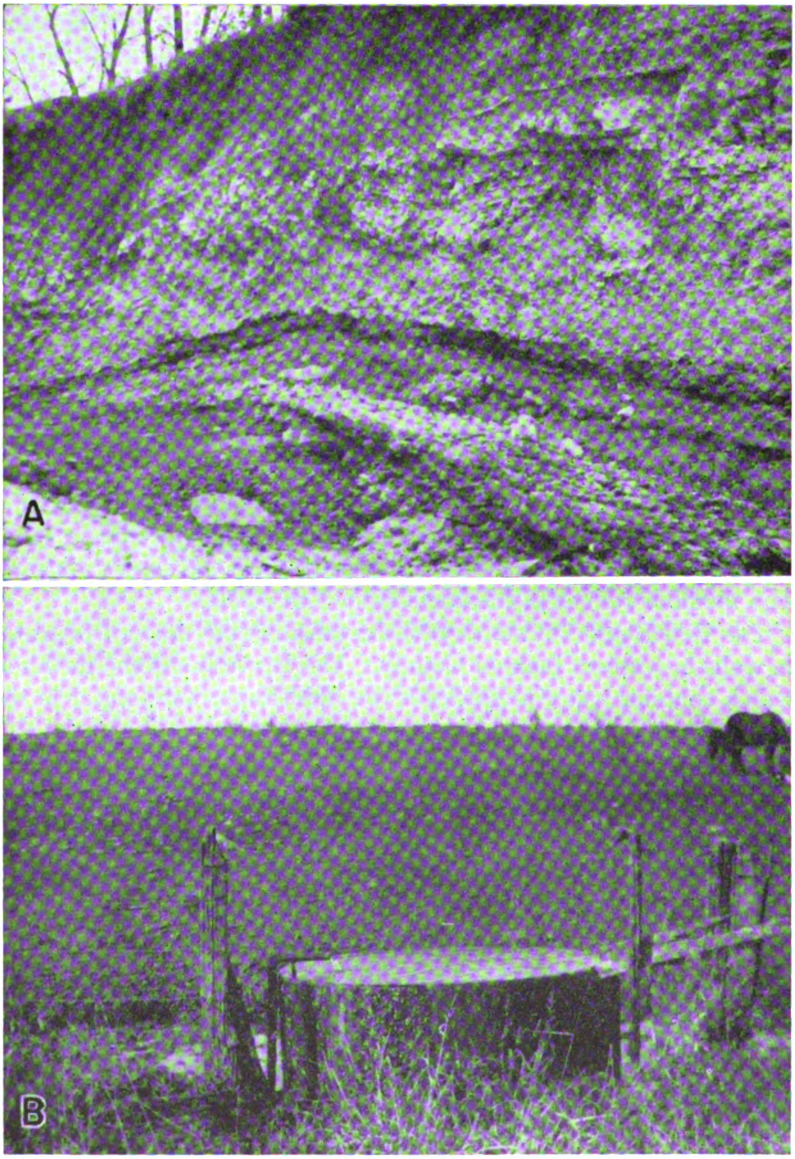

PLATE 7. **A**, Exposure of Roca shale, NE¼ NW¼ sec. 16, T. 7 S., R. 13 E. **B**, Flow of water from spring issuing from the Neva limestone member of the Grenola limestone; SW¼ SE¼ sec. 28, T. 7 S., R. 14 E.

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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.

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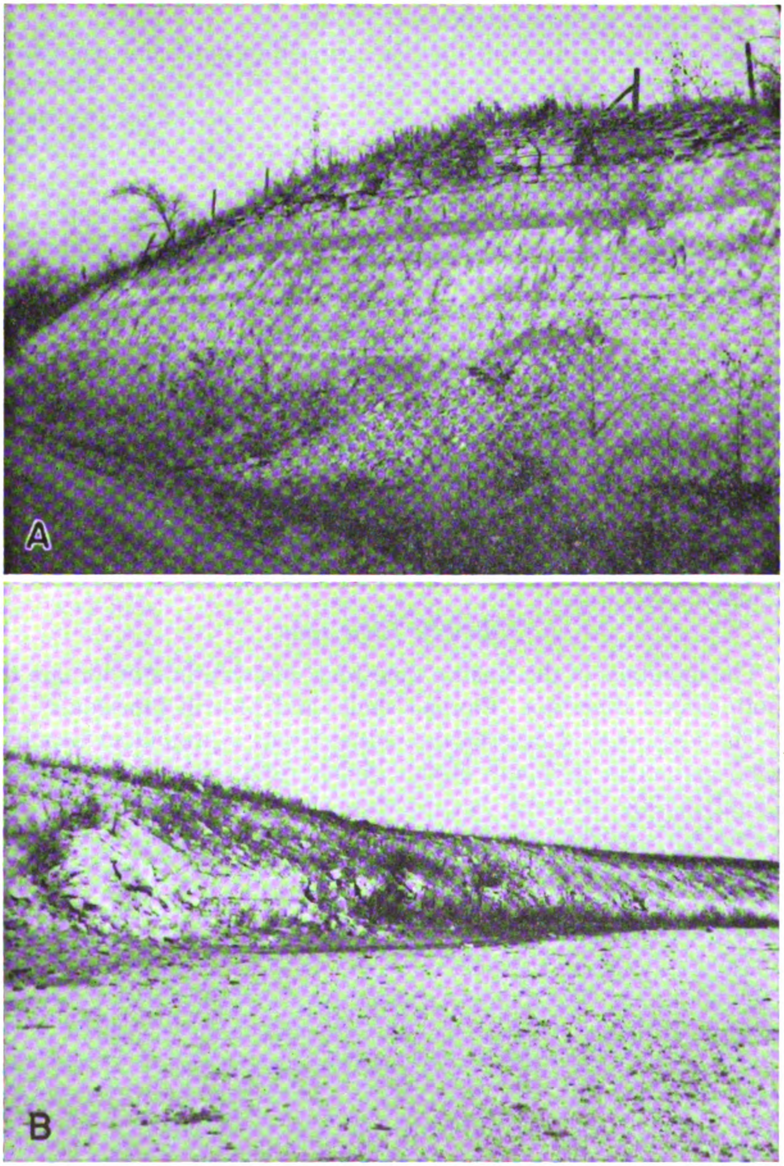

PLATE 8. **A**, Eskridge shale and Cottonwood limestone members of the Beattie formation; in road cut, SE¼ SE¼ sec. 34, T. 6 S., R. 13 E. **B**, Upper part of Cottonwood limestone member; in quarry, SE¼ SW¼ sec. 27, T. 7 S., R. 13 E.

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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.

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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

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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.

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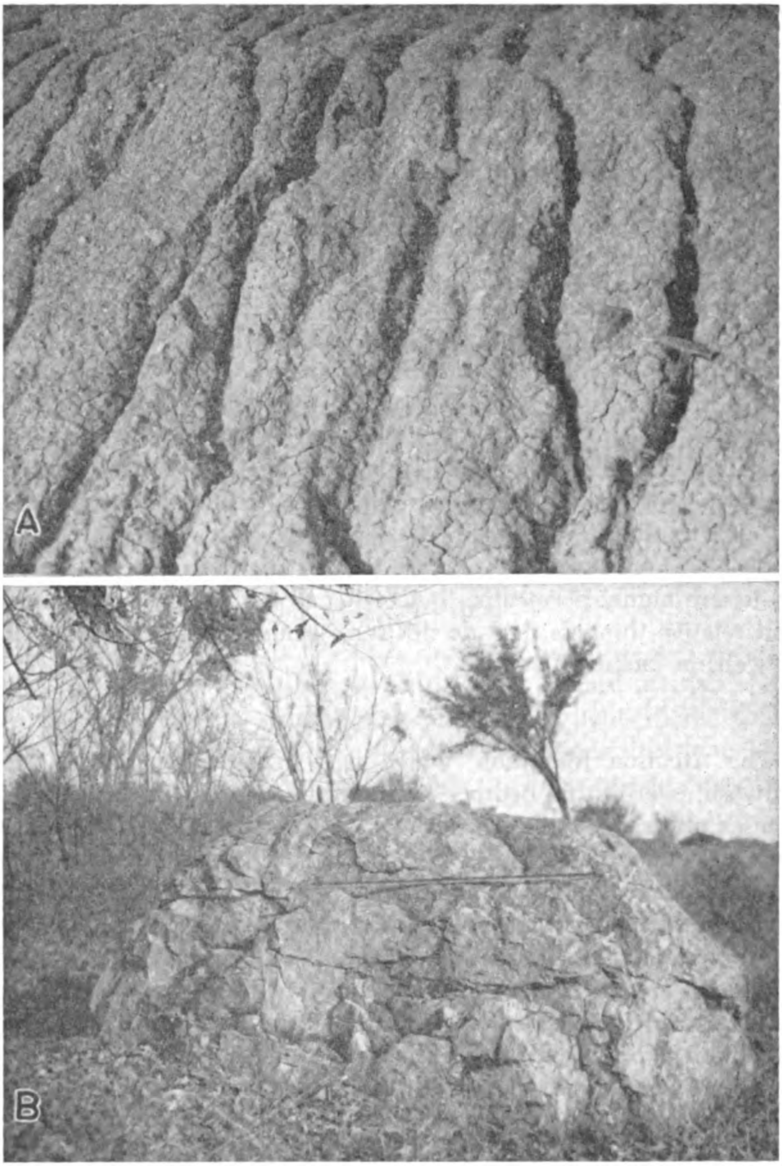

Plate 9. **A**, Glacial till in road cut, SE¼ NE¼ sec. 9, T. 6 S., R. 14 E. **B**, Glacial erratic in the SW¼ NW¼ sec. 6, T. 6 S., R. 13 E.

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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.

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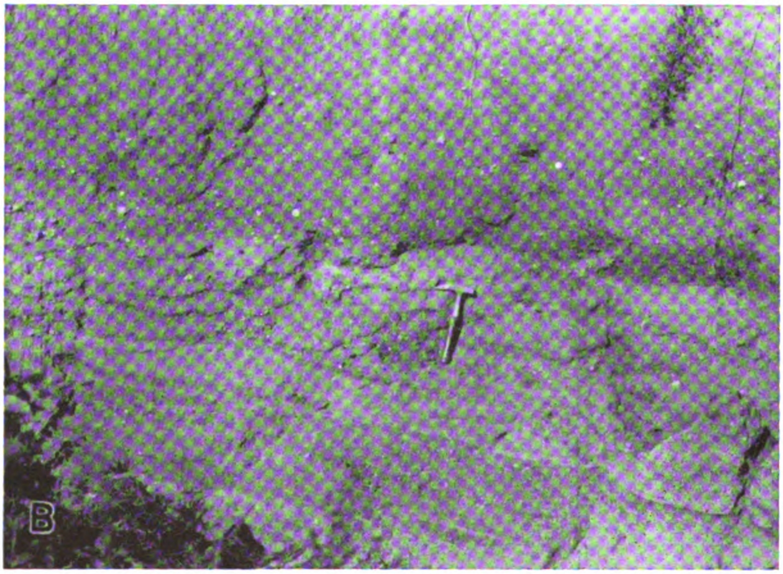

Plate 10. **A**, Deposit of glacial sand and gravel, SE¼ sec. 29, T. 6 S., R. 14 E. **B**, Sand and gravel interstratified with Kansas till; SW¼ NW¼ sec. 27, T. 6 S., R. 14 E. (Photo by A. R. Leonard, June 1949.)

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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.

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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.

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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.

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-16-20aa	NE¼NE¼ sec. 20	Fred Olsen	B	48	12	Ct	Sand and gravel	do	Cy, W	D,S	Land surface	0	30	....	
-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	
-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.
-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.
-16-25ac	SW¼NE¼ sec. 25	Frank Banaka	Du	32	40	R	Limestone	Maple Hill?	Cy, H	D,S	Land surface	0	14	....	
-16-25cb	NW¼SW¼ sec. 25	Fred May	Du,B	40	42-14	R,Ct	Gravel	Glacial deposits	Cy, W	S	do	0	8	....	
-16-25cc	SW¼SW¼ sec. 25	E. Hollenbeck	Du	40	36	R	Sand and gravel	do	Cy, H	D	do	0	34	....	
-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.
-16-28dc	SW¼SE¼ sec. 28	Mrs. J. E. Higby	Dr	90	6	GI	Sandstone	Dry-Friedrich	Cy, W	D,S	Land surface	0	35	....	
-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	
-16-33da	NE¼SE¼ sec. 33	Robt. Love	Du	48	36	R	do	do	Cy, W	S	Land surface	0	22	....	
-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	
-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.														
-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.
-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	
-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.
-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	
-12-25dc	SW¼SE¼ sec. 25	M. McKinsey	Dr	117	6	GI	do	Beattie	Cy, W	D,S	do	0	65	....	
-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.														
-13-1aa	NE¼NE¼ sec. 1	R. Swindale	Dr	115	6	GI	Limestone	Grenola	Cy, W	D,S	do	0	77	....	
-13-7cd	SE¼SW¼ sec. 7	E. Smith	Dr	120	6	GI	do	Beattie	Cy, H	D,S	do	0	75	....	
-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.
-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	
-13-12cd	SE¼SW¼ sec. 12	Herman Myer	Dr	60	6	GI	do	do	Cy, W	S	Land surface	0	40	....	
-13-14bb	NW¼NW¼ sec. 14	Asa Freel	Dr	145	6	GI	do	Red Eagle	Cy, G	S	do	0	40	....	
-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.
-13-18dd	SE¼SE¼ sec. 18	Mrs. N. A. Casebeer	Dr	84	6	GI	do	do	Cy, H	D,S	do	0	30	....	
-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.
-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	
-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.
-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.
-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.
-13-30ad	SE¼NE¼ sec. 30	Evan Lewelling	Dr	65	6	GI	do	Grenola	Cy, W	D,S	Land surface	0	20	....	

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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.) (4)	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. 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.

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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 Kranz	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	....	

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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	

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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: 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.

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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	

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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: 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. 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.

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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 deposits...	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.

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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		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. 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	
9-16-17ac	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.

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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

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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

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	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

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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

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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

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	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

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	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

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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

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	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

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	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

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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

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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

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	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

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	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

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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

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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

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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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STATE GEOLOGICAL SURVEY OF KANSAS

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BULLETIN 102

1953 REPORTS OF STUDIES

Printed by authority of the State of Kansas
Distributed from Lawrence

UNIVERSITY OF KANSAS PUBLICATION
1953

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1953 REPORTS OF STUDIES

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STATE GEOLOGICAL SURVEY OF KANSAS, BULLETIN 102
1953 REPORTS OF STUDIES, PART 1, PAGES 1-76, FIGURES 1-5, PLATES 1-12
MAY 15, 1953

PETROGRAPHIC STUDY OF SOUTHEASTERN KANSAS COALS

By
WILLIAM W. HAMBLETON

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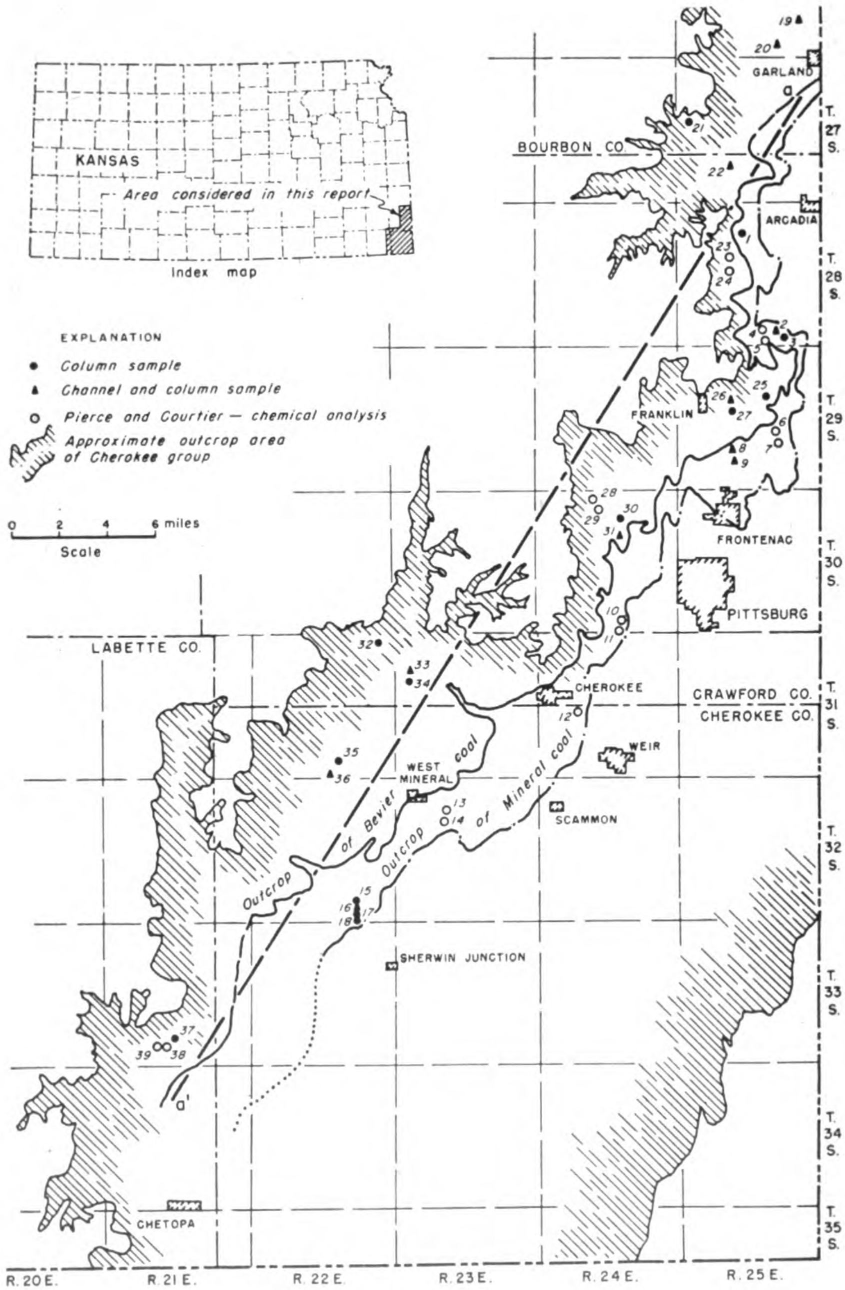

FIG. 1.—Southeastern Kansas coal field, general geology and sample locations. (Details concerning locations, numbered 1 through 39, are given in Table 5.)

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ABSTRACT

As a coal state, Kansas ranks 16th in the nation, producing about $8,000,000 worth of coal annually. Most of the coal is produced from rocks of Pennsylvanian age in southeastern Kansas. Because most of these coals are thin and considerable overburden must be removed in mining them, effective utilization is important. Coal petrography, a branch of geology dealing with the constitution of coal as determined with the microscope, has contributed greatly to a better understanding of the nature of coal and has supplied much information concerning coal utilization. This report represents data on the petrographic constitution of the Mineral, Croweburg, and Bevier coals of southeastern Kansas and correlates these data with coal utilization.

A summary of coal classifications and petrographic techniques is followed by a description of the lithology and chemical composition of the coals. The coals were analyzed by a petrographic evaluation of several coal components (anthraxylon, attritus, and fusain) from 400 thin sections and 22 column samples. The results are summarized in bar diagrams which show that the coals are relatively uniform in petrographic composition and are characterized by a high content of finely banded translucent attrital material. The occurrence and distribution of mineral matter is described.

The petrographic composition is related to several chemical and physical properties which affect coal utilization. Particular consideration is given to the friability of the coals and to their amenability to hydrogenation. The effect of the mineral matter on the preparation of a low ash coal concentrate is also discussed.

INTRODUCTION

Coal petrography is a branch of geology dealing with the constitution of coal as determined with the microscope. Investigations in this field of geology have contributed greatly to a better understanding of the nature of coal and have supplied much information concerning its origin and proper utilization. Since coal utilization has become increasingly important in modern technological processes, much attention has been devoted to studies of the relationship between the various chemical and physical properties of coal and the selection of the best coals for particular purposes. Coals do not, however, exhibit uniform chemical and physical properties even within a single bed. Petrographic studies have been invaluable in revealing the reasons for this lack of uniformity and have established correlation of chemical and physical properties with the constituents of coal as seen under the microscope.

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As a coal state, Kansas ranks 16th in the nation, producing about $8,000,000 worth of coal annually. Most of the coals are thin and considerable overburden must be removed in mining them. It is therefore especially important that Kansas coals be utilized to best advantage. This report correlates detailed coal petrography with some physical and chemical properties of several selected commercial coals from southeastern Kansas.

The Southeastern Kansas coal field (chiefly in Crawford and Cherokee Counties, but partly in Bourbon and Labette Counties) is the oldest and most important coal-mining area in Kansas. All the rocks exposed in this area belong to the Pennsylvanian System except for some Mississippian limestone in the southeast corner of Cherokee County. The coals occur in the Cherokee group of the middle Pennsylvanian Desmoinesian Series. The Cherokee group is defined (Moore, 1936, p. 55) to include strata between the upper unconformable surface of the Mississippian rocks and the base of the Fort Scott limestone. The average thickness of Cherokee rocks in southeastern Kansas is about 400 feet. The outcrop area is about 20 miles wide, extending northeast into Missouri and southwest into Oklahoma. Cherokee rocks are mainly clastic and consist of gray and black shales with lesser amounts of sandstone and a few thin beds of limestone.

Of the 15 coal beds which have been identified (Abernathy, 1937) in the section (Fig. 2), the most economically important coals are the Weir-Pittsburg, Mineral, and Bevier. According to Abernathy, Jewett, and Schoewe (1947, p. 6), the Weir-Pittsburg is the thickest coal in the State and has had the largest total production. It lies 175 to 250 feet above the base of the Cherokee and dips northeastward about 20 feet to the mile. The Mineral coal (sometimes called the "Upper" Weir-Pittsburg) lies from 65 to 80 feet above the Weir-Pittsburg and is now the most actively mined coal in Kansas. The Bevier lies about 100 feet below the top of the Cherokee group and holds second position in current production.

Scope of investigation.—The Mineral and Bevier coals were selected for study because they are most actively mined at present and would therefore yield a better distribution of samples for petrographic analysis. Moreover, the results of the study would be of greater value to coal producers. One sample of Croweburg coal was included in the study because the sample was easily obtained in a strip mine where the Mineral coal also was sampled. Twenty-

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four column samples of coal were cut from fresh exposures in Crawford, Cherokee, Labette, and Bourbon Counties. The distribution of samples, determined largely by strip-mine activity, extends in a northwest-southeast belt from Garland to Sherwin Junc-

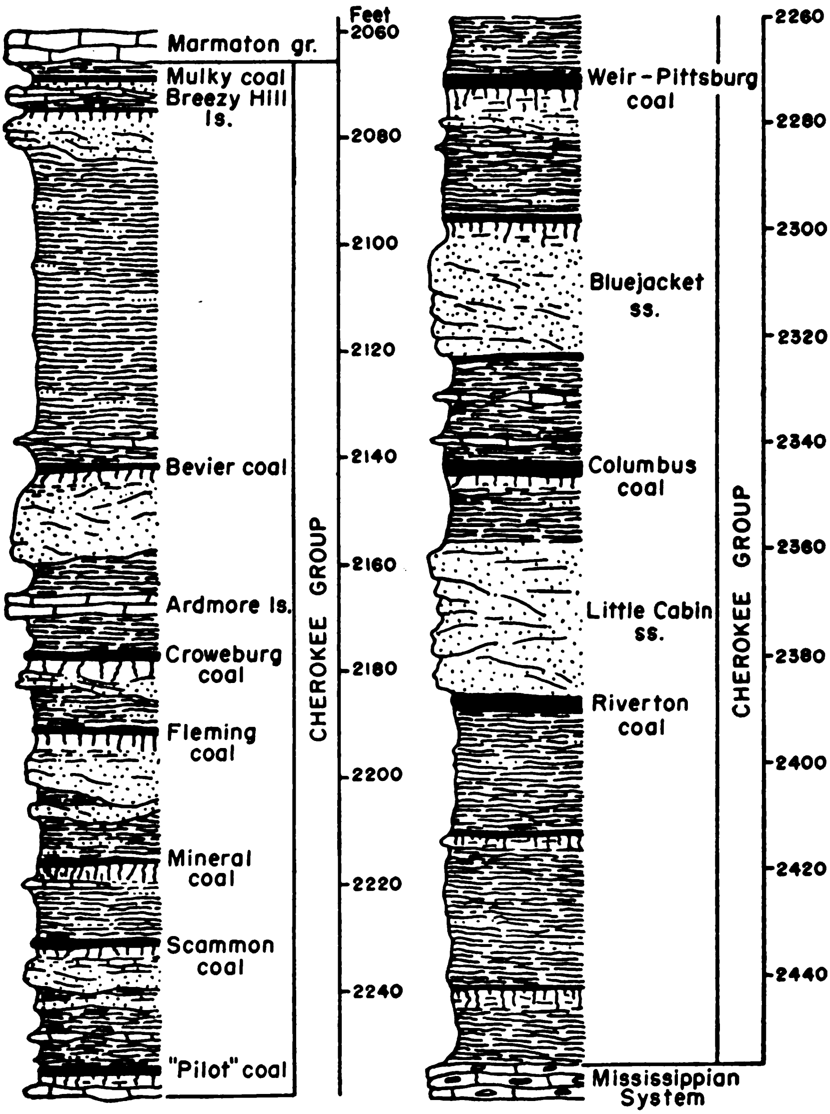

FIG. 2.—Generalized columnar section showing coals of the Cherokee group. (After Moore and others, 1951.)

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tion. At 11 localities, composite channel samples for chemical analysis were taken immediately adjacent to the column samples. The outcrop of the coals and the location of samples are shown on Figure 1.

Previous work.—The first comprehensive report on Kansas coal, written by Haworth and Crane (1898), deals largely with the Southeastern Kansas coal field in its early stage of development. Young and Allen (1925) furnished information on engineering and production methods and included data from proximate and ultimate analyses and carbonization and distillation tests. Moore and Landes (1927) discussed the coal of southeastern Kansas in their report on the underground resources of Kansas. Pierce and Courtier (1938) published an excellent report on the geology and resources of the field and included a structural map on the Weir-Pittsburg coal and numerous chemical analyses. In the same year, Abernathy (1938) published on cyclothems in the Cherokee group. Subsequent publications have included a paper by Jewett and Schoewe (1942), a map of mined areas in the Weir-Pittsburg bed (Abernathy, 1944), a discussion of the strip-mined areas by Abernathy (1946), and a summary of the coal reserves in Kansas by Abernathy, Jewett, and Schoewe (1947). The State Geological Survey now has in preparation reports on the coal reserves of the Cherokee group and on the stratigraphy of these rocks.

Since 1942 the State Geological Survey has been engaged in a detailed inventory of all coal reserves in Kansas. Published reports on coals other than those in the Cherokee rocks include reports on coals of the Douglas group (Bowsher and Jewett, 1943), the Wabaunsee group (Schoewe, 1946), the Thayer bed (Schoewe, 1944), and the Permian rocks (Schoewe, 1951), and the lignite coal resources of the Cretaceous rocks of Kansas (Schoewe, 1952).

Acknowledgments.—Appreciation is expressed to Robert M. Dreyer for his considerable help and critical reading of the manuscript and to Gilbert H. Cady (Illinois Geological Survey) and Bryan C. Parks (U. S. Bureau of Mines) for helpful suggestions and advice. I further wish to acknowledge the financial assistance of the Pittsburg and Midway Coal Mining Company, the Hume-Sinclair Coal Mining Company, and the Shell Oil Company. Chemical analyses were made under the supervision of Russell T. Runnels of the Kansas Geological Survey and Prescott Underwood and James Lammons assisted in the preparation of thin sections.

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COAL CLASSIFICATION

Heterogeneity in Coal

The sum character of any coal may be considered the result of the collective operation of physical, chemical, and biological processes (Schopf, 1948a) and must include both contemporaneous and post-depositional changes. Differences in the history of formation of coal are reflected in its present lithology and properties. The coal inherits certain initial attributes due to plant morphology and environment. It acquires additional attributes resulting from diagenetic and metamorphic processes. Factors operating in the growth and depositional environment include depth of water, temperature, boundary conditions, chemical character of the depositional medium, and rate of burial. These factors largely determine the growth and distribution of the biological population, its death, degree, and manner of decomposition, and its accumulation and preservation. This combination of physical, chemical, and biological processes determines the initial attributes of the accumulating vegetable material.

Subsequent to deposition and prior to consolidation, certain diagenetic processes, which are largely biochemical, alter the vegetable accumulation to peat and superimpose additional attributes on the coalified material.

In the final stage of coalification, metamorphic processes become more and more intensive and may indeed proceed so far as to obliterate the early character of the coal.

The inherited and acquired attributes therefore produce a physical and chemical heterogeneity in coal which is called its constitution. Two general categories of variation in coal constitution are now recognized as the result of efforts to classify coals on the basis of their physical and chemical properties.

Rank Variation

In the first category are rank variations which are established on the basis of carefully selected chemical criteria. The rank of coal is its stage of coalification in the series peat, lignite, bituminous coal, and anthracite coal. It depends largely on the extent to which metamorphic processes have affected the inherited attributes of a coal. An increase in rank is marked by the relative decrease of such

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constituents as moisture, oxygen, and volatile matter and the relative increase in carbon. Transitions in physical properties are also evident. The rank classification adopted by the American Society for Testing Materials (1938), as illustrated in Table 1, is in current usage. It is based on proximate analysis and calorific determinations calculated to the mineral-matter-free basis according to the

TABLE 1.—*Modified A.S.T.M. classification by rank* (A.S.T.M., 1938, p. 2)

Class	Group	Limits of fixed carbon or B.t.u. on mineral-matter-free basis	Requisite physical properties
I Anthracite	1. Metanthracite	Dry F.C. 98 percent or more	
	2. Anthracite	Dry F.C. 92 percent or more and less than 98 percent	Nonagglomerating
	3. Semianthracite	Dry F.C. 86 percent or more and less than 92 percent	
II Bituminous	1. Low-volatile bituminous	Dry F.C. 78 percent or more and less than 86 percent	
	2. Medium-volatile bituminous	Dry F.C. 69 percent or more and less than 78 percent	
	3. High-volatile A bituminous	Dry F.C. less than 69 percent* and moist B.t.u.** 14,000 or more	
	4. High-volatile B bituminous	Moist B.t.u. 13,000 or more but less than 14,000	
	5. High-volatile C bituminous	Moist B.t.u. 11,000 or more but less than 13,000	Either agglomerating or nonweathering
III Subbituminous	1. Subbituminous A coal	Moist B.t.u. 11,000 or more but less than 13,000	Both weathering and nonagglomerating
	2. Subbituminous B coal	Moist B.t.u. 9,500 or more but less than 11,000	
	3. Subbituminous C coal	Moist B.t.u. 8,300 or more but less than 9,500	
IV Lignitic	1. Lignite	Moist B.t.u. less than 8,300	Consolidated
	2. Brown coal	Moist B.t.u. less than 8,300	Unconsolidated

* Coals having 69 percent or more fixed carbon (F.C.) on the dry, mineral-matter-free basis are classified according to fixed carbon regardless of B.t.u.
** Moist B.t.u. refers to coal having its natural bed moisture but not including visible water on the surface of the coal.

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Parr (1928) formulas. Physical criteria for differentiation also exist but are more difficult in application. McCabe (1937), for example, has shown that the angle of polarization and the index of refraction vary systematically with increase in rank.

Type Variation

Of a more fundamental nature are those variations caused by differences in the physical constitution of coal. These are called type variations and are most commonly determined by petrographic methods. Type variations are due to the properties acquired through the interplay of plant morphology, environment, and diagenetic processes. The importance of type variation declines with increasing rank since effects of progressive metamorphism tend to obliterate the original characteristics. Anthracites of a similar rank therefore display great similarity in appearance.

However, most low-rank coals are banded in appearance. Such coals consist of fine laminae and thicker bands of bright material alternating with duller material. The characterization of these banded ingredients has been the basis for classification according to type.

Dawson (1859) observed the banded materials megascopically and concluded that they were separate entities. Somewhat later, Muck (1881) recognized that there were at least three distinctly different components which he called "glanzkohle," "mattkohle," and "faserkohle" (bright coal, dull coal, and mineral charcoal).

The application of the microscope to the investigation of coal is first recorded in the work of Witham (1833) and Hutton (1833), who demonstrated the vegetable origin of bituminous coals beyond question and supplied many data on the kinds of plants and plant structures preserved in coal. These early observations provided the background for modern research on the physical constitution of coal up to the time of the microscopic studies of White and Thiessen (1914).

Two different classes of petrographic entities have been recognized in coal. Those based on recognition of plant parts and pieces as well as some kinds of decomposition products, have been called "phyterals" by Cady (1942, p. 347). The identity of a phyteral does not change throughout the metamorphic stages of coal formation al-

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though its chemical and physical composition vary in a pronounced manner. Phyteral content is therefore fixed at the beginning of coalification. However, recognition of a phyteral usually becomes more difficult with advanced metamorphism.

Entities based on the recognition of physical and chemical similarities were called "macerals" by Stopes (1935). They are identified on the basis of similarity in composition, as are minerals. A given phyteral may be represented by several kinds of macerals and a given maceral may be constituted from different types of phyterals.

Although the phyteral and maceral concepts were not expressed in the classifications of Stopes (1919) and Thiessen (1920), the implications were nevertheless present.

MACERAL CLASSIFICATION

In her original classification, Stopes (1919) recognized four ingredients which she named vitrain, clarain, durain, and fusain. Definition and identification were based upon the properties of the hand specimen, supplemented by microscopic observations. The terminology was widely used in Europe although controversy was aroused by Stopes' observations concerning the nature and origin of vitrain. In 1935, Stopes expanded her original classification to reclassify vitrain, clarain, fusain, and durain as coal types and proposed an additional series of names to characterize the macerals or organic units of the coal types. This classification was adopted by the Second International Conference on Carboniferous Stratigraphy at Heerlen in 1935. All coals were regarded as aggregates of one or more of the primary types.

Vitrain.—Vitrain occurs in thin horizontal bands up to 20 mm thick and has a brilliant glossy luster. It is microscopically structureless, homogeneous, and breaks with a conchoidal fracture. Vitrain was originally described as translucent in thin sections and microscopically structureless. In response to the controversy regarding microscopic structure, the term was expanded to include eu-vitrain (or structureless vitrain) and pro-vitrain (which shows structure). The maceral of vitrain is vitrinite. It is subdivided into collinite (vitrinite devoid of structure) and tellinite (vitrinite showing structure on polishing, etching, or in thin sectioning). Stopes also proposed that each recognizable plant tissue, organ, or

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secretion be given a distinct name within the general category vitrinite. Thus corky tissue in vitrain is called suberinite; material thought to be resin, resinite; exine material, exinite; cuticular material, cutinite.

Clarain.—Clarain is a bright striated coal with a silky luster, not as brilliant or homogeneous as vitrain, lacking in conchoidal fracture, and consisting of thin bands stratified parallel to the bedding plane. It is predominantly translucent in thin section and may be composed of a variety of macerals of small size and concentrated to a varying degree. Vitrinite plus micronite (an opaque maceral) and fusinite (the maceral of fusain) are the usual constituents.

Durain.—Durain is a hard, compact, dull coal which is megascopically structureless and gray to dull black in color. It is largely opáque in thin section since the predominant maceral is micronite. However, other macerals may be present in minor amount.

Fusain.—Fusain consists of irregular wedges lying on bedding planes at various angles. It is fibrous and dull in appearance and consists of a porous, friable material resembling charcoal which breaks down to a fine dust. It is cellular and opaque in thin section and composed of the maceral fusinite.

Boghead and cannel coal.—In addition to the banded coals, the nonbanded varieties, cannel and boghead, were recognized. Nonbanded coals contain essentially no vitrain but are composed of clarain and durain microdebris with large quantities of spore exines, pollen, and oil algae. If the algal content is low, the coal is a cannel; if high, it is a boghead. Megascopically, they are clean, compact blocks of massive structure and fine-grained texture. Usually they are dark gray to black, have a greasy luster, and a marked conchoidal fracture.

PHYTERAL CLASSIFICATION

Thiessen (1920) considered coal to be composed of two visibly different major components present in various types of coal in varying proportions. He named these components anthraxylon and attritus. He accepted the well-established term fusain for designating the third (and minor) component. Thiessen's classification is held to be genetic in origin since the microscopically differentiated components (petrographic components) can be related to plant morphologic units now called phyterals.

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Anthraxylon.—Anthraxylon was described as relatively simple in structure and essentially homogeneous in appearance. It was recognized to be the fairly well-preserved cellular tissues of stems, branches, twigs, roots, sporangia, and leaves which survived plant decay in the early stages of coal formation. Anthraxylon bands are identified megascopically by their bright luster, black color, brittleness, and smooth fracture. In thin section anthraxylon appears in bright-orange, red, or brownish bands and often exhibits well-preserved cellular structure.

Attritus.—Attritus was defined as a mixture of macerated plant debris, finely divided during the process of plant decay and subsequently coalified. Its composition is not simple and thin sections show that it is composed of many ingredients. Most attritus is translucent and exhibits the orange, red, and brown colors of anthraxylon although some of it is nearly or completely opaque at standard thicknesses of 10 microns. The opaque ingredients are called opaque attritus whereas the translucent material is translucent attritus. Translucent attritus includes humic degradation matter, a term applied to the cellulosic or lignocellulosic fragments of wood, phloem, cortex, and leaves; resin bodies, the dark-yellow to light-brown globules of resin which were once the cell contents of xylem and leaves; spore and pollen exines, the brilliant-orange to yellow cases of spores and pollen which have become flattened during coalification and appear as flattened rings in section; and cuticle, the bright yellow-golden bands with serrated edges which were the former coverings of leaves and stems. Megascopically, attrital coal is characterized by its dull color and striated appearance when interbanded with fine shreds of anthraxylon. It breaks irregularly into large fragments.

Fusain.—The fusain of Thiessen's classification has the same meaning as it did in that of Stopes. It is a minor component of most coals and is characterized by its friability and softness. It resembles charred wood and is sometimes referred to as mineral charcoal. In thin section it is distinguished by its opaqueness and cellular structure.

Thiessen's system of classifying coal into types after thin section analysis is based on the aggregate character of the coal in terms of limiting quantities of the petrographic components or ingredients. It should be recognized that the term "coal type" as used by the Bureau of Mines differs from the "rock or coal type" of Stopes

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in which all coals are regarded as aggregates of one or more primary coal types. The Bureau of Mines (Table 2) now recognizes five types of coal and has established the critical limits for each type as recently stated by Parks and O'Donnell (1948, p. 537).

Despite claims to the contrary, it seems that only a few of the common petrographic terms used in either classification have either a precise botanical or compositional implication. Some of the maceral terms clearly denote parts of plants while others infer a chemical relation which can scarcely be determined petrographically. The terms opaque attritus and fusain as used by Thiessen are not botanical in origin. In addition, much uncertainty has existed concerning the significance of one set of names in terms of the other. Table 3 is an effort to show the correlation between the two different terminologies as suggested by Raistrick and Marshall (1939, p. 271). Several authors, in recent years, have attempted to resolve and clarify these differences and to develop the history of the nomenclature. Among these are Roos (1937), Cady (1945, pp. 86-102), and Raistrick and Marshall (1939, p. 178-205). Such efforts may be futile since there is still basic disagreement as to the meaning of the term "coal type."

In general, it may be said that both classifications depend to a certain extent on maceral and phyteral criteria. However, if the theoretical limitations of each are understood, there is no essential reason why either one cannot be used for certain types of petrographic analysis.

In the discussion and analyses of Kansas coals which follow, the phyteral classification of Thiessen and the Bureau of Mines will be used exclusively. The scheme is simple and, in addition, numerous petrographic analyses on a wide variety of coals have been made by the Bureau of Mines. These petrographic analyses provide a ready basis for comparison with this study.

PREPARATION TECHNIQUES FOR MICROSCOPIC STUDY

Several preparation techniques have been used widely for the microscopic examination of coal. Thin sections are generally preferred by investigators in the United States since their use makes possible the more certain identification of the various macerals and phyterals. However, specimens are sometimes prepared by polishing and by maceration. Polished section techniques have been

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TABLE 2.—*Type classification of coals*
(U.S. Bureau of Mines) (Parks and O'Donnell, 1948, p. 537)

Type	Critical amounts of components
Cannel coal	Less than 5 percent anthraxylon and predominantly transluscent attritus with little or no oil algae.
Boghead coal	Less than 5 percent anthraxylon and the transluscent attritus predominantly oil algae.
Bright coal	More than 5 percent anthraxylon and less than 20 percent opaque attritus.
Semisplint coal	More than 5 percent anthraxylon and 20 to 30 percent opaque attritus.
Splint coal	More than 5 percent anthraxylon and more than 30 percent opaque attritus.

TABLE 3.—*Nomenclature of coal petrology** (Raistrick and Marshall, 1939, p. 271)

	British nomenclature		German nomenclature			American nomenclature
Macroscopic character of the coal	Rock types	Macerals (constituents)	Streifen-arten	Gefuege-bestand-teile	Coal types	Constituents
Uniform brilliant black bands	Vitrain	Vitrinite: translucent in thin section; cellular structure may or may not be well preserved: a. Collinite—structureless; b. Tellinite—structure preserved; i. Xylinite-formed from wood tissues;	Vitrit	Vitrinit		Anthraxylon. Term used to include the uniform brilliant bands (or their counterparts) in coals of all ages

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		ii. Periblinite-formed from cortical tissues; iii. Suberinite-formed from cork tissues				
Charcoal-like layers and fragments which readily soil the fingers	Fusain	Fusinite: cell structure well preserved. Cell walls opaque; cell cavities either empty or occupied by mineral matter	Fusit	Fusinit		Fusain
Bright coal: clearly laminated; composed of innumerable brilliant fragments and bands with some duller material	Clarain	Containing (translucent orange or yellow in thin section): Vitrinite; Resinite—resin bodies; Exinite—which includes i. Cutinite—from cuticles, ii. Sporinite—from spores; together with a little: Micrinite-granular opaque matter Fusinite	Clarit	 Micrinit Fusinit	Bright coal	Containing: Anthraxylon; spores; cuticles; resins; etc., together with opaque and semi-translucent attritus; and fusain
Dull coal: dull and nonreflecting in the hand specimen; lamination poor or absent	Durain	Containing: Fusinite; Micrinite; Resinite; Exinite i. Cutinite, ii. Sporinite; and a very little Vitrinite	Durit		Splint coal	Very largely opaque and semi-translucent attritus with spores, cuticles, resins, and a little anthraxylon

* British and German terminology as recommended by the International Committee at Heerlen, 1935. Corresponding American terms are those used by U.S. Bureau of Mines.

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described by Winter (1923), Stach (1928), Duparque (1933), and Roos (1937). The method involves the production of a plane, highly polished surface on the coal which may be modified by relief polishing or etching. The surface is then studied with a reflecting microscope. McCartney (1949) has suggested a refinement of the method for use with the electron microscope. The maceration technique was introduced by Schulze (1855) and has been discussed by von Gumbel (1883), White and Thiessen (1914, pp. 216-218), Schopf (1938), and others. It involves oxidizing the humic portions of coal and leaching them with alkaline solutions so as to leave the less soluble, translucent portions for microscopic examination.

Thin Section Technique

The method of preparing a representative sequence of thin sections from a column sample of coal was developed at the Bureau of Mines by Thiessen, Sprunk, and O'Donnell (1938) for use in the quantitative microscopic determination of petrographic components. The technique used in this study was the same except for minor variations. Other petrographic work has demonstrated that optimum analytical results are obtained when the coal is sampled in such a manner as to preserve the stratification of the coal. The ideal sample is an unbroken column of coal, about 12 inches square in cross-section, cut perpendicularly to the bedding plane and including all the coal from the top to the bottom of the bed. Since petrographic studies are usually made in conjunction with other tests, a channel sample may be taken immediately adjacent to the column sample. In the laboratory, a subcolumn approximately 3 inches wide and 3 inches deep is cut with a 12 x 0.0625 inch resinoid-bonded Crystolen cut-off wheel (standard designation C46-P-8B) operating dry at about 12,000 surface feet per minute. The subcolumn is then mounted in plaster of paris and cut into two parts normal to the bedding. One part of the subcolumn is reserved for polishing and the other for thin sectioning.

Mention should be made of the necessity of eliminating the coal dust resulting from dry cutting. A special saw was designed for the purpose. The cut-off wheel was mounted on a ⅝-inch belt-driven mandrel so as to project through a slotted table top. The lower part of the wheel was enclosed and connected by flexible tubing to the intake end of a motor-driven blower and the blower

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in turn connected to a 30 x 30 x 16 inch galvanized steel tank equipped with a series of baffles and fiberglass filter. A plexiglass shield one-half inch thick provided protection from the exposed part of the wheel.

Preliminary polishing of one mounted subcolumn is done on a 3 x 3 foot piece of plate glass using successively finer carborundum powder sludges. The final polish is achieved by stroking the column with a fine-grained, yellow Belgian hone and then buffing it with a Selvyt cloth and a paste of Lakeside polishing compound No. 27. After a thorough drying, the polished surface is painted with a 5 percent solution of water-soluble polyvinyl alcohol (Dupont Elvanol 51-05) to prevent surface oxidation. The polished columns thus serve as permanent sample specimens and can also be used for macroscopic studies.

Thin sections are prepared from the remaining part of the subcolumn. Beginning at the top and continuing to the bottom, parallel lines spaced about 0.8 inch apart are marked on the coal with a red wax pencil and small numbered blocks are cut with an 8 x 0.0312 inch cut-off wheel (standard designation C80-P-5B) using the lines as a guide. Each block is trimmed to a length of about 1 inch.

One face of each block is then ground on rotating laps with successively finer abrasives, polished on a yellow Belgian hone, and buffed on a mounted Selvyt cloth with Lakeside polishing compound No. 27. After thorough drying in an oven and proper orientation, the block is cemented to a frosted standard glass slide with Lakeside No. 70 cement. Frosting of the slides has proved to be especially beneficial in securing good sections as suggested by Gibbs and Evans (1950, p. 2). The excess coal is next sawed off with the 8-inch cut-off wheel leaving about one-fourth inch of coal on the slide.

The mounted blocks are then ground to a thickness of about 10 microns. This is done by using successively finer carborundum sludges on rotating laps until the section just begins to transmit light. This is a somewhat critical point and can be determined only by experience. Too close grinding on the lap will ruin the section.

After trimming the superfluous cement from around the edges of the section with a razor blade, the section is transferred to the yellow Belgian hone. The hone is mounted in a wooden block sloping away from the worker and a stream of water is played on it.

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The section is honed with forward strokes and slight pressure until it transmits light uniformly and shows an orange to red color. The section is then transferred to a light box and gently rubbed with a cork dipped in Lakeside polishing compound No. 27 to produce an even section. The section is finally labeled and painted with polyvinyl alcohol.

In previous work, each section had been ground to completion by a single operator. It was found that this procedure does not lend itself well to the production of a large number of sections. Consequently, the sections were ground in column lots with one operator doing the coarse grinding on the laps and a second the work on the hone and light box. However, in the interval between the two stages of preparation, the section frequently dried out, oxidized, and contracted so that a useless section resulted. On the suggestion of B. C. Parks of the Bureau of Mines (personal communication) the slides were immersed in glycerine except when being improved.

MICROSCOPIC ANALYSIS BY THE RIBBON TRANSECT METHOD

In 1930, Thiessen set up a method of microscopic analysis and a type classification of coal that has been generally followed as standard practice by the coal petrography laboratory of the Bureau of Mines. It has subsequently undergone such changes that Parks and O'Donnell (1948) have described the modified procedure. In the discussion which follows, this procedure is described, modified, and evaluated.

The sequence of thin sections, prepared in the manner described earlier, is essentially a disconnected, transparent, ribbon-like sample of coal about 10 microns thick and 1 inch wide, representing the entire coal bed. The ribbon sample of sections is not, however, a complete representation because of some loss from sawing and polishing. A recovery of 90 to 95 percent of the height of the original column is considered not unusual by the Bureau of Mines.

The ribbon transect method of statistically evaluating the relative amounts of anthraxylon, opaque attritus, translucent attritus, and fusain in a coal bed is nothing more than refined visual estimate employing the principle of the Rosiwal analysis (Head and others,1932). It is based on the assumption that the sum of the areas of each of the components in a random section of uniform rock is proportional to the volume of that constituent in the rock. In

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practice, actual areas are seldom measured, but rather a linear traverse is made. Coal is inherently heterogeneous so that the assumption of uniformity is not valid. Nevertheless, it is probably valid to assume that each increment of the coal parallel to the bedding plane will exhibit homogeneity over a limited area. Thin sections cut normal to the bedding should therefore represent statistically the coal in the area and Rosiwal analysis may be used if its limitations are appreciated.

Any type of microscope equipped with a mechanical stage is satisfactory for the measurements. Although the Bureau of Mines prefers the binocular type, a petrographic microscope was used in this work since it facilitated identification of mineral components of the coal. A grid micrometer disc on which is centered a 10 mm square field divided into 100 1.0 x 1.0 mm constituent squares is inserted in the ocular. Each square is further subdivided into four subsquares 0.5 x 0.5 mm on a side. The values represent the real dimensions of the squares scribed on the disc. Since only one central vertical tier of squares is used, each transect field is 10 mm long by 1.0 mm wide and consists of 10 major 1.0 x 1.0 mm constituent squares and 20 1.0 x 0.5 mm subsquares. Because it is pertinent to later discussion, mention is made that the Bureau of Mines employs a Whipple disc, which is a 7 mm square field divided into 100 0.7 mm squares with the central one subdivided into 25 0.14 mm squares. Usage is largely a matter of convenience.

Under microscopic magnification, the dimensions change; therefore it is necessary to calibrate the disc with a stage micrometer for different powers of magnification as shown in Table 4.

It has been the practice of the Bureau of Mines to measure opaque attritus and fusain at a magnification of 60X and anthraxylon at 150X. Translucent attritus is determined by difference. Since it seems doubtful that any unique advantage is gained by

TABLE 4.—*Calibrated values of grid micrometer with petrographic microscope B&L LM5919*

Magnification	Central vertical transect field length, mm	1 Constituent square length, mm	1 Subsquare length, mm
0	10.0	1.00	0.500
40	5.35	0.535	0.268
100	1.33	0.133	0.067

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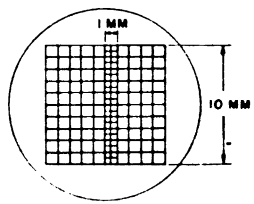
COAL BED ____________
COLUMN SAMPLE NO ________

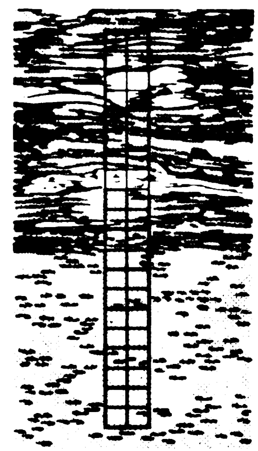
PETROGRAPHIC ANALYSIS OF COAL
RIBBON TRANSECT METHOD

DATE ____________

SECTION	AVERAGE	TRANSECT	ANTHRAXYLON > 1/4 SUBSQUARE			OPAQUE ATTRITUS			FUSAIN > 1/2 SUBSQUARE			TRANSLUCENT ATTRITUS	REMARKS
NO	THICKNESS	FIELDS	CONSTITUENT SQUARES	SUB-SQUARES	%	CONSTITUENT SQUARES	SUB-SQUARES	%	CONSTITUENT SQUARES	SUB-SQUARES	%	% BY DIFFERENCE	



GRID MICROMETER



MICROSCOPIC VIEW OF THIN SECTION SHOWING SUPERIMPOSED CENTRAL TRANSECT FIELD

NOTE: AREA PERCENTAGE IS CALCULATED BY: 10 (TOTAL CONSTITUENT SQUARES) + (SUBSQUARES/2) / (TOTAL TRANSECT FIELDS) FOR EACH CONSTITUENT ENTITY.

FIG. 3.—Sample data sheet and illustration of microscopic measurement of coal components.

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changing magnifications, all components have been determined at 100X in this study.

Measurements are made by turning the mechanical stage of the microscope so as to move the central vertical transect field of the grid micrometer along a line extending from the bottom to the top of the section. Two such traverses are made for a better statistical average; one near the middle of the right half of the section and the other near the middle of the left half. The traverse is not made continuously; the thin section is moved a distance equal to the length of the transect field and when the number of constituent squares and subsquares occupied by each of the coal components has been estimated and tabulated, the section is again moved the length of the transect field. These field moves are continued until the section is crossed. A horizontal shift of the stage brings the section into position for the second traverse. The total number of transect fields is tabulated and checked against the total distance traversed as determined with the mechanical stage vernier by multiplying the number of transect fields by the calibrated length of each transect field. A sample data sheet and an illustration of the use of the grid micrometer are shown in Figure 3.

After all the thin sections representing the column sample have been measured in this manner, the data for the components of each slide are converted to percentages using the relation:

$$\text{Area percentage for each component} = \frac{10\ (\text{No. constituent squares}) + (\text{No. subsquares}/2)}{\text{Total number of transect fields}}$$

The percentage distribution of anthraxylon, translucent attritus, opaque attritus, and fusain in each thin section is tabulated graphically by bar diagram as illustrated in Plate 1. On the basis of this distribution, the coal is classified according to type and a profile of the coal results. Due to loss in cutting and grinding, the tabulated distances and lengths on the bar diagrams are in error by the amount of loss.

Critical Limits

Although the Bureau of Mines has published the results of numerous petrographic studies of coal, actual determinative procedures have always been omitted from the reports. Considerable uncertainty had existed regarding the validity of the method until

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Parks and O'Donnell (1948) fully described procedures and evaluated the influence of such factors as microscopic magnification, thin section coverage, and errors arising from the personal element. However, several important considerations were overlooked in the paper by Parks and O'Donnell. Personal communication with the authors and reference to a discussion of the paper by Schopf (1948) have contributed to the following examination of critical limits.

Subsize thresholds.—Parks and O'Donnell (1948, p. 536) state:

> No particular difficulty is experienced in recognizing attritus in thin sections under the microscope. The heterogeneous mixture of ingredients of different shape, structure, translucence, and color occur in layers that are easy to distinguish from the other banded components.

They further say:

> Anthraxylon can also be easily recognized in a thin section when seen with transmitted light under the microscope. It is present in prominent orange bands, sometimes shaded toward brown to red, and usually shows well-preserved cellular structures of a woody tissue seen in cross-sectional or longitudinal view.

These statements are substantially true when the anthraxylon bands are wide and the attritus extremely fine. However, difficulty is experienced in deciding whether certain fairly fine translucent components of attritus shall be classified with the atrital or the anthraxylous material. In other words, at what point does the translucent component cease being preserved cellular tissues of stems, branches, twigs, etc., and become part of a mixture of finely divided plant debris. Realizing the question was largely one of size, Schopf discovered that according to standard practice of the Bureau of Mines laboratory, anthraxylon is not identified in any particles or strands thinner than 0.014 mm. This subsize threshold was chosen empirically because the subsquares of the calibrated Whipple disc were determined to be about 0.014 mm at a magnification of approximately 150X—the magnification used to measure anthraxylon.

It seems entirely possible that the use of this arbitrary limit may constitute a source of error which has been overlooked. It was earlier stated that all determinations for components other than anthraxylon were made at a magnification of 60X. At this magnification, the subsquares are no longer 0.014 mm but 0.037 mm. Hence, in traversing attrital material, it would be possible to miss strands of anthraxylon 0.014 mm wide.

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Schopf also gives the subsize threshold for the microscopic determination of fusain as 0.037 mm—the size of a subsquare at a magnification of 60X. All smaller opaque material is assigned to opaque attritus.

In view of the large accumulation of data using these limiting values, it seems necessary for comparison purposes that they be tentatively accepted as part of the definition of anthraxylon and fusain in quantitative work. However, since they are only visual estimates, certain liberties may be taken for the sake of convenience. Anthraxylon is here defined as any translucent strand larger than one-fourth of a subsquare at a magnification of 100X. A subsquare at this magnification is 0.067 mm high; therefore one-fourth of a subsquare is 0.017 mm as compared with the Bureau of Mines value of 0.014 mm. Similarly, the subsize threshold for fusain is given as one-half of a subsquare at a magnification of 100X. This is 0.033 mm as compared with the Bureau of Mines value of 0.037 mm.

The problem of establishing limiting subsize thresholds for certain of the petrographic components is not unique to the Bureau of Mines and should be subjected to closer scrutiny since it stems from some very fundamental considerations. Cady (1942, pp. 343-346), in discussing a parallel situation involving the Stopes classification, pointed out that uncertainty had developed concerning the application of the term "vitrain" to vitrainlike material of small dimension which may make up a considerable portion of a clarain band. He also concluded that the distinction was one of size and that limiting values were necessary. In an attempt to resolve the situation, he suggested that all the thin vitrainlike bands composing clarain be called "micro-vitrain" and set the lower limiting value for vitrain at 2 mm with a tolerance of 1 mm. Justification for this is based on the fact that, in the natural breakage of coal, the thicker vitrain bands tend to break away from the rest of the coal and concentrate in the small screen sizes whereas the finer bands tend to remain intimately associated with the clarain which concentrates in the larger sizes. The limiting value is thus a function of the physical properties of vitrain and clarain since vitrain is characteristically friable and clarain is not. This approach is not necessarily the complete answer but is at least suggestive that limits should be established on the basis of physical or chemical behavior.

Color, thickness, and opacity.—Another important point which has not received sufficient consideration is the question of color and

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light transmission in connection with quantitative analytical work. In the description of each of the petrographic components, reference was made to its color or opacity. Essentially then, color comparison is an important basis for identification and can be appreciated only by direct examination since most photographs of thin sections are not reproduced in color. However, accurate comparison precludes that all sections be ground to the same thickness since light transmission is partially a function of the thickness of the section. This factor is of relatively minor importance in the identification of anthraxylon and translucent attritus but becomes extremely important for opaque attritus and fusain where identification is based largely on opacity. These components cannot, however, be regarded as totally opaque but only as possessing varying degrees of opacity since all of them probably can be made to transmit light if cut thin enough. There is, then, a very real problem for the petrographer who, for example, attempts to classify a dark-brown attrital material as opaque or translucent attritus when it is almost impossible to achieve uniformity in thickness of the section. He is beset by the same problem when he tries to classify opaque attritus and fusain since there is ample evidence that they, too, are gradational. The question involves not only the establishment of criteria for opacity but also a reconsideration of the fundamental basis of the classification. It is now apparent that opacity is an attribute which may be acquired by all kinds of plant materials to a varying degree and is dependent upon the activity and duration of the process which produced it. Study of numerous thin sections indicates that much so-called opaque attritus is actually crushed fusinized material and that cellular fusain maintains its open cell structure only because the spaces have been filled with mineral matter at an early stage in the process of coalification. This problem will be considered further in the discussion of the petrography of Kansas coals.

LITHOLOGY AND CHEMICAL COMPOSITION OF THE MINERAL, CROWEBURG, AND BEVIER COALS

Mineral Coal

Lithology.—The Mineral coal is named from the town of Mineral in northwestern Cherokee County, where it has been mined extensively. The outcrop of the Mineral coal follows a generally

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northeast trend from a point 2 miles northwest of Sherwin Junction to a point west of Franklin where it turns north and parallels the State line until it swings into Missouri south of Garland. Column samples were collected at eight localities along this trend and, at three places, composite channel samples for chemical analysis were collected immediately adjacent to the column samples. The chemical analyses from these samples are supplemented by data from the analyses of Pierce and Courtier (1938, table 1.) On the map showing the location and distribution of samples (Fig. 1) the localities are numbered in sequence from northeast to southwest and all tabulated data are arranged in a similar manner for easy comparison. Table 5 gives the exact location of the samples.

The coal is obtained from strip mines with an overburden of about 20 feet of dark-gray to black shale. In some places, the coal is capped by a discontinuous dark-gray fossiliferous limestone which locally thickens and cuts out the coal as at the Mackie-Clemens operation (Loc. 9, Fig. 1).

The thickness of the Mineral coal averages 15.2 inches, ranging from 10.4, to 21.1 inches. Pierce and Courtier (1938, p. 71) indicate that the limits are between 17 and 24 inches but it is apparent that these thicknesses include several inches of bone or shaly coal which is characteristically present at the top of the bed. This material is usually removed in mining operations and should not be included as coal.

The Mineral coal is a typical, finely banded, attrital coal. Wide anthraxylon bands are scarce and seldom exceed 1 mm in thickness. Megascopic fusain is readily observable, but randomly distributed. The fusain is usually concentrated at several horizons in any particular sample, but appears lenticular. It is found at a different horizon in adjacent samples. Vertical butt and face cleats as well as other fractures are filled with calcite which partially accounts for the unusually high ash content. The calcite acts as a binder permitting the mining of large lumps which would otherwise fall into smaller sizes. Much pyrite is present in nodules and lenticular bodies parallel to the bedding. The coal at the south end of the field is of particular interest because of these pyrite nodules and associated "coal balls." "Coal balls" have been found principally in the Pittsburg-Midway No. 15 mine (Locs. 15, 16, 17, 18, Fig. 1) where they always occur in the upper 6 inches of the coal. This subject is discussed further under "Mineral Matter in Coal."

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Chemical composition and rank—Proximate chemical analyses of 12 samples of Mineral coal are tabulated in Table 6 as determined by the method of Stanton, Fieldner, and Selvig (1939). For purposes of comparison, all analyses have been calculated to the moisture and ash-free basis and are so designated in the following dis-

TABLE 5.—*Location of samples*

Locality no.	Sample no.	Bed	County	Description
1	Cr-2-M**	Mineral	Crawford	NE¼ NE¼ sec. 9, T. 28 S., R. 25 E.; abandoned strip mine
2	Cr-4-M†	do	do	NE¼ SW¼ sec. 35, T. 28 S., R. 25 E., one-half mi. northwest Mulberry; strip mine, Palmer Coal Co.
3	Cr-3-M**	do	do	Cen. sec. 35, T. 28 S., R. 25 E., one-half mi. northwest Mulberry; strip mine, Palmer Coal Co.
4	B-2659*	do	do	NE¼ sec. 34, T. 28 S., R. 25 E.; abandoned strip mine, A. B. McKay Coal Co.
5	B-2660*	do	do	Near Cen. E. line sec. 34, T. 28 S., R. 25 E.; abandoned strip mine, A. B. McKay Coal Co.
6	B-2655*	do	do	SW¼ sec. 23, T. 29 S., R. 25 E.; abandoned strip mine, Clemens Coal Co. No. 23
7	B-2656*	do	do	SW¼ sec. 23, T. 29 S., R. 25 E.; abandoned strip mine, Clemens Coal Co.
8	Cr-1-C†	Croweburg	do	SE¼ NW¼ sec. 28, T. 29 S., R. 25 E., 1 mi. north highway 160 at Frontenac; center of strip mine, Mackie Clemens Fuel Co.
9	Cr-8-M†	Mineral	do	SE¼ SW¼ sec. 28, T. 29 S., R. 25 E., 1 mi. north highway 160 at Frontenac; south end of strip mine, Mackie Clemens Fuel Co.
10	B-2665*	do	do	SW¼ sec. 34, T. 30 S., R. 24 E.; abandoned strip mine, Pittsburg-Midway No. 17
11	B-2666*	do	do	SW¼ sec. 34, T. 30 S., R. 24 E.; abandoned strip mine, Pittsburg-Midway No. 17
12	B-2652*	do	Cherokee	700 ft. west, 15 ft. south of NE cor. sec. 20, T. 31 S., R. 24 E.; abandoned strip mine, Commercial Fuel No. 2
13	B-2667*	do	do	SW¼ NW¼ sec. 9, T. 32 S., R. 23 E.; abandoned strip mine, Pittsburg-Midway No. 15
14	B-2668*	do	do	NW¼ sec. 9, T. 32 S., R. 23 E.; abandoned strip mine, Pittsburg-Midway No. 15
15	Ck-5-M**	do	do	NE¼ NW¼ sec. 35, T. 32 S., R. 22 E., active strip mine, Pittsburg-Midway No. 15
16	Ck-4-M†	do	do	SE¼ NW¼ sec. 35, T. 32 S., R. 22 E., 2½ mi. north Sherwin Junction; active, Pittsburg-Midway No. 15
17	Ck-3-M**	do	do	SE¼ SW¼ sec. 35, T. 32 S., R. 22 E.; active, Pittsburg-Midway No. 15
18	Ck-2-M**	do	do	SE¼ SW¼ sec. 35, T. 32 S., R. 22 E.; 300 yds. south of Ck-3-M, active Pittsburg-Midway No. 15

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19	Bn-3-B†	Bevier	Bourbon	SW¼ NW¼ sec. 25, T. 26 S., R. 25 E.; 1.7 mi. north Kansas highway 7 at Garland; custom strip mine
20	Bn-2-B†	do	do	SE¼ NW¼ sec. 35, T. 26 S., R. 25 E., 1 mi. northwest Garland; active strip mine, Kelly-Carter Coal Co.
21	Bn-1-B**	do	do	NW¼ SE¼ sec. 18, T. 27 S., R. 25 E., west of highway 69, 1.3 mi. north of Crawford Co. line, custom strip mine, Pellet Coal Co.
22	Cr-9-B†	do	Crawford	SW¼ NE¼ sec. 28, T. 27 S., R. 25 E., active strip mine, Pryor Coal Co.
23	B-2669*	do	do	Cen. S. line NW¼ sec. 16, T. 28 S., R. 25 E., abandoned strip mine, Pioneer Coal Co.
24	B-2670*	do	do	Near Cen. SW¼ sec. 16, T. 28 S., R. 25 E.; abandoned strip mine, Pioneer Coal Co.
25	Cr-5-B**	do	do	NW¼ NE¼ sec. 15, T. 29 S., R. 25 E., 2.7 mi. west Franklin; active strip mine, Mackie Clemens Fuel Co.
26	Cr-6-B†	do	do	SE¼ NW¼ sec. 16, T. 29 S., R. 25 E., 1.5 mi. east Franklin; active strip mine, Mackie Clemens Fuel Co.
27	Cr-7-B**	do	do	NE¼ SW¼ sec. 16, T. 29 S., R. 25 E., 1.2 mi. east Franklin; active strip mine, Mackie Clemens Fuel Co.
28	B-2658*	do	do	Sec. 4, T. 30 S., R. 24 E., abandoned strip mine, Eagle-Cherokee Coal Mining Co.
29	B-2657*	do	do	SE¼ sec. 4, T. 30 S., R. 24 E., abandoned strip mine, Eagle-Cherokee Coal Mining Co.
30	Cr-12-B**	do	do	NW¼ NE¼ sec. 10, T. 30 S., R. 24 E., 3.5 mi. west Frontenac; active strip mine, Eagle-Cherokee Coal Mining Co.
31	Cr-14-B†	do	do	NE¼ SW¼ sec. 10, T. 30 S., R. 24 E., active strip mine, Eagle-Cherokee Coal Mining Co.
32	Cr-11-B**	do	do	SE¼ NW¼ sec. 1, T. 31 S., R. 22 E., 1 mi. northwest Monmouth; active strip mine, Lightening Creek Coal Co.
33	Cr-13-B†	do	do	NW¼ SE¼ sec. 7, T. 31 S., R. 23 E., 0.75 mi. southeast Monmouth; active strip mine, Apex Coal Co.
34	Cr-10-B**	do	do	SW¼ SE¼ sec. 7, T. 31 S., R. 23 E., 400 yds. south of Cr-13-B, active strip mine, Apex Coal Co.
35	Ck-1-B**	do	Cherokee	SE¼ NE¼ sec. 34, T. 31 S., R. 22 E., 4 mi. northwest Mineral; active strip mine, Pittsburg-Midway No. 18
36	Ck-6-B†	do	do	NW¼ SE¼ sec. 34, T. 31 S., R. 22 E., 4 mi. northwest Mineral; active strip mine, Pittsburg-Midway No. 18
37	Lt-1-B**	do	Labette	SW¼ SW¼ sec. 27, T. 33 S., R. 21 E., active strip mine, Gallagher Coal Co.
38	B-2664*	do	do	NE¼ sec. 33, T. 33 S., R. 21 E., abandoned strip mine, Vanduker Coal Co.
39	B-2663*	do	do	NE¼ sec. 33, T. 33 S., R. 21 E., abandoned strip mine, Vanduker Coal Co.

Samples are designated as follows: *Chemical analysis from Pierce and Courtier (1938 table 1), **column sample; †column sample and composite channel sample for chemical analysis.

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cussion unless otherwise stated. This has been done for several reasons: (1) some of the samples were analyzed after air drying so that the actual bed moisture is not known, and (2) irregularities due to variable ash content are eliminated and the actual coal material may be compared.

The average fixed carbon content is 58.7 percent and the coal has an average calorific value of 14,980 B.t.u. Sulfur is high, averaging 5.1 percent. The ash is unusually high, averaging 13.4 percent on the moisture-free basis. However, comparison of the analyses indicates that the coal is remarkably uniform in composition over a

TABLE 6.—*Chemical analyses of coal from the Southeastern Kansas coal field*

									Mineral matter-free basis		
Locality	Sample no.	Condition*	Moisture	Volatile	Fixed carbon	Ash	Sulfur	Calorific value B.t.u.	Moist B.t.u.	Dry fixed carbon	Rank
						Mineral coal					
2	Cr-4-M	b	1.5	32.1	50.2	16.3	6.2	11,960	....	......	....
		c		32.6	51.0	16.5	6.3	12,140			
		d		39.0	61.0	......	10.8	14,540			
4	B-2659**	a	4.8	33.9	49.5	11.8	3.5	12,530	14,510	60.8	High vol. A
		c		35.6	52.1	12.3	3.7	13,150			bituminous
		d		40.6	59.4	......	4.2	15,010			
5	B-2660**	a	4.3	34.3	40.8	13.4	4.6	12,300	14,560	66.2	High vol. A
		c		35.8	50.2	14.0	4.8	12,850			bituminous
		d		41.6	58.4	......	5.6	14,940			
6	B-2655**	a	4.4	34.2	48.8	12.6	4.8	12,420	14,550	61.0	High vol. A
		c		35.8	51.0	13.2	5.1	13,000			bituminous
		d		41.3	58.7	......	5.8	14,960			
7	B-2656**	a	5.1	34.7	48.7	11.5	3.6	12,490	14,360	59.8	High vol. A
		c		36.6	51.3	12.1	3.8	13,160			bituminous
		d		41.6	58.4	......	4.4	14,970			
9	Cr-8-M	b	1.1	33.9	51.5	13.6	4.3	12,910	....	......	....
		c		34.3	52.1	13.8	4.3	13,050			
		d		39.7	60.3	......	5.0	15,140			
10	B-2665**	a	4.4	33.5	45.7	16.4	3.3	11,930	14,610	59.2	High vol. A
		c		35.1	47.7	17.2	3.5	12,480			bituminous
		d		42.4	57.6	......	4.2	15,080			
11	B-2666**	a	4.0	35.8	49.3	10.9	3.9	12,690	14,500	59.2	High vol. A
		c		37.3	51.3	11.4	4.0	13,220			bituminous
		d		42.1	57.9	......	4.6	14,920			
12	B-2652**	a	5.1	33.2	46.8	14.9	3.6	12,060	14,520	60.0	High vol. A
		c		35.0	49.3	15.7	3.8	12,710			bituminous
		d		41.5	58.5	......	4.5	15,080			
13	B-2667**	a	3.6	34.3	50.5	11.6	3.4	12,870	14,850	61.5	High vol. A
		c		35.5	52.5	12.0	3.5	13,350			bituminous
		d		40.4	59.6	......	4.0	15,160			
14	B-2668**	a	2.9	35.1	51.5	10.5	2.8	13,110	14,950	60.5	High vol. A
		c		36.2	53.0	10.8	2.9	13,510			bituminous
		d		40.6	59.4	......	3.2	15,140			

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16	Ck-4-M	b	1.1	38.7	48.2	12.0	4.5	12,910	....	......	....
		c		39.1	48.7	12.1	4.6	13,050			
		d		44.5	55.4	......	5.2	14,850			
Average moisture, ash-free				41.3	58.7	13.4	5.1	14,980			
						Bevier coal					
19	Bn-3-B	b	1.4	34.4	49.9	14.2	8.8	12,570	....	......	....
		c		34.9	50.6	14.4	8.9	12,750			
		d		40.8	59.1	......	10.4	14,890			
20	Bn-2-B	b	1.3	35.8	47.0	16.0	2.8	11,820	....	......	....
		c		36.3	47.6	16.2	2.8	11,980			
		d		43.3	56.8	......	3.3	14,300			
22	Cr-9-B	b	1.1	36.8	52.1	10.0	2.5	13,910	....	......	....
		c		37.2	52.6	10.1	2.5	14,060			
		d		41.4	58.5	......	2.8	15,640			
23	B-2669**	a	3.4	37.6	50.6	8.4	2.8	13,250	14,650	58.4	High vol. A bituminous
		c		38.9	52.4	8.7	2.9	13,720			
		d		42.6	57.4	......	3.1	15,030			
24	B-2670**	a	4.6	36.9	48.6	9.9	2.4	12,940	14,570	57.5	High vol. A bituminous
		c		38.7	51.0	10.3	2.5	13,570			
		d		43.1	56.9	......	2.8	15,140			
26	Cr-6-B	b	1.4	35.1	50.3	13.2	2.7	13,310	....	......	....
		c		35.6	51.0	13.4	2.7	13,500			
		d		41.1	58.9	......	3.1	15,590			
28	B-2658**	a	3.4	34.3	49.6	12.7	2.4	12,700	14,860	60.3	High vol. A bituminous
		c		35.5	51.3	13.2	2.5	13,150			
		d		40.9	59.1	......	2.9	15,140			
29	B-2657**	a	4.3	35.4	46.4	13.9	2.3	12,280	14,580	58.0	High vol. A bituminous
		c		36.9	48.6	14.5	2.4	12,830			
		d		43.2	56.8	......	2.8	15,010			
31	Cr-14-B	b	1.1	35.0	47.2	16.7	4.2	12,250	....	......	....
		c		35.4	47.7	16.9	4.2	12,380			
		d		42.6	57.4	......	5.1	14,900			
33	Cr-13-B	b	1.4	35.1	47.9	15.6	2.7	12,290	....	......	....
		c		35.6	48.6	15.8	2.7	12,460			
		d		42.3	57.7	......	3.2	14,800			
36	Ck-6-B	b	1.5	36.3	45.1	17.2	4.2	11,340	....	......	....
		c		36.9	45.8	17.5	4.3	11,510			
		d		44.7	55.5	......	5.2	13,950			
38	B-2664**	a	3.5	42.0	48.6	5.9	3.1	13,660	14,720	59.7	High vol. A bituminous
		c		43.5	50.4	6.1	3.2	14,150			
		d		46.3	53.7	......	3.4	15,070			
39	B-2663**	a	3.7	40.8	47.7	7.8	3.1	13,330	14,700	55.0	High vol. A bituminous
		c		42.4	49.5	8.1	3.2	13,850			
		d		46.1	53.9	......	3.5	15,070			
Average moisture, ash-free				43.0	57.1	17.7	3.9	14,690			
						Croweburg coal					
8	Cr-1-C	b	0.9	35.3	49.0	14.8	7.3	11,450	....	......	....
		c		35.6	49.4	14.9	7.4	11,550			
		d		41.8	58.0	......	8.7	13,570			

*The form of analysis is denoted as follows: a, as received at the laboratory; b, air dried; c, moisture free; d, moisture and ash free.

**Analyses from Pierce and Courtier (1938, table 1).

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large area. With the exception of one sample, the calorific values do not differ from the average by more than several hundred B.t.u. and the fixed carbon values are within a few percent of the average. Sulfur and ash are somewhat more variable, as might be expected.

The chemical analyses for which the bed moisture is known have also been calculated to the mineral-matter-free basis so that the coal could be classified according to A.S. T.M. rank designation (Table 1). Rank designation is determined by moist mineral-matter-free B.t.u. and dry mineral-matter-free fixed carbon according to the Parr (1928) equations as follows:

1) $$\text{Moist mineral-matter-free B.t.u.} = \frac{\text{B.t.u. (as received)} - 50\ \text{S}}{100 - (1.08 \times \text{ash} + 0.55\ \text{S})} \times 100$$

2) $$\text{Dry mineral-matter-free fixed carbon} = \frac{\text{fixed carbon (as received)} - 0.15\ \text{S}}{100 - (\text{moisture} + 1.08 \times \text{ash} + 0.55\ \text{S})} \times 100$$

These equations result from efforts to increase the ash value to represent the original quantity of mineral matter present in the raw coal.

The mineral-matter-free tabulations of Table 6 indicate that the Mineral coal is a high volatile A bituminous coal according to the A. S. T. M. classification.

Although no coking tests on the coal were made, the agglomerating index was determined as described by Stanton, Fieldner, and Selvig (1939, pp. 36-37). The agglomerating index (Table 7) indicates the coking and caking properties of bituminous coal and is found by examination of the residue left in the platinum crucible from the volatile matter determination. It is of limited value for indicating coking properties since the coal is heated much more rapidly than that coked in commercial ovens. Thus, coals that yield good cokes in commercial practice always give well-coked residues from the volatile-matter determination, but the reverse is not always true. As shown in Table 8, the Mineral coal is classed as Cg or Cf, which means that it is a good to fair caking agglomerate coal—e.g., it will produce a button showing medium to strong swelling and good cell structure, has a characteristic metallic lustre, and generally will support a 500 gram weight. The buttons barely meet the 500 gram weight requirement since the cell walls tend to be thin and are easily crushed although the button supports the weight. It is doubtful that the coal would make good metallurgical grade coke

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since it is not particularly strong and has a high sulfur content which is 3 to 4 percent higher than the maximum tolerance of 1.5 percent sulfur.

Bevier Coal

Lithology.—The Bevier coal lies just above the Ardmore limestone and its outcrop is practically coincident with that of the Ardmore. It roughly parallels the Mineral coal beginning at a point several miles southeast of Oswego and continuing northeasterly until it crosses the State line into Missouri north of Garland.

Column samples were collected at 14 localities along the outcrop in strip mines and at 7 places composite channel samples for chemical analysis were collected immediately adjacent to the column samples. The chemical analyses are supplemented by data from Pierce and Courtier (1938, table 1).

Table 7.—*Agglomerating and coking properties of coals based on examination of residue incident to the volatile-matter determination*
(Stanton, Fieldner, and Selvig, 1939, p. 37)

Designation		Appearance of residue from standard method for determination of volatile matter in coal
Class	Group	
Nonagglomerating (button shows no swelling or cell structure and will not support 500 g without pulverizing)	NA (nonagglomerate)	NAa-noncoherent residue NAb-coke button shows no swelling or cell structure and after removal from crucible will pulverize under a weight of 500 grams
Agglomerating (button shows swelling or cell structure or will support 500 g without pulverizing)	A (agglomerate) button dull black and sintered; shows no swelling or cell structure	Aw (weak agglomerate)—buttons come out of crucible in more than one piece Af (firm agglomerate) — buttons come out of crucible in one piece
	C (caking) shows swelling or cell structure	Cp (poor caking)—button shows slight swelling with small cells; has slight gray luster Cf (fair caking)—button shows medium swelling and good cell structure; has characteristic metallic luster Cg (good caking)—button shows strong swelling and pronounced cell structure, with numerous large cavities and cells; has a characteristic metallic luster

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The Bevier coal lies 80 to 100 feet below the top of the Cherokee shale and is mined from strip pits having an overburden of 25 to 30 feet of dark-gray to black shale. The shale may contain several beds of dark shaley limestone ranging from 2 to 30 inches in thickness. These thin limestones are most prominent in the northern part of the field. Locally, as much as 50 feet of overburden may be removed. A typical underclay is found immediately below the coal and this is, in turn, underlain by the Ardmore limestone.

The average thickness of the coal where sampled is 14.7 inches; its thickness ranges from 12 to 17.5 inches. Like the Mineral coal, it is finely attrital with few anthraxylon bands exceeding a thickness of 1 mm. It contains numerous megascopic lenses of fusain. It also contains many vertical calcite-filled fractures which are even more prominent than in the Mineral coal and probably account for the higher ash content of the Bevier. Pyrite nodules are not so numerous and the coal consequently has a lower sulfur content.

There is some evidence of structural deformation in the Bevier. At least four faults were encountered in the Pryor Coal Company operation at the north end of the field northwest of Arcadia (Loc. 22, Fig. 1). The faults had an east-west strike and dipped steeply to the south. Vertical displacement was about 2 feet so that the coal had to be mined at several levels. The coal also had a rolling or gently folded surface.

Chemical composition and rank.—Chemical analyses of 13 samples of Bevier coal are listed in Table 6. The average fixed carbon content is 57.1 percent and the average calorific value is 14,690 B.t.u. Sulfur averages 3.9 percent and the ash is 17.7 percent on the moisture-free basis. In comparison with averaged Mineral coal analyses (Table 6) the Bevier is lower in calorific value, fixed carbon, and sulfur but higher in ash. The differences are not large but may be an indication of the operation of Hilt's law, which predicts that stratigraphically lower coals have higher fixed carbon (lower volatile) and calorific values due to increasing pressure and temperature rather than initial differences in the coal materials.

Comparison of individual Bevier analyses shows that the coal does not exhibit quite the same areal uniformity as does the Mineral. Although fixed carbon values have a range of about 5 percent and deviate from the average by only a few percent, the calorific values are quite variable and range from 13,950 to 15,640 B.t.u.

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Chemical analyses calculated to the mineral-matter-free basis classify the Bevier coal as a high volatile A bituminous coal according to A.S.T.M. rank designation.

The agglomerating index is given for seven samples in Table 8. The Bevier is an agglomerate Cf to Cg or good to fair caking coal and exhibits approximately the characteristics of the Mineral coal. Although the lower sulfur content would make it more desirable as a domestic coke, the sulfur is still above the limit of 1.5 percent set for metallurgical coke.

Croweburg Coal

Lithology.—The Croweburg coal is named from the town of Croweburg in northeastern Crawford County, where it was mined extensively at one time. It lies about 25 feet above the Mineral coal between the Mineral and Bevier so that its outcrop is between and roughly parallel to these coals. Only a small quantity of Croweburg coal is produced at the present time and good exposures are rare.

A column sample with an adjoining composite sample for chemical analysis was collected at the Mackie Clemens strip mine (Loc. 8, Fig. 1) where both the Mineral and Croweburg coals are mined in a single operation. The Fleming coal also is exposed in the same mine but is so thin and of such poor quality that is rejected as refuse.

About 12 feet of shale overlies the Croweburg. It is dark gray at the base and grades upward into a lighter gray color. The top consists of about 3 feet of black fissile shale containing numerous concretions and phosphate nodules.

The coal is about 12 inches thick at the locality where sampled. Pierce and Courtier (1938, p. 75) report that this thickness is average for the bed. It is a finely attrital coal with few wide anthraxylon bands and several distinct layers of fusain.

Chemical composition and rank.—Average analyses of the Croweburg coal are not available so that its chemical composition is reported here from a single determination (Table 6) which may not be representative. At a single locality, the coal has a fixed carbon content of 58.0 percent, an ash content of 14.9 percent, and a calorific value of 13,570 B.t.u. Sulfur comprised 8.7 percent on a moisture-free basis. It is roughly comparable to the Mineral coal (Table 6) although the calorific value is considerably lower.

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TABLE 8.—*Agglomerating index from volatile matter residue from Kansas coal*

Sample	Coal	Agglomerating index	Support 500 grams
Bn-3-B	Bevier	Cf	Yes
Bn-2-B	do	Cg	Yes
Cr-9-B	do	Cg	Yes
Cr-6-B	do	Cf	Yes
Cr-14-B	do	Cg	Yes
Cr-13-B	do	Cg	Yes
Ck-6-B	do	Cf	Yes
Cr-4-M	Mineral	Cf	Yes
Cr-8-M	do	Cg	Yes
Ck-4-M	do	Cg	Broke in several pieces
Cr-1-C	Croweburg	Cg	Yes

The "as received" analysis has not been converted to the mineral-matter-free basis for purposes of rank designation because the bed moisture is not known. However, rough approximation indicates that the calorific value would fall between 13,000 and 14,000 B.t.u. and that fixed carbon would be less than 69 percent so that the coal is probably high volatile B bituminous.

The agglomerating index (Table 8) rates the coal as an agglomerate Cg or good caking coal. However, the sulfur content is far too high for metallurgical purposes.

Regional Variation in Chemical Properties

A knowledge of the regional variation in coal is of considerable importance to the producer since it enables him to predict the quality of his product in new ventures or in the extension of old fields. The chemical analyses of the Mineral and Bevier coals have shown that the Mineral is relatively uniform along the strike and that the Bevier is somewhat more variable. Variations in fixed carbon and volatile matter are commonly regarded as an indication of the stage of coalification or rank. Calorific variations arise in the same manner but may be a more sensitive index of coal type variation since the calorific value of hydrogen is greater than that of carbon.

The possibility that a small systematic variation might be discernible in the raw data resulted in the plot of fixed carbon and calorific value versus distance as shown in Figure 4. The Mineral

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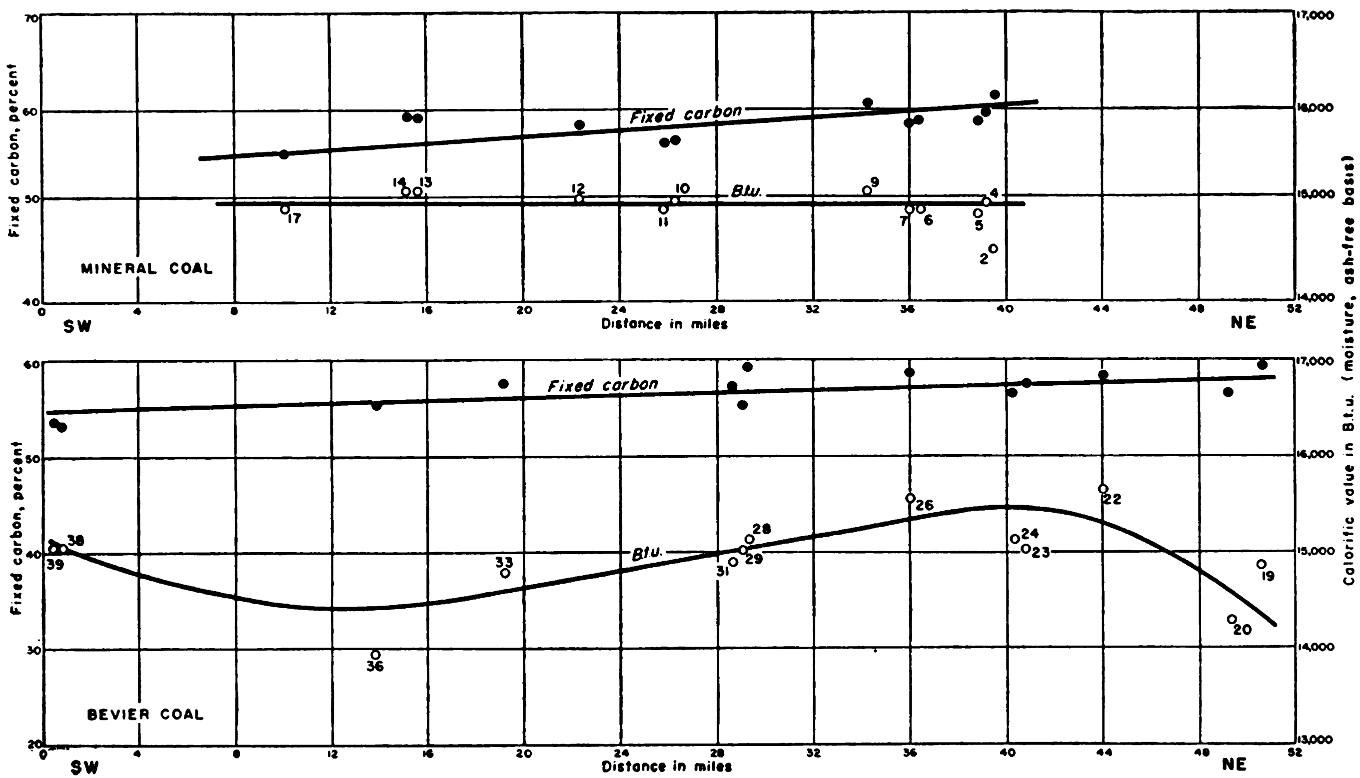

FIG. 4.—Regional variation of fixed carbon and B.t.u. values in Mineral and Bevier coals. (Numbers refer to locations projected to line a-a′, Fig. 1.)

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and Bevier sample locations have been projected to the line a-a′ of Figure 1.

There are not a sufficient number of plotted points to define clearly regional variation but smooth curves which have been drawn at least suggest that the fixed carbon content of both coals increases from south to north. The calorific value of the Mineral coal is so uniform that the curve has almost no slope whereas the calorific value of the Bevier shows relatively wide variation.

Interpretation of these curves is speculative, but is considered in order to indicate the results which might be expected with a greater number and wider distribution of samples.

The Cherokee basin, in which coal accumulation took place, came into existence after Mississippian time. It was bounded on the north by the Bourbon arch which separated it from the Forest City basin. Within the basin are several known or inferred structural elements. Pierce and Courtier (1938, p. 53) have described the northwest-trending Pittsburg anticline and Dreyer (1947) has shown the probable existence of additional features through geophysical investigation. Since it has been demonstrated that the increased temperatures and pressures which accompany orogenic activity may produce an increase in the rank of coal, the effect of the above structural elements should be considered.

Little is known of the orogenic activity during Cherokee time. Nevertheless, tentative suggestion is made that activity of the Bourbon arch may have accounted for the increase in fixed carbon from south to north. One line of evidence lies in the structure of the Bevier coal mentioned earlier. Four faults were described at the north end of the field. These faults roughly parallel the Bourbon arch and may have been produced by movement of the arch.

However, at least part of the variation is probably due to analytical technique. The Bureau of Mines (Stanton, Fieldner, and Selvig, 1939, p. 59) permits difference of 0.5 percent for two volatile-matter determinations made in the same laboratory and 1.0 percent for determinations made in different laboratories. The fixed carbon tolerances should therefore be of the same order of magnitude. Differences of 0.3 and 0.5 percent are allowed for two calorific determinations made in the same laboratory and in different laboratories respectively. The overall differences between maximum and minimum values for the Mineral and Bevier coals are more of

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the order of 5 percent. Some part of this variation is systematic, but some is undoubtedly analytical.

PETROGRAPHY OF THE MINERAL, CROWEBURG, AND BEVIER COALS

Description of Components

The Mineral, Croweburg, and Bevier coals were studied petrographically from approximately 400 thin sections and from 22 column samples. Since the three coals show marked similarities, they are discussed here as a group rather than individually.

The outstanding characteristic of the coals is their finely banded appearance. The anthraxylon bands range from a maximum width of about 5 mm to the arbitrary lower limit of 0.017 mm and rarely exceed 1 mm. Typical bands of anthraxylon are shown in Plate 2, A and B. The relatively homogeneous nature of the anthraxylon is distinctive and aids in separating it from adjacent attrital coal. The bands are characteristically bright orange to red and in places are bounded by brilliant orange or yellow cuticular material having a serrated edge on its proximal side (Pl. 5, A and B). Anthraxylon exhibits several forms which depend on the part of the plant sectioned, the direction of the section, and the state of preservation of the material. Many bands are not continuous, but pinch out within a short distance or split into a number of finer bands due to branching or degradation. Lenticular bands are indicative of transverse sections. Some bands are double because the original stems were hollow cylinders.

Cell structure was not seen in most sections of anthraxylon either because the plant material had undergone considerable alteration before coalification or because of lack of contrast between the cell walls and the material filling the lumens. Plate 2 C is a section of anthraxylon showing traces of deformed cell structure. Plate 2 D is a section of anthraxylon cut parallel to the bedding and in a direction longitudinal to the plant cells. The boxlike nature of the cells can be seen clearly.

Translucent attritus is usually heterogeneous. It consists of a closely knit debris of anthraxylon fragments, spore exines, bits of cuticle, resin bodies, and other degradation products plus extremely fine particles of calcite, pyrite, quartz, and clay minerals. Typical examples of translucent attritus are shown in Plates 3, 4, and

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8C. Some translucent attritus consists entirely of small fragments which are distinguished from anthraxylon solely on the basis of size. Since most of the anthraxylon falls in the fine size range, distinction between attritus and anthraxylon is difficult. The constituents of Plate 3A are similar in appearance but the band in the middle of the section is classified as anthraxylon whereas the remainder of the material is translucent attritus.

Although the spore content of the coal is remarkably low, the megaspore exines can be distinguished easily when they do occur. Megaspores are brilliant yellow bodies, up to 1 mm in length, resembling a flattened tube in cross section. The ends may be invaginated as shown in Plate 5D. Plate 5C shows a cluster of megaspores at a lower magnification. The microspores are much smaller and may be mistaken for fragments of cuticle.

Bright red globular resin bodies are abundant in both translucent attritus and anthraxylon. Plate 4 illustrates how bands of anthraxylon and attritus have been compressed around more resistant resin bodies.

Fusain is one of the most striking components of these coals and, in places, one of the most difficult to distinguish because of its similarity to certain types of opaque attritus. At its best, it consists of cellular material with opaque cell walls and translucent spaces between the walls which have been filled with calcite. Some types of fusain are clearly transverse sections of altered wood or cortex (Pl. 6A, lower part of B, and C) since the same kinds of cells can be seen in unaltered plants. Fusain has a fibrous appearance if the cells have been cut in a longitudinal direction (Pl. 6, upper part of B) or if the original material consisted of resin rodlets. Other fusain occurs in fine irregular fragments derived from the deformation or crushing of the cellular type or from the alteration of finer woody debris. Plate 7B shows fusain in which the cell walls have been deformed so that the calcite-filled spaces no longer exhibit regularity. Fusain, in many cases, occurs in lenticular bodies (Pl. 7A).

Opaque attritus is a relatively minor constituent of the coals. When it does occur, it is found, in most places, near the top or bottom of the column. Clearly recognizable opaque attritus contains translucent anthraxylon-like fragments, cuticle, and spore exines in addition to the opaque constituents. Plate 3C shows opaque attritus intercalated with translucent material. Plate 5, C and D,

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shows examples of opaque attritus containing spore exines and fragments of cuticular material.

The most perplexing problem in the petrographic analysis of the coal was the differentiation of the opaque or semiopaque constituents. Opaque attritus may have a transitional relation with translucent attritus or anthraxylon. In such cases, the translucent constituents become progressively more opaque and grade into fusainlike material. Plate 7D is a typical example of this transition. The material at the bottom of the section is clearly anthraxylon. It changes upward into semiopaque matter which in turn becomes progressively more opaque and acquires the expanded structure of fusain. Since the boundaries of these constituents are not defined clearly, the analytical results are dependent, to a large measure, on the judgment of the observer. Plate 7C shows that other coal constituents may alter to fusain. The round opaque body is a fusinized resin globule.

Origin of Opaque Components

Because the opaque components are of considerable importance in both coal classification and coal utilization, it is pertinent to review briefly the ideas concerning the origin of these constituents. In general, two schools of thought have existed (Hendricks, 1945, pp. 19-21) concerning fusain. The first attributed the origin to forest fires, and the second to some form of chemical alteration prior to burial. The forest-fire theory has found little favor because of the improbability of extensive fires in typical peat swamps and the absence of ash layers. In addition, fragile plant structures are fusinized and plant stems are found with fusain on the interior. The chemical alteration theories include dehydration during periods of dryness or by sulfuric acid, carbonization as the result of catalytic action, impregnation with various salts or gases which promote carbonization and inhibit aerobic decay, and the local action of thermophilic bacteria.

The origin of opaque attritus has received relatively little attention and most investigators have considered it a separate entity from fusain. Thiessen and Sprunk (1936) observed a transitional relation between opaque and translucent constituents in their studies of the Upper and Lower Cedar Grove coals of West Virginia. Fieldner and Schmidt (1941, p. 12) suggested that opaque

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attritus resulted from advanced decomposition due to the action of biological agencies and that as decay progressed, the attritus became more opaque.

Certain observations may be made concerning the origin of the opaque constituents as illustrated in Kansas coals.

(1) The process or processes which produce fusain may act upon any of the plant materials and the resulting degree of opacity is dependent upon the intensity and duration of the process. In addition, it is likely that certain plant tissues are more susceptible to fusinization than others. Thin sections show the gradation of anthraxylon and translucent attritus into opaque attritus and fusain. It seems probable that had the process producing the gradation been of sufficient intensity and duration, all the material would have been fusinized. Since fusinized resin bodies have been found, it is evident that even the more resistant plant materials are susceptible to fusinization.

(2) The process of fusinization was operative in the early stages of coalification. Cellular fusain is able to maintain its open structure because the cells are filled with calcite. The other coal material is seen to be compressed around the structurally supported fusain. Therefore fusinization and impregnation took place prior to compaction of the surrounding coal and the process may be regarded as diagenetic. If coalification had proceeded in a normal manner, cell cavities would have filled with humic material and later fusinization would have produced a homogeneous rather than a cellular fusain.

(3) Fusinization can be local in nature. Most fusain in Kansas coals cannot be traced for any distance laterally whereas, in some coals, fusain bands are persistent. It would seem that fusain is produced by a number of processes, some of which are local in action whereas others are not.

(4) Much that has been classed as opaque attritus is probably crushed and compacted fusain. In cases where no calcite impregnation of cells took place, the structurally weak fusain was not able to maintain its open spaces. Undoubtedly much of the crushed fusain has been classified as opaque attritus since fusain is identified largely on the basis of its open cell structure.

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Analysis of Components

In Plate 1, the type of coal and the percentage of components in each thin section have been shown graphically for 22 column samples. As illustrated in Plate 1A, the type of coal is designated at the left side of the figure. Distances from the top of the bed are given at the left margin. The thickness of each lithologic unit and its description number are shown in the next two columns. The percentage loss in the lower left corner is an indication of the amount of coal lost through sawing and grinding. It was determined by dividing the thickness of the column sample after grinding (as determined from the sum of the thin section widths) by the original thickness of the column before grinding. Approximately true thickness can be found by multiplying the diagram thickness by the percent loss and adding the product to the diagram thickness. The percentages of anthraxylon, translucent attritus, opaque attritus, and fusain are shown by bar diagram to the right of the figure.

MINERAL COAL

Petrographic analyses of the Mineral coal are shown in Plate 1, A to G. With few exceptions, the Mineral coal is a uniformly bright coal. It is characterized by a relatively large content of translucent attritus. Opaque attritus and fusain are minor constituents. In the few cases where opaque attritus increases to the extent that parts of the coal are classified as semisplint or cannel, these constituents are confined to the top or bottom of the bed. Sample Ck-3-M (Pl. 1C) contains 0.8 inch of semisplint at the top of the column. Sample Cr-8-M (Pl. 1D) has 0.6 inch of semisplint about 1.4 inches from the top and another semisplint band 0.8 inch wide at the bottom of the bed. Sample Ck-5-M (Pl. 1E) is somewhat peculiar in that it contains a thin band of cannel coal at the bottom of the bed. Although this band meets the petrographic requirements of a cannel, it does not have the typical compact and nonbanded canneloid appearance. About 1.4 inches of the column is missing since part of the coal was too friable to section or polish.

Banded or nodular pyrite is relatively rare in the Mineral coal except at the south end of the field. Although these impurities are described as pyrite in the diagrams, they are actually "coal balls" and contain considerable calcite. Samples Ck-4-M (Pl. 1F) and Ck-

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2-M (Pl. 1G) both show that the nodules are confined to the upper portion of the coal bed.

The average analysis for each column is tabulated in Table 9 and the average of these analyses is shown at the bottom of the table. It is interesting to note that opaque attritus increases from north to south until it reaches a maximum of 9.0 percent just north of Frontenac (sample Cr-8-M) and then decreases to the south. This variation may not be significant since relatively few Mineral coal samples have been analyzed. Nevertheless, the opaque attritus content of the coal is lower in the north and south ends of the field.

TABLE 9.—*Summary of data on petrographic analyses of column samples of coals from the Southeastern Kansas coal field*

Locality no.	Sample no.	Thickness, inches	Anthraxylon, percent	Translucent attritus, percent	Opaque attritus, percent	Fusain, percent
			Mineral coal			
1	Cr-2-M	10.4	26.1	66.9	2.6	4.4
2	Cr-4-M	13.5	21.3	69.0	1.4	8.2
3	Cr-3-M	18.5	24.1	64.3	3.9	7.6
9	Cr-8-M	21.1	33.5	50.9	9.0	10.3
15	Ck-5-M	14.3	31.2	59.4	2.7	6.6
16	Ck-4-M	18.4	41.1	51.6	1.4	5.9
18	Ck-2-M	10.4	34.4	58.6	1.5	5.5
	Average	15.2	30.2	60.1	3.2	6.9
			Bevier coal			
19	Bn-3-B	12.9	45.5	40.4	8.0	6.1
20	Bn-2-B	14.0	54.4	35.4	4.8	5.4
21	Bn-1-B	12.1	41.7	40.7	1.6	16.0
22	Cr-9-B	15.9	38.3	53.8	4.4	3.5
25	Cr-5-B	16.8	27.5	53.9	4.2	14.4
26	Cr-6-B	17.5	33.7	55.5	5.8	5.1
27	Cr-7-B	15.0	36.2	55.6	4.5	3.8
30	Cr-12-B	16.1	36.1	52.7	4.4	6.8
31	Cr-14-B	15.4	32.0	53.7	9.7	4.7
32	Cr-11-B	14.1	36.8	53.1	5.1	5.0
33	Cr-13-B	15.4	35.4	49.8	4.2	10.5
34	Cr-10-B	15.7	31.7	55.7	6.9	5.7
35	CK-1-B	13.4	36.2	50.3	8.2	5.3
37	Lt-1-B	12.0	44.4	38.2	11.4	6.0
	Average	14.7	37.9	49.2	5.9	7.0
			Croweburg coal			
8	Cr-1-C	11.5	21.0	58.2	7.7	13.1

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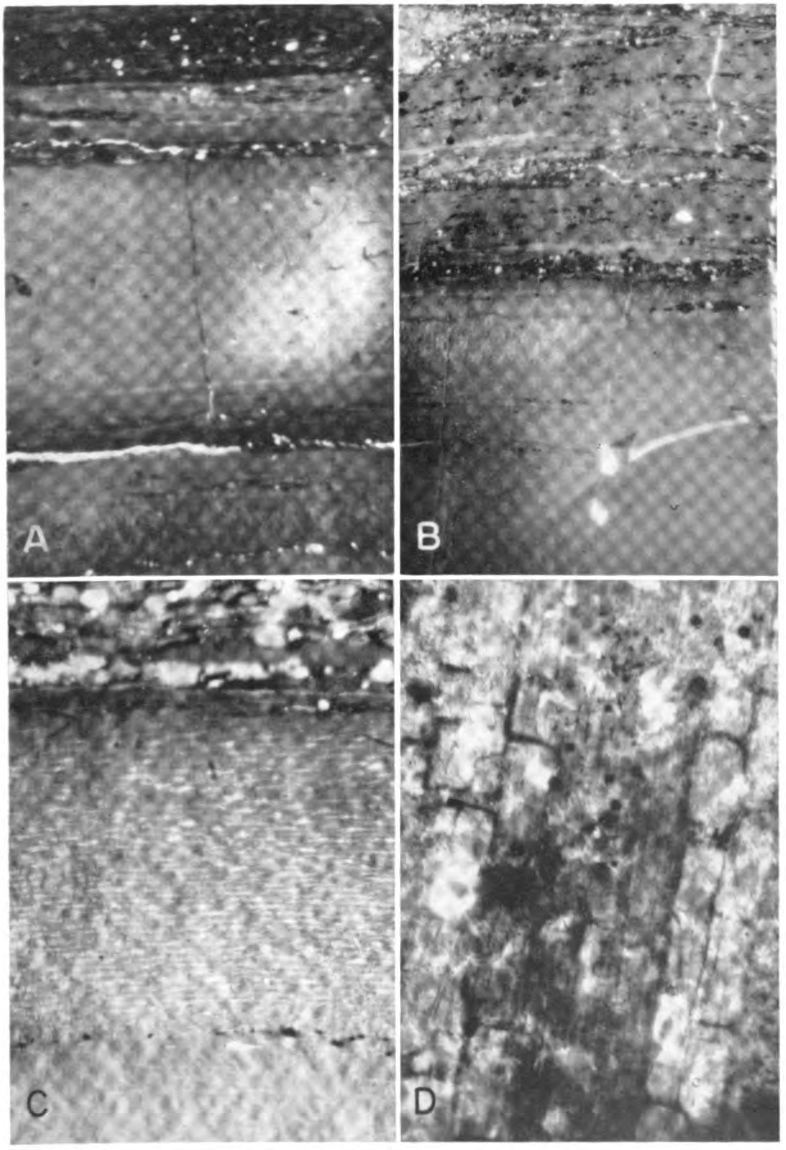

PLATE 2. Thin sections showing anthraxylon bands and cell structure. **A**, Anthraxylon band below with attrital coal above (Bevier, X 95). **B**, Anthraxylon band with translucent attritus above. Attritus contains small particles of opaque pyrite and translucent calcite and clay minerals (Mineral coal, X 95). **C**, Deformed cell structure in anthraxylon (Bevier coal, X 350). **D**, Anthraxylon band cut parallel to bedding. Boxlike nature of cells is evident (Mineral coal, X 150).

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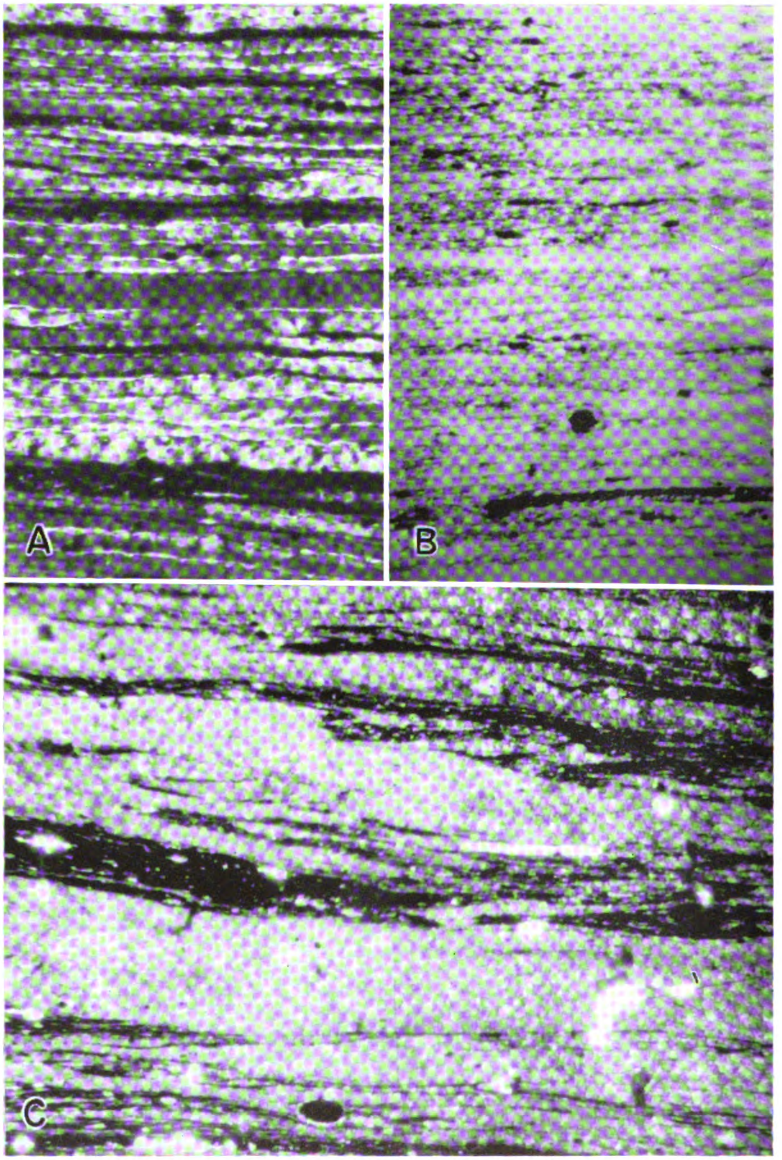

PLATE 3. Thin sections of attrital coal. **A**, Banded translucent attritus. Wide band near center is classified as anthraxylon on basis of size (Mineral coal, X 125). **B**, Translucent attritus composed of shredlike fragments. Opaque bodies are pyrite (Mineral coal, X 125). **C**, Opaque attritus intercalcated with bands of anthraxylon and translucent attritus (Bevier coal, X 95).

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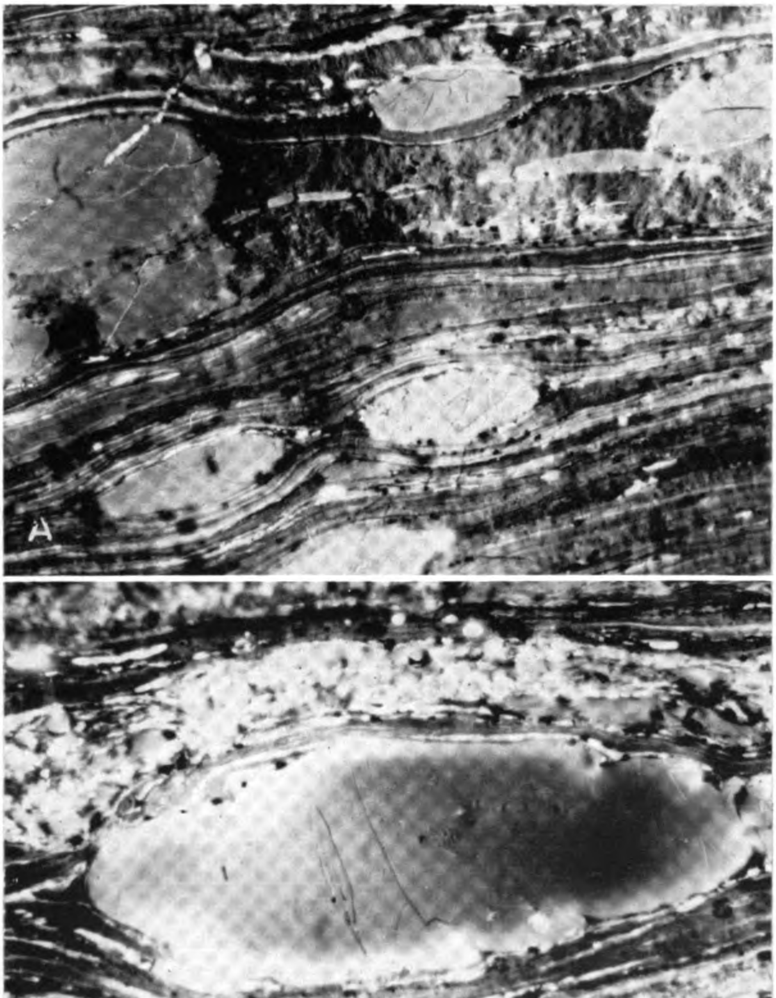

Plate 4. Resin bodies. **A,** Resin bodies in anthraxylon and translucent attritus. Note how bands have been compressed around resistant resin bodies (Bevier coal, X 125). **B,** Large resin body in translucent attritus (Bevier coal, X 125).

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BEVIER COAL

Petrographic analyses of the Bevier coal are shown in Plate 1, H to U. The Bevier is also a uniformly bright coal except for a few thin bands of splint and semisplint coal. Translucent attritus again predominates whereas opaque attritus and fusain are relatively minor constituuents. No splint or semisplint coal is encountered north of Franklin in Crawford County. The first occurrence is in sample Cr-5-B (Pl. 1L) which has a thin band of semisplint near the top of the bed. There is also a layer of almost pure fusain about 11.5 inches from the top of the bed which does not fit into the type classification scheme. Other samples to the south show small amounts of splint or semisplint near the top or bottom of the bed. Samples Cr-14-B (Pl. 1P) and Cr-11-B (Pl. 1Q) are exceptions to this general rule since semisplint coal occurs near the middle of the bed.

Nodular or banded pyrite is rare in the Bevier coal. The only occurrence was in sample Ck-1-B (Pl. 1T) about 8 inches from the top of the sample.

The average analysis for each column sample is tabulated in Table 9 and the average of the analyses for all the columns is shown at the bottom of the table. The distribution of components is somewhat erratic and there is no apparent systematic variation.

CROWEBURG COAL

A single analysis of the Croweburg coal is shown in Plate 1V. It is similar in most respects to the Mineral and Bevier coals. The most abundant constituent is translucent attritus. A relatively thick band of splint coal occurs near the bottom of the bed. The average analysis of the column is tabulated in the lower part of Table 9.

COMPARISON OF THE COALS

In comparing the analyses of the coals, it is important to note that the Bevier coal is somewhat higher in anthraxylon, opaque attritus, and fusain than the Mineral coal. The economic significance of these differences will be discussed later in reference to coal utilization. Since the distribution of splint and semisplint coal is similar for all the beds, it may be pertinent to mention that

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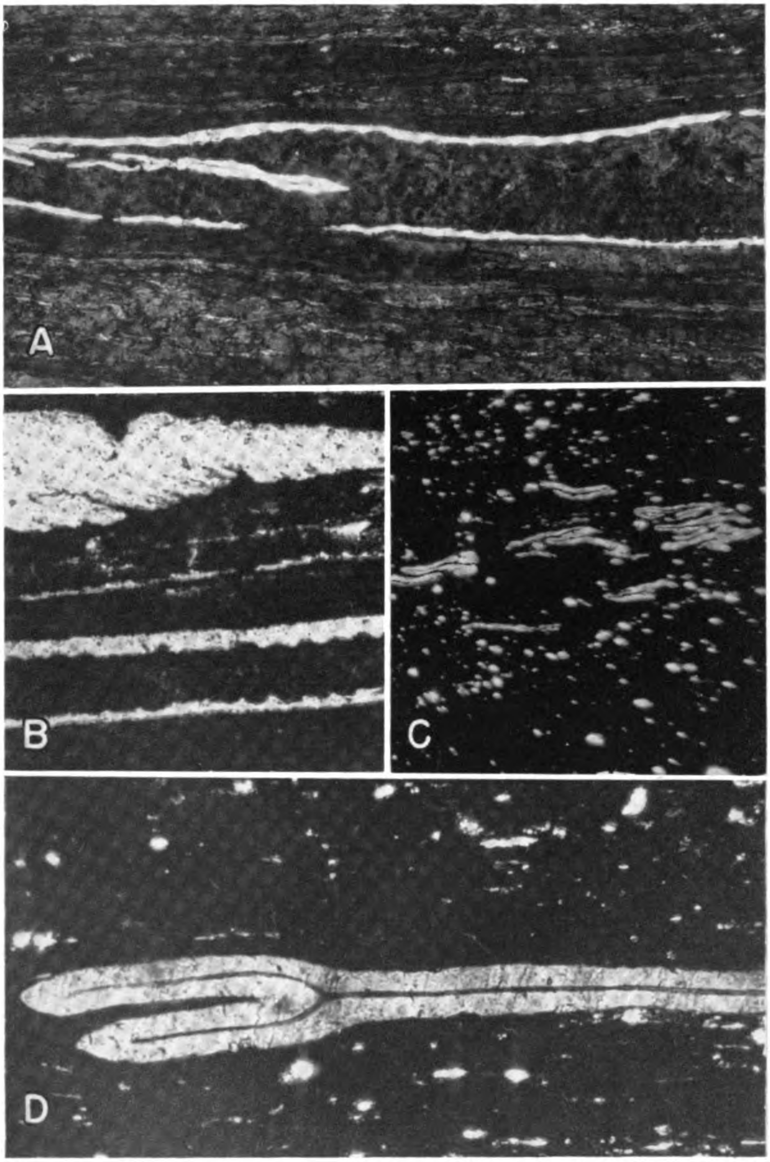

PLATE 5. Thin sections showing cuticle and spores. **A,** White material is cuticle which surrounds a stem, in longitudinal section (Mineral coal, X 50). **B,** Fragments of cuticle. Lower double layer is a longitudinal section of a stem. Note the characteristic serrated edge on the inner side of each layer (Mineral coal, X 125). **C,** Cluster of megaspore exines or cases in opaque attritus (Mineral coal, X 100). **D,** Megaspore in opaque attritus. The double character of the spore case is clearly evident. Note the invaginated end of the case (Mineral coal, X 190).

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one of the advantages of column analysis is to show the distribution of coal types so that selective mining may be employed intelligently. The value of such a practice in mining Kansas coals is doubtful, however, because of the thinness of the beds and the relatively small contribution of the splints and semisplints to the overall character of the coal.

Mineral Matter

Chemical analyses of the Mineral, Croweburg, and Bevier coals already have indicated their relatively high ash content. However, the ash value contributes little to an understanding of the identity and distribution of the mineral matter which is responsible for the ash. Such information is important for several reasons: (1) it aids in determining the extent of economical coal beneficiation; (2) the chemical and physical properties of coal are influenced by the character of the mineral matter; (3) it is a reflection of the geologic history of the coal bed.

KINDS OF MINERAL MATTER

Two kinds of mineral matter are generally found in all coals. The first is called "inherent mineral matter" and refers to that portion organically combined with the coal. It cannot be determined petrographically and includes those elements which have been assimilated by plants for nutritive purposes. The second is known as "extraneous mineral matter" and includes that portion which is foreign to the plant material. Extraneous mineral matter is the larger contributor to the total ash content. It consists of detrital minerals deposited during coal accumulation and minerals deposited from solution or suspension during and after coal accumulation. Most of the mineral matter in Kansas coal is of the latter type.

METHOD OF STUDY

The techniques used in the study of the mineral constituents are outlined as follows:

(1) Approximately a 25 gram sample, crushed to minus 60 mesh size, was split from each of the channel samples used for chemical analysis. After weighing, the sample was placed in a large separa-

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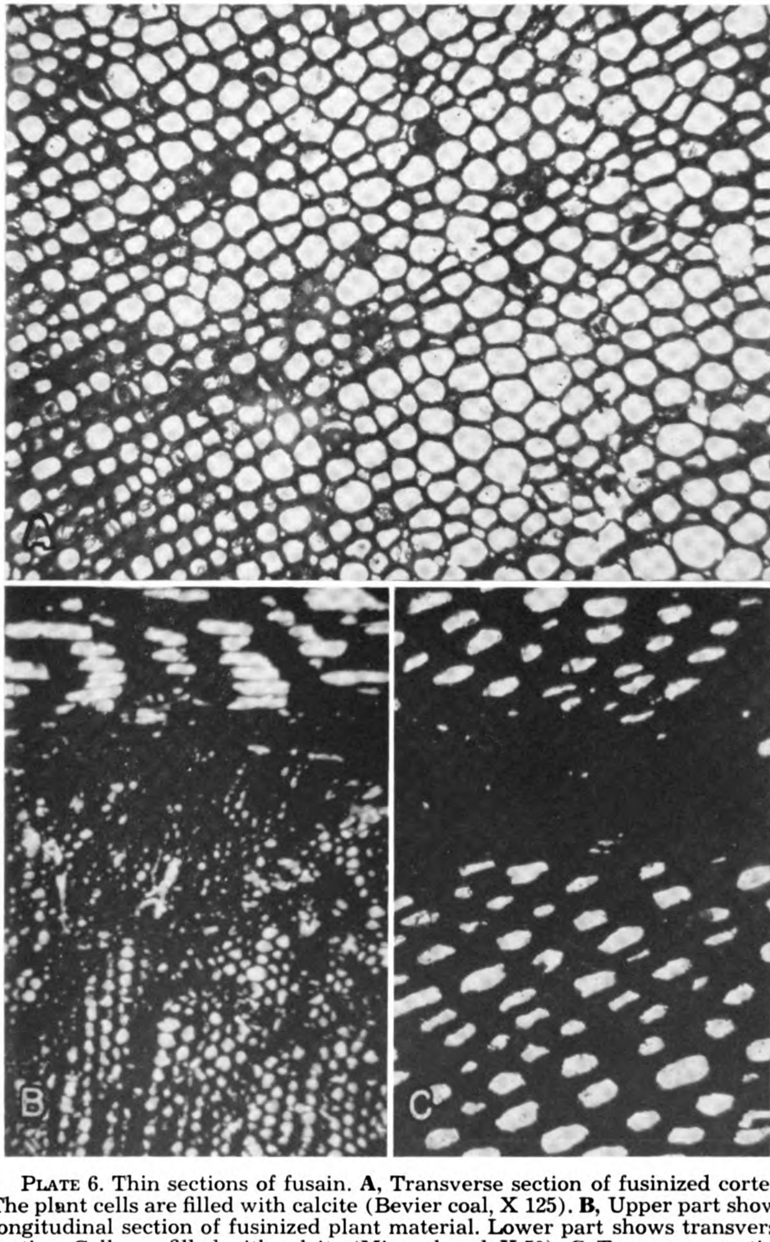

PLATE 6. Thin sections of fusain. **A,** Transverse section of fusinized cortex. The plant cells are filled with calcite (Bevier coal, X 125). **B,** Upper part shows longitudinal section of fusinized plant material. Lower part shows transverse section. Cells are filled with calcite (Mineral coal, X 50). **C,** Transverse section of fusinized thick-walled plant cells (Bevier coal, X 125).

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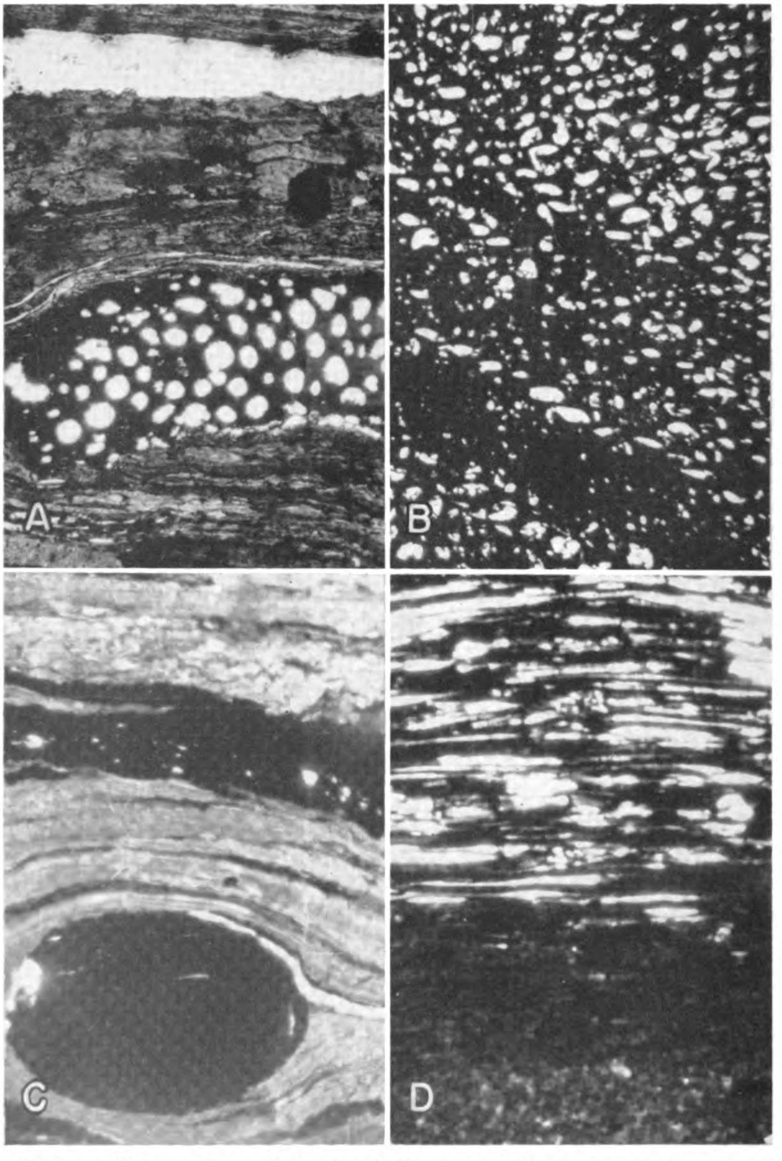

PLATE 7. Thin sections of fusain. **A,** Section of fusain lens in translucent attritus (Mineral coal, X 100). **B,** Fusain showing deformed plant cells (Mineral coal, X 125). **C,** Opaque body in lower part is a fusinized resin globule; opaque band above is fusain (Mineral coal, X 135). **D,** Material at bottom is anthraxylon. Note the change upward into opaque attritus and fusain (Mineral coal, X 50).

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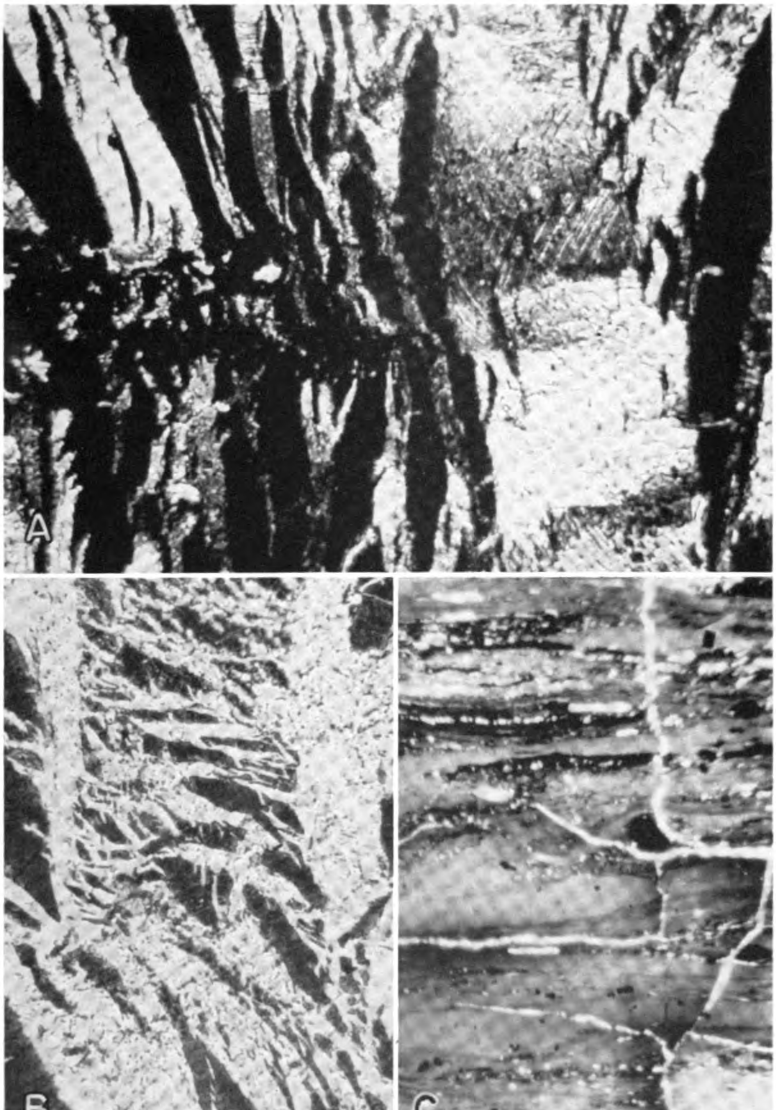

Plate 8. Thin sections of mineral matter in coal. **A,** Intricate pattern of calcite in minute fractures in coal, under crossed nicols. Note cleavage and twinning in calcite (Mineral coal, X 125). **B,** Calcite filling fractures in coal (Mineral coal, X 125). **C,** Section shows distribution of minerals along banding in translucent attritus. Small opaque bodies are pyrite; lighter bodies consist largely of clay minerals. Notice the cube of pyrite in the upper right corner (Mineral coal, X 120).

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tory funnel containing a 1.70 specific gravity solution of bromoform and carbon tetrachloride. Upon complete separation, the float-sink fractions were collected on filter paper, washed with acetone, dried, and weighed.

(2) The sink fraction was placed in a 2.90 specific gravity solution of tetrabrom-ethane and after separation, the float-sink fractions were collected and washed.

(3) Part of the 2.90 sink fraction was mixed with bakelite powder and mounted in a bakelite disc for polishing. The polished section was studied with a reflecting microscope. Color, hardness, internal reflection, and anisotropism were used to identify the opaque minerals.

(4) Both the float and sink fractions from the 2.90 specific gravity separation were examined with the aid of binocular, petrographic, and reflecting microscopes. Hydrochloric acid solubility, flame reactions, optical properties, and microchemical tests were used to identify the minerals.

(5) The thin sections prepared for column analysis were used to study the form and distribution of the minerals.

(6) Polished sections of pyrite nodules were made for study with the reflecting microscope and peels of the "coal balls" were made.

MINERAL ASSEMBLAGE AND DISTRIBUTION

Although the mineral content of Kansas coals is high, the kinds of minerals are few. Calcite and pyrite are the most important constituents. There are also lesser amounts of aragonite, marcasite, sphalerite, quartz, apatite, and clay minerals.

Detrital minerals.—The only known detrital minerals in the coals are quartz, apatite, and clay minerals. They are found mainly in the attrital portions of the coal and along bedding planes. A number of well-rounded grains of quartz and apatite were seen in the float-sink fractions of several samples. Clay minerals are the most abundant detrital constituents.

Calcite.—Calcite is the most important mineral constituent of the coals. It has two different modes of occurrence. The largest amount of calcite is found in cleats and dessication fractures where it may be associated with aragonite. The fractures usually traverse the coal normal to the bedding and may exhibit intricate, branching

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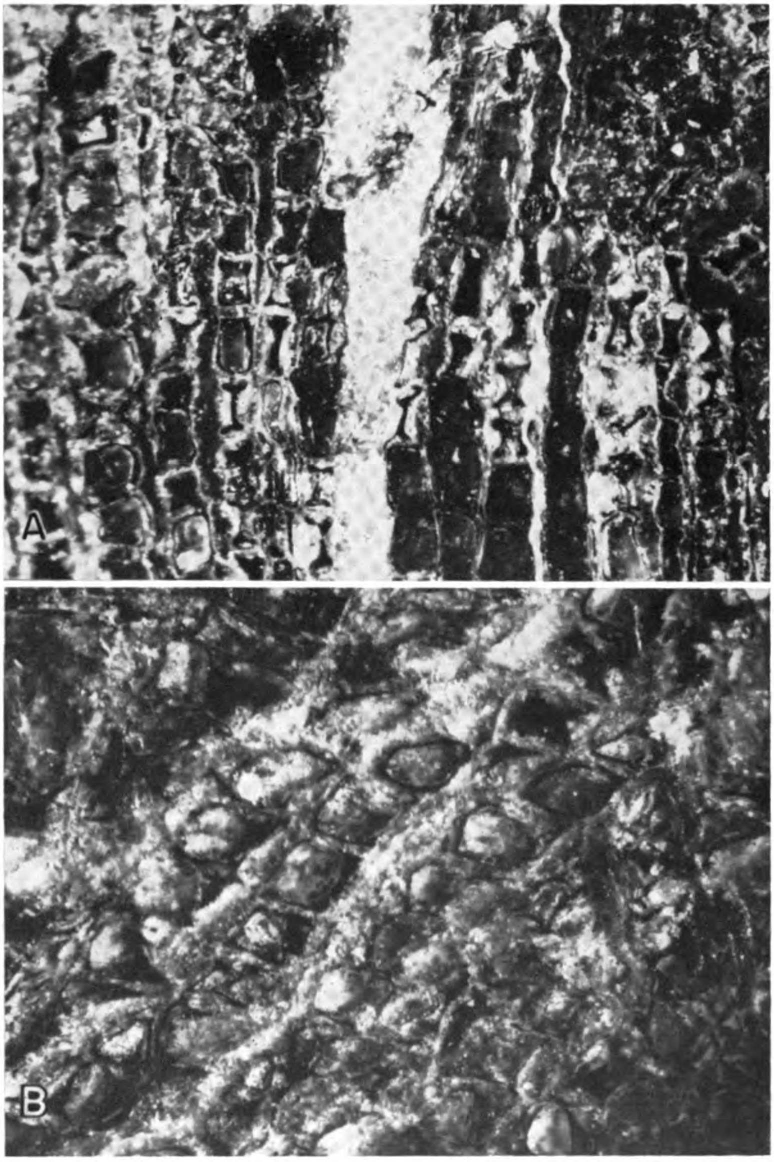

Plate 9. Calcite in "coal balls." **A,** Photomicrograph of a coal ball taken with a reflecting microscope using obliquely incident light. The material in the center of the boxlike cells is calcite; the original woody plant material is preserved in the cell walls (X 80). **B**, Same, showing different section of plant cells (X 85).

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patterns as shown in Plate 8 A and B. Aragonite was identified in the crushed samples by its orange color, fibrous appearance, and refractive index. In thin sections, the aragonite resembles calcite but usually can be distinguished by its biaxial interference figure and fibrous structure. It may grade into coarsely crystalline calcite which shows undulatory extinction, indicating that at least some of the calcite has resulted from an aragonite-calcite transition. Little is known of the stability range or the conditions favoring the precipitation of aragonite. Rankama and Sahama (1950, p. 470) state that ground water often precipitates calcium carbonate either as calcite or aragonite. The stability of aragonite is probably a sensitive function of the partial pressure of carbon dioxide, temperature, and pH. The fracture-filling type of carbonate probably was deposited after coalification since it is unlikely that such fractures could develop in plastic peat.

Calcite also occurs in the open spaces of fusain (Pls. 6 and 7) and as the impregnating material of "coal balls." This calcite probably was deposited prior to coalification since it provides structural support for the cells which could not have maintained their form unless they were filled before compaction of the surrounding coal. This type of calcite is easily identified in both the crushed samples and the thin sections. In the crushed samples, the cell walls are often broken away from the calcite so that it emerges as a cast of the cell interior and looks like a small, milled cylinder.

The "coal balls," which are found only in the Mineral coal, are of particular interest. They are nodules or laterally persistent bands of calcite-impregnated plant material. Since the original woody parts of the plant are preserved in the calcite, they have been an important source of information concerning the structure of coal-forming plants. Plate 9 shows two photomicrographs of polished "coal balls" taken with the aid of a reflecting microscope using obliquely incident light. Plate 10 is a projection print of a peel of the same material. In both cases, the original cell walls can be seen clearly.

Pyrite.—Pyrite is widely distributed throughout the coal beds and is occasionally associated with marcasite. It occurs principally as disseminations in the attrital parts of the coal as shown in Plate 8C. Well-developed cubes like the one in the upper right corner of the photograph can be seen in some thin sections. The small opaque particles in the photograph are also pyrite.

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Plate 10. "Coal ball" peel. The woody plant material is preserved in calcite and can be seen distinctly. Black material is coal (Mineral coal, X 16).

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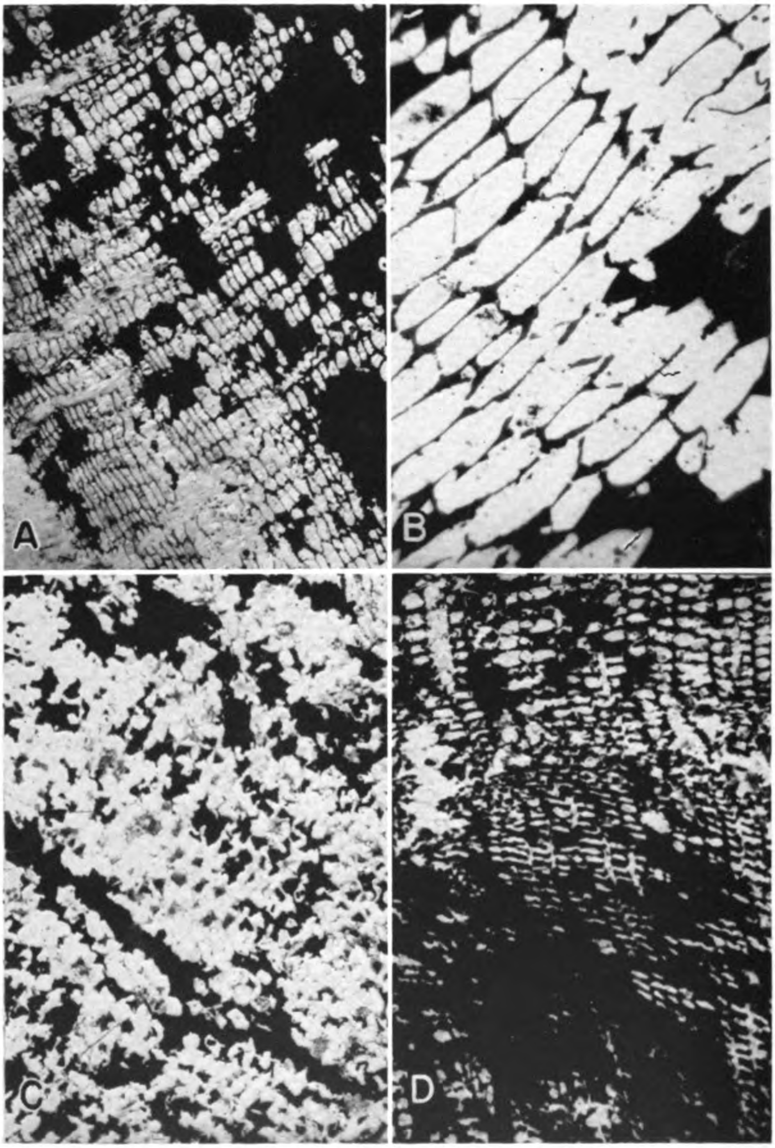

Plate 11. Pyrite in coal. Photomicrographs of polished sections taken with the reflecting microscope using vertically incident light. **A**, White material is pyrite; black material is calcite and coal. Pyrite has replaced calcite which originally filled cell cavities and has partially replaced coal (Mineral coal, X 95). **B**, Pyritic replacement of calcite at higher magnification (Mineral coal, X 375). **C**, Coalescence of pyrite where it replaces calcite and coal (Mineral coal, X 95). **D**, Pyritic replacement of calcite and coal. Plant cells have been somewhat deformed (Mineral coal, X 95).

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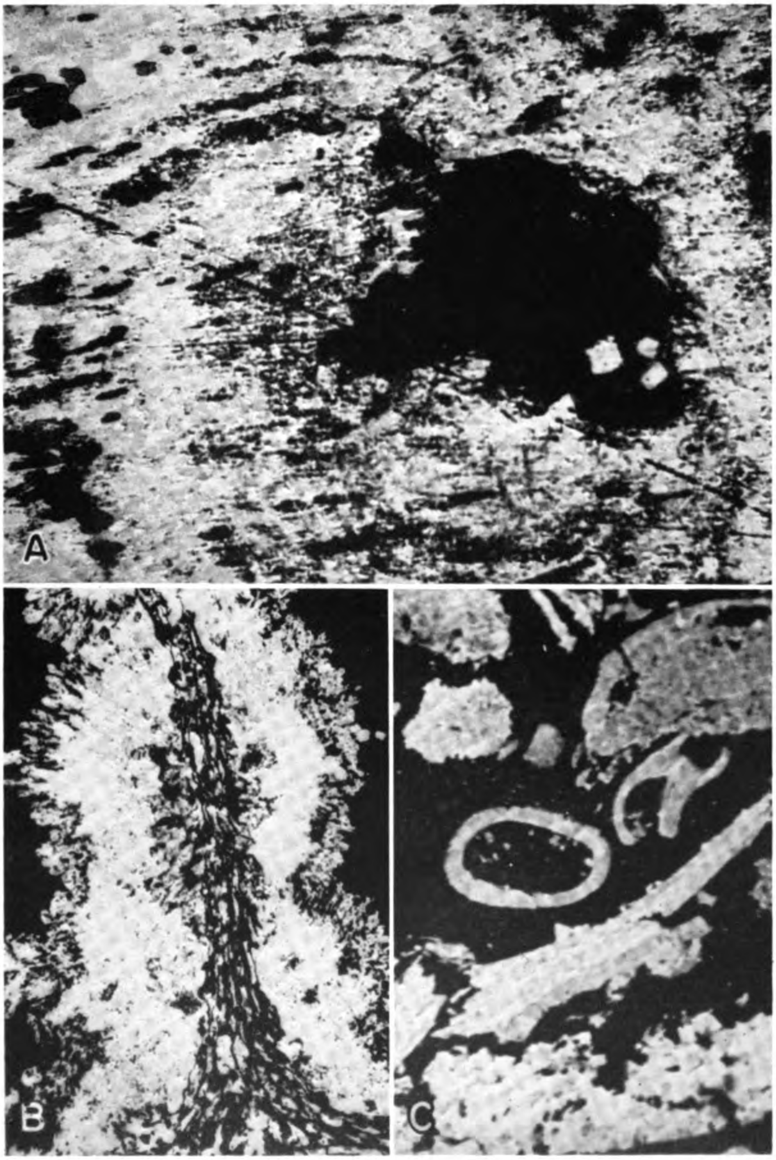

Plate 12. Pyrite in coal. Photomicrographs of polished sections taken with the reflecting microscope using vertically incident light. **A**, Transverse section of a plant stem replaced by pyrite. White material is pyrite. The stem is almost completely replaced at its periphery but is only partially replaced at the center (Mineral coal, X 95). **B**, Longitudinal section showing same relation as above (Mineral coal, X 95). **C**, Pyritized plant debris. Note transverse section in center (Mineral coal, X 95).

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Although quantitatively less important, the most interesting occurrence of pyrite is in nodules and bands. The distribution of these forms was shown earlier in the profile diagrams of the column samples. The nodules and bands of the Kansas coals are never simple, concretionary forms deposited along bedding planes, but are intimately associated with the plant material. In most cases, the pyrite replaces calcite which had either filled fusain open spaces or impregnated "coal balls." In other cases, the pyrite completely replaces the entire plant or coal material so that evidences of earlier calcite are entirely lacking. In some places, transitions from partially replaced calcite and plant material to massive pyrite are found. Relations of this kind were observed in polished sections. Plate 11 shows pyrite replacing the calcite filling of plant cells. In Plate 11A and B, the cell structure is preserved intact, for the most part, so that each cell is individually outlined in pyrite. Toward the lower left corner of Plate 11A, there are areas of more complete replacement. The white material in the photographs is pyrite, the dark partitions between the blebs of pyrite are preserved cell walls, and the remainder of the dark material is principally calcite. Plate 11C shows replacement of both calcite and coal. The areas of pyrite have begun to coalesce where calcite and coal are replaced. Plate 11D shows partial replacement and also illustrates minor deformation of the plant structure. Pyritic replacement of individual plant parts is illustrated in Plate 12. A transverse section of a stem in Plate 12A shows almost complete replacement of the peripheral part and only partial replacement of the central portion. Plate 12B is a longitudinal section of a stem which again shows only partial replacement in the pithy part of the plant. The difference in the character of the pith cells and the wood and cortex cells is rather well illustrated. Plate 12C shows a mixture of replaced plant debris. In one place, a transverse section of a replaced stem can be seen.

The origin of pyrite is somewhat problematic. However, most authors agree (see Rankama and Sahama, 1950, p. 668) that iron sulfide is precipitated in stagnant water in the presence of hydrogen sulfide. The processes which produce hydrogen sulfide are bacterial reduction of sulfoproteins, bacterial reduction of sulfates, and bacterial action on free sulfur. Dissolved iron compounds such as ferrous sulfate, as well as colloidal and precipitated ferric hydroxide, react with the hydrogen sulfide to form iron sulfide. Marcasite

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was identified in a few places. The presence of marcasite is not too surprising in the light of Buerger's (1934) studies of the pyrite-marcasite relation. Buerger points out that pyrite and marcasite can precipitate together—the proportion of marcasite being a function of the hydrogen ion concentration (e.g., the lower the pH, the greater the amount of marcasite).

Sphalerite.—Sphalerite is a minor constituent of the coals. Traces of it were found in the sink fractions of all but a few of the samples. No sphalerite was positively identified in the thin sections. This could easily be due to the loss of such a constituent in cutting to a thickness of 10 microns since much of the calcite could not even be saved. The sphalerite distribution can only be inferred from the angularity of the fragments in the crushed samples. In all probability it was deposited in the calcite-filled cleats and fractures.

The distribution of the mineral matter in the coal has historical significance in that it has served to indicate something of the origin of fusain. It might also be inferred from the extremely low content of detrital minerals in Kansas coals that extremely stable conditions prevailed during the time of coal accumulation.

COAL PETROGRAPHY AS RELATED TO COAL UTILIZATION

As early as 1923, Stopes and Wheeler had observed differences in the banded components of coal with respect to distillation and coking qualities. It is now recognized that the petrographic components of coal have differing chemical and physical properties and that these properties are of importance in effective coal utilization. Some of the physical and chemical properties of the petrographic components are summarized in the following discussion. Since a practical concern of coal petrography is to determine the significance of petrographic differences with regard to various utilization practices, some fields of application are suggested and the significance of mineral matter in coal is evaluated.

Physical Properties

SPECIFIC GRAVITY

Variations in specific gravity inherently due to type differences have been little explored according to McCabe (1945, p. 313). An-

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thraxylon is usually found to have the lowest apparent specific gravity whereas fusain has the highest. These differences largely reflect the ash content although pure fusain has a distinctly higher specific gravity than the other components. Some application of the property may be found in dust removal since a large part of the dust is composed of fusain. It is also possible that specific gravity differences could be utilized to prepare pure ingredients from Kansas coal should the need arise for a coal with particular properties.

RESISTIVITY

McCabe (1937, p. 277) reports that moisture-free vitrain (anthraxylon) and clarain (translucent attritus) are nonconductors. Fusain, in contrast, exhibited a low restivity. Davis and Younkins (1929) were thus able to separate fusain electrostatically from associated bone and mineral matter in the high specific gravity fraction. No efforts have been made to determine the feasibility of cleaning Kansas coal refuse by this method.

FRIABILITY

One measure of the strength of coal is its ability to withstand disintegration during handling. This is called friability and depends on toughness, elasticity, and fracture characteristics as well as on strength. However, the friability test is the measure of strength most frequently used. The work of McCabe (1936) on Illinois coals has shown that the petrographic components differ markedly in friability: fusain is structurally the weakest; vitrain (anthraxylon) is brittle but stronger than fusain; clarain (translucent attritus) is relatively strong and nonfriable; and durain (opaque attritus) is the strongest of the group. The counterparts of Thiessen's (1920) classification possess the same relative friability.

This information is of immediate significance in the mining process. For example, a coal bed high in fusain and anthraxylon responds more readily to cutting than does one high in opaque and translucent attritus. One the other hand, mines in splint coals are not as dusty, the proportion of lump is higher, not as much is lost in cleaning, but a larger charge is required in shooting. These factors influence total cost, ultimate recovery, and mine safety.

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Another concern is in the operation of washing plants. A coal high in anthraxylon and fusain will produce an excess of fines which have little market value and may cause a plant to operate below capacity.

The most important significance of variable friability lies in the field of coal preparation. McCabe (1936) has shown, from a petrographic study of screenings of the Illinois Herrin (No. 6) Seam coal, that the concentration of certain constituents can be brought about by mechanical processing, thus producing a type of coal concentrate having vastly different characteristics from the bed coal. He reported that, although the vitrain (anthraxylon) content was only 20 percent in the bed coal, in the 1.25-0.75 inch screen size it had increased to 42 percent and reached 79 percent in the minus 48 mesh size. Extended studies have also shown that, in the natural fine sizes of Illinois coals, the vitrain content increases as indicated above but that, in the minus 48 mesh size, the fusain content increases and finally exceeds the vitrain in the minus 100 mesh size.

This distribution of vitrain and fusain in the fine sizes of Illinois coals suggested that it might be possible to show the reverse relationship in Kansas coals—e.g., the distribution of fine sizes should be some function of the distribution of anthraxylon and fusain in the bed sample. Therefore, the ratio of opaque attritus plus translucent attritus to anthraxylon plus fusain was calculated as the independent variable for each of the column samples and designated the "nonfriability ratio." These data are tabulated in Table 10. It would have been more desirable to use the inverse relation and designate it the "friability ratio." However, within the

TABLE 10.—*Friability data*

Sample no.	Anthraxylon, percent	Fusain, percent	Nonfriability ratio*	Minus 18 mesh, percent	Sieve ratio**
Bn-2-B	54.4	5.4	0.67	17.8	4.6
Bn-3-B	45.5	6.1	0.94	18.2	4.5
Ck-4-M	41.1	5.9	1.1	18.2	4.5
Cr-13-B	49.8	10.5	1.2	16.8	5.0
Cr-9-B	38.3	3.5	1.4	13.1	6.3
Cr-6-B	33.7	5.1	1.6	15.1	5.6
Cr-1-C	21.0	13.1	1.9	12.3	7.1
Cr-4-M	21.3	8.2	2.4	11.1	8.0

*Ratio of opaque attritus plus translucent attritus to anthraxylon plus fusain.
**Ratio of percent of sample plus 18 mesh to percent minus 18 mesh.

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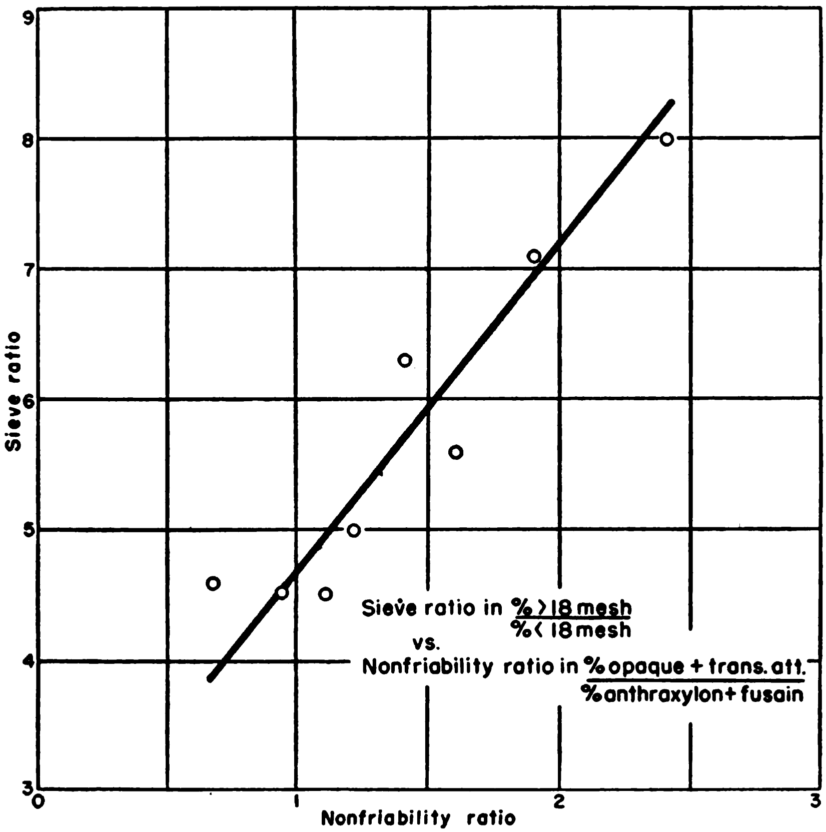

FIG. 5.—Distribution of fines as a function of petrographic composition.

range of Kansas coals the distribution of values is too narrow for convenient manipulation.

From the range of ratios, eight samples were selected which were representative of the possible values. The samples were crushed to one-half inch size in a Blake jaw crusher, cut to about 200 grams in Jones splitter, and sieved through an 18-mesh screen (1 mm). The minus 18 mesh size was weighed and the percent by weight determined. In order to narrow the spread of points in plotting the data, a ratio of plus 18-mesh size to minus 18-mesh size was calculated as the dependent variable and designated the "sieve ratio." These ratios are tabulated with the nonfriability ratios in Table 10. Figure 5 is the plot of nonfriability ratio versus

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sieve ratio and shows that there is a linear relation between the two. It is somewhat surprising that the relationship is shown so well since there are variables which have not been considered. For example, it might be expected that fusain would actually contribute more to the fine sizes than anthraxylon. Another difficult factor to evaluate is the mineral content of the coal. In the larger sizes it is probable that the mineral matter would act as a binder and reduce the percentage of fines whereas with finer crushing it might contribute appreciably to the fines. Since the ash content of the samples does not have a range of greater than 5 percent and since all the samples were subjected to standard treatment, it may be that the mineral matter contributed equally to all the samples.

Because the petrographic components differ in chemical behavior, their segregation according to relative friability imparts different properties to the various sizes of commercial coal. The ash content, ash-fusing temperature, volatile content, and coking qualities may differ. An understanding of such variations is important to the producer who is interested in maintaining a uniform product and to the consumer who is interested in a coal with particular characteristics. The petrographic composition is thus an important element of coal preparation since different coals can be blended and different sizes of the same coal can be mixed to obtain the desired characteristics.

As an example of practical importance, McCabe, Konzo, and Rees (1942) investigated the possibility of adapting banded ingredients for combustion in underfed domestic stokers since a high anthraxylon content results in excessive caking. Cady (1945, pp. 124-130) reports that other fields of application lie in coking or briquetting since fusain is noncoking and in excess of 15-20 percent acts to weaken the structure of the coke and briquettes.

Chemical Properties

There is much evidence that differences in chemical composition or behavior may be correlated with differing petrographic components. However, the results of such studies are sometimes regarded with reservation due to the inadequacy of chemical methods to determine completely the complex chemical structures. In addition, the petrographic purity of the material studied is not always beyond question.

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The general chemical nature of the components of coal is known largely through the research of Thiessen (1947) and his coworkers who have been able to relate coal structures to the structures of modern plants. Pollen, spores, cuticle, and algae are of a waxy and fatty character and hence are resistant to alteration. The waste products or resins of plant materials also fall in this general category. Probably the principal plant materials are lignin or cellulose since they predominate in the cell walls of the higher plants. Cellulose is a relatively unstable compound but it is at least represented by residues. The lignins alter to humic acid or humins.

PROXIMATE AND ULTIMATE ANALYSIS

Sprunk and others (1940, pp. 28-36) report that the average analyses of a number of associated bright and splint coals reveal significant differences if compared on an ash- and moisture-free basis. Splint coals are higher in fixed carbon, generally high in ash and ash-fusion temperature, and have a higher calorific value. Bright coals are lower in sulfur and higher in moisture, hydrogen, nitrogen, and oxygen and may thus have a higher total volatile content. However splints often contain abundant spores and resin so that the low volatile content due to the opaque constituents is increased and may be similar to that of anthraxylon. The higher sulfur and ash of splint coals may be attributed to the influx of clay, pyrite, and other mineral matter. The ash content of fusain is often unusually high because of mineral infiltration into open spaces and high adsorption capacity. Fusain is also lowest in volatiles and highest in fixed carbon. Since the Kansas coals are rather uniform in petrographic composition, it might be expected that their chemical composition would be fairly uniform as shown earlier.

CARBONIZATION

According to Sprunk and others (1940, pp. 37-49), splint coals yield smaller amounts of water of decomposition than associated bright coals and usually a smaller amount of gas. The coal tar and oil products seem to vary in either direction; doubtlessly a reflection of the spore and resin content since these constituents are high in waxes and oil. The relative coking qualities of the different types of coal are not certain. However, the coke yield seems to increase regularly with an increase in fixed carbon in both bright and splint

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coals. It is known that fusain does not coke and that its presence in large quantities prevents coking of the other ingredients. Hoffmann (1930) has shown that, although there are varieties of vitrain (anthraxylon) which will not coke, generally speaking it forms a better coke than durain (opaque attritus). On the basis of petrographic analysis, it seems that the coke yield of the Mineral, Croweburg, and Bevier coals should be good. However, the high ash and sulfur contents are responsible for an unsatisfactory product.

CHEMICAL REACTIVITY

Chemically, coals are natural polymers which may be investigated by studies of thermal decomposition in the presence or absence of solvents, oxidation, and reduction reactions. Lowrey (1942, p. 384), in a summary of such studies, shows that chemical reactivity usually decreases from brights to dulls to fusain and that there is no indication of the presence of essentially distinct types of chemical compounds peculiar to any of the ingredients of banded coal. They usually show a gradation of properties from one to the next.

HYDROGENATION

Hydrogenation is a reduction reaction which would be discussed under "Chemical Reactivity" except that it merits special attention. In areas of dwindling oil reserves, the conversion of coal to liquid fuel by hydrogenation has long been a subject of intensive investigation. Realizing that such a process might, at some future date, become essential to the power requirements of the United States, the Bureau of Mines has investigated the amenability of various types of coal to hydrogenation. Storch and others (1941) have described the process, the experimental plant, and assays of typical coals.

The essential differences between bituminous coal and petroleum are the higher ratio of the number of carbon atoms to hydrogen atoms in coal; the lower oxygen, nitrogen, and sulfur content of petroleum; and the lower molecular weight of the petroleum molecules. In order to produce petroleum-like material from coal, it is necessary to double the number of hydrogen atoms; to remove most of the oxygen, nitrogen, and sulfur; and to crack the coal molecules until their weight equals that of the petroleum molecules. In 1913, Bergius (1926) discovered how to add hydrogen

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to coal at a temperature of 450°C. and at 200 atmospheres hydrogen pressure. Under such conditions, most of the oxygen was eliminated as water, the nitrogen as ammonia, and the sulfur as hydrogen sulfide. A petroleum-like liquid resulted. Suitable contact catalysts subsequently were developed to increase the speed of hydrogen addition to the cracked coal.

Fisher and other (1942) have shown, on the basis of small-scale bomb tests of 129 samples, that bright coals are more suitable than splint coals for conversion to liquid products. The petrographic components may be classed into two groups with respect to yield. The first group is easily liquefied and includes anthraxylon and all the organic constituents of translucent attritus, such as woody degradation matter, leaves, spores, pollens, cuticle, and algae. This applies to coal containing less than 89 percent carbon on the moisture-free and ash-free basis. The second group is more difficult to liquefy and includes opaque attritus and fusain. The average yield of opaque attritus from splints is about 60 percent at 430° C. for 3 hours in the presence of stannous chloride with an initial hydrogen pressure of 1,000 psi. Individual samples of opaque attritus, however, show a range in yield from 39 to 79 percent. This was attributed to variation in opacity since the less opaque matter would be expected to hydrogenate more readily. Seven samples of fusain gave a yield ranging from 15 to 27 percent, indicating that it is the most resistant of all the petrographic components.

Considerable success has been attained in selecting the best coals for large-scale tests. Further, with the aid of microscopic analysis, it has been possible to predict the yield of acetone insoluble residue with a fair degree of accuracy. Predictions of this kind are made on the following basis, provided proximate analysis indicates less than 89 percent fixed carbon on a moisture-free and ash-free basis:

Ash and fusain	Should yield 100 percent residue
Opaque attritus	Should yield 38 percent residue
All other constituents	Should yield no residue

The extent to which liquefaction yield from hydrogenation can be correlated with and predicted from petrographic analysis depends upon the accuracy and completeness of the analysis. Better correlations should be obtained when the opacity of the petrographic components is more completely defined by physical cri-

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teria. Although the method is not completely accurate, it is adequate for rejecting unsuitable coals. In addition, the concentration of high liquid-yield components by mechanical processing based on petrographic analysis seems to be an imminent possibility.

No experimental hydrogenation yield data are currently available for Kansas coals but the probable yield has been calculated according to the method described above. The calculated probable residue yield for each column sample and the average calculated probable yield for the bed are tabulated in Table 11.

Since the predicted liquefaction yield is largely a function of translucency, the ratio of anthraxylon plus translucent attritus to opaque attritus plus fusain has been calculated and designated the

TABLE 11.—*Predicted hydrogenation residues*

Locality no.	Sample no.	Translucency ratio	Predicted yield, percent*
		Bevier coal	
19	Bn-3-B	6.1	9.3
20	Bn-2-B	8.8	7.3
21	Bn-1-B	4.7	16.6
22	Cr-9-B	11.7	5.3
25	Cr-5-B	4.4	16.1
26	Cr-6-B	8.2	7.4
27	Cr-7-B	11.1	5.6
30	Cr-12-B	7.9	8.6
31	Cr-14-B	6.0	8.6
32	Cr-11-B	8.9	7.0
33	Cr-13-B	5.8	12.2
34	Cr-10-B	6.9	8.5
35	Ck-1-B	6.4	8.6
37	Lt-1-B	4.7	10.6
Average		7.2	9.4
		Mineral coal	
1	Cr-2-M	13.3	5.4
2	Cr-4-M	9.4	8.8
3	Cr-3-M	7.7	8.9
9	Cr-8-M	4.4	13.9
15	Ck-5-M	9.7	7.7
16	Ck-4-M	12.7	6.5
18	Ck-2-M	13.3	6.1
Average		10.1	8.2
		Croweburg coal	
8	Cr-1-C	2.8	16.2

*Hydrogenation residue determined as follows: opaque attritus, 38 percent; fusain, 100 percent; all other constituents, none .

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"translucency ratio." An opacity ratio might have been used except that such values would have a narrow distribution for Kansas coals. This devise provides a simple method for characterizing the translucency or opacity of a coal in terms of a single value and could be used as a basis for describing regional variation.

No attempt has been made to plot regional variation in the Mineral and Bevier coals because the values seem to be erratic on the basis of relatively few data. Certain general observations can be made nevertheless. (1) The Bevier coal has a lower average translucency ratio than the Mineral coal and could thus be expected to produce a lower liquefaction yield. (2) The Mineral coal data are suggestive of a trend which could be substantiated only with additional information. Just north of Frontenac, the coal has a low translucency ratio and hence probably a low liquefaction yield. Both north and south of this low, the ratios increase although there is a considerable interval between this point and the nearest point to the south. (3) The coals are probably amenable to hydrogenation and should produce good yields except for the high ash content which contributes to the total residue. Beneficiation would undoubtedly make them more desirable for this purpose.

Significance of Mineral Matter

The distribution of the mineral matter in the coal is important from the standpoint of beneficiation. It has been shown that the principal minerals are pyrite and calcite which are intimately associated with the coal. The larger quantity of pyrite is finely disseminated and much of the calcite occurs either in fusain or in the finely branching parts of the fractures and cleats. Such a distribution means that the coal must be crushed to a fine size if most of the mineral matter is to be released or that a substantial part of the coal must be rejected as refuse if it is cleaned in a low specific gravity zinc chloride solution. However, some of the pyrite and calcite can be removed in the nodular form. It thus seems that the coals can be improved to a certain extent but that preparation of a low-ash coal concentrate is not economically feasible. In an effort to test this contention, ash determinations were run on two of the minus 60 mesh samples which were the float fractions from the 1.70 specific gravity separation. Ash determinations had also been made on the original samples. In one sample the ash content decreased from

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12.0 to 6.6 percent and in the other it decreased from 10.0 to 7.4 percent (decreases of 45 and 26 percent, respectively). In ordinary cleaning it would be impractical to grind the coal so finely or to use such a high-gravity solution.

No effort has been made to determine the effect of the mineral matter content on the chemical and physical properties of the coal. However, Gauger (1936) has been able to show the effect of mineral composition of the slagging characteristics of coal in carbonization studies.

SUMMARY AND CONCLUSIONS

The petrographic as well as the chemical and physical properties of the Mineral and Bevier coals of southeastern Kansas have been described in detail. Correlations which have been established are significant in the more effective utilization of the coals. The results of the study are summarized below.

(1) The average proximate chemical analysis (moisture- and ash-free basis) of the Mineral coal is 14,980 B.t.u., 5.1 percent sulfur, and 58.7 percent fixed carbon. The average ash content is 13.4 percent (moisture-free basis). The coal is remarkably uniform in composition. It is a high volatile A bituminous coal (A.S.T.M. rank designation) and should make a fair coke except for the high sulfur content. The average analysis of the Bevier coal is 14,690 B.t.u., 3.9 percent sulfur, 57.1 percent fixed carbon, and 17.7 percent ash. The rank and coking qualities are similar to those of the Mineral coal.

(2) The coals exhiibt a small, systematic regional variation in fixed carbon content which may be related to geologic structure. Fixed carbon increases from southwest to northeast.

(3) The coals were analyzed petrographically. They are finely banded attrital coals in which the anthraxylon bands do not exceed 5 mm in width, fusain is conspicuous, and opaque attritus is a relatively minor constituent. The types of coal and the percentage of components have been shown graphically for 22 column samples. The coals are bright coals which may contain thin bands of splint or semisplint coal near the top or bottom of the bed. The Mineral coal contains an average of 30.2 percent anthraxylon, 60.1 percent translucent attritus, 3.2 percent opaque attritus, and 6.9 percent fusain. The Bevier contains 37.9 percent anthraxylon, 49.2 percent translucent attritus, 5.9 percent opaque attritus, and 13.1 percent fusain.

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(4) The opaque constituents of the coal are difficult to identify due to a gradational relation with other constituents. The process which produces opacity in bituminous coals is uncertain. However, study of Kansas coals indicates that (a) the process (here called fusinization) which produces fusain may act upon any of the plant materials and the resulting degree of opacity is dependent upon the intensity and duration of the process, and (b) fusinization is operative in the early stages of coalification and may be local in nature.

(5) The ribbon transect method of analysis can be used for the comparison of column samples of coal. There are, however, a number of serious disadvantages. (a) The differences between anthraxylon and attritus, as well as between opaque attritus and fusain, are based on arbitrary critical size limits. Since the differences are of a more fundamental nature, they should be defined by significant chemical or physical criteria. (b) Another basis for differentiation is opacity. There are no critical limits for distinguishing opacity which is a function of the degree of fusinization, the thickness of the section, and the kind of illumination. Although it is difficult to cut coal sections to uniform thickness, standard illumination should be defined. (c) The term "opaque attritus" is misleading in those places where its gradation to anthraxylon is obvious. (d) Fusain is classified largely on the basis of its open cell structure. In those cases where the open spaces have not been supported by mineral matter, the crushed fusain resembles opaque attritus. Much fusain has undoubtedly been classified as opaque attritus. (e) The type classifications in current usage are not completely adequate. The results of petrographic analysis will be more reliable when a satisfactory classification has been devised.

(6) The essential mineral constituents of Kansas coals are calcite and pyrite. Aragonite, marcasite, sphalerite, quartz, apatite, and clay minerals are lesser constituents. Calcite occurs in cleats and fractures in the coal as well as in the open spaces of fusain. It is also the impregnating agent of "coal balls." Pyrite is found disseminated in the attrital material and replacing calcite and plant material.

(7) The relation of petrographic composition to coal utilization shows that there is a linear relation between the sum of anthraxylon plus fusain and the friability of the coal. On the basis of the percentage of opaque constituents, it is possible to predict the probable amenability of the coals to hydrogenation. Except for the

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high ash content, the coals should hydrogenate readily. Since most of the mineral matter in the coals is finely disseminated and intimately associated with the coal, it is doubtful that a low-ash concentrate is economically feasible. Ash determinations on two of the float fractions from 1.70 specific gravity separation show reductions in ash of 45 and 26 percent respectively.

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STATE GEOLOGICAL SURVEY OF KANSAS, BULLETIN 102
1953 REPORTS OF STUDIES, PART 2, PAGES 77-92, FIGURE 1, PLATES 1-2
JUNE 15, 1953

A SPINY APTYCHUS FROM THE CRETACEOUS OF KANSAS

By

ALFRED G. FISCHER AND ROBERT O. FAY

CONTENTS

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ILLUSTRATIONS

TABLES

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ABSTRACT

Surficial characters and internal structures of a new species of ammonoid opercula, *Spinaptychus sternbergi*, discovered in the Cretaceous Niobrara formation of western Kansas, are described and illustrated. The Kansas specimens are better preserved and larger than any previously described species of the genus and represent the first record of the genus from North America. Orientation of growth lamellae leads to the conclusion that *Spinaptychus* was not a strictly external structure, because the outer margins of its exterior surface at least evidently were covered by mantle tissues.

INTRODUCTION

Mr. George F. Sternberg, of the Fort Hays Kansas State College Museum, during years of collecting by himself and others, has obtained a number of ammonoid opercula from the Cretaceous Niobrara formation of western Kansas. Most of these aptychi are fragmentary, but two pairs are nearly complete. All belong to the genus *Spinaptychus* Trauth, previously recorded only from the Cretaceous of England and of Palestine. The material which Mr. Sternberg kindly turned over to us for study consists of two nearly complete pairs of aptychi, one fragmentary valve of extraordinarily large size, and numerous fragments.

SYSTEMATIC DESCRIPTION

Genus *Spinaptychus* Trauth, 1927

Records of the genus.—The genus *Spinaptychus* was established by Trauth (1927), with *Aptychus spinosus* Cox (1926) as its type. At the time of Trauth's publication, and seemingly to the present day, the type species is the only one referred to *Spinaptychus*. The genus is distinctively characterized by its ornamentation, the exterior surface being covered with tubercles which bear a pit at their apex.

Cox's specimens came from the *Micraster coranguinum* zone (Santonian, lower Senonian) of Kent, England. Cox illustrated an exterior view of a rather incomplete pair of valves, another likewise fragmentary exterior of a single valve, and the interior of a nearly complete valve. He also described, but did not illustrate, the internal microstructure.

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In 1929, the genus *Spinaptychus* was recorded by Picard from the Upper Cretaceous (Senonian, probably Campanian) of Palestine, near Jericho. The single specimen, a fragment showing the exterior surface and mold of the interior, was referred to *Aptychus* (*Spinaptychus*) *spinosus* Cox. The aptychus is covered with tubercles, but two possibly notable differences from *A. spinosus* are mentioned: (1) the pore at the top of the tubercle is elliptical rather than circular and (2) the tubercles are arranged rather loosely in concentric rows parallel to the lateral margin.

To our knowledge, these are the only documented occurrences of *Spinaptychus*. Therefore, it is especially interesting to find a distinctive aptychus of this type in the Smoky Hill chalk member of the Niobrara formation of the Cretaceous interior seaway of North America.

General morphology.—Like other aptychi, *Spinaptychus* occurs in bilaterally paired valves, which are thought to have served as opercula for the shell of some ammonoid. Each valve is slightly arched. The concave surface, which is marked only by growth lines (Pl. 2B), is interpreted to be the inner surface of the operculum attached to the flesh of the mantle.

The outer convex surface of the aptychus shows only faint growth lines, but is studded with tubercles, most of which bear a craterlike pit (Pl. 1B and D). The outline of each valve is roughly triangular. The short side of the triangle forms part of the dorsal side of the aptychus, which presumably fitted against the dorsal margin of the aperture. The inner, or harmonic, margins are relatively straight but sufficiently curved so that the valves, when laid out flat, are in contact along less than half of their length, gaping rather widely at the ventral end (Pl. 1B). The lateral and ventral margins form a continuous sweeping curve. The growth lines on the inner surface of the valves show that growth of the aptychus took place along the lateral and ventral margins only.

Along the harmonic margins is an outwardly convex and inwardly concave flange, which is narrow or absent in the dorsal (juvenile) region but expands progressively toward the venter (Pls. 1A, 2B).

Although Cox reported that his specimens were considerably altered by recrystallization, he distinguished three layers: (1) an

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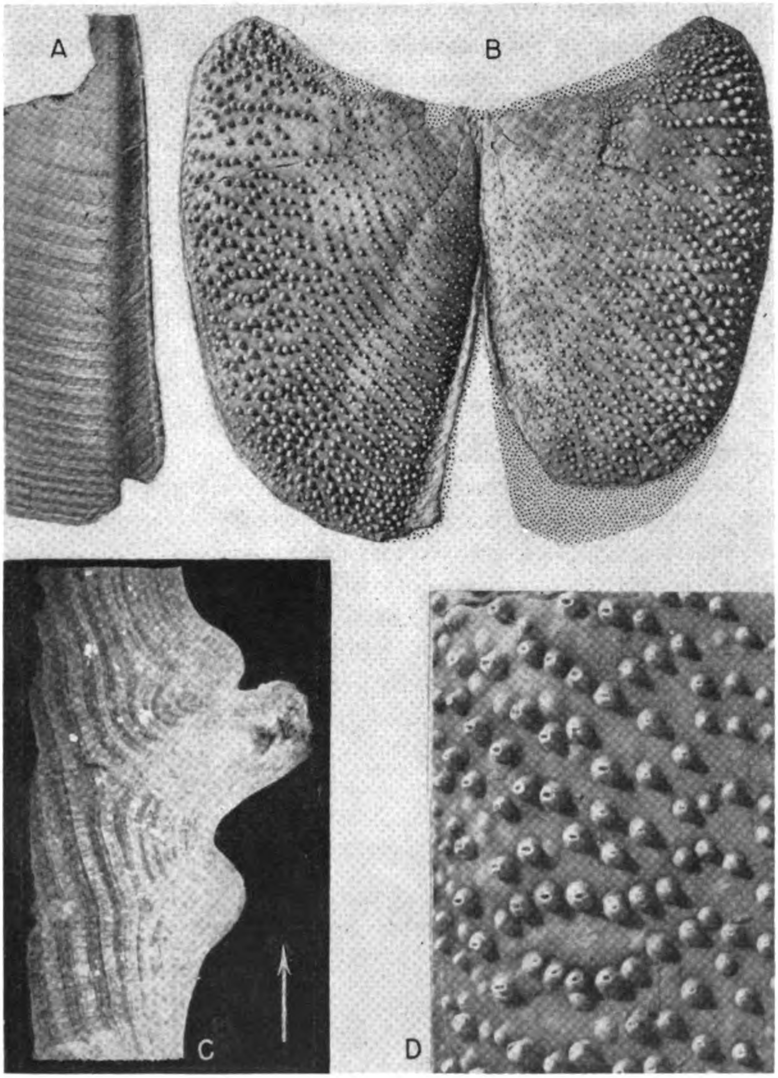

PLATE 1.—*Spinaptychus sternbergi,* n.sp., from the Niobrara formation of Logan and Gove Counties, Kansas. **A,** Paratype (Mus. no. 2683). Inner view of harmonic margin of left valve showing the nature of the harmonic flange (× 0.75). **B,** Holotype (Mus. no. 2022). Outer view (×0.45). **C,** Paratype (Mus. no. 2906). Projection print of transverse thin section of mature region, cut normal to growth lines, showing microstructure of shell. Tone of print is reversed. Arrow points to ventrolateral margin (× 8.25). **D,** Holotype (Mus. no. 2022). Enlarged portion of mature region of right valve near lateral margin (×1.2).

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inner dense layer; (2) a thick middle layer which had lost all structure owing to recrystallization; and (3) an outer laminar layer. The spines were described as hollow down to the level of the middle layer. Unfortunately, Cox published no illustrations of the internal structure. Cox's conception of internal microstructure is at variance with that observed in the Kansas specimens described below. These are similar in general surface character to *Spinaptychus spinosus* (Cox) but differ in outline, size, and pitting of tubercles. Clearly, our specimens represent a different species, which is here named for Mr. George F. Sternberg, the collector.

Spinaptychus sternbergi, n. sp.

Outline.—Measurements of our specimens are given in Table 1. The earlier and intermediate growth stages show a distinctly triangular outline, the ventral and lateral margins forming a continuous sweep to a rather sharp mid-ventral point (Pl. 2A and B). Later stages are somewhat more quadrate in outline (Pl. 1B). The width of our smaller specimens is 65 percent of the length, and the width of a larger specimen (holotype) equals 67 percent of the length. The angle between the dorsal and harmonic margins is about 104 degrees.

TABLE 1.—*Table of comparative data*

	Length (dorsoventral) mm	Width, mm	Inflation, mm	Thickness (maximum) of shell, mm	Apical angle	Angle of taper of harmonic groove	Width of largest spines, mm	Height of largest spines, mm	Unpitted spines	Shape of pits in spines
S. spinosus (Cox)	48-65	38-52	9	thin	90°	5°	2½	3	?	circ.
S. spinosus, Picard	55	48	?	?	80°	?	1½	1	?	ellipt.
S. sternbergi, n.sp.										
Holotype (2022)	150	82	11	?	?	4°	2	2	yes	ellipt.
Paratype (2685)	90	58	5	1	104°	5°	1	1	yes	ellipt.
Paratype (2683)	170	100-105	10	2½	104°	4°	2½	2½	yes	ellipt.

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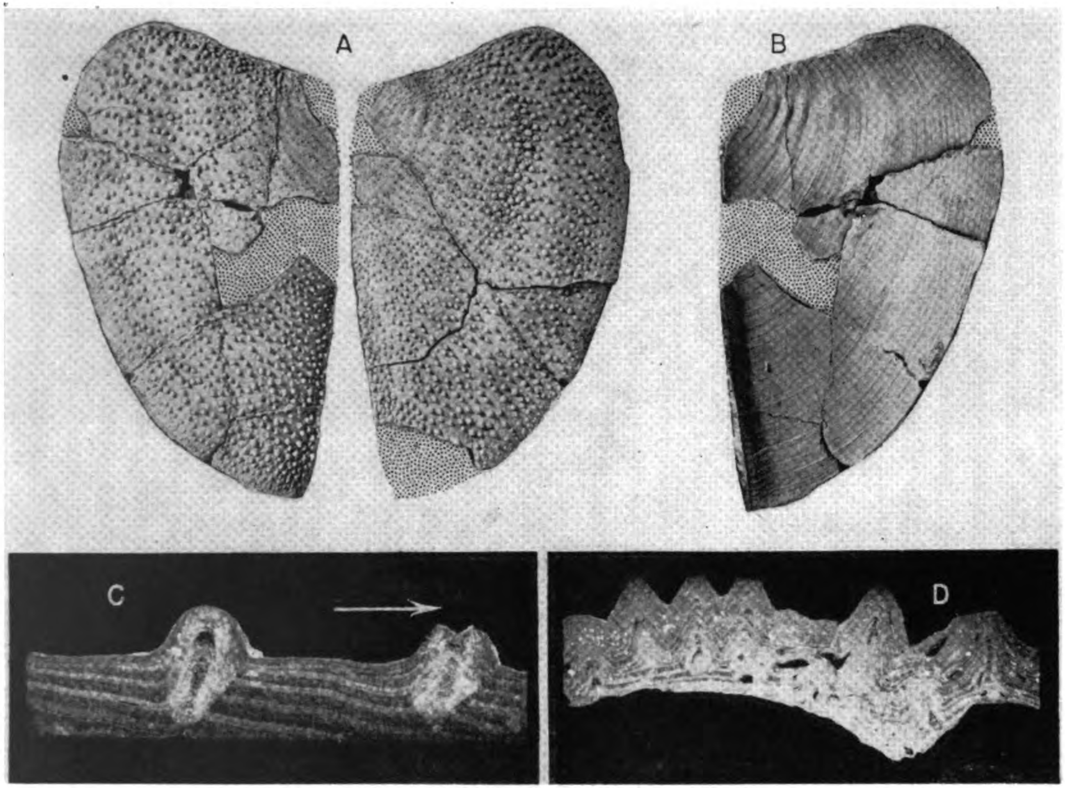

Plate 2.—*Spinaptychus sternbergi*, n.sp., from the Niobrara formation of western Kansas. **A, B,** Paratype (Mus. no. 2685). **A,** Outer view of right and left halves of an immature specimen. **B,** Interior of right valve. Both × 0.65. **C,** Paratype (Mus. no. 2907). Projection print of transverse thin section, normal to growth lines, showing canals in tubercles. Tone reversed. Arrow points to ventrolateral margin (×7.5). **D,** Paratype (Mus. no. 2908). Projection print of transverse thin section of valve, through harmonic flange (at right), parallel to growth lines. Tone of print is reversed (×4.5).

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Inner surface.—The inner surface of the valves is dull, partly discolored by carbonaceous matter in one of the specimens, and distinctly marked by growth lamellae. In the early stages these growth lamellae are broad and are separated by rather faint lines. The later growth lamellae, found near the margins of larger specimens, are narrower but are sharply separated, so that the periphery takes on a rugose appearance. The inner surface bears a well-defined harmonic flange (Pls. 1A, 2D).

Outer surface.—The outer surface is dense and lacks well-defined growth lines. It bears numerous tubercles generally distributed at random and varying in degrees of spacing. The tubercles on the juvenile portion near the corner between the dorsal and harmonic margins are nearly microscopic and are widely spaced. They become more closely spaced and larger toward the periphery, the largest tubercles reaching a height of 2.5 mm. Along the peripheral margins the tubercles are small, for these are not yet fully formed. Actual size and spacing vary from one specimen to another. Only one, the holotype, shows a concentric arrangement of tubercles in the immature parts of the valves. In more mature regions of the aptychi, the large pitted tubercles are not alone, for between them may lie irregularly scattered domelike mounds and unpitted tubercles of intermediate size. The more prominent tubercles in any region of the aptychus contain an elliptical pit at their tip, commonly surrounded by an elevated rim (Pl. 1D, Fig. 1A-C). The long axes of the pits are radially oriented, that is, normal to the growth lines. The region surrounding the pit seems to have been somewhat worn away as though the tips of the spines suffered abrasion.

Microstructure.—Thin sections of our well-preserved specimens (Pls. 1B; 2C and D) show a structure at variance with that described by Cox. The Kansas aptychi are essentially uniform in structure, composed of growth bands or laminae which were laid down successfully at the ventral and lateral margins. Each of these laminae slants peripherally from its termination at the outer surface to the place of disappearance on the inner surface of the aptychus (Pls. 1C, 2C; Fig. 1C). Each lamina terminates at the outer surface in a wedge-edge, which is hardly discernible in exterior view of the surface; it increases in thickness inwardly,

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so as to form a broad band on the inner surface of the aptychus. The laminae are alternately clear and turbid; the clear ones form ridges on the inner surface, whereas the turbid ones form the intervening depressions. Toward the exterior, the contrast between these laminae is lost because of prevailing turbidity of the shell structure. Both types of laminae are subdivided into thinner lamellae, which are crossed at right angles by the calcite fibers composing them. The orientation of growth laminae leaves no doubt that they were *laid down on the outer, convex side of the valves.*

Cross sections of the tubercles show that they are produced by upward doming of the laminae (Pl. 2C). As is also evident from surface inspection, newly formed tubercles at the edge of the aptychus are relatively small. Growth of the tubercles occurs by superposition of successive laminae.

Cox described the spines of his specimens as hollow down to the "middle layer" of the aptychus—that is, deep into the valve. The depth to which the pits extend in the tubercles of our Kansas specimens is not certain. We cut numerous sections in an effort to determine this matter and concluded that an open tube is probably restricted to the upper parts of the large tubercles (Pls. 1C, 2C and D; Fig. 1A-C). Sections needed for solution of this problem must be cut parallel to the axis of the spine. Since these axes generally are inclined and may be curved, one is likely to cut them obliquely. We believe that Plate 1C, Plate 2C (right tubercle), and Figure 1A and B are essentially parallel to the axes of some of the tubercles shown.

The small spines show a core of clear or cloudy calcite, crossed at intervals by single growth laminae. The structure suggests a pulpy, poorly calcified, perhaps vesicular core which became recrystallized and filled during diagenesis. Large tubercles are similarly built in the lower part, but are topped by a nipplelike protuberance, which contains an open canal (Fig. 1A).

The low nonperforate tubercles are revealed as blisterlike structures filled with coarsely crystalline calcite of secondary origin (Fig. 1C).

To sum up differences between observations of Cox on the English *Spinapytchus* and those made by us on the Kansas specimens. (1) We have not found a threefold division of the shell,

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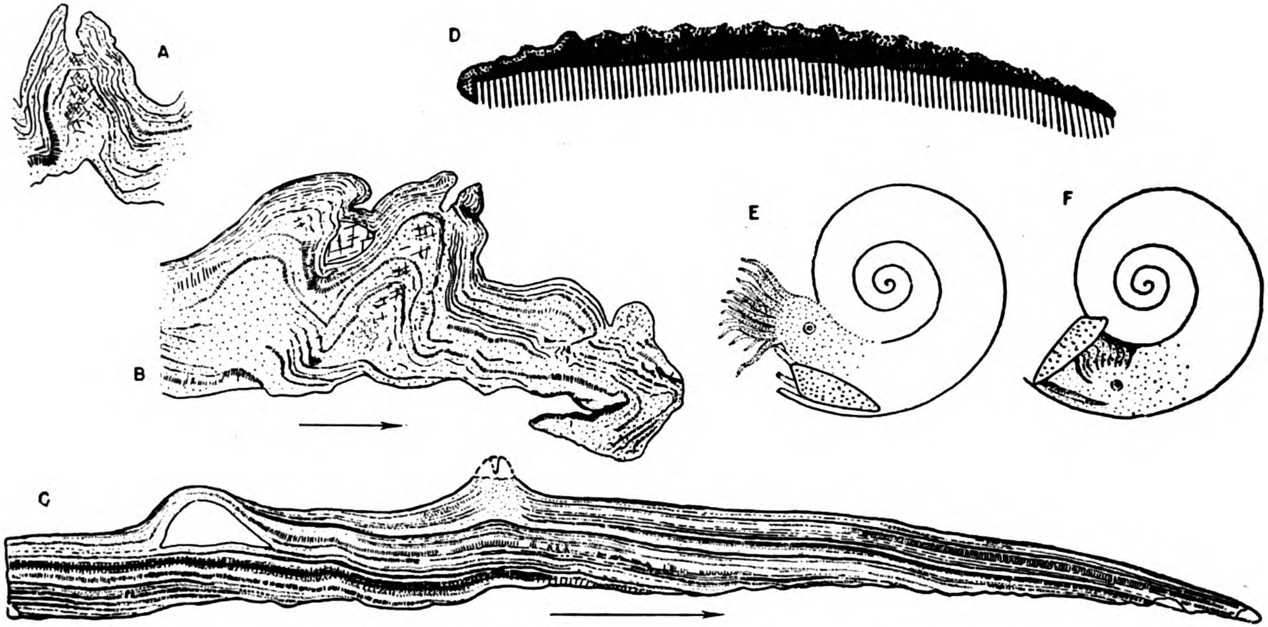

Fig. 1.—Thin sections and restorations of aptychi. Arrows indicate direction toward ventrolateral margin. **A**, Mus. no. 2684, section across a gerontic aptychus near ventrolateral margin (×15). Large tubercle showing canal in upper part and structureless calcite crossed by occasional growth laminae in middle and lower parts. **B**, Mus. no. 2684, thin section of tubercles of a gerontic aptychus close to ventrolateral margin which in this specimen is curled under (×15). **C**, Mus. no. 2907a, radial section cut to the edge of the ventrolateral margin of an immature specimen. Note imbrication of growth lamellae and cross section of nonperforate blisterlike tubercle (×24). **D**, Diagrammatic dorsoventral section of aptychus and restored tissues. Tissues of attachment are crosshatched, secreting tissue stippled. **E**, Restoration, head extended. **F**, Restoration, head withdrawn.

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but rather a uniform structure of imbricate laminae. (2) Furthermore, we are not convinced that the pores in tubercles of our specimens extended as tubes deep into the aptychus in the manner described by Cox. The question rises as to whether these differences may be sufficient to warrant generic distinction. We have not seen Cox's sections, and, lacking figures of them, we are doubtful as to actuality of difference in original shell structure of the British and American specimens. If the mid-portion of the aptychus sections illustrated in Plates 1 and 2 had been recrystallized, it is probable that we would have described our material as three-layered. Therefore, until proved otherwise, it seems reasonable to interpret major microstructure differences between Cox's description of *Spinaptychus* and our own observations of presumed *Spinaptychus* from Kansas as attributable to differences in preservation.

Although our specimens are judged to be congeneric with those described by Cox and by Picard, they differ from Cox's specimens in size, proportions, and the nature of the tubercles, and from Picard's specimens at least in size and shape.

As shown by their dimensions (Table 1), the Kansas specimens greatly exceed the others in size. They are narrower (laterally) and longer (dorsoventrally) than the form described by Cox and differ from both the British and Palestinian material in the nature of the dorsal margin. Picard's and Cox's forms show an angle of approximately 90 degrees between the harmonic and dorsal margins, whereas our specimens show an angle of 104 degrees. The dorsal margins of their specimens form a nearly straight line; the dorsal margins of ours form a concave embayment, designed to fit against a more deeply impressed whorl.

The tubercles of our two paratypes and of all the available fragments show a random distribution, as do those of Cox's species. The holotype of *Spinaptychus sternbergi* clearly differs from the type of *S. spinosus* from England but resembles Picard's specimen in having the tubercles of intermediate growth stages aligned parallel to the lateral and ventral margins. This alignment is not present in early stages and is lost in the adult. In the absence of other distinguishing characters, we believe that such alignment may be a matter of individual variation.

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Our specimens agree with the Palestinian one and differ from the British form (as described by Cox) in possessing elliptical rather than circular craters. Neither Cox nor Picard mentions the presence of nonperforate tubercles, which are abundant in our form.

It may be concluded, therefore, that our specimens are specifically distinct from the British and Palestinian specimens referred to *Spinaptychus spinosus* (Cox). The question may be raised as to whether all our specimens from Kansas are conspecific. Despite some variation in shape and ornamentation, we believe that they do belong to the same species. Size, distribution, and arrangement of tubercles may vary widely on a single specimen; subquadrate shape and the development of a great harmonic flange are clearly expressions of ontogeny.

Orientation and growth of Spinaptychus.—Descriptions of aptychi and attempts at explaining their zoological affinities and function have been made by many writers since the beginning of paleontology. Trauth (1927, 1928, 1931) summarized everything known about aptychi up to that time and added a wealth of new information. Trauth's conclusions on orientation and growth of aptychi are summarized below.

Fortunate finds of aptychi in position occupied during life have proved beyond doubt that they are skeletal structures of ammonoids which served as opercula to close the aperture. They have further substantiated the conclusion, previously reached on the basis of aptychus structure, that the convex side of the valves is the outer one and the concave side the inner one.

It has become so customary to interpret ammonoids by analogy with the modern *Nautilus* that one is tempted, at first glance, to interpret the aptychus as homologous to the *Nautilus* hood, the tough mass of tissue lying above the head and largely closing the aperture when the head is withdrawn. Trauth and others have shown that while the aptychus served the function of the nautiloid hood, it is not a morphological equivalent of this structure, for it was placed differently. The majority of aptychi found in association with shells are located within the living chamber, lying along its ventral margin. The dorsal margin of these aptychi points forward and the ventral margin toward the rear. The ex-

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ternal side is down, the internal side up. This orientation is so common and constant that it has become known as the normal position. It led some early observers to the erroneous conclusion that the aptychi functioned as protective shields over the female reproductive organs.

It seems only logical to conclude that the aptychi were carried normally in this position. When the head was retracted, the valves slid forward and upward to close the aperture. When the head was extended, the valves of the aptychus were presumably retracted below into a ventral mantle pocket.

This hypothesis is supported by other lines of evidence. It explains why the majority of ammonoid opercula are of the two-valved aptychus type rather than single shields (anaptychi), for in compressed shells a two-valved construction was necessary to permit folding of the operculum, which otherwise could not have been accommodated in the narrow ventral part of the living chamber. The hypothesis is further supported by observation that in many aptychi shell matter was added on the external surface of the valves (as in *Spinaptychus*). If the valves had been located in the position of the *Nautilus* hood, such deposits could only have been formed by a special mantle flap over their exterior. In the position envisaged by Trauth, this deposition could be accomplished by the ventral tissue lining of the pocket in which the aptychus rested when withdrawn.

Affinities.—The aptychi here described have not been found attached to, or in close association with, ammonoid conchs. We are not able to identify with certainty, therefore, the species or genus of ammonoid conch for which *Spinaptychus sternbergi* served as an operculum. Whatever its identity, the ammonoid which bore this aptychus must have been very large, and the cross section of its whorls must have been something between heart-shaped and subquadrate. Cox has suggested that *Spinaptychus* may belong to the so-called *Mortoniceras*, which subsequently has been renamed *Texanites* Spath.

Ammonoid conchs have been reported from the Niobrara formation (Morrow, 1935), but specimens evidently are rare and in this formation are found preserved only as molds. Morrow lists a questionable *Pachydiscus*, and the University of Kansas col-

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lections contain a *Texanites* from the Niobrara formation of Trego and Ellis Counties, Kansas. The latter specimen has a whorl cross section which seems to be an excellent fit for *Spinaptychus sternbergi.* Accordingly, we concur with Cox in judging that in all probability *Spinaptychus* constitutes the operculum of "*Mortoniceras*" (=*Texanites*).

The discovery of more aptychi than conchs in the chalk is almost certainly a matter of preservation. The aptychi, composed of calcite, are among the best preserved fossil remains found in the chalk, whereas the aragonitic conchs were dissolved during diagenesis and the resulting molds have been partly crushed or obliterated during compaction of the chalk. The conchs are therefore more obscure and less commonly collected.

The relationships of *Spinaptychus* to other types of aptychi are not clear. Little is known about the structure of Cretaceous aptychi, and most comparisons therefore must be made with the much better known Jurassic forms, none of which closely resembles *Spinaptychus.* The pitted tubercles covering the outer surface of *Spinaptychus* are unique. The black layer on the concave inner surface of the valves is the remainder of a conchiolinic "inner layer," a structure characteristic of the Jurassic cornaptychi (belonging to the harpoceroids). In other Jurassic calcareous ammonoid valves, this thin layer is calcified. Unlike *Spinaptychus,* the main layer of the cornaptychi is cellular. The imbrication of growth layers in our specimens suggests the structure of the Jurassic laevaptychi, but in these, again, the layer is cellular.

It seems, therefore, that *Spinaptychus,* while unique in ornamentation, is conservative or even primitive in terms of basic shell structure. Trauth's studies indicate that this may be true for other Cretaceous aptychi as well.

TYPES AND REPOSITORY

All types are deposited in the Fort Hays Kansas State College Museum, Fort Hays, Kansas.

Holotype.—Mus. no. 2022. Horizon: upper Smoky Hill chalk member, Niobrara formation. Locality: about 2 miles northeast

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of Pyramid rocks, Gove County, Kansas. Collector: George F. Sternberg in about 1942.

Paratypes.—Mus. no. 2083. Horizon: upper Smoky Hill chalk member, Niobrara formation. Locality: about 2 miles northeast of Pyramid rocks, Gove County, Kansas. Collector: George F. Sternberg.

Mus. no. 2296. Horizon: upper Smoky Hill chalk member, Niobrara formation. Locality: about 4 miles southeast of Elkader, Logan County, Kansas. Collector: Robert Taylor in fall of 1949.

Mus. no. 2683. Horizon: upper Smoky Hill chalk member, Niobrara formation. Locality: 3 miles southeast of Elkader, Logan County, Kansas. Collector: Robert Taylor on October 8, 1949.

Mus. no. 2685. Horizon: upper Smoky Hill chalk member, Niobrara formation. Locality: about 4 miles southwest of Castle Rock, Gove County, Kansas. Collector: George F. Sternberg.

Mus. no. 2906. Horizon: Niobrara formation. Locality: Logan and Gove Counties, Kansas.

Mus. no. 2907. Same as no. 2083.

Mus. no. 2907a. Same as no 2083.

Mus. no. 2908. Same as no. 2683.

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State Geological Survey of Kansas, Bulletin 102
1953 Reports of Studies, Part 3, Pages 93-104, Figures 1-3
October 1, 1953

COMPOSITION OF SOME URANIUM-BEARING PHOSPHATE NODULES FROM KANSAS SHALES

By

Russell T. Runnels, John A. Schleicher, and
H. S. Van Nortwick

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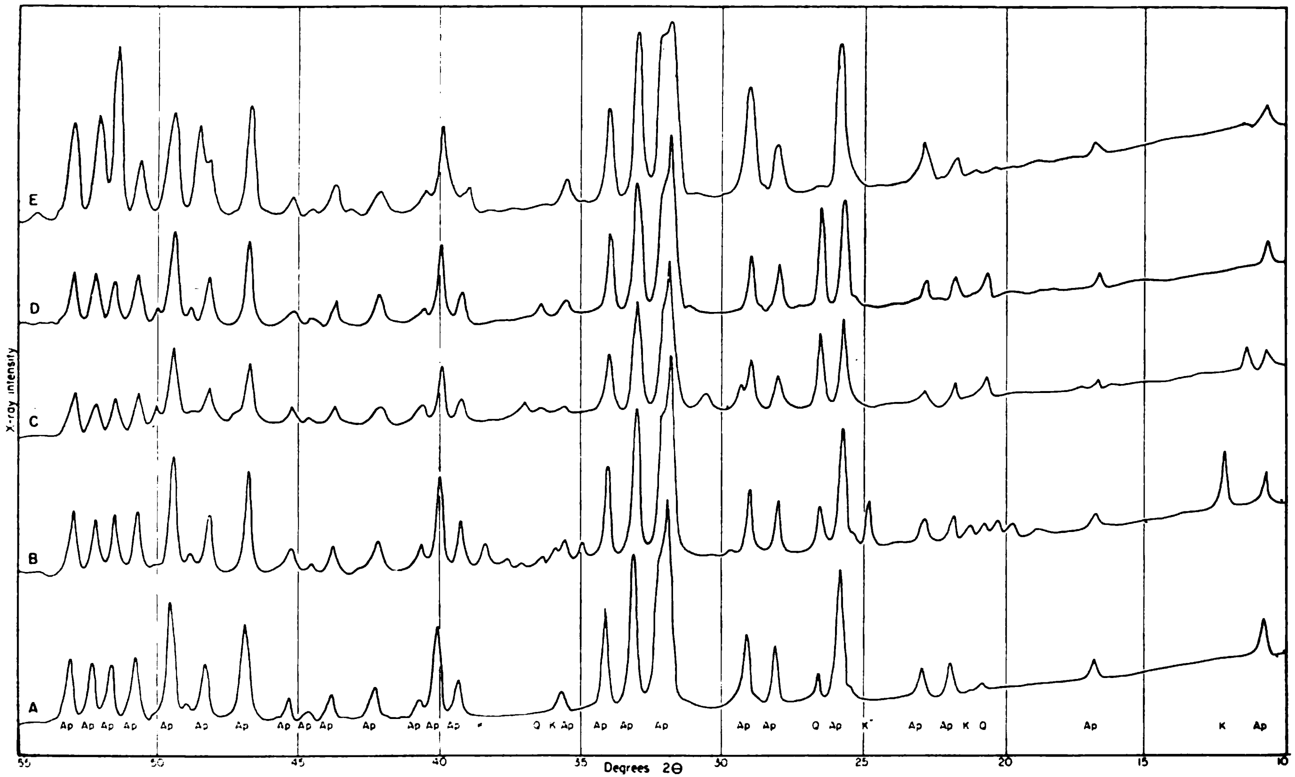

Fig. 1.—Smoothed traced spectrogoniometer record of x-ray scattering distribution. **A,** 5020, nodules from Muncie Creek shale; **B,** 52263, nodules from Heebner shale; **C,** 5021, nodules from Pleasanton shale; **D,** Bureau of Standards 56b, Tenn. brown rock phosphate; **E,** crystalline fluoapatite. Abbreviations: Ap, apatite; Q, quartz; and K, kaolin. Records prepared by Ada Swineford using nickel-filtered copper radiation.

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ABSTRACT

Detailed analyses of uranium-bearing phosphate nodules from 11 localities in eastern Kansas are reported. Seven Pennsylvanian shales were sampled. Graphs showing relationships between phosphate content and several constituents, including uranium, are presented. Combined evidence suggests that the nodules consist of collophane and dahllite with varying mixtures of impurities, primarily quartz and clay. The average composition of the 11 samples was 30.2 percent P_2O_5, 0.017 percent U_3O_8, and 3.2 percent fluorine.

INTRODUCTION

During the last 5 years the scope of the studies on eastern Kansas black shales by the State Geological Survey has been expanded from investigations of their possible utilization as fertilizers to the determination of their shale oil content, and more recently to the long-range search for uranium reserves. According to releases to the public press the Atomic Energy Commission has developed an economically feasible method for extraction of uranium from rock phosphate during the manufacture of superphosphate fertilizer. If these phosphatic nodules from black shales can be utilized, another large reserve of uranium will become available. Detailed analyses of the different nodules were required as a first step.

In 1949 the State Geological Survey of Kansas published a report on phosphatic shales in eastern Kansas (Runnels, 1949), and in 1952 a report on oil shale (Runnels and others, 1952) treating many of the same stratigraphic units was published. This has indicated several possible uses of the shale in bulk without special beneficiation or separation. During the course of these studies, samples of the phosphatic nodules that occur in the shales were collected and this paper reports the results of analyses of these concentrated nodules freed from the shale matrix that contains them. Metallurgical studies directed toward the development of economically feasible methods of separation of nodules from shale are now being conducted (summer 1953) by Kenneth E. Rose in our laboratories. Although the potential future value of the uranium content of these nodules is not known, the fact that their phosphate content is roughly comparable to that of commercial rock phosphate makes them of interest as a potential fertilizer source.

GEOLOGY

The 11 locations reported here include samples from seven different shale beds of Pennsylvanian age. The samples were selected

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to cover possible changes in composition or mineralogy with changes in stratigraphic positions. Some thin shale beds from coal stripping areas were studied because of availability, whereas other shale beds were selected because of the large reserves they contained.

In ascending order the shales examined are described below (Moore and others, 1951).

Shale from the Cherokee group.—The shale above the Mulky coal was tested. This shale occurs uniformly below the Fort Scott limestone a few feet above the Mulky coal. It is black fissile shale with abundant round to oval phosphate concretions throughout. Because of the general availability of this shale, samples were collected from several locations in Crawford and Labette Counties (Table 1, lab nos. 5022, 50545, and 50546).

Little Osage shale member.—Nodules from the Little Osage shale member of the Fort Scott limestone were collected because of the general uniformity of the shale as well as availability of the unit due to quarrying of the Fort Scott limestone. Shale oil analyses from this unit were uniformly high. One sample of nodules was obtained from this shale (Table 1, lab no. 50547).

Anna shale member.—The Anna shale member of the Pawnee limestone, which occurs just below the Myrick Station limestone member, was sampled because of the abundance of the nodules. In general, this shale is not readily accessible; however, the general purity of the nodules (34 percent P_2O_5) and the rather high value of uranium (0.02 percent U_3O_8) prompted its consideration.

Lake Neosho shale member.—Two samples were obtained from the Lake Neosho shale member of the Altamont limestone. In the sample from Linn County (Table 1, lab no. 5023) the nodules were collected from a weathered remnant of shale. As the nodules were somewhat anomalous chemically, a fresh sample was obtained from Crawford County (Table 1, lab no. 50548) for comparison.

Shale of the Pleasanton group.—The Pleasanton group contains a shale which has a consistent black fissile bituminous facies and which crops out from northern Neosho County to southern Labette County. This bituminous facies gradually increases in thickness from less than 15 feet in the northern part of Neosho County to about 30 feet in the vicinity of Parsons, Kansas. Most of this thickness was exposed in a county quarry 6 miles south and 4 miles west of Parsons (Table 1, lab no. 5021). The top 18 feet is barren of

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TABLE 1.—*Location and description of shales sampled*

Graph no.	Lab no.	County	Location	Stratigraphic horizon	Thickness, feet
1	5020	Wyandotte	12-11-24E	Muncie Creek shale member, Iola limestone	3
2	5021	Labette	SE SE 17-32-19E	Pleasanton shale	6 ft. zone, possible 10 ft. additional
3	5022	do	SE NE 16-33-21E	Shale above Mulky coal, Cherokee shale	3
4	5023	Linn	NE NE 8-22-24E	Lake Neosho shale member, Altamont limestone	weathered remnant
5	50545	Crawford	SW SE 16-31-23E	Shale above Mulky coal, Cherokee shale	3
6	50546	Labette	NE NW 2-35-20E	do	3
7	50547	do	NW SW 9-34-20E	Little Osage shale member, Ft. Scott limestone	4
8	50548	Crawford	SW NW 30-29-21E	Lake Neosho shale member, Altamont limestone	4
9	50549	Labette	NW SW 3-33-20E	Anna shale member, Ft. Scott limestone	4
10	52263	Douglas	SW 25-12-19E	Heebner shale member, Oread limestone	3
11	52331	Wilson	NE SW 29-29-17E	Muncie Creek shale member, Iola limestone	3

nodules but the next 10 feet, and possibly more of the unit, shows numerous if not abundant nodules. These nodules are somewhat different than many of the others in that they often have a core of iron sulfide. The shale itself contains a higher than average amount of iron sulfide. The nodule-bearing portion of this shale crops out over a wide area which is generally favorable for stripping and as such represents a very large reserve.

Muncie Creek shale member.—Nodules from the Muncie Creek shale member of the Iola limestone were the first to be examined in this study. The Wyandotte County location (Table 1, lab no. 5020) yielded nodules that averaged 37.1 percent P_2O_5 and 0.03 percent U_3O_8. There is much evidence that these nodules have been reworked, probably being redeposited during final deposition and initial compaction of the shale. Another sample from the Muncie Creek shale taken in Wilson County (Table 1, lab no. 52331) about 150 miles south showed well-formed nodules with no evidence of reworking. These nodules seem to reflect the general silty nature of the shale.

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Heebner shale member.—The Heebner shale member of the Oread limestone is a persistent black shale occurring between the Plattsmouth and Leavenworth limestone members. The shale is well known to oil men because of its very large gamma ray emission. The nodules collected from a fresh outcrop in Douglas County (Table 1, lab no. 52263) were generally well formed and numerous. The abundance was about the same as in other shales. However although the phosphate content was fairly high (32 percent P_2O_5), the uranium content was not anomalous (0.017 percent U_3O_8).

LABORATORY PROCEDURE

Preliminary treatment.—All samples of nodules were separated manually from the shale matrix. Usually this necessitated only removing a few pieces of shale clinging to some of the rougher nodules. Sometimes a tumbling action in the sample bag was sufficient. In a few instances the nodules were rinsed quickly in distilled water and allowed to dry in air. The clean nodules were then crushed in a small jaw crusher and split in a Jones riffle splitter until two samples of approximately 50 grams remained. This laboratory sample was ground by hand to pass an 80-mesh screen, placed in small paper sample bags, and stored in the chemistry laboratory.

Chemical analyses.—Chemical analyses for phosphate, fluorine, uranium oxide, calcium oxide, silica, alumina, total iron as ferric oxide, magnesium oxide, sulfate sulfur, sulfide sulfur, potassium oxide, sodium oxide, and loss on ignition were made (Table 2). Uranium oxide was the most critical component and because of its small percentage was one of the more difficult analyses.

Since expensive equipment for so few samples did not seem to be justified, a gravimetric method described by Hillebrand (Hillebrand and Lundell, 1946) was selected. This method is based upon the fact that sexivalent uranium is not precipitated by cupferron reagent thus allowing iron, vanadium, titanium, zirconium, tin, and copper to be separated. The sexivalent uranium can then be passed through mercury amalgamated zinc in a Jones reductor to reduce it to quadravalent uranium which can be collected by cupferron. The only disadvantage to this method is the relatively large blank determination obtained from the reagents used, primarily nitric and sulfuric acids even of "reagent grade."

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TABLE 2.—*Chemical analyses of nodules*

Lab no.	P_2O_5	U_3O_8	F	CaO	L.O.I.*	SO_3	S	SiO_2	Al_2O_3	MgO	Fe_2O_3†	TiO_2‡	K_2O	Na_2O
5020	37.34	0.03	4.03	52.46	4.55	nil	0.30	0.93	2.99	0.64	0.30	0.21	0.09	0.07
5021	27.22	0.011	2.84	42.32	11.71	0.94	2.53	6.93	2.57	0.11	6.65	0.21	0.24	0.25
5022	28.62	0.024	2.76	39.78	8.97	0.11	0.15	12.29	6.75	0.77	1.26	0.24	0.08	0.05
5023	28.23	0.007	3.51	44.27	7.19	nil	0.21	11.33	6.18	0.81	1.72**	-	-	-
50545	24.72	0.010	2.45	35.02	9.68	0.17	0.96	18.94	6.12	0.05	3.42	0.57	0.29	0.22
50546	29.01	0.010	2.99	42.12	9.71	0.13	0.09	10.37	6.03	0.08	1.04	0.37	0.03	0.05
50547	30.88	0.029	3.40	44.71	11.14	0.15	0.63	6.93	2.64	0.32	1.77	0.54	0.31	0.21
50548	30.44	0.021	3.43	43.74	10.39	0.12	0.70	8.86	2.59	0.20	2.38	0.43	0.03	0.04
50549	34.10	0.020	3.62	47.77	6.81	nil	-	4.07	1.25	0.11	2.47	0.37	0.03	0.05
52263	31.95	0.017	3.24	46.38	6.29	0.44	0.05	6.73	5.08	0.35	0.48	0.36	0.26	0.36
52331	29.93	0.007	2.94	42.11	9.51	1.05	0.03	7.10	3.94	0.37	4.02	-	0.45	0.30

*Loss on ignition 105°C. to 1000°C.
†Total iron expressed as ferric oxide.
‡Precipitated gravimetrically with cupferron.
**TiO_2 not separated.

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Fluorine was determined by steam distillation of fluosilicic acid collected in water and titrated with thorium nitrate using an indicator composed of alizarin red and zirconium nitrate. This method as described in Scott (1939) gave precise results with fluorine contents ranging from more than 4 percent to as low as a few tenths of 1 percent. Duplicate results were obtained with Bureau of Standards samples 56b and 120.

The other determinations made were by methods usually used for rock and mineral analysis. General references are Kolthoff and Sandell (1946), Hillebrand and Lundell (1946), Scott (1939), and other comparable texts.

X-ray diffraction patterns.—X-ray diffraction was used on three of the nodule samples. Ada Swineford, petrographer and clay mineralogist for the Geological Survey, prepared spectrogoniometer records of three nodule samples, one specimen of crystalline fluoapatite, and the U. S. Bureau of Standards sample 56b. Nickel-filtered copper radiation was used.

Differential thermal analyses.—Differential thermal analysis was performed on two nodule samples by Norman Plummer, geologist in charge of the ceramics division, using a Leeds and Northrup instrument.

DISCUSSION OF RESULTS

The x-ray diffraction analyses showed two major facts: (1) the d-values for the (231) and (004) reflections and the spacings between them from the phosphate compounds agree with the values given by Silverman, Fuyat, and Weiser (1951) for a carbonate-fluoapatite and (2) the largest impurity is quartz. The presence of quartz is not surprising as the shales themselves contain a large percentage of silt. It is surprising, however, that clay and possibly small amounts of iron and aluminum phosphates were not found. A small percentage of kaolin mineral was noted in sample 52263. Figure 1 shows the x-ray diffraction data on the five samples.

Other observations that can be made from Figure 1 are: (a) there are very few differences between the nodules and the "phosphorite" 56b; (b) the Heebner shale sample (52263) is the only sample which shows any clay, and the kaolin reflections are very sharp, suggesting large well-defined crystals; (c) there are almost no unexplained peaks. This is of interest since the chemical analy-

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TABLE 3.—*Calculated values from nodule composition*

Element	Average composition	Calculated composition of major constituents*	Theoretical fluoapatite	Theoretical dahllite
P_2O_5	30.2	37.6	42.22	41.32
CaO	43.7	54.4	54.01	52.86
F	3.2	3.98	3.77	-
U_3O_8	0.017	0.021	-	-
L.O.I**	8.7	(CO_2) 3.9	-	(CO_2) 5.82

*Using 3.2 percent CO_2 to obtain a total of 80.34 percent major constituents.
**Loss on ignition 105°C. to 1000°C.

ses show sufficient impurities in all the sedimentary phosphates (both nodules and 56b) to be detected by x-ray diffraction if combined in one or two compounds.

Because of the impurities reported by chemical analysis and not detected by x-ray diffraction techniques, two samples of nodules were subjected to differential thermal analysis techniques. No extraneous compounds were found, and in general the method substantiated previous conclusions that the primary mineral present is a carbonate-bearing fluoapatite. The small amount of kaolin in sample 52263 was detected.

In an effort to determine more closely the mineralogical form of the phosphate mineral (or minerals) in the nodules, the average composition of the 11 samples was calculated for comparison with the theoretical value of the various phosphate minerals. Table 3 shows this average composition. It also shows theoretical composition of fluoapatite and dahllite. An approximate recast of the major compounds in the average nodule analysis was made by assuming 3.2 percent carbon dioxide (Silverman, Fuyat, and Weiser, 1951). It is of interest to note that the calculated recast shows higher fluorine than theoretical apatite, while phosphate is definitely lower than theoretical, and calcium is about the same.

Rankama (in Rankama and Sahama, 1949, p. 217) states: "Collophane, the microcrystalline carbonate-fluoapatite, and dahllite (oxyfrancolite) are the chief phosphate minerals present in marine phosphate nodules." This author states (p. 591) that modern nodules collected on the coast of Southern California average 67 percent $Ca_3(PO_4)_2$ with a fluorine content of 2.47 to 3.36 percent.

It was necessary to establish a uniform method for comparing the various samples. The most logical method seemed to be a series of graphs (Figs. 2 and 3). These graphs plot phosphate content against uranium oxide (Fig. 2A), fluorine (Fig. 2B), and calcium

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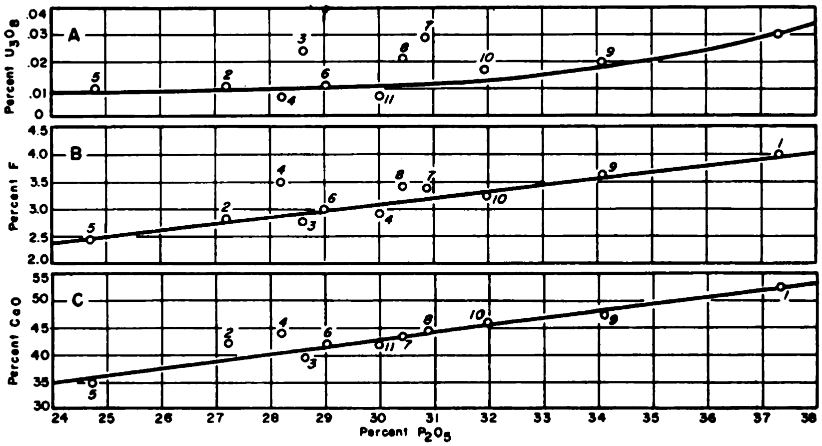

FIG. 2.—Graphs showing relationship between phosphate content and other constituents. **A**, Percent U_3O_8 vertically, P_2O_5 horizontally; **B**, percent F vertically, P_2O_5 horizontally; **C**, percent CaO vertically, P_2O_5 horizontally.

oxide (Fig. 2C). These graphs verified that the nodules have essentially the same mineral composition. They indicate also that several of the analyses for uranium content were too high. Thus the average value of 0.017 U_3O_8 (Table 3) seems high when compared to values obtained from Figure 2A. On the other hand, there is evidence that with a higher phosphate content more uranium will precipitate, under the general limitations of marine deposition. If a location where the phosphate concentration in the nodules is 35 percent were selected, then slightly more than 0.02 percent U_3O_8 could be expected. Also, one could expect that if the maximum phosphate content of 42 percent were obtained, 0.04 percent or more U_3O_8 would be present.

Figure 3 further shows the relationship between uranium oxide and phosphate content. In this graph uranium oxide is plotted vertically and fluorine is plotted horizontally. The result is a curve very similar to the curve obtained in Figure 2A.

It is possible that the curve in Figure 2A could result if there were no relationship between uranium oxide and phosphate content. However, the curve obtained in Figure 3A using fluorine suggests a valid relationship. Although the fluorine is dependent upon phosphate, it varies over a short range compared with phosphate. If the uranium were present in a random manner, it would be shown by plotting it against a more sensitive component such as fluorine.

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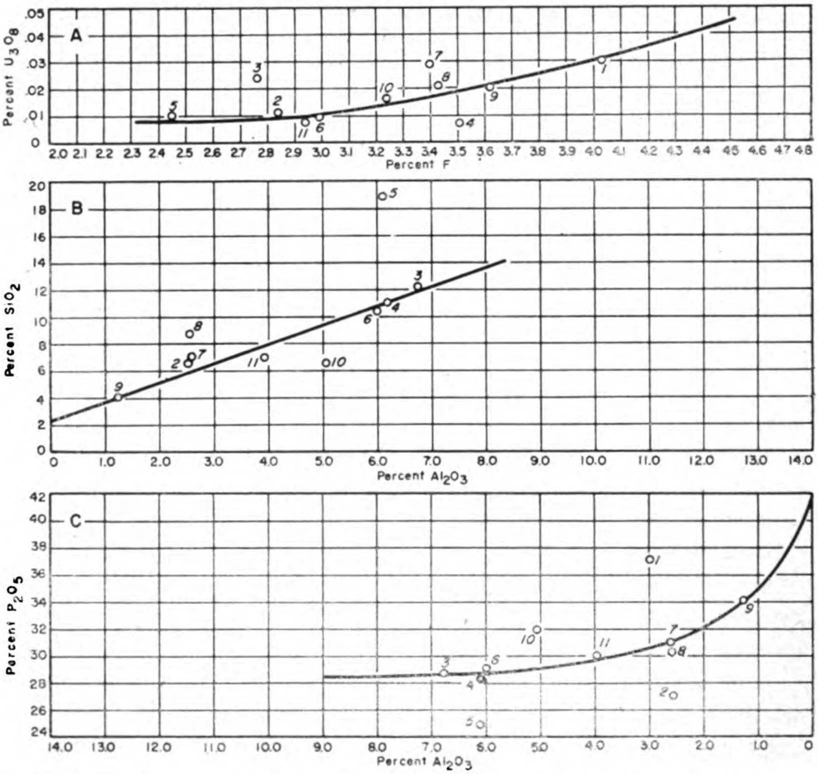

Fig. 3.—Graphs showing relationship between A, fluorine and uranium, B, silica and alumina, and C, alumina and phosphate.

Figures 3B and 3C were prepared to see if any relationship could be established concerning silica and alumina. Figure 3B plots silica against alumina. The general grouping along a straight line suggests that aluminum silicates of some nature exist in the nodules. The values above the line indicate quartz is present. The values which are below the line indicate an excess of alumina. In Figure 3C, which plots phosphate and alumina, samples indicating an excess of alumina in Figure 3B are now above the curve. The obvious conclusion would be that the analysis for aluminum is wrong, however; sample 52263 is the sample showing kaolin and sample 5020 was rechecked several times. No final explanation for this particular constituent is apparent at this time.

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SUMMARY

The phosphatic nodules in Pennsylvanian black shales collected from 11 localities in eastern Kansas have an average composition of 30.2 percent P_2O_5, 0.017 percent U_3O_8, and 3.2 percent F. These are combined in a form tentatively identified as a carbonate-bearing fluoapatite mineral. Chemically the percentages lie between those of fluoapatite and dahllite. The sedimentary origin of the nodules tends to emphasize the possibility of the presence of dahllite (carbonate apatite) but the x-ray diffraction patterns agree with previous work suggesting a single carbonate-fluoapatite mineral.

Much additional detailed work with x-ray diffraction is needed to prove definitely whether or not an intimate mixture of carbonate apatite (dahllite) and fluoapatite would appear as a separate mineral. Rankama (Rankama and Sahama, 1951) refers to collophane as a carbonate-fluoapatite but he also assumes that dahllite, a definite carbonate apatite, is usually present in sedimentary phosphates. Silverman, Fuyat, and Weiser (1951) refer to carbonate-bearing fluoapatite as a separate mineral without reference to collophane or dahllite.

For this paper we are assuming that the carbonate-bearing apatite reported by the x-ray diffraction studies is "microcrystalline collophane" and that dahllite is probably present although not definitely established.

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State Geological Survey of Kansas, Bulletin 102
1953 Reports of Studies, Part 4, Pages 105-116
October 15, 1953

EXPERIMENTAL SEPARATION OF IRON-BEARING MINERALS FROM CERTAIN KANSAS CLAYS

By

Frank W. Bowdish

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TABLE 1.—*Size distribution of clays and certain mineral fractions from them based upon total weight of crude clay*

Size	*Gray clay from Cloud County*		*Black clay from Cloud County*			*Cherokee County clay*	
	Weight, percent of total	Pyrite, percent of total weight	Weight, percent of total	Pyrite, percent of total weight	Lignite, percent of total weight	Weight, percent of total	Sink product, percent of total weight
18-13 mm	0.06	0.055	0.11	0.107			
13- 9 mm	0.09	0.079	0.03	0.030			
9 mm-3 mesh	0.11	0.066	0.01	0.008			
3- 4 mesh	0.10	0.037	0.02	0.019			
4- 6 mesh	0.07	0.014	0.03	0.027			
6- 8 mesh	0.06	0.017	0.02				
8- 10 mesh	0.05		0.02	0.049	0.078		
10- 14 mesh	0.04	0.040	0.04				
14- 20 mesh	0.03		0.05			0.53	0.286
20- 28 mesh	0.05		0.12			0.55	0.330
28- 35 mesh	0.09		0.24		0.120	0.74	0.506
35- 48 mesh	0.10	0.100	0.34			1.37	1.077
48- 65 mesh	0.13		0.37			1.99	1.692
65-100 mesh	2.35		1.66			2.17	1.715
100-150 mesh	2.49		3.80	0.007		1.00	0.659
150-200 mesh	9.32		9.30			1.09	0.462
200-270 mesh	7.02		4.96			0.72	0.198
-270 dry screening	4.43	0.002	3.11			0.80	
-270 wet screening	73.44		75.77			89.04	
Totals	100.00	0.410*	100.00	0.250*	0.198**	100.00	6.925*

*Includes only material coarser than 270 mesh.
**Includes only material coarser than 65 mesh.

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ABSTRACT

Two light-firing clays from Cloud County and one from Cherokee County were investigated in an effort to devise methods for the elimination of dark spots which appear upon firing caused by coarse pyrite or siderite. The clays were sized and fractionated to determine the occurrence and distribution of the iron minerals. Various methods for the removal of the iron minerals were tested and fired bricks were made from the purified clay products. All three clays were found to be amenable to improvement by simple beneficiation methods involving some combination of screening, classification, or magnetic separation.

INTRODUCTION

Several plants in Kansas make light-colored, buff, tan, or nearly white facing bricks, and other light-colored ceramic products. In some places the clay from which light-colored bricks and other ceramic articles may be made contains small amounts of coarse iron minerals, primarily pyrite, that cause difficulties in manufacture. The iron in each particle fluxes the clay around it during firing, and if it is located near the surface, a black spot appears. Also the iron particles may expand on firing and cause blisters or "broken-out" places. The size of the resulting black spot depends upon the size of the pyrite particle, but since clays are usually ground only to about 8 mesh, the spots may be very noticeable on a light-colored surface.

The present investigation was undertaken in an effort to determine if a relatively low-cost type of beneficiation would produce a significant removal of iron minerals from raw clay. Three light-firing clays examined in order to determine the type and distribution of the iron mineral were subjected to several types of treatment. Two of the samples are from adjacent beds in the Janssen member of the Cretaceous Dakota formation in Cloud County near Aurora, Kansas (Plummer and Romary, 1947; Plummer and Hladik, 1953). At the place where it was sampled (SE¼ sec. 32, T. 7 S., R. 2 W.) the Janssen member is 40 feet thick; the samples are from the upper 18 feet. Both of these clays are light firing, but their unfired appearance is quite different. One is light gray, the other is black owing to fine lignite deposited with the clay. The two clays are used together, but were investigated separately because of differences in their appearance. The third sample is from the underclay below the Mineral coal in the Pennsylvanian Cherokee group in Cherokee County near Weir, Kansas (SW¼ sec. 34, T. 31 S., R. 24 E.).

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Each clay was sized and fractionated to determine, at least partially, its mineralogical composition. Following this, certain tests were made to indicate how the objectionable minerals might be removed. Small bricks were made by the Geological Survey's Ceramics Division from the test products in order to indicate the quality of fired ware that could be produced.

SIZING AND FRACTIONATION OF CLAY SAMPLES

Each of the three clays in this investigation was sized and fractionated to determine its mineralogical composition. The details were varied with each sample, but in general, the procedure consisted of wet and dry screening followed by heavy liquid separation with magnetic separation of the specific gravity fractions. The final fractions were examined with a low-power binocular microscope, and with either a petrographic or a metallographic microscope after proper mounting and preparation.

Gray clay from Cloud County.—The large sample of gray clay from the Cloud County locality was crushed to finer than 1¼ inches and mixed thoroughly. The laboratory sample consisted of 10 kg of the large sample. The laboratory sample was soaked in water and stirred until the lumps of clay and sand disintegrated and became suspended in the water. This slurry was screened at 20 mesh and the plus 20-mesh sand was washed free of fine material. The minus 20-mesh pulp was further sized by wet screening at 100 and 270 mesh. Dry screen analyses on each sand fraction were made and these data were used to calculate the size distribution of the clay as shown in Table 1.

The coarse pyrite was separated by hand sorting each size fraction down to 8 mesh. The sand from 8 to 20 mesh was panned to separate pyrite from lighter material. These data together with information gained by fractionating the finer sand were used to calculate the pyrite distribution shown also in Table 1.

Samples of the 20- to 100-mesh and the 100- to 270-mesh fractions were treated with tetrabromoethane to separate particles with specific gravity greater than 2.96 from ones of lower specific gravity. The sink product (those particles with a gravity more than 2.96) from the 20- to 100-mesh material was mainly pyrite and attached quartz grains. A sample of the sink product mounted in bakelite was ground and polished to reveal the cross

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section of the particles. Nearly all the pyrite in this clay is in the form of irregular spheres ranging in size from more than 13 mm in diameter to about 100 mesh. Most of the finer pyrite lumps are coated with attached grains of quartz, and many of the pyrite particles as seen in the polished section, contain occluded quartz grains.

The sink product from the 100- to 270-mesh fraction contains a variety of minerals besides pyrite. This material was separated at high magnetic intensity by passing it through a Frantz Isodynamic separator (Gaudin and Spedden, 1943). A petrographic examination of the magnetic and nonmagnetic fractions revealed the presence of tourmaline, zircon, brookite, staurolite, rutile, pyrite, and unidentified black and white opaque minerals. The quantity of these minerals is very small, however, because the sink fraction amounts to only 0.125 percent of the crude clay.

The sandy part of this clay contains muscovite in noticeable quantities. The float material (those particles with a gravity less than 2.96) from the 100- to 270-mesh fraction was separated into mica and quartz products on the Isodynamic separator, and from these data the crude clay was estimated to contain 0.5 percent muscovite. A product containing a high proportion of this mica was prepared by flotation of the 100- to 270-mesh material using amine as the collector. This product was fired in a crucible to check the possibility that the mica might expand and cause cracks in the finished ware. No expansion was noted.

Black clay from Cloud County.—A sample of the black clay from the Cloud County locality was sized and fractionated in much the same way as was the sample of gray clay. A 10 kg sample of the crushed and mixed clay was pulped in water and wet screened at 20 and 270 mesh. The oversize portions were dry screened and the size distribution of the clay was calculated as shown in Table 1. A sample of the 20- to 270-mesh material was segregated in tetrabromoethane, and the sink fraction was separated into two parts on the Isodynamic separator. Petrographic examination of the sink fractions showed the presence of tourmaline, zircon, rutile, pyrite, opaque minerals, and very minor amounts of several others. These heavy minerals amount to only 0.106 percent of the clay. The float fraction is more than 99 percent quartz.

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The pyrite distribution shown in Table 1 was calculated from data obtained by hand sorting and panning of the plus 20-mesh material, and from fractionation of the minus 20-mesh material. The pyrite in the black clay seems to have replaced pieces of lignite or wood, as much of the pyrite is in the form of fossilized wood. This is in distinct contrast to the concretionary form of the pyrite in the gray clay.

The lignite, which gives the clay its black color, ranges in size from about 8 mesh to much finer than 270 mesh. The quantity and distribution of coarse lignite was noted during the dry screening as shown in Table 1. The quantity of plus 270-mesh lignite amounts to only about 0.2 percent of the clay. Although no determination of the quantity present was made, only a small proportion of very fine lignite is required to color the clay.

Clay from Cherokee County.—A sample of clay collected near Weir was received as ground clay in which any lumps of pyrite or other mineral coarser than 8 mesh had been broken. Examination of the sample indicated that the original clay probably contained no pyrite coarser than 8 mesh; hence, the size analysis of the ground material is probably the same as would be obtained from lump clay. A 1 kg sample of the ground material was pulped in water and wet screened at 270 mesh. The oversize was dry screened and the size distribution of the clay calculated as shown in Table 1. A sample of the plus 270-mesh sand was separated in tetrabromoethane to give float and sink products. The sink product amounting to about 7 percent of the clay was screened; its distribution is shown in Table 1.

The 65- to 100-mesh fraction of the sink product was separated into three portions with the Isodynamic separator. More than 93 percent of this fraction is quite magnetic; about 6.4 percent is nonmagnetic. The intermediate portion amounts to only 0.3 percent. The strongly magnetic and the nonmagnetic parts were mounted in bakelite, ground, and polished so that the cross section of the particles could be seen. Examination with a metallographic microscope revealed that the magnetic portion consists of rough spheres of siderite pseudomorphic after pyrite. Many of the particles contain cores of unaltered pyrite. The nonmagnetic fraction contains spheres of pyrite that have not been altered. Examination with a stereoscopic microscope revealed that

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at all sizes the sink product consists almost entirely of spheres of siderite and pyrite.

BENEFICIATION

As all the clays considered in this investigation fire to light colors, the contained pyrite or siderite particles cause black spots which are objectionable.

If the iron minerals could be removed economically, these clays would be more desirable for brick making, and additional uses for which the crude clays are unsuited, such as pottery, wall tile, quarry tile, or refractories, might be found for the beneficiated clays. With these objectives in mind a number of tests were made to remove pyrite and/or lignite from the clay. Part of these tests were made on a sample containing both gray clay and black clay from Cloud County in about the same proportions as they occur in the pit. Test bricks from the beneficiated clay samples were made and fired in order to indicate by their color and properties the results of the tests.

Screening and Flotation Tests

Mixed gray and black clay from Cloud County.—The fractionation of a mixed sample of gray and black clay from the Cloud County locality showed that the pyrite they contain is relatively coarse. By passing the material through a 20-mesh screen it was possible to remove 75 percent of the pyrite from the gray clay and 96 percent of it from the black clay. Sizing of the gray clay at 100 mesh will remove 99.5 percent of the pyrite. Thus the objectionable material may be removed by simple wet screening or classification. Accordingly, tests were made in which the clay was pulped in water and wet screened at 20 and 100 mesh.

Only part of the lignite is removed by screening the clay, the rest passing even the finest screens to contaminate the clay. Several flotation tests to remove lignite that passed the 20- or 100-mesh screens were made. Best flotation results were obtained by dispersing the clay with calgon (sodium hexametaphosphate) and using oleic acid, kerosene, and pine oil as flotation reagents. Test bricks made from samples prepared by screening alone and by screening and flotation indicate that the latter method gave

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no improvement over screening alone. Screening of the clay at 20 mesh eliminated all but a few small black spots and screening at 100 mesh eliminated all visible spots.

Black clay from Cloud County.—Flotation of lignite was included in three tests on the black clay from Cloud County. The gray clay contained almost no lignite. In one test the lignite was floated by using calgon, oleic acid, kerosene, and pine oil, followed by screening the nonfloat at 100 mesh to remove coarse material. In the other two tests flotation was applied to part of the minus 270-mesh pulp from the sizing and fractionation work. In one of these, the clay was further refined by sedimentation and decantation as discussed later. Test bricks show that removal of pyrite by screening is all the treatment necessary to produce clay from which objects without black spots may be made.

Clay from Cherokee County.—Much of the iron mineral in the clay from the Cherokee County locality is in the form of pyrite altered to siderite. Inasmuch as siderite is quite magnetic, the logical method of treatment was wet magnetic separation. A series of tests compared the effect of screening alone with screening and magnetic separation in the Frantz Ferrofilter. Test bricks show that wet screening at 20 mesh or finer eliminates the particles that cause blisters and relatively large dark spots in the fired ware. Bricks made from clay screened at 20 mesh show a multitude of easily visible black spots, and those from minus 100-mesh clay have many barely visible spots. Screening at 270 mesh eliminates all visible specks. Magnetic separation of the screened clay eliminates all visible specks from minus 100-mesh material and all but a few of those from minus 20-mesh material. These latter spots are attributed to pyrite particles that cannot be removed by magnetic separation.

Sedimentation and Decantation Tests

All three clays considered contain considerable amounts of sand or silt, which is almost entirely quartz. Although the clay with this quartz is acceptable for the manufacture of brick, there are other possible uses in which the excess quartz would be detrimental.

The possibility of producing a refined light-firing clay for uses other than brick making was checked. Part of the minus 270-

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mesh pulp from the sizing test of the gray clay from Cloud County was dispersed and permitted to settle for 2 hours in a pan about 4 inches deep. The unsettled clay was decanted, and the process repeated twice with the clay and silt that settled to the bottom. Thus a clay fraction containing particles finer than 5 or 10 microns was obtained. The black clay from Cloud County was separated in the same manner in one test, and in addition sedimentation and decantation were tried on a sample of this clay from which part of the lignite had been removed by flotation. A sample of the clay from Cherokee County was treated in the same way after it had been pulped and wet screened at 100 mesh followed by magnetic separation in the Ferrofilter.

Test bricks show that the fine fractions from the Cloud County clays are relatively light in color, having a pronounced yellowish-green color when fired. Flotation of the lignite made no noticeable difference in the black clay. The fine fraction from the Cherokee County clay burns to a definite red color, the iron that gives the buff color to bricks from this clay being concentrated in the extreme fines.

SUMMARY

Sizing and fractionation tests on the three clays revealed the minerals present and their distribution in the size fractions coarser than 270 mesh. In the gray clay from Cloud County pyrite occurs as round balls or concretions ranging in size from about 13 mm in diameter to about 100 mesh and amounting to about 0.4 percent of the sample. About 75 percent of this pyrite is coarser than 20 mesh and about 99.5 percent is coarser than 100 mesh. A heavy mineral fraction coarser than 270 mesh and amounting to about 0.13 percent of the sample contains a variety of minerals including tourmaline and zircon. It is estimated that about 0.5 percent of the clay is muscovite, which because of its platelike structure is quite noticeable.

The black clay from a bed overlying the gray clay contains about 0.25 percent pyrite. In this clay the pyrite is pseudomorphic after lignite, with 96 percent of it being coarser than 20 mesh. This clay is black due to fine lignite; lignite coarser than 270 mesh amounts to 0.2 percent of the clay. The heavy mineral fraction coarser than 270 mesh amounts to only 0.11 percent of the

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clay. Both the gray and the black clay from Cloud County contain large amounts of quartz sand or silt. About 25 percent of each is coarser than 270 mesh, and there is a large amount of fine sand in the minus 270-mesh part. In fact, in sedimentation and decantation tests intended to make a separation at 5 to 10 microns, the fine portion amounted to only 28.4 percent of the gray clay and 35.5 percent of the black clay.

The clay from Cherokee County contains about 10 percent siderite pseudomorphic after pyrite and unaltered pyrite. Of this more than 80 percent is coarser than 100 mesh. This clay contains less coarse sand than the Cloud County clays, but even so, only 31.3 percent of it was recovered as a fine fraction after sedimentation and decantation.

Separation tests on the Cloud County clays showed that wet screening at 20 mesh eliminated all but a few dark spots from fired test bricks, and wet screening at 100 mesh eliminated all visible black spots. Flotation of the lignite in the screen undersize pulp made no change in appearance of the test bricks. The clay mineral fractions from these clays are light firing and might be useful as ball clay in ceramic bodies or in refractories.

Separation tests on the Cherokee County clay showed that screening at 20 or 100 mesh eliminated nearly all the dark spots. Magnetic separation in combination with screening eliminated all visible spots. The clay mineral fraction of this clay fires quite red, and this fact would make it unsuitable for some purposes.

ECONOMIC CONSIDERATIONS

The wet screening of all the clay used in the manufacture of brick is not feasible because of the cost of the process. There is a possibility, however, that a large proportion of the pyrite and siderite in the larger particles could be removed by partial wet screening, and at a reasonable cost. In the dry pans commonly used in brick plants for grinding clay the ground clay passes through coarse slots in the bottom to a vibrating 8-mesh screen and the oversize is returned to the pan for further grinding. Due to the cushioning effect of the clay in the mill, hard particles are reduced in size very slowly, and in some cases must be removed from the mill pan by hand. It is probable that much of the pyrite and siderite will be found in the oversize, and if this material were blunged in an equal weight of water, with a dispersing

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agent, a large amount of the pyrite and other hard particles could be removed by wet screening through a 20- or 30-mesh sieve. The slip, or slurry, could then be fed to the pug mill and used for tempering water. If the oversize did not exceed 20 percent of the total weight of clay being processed the amount of water used for blunging, or pulping, would not be excessive for tempering the clay used for extrusion. If barium carbonate were used in the clay it could be added to the water in the blunging process, and if sodium carbonate were used for dispersion some clays would be benefitted by its use (Plummer and Hladik, 1953).

The sedimentation and decantation process produces two potentially useful products. The clay fraction is essentially a very fine-grained ball clay, and in the case of the Cloud County (Dakota formation) clays, light-firing. The silt fraction contains some clay and, except for the pyrite and siderite, is a relatively pure material. If the slip, or slurry, were screened through a 20-mesh or finer sieve much of the pyrite and siderite could be removed from the clay, thus producing two types of material adapted to special uses. Magnetic separation could be combined with the screening with beneficial results.

The fine clay portion, essentially a very fine-grained ball clay, could be used as the plastic clay addition to pottery bodies or floor and wall tile bodies. Its range of usefulness would be limited only by the slight color. The light greenish-yellow color in the fired Cloud County clay would show up only as a slight tinting in vitrified ware.

The silt fraction in all three clays fires to a very light color. In the case of the Cloud County clays the color is almost white, and the material is refractory. This silty material contains enough clay for forming into bricks either by the plastic or dry-press method, and is well suited to the manufacture of highly siliceous or "semi-silica" fire bricks of the type in demand for heat regenerator checker work in steel mills.

The data obtained on the clays tested should not be considered valid only for those mentioned. Both the Cloud and Cherokee County clays tested are typical of wide-spread deposits in their respective areas.

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State Geological Survey of Kansas, Bulletin 102
1953 Reports of Studies, Part 5, Pages 117-124, Plates 1-4
October 15, 1953

ELECTRON MICROSCOPY OF FIRED GLAZE SURFACES

By

Ada Swineford and Norman Plummer

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ILLUSTRATIONS

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ABSTRACT

A standard replica technique of electron microscopy is applied to the study of the finer surface features of a black glossy submetallic glaze. Electron micrographs indicate the presence of large plane glossy areas, broad flat-topped plateaus, narrow rough-textured ridges, areas of fine wrinkles, rough jagged regions, crystals, bubbles, and intersecting grooves or cracks. Detailed interpretation is deferred until further studies are made.

INTRODUCTION

The general appearance of a glaze depends largely upon the character of the glaze surface and its effect upon the light which is reflected from it. Some of the surface features of glazes are so small that although their effect is readily discernible, their true character is not known. The overall inadequacy of light microscopy in the study of glaze surfaces is illustrated by the old controversies in the literature concerning the character of mat glazes (*viz.* Binns, 1903; Pence, 1912, 1913; Purdy, 1912; Staley, 1912).

The purpose of this paper is the description of a well-known technique of electron microscopy as applied to one particular glaze. Interpretations of the various features observed are only tentative, and perhaps raise more questions than they answer.

The idea of the microscopic study of the surfaces of finished ceramic products by replica methods is not new; it was suggested by Hillier (1946) as a promising field for electron microscopy. A Faxfilm replica technique was used in light microscopy by Allen and Friedburg (1948) in examination of scratches and thermal cracks on enamels, glazes, and glass. The low resolving power of light restricts observation in a light microscope to the gross character of features coarser than 1 or 2 microns. Published data on crystallite sizes in glazes are rare; Insley (1927) describes some glazes with maximum length of mullite crystals ranging from 5 to 20 microns. Pence (1913) describes crystals having dimensions of about 1×6 microns, at the surface of a glaze and throughout the mass. Crystals smaller than 5 microns come within the range suitable for electron microscopy. Although Allen and Friedburg (1948) report that extensive electron microscope studies of surfaces are being conducted in ceramics and related fields, few or no descriptions of electron microscopy of glaze surfaces have reached the publication stage.

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Thanks are expressed to C. C. McMurtry who made the electron micrographs in the Department of Oncology, University of Kansas Medical School, in 1951.

LABORATORY TECHNIQUE

Various methods of replication for electron microscopy are described in standard textbooks (i.e., Cosslett, 1951). The type of replica used for the present study is a single-stage collodion film. The method is briefly summarized here so that the reader who is not familiar with techniques of specimen preparation for the electron microscope can more readily interpret the micrographs.

A few drops of a dilute (ca. 2 percent) solution of collodion in amyl acetate are poured on the clean glaze surface and the excess is drained off. After the amyl acetate has evaporated the glazed surface is immersed in water and the film of collodion is teased off so that it floats on the surface of the water. It is then transferred to a specimen screen. Before placing the replica in the microscope the surface relief and contrast are accentuated by evaporating chromium onto the specimen *in vacuo* at a low angle (in this case 5:1). The projections on the surface receive heavy deposits of the metal, while the area on their lee sides is protected. This gives the effect of a shadow five times as long as the projection is high, and makes possible the measurement of the depth or height of the irregularities.

The single-stage replica is of necessity a negative replica; that is, a projection on the replica represents a depression in the glaze surface, and vice versa. This fact must be kept in mind for proper interpretation of the micrographs.

A replica suitable for electron microscopy must be thin (less than 0.2 micron), and such exceedingly thin films cannot be stripped from a very rough surface. Cosslett (1951, p. 223) indicates that the surface irregularities should be less than 1 micron in elevation, and that more rugged surfaces should be replicated by a nonstripping process. The process of stripping may also pro-

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PLATE 1. Electron micrographs showing fired glaze surface replica shadowed with Cr at ca. 18°

A. Smooth, nearly featureless surface of glassy area. × 28,000.

B. Level plateau 4 microns in diameter, 0.07 micron in elevation. Note depressed perimeter, rough "reaction rim." × 19,500.

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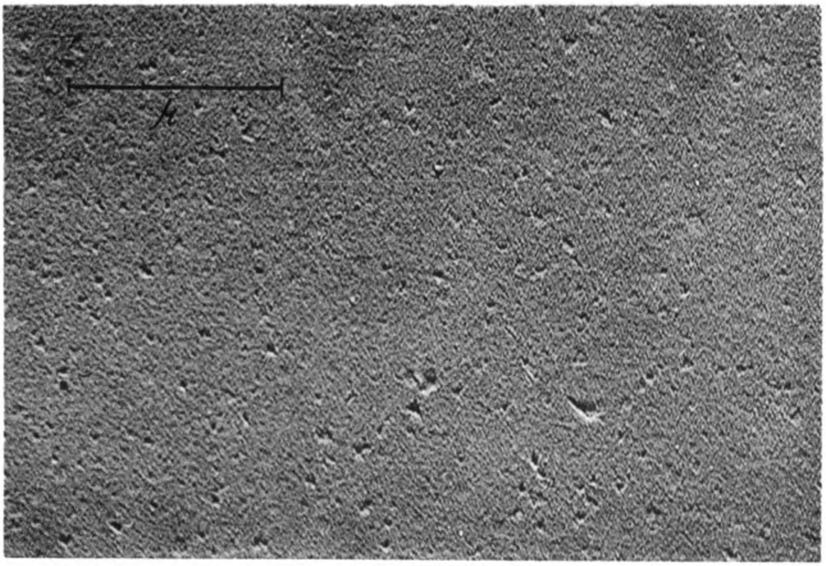

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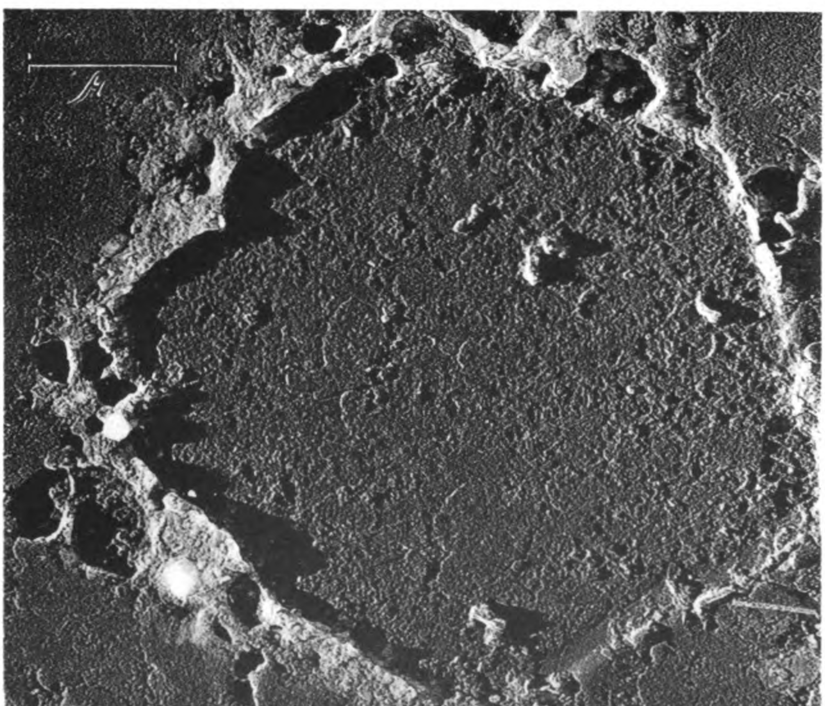

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Swineford and Plummer — Electron micrographs of glaze replicas.

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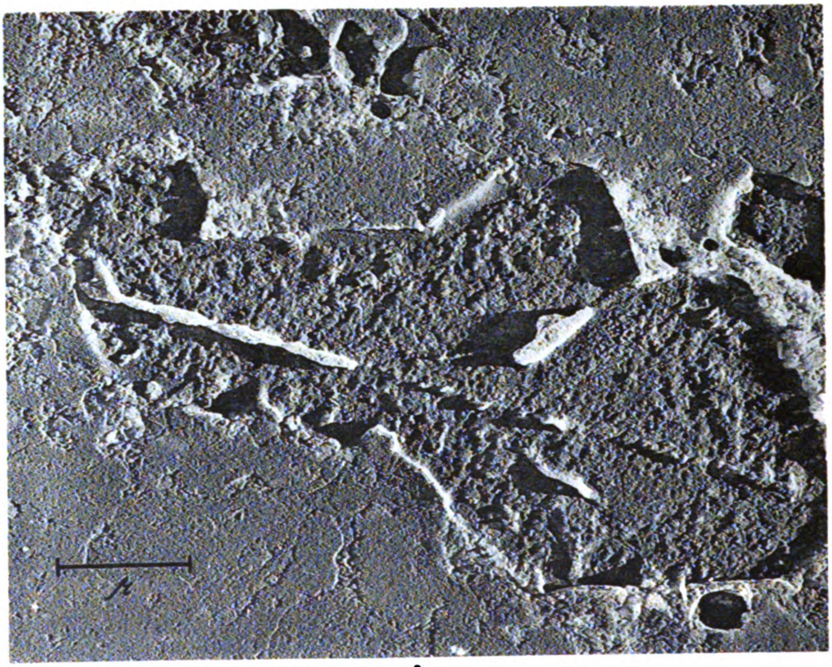

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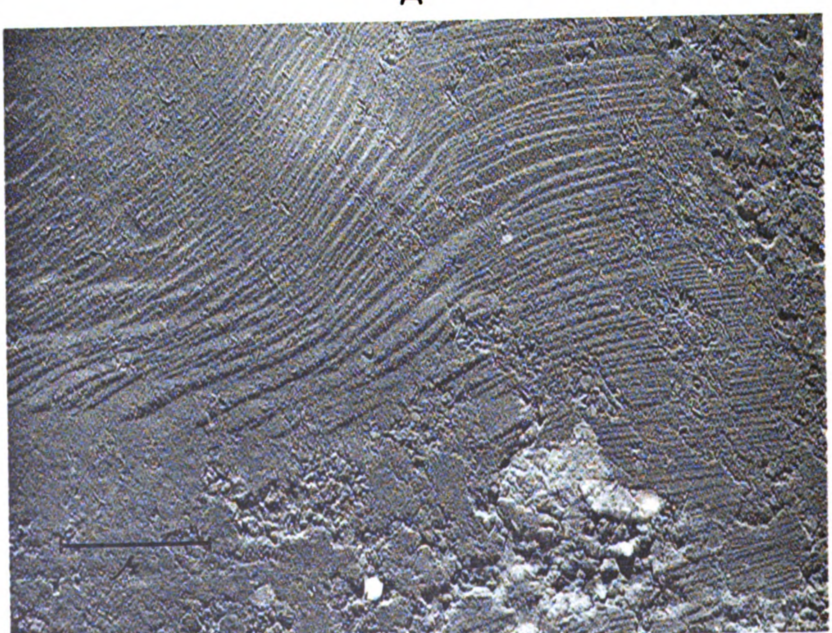

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SWINEFORD AND PLUMMER — Electron micrographs of glaze replicas.

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duce strain lines or tears in the film which can be misinterpreted as structures in the glaze.

The resolution obtainable from a replica in the electron microscope, although much better than that in a light microscope, is worse than the resolving power of the instrument. This is because the collodion itself has a grainy structure, the units being about 100 A in diameter. Thus the resolution in collodion replicas is of the order of 200 to 300 A (Cosslett, 1951, p. 219). The grain of the collodion and possible granulation of the chromium coating must be recognized as such and not interpreted as grain on the glaze surface.

CHARACTER OF THE GLAZE

The specimen examined is a black glaze with a glossy surface speckled with minute frosty areas (ca. 50 to 300 microns in diameter) which are visible to the naked eye and seem to have a submetallic sheen. The composition is as follows:

Eagle Picher frit	37.61 percent
Feldspar	15.05
Whiting	3.91
Zinc oxide	2.12
Barium carbonate	5.14
Clay	13.05
Flint	23.12
	100.00

Add black stain: DF-576 . . . 5.5 percent

The equivalent formula of the base glaze without the black stain is:

PbO	.5500				
K_2O	.0751				
Na_2O	.0231	Al_2O_3	.2230	SiO_2	3.0000
CaO	.1518				
ZnO	.1000				
BaO	.1000				

The exact composition of the black stain is not known, but such stains commonly contain at least four of the oxides of cobalt, copper, iron, manganese, or chromium. The following black stain is

PLATE 2. Electron micrographs showing fired glaze surface.

A. Level plateau with groove. Note rough surface of plateau as compared with smooth surface of surrounding glass. × 17,500.

B. Wrinkled surface and crystalline area (upper right-hand corner). Wrinkles are judged to be replicas of glaze, but may possibly be artifacts. × 19,500.

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in commercial use: CuO, 18 percent; CoO, 18 percent; FeO, 10 percent; MnO_2, 36 percent; and Cr_2O_3, 18 percent. If this black stain were calculated into the glaze the empirical formula would be:

PbO	.4526				
K_2O	.0618				
Na_2O	.0190				
CaO	.1249				
ZnO	.0823	Al_2O_3	.1835	SiO_2	2.4685
BaO	.0823	Cr_2O_3	.0206		
CuO	.0392				
CoO	.0417				
FeO	.0242				
MnO	.0720				

The coloring metallic oxides present in black stains of this type are so proportioned that the colors produced by the silicates of the metals completely neutralize each other. A true gray can be produced from a good black glaze by mixing it with a white glaze. If an excess of the black stain—more than can be combined as silicates—is present in the glaze, the black oxides will be suspended in the glass. The submetallic sheen is commonly attributed to this excess of metallic oxides. If the above black stain were increased to 10 percent, for example, the glaze would be a definite "gunmetal."

The Eagle Picher frit consists of about 15 percent SiO_2 and 85 percent PbO. The clay is a ball clay from the Dakota formation of central Kansas; its mineralogical composition is about 40 percent kaolinite, 30 percent quartz, 20 percent illite and muscovite, a trace of feldspar, and a slight but definite indication of a mixed-layer mineral. The glaze was fired to cone 01 (2030°F.).

The glaze surface seems entirely smooth to the touch, and study of a Faxfilm replica under the light microscope reveals less detail than can be seen by direct observation of the glaze.

The electron microscope shows several types of surface features, most of which are considerably less than a micron in order of magnitude (Pls. 1 to 4). The various types are listed below.

1. Large plane glassy areas, showing almost nothing which cannot be attributed to collodion structure (Pl. 1A).

PLATE 3. Electron micrographs showing fired glaze surface.

A. Rough jagged surface; possibly unabsorbed refractory part of glaze. × 20,000.

B. Dendritic pattern of rough narrow ridges. × 20,000.

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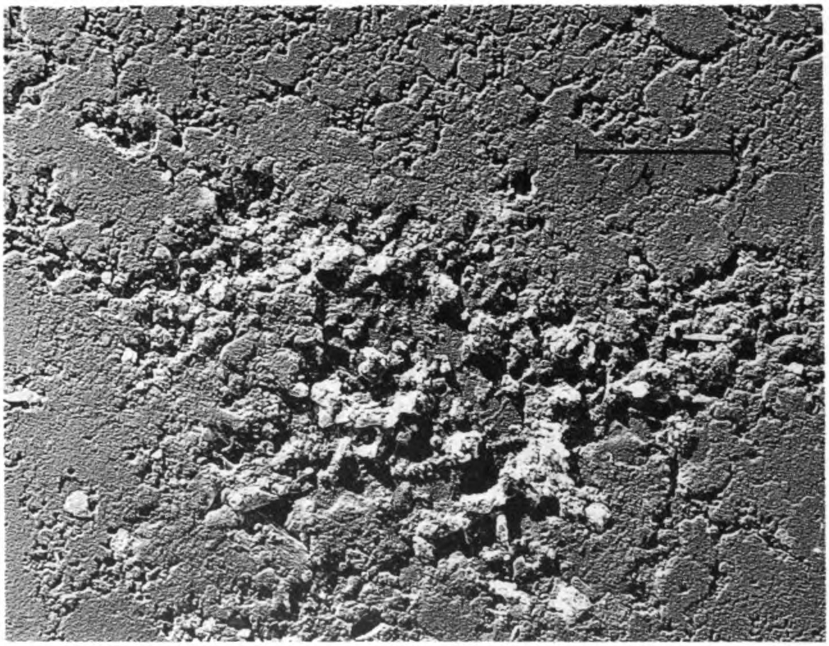

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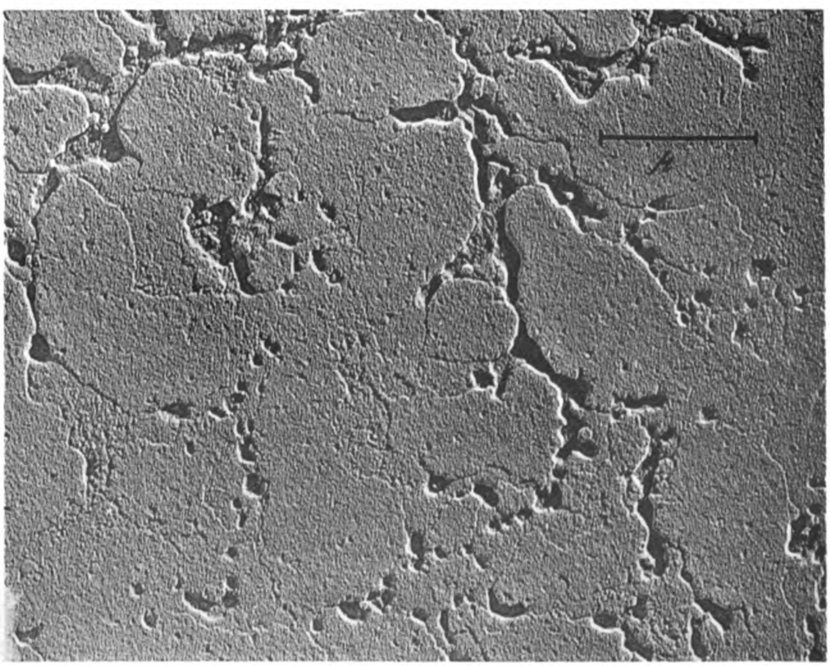

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SWINEFORD AND PLUMMER — Electron micrographs of glaze replicas.

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Swineford and Plummer — Electron micrograph of a glaze replica.

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2. Broad, flat-topped projections or plateaus. These appear as flat-bottomed depressions in the negative replicas (Pls. 1B and 2A). The tops of the plateaus are rougher than the other surfaces, and they seem to be surrounded by a depressed area. Immediately adjacent to the foot of a typical plateau is a disturbed or bubbly area.

3. Narrow, rough-textured ridges (some discontinuous) having dendritic pattern, with smooth flat intervening "lowland" (Pl. 3B).

4. Areas of fine wrinkles, generally adjacent to some more rugged feature (Pls. 2B and 4). Some of the wrinkles have a chevron pattern.

5. Rough jagged regions (Pl. 3A).

6. Crystals. Crystals having triangular faces are suggested in the upper right corner of Plate 2B. These are approximately 0.1 micron in diameter. Another crystal (possibly an octahedron) appears in Plate 4, just below the micron mark.

7. Bubble. The replica of an unbroken bubble about 1.2 microns in diameter is clearly shown in Plate 4.

8. Intersecting grooves (Pl. 4). These grooves range in diameter from 0.05 to 0.2 microns and strongly resemble craze features.

Detailed interpretation of the micrographs must be deferred until more data are available. In conclusion it should be noted that there are two general levels to the glaze: a somewhat rough upper level and a more extensive smooth glassy lower level. The total relief (except for the "craze" cracks) is much less than 0.1 micron. The rough areas are judged to be parts which did not melt completely and become assimilated into the glass, and the bubbly areas around the perimeters of some of them are probably reaction rims.

The wrinkles may indicate rapid cooling or flowage of the glass after a thin scum had developed on its surface. On the other hand they may not be part of the glaze at all, but perhaps were formed in the collodion during the production of the replica. Further study may determine whether or not these wrinkles are artifacts.

PLATE 4. Electron micrograph of glaze surface, showing curved intersecting grooves (craze pattern?), wrinkles, crystal, and bubble. × 15,000.

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CONCLUSIONS

The minute frost-speckled appearance of the black glaze is judged to be due to incomplete melting of the raw material. The submetallic sheen is not explained, but it may be an effect of the total surface relief, which is between 0.05 and 0.1 micron.

Electron microscopy of surface replicas is judged to be a promising method for the study of relatively smooth glaze surfaces. The internal structure of fired glaze batches could also be examined by replication of fracture surfaces.

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State Geological Survey of Kansas, Bulletin 102
1953 Reports of Studies, Part 6, Pages 125-144, Figures 1-10
October 30, 1953

EXPERIMENTS IN THE RAPID DRYING OF PLASTIC CLAY BRICK

By

Norman Plummer and William B. Hladik

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ILLUSTRATIONS

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ABSTRACT

In some types of plants the rapid drying of clay products is desirable. Experimental drying of face brick made from a plastic fire clay indicated that in these cases conventional methods required far too much time. At an ambient drier temperature of 300° F., or higher, and in an atmosphere containing a higher percentage of water vapor, face brick were dried successfully in one-half to one-third the time required with other methods.

INTRODUCTION

Purpose of the Investigation

In the conventional type of brick plant where the ware is fired in periodic kilns the time consumed in drying is of minor importance, although the original investment in drier capacity and drier cars is increased in proportion to the time required for drying. In plants using a combination drier-tunnel kiln it is important, however, that the drying time be reduced to a minimum because the ware is set on the kiln cars from the off-bearing belt. Because these cars must go through the drier the number of highly expensive kiln cars required may be greatly increased, especially if the clay permits rapid firing of the brick.

The first objective of this investigation was to determine the length of time required by conventional methods to dry the plastic fire clay face brick selected for testing. The second objective was to find some means of decreasing, as compared to conventional methods, the time required for drying.

Published Information on Drying

Although the literature on the drying of clay ware is rather extensive the bulk of the material has been published in periodicals such as the Journal of the American Ceramic Society, Transactions of the British Ceramic Society, Transactions of the Ceramic Society (English), Journal of the Canadian Ceramic Society, and Industrial and Engineering Chemistry. The few books commonly cited as references on this subject include Greaves-Walker (1948), Lovejoy (1927), and Wilson (1927). In addition to the above we have found a great deal of helpful information on drying in Norton (1949, 1952) and McNamara (1939).

The literature on this subject covers the field very thoroughly, including discussions of the fundamental principles of drying,

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drier design and calculations on design and heating, drier construction and operation, and the drying characteristics of clays. Very little of the literature on drying includes reports on experimental drying (Morgan and Hursh, 1939; Norton, 1949), and we were able to find but one reference to the drying of clay ware at temperatures above 212° F.

Anwyl (1951) states that in two types of periodic driers employing vertical movement of heated air, temperatures higher than 212°F. were used. In the first type no fans were used and air was brought through small ducts to the floor of the drier tunnel about 6 feet below the car deck. On page 42 he states: "Heat was supplied by small fires on the floor level, and air flow was induced by rise of the hot products of combustion of the fires, thus heating the ware by convection. The moisture and other products of combustion escaped from the unit through vents in the roof . . ." Temperatures were "much above the boiling point of water."

The second type was similar to the first in that the air flow was vertical. Instead of slow-moving hot air from a fire, however, high velocity heated air was used. Temperatures in excess of 300° F. were used at the beginning of the drying cycle. Anwyl does not mention the humidity of the air in the driers, but one would judge that the humidity would have to be rather high to permit drying at those temperatures.

Acknowledgments

We wish to express our appreciation to T. J. Orrender, President of the Salina Brick and Tile Company, for his cooperation in furnishing us a large supply of face brick for the drying tests.

TESTING

Analysis of the Problem

The drying of clay ware is accomplished by the evaporation of water from the surface of the ware. Most of the water evaporated from the piece of ware must come from the interior through interconnecting pores or channels. The rate of this internal flow of water is determined by the moisture gradient between the wetter and drier portions, the permeability of the ware, and the viscosity of the water. We can increase the moisture gradient by increasing

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the flow of dry air around the surface of the piece. The permeability can be increased by adding coarser materials to the ware, such as sand or grog. The viscosity of the water can be decreased by working at a higher temperature.

If the moisture gradient is increased beyond a certain point cracking or rupture of the ware will result from differences in shrinkage within the ware. In most cases increasing the permeability is not desirable both because of the changed appearance of the finished ware and increased cost. Working at higher temperatures to decrease the viscosity of the water seems to offer a promising approach to increasing the rate of drying. If, however, dry air at a high temperature is used for drying, the moisture gradient will be increased, with resulting cracked or ruptured ware. If the rate of evaporation from the surface could be decreased at the same time the temperature is increased the moisture gradient would be reduced, and at the same time the rate of drying increased due to the lowered viscosity of water.

Increasing the humidity of the surrounding air will reduce surface evaporation on the ware and eliminate cracking. Most modern drying systems include humidity control as an essential feature. The commonest form of drier used in the brick industry is a tunnel through which the ware passes on drier cars. The air movement is from the dry end to the wet end of the drier. Thus the nearly dried brick receive the hottest and driest air. The temperature of the air decreases toward the wet, or entrance end of the drier, and the humidity increases in the same direction due to moisture picked up from the bricks in the drying process. Thus the surface of the wet brick near the entrance of the drier is kept moist and the moisture gradient reduced. As the interiors of the brick become drier they are able to withstand the higher temperatures and lower humidity near the exit end of the drier. Periodic driers operate on the same principle, but moisture must be added to the air by artificial means at the beginning of the drying cycle. Temperatures commonly employed in drying brick range from about 120° F. at the beginning of the drying cycle to 180° F. at the end. These temperatures are relatively low.

Drying of clay ware can be divided into three well-defined stages. The water added to the clay to produce a plastic mass must be removed first. During the first stages of water removal the clay ware shrinks in direct proportion to the volume of water

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removed. In ceramic terminology this is shrinkage water. After the shrinkage water is removed the remaining water retained in the cavities between the clay particles is called the pore water. Shrinkage water is difficult to remove rapidly because a moisture gradient produces differential shrinkage. The surface of the piece will be much drier than the interior and will shrink a greater amount, resulting in cracking near the surface. Differences in the amount of moisture from one end or side of the piece to the other also produce warping. The pore water can be removed with relative ease both because of increased permeability and lack of differential shrinkage.

In most clay drying processes the third stage of water removal is carried out in the kilns. Clays dried at 212° F. will retain some moisture as hygroscopic water which can be removed at a temperature of 280°F. or higher. Clays heated to 300°F. are usually free of hygroscopic moisture. Although the amount of water so retained is small it is sufficient to cause rupture of ceramic ware heated too rapidly. In a continuous drier-tunnel kiln process, drying and pre-heating, or initial stages of firing, must be considered as a whole. Clay dried in a periodic drier to 300° F. and allowed to cool before setting in the kiln would regain most of the hygroscopic moisture. Therefore, the pre-heating from 212° to 300° F. must be carried out in the kiln.

The clay used for the drying tests reported here is a plastic fire clay from the Terra Cotta member of the Dakota formation. The deposit is described by Plummer and Romary (1947) under the location number TC-1. The clay is mined by the Salina Brick and Tile Company from a deposit in the SE¼ sec. 14, T. 15 S., R. 6 W., Ellsworth County. It is a "tight" or "fat" clay of the type that usually requires slow drying.

Differential thermal analysis of this clay (Fig. 1) indicates that the chief clay constituent is kaolinite, but minor endothermic inflections at 700° C. and 900° C. are probably indicative of montmorillonite and illite, and possibly a mixed-layer type of clay mineral. Either of these clay minerals would increase the plasticity and water retention of the clays. The differential thermal analysis on this clay was run on the wet material taken from a brick just as it came from the off-bearing belt. The endothermic peak near 100° C. is therefore abnormally large. The hygroscopic moisture peak slightly above 150° C. is quite small but

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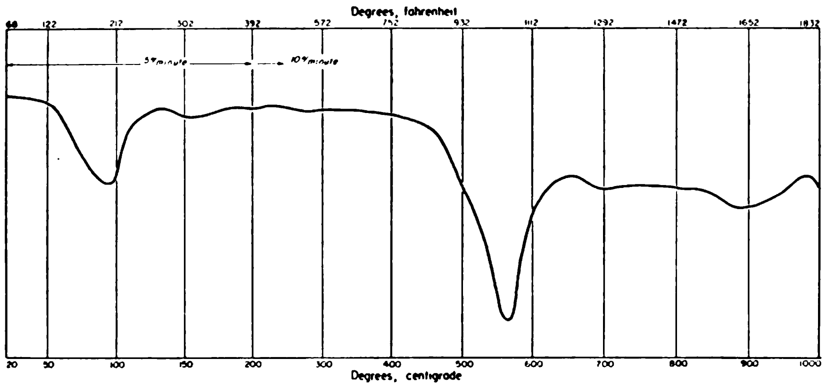

FIG. 1.—Differential thermal curve of buff-firing clay from which test bricks were made.

normal in size. The peak extends to about 180° C. because of the rapid rate of drying and possibly because of higher temperature water given off by illite or montmorillonite. These curves indicate that the greater part of the water is removed between the temperatures of 50° C. (122° F.) and 100° C. (212° F.), and that a minor amount is removed slightly above and below 150° C. (302° F.).

On consideration of the above factors we concluded that rapid drying of the TC-1 clay could be accomplished only by a combination of high temperature and high humidity.

Methods and Equipment Used in Testing

The brick used for the drying test were full-sized, cored face brick with a textured surface on one side and both ends. The wet bricks were taken directly from the off-bearing belt, wrapped in oil paper, and packed closely in a box to prevent drying before being shipped to the ceramics laboratory of the State Geological Survey. Most of the bricks tested were buff-firing, but a few more plastic red-firing bricks were also included.

In the tests the brick were set in courses of 10 brick each, and in two to four courses. The spacing of the brick was similar to that used in placing brick on a plant drying car. In the final tests three courses, or a total of 30 brick were used for each batch.

The first drying test was attempted in an electrically heated drier with a thermostatic control. Due to the heavy load of bricks

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the temperature dropped from the normally maintained 212° F. to about 130°F. immediately after placing the bricks in the drier. The temperature increased very slowly, and after a 24-hour interval was at 160° F. For the next 6 hours the temperature increased more rapidly to 180° F., but the bricks were obviously damp in protected spots after a total drying time of 30 hours. The drying process was slowed by the fact that all but the lower part of the pile of bricks was enclosed in oil paper during the first 8 hours of the drying. This was done to keep a humid atmosphere around the bricks.

All subsequent tests were conducted in a Denver Fire Clay Company gas-fired muffle kiln having a capacity of 12 cubic feet. The kiln is the fire tube muffle type. In the drying tests the three front tubes were removed, thus permitting the escape of moist air through the crown. The kiln floor and crown are not completely gas tight; therefore if the dampers were partially closed some of the gases from combustion entered the ware chamber.

The test bricks were set on a single course of fired bricks, which in turn was placed on a thin silicon carbide slab supported so that heat was free to circulate beneath it (Fig. 2). A thermocouple was placed near the test bricks to record the temperature of the drier atmosphere. Another thermocouple was placed inside a brick located in the center of the middle course. The hole through which the thermocouple leads entered was carefully plugged with wet clay.

During the first series of tests in this drier-kiln we were unable to determine how far the drying had proceeded at any stage of the process. To correct this testing defect the bricks were placed on a balance with the beam extending through a built-up kiln door. The assembly was carefully balanced before the beginning of the drying process, and as water was lost weights were removed from the outside end of the balance beam. Some error in weighing was produced by the lengthening of the hot end of the beam, and by the difference in specific gravity of the atmosphere within the drier and outside. Some attempt was made to compensate for these errors, but the temperature-weight loss curves indicate that an appreciable error remained (Figs. 3-7).

Throughout most of the tests a humid atmosphere was maintained in the drier by running a thin stream of water into a shallow pan placed near the hot drier floor. This pan was drained

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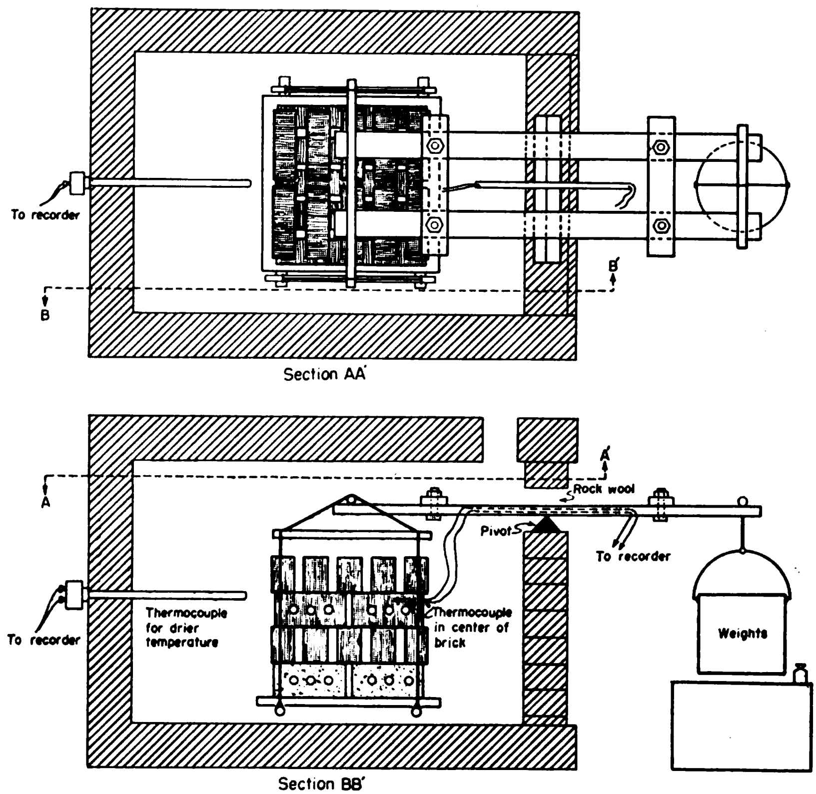

FIG. 2.—Sectional views of drier used in tests, showing method of supporting test bricks on a balance.

by a copper tube to the outside of the drier so water in excess of that vaporized by the heat did not accumulate in the pan. During the earlier stages of the drying enough water was run into the pan so that a slow drip was maintained from the drain tube. This provided a rough control of humidity within the drier inasmuch as more water vapor was provided with increasing temperatures. This device is not shown in Figure 2.

Some means of determining humidity within the drier would be highly desirable. All the commonly employed devices can be used only at temperatures below 212° F., however, and would have been useless in conducting higher temperature drying tests. In fact, at temperatures above 212° F., and at atmospheric pressure, the amount of water vapor held in the drying atmosphere

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should be expressed as percentage of super-heated steam rather than as humidity.

Data on Drying Tests

In addition to the attempted drying test in our electric drier, seven tests were run in the kiln-drier previously described. In drying test No. 1 (Fig. 3) an attempt was made to dry the bricks

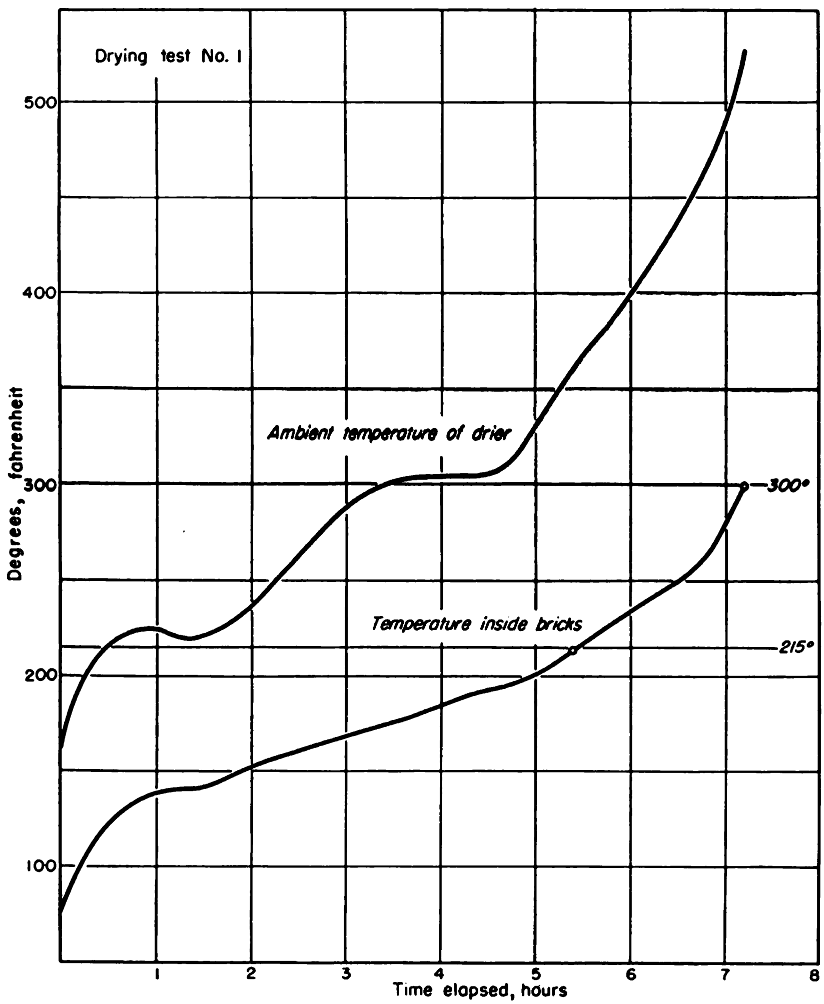

Fig. 3.—Graph showing temperature curves for drying test No. 1.

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in less than 8 hours in a moderately humid atmosphere. A temperature of 215° F. was reached in 5.5 hours when several of the bricks were partially broken. At the end of the cycle most of the bricks were broken.

Throughout the drying tests a temperature of 215° F. has been considered the end-point of a normal drying time, rather than 212°, to allow for instrumental error (Figs. 3-9). Actually the error in some cases was much greater than this, as will be pointed out in subsequent paragraphs.

The drying time for test No. 2 (Fig. 4) was lengthened to almost 11 hours. After approximately 5 hours of drying, a previously weighed and marked brick was taken out and weighed, indicating that 50 percent of the water had been taken out. After a little more than 8 hours 75 percent of the water had been dried from the brick. At the end of the drying cycle the marked brick was broken in several pieces but another brick was weighed and returned to the drier. Twelve hours later the same brick was taken out of the still warm drier and found to be appreciably

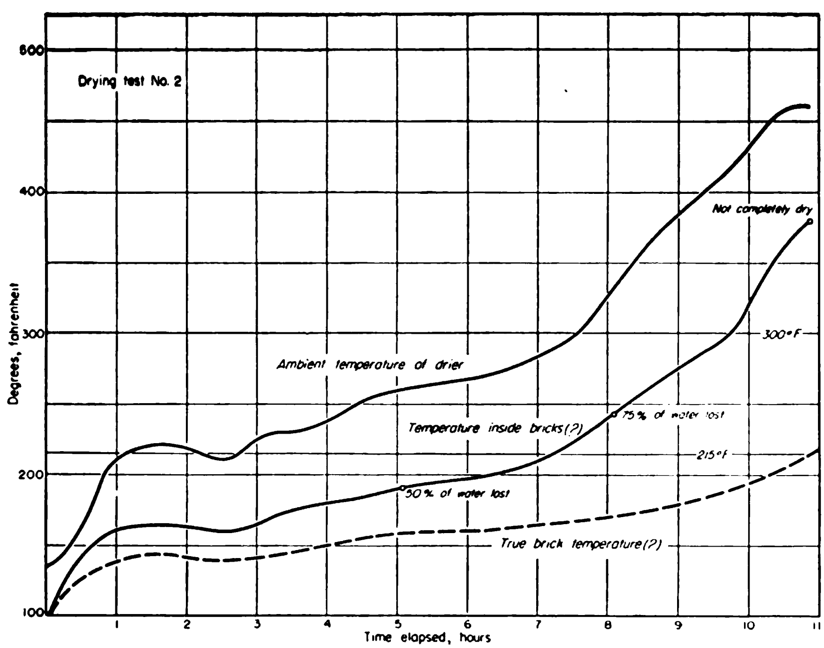

Fig. 4.—Graph showing temperature curves for drying test No. 2.

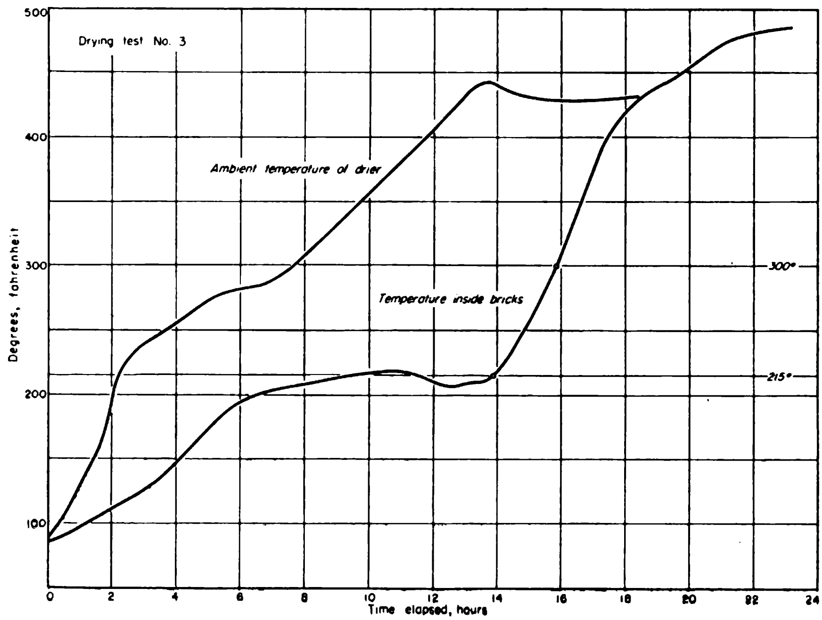

FIG. 5.—Graph showing temperature curves for drying test No. 3.

lighter. Inasmuch as this brick was not dry after nearly 11 hours, we concluded that the inside brick temperature recorded must have been much higher than the average of the bricks. The estimated temperature inside the bricks is indicated by a dotted line in Figure 4. Only 2 of the 30 bricks remained entirely undamaged by this drying test.

In drying test No. 3 (Fig. 5) the rate of heating was decreased and the humidity increased somewhat. No attempt was made to weigh the bricks on this test so drying may have been completed before the end of the heating cycle. We believe, however that the curve plotted for the temperature inside the one test brick indicates that all the tempering water was removed after 11 hours of drying by the rapid upward swing at that point. Most of the bricks were sound at the completion of this test.

At this point in the investigation we concluded that it would be necessary to weigh the bricks during the drying process in order to regulate the heat input and to enable us to determine the completion of drying. Subsequent test batches were there-

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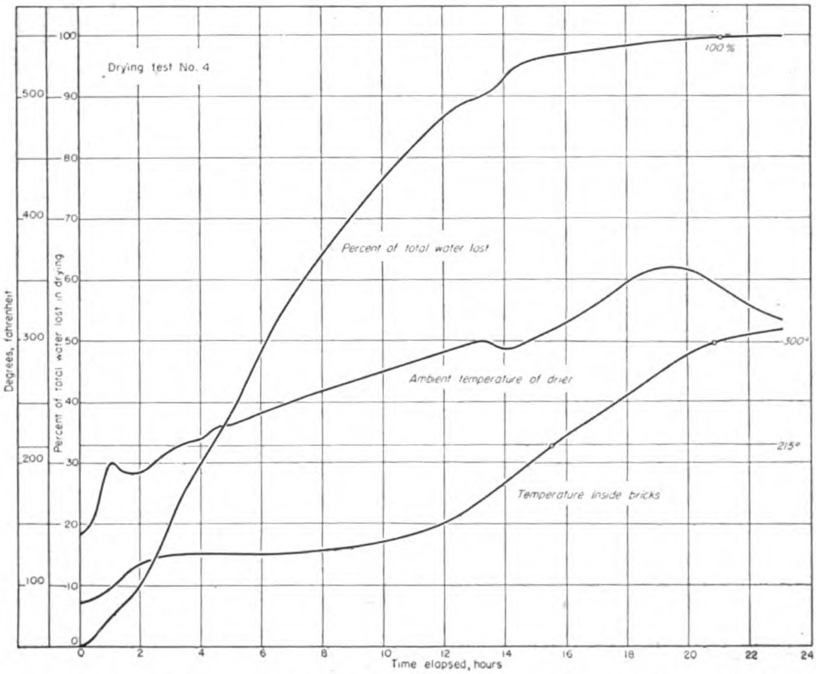

FIG. 6.—Graph showing temperature and water loss curves for drying test No. 4.

fore weighed throughout the drying cycle by the device shown in Figure 2.

With drying test No. 4 (Fig. 6) the temperature of the drier atmosphere was increased more slowly than in previous tests, and an attempt was made to keep the humidity somewhat higher. The temperature inside the brick containing the thermocouple reached 215° after 14.75 hours and 97.7 percent of the tempering water had been dried from the 30 bricks. Under ordinary plant conditions the bricks at this stage would have been considered completely dry. According to the temperature-water loss curves the last of the hygroscopic moisture was removed after 20.5 hours, corresponding to a brick temperature a few degrees above 300° F. The test bricks were dried without breaking or warping, but the time consumed in drying was not at the minimum of 8 hours that we hoped to attain.

For drying test No. 5 (Fig. 7) the drier temperature was increased as rapidly as possible to 300° F. and the humidity was in-

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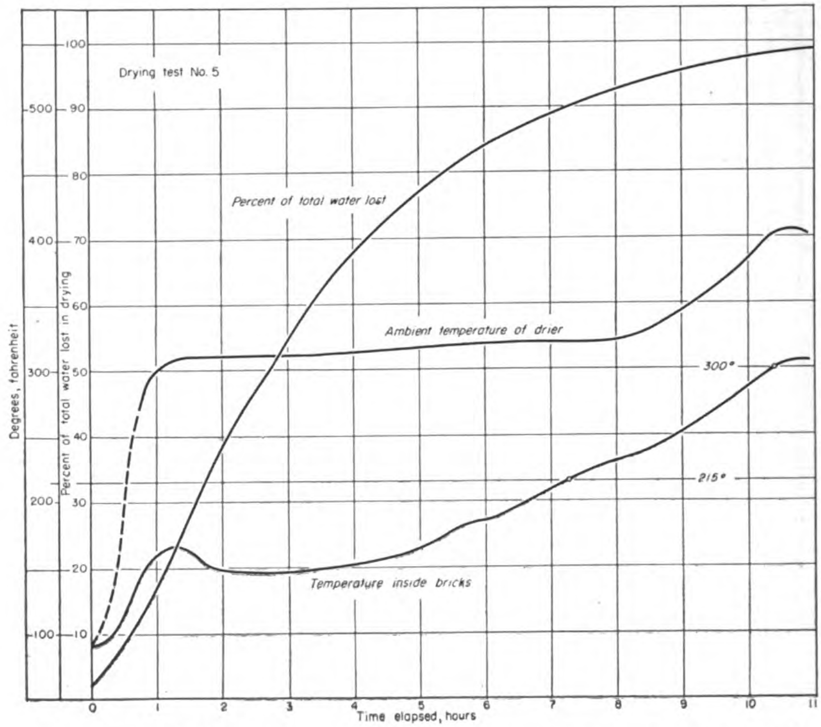

Fig. 7.—Graph showing temperature and water loss curves for drying test No. 5.

creased to near saturation at the beginning of the drying cycle. The high humidity was attained in a rather unconventional manner by nearly closing the flue damper to the drier, thus adding the water resulting from the combustion of natural gas to that provided by the drip pan. The water content of the drier atmosphere was so high that water condensed and dripped from all small openings to the outside of the drier. The temperature of the drier was increased to 300°F. in 1 hour, to 320° in a total of 8 hours, and then increased rapidly to obtain a temperature of 400° at the end of 11 hours. According to the instrument readings the temperature inside the bricks attained 215° after 7.15 hours, although weighing indicated that only 90 percent of the tempering water had been lost, and at the end of the cycle that 98 percent had been driven out. It is obvious that either the temperature inside the one brick containing the thermocouple was higher than the average, or that the weighing device was not accurate. It was

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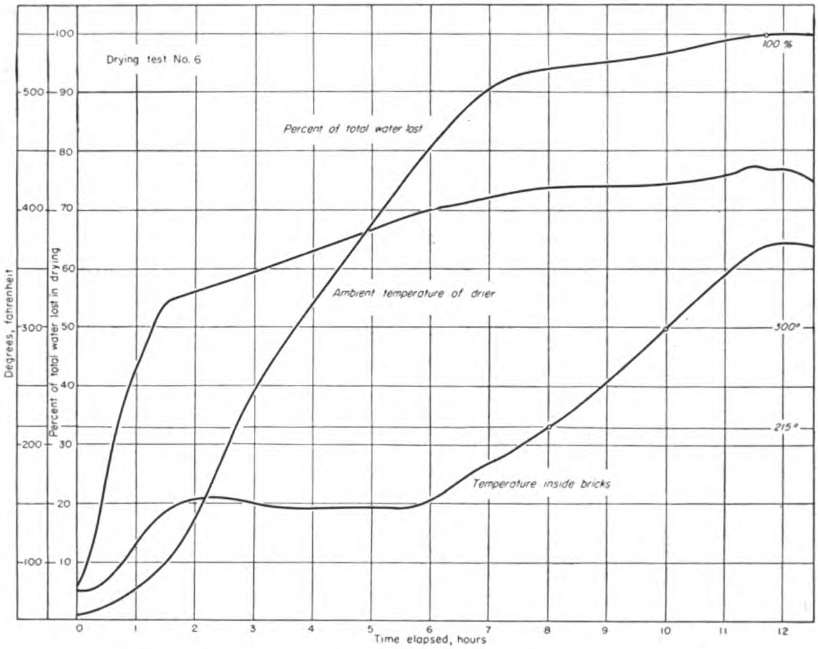

FIG. 8.—Graph showing temperature and water loss curves for drying test No. 6.

clear, however, that a means of rapid drying has been found. If the beginning temperatures for drying are considered as 300° for the drier and 120° F. for the brick the apparent drying time was about 7 hours for 212° dryness, or 9.5 hours for 300° dryness. Two of the 30 bricks were cracked.

During drying test No. 6 (Fig. 8) an attempt was made to obtain brick weights and temperatures inside the bricks that were more nearly correct. High humidity (or more correctly, a high percentage of super-heated steam) was maintained during a longer period of drying, and temperature differences between drier and bricks were greater. The recorded temperature inside the bricks attained 215° after a total of 8 hours drying, or 7 hours after the brick had reached a temperature of 115° and the drier 255° F. A temperature of 300° was attained in 9 to 10 hours, but, according to the balance weighing, complete dryness was reached after 10.75 to 11.75 hours. We believe that in this case the weighing was in error due to differences of specific gravity of the atmosphere inside the drier and the outside air and expansion of the

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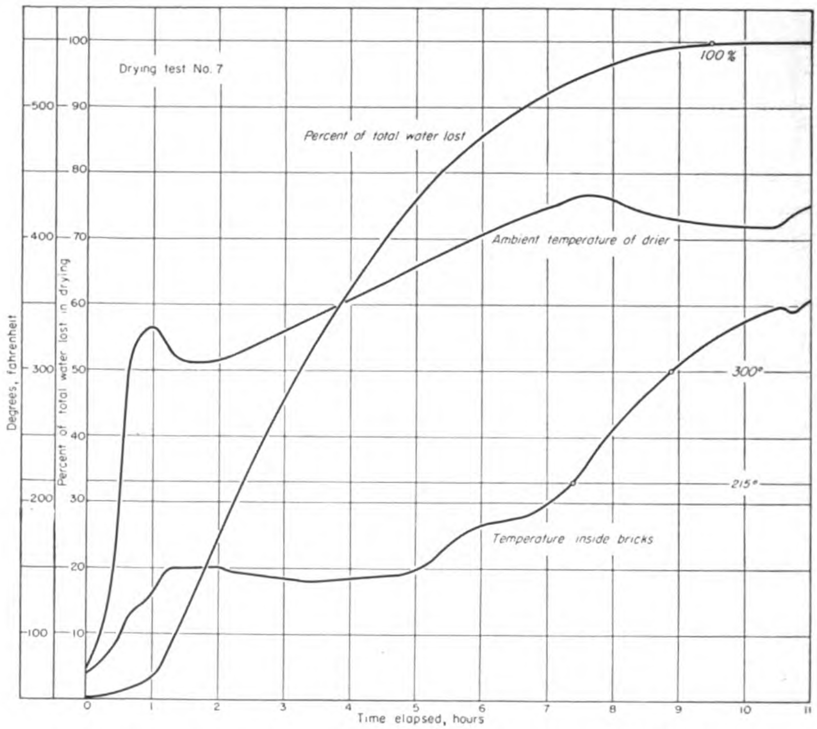

FIG. 9.—Graph showing temperature and water loss curves for drying test No. 7.

hot end of the balance arm. All the dried bricks were completely sound.

Drying test No. 7 (Fig. 9) was conducted with even greater care than test No. 6, and the drier temperature brought to 300° F. as nearly instantaneously as possible. Due to increased humidity (or percentage of super-heated steam) brick temperatures kept down to previous levels despite increased drier temperatures. After 7.4 hours total drying time the brick temperatures had reached 215° F., and a rapid increase in the slope of the brick temperature versus time indicates complete dryness despite the weight indication of 94 percent water loss. After 8.9 hours total drying time the brick had reached a temperature of 300° F., 99 percent water loss was indicated, and the drier temperature had dropped from a maximum of 440° F. to 415°. Complete dryness was indicated as occurring after 9.5 hours total drying time, or

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approximately 35 minutes after the brick had reached a temperature of 300° F. If drying is considered as beginning when the drier temperature reached 300° and the brick temperature 110° F. the tempering water was completely lost after 6.8 hours, and the hygroscopic water after 8.3 hours. Although this drying test included some red-firing bricks made from an even more plastic clay than that used for the manufacture of the buff-firing ones, none of the brick were cracked or warped in the drying process.

The inconsistencies found to occur between brick temperatures and percent of total water removed are due not only to inherent errors in the weighing mechanism, but also to the fact that the completely dried bricks were weighed after having reached temperatures well in excess of 300° F. Loss of water was calculated on the basis of the differences of the weight of

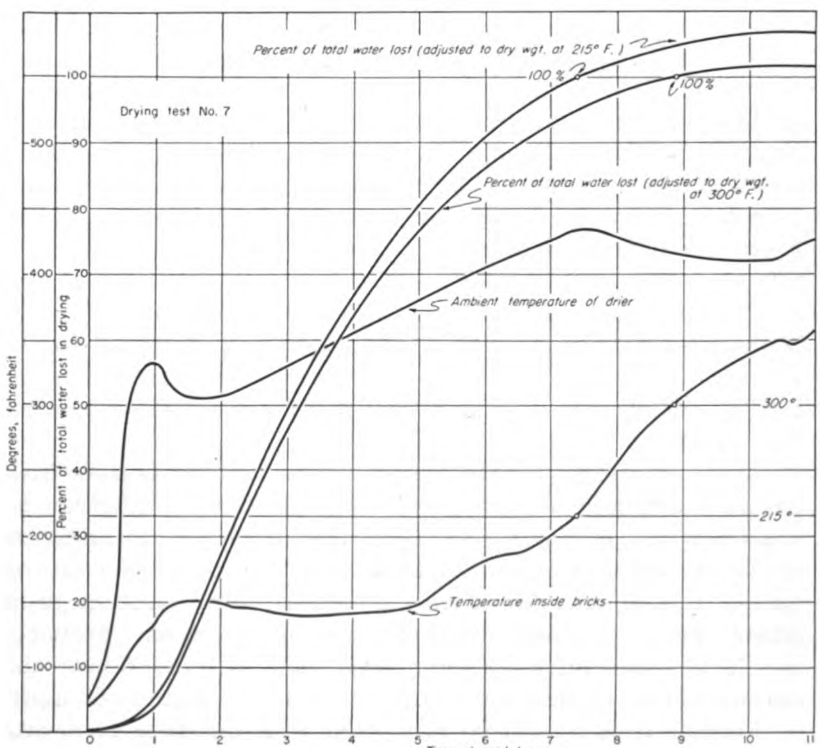

Fig. 10.—Graph showing temperature and adjusted water loss curves for drying test No. 7.

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the bricks before drying and after having reached this high temperature. The color of the brick indicated that some oxidation of iron and organic materials had taken place. It is also probable that some higher temperature water was driven off. The differential thermal analysis curve (Fig. 1) indicates that an endothermic reaction did occur above 300° F. If these factors are correctly interpreted the water loss curves should be adjusted so that 100 percent dryness coincides with the 300° brick temperature if the drying plus preheating is considered the end point, or if 212° F. dryness is the purpose of the process the 100 percent dryness point should coincide with 212° F. temperature of the bricks (or 215° as used in these tests). Such an adjustment would have been made in all the curves if lower temperature points on the curve could have been correctly estimated. Adjustments to both end points have been made for drying test No. 7 and are shown in Figure 10.

SUMMARY AND CONCLUSIONS

The length of time required to dry brick made from a plastic clay can be shortened only by increasing temperatures, by increasing the movement of drying air, or a combination of both. Increase of drying temperatures was used in the drying tests described because laboratory facilities were best adapted to this procedure, and because increased air movement would also tend to increase surface drying in proportion to interior drying of the bricks. Increase of temperatures and an increased rate of temperature rise will also produce excessive surface drying at the expense of interior brick drying unless controlled by increasing humidity.

Eight drying tests indicate that a safe drying time of more than 24 hours required with conventional methods of drying can be shortened to less than 8 hours with drier temperatures in excess of 300° F. and with high humidity throughout most of the drying cycle. At temperatures above 212° F. the term "percentage of water vapor," or "percentage of super-heated steam" probably should be substituted for "humidity," although at or near the surface of the wet bricks the term "humidity" continues to apply.

Further tests should be conducted with this type of drying and with some improvements of the equipment used. Some means of measuring humidity, or percentage of water vapor in the atmos-

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phere of a drier at temperatures above 212°F., is especially needed.

The type of drying described in this report would be most easily adaptable to the periodic type of drier if applied on a commercial scale. It is probable, however, that such drying could be carried out in a continuous tunnel-type drier if the heat were applied from the bottom of the drier and the air movement was vertical rather than horizontal. If a continuous drier were used, special precautions would have to be taken when additional loaded drier cars were placed in, or taken out of the drier. A vestibule at both ends of the drier may be required to prevent shock cooling or heating and rapid changes in the drying atmosphere. Such vestibules are found in some types of combination drier and tunnel kiln. With this combination it is especially important to avoid cooling the bricks at the end of the 300° drying temperature and the beginning of the kiln firing. It would be possible to dry to 212° F. with the method used in the tests and to carry out the pre-heating from 212° to 300° in the low temperature zone of the kiln. This method, however, would require additional time because humidity control is not feasible in the pre-heating zone of a tunnel kiln.

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State Geological Survey of Kansas, Bulletin 102
1953 Reports of Studies, Part 7, Pages 145-173, Figures 1-8
October 30, 1953

IMPROVEMENT OF SOME KANSAS CLAYS THROUGH THE CONTROL OF pH AND OF SOLUBLE SULFATES

By
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TABLES

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ABSTRACT

For a number of years brick manufacturers have found that the control of pH through the addition of an alkaline salt, usually sodium carbonate, to some types of clays and shales results in an improvement of extrusion characteristics, dry strength, fired strength, and color, and lowers the absorption of the fired brick. Dakota formation fire clays used in the manufacture of face brick were investigated to determine the optimum amount of sodium carbonate required to produce the desired results. Inasmuch as the presence of sulfates in the clay or tempering water reduces the effectiveness of the sodium carbonate additions, tests were also conducted to determine the amount of barium carbonate required to convert all the sulfate to insoluble barium sulfate. Brick made in a laboratory extrusion machine were used to determine the improvement of the green and fired characteristics of the brick by the additions. Results were also checked by plant production of brick containing the same additions. In one case the use of barium carbonate alone proved sufficient.

INTRODUCTION

Investigations of the improvement of stiff-mud extruded brick by the control of pH through the addition of small amounts of sodium carbonate (soda ash) to the clays and shales were started in 1930 at the University of Wisconsin. The results of these investigations were first published in the Journal of the American Ceramic Society by Barker and Truog (1938). Additional articles by the same authors appeared in the Journal in 1939 and 1941. Since 1938 the methods recommended by Barker and Truog have been used rather extensively. In some cases the addition of the correct amount of soda ash to the clay or shale has resulted in marked improvements both in ease of manufacture and quality of finished brick.

The green working characteristics and the fired properties of clays are determined by the particle size and types of clay minerals present, by the particle size and chemical characteristics of the nonclay fraction, by the proportion of clay to nonclay constituents, and by the ion-exchange characteristics of the clayey mass. Kaolinitic clays have low ion-exchange capacity, illitic clays occupy an intermediate position, and montmorillonoids have high ion-exchange capacity. In clay materials the commonest exchangeable cations are Ca^{++}, Mg^{++}, H^{++}, K^{+}, NH_4^{+}, and Na^{+}, frequently in about that order of relative abundance. The common anions in clay materials are SO_4^{--}, Cl^{-}, PO_4^{---}, and NO_3^{-}. The relative abundance of the anions is not yet known (Grim, 1953).

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Throughout this report the term "ion exchange" is used in preference to the more common but less accurate "base exchange." This usage, as well as the general information given on ion exchange, is taken from Grim (1953, pp. 126-160).

If the clay mass contains available ions in the form of compounds such as calcium carbonate, sulfuric acid, or alkaline feldspars, the base exchange positions will be taken up by the available ions, and calcium, hydrogen, or sodium clays will result. Hydrogen and sodium clays deflocculate easily, whereas calcium clays tend to flocculate. In the case of soils, improvements result from the addition of calcium carbonate in the form of pulverized limestone to acid or sodium soils by the resulting flocculation which confers a granular or porous structure. The opposite effect is usually desired in clays used for manufacturing brick or other ceramic articles. The deflocculated clay contains a minimum of water and dries to a dense and hard mass. Sodium compounds such as sodium hydroxide, sodium carbonate (soda ash), and sodium silicate are commonly used to produce deflocculation in clays used for ceramics. In the heavy clay products industries soda ash is the cheapest and most effective.

In a sense the title of this report is misleading. The control of pH does not in fact produce the improvements in clays. The improvements are caused by the deflocculation of the clays through the addition of reagents such as sodium carbonate. The determinations of the pH of clays to which varying amounts of the reagent have been added is the method used for the determination of the optimum amount of the reagent (in this case, sodium carbonate) to be used for deflocculation. Empirical tests indicate that optimum additions of the reagent can be revealed by plotting the pH determinations on a graph. A leveling off, or a bench on the curve, occurs with the optimum additions of the reagent.

The dominant clay mineral present in clays of the Dakota formation in Kansas is kaolinite, although minor amounts of illite, montmorillonite, and mixed-layer minerals may be present. Theoretically these clays should be hydrogen clays with a pH on the acid side. Actually almost all fresh clays from this source give a basic reaction ranging from 7.1 to 10.0 pH when tested with the glass electrode meter. After aging the pH of the clays becomes acid, pH readings ranging from 6.9 down to 3.5, possibly due to both complete drying and to slow disintegration of small

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amounts of iron sulfide. Calcium is usually present in these clays in small amounts as shown by a total CaO content of less than 1 percent. Alkalies are present in somewhat larger quantities, but sodium oxide and potassium oxide usually do not exceed a total of 3 percent. The alkalies are brought into the clay by illite and montmorillonite clay minerals, feldspar, and muscovite. Magnesium is usually more abundant than calcium in the Dakota formation clays, but total MgO, as determined by chemical analysis, seldom exceeds 2 percent. Sulfur trioxide ranges from a slight trace to 0.1 percent. Chemical analyses of the three clays discussed in this paper are given in Table 1.

It will be noted that the constituents normally expected to affect ion-exchange positions and the deflocculation of clays are present in these three clays in amounts much less than the maximums given above. If, however, even a small proportion of the calcium, sodium, and magnesium is available to fill exchange positions the pH and deflocculation characteristics of the clays would be definitely affected. Calcium hydroxide added in amounts as small as 0.035 percent produce easily detected changes in a clay.

The very light-buff or nearly white bricks produced from siliceous fire clays in the Dakota formation of Kansas must be fired to relatively high temperatures ranging from cone 5 (approximately 2160° F.) to cone 10 (approximately 2300° F.). In some cases the high percentage of quartz in the clays results in excessive power consumption in extruding the stiff mud. It was concluded that alterations of the pH of the clays through the correct additions of soda ash should decrease power consumption, produce a tougher dry brick, and decrease firing temperatures.

At the request of two brick plants, such tests were conducted on specific clay blends. Samples for the tests were furnished by the companies, and the results of plant tests were also reported to us by them.

TESTING

Methods Used in Testing

The method outlined by Barker and Truog (1938, 1939, 1941) for the determination of the optimum pH of a clay was used by us in this investigation, but with slight modifications.

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Samples consisting of 100 grams of clay were put in beakers and 250 cc distilled water added to each. Varying amounts of sodium carbonate ranging from 0.1 to 1.0 percent of the dry weight of the clay were added. The clay suspensions were stirred for 15 minutes, then the pH of each determined by the glass electrode method. Additional pH determinations were made after periods ranging up to 24 hours, or until the pH had reached a stable level. The pH values resulting from these tests were plotted on graph paper on the vertical axis (as ordinates) and the percentages of sodium carbonate added on the horizontal axis (as abscissas). Barker and Truog (1941) classified the curves obtained with various clays into three general types (Fig. 1).

The type-A curve has a definite single break in the slope. Experiments have proved that the optimum percentage of sodium carbonate is indicated by the break in the curve, just after it flattens out. The type-B curve has two or more breaks in the curve. In this case the optimum percentage of sodium carbonate required is not so clearly indicated. In general, if the first break in the curve occurs at a pH below 7.0 the next higher break represents

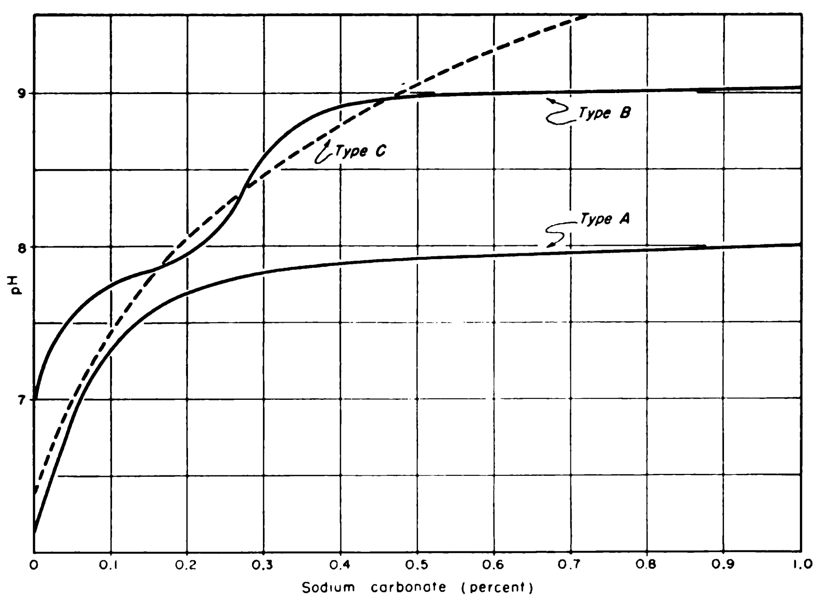

FIG. 1.—Graph showing three generalized types of pH versus sodium carbonate curves.

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the optimum percentage. If the first break occurs at a pH above 7.0 it is possible that the percentage of sodium carbonate indicated at that break will be sufficient.

The type-C curve has no definite break in the slope and therefore no definite percentage of sodium carbonate is indicated for the optimum. The presence of relatively large percentages of exchangeable magnesium may produce this type of curve in a clay. Since illitic clays contain exchangeable magnesium they are likely to produce a type-C curve. The addition of a very small amount of calcium hydroxide to the clay suspension changes the characteristics of the clay so that in some cases a type-A or type-B curve is produced.

Because the C-54-A clay produced a type-B curve with an indeterminate break-off point to indicate the optimum addition of sodium carbonate, additional tests were run with a small percentage of calcium hydroxide added in equal amounts to each of the beakers containing the varying amounts of sodium carbonate. To test the effect of calcium hydroxide without the influence of the sodium carbonate addition varying amounts of calcium hydroxide were added to the clay by the same method employed for the sodium carbonate additions. In all cases the necessary amount of barium carbonate was included in the test batches (Figs. 3 and 4).

In addition to the pH determinations specified by Barker and Truog we determined the relative amount of deflocculation with varying additions of the sodium or calcium salts by measuring the height of sediment remaining in the beakers after standing from 18 to 72 hours. In suspensions that were insufficiently deflocculated the sediment had settled to a relatively low level with a large amount of clear water at the top. The deflocculated suspensions had almost no clear water at the top and the sediment level was correspondingly high (Figs. 5 and 7).

In addition to the pH determinations with a series of increasing percentages of sodium carbonate additions, we also determined the minimum barium carbonate required to eliminate sulfate scum on the fired clays. Inasmuch as barium carbonate is used by both brick plants for this purpose it was necessary to include the effects of barium carbonate in the sodium carbonate addition tests. Furthermore, barium carbonate has a definitely beneficial effect on the deflocculation characteristics of the clay

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because it converts the detrimental soluble sulfates to insoluble barium sulfate.

The method used to determine the amount of barium carbonate required to convert the soluble sulfates in a clay is the one commonly employed by the heavy clay industries for this purpose. A series of 100-gram samples of the clay are weighed into beakers. Increasing amounts of barium chloride are added to each in the series, beginning with 0.05 percent and increasing to 1.00 percent. Distilled water in amounts sufficient to produce a thin slip is added to each of these and the mixture stirred thoroughly. After standing for 12 hours or more the clay settles out leaving clear liquid at the top. This solution contains the excess barium chloride, if present. A small amount of sulfuric acid is added to each of the beakers. In the beakers containing more barium chloride than necessary to neutralize the soluble sulfates the barium chloride is converted to barium sulfate by the acid and the clear solution becomes cloudy. The liquid in beakers containing insufficient additions of barium chloride remains clear. The correct addition of barium chloride is indicated by the beaker containing a cloudy solution and the smallest percentage of the barium salt. An equivalent addition of barium by the use of barium carbonate is calculated from the percentage of barium chloride required. In the tests we ran the water used at the brick plants was added to the distilled water in the amount used to temper the stiff mud used for extrusion. This procedure was necessary because the tempering water contains more soluble sulfates than the clay.

Chemical, Mineralogical, and Physical Properties

The two light buff- to white-firing clays tested in this investigation are typical of those found in the upper (Janssen) member of the Dakota formation in central and north-central Kansas (Plummer and Romary, 1947). In both cases slightly less than 20 feet of clay is mined from the Janssen member, and the clays are very much alike in general appearance. The uppermost part of the beds is dark gray to nearly black, and the lower part ranges from gray to very light gray. The clays are overlain by sand or silt within which is the contact between the upper Dakota formation and the lower part of the Graneros shale formation. The red-

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firing clay from Barton County (BT-3-R) occurs in the upper part of the Terra Cotta member of the Dakota formation, and immediately underlies the light-firing clay of the Janssen member described above. Almost 20 feet of buff-firing clay underlies the light-firing clay from Cloud County (C-54-A and C-54-P). This clay also occurs in the Janssen member. Red-firing clay of the Terra Cotta member underlies a total of nearly 40 feet of buff-firing clays of the Janssen member.

Cloud County clay.—The light-buff to nearly white-firing clay blends, C-54-A and C-54-P, are mined in the SE¼ sec. 32, T. 7 S., R. 2 W., Cloud County. These two clay blends are mined from the same deposit and differ only in that C-54-P contains a slightly greater proportion of plastic clay. The upper part of the bed consists of a slightly silty, almost black clay containing lignite associated with pyrite. The lower and greater proportion of the deposit mined consists of very light-gray silty clay containing very little lignite. Pyrite is present in this clay in the form of rounded pellets. Most of these pellets are coarse enough to be retained on a 100-mesh sieve (Bowdish, 1953).

Differential thermal analysis of the combined clays from this bed (C-54-A) indicates that the dominant clay mineral present is kaolinite (Fig. 2). The major endothermic peak below 600° C. and the exothermic peak at about 960° C. are typical for kaolinite. Minor endothermic deflections at 200°, 700°, and 900° C. indicate small percentages of illite and montmorillonite. The lignite and other organic matter and the pyrite produce the large exothermic deflection at 400° C. The C-54-P blend included in the series of tests is taken from the same deposit as C-54-A, and differs from it only in that a greater proportion of more plastic clay is included.

Chemical analysis (Table 1) of this clay indicates that illite and montmorillonite are present in relatively small amounts (the percentages of magnesium oxide and the alkalies are quite low). Allowing for the small amount of muscovite known to occur in this clay and the probability of some feldspar, the proportion of illite or montmorillonite to kaolinite is even lower than if all the potassium were ascribed to the clay minerals. If all the alumina present in this clay is calculated as present in kaolinite the total clay content is less than 35 percent. The remaining 65 percent is largely made up of finely divided quartz.

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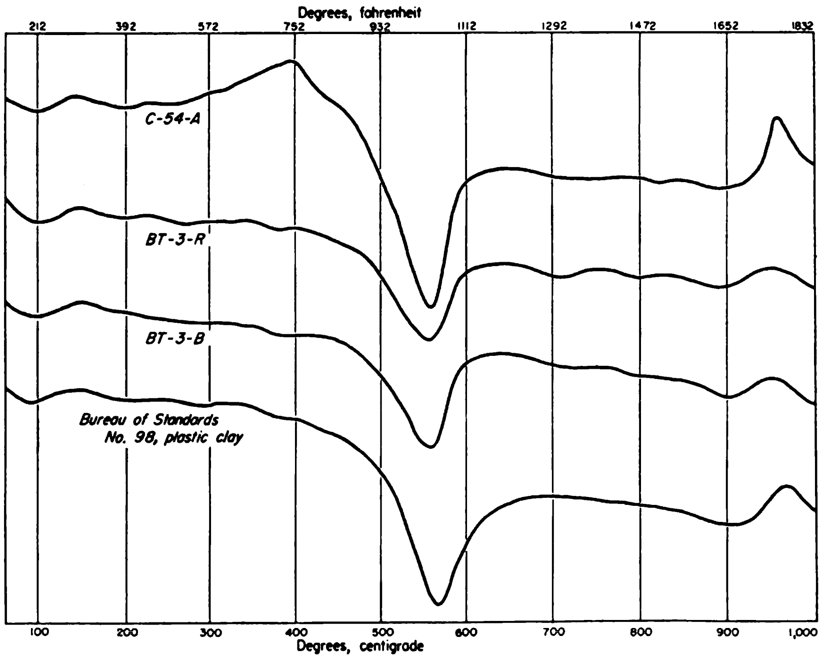

FIG. 2.—Differential thermal analysis curves of three test clays and Bureau of Standards plastic clay standard 98.

Despite the low percentage of clay minerals and the relatively high quartz content this clay is fairly plastic and works unusually well in stiff mud extrusion. As might be expected with a clay of this type no unusual drying problems are encountered.

Considered as a mixture of kaolinite and quartz this is an unusually pure material containing very few fluxes in the form of calcium, magnesium, sodium, or potassium oxides. As a result this clay is quite refractory and requires high-temperature firing to produce a sound brick. Laboratory tests (Table 3) indicate that at cone 8 (about 2240°F.) the C-54-A clay is slightly underfired. The primary purpose in investigating this clay was to find a means of decreasing the absorption and increasing the compressive strength of the brick. Although the chief method used to achieve this purpose was through pH and sulfate control, firing schedules based on reactions revealed by differential thermal analysis (Fig. 2) were recommended, as well as changes in drying methods.

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TABLE 1.—*Chemical analyses of the three clays investigated and Bureau of Standards plastic clay standard sample 98*

Constituent	C-54-A	BT-3-B	BT-3-R	Bureau of Standards no. 98
SiO_2	76.05	78.75	73.18	59.11
Al_2O_3	13.77	12.43	12.14	25.54
Fe_2O_3	1.21	1.21	5.84	2.05
TiO_2	1.35	1.20	1.16	1.43
CaO	0.25	0.26	0.58	0.21
MgO	0.39	0.35	1.10	0.72
P_2O_5	nil	trace	0.10	0.08
SO_3	trace	nil	trace	0.07
K_2O	0.48	1.02	1.38	3.17
Na_2O	0.08	0.21	0.21	0.28
Ignition loss	5.85	4.17	4.65	7.28
Total	99.43	99.63	100.34	99.94*

*ZrO_2, V_2O_5, Cr_2O_3, MnO, and CuO, totaling 0.10 percent, raises the grand total to 100.04 percent.

Barton County clay.—The Barton County clays included in this investigation (BT-3-B and BT-3-R) are mined in the SW¼ sec. 21, T. 18 S., R. 13 W., and are used in the manufacture of light-buff to red face brick. The materials are mined in benches and combined at the plant. The upper and lower benches of the buff-firing material consist of plastic gray clay with a small amount of black clay at the top of the upper bench. The middle bench is a slightly clayey, fine-grained, light-gray silt. The red-firing clay underlies the buff-firing material.

Differential thermal analysis of the mixture (BT-3-B) used in the manufacture of light-buff face brick (Fig. 2) shows that kaolinite is the dominant clay mineral. Small inflections at 700° and 900° C. indicate illite and montmorillonite in amounts slightly greater than found in the C-54-A clay. Chemical analysis (Table 1) confirms this conclusion in that the potassium oxide content is also slightly higher. The slightly lower firing temperature of this clay as compared to C-54-A or C-54-P also indicates the presence of the alkaline fluxes in greater amounts. In either case, however, the flux content is fairly low. The total clay mineral content of the two clays is approximately the same, and the dominant mineral present is finely divided quartz. Pyrite is present in very small amounts. The red-firing clay (BT-3-R) mined be-

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low the buff-firing section is similar to the upper section with the exception of a higher iron oxide content (Table 1). To judge from the yellow color of the clay the iron is present in the form of limonite and the differential thermal analysis shows minor endothermic inflections between 250° and 400° C., which is within the correct range for the thermal reactions of limonite.

These clays (BT-3-B and BT-3-R) are fairly plastic despite the high quartz content, but require a rather high consumption of power on extrusion, especially the buff-firing clay. Reduction of power consumption was the primary objective of the pH and sulfate ion control tests on these clays. Other and rather unexpected benefits were realized, however.

Data on pH and Sulfate Ion Control Tests

Cloud County clay.—Seven series of pH determinations were run on the C-54-A clay with varying additions of deflocculating agents. Series 1 consisted of increasing additions of sodium carbonate ($NaCO_3$) to the dilute clay-distilled water suspensions. Inasmuch as the clay itself has a pH of 7.41, the plotted pH-soda ash (sodium carbonate) curve is all in the alkaline pH range. This curve is an indeterminate type-B with no positive indication of optimum pH (curve 1, Fig. 3). A slight bench occurs in the curve at a pH of 8.45 at the 0.3 percent addition of sodium carbonate, a second at 8.87 at the 0.5 percent addition of sodium carbonate, and a broad bench extending somewhat below 9.18 pH and above 9.21 with an indicated optimum of about 0.75 percent sodium carbonate. The pH curve takes another upward slope, however, from 9.25 pH at the addition of 0.9 percent sodium carbonate. It was judged that the amounts indicated were much too high from the point of view of economy unless the slightly indicated 0.3 percent addition was correct.

Inasmuch as barium carbonate is used at the brick plant and would necessarily influence the addition of any deflocculating material added we decided to use barium carbonate in all subsequent tests. The optimum percentage addition of barium carbonate required to make the soluble sulfates insoluble was determined by the method previously described. This optimum percentage is between 0.25 and 0.30 percent barium carbonate.

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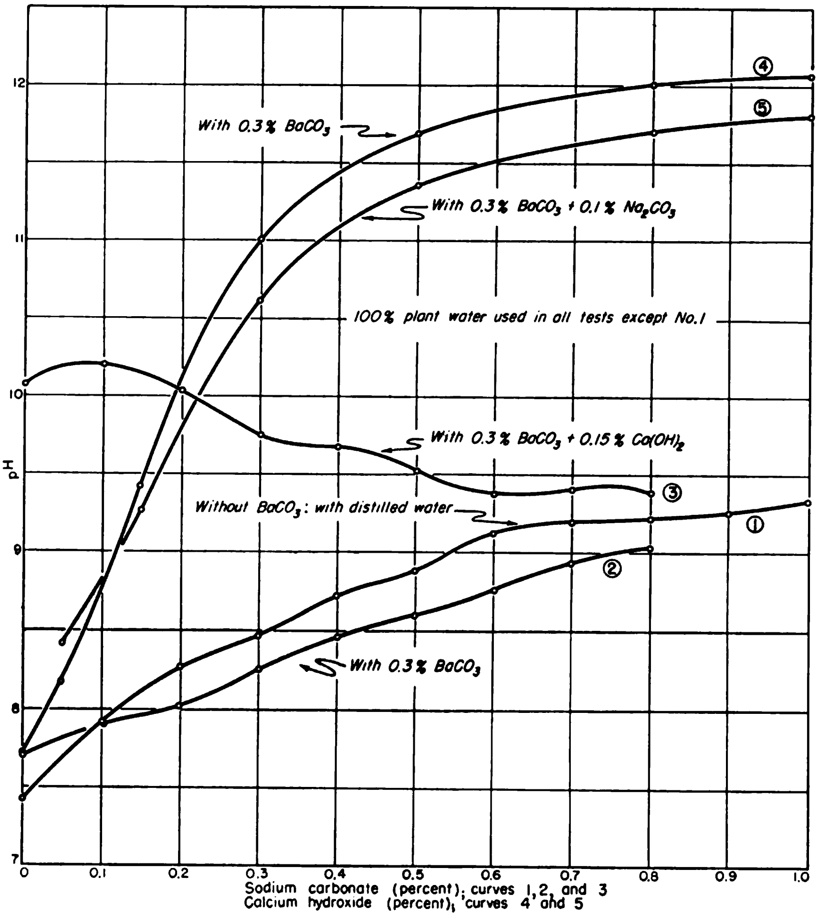

FIG. 3.—Graph showing changes of pH of clay C-54-A with increasing additions of sodium carbonate (series 1, 2, and 3) and with increasing additions of calcium hydroxide (series 4 and 5).

Series 2 was the same as series 1 with the exception that 0.3 percent barium carbonate was added to each of the tests in the series. The general shape of the plotted curve (curve 2, Fig. 3) was similar to that for series 1. Slight benches occurred in the curve at a pH of 8.03 (0.2 percent Na_2CO_3), at a pH of 8.58 (0.5 percent Na_2CO_3), and near the end of the curve at a pH of 9.04 (0.8 percent Na_2CO_3). On the whole this series of tests gave no positive indication of an optimum sodium carbonate addition.

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According to Barker and Truog (1941, pp. 320-321) the addition of calcium hydroxide ($Ca(OH)_2$) will in some cases greatly favor the adsorption of sodium by the exchange material, especially with clays giving the C-type curve. Inasmuch as the curves for series 1 and 2 were somewhat like a C-type curve we considered it advisable to add equal amounts of calcium hydroxide to a series of samples containing varying amounts of sodium carbonate. In series 3 we added 0.15 percent calcium hydroxide (hydrated lime) to each of the beakers in series 2. An anomalous curve trending generally downward was obtained by plotting the pH determinations made on series 3 (curve 3, Fig. 3). Obviously the addition of 0.15 percent calcium hydroxide complicates rather than solves the problem.

The next step in the investigation was to add varying amounts of calcium hydroxide to a series of tests. Barium carbonate was added in equal amounts to each as discussed above. It was hoped that this test would give an indication of the optimum amount of calcium hydroxide to use. A smooth A-type curve was obtained from the plotted pH determinations on series 4 (curve 4H, Fig. 3) with approximately 0.8 percent calcium hydroxide at a pH of 12.00 as the indicated optimum. In series 5, 0.1 percent sodium carbonate was added in equal amounts to series 4 (curve 5, Fig. 3). The shape of the plotted curve was again a smooth A-type, but the general level of the pH determinations was lower. About 0.8 percent calcium hydroxide was also indicated as the optimum, but the pH at this addition was lowered to 11.70. At one point on the curve (when 0.05 percent calcium hydroxide was added), however, the 0.1 percent addition of sodium carbonate raised the pH from 8.17 to 8.41.

For series 1, distilled water was used in the suspension. In series 2, 3, 4, and 5, water from the brick plant well was used. At this point in the tests we decided that the use of 250 cc brick plant water to 100 grams of clay was introducing an error in that less than 20 percent brick plant water (water used in tempering amounts to 20 percent of the dry weight of the clay) is used in tempering water for the extruded brick. In the remaining series of tests only 20 cc brick plant water was used. To this 180 cc distilled water was added to correct the ratio of water to clay.

In series 6 the beakers contained 20 percent plant water, 180 percent distilled water, 0.27 percent barium carbonate, and vary-

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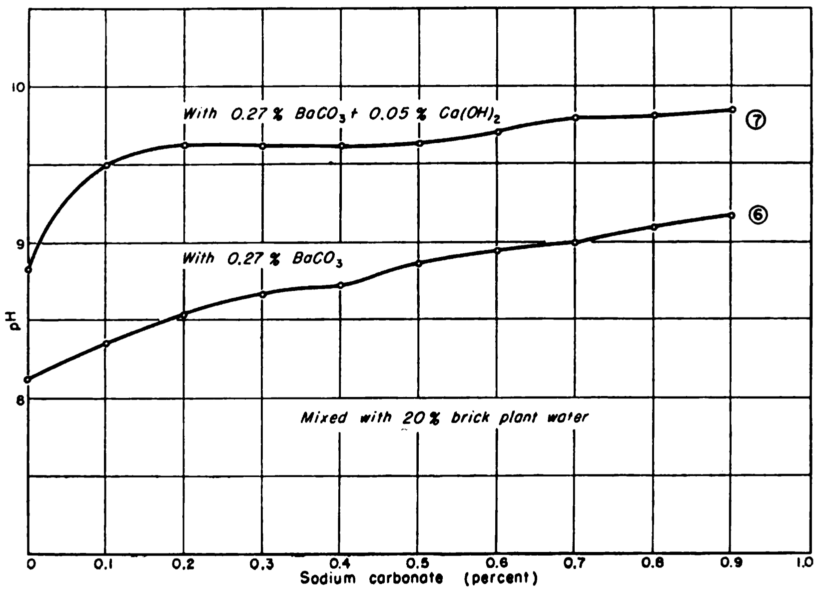

Fig. 4.—Graph showing change of pH of clay C-54-A with increasing additions of sodium carbonate (series 6 and 7).

ing amounts of sodium carbonate. The substitution of some brick plant well water for distilled water raised the pH of the beaker containing barium carbonate but no sodium carbonate from 7.70 to 8.12.

The curve plotted from series 6 (curve 6, Fig. 4) was essentially the same as that for series 2, although at a higher pH level, and the benches occurred at pH 8.66 to 8.72 (0.35 sodium carbonate added) and between pH 8.94 to 9.00 (0.65 percent sodium carbonate).

Series 7 differed from series 6 only in that 0.05 percent $Ca(OH)_2$ (calcium hydroxide) was added to each of the beakers in the series. The curve (curve 7, Fig. 4) plotted from the pH determinations in this series was a definite type-B, closely approaching a type-A. A broad bench was apparent at the points on the curve where 0.2, 0.3, and 0.4 percent was added. In each case the pH was 9.12. There was a slight rise in pH above this with 0.5, 0.6, and 0.7 percent additions of sodium carbonate, but the curve tends to level off again on the 0.8 and 0.9 percent additions, reaching a maximum pH of 9.35 when 0.9 percent sodium carbonate was added. With no sodium carbonate added, but with

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0.05 percent calcium hydroxide and 0.27 percent barium carbonate, the pH was 8.82. The increase from a pH of 8.12 in series 6 to 8.82 in series 7 was due entirely to the 0.05 percent calcium hydroxide added.

Inasmuch as the curve plotted from series 7 gave a positive indication of an optimum addition of sodium carbonate plus calcium hydroxide and barium carbonate we considered the pH determination tests completed. The optimum amount of sodium carbonate addition was judged to be 0.25 percent because this position on the curve is just above the break. With this amount of sodium carbonate plus 0.05 percent $Ca(OH)_2$ and 0.27 $BaCO_3$ the pH of the suspension was 9.12.

After the beakers containing the clay suspensions with varying amounts of reagents had stood in the laboratory for several hours we found a regular variation in the height of sediment in the bottom of the beakers and the amount of clear water remaining at the top. In poorly deflocculated suspensions we found a minimum height of sediment in the bottom and a maximum amount of clear water at the top of the beakers. The more complete the deflocculation the greater was the height of the sediment, and the clear water on top decreased to almost zero, and was cloudy with colloidal suspensions.

It occurred to us that the height of the sediment in the beakers was a rough but definite measure of the degree of deflocculation. The height of sediment in each beaker was carefully measured and plotted on graphs similar to those used to plot the pH-soda ash curves (Fig. 5).

Plotted height-of-sediment or deflocculation curves are given for four of the series of tests. For series 2 containing 0.3 percent barium carbonate and varying amounts of sodium carbonate the deflocculation curve is a definite type-A with a maximum deflocculation attained with the addition of slightly more than 0.5 percent sodium carbonate (curve 2H, Fig. 5). The deflocculation curve for series 7 (curve 7H, Fig. 5) which was judged to indicate the correct percentage additions is a definite B-type curve with a clearly defined bench produced with additions of 0.1 and 0.2 percent sodium carbonate and a definite maximum deflocculation with the addition of 0.6 percent sodium carbonate. If the lower bench is considered indicative the 0.25 percent addition of sodium carbonate is more than sufficient.

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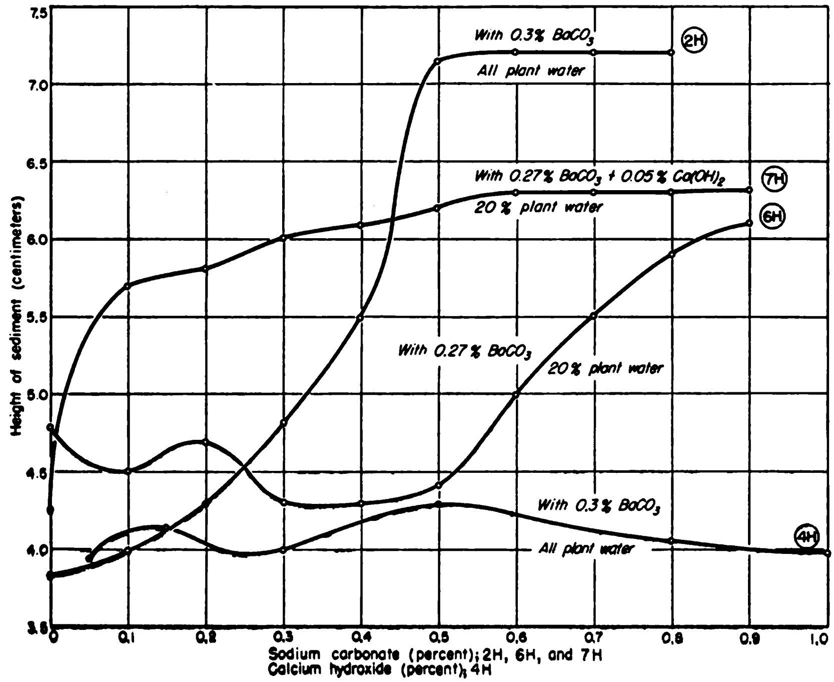

FIG. 5.—Graph showing change in height of sediment of C-54-A clay with increasing additions of sodium carbonate for series 2, 6, and 7, and with increasing additions of calcium hydroxide for series 4. Height of sediment indicates degree of deflocculation.

The deflocculation curve for series 6 (curve 6H, Fig. 5) is irregular, with two downward inflections at 0.1 percent addition of sodium carbonate (Na_2CO_3) and again at 0.3, 0.4, and 0.5 percent additions. The curve rises sharply at additions of more than 0.5 percent sodium carbonate, but does not flatten out at the end. It seems that the excess of plant water used in series 2 was definitely beneficial to deflocculation (curve 2H, Fig. 5), although the bench above 0.5 percent addition of sodium carbonate indicates an amount in excess of that desired from the point of view of cost.

The deflocculation curve for series 4 in which calcium hydroxide was used instead of sodium carbonate (curve 4H, Fig. 5) differs markedly from the pH curve for the same series (curve 4, Fig. 3). Although the increasing additions of calcium hydroxide produced a smooth A-type curve for the pH determinations, the deflocculation curve reveals that calcium hydroxide does not deflocculate. The deflocculation is irregular and has a downward trend above 0.5 percent addition of calcium hydroxide. The upward inflections probably indicate buffering of the suspension.

A second series of tests was run on the more plastic clay blend C-54-P. Inasmuch as this blend differs so little from C-54-A blend it was possible to take some short cuts in the testing procedure. For example, additions of sodium carbonate did not exceed 0.55 percent.

A series of test suspensions containing varying amounts of barium chloride indicated that 0.25 percent barium carbonate is sufficient to neutralize the soluble sulfates in the C-54-P clay. This is slightly below the 0.27 percent indicated for the C-54-A blend. In the subsequent tests with varying additions of sodium carbonate and calcium hydroxide 0.25 percent was added to the clay. As in the previous tests with C-54-A, 20 percent water from the brick plant well plus 180 percent distilled water was used in the preparation of the suspensions.

In series 8 all the suspensions contained 0.25 percent barium carbonate, but increasing amounts of sodium carbonate. The curve showing increase of pH with increasing additions of sodium carbonate (curve 8, Fig. 6) is about half way between an A-type and a C-type curve except that the lower slope of the curve up to 0.25 percent addition of sodium carbonate has a slight downward inflection. It is possible that additions of more than 0.55 percent sodium carbonate would have revealed a flattening out to an A-type curve, but the amount of sodium carbonate would have been excessive as far as cost is concerned.

In an attempt to modify this curve, 0.035 percent calcium hydroxide ($Ca(OH)_2$) was added to each of the suspensions in series 9. The curve resulting from these additions (curve 9, Fig. 6) is a definite B-type with a definite plateau between 0.05 and 0.10 percent additions of sodium carbonate (pH 8.19) and another from 0.35 percent addition of sodium carbonate (pH 8.73) and the end of the curve at 0.55 percent sodium carbonate (pH 8.77).

Series 10 was identical to series 9 except that 0.05 percent calcium hydroxide instead of 0.035 percent was added to each of the test suspensions. The resulting plotted curve (curve 10, Fig. 6) was generally modified downward as compared to series 9, but the plateau between 0.05 (pH 8.15) and 0.10 percent (pH

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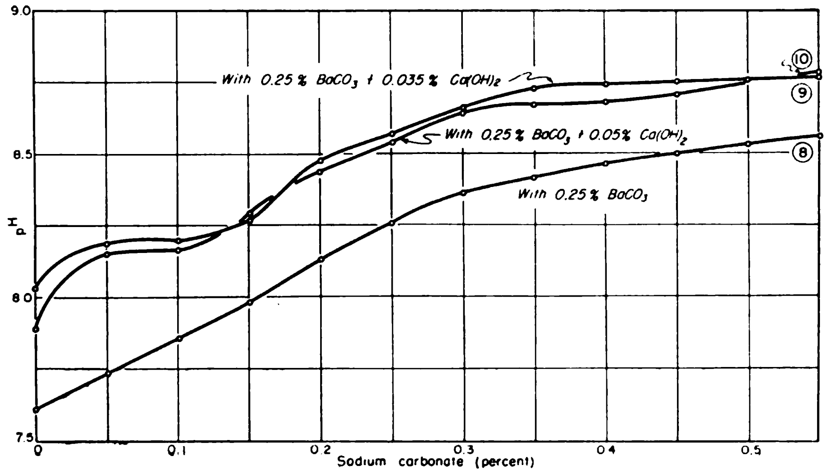

FIG. 6.—Graph showing change of pH of C-54-P clay with increasing additions of sodium carbonate for series 8, 9, and 10.

8.16) additions of sodium carbonate remained, and the higher plateau showed a more definite flattening between 0.3 (pH 8.66) and 0.4 percent (pH 8.70) additions of sodium carbonate. Above this point the curve turned upward slightly and reached a maximum of pH 8.78 with the addition of 0.55 percent sodium carbonate.

The height of sediment accumulated in the beakers after 24 hours settling was plotted against percentage sodium carbonate to obtain a deflocculation curve similar to that obtained for previous tests. In series 8, containing only barium carbonate and varying amounts of sodium carbonate, the plotted curve (8H, Fig. 7) showed three very definite plateaus. The first occurs between additions of 0.15 and 0.30 percent sodium carbonate, the second between 0.35 and 0.40 percent additions, and the third from 0.50 to 0.55 percent additions of sodium carbonate. The upper break or plateau apparently represents complete deflocculation because all the sediment remained in suspension with no clear water at the top.

The deflocculation curve for series 9 (curve 9H, Fig. 7) showed an upward bend at 0.10 percent addition of sodium carbonate, slight break in the curve beginning at 0.20 percent and ending at 0.30 percent additions of sodium carbonate, and a plateau from 0.50 to 0.55 percent additions of sodium carbonate. The plateau

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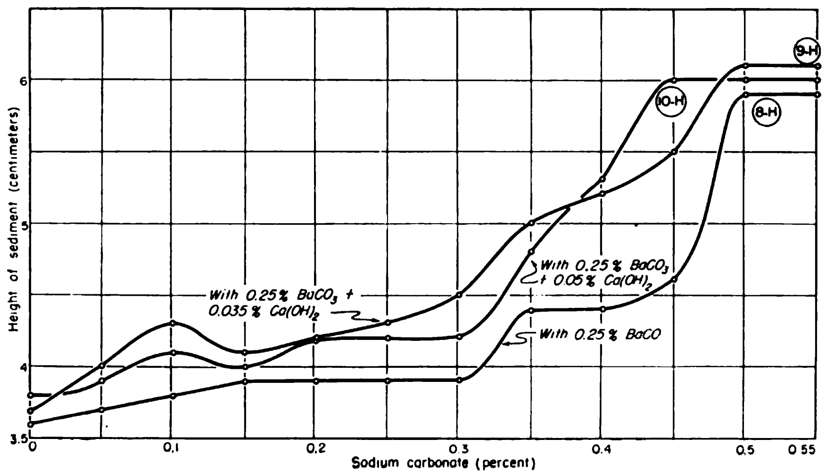

FIG. 7.—Graph showing change in height of sediment of C-54-P clay with increasing additions of sodium carbonate for series 8, 9, and 10.

for curve 9H occurred within the same range as the third for curve 8H. This series contained uniform additions of 0.035 percent calcium hydroxide and varying amounts of sodium carbonate.

Series 9 contained uniform addition of 0.50 percent calcium hydroxide and varying amounts of sodium carbonate. The deflocculation curve for this series (curve 10H, Fig. 7) was similar to curve 9H. The upward bend occurred at the same point, but instead of an intermediate break in the curve as in 9H a plateau occurred between 0.20 and 0.30 percent additions of sodium carbonate. The upper plateau for curve 10H extended from 0.45 percent to 0.55 percent additions of sodium carbonate, instead of from 0.50 to 0.55 as in curve 9H. In both series 9 and 10 complete deflocculation was achieved by the additions of sodium carbonate as indicated by the upper plateau.

On consideration of both the pH versus sodium carbonate and the height-of-sediment versus sodium carbonate curves we concluded that series 10 gave the most definite indications for optimum additions of sodium carbonate and calcium hydroxide.

Barton County clay.—Only two series of pH determinations were run on the BT-3-B clay from Barton County (Fig. 8). Series 11 was run without barium carbonate and the suspensions were prepared with distilled water. The curve plotted (curve 11, Fig. 8) from series 11 was a distinct B-type with a well-defined

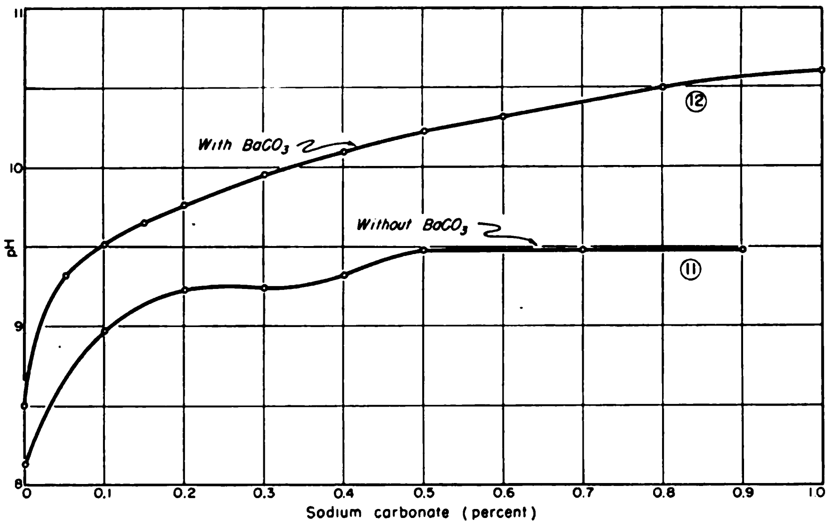

FIG. 8.—Graph showing change of pH of BT-3-B clay with increasing additions of sodium carbonate for series 11 and 12.

bench at a pH of 9.23 and with additions of 0.2 to 0.3 percent soda ash. Above a pH of 9.47 the curve was flat to the end. This curve definitely indicates that 0.2 to 0.25 percent soda ash is sufficient for this clay.

Inasmuch as barium carbonate was to be used in the clay mix for the purpose of correcting sulfate scum, a series of tests was run to determine the optimum addition of barium carbonate. The clay itself contains almost no soluble sulfates, as shown by both chemical analysis and the usual brick-plant testing technique. Tests run on the plant water, however, indicated that 0.08 to 0.10 percent barium carbonate was required to produce insoluble sulfates from the soluble ones present in the clay and the water.

In series 12, therefore, 0.08 percent barium carbonate was added to all the tests in the series containing increasing percentages of soda ash. The pH determinations were plotted (curve 12, Fig. 8) and produced a distinct type-A curve. The break in the curve occurred at a pH of 9.50, indicating that slightly more than 0.1 percent sodium carbonate would be required for deflocculation. Actually, 0.12 percent was chosen as representing an adequate amount.

Mixed with distilled water only the clay has a pH of 8.12. The clay from the Cloud County plant, under the same conditions, has

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a pH of 7.41. After the addition of the required amount of barium carbonate (0.27 percent) the pH of C-54-A clay was increased to 8.12, whereas the addition of the required 0.08 percent barium carbonate to the BT-3-B clay increased the pH to 8.50.

After optimum additions of barium carbonate and sodium carbonate to the BT-3-B clay the pH increased to 9.56. The addition of optimum percentages of barium carbonate, sodium carbonate, and calcium hydroxide to the C-54-A clay increased the pH to 9.12.

Only a few pH determinations were run on the red-firing clay from Barton County (BT-3-R). These few determinations indicated that the characteristics of the clays were so similar that separate tests were not necessary.

Larorατory Test Brick Production

Test brick were produced with an International Clay Machinery Company de-airing extrusion machine identical in operating principle to the full-scale de-airing brick plant machines. A square die 1.125 by 1.125 inches was used, producing a brick this size in cross section and any length desired. For this series of tests the bricks were cut off by a wire in 7-inch lengths. Full vacuum was used on the de-airing. The water content of the clay was adjusted to produce an extruded column with nearly the same degree of softness, or apparent plasticity for all the tests. This was done in order to make the straight clay runs and those containing additives as nearly comparable as possible. After careful and complete drying to 110° C. the bricks were fired on a slow schedule to the temperatures used in the manufacture of brick from these clays.

On each set of test brick the absorption after 24 hours submersion in cold water, absorption after 5 hours submersion in boiling water, saturation coefficient, and modulus of rupture (transverse breaking strength) for both raw dry and fired bricks were determined according to A.S.T.M. standard method of sampling and testing brick (A.S.T.M., 1952, Designation C 67-50).

The water of plasticity, linear drying shrinkage, linear fired shrinkage, bulk specific gravity, and apparent specific gravity were determined by the American Ceramic Society's standard methods (Watts and others, 1928).

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Cloud County.—Three batches of C-54-A clay were prepared for the extrusion tests. Water from the brick plant well was used for mixing all three batches. The batch compositions and assigned laboratory numbers are given in Table 2.

The percentage of water used, based on the dry weight of the ingredients, was determined by trial extrusions. The percentages given were determined from the loss of weight on drying, and are, in fact, the water of plasticity.

The C-54-A clay, without additions except barium carbonate, extrudes almost perfectly, forming a smooth, firm column. Test batch C-54-AB, containing 0.80 percent calcium hydroxide (slaked lime) was harsh and seemed to require more power for extrusion. The extruded column was firm but lacked the cohesiveness of the straight clay (C-54-A) batch. Test batch C-54-AC containing barium carbonate, soda ash, and calcium hydroxide was very similar to the C-54-A batch with the exception that the clay column seemed slicker.

After the bricks were completely dry part of each batch was broken on a transverse strength testing machine on 5-inch spans. The test brick were then fired slowly to cone 8 (approximately 2240° F.). Part of the fired brick were also tested in the transverse strength testing machine, also on a 5-inch span.

The data on the ceramic tests of these three test batches are given in Table 3.

Data on batch C-54-AC, containing 0.27 percent barium carbonate, 0.25 percent sodium carbonate, and 0.05 percent calcium hydroxide shows that these additions have definitely improved the quality of both the unfired and the fired brick over the C-54-A test batch containing only clay and barium carbonate. Because the clay is deflocculated in the C-54-AC test batch the water of plasticity is lower. Inasmuch as the dimensions of the freshly extruded bricks are the same, the deflocculated clay bricks contain more clay and are therefore more dense. This fact is re-

TABLE 2.—*Batch composition of C-54-A clay for extrusion tests*

Test batch number	C-54-A clay, percent	Water, percent	Sodium carbonate, percent	Barium carbonate, percent	Calcium hydroxide, percent
C-54-A	99.73	16.44	0	0.27	0
C-54-AB	98.93	20.24	0	0.27	0.80
C-54-AC	99.43	15.05	0.25	0.27	0.05

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TABLE 3.—*Data on ceramic tests of C-54-A clay with various additions*

	C-54-A	C-54-AB	C-54-AC
PLASTIC AND DRY DATA			
Water of plasticity, percent	16.44	20.54	15.05
Linear shrinkage, percent	5.18	4.84	3.86
Modulus of rupture, psi	502	467	677
FIRED DATA (cone 8)			
Linear shrinkage, percent	1.16	1.65	1.26
Total linear shrinkage, percent	6.33	6.44	5.14
Cold water absorption, percent	9.88	12.25	8.71
Boiling water absorption, percent	12.31	14.64	11.27
Saturation coefficient	0.80	0.84	0.77
Apparent specific gravity	2.57	2.52	2.50
Bulk specific gravity	1.95	1.84	1.95
Modulus of rupture, psi	1915	1260	2004

flected in the lowered drying shrinkage, and in the higher dry transverse strength of the dried bricks. Both lowered shrinkage and higher transverse strength should decrease losses in handling, in setting the kiln, and in the kiln after setting. It was hoped that the increased dry strength, plus slightly lower temperature sintering, would reduce losses in the kiln due to the load borne in the lower part of the setting, particularly at the point in the firing when the bricks are the weakest. This point probably occurs just after the molecular water is driven off at about 1100° F. This point is indicated by the return of the endothermic peak to the base line in the differential thermal analysis (Fig. 2).

The fired C-54-AC treated test bricks have lower absorptions and a significantly lower saturation coefficient in comparison to the C-54-A control batch. The modulus of rupture (transverse strength) is 4.6 percent higher.

The C-54-AB test batch containing 0.8 percent calcium hydroxide in addition to the barium carbonate produced a poorer quality of brick in every respect. This indicates without doubt that the clay was flocculated and that a pH curve derived from increasing addition of calcium hydroxide ($Ca(OH)_2$) has no significance so far as diagnosis for improvement of clays is concerned.

For the ceramic tests on the C-54-P plastic clay blend three batches were prepared. The test batch compositions, with assigned laboratory numbers, are given in Table 4.

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TABLE 4.—*Batch composition of C-54-P clay for extrusion tests*

Test batch number	C-54-P clay, percent	Water, percent	Sodium carbonate, percent	Barium carbonate, percent	Calcium hydroxide, percent
C-54-PA	99.75	17.37	0	0.25	0
C-54-PB	99.50	15.70	0.20	0.25	0.05
C-54-PC	99.25	14.82	0.45	0.25	0.05

The 0.20 percent addition of sodium carbonate is clearly indicated only on the deflocculation curve (10H, Fig. 7). The 0.45 percent addition of sodium carbonate is clearly indicated on the deflocculation curve but on the pH versus sodium carbonate curve (10, Fig. 6) this amount is slightly in excess of the indicated optimum.

No significant difference was noted in the extrusion characteristics of the three test batches. It will be noted that the percentage of water required to give comparable workability decreases with the addition of sodium carbonate, however.

Immediately after extrusion long bars of the wet clay were placed in a drier previously heated to 212° to 230°F. Neither the C-54-PA nor the C-54-PB batches showed any significant cracking. The brick made from the C-54-PC batch was cracked only slightly.

The ceramic tests for the C-54-P batches were exactly the same as those described for the C-54-A batches. The results of these tests are given in Table 5.

The data on the three test batches made from the C-54-P clay mix are very similar to those for the C-54-A mix. The only vari-

TABLE 5.—*Data on ceramic tests of C-54-P clay with various additions*

	C-54-PA	C-54-PB	C-54-PC
PLASTIC AND DRY DATA			
Water of plasticity, percent	17.37	15.70	14.82
Linear shrinkage, percent	5.09	4.60	4.33
Modulus of rupture, psi	521	776	838
FIRED DATA (cone 8)			
Linear shrinkage, percent	1.72	2.02	1.82
Total linear shrinkage, percent	6.81	6.62	6.15
Cold water absorption, percent	8.29	7.18	6.48
Boiling water absorption, percent	10.61	9.38	8.83
Saturation coefficient	0.78	0.76	0.73
Apparent specific gravity	2.54	2.52	2.50
Bulk specific gravity	2.00	2.04	2.05
Modulus of rupture, psi	2668	2800	2933

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able in the C-54-P batches is the percentage of sodium carbonate. C-54-PA contains no sodium carbonate, C-54-PB contains 0.20 percent, and C-54-PC contains 0.45 percent. Increasing amounts of sodium carbonate decrease the water of plasticity and linear drying shrinkage and increase the modulus of rupture on the dry bricks to a remarkable extent. The dry transverse strength (modulus of rupture) of C-54-PB is 49 percent greater than C-54-PA and C-54-PC is 61 percent greater than C-54-PA.

The test batches fired to cone 8 show the differences that should be expected for all the data except the linear firing shrinkage. The linear shrinkage for C-54-PB is greater than that for either C-54-PA or C-54-PC. Absorptions, saturation coefficient, and bulk specific gravity indicate a definite improvement of the clay mix with the addition of 0.20 percent sodium carbonate, and a greater improvement with the 0.45 percent addition. This correlates with a 5.0 percent increase in the modulus of rupture with 0.20 percent addition of sodium carbonate (C-54-PB) and a 9.9 percent increase with the addition of 0.45 percent sodium carbonate (C-54-PC).

Inasmuch as the C-54-PC batch shows greater improvement in all dry and fired properties it is obvious that the addition of 0.45 percent sodium carbonate, plus 0.05 percent calcium hydroxide and 0.25 percent barium carbonate, is definitely indicated.

Barton County.—Three test batches were also prepared from the BT-3-B clay but with additions differing from those used for the C-54-A and C-54-P clay blends. The batch compositions and assigned laboratory numbers are given in Table 6.

Although a more accurate test would have been made with the use of brick plant water, distilled water was used in all the tests, 18 percent being added to each batch. Slight differences in moisture content of the clay resulted in the differences in tempering water shown in Table 6.

All three batches produced a clean column on extrusion, but the ones with sodium carbonate added (BT-3-BN) and with both

TABLE 6.—*Batch composition of BT-3-B clay for extrusion tests*

Test batch number	BT-3-B clay, percent	Water, percent	Sodium carbonate, percent	Barium carbonate, percent
BT-3-B	100	18.60	0	0
BT-3-BN	99.85	18.49	0.15	0
BT-3-BB	99.80	18.71	0.12	0.08

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sodium carbonate and barium carbonate (BT-3-BB) produced a smoother column, especially BT-3-BB. Power consumption on extrusion was measured by means of an ammeter on the extrusion machine motor and indicated that the additions reduced power consumption. The reduction of power required for extrusion was the primary objective of the tests, yet other improvements resulted.

Subsequest tests were carried out as outlined for the C-54-A clay. The results of the tests are given in Table 7.

Although the test batches containing additions show definite improvement over the straight clay batch (BT-3-B), the one containing both barium carbonate and sodium carbonate (BT-3-BB) is superior to one containing only sodium carbonate (BT-3-BN). Surprisingly the batch containing only soda ash has a higher drying shrinkage than either of the others. This indicates that deflocculation was not complete. The modulus of rupture (transverse strength) of the BT-3-BN batch was also lower than the other two, despite the fact that an improvement in all other fired properties has resulted from the addition of 0.15 percent sodium carbonate. It is possible that incomplete deflocculation may have a detrimental effect on fired strength but there is no obvious explanation of the effect produced.

From the above data the BT-3-BB test batch additions were recommended for a full-scale production test. From the laboratory data we concluded that the desired reduction in power consumption for extrusion would be realized, and that drier and

TABLE 7.—*Data on ceramic tests of BT-3-B clay with and without additions*

	BT-3-B	BT-3-BN	BT-3-BB
PLASTIC AND DRY DATA			
Water of plasticity, percent	18.60	18.49	18.71
Linear shrinkage, percent	6.03	6.55	5.78
Modulus of rupture, psi	693	852	797
FIRED DATA (cone 5)			
Power required indicated by amperes	2.20	2.11	2.07
Linear shrinkage, percent	1.71	1.61	1.52
Total linear shrinkage, percent	7.74	8.16	7.50
Cold water absorption, percent	8.04	7.67	7.63
Boiling water absorption, percent	9.74	9.53	9.68
Saturation coefficient	0.83	0.80	0.79
Apparent specific gravity	2.53	2.52	2.54
Bulk specific gravity	2.03	2.03	2.04
Modulus of rupture, psi	2685	2667	2869

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handling losses would be lower. We also concluded that losses in the kiln would be reduced, and that a stronger brick with lower absorption would result. The fact that the saturation coefficient was lowered from 0.83 to 0.79 is significant in that the producer of face brick having a saturation coefficient of 0.80 or lower can waive the A.S.T.M. requirements on absorption and compressive strength.

Brick Plant Production Tests

Plant trials were run on the Barton County clays BT-3-B and BT-3-R with additions of barium carbonate and with additions of barium carbonate plus sodium carbonate (soda ash). The addition of the recommended amount of barium carbonate alone reduced power consumption somewhat, brightened the color of the fired brick, and lowered the temperature required to obtain the desired absorptions (produced a harder-fired brick at the same temperature). An unexplained benefit from the addition of barium carbonate was the reduction of burning time by a half-day, apparently because the heat traveled through the mass of ware more rapidly. The results from the addition of sodium carbonate were inconclusive.

Brick plant trials have not been run on the C-54-A clay blend, and one test run with the C-54-P mix containing 0.20 percent sodium carbonate (C-54-PB) did not furnish reliable data on the fired properties because of defects that occurred in drying due to the increased density of the treated clay. Conclusive results can be obtained only by modifying the drying techniques.

SUMMARY AND CONCLUSIONS

The addition of small amounts of sodium carbonate (soda ash) to Dakota formation clays used in the production of face brick improved both the green and fired properties of test bricks produced in the laboratory. Less water was required for tempering the brick, resulting in a denser dried brick, decreased drying shrinkage, and a large increase in dried transverse strength. Due to increased density the treated brick must be dried more slowly. The fired brick to which sodium carbonate (and in some cases a very small amount of calcium hydroxide) had been added showed decreased absorption and saturation coefficient and increased transverse strength.

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Although pH determinations were used to determine the amount of sodium carbonate needed for optimum deflocculation, the ratio of clear water to sediment in the beakers containing varying amounts of the reagent seemed to give a clearer indication of optimum deflocculation than the curves showing increase of pH with increasing additions of sodium carbonate.

Although plant tests have not been extensive enough to check the results of most of the laboratory tests, we have concluded the chief benefits will be realized in the decreased absorptions and increased strength of the fired brick. Improvement in the green, or unfired, properties of the Dakota clays is less significant because the untreated clays extrude easily and the dry strength is usually sufficient to permit handling without excessive breakage.

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BULLETIN 103

OIL AND GAS DEVELOPMENTS IN KANSAS DURING 1952

By

W. A. VER WIEBE, E. D. GOEBEL, J. M. JEWETT,
and A. L. HORNBAKER

Printed by Authority of the State of Kansas
Distributed from Lawrence

UNIVERSITY OF KANSAS PUBLICATIONS
AUGUST 1953

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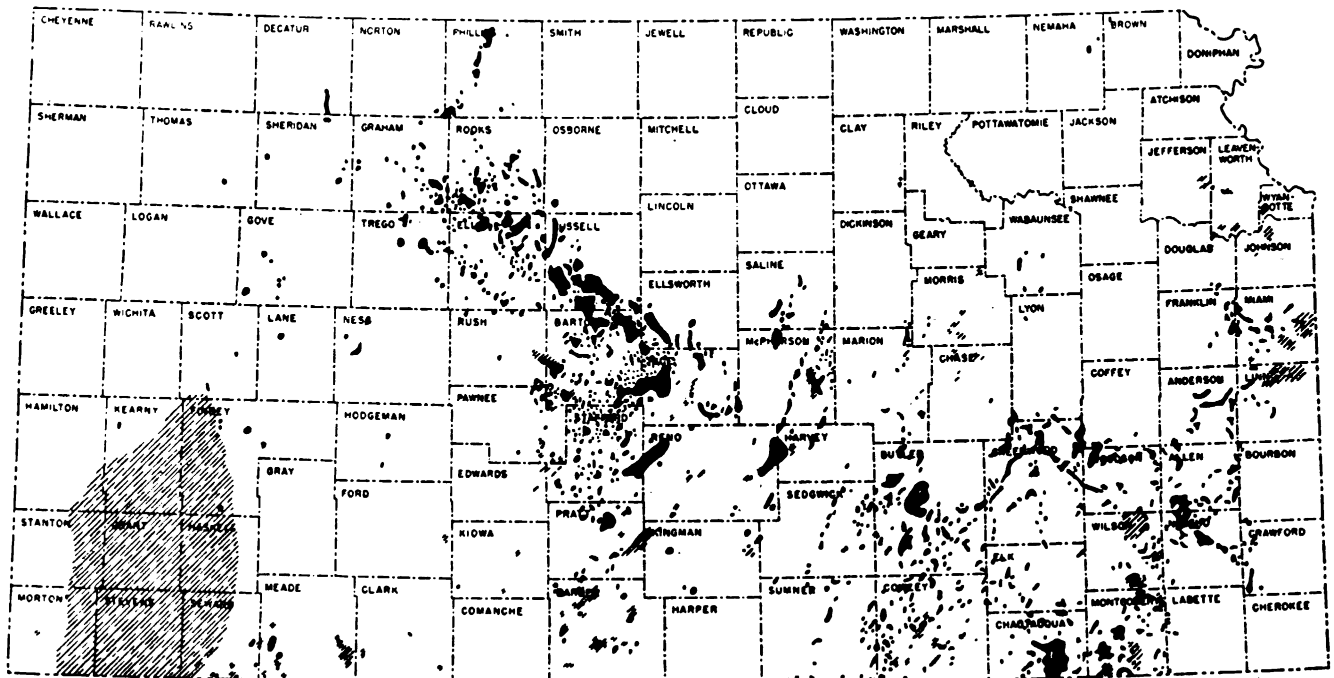

Fig. 1.—Index map of Kansas showing oil and gas producing areas.

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OIL AND GAS DEVELOPMENTS IN KANSAS DURING 1952

By

W. A. Ver Wiebe, E. D. Goebel, J. M. Jewett, and A. L. Hornbaker

ABSTRACT

Kansas oil production in 1952 totaled 114,399,556 barrels, which was 0.4 percent more than in 1951. In value the 1952 output of crude oil increased to $294,006,859 from $292,754,781 in the preceding year.

Natural gas production in Kansas reached an all-time high of 408.7 billion cubic feet (14.65 psia.); the Hugoton Gas Area produced 375 billion cubic feet, 92 percent of the State's total.

During the year 157 new oil and 10 new gas pools were discovered, far exceeding discoveries for any previous year. Eight previously abandoned oil or gas pools were revived.

Discovery of oil production from zones older than the Chase group in the Hugoton Gas Area is a significant development. Osborne, Lane, and Thomas Counties brought the total number of past and present oil-producing counties to 78.

In 1952, 5,136 wells of record, 4 percent more than in 1951, were drilled in 84 Kansas counties in connection with the petroleum industry. Of the recorded completions, 2,396 were oil wells, 305 were gas wells, 2,045 were dry holes, and 387 were salt-water disposal wells or wells used as input wells in connection with secondary recovery operations. Of the dry holes, 725 were wildcats.

As in 1951, Barton County with a production of 16,959,379 barrels, was the largest oil producer among the counties. Russell and Ellis Counties, ranked second and third, each produced more than 11 million barrels. The Trapp field of Russell and Barton Counties was the top-ranking field of the State with a production of 6,279,833 barrels of oil in 1952. The State's top five oil fields—the Trapp, Kraft-Prusa, Chase-Silica, Hall-Gurney, and Bemis-Shutts—accounted for more than 24 million barrels of the State's total oil production of 114.4 million barrels.

In 1952, Kansas produced 196 million gallons of natural gas liquids valued at more than 12 million dollars. There are more than 168 million barrels of natural gas liquids listed as proved reserves.

The proved reserves of Kansas crude oil at the end of the year were 917 million barrels, 125 million barrels more than last year's estimated reserves. Proved reserves of natural gas are about 14.2 trillion cubic feet, the highest in the State's history.

Production from secondary recovery projects in Kansas accounted for 9,196,510 barrels of oil during 1952. A total of 5,902 producing wells and 4,507 injection wells were reported operating during the year. Greenwood County led all other counties in the amount of oil produced by secondary recovery methods with 4,528,863 barrels.

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INTRODUCTION

During 1952 new records were established in all phases of the Kansas petroleum industry. New highs were attained in the production of crude oil, natural gas, natural gasoline, and LPG. The dollar value of these resources exceeded all previous records. The number of new wells drilled and the number of new oil and gas pools discovered reached the highest figure ever attained by the industry in Kansas.

New zones of production as well as new areas of production were developed in Kansas during 1952. The finding of shallow production in the older oil fields along the Central Kansas uplift was a notable development. Osborne, Lane, and Thomas Counties were added to the family of Kansas oil producing counties, bringing the total number of Kansas counties that have or are producing oil or gas to 78. A significant development in the industry was the discovery of commercial quantities of oil in the Lansing-Kansas City group of rocks within the defined area of the Hugoton Gas Area. Significant gains were made by the petroleum industry through the discovery of three other new oil fields in Finney County, four oil fields in Decatur County, nine oil fields in Graham County, four in Gove County, and 14 new "Bartlesville" and Mississippian oil fields in Cowley County.

As in 1951, Stafford County led all other counties in the number of new pool discoveries with 23 oil and 2 gas pools. Other counties with large numbers of new discoveries are: Barton 17 oil, 1 gas; Ellis 16 oil; Rooks 15 oil; and Cowley 14 oil.

Crude oil production increased nearly half a million barrels over the 1951 figure in spite of the May oil worker's strike during which the monthly pipe-line runs were more than 4.5 million barrels below the State allocation. Subsequent increases in the monthly allocations helped to make up some of the difference during the remainder of the year. Increases in the amount of oil produced through secondary recovery methods helped to realize the overall increase in crude production.

Natural gas production showed an increase of 0.4 percent over the 1951 figure, while the production of natural gas liquids increased 6.5 percent. Proved reserves of natural gas in Kansas increased 5.5 percent, while the proved reserves figure for the nation increased only 3.1 percent.

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Figure 1 is a map of Kansas showing in a general way areas within which there is production of oil or gas or both. Only a small fraction of the oil and gas territory is actually in production or included within pools because there are broad areas of barren country between pools. The map is useful, however, in showing county relations and also an idea of how large a percentage of the State may be considered "oil and gas territory."

A condensed petroleum data table (Table 2) shows at a glance the trends of the various phases of the industry in Kansas, as well as corresponding trends in the United States. Comparison of the two right hand columns of Table 2 shows whether or not Kansas is holding its own in the nation's petroleum industry.

Production and value.—Production of crude oil in Kansas during 1952, 114.4 million barrels, is about half a million barrels more than the previous high set in 1951. No notable change occurred in the price of crude oil in the State; the calculated value of the production totals more than 294 million dollars.

Natural gas production during 1952 increased to more than 408.7 billion cubic feet (Kansas Corporation Commission figure calculated at 14.65 psia.) or 0.4 percent more than the 1951 figure. Natural gas from the Hugoton Gas Area and other parts of "western Kansas" has a minimum value of 8 cents per thousand cubic feet at 16.4 psia. at the well head established by the Kansas Corporation Commission. However, they have estimated the average value at 9 cents per thousand cubic feet; this figure has been applied to all Kansas natural gas production, including the minor amount of unprorated production, much of which probably brings a higher price. Thus, the 1952 natural gas production from the State was valued at more than 32.8 million dollars.

Kansas production of natural gas liquids during 1952, 196.5 million gallons, set a new record in value also, more than 12 million dollars. Revised figures of the 1951 production were 184.4 million gallons valued at 11.3 million dollars.

The total value of Kansas raw products of the petroleum industry (crude oil, natural gas, and natural gas liquids) produced in 1952 was 338.9 million dollars, which was a new record, exceeding all previously established highs.

Barton County continued to be the largest oil producer in the State. Table 3 shows that the seven largest producing counties

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TABLE 2.—*Petroleum data table showing percentage changes for Kansas and the United States, 1951-1952*

	Kansas figures 1951	Kansas figures 1952	Kansas percentage change	United States percentage change
1. Crude oil production (barrels)	113,912,366[1]	114,399,556[1]	+ 0.4	+1.9
2. Value of crude oil produced	$292,754,781	$294,006,859	+ 0.4	....
3. Kansas crude production as percentage of U.S. total	5.2	5.1	— 1.9	....
4. Average price of crude	$2.57	$2.57	....	....
5. Rank of Kansas among oil-producing states	5th	5th	....	....
6. Proved reserves of liquid hydrocarbons (at year end), barrels	951,515,000[2]	1,085,216,000[2]	+14.1	+2.4
7. Ratio of proved liquid hydrocarbon reserves to current annual production	8.0:1	9.0:1	+12.5	....
8. Oil producing area of "western Kansas"[3] counties (acres)	553,548	598,490	+ 8.1	....
9. Natural gas production, M cu. ft.	407,192,252[4]	408,732,836[4]	+ 0.4	+8.4
10. Value of natural gas produced	$29,099,451[5]	$32,860,740[5]	....	....
11. Production of natural gasoline and LPG (natural gas liquids), gallons	184,443,772[1]*	196,461,804[1]	+ 6.5	+6.6
12. Value of natural gasoline and LPG	$11,317,620[6]*	$12,023,205[6]	+ 6.2	....
13. Proved reserves of natural gas, millions of cubic feet	13,457,498[2]	14,193,565[2]	+ 5.5	+3.1
14. Ratio of proved natural gas reserves to current annal production	30.2:1	34.3:1	+13.6	....
15. Gas producing area of "western Kansas" (acres)	2,310,850	2,502,200	+ 8.3	....
16. New oil and gas pools discovered	154[9]	167[9]	+ 8.4	....
17. Recorded well completions in Kansas				
Oil	2,152[7]	2,396[7]	+10.9	....
Gas	343[7]	305[7]	—11.1	....
Dry	1,884	2,045	+ 7.5	....
Salt-water disposal	529[8]	387[8]		
Total recorded	4,908	5,136	+ 4.6	....
Wildcats and discovery wells (included in above total)	656	725		

[1] Figures supplied by Kansas Corporation Commission, Conservation Division.

[2] Figures from American Petroleum Institute and American Gas Association, 1952. Barrels have 42 U.S. gallons and gas is based at 14.65 psia. at 60° F.

[3] The petroleum area of "western Kansas" is taken to include all producing counties west of the Cowley-Butler-Marion-Dickinson County tier.

[4] Figures supplied by Kansas Corporation Commission recalculated to base 14.65 psia.

[5] Natural gas from Hugoton Gas Area and other parts of "western Kansas" has a minimum value of 8 cents per M cubic feet at 16.4 psia. at the well head established by the Kansas Corporation Commission; however, they have estimated the average value at 9 cents per M cubic feet and this figure has been applied to all 1952 Kansas production.

[6] This aggregate figure is based on unit values of the several products that reflect wholesale prices at the plant.

[7] Includes pool wells and new discoveries.

[8] Includes salt-water disposal and recorded secondary recovery input wells.

[9] Omitting revived pools.

* Revised figures.

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TABLE 3.—*Largest oil-producing counties in Kansas during 1952*

Rank	County	Producing acreage	Total production, barrels
1	Barton	106,000	16,959,379
2	Russell	78,630	11,635,324
3	Ellis	51,630	11,070,399
4	Rice	68,360	9,566,545
5	Butler	64,660	8,164,208
6	Rooks	34,460	7,287,132
7	Stafford	47,220	6,462,936

have not changed rank for three years. Table 4 shows that the Hall-Gurney field replaced the Bemis-Shutts field in fourth place, moving the latter to fifth in field production. The Trapp field (Barton and Russell Counties) maintained first place. Annual oil production in Kansas from 1890 through 1952 is shown graphically in Figure 2. A summary of oil produced, imported, used, and exported during 1952 is given in Table 5.

It should be noted that in Table 2 and in the abstract, figures on the production of natural gas in Kansas have been calculated to a pressure base of 14.65 pounds per square inch absolute to correspond with analogous figures published by the American Petroleum Institute, the American Gas Association, the U.S. Bureau of Mines, and the leading oil and gas periodicals. This is a rather common pressure base on which gas is sold to the consumer. However, the Kansas Corporation Commission, dealing largely with the production of gas at the well head, uses a pressure base of 16.4 psia. A change to the more common pressure base is now being considered by the Kansas Corporation Commission. In the general production table (Table 67) figures on gas production of the many pools are based on 16.4 psia.

Separate detailed production tables for oil and gas are given in this bulletin. Each includes in alphabetical order all counties in the State which have oil or gas production. The listing of each county shows both current and known cumulative production,

TABLE 4.—*Largest oil-producing fields in Kansas during 1952*

Rank	Pool	Age, years	County	Total production, barrels
1	Trapp	17	Russell-Barton	6,279,833
2	Kraft-Prusa	16	Barton-Ellsworth	5,415,209
3	Chase-Silica	22	Rice-Barton-Stafford	4,898,753
4	Hall-Gurney	22	Russell-Barton	4,199,197
5	Bemis-Shutts	18	Ellis	3,642,381

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TABLE 5.—*Summary of oil produced, imported, used, and exported in 1952*
(From the Conservation Division, Kansas Corporation Commission)

	Barrels of oil
Produced	114,399,556
Imported	20,312,717
Total	134,712,273
Exported	54,125,689
Refined and used in Kansas	80,586,584
Total	134,712,273

producing area, names of pools (alphabetically arranged), discovery year, producing zones, and reported number of producing wells. Totals for each county are given so that comparisons can be made. Where oil or gas pools extend across county lines every effort has been made to divide accurately the respective productions on the basis of the output of the leases themselves. All figures are compiled with reasonable diligence: however, precise accuracy is not claimed. It is impossible at the present time to assign Hugoton Gas Area production to each of the nine counties which contribute.

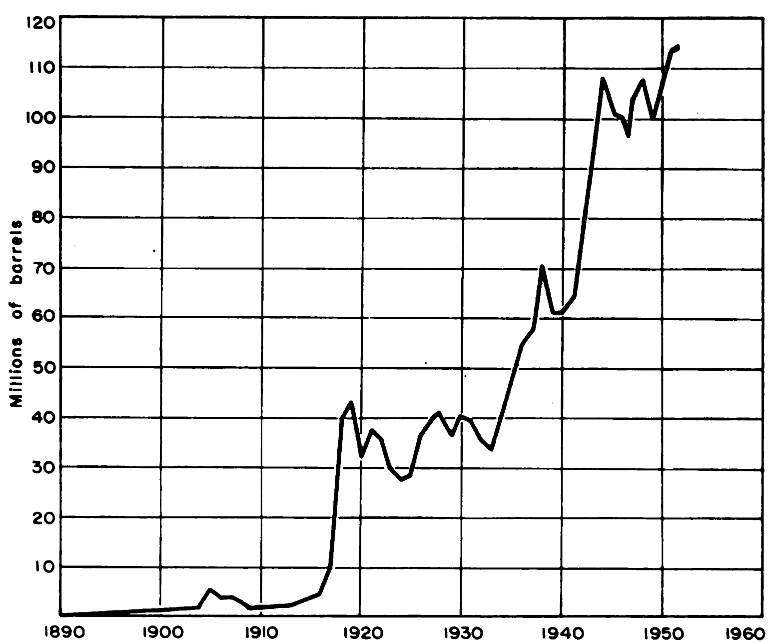

FIG. 2.—Annual oil production in Kansas from 1890 to 1952.

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Owing to the fact that the gravity of oil varies rather widely from pool to pool, it is not practical to assign dollar valuation to production from the various counties.

Reserves.—Kansas proved reserves of liquid hydrocarbons (crude oil plus natural gas liquids), as of December 31, 1952, were 1,085.2 million barrels. This represents an increase of 14.1 percent, while the national trend increased only 2.4 percent. Kansas proved reserves of crude oil were estimated to be 916 million barrels (API-AGA, 1952, p. 9) at the end of 1952. This represents an increase in the estimate of crude oil reserves of more than 125 million barrels.

Proved reserves of natural gas in Kansas at the end of 1952 were estimated by the Reserves Committee of the American Gas Association to be 14.2 trillion cubic feet, an increase of 5.5 percent. Kansas proved reserves of natural gas liquids, 163.5 million barrels, increased the 1951 estimate by 2.4 percent. All estimates of reserves are taken from the American Petroleum Institute and American Gas Association's annual report on reserves.

Area of production.—The producing area of Kansas oil and gas pools or the producing oil and gas area (the two overlap in some cases) has been calculated and shown as accurately as reasonably possible. It should be noted, however, that the producing areas as shown by the maps and in the figures are those that would be arrived at if an oil-production man rather than a geologist were drawing the field limits. Pool boundaries have been drawn a short distance outside the outermost producing wells. Where dry holes show the boundaries, the limits have been drawn between dry holes and the producing wells. Undoubtedly, the drawing areas of the reservoirs in many cases extend considerably beyond the limits as indicated. However, for practical purposes, the limits have been drawn and areas calculated on the basis of lines drawn just outside the productive area demonstrated by present development.

In the case of eastern Kansas counties, it has seemed desirable to omit from the map (Plate 1) the boundaries of the oil fields as they were drawn many years ago, since they contain very large areas that are not producing at the present time. Only areas that were producing oil during 1952 are shown on the map and assigned acre areas in the table. It is the custom of the State Geological Survey of Kansas to issue, about every five years, a bul-

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letin on the oil and gas developments in eastern Kansas. Bulletin 77 by John Mark Jewett, published in 1949, is the latest. A similar report, to be published this year, is in preparation. In such bulletins the limits and significance of boundaries of the old fields, most of the areas of which are now unproductive, are shown.

New pools.—During 1952, 157 new oil pools and 10 new gas pools were discovered in Kansas. Eight previously abandoned oil pools were revived during the year. Of the 165 new and revived oil pools, 8 were carried on the scout reports as dry and abandoned, while 3 of the pools were combined with other pools. Stafford County had 25 new pools discovered, Barton County 18, Ellis County 16, Rooks County 15, and Cowley County 14.

The new pool discoveries are listed in Table 6. The number of new oil and gas pools discovered during 1952 far exceeds any previous record. During 1952, Lane, Osborne, and Thomas counties were added as oil-producing counties. The total of Kansas counties which have in the past or are at present producing commercial quantities of oil or gas or both is 78.

TABLE 6.—*New oil and gas fields discovered in Kansas during 1952*

County, pool, and location of discovery well	Discovery well	Producing zone	Production depth, feet	Month of discovery	Initial production per day, bbls.
Barber County					
Amber Creek NE SW 36-30-12W	W. J. Coppinger No. 1 Herndon	Mississippian	4,296 (top)	Nov.	28
Stumph SW SW 7-32-14W	Natl. Coop. Ref. Assn. No. 1 Stumph-Smith	Simpson	4,963-4,970	July	509
Turkey Creek North NE SE 17-30-15W	Nadel & Gussman No. 1 Gypsum "B"	Penn. basal conglomerate	4,541-4,553	Jan.	25
Barton County					
Alefs SW SW 14-19-14W	Ben F. Brack Oil Co., Inc. No. 1 Alefs	Arbuckle	3,474-3,482	Apr.	30
Bieberle NW NW 4-19-11W	Shelley-Miller Drlg. Co. No. 1 Bieberle	Arbuckle	3,395-3,405	Oct.	123
Buckbee Southwest SW SE 15-20-12W	Lewis Drlg. Co. No. 1 Buckbee	Arbuckle	3,373-3,385	Dec.	1,551
Frank SE SW 7-19-12W	Alpine Oil & Royalty Co., No. 1 Hammeke "B"	Lans.-K.C.	3,322-3,328	Mar.	75
Great Bend Airport SE NW 26-19-14W	Honaker Drlg. Co., Inc. No. 1 Opie	Lans.-K.C.	3,320-3,324	Jan.	1,272
Great Bend Southwest NW SE 25-19-14W	Thomas H. Allan et al. No. 1 Clarke	Lans.-K.C.	3,322-3,326	Jan.	296
Hawkins NE NW 3-19-13W	Derby Drlg. Co. No. 1 Hawkins	Arbuckle	3,393-3,409	July	110
Heizer Northeast SE NW 15-19-14W	Isern Bros. et al. No. 1 Weber	Lans.-K.C.	3,353-3,367	Mar.	77
Heizer Southwest SW SW 21-19-14W	Honaker Drlg. Co. No. 1 Witte	Penn. basal conglomerate	3,496-3,501	June	2,224,000 cu. ft. gas

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Hiss East NW NW 33-20 13W	Musgrove Petro. Corp. No. 1 Hiss	Arbuckle	3,549-3,566	Dec.	50
Kramp NE NE 7-19-11W	J. A. Terteling & Sons No. 1 Kramp	Arbuckle	3,351-3,385	Oct.	90
Liberty NW SW 23-20-14W	Petroleum Inc. No. 1 Janne	Lans.-K.C.	3,341-3,346	Nov.	25
Lott SW SW 26-16-12W	Honaker Drlg. Co. No. 1 Lamatsch (Now part of the Beaver South field)	Arbuckle	3,354 (top)	Jan.	50
Mary Ida North NW SE 25-18-11W	Overland Drlg. Co. No. 1 Ames	Arbuckle	3,304-3,311	Dec.	D & A
Peach (Revived) SW NE 25-16-14W	Anschutz Drlg. Co. No. 1 Chaloupka (SEc NW 25-16-14W)*	Lans.-K.C.	3,373-3,377	Jan.	10
Redwing South SE NW 6-18-12W	E. H. Adair Oil Co. No. 1 Eveleigh "E"	Arbuckle	3,325-3,333	Mar.	30
Sandrock South NE SE 28-20-13W	Petroleum Inc. No. 1 Tucker "A"	Lans.-K.C.	3,418-3,430	Aug.	504
Walnut Creek SW NE 8-19-13W	Sohio Petro. Co. No. 1 Cook "B"	Lans.-K.C.	3,347-3,354	Nov.	190
Butler County					
Bare SE NW 31-28-5E	White & Ellis Drlg. Co. No. 1 Bare	"Bartlesville"	2,778-2,789	June	11
Brickley Southwest SW SE 3-27-7E	K. T. Wiedemann No. 1 Lucas	"Bartlesville"	2,699-2,732	Sept.	20
Murdock NW NW 23-25-3E	R. J. Wixson Drlg. Co. No. 1 Brainerd	Mississippian	2,709-2,719	Feb.	10
Clark County					
Snake Creek SE SE 21-34-21W	Sunray Oil Corp. No. 1 Harper	Morrowan	5,452-5,460	May	6,500,000 cu. ft. gas
Cowley County					
Arkansas City West SW SW 23-34-3E	Aylward Drlg. Co. No. 1 Land-Power	"Bartlesville"	3,291-3,295	Apr.	58
Bergkamp NW SE 6-35-4E	Smitherman-Cohen Drlg. Co. No. 1 Bergkamp	"Bartlesville"	3,202-3,225	Feb.	74
Bergkamp Northwest NW NW 6-35-4E	Flossmar Oil & Gas Co. No. 1 Maurer-Neuer	"Bartlesville"	3,208-3,211	Nov.	25
Bogner SE NE 24-31-5E	Palmer Oil Corp. No. 1 Bogner	Mississippian	2,999-3,053	Mar.	25
Cabin Valley NE NE 31-33-6E	Crest Petroleum, Inc. No. 1 Berry	"Layton"	2,188-2,197	June	25
Canfield NE NW 13-34-3E	Aylward Drlg. Co. No. 1 Canfield	"Bartlesville"	3,375-3,379	May	13
Copeland NW NE 5-35-4E	Spencer & Tobias No. 1 Copeland	Mississippian	3,211-3,224	Dec.	2
Dutch Creek NE NW 35-31-4E	Helmerich & Payne No. 1 Stucky	"Bartlesville"	2,924-2,938	Dec.	2
Enterprise Northeast NW SE 35-33-3E	Helmerich & Payne No. 1 Wright "F"	"Bartlesville"	3,335-3,347	Sept.	443
Fussell NW SE 14-34-3E	Crest Drlg. Co. No. 1 Fussell	"Bartlesville"	3,348-3,360	Oct.	50
Gibson South SE NW 32-34-3E	The Texas Co. No. 1 L. M.Bryant (Now part of the Gibson field)	"Bartlesville"	3,383-3,388	Feb.	80
Harvey NW NW 23-34-3E	Martin & Cash Drlg. Co. No. 1 Harvey	"Bartlesville"	3,278-3,296	July	2,382
Harvey Northwest SW NE 15-34-3E	Smitherman & Cohen No. 1 Oglesbee	"Bartlesville"	3,298-3,318	Oct.	3,000
Turner West SE NE 25-32-5E	Coop. Ref. Assn. & E. F. Wakefield No. 1 Abildgard	Mississippian	3,054 (top)	Mar.	16
Decatur County					
Adell Northwest SE NE 34-5-27W	Continental Oil Co. No. 1 Geo. Gillespie	Lans.-K.C.	3,632-3,686	Jan.	1,192

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TABLE 6.—*New oil and gas fields discovered in Kansas during 1952, continued*

County, pool, and location of discovery well	Discovery well	Producing zone	Production depth, feet	Month of discovery	Initial production per day, bbls.
Feely SE SW 2-5-27W	Continental Oil Co. No. 1 C. E. Feely	Lans.-K.C.	3,590-3,604	May	784
Hardesty NE NE 22-5-27W	Continental Oil Co. No. 1 J. E. Hardesty	Lans.-K.C.	3,642-3,658	Feb.	844
Monaghan SW SW 15-2-27W	E. K. Carey No. 1 Monaghan	Lans.-K.C.	3,514-3,569	July	24
Ellis County					
Antonino Townsite East NE NE 1-15-19W	Petroleum, Inc. No. 1 Wilson "B"	Lans.-K.C.	3,344-3,346	Aug.	83
Bielman SW SW 24-15-18W	Jones, Shelburne & Farmer, Inc. No. 1 Bielman	Arbuckle	3,496-3,500	July	75
Emmeram Townsite SW NE 6-13-16W	Victor Drlg. Co. No. 1 Windholz	Arbuckle	3,520-3,530	Oct.	600
Experiment SW SW 8-14-18W	Shelley-Miller Drlg. Co. No.1 Kansas State	Arbuckle	3,675-3,680	May	114
Giinther NE SW 17-11-19W	Natl. Coop. Ref. Assn. No. 1 Giinther	Arbuckle	3,554-3,558	Apr.	111
Hertel NE NW 16-14-16W	Anschutz Drlg. Co., Inc. No. 1 Hertel	Lans.-K.C.	3,134-3,172	May	76
Hertel Southwest SE NE 17-14-16W	Musgrove Petro. Corp. No. 1 Rohleder	Lans.-K.C.	3,215-3,219	July	259
Jensen NE NE 26-12-18W	B & R Drlg., Inc. No. 1 "B" Jensen	Arbuckle	3,621-3,625	Feb.	79
Nicholson North SW NW 19-11-20W	Imperial Petro Co., Inc. No. 1 Vance	Lans.-K.C.	3,610-3,614	Jan.	316
Pleasant Northwest SE SW 27-13-20W	Imperial Petro Co., Inc. No. 1 Giebler "B"	Arbuckle	3,814-3,830	Aug.	304
Raynesford SW NW 17-13-20W	Imperial Petro Co., Inc. No. 1 Raynesford "A"	Penn. basal conglomerate	3,870-3,875	Aug.	132
Raynesford East NW SW 16-13-20W	Victor Drlg., Inc. & Deep Rock Oil Corp. No. 1 Brungardt	Arbuckle	3,861-3,870	Dec.	173
Rome SE NE 27-13-17W	Murfin Drlg. Co. No. 1 Rome	Arbuckle	3,525-3,530	Dec.	459
Sessin SW NE 15-11-19W	Okmar Oil Co. No. 1 Sessin "B"	Arbuckle	3,499-3,502	Feb.	2,236
Sunnydale SW NE 1-14-20W	Kenneth A. Ellison No. 1 Hertel	Arbuckle	3,850-3,860	Nov.	20
Ubert Northwest NW NW 1-13-18W	Alpine Oil & Royalty Co., Inc. No. 1 Grissman	Arbuckle	3,592-3,606½	May	251
Weisner (revived) NW NW 36-12-20W	Flynn Oil Co. No. 1 Weisner (old well worked over)	Penn. basal conglomerate	3,863½-3,890	May	D & A
Ellsworth County					
Andrews NW NW 4-17-8W	El Dorado Refg. Co. No. 1 Andrews	Arbuckle	3,302-3,305	Aug.	132
Maes SW SE 26-17-8W	E. K. Carey Drlg. Co., Inc. No. 1 Maes	Arbuckle	3,341-3,357	Feb.	478
Finney County					
Beyer SE NW 24-26-33W	W. J. Coppinger No. 1 Beyer	Lans.-K.C.	4,398-4,406	Dec.	191

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Damme South **SW SE 28-22-33W**	W. L. Hartman No. 10 Damme	Mississippian	4,690 (top)	Oct.	244
Sonderegger **NE NE 21-22-31W**	Coop. Ref. Assn. No. 1 Sonderegger	Mississippian	4,737 (top)	Dec.	295
Stewart **SW NW 6-23-30W**	Coop. Ref. Assn. No. 1 Stewart	Mississippian	4,710 (top)	Oct.	24
Gove County					
Beougher **NW SE 8-13-30W**	Skiles Oil Corp. No. 1 Beougher	Lans.-K.C.	4,079-4,082	Mar.	4
Lundgren **NE NW 30-14-29W**	Skiles Oil Corp. No. 1 Lundgren	Mississippian	4,306-4,316	Mar.	Temp. abd.
Lundgren South **NE SW 31-14-29W**	Wycoff-Williams No. 1 Lundgren	Mississippian	4,277-4,283	Aug.	236
Pyramids **NW NW 9-15-31W**	D. R. Lauck Oil Co., Inc. No. 1 Jones (old well worked over)	Marmaton	4,280-4,290	June	150
Graham County					
Alda (revived) **NW SW 15-7-22W**	Murfin Drlg. Co. No. 1 Davis (NWc 15-7-22W)*	Lans.-K.C.	3,694-3,697	Dec.	31
Alda West **SW NW 16-7-22W**	Murfin Drlg. Co. No. 1 Worcester	Lans.-K.C.	3,719-3,722	June	387
Bass Southwest **SE NE 14-10-21W**	Jones, Shelburne & Farmer, Inc. No. 1 Acheson (Now part of the Cooper field)	Arbuckle	3,786-3,794	Mar.	364
Dorman **NW NW 30-10-23W**	Musgrove Petro. Corp. No. 1 Dorman	Lans.-K.C.	3,921-3,928	Feb.	345
Mickleson **NW SE 27-8-22W**	Jones, Shelburne & Farmer, Inc. No. 1 Mickleson	Arbuckle	3,759-3,775	Oct.	278
Noah **NW SE 27-10-21W**	Jones, Shelburne & Farmer, Inc. No. 1 Noah "D"	Arbuckle	3,786-3,793	May	234
Schmied **NW SE 21-8-25W**	Bay Petro Corp. No. 1 Schmied	Lans.-K.C.	3,740-3,744	May	68
Schmied North **SE SW 16-8-25W**	Empire Drlg. Co. No. 1 Madden-Davis	Lans.-K.C.	3,795-3,801	Oct.	80
Schnebly **SE SE 8-8-22W**	Murfin Drlg. Co. No. 1 Schnebly	Lans.-K.C.	3,507-3,512	Oct.	214
White **NW SW 25-10-21W**	Petroleum, Inc. No. 2 White	Arbuckle	3,716-3,720½	May	154
Harper County					
Bluff Creek **SW NW 24-34-5W**	The Texas Co. No. 1 Baker	Lans.-K.C.	3,938-3,943	Sept.	26
Kingman County					
Artesian Valley **NE NE 22-27-10W**	Amerada Petro. Corp. No. 1 Richardson	Viola	4,315-4,323	June	2,359
Casley **SW NW 11-28-5W**	Pabco Drlg. Co. No. 1 Casley	Mississippian	3,794-3,801	Oct.	318
Lane County					
North Fork **NE SW 19-17-29W**	Hugoton Prod. Co. No. 1 Floyd	Lans.-K.C.	4,333-4,352	June	160
Marion County					
Biscuit Hill **N½ SE 33-21-4E**	W. R. Atkinson et al. No. 1 Brown	Mississippian	2,269-2,275	Mar.	3
Shank **SE NW 12-22-3E**	Aladdin Petro. Corp. No. 1 Burton	Mississippian	2,474-2,501	July	75
Meade County					
Bromwell **SW NW 7-34-29W**	R. E. Adams No. 1 Bromwell	Morrowan	5,901-5,908	Apr.	25

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TABLE 6.—*New oil and gas fields discovered in Kansas during 1952, continued*

County, pool, and location of discovery well	Discovery well	Producing zone	Production depth, feet	Month of discovery	Initial production per day, bbls.
Fringer NE NE 7-35-29W	Columbian Fuel Co. No. 2 Adams "G"	Morrowan	5,780-5,793	May	5,213,000 cu. ft. gas
Stevens NE NE 32-32-30W	Columbian Fuel Co. No.1 Stevens	Morrowan	5,560-5,597	Sept.	8,755,000 cu. ft. gas
Osborne County					
Ruggles NW NW 23-10-15W	Anderson-Prichard Oil Corp. No. 1 Ruggles	Penn. basal conglomerate	3,394-3,410	Jan.	193
Pawnee County					
Benson South SE SW 30-23-15W	M. B. Armer Drlg. Co., Inc. No. 1 Garvin	Lans.-K.C.	3,754-3,758	June	401
Larned (revived) SW NE 34-21-16W	Musgrove Petro. Corp. No. 1 Phinney (NE SW 28-21-16W)*	Arbuckle	3,851-3,856	Sept.	3,000
Phillips County					
Fredericksburg NE NW 4-1-18W	Alpine Oil & Royalty Co., Inc. No. 1 Kauk	Lans.-K.C.	3,457-3,460	Mar.	50
Hansen West SE NE 15-5-20W	J. H. Johnson No. 1 Lappin	Arbuckle	3,543-3,554	Dec.	15
Pratt County					
Barnes NE SW 25-27-12W	Anschutz Drlg. Co., Inc. No. 1 Barnes	Simpson	4,328-4,336	Jan.	7,860,000 cu. ft. gas
Blowout NE NE 8-27-14W	Lion Oil Co. No. 1 Eubank	Lans.-K.C.	3,929-3,936	Jan.	oil. bbl. 20 8,000,000 cu. ft. gas
Chance East NE SE 34-26-13W	R. W. Rine Drlg. Co. No. 1. Briggeman	Viola	4,261-4,277	June	220
Jarboe N½ SE 25-26-14W	Rine Drlg. Co. No. 1 Jarboe (old well worked over)	Lans.-K.C.	3,834-3,848	Sept.	3½
Reno County					
Keddie NE SW 26-23-10W	Nadel & Gussman No. 1 Paine (old well worked over)	Lans.-K.C.	3,299 (top)	July	D & A
Nicklaus Lot 3 3-26-4W	Saturn Drlg., Inc. No. 1 Nicklaus	Lans.-K.C.	3,249-3,251	Nov.	87
Sankey Southwest NW SE 21-22-10W	Natl. Coop. Ref. Assoc. No. 1 Schweizer	Viola	3,548-3,550	Jan.	483
Rice County					
Bingham NE NW 35-19-9W	W. L. Hartman No. 1 Bingham	Arbuckle	3,332 (top)	Apr.	25
Calf Creek North SW NE 28-18-10W	Vickers Petro. Co., Inc. No. 1 Roesler "B"	Arbuckle	3,248-3,261	Dec.	80
Click (revived) SW SE 3-18-7W	A. D. Allison No. 1 Click (SEc NE 3-18-7W)*	Lans.-K.C.	3,050-3,054	Mar.	25
Fair SW SE 15-21-10W	Magnolia Petro. Co. No. 1 James H. Fair	Penn. basal conglomerate	3,358-3,368	Jan.	11
Farmer NE SE 24-18-10W	Nadel & Gussman No. 1 Bredfeldt	Arbuckle	3,222-3,228	May	1,166
Galt (revived) SW NE 8-18-7W	Birmingham-Bartlett Drlg. Co. No. 1 Fergueson (NW NE 8-18-7W)*	Arbuckle	3,193-3,197	July	152
Schulz NE NE 15-18-10W	Ash-Mur Drlg. Co. No. 1 Schulz (old well worked over)	Arbuckle	3,500 (top)	Aug.	D & A

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Rooks County

Bartos SW SW 15-9-19W	Grant Oil Co. No. 1 Bartos	Arbuckle	3,544-3,549	June	50
Bassett Southwest SW NW 29-10-20W	Virginia Drlg. Co. No. 1 Thomas	Arbuckle	3,679 (top)	Dec.	28
Baumgarten Northeast NE NE 30-9-18W	Heathman & Strain Drlg. Co. No. 1 Jelinek	Arbuckle	3,608-3,617	Dec.	149
Brungardt SE SE 35-10-17W	Champlin Refg. Co. No. 1 Brungardt	Lans.-K.C.	3,194-3,210	Aug.	233
Dancer NE NW 4-8-17W	Murfin Drlg. Co. No. 1 Dancer	Lans.-K.C.	3,140-3,152	Feb.	227
Dopita East SE SE 29-8-17W	Murfin Drlg. Co. No. 1 Stamper	Lans.-K.C.	3,304-3,410	Aug.	25
Elm Creek West SE NE 24-8-18W	Jones, Shelburne & Farmer, Inc. No. 1 Thomas (Now part of the Elm Creek field)	Arbuckle	3,422-3,427	Feb.	46
Fehnel NE SW 16-10-19W	Champlin Refg. Co. No. 1 Fehnel	Lans.-K.C.	3,480-3,494	July	45
Hillside SW SW 12-8-20W	Deep Rock Oil Co. No.1 Gosselin	Shawnee	3,206-3,214	Jan.	55
Laura Southeast NW SE 30-10-20W	B & R Drlg. Co. No. 1 Schneider "B"	Arbuckle	3,667-3,672	Aug.	178
Lynd Southwest SW SE 5-10-19W	L.B. Stableford No. 1 Mabel Sutor	Arbuckle	3,759-3,763	May	80
McMullen NE SW 33-8-17W	Jones, Shelburne & Farmer, Inc. No. 1 McMullen	Arbuckle	3,454-3,459	Sept.	365
Medicine Creek NW SE 18-8-16W	Herndon Drlg. Co. No. 1 Chesney	Lans.-K.C.	3,050-3,067	June	62
Mt. Ayr NE SE 13-10-18W	Republic Nat. Gas Co. No. 1 Miller	Lans.-K.C.	3,554-3,566	July	11
Zurich Southwest SW SE 34-10-19W	Mallonee Drlg. Co. No. 1 Aksamit	Lans.-K.C.	3,385-3,394	Nov.	37

Rush County

Big Timber NW SW 5-16-18W	John Lindas Oil, Inc. No. 1 Herklotz	Arbuckle	3,613½-3,617½	June	D & A
Stegman SE NE 11-16-17W	Northern Ord., Inc. No.1 Stegman	Lans.-K.C.	3,376-3,384	Dec.	D & A
Timken SE NW 28-18-17W	E. H. Adair Oil Co. No. 1 Peterson	Arbuckle	3,729-3,751	June	259

Russell County

Fay NE SW 2-12-15W	D. R. Lauck Oil Co., Inc. No. 1 Shaffer	Arbuckle	3,238-3,250	Oct.	141

Saline County

Gypsum Creek North NE NW 33-16-1W	E.K. Carey Drlg. Co., Inc. No.1 Stein	Mississippian	2,594-2,614	June	303
Holm North NE SW 20-16-3W	Natl. Assoc. Petro. Co. No. 1 Nelson	Viola	3,427-3,437	May	44
Holm Southeast NW SE 32-16-3W	Bay Petro. Corp. No. 1 Holt	Viola	3,388-3,398	Jan.	17
Salemsborg SW SW 5-16-3W	Phillips & Sanderson No. 1 Johnson	Viola	3,381-3,435	Nov.	120

Sedgwick County

Crestview NW SW 1-27-1E	E. B. Shawver No. 1 Holmes Est.	"Burgess"	2,982-2,985	Jan.	25
Eastborough North (revived) N½ SW 4-27-2E	W. L. Hartman No.1 Rolland (SE NE 8-27-2E)*	Arbuckle	3,376-3,401	July	25

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TABLE 6.—*New oil and gas fields discovered in Kansas during 1952, concluded*

County, pool, and location of discovery well	Discovery well	Producing zone	Production depth, feet	Month of discovery	Initial production per day, bbls.
Gehring-Rick SW NE 16-28-2E	John P. Gaty No. 1 Rick (old well worked over)	Mississippian	2,950 (top)	June	15
Prairie Creek NE NW 25-25-2E	John P. Gaty No. 1 Bodecker "A"	Mississippian	2,812-2,818	May	26
Seward County					
Hawks SE NW 18-35-31W	J. M. Huber Corp. No. 1 Lofland-Hawks (old well worked over)	Morrowan	5,927 (top)	July (1951)	3,549,000 cu. ft. gas
Kismet South SE NW 26-33-31W	Flynn Oil Co. No. 1 Jury	Mississippian	5,770-5,860	May	25
Liberal-White SW SW 35-34-32W	Northern Ord., Inc. No. 1 White	Morrowan	5,906-5,910	Mar.	480,000 cu. ft. gas
Sheridan County					
George NW NE 17-9-26W	Graham-Messman-Rinehart Oil Co. No. 1 George Mills	Lans.-K.C.	4,023-4,034	May	447
Moss SW NE 2-8-30W	Moss-Mountfield-Anderson No. 1 Anderson	Lans.-K.C.	4,033½-4,037½	Dec.	D & A
Stafford County					
Brunselmeyer NE NE 2-22-13W	Anschutz Drlg. Co. No. 1 Brunselmeyer	Arbuckle	3,652 (top)	Sept.	467
Crissman NE SW 16-23-14W	Westgate-Greenland Oil Co. No. 1 Crissman	Lans.-K.C.	3,664-3,672	July	202
Crissman North NE NE 9-23-14W	Westgate-Greenland Oil Co. No. 1 Batchman	Lans.-K.C.	3,669-3,677	Dec.	282
Curtis West NW NW 12-22-14W	Westgate-Greenland Oil Co. No. 1 Williams "A"	Arbuckle	3,744-3,796	Feb.	330
Farmington West SE NE 6-25-15W	Cities Service Oil Co. No. 1 Westgate	"Penn. sand"	4,164-4,206	June	4,190,000 cu. ft. gas
Grow West SW SW 16-21-13W	Western Rig Co., Inc. No. 2 Grow (Now part of the Hazel West field)	Arbuckle	3,677-3,680	May	199
Happy Valley SW NE 15-23-13W	Petroleum, Inc. No. 1 Ward	Arbuckle	3,810-3,819	May	36
Helene SW SE 16-22-12W	Heathman & Co. No. 1 Spangenberg	Arbuckle	3,685-3,695	Oct.	223
Hickman South SW SE 34-21-14W	Petroleum, Inc. No. 1 Schartz "B"	Lans.-K.C.	3,567-3,575	Oct.	45
Hill NW NW 11-23-12W	Alpine Oil & Gas Corp. No. 1 Hill	Lans.-K.C.	3,447-3,454 3,456-3,460	Dec.	4,675,000 cu. ft. gas
Hudson NE SW 33-22-12W	Birmingham-Bartlett Drlg. Co. No. 1 Dohrman	Lans.-K.C.	3,495-3,500	Mar.	334
Koelsch SW SW 24-24-14W	Helmerich & Payne No. 1 Koelsch	Lans.-K.C.	3,750-3,758	Oct.	2,583
Koelsch Southeast SE SW 25-24-14W	Hilton Drlg. Co. No. 1 Koelsch	Arbuckle	4,187-4,191	Nov.	3,000
Lincoln Northwest NE NW 29-21-14W	Westgate-Greenland Oil Co. No. 1 Weirauch	Arbuckle	3,778-3,785	Oct.	25
Mt. View NE SE 29-22-13W	Petroleum, Inc. No. 1 Walls	Lans.-K.C.	3,641-3,649	July	505
North Star SE NW 27-24-12W	Coop. Ref. Assn. No. 1 Byer' "B"	Viola	3,915-3,931	May	341
Oscar West NW NE 22-22-14W	Imperial Drlg. Co. No. 1 Prichard	Lans.-K.C.	3,593-3,601	May	1,863
Pleasant Grove NE SW 26-22-12W	Shelley-Miller Drlg. Co. No. 1 Spangenberg	Lans.-K.C.	3,462-3,470	July	253

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Rose Valley SE SW 36-25-13W	M. B. Armer No. 1 Walter	Lans.-K.C.	3,824-3,830	June	81
St. John North NE SE 20-23-13W	Derby Oil Co. No. 1 Schulz	Lans.-K.C.	3,603-3,607	Nov.	505
St. John Northwest NE NW 20-23-13W	Anschutz Drlg. Co., Inc. No. 1 Schulz	Lans.-K.C.	3,644-3,650	June	144
Strobel NW SW 9-22-14W	Petroleum, Inc. No. 1 Strobel "C"	Arbuckle	3,864-3,872	July	94
Strobel Northwest NE NW 8-22-14W	Petroleum, Inc. No. 1 Strobel "B"	Simpson	3,852-3,854	July	100
Syms Southeast NW NW 27-21-12W	Adair Oil Co. No. 1 Shumway	Arbuckle	3,565-3,570	Oct.	2,120
Taylor NE NW 15-21-14W	Stanolind Oil & Gas Co. No. 1 Taylor	Simpson	3,688-3,692	Jan.	104
Sumner County					
Caldwell Northwest SE SE 8-35-3W	Mid-Continent Petro. Corp. No. 1 Seltzer	Simpson	4,835-4,855	Sept.	356
Hunnewell (revived) NW NE 18-35-1E	Herndon Drlg. Co. No. 1 Kerr (Location of original discovery well not available)	Mississippian	3,602-3,618	Oct.	18
Slate Creek NW SE 9-33-2E	W. J. Coppinger No. 1 Brann-Martin	Lans.-K.C.	2,804-2,816	Apr.	25
Thomas County					
Mingo NE SW 19-9-32W	Trans-Tex Drlg. Co. No. 1 Keller	Mississippian	4,680-4,684	Dec.	50
Trego County					
Ellis South NE NE 12-13-21W	Carl Todd Drlg. Co. No. 1 Newcomer	Arbuckle	3,822-3,837	Oct.	152
Groff SW SW 26-14-21W	Jones, Shelburne & Farmer, Inc. No. 1 Groff	Penn. basal conglomerate	3,822-3,832	Nov.	78
Nieden SE SW 16-12-23W	Wick's Petro. Co. No. 1 Nieden	Mississippian	3,850-3,857	Mar.	42
Ridgeway SW NW 26-12-21W	The Texas Co. No. 1 Schoenthaler	Arbuckle	3,896-3,909	Feb.	268
Sunny Slope SE SE 21-14-21W	Deep Rock Oil Corp. No. 1 Zeman	Marmaton	3,848-3,862	Jan.	248
Woodson County					
Steele SW NW 20-23-15E	Moreland & Harris No. 1 Steele	Mississippian	1,525-1,542	May	15

*Location of original discovery well.

For the first time in this series of bulletins, a table of new oil and/or gas zones discovered in old producing fields during 1952 is included. Data similar to that presented for new pool discoveries are given in Table 7.

Abandoned pools.—Only one oil pool was officially abandoned during 1952 by the Kansas Nomenclature Committee. Thirty-two oil or gas pools were combined with other pools after it was determined that the pools had common reservoirs. As has been the custom of the Survey, the outlines of the abandoned pools are omitted from the maps in this bulletin. Total production from

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TABLE 7.—*New oil or gas zones in old producing fields*

County, pool, and location of discovery well	Discovery well	Producing zone	Production depth, feet	Month of discovery	Initial production per day, bbls.
Barton County					
Alefs SW SW 14-19-14W	Ben F. Brack Oil Co., Inc. No. 1 Alefs	Lans.-K.C.	3,334-3,341	June	30
Bernard NE SW 10-19-11W	C. E. Ash No. 6 J. H. Musenberg "D"	Topeka (Shawnee)	2,866-2,872	Feb.	1,437
Great Bend Airport NE SW 26-19-14W	Honaker Drlg. Co., Inc. No. 3 Essmiller	Arbuckle	3,473-3,485	May	3,000
Hammer NW SW 36-19-12W	W. L. Hartman No. 2 Flora Birzer	Lans.-K.C.	3,088 (top)	Jan.	50
Hawkins NE NW 3-19-13W	Rocket Drlg. Co. No. 1 Hawkins (old well plugged back)	Lans.-K.C.	3,158 (top)	Nov.	291
Kraft-Prusa NW NW 32-16-11W	Natl. Coop. Ref. Assn. No. 5 Joseph	Douglas	2,997-3,009	June	211
Werner-Robl SW NE 30-19-11W	W. L. Hartman No. 2 Mary Roth	Arbuckle	3,364 (top)	Jan.	15
Cowley County					
Gibson South SE NW 32-34-3E	The Texas Co. No. 2 Bryant "A"	Mississippian	3,400-3,412	June	39
Ellis County					
Burnett SE NW 12-11-18W	Skelly Oil Co. No. 3 Kempe "C" (old well worked over)	Shawnee	2,967-2,973	Feb.	83
Emmeram Townsite SW NE 6-13-16W	Victor Drlg. Co. No. 1 Windholz	Lans.-K.C.	3,291-3,296	Oct.	600
Giinther SW NE 17-11-19W	Natl. Coop. Ref. Assn. No. 2 Giinther	Lans.-K.C.	3,439-3,448	June	33
Herl NE SE 28-14-17W	Lion Oil Co. No. 4 Herl	Penn. basal conglomerate	3,453-3,461	Feb.	162
Jensen NW NW 25-12-18W	Heathman & Co. No. 1 Staab	Lans.-K.C.	3,531-3,541	Mar.	315
Mendota NW SE 6-11-20W	Magnolia Petro. Co. No.1 Richards "B"	Lans.-K.C.	3,530-3,540	May	10
Ellsworth County					
Heiken SW SE 25-17-10W	Skelly Oil Co. No. 1 Stumps	Lans.-K.C.	2,974-2,982	Mar.	50
Graham County					
Noah SW NE 27-10-21W	Phillips Petro. Co. No. 1 Noah	Lans.-K.C.	3,651-3,658	Sept.	34
Smith-Denning West NE NW 6-10-21W	D. G. Hansen No. 2 Brown	Lans.-K.C.	3,581-3,611	Jan.	187
Kingman County					
Pat Creek SW SW 20-28-9W	Nebraska-Wyoming Oil Co. No. 2 Darlington	Simpson	4,475-4,493	July	65
Meade County					
Novinger NE SW 23-33-30W	Lansekan Co., Inc. No. 7 Langhoffer	Morrowan	5,765-5,786	Dec.	150
Osborne County					
Ruggles SE NW 23-10-15W	Anderson-Prichard Oil Corp. No. 6 Ruggles "A"	Toronto (Shawnee)	2,986-2,989	June	51
Ruggles SW SW 14-10-15W	Sohio Petro. Co. No. 1 Isenberg	Lans.-K.C.	3,024-3,026	Mar.	41

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Pawnee County

Benson Southeast NE NW 32-23-15W	Cities Service Oil Co. No. 2 Becker "B"	Lans.-K.C.	3,709-3,729	Apr.	1928
Evers SW SW 36-21-16W	Iron Drlg. Co. No. 1 Prosser "B"	Arbuckle	3,906-3,917	Feb.	140
Evers NE NE 2-22-16W	Iron Drlg. Co. No. 1 Shady "A"	Simpson	3,861-3,865	Feb.	39

Pratt County

Barnes SE SW 25-27-12W	Hamilton Bros. No. 4 Barnes "A"	Lans.-K.C.	3,620-3,632	Nov.	D & A
Chance NE SW 33-26-13W	Rine Drlg. Co. No. 1 Jo (old well worked over)	Viola	4,250-4,260	Jan.	8
Chance East NW SW 35-26-13W	R. W. Rine Drlg. Co. No. 1 Briggeman "B"	Mississippian	4,138 (top)	Sept.	198

Reno County

Haven NW SW 10-25-4W	Midstates Oil Corp. No. 1. Schlickou "A"	Viola	3,939-3,947	Jan.	SWDW

Rice County

Ixl South NW NE 9-19-10W	Skiles Oil Corp. No. 2 Boldt (This pool now part of the Ixl pool)	Arbuckle	3,334-3,340	Mar.	427

Rooks County

Gra-Rook SW SW 17-9-20W	Anschutz Drlg. Co. No. 1 Pfannensteil	Penn. basal conglomerate	3,810-3,825	Aug.	40
Jelinek SE NE 14-9-19W	Harry Gore No. 9 Ruder	Dodge (Shawnee)	3,220-3,224	June	97
McHale SE SE 7-9-18W	Grant Oil Co. No. 1 Cabbage	Lans.-K.C.	3,436-3,460	Apr.	5
Nettie CSL SW 33-9-17W	Palmer Oil Corp. No. 1 Schrandt (old well plugged back)	Simpson	3,499-3,502	Mar.	25
Palco Southeast NW NE 10-10-20W	Barnett Oil Co. No. 1 Sparks "A"	Lans.-K.C.	3,728-3,732	June	25
Slate NW SW 31-6-19W	Morris Sitrin No. 1 Ostemeyer (old well worked over)	Lans.-K.C.	3,291 (top)	July	105
Zurich NW SE 35-10-19W	C-G Drlg. Co. No. 1 Casey	Shawnee (Topeka)	3,087-3,097	Apr.	25

Stafford County

Crissman SE NW 16-23-14W	Westgate-Greenland Oil Co. No. 1 Beaver	Arbuckle	4,006-4,012	Aug.	150
Crissman NE SW 16-23-14W	Westgate-Greenland Oil Co. No. 2. Crissman	Simpson	3,984-4,000	Aug.	347
Curtis West NE NE 11-22-14W	Westgate-Greenland Oil Co. No. 3 Williams	Lans.-K.C.	3,570-3,582	May	355
Eden Valley NW NW 29-21-13W	Cities Service Oil Co. No. 5 Essmiller "B"	Lans.-K.C.	3,496-3,508	Sept.	2,519
Gates SW SW 27-21-13W	Lion Oil Co. No. 4 Gates (old well plugged back)	Viola	3,635-3,651	Feb.	60
Grow SW SE 16-21-13W	Westgate-Greenland Oil Co. No. 6 Grow	Lans.-K.C.	3,463-3,476	June	186
Leo SW SE 7-21-13W	Petroleum, Inc. No. 1 Witt "C"	Lans.-K.C.	3,475-3,504	Jan.	972
Moon NW NE 4-22-13W	Derby Drlg. Co. No. 1 Gates	Penn. basal conglomerate	3,643-3,677	Jan.	659
North Star SW NE 27-14-12W	Gulf Oil Corp. No. 1 Jenkins	Simpson	4,063-4,072	Aug.	662
Oscar SE NW 23-22-14W	S. A. Berwick No. 1 George Hoffmaster	Viola	3,777-3,785	Jan.	7
Richland NW SE 22-24-14W	Alpine Oil & Royalty Co. No. 1 White	Mississippian	4,032-4,052	Nov.	143

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TABLE 7.—*New oil and gas zones in old producing fields, concluded*

County, pool, and location of discovery well	Discovery well	Producing zone	Production depth, feet	Month of discovery	Initial production per day, bbls.
Strobel SW NW 9-22-14W	Petroleum, Inc. No. 1 Strobel "A"	Lans.-K.C.	3,659-3,663	Nov.	427
Sumner County					
Anson NW NW 36-30-2W	Anderson-Prichard Oil Corp. No. 1 Riner	Lans.-K.C.	3,264-3,276	June	50
Guelph NW NE 6-35-1E	Herndon Drlg. Co. No. 7 Gurley	Arbuckle	3,969 (top)	Feb.	120
Trego County					
Ridgeway SE NW 26-12-21W	The Texas Co. No. 3 Schoenthaler	Lans. K.C.	3,693-3,699	Apr.	361

abandoned areas is listed at the bottom of each county summary (Tables 66 and 67).

Wells drilled during 1952.—There were 5,136 wells recorded as being drilled in the State during 1952. It is certain that numerous shallow wells in several eastern Kansas counties were not recorded and thus are not included in this tabulation. Of the tests reported 2,396 were oil wells, 305 were gas wells, 2,045 were dry and abandoned holes, and 387 were salt-water disposal or were input wells drilled in connection with secondary recovery operations. New pool discoveries and pool revivals accounted for 175 of the oil and gas wells; 557 of the dry holes were dry wildcat tests. No estimate as to the number of wells drilled but not reported has been attempted.

Nine Kansas counties had more than 200 wells recorded drilled in 1952. As in previous years, Barton County led all others with 534. Following in order were Butler County (486), Russell County (355), Ellis County (318), Stafford County (310), Cowley County (300), Rooks County (279), Rice County (259), and Greenwood County (242). These nine counties accounted for 60.4 percent of the total number of wells drilled in the State during 1952.

Test wells drilled within 1½ miles of the outside boundaries of producing pools are called extension wells and are not shown on county maps in this bulletin. Test wells resulting in dry holes drilled outside this 1½ mile limit are classed as "wildcat wells" and are shown by a symbol on the maps of western Kansas counties. Any county having four or more such dry wildcat wells

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drilled in 1952 has a table listing data on the wells included under the write-up of that county.

The various tops of the formations listed in the tables have been determined through the use of electric logs if they were available. An asterisk in front of the well name in the tables indicates that no electric log is available for that well. In such cases various sources of information have been used to determine the tops of the formations. These include the Kansas Sample Log Service, Independent Oil and Gas Service, drillers logs, and other sources within the Survey.

As pool boundaries are rarely exact, the classification of wildcat wells becomes somewhat arbitrary. Hence, the total number of wildcat wells the reader may obtain from different sources is likely to vary somewhat.

For the purposes of the tables, wells counted as 1952 completions are those which have been finished within the year and which have been drilled to completion in one operation. Old wells worked over, although they came in as producers, are not counted as 1952 completions. The 1952 wells abandoned as dry and then converted to salt-water disposal use have sometimes been classed as dry holes, unless it was plain that they were drilled expressly for salt-water disposal.

Straggler Wells.—After the statistical records have been finished for each year, late reports of completed wells continue to come in. These are referred to as stragglers, reported in the bulletin for the following year, but are credited to the year in which the wells were completed. There are 206 stragglers for 1951, which are shown by counties in Table 8.

Well elevations.—Elevations of many wildcat tests in the State are given in tables or in the text. Publication of elevations of many wildcat wells was made possible through the cooperation of Laughlin-Simmons and Company, Tulsa, Oklahoma.

Eastern Kansas counties.—Counties lying wholly east of the sixth principal meridian are regarded as being in eastern Kansas, an area that has been treated separately in some reports (Jewett, 1949) and is treated somewhat differently from western Kansas in this report. Plate 1 is a map of eastern Kansas counties. Locations of areas that produced oil in 1952, rather than recognized oil fields, are shown. Locations of secondary recovery projects are shown on the same map.

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The most significant new development in eastern Kansas during 1952 was the discovery of 10 new "Bartlesville," 3 Mississippian, and 1 "Layton" horizons of production in Cowley County. One new pre-Pennsylvanian field was opened west of the Nemaha anticline, the **Murdock,** in Butler County. New production east of the anticline in Butler County includes two "Bartlesville sand" pools, the **Bare** and **Brickley Southwest.**

TABLE 8.—*Wells completed in 1951 but reported in 1952*

County	Oil	Gas	Dry	Salt-water disposal or input
Allen	....	....	....	....
Barber	1	....	....	....
Barton	24	....	5	....
Butler	11	....	2	5
Coffey	....	....	1	....
Cowley	2	....	3	....
Elk	....	....	....	3
Ellis	12	....	3	1
Ellsworth	3	....	....	1
Finney	....	2	....	1
Ford	1	....	....	....
Graham	4	....	2	....
Grant	....	4	....	....
Greenwood	1	....	2	12
Harvey	2	....	....	....
Haskell	....	4	....	....
Hodgeman	1	....	....	....
Kearny	....	1	....	....
Kingman	3	....	....	....
McPherson	2	....	....	....
Marion	3	....	1	....
Meade	....	1	....	....
Montgomery	1	....	3	....
Morton	....	2	....	....
Neosho	....	....	1	....
Norton	....	....	1	....
Osage	....	....	1	....
Pawnee	1	....	2	....
Phillips	8	....	1	....
Pratt	2	....	1	....
Rice	7	....	2	....
Rooks	4	....	2	....
Russell	9	....	2	....
Saline	3	....	2	....
Seward	....	2	2	....
Sheridan	....	....	1	....
Stafford	11	....	....	....
Stanton	....	1	....	....
Stevens	....	4	....	....
Sumner	2	....	1	....
Trego	1	....	2	....
Total	119	21	43	23

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The other major development in eastern Kansas was the intensification of the search for areas suitable for secondary recovery projects. A very significant amount of oil is produced in eastern Kansas by secondary recovery methods, principally water-flooding. During 1952, the total oil produced by secondary recovery methods, including an estimate of those projects not specifically reporting, was more than 10 million barrels. Data on secondary recovery operations are listed in Table 1.

Acknowledgments.—T. A. Morgan, J. P. Roberts, D. C. Lilley, and H. A. Beverlin of the Conservation Division of the State Corporation Commission have for a long time cooperated to the fullest extent with the Geological Survey. Without their cooperation this report would not be possible.

It would have been impossible to assign much of the oil production in eastern Kansas to definite areas or even to counties without the cooperation of the several persons and organizations who are sending monthly oil purchase reports to the Survey and who have helped in other ways. Thanks are expressed to: A. J. Becker; Marvin E. Boyer; Cities Service Oil Company; Continental Oil Company; Cooperative Refinery Association; The El Dorado Refining Company; Virgil Gamble; Joplin Refining Company; Kanotex Refining Company; Kansas City Testing Laboratory; Joe Maclaskey; W. L. Maclaskey; M. F. A. Oil Company; Sinclair Oil and Refining Company; Sinclair Prairie Oil Company; Skelly Oil Company; Skiles Oil Corporation; Standard Oil Purchasing Company; Stekoll Petroleum Company; and White Eagle Purchasing Company, Inc.

Thanks are given to the various members of the Kansas Nomenclature Committee, Kansas-Oklahoma Division of the Mid-Continent Oil and Gas Association, for giving us their data on the new oil and gas pools discovered during the year and for their area descriptions of existing pools.

Thanks are extended to numerous companies and individuals who have contributed information on secondary recovery production and drilling activities connected with secondary recovery for the year. Numerous people and companies have contributed also to gas production figures for the year.

Many people engaged in various phases of the petroleum industry in Kansas have been generous in giving us data that have been used in this report. Here should be listed Gene Brinegar,

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Frank Brooks, B. F. Brundred, Virgil Cole, Mack C. Colt, John A. Edwards, Lee Garrett, Thomas W. Lee, William McHugh, J. H. Page, Carl L. Pate, Harold O. Smedley, W. L. Stryker, Charles W. Studt, Joe Svoboda, Albert Sweeney of the Interstate Oil Compact Commission, Harvel White, and Earl A. Whitworth.

Special thanks are due to Laughlin-Simmons and Company of Tulsa, Oklahoma, for permission to publish certain well elevations and to J. D. Davies of the Kansas Sample Log Service for permission to use data on some rank wildcat tests drilled during the year. Thanks are also extended to the Independent Oil and Gas Service for their scouting service which has been most helpful.

The Survey is pleased to acknowledge assistance from Vance E. Rowe and his Petroleum Statistical Guide, Inc., in connection with his supplying a large part of the crude oil production figures.

SECONDARY RECOVERY

Repressuring of oil-bearing rocks by injection of water, air, or gas or a combination of these agents, has become a principal method of oil production in Kansas since official sanction and status were given the practice through the passage of a law in Kansas in 1935. Grandone (1944) reported that after passage of the law, the first legal project was organized by the York State Oil Company in the Seeley pool of northern Greenwood County in May of 1935. Pointing up the significance of the secondary recovery activities in the State, especially in the Cherokee basin and the southern part of the Forest City basin, is the fact that production has risen from an estimated 5 million barrels in 1942 to more than 10 million barrels this year, accounting for more than 9 percent of the State's total production this year. The reported production for 1952 totaled 9,196,510 barrels, and the 10 million barrel figure is reached by adding an estimate of those operations not reporting specifically.

Table 1 lists all the secondary recovery operations in the State for which permits to flood have been issued by the Conservation Division of the Kansas Corporation Commission. Of the 170 projects listed, 143 reported a total of 5,902 wells producing oil by secondary recovery methods and 4,507 wells which were utilized as input wells for injection of a repressuring medium. Of the

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TABLE 9.—*Data on seven counties producing oil by secondary recovery in 1952*

County	Number of projects, 1952	Total oil production 1952, bbls.	Secondary recovery oil production 1952, bbls.	Percent of total production
Allen	11	609,577	280,872	46.1
Anderson	9	576,882	501,842	86.9
Butler	18	8,164,208	1,708,523	20.1
Greenwood	48	6,834,217	4,528,863	66.2
Miami	9	591,153	527,059	89.1
Montgomery	16	677,827	543,736	80.2
Neosho	9	645,001	469,624	72.8

total 162 are located east of the sixth principal meridian, which runs north and south through Wichita.

Greenwood County as in past years led all other counties in the number of projects operating as well as in production attributable to secondary recovery (Table 9). During 1952, 48 projects in Greenwood County accounted for more than 4.5 million barrels of oil, while 18 projects in Butler County, the second largest producer of oil by secondary recovery methods, accounted for more than 1.7 million barrels. These two counties accounted for more than half the oil produced through repressuring projects in Kansas.

The following zones listed in the order of their importance provided the bulk of the oil produced through secondary recovery methods: "Bartlesville sand," "Peru sand," and "Wayside sand." Salt water was used for repressuring in most of the Kansas projects. Of the many subsurface zones from which salt water is obtained for repressuring, the three main ones are sandstones of the Douglas group, Arbuckle dolomite, and produced water from the "Bartlesville sand." Principal sources of fresh water are shallow ground-water reservoirs, lakes, streams, and municipal water supplies. Where combined fresh and salt water is used the brine is obtained commonly from the local oil-producing formation. Treatment of salt water includes aeration, addition of chemicals, settling, and filtration singly or in various combinations. Fresh water requires treatment more commonly than brines. Such treatment includes adding lime, chlorine, alum, and settling and filtering or some combination of these. Most users of combined fresh and salt water use treating methods.

In general ground water is the most satisfactory type for water flooding, because the quality of river water varies greatly

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TABLE 10.—*Estimated water-flood oil reserves in eastern Kansas counties**

County	Million barrels of oil	County	Million barrels of oil
Allen	9	Greenwood	93
Anderson	7	Linn	2
Bourbon	1	Lyon	4
Butler	57	Miami	19
Chautauqua	2	Montgomery	14
Cowley	14	Neosho	8
Crawford	1	Wilson	1
Elk	2	Woodson	3
Franklin	13		

* Estimates made by A. E. Sweeney, Jr., Interstate Oil Compact Commission.

with the seasons; hence the treatment necessary varies from time to time. Ground water usually remains uniform in chemical composition for long periods; therefore any treatment required before injection need not be changed.

Table 10 shows estimated reserves of oil in eastern Kansas counties believed to be recoverable by water flooding. The table is based primarily on Sweeney's estimates (1949). Dahlgren (1951) gave an estimate of total recoverable reserves by secondary recovery methods as of January 1, 1950, as more than 238 million barrels. At the present rate of production, this would cover more than a 20-year period.

NATURAL GAS

General.—The transmission of natural gas across state lines to market, and the approval of new cross-country gas pipe lines falls under the jurisdiction of the Interstate Commerce Commission and the Federal Power Commission respectively. Approval of transmission of gas and construction of pipe lines for interstate traffic is based both on a greatest-good-to-the-greatest-number consideration and on investment values. On these two counts, Kansas, ranking fifth among the gas-producing states, with large reserves and small population, has a minor voice in the use determination of the gas. While Kansas producers desire to export surplus gas for income which returns to the State, Kansas consumers, both domestic and industrial, complain of the exportation of the State's natural resource on the grounds of alleged loss of income and depletion of reserves. Table 11 and Figure 3 indicate that a significant portion of our gas production is being exported annually.

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TABLE 11.—*Statistical summary of Kansas natural gas production and use, 1949-1952*

	(Millions of M cu. ft. at 16.4 psia.) 1949	1950	1951	1952	Percentage change 1951-1952
Natural gas produced in Kansas	263.2	323.3	363.7	365.1	+ 0.4
Imported from outside the State	118.8	53.2	42.7	60.0	+40.6
Total to account for	382.0	376.5	406.4	425.1	+ 4.6
Gas consumed in Kansas during year					
Domestic	64.9	75.2	85.0	91.0	+ 7.1
Industrial, misc., and losses	106.0	112.8	117.0	124.1	+ 6.1
Carbon black	14.0	14.1	15.5	13.9	—10.3
Total Kansas consumption	184.9	202.1	217.5	229.0	+ 5.3
(Consumption as pct. of prod.)	(70.3)	(62.7)	(59.8)	(62.7)	+ 4.9
Exported from state	197.1	175.4	188.9	196.1	+ 3.8
Total	382.0	377.5	406.4	425.1	+ 4.6

The answer seems to be the development of more industry and consuming population in Kansas. Either processing the gas into chemicals or using the resource as industrial fuel or both will guarantee that an optimum part of the potential value of our natural gas will be realized in Kansas.

Production and use.—The amounts of natural gas produced from the principal Kansas fields during 1952 are shown by county in Table 67. Production in the "eastern Kansas" fields, which had their peak production about 50 years ago, was less than 1 per cent, while production from the Hugoton Gas Area in southwestern Kansas was almost 92 percent of the State's total for 1952.

Table 11, showing some statistics on Kansas natural gas from 1949 through 1952, reveals some important trends. The production of natural gas from 1949 through 1952 showed annual increases. During 1952, importation from outside the State increased about 40 per cent; however, exportation of natural gas increased only a little less than 4 percent. Total Kansas domestic and industrial consumption, omitting carbon black, is at an all-time high. The use of natural gas in the carbon black industry in Kansas has recently been supplemented by the use of natural gas liquids and probably partially explains the annual decrease in the use of natural gas in that industry. About 45 percent of our total gas production, that produced and imported, was exported during 1952. This larger percentage of exportation of natural gas is believed to be a smaller proportion than most Kansans realize.

New developments.—Ten new gas pools were discovered in Kansas during 1952. The new discoveries are in Barton, Clark,

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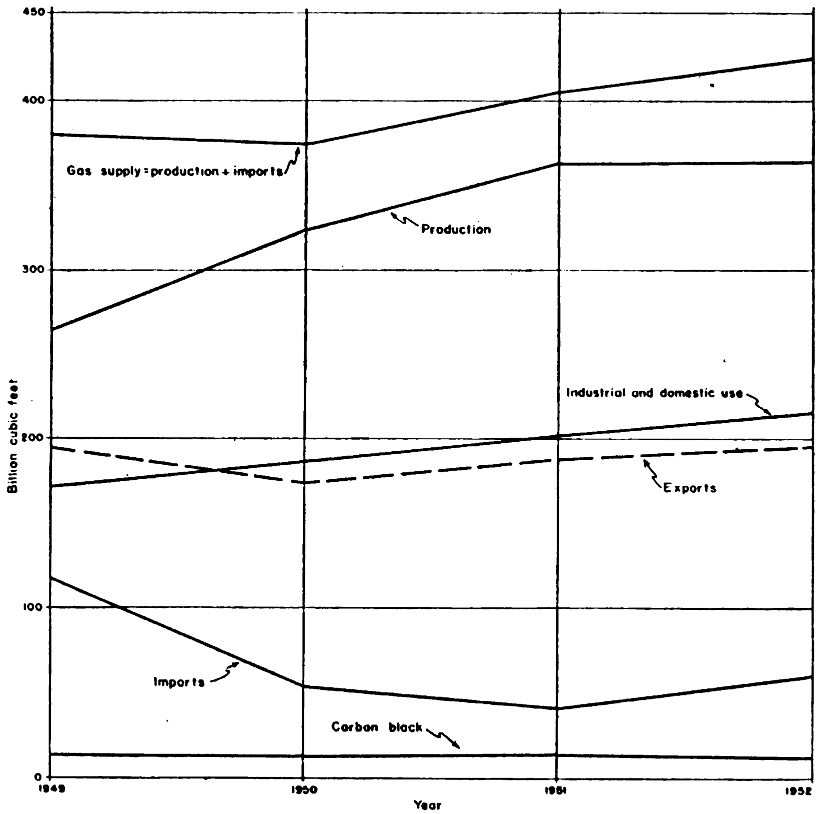

FIG. 3.—Use and disposition of Kansas natural gas.

Meade, Pratt, Seward, and Stafford Counties. The new production in Clark, Meade, and Seward Counties is thought to be from the Atokan or Morrowan Series. All other new gas production is from younger beds (Table 6).

Since the extension of the Greenwood pool in Morton County with two additional gas wells and one new producing zone during 1952, much activity has taken place in the vicinity of the pool, and from all indications a major field is being developed just west of the Hugoton Gas Area.

On July 30, 1952, the McKinney gas field in Meade County was assigned a basic proration order by the Kansas Corporation Commission. An investigation of the feasibility of continuing proration for the Otis-Albert field (Rush and Barton

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Counties) resulted in continuance of the basic order concerning the field.

The Hugoton Gas Area.—The Hugoton Gas Area, with its extensions across the Oklahoma "strip" and well into the Texas panhandle, is regarded as containing one of the world's largest known gas reserves. Production from the Kansas part of the field, more than 50 percent of the total, is shown by years in Table 12. It is interesting to note that production from the field in Kansas has increased more than 8 fold in the 11-year period from 1942 to 1952, and is at an all-time high at the present.

The producing area of the Hugoton Gas Area has been limited by the Kansas Nomenclature Committee to gas produced from formations in the Chase group of the Permian System. The lateral stratigraphic or structural features of the gas-producing area are not clearly marked, so that the outline of the producing area changes with each new well drilled on the borders. Plate 2 shows the approximate boundaries of the Hugoton Gas Area as outlined at the end of 1952 by wells having been reported with initial daily capacities of 1 million cubic feet or more. The porosity of the rocks of the Chase group seems to control productivity.

Wells with initial capacities of less than 1 million cubic feet per day after acidization may not be saved by the larger companies, those producing 5 to 15 million cubic feet per day are usual, and big wells produce more than 30 million cubic feet of gas per day. The average depth to the producing zone is about 2,500 feet.

A significant development is the discovery of commercial quantities of oil in the Lansing-Kansas City rocks on the Beyer farm in the SE¼ SE¼ NW¼ sec. 24, T. 26 S., R. 33 W., Finney County, about 12 miles south of Garden City, well within the geographic limits of the Hugoton Gas Area but not within the

TABLE 12.—*Production from the Kansas part of the Hugoton Gas Area*

Year	M cu. ft. gas (14.65 psia.)	Year	M cu. ft. gas (14.65 psia.)
1938	29,843,417	1946	119,637,983
1939	32,424,301	1947	157,663,036
1940	37,083,797	1948	185,872,594
1941	40,759,482	1949	247,868,876
1942	46,365,484	1950	320,545,480
1943	70,921,532	1951	371,002,475
1944	92,922,821	1952	375,081,748
1945	90,345,203		

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TABLE 13.—*Average analysis of natural gas from Hugoton Gas Area* (From Keplinger, Wanenmacher, and Burns, 1948)

Gases	Percent
Methane	74.26
Nitrogen	14.27
Ethane	5.81
Propane	3.52
Butane	1.48
Pentane plus	0.65
Total	99.99

stratigraphically defined limits of the field. Initial production assigned the new well was 191 barrels of oil per day. The successful completion of this well emphasizes the fact that older dry holes located within the main Hugoton Gas Area which penetrated well beyond the productive zones of the gas area do not preclude the presence of important quantities of oil or gas below the defined Hugoton Gas Area.

The Hugoton Gas Area is under rigid proration by the Kansas Corporation Commission, Division of Conservation. Commonly only one well may be drilled in each 640 acres, and allowable production for wells or group of wells is established on a monthly basis in a manner designed to conserve the gas supply. The spacing accounts for the fact that the surface evidences of a huge gas reservoir are few.

Gas from the Hugoton Gas Area is of rather high quality as indicated by Table 13. It yields about 0.5 gallon of natural gasoline condensate per thousand cubic feet, and has a heating value of roughly 1,000 B.t.u. per cubic foot. The majority of the State's natural gasoline plants are within the borders of the Hugoton Gas Area. The State's three carbon black plants are also located within the geographical limits of the Hugoton Gas Area.

The Defenders and Traders Gas Company's successful gas well in 1922, in sec. 3, T. 35 S., R. 34 W., Seward County, has been accredited as the discovery well of the Hugoton Gas Area proper. The well opened the Liberal gas field, which has since been joined to the Hugoton Gas Area. Rapid development of the huge gas reservoir in southwestern Kansas came in the early 1940's. The number of producing gas wells in the field passed the 2,000 mark and the area reached 2 million acres by the end of 1949. Gas wells drilled in the Hugoton Gas Area by counties are shown in Table 14. At the close of 1952, there were 2,874 producing gas

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TABLE 14.—*Gas wells drilled in Hugoton Gas Area by counties*

County	During 1952	Total to date
Finney	49	269
Grant	29	554
Hamilton	8	21
Haskell	30	302
Kearny	75	452
Morton	27	230
Seward	10	224
Stanton	7	184
Stevens	17	709
Total	252	2,945

wells and the area of the Kansas part of the Hugoton Gas Area was about 2,433,560 acres. It includes two entire counties (Stevens and Grant) and parts of seven others (Finney, Hamilton, Haskell, Kearny, Morton, Seward, and Stanton). Judging by the past year's developments, widening of the field has no particular pattern.

Reserves of the Kansas part of the Hugoton Gas Area are discussed under reserves of natural gas and natural gas liquids.

Natural gasoline and liquefied petroleum gas production.—With the addition of the Hugoton Production Company's natural gasoline plant at Ulysses, the total number of operating plants in Kansas was 18 at the end of 1952. In 1951 this plant produced 76,554 barrels of natural gasoline, 70,986 barrels of LPG, 31,875 barrels of propane, and 3,860 barrels of butane for a total of 183,275 barrels in 1951. A corrected daily average of natural gasoline and LPG processed during 1951, is 11,933 barrels.

The daily average for 1952, as supplied by the Conservation Division of the Kansas Corporation Commission, was 12,781 barrels. A break-down of type of production and producing plant is given in Table 15. The State's output during 1952, broken down into the four main products, together with estimated values at the plants is shown in Table 16. Production of Kansas plants for the last 12 years is shown in Table 17.

The growth of LPG has been the greatest in proportion of any part of the petroleum industry. For many years, LPG was produced mainly as a by-product of natural gasoline production. Now the total production of liquefied petroleum gases for the country as a whole exceeds the output of the regular natural gasoline grades and natural gasoline mixtures. In 1952, the sales of LPG in the United States were estimated (Benz and Tucker,

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1953, p. 58) at 4,110 million gallons exclusive of any product used in the manufacture of aviation and motor gasoline or synthetic rubber. This represents a gain of about 6.7 percent. The amount of LPG used domestically, including internal combustion engine fuel purposes, rose 9.2 percent during 1952.

TABLE 15.—*Natural gasoline and LPG processed in 1952**
(From the Conservation Division, Kansas Corporation Commission)

	Natural gas	Butane	Propane	LPG	Total
Cities Service Oil Co.					
Arkansas City, Cowley Co.	46,524			87,371	133,895
Burrton, Reno Co.	64,047		20,245	70,538	154,830
Wichita, Sedgwick Co.	469,645		151,444	161,472	782,561
Colorado Interstate Gas Co.					
Lakin, Kearny Co.	106,016				106,016
Deerfield Petroleum, Inc.					
Deerfield, Kearny Co.	136,399		22,967	23,097	182,463
Drillers Gas Co.					
Cheney, Sedgwick Co.	13,575			3,414	16,989
Flynn Oil Co.					
Otis, Rush Co.	46,897			5,363	52,260
Hugoton Production Co.					
Ulysses, Grant Co.	185,710	50,138	118,925	101,425	456,198
A. R. Jones Oil & Oper. Co.					
Pawnee Rock, Barton Co.	8,782 (Drip)				8,782
Kansas Power & Light Co.					
Medicine Lodge, Barber Co.	34,760				34,760
Magnolia Petroleum Co.					
Ulysses, Grant Co.	140,599	49,219	62,743		252,561
Northern Natural Gas Co.					
Holcomb, Finney Co.	49,652				49,652
Sublette, Haskell Co.	472,543				472,543
Panhandle Eastern Pipe Line Co.					
Liberal, Seward Co.	466,079	88,079	111,545		665,703
Skelly Oil Co.					
Cunningham, Kingman Co.	73,540	84,086			157,626
Stanolind Oil & Gas Co.					
Ulysses, Grant Co.	443,785	62,836	188,208	383,859	1,078,688
Sunray Oil Corporation					
Rainbow Bend, Cowley Co.	11,439			2,633	14,072
The Texas Company					
Atlanta, Cowley Co.	32,113			25,950	58,063
Totals	2,802,105	334,358	676,077	865,122	4,677,662
1952 daily average in barrels					12,781
Corrected daily average in barrels in 1951					11,933

* Figures in 42-gallon barrels.

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TABLE 16.—*Production and estimated value of natural gas liquids in Kansas, 1952**

	Barrels	Gallons	Unit price	Value
Natural gasoline	2,802,105		$2.95	$8,266,210
Propane	676,077			
Butane	334,358	42,438,270	0.05	2,121,914
LPG	865,122	36.335,124	0.045	1 635,081
Totals	4,677,662	196,461,804		$12,023,205

* Production figures supplied by Kansas Corporation Commission; average unit values at point of production have been obtained from sources considered to be reliable.

During 1952 the first use of LPG in conjunction with natural gas in the production of carbon black was reported. More than 118,747 barrels of LPG was reported used along with 13,966,108 thousand cubic feet of natural gas to produce about 89 million pounds of carbon black in Kansas during 1952.

Low-cost temporary storage was one of the larger problems facing the expanding LPG industry. This problem, created by the seasonal demand for the product, has been partially answered by the experiments that have been in progress over the past few years. These consist of injecting LPG into wholly or partially depleted salt-water, gas, or distillate sands. Recently, and especially in Kansas, emphasis has been placed on the creation of underground cavities by washing out salt beds.

Pipe lines.—Kansas ranks seventh among the states in mileage of petroleum industry pipe lines. At the end of 1952, Kansas is estimated to have had a total of more than 33,000 miles of pipe lines. This figure allows for those lines removed, reclaimed, or discontinued. A new petroleum industry map showing the major pipe lines of Kansas is now being prepared by the State Geological Survey and is expected to be available for distribution by late 1953.

TABLE 17.—*Kansas production of natural gasoline and allied products, 1941-1952**

Year	Production M gals.	Year	Production M gals.
1941	85,691	1947	99,195
1942	81,828	1948	107,563
1943	85,206	1949	113,807
1944	69,834	1950	155,233
1945	72,637	1951	182,932
1946	82,591	1952	196.462

* Figures from 1941 through 1948 from World Oil (1951, p. 154). Figures for 1949 through 1952 supplied by Kansas Corporation Commission. Note the 1951 production figure has been corrected from that published in Bulletin 97.

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Reserves of natural gas and natural gas liquids.—During 1952 proved reserves of natural gas in Kansas (as estimated by the Reserves Committee of Am. Petroleum Institute and Am. Gas Assn.) increased 5.5 percent, while the natural gas reserves for the nation increased only 3.1 percent. There are 14.2 trillion cubic feet, or about 35 years' supply at the present rate of consumption. Hydrocarbon liquids contained in the proved reserves of gas are more than 168 million barrels, an increase of 5.4 percent. Estimate figures are given in Table 18.

Keplinger, Wanenmacher, and Burns (1948) estimated that 51.7 percent of the Hugoton Gas Area, as then defined, was in Kansas. Of the total reserves they estimated that 14,051 billion cubic feet were contained in the Kansas part of the field. No later estimates have been made.

Three important features of the reserve picture in Kansas at the end of 1952 are: (1) new discoveries and extensions of proved areas are being made about as rapidly as the producing areas are being depleted, (2) Kansas proved reserves of natural gas liquids are more than 50 percent of the quantity of gasoline contained in the proved reserves of crude oil in the State, and (3) Kansas showed a material increase in reserves of natural gas and natural gas liquids, while the total increase for the United States was the smallest since 1947.

The significance of Kansas reserves of natural gas liquids is commonly overshadowed by our thinking in terms only of the value of crude oil and natural gas. Natural gas liquids, consisting of natural gasoline, condensate, and LPG (mainly propane and butane), supplement our supplies of gasoline for motor vehicles and fuels for industry and domestic use.

Reserve figures may be misleading unless properly interpreted. It must be kept in mind that the published petroleum reserve

TABLE 18.—*Kansas proved reserves of natural gas and natural gas liquids, December 31, 1952* (American Petroleum Institute and American Gas Association, 1952)

	Reserves* as of 12-31-51	Extensions and revisions 1952	New discoveries 1952	Production during 1952	Proved reserves 12-31-52	Nonassociated, associated, and dissolved	Changes in reserves during 1952	Percentage change 1951-1952
Natural gas liquids	159,569	14,666	260	6,268	168,227		+8,658	+5.4
Natural gas	13,457,498	1,167,567	21,912	454,522	14,193,565	14,160,828	+736,067	+5.5

* Reserves of natural gas liquids are thousands of barrels of 42 U.S. gallons; reserves of natural gas are millions of cubic feet calculated at 14.65 psia. at 60° F.

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figures are clearly stated to represent proved reserves. The figures in Table 18 (API and AGA, 1952, p. 6) "do not include (1) oil under the unproven portions of partly developed fields; (2) oil in untested prospects; (3) oil that may be present in unknown prospects in regions believed to be generally favorable; (4) oil that may become available by fluid injection methods from fields where such methods have not yet been applied; (5) oil that may become available through chemical processing of natural gas; (6) oil that can be made from oil shale, coal or other substitute sources." (The above policy of the Reserves Committee applies equally to natural gas and natural gas liquids.)

In summary, the reserve figures represent areas of oil and gas that are essentially "drilled out" and do not include oil to be realized by secondary recovery (fluid injection) except in operating properties. They represent production we could depend on if the industry stopped developing and searching for new deposits. Actually, reserves in the country have been maintained for many years by current new developments in spite of high annual consumption. The condition should continue so long as there are adequate incentives for continued search.

MAPS

Figure 1 is an index map of the State showing in a general way the oil and gas producing areas. The Hugoton Gas Area (southwestern Kansas) is shown on Plate 2 which is in the pocket on the back cover. Most of the other "western" Kansas counties having oil or gas production are shown on Figures 4 through 15 grouped together on the succeeding pages. Plate 1 shows areas of production in "eastern" Kansas counties. The line between "eastern" and "western" Kansas is the 6th principal meridian which passes through Wichita. Sedgwick and Sumner Counties, which cross this line, are considered as western Kansas counties.

For western Kansas the entire area designated as a field is shown on the map. In eastern Kansas only the part of the field producing oil during 1952 is shown on the map; this is deemed advisable because large areas in the older eastern Kansas fields are not producing oil at the present time. Another important difference is that gas-producing areas in western Kansas are shown but they are not shown on the eastern Kansas map.

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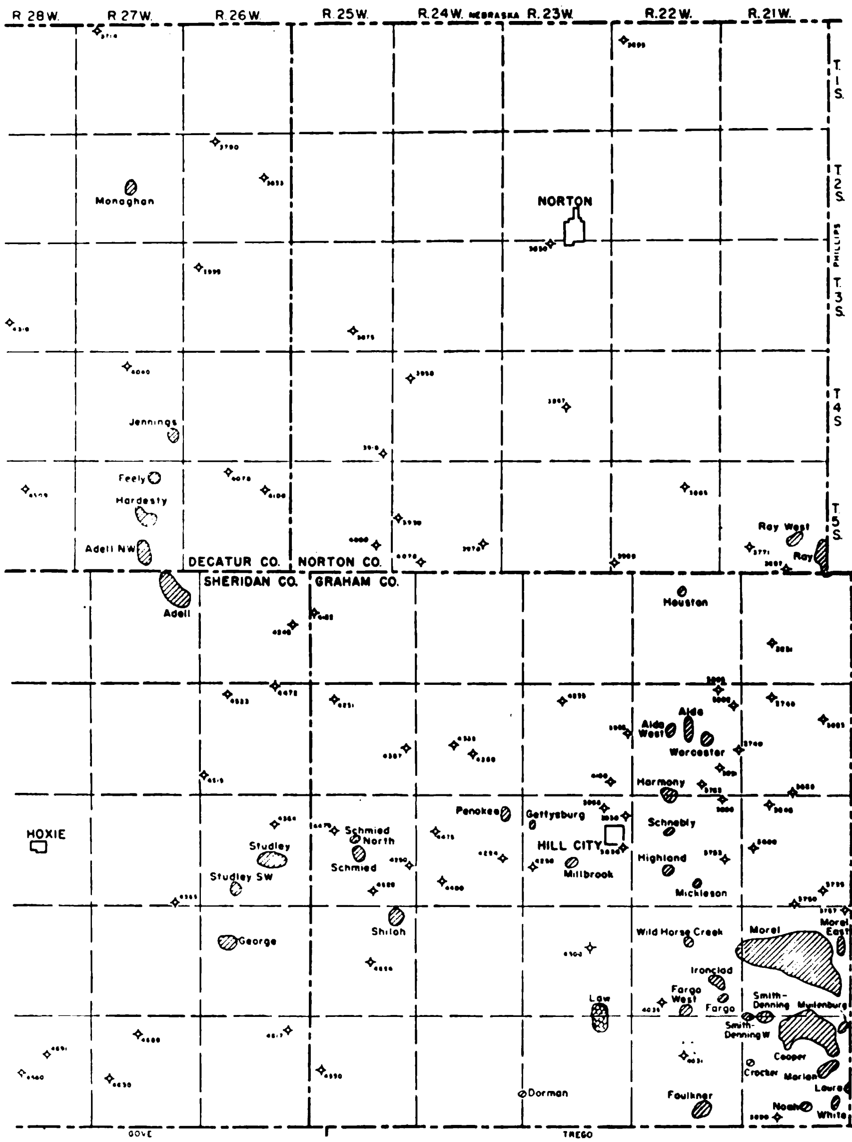

FIG. 4.—Map of Graham, Norton, and parts of Decatur and Sheridan Counties.

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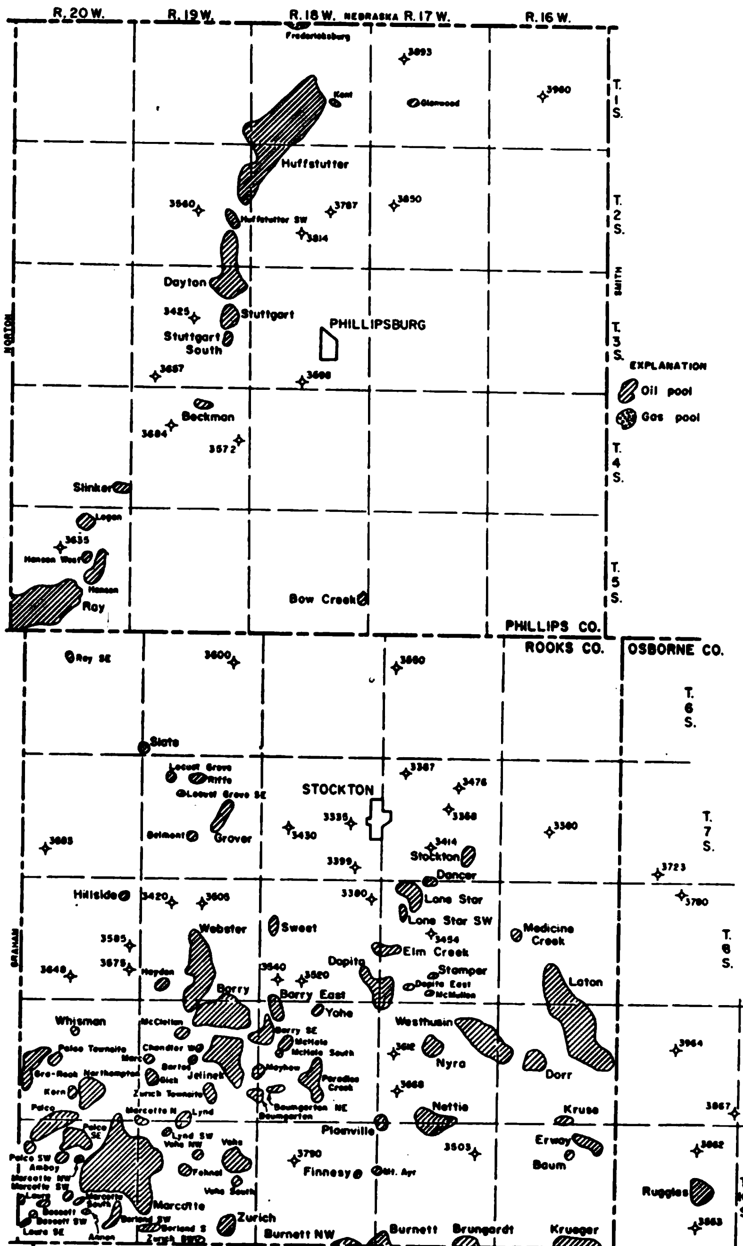

Fig. 5.—Map of Phillips and Rooks Counties and part of Osborne County.

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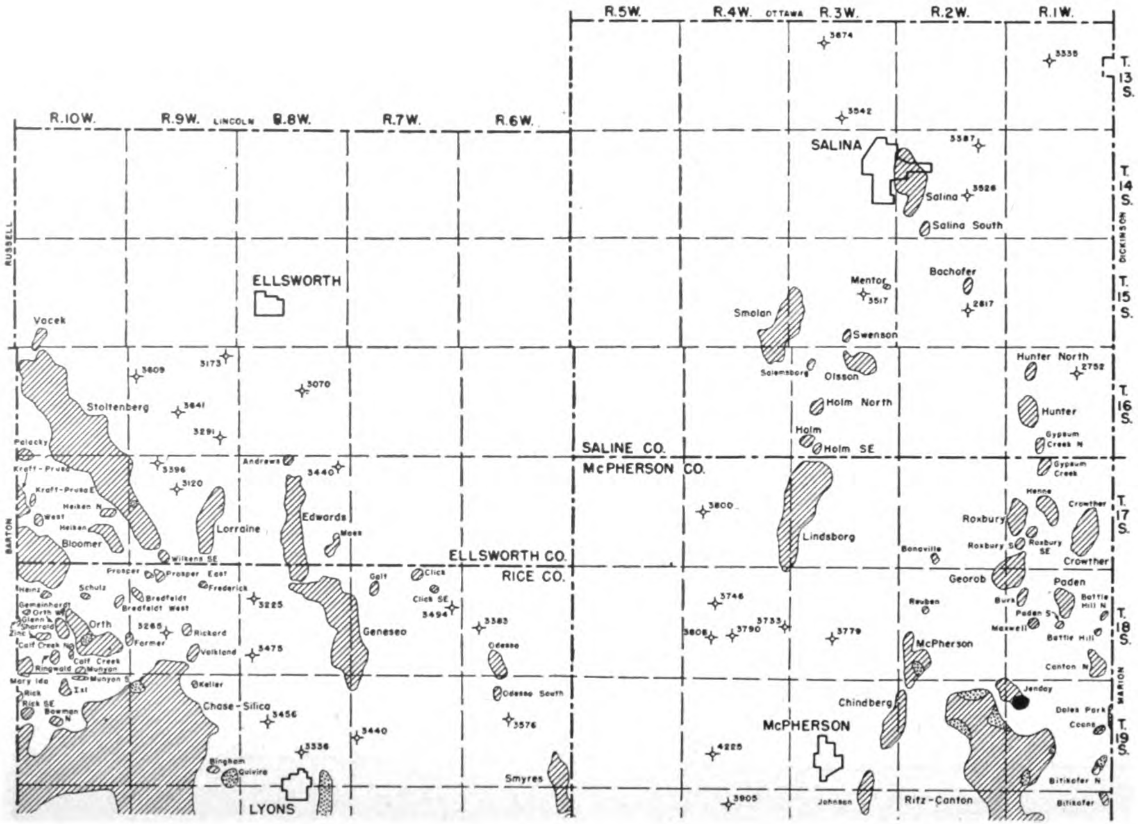

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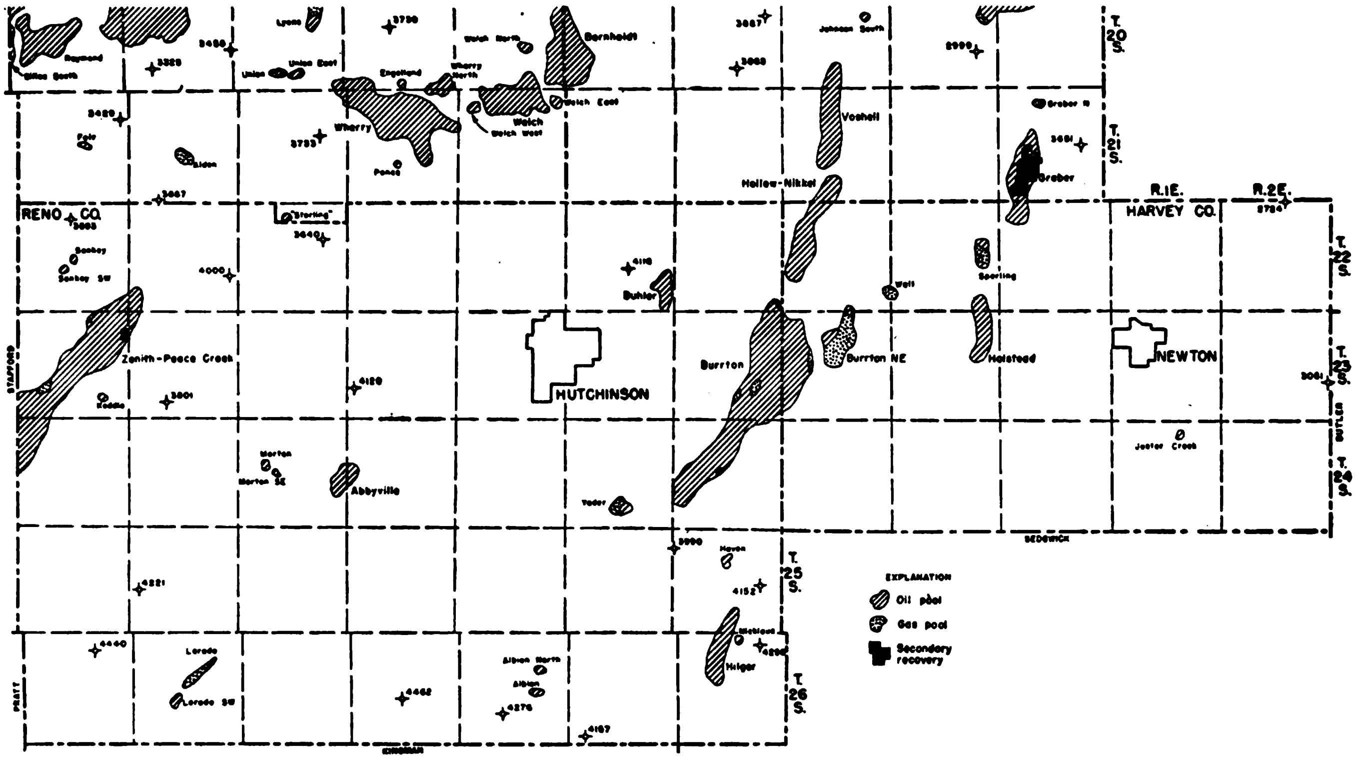

FIG. 6.—Map of Ellsworth, Harvey, McPherson, Reno, Rice, and Saline Counties.

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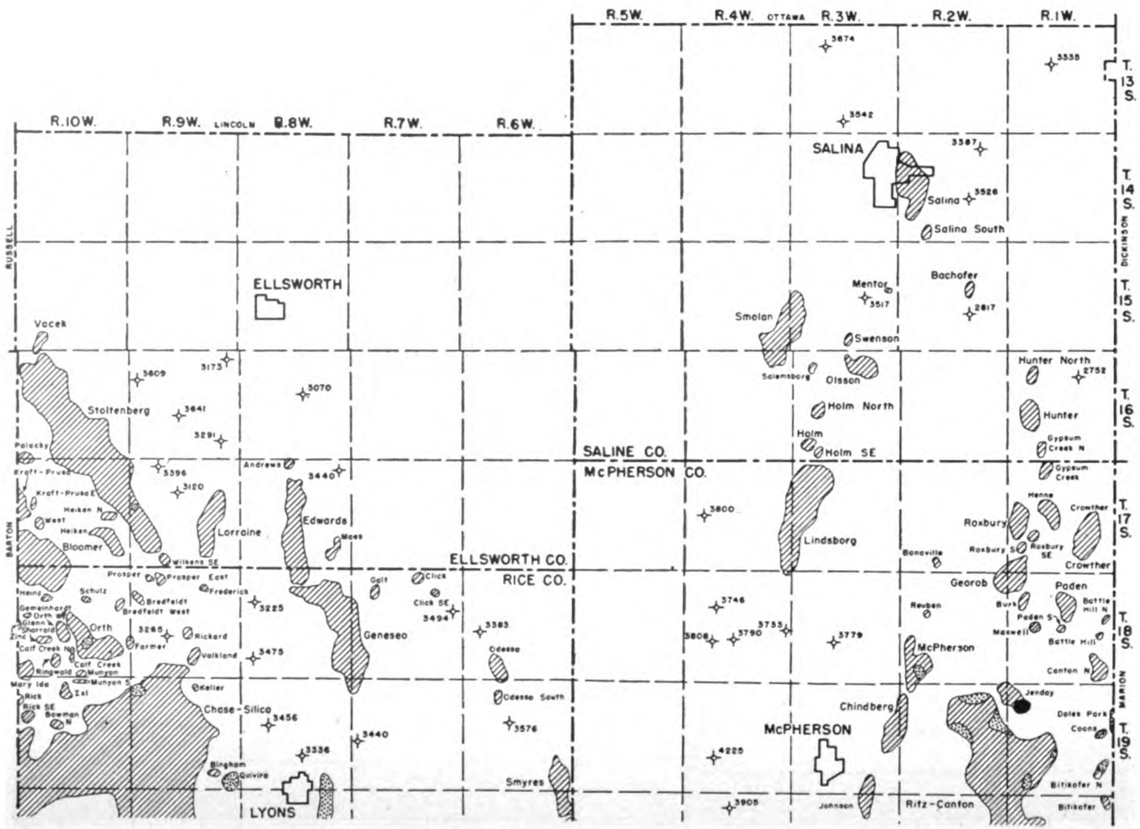

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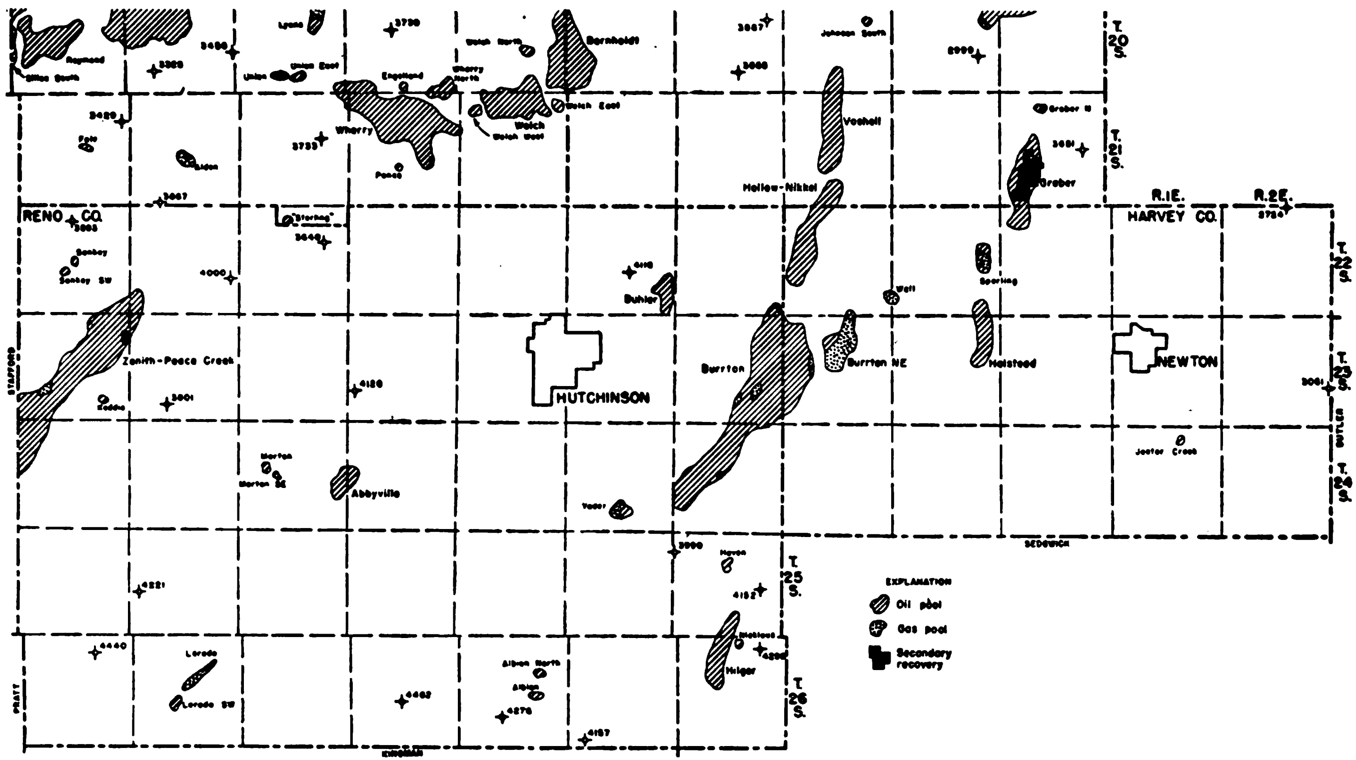

FIG. 6.—Map of Ellsworth, Harvey, McPherson, Reno, Rice, and Saline Counties.

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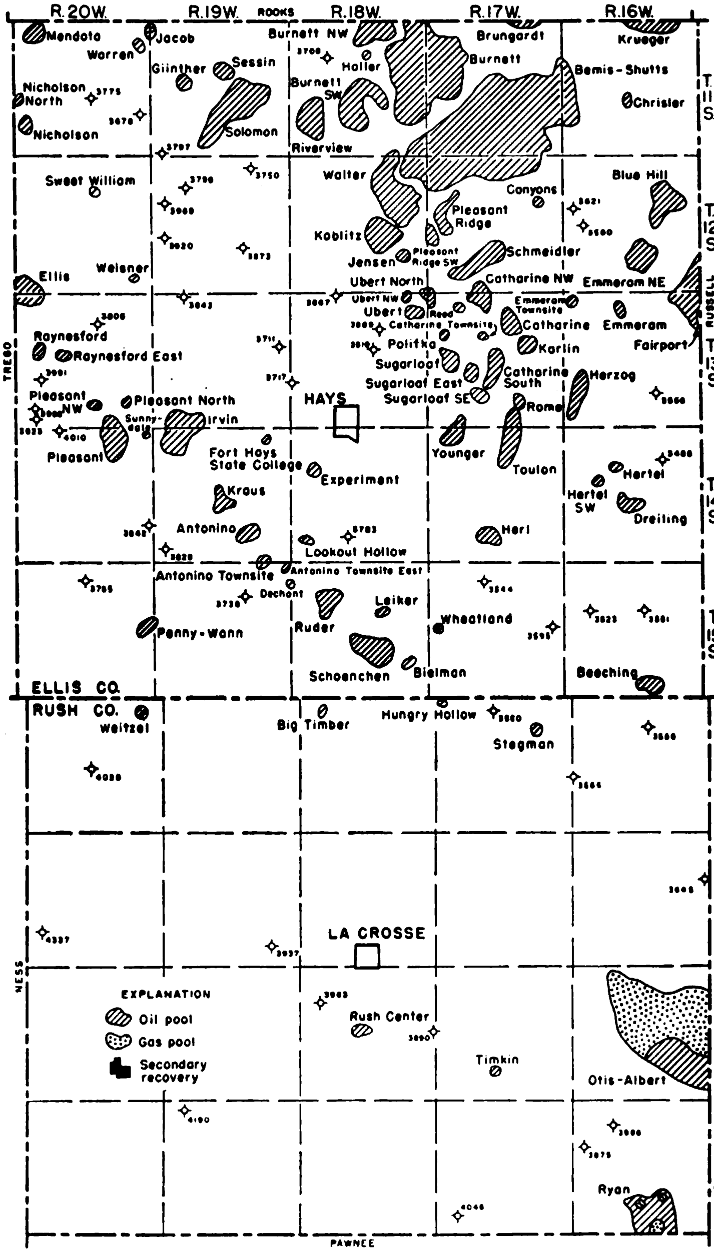

FIG. 7.—Map of Ellis and Rush Counties.

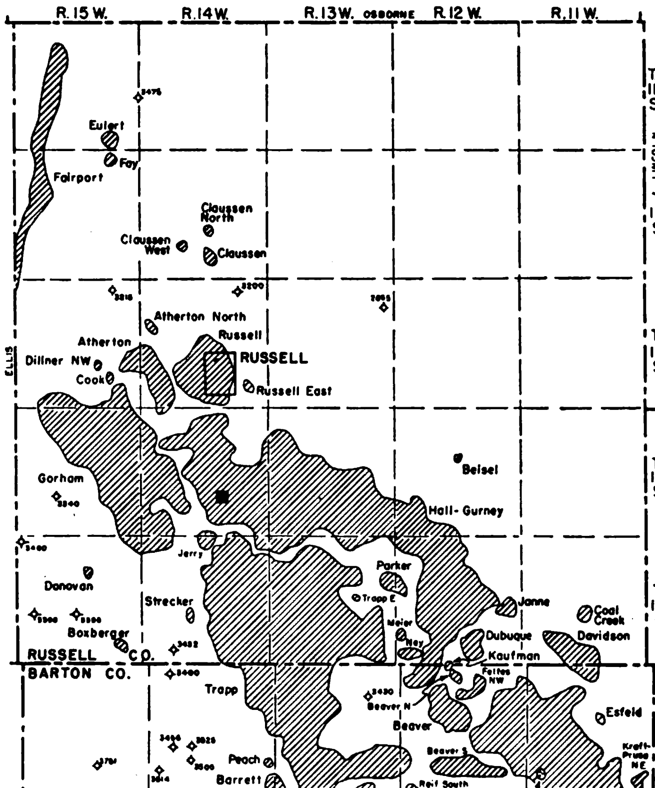

FIG. 8.—Map of Barton and Russell Counties.

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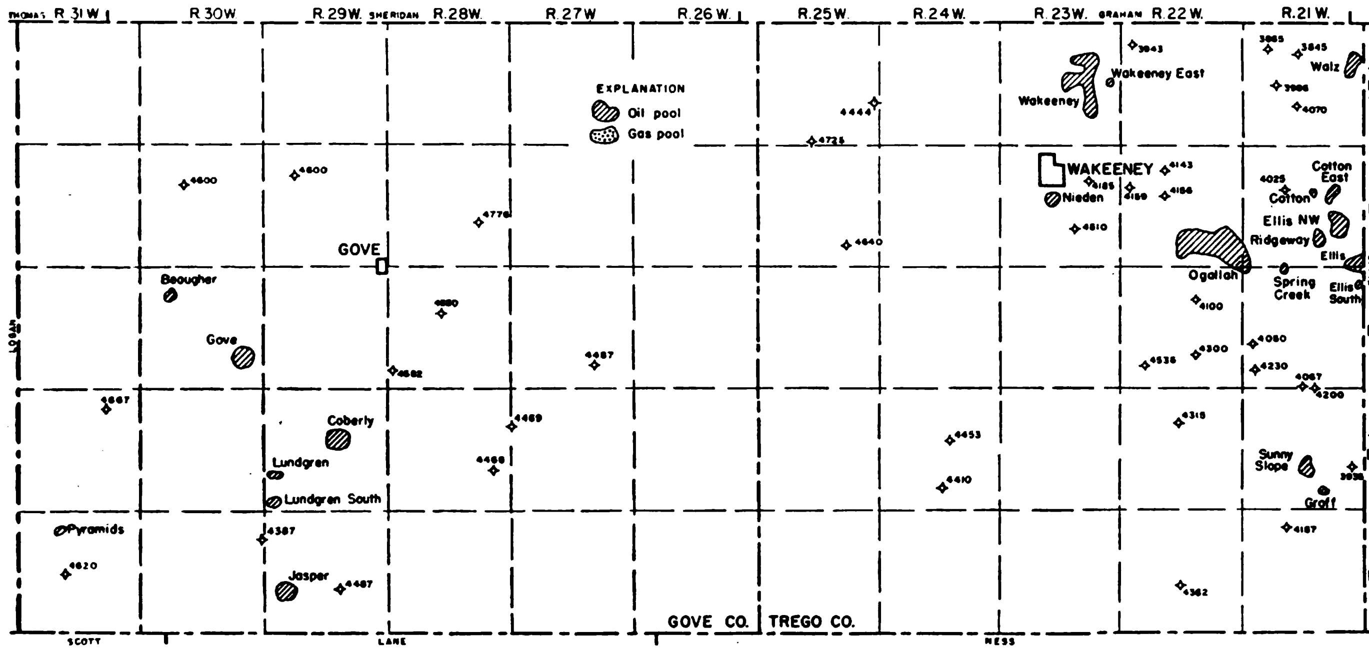

Fig. 9.—Map of Gove and Trego Counties.

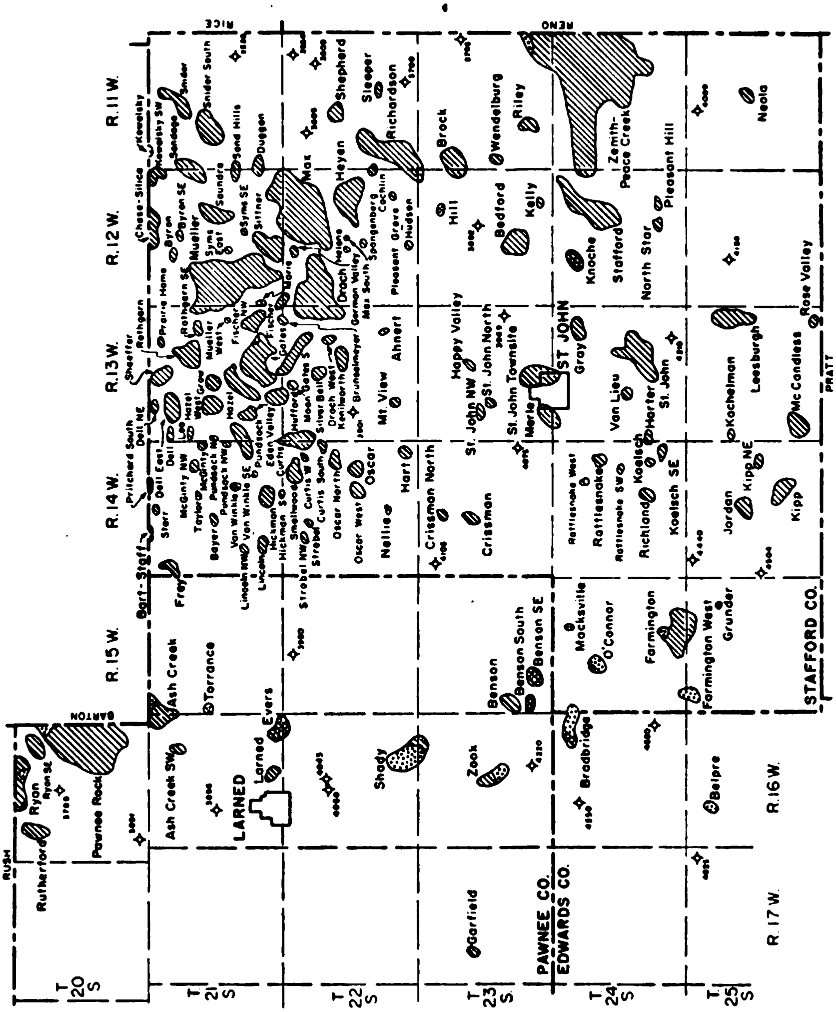

FIG. 10.—Map of Stafford and parts of Edwards and Pawnee Counties.

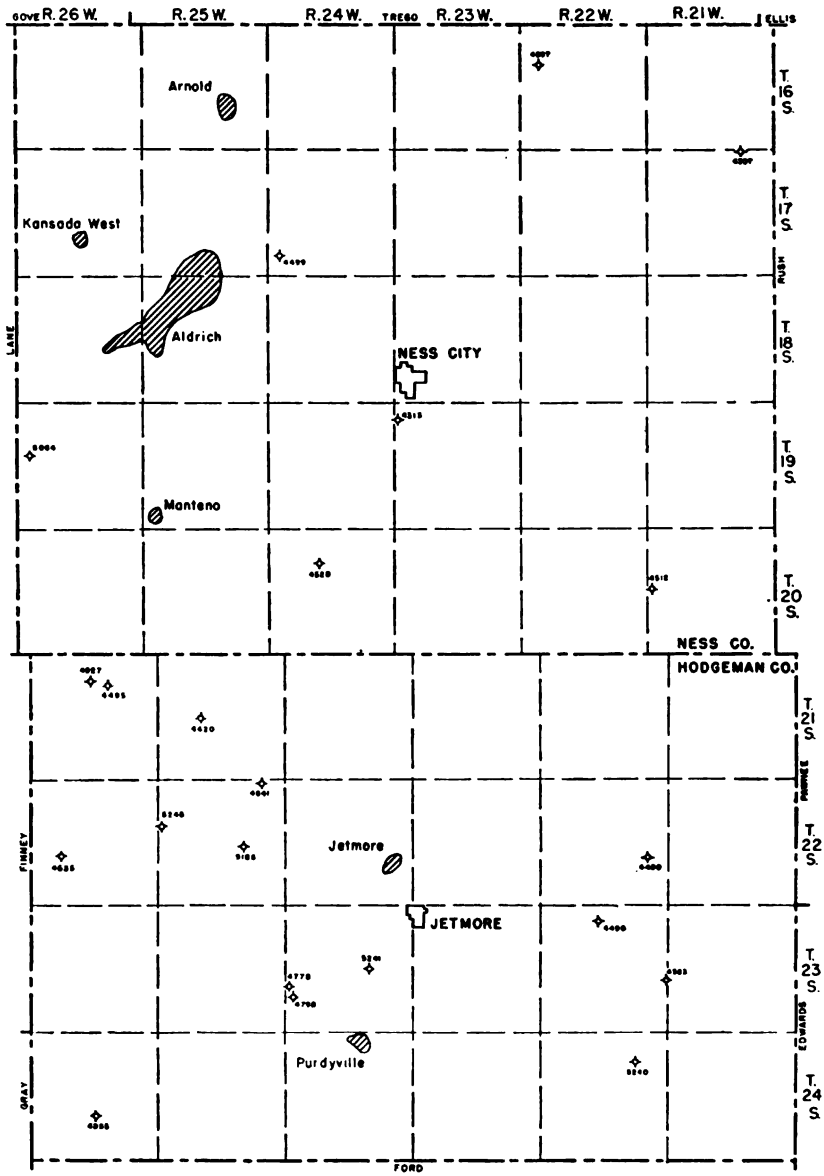

Fig. 11.—Map of Hodgeman and Ness Counties.

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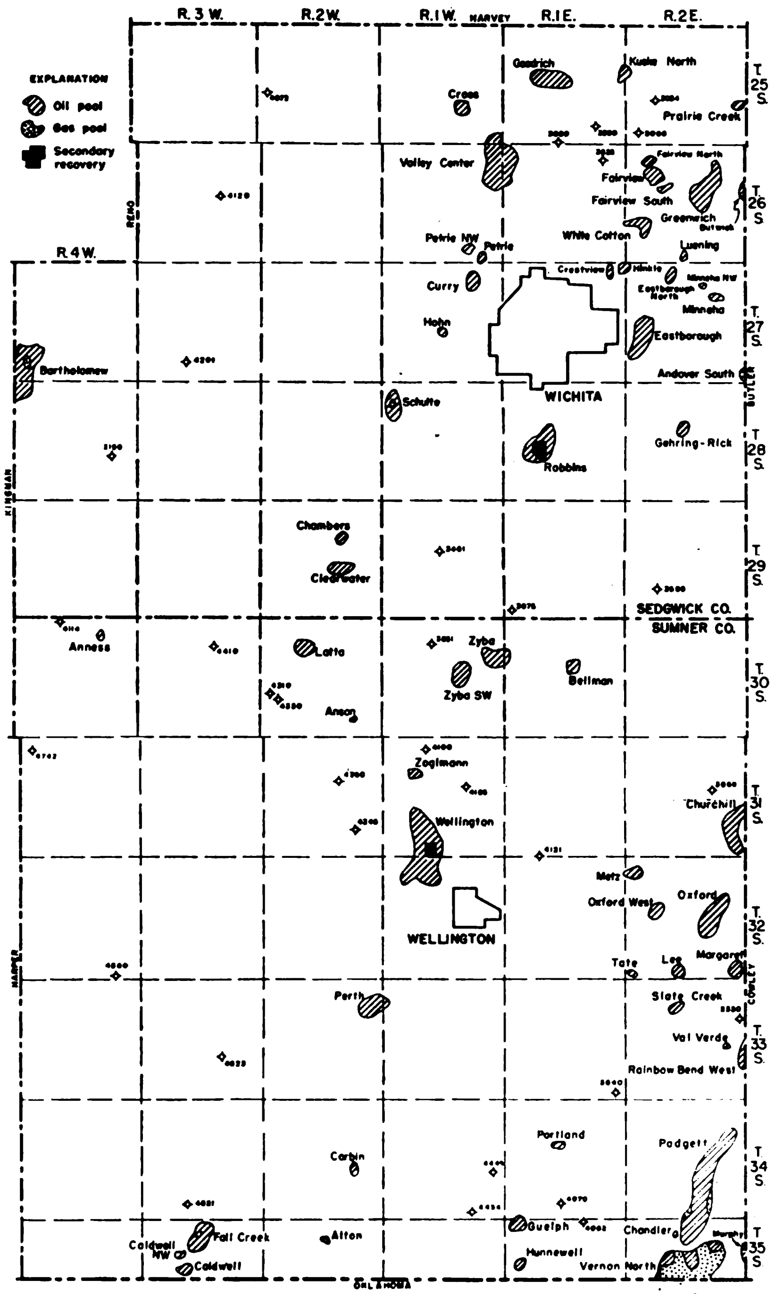

FIG. 12.—Map of Sedgwick and Sumner Counties.

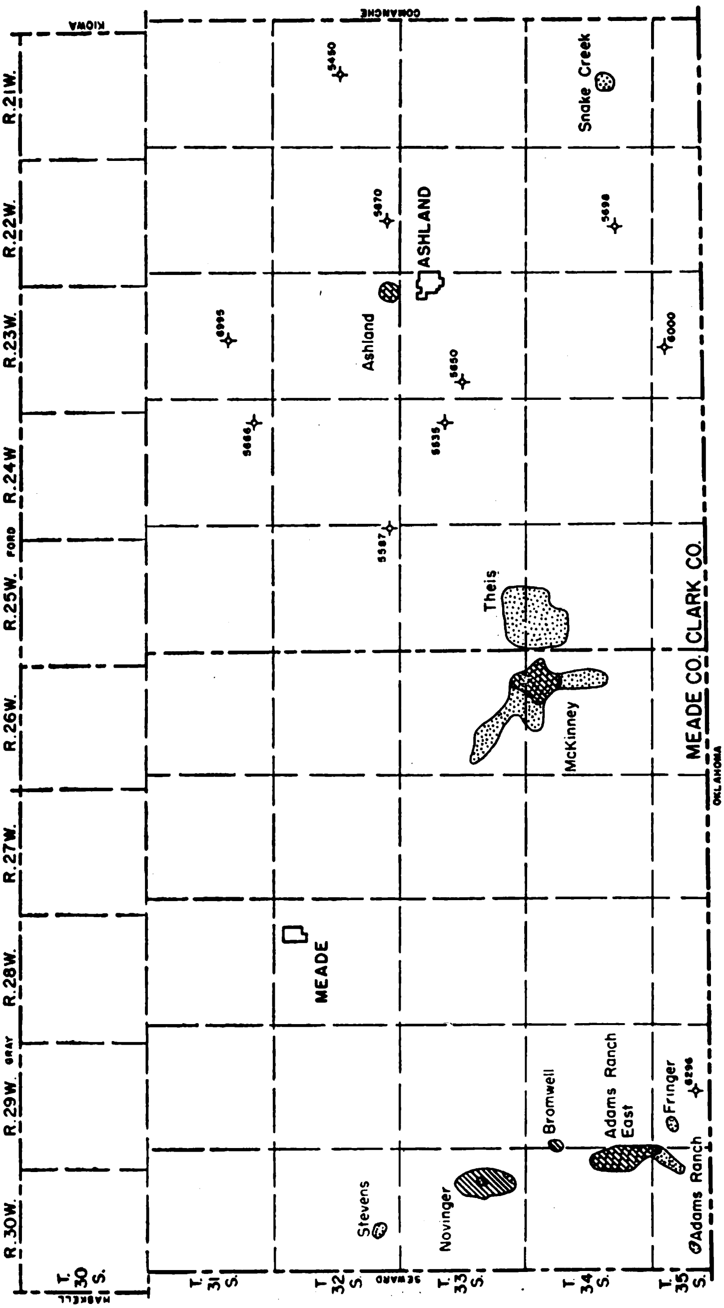

FIG. 13.—Map of Meade and Clark Counties.

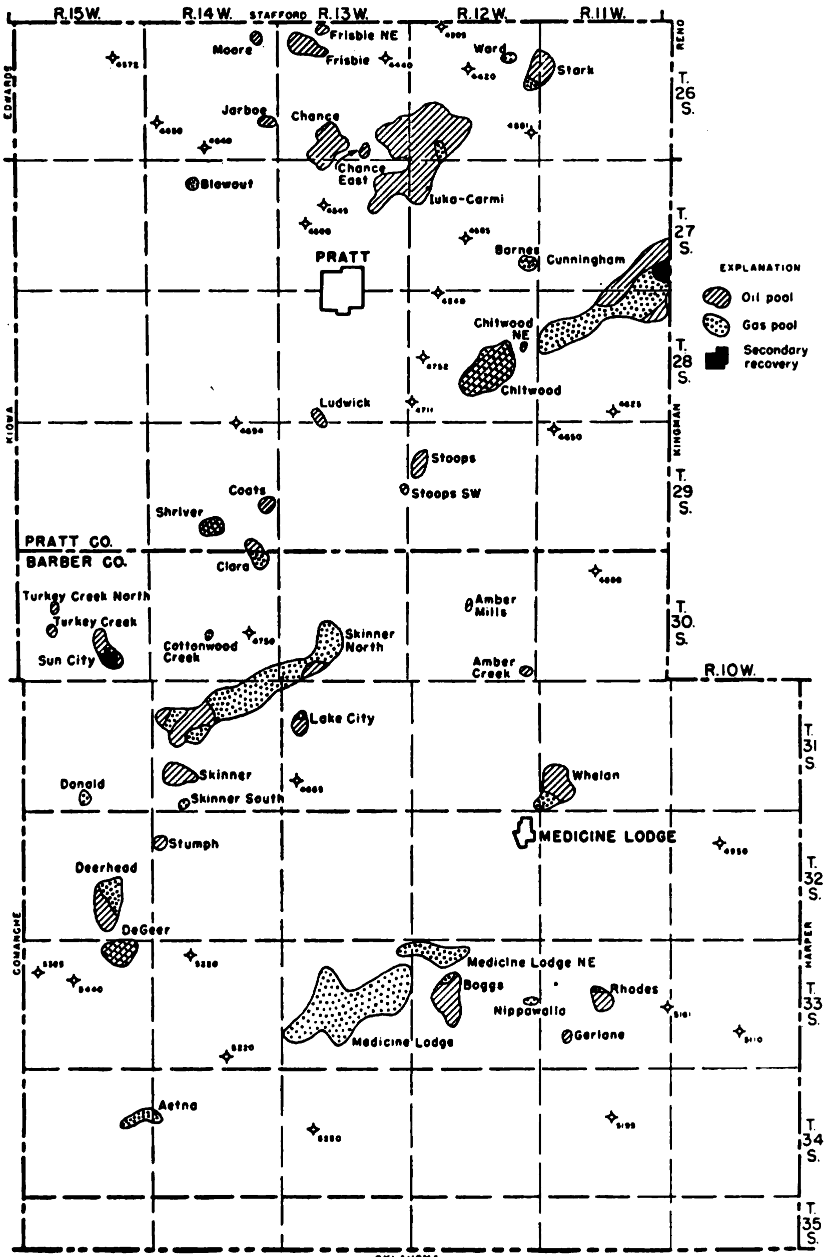

FIG. 14. Map of Barber and Pratt Counties.

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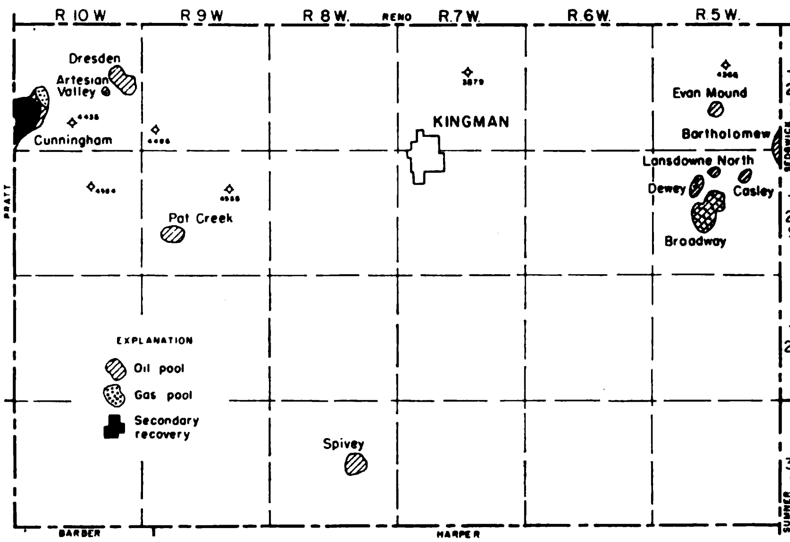

FIG. 15.—Map of Kingman County.

ALLEN COUNTY

(Map Pl. 1)

The 1952 production: oil from 26 areas in 10 fields 609,577 barrels including approximately 280,872 barrels from secondary recovery operations, gas 385,683 thousand cubic feet. Wells drilled in 1952 (recorded): oil 69, dry 6, input 67, total 142.

Developments during 1952.—Oil production in Allen County was much greater than in 1951. The greatest drilling activity reported was in connection with water-flooding operations in the **Humboldt-Chanute** field. No wildcat wells were reported. All wells reported are pool wells (Table 19).

TABLE 19.—*Pool wells drilled in Allen County during 1952*

Field	Oil wells	Dry holes	Injection wells on water-flood projects
Bronson-Xenia	2	....	11
Elsmore Shoestring	2	....	8
Humboldt-Chanute	56	5	48
Iola	5	....	....
Moran	4	1	....
Total	69	6	67

Oil production in Allen County fields is listed in Table 66. Gas production is listed in Table 67. Locations of areas that produced oil in 1952 and of secondary recovery projects in the county are shown on Plate 1. Secondary recovery data are recorded in Table 1.

ANDERSON COUNTY

(Map Pl. 1)

The 1952 production: oil from 13 areas in 7 fields 576,882 barrels including approximately 501,842 barrels from secondary recovery projects, gas 919 thousand cubic feet. Wells drilled in 1952 (recorded): oil 27, dry 2 (wildcats), input 33, total 62.

Developments during 1952.—Oil production was somewhat greater than in 1951 when 551,340 barrels was reported. The reported gas production came from 5 wells in the southeast part of the county. There were 19 oil wells and 15 water input wells reported on water-flooding projects in the **Bush City-Centerville** area. One oil well and two water input wells were reported in the **Garnett Shoestring** field. In the **Colony-Welda** field 7 oil wells and 16 input wells were reported in secondary recovery projects.

Two dry wildcat tests were reported in Anderson County in 1952. The Ingelright No. 1 Hirt well, NW¼ NW¼ sec. 15, T. 20 S., R. 18 E., was abandoned at a depth of 1,010 feet. The Jensen and Lind, Snoffer and Son No. 1 Freeman Borth well in sec. 4, T. 22 S., R. 18 E., was drilled to a total depth of 1,653 feet.

Oil production in Anderson County fields is listed in Table 66 and gas production in Table 67. Locations of areas that produced oil in 1952 and of water-flooding projects are shown on Plate 1. Data on secondary recovery projects are listed in Table 1.

BARBER COUNTY

(Map Fig. 14)

The 1952 production from 23 pools: oil 986,825 barrels, gas 6,407,405 thousand cubic feet. Wells drilled in 1952: oil 18, gas 7, dry 19, total 44 including 11 wildcats. New pools discovered 3. Secondary recovery projects 1.

Developments during 1952.—Drilling activity increased about 30 percent and oil production showed a modest gain. Gas production declined almost one-third during the year.

W. J. Coppinger opened the new **Amber Creek** pool in sec. 36, T. 30 S., R. 12 W., about 3 miles from the **Amber Mills** pool

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discovered last year. The new pool was assigned an initial potential of 28 barrels of oil per day and 14 percent water, producing from Mississippian strata below 4,300 feet depth.

The second new pool, the **Stumph,** was discovered by the National Cooperative Refinery Association in sec. 7, T. 32 S., R. 14 W. on the Stumph-Smith lease about 1½ miles southwest of the **Skinner South** pool. The new well produces from Simpson rocks between 4,963 and 4,970 feet depth. The discovery well swabbed 15 barrels of oil per hour on a preliminary test and later was given a rating of 509 barrels per day.

Nadel and Gussman found oil in Pennsylvanian basal conglomerate between the depths of 4,541 and 4,553 feet on their Gypsum "B" lease in sec. 17, T. 30 S., R. 15 W. The new oil pool, just north of the **Turkey Creek** field, was named **Turkey Creek North.** Commercial production was not found in the Lansing rocks, which produce in the **Turkey Creek** field, but good shows of oil in the

TABLE 20.—*Dry wildcat tests drilled in Barber County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Viola, feet	Depth to top of Arbuckle, feet	Total depth, feet
W. J. Coppinger No. 1 Meeks	SE¼ SE¼ SE¼ 4-30-11W	3,869	4,650	4,829	4,880
*Natl. Coop. Ref. Assn. No. 1 Lambert	NE¼ SE¼ SE¼ 23-30-14W	3,919	4,498	4,700	4,750
Barbara Oil & Cities Service No. 1 Harriet Mills	NW¼ NW¼ NE¼ 30-31-13W	3,752	4,433	4,636	4,665
Continental Oil Co. No. 1 R. Gerstner	NW¼ SW¼ NW¼ 9-32-10W	3,697	4,684	4,893	4,950
*Prime Drlg. & Elliott Davis No. 1 Nellie Clark	NW¼ NW¼ NW¼ 27-33-10W	3,785	4,831	5,085	5,110
Carl Todd Drlg. Co. No. 1 "A" Burns	NE¼ NE¼ NE¼ 24-33-11W	3,850	4,899	5,136	5,161
Anschutz Drlg. Co. No. 1 Mills	C NE¼ SE¼ 5-33-14W	4,085	4,938	5,182	5,220
Champlin Refg. Co. No. 1 William A. Wheats	C NE¼ NW¼ 34-33-14W	4,078	4,967	....	5,220
Anschutz Drlg. Co. No. 1 Winters	SW¼ SW¼ NE¼ 7-33-15W	4,106	5,082	5,344	5,385
*Fischer Oil Co. No. 1 J. W. Brass	C W2 SW¼ SW¼ 9-33-15W	4,252(?)	5,154	5,402	5,440
*Aylward Drlg. Co. et al. No. 1 Blunk	SW¼ SE¼ SW¼ 17-34-13W	4,096	5,081	....	5,250

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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basal conglomerate were tested. Hydrafracing resulted in the assignment of a minimum potential.

Routine drilling in presently producing pools added 1 Viola limestone producer to the **Amber Mills** pool, 1 Lansing ("Massey" zone) producer and 1 Pennsylvanian basal conglomerate producer to the **Sun City** field, and 5 extension wells to the **Whelan** pool. Six of the 7 new oil wells in the **Rhodes** pool were added on its western side. The Sinclair Oil Company found 3 million cubic feet of gas per day in uppermost Mississippian rocks on the northwestern flank of the pool. One of the 4 large gas wells completed in the **Medicine Lodge Northeast** field, which produces from Tonganoxie sandstone, the Skelly Oil Company No. 3 Alexander well, is capable of producing more than 80 million cubic feet of gas per day.

The gas repressuring project operated in the **Sun City** field by the Great Lakes Carbon Corporation reported no new developments. Data on this project are given in Table 1.

New pools are listed in Table 6. Pertinent data on the dry wildcats are given in Table 20 and Figure 14 shows the location of the producing areas and dry wildcats. Oil production is listed in Table 66 and gas production in Table 67.

BARTON COUNTY

(Map Fig. 8)

The 1952 production from 120 pools: oil 16,959,379 barrels, gas 2,675,466 thousand cubic feet. Wells drilled in 1952: oil 271, gas 4, dry 253, salt-water disposal 6, total 534 including 26 wildcats. New pools discovered 17, revived 1, combined 11.

Developments during 1952.—Oil production declined about 2 million barrels during the year, while gas production decreased modestly. Barton County maintained its place as the leading oil-producing county and the county having the most wells drilled during the year.

Of the wildcat wells completed, 17 were successful in finding new oil and/or gas pools. These new pools are the **Alefs, Bieberle, Buckbee Southwest, Frank, Great Bend Airport, Great Bend Southwest, Hawkins, Heizer Northeast, Heizer Southwest, Hiss East, Kramp, Liberty, Lott, Mary Ida North, Redwing South, Sandrock South,** and **Walnut Creek**. The **Peach** pool, originally discovered in 1944 and abandoned two years later, was revived

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TABLE 21.— *Dry wildcat tests drilled in Barton County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
*Nadel & Gussman No. 1 Ehrlich	SE¼ SE¼ NW¼ 11-16-13W	3,134	3,396	3,430
B & R Drlg., Inc. No. 1 Nuss	SW¼ SE¼ NE¼ 6-16-14W	3,109	3,365	3,400
*John Lindas Oil, Inc. No. 1 Eurich	SW¼ SW¼ SW¼ 20-16-14W	3,187	3,448	3,456
*Derby Drlg. Co. No. 1 Ochs	SE¼ SE¼ SE¼ 20-16-14W	3,230	3,485	3,525
Derby Drlg. Co. No. 1 Schneider	SE¼ SE¼ NE¼ 29-16-14W	3,233	3,477	3,505
Musgrove Petro. Corp. No. 1 Brown	SE¼ SE¼ SW¼ 30-16-14W	3,202	3,479	3,514
*Natl. Coop. Ref. Assn. No. 1 Oliverius	SE¼ NE¼ SW¼ 27-16-15W	3,283	3,651	3,751
*Ben F. Brack Oil Co., Inc. No. 1 Farrell	NE¼ NE¼ NW¼ 19-17-12W	3,162	3,404	3,412
John Lindas Oil, Inc. No. 1 Rziha	NE¼ NE¼ SE¼ 20-17-12W	3,194	3,444	3,452
Ben F. Brack Oil Co., Inc. No. 1 Seide	NW¼ NW¼ SW¼ 9-17-15W	3,253	3,558	3,597
Stanolind Oil & Gas Co. No. 1 Leo Stos	NW¼ NE¼ NE¼ 18-17-15W	3,300	3,546	3,775
Ben F. Brack Oil Co., Inc. No. 1 Stos	SE¼ NW¼ SW¼ 19-17-15W	3,354	3,614	3,734
Ben F. Brack Oil Co., Inc. No. 1 Ohnmacht	NE¼ SE¼ NW¼ 20-17-15W	3,353	3,600	3,605
Sheedy & Sheedy No. 1 Pospishel	SE¼ SW¼ SE¼ 20-17-15W	3,346	....	3,550
*Northern Ordnance, Inc. No. 1 Schreiber	NE¼ NE¼ NE¼ 33-17-15W	3,297	3,604	3,644
*Carl Todd Drlg. Co. et al. No. 1 Bartonek	SE¼ SE¼ SE¼ 36-17-15W	3,269	3,525	3,557
Darby & Bothwell, Inc. No. 1 Laudick	NW¼ NW¼ NE¼ 22-18-14W	3,173	3,422	3,465
D. R. Lauck Oil Co., Inc. No. 1 Trester	SE¼ SE¼ NW¼ 33-18-14W	3,252	3,547	3,588
*Hilton Drlg. Co., Inc. No. 1 Millin	SE¼ SW¼ NW¼ 22-19-13W	3,207	....	3,502
*L. D. Sargent No. 1 Jurgenson	NW¼ NW¼ NW¼ 27-19-15W	3,290	3,639	3,710
*Buick Drlg. et al. No. 1 Rugan	NE¼ NE¼ SE¼ 33-20-11W	3,144	3,448	3,475
E. H. Adair Oil Co. No. 1 L. Merten	NE¼ NE¼ SE¼ 1-20-14W	3,224	3,475	3,550
*Duke & Wood Drlg. Co. No. 1 Luce	SW¼ SW¼ NE¼ 8-20-14W	3,295	3,614	3,645
*Vickers Petro. Co., Inc. No. 2 Benjamin	NW¼ NE¼ SW¼ 31-20-14W	3,344	3,656	3,700

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John Lindas Oil, Inc. No. 1 Kliewer	NW¼ NW¼ NE¼ 1-20-15W	3,305	3,623	3,666
John Lindas Oil, Inc. No. 1 Cameron	SE¼ SE¼ SE¼ 3-20-15W	3,359	3,717	3,805

* No electric log availaable. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

during the year by the Anschutz Drilling Company. The **Lott** pool, one of the 1952 discoveries, was combined with the **Beaver South** field during the year. Nine of the new pools produce their oil from Arbuckle strata; all the others produce from porous zones in the Lansing-Kansas City group, except the **Heizer Southwest,** the one new gas pool of the county, which produces from Pennsylvanian basal conglomerate.

Seven new producing zones in old fields were discovered during 1952. In most cases either the Arbuckle dolomite or the Lansing-Kansas City group was added. According to available information in the **Beaver Northwest** field, combined during the year with the **Hall-Gurney** field of Russell County, commercial oil production was found in Pre-Cambrian rocks by the National Cooperative Refinery Association No. 7 Hofmeister well. Other new producing zones are listed in Table 7.

Of the 26 dry wildcat tests, 9 reported shows of oil and or gas. Two of the unsuccessful tests were near the abandoned **Pospishel** field and one was close to the abandoned **Millard** field.

During the year, 45 old wells were worked over in the county. Of these, 27 were declared oil producers, 10 dry, and 8 converted to salt-water disposal wells.

Two of the wells drilled especially for salt-water disposal give us interesting information on the thickness of the Arbuckle in Barton County. The Wunderlich No. 5 Roessler B well in sec. 14, T. 18 S., R. 11 W. found more than 500 feet of the Arbuckle dolomite. The Lee Drilling Company No. 7 Bryant well in sec. 26, T. 20 S., R. 12 W. found the top of the Arbuckle dolomite at 3,447 feet; at the total depth, 4,018 feet, the well was still in the Arbuckle.

Many fields producing from the same formation and in close proximity were combined. During the year the following combinations were recorded by the Kansas Nomenclature Committee: **Bryant Southeast** with **Chase-Silica; Hiss West** with **Pritchard; Kowalsky Northwest** with **Kowalsky; Eveleigh** with **Boyd; Dartmouth** and **Dartmouth Northwest** with **Fort Zarah; Boyle** with

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Carroll; Laudick and **Lott** with **Beaver South; Cheyenne View North** with **Cheyenne View;** and **Beaver Northwest** with **Hall-Gurney.**

Oil production is given in Table 66, gas production in Table 67, and wildcat well data in Table 21. Figure 8 shows the oil and gas pools and the dry wildcat tests. The new pools are listed in Table 6.

BOURBON COUNTY

(Map Pl. 1)

The 1952 production from 3 fields: oil 56,984 barrels.

Developments during 1952.—Oil production in Bourbon County was much greater than in 1951. One deep wildcat well, the Harry S. Perry No. 1 C. R. Burney well in the SW¼ sec. 22, T. 25 S., R. 25 E., was reported abandoned as a dry hole early in 1953. The driller's log indicates that the top of Mississippian limestone was reached at 375 feet, top of the Chattanooga shale at 800 feet, and the top of the Arbuckle rocks at 814 feet. The depth to Pre-Cambrian rocks is probably 1,680 feet. Total depth was 1,945 feet.

Oil production in Bourbon County in 1952 is listed in Table 66. Areas that produced oil are shown on Plate 1. Information on two secondary recovery projects in Allen and Bourbon Counties is summarized in Table 1.

BROWN COUNTY

(Map Pl. 1)

The 1952 production from 1 field: oil 5,001 barrels. Wells drilled in 1952: oil 1, dry 1 (wildcat).

Developments during 1952.—One oil well was added to the **Livengood** field in 1952. Initial daily production of the well was reported as 12 barrels of oil and 95 percent water.

In October a dry wildcat test, in the NW¼ NW¼ NW¼ sec. 10, T. 1 S., R. 17 E., the Palensky and Sons No. 1 Babcock well, reached a total depth of 2,600 feet. The following tops were reported: Kansas City, 805; Mississippian, 2,163; Kinderhookian, 2,334; and "Hunton," 2,580 feet.

Production of the **Livengood** field is listed in Table 66. Locations of the field and of the dry wildcat well drilled in 1952 are shown on Plate 1.

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BUTLER COUNTY

(Map Pl. 1)

The 1952 production: oil from 62 fields 8,164,208 barrels including approximately 1,708,523 barrels from secondary recovery operations. Wells drilled in 1952: oil 254, dry 144, water input 83, salt-water disposal 5, total 486 including 23 wildcats. New pools discovered 3.

Developments during 1952.—Three new oil fields were opened in Butler County during 1952. The **Bare**, which produces from "Bartlesville sand" between 2,778 and 2,798 feet, was discovered by the White and Ellis No. 1 Bare well in the SE¼ SE¼ NW¼ sec. 31, T. 28 S., R. 5 E. Initial daily production of the well was 11 barrels of oil. Five dry holes and one oil well were added in the field. The K. T. Wiedemann No. 1 Lucas well, in the SW¼ SW¼ SE¼ sec. 3, T. 27 S., R. 7 E., opened the **Brickley Southwest** pool. Daily production of 20 barrels of oil from the "Bartlesville sand" was found between 2,699 and 2,732 feet. Three dry holes were drilled in the field later in the year. Mississippian limestone between 2,709 and 2,719 feet yields oil in the **Murdock** pool, found by the Wixson Drilling Co. No. 1 Brainerd well in the NW¼ NW¼ NW¼ sec. 23, T. 25 S., R. 3 E. Daily production was rated

TABLE 22.—*Pool wells drilled in Butler County during 1952*

Field	Oil wells	Dry holes	Injection wells on water-flood projects	Salt-water disposal wells
Allen-Robison	....	4	....	....
Augusta	14	1 1*	....	....
Augusta North	1	....	....	....
Bare	2	5	....	....
Blankenship	11	6	3	....
Brandt-Sensenbaugh	4 1*	1	....	....
Brickley	2	4	....	....
Brickley Southwest	1	3	....	....
Butwick Northeast	....	1	....	....
DeMoss	....	1	....	....
Douglass	....	2	....	....
Eckel	....	1	....	....
Edgecomb	....	1	....	....
Elbing	7	2	....	1 3*
Elbing East	....	2	....	....
El Dorado	92 11*	4	58	(2 water supply)
Ferrell	2	....	....	....

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TABLE 22.—*Pool wells drilled in Butler County during 1952, concluded*

Field	Oil wells	Dry holes	Injection wells on water-flood projects	Salt-water disposal wells
Four Mile Creek	2	2	....	....
Fox-Bush	13	16	22	....
Garden	5	2	....	....
Guyot	....	2	...	....
Hartenbower	1	1	....	....
Hartenbower South	....	1	....	....
Haverhill	....	1	....	....
Hazlett	17	6	2	1
Hickory Creek	1	....	....	....
Joseph	....	1	....	....
Keighley	1	2	....	....
Knox	....	4	....	....
Kramer-Stern	11	7	....	....
Leon	....	12	....	2
Mahannah	....	1	....	....
McCann	....	1	....	....
McCraig	....	2	....	....
McCullough	....	1	....	....
Minneha	....	1	....	....
Muddy Creek	4	4	....	....
Murdock	1	2	....	....
Pettit	....	1	....	....
Pierce	2	1	....	....
Pierce West	1	....	....	....
Potwin	3	1	....	....
Reynolds-Schaffer	8	3	....	1
Salter	1	1	....	....
Semisch	26	4	....	....
Seward	4	2	....	....
Smock-Sluss	2*	....	....	....
Snowden-McSweeney	17	4	....	....
Thompson	....	1	....	....
Weaver	....	3	....	....
Young	....	3	....	....
Total	254	121	83	5

*Old wells worked over

at 10 barrels of oil. Two dry holes were drilled in the field later in the year.

Of the 1952 oil production, 3,437,824 barrels came from the **El Dorado** field, whose cumulative production is more than 211 million barrels of oil. The field has 92 new oil wells drilled during the year. In addition, 11 old wells worked over began production.

Oil production in the various Butler County fields is listed in Table 66. Locations of areas that produced oil in 1952 and of secondary recovery projects are shown on Plate 1. Data on water-flooding operations are listed in Table 1. Data on pool wells

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TABLE 23.—*Dry wildcat test drilled in Butler County during 1952*

Company and farm	Location	Depth to top of Kansas City, feet	Depth to top of Mississippian, feet	Total depth, feet
*R. J. Wixson Drlg. Co. No. 1 Langley	NE¼ NW¼ SW¼ 33-23-3E	2,220	2,680	2,946
Saturn Drlg., Inc. No. 1 Mamie Harsh	SE¼ SW¼ SE¼ 32-23-8E	2,010	2,754	2,784
*Rex & Morris Drlg. Co. No. 1 Poffinbarger	NE¼ SE¼ SE¼ 14-24-4E	2,080	2,460	2,490
*J. H. Wagner No. 1 C. R. Joseph	NE¼ NE¼ NE¼ 22-24-4E	2,100	2,490	2,615
*White & Ellis Drlg. Co. No. 1 Dornbos	SE¼ SE¼ NE¼ 14-24-5E	2,050	....	2,650
Saturn Drlg., Inc. No. 1 Stone	NW¼ NW¼ NE¼ 23-24-7E	2,005	2,731	2,773
*Rex & Morris Drlg. Co. No. 1 Dailey	SW¼ SW¼ NW¼ 30-24-7E	2,346	2,700	2,728
*Time Petro. Co. No. 1 Schimpff	NE¼ NE¼ SW¼ 4-24-8E	1,906	2,695	2,705
R. J. Wixson Drlg. Co. et al. No. 1 Reed	SW¼ SW¼ SE¼ 29-25-3E	2,320	2,757	2,816
*Murfin Drlg. Co. No. 1 Dickson	SW¼ SE¼ SE¼ 36-25-6E	....	2,747	2,758
*Imperial Petro. Co., Inc. No. 1 Liggett	NE¼ NE¼ SW¼ 34-25-7E	2,054	2,741	2,791
*Imperial Petro. Co., Inc. et al. No. 1 Jahren Ranch	NE¼ SE¼ SE¼ 30-25-8E	2,076	2,781	2,807
*Imperial Petro. Co., Inc. No. 1 Jahren	NE¼ Lot 4 30-25-8E	2,060	2,754	2,773
*Rex & Morris Drlg. Co. No. 1 Shaffer	SW¼ SW¼ NW¼ 23-26-3E	2,354	2,775	2,795
*J. P. Gaty No. 1 Stephens	NE¼ SE¼ NE¼ 28-26-3E	2,341	2,800	2,863
*Rex & Morris Drlg. Co. No. 1 Anderson	SE¼ SE¼ SW¼ 29-26-3E	2,381	2,812	3,265
*White & Ellis Drlg. Co. et al. No. 1 Frazier	NW¼ NW¼ NE¼ 20-26-4E	2,143	2,620	2,922
*J. P. Gaty No. 1 Scott	NE¼ NW¼ NW¼ 17-27-3E	2,360	....	2,569
Mallonee Drlg. Co. No. 1 Young	SE¼ NE¼ SE¼ 3-28-3E	2,293	2,779	3,116
*Eckland Drlg. Co. No. 1 Leaply	SE¼ SW¼ NE¼ 31-28-3E	2,460	3,010	3,300
*Mallard Drlg. Co. et al. No. 1 C. W. Clark	NE¼ SW¼ NE¼ 19-28-5E	2,165	2,763	2,800
*Ben Gralapp No. 1 Simmons	NW¼ NE¼ SE¼ 3-29-3E	2,300	2,785	3,044
*Rex & Morris Drlg. Co. No. 1 Carsten	SE¼ NE¼ SW¼ 26-29-3E	2,550	....	3,252

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service and other available data sources have been used.

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drilled in 1952 are listed in Table 22, and data on dry wildcat wells are listed in Table 23. New pools are listed in Table 6.

CHASE COUNTY

(Map Pl. 1)

The 1952 production: oil from 3 fields 30,629 barrels; gas 65,145 thousand cubic feet from 2 active fields. Wells reported drilled in 1952: oil 1, dry 4, total 5 including 2 wildcats.

Developments during 1952.—The production of oil was slightly less than in 1951. Reported gas production increased nearly 7 million cubic feet. Two dry wildcat wells were drilled. One oil well and one dry hole were reported in the **Teeter** field, and a dry hole in the Bazaar field. Gas production came from the **Davis** and **Elmdale** fields.

The George Martin No. 1 Winsor well in the SW¼ SW¼ NW¼ sec. 2, T. 20 S., R. 6 E., drilled to a total depth of 2,532 feet, found the Lansing group at 1,474 feet and the Viola at 2,027 feet. The R. E. Mendenhall No. 3 Piper well, SW¼ NW¼ NW¼ sec. 14, T. 20 S., R. 9 E., reached the Mississippian limestone at 2,445 feet; total depth was 2,484 feet

Oil production statistics in Chase County are listed in Table 66 and gas in Table 67. Locations of areas that produced oil in 1952 and of wildcat wells drilled are shown on Plate 1.

CHAUTAUQUA COUNTY

(Map Pl. 1)

The 1952 production: oil from 15 fields 798,706 barrels; gas 126,227 thousand cubic feet. Wells drilled in 1952 (recorded): oil 2, dry 6, input 4, total 12.

Developments during 1952.—Oil production in Chautauqua County was somewhat less than in 1951. With quite incomplete coverage one dry hole was reported in each of the **Elgin, Frazier, Hale-Inge, Peru-Sedan, Wauneta,** and **Wayside-Havana** fields.

Oil production data for Chautauqua County are listed in Table 66. Gas production is listed in Table 67. Locations of areas that produced oil in 1952 are shown on Plate 1. Drilling on secondary oil recovery projects is reported in Table 1, although no production was reported for these projects.

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CHEYENNE COUNTY

There was no reported production from the county's one named pool, the Judy. Wells drilled during 1952: total 5 including 4 dry wildcats.

Developments during 1952.—The Ben F. Brack Oil Co., Inc., drilled their No. 2 Judy well in sec. 35, T. 1 S., R. 39 W., southeast of the now temporarily abandoned discovery well of the **Judy** pool. All drill-stem tests made on the offset test were unsuccessful. Important marker horizons encountered in drilling are: Ft. Hays limestone, 1,551; Dakota formation, 2,432; Morrison formation, 2,643; Stone Corral dolomite, 3,074; Topeka limestone, 3,960; Lansing-Kansas City group, 4,149; Marmaton group, 4,397; Cherokee group, 4,654; Mississippian limestone, 4,854; and Mississippian dolomite, 4,875 feet depth.

The Deep Rock Oil Corporation completed an important deep test in the northwestern part of the county on the Clark farm in sec. 23, T. 1 S., R. 42 W. The important marker horizons were found at the following depths: Dakota formation, 2,445; Morrison formation, 2,866; Stone Corral dolomite, 3,508; Topeka limestone, 4,247; Lansing-Kansas City group, 4,586; Mississippian strata, 5,332; Arbuckle dolomite, 5,403; Lamotte sandstone, 5,505; and weathered Pre-Cambrian granite 5,632 feet. The drill-stem tests made at several critical levels failed to reveal the presence of either oil or gas.

The Service Drilling Company completed a test on the Beeson farm in sec. 8, T. 3 S., R. 38 W., for which the following tops were reported: Ft. Hays limestone, 1,830; Dakota formation, 2,251; Morrison formation, 2,782; Stone Corral dolomite, 3,360; Lansing-Kansas City group, 4,488; Cherokee group, 4,962; Mississippian rocks, 5,189; and Arbuckle dolomite, 5,375 feet depth. A drill-stem test from 4,540 to 4,595 recovered some free oil, but the other tests were negative. The hole was abandoned at a total depth of 5,392 feet.

The wildcat test drilled by Sam King et al. on the Martin farm in sec. 10, T. 4 S., R. 41 W., had to be abandoned at a relatively shallow depth because of lost circulation of drilling muds. The hole was drilled deep enough to find the Morrison formation at 2,745 feet and the Permian redbeds at 2,970 feet depth. Total depth was 3,075 feet.

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A careful analysis of available well cuttings and electric log of The Texas Company No. 1 Walz well in sec. 3, T. 5 S., R. 42 W. allows the following summation. The Ft. Hays limestone was found at 1,750, Codell sandstone at 1,820, Greenhorn limestone at 2,002, and Dakota formation at 2,188 feet depth. The D and J sands of the Dakota formation, now producing in the Denver-Julesburg basin in southwestern Nebraska, were present in this test. Other tops are: Permian redbeds, 2,956; Blaine formation, 3,007; Stone Corral dolomite, 3,272; Ft. Riley limestone, 3,451; Topeka limestone, 4,115; Lansing-Kansas City group, 4,340; base of the Kansas City, 4,626; Marmaton group, 4,696; Cherokee group, 4,814; Mississippian strata, 5,038; Arbuckle, 5,222; and Lamotte sandstone, 5,337 feet depth. The test was abandoned at 5,387 feet. The bottom-hole pressures in this test were uniformly below normal.

CLARK COUNTY

(Map Fig. 13)

The 1952 production from 3 fields: oil 13,043 barrels, gas 263,971 thousand cubic feet. Wells drilled in 1952: oil 1, gas 2, dry 10, total 13 including 9 dry wildcats. New pools 1.

Developments during 1952.—The new pool in Clark County, the **Snake Creek,** was discovered by Sunray Oil Corporation on the Harper lease in sec. 21, T. 34 S., R. 21 W. Several sands in Lower Pennsylvanian rocks were tested, one between 5,452 and 5,460 feet had shows of both oil and gas. Another between 5,536 and 5,545 feet showed oil, water, and a small amount of gas after hydrafrac had been used. A show of gas and a little oil were found in the top of the Mississippian rocks between 5,540 and 5,550 feet. The hole, drilled into Arbuckle dolomite without further shows, was plugged back to the sand at 5,452 and completed with a rated potential of 6½ million cubic feet of gas per day and 48 barrels of light oil per day. The producing sand has been tentatively assigned to the Morrowan Series.

In the **Ashland** pool, a second producer rated at 134 barrels of oil per day was completed in the Lansing limestone. The Skelly Oil Company successfully drilled a second gas producer in the **Theis** gas pool on the "D" lease in sec. 8, T. 34 S,. R. 25 W. Its rated capacity is 4½ million cubic feet of gas per day.

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TABLE 24.—*Dry wildcat tests drilled in Clark County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Mississippian, feet	Total depth, feet
Gulf Oil Corp. No. 1 Abel Ranch	C SE¼ SE¼ 21-31-23W	2,466	4,552	5,508	6,995
J. M. Huber Corp. No. 1 Denton	NE¼ NE¼ NE¼ 35-31-24W	2,381	4,447	5,435	5,666
Panoma Corp. No. 1 Stephens	NE¼ SE¼ NW¼ 22-32-21W	2,056	4,520	5,435	5,450
Stanolind Oil & Gas Co. No. 1 George Z. Perry	SW¼ SW¼ NE¼ 33-32-22W	2,016	4,458	5,337	5,670
*Leftoutch et al. No. 1 Du Vall	NE¼ NE¼ SE¼ 36-32-25W	2,197	4,456	5,377	5,587
Stanolind Oil & Gas Co. No. 1 David S. Santee	SE¼ SE¼ SE¼ 18-33-23W	2,004	4,422	5,324	5,650
Graham-Messman-Rinehart Oil Co. No. 1 Gardiner	NE¼ NE¼ NE¼ 14-33-24W	2,048	4,429	5,330	5,535
*J. M. Huber Corp. et al. No. 1 Arnold	C NW¼ NW¼ 28-34-22W	1,827	4,418	5,493	5,698
Skelly Oil Co. No. 1 G. M. Dunne	SW¼ SE¼ NW¼ 4-35-23W	1,875	4,490	5,601	6,000

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

Only one of the 9 dry wildcat tests penetrated the Arbuckle dolomite; however, most of the others were drilled well into Mississippian strata. No shows of oil were reported in these tests.

The new pool is listed in Table 6. Data on dry wildcat tests are given in Table 24. Locations of producing areas and dry wildcat tests are shown on Figure 13. Data on oil production are given in Table 66, and on gas production in Table 67.

CLAY COUNTY

(Map Pl. 1)

The 1952 production from 2 fields: oil, none reported. Wells drilled in 1952: oil 2, dry 2, total 4, including 1 wildcat.

Developments during 1952.—No oil production figures were available for Clay County's two known pools. Drilling in the county added a new oil well and a dry hole to the **Wakefield** field, one dry wildcat, and a dry hole in the **Wakefield Northeast** field. The dry wildcat is the Mahoney and Fehr No. 1 Wiese well, NW¼ SE¼ NW¼ sec. 27, T. 9 S., R. 4 E. The well, drilled to a total depth of 1,920 feet in June, reached the top of Mississippian limestone at 1,883 feet.

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Oil production statistics in Clay County are listed in Table 66. Locations of the producing fields and of the wildcat well drilled in 1952 are shown on Plate 1.

CLOUD COUNTY

Wildcat tests have been drilled in Cloud County from time to time, but so far no producing pool has been discovered.

Exploration during 1952.—During 1952 Thos. H. Allan et al. made the first test in Cloud County since 1950. The hole was put down on the Cleveland farm in the SW¼ SW¼ NE¼ sec. 14, T. 6 S., R. 2 W., to a total depth of 3,320 feet. This dry test, according to the sample log prepared by J. D. Davies, found the following marker horizons: Lansing-Kansas City, 1,912; Mississippian, 2,484; "Hunton," 2,753; Viola, 2,971; Simpson, 3,175; and Arbuckle, 3,286 feet depth. There were no shows of oil or gas, although many zones penetrated were porous.

COFFEY COUNTY

(Map Pl. 1)

The 1952 production: oil 85,651 barrels from 5 fields; gas 11,477 thousand cubic feet. Wells drilled in 1952 (reported): oil 8, dry 8, total 16 including 1 wildcat.

Developments during 1952.—Reported drilling activity in Coffey County during 1952 included 16 wells compared with 22 reported in 1951. Pool wells drilled in the county are listed in Table 25. The dry wildcat well drilled during the year is the Thomsen and Hartig No. 1 O'Narra well, NE¼ NE¼ SE¼ sec. 14, T. 21 S., R. 13 E., which was abandoned at 1,805 feet in August. The following tops were reported: Kansas City limestone, 1,007 feet; "Peru sand," 1,429 feet; "Cattleman sand," 1,470 feet, Mississippian limestone, 1,801 feet.

Locations of areas that produced oil in 1952 are shown on Plate 1. Oil production statistics are listed in Table 66.

TABLE 25.—*Pool wells drilled in Coffey County during 1952*

Field	Oil wells	Dry holes
Dunaway	1	....
Van Noy	4	6
Virgil North	3	....
Winterscheid	....	1
Total	8	7

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COWLEY COUNTY

(Map Pl. 1)

The 1952 production: oil from 77 fields 2,165,504 barrels including approximately 229,046 barrels from secondary recovery operations, gas 554,906 thousand cubic feet reported from 8 wells. Wells drilled in 1952 (reported): oil 141, gas 4, dry 134, input 18, water supply 1, salt-water disposal 2, total 300 including 19 wildcats. New pools discovered 14, pools combined 1.

Developments during 1952.—Cowley County, with 14 new fields opened, by far outranked all other eastern Kansas counties in pool discoveries in 1952. Nine of the new oil pools produce from the "Bartlesville sand," three from Mississippian limestone, and one from "Layton sand." In April the **Arkansas City West** field was

TABLE 26.—*Pool wells drilled in Cowley County during 1952*

Field or pool	Oil wells	Gas wells	Dry holes	Injection wells on water-flood projects	Salt-water disposal wells
Arkansas City	....	....	3	....	....
Arkansas City West	1	....	6	....	....
Baird	3	....	4	....	....
Baird East	2	....	3	....	....
Bergkamp	13	....	5	....	....
Bergkamp Northwest	1	....	1	....	....
Bogner	1	....	1	....	....
Box	1	....	2	....	....
Brown	1	....	....	....	....
Bruce	....	....	1	....	1
Burden	1	....	1	....	....
Cabin Valley	3	....	1	....	....
Canfield	2	....	1	....	....
Copeland	1	....	3	....	....
Couch	4	....	....	....	....
Countryman	1	....	2	....	....
Daniels	....	....	2	....	....
David	8	....	2	....	....
David South	4	....	....	....	....
Deichman	2	....	1	....	....
Denton	....	....	1	....	....
Dexter	1	....	2	....	....
Dunbar	....	....	1	....	....
Dutch Creek	1	....	2	....	....
Eastman	....	....	3	....	....
Elrod	1	....	....	....	....
Enterprise	....	....	2	....	....
Enterprise Northeast	3	....	2	....	....
Estes	....	....	1	....	....
Ferguson Northwest	2	....	....	....	....
Frog Hollow	....	....	1	....	....
Frog Hollow East	....	....	3	....	....
Fussell	1	....	....	....	....
Geuda Springs	3	....	4	....	....
Geuda Springs West	....	....	1	....	....

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TABLE 26.—*Pool wells drilled in Cowley County during 1952, concluded*

Field or pool	Oil wells	Gas wells	Dry holes	Injection wells on water-flood projects	Salt-water disposal wells
Gibson	29	3	6	....	1
Graham	....	....	1	....	....
Harvey	13	....	2	....	....
Henderson	....	....	1	....	....
Hittle	....	....	1	....	....
Hower	1	....	1	....	....
Jarvis	1	....	2	....	....
McKay	14	....	4	....	....
Mansur	....	....	1	....	....
Millett	....	....	1	....	....
Murphy	4	....	5	....	....
New Salem	....	1	1	....	....
Nigger Creek	....	....	1	....	....
Otto	....	....	2	....	....
Rahn	....	....	1	....	....
Rahn Southwest	....	....	1	....	....
Rainbow Bend	....	....	2	16	(1 water supply)
Rainbow Bend Northeast	1	....	....	....	....
Rainbow Bend West	2	....	....	....	(1 water supply)
Rock	5	....	1	2	....
Rock North	1	....	2	....	....
Slick-Carson	....	....	1	....	....
State	5	....	4	....	....
Thurlow	1	....	1	....	....
Tisdale	....	....	3	....	....
Turner	....	....	2	....	....
Turner West	1	....	....	....	....
Walnut Bend	....	....	1	....	....
Weathered	....	....	1	....	....
Wilmot-Floral	....	....	1	....	....
Winfield	2	....	3	....	....
Total	141	4	115	18	2

opened by the Aylward Drilling Company No. 1 Land-Power well in the SW¼ SW¼ sec. 23, T. 34 S., R. 3 E. Initial daily production from "Bartlesville sand" was rated at 58 barrels of oil. The Smitherman-Cohen Drilling Company No. 1 Bergkamp well in the NE¼ SE¼ sec. 6, T. 35 S., R. 4 E., opened the **Bergkamp,** another "Bartlesville sand" pool. Production of 74 barrels of oil per day was reported from a zone between 3,202 and 3,225 feet. Another "Bartlesville sand" pool, the **Bergkamp Northwest,** was discovered by the Flossmar Oil and Gas Company No. 1 Maurer-Neuer well in the NW¼ NW¼ sec. 6, T. 35 S., R. 4 E. The producing formation lies between 3,208 and 3,211 feet; initial production of the discovery well was reported to be 25 barrels of oil per day. The Palmer Oil Corp. No. 1 Bogner well, in the SE¼ NE¼ sec. 24, T. 31 S., R. 5 E., is the discovery well of the **Bogner**

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pool, in Mississippian limestone between 2,999 and 3,053 feet. Initial daily production of the well was rated at 25 barrels of oil. The **Cabin Valley**, a "Layton sand" pool between 2,188 and 2,197 feet, was found by the Crest Petroleum Company No. 1 Berry well, NE¼ NE¼ sec. 31, T. 33 S., R. 6 E. This well also was rated

TABLE 27.—*Dry wildcat tests drilled in Cowley County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Kansas City, feet	Depth to top of Mississippian, feet	Total depth, feet
*The Palmer Oil Corp. No. 1 Williams	NE¼ NE¼ SW¼ 14-30-3E	1,223	2,464	3,093	3,186
*White & Ellis Drlg. Co. No. 1 Snodgrass	NE¼ NE¼ NE¼ 36-30-6E	....	2,170	2,972	3,045
*White & Ellis Drlg. Co. No. 2 Snodgrass	NW¼ SW¼ NE¼ 36-30-6E	....	....	2,884	2,917
*Beaumont Petro. Co. No. 1 Riding	NW¼ NW¼ NW¼ 3-30-7E	....	2,137	2,889	2,955
*H. J. Uhl No. 1 Schoup	SW¼ SW¼ NW¼ 21-31-3E	....	2,528	3,105	3,155
*The Palmer Oil Corp. No. 2 Bogner	SE¼ SW¼ NE¼ 24-31-3E	....	2,308	3,020	3,498
*Laura Jane Oil Co., Inc. No. 1 Hammil	S2 SE¼ SW¼ 19-31-4E	1,138	2,410	2,958	2,965
*Earl F. Wakefield No. 1 Bernstorf	SW¼ NW¼ SW¼ 33-31-4E	1,185	2,496	3,024	3,033
Hill & Hill No. 1 Ireton	SW¼ SW¼ NE¼ 11-32-3E	1,185	2,554	3,086	3,415
*Earl F. Wakefield No. 1 Weigle	NW¼ NE¼ NE¼ 7-32-6E	1,364	2,452	3,147	3,180
Russell Cobb No. 1 Kroth	SE¼ SW¼ NE¼ 12-33-3E	1,177	2,785	3,231	3,268
Time Petro. Co. No. 1 Murat	NW¼ NW¼ NE¼ 25-33-3E	1,166	2,801	3,337	3,353
*Russell Cobb No. 1 Thompson	SE¼ SW¼ SE¼ 17-33-4E	1,163	2,708	3,233	3,244
*Martin & Cash Drlg. Co. No. 1 Collinson	NE¼ NE¼ SW¼ 21-33-4E	1,156	....	3,164	3,177
*Earl F. Wakefield No. 1 Morris	SE¼ SE¼ SE¼ 33-33-4E	1,192	2,683	3,249	3,285
*Watson Drlg. Co., Inc. No. 1 Jarvis Ranch	NW Lot 8 7-34-8E	....	2,115	2,694	2,714
*Aladdin Petro. Corp. No. 1 Marshall	SE¼ NE¼ NW¼ 2-35-3E	1,127	2,815	3,413	3,465
*Alyward Drlg. Co. No. 1 Brandenburg	SE¼ NE¼ SW¼ 3-35-3E	1,128	2,829	3,428	3,455
*Aladdin Petro. Corp. No. 1 Tudhope	NW¼ NW¼ SE¼ 11-35-3E	1,162	2,835	3,424	3,474

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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at 25 barrels of oil per day. The **Canfield** pool, in "Bartlesville sand" between 3,375 and 3,379 feet, was found by the Aylward Drilling Company No. 1 Canfield well, NE¼ NW¼ sec. 13, T. 34 S., R. 3 E. The daily production of the well was rated at 13 barrels of oil. The Spencer and Tobias No. 1 Copeland well, NW¼ NE¼ sec. 5, T. 35 S., R. 4 E., is the discovery well of the **Copeland** pool. Production is from Mississippian limestone in a zone between 3,211 and 3,224 feet.

The **Dutch Creek** pool, in "Bartlesville sand" between 2,924 and 2,938 feet, was opened by the Helmerich and Payne No. 1 Stuckey well, NE¼ NW¼ sec. 35, T. 31 S., R. 4 E. The daily potential was rated at 2 barrels of oil. The **Enterprise Northeast** pool was found in "Bartlesville sand" between 3,335 and 3,347 feet, by the Helmerich and Payne No. 1 Wright well, NE¼ SE¼ sec. 35, T. 33 S., R. 3 E. Initial daily production was rated at 443 barrels of oil. The Crest Drilling Co. No. 1 Fussell well, NW¼ SE¼ sec. 14, T. 34 S., R. 3 E., is the discovery well of the **Fussell** pool. The producing zone is in "Bartlesville sand" between 3,348 and 3,360 feet. Initial daily production of the discovery well was rated at 50 barrels of oil. The **Gibson South,** a "Bartlesville sand" field, was opened by The Texas Company No. 1. L. M. Bryant well, SE¼ NW¼ sec. 32, T. 34 S., R. 3 E. Initial daily production of 80 barrels of oil was found between 3,383 and 3,388 feet. The field, opened in February, was combined with the **Gibson** later in the year. The Martin and Cash Drilling Company No. 1 Harvey well, NW¼ NW¼ sec. 23, T. 34 S., R. 3 E., opened the **Harvey** pool, in "Bartlesville sand" from 3,278 to 3,296 feet. The initial daily production of the discovery well was rated at 2,382 barrels of oil. The **Harvey Northwest** pool was discovered by the Smitherman and Cohen No. 1 Oglesbee well SW¼ NE¼ sec. 15, T. 34 S., R. 3 E. This was a maximum well (3,000 barrels of oil daily). The "Bartlesville sand" is between 3,298 and 3,318 feet. The **Turner West** pool produces from Mississippian limestone at a depth of 3,054 feet. It was discovered by the Cooperative Refinery Association No. 1 Abildgard well, SE¼ NE¼ sec. 25, T. 32 S., R. 5 E. The initial daily production of the well was 16 barrels of oil.

The Texas Company No. 2 Bryant "A" well found production in Mississippian rocks, a new producing zone in the **Gibson South** field (Table 7).

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In addition to the field openers, 19 wildcats were abandoned as dry holes in Cowley County in 1952. Data on these dry wildcats are listed in Table 27. Drilling was active also in formerly established pools. Data on pool wells in the county are listed in Table 26.

Oil production in the various Cowley County fields is listed in Table 66. Gas production is listed in Table 67. Data on secondary recovery operations are listed in Table 1. Locations of areas in Cowley County that produced oil in 1952 and locations of secondary recovery projects are shown on Plate 1. New pools are listed in Table 6.

CRAWFORD COUNTY

(Map Pl. 1)

The 1952 production: oil from 7 fields, 47,097 barrels, gas 29,270 thousand cubic feet. Wells drilled in 1952 (reported): oil 3, input 2, total 5.

Developments during 1952.—Oil production in Crawford County declined somewhat in 1952. Reported gas production came from 19 commercial wells. Three oil wells and 2 water input wells were reported drilled in the **McCune** field. Oil production in the Crawford County fields is listed in Table 66 and gas production in Table 67. Statistics on secondary recovery operations in the county are included in Table 1. Locations of areas that produced oil in 1952 and of water-flooding projects are shown on Plate 1.

DECATUR COUNTY

(Map Fig. 4)

The 1952 production from 5 pools: oil 172,424 barrels. Wells drilled during 1952: oil 21, dry 21, salt-water disposal 1, total 43 including 11 wildcats. New pools discovered 4.

Developments during 1952.—Decatur County became one of the oil-producing counties in Kansas during 1951 with the discovery of the **Jennings** pool. The favorable recovery from this pool resulted in the drilling of 15 wildcat tests. Four of these opened new pools, the **Adell Northwest, Feely, Hardesty,** and **Monaghan.** The first to be found during 1952 was the **Adell Northwest** pool, opened by the Continental Oil Company on the George Gillespie farm in sec. 34, T. 5 S., R. 27 W., only a few miles northwest of the **Adell** pool in adjoining Sheridan County.

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The oil occurs in the Lansing-Kansas City limestone between 3,632 and 3,686 feet. The discovery well was given a rating of 1,192 barrels of oil per day. During the year, 12 additional oil wells were completed in the pool, more than half of which have a potential capacity of more than 1,000 barrels of oil per day, one is a maximum, (3,000 barrel) well.

The **Hardesty** pool was discovered by Continental Oil Company on the Hardesty farm in sec. 22, T. 5 S., R. 27 W., in the same township as the **Adell Northwest** pool. The discovery well has been given a potential capacity of 844 barrels of oil per day from Lansing limestone at a depth of 3,642 to 3,658 feet. In May, the Continental Oil Company opened the **Feely** pool in sec 2, T. 5 S., R. 27 W., 5 miles north of the **Adell Northwest**. The company completed 2 more oil wells in the new pool during the year. The **Monaghan** pool was found by E. K. Carey on the Monaghan farm in sec. 15, T. 2 S., R. 27 W. The discovery well has a rating of 24

TABLE 28.—*Dry wildcat tests drilled in Decatur County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
*Sauvage & Dunn Drlg. Co., Inc. No. 1 Foley	SW¼ SE¼ NW¼ 5-1-27W	2,650	3,390	3,704‡	3,714
J. M. Huber Corp. No. 1 Railsback	SE¼ SE¼ NE¼ 5-2-26W	2,583	3,405	3,735‡	3,790
*Brooks Hall & Strain Drlg. Co. No. 1 Odle	NW¼ NW¼ SE¼ 14-2-26W	2,508	3,335	3,742	3,833
Musgrove Petro. Corp. No. 1 Mines	SE¼ SE¼ SW¼ 11-2-30W	2,775	3,755	4,266	4,320
Anderson-Prichard Oil Corp. No. 1 Wennihan	SE¼ SE¼ NE¼ 7-3-26W	2,578	3,525	3,903	3,995
Franco Central Oil Co. No. 1 Rudogph Pachner	SE¼ SE¼ NW¼ 28-3-28W	2,739	3,753	4,284	4,310
*A. C. Swain No. 1 W. Lauda	SE¼ SE¼ SE¼ 4-4-27W	2,643	3,570	3,995	4,040
Sauvage & Dunn Drlg. Co., Inc. No. 1 Simpson	NE¼ NE¼ SW¼ 4-5-26W	2,607	3,631	4,015	4,070
*Sauvage & Dunn Drlg. Co., Inc. et al. No. 1 Thieson	NW¼ NW¼ SE¼ 11-5-26W	2,613	3,668	4,038	4,100
Lohmann & Johnson Drlg. Co., Inc. No. 1 Johnson	NW¼ NW¼ SW¼ 10-5-28W	2,694	3,886	4,498	4,509
E. K. Carey No. 1 Wachendofer	NE¼ NE¼ SW¼ 35-5-29W	2,814	3,945	4,516†	4,525

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.
‡ Depth to the top of the granite wash, feet.
† Depth to the top of the Viola, feet.

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barrels of oil per day from the Lansing limestone from 3,514 to 3,569 feet.

Four of the 11 dry wildcat tests put down in the county during the year reported oil-cut mud. The important marker horizons encountered in drilling these tests are given in Table 28. The locations of the producing pools and dry wildcat tests are shown on Figure 4. Oil production is given in Table 66, and the new pools are listed in Table 6.

DICKINSON COUNTY

(Map Pl. 1)

The 1952 production from 4 fields: oil 108,313 barrels. Wells drilled in 1952 (reported): oil 2, dry 3, total 5 including 1 wildcat.

Developments during 1952.—Two new oil wells and one dry hole were added to the **Lost Springs Northeast** field. A dry hole was drilled in the **Lost Springs** field. One dry wildcat well was drilled in the county. It is the Sterling Drilling Company et al. No. 1 Hill well, NW¼ NE¼ NW¼ sec. 34, T. 14 S., R. 3 E., which was drilled to a total depth of 2,365 feet. The surface elevation of the well is 1,365 feet and the top of Mississippian "chat" was reported at 2,292 feet.

Oil production in the Dickinson County fields is listed in Table 66. Locations of areas that produced oil in 1952 are shown on Plate 1.

DOUGLAS COUNTY

(Map Pl. 1)

The 1952 production: oil from 1 field 1,580 barrels (estimated); gas no commercial production reported from 2 fields.

Developments during 1952.—Oil production in Douglas County is in the **Baldwin** field in the southeast part of the county. Small amounts of gas were produced for local rural consumption in the **Lawrence** and **Eudora** fields.

Oil production is listed in Table 66 and the area that produced oil in 1952 is shown on Plate 1.

EDWARDS COUNTY

(Map Fig. 10)

The 1952 production from 2 pools: oil 23,810 barrels, gas 213,093 thousand cubic feet. Wells drilled in 1952: oil 1, gas 2, dry 7, total 10, including 5 wildcats.

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TABLE 29.—*Dry wildcat tests drilled in Edwards County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Viola, feet	Depth to top of Arbuckle, feet	Total depth, feet
Kenneth A. Ellison No. 1 Duddle	NE¼ NE¼ NE¼ 8-24-16W	3,791	4,324	4,519	4,550
Armer Drlg. Co., Inc. No. 1 Elmore	SE¼ SE¼ NW¼ 25-24-16W	3,805	4,337	4,607	4,680
D. R. Lauck Oil Co., Inc. No. 1 Johnson	NE¼ NE¼ SW¼ 1-25-17W	3,916	4,513	4,772	4,825
Natl. Assoc. Petro. Co. No. 1 Madden	C. SW¼ NW¼ 13-26-18W	4,045	4,656	4,810	4,966
Virginia Drlg. Co., Inc. et al. No. 1 T. A. Smith	NE¼ NE¼ NE¼ 27-26-18W	4,086	4,707	4,962	4,995

Developments during 1952.—Oil production increased about 5,000 barrels, while gas production dropped about one-third.

Two new gas wells were completed in the **Bradbridge** pool in the northeastern corner of the county by M. B. Armer. Both wells obtain production from the Lansing limestone at about 3,755 feet depth. One is rated at 8 million and the other at 9 million cubic feet per day. The new oil well in the same pool was drilled by Max Cohen on the Klein lease in sec. 2, T. 24 S., R. 16 W.

The oil and gas producing areas and dry wildcat tests are shown on Figure 10. Important marker horizons encountered in drilling the dry wildcat tests are listed in Table 29. Oil production is given in Table 66, gas production in Table 67.

ELK COUNTY

(Map. Pl. 1)

The 1952 production: oil from 23 fields 175,746 barrels including approximately 17,042 barrels from secondary recovery projects, gas 292,081 thousand cubic feet. Wells drilled in 1952 (reported): dry 8, input 3, total 11.

Developments during 1952.—Oil production in Elk County remained about stationary in 1952. The eight dry holes reported in established fields are **Collyer** 1, **Fleming** 3, **Love** 1, **Mills** 1, **Schade** 1, and **Starr** 1. Three water input wells were reported in the **New Albany** field.

Oil production in the various Elk County fields is listed in Table 66 and gas production in Table 67. Water-flooding activities are listed in Table 1. Locations of areas that produced oil in 1952 are shown on Plate 1.

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ELLIS COUNTY

(Map Fig. 7)

The 1952 production from 75 pools: oil 11,070,399 barrels. Wells drilled in 1952: oil 158, gas none, dry 151, salt-water disposal 9, total 318 including 33 wildcats. New pools discovered 16, revived 1, pools combined 3.

Developments during 1952.—Oil production in Ellis County decreased about 5 percent during 1952; however, the county maintained its position as third largest oil-producing county in the State. No commercial quantities of gas were reported. The number of new wells drilled during 1952 exceeds the total for 1951 by about 23 percent. Among the wildcats, 16 were successful in finding new pools, making the county also third in the number of new discoveries during 1952. They are: **Antonino Townsite East, Bielman, Emmeram Townsite, Experiment, Günther, Hertel, Hertel Southwest, Jensen, Nicholson North, Pleasant Northwest, Raynesford, Raynesford East, Rome, Sessin, Sunnydale,** and **Ubert Northwest.** The **Weisner** pool was revived. Ten of the new pools produce oil from the Arbuckle dolomite,

TABLE 30.—*Dry wildcat tests drilled in Ellis County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
*Natl. Coop. Ref. Assn. No. 2 Cave	NW¼ NW¼ SE¼ 8-11-18W	3,256	3,657	3,706
*J. W. Barden Drlg. Co. No. 1 Zerfas	SW¼ SW¼ SE¼ 31-11-19W	3,421	3,763	3,797
Walters Drlg. Co. No. 2 Cromb	SE¼ SW¼ NW¼ 22-11-20W	3,438	3,755	3,775
Herndon Drlg. Co. No. 1 Davis "B"	SE¼ NE¼ NW¼ 25-11-20W	3,309	3,622	3,678
Brunson Drlg. Co., Inc. et al. No. 1 Hoff	SE¼ SE¼ NW¼ 18-12-16W	3,262	3,557	3,621
*Alpine Oil & Royalty Co. No. 1 Weigel	NE¼ NE¼ NE¼ 30-12-16W	3,298	3,566	3,580
Brunson Drlg. Co. et al. No. 1 Anna Leinmiller	NE¼ NE¼ SW¼ 2-12-19W	3,419	3,699	3,750
Braden Drlg. Co. No. 1 Spreen	SW¼ SW¼ NE¼ 8-12-19W	3,452	3,750	3,798
John Lindas Oil, Inc. No. 1 Hagen	NW¼ NW¼ NE¼ 18-12-19W	3,545	3,852	3,969
John Lindas Oil, Inc. No. 1 Nickols Trust	NW¼ NW¼ SE¼ 19-12-19W	3,523	3,883	3,920
Shelley-Miller Drlg., Inc. No. 1 Dreiling	NE¼ NE¼ NE¼ 27-12-19W	3,485	3,823	3,873

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TABLE 30.—*Dry wildcat tests drilled in Ellis County during 1952, concluded*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
Victor Drlg., Inc. No. 1 Dortland	SW¼ SW¼ NW¼ 26-13-16W	3,187	3,526	3,556
*Graham-Messman-Rinehart Oil Co. No. 1 Riemsnyder	NW¼ NW¼ NW¼ 4-13-18W	3,492	3,848†	3,867
*Stearns Drlg. Co. et al. No. 1 Fellers	NE¼ NE¼ SE¼ 10-13-18W	3,490	3,802	3,889
*Petroleum, Inc. No. 1 Braun "A"	NE¼ NE¼ SW¼ 15-13-18W	3,434	3,784	3,810
*Virginia Drlg. Co. et al. No. 1 Brull	SW¼ SW¼ SW¼ 19-13-18W	3,344	3,668	3,717
*Jones, Shelburne & Farmer Inc. No. 1 Middlekauf	NE¼ NE¼ NW¼ 5-13-19W	3,462	3,803	3,843
*Sitrin & Murfin et al. No. 1 Sack	SW¼ SW¼ NE¼ 13-13-19W	3,373	3,681	3,711
Graham-Messman-Rinehart Oil Co. No. 1 Jacques	SW¼ SW¼ NE¼ 10-13-20W	3,424	3,724‡	3,805
Imperial Drlg. Co. No. 1 Flax	SW¼ SW¼ SW¼ 20-13-20W	3,590	3,972	3,991
Carl Todd Drlg. Co. No. 1 Boos	NE¼ NE¼ SE¼ 31-13-20W	3,560	3,902	3,923
Imperial Drlg. Co. No. 1 Kroeger	NE¼ NE¼ NE¼ 31-13-20W	3,583	3,940	3,988
*Natl. Coop. Ref. Assn. No. 1 Robbin	NW¼ NE¼ SW¼ 11-14-16W	3,160	3,435	3,485
John Lindas Oil, Inc. No. 1 Strecklein "A"	SE¼ SE¼ SW¼ 28-14-18W	3,356	3,692	3,783
Brunson Drlg. Co. et al. No. 1 Rose B. Ward	SW¼ SW¼ NE¼ 31-14-19W	3,414	3,768	3,828
Imperial Drlg. Co. No. 1 Gabel	NE¼ NE¼ NE¼ 5-14-20W	3,609	3,973	4,010
Keystone Petro., Inc. No. 1 Jenny Lee	SE¼ SE¼ NE¼ 25-14-20W	3,433	3,765	3,842
Todd Drlg. Co. et al. No. 1 Schmidtberger	NE¼ NE¼ NW¼ 15-15-16W	3,202	3,504	3,551
Anderson-Prichard Oil Corp. No. 1 Arnold	NW¼ NW¼ NW¼ 17-15-16W	3,214	3,512	3,523
*Murfin & Oil Trading Corp. No. 1 Philip	SW¼ SW¼ SE¼ 4-15-17W	3,249	3,527	3,544
Musgrove Petro. Corp. No. 1 Kippes	SW¼ SW¼ SE¼ 13-15-17W	3,249	3,538	3,595
The Texas Company No. 1 Urban	NW¼ NW¼ SW¼ 11-15-19W	3,328	3,670	3,738
*Barnett Drlg., Inc. et al. No. 1 Philip	SW¼ SW¼ SW¼ 3-15-20W	3,362	3,742	3,765

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

† Depth to the top of the weathered Arbuckle, feet.

‡ Depth to the top of the Pennsylvanian basal conglomerate, feet.

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1 from the Pennsylvanian basal conglomerate, and 5 from the Lansing-Kansas City limestone sequence.

During the year new producing zones were found in both new and older pools. The three main producing zones in this county in order of importance are the Arbuckle dolomite, the Lansing-Kansas City limestone, and the Pennsylvanian basal conglomerate. Where one of them is productive often one or both of the others is also productive. New producing zones discovered during the year are listed in Table 7.

The following pool consolidations took place during 1952: **Irvin North** and **Irvin Northeast** with **Irvin; and Christina** with **Emmeram Northeast**.

Old wells worked over provided 13 oil wells, 6 dry holes, and 8 salt-water disposal wells. Seven locations were abandoned during 1952.

Only one of the 33 dry wildcat tests did not penetrate the Arbuckle dolomite; 22 reported no shows of oil or gas. The wildcat test in the abandoned **Cromb** pool recovered only salt-water from a drill-stem test in the Arbuckle dolomite.

In the **Solomon** pool, three times as many new oil wells were added to the pool as dry holes. The **Irvin** pool, including the combinations, added 14 oil wells and 6 dry holes.

Pertinent geological information was furnished by some of the salt-water disposal wells. The Westgate-Greenland No. 4 Day well in sec. 8, T. 11 S., R. 17 W. found more than 520 feet of Arbuckle dolomite. The Shell Oil Company No. 2 Rumsey "W" well in sec. 23, T. 11 S., R. 17 W. penetrated nearly 540 feet of Arbuckle before entering Pre-Cambrian granite at 3,884 feet. The B & R Drilling Company No. 5 Stackhouse "A" well in sec. 23, T. 12 S., R. 18 W. found almost 500 feet of Arbuckle dolomite. In the **Irvin** pool, The Texas Company No. 3 Riedel well in sec. 31, T. 13 S., R. 19 W. found only 137 feet of Arbuckle dolomite, entering Pre-Cambrian granite at 4,052 feet. In the southwestern part of Ellis County, the Arbuckle ranges in thickness from 20 to 50 feet and rests upon the Lamotte sandstone.

Pertinent information on the new Ellis County oil pools is found in Table 6. Locations of producing areas and dry wildcat tests are shown on Figure 7. Dry wildcat tests made during 1952 are listed in Table 30. Oil production by pools is given in Table 66.

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ELLSWORTH COUNTY

(Map Fig. 6)

The 1952 production from 14 pools: oil 3,856,505 barrels, gas 40,446 thousand cubic feet. Wells drilled in 1952: oil 39, dry 55, salt-water disposal 3, total 97 including 8 wildcats. New pools discovered 2, combined 1.

Developments during 1952.—During 1952 oil production dropped slightly, gas production decreased more than one-half, and drilling activity dropped off almost 10 percent from 1951. Two new pools, the **Andrews** and the **Maes,** were found. In the **Andrews** pool, the El Dorado Refining Company No. 1 Andrews well in sec. 4, T. 17 S., R. 8 W. found oil in the Arbuckle dolomite. This pool lies just north of the **Edwards** pool. The **Maes** pool, in sec. 26 of the same township, was discovered by the E. K. Carey Drilling Company No. 1 Maes well which produces oil from Arbuckle dolomite at a depth of 3,341 feet. Further information on these two pools is given in Table 6. In the **Heiken** pool, the Lansing-Kansas City strata was added as a new producing zone by Skelly Oil Company with the completion of a 50 barrel per day well. Additional data on this new producing zone are given in Table 7.

The **Edwards** and **Edwards North** pools were combined during 1952.

TABLE 31.—*Dry wildcat tests drilled in Ellsworth County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Penn. basal congl., feet	Depth to top of Arbuckle, feet	Total depth, feet
*Coffman, Blair & Ward No. 1 Westerman	SE½ NE¼ NW¼ 15-16-8W	2,573	....	2,971	3,070
*Bay Petro. Corp. No. 1 Wilkens	N½ NE¼ SW¼ 1-16-9W	2,755	3,097	3,142	3,173
*Musgrove Petro. Corp. No. 1 Valenta	NE¼ NE¼ SW¼ 7-16-9W	3,006	3,332	3,573	3,609
*Musgrove Petro. Corp. No. 1 Roelfs	NE¼ NE¼ SE¼ 21-16-9W	3,011	3,380	3,626	3,641
*Hinkle Oil Co. No. 1 Becker	NE¼ SE¼ NE¼ 35-16-9W	2,843	3,188	3,283	3,291
*Stag Drlg. Inc. No. 1 Hokr	NE¼ NE¼ SW¼ 1-17-8W	2,813	3,204	....	3,440
*Dozier Oil Co. No. 1 Wilkens	SW¼ SW¼ NE¼ 5-17-9W	2,956	3,273	3,384	3,396
*Dozier Oil Co. No. 1 Ehrhorn	SE¼ SW¼ SE¼ 9-17-9W	2,916	....	....	3,120

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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Most of the drilling activity during the year was concentrated in T. 17 S., Rs. 8 and 10 W., in the **Edwards** and **Stoltenberg** pools. The **Stoltenberg** pool added 10 extension oil wells and the **Edwards** 3. In the new **Maes** pool 14 oil wells (including the discovery well) were completed. Eight of these were given maximum initial potentials (3,000 barrels of oil per day.)

In the **Stoltenberg** pool, the National Cooperative Refinery Association No. 5 Harbacek well in sec. 7, T. 16 S., R. 10 W. found almost 500 feet of Arbuckle dolomite; Pre-Cambrian granite was reached at 3,827 feet depth. The Artnell Drilling Company No. 4 Stoltenberg "B" well in sec. 36, T. 16 S., R. 10 W. found more than 400 feet of Arbuckle dolomite, entering Pre-Cambrian granite at 3,798 feet.

Data on dry wildcat tests are given in Table 31. Locations of producing areas and dry wildcat tests are shown on Figure 6. Data on oil production are given in Table 66, and gas production in Table 67.

FINNEY COUNTY

(Map Pl. 2)

The 1952 production from 6 pools: oil 197,589 barrels; gas production of the Hugoton Area is not segregated as to counties, other gas 56,839 thousand cubic feet. Wells drilled in 1952: oil 5, gas 50, dry 3, total 58 including 2 wildcats. New pools discovered 4.

Developments during 1952.—Although oil production showed a slight decline, drilling activity more than doubled during 1952. Four new oil pools were found during the year. They are the **Beyer, Damme South, Sonderegger,** and **Stewart** pools. The **Beyer** pool is within the Hugoton Gas Area about 10 miles south of Garden City in sec. 24, T. 26 S., R. 33 W. The W. J. Coppinger No. 1 Beyer well found oil in the Lansing-Kansas City limestone between depths of 4,398 and 4,406 feet. The discovery well is capable of yielding 191 barrels per day. The **Damme South** pool, 9 miles northwest of Garden City in sec. 28, T. 22 S., R. 33 W., produces from Mississippian strata between 4,767 and 4,776 feet. The discovery well has been rated at 244 barrels of oil per day. Cooperative Refinery Association found oil in the Mississippian strata between 4,737 and 4,748 feet on the Sonderegger farm in sec. 21, T. 22 S., R. 31 W., 12 miles east of the **Damme South** pool. The rated potential of the well is 295 barrels per day. A few miles

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northeastward the Cooperative Refinery Association opened the **Stewart** pool on the Stewart farm in sec. 6, T. 23 S., R. 30 W. The oil occurs in Mississippian rocks from 4,738 to 4,744 and 4,817 to 4,825 feet.

The Shell Oil Company wildcat test 22 miles northeast of Garden City on the Bauman farm in the NE¼ NE¼ NE¼ sec. 4, T. 22 S., R. 29 W., reached a total depth of 5,347 feet. From an elevation above sea level of 2,661 feet, the following marker horizons were encountered: Topeka limestone, 3,560; Lansing-Kansas City group, 3,890; Mississippian strata, 4,570; Viola dolomite, 5,046; and Arbuckle dolomite, 5,222 feet depth. Several drill-stem tests were taken, but no shows were reported.

B & R Drilling Company and National Cooperative Refinery Association drilled to the Mississippian rocks on the O'Brien lease in the SE¼ SE¼ SE¼ sec. 13, T. 21 S., R. 34 W. about 1½ miles from the **Nunn** pool. Shows of gas were found from 2,553 to 2,609 feet depth in the Herington limestone.

Of the 50 new gas wells completed in the county during 1952, 49 were in the Hugoton Gas Area. The other gas well is in the **Damme** pool in sec. 21, T. 22 S., R. 33 W.

Finney County wells are shown on Plate 2. Information on the four new oil pools is given in Table 6. Oil production is given in Table 66, and gas production is listed under Finney County and Hugoton in Table 67. Additional information on the Hugoton Gas Area is reported in the chapter on natural gas.

FORD COUNTY

The 1952 production from 1 pool: oil 1,938 barrels, gas none reported. Wells drilled in 1952: 5 wildcats.

Developments during 1952.—With one exception all the wildcats drilled during 1952 tested only the rather porous dolomitic limestone of the Warsaw formation which here lies near the top of the Mississippian System. Table 32 gives the location and the important geologic tops of the wildcat wells. The deep test, drilled by the Deep Rock Oil Corporation on the Raymond farm in sec. 21, T. 29 S., R. 25 W. encountered below the Mississippian, Viola dolomitic limestone, 6,299; Simpson clastic rocks, 6,434; and Arbuckle dolomite, 6,468 feet. Drill-stem tests found only salt water.

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TABLE 32.—*Dry wildcat tests drilled in Ford County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Mississippian, feet	Total depth, feet
Graham-Messman-Rinehart Oil Co. No. 1 Hattrup	NW¼ NW¼ NE¼ 23-26-21W	2,280	4,152	4,812	4,851
Deep Rock Oil Corp. et al. No. 1 H. A. Kinkaid	NW¼ NE¼ SE¼ 34-26-26W	2,570	4,256	4,986	5,465
*I. W. Siegel et al. No. 1 Dinkela	NE¼ NE¼ NW¼ 21-27-23W	2,405	4,274	4,999	5,100
Deep Rock Oil Corp. No. 1 Raymond	NW¼ SW¼ NW¼ 21-29-25W	2,599	4,460	5,232	6,501
I. W. Siegel et al. No. 1 Lutz	SW¼ SW¼ NE¼ 23-29-26W	2,536	4,326	5,063	5,105

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

Early in 1953, a successful gas well was completed by Armer on the Helmers farm in sec. 25, T. 28 S. R. 21 W. The capacity of the new well is nearly 2 million cubic feet per day from upper Mississippian rocks at a depth of 5,024 to 5,040 feet.

Data on oil production are given in Table 66.

FRANKLIN COUNTY

(Map Pl. 1)

The 1952 production from 9 areas in 2 fields: oil 406,698 barrels, including approximately 377,877 barrels from water-flooding projects. Wells drilled in 1952 (reported): oil 63, input 25, dry 1 (wildcat), total 89.

Developments during 1952.—The total oil production in Franklin County increased considerably in 1952. Most of the drilling was done in connection with water-flooding activities in the eastern part of the county. One dry wildcat, the E. L. Edwards No. 1 Cramer well, in the SW¼ SW¼ SW¼ sec. 26, T. 16 S., R. 18 E., was drilled to a total depth of 1,410 feet. The top of Mississippian limestone was reached at 1,340 feet.

Data on water-flooding projects in Franklin County are listed in Table 1. Oil production in the various areas is listed in Table 66. Areas that produced oil and secondary recovery operations are shown on Plate 1.

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GEARY COUNTY

Wildcat wells have been drilled from time to time in Geary County, but so far no producing pool has been found.

Exploration during 1952.—According to Geological Survey records only 15 tests have been drilled in Geary County (Jewett, 1949, p. 175; Ver Wiebe and others, 1940, p. 60) previous to 1952. Three tests were drilled in 1952.

The F. G. Holl No. 1 Smiley well, in the NE¼ NE¼ SW¼ sec. 7, T. 12 S., R. 7 E., was drilled to a depth of 2,362 feet in October 1952. Tops reported are Lansing, 1,454; conglomerate, 1,950; Mississippian limestone, 1,984; Kinderhookian, 2,092; and "Hunton" limestone, 2,262 feet. The surface elevation is 1,429 feet. The F. G. Holl et al. No. 1 Eseli well, in the NW¼ NW¼ SE¼ sec. 24, T. 12 S., R. 7 E., was abandoned as a dry hole at a total depth of 2,656 feet. From a surface elevation of 1,280 feet, the top of the Lansing rocks was reached at 1,324 feet, Mississippian limestone at 1,830 feet, base of Mississippian limestone at 1,925 feet, top of "Hunton" limestone at 2,096 feet, top of Viola limestone at 2,441 feet, top of Simpson group at 2,559 feet, and top of the Arbuckle rocks at 2,605 feet.

The third 1952 test in Geary County is the F. G. Holl No. 1 Poole well, in the NE¼ NE¼ SE¼ sec. 7, T. 12 S., R. 8 E. The total depth is 2,167 feet. From a surface elevation of 1,259 feet the top of Lansing rocks was reached at 1,295 feet, conglomerate at 1,753 feet, Mississippian limestone at 1,801 feet, and top of the "Hunton" limestone at 2,101 feet.

GOVE COUNTY

(Map Fig. 9)

The 1952 production from 7 pools: oil 26,501 barrels. Wells drilled in 1952: oil 5, dry 16, total 21 including 12 dry wildcats. New pools discovered 4.

Developments during 1952.—Despite limited exploratory drilling, four new oil pools were found in Gove County during 1952. One of the new pools, the **Beougher,** was found by the Skiles Oil Corporation No. 1 Beougher well in sec. 8, T. 13 S., R. 30 W. The top of the Lansing was found at 3,808 feet, but good porosity with oil saturation was not found until between 4,079 and 4,082 feet. The well was completed as a producer with a capacity of 4 barrels per day. The Skiles Oil Corporation No. 1 Lundgren well in sec.

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30, T. 14 S., R. 29 W., failing to find oil in Pennsylvanian rocks, was drilled into the Mississippian where production was found. In the next mile south of the **Lundgren** pool, Wycoff and Williams completed a well on the Lundgren farm to open the **Lundgren South** pool. Here oil was found in the Mississippian between 4,277 and 4,283 feet. Initial potential was rated at 236 barrels per day. An old well was worked over by D. R. Lauck on the Jones farm in sec. 9, T. 15 S., R. 31 W., to open the **Pyramids** pool. The test failed to find oil in the Mississippian rocks and was therefore plugged back to a good showing in the Marmaton limestones between the depths of 4,280 and 4,290 feet. A pumping potential of 150 barrels per day was established. The test was drilled to a depth of 5,027 feet (700 feet below the top of the Mississippian) before being plugged back.

Five of the 12 dry wildcats had shows of oil or gas. The test drilled by Ben Brack on the Graham farm in sec. 26, T. 12 S.,

TABLE 33.—*Dry wildcat tests drilled in Gove County during 1952*

Company and farm	Location	Depth to top of Heebner, feet	Depth to top of Lans.-K.C., feet	Depth to top of Mississippian, feet	Total depth, feet
*Ben F. Brack Oil Co., Inc. No. 1 Graham	NE¼ NE¼ NW¼ 26-12-28W	3,845	3,875	4,500	4,776
Graham-Messman-Rinehart Oil Co. No. 1 Lameroux	NW¼ NW¼ SE¼ 8-12-29W	3,891	3,929	4,490	4,600
Musgrove Petroleum Corp. No. 1 Wilson	NW¼ NW¼ NW¼ 16-12-30W	3,886	3,929	4,489	4,600
Skiles Oil Corp. No. 1 Peirano	SE¼ SE¼ SE¼ 27-13-27W	3,740	3,781	4,370	4,487
*Prime Drlg. Co. et al. No. 1 Mendenhall	SW¼ SW¼ NE¼ 16-13-28W	3,759	3,799	4,396	4,550
B & R Drilling, Inc. No. 1 Johnson	NW¼ NW¼ NW¼ 31-13-28W	3,805	3,843	4,429	4,582
Skiles Oil Corp. et al. No. 1 Hefner	NE¼ NE¼ NE¼ 13-14-28W	3,697	3,737	4,317	4,469
C. L. Carlock No. 1 Coberly	NW¼ NW¼ NW¼ 26-14-28W	3,700	3,738	4,346	4,468
*D. R. Lauck Oil Co., Inc. No. 1 Sharp	NW¼ NW¼ NW¼ 11-14-31W	3,880	3,923	4,562	4,667
Skiles Oil Corp. et al. No. 1 Bruney	SW¼ SW¼ SE¼ 22-15-29W	3,640	3,678	4,296	4,487
Skiles Oil Corp. No. 1 Ikenberry	SE¼ SE¼ NE¼ 12-15-30W	3,590	3,625	4,263	4,387
*LaFayette Oil Co. No. 1 Wier Nichols	NW¼ NW¼ NW¼ 21-15-31W	3,750	3,792	4,412	4,620

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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R. 28 W. found Mississippian chert at 4,500 feet, Viola limestone at 4,694 feet, and Arbuckle dolomite at 4,740 feet, before it was abandoned as a dry hole. All other wildcat tests ended in Mississippian rocks (did not test the Arbuckle dolomite).

The dry wildcat tests are described in Table 33, and the new pools are listed in Table 6. The new pools and dry wildcat tests are shown on Figure 9. Production data on the Gove County pools are listed in Table 66.

GRAHAM COUNTY

(Map Fig. 4)

The 1952 production from 33 pools: oil 3,910,297 barrels, gas 11,225 thousand cubic feet. Wells drilled in 1952: oil 54, dry 112, salt-water disposal 1, total 167 including 40 wildcats. New pools discovered 9, revived 1, combined 2, abandoned 1.

Developments during 1952.—Oil production increased about 300,000 barrels over the previous year, but drilling decreased about 18 percent. Gas production from the **Law** pool was reported for the first time.

Wildcat exploration resulted in the discovery of nine new pools. They are in alphabetical order: the **Alda West, Bass Southwest, Dorman, Mickleson, Noah, Schmied, Schmied North, Schnebly,** and **White.** The **Alda** pool which has not been active for some years was abandoned early in the year, then was revived when the Murfin Drilling Company finished its test on the Davis farm in sec. 15, T. 7 S., R. 22 W. as a producer from the Lansing-Kansas City limestones. All the new pools except the **Mickleson, Noah,** and the **White** which produce from the Arbuckle dolomite derive their oil from the Lansing-Kansas City. Before the end of the year, the **Bass** and **Bass Southwest** pools were merged with the **Cooper** pool. The Lansing-Kansas City rocks were added as a new producing zone in the **Noah** and **Smith-Denning West** pools.

Forty dry wildcat tests were drilled in Graham County during 1952. The sequence of beds in this county is now well known. The Pennsylvanian rocks rest directly upon the Arbuckle dolomite in the northern and eastern parts of the county, but toward the southwest the Mississippian rocks and Ordovician rocks younger than the Arbuckle are found.

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With the combining of the adjacent pools to the **Cooper** pool, 19 extension wells were added during the year. The **Morel** pool, with 7, was second.

The 9 new pools and 1 revived pool are described in Table 6. The 2 new producing zones in established pools are listed in Table 7. The 40 dry wildcats, the largest number of such wells drilled in a single county during the year, are listed and described in Table 34. The producing pools and dry wildcat tests are shown on Figure 4. Oil production from the county is reported in Table 66, gas in Table 67.

TABLE 34.—*Dry wildcat tests drilled in Graham County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
The Texas Company No. 1 Goff	SW¼ SW¼ SE¼ 20-6-21W	2,275	3,544	3,810	3,831
*Empire Drilling Co. No. 1 Muir	NW¼ NW¼ NW¼ 18-6-25W	2,553	3,656	4,069	4,122
Keating Drilling Co. No. 1 Minnie McKisson	NE¼ NW¼ SE¼ 5-7-21W	2,177	3,430	3,687	3,740
Mid Plains Oil Corp. No. 2 Napue	SE¼ SE¼ SW¼ 11-7-21W	2,134	3,382	3,637	3,693
Keating Drilling Co. No. 1 W.K.I.T. School	SE¼ SE¼ SE¼ 33-7-21W	2,068	3,321	3,616	3,655
Anschutz Drilling Co., Inc. No. 1 Gibb	NE¼ NE¼ NE¼ 2-7-22W	2,250	3,502	3,835	3,885
Keating Drilling Co. No. 1 Worcester	NW¼ NW¼ NE¼ 12-7-22W	2,248	3,492	3,768	3,802
Murfin Drilling Co. et al. No. 1 Wallace	SE¼ SE¼ NE¼ 24-7-22W	2,157	3,395	3,709	3,740
Murfin Drilling Co. et al. No. 1 Zeman "C"	NE¼ SE¼ NE¼ 26-7-22W	2,243	3,480	3,879	3,891
*D. G. Hansen No. 1 Jones	NE¼ NE¼ NE¼ 34-7-22W	2,168	3,409	3,754	3,763
*Empire Drilling Co. No. 1 Waggoner	SW¼ SW¼ SW¼ 4-7-23W	2,458	3,747	4,176	4,235
The Texas Company No. 1 R. J. Wolf	SE¼ SE¼ SE¼ 13-7-23W	2,289	3,547	3,916	3,955
Anschutz Drilling Co., Inc. No. 1 R. Michaells	NE¼ NE¼ NE¼ 32-7-23W	2,391	3,694	4,148	4,180
*Empire Drilling Co. No. 1 E. P. Goddard	NW¼ SW¼ NW¼ 21-7-24W	2,426	3,692	4,284	4,335
*Nadel & Gussman No. 1 Paxton	SW¼ SW¼ SW¼ 22-7-24W	2,414	3,701	4,189	4,260
*Prime Drlg. Co. et al. No. 1 Lindenman	SW¼ SW¼ SE¼ 5-7-25W	2,549	3,695	4,201	4,251
Herndon Drilling Co. No. 1 Keith	NW¼ NW¼ SE¼ 24-7-25W	2,514	3,770	4,376	4,387

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TABLE 34.—*Dry wildcat tests drilled in Graham County during 1952, concluded*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
Prime Drlg. Co. et al. No. 1 Gosselin	SE¼ SE¼ NW¼ 5-8-21W	2,064	3,284	3,623	3,648
*Taxman Oil Co. No. 1 Calhoun	SW¼ SW¼ SE¼ 18-8-21W	2,056	3,294	3,644	3,660
Veeder Sup. & Dev. Co. No. 1 Guilleaume	SW¼ SW¼ SW¼ 34-8-21W	2,142	3,347	3,716	3,750
Hay Drilling Co. No. 1 Dickey	NE¼ NE¼ NW¼ 35-8-21W	2,116	3,372	3,707	3,735
Harry Gore & Veeder Sup. Co. No. 1 Gordon	NW¼ NW¼ NW¼ 1-8-22W	2,170	3,395	3,778	3,800
Keating Drilling Co. No. 1 Gosselin	NW¼ NW¼ SW¼ 24-8-22W	2,146	3,389	3,711	3,753
Harry Gore & Veeder Sup. Co. No. 1 Griffith	NE¼ NE¼ SW¼ 2-8-23W	2,253	3,521	3,902	3,955
Harry Gore & Veeder Sup. Co. No. 1 Hill City	NW¼ NW¼ NE¼ 12-8-23W	2,208	3,477	3,894	3,930
S. A. Berwick Drlg. Co. No. 1 Sandbar	SE¼ SE¼ SW¼ 13-8-23W	2,121	3,382	3,780	3,836
Empire Drlg. Co. & Harry Gore No. 1 Brinkmeyer	SE¼ SE¼ SW¼ 19-8-23W	2,267	3,634	4,200	4,250
Prime Drilling Co. et al. No. 1 Goddard	SE¼ SE¼ SE¼ 7-8-24W	2,378	3,727	4,385	4,475
*Peel-Hardman Oil Producers No. 1 Gates	NE¼ NW¼ SE¼ 23-8-24W	2,240	3,592	4,217	4,254
The Texas Company No. 1 B. A. Fox	NW¼ SE¼ SW¼ 29-8-24W	2,336	3,695	4,352	4,400
*Empire Drilling Co. No. 1 H. Madden	SW¼ SW¼ SW¼ 8-8-25W	2,431	3,749	4,445	4,479
*I. W. Siegel No. 1 Engleman	SW¼ SW¼ SE¼ 24-8-25W	2,340	3,659	....	4,250
*Peel-Hardman Oil Producers No. 1 Setchell	NE¼ NW¼ NE¼ 34-8-25W	2,484	3,788	4,480	4,528
Jones, Shelburne & Farmer, Inc. No. 1. St. Peter	NE¼ NE¼ NE¼ 1-9-21W	2,094	3,351	3,727	3,757
Murfin Drilling Co. No. 1 Farrell	NE¼ NE¼ NW¼ 32-9-22W	2,359	3,619	4,017	4,035
The Palmer Oil Corp. No. 1 Robinson	NE¼ NE¼ NE¼ 17-9-23W	2,412	3,747	4,274	4,300
Keating Drilling Co. No. 1 Minium	SE¼ SE¼ SW¼ 15-9-25W	2,594	3,904	4,623	4,654
Jones, Shelburne & Farmer, Inc. No. 1 Noah "F"	NE¼ NE¼ SE¼ 32-10-21W	2,205	3,525	3,859	3,890
*Natl. Coop. Ref. Assn. No. 1 Griffith	NE¼ NE¼ NE¼ 16-10-22W	2,258	3,542	3,966	4,031
Musgrove Petro. Corp. No. 1 Wolf	SE¼ SE¼ SW¼ 18-10-25W	2,540	3,799	4,478	4,550

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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GRANT COUNTY

(Map Pl. 2)

The county lies entirely within the Hugoton Gas Area, the production of which is not segregated as to counties. No oil produced. Wells drilled in 1952: total 29 (all gas).

Developments during 1952.—Drilling activity during the year dropped off slightly more than 50 percent from the previous year. Almost all the available drilling sites are occupied. By townships the heaviest concentration of drilling was in Ts. 27 and 29 S., R. 37 W. The new wells are indicated on Plate 2.

Some of the 1952 gas wells show very large potentials. One well drilled by the Columbian Fuel Corporation on the Trafton ranch in sec. 10, T. 27 S., R. 35 W. was rated at 45 million cubic feet per day after being acidized with 15,000 gallons of acid. The largest new gas well in T. 29 S., R. 37 W. was drilled on the Shaw lease (sec. 10) by the Hugoton Production Company. After acidizing with 16,000 gallons of acid it flowed at the rate of 43 million cubic feet per day. Several other new wells in Grant County are rated at 30 million or more. An average of about 26 million cubic feet per day was established during 1952.

Production, the active area, and producing zones are shown under Hugoton in Table 67. Additional data on the Hugoton Gas Area are given in the chapter on natural gas.

GREENWOOD COUNTY

(Map Pl. 1)

The 1952 production: oil from 52 fields 6,834,217 barrels including approximately 4,528,863 barrels from secondary recovery operations. Wells drilled in 1952: oil 110, dry 56, input 81, water supply wells 4, total 251 including 12 wildcats.

Developments during 1952.—Data on the 12 dry wildcat wells drilled in Greenwood County in 1952 are listed in Table 36. Data on pool wells are listed in Table 35. For several years Greenwood County has been the leader in number of secondary recovery projects operating, and in barrels of oil produced by water-flooding methods. Secondary recovery statistics are listed in Table 1.

Oil production in the various Greenwood County fields is listed in Table 66. Locations of areas that produced oil in 1952 and of water-flooding operations in the county are shown on Plate 1.

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TABLE 35.—*Pool wells drilled in Greenwood County during 1952*

Field or pool	Oil wells	Dry holes	Injection wells on water-flood projects	Water-supply wells on water-flood projects
Atyeo	1	....	14	....
Beaumont	9	....	....	....
Browning	3	1	....	....
Burkett	....	1	....	....
Burt	....	3	....	....
Climax	1	1	....	....
DeMalorie-Souder	4	7	5	1
Dunaway	2	....	....	....
Fankhouser	5	....	....	....
Hamilton	2	5	1	....
Jobes	4	....	....	....
Lamont	4	2	1	....
Madison	8	2	8	1
"Mignot"	1	1	....	....
Neal	....	1	....	....
Polhamus	1	....	1	....
Quincy	2	1	1	....
Sallyards	1	....	2	....
Scott	....	1	....	....
Seeley-Wick	5	1	24	1
Teeter	17	....	14	....
Teichgraber	1	2	2	1
Thrall-Aagard	25	6	6	1
Tonovay	1	3	....	....
Toronto	....	2	....	....
Virgil	5	3	2	....
Virgil North	8	....	....	....
Wiggins	....	1	....	....
Total	110	44	72	5

TABLE 36.—*Dry wildcat tests drilled in Greenwood County during 1952*

Company and farm	Location	Depth to top of Mississippian, feet	Total depth, feet
*Derby Drlg. Co. et al. No. 1 Curry	SW¼ SW¼ SW¼ 11-23-11E	1,950	1,975
*Derby Drlg. Co. et al. No. 1 Redding	NW¼ NE¼ NW¼ 11-23-11E	2,020	2,049
Saturn Drlg., Inc. No. 1 Zebold	SE¼ SW¼ NE¼ 6-24-9E	2,439	2,484
*Raymond Smith No. 1 Snider	SE¼ NE¼ NW¼ 16-24-11E	2,055	2,090
*Davis & Conkey No. 1 Winters	NE¼ SE¼ NE¼ 32-24-13E	1,572	1,618
*Ward A. McGinnis No. 1 Olson	NW¼ NW¼ SW¼ 9-25-8E	2,450	2,484
*Ward A. McGinnis No. 1 Lewis	SW¼ SE¼ NW¼ 15-25-9E	2,220	2,222

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*E. E. Souder et al. No. 1 Salyard	SE¼ SE¼ SE¼ 27-25-9E	2,203	2,378
*Mallard Drlg. Co. No. 1 Anderson	CN½ NE¼ SW¼ 14-25-10E	2,046	2,090
*Mouser Drlg. Co. No. 1 Anspaugh	SW¼ NW¼ NE¼ 17-27-10E	2,181	2,200
*Ben Hermes et al. No. 1 Shinkle	.... 16-27-13E	....	1,585
White & Ellis et al. No. 1 Kinman	NE¼ SW¼ NW¼ 11-28-10E	2,143	2,543

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service and other available data sources have been used.

HAMILTON COUNTY

(Map Pl. 2)

The county lies partly within the Hugoton Gas Area, the production of which is not segregated as to counties. No oil produced. Wells drilled in 1952: total 8 (all gas).

Developments during 1952.—During 1952, eight more gas wells were added to the Hamilton County portion of the Hugoton Gas Area. Seven of the new wells are in T. 26 S., R. 39 W. The other well is in sec. 3, T. 26 S., R. 40 W. The new wells ranged in initial potential from 3.3 million to 22.4 million cubic feet of gas per day. Their average initial potential is about 13 million cubic feet per day.

The new Hamilton County wells are shown on Plate 2. Production, the active area, and producing zones are given under Hugoton in Table 67, and additional data on the Hugoton Gas Area are given in the chapter on natural gas.

HARPER COUNTY

The 1952 production from 3 pools: oil 15,142 barrels, gas 74,971 thousand cubic feet. Wells drilled in 1952: oil 1, dry 6, total 7 including 5 dry wildcats. New pools discovered 1.

Developments during 1952.—One of the wildcat tests drilled in Harper County during 1952 was successful in finding a new oil pool, the **Bluff Creek**. In The Texas Company No. 1 Baker, the discovery well, in sec. 24, T. 34 S., R. 5 W., a drill-stem test in the Kansas City limestone between 3,936 and 3,950 feet showed oil. Tops of lower formations tested are Mississippian rocks, 4,432; Chattanooga shale, 4,860; Viola limestone, 4,878; Simpson shales and sandstone, 4,890; and Arbuckle dolomite, 5,089 feet. No shows were found in the older rocks and the hole was plugged back to

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TABLE 37.—*Dry wildcat tests drilled in Harper County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of K.C., feet	Depth to top of Mississippian, feet	Total depth, feet
Adkins & Potter No. 1 Daniels	S½ SE¼ NW¼ 19-32-5W	1,334	3,696	4,370	4,407
Morrison Drlg. Co. No. 1 Himners	NE¼ NE¼ NE¼ 31-32-5W	1,345	3,719	4,360	4,846
Morrison Drlg. Co. et al. No. 1 Miller	NE¼ SW¼ NW¼ 23-32-7W	1,407	3,850	4,410	4,953
The Texas Company No. 1 H. L. Wilcox	NE¼ SW¼ NW¼ 22-34-6W	1,278	3,866	4,550	5,329
*Morrison Drlg. Co. No. 1 Hanna	SW¼ NW¼ NE¼ 19-34-8W	1,274	4,078	4,625	4,749

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

3,938 to 3,943 feet where the casing was perforated. After acidizing, the well was rated as having a capacity of 26 barrels of oil per day.

The dry wildcat tests are pretty well scattered. The Atkins and Potter test on the Wulf farm tested only the upper 80 feet of the Mississippian. The Morrison Drilling Company No. 1 Himners test tested all formations down to and including the Simpson sandstone. A show of oil and gas was found in the upper part of the Kansas City limestones at 3,719 feet. The Morrison Drilling Company test on the Miller farm penetrated all rocks down to the upper part of the Arbuckle dolomite. A fair show of oil and gas was found in the upper Mississippian at 4,412 feet. The Texas Company hole on the Wilcox farm in sec. 22 was carried into the "Wilcox sand" to a total depth of 5,291 feet. A good show of gas and some oil was found in Mississippian rocks at 4,596 feet in a cherty zone. The Morrison Drilling Company No. 1 Hanna test was drilled 125 feet into the Mississippian strata before it was abandoned as a dry hole.

Oil production during 1952 increased considerably in Harper County, especially since only one well was added to those previously producing. Oil production data are listed in Table 66, and gas production in Table 67. The new pool is described in Table 6.

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HARVEY COUNTY

(Map Fig. 6)

The 1952 production from 8 pools: oil 159,286 barrels, gas 546,314 thousand cubic feet. Wells drilled in 1952: oil 7, dry 4, total 11, including 2 dry wildcats.

Developments during 1952.—Although only about half as much drilling was done in 1952, oil production in Harvey County showed an increase of about 5,000 barrels.

Four small producers were added to the **Burrton** Mississippian pool, and 1 Mississippian well and 2 "Hunton" wells to the **Hollow-Nikkel** pool. Two dry wildcat tests were made in the eastern part of the county. The J. P. Gaty et al. test on the White farm in the NE¼ NE¼ NW¼ sec. 3, T. 22 S., R. 2 E., about 7 miles northeast of the town of Newton, was abandoned at 2,724 feet when the operator failed to find production in basal Pennsylvanian rocks. The second test, about 10 miles southeast of Newton on the Voth farm in the S½ SE¼ SE¼ sec. 24, T. 23 S., R. 2 E., was abandoned by J. P. Gaty at a total depth of 3,061 feet, 300 feet below the top of the Mississippian rocks in that area.

Figure 6 shows the producing areas and dry wildcat tests drilled in Harvey County during 1952. Oil production data are listed in Table 66, and gas production in Table 67.

HASKELL COUNTY

(Map Pl. 2)

The 1952 production, all from the Hugoton Gas Area, is not segregated as to counties. Wells drilled in 1952: total 30 (all gas).

Developments during 1952.—The 30 new gas wells which were added to the Haskell County portion of the Hugoton Gas Area during 1952 did not appreciably change the eastern boundary of the producing area. The significance of this year's drilling lies in the fact that no dry holes were reported. The new wells range in size of initial potential from 0.5 million to 41.0 million cubic feet of gas per day. The average of the new wells is about 9.6 million cubic feet.

Haskell County wells are shown on Plate 2. Production, the active area, and producing zones are given under Hugoton in Table 67, and additional data on the Hugoton Gas Area are given in the chapter on natural gas.

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HODGEMAN COUNTY

(Map Fig. 11)

The 1952 production from 2 pools: oil 133,928 barrels. Wells drilled in 1952: oil 2, dry 18, total 20 including 15 dry wildcats.

Developments during 1952.—Although drilling decreased slightly during 1952, the oil production from the county was double the 1951 figure. Outside of the 2 extension wells added to the **Purdyville** pool, no tests were able to locate new production. Three of the 18 dry holes were very near the **Purdyville** pool, and the other 15 dry wildcats were fairly well scattered over the county.

TABLE 38.—*Dry wildcat tests drilled in Hodgeman County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Mississippian, feet	Depth to top of Arbuckle, feet	Total depth, feet
Metropolitan Petro. Corp. No. 1 Jackson	NE¼ NE¼ NE¼ 20-21-25W	2,324	3,728	4,318	....	4,420
*Victor Drilling, Inc. No. 1 Dumler	NW¼ SE¼ NE¼ 9-21-26W	2,424	3,801	4,403	4,907	4,927
*Trans Era Petro., Inc. No. 1 Sinclair "B"	NW¼ NW¼ SE¼ 10-21-26W	2,408	3,762	4,404	....	4,495
Graham-Messman-Rinehart Oil Co. No. 1 Ruff	NW¼ NW¼ SW¼ 24-22-22W	2,157	3,819	4,420	....	4,480
Graham-Messman-Rinehart Oil Co. No. 1 Hartley	NE¼ NE¼ NE¼ 2-22-25W	2,463	3,974	4,569	....	4,641
Texoma Prod. Co. No. 1 Nilhas	NW¼ NW¼ NW¼ 18-22-25W	2,540	3,975	4,617	5,178	5,246
W. J. Coppinger No. 1 C. J. Schmitt	NW¼ NW¼ NW¼ 23-22-25W	2,515	3,966	4,626	5,163	5,186
John Lindas Oil, Inc. No. 1 Clutter	NE¼ NE¼ SW¼ 20-22-26W	2,504	3,912	4,540	....	4,635
Kenneth A. Ellison No. 1 Baldrey	NW¼ NW¼ SE¼ 4-23-22W	2,191	3,829	4,438	....	4,490
Graham-Messman-Rinehart Oil Co. No. 1 Gleason	NE¼ NE¼ SE¼ 24-23-22W	2,282	3,968	4,550	....	4,583
Simon Lebow No. 1 Reed	SE¼ SE¼ SE¼ 15-23-24W	2,424	4,060	4,716	5,230	5,241
*I. W. Siegel No. 1 Charles	SW¼ SW¼ SW¼ 19-23-24W	2,502	4,055	4,728	....	4,778
*I. W. Siegel No. 1 Wyatt	SE¼ NW¼ NW¼ 30-23-24W	2,512	4,076	4,750	....	4,798
Armer Drilling Co., Inc. No. 1 Mary Hall	SE¼ SE¼ NW¼ 11-24-22W	2,305	4,009	4,615	5,178	5,240
Pabco Drilling, Inc. No. 1 Alexander	SW¼ SW¼ SW¼ 22-24-26W	2,575	4,176	4,837	....	4,985

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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Five of the dry wildcat tests penetrated the Arbuckle dolomite. The other tests drilled only into the Mississippian limestone. Only one of the Arbuckle tests reported shows of oil, the W. J. Coppinger No. 1 C. J. Schmitt test in sec. 23, T. 22 S., R. 25 W. Three of the Mississippian tests reported shows of oil. Perhaps the best show of oil in the dry wildcat tests was in drill-stem tests by Graham-Messman-Rinehart Oil Company on the Hartley test in sec. 2, T. 22 S., R. 25 W., where at 4,571 to 4,581 feet depth, 12 barrels of oil was swabbed per hour. Further testing showed a decline in the rate, and the well was declared noncommercial.

The dry wildcat tests are listed in Table 38. Oil production is given in Table 66. The producing areas and dry wildcat tests are shown on Figure 11.

JACKSON COUNTY

(Map Pl. 1)

Wildcat wells have been drilled in Jackson County from time to time, but as yet no producing pool has been found.

Exploration during 1952.—The Skelly Oil Co. No. 1 Beighley well, NE¼ NW¼ SE¼ sec. 14, T. 7 S., R. 13 E., was abandoned as a dry hole in February 1952. The total depth of the well is 3,603 feet. The top of Mississippian limestone was logged at 2,415 feet, the top of "Hunton" limestone at 2,783 feet, top of Viola limestone at 3,343 feet, top of Simpson rocks at 3,438, and the top of the Arbuckle limestone at 3,567 feet.

The Geological Survey has record of 10 wells drilled in the county previous to 1952 (Jewett, 1949, Table 44).

JEFFERSON COUNTY

(Map Pl. 1)

The 1952 production from 2 fields: oil 1,494 barrels, gas 40,130 thousand cubic feet.

Developments during 1952.—A part of the McLouth gas field was being conditioned for underground storage of natural gas.

Reported gas production from the **McLouth** area was much greater than in 1951 when only 391 thousand cubic feet was reported. Oil production declined sharply.

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Oil production statistics in Jefferson County are listed in Table 66, and gas in Table 67. Areas that produced oil in the county in 1952 are shown on Plate 1.

JEWELL COUNTY

Wildcat wells have been drilled from time to time in Jewell County, but so far no producing pool has been found.

Exploration during 1952.—During 1952, one exploratory test was drilled in Jewell County. Harry Mann et al. drilled the test on the Beard farm in the NE¼ SW¼ SW¼ sec. 10, T. 5 S., R. 10 W. From an elevation of 1,636 feet above sea level, the following marker horizons were encountered: Topeka limestone, 2,380; Lansing strata, 2,691; Mississippian rocks, 3,368; Viola dolomite, 3,690; Simpson group, 3,900; and Arbuckle dolomite, 3,990 feet depth. The well was abandoned at a total depth of 4,052 feet after two drill-stem tests proved unsuccessful in finding commercial quantities of oil or gas.

JOHNSON COUNTY

(Map Pl. 1)

The 1952 production: oil none reported, gas 27,668 thousand cubic feet.

Developments during 1952.—No oil was reported from Johnson County in 1952. Gas production was in the **Gardner** and **Olathe** fields. Some drilling for gas in "Bartlesville sand" in the **Dallas** area was reported but logs were not available to the Geological Survey.

Gas production in the county is listed in Table 67.

KEARNY COUNTY

(Map Pl. 2)

The 1952 production from 1 pool: oil 28,229 barrels, gas, Hugoton Gas Area production not segregated as to counties. Wells drilled in 1952: total 75 (all gas).

Developments during 1952.—This county lies at the north end of the large Hugoton Gas Area. The addition of 75 gas wells to the Hugoton Gas Area within the boundary as drawn in 1951 is the most significant development in the county. The new gas wells are concentrated in a northeast-southwest trend west of Lakin. The new wells ranged in size from 900,000 cubic feet to

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38.8 million cubic feet of gas per day. The average of these new wells is 11.4 million cubic feet per day. Large amounts of acid were required in several of the wells in order to make producers of them.

The oil production from the county's one oil pool decreased modestly in 1952. No new developments were reported in the **Patterson** oil field.

The Kearny County wells are shown on Plate 2. Production, the active area, and producing zones are shown under Hugoton in Table 67, and additional information on the Hugoton Gas Area given in the chapter on natural gas. Oil production is listed in Table 66.

KINGMAN COUNTY

(Map Fig. 15)

The 1952 production from 11 pools: oil 682,537 barrels, including production from 1 secondary recovery project, gas 1,324,915 thousand cubic feet. Wells drilled in 1952: oil 10, gas 1, dry 12, salt-water disposal 1, total 24 including 6 dry wildcats. New pools discovered 2.

Developments during 1952.—Drilling activity in Kingman County decreased from 92 wells in 1951 to only 24 in 1952, but both oil and gas production showed an appreciable gain over the previous year.

TABLE 39.—*Dry wildcat tests drilled in Kingman County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
Transit Corporation No. 1 Ambler	NE¼ NW¼ NW¼ 15-27-5W	1,521	3,010	4,336	4,366
*Virginia Drlg. Co. et al. No. 1 Rayl	CS½ NW¼ NW¼ 15-27-7W	1,519	3,124	3,815†	3,879
*Coop. Ref. Assn. No. 1 Sheldon "C"	SE¼ SE¼ SW¼ 30-27-9W	1,664	3,437	4,450	4,486
*Solar Oil Company No. 1 Henry Gibbens	NW¼ NW¼ SE¼ 28-27-10W	1,655	3,455	4,390	4,435
Continental Oil Co. et al. No. 1 Hall	SW¼ SW¼ SW¼ 11-28-9W	1,640	3,442	4,512	4,555
Kenneth Ellison et al. No. 1 Wagner	NE¼ NE¼ SW¼ 10-28-10W	1,701	3,559	4,532	4,564

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

† Depth to the top of the Mississippian, feet.

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One of the new oil pools, the **Artesian Valley**, is in the northwestern corner of the county in sec. 22, T. 27 S., R. 10 W. The Amerada Petroleum Corporation No. 1 Richardson well has a potential of 2,359 barrels of oil per day from the Viola limestone from depths of 4,315 to 4,323 feet. Some gas production has been reported from this new pool. The second pool was found in the eastern part of the county in sec. 11, T. 28 S., R. 5 W. There the Pabco Drilling Company found the **Casley** pool with the No. 1 Casley well which produces oil from dolomite of the Osagian Series (Mississippian) from depths of 3,794 to 3,801 feet. A new producing zone for the **Pat Creek** field, the Simpson, was discovered by the Nebraska-Wyoming Oil Company No. 2 Darlington well in sec. 20, T. 28 S., R. 9 W.

Three new oil wells were added to the **Broadway** pool, 1 to the **Dewey** pool, 2 to the **Dresden** pool, and 1 oil and 1 gas well were added to the **Spivey** pool.

All six of the dry wildcat tests drilled in the county during the year penetrated the Arbuckle dolomite; five had shows of oil or gas.

Locations of producing areas and dry wildcat tests are shown on Figure 15. Oil production data are given in Table 66, and gas production in Table 67. Information on the two new pools is found in Table 6, and data on the new producing zone are given in Table 7. The one secondary recovery project is reported in Table 1. Dry wildcat tests are listed in Table 39.

KIOWA COUNTY

The 1952 production from 2 pools: oil 7,219 barrels, gas 33,714 thousand cubic feet (miscellaneous).

Developments during 1952.—No tests were reported in Kiowa County during 1952. Some oil production was reported from the **Brenham** pool for the first time. The bulk of Kiowa County's oil production comes from the **Exel** pool.

Oil production is listed in Table 66. Similar information on gas is given in Table 67.

LABETTE COUNTY

(Map Pl. 1)

The 1952 production: oil from 7 fields 7,461 barrels; gas 19,614 thousand cubic feet. Wells drilled in 1952 (reported): oil 12, input 8, total 20.

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Developments during 1952.—The 1952 oil production in Labette County was considerably greater than in 1951, when 4,556 barrels was reported. Reported gas production came from 12 commercial wells.

Data on oil production in the county are listed in Table 66, and gas in Table 67. Locations of areas that produced oil in 1952 are shown on Plate 1. Data on the secondary recovery project started in 1952 are given in Table 1.

LANE COUNTY

The 1952 production from the county's first pool: oil 2,954 barrels. Wells drilled in 1951: oil 1, dry 5, total 6 including 3 dry wildcats. New pools discovered 1.

Developments during 1952.—Wildcat tests have been drilled in Lane County from time to time, but it was not until 1952 that a successful one was completed. This year the Hugoton Production Company found oil on the Floyd farm in sec. 19, T. 17 S., R. 29 W. to open the **North Fork** pool. The test hole was drilled 110 feet into the Mississippian rocks. Some free oil came into the hole between the depths of 4,335 to 4,357 feet in the Lansing-Kansas City. Casing set through this zone was later perforated between 4,333 and 4,352 feet, and after two shots of acid of 500 gallons and 2,000 gallons respectively, a swabbing test showed 56 barrels of oil per hour for 9 hours. The official production test by the State Corporation Commission later fixed the potential of this well at 160 barrels per day. Two wells drilled later in the year within 1½ miles resulted in dry holes.

From an elevation of 2,693 feet above sea level, the B & R Drilling Company No. 1 Hagans well in the NW¼ NW¼ NW¼ sec. 16, T. 16 S., R. 30 W., drilled to a total depth of 4,589 feet, about 200 feet into Mississippian strata. Important marker horizons encountered in drilling are: Topeka limestone, 3,512; Lansing limestone, 3,785; base of the Kansas City limestone, 4,080; and Mississippian strata, 4,389 feet depth.

Important marker horizons encountered by the dry wildcat test put down by Trans Era Petroleum Company et al. on the Fenly lease in the NW¼ NW¼ NW¼ sec. 19, T. 18 S., R. 27 W., from an elevation of 2,716 feet above sea level, are: Topeka limestone, 3,655; Lansing limestone, 4,000; base of the Kansas City limestone, 4,320; and Mississippian rocks, 4,665 feet depth.

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The electric log for the Amerada Petroleum Corporation dry wildcat test on the Ohnmacht farm in the SE¼ SE¼ NE¼ sec. 5, T. 20 S., R. 29 W. shows top of Dakota sandstone, 842; Permian redbeds, 1,415; Blaine gypsum, 1,593; Stone Corral dolomite, 2,163; Ft. Riley limestone, 2,970; Heeber black shale, 4,014; Lansing limestone, 4,061, and Mississippian at 4,699 feet depth. The well was drilled from an elevation of 2,865 feet above sea level and abandoned at a total depth of 4,785 feet. No shows of oil or gas were reported in the dry wildcat tests.

The new pool is described in Table 6. The production from the county's first pool is given in Table 66.

LEAVENWORTH COUNTY

(Map Pl. 1)

The 1952 production: no oil reported; gas 6,608 thousand cubic feet.

Developments during 1952.— No oil was reported from the **Banker's Life** and **Ackerland** fields in the western part of Leavenworth County. Gas production was in the **Roberts-Maywood** area. A wildcat location, NE¼ NE¼ SW¼ sec. 35, T. 11 S., R. 22 E., was reported abandoned in September.

Oil production in Leavenworth County is listed in Table 66, and gas in Table 67. Areas that produced oil in 1952 are shown on Plate 1.

LINCOLN COUNTY

Wildcat tests have been drilled in Lincoln County from time to time, but so far no oil or gas pool has been found.

Exploration during 1952.—One dry wildcat test was drilled in Lincoln County during 1952. On the Harms farm in the SE¼ NW¼ SE¼ sec. 9, T. 12 S., R. 7 W., it was drilled by the Penguin Petroleum Company for Kenneth A. Ellison. According to the sample log prepared by J. D. Davies, the following tops were encountered in drilling: Lansing limestone, 2,424(?); Mississippian rocks, 3,108: "Hunton" limestone, 3,405; Viola limestone, 3,580; Simpson sandstone, 3,723; and Arbuckle dolomite, 3,800 feet depth. The test, drilled from an elevation of 1,362 feet above sea level, was abandoned at a total depth of 3,820 feet.

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LINN COUNTY

(Map Pl. 1)

The 1952 production: oil from 9 areas in 3 fields 62,136 barrels including approximately 58,375 barrels from secondary recovery operations, gas 1,600 thousand cubic feet. Wells drilled in 1952 (reported): oil 22, input 12, total 34.

Developments during 1952.—Most of the oil produced in 1952 in Linn County came from four secondary recovery projects (Table 1). Gas production was confined to the **LaCygne-Cadmus** area. Oil production in the Linn County fields is listed in Table 66. Areas that produced oil during the year are shown on Plate 1.

LOGAN COUNTY

Wildcat wells have been drilled in Logan County from time to time, but so far no oil or gas pool has been found.

Exploration during 1952.—During 1952, six dry wildcat tests were drilled in Logan County. All were in the eastern third of the county. The locations, elevations, and important marker horizons encountered in drilling these wells are listed in Table 40.

In the B & R Drilling Company No. 1 Johnson "F" test in sec. 10, T. 11 S., R. 32 W., a show of gas and some oil were found between 4,103 and 4,148 feet, about 50 feet below the top of the Lansing limestone. The well was drilled 150 feet into Mississippian rocks. In the Skiles Oil Corporation No. 1 Sharp well, free oil was found in a sandy zone just above the Mississippian at 4,652

TABLE 40.—*Dry wildcat tests drilled in Logan County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Mississippian, feet	Total depth, feet
B & R Drlg., Inc. No. 1 Johnson "F"	NE¼ NE¼ SE¼ 10-11-32W	3,045	4,044	4,646	4,800
Skiles Oil Corp. No. 1 Sharp	SE¼ SE¼ SE¼ 15-11-32W	3,047	4,073	4,662	4,761
E. K. Carey Drlg. Co. No. 1 Burkhead	NE¼ NE¼ NE¼ 21-13-33W	2,925	3,874	4,550	4,650
D. R. Lauck Oil et al. No. 1 Briggs Ranch	NE¼ NE¼ NE¼ 35-13-33W	2,934	3;898	4,561	4,688
Ashland Oil & Refg. Co. No. 1 Briggs Ranch	SE¼ SE¼ SW¼ 14-14-33W	2,707	3,671	4,355	4,500
Vickers Petro. Co., Inc. No. 1 DeWeese	SW¼ SW¼ SW¼ 13-15-33W	2,795	3,758	4,488	4,692

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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TABLE 41.—*Pool wells drilled in Lyon County during 1952*

Field or pool	Oil wells	Dry holes	Salt-water disposal wells
Atyeo	....	1	....
Bradfield	1	1	....
Fankhouser	2	....	....
Ritchey-Moore	1	5	1
Rock Creek	....	1	....
Total	4	8	1

to 4,656 feet depth. A show of oil in Morrowan rocks between 4,372 and 4,404 feet was found by the Vickers Petroleum Company No. 1 DeWeese test in sec. 13, T. 15 S., R. 33 W.

LYON COUNTY

(Map Pl. 1)

The 1952 production: oil from 6 fields 264,969 barrels including 212,108 barrels from secondary recovery operations. Wells drilled in 1952 (reported): oil 4, dry 14, input 1, salt-water disposal 1, total 20 including 6 dry wildcats.

Developments during 1952.—Data on pool wells drilled in Lyon County in 1952 are listed in Table 41; data on the six wildcat wells are listed in Table 42. Oil production was slightly less than in 1951, when the county produced 286,790 barrels of oil. One drilling location was abandoned during the year.

TABLE 42.—*Dry wildcat tests drilled in Lyon County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Mississippian, feet	Depth to top of "Hunton," feet	Depth to top of Arbuckle, feet	Total depth, feet
White & Ellis Drlg. Co. et al. No. 1 Day	NE¼ NE¼ SE¼ 16-16-11E	1,393	1,392	2,351	2,907	....	3,134
Stanolind Oil & Gas Co., No. 1 N. Christensen	SW¼ SW¼ NW¼ 9-17-11E	1,267	1,236	2,260	2,780	2,988	3,015
*Ben F. Brack Oil Co., Inc. No. 1 Miller	NE¼ NE¼ SW¼ 24-19-11E	1,106	....	2,012	2,461§	2,614	2,630
*J. P. Gaty No. 1 Van Sickle	SE¼ NW¼ NW¼ 16-20-12E	1,189	1,255	2,020	....	....	2,030
*Ben F. Brack Oil Co., Inc. No. 1 Rachel Williams	NW¼ NW¼ NW¼ 18-21-10E	....	1,528†	2,348	2,799§	2,845‡	2,885
Emery Construction Co. No. 1 Rossillian	CW½ W½ E½ 2-21-11E	1,201	....	2,064	2,579‡	2,645	2,675

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.
† Depth to the top of the Kansas City, feet.
‡ Depth to the top of the Simpson, feet.
§ Depth to the top of the Viola, feet.

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Oil production statistics for the various fields are listed in Table 66. Areas that produced oil and secondary recovery projects are shown on Plate 1. Secondary recovery projects are summarized in Table 1.

McPHERSON COUNTY

(Map Fig. 6)

The 1952 production from 32 pools: oil 3,366,023 barrels including 688,411 barrels from secondary recovery projects; gas 3,591 thousand cubic feet. Wells drilled in 1952: oil 7, gas 2, dry 29, salt-water disposal 1, total 39 including 12 dry wildcats.

Developments during 1952.—Oil production in McPherson County increased more than 40,000 barrels in 1952; gas production decreased considerably. One more well was drilled in the county during 1952 than in 1951.

TABLE 43.—*Dry wildcat tests drilled in McPherson County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Mississippian, feet	Depth to top of Arbuckle, feet	Total depth, feet
Continental Oil Co. No. 1 Hattie Anderson	SW¼ SW¼ SW¼ 17-17-4W	1,440	2,462	3,123	3,753	3,800
The Texas Co. No. 1 Schmidt	NW¼ SE¼ SW¼ 21-18-3W	1,533	2,462	3,122	3,746	3,779
Anschutz Drilling Co. No. 1 Davis	NE¼ NE¼ NE¼ 17-18-4W	1,403	2,454	3,084	3,724	3,746
B & R Drlg., Inc. No. 1 Kumle	SW¼ SW¼ SE¼ 20-18-4W	1,425	2,481	3,114	3,762	3,808
Victor Drlg., Inc. No. 1 Swanson	SE¼ SE¼ SE¼ 21-18-4W	1,460	2,490	3,122	3,760	3,790
*E. K. Carey Drlg. Co., Inc. No. 1 Nelson	NE¼ NE¼ NE¼ 24-18-4W	1,279	....	3,071	3,709	3,733
Natl. Coop. Ref. Assn. No. 1 Conway	NE¼ NW¼ NE¼ 29-19-4W	1,531	2,657	3,320	3,933	4,225
*Lindsley Drlg. Co. No. 1 Anna Koehn	NE¼ NE¼ NE¼ 26-20-2W	1,522	2,321	2,941	....	2,999
Anschutz Drlg. Co. et al. No. 1 Sitts	SW¼ SW¼ SE¼ 4-20-4W	1,487	2,593	3,245	3,885	3,905
*Anschutz Drlg. Co. No. 1 Crary	NW¼ NW¼ NW¼ 13-20-4W	1,491	2,543	3,194	3,864	3,887
Anschutz Drlg. Co. et al. No. 1 Mitchell	SW¼ SW¼ SE¼ 27-20-4W	1,465	2,570	3,221	3,857	3,885
Penguin Petro., Inc. No. 1 Regier	NE¼ NE¼ NE¼ 23-21-1W	1,525	2,361	2,975	3,622	3,651

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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The new oil and gas wells were not concentrated in any one pool. The extensions to existing production are: 1 gas well added to the **Bitikofer North;** 1 gas well to the **Graber North;** 2 oil wells to the **Lindsborg;** 2 oil wells to the **McPherson;** and 1 oil well each to the **Paden South, Reuben,** and **Ritz-Canton** pools. Two old wells worked over in the **Voshell** pool began production.

Of the 12 dry wildcat tests drilled, only 3 reported shows of oil or gas. A show of oil was found in the Victor Drilling Company No. 1 Swanson well in sec. 21, T. 18 S., R. 4 W., between 3,644 and 3,650 feet in the Viola limestone, and also between 3,685 and 3,690 feet in the Simpson sandstone. The Lindsley Drilling Company test on the Koehn farm in sec. 26, T. 20 S., R. 2 W., reported a show of gas in the Mississippian at 2,960 feet depth. In the National Cooperative Refinery Association Arbuckle test in sec. 29, T. 19 S., R. 4 W., a show of oil was found from 3,886 to 3,908 feet depth, in the Simpson sandstone. The well was converted to salt-water disposal.

No new developments were reported in the Barbara Oil Company's pilot flood of the Mississippian rocks in secs. 6, 7, and 8, T. 19 S., R. 1 W.

Oil production data for McPherson County are listed in Table 66. Gas production is given in Table 67. Dry wildcats drilled during the year are described in Table 43, and locations of producing areas and dry wildcat tests are shown on Figure 6. Information of the county's secondary recovery projects is given in Table 1.

MARION COUNTY

(Map Pl. 1)

The 1952 production: oil from 18 fields 567,290 barrels, gas 69,180 thousand cubic feet. Wells drilled in 1952: oil 18, dry 28, total 46, including 6 dry wildcats. New pools discovered 2.

Developments during 1952.—The **Biscuit Hill,** a Mississippian limestone pool between 2,269 and 2,275 feet, was discovered by the W. R. Atkinson et al. No. 1 Brown well, N½ SE¼ sec. 33, T. 21 S., R. 4 E., in March. Initial daily production was established at 3 barrels of oil. The Aladdin Petroleum Corp. No. 1 Burton well, SE¼ NW¼ sec. 12, T. 22 S., R. 3 E., opened the **Shank** field. Oil was found in Mississippian limestone between 2,474 and 2,501 feet. The well was completed in July with initial

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TABLE 44.—*Pool wells drilled in Marion County during 1952*

Field or pool	Oil wells	Dry holes
Antelope North	1	1
Biscuit Hill	1	....
Bitikofer	....	1
Coons	....	1
Covert-Sellers	4	1
Florence	1	3
Lost Springs	1	1
Lost Springs East	1	1
Lost Springs Southeast	....	1
Peabody	7	3
Propp	....	1
Shank	1	3
Wenger	1	5
Total	18	22

daily production rated at 75 barrels of oil. Six other wildcats in the county were dry. Data on pool wells drilled during the year in Marion County are listed in Table 44. Data on the dry wildcat wells are listed in Table 45.

Production statistics in the Marion County oil fields are listed in Table 66. Gas statistics are listed in Table 67. Locations of areas that produced oil in the county in 1952 are shown on Plate 1.

TABLE 45.—*Dry wildcat tests drilled in Marion County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Mississippian, feet	Depth to top of Viola, feet	Total depth, feet
*Western Central Petro. No. 1 Knaak	S2 S2 SW¼ 24-19-2E	1,970	2,550	2,945	2,975
George Martin No. 1 Boettcher	SW¼ SW¼ SE¼ 11-19-4E	1,753	2,285	2,634	2,666
*Aladdin Petro. Corp. No. 1 Stenzel	SW¼ SE¼ NW¼ 18-19-5E	....	2,302	2,453‡	2,532
*Slusser Drlg. Co. No. 1 Meireroff	SE¼ NE¼ SW¼ 27-19-5E	1,726	2,208	2,419	2,439
*K. T. Wiedemann No. 1 Hawk	SW¼ SW¼ NE¼ 31-22-4E	2,047†	2,448	....	2,501
Donald T. Ingling et al. No. 1 Logan	SE¼ NE¼ NW¼ 29-22-5E	1,803	2,412	2,604	2,810

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.
† Depth to the top of the Kansas City, feet.
‡ Depth to the top of the "Hunton," feet.

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MEADE COUNTY

(Map Fig. 13)

The 1952 production from 7 pools: oil 203,012 barrels, gas 550,126 thousand cubic feet. Wells drilled in 1952: oil 25, gas 11, dry 12, total 48 including 1 wildcat. New pools discovered 3.

Developments during 1952.—Three times as many wells were drilled as in 1951. Three new pools were found in Meade County. In April, R. E. Adams found oil in Morrowan beds on the Bromwell lease in sec. 7, T. 34 S., R. 29 W. This new pool, the **Bromwell,** is located several miles north of the **Adams Ranch East** pool and a similar distance southeast of the **Novinger** pool. A porous sand near the base of the Pennsylvanian (identified as of Morrowan age) between the depths of 5,899 and 5,908 feet showed free oil and some gas. Drilling continued, however, to test Mississippian rocks, the top of which was found at 5,964 feet. After drilling to 6,180 feet, the well was plugged back, casing set, and perforations made between the depths of 5,901 and 5,908 feet. Initial potential of 25 barrels per day was assigned to the new well.

The new **Fringer** gas pool was found by the Columbian Fuel Corporation No. 2 Adams "G" well in sec. 7, T. 35 S., R. 29 W. Gas occurs in Morrowan rocks between 5,780 and 5,793 feet.

The **Stevens** gas pool was opened by the Columbian Fuel Corporation No. 1 Stevens well in sec. 32, T. 32 S., R. 30 W. in September. The Morrowan producing zone lies between 5,560 and 5,597 feet; the well was rated at 8.7 million cubic feet per day.

In the **Novinger** pool, opened during 1951, 23 additional oil wells were completed. The Lanskan Oil Company No. 7 Langhofer well in sec. 23, T. 33 S., R. 30 W., failing to find oil in the Marmaton, opened production in a Morrowan sandstone, resulting in a new producing zone for the **Novinger** field.

The one wildcat in the county during the year was drilled by the Deep Rock Oil Corporation on the Adams "B" lease in the Cen. NW¼ NE¼ sec. 16, T. 35 S., R. 29 W., to a total depth of 6,296 feet. The Lansing limestone was encountered at 4,409 feet, Morrowan beds at 5,846 feet, and the Mississippian at 5,966 feet depth. A show of oil was found between 6,054 and 6,062 feet depth, but there was too much water present to allow commercial production.

The new pools are listed in Table 6, and the new producing zone in Table 7. Locations of producing areas and dry wildcat

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tests are shown on Figure 13. Oil production is listed in Table 66 and gas production in Table 67.

MIAMI COUNTY

(Map Pl. 1)

The 1952 production: oil from 15 areas in 3 fields 591,153 barrels including approximately 527,059 barrels from secondary recovery projects, gas 47,000 thousand cubic feet. Wells drilled in 1952 (reported): oil 42, input 1, total 43.

Developments during 1952.—Drilling was chiefly in connection with water-flooding operations which are important in the county. The total production was greater than in 1951.

Data on secondary recovery projects in Miami County are listed in Table 1. Oil production in the various areas is listed in Table 66 and gas in Table 67. Locations of areas that produced oil in 1952 and of operating water-flooding projects are shown on Plate 1.

MITCHELL COUNTY

Wildcat wells have been drilled from time to time in Mitchell County, but to date no oil or gas pool has been discovered.

Exploration during 1952.—Two wildcat tests were completed in Mitchell County during 1952. The Murfin Drilling Company No. 1 Wessling well, in the SE¼ SE¼ NE¼ sec. 35, T. 6 S., R. 7 W., from an elevation of 1,444 feet above sea level, found the Heebner black shale at 2,318; Lansing limestone at 2,475; the Mississippian at 3,130, the "Hunton" at 3,420, Viola limestone at 3,585, the Simpson at 3,830, and Arbuckle dolomite at 3,940 feet depth. As there were no shows of oil or gas, the hole was abandoned at the total depth of 4,113 feet. Harms and Knight drilled a wildcat test on the Peters farm in the SW¼ SW¼ SW¼ sec. 11, T. 9 S., R. 7 W. From an elevation of 1,487 feet above sea level, the Lansing limestone was found at 2,579, the Mississippian at 3,238, "Hunton" dolomite at 3,482, Viola limestone at 3,639, Simpson rocks at 3,874, and Arbuckle dolomite at 3,932 feet. As no favorable indication of either oil or gas was encountered, the hole was abandoned at the total depth of 3,985 feet.

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TABLE 46.—*Pool wells drilled in Montgomery County during 1952*

Field or pool	Oil wells	Dry holes	Injection wells on water-flood projects	Water-supply wells on water-flood projects
Caney	2	....	1	....
Caney West	....	1	....	....
Coffeyville-Cherryvale	1	3	....	....
Neodesha	10	1	12	1
Jefferson-Sycamore	11	1	2	....
Tyro	1	2	....	....
Wayside-Havana	2	....	....	1
Total	27	8	15	2

MONTGOMERY COUNTY

(Map Pl. 1)

The 1952 production: oil from 49 areas in 10 fields 677,863 barrels including approximately 543,736 barrels from secondary recovery operations, gas 554,298 thousand cubic feet. Wells drilled in 1952 (reported): oil 27, dry 8, input 15, water-supply 2, total 52.

Developments during 1952.—Oil production in Montgomery County was greater than in 1951. A large percentage was from secondary recovery operations.

Oil production in Montgomery County fields is listed in Table 66 and gas in Table 67. Data on secondary recovery operations are listed in Table 1. Areas of oil production in 1952 and locations of secondary recovery operations are shown on Plate 1. Data on wells reported drilled in Montgomery County fields in 1952 are listed in Table 46.

MORRIS COUNTY

(Map Pl. 1)

The 1952 production: oil from 3 fields 47,860 barrels, gas 45,573 thousand cubic feet. Wells drilled in 1952 (reported): oil 3, dry 1, total 4.

Developments during 1952.—Oil production in Morris County was less than in 1951. Gas production was also less than reported in 1951. One dry hole was reported in the **Three Mile Creek** field, and 3 oil wells in the **Three Mile Creek South** field.

Oil production statistics in the Morris County fields are listed in Table 66 and gas in Table 67. Locations of areas that produced oil in 1952 are shown on Plate 1.

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MORTON COUNTY

(Map Pl. 2)

The 1952 production from 2 pools: oil none reported, gas 55,254 thousand cubic feet from the Richfield pool. Other gas production, all from the Hugoton Gas Area, not segregated as to counties. Wells drilled in 1952: gas 29, dry 3, total 32 including 2 dry wildcats.

Developments during 1952.—The **Greenwood** gas pool, found during 1951, was increased in area by the completion of 2 additional gas wells. Gas occurs in a Morrowan (?) sandstone in the original discovery well. Both new wells tested the Mississippian. The well in sec. 11, T. 33 S., R. 42 W. penetrated 150 feet of Mississippian strata before being plugged back. The casing was perforated opposite good gas shows in the Topeka and several other limestones in the Shawnee group. The well was completed at a depth of 2,988 to 3,018, about 45 feet below the top of the Topeka limestone. Its capacity is nearly 16 million cubic feet per day after liberal acid treatment. The second new gas well in this pool, in sec. 15 on the "C" lease of the Greenwood property, also drilled 150 feet into the Mississippian before being plugged back. It was completed in a Morrowan sand 60 feet above the Mississippian. After acid, its potential capacity was 4½ million cubic feet per day.

Only 1 dry hole was drilled in the Morton County part of the Hugoton Gas Area, while 27 new gas wells were drilled. Most of the new wells were in Ts. 34 and 35 S., R. 41 W., extending the area of the field in Morton County about 6,000 acres.

Two important dry wildcat tests were completed during the year by the Colorado Interstate Gas Company. One is located on the Hayward ranch in the Cen. S½ S½ sec. 9, T. 32 S., R. 42 W., 8 miles west of Richfield and 15 miles west of the gas area. From an elevation of 3,514 feet above sea level the following tops were recorded: Stone Corral anhydrite, 1,440; Lansing limestone, 3,305; Marmaton limestone, 3,719; Cherokee shale, 3,930; Atokan rocks, 4,186; Morrowan rocks, 4,540 feet; Chesteran Series (Mississippian), 5,104; Ste. Genevieve limestone, 5,219; and St. Louis limestone, 5,286 feet. A sand between 4,905 and 4,930 feet showed a good trace of free oil. The hole was abandoned at a total depth of 5,341 after numerous drill-stem tests.

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The second wildcat drilled by the Colorado Interstate Gas Company is 6 miles farther west on the Dreyer ranch in the SW¼ SW¼ SW¼ sec. 3, T. 32 S., R. 43 W., from an elevation of 3,607 feet above sea level. The tops reported by the driller's log are: Stone Corral, 1,445; Lansing limestone, 3,276; Marmaton group, 3,655; Atokan, 4,148; Morrowan, 4,536; Chesteran (Mississippian), 5,140; Ste. Genevieve limestone, 5,226; and St. Louis limestone, 5,328 feet depth. The hole was abandoned at a total depth of 5,349 feet; no shows were reported.

Production, the active area, and producing zones are shown under Hugoton in Table 67. Additional data on the Hugoton Gas Area are given in the chapter on natural gas. Location of the Morton County wells is shown on Plate 2. The named oil pools are listed in Table 66, and gas production in Table 67.

NEMAHA COUNTY

(Map Pl. 1)

The 1952 production from 2 fields: oil 34,223 barrels. Wells drilled during 1952: dry 1.

Developments during 1952.—A dry hole was completed in the **Strahm** field in September. It is the Midstates Refining Company No. 1 Dribelbis, SE¼ SE¼ SW¼ sec. 22, T. 2 S., R. 14 E., which was drilled to a total depth of 3,629 feet. The following tops were reported: Lansing, 1,344; Mississippian, 2,480; Kinderhookian, 2,650; "Hunton," 2,895; Maquoketa, 3,560; and Viola, 3,613 feet.

Oil production from the two Nemaha County fields is listed in Table 66. Locations of the fields are shown on Plate 1.

NEOSHO COUNTY

(Map Pl. 1)

The 1952 production from 23 areas in 9 fields: oil 645,001 barrels, including approximately 469,624 barrels from secondary recovery projects; gas 133,490 thousand cubic feet. Wells drilled in 1952: oil 32, dry 2, input 28, total 62.

Developments during 1952.—Oil production in Neosho County was slightly more than in 1951. Reported gas production was much less than that of the previous year. Reported drilling includes: 31 oil wells, 20 water input wells, and 1 dry hole in the **Humboldt-Chanute** field and 1 dry hole in the **Urbana** field. Prac-

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tically all drilling was done in connection with secondary recovery operations.

Oil production in the various Neosho County fields is listed in Table 66, and gas in Table 67. Data on water-flooding operations are included in Table 1. Areas that produced oil and locations of secondary recovery operations are shown on Plate 1.

NESS COUNTY

(Map Fig. 11)

The 1952 production from 4 pools: oil 318,853 barrels. Wells drilled during 1952: oil 5, dry 9, total 14 including 7 dry wildcats.

Developments during 1952.—Ness County oil production showed a 20,000 barrel gain over the amount produced during 1951, while the same number of holes were drilled.

Five extension oil wells and two dry holes were added to the **Aldrich** pool. The seven dry wildcats were well scattered over the county. Five of these had shows of oil. The most encouraging shows of oil were encountered in the D. R. Lauck Oil Company test on the McCreight lease in sec. 9, T. 20 S., R. 24 W. In the Mississippian rocks, a drill-stem test from 4,419 to 4,430 feet depth showed 65 feet of oil and mud-cut oil. Further testing resulted in recovery of only water.

TABLE 47.—*Dry wildcat tests drilled in Ness County during 1952*

Company and farm	Location	Depth to top of anhydrite, feet	Depth to top of Lans.-K.C., feet	Depth to top of Mississippian, feet	Total depth, feet
*Vickers Petro. Co., Inc. No. 1 Squier	SE¼ SE¼ SE¼ 7-16-22W	1,785	3,859	4,409	4,597
*Heathman & Co. No. 1 Elmore	NE¼ NE¼ NW¼ 2-17-21W	1,481	3,634	....	4,307
Franco Central Oil Co. et al. No. 1 John A. Weeks "A"	NE¼ NE¼ NW¼ 31-17-24W	1,741	3,839	4,433	4,499
Sohio Petro. Co. No. 1 Pfannenstiel	SW¼ SW¼ SW¼ 6-19-23W	1,515	3,688	4,281	4,315
Jackson Drlg. Corp. No. 1 Brenner-Antennen	SW¼ SW¼ NE¼ 18-19-26W	1,920	3,938	4,566	5,064
Pabco Drlg., Inc. No. 1 Schwein	SW¼ SW¼ SW¼ 18-20-21W	1,408	3,763	4,360	4,512
D. R. Lauck Oil Co., Inc. No. 1 McCreight	NE¼ NE¼ SW¼ 9-20-24W	1,584	3,810	4,394	4,528

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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Locations of producing areas and dry wildcat tests are shown on Figure 11. The marker horizons encountered in drilling the seven dry wildcat tests are described in Table 47. Oil production data are given in Table 66.

NORTON COUNTY

(Map Fig. 4)

The 1952 production from 2 pools: oil 53,987 barrels. Wells drilled during 1952: oil 1, dry 16, total 17 including 14 dry wildcats.

Developments during 1952.—Production and drilling during 1952 were about the same as 1951. One oil well was completed in the **Ray West** pool.

TABLE 48.—*Dry wildcat tests drilled in Norton County during 1952*

Company and farm	Location	Depth to top of anhydrite, feet	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
*Empire Drlg. Co. No. 1. Atens Estate	SE¼ SE¼ SW¼ 6-1-22W	1,925	3,398	3,648†	3,695
Keating Drlg. Co. No. 1 Wesley	NW¼ NW¼ NE¼ 4-3-23W	1,875	3,362	3,582	3,630
*Empire Drlg. Co. No. 1 Gray	SW¼ SE¼ SE¼ 27-3-25W	1,885	3,387	3,721	3,875
Harry Gore No. 1 Bullock	NE¼ NE¼ NW¼ 22-4-23W	2,005	3,537	3,801†	3,857
The Texas Co. No. 1 Gleason	SE¼ SE¼ NE¼ 7-4-24W	2,120	3,594	3,896	3,950
Anschutz Drlg. Co. No. 1 Zeirlin	NW¼ NW¼ SE¼ 36-4-25W	2,016	3,518	3,868	3,918
Brooks Hall No. 1 Voss	NE¼ NE¼ SW¼ 29-5-21W	1,941	3,535	....	3,771
Saturn Drlg., Inc. et al. No. 1 Sullivan	SE¼ SE¼ SW¼ 34-5-21W	1,846	3,446	3,675	3,697
Harry Gore No. 1 Voss	SE¼ NE¼ NE¼ 10-5-22W	1,720	3,291	3,540	3,605
Empire Drlg. Co. No. 1 Schuck	SW¼ SW¼ NW¼ 31-5-22W	1,985	3,574	3,941	3,999
Musgrove Petro. Corp. No. 1 Joseph Hickert	NE¼ NW¼ NW¼ 19-5-24W	2,010	3,516	3,898	3,930
*Jones, Shelburne & Farmer, Inc. No. 1 Carl Dwyer	SE¼ SE¼ NE¼ 26-5-24W	1,990	3,537	3,920	3,970
*Jones, Shelburne & Farmer, Inc. No. 1 Hickert	SW¼ SW¼ NE¼ 32-5-24W	2,105	3,638	4,054	4,078
*Musgrove Petro. Corp. No. 1 John Hickert	SW¼ SW¼ NW¼ 25-5-25W	....	3,523	3,950	4,000

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.
† Depth to the top of the granite wash, feet.

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The 14 dry wildcats, listed in Table 48 and shown on Figure 4, are scattered through the southern and western part of the county, near the production in northeastern Sheridan County and eastern Decatur County. The Keating Drilling Company No. 1 Wesley test in sec. 4, T. 3 S., R. 23 W. had a good show of oil in the Lansing limestone and another show in the Arbuckle dolomite at 3,585 feet depth. The Reagan sandstone was found at 3,599 feet and the Pre-Cambrian granite at 3,630 feet. The Brooks Hall No. 1 Voss test in sec. 29, T. 5 S., R. 21 W. had a good show of oil 130 feet below the top of the Lansing and also 100 feet lower. The Harry Gore No. 1 Voss well in sec. 10, T. 5 S., R. 22 W. had a show of oil near the top of the Lansing limestone. Some gas was found in the top of the Arbuckle dolomite at 3,542 feet depth. The Reagan sandstone was found at 3,560 and granite wash at 3,585 feet depth.

The county's production by pools is listed in Table 66.

OSAGE COUNTY

(Map Pl. 1)

Wildcat wells have been drilled from time to time in Osage County, but as yet no producing pool has been discovered.

Exploration during 1952.—Three dry wildcat wells were drilled in Osage County in 1952. The Cities Service Oil Company No. 1 Dilworth test, NW¼ NW¼ SW¼ sec. 7, T. 15 S., R. 17 E., was drilled to a total depth of 2,202 feet. Tops reported are: Lansing, 531; Mississippian, 1,610; "Hunton," 1,910; Viola, 1,991; Simpson, 2,077, and Arbuckle, 2,079 feet.

The C. N. Rupe No. 1 Sturdy well, NE¼ NE¼ SW¼ sec. 23, T. 17 S., R. 15 E., was abandoned at a total depth of 2,300 feet. Tops reported are: Mississippian, 1,620; Kinderhookian, 2,057; "Hunton," 2,133; Viola, 2,151; Simpson, 2,202, and Arbuckle, 2,244 feet.

The third dry hole drilled in Osage County in 1952 is the L. E. Smith and L. G. Cameron No. 1 J. W. Vanderscise, NW¼ NW¼ SW¼ sec. 31, T. 17 S., R. 16 E. These tops were reported: Lansing, 487; Kansas City, 688; Mississippian, 1,544; Kinderhookian, 1,926; Viola, 2,033; and Arbuckle, 2,112 feet. The total depth is 2,172 feet.

Locations of the three wells are shown on Plate 1.

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OSBORNE COUNTY

(Map Fig. 5)

The 1952 production from 1 pool: oil 73,200 barrels. Wells drilled during 1952: oil 12, dry 10, total 22 including 8 wildcats. New pools discovered 1.

Developments during 1952.—The first oil pool for Osborne County was found early in 1952, when the Anderson-Prichard Oil Corporation completed the first test on the Ruggles farm in sec. 23, T. 10 S., R. 15 W. The oil was found in the Pennsylvanian basal conglomerate. The new well is rated at 193 barrels of oil per day. The test showed free oil in the top of the Lansing limestone and considerable gas was encountered at several places lower in the Lansing sequence. A drill-stem test from 3,395 to 3,410 feet depth revealed 510 feet of oil in the hole. The test, drilled to test the Arbuckle dolomite which was found at 3,489 feet (no shows), was plugged back and the casing perforated between 3,394 and 3,410 feet. Before the end of the year, enough wells had been drilled around the discovery well to enlarge the pool to 12 wells.

Two wells in the **Ruggles** pool discovered new producing zones during 1952. In March, the Sohio Petroleum Company No.

TABLE 49.—*Dry wildcat tests drilled in Osborne County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Penn. basal congl., feet	Depth to top of Arbuckle, feet	Total depth, feet
Anderson-Prichard Oil Corp. No. 1 Stephenson	NE¼ NE¼ SE¼ 32-7-15W	1,867	3,074	3,462	3,666	3,723
Anderson-Prichard Oil Corp. No. 1 Gregory	SW¼ SW¼ NW¼ 3-8-15W	1,901	3,103	3,492	3,730	3,780
*Beach & Talbot No. 1 Tatkenhorst	SE¼ SE¼ NE¼ 16-9-15W	2,068	3,293	3,692	3,957	3,964
L. B. Stableford No. 1 Meyer	NE¼ NE¼ SE¼ 36-9-15W	1,955	3,207	3,596	3,826	3,867
*Cox & Cox No. 1 Meyer	NW¼ NW¼ NW¼ 15-10-14W	2,014	3,218	3,617	3,879	3,910
*Duke & Wood Drlg. Co. No. 1 Harrell	SE¼ NW¼ NE¼ 28-10-14W	1,854	3,102	3,489	....	3,654
Walters Drlg. Co. No. 1 Meyers	SE¼ NE¼ NE¼ 10-10-15W	1,998	3,244	3,637	3,828	3,862
*Musgrove Petro. Corp. No. 1 Worley	SW¼ NW¼ NW¼ 35-10-15W	1,759	2,972	3,332	3,534	3,553

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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1 Isenberg well in sec. 14, T. 10 S., R. 15 W. found commercial quantities of oil in the Lansing-Kansas City group between depths of 3,024 and 3,026 feet. The Anderson-Prichard Oil Corporation No. 6 Ruggles "A" well found a producing zone in the Toronto limestone from 2,986 to 2,989 feet depth. These new producing zones have been described by the Kansas Nomenclature Committee, and are listed in Table 7.

The wildcat tests drilled during 1952 are listed in Table 49. The test on the Tatkanhorst farm drilled by Beach and Talbott in sec. 16, T. 9 S., R. 15 W. had a show of oil in limestone 60 feet below the top of the Lansing and another show of oil 160 feet lower in basal Kansas City limestone. Neither was sufficient to make a commercial well. None of the other wildcats had shows of oil or gas.

The location of the producing area and part of the dry wildcats are shown on Figure 5. The new pool is listed in Table 6. Osborne County's 1952 oil production is listed in Table 66.

OTTAWA COUNTY

Wildcat wells have been drilled from time to time in Ottawa County, but as yet no oil or gas pool has been found.

Exploration during 1952.—During 1952, one exploratory test was made in Ottawa County. Veverka, Gassoway and Ordway drilled to 3,805 feet on the Kiem farm in the NW¼ NW¼ NW¼ sec. 33, T. 9 S., R. 5 W. From an elevation of 1,540 feet above sea level, the following marker horizons were reported: Ft. Riley limestone, 1,098; Heebner shale, 2,420; Lansing-Kansas City group, 2,538; base of the Kansas City group, 2,925; Mississippian limestone, 3,256; "Hunton" limestone, 3,612; and Viola limestone, 3,785 feet depth.

PAWNEE COUNTY

(Map Fig. 10)

The 1952 production from 15 pools: oil 543,951 barrels, gas 2,986,948 thousand cubic feet. Wells drilled in 1952: oil 23, gas 7, dry 19, total 49 including 7 dry wildcats. New pools discovered 1, revived 1, combined 2.

Developments during 1952.—Oil production in Pawnee County showed an increase of more than 100,000 barrels; gas declined

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more than 26 percent during 1952. Seventeen more tests were attempted in the county during 1952 than in 1951.

The county's new oil pool, the **Benson South**, was brought in by M. B. Armer Drilling Company on the Garvin farm in sec. 30, T. 23 S., R. 15 W. The discovery well produces from a porous zone 125 feet below the top of the Lansing-Kansas City group. An initial potential of 401 barrels of oil per day was assigned.

The **Larned** pool, officially abandoned during 1951, was revived during 1952 by the Musgrove Petroleum Corporation No. 1 Phinney test in sec. 34, T. 21 S., R. 16 W. A maximum potential was assigned the revival well, which produces from the Arbuckle dolomite from 3,851 to 3,856 feet depth. Before the close of the year, 4 extension wells, 2 of which were maximum, were added to the revived pool.

Two new producing zones, the Simpson and Arbuckle, were added to the **Evers** pool, and the Lansing-Kansas City was added to the **Benson Southeast** pool during 1952. These new producing zones are listed in Table 7.

Pools combined during the year are the **Rutherford East** with the **Ryan**, and the **Pawnee Rock West** with the **Pawnee Rock** pool.

Four extension oil wells and 3 gas wells were added to the **Benson Southeast** pool, 4 oil and 1 shut-in gas wells were added to the **Evers** pool, and 7 oil wells were added to the **Pawnee Rock** pool.

TABLE 50.—*Dry wildcat tests drilled in Pawnee County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
Vickers Petro. Co., Inc. No. 1 Gustafson	SW¼ SW¼ SW¼ 10-20-16W	2,041	3,467	3,752	3,789
*T. H. Mastin et al. No. 1 Finger	NE¼ NE¼ SE¼ 31-20-16W	2,022	3,487	3,791	3,891
Armer Drilling Co., Inc. No. 1 De Roo	SW¼ SW¼ SE¼ 17-21-16W	2,001	3,464	3,802	3,896
Jackson Drilling Corp. No. 1 Crane	SW¼ SW¼ NE¼ 4-22-15W	1,983	3,517	3,948	3,980
*Flynn Oil Co. No. 1 Michael	SW¼ SW¼ SW¼ 10-22-16W	2,034	3,595	4,035	4,043
*Alpine Oil & Royalty Co., Inc. No. 1 Ingels	NW¼ NW¼ NE¼ 16-22-16W	2,038	3,584	3,964	4,060
Transit Corp. et al. No. 1 Wurm	NW¼ NW¼ NE¼ 34-23-16W	2,072	3,690	4,166	4,220

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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Gas production was reported for the first time in several years from the **Torrance** pool. Nadel and Gussman brought in an 18 million cubic feet per day well on the Bird lease in sec. 19, T. 21 S., R. 15 W., during 1952. Production comes from 3,810 to 3,816 feet in the Arbuckle dolomite.

Five of the seven dry wildcat tests had shows of oil or gas. In the Jackson Drilling Corporation No. 1 Crane test, free oil was found between the depths of 3,573 and 3,617 feet, 55 feet below the top of the Lansing limestone. Many of the gas shows in the other dry wildcat tests occurred in the top part of the Arbuckle dolomite. These tests are listed in Table 50.

The new pools are listed in Table 6. Locations of producing areas and dry wildcat tests are shown on Figure 10. Oil production data are given in Table 66, and gas production data in Table 67.

PHILLIPS COUNTY

(Map Fig. 5)

The 1952 production from 15 pools: oil 2,689,906 barrels. Wells drilled in 1952: oil 29, dry 23, total 52 including 12 dry wildcats. New pools discovered 2.

Developments during 1952.—Drilling activity dropped off considerably from the previous year, while production remained steady.

The first new Phillips County pool, the **Fredericksburg,** was found in March when the Alpine Oil and Royalty Company finished a Lansing limestone test on the Kauk farm in sec. 4, T. 1 S., R. 18 W. An initial potential of 50 barrels of oil per day was given the discovery well, which was drilled to a total depth of 3,460 feet. Late in the year, J. H. Johnson on the Lappin lease in sec. 15, T. 5 S., R. 20 W., discovered oil in the Arbuckle dolomite for the county's second new oil pool, called the **Hansen West.** The well, given an initial potential of 15 barrels of oil per day, was drilled to a total depth of 3,554 feet.

Eight extension oil wells were added to the **Huffstutter** pool, 4 to the **Huffstutter Southwest** pool, and 6 to the **Stuttgart** pool. Six old wells were worked over in the county, resulting in 3 oil wells, 2 dry holes, and 1 salt-water disposal well.

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TABLE 51.—*Dry wildcat tests drilled in Phillips County during 1952*

Company and farm	Location	Depth to top of Topeka, feet	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
Musgrove Petro. Corp. No. 1 Jackson	SW¼ SW¼ NE¼ 21-1-16W	3,118	3,393	3,939†	3,980
*R. W. Rine Drlg. Co. No. 1 Frazer	NW¼ NW¼ SE¼ 8-1-17W	3,107	3,356	3,831†	3,893
*Anschutz Drlg. Co. No. 1 Cannon	SW¼ SW¼ SW¼ 17-2-17W	3,040	3,312	3,827	3,850
Superior Oil Co. No. 1 Good	SE¼ NE¼ NE¼ 22-2-18W	3,131	3,347	3,757	3,787
*Jones, Shelburne & Farmer Inc. No. 1 Doman	SE¼ SE¼ NW¼ 28-2-18W	3,120	3,343	3,756	3,814
*Lewis Drlg. Co. et al. No. 1 Merklein	NW¼ SE¼ NW¼ 22-2-19W	....	3,399	....	3,560
Sohio Petro. Co. No. 1 Hansen	SW¼ NW¼ NE¼ 33-3-18W	2,898	3,143	3,577	3,598
*Lewis Drlg. Co. et al. No. 1 Merklein "A"	NE¼ NE¼ SE¼ 16-3-19W	3,020	3,265	....	3,425
Natl. Assoc. Petro. Co. No. 1 Pfleiger	NW¼ NW¼ SW¼ 32-3-19W	3,041	3,274	3,592	3,657
The Texas Company No. 1 John Schurz	SE¼ SE¼ SE¼ 8-4-19W	3,019	3,266	3,585	3,684
Anderson-Prichard Oil Corp. No. 1 Becker	NE¼ NE¼ SW¼ 13-4-19W	2,936	3,173	3,519	3,572
The Texas Company No. 1 Emery	NE¼ NW¼ NW¼ 16-5-20W	3,054	3,298	3,580	3,635

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.
† Depth to the top of the Viola, feet.

Five of the 12 dry wildcat tests had shows of oil or gas. Most of the dry tests were drilled north of Phillipsburg. The important marker horizons encountered in drilling these tests are listed in Table 51.

Locations of producing areas and dry wildcat tests are shown on Figure 5. Oil production data are given in Table 66. Information on new pools is given in Table 6.

PRATT COUNTY

(Map Fig. 14)

The 1952 production from 20 pools: oil 2,733,095 barrels including production from 1 secondary recovery project, gas 2,646,761 thousand cubic feet. Wells drilled in 1952: oil 53, gas 2, dry 35, salt-water disposal 1, total 91 including 16 dry wildcat tests. New pools discovered 4.

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Developments during 1952.—About one-third more wells were attempted in Pratt County during 1952 than in 1951. Oil production increased about 300,000 barrels, and gas production increased considerably. Most of the new drilling was concentrated in the **Chance** and **Iuka-Carmi** pools.

The discovery well of the new **Barnes** gas pool was drilled by Anschutz Drilling Company on the Barnes property in sec. 25, T. 27 S., R. 12 W. The pool is located 6 miles west of the **Cunningham** pool. The discovery well, which found gas in the Simpson sandstone, is rated at almost 8 million cubic feet of gas per day.

TABLE 52.—*Dry wildcat tests drilled in Pratt County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Viola, feet	Depth to top of Simpson, feet	Depth to top of Arbuckle, feet	Total depth, feet
Mercury Drlg. Co. No. 1 Hawver	NW¼ NW¼ NE¼ 5-26-12W	3,631	4,090	4,175	4,267	4,305
Natl. Coop. Ref. Assn. No. 1 Long	NW¼ NW¼ NE¼ 16-26-12W	3,670	4,161	4,240	4,345	4,420
*Natl. Coop. Ref. Assn. No. 1 Burkner	SE¼ SE¼ SW¼ 25-26-12W	3,666	4,295	4,392	4,481	4,581
*Murfin Drlg. Co. No. 1 Nesbitt	NE¼ NE¼ SE¼ 11-26-13W	3,720	4,245	4,332	4,399	4,440
*Metropolitan Oil Co. No. 1 Randle	SE¼ SE¼ NW¼ 30-26-14W	3,910	4,435	4,547	4,622	4,650
Lion Oil Co. No. 1 Callahan	NW¼ NW¼ SE¼ 33-26-14W	3,901	4,444	4,506	4,610	4,640
Anderson-Prichard Oil Corp. No. 1 Long	SW¼ SW¼ NE¼ 11-26-15W	3,822	4,359	4,469	4,512	4,572
Lion Oil Co. No. 1 Allen	NW¼ NW¼ SE¼ 21-27-12W	3,703	4,319	4,391	4,483	4,585
Lion Oil Co. No. 1 Airport	SE¼ SE¼ SE¼ 8-27-13W	3,859	4,361	4,412	4,527	4,545
B & R Drlg., Inc. No. 1 City of Pratt	SW¼ SW¼ SW¼ 17-27-13W	3,875	4,362	4,420	4,529	4,600
Armer Drlg. Co., Inc. et al. No. 1 Wagner	SW¼ SW¼ NE¼ 34-28-11W	3,707	4,398	4,487	4,585	4,625
John Lindas Oil, Inc. No. 1 Lunt	NW¼ NE¼ NW¼ 5-28-12W	3,718	4,310	4,402	4,510	4,540
Time Petro. Co. No. 1 Banberry	SE¼ SE¼ SW¼ 18-28-12W	3,829	4,424	4,505	4,646	4,752
Pabco Drlg., Inc. No. 1 Fincham	SW¼ NW¼ NW¼ 31-28-12W	3,868	4,483	4,578	4,702	4,711
*Cities Service Oil Co. No. 1 Lynch "B"	SW¼ SW¼ NE¼ 6-29-11W	3,780	4,422	4,506	4,618	4,650
Lion Oil Co. No. 1 Omo	NW¼ NW¼ NW¼ 2-29-14W	3,982	4,472	4,556	4,648	4,694

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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A second gas pool, the **Blowout,** was found by the Lion Oil Company when the first test on the Eubank lease was completed in sec. 8, T. 27 S., R. 14 W. Here the gas, in the amount of 8 million cubic feet per day also, was found in a porous zone within the Lansing limestone. The **Chance East** pool, between the **Chance** and the **Iuka-Carmi** pools, was opened by Rine Drilling Company with a 220 barrel per day oil well from the Viola limestone on the Briggeman farm in sec. 34, T. 26 S., R. 13 W. The **Jarboe** pool was also opened by the Rine Drilling Company, when an old well worked over on the Jarboe lease was assigned an initial potential of 3½ barrels of oil per day from the Lansing-Kansas City sequence in sec. 25, T. 26 S., R. 14 W.

Seventeen oil wells and 1 dry hole were added as extension wells to the **Chance** pool, and 33 oil wells and 11 dry holes were added to the **Iuka-Carmi** pool.

The following new producing zones were officially recognized during the year: **Barnes,** Lansing-Kansas City; **Chance,** Viola; and **Chance East,** Mississippian. These new producing zones are tabulated in Table 7.

Seven of the 16 dry wildcat tests reported shows of oil or gas. Good shows of oil and gas were found in the Lion Oil Company No. 1 Callahan test in sec. 33, T. 26 S., R. 14 W. Strongest shows were in the Lansing limestone 27 feet below the top, where 75 feet of free oil was reported. Both oil and gas shows were found in the Anderson-Prichard Oil Corporation No. 1 Long test in sec. 11, T. 26 S., R. 15 W., where three zones in the Lansing-Kansas City sequence showed promise. Much testing was done on the Lion Oil Company No. 1 Allen "A" well in sec. 21, T. 27 S., R. 12 W., without commercial results.

Data on the new oil and gas pools are given in Table 6. Locations of producing areas and dry wildcat tests are shown on Figure 14, and dry wildcat tests are listed in Table 52. Oil production information is given in Table 66, and gas production figures in Table 67. Data on the secondary recovery project which extends into Kingman County is given in Table 1.

RENO COUNTY

(Map Fig. 6)

The 1952 production from 17 pools: oil 1,473,362 barrels including 3,400 barrels from 1 secondary recovery project, gas 120,734 thousand cubic feet. Wells drilled during 1952: oil 11,

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dry 24, salt-water disposal 1, total 36 including 14 dry wildcats. New pools discovered 3.

Developments during 1952.—The National Cooperative Refinery Association in drilling southwest of the **Sankey** pool on the Schweizer lease in sec. 21, T. 22 S., R. 10 W. found oil in the Viola limestone at 3,548 feet depth. The new well, opening the **Sankey Southwest** pool, is capable of producing 483 barrels of oil per day. The second new pool is the **Nicklaus** pool, located very close to the old **Hilger** pool in the southeastern part of the county. Here the Saturn Drilling Company found oil on the Nicklaus farm in sec. 3, T. 26 S., R. 4 W. in a porous zone of the Lansing-Kansas

TABLE 53.—*Dry wildcat tests drilled in Reno County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Viola, feet	Depth to top of Arbuckle, feet	Total depth, feet
*Braden Drlg. Co. No. 1 Stoughton	NE¼ NE¼ SW¼ 22-22-5W	....	3,962	4,065	4,116
Transit Corp. et al. No. 1 Welker	NE¼ NW¼ NE¼ 14-22-8W	3,076	....	3,580†	3,640
Stag Drlg. Inc. No. 1 Schumucker	SW¼ SW¼ SE¼ 24-22-9W	3,140	3,828	3,945	4,000
*Bud Edwards Drlg. Co. No. 1 Titus	SE¼ SE¼ SE¼ 4-22-10W	3,111	3,460	3,554	3,593
*Braden Drlg. Co. No. 1 Russell	SE¼ SE¼ NW¼ 30-23-7W	3,092	3,988	4,080	4,120
*Musgrove Petro. Corp. No. 1 Davidson	NW¼ NW¼ NW¼ 33-23-9W	3,303	....	3,765†	3,801
The Derby Oil Co. No. 1 House	NW¼ NW¼ NW¼ 7-25-4W	2,737	3,938	3,961‡	3,990
R. H. Godfrey No. 1 Smith	NE¼ NE¼ NE¼ 23-25-4W	2,755	4,024	4,129	4,152
*Musgrove Petro. Corp. No. 1 Jones	SW¼ SW¼ NE¼ 19-25-9W	3,423	4,132	....	4,221
The Texas Co. No. 1 Schmitz	NE¼ SW¼ SE¼ 2-26-4W	2,876	4,131	4,242	4,298
Kewanee Oil Co. No. 1 Hettinger	SE¼ NE¼ SE¼ 31-26-5W	2,981	4,135	....	4,157
*S. A. Murphy et al. No. 1 Stucky	SE¼ SE¼ NW¼ 28-26-6W	3,051	4,117	4,236	4,276
*Bay Petro. Corp. et al. No. 1 Ray	N2 N2 SE¼ 21-26-8W	3,342	4,292	4,421	4,462
Armer Drlg. Co., Inc. No. 1 Goesling	SE¼ SE¼ SE¼ 3-26-10W	3,467	4,204	4,387	4,440

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

† Depth to the top of the Mississippian, feet.

‡ Depth to the top of the Simpson, feet.

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City at a depth of 3,249 feet. The discovery well is rated as having a capacity of 87 barrels of oil per day. The **Keddie** pool discovery well, in sec. 26, T. 23 S., R. 10 W., an old well worked over, was carried as dry and abandoned.

The Mid-States Oil Corporation No. 1 Schlickou "A" test in sec. 10, T. 25 S., R. 4 W., was named as discovering a new Viola producing zone in the **Haven** pool, but later in the year, the well was converted to a salt-water disposal well (Table 7).

Among the new oil wells in this county, 6 are in the **Buhler** pool. Each produces from Simpson sandstone. One new oil well producing from Mississippian "chat" was completed in the western part of the **Burrton** pool. One new Viola oil well was added to the **Haven** pool, in the southeastern part of the county.

Six of the 14 dry wildcat tests had shows of oil or gas. The Derby Oil Company No. 1 House test in sec. 7, T. 25 S., R. 4 W., had a show of gas in the top part of the Mississippian. Bay Petroleum Corporation in their test on the Ray farm in sec. 21, T. 26 S., R. 8 W., had a good show of oil and also gas in the Lansing limestones at 3,405 feet depth, 50 feet below the top of that formation.

The new pools are described in Table 6. Dry wildcat tests are listed in Table 53, and are shown with the producing areas on Figure 6. Oil production is given in Table 66, and gas production in Table 67. Data on the secondary recovery project are reported in Table 1.

RICE COUNTY

(Map Fig. 6)

The 1952 production from 55 pools: oil 9,566,545 barrels, gas 450,848 thousand cubic feet. Wells drilled in 1952: oil 154, dry 102, salt-water disposal 3, total 259 including 15 dry wildcats. New pools discovered 5, revived 2, combined 1.

Developments during 1952.—Drilling activity in Rice County during 1952 increased by 18 wells. Oil production increased by about 63,000 barrels, while the gas production from the county declined considerably.

The new pools found during the year are the **Bingham, Calf Creek North, Fair, Farmer,** and **Schulz.** The **Bingham** pool discovery well was drilled by W. L. Hartman on the Bingham lease

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in sec. 35, T. 19 S., R. 9 W., next to the **Quivira** gas field. The new pool derives its production from the Arbuckle at 3,332 feet depth. The **Calf Creek North** pool, discovered by Vickers Petroleum Company on the Roesler "B" lease in sec. 28, T. 18 S., R. 10 W., produces oil from the Arbuckle dolomite. Drilling on the Fair lease in sec. 15, T. 21 S., R. 10 W., Magnolia Petroleum Company brought in the discovery well of the new **Fair** pool, which produces from the Pennsylvanian basal conglomerate. The Arbuckle dolomite is the producing zone of the new **Farmer** pool, discovered by the Nadel and Gussman No. 1 Bredfeldt well, which was assigned an initial potential of 1,166 barrels of oil per day, the

TABLE 54.—*Dry wildcat tests drilled in Rice County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Viola, feet	Depth to top of Arbuckle, feet	Total depth, feet
Continental Oil Co. No. 1 Peter Wolf	SW¼ SW¼ NW¼ 20-18-6W	2,744	3,169‡	....	3,383
J. R. Greeley Drlg. Co. No. 1 Bronleewe	SW¼ SW¼ NE¼ 13-18-7W	2,734	3,357	3,467	3,494
*A. J. Stormfeltz No. 1 Jansen	SE¼ SW¼ SE¼ 7-18-8W	2,895	....	....	3,225
Victor Drlg. Co. No. 1 Barker	SE¼ SW¼ SE¼ 30-18-8W	2,901	3,334	3,443	3,475
*Pickrell Drlg. Co. No. 1 Schoonover	SW¼ SW¼ SW¼ 21-18-9W	2,882	....	3,225	3,265
L. B. Jackson et al. No. 1 Ramage	SW¼ SW¼ NE¼ 16-19-6W	2,702	3,443	3,538	3,576
*Dozier Oil Co. No. 1 Engelland	SW¼ SE¼ NW¼ 19-19-7W	2,921	3,257‡	....	3,440
*Flynn Oil Co. No. 1 Gray	NW¼ NW¼ SE¼ 17-19-8W	2,854	3,325	3,426	3,456
*Dozier Oil Co. No. 1 Stewart	SE¼ SE¼ NW¼ 27-19-8W	2,893	3,225‡	....	3,336
O. A. Beech No. 1 Leonard	NW¼ NW¼ SE¼ 16-20-7W	2,924	3,597	3,695	3,730
*Stag Drlg. Inc. et al. No. 1 Roth	SE¼ SE¼ SE¼ 24-20-9W	2,906	3,239‡	....	3,455
*Anschutz Drlg. Co. No. 1 Fair	SW¼ SE¼ SE¼ 29-20-9W	2,928	....	3,295	3,325
Pickrell Drlg. Co. No. 1 Bell	SE¼ SE¼ NW¼ 15-21-8W	2,932	3,593	3,703	3,733
*Morrison Drlg. Co., Inc. No. 1 Howe	SW¼ SW¼ SE¼ 32-21-9W	3,056	3,516	3,645	3,667
*Graham-Messman-Rinehart Oil Co. No. 1 Isern	NW¼ NW¼ SE¼ 12-21-10W	2,974	3,318‡	3,399	3,429

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.
‡ Depth to the top of the Pennsylvanian basal conglomerate, feet.

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largest of any of the 1952 discoveries. When working over an old well on the Schulz lease Ash-Mur Drilling Company was thought to have a new pool and the name of the lease was assigned, but completion of the test reported the hole dry and abandoned.

The **Click** and **Galt** pools, revived during the year, obtain production from Lansing-Kansas City and Arbuckle, respectively.

After the Skiles Oil Corporation No. 2 Boldt test in the **Ixl South** pool found production in the Arbuckle, the pool was combined with the **Ixl** pool, which also produces from the Arbuckle.

There were many pool extensions during the year. The ones having the larger additions are: **Bornholdt,** 11 new oil wells and 4 dry holes; the Rice County portion of **Chase-Silica,** 26 new oil wells, 16 dry holes, 3 salt-water disposal wells, and 2 abandoned locations; **Edwards,** 8 oil wells and 1 dry hole; **Geneseo,** 19 oil wells and 8 dry holes; **Smyres,** 15 oil wells and 4 dry holes; and **Welch,** 15 oil wells and 2 dry holes.

Six of the 15 dry wildcats reported shows of oil or gas. The Continental Oil Company test, very close to the abandoned **Jennings** pool, reported no shows. The Arbuckle test put down by the Pickrell Drilling Company on the Schoonover lease was in the abandoned **Cow Creek** field. Only salt-water was recovered on drill-stem tests.

The new and revived pools are described in Table 6, the new producing zone in Table 7. Pertinent data on the dry wildcat tests are listed in Table 54. Locations of producing areas and dry wildcat tests are shown on Figure 6. Oil production is listed by pools in Table 66, and gas production in Table 67.

ROOKS COUNTY

(Map Fig. 5)

The 1952 production from 82 pools: oil 7,287,132 barrels. Wells drilled during 1952: oil 137, dry 141, salt-water disposal 1, total 279 including 24 dry wildcats. New pools discovered 15. Pools combined 3.

Developments during 1952.—Oil production increased almost 200,000 barrels in Rooks County during 1952. Drilling activity remained steady.

The wildcat wells found 15 new pools during the year. The names of the new pools arranged in alphabetical order are: **Bartos, Bassett Southwest, Baumgarten Northeast, Brungardt, Dancer,**

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Dopita East, Elm Creek West, Fehnel, Hillside, Laura Southeast, Lynd Southwest, McMullen, Medicine Creek, Mt. Ayr, and **Zurich Southwest.** Seven of these new pools derive oil from the Arbuckle dolomite, seven secure oil from Lansing-Kansas City limestones and one, the **Hillside,** produces oil from a limestone in the Shawnee group. The initial capacity of the discovery wells ranged from 11 barrels for the **Mt. Ayr** pool to 365 barrels for the **McMullen** pool. Further details about the new pools are given in Table 6. Before the year closed the **Elm Creek West** pool was joined to the **Elm Creek**. Other pool combinations are the **Eagle Creek** with the **Marcotte,** and **Chandler** with **Jelinek.** The **Berland North** pool was redescribed as the **Marcotte North** pool.

New producing zones were found in seven old pools during the year. The **Gra-Rook** pool, which produces from Arbuckle and Lansing, added the Pennsylvanian basal conglomerate. The **Jelinek** pool, where only Arbuckle had produced heretofore, now has some production from the Dodge (Shawnee) limestones. In the **McHale** pool, the Lansing-Kansas City group was added. The

TABLE 55.—*Dry wildcat tests drilled in Rooks County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
Lewis Drlg. Co. No. 1 Kemmler	NW¼ NW¼ SE¼ 7-6-17W	3,144	3,522†	3,550
*E. F. Madden et al. No. 1 Shaw	SE¼ SE¼ NW¼ 11-6-19W	3,298	3,569	3,600
Keating Drlg. Co. No. 1 Sayles	NE¼ NE¼ SW¼ 21-7-16W	2,940	3,315	3,360
*T. M. Evans No. 1 Webster	NW¼ NW¼ SW¼ 5-7-17W	3,055	3,368	3,387
Lewis Drlg. Co. No. 1 Moore	SE¼ SE¼ NE¼ 10-7-17W	3,027	3,451	3,476
*Armer Drlg. Co., Inc. No. 1 Rumsey	SE¼ SW¼ NW¼ 15-7-17W	2,937	3,327	3,358
Lewis Drlg. Co. et al. No. 1 Cramer	NE¼ NE¼ SW¼ 28-7-17W	2,997	3,366	3,414
*Westgate-Greenland Oil Co. No. 1 Hindman	SE¼ SE¼ NW¼ 20-7-18W	3,084	3,378	3,430
Harry Koplin No. 1 Tatum	NE¼ SE¼ NW¼ 23-7-18W	2,977	3,306	3,335
*John Lindas Oil, Inc. No. 1 Roelfs	SE¼ SW¼ NE¼ 35-7-18W	3,088	3,394	3,399
Jones, Shelburne & Farmer, Inc. No. 1 Thyfault	NW¼ NW¼ SW¼ 29-7-20W	3,303	3,663	3,683
*Murfin Drlg. Co. No. 1 Schindler	NW¼ NW¼ SE¼ 16-8-17W	3,094	3,434	3,454

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TABLE 55.—*Dry wildcat tests drilled in Rooks County during 1952, concluded*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
Murfin Drlg. Co. No. 1 Williams	SW¼ SW¼ SE¼ 1-8-18W	3,052	3,350	3,380
Lee Phillips Oil Co. No. 1 Thompson	SW¼ SW¼ SW¼ 28-8-18W	3,227	3,488	3,520
*Trans Era Petro., Inc. No. 1 Hayes	SE¼ SE¼ SE¼ 30-8-18W	3,235	3,502‡	3,540
*Morris Sitrin et al. No. 1 Lowry	NW¼ NW¼ NE¼ 8-8-19W	3,137	3,394	3,420
Republic Natural Gas Co. No. 1 Schneider	NW¼ NW¼ NW¼ 10-8-19W	3,140	3,445	3,505
Murfin Drlg. Co. No. 1 Raynor	SE¼ SE¼ NW¼ 24-8-20W	3,263	3,555	3,585
B & R Drlg., Inc. No. 1 Whisman	NE¼ NE¼ SW¼ 25-8-20W	3,284	3,534	3,575
Anschutz Drlg. Co. No. 1 Berland	SE¼ SE¼ SW¼ 28-8-20W	3,293	3,613	3,648
*Dizdar Investment Co. No. 1 Green	NE¼ NW¼ SE¼ 18-9-17W	3,211	3,492‡	3,612
*Jones, Shelburne & Farmer, Inc. No. 1 Adams	NE¼ NE¼ SE¼ 30-9-17W	3,320	3,638	3,668
*Honaker Drlg. Co. No. 1 Dorland	SE¼ SE¼ NE¼ 11-10-17W	3,174	3,476	3,503
C-G Drlg. Co. No. 1 Ordway	NE¼ NE¼ NE¼ 17-10-18W	3,424	3,765	3,790

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.
†Depth to the top of the erosional Arbuckle, feet.
‡ Depth to the top of the Pennsylvanian basal conglomerate, feet.

Simpson now produces in the **Nettie** pool. In the **Palco Southeast** pool one well found the Arbuckle dry and secured oil from the Lansing-Kansas City. The **Slate** pool in the northwestern part of the county now has some production from the Lansing-Kansas City limetsones. In the **Zurich** pool, the Shawnee was added to the list of producing zones. Additional data on the new producing zones are given in Table 7.

Data on location and tops in the dry wildcat tests are given in Table 55. A few additional data on oil shows will be of interest. The Lewis Drilling Company No. 1 Kemmler test in sec. 7, T. 6 S., R. 17 W. had a good oil show in the top of the Lansing limestone. A similar show of oil was found in the Lewis Drilling Company No. 1 Moore test in sec. 10, T. 7 S., R. 17 W. The Evans No. 1 Webster had a show of oil in the Shawnee group at 2,955 feet, 60 feet below the top. Westgate-Greenland Oil Company reports

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a show of oil in their Hindman test at 3,250 feet, 150 feet below the top of the Lansing. Farther south where the oil pools are closer together the wildcats had shows of oil at many places.

Many pool extension wells were drilled during 1952. Some of the larger amounts of new oil wells are: **Burnett,** 9 oil wells and 2 dry holes; **Jelinek,** 14 oil wells and 9 dry holes; **Marcotte,** 33 oil wells and 18 dry holes; and **Nettie,** 8 oil wells and 2 dry holes.

Locations of producing areas and dry wildcat tests are shown on Figure 5. Oil production data are given in Table 66.

RUSH COUNTY

(Map Fig. 7)

The 1952 production from 8 pools: oil 267,500 barrels, gas 1,952,923 thousand cubic feet (estimated). Wells drilled during 1952: oil 8, dry 20, total 28 including 13 wildcats. New pools discovered 3.

Developments during 1952.—In comparison with the previous year nearly twice as many test holes were drilled in Rush County during 1952; however, both oil and estimated gas production declined. The names of the new pools discovered during 1952 are the **Big Timber, Stegman,** and the **Timken** pools. Two produce oil from the Arbuckle dolomite and the third produces from Lansing-Kansas City limestones. Further details are given in Table 6. Two of the new pools, the **Big Timber** and the **Stegman,** were abandoned early in 1953 because of small production. The discovery well in the **Timken** pool was rated as having a capacity of 259 barrels per day.

The 13 dry wildcats are scattered over the area of the county. Some data, such as the location and selected tops, are given in Table 56. A small show of gas was found in the Overland Drilling Company No. 1 Brungardt test, sec. 4, T. 16 S., R. 17 W., at 3,538 feet in the top of the Arbuckle dolomite. Some oil was reported at 3,917 feet in the Heathman Company et al. No. 1 Campbell test, sec. 21, T. 16 S., R. 20 W.

Six extension oil wells were added to the Rush County part of the **Ryan** pool.

Locations of producing areas and dry wildcat tests are shown on Figure 7. Oil production is given in Table 66, and gas production in Table 67.

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TABLE 56.—*Dry wildcat tests drilled in Rush County during 1952*

Company and farm	Location	Depth to top of anhydrite, feet	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
Northern Pump Co. No. 1 Hopkins	NE¼ SW¼ NW¼ 10-16-16W	1,060	3,222	3,532	3,585
*Northern Ord., Inc. No. 1 Stremel	SW¼ SW¼ NW¼ 19-16-16W	1,085	3,253	3,540	3,565
*Overland Drlg. Co. No. 1 Brungardt	NW¼ NW¼ SE¼ 4-16-17W	1,123	3,280	3,537	3,550
Heathman & Co. et al. No. 1 Campbell	NE¼ NE¼ NE¼ 21-16-20W	1,420	3,546	3,978	4,028
Lion Oil Co. No. 1 Treloggen	NE¼ NE¼ NE¼ 13-17-16W	1,102	3,321	3,611	3,645
The Texas Co. No. 1 W. J. Laughlin	NE¼ NE¼ NE¼ 35-17-19W	1,282	3,497	3,914	3,937
*Strain Drlg. Co. et al. No. 1 Irvin	SW¼ SW¼ NE¼ 30-17-20W	1,442	3,652	4,322‡	4,337
*E. H. Adair Oil Co. No. 1 Schneider	NE¼ NE¼ SE¼ 7-18-18W	1,265	3,515	3,738	3,963
E. H. Adair Oil Co. No. 1 O'Borny	SE¼ SE¼ SE¼ 13-18-18W	1,180	3,438	3,827	3,890
*Flynn Oil Co. No. 1 Tammen	NE¼ NE¼ NE¼ 8-19-16W	1,175	3,542	3,956	3,986
*Adair & Graham No. 1 Folkerts	NE¼ NE¼ NW¼ 18-19-16W	1,171	3,520	3,860	3,875
Wentworth Drlg. Co. No. 1 Gunn	NE¼ NE¼ NE¼ 31-19-17W	1,275	3,599	3,984	4,045
*D. R. Lauck Oil Co., Inc. et al. No. 1 West	SE¼ SE¼ NE¼ 6-19-19W	1,298	3,600	4,115	4,190

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.
‡ Depth to the top of the Viola, feet.

RUSSELL COUNTY

(Map Fig. 8)

The 1952 production from 29 pools: oil 11,635,324 barrels, gas 10,147 thousand cubic feet. Wells drilled during 1952: oil 256, gas 3, dry 93, salt-water disposal 3, total 355 including 9 dry wildcats. New pools discovered 1, pools combined 4.

Developments during 1952.—The 355 wells drilled in Russell County in 1952 is 108 more than drilled in 1951. Although oil production decreased slightly, this county maintained its position as the second largest oil-producing county in the State.

The name of the one new pool is the **Fay**. It was found by the D. R. Lauck Oil Company No. 1 Shaffer test in sec. 2, T. 12 S. R. 15 W. The oil was found in the top part of the Arbuckle dolomite at a depth of 3,238 feet. The producing zone is 12 feet thick.

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An official rating of 141 barrels of oil per day was assigned to the discovery well.

The following pool combinations took place during 1952: the **Ely** with the **Trapp** pool; and the **Homer, Homer Southeast, Ehrlich,** and **Beaver Northwest** (Barton County) with the **Hall-Gurney** field.

The method known as "sand fracturing" has opened production from several sands near the level of the Tarkio limestone. Many new wells in the **Hall-Gurney** pool are now producing from the sands above and below the Tarkio limestone. Some wells in the **Gorham** and western part of the **Trapp** pool also produce from this zone. Of the total number of new oil wells in Russell County for the year, 60 percent are Tarkio wells and more than half of these are in the **Hall-Gurney** pool. Nearly 30 percent of the new wells produce from the Arbuckle dolomite.

Production from Tarkio sands in earlier years (then called Indian Cave sand) was small. In sand fracturing, special sand is suspended in prepared heavy oil and pumped into the producing formation under pressure, forcing the mixture of sand and oil ing the producing sand. When the prepared oil is later removed,

TABLE 57.—*Dry wildcat tests drilled in Russell County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
*Anderson-Prichard Oil Corp. No. 1 Cook	SE¼ SE¼ NE¼ 24-11-15W	2,991	3,400	3,475
Flynn Oil Company No. 1 Dauber	SW¼ SW¼ NE¼ 12-13-13W	2,776	....	2,855
*Nadel & Gussman No. 1 Dumler	NW¼ NW¼ SE¼ 2-13-14W	2,834	3,157	3,200
*H. A. Horwitz No. 1 Shaffer	SW¼ SW¼ NE¼ 2-13-15W	2,897	3,178	3,215
Victor Drilling Co. No. 1 Foster	NE¼ NE¼ NE¼ 29-14-15W	3,025	3,309	3,340
*Duke & Wood Drlg. Co. No. 1 F. E. Keil	SW¼ SW¼ NE¼ 32-15-14W	3,130	3,377‡	3,432
*Brunson Drlg. Co., Inc. et al. No. 1 Aley	NW¼ NW¼ NW¼ 6-15-15W	3,185	3,453	3,460
K & E Drlg., Inc. No. 1 Aley-Foster "A"	SW¼ SW¼ NE¼ 19-15-15W	3,055	3,349	3,398
Shelley-Miller Drlg., Inc. No. 1 Janne	SE¼ SE¼ NW¼ 21-15-15W	3,114	3,368	3,395

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.
‡ Depth to the top of the Pennsylvanian basal conglomerate, feet.

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the suspended sand grains remain in the producing zone holding the grains in the standstone apart and thus providing avenues of migration for the oil.

Table 57 gives locations and important tops on the nine dry wildcat tests drilled during 1952. All are in the western and southern parts of the county. Many of them had good shows of oil in the Lansing sequence of limestones and a few had shows in older rocks, especially the Arbuckle dolomite.

Locations of producing areas and dry wildcat tests are shown on Figure 7. Oil production data are given in Table 66, and gas production in Table 67. Information on the new pool is given in Table 6. Data on a secondary recovery project begun in 1952 are listed in Table 1.

SALINE COUNTY

(Map Fig. 6)

The 1952 production from 14 pools: oil 1,071,522 barrels. Wells drilled during 1952: oil 63, dry 24, total 87 including 8 dry wildcats. New pools discovered 4.

Developments during 1952.—About 15 percent fewer wells were drilled than in 1951; however, oil production showed an increase of more than 50 percent. The **Smolan** pool almost doubled

TABLE 58.—*Dry wildcat tests drilled in Saline County during 1952*

Company and farm	Location	Depth to top of Mississippian, feet	Depth to top of Viola, feet	Depth to top of Arbuckle, feet	Total depth, feet
*Jones, Shelburne & Farmer, Inc. No. 1 Markley	NE¼ NE¼ NW¼ 16-13-1W	2,440	3,100	3,285	3,335
*Musgrove Petro. Corp. No. 1 Link	NW¼ NW¼ NW¼ 9-13-3W	2,851	3,530	....	3,674
*W. G. Burns No. 1 Shamburg	SE¼ SE¼ NE¼ 33-13-3W	2,842	3,510	....	3,542
Atlantic Refg. Co. No. 1 Hoeffner	SW¼ SW¼ SE¼ 2-14-2W	2,527	3,135	3,318	3,387
*Murfin Drlg. Co. et al. No. 1 Hoeffner	NW¼ NW¼ SW¼ 23-14-2W	2,683	3,345	3,509	3,526
*W. R. White No. 1 Ekstrom	NW¼ NW¼ NW¼ 26-15-2W	2,810	....	....	2,817
*Murfin Drlg. Co. et al. No. 1 Millikin	SE¼ SW¼ SW¼ 14-15-3W	2,737	3,331	3,507	3,517
*Westgate-Greenland Oil Co. No. 1 Ade	SW¼ SW¼ NW¼ 11-16-1W	2,655	....	....	2,752

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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its 1951 production, accounting for much of the increase in the county's total production.

Wildcat drilling opened four new pools in Saline County during 1952, all rather close to older pools. They are: **Gypsum Creek North, Holm North, Holm Southeast,** and **Salemsborg.** The initial potentials on the discovery wells range from 17 to 303 barrels of oil per day. The **Gypsum Creek North** pool produces from the Mississippian, while the other three derive their oil from the Viola limestone.

In the **Salina** pool, 4 extension oil wells and 2 dry holes were added. Only 3 dry holes were added to the **Smolan** pool, while 39 new oil wells were drilled. The new **Gypsum Creek North** pool had 6 new oil wells including the discovery well. The **Holm, Holm North,** and **Holm Southeast** accounted for 10 oil wells during the year.

Only four of the dry wildcats entered the Arbuckle dolomite. None reported shows of oil or gas. The locations of these dry wildcat tests and the important marker horizons penetrated are tabulated in Table 58.

Oil production is given in Table 66. Locations of producing areas and dry wildcat tests are shown on Figure 6. The four new pools are listed in Table 6.

SCOTT COUNTY

(Map Pl. 2)

The 1952 production from 2 pools: oil 71,595 barrels, gas 40,307 thousand cubic feet. Wells drilled in 1952: oil 2, dry 5, total 7 including 3 dry wildcats.

Developments during 1952. — Oil production from Scott County's two oil pools more than doubled during 1952; one less well was drilled. One new oil well was added to the **Keystone** pool, where the production comes from the Lansing limestones. Some gas production was reported also from the **Keystone** pool. The other new oil well is in the northeastern part of the **Shallow Water** field, where production is from Mississippian strata.

Three dry wildcats were reported during the year. The Imperial Petroleum Company's test on Fee land, in the SW¼ NE¼ NW¼ sec. 19, T. 17 S., R. 31 W., reported shows of oil in three places within the Lansing-Kansas City group, and one within the Marmaton group of rocks. The test was abandoned at 4,685 feet

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depth because of too much water. Important marker horizons encountered in drilling from an elevation of 2,969 feet above sea level are: Heebner, 3,900; Lansing, 3,940, and Mississippian, 4,585 feet depth.

From an elevation of 2,952 feet above sea level, the Flynn Oil Company test on the Harris property in the NE¼ NE¼ NE¼ sec. 29, T. 18 S., R. 32 W. encountered the following marker horizons: Heebner, 3,898; Lansing, 3,943; and Mississippian, 4,630 feet depth. Total depth was 4,785 feet.

The Parker dry wildcat test on the Franklin farm in the Cen. NW¼ NE¼ sec. 3, T. 18 S., R. 34 W., from an elevation of 3,119 feet above sea level, reported the following tops: Heebner, 4,005; Lansing, 4,056; and Mississippian, 4,766 feet depth. This test was abandoned at a total depth of 4,895 feet.

Locations of producing areas and dry wildcat tests are shown on Plate 2. Oil production data are given in Table 66, and gas in Table 67.

SEDGWICK COUNTY

(Map Fig. 12)

The 1952 production from 33 pools: oil 1,238,673 barrels including 26,733 barrels from 2 secondary recovery projects, gas 651,744 thousand cubic feet. Wells drilled in 1952; oil 20, dry 28, salt-water disposal 1, total 49 including 12 dry wildcats. New pools discovered 3, revived 1.

Developments during 1952.—During 1952, three new oil pools were discovered and one was revived. The new pools are: **Crestview, Gehring-Rick,** and **Prairie Creek.** The **Eastborough North** pool was revived. The **Gehring-Rick** pool resulted from reworking an old dry hole.

The **Crestview** pool was discovered by the E. B. Shawver No. 1 Holmes Estate well in sec. 1, T. 27 S., R. 1 E. Here the oil was found in the "Burgess sand" (Pennsylvanian). A potential capacity of 25 barrels of oil per day was assigned. The **Eastborough North** pool, discovered in 1938 and abandoned in 1947, was revived by the W. L. Hartman No. 1 Rolland well in sec. 4, T. 27 S., R. 2 W., which found oil in the Arbuckle dolomite at a depth of 3,376 feet. The original test in the **Gehring-Rick** pool, on the Gehring farm in sec. 16, T. 28 S., R. 2 E., found the "Burgess sand" dry. Later, the top of the Mississippian chat at 2,950 feet was found productive. The **Prairie Creek** pool was discov-

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ered by J. P. Gaty on the Bodecker "A" lease in sec. 25, T. 25 S., R. 2 E. When the "Burgess sand" was not found, the test was drilled into Mississippian "chat," where a minimum potential was assigned to the well.

Eleven extension oil wells and 2 dry holes were added to the Sedgwick County part of the **Bartholomew** pool. The other extension oil wells were well scattered throughout the county's other producing pools.

Of 28 dry holes drilled during the year in the county, 12 were wildcats. The Champlin Refining Company No. 1 Caple test in sec. 19, T. 25 S., R. 2 W., was drilled 26 feet into the Arbuckle dolomite. Several drill-stem tests were unsuccessful. Another test by Champlin on the Peltzer farm in sec. 15, T. 27 S., R. 3 W., entered the Arbuckle dolomite. The dry wildcat test drilled by the Pabco Drilling Company 7 miles east of the **Bartholomew**

TABLE 59.—*Dry wildcat tests drilled in Sedgwick County during 1952*

Company and farm	Location	Depth to top of Lansing, feet	Depth to top of Mississippian, feet	Depth to top of Arbuckle, feet	Total depth, feet
*Saturn Drlg., Inc. No. 1 Mark	NW¼ NW¼ SE¼ 26-25-1E	2,261	3,009	3,580	3,590
*Morrison Drlg. Co., Inc. No. 1 Lee	SE¼ SW¼ SE¼ 33-25-1E	2,325	3,068	3,590	3,609
*Charles Carlock No. 1 Penner	NE¼ NE¼ SW¼ 20-25-2E	2,530†	3,014	....	3,034
*Charles Carlock No. 1 Hunter	SW¼ SW¼ NE¼ 31-25-2E	2,567†	3,059	....	3,066
J. P. Gaty No. 1 Clark	SE¼ NW¼ SE¼ 2-26-1E	2,325	3,047	3,580	3,625
*Earl F. Wakefield No. 1 Long	SW¼ NE¼ SW¼ 31-29-1E	2,803†	3,330	3,825‡	3,875
*Sunray Oil Corp. No. 1 Farber	SW¼ SW¼ NE¼ 29-29-2E	2,636†	3,124	3,544‡	3,585
Champlin Refg. Co. No. 1 E. M. Caple	SE¼ SE¼ NW¼ 19-25-2W	2,593	3,414	4,046	4,072
Champlin Refg. Co. No. 1 Peltzer	NE¼ NE¼ SE¼ 15-26-3W	2,704	3,529	4,097	4,120
*Pabco Drlg., Inc. No. 1 Kramer	NE¼ NW¼ NW¼ 33-27-3W	2,819	3,694	4,167‡	4,201
*J. R. Greeley Drlg. Co. No. 1 Chesney	SE¼ NW¼ SE¼ 23-28-4W	2,877	....	....	3,150
*Saturn Drlg., Inc. No. 1 Walker	SE¼ SE¼ NE¼ 16-29-1W	2,542	3,404	....	3,461

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.
† Depth to the top of the Kansas City, feet.
‡ Depth to the top of the Simpson, feet.

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pool on the Kramer farm in sec. 33, T. 27 S., R. 3 W. had a fair show of oil just below the top of the Viola limestone.

Locations of producing areas and dry wildcat tests are shown on Figure 12. Oil production data are given in Table 66, and gas in Table 67. Data on the two secondary recovery projects are listed in Table 1. Data on the new and revived pools are listed in Table 6. Dry wildcat tests are tabulated in Table 59.

SEWARD COUNTY

(Map Pl. 2)

The 1952 production from 7 pools: oil 61,856 barrels, gas 4,540,552 thousand cubic feet, exclusive of production from the Hugoton Gas Area, not segregated as to counties. Wells drilled in 1952: oil 1, gas 11, dry 5, total 17 including 2 dry wildcat tests. New pools discovered 3.

Developments during 1952.—Although drilling activity decreased more than half, three new pools were discovered, oil production doubled, and gas production from areas exclusive of the Hugoton Gas Area more than doubled.

The new pools are the **Kismet South** (oil) and **Hawks** and **Liberal-White** gas pools. The **Kismet South** oil pool was discovered by the Flynn Oil Company No. 1 Jury well in sec. 26, T. 33 S., R. 31 W. Production comes from Mississippian strata at 5,770 feet depth, 200 feet below the top. The **Hawks** gas pool was discovered when an old well on the Lofland-Hawks property in sec. 18, T. 35 S., R. 31 W. worked over by the J. M. Huber Oil Corporation found 3.5 million cubic feet of gas in Morrowan rocks. This pool was discovered in July 1951, but was not officially named and recognized until 1952. The **Liberal-White** gas pool was discovered by Northern Ordnance, Incorporated, on the White lease in sec. 35, T. 34 S., R. 32 W. Production is from the Morrowan rocks also.

During the year, the **Light** pool, discovered in 1951, was renamed the **Liberal-Light** pool by the official Kansas Nomenclature Committee.

A dry wildcat test drilled during the year was put down by Lansekan et al. on the Good property in the W½ NE¼ NW¼ sec. 16, T. 34 S., R. 31 W., to a total depth of 5,959 feet. The test is 3 miles south of the **Kneeland** pool. Important tops encountered in drilling from an elevation of 2,519 feet above sea level are:

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Lansing limestones, 4,307 (?); Marmaton group, 5,002; and Mississippian strata, 5,570 feet depth.

In the Columbian Fuel Corporation No. 1 Adams "H" test in sec. 25, T. 34 S., R. 31 W., drill-stem tests in the known producing zone of the **Kneeland** pool were unsuccessful. The gas wells added to the Hugoton Gas Area in Seward County are concentrated in the northern half of the county.

Seward County wells are shown on Plate 2. Gas production is given in Table 67 and oil production in Table 66. The pertinent information on the new oil and gas pools is listed in Table 6. Additional data on the Hugoton Gas Area are given in the chapter on natural gas.

SHERIDAN COUNTY

(Map Fig. 4)

The 1952 production from 5 pools: oil 394,353 barrels. Wells drilled in 1952: oil 1, dry 19, total 20 including 14 dry wildcats. New pools discovered 2.

Developments during 1952.—Two new oil pools were named, although the discovery well of one, the **Moss,** was declared dry and abandoned.

The one successful wildcat drilled during the year opened the new **George** pool in sec. 17, T. 9 S., R. 26 W., about 4 miles south of the **Studley Southwest** pool. The Graham-Messman-Rinehart Oil Company tested the top of the Mississippian before plugging back to make the producer from the Lansing-Kansas City group from 4,023 to 4,034 feet depth on the George Mills property.

Six of the 14 dry wildcat tests put down in Sheridan County during 1952 reported shows of oil or gas. The test on the Wyant farm in sec. 25, T. 6 S., R. 30 W., drilled by the Anschutz Drilling Company reported a show of oil in the Marmaton group at 4,366 feet depth. Anschutz found a show of oil 32 feet below the top of the Lansing limestone in the Andregg test in sec. 2, T. 7 S., R. 26 W. In the Anschutz Drilling Company test on the Dally farm in sec. 10, T. 8 S., R. 30 W., a trace of oil was found near the top of the Lansing limestone. A show of oil in the Pennsylvanian basal conglomerate at 4,330 feet depth, 125 feet above the top of Mississippian rocks, was found by Anschutz Drilling

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TABLE 60.—*Dry wildcat tests drilled in Sheridan County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of Lans.-K.C., feet	Depth to top of Arbuckle, feet	Total depth, feet
*Empire Drlg. Co. et al. No. 1 Ward	SW¼ SW¼ SW¼ 13-6-26W	2,615	3,710	4,197	4,248
*Anschutz Drlg. Co. No. 1 Wyant	N2 N2 NE¼ 25-6-30W	2,896	3,996	4,566‡	4,585
Anschutz Drlg. Co. No. 1 Andregg	NW¼ NW¼ NW¼ 2-7-26W	2,598	3,782	4,468	4,472
Herndon Drlg. Co. No. 1 Barnett	NW¼ NW¼ SE¼ 5-7-26W	2,627	3,812	4,344‡	4,523
Anschutz Drlg. Co. No. 1 Phillips & Marshall	SW¼ SW¼ SW¼ 30-7-26W	2,634	3,842	4,412‡	4,515
*Anschutz Drlg. Co. No. 1 F. Andregg	SW¼ SW¼ NW¼ 11-8-26W	2,530	3,748	4,290‡	4,364
*Carl Todd Drlg. Co. et al. No. 1 Harris	SW¼ SW¼ SE¼ 35-8-27W	2,622	3,776	4,327‡	4,365
Anschutz Drlg. Co. et al. No. 1 Dally	SW¼ SW¼ SE¼ 10-8-30W	2,939	4,068	4,628‡	4,735
*Victor Drlg., Inc. No. 1 Baalman	SW¼ SW¼ SW¼ 3-9-30W	2,942	4,015	4,566‡	4,644
B & R Drlg., Inc. No. 1 Carder	NE¼ NE¼ SE¼ 2-10-26W	2,574	3,835	4,553	4,617
Victor Drlg., Inc. No. 1 Zerr	NE¼ NE¼ NW¼ 9-10-27W	2,694	3,852	4,662	4,680
Prime Drlg. Co. et al. No. 1 Falloon	SE¼ SE¼ NE¼ 19-10-27W	2,658	3,793	4,607	4,630
Armer Drlg. Co., Inc. et al. No. 1 Bieker	NW¼ NW¼ NE¼ 15-10-28W	2,745	3,852	4,670	4,691
Anschutz Drlg. Co. et al. No. 1 Rupp	NW¼ NW¼ NW¼ 21-10-28W	2,740	3,863	4,430‡	4,560

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.
‡ Depth to the top of the Mississippian, feet.

Company in their test on the Rupp farm in sec. 21, T. 10 S., R. 28 W.

The locations of the producing areas and dry wildcat tests are shown on Figure 4. The new pools are listed in Table 6. Oil production data are given in Table 66. Data on the dry wildcat tests are summarized in Table 60.

SHERMAN COUNTY

Wildcat wells have been drilled from time to time in Sherman County, but so far no oil or gas pool has been found.

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Exploration during 1952.—One new attempt to find production was made in Sherman County during 1952. Kingwood Oil Company and Aurora Gasoline Company tested to the Arbuckle dolomite on the Rauckmann farm in the SE¼ SE¼ NE¼ sec. 11, T. 8 S., R. 40 W. From an elevation of 3,707 feet above sea level, the following formations were encountered: Morrison clays, 2,547; Stone Corral anhydrite, 3,176; Herington limestone, 3,315; Ft. Riley limestone, 3,420; Topeka limestone, 4,184; Heebner shale, 4,330; Lansing-Kansas City group, 4,380; Marmaton group, 4,782; Cherokee group, 4,970; Mississippian strata, 5,200; and Arbuckle dolomite, 5,471 feet depth. A drill-stem test between 4,114 and 4,120 feet depth recovered some oil, but too much water to make a commercial well.

SMITH COUNTY

Wildcat wells have been drilled in Smith County from time to time, but as yet no oil or gas pool has been found.

Exploration during 1952.—One attempt to find production was made in Smith County during 1952. The rank wildcat test was put down by the Wakefield Drilling Company on the Stockton farm in the SW¼ SW¼ SW¼ sec. 26, T. 2 S., R. 15 W., to a total depth of 3,900 feet. From an elevation of 1,852 feet above sea level, this test is reported to have found the following formations: Topeka limestone, 2,772; Heebner shale, 3,003; Lansing limestones, 3,050; Mississippian strata, 3,670; "Hunton" limestone, 3,725; and Viola limestone, 3,785 feet depth. No shows of oil or gas were reported.

STAFFORD COUNTY

(Map Fig. 10)

The 1952 production from 123 pools: oil, 6,462,936 barrels, gas 1,373,846 thousand cubic feet. Wells drilled in 1952: oil 152, gas 4, dry 150, salt-water disposal 4, total 310 including 15 dry wildcats. New pools discovered: oil 23, gas 2, total 25. Pools combined 4.

Developments during 1952.—The same number of new oil and gas pools were discovered in Stafford County during 1952 as during 1951. Oil production increased by a little more than 126,000 barrels.

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TABLE 61.—*Dry wildcat tests drilled in Stafford County during 1952*

Company and farm	Location	Depth to top of Lans.-K.C., feet	Depth to top of Penn. basal congl., feet	Depth to top of Arbuckle, feet	Total depth, feet
Shelley-Miller Drlg., Inc. No. 1 Fair	SE¼ SE¼ SE¼ 23-21-11W	3,092	3,380	3,500	3,530
Walters Drlg. Co. No. 1 Hamilton	SE¼ SE¼ NE¼ 2-22-11W	3,133	3,426	3,534	3,564
The Palmer Oil Corp. No. 1 "A" Fair	NW¼ NW¼ NE¼ 8-22-11W	3,196	3,488	3,586	3,605
*Buick Drlg., Inc. No. 1 Beckerdite	NW¼ NW¼ SE¼ 11-22-11W	3,155	3,440	3,575	3,600
*Lewis Drlg. Co. No. 1 Herrell	SW¼ SE¼ NE¼ 34-22-11W	3,240	3,570	3,672	3,700
*Armer Drlg. Co., Inc. No. 1 Soeken	NW¼ NW¼ NW¼ 20-22-13W	3,447	....	3,850	3,901
Armer Drlg. Co., Inc. No. 1 Reed	SW¼ SW¼ SE¼ 12-23-11W	3,270	3,638	3,744	3,785
Armer Drlg. Co., Inc. No. 1 McGill	SE¼ NE¼ SW¼ 15-23-12W	3,365	3,680	3,817	3,892
Armer Drlg. Co., Inc. No. 1 Smolik	NE¼ NE¼ SW¼ 24-23-13W	3,454	3,782	3,918	3,969
Jackson Drlg. Corp. No. 1 Sutton	SE¼ SE¼ SW¼ 6-23-14W	3,568	....	4,072	4,105
John Lindas Oil, Inc. No. 1 Batchman	SW¼ SW¼ NE¼ 25-23-14W	3,569	3,939	4,062	4,075
*John Lindas Oil, Inc. No. 1 Asher	SW¼ SW¼ NE¼ 35-24-13W	3,591	....	4,184	4,210
K & E Drlg., Inc. et al. No. 1 Jenkins	SW¼ SW¼ SW¼ 9-25-12W	3,571	3,930	4,156	4,188
Westgate-Greenland Oil Co. No. 1 Roy Wilson	SW¼ NE¼ NE¼ 6-25-14W	3,752	4,129	4,396	4,440
*Alpine Oil & Royalty Co., Inc. No. 1 Wilson	SW¼ SW¼ NW¼ 19-25-14W	3,762	4,179	4,435	4,504

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

The new gas pools are the **Farmington West**, with an initial potential of more than 4.1 million cubic feet per day, and the **Hill**, with initial capacity of about 4.7 million cubic feet per day. The new oil pools are the **Brunselmeyer, Crissman, Crissman North, Curtis West, Grow West, Happy Valley, Helene, Hickman South, Hudson, Koelsch, Koelsch Southeast, Lincoln Northwest, Mt. View, North Star, Oscar West, Pleasant Grove, Rose Valley, St. John North, St. John Northwest, Strobel, Strobel Northwest, Syms Southeast,** and **Taylor.** The initial capacities of the discovery wells of these new oil pools ranged from the minimum (25 barrels per day) to the maximum (3,000 barrels per day) set

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by the State Corporation Commission. The Lansing-Kansas city group produces in 12 of the new pool discoveries and the Arbuckle dolomite in 9. One of the new oil pools, the **Grow West,** was found to be an extension of an older pool, **Hazel West,** and was combined before the end of the year.

Other pool combinations effective during 1952 are the **Mueller Northwest** with the **Mueller**, the **Drach Northwest** with **Gates South,** and the **Eric** with the **Dell East.**

Twelve new producing zones in old oil fields were described during 1952. The pertinent data on depth, production, and zone are listed in Table 7. Stafford County led all other Kansas Counties in this phase of development as it did in the number of new pools discovered during 1952.

Of the producing pools in Stafford County, 63 had at least one oil well completed during 1952. The **Fischer Northwest** pool had 10 oil wells and 3 dry holes; **Gates South** had 9 oil wells and 2 dry holes; **Eden Valley**, 8 oil wells and 2 dry holes; **Mueller,** 7 oil wells, 6 dry holes, and 1 salt-water disposal well; and **Smallwood,** 7 oil wells, 4 dry holes, and 1 salt-water disposal well.

Of 28 old wells worked over in Stafford County, 17 were converted to oil wells, 2 to gas wells, 2 to salt-water disposal, and 7 were dry. The gas wells added by working over old wells were in the **Bradbridge** and **Gates** pools.

Six of the 15 dry wildcat tests reported shows of oil or gas. Two tests specifically reported no shows. These are the Armer Drilling Company No. 1 McGill test in sec. 15, T. 23 S., R. 12 W. and the Armer No. 1 Smolik test in sec. 24, T. 23 S., R. 13 W. In the Jackson Drilling Corporation No. 1 Sutton test in sec. 6, T. 23 S., R. 14 W., some free oil was recovered in a test from 3,764 to 3,776 feet depth. Further testing resulted in too much water. The 15 dry wildcat tests are described in Table 61.

The new pools are listed in Table 6, the new producing zones in old fields in Table 7. Locations of producing areas and dry wildcat tests are shown on Figure 10. Oil production data are given in Table 66 and gas production data in Table 67.

STANTON COUNTY

(Map Pl. 2)

The 1952 production—all from the Hugoton Gas Area—not segregated as to counties. Wells drilled in 1952: total 7 (all gas).

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Developments during 1952.—Seven gas wells were added to the Stanton County part of the Hugoton Gas Area. Three of these wells were completed by the United Producing Company and the other four by Stanolind Oil and Gas Company. The initial potential of these new wells ranged from less than 0.5 million cubic feet to more than 12 million cubic feet per day.

Stanton County wells are shown on Plate 2. Gas production and the producing zones are listed under Hugoton in Table 67. Additional data on the Hugoton Gas Area are given in the chapter on natural gas.

STEVENS COUNTY

(Map Pl. 2)

The 1952 production—all from the Hugoton Gas Area—not segregated as to counties. Wells drilled in 1952: total 17 (all gas).

Developments during 1952.—Stevens County, lying in the south edge of the Kansas part of the Hugoton Gas Area, originally had 792 available locations for gas wells (one well per section). Gas wells have been drilled in every township in this county. At the beginning of 1952 approximately 50 locations were available for new wells; 17 new Permian gas wells were completed during the year.

Of the 17 new gas wells, 13 were completed by the Hugoton Production Company. The wells range in initial potential from 1.6 million to 42.9 million cubic feet of gas per day. The average initial potential of these new wells is more than 24 million cubic feet per day.

Stevens County wells are shown on Plate 2; gas production, the active area, and producing zones are shown under Hugoton in Table 67. Additional data on the Hugoton Gas Area are given in the chapter on natural gas.

SUMNER COUNTY

(Map Fig. 12)

The 1952 production from 31 pools: oil 1,811,250 barrels including 5,000 barrels from 1 secondary recovery project, gas not reported. Wells drilled in 1952: oil 27, dry 46, salt-water disposal 3, total 76 including 21 dry wildcats. New pools discovered 2, revived 1.

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TABLE 62.—*Dry wildcat tests drilled in Sumner County during 1952*

Company and farm	Location	Depth to top of "Stalnaker," feet	Depth to top of Mississippian, feet	Depth to top of Arbuckle, feet	Total depth, feet
Natl. Assoc. Petro. Co., No. 1 Zimmerman	SE¼ SW¼ SE¼ 32-31-1E	2,595	3,555	4,100	4,121
*The El Dorado Refg. Co. No. 1 Slack	NE¼ NW¼ SW¼ 14-31-2E	2,230	3,179	3,618	3,668
*Earl F. Wakefield No. 1 Messner	NE¼ NE¼ SW¼ 36-33-1E	2,547	3,577	....	3,640
*L. B. Jackson No. 1 J. O. Yeager	SE¼ SE¼ SE¼ 12-33-2E	2,230	3,263	....	3,330
*Herndon Drlg. Co. No. 1 Alcorn	SE¼ NE¼ NE¼ 33-34-1E	2,660	3,726	....	4,070
Frank Murton No. 1 Gurley	NE¼ NE¼ NE¼ 3-35-1E	2,555	3,720	....	4,062
Hill & Hill et al. No. 1 La Force	SE¼ NW¼ NW¼ 9-30-1W	2,565	3,462	....	3,851
*W. L. Hartman No. 1 Corn	SE¼ SE¼ SE¼ 19-30-2W	2,847	3,773	4.305	4,330
W. L. Hartman No. 1 Vesta Corn	NE¼ SE¼ SW¼ 19-30-2W	2,932	3,758	4,282	4,310
The Texas Co. No. 1 O. J. Ziegler	SW¼ SW¼ NE¼ 10-30-3W	2,883	3,790	4,378	4,410
*Jackson Drlg. Co. No. 1 Luella Stewart Estate	NW¼ NW¼ NW¼ 4-30-4W	3,200	4,012	....	4,114
Earl F. Wakefield No. 1 Proud	NW¼ NW¼ SW¼ 4-31-1W	2,675	3,622	4,073	4,100
*Alpine Oil & Royalty Co., Inc. No. 1 Lonnberg	SW¼ SW¼ NW¼ 14-31-1W	2,693	3,650	4,153	4,165
*Natl. Coop. Ref. Assn. No. 1 Dennison	S2 S2 SE¼ 10-31-2W	2,820	3,786	4,301	4,360
*Morrison Drlg. Co., Inc. No. 1 Botkin	NW¼ SW¼ SE¼ 26-31-2W	2,797	3,800	....	4,245
W. L. Hartman No. 1 Hamilton	NW¼ NW¼ SE¼ 6-31-4W	3,219	4,149	4,702	4,742
*Carl Hipple Oil Co. No. 1 Stewart Estate	SE¼ SE¼ SE¼ 35-32-4W	2,989	4,017	4,536	4,560
Dunne & Strait Drlg. Co. No. 1 Rohrer	SE¼ SE¼ SE¼ 22-33-3W	....	4,048	....	4,523
*Aylward Drlg. Co. No. 1 Koblitz	NE¼ SE¼ SW¼ 24-34-1W	2,814	3,905	4,402	4,445
Time Petro. Co. No. 1 City of South Haven	N2 NW¼ SW¼ 35-34-1W	2,860	3,934	4,406	4,434
The Texas Co. No. 1 M. E. Kloefkorn	SE¼ NW¼ NW¼ 33-34-3W	3,185	4,336	....	4,821

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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Developments during 1952. — Oil production in Sumner County increased by more than 150,000 barrels. Drilling activity in the county decreased comparatively, but the number of wildcat tests attempted increased.

The **Caldwell Northwest** pool was discovered by the Mid-Continent Petroleum Corporation No. 1 Seltzer test in sec. 8, R. 35 S., R. 3 W., where Simpson production was found. The **Caldwell** pool to the southwest also produces from Simpson rocks. The W. J. Coppinger No. 1 Brann-Martin test opened the **Slate Creek** pool, with Lansing production. The revived **Hunnewell** pool, which was discovered in April of 1927 and produced some gas from the Lawrence formation, was reopened by the Herndon Drilling Company No. 1 Kerr well in sec. 18, T. 35 S., R. 1 E., finding oil production in Mississippian strata. The test was carried to the Simpson sandstone, but later plugged back to the Mississippian.

Two new producing zones in older oil fields were officially described during the year. The Lansing-Kansas City group of rocks was designated as a new zone in the **Anson** pool, and the Arbuckle dolomite in the **Guelph** pool.

Eight of the 21 dry wildcat tests reported shows of oil or gas. The Texas Company test on the Ziegler farm in sec. 10, T. 30 S., R. 3 W., reported shows of oil in the Lansing-Kansas City group, Mississippian strata, and the Simpson sandstone. The National Cooperative Refinery Association No. 1 Dennison test in sec. 10, T. 31 S., R. 2 W., reported shows in the top portion of the Mississippian rocks. The Time Petroleum Company No. 1 City of South Haven test in sec. 35, T. 34 S., R. 1 W. had a show of oil at 3,568 feet depth in the "Layton sand."

The largest development program in the county during the year was in the **Guelph** pool, where 13 oil wells and 2 dry holes were completed. The other oil wells were scattered throughout the county.

The new and revived pools are listed in Table 6; new producing zones in old oil fields are given in Table 7. Locations of producing areas and dry wildcat tests are shown on Figure 12. Data on dry wildcats are given in Table 62. Oil production is listed in Table 66. Data on the one secondary recovery project, the Wellington unit, are given in Table 1.

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THOMAS COUNTY

The 1952 production from the county's first pool: oil 1,208 barrels. Wells drilled in 1952: oil 1, dry 4 (all wildcats), total 5. New pool discovered 1.

Developments during 1952.—During 1952, Thomas County was added to the Kansas oil producing counties. The county's first pool was discovered by Trans-Tex Drilling Company on the Keller farm in sec. 19, T. 9 S., R. 32 W. Drilled from an elevation of 3,109 feet above sea level to a total depth of 5,100 feet, the well ended in the Arbuckle dolomite. Commercial oil production was found in Mississippian strata from 4,680 to 4,684 feet depth. The new pool was named the **Mingo,** because of its proximity to the town of Mingo.

The electric log of the well as interpreted by William McHugh is as follows: Greenhorn limestone, 1,429; Dakota group, 1,575; Morrison formation, 2,128; Permian redbeds, 2,252; Cedar Hills sandstone, 2,387; Stone Corral dolomite, 2,650; Ft. Riley limestone, 3,071; Topeka limestone, 3,861; Heebner shale, 4,040; Lansing limestones, 4,079; Mississippian strata, 4,654; Viola limestone, 5,002; and Arbuckle dolomite, 5,042 feet depth.

Four dry wildcat tests drilled in Thomas County were unsuccessful. These tests are listed in Table 63. Three of the four tests stopped in Mississippian rocks. The Ashland Oil and Refining Company No. 1 Misner test in sec. 33, T. 8 S., R. 32 W. found a show of oil at 4,052 feet depth, in the Toronto limestone.

The new pool is described in Table 6, and oil production from the pool is given in Table 66.

TABLE 63.—*Dry wildcat tests drilled in Thomas County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of anhydrite, feet	Depth to top of Lans.-K.C., feet	Depth to top of Mississippian, feet	Total depth, feet
Ashland Oil & Refg. Co. No. 1 Misner	NE¼ NE¼ NE¼ 33-8-32W	3,082	2,680	4,088	4,664	5,033
Wycoff & Williams No. 1 B. Chase	NE¼ NE¼ SE¼ 1-9-33W	3,110	2,690	4,096	4,670	4,833
H. K. Riddle No. 1 Albers	NW¼ NW¼ NE¼ 26-10-32W	3,051	2,610	4,066	4,670	4,770
D. R. Lauck Oil Co., Inc. No. 1 Stover	SW¼ SW¼ NE¼ 29-10-35W	3,326	2,818	4,186	4,892	4,995

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

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TREGO COUNTY

(Map Fig. 9)

The 1952 production from 14 pools: oil 801,645 barrels. Wells drilled in 1952: oil 55, dry 50, salt-water disposal 2, total 107 including 27 dry wildcats. New pools discovered 5, combined 1.

Developments during 1952.—Drilling activity increased about 25 percent and production tripled. Wildcat activity was widespread, resulting in five new oil pools being discovered during the year. These new pools are the **Ellis South, Groff, Nieden, Ridgeway,** and **Sunny Slope.** Initial production in these new pools ranges from 42 to 248 barrels of oil per day. The discovery wells of these new pools are listed in Table 6. Four different formations, the Arbuckle dolomite, Mississippian strata, Pennsylvanian basal conglomerate, and Marmaton group, produce between drilling depths of 3,800 and 3,900 feet.

The Texas Company was successful in opening a new producing zone in an old oil field, the **Ridgeway,** with their completion of Lansing-Kansas City production in their No. 3 Schoenthaler well in sec. 26, T. 12 S., R. 21 W.

The **Ogallah** pool is the county's largest oil pool. During 1952, the **Ogallah West** pool, also producing from Arbuckle dolomite, was combined with the **Ogallah.** Eight dry holes and 36 oil wells were added in 1952. The extension wells ranged in size from less than 100 to 3,000 barrels of oil per day. The **Ogallah** pool accounted for 70 percent of Trego County's 1952 production.

Only 6 of the 27 dry wildcat tests indicated shows of oil or gas, and only 2 did not penetrate the Arbuckle dolomite. The Prime Drilling Company test on the Kircheck farm in sec. 7, T. 11 S., R. 22 W., had free oil in the Arbuckle dolomite at 3,920 feet depth, but not in sufficient quantities to make a well. The Bongarf test by Jones, Shelburne & Farmer in sec. 31, T. 13 S., R. 21 W. reported a good show of oil 75 feet above the top of the Arbuckle dolomite. The dry wildcats are listed in Table 64.

TABLE 64.—*Dry wildcat tests drilled in Trego County during 1952*

Company and farm	Location	Surface elevation, feet	Depth to top of anhydrite, feet	Depth to top of Lansing, feet	Depth to top of Arbuckle, feet	Total depth, feet
*Jones, Shelburne & Farmer Inc. No. 1 Monroe	NW¼ NW¼ NW¼ 8-11-21W	2,158	1,635	3,459	3,825	3,865
*Aurora Gasoline Co. No. 1 Osborn	SW¼ SW¼ NE¼ 9-11-21W	2,113	1,575	3,406	3,818	3,845

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Aurora Gasoline Co. No. 1 Osborn "A"	SE¼ SE¼ SW¼ 17-11-21W	2,262	1,740	3,569	3,968	3,986
*Aurora Gasoline Co. No. 1 Osborn-Monroe "A"	SW¼ SW¼ SE¼ 21-11-21W	2,297	1,650	3,608	4,033	4,070
Prime Drlg. Co. No. 1 Kircheck	NW¼ NW¼ NE¼ 7-11-22W	2,226	1,695	3,498	3,920	3,943
*Armer Drlg. Co., Inc. No. 1 Brown	SW¼ SW¼ SW¼ 24-11-25W	2,475	2,080	3,816	4,372†	4,444
*Armer Drlg. Co., Inc. No. 1 Weissbeck	SW¼ SW¼ SE¼ 33-11-25W	2,577	....	3,903	4,685	4,725
Peel-Hardman Oil Producers No. 1 Marquand	SE¼ SE¼ NE¼ 17-12-21W	2,287	1,719	3,588	3,975	4,025
Lee Phillips Oil Co. No. 1 Rinker	NW¼ NW¼ NW¼ 9-12-22W	2,369	1,805	3,654	4,093	4,143
Barnett Oil Co. No. 1 Benson	SW¼ NW¼ NW¼ 16-12-22W	2,360	1,790	3,663	4,126	4,156
*Lewis Drlg. Co. No. 1 Marquiss	NE¼ NW¼ NW¼ 18-12-22W	2,411	1,823	3,668	4,125	4,159
Graham-Messman-Rinehart Oil Co. No. 1 Hixson	SE¼ SE¼ NW¼ 11-12-23W	2,423	1,847	3,675	4,154	4,185
*Wick's Petro. Co. No. 1 Strain	NE¼ NW¼ NE¼ 27-12-23W	2,389	....	3,738	4,442	4,510
Victor Drlg., Inc. No. 1 Lorimer	SE¼ SE¼ SW¼ 26-12-25W	2,478	2,050	3,822	4,603	4,640
*Earl F. Wakefield et al. No. 1 Petty	NE¼ NE¼ SW¼ 19-13-21W	2,246	1,680	3,603	4,000	4,050
*Jones, Shelburne & Farmer Inc. No. 1 Bongarf	NW¼ NW¼ NE¼ 31-13-21W	2,356	1,773	3,732	4,205	4,230
*Jones, Shelburne & Farmer Inc. No. 1 Gilson	SE¼ SE¼ SE¼ 33-13-21W	2,267	1,650	3,623	4,036	4,067
Sohio Petro. Co. No. 1 Herman "B"	SE¼ SW¼ SW¼ 34-13-21W	2,280	1,660	3,628	4,044	4,200
*Don E. Pratt et al. No. 1 Hamburg	SE¼ NW¼ SE¼ 10-13-22W	2,299	1,743	3,699	....	4,100
*Maybrier & Castle No. 1 Mong	SW¼ SW¼ NE¼ 27-13-22W	2,316	1,880	3,711	4,254	4,300
Deep Rock Oil Corp. No. 1 Winona "A"	SW¼ SW¼ SW¼ 29-13-22W	2,420	1,880	3,815	4,458	4,535
Jones, Shelburne & Farmer Inc. No. 1 Waggoner	NE¼ NE¼ NW¼ 25-14-21W	2,121	1,440	3,497	3,884	3,935
*Jones, Shelburne & Farmer Inc. No. 1 Zerfas	SE¼ SE¼ SE¼ 9-14-22W	2,360	1,670	3,660	4,260	4,315
*Jones, Shelburne & Farmer Inc. No. 1 Deinse	NE¼ NE¼ SW¼ 15-14-24W	2,265	1,685	3,593	4,430	4,453
*Jones, Shelburne & Farmer Inc. No. 1 Abell	SW¼ SW¼ SW¼ 27-14-24W	2,196	1,610	3,528	4,340	4,410
Armer Drlg. Co., Inc. No. 1 Nicholson	SW¼ SW¼ SW¼ 4-15-21W	2,164	1,507	3,569	4,137	4,187
Kenneth A. Ellison No. 1 Ryan	SE¼ SE¼ NE¼ 21-15-22W	2,918	1,550	3,608	4,295	4,352

* No electric log available. Kansas Sample Log Service, Independent Oil & Gas Service, and other available data sources have been used.

† Depth to the top of the Mississippian, feet.

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Locations of producing areas and dry wildcat wells are shown on Figure 9. The new producing zone in the **Ridgeway** field is listed in Table 7. Oil production data are given in Table 66.

WABAUNSEE COUNTY

(Map Pl. 1)

The 1952 production from 5 fields: oil 333,294 barrels. Wells drilled in 1952 (reported): oil 1, dry 2 (wildcats), total 3.

Developments during 1952.—Oil production in Wabaunsee County was somewhat less than in 1951. For the first year since 1949 no pool was discovered in the county. Only two wildcat wells were drilled.

The Carter Oil Co. No. 1 Buchli well in the SE¼ SW¼ SE¼ sec. 2, T. 15 S., R. 10 E., in the **Woodbury** field, was rated as having an initial daily production of 122 barrels of oil. It was completed in October. One old well, the Alf M. Landon No. 1 Waugh, SE¼ SE¼ NW¼ sec. 11, T. 13 S., R. 12 E., was worked over but abandoned. The Carter Oil Co. No. 1 Davison well, SW¼ NW¼ SE¼ sec. 8, T. 14 S., R. 10 E., was drilled to a depth of 3,394 feet. These tops were reported: Lansing, 1,576; Kansas City, 1,720; Mississippian, 2,552; Kinderhookian, 2,860; "Hunton," 3,039; Maquoketa, 3,182; Viola, 3,260; Decorah, 3,324; and Simpson, 3,342 feet.

The second dry wildcat well drilled in Wabaunsee County in 1952 is the Valley Steel Company No. 1 Mayer, SE¼ SE¼ NW¼ sec. 32, T. 14 S., R. 10 E. The total depth is 3,396 feet with tops as follows: Lansing, 1,631; Kansas City, 1,790; Mississippian, 2,594; Kinderhookian, 2,910; "Hunton," 3,065; Maquoketa, 3,196; Viola, 3,261; and Simpson, 3,242 feet.

Locations of the two dry wildcat wells drilled in Wabaunsee County in 1952 and areas that produce oil are shown on Plate 1.

Oil production statistics in the Wabaunsee County fields are listed in Table 66.

WALLACE COUNTY

Wildcat wells have been drilled in Wallace County from time to time but so far no producing pool has been discovered.

Exploration during 1952.—During 1952 three tests were attempted in Wallace County. These are the first holes drilled in

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the county since 1945. Flynn Oil Company, F. W. Wyant, et al. made the first attempt in 1952 on the Pearce farm in the NW¼ NW¼ SW¼ sec. 4, T. 14 S., R. 42 W. The dry hole was drilled to a total depth of 5,063 feet, from an elevation above sea level of 3,354 feet. An interpretation of the electric log of this well is as follows: Stone Corral dolomite, 2,534; Topeka limestone, 3,708; Heebner shale, 3,894; Lansing limestones, 3,942; base of the Kansas City limestones, 4,323; Marmaton group, 4,338; Cherokee group, 4,514; and the Mississippian (Ste. Genevieve formation), 4,780 feet.

The year's second test in Wallace County was drilled by Rexall Drilling Company for Bigsby and McKubbin on the Hill lease in the Cen. SW¼ SE¼ sec. 36, T. 11 S., R. 42 W. The corrected elevation was given as 3,734 feet above sea level, and the well was drilled to a total depth of 5,215 feet. Important marker horizons encountered in drilling according to the electric log are: Lansing, 4,250; Cherokee, 4,715; Morrowan, 4,956; and Mississippian, 5,093 feet depth.

The third well, on the Worley farm in the SW¼ NE¼ SE¼ sec. 27, T. 12 S., R. 42 W., was drilled by H. K. Riddle. Top card information on this dry test is as follows: Morrison, 2,468; Blaine, 2,820; Stone Corral, 3,050; Lansing, 4,600; Marmaton, 4,890; Cherokee, 5,062; and Mississippian, 5,277 feet depth. No shows were encountered in drilling this test to a total depth of 5,590 feet.

WICHITA COUNTY

Wildcat wells have been drilled in Wichita County from time to time but so far no producing pool has been discovered.

Exploration during 1952.—During 1952 one dry wildcat test was drilled in Wichita County. The test was put down by the B & R Drilling Company on the Darbro ranch in the SW¼ SW¼ NE¼ sec. 32, T. 20 S., R. 38 W. Drilling to a total depth of 5,100 feet, from an elevation of 3,434 feet above sea level, the following marker horizons were encountered: Dakota group, 750; Morrison formation, 1,140; Blaine formation, 1,640; Stone Corral dolomite, 2,355; Krider dolomite, 2,898; Heebner shale, 4,099; Lansing limestones, 4,147; base of the Kansas City limestones, 4,462; Cherokee group, 4,698 (?); and Mississippian strata, 4,993 (?) feet depth.

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WILSON COUNTY

(Map Pl. 1)

The 1952 production: oil from 22 areas in 10 fields 67,271 barrels, gas 185,316 thousand cubic feet.

Developments during 1952.—Oil production in Wilson County was slightly less than in 1951. No wells were reported drilled during 1952.

Oil production in the various Wilson County fields is listed in Table 66, and gas in Table 67. Locations of areas that produced oil in 1952 are shown on Plate 1.

WOODSON COUNTY

(Map Pl. 1)

The 1952 production: oil from 19 fields 631,511 barrels, gas 41,732 thousand cubic feet. Wells drilled in 1952 (reported): oil 38, dry 21, total 59. New pools discovered 1.

Developments during 1952. — Oil production in Woodson County was slightly greater than in 1951. Gas production showed a decided increase over the amount reported in 1951. The **Steele,** a Mississippian limestone pool, was discovered in May 1952 by the Moreland and Harris No. 1 Steele well in the SW¼ NW¼ sec. 20, T. 23 S., R. 15 E. The initial potential of the discovery well was 15 barrels of oil. The reservoir in the upper part of Mississippian limestone lies from 1,525 to 1,542 feet in the discovery well. Two additional oil wells and two dry holes were drilled in the field during the year.

TABLE 65.—*Pool wells drilled in Woodson County during 1952*

Field or pool	Oil wells	Dry holes
Batesville	1	....
Hoagland	9	4
Jobes	....	1
Quincy	....	1
Steele	3	2
Toronto	....	1
Virgil North	....	1 (Temp. abandoned)
Weide	4	4
Winterscheid	19	7
Wissman	1	....
Yates Center	1	....
Total	38	21

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Data on pool wells drilled in Woodson County in 1952 are listed in Table 65. Statistics on secondary recovery operations in the county are listed in Table 1. Oil production in the various fields is listed in Table 66 and gas in Table 67. Locations of areas that produced oil in 1952 and of water-flooding projects are shown on Plate 1.

WYANDOTTE COUNTY

(Map Pl. 1)

The 1952 production: gas 4,920 thousand cubic feet.

Developments during 1952.—No oil was reported produced in Wyandotte County. The gas production came from 3 wells in the **Roberts-Maywood** area which extends into Leavenworth County.

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TABLE 66.—Oil production in Kansas during 1952

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
			ALLEN COUNTY				
Bronson-Xenia*	17-25-21E	2,400			24+	"Bartlesville"	700
a			79,904				
b			2,222				
Colony West* (1922)	15-23-18E	700			10+	"Squirrel"	820
a			2,111				
b			83,547				
Davis-Bronson*	24-21E	540			2+	"Bartlesville"	720
a			704				
b			6,861				
Elsmore Shoestring (1908)	5-26-21E	600	46,717		48+	"Bartlesville"	650
Elsmore West (1911)	12-26-20E	620			22+	"Bartlesville"	775
a			7,785				
b			295				
Humboldt-Chanute*	26-18E	12,000			277+	"Bartlesville"	850
a			13,264				
b			189,558				
c			5,514				
d			1,451				
e			4,715				
f			3,244				
g			23				
Iola	24-18E	3,600			25+	"Bartlesville"	850
a			92,473				
b			5,770				
c			2,852				
d			327				
e			311				
f			29,440				
Moran (1903)	25-20E	500			5+	"Bartlesville"	820
a			7,069				
b			2,147				
Neosho Falls* (1928)	29-23-17E	800	4,093		1+	"Squirrel" Mississippian	950 1,200
Seibert	5-26-20E	300	502		1+	"Bartlesville"	680
Miscellaneous			16,678				
Total Allen County		22,060	609,577	15,413,828 recorded	415+		
			ANDERSON COUNTY				
Bush City Shoestring (1921)	28-20-21E	4,200	338,296		568	"Squirrel"	620
Centerville* (1920)	10-21-22E	1,300	119,215		60+	"Squirrel" "Bartlesville"	480 720
Colony-Welda (1916)	4-23-19E	1,900			99+	"Weiser"	600
a			1,554			"Squirrel"	780
b			40,608				
Colony West* (1922)	15-23-18E	900			10+	"Squirrel"	825
a			4,028				
b			760				
c			9,049				
Garnett Shoestring (1904)	32-20-20E	1,000			168+	"Squirrel"	700
a			2,722			"Garnett"	800
b			11,870				
c			13,943				
Kincaid (1921)	10-23-21E	900			36+	"Bartlesville"	750
a			23,363				
b			4,353				

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Selma (1929)	9-22-21E	200	2,318		1+	"Bartlesville"	700
Miscellaneous			4,803				
Total Anderson County		10,400	576,882	14,910,963 recorded	942+		

BARBER COUNTY

Amber Creek (1952)	36-30-12W		no report	none		Mississippian	4,296
Amber Mills (1951)	15-30-12W		no report	none		Viola	4,480
Boggs (1946)	17-33-12W	1,250	260,481	1,649,237	32	Simpson	4,806
Clara* (1948)	36-29-14W	40	10,621	39,547	1	Simpson	4,472
Deerhead (1943)	22-32-15W	400	52,221	636,321	10	Viola	4,950
DeGeer (1948)	2-33-15W	600	12,941	734,680	16	Viola	5,176
Gerlane (1950)	29-33-11W	40	5,913	14,837	1	"Miss. chat"	4,530
Lake City (1937)	7-31-13W	200	2,430	298,900	2	Viola	4,435
						Simpson	4,530
						Arbuckle	4,607
Medicine Lodge (1937)	13-33-13W		no report	45,703		"Misener"	4,845
Rhodes (1949)	15-33-11W	1,000	245,676	529,980	25	Mississippian	4,551
						Viola	4,803
Skinner (1943)	29-31-14W	800	102,261	1,666,081	25	Viola	4,626
						Simpson	4,422
Skinner North	29-31-14W	1,600	Included with Skinner			Viola	
						Arbuckle	
Stumph (1952)	7-32-14W	40	4,706	4,706	1	Simpson	4,963
Sun City (1941)	35-30-15W	640	62,845	1,496,157	13	Lans.-K.C.	4,344
Turkey Creek (1943)	20-30-15W	40	2,723	51,964	1	Lans.-K.C.	4,345
						Simpson	4,438
Turkey Creek North (1952)	17-30-15W	40	2,805	2,805	1	Penn. congl.	4,541
Whelan (1934)	32-31-11W	1,200	221,202	2,561,813	26	"Chat"	4,355
Pools or fields abandoned				3,270			
Total Barber County		7,850	986,825	9,736,001 recorded	154		

BARTON COUNTY

Ainsworth South (1937)	10-17-13W	2,000	165,189	3,617,364	66	Lans.-K.C.	3,170
						Arbuckle	3,390
Alefs (1952)	14-19-14W	80	17,247	17,247	2	Lans.-K.C.	3,334
						Arbuckle	3,474
Ameh (1951)	19-18-11W	80	15,097	25,349	2	Lans.-K.C.	3,103
Ames (1943)	22-18-11W	1,000	170,448	1,254,913	32	Lans.-K.C.	3,042
						Arbuckle	3,348
Ames Northwest (1947)	9-18-11W	80	4,109	14,492	2	Lans.-K.C.	3,106
						Arbuckle	3,312
Anton (1950)	28-19-11W	80	850	7,386	2	Arbuckle	3,342
Ash Creek* (1947)	31-20-15W	540	7,908	469,508	9	Arbuckle	3,787
Axman (1949)	19-17-14W	120	17,400	97,405	3	Arbuckle	3,400
Barrett (1943)	36-16-14W	800	29,639	153,468	8	Lans.-K.C.	3,355
						Arbuckle	3,463
Bart-Staff* (1951)	4-21-14W	400	95,512	132,805	11	Lans.-K.C.	
						Arbuckle	3,572
Batchman (1950)	19-20-12W	80	8,514	25,816	2	Arbuckle	3,459
Beaver (1934)	16-16-12W	1,200	59,293	2,996,248	33	Oread	2,885
						Toronto	2,938
						Arbuckle	3,348
						Reagan	3,335
Beaver North (1937)	4-16-12W	300	29,203	619,915	9	Arbuckle	3,316
Beaver Northwest (1942)	6-16-12W	Combined with Hall-Gurney					
Beaver South (1945)	27-16-12W	1,500	130,944	527,366	24	Socy	
						Arbuckle	3,359
Behrens (1944)	6-20-15W	950	37,642	541,999	19	Arbuckle	3,719
Bergtal (1941)	22-20-15W		no report	2,333		Arbuckle	
Bergtal South (1951)	27-20-15W		no report	108		Arbuckle	3,775
Bernard (1950)	10-19-11W	320	101,202	139,196	13	Shawnee	2,866
						Lans.-K.C.	3,224
						Arbuckle	
Bieberle (1952)	4-19-11W	40	931	931	1	Arbuckle	3,395

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Blood Creek (1950)	9-18-13W	40	no runs	2,077	1	Lans.-K.C.	3,078
Bloomer* (1936)	36-17-11W	1,170	315,071	10,537,728	67	Lans.-K.C.	3,044
						Arbuckle	3,257
Bloomingdale (1950)	8-18-11W	40	no runs	4,692	1	Arbuckle	3,366
Boyd (1942)	4-18-14W	3,840	785,174	5,016,369	115	Lans.-K.C.	3,177
						Arbuckle	3,438
						Pre-Cambrian	3,311
Boyle (1950)	17-17-14W	Combined with Carroll					
Bryant Southeast (1949)	26-20-12W	Combined with Chase-Silica					
Buckbee (1949)	14-20-12W	40	3,635	14,527	1	Arbuckle	3,352
Buckbee Southwest (1952)	15-20-12W	40	1,194	1,194	1	Arbuckle	3,373
Capitol View (1950)	9-17-14W	40	2,692	10,028	1	Lans.-K.C.	3,230
Carroll (1944)	21-17-14W	2,000	268,596	1,865,323	45	Lans.-K.C.	3,109
						Arbuckle	3,356
Carroll Southwest (1947)	32-17-14W	80	6,128	47,534	4	Lans.-K.C.	3,193
Chase-Silica* (1931)	32-19-9W	17,680	961,148	52,011,933	442	Lans.-K.C.	2,955
						Arbuckle	3,328
Cheyenne View (1949)	12-19-12W	1,280	308,948	818,438	53	Lans.-K.C.	3,152
						Arbuckle	3,390
						Penn. congl.	3,393
Cheyenne View North(1950)	1-19-12W	Combined with Cheyenne View					
Dartmouth (1951)	27-19-12W	Combined with Fort Zarah					
Dartmouth Northwest(1951)	28-19-12W	Combined with Fort Zarah					
Davidson* (1930)	4-16-11W	80	5,309	240,450	2	Lans.-K.C.	3,016
						Sooy	3,317
						Arbuckle	3,314
Dundee (1945)	29-20-14W	80	1,335	13,652	2	Arbuckle	3,507
Eberhardt (1935)	14-19-11W	320	14,572	422,433	7	Lans.-K.C.	3,194
Ellinwood North (1937)	33-19-11W	40	2,054	85,179	1	Arbuckle	3,328
Esfeld (1947)	15-16-11W	40	337	7,875	1	Arbuckle	3,343
Eveleigh (1943)	11-18-14W	Combined with Boyd					
Feltes Northwest (1945)	3-16-12W	400	45,041	395,579	7	Arbuckle	3,342
Fort Zarah (1950)	30-19-12W	3,200	937,525	1,269,645	106	Lans.-K.C.	3,157
						Arbuckle	3,384
Fort Zarah North (1951)	19-19-12W	320	32,067	38,061	5	Lans.-K.C.	3,208
Frank (1952)	7-19-12W	80	1,332	1,332	2	Lans.-K.C.	3,322
Fransen (1949)	6-20-12W		no report	295		Lans.-K.C.	3,196
Great Bend Airport (1952)	26-19-14W	640	100,852	100,852	12	Lans.-K.C.	3,320
						Arbuckle	3,473
Great Bend East (1951)	34-19-13W	40	949	949	1	Lans.-K.C.	3,234
Great Bend Southwest (1952)	25-19-14W	200	26,701	26,701	5	Lans.-K.C.	3,322
Great Bend West (1951)	23-19-14W	120	22,755	25,046	3	Lans.-K.C.	3,332
Hagan (1938)	20-20-11W	160	24,136	416,450	6	Arbuckle	3,323
Hall-Gurney* (1931)	30-14-13W	640	246,981	1,166,648	28	Shawnee	
						Lans.-K.C.	3,066
						Sooy	
						Arbuckle	
Hammeke (1950)	17-19-11W	120	20,183	66,006	3	Lans.-K.C.	3,065
Hammeke Southeast (1950)	17-19-11W	120	14,497	49,486	3	Lans.-K.C.	3,089
Hammer (1940)	35-19-12W	760	164,720	566,111	20	Lans.-K.C.	3,088
						Arbuckle	3,348
Hammer North (1949)	23-19-12W	1,280	227,530	1,002,556	59	Lans.-K.C.	3,222
						Arbuckle	3,344
						Penn. congl.	3,407
Harrison (1951)	18-20-13W	40	2,001	4,160	1	Arbuckle	3,520
Hawkins (1952)	3-19-13W	40	3,721	3,721	1	Lans.-K.C.	3,158
						Arbuckle	3,393
Heizer (1935)	16-19-14W	40	2,079	46,647	1	Lans.-K.C.	3,228
Heizer Northeast (1952)	15-19-14W	80	5,557	5,557	2	Lans.-K.C.	3,353
Hiss (1936)	31-20-13W	240	17,840	603,787	6	Lans.-K.C.	3,270
Hiss East (1952)	33-20-13W		no report	none		Arbuckle	3,549

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Hiss South (1950)	31-20-13W	120	18,019	46,500	3	Arbuckle	3,542
Hiss Southeast (1948)	32-20-13W	320	22,660	122,647	8	Lans.-K.C.	3,414
						Arbuckle	3,545
Hiss West (1945)	36-20-14W	Combined with Pritchard					
Hoisington (1938)	21-17-13W	640	98,695	1,246,020	34	Lans.-K.C.	3,222
						Arbuckle	3,440
Homestead (1948)	22-18-13W	40	1,177	12,720	1	Arbuckle	3,310
Kaufman* (1947)	33-15-12W		no report	6,026		Lans.-K.C.	
						Arbuckle	3,311
						Pre-Cambrian	
Klepper (1951)	2-19-11W	640	56,511	59,150	9	Lans.-K.C.	3,220
Klug (1946)	28-17-13W	80	3,205	38,315	2	Arbuckle	3,414
Klug North (1948)	27-17-13W	120	15,827	92,500	3	Arbuckle	3,377
Kowalsky* (1941)	32-20-11W	900	198,885	768,646	28	Lans.-K.C.	3,135
						Arbuckle	3,378
Kowalsky Northwest (1947)	30-20-11W	Combined with Kowalsky					
Kraft-Prusa*(1937)	10-17-11W	25,200	5,270,487	65,638,562	782	Shawnee	2,885
						Douglas	2,997
						Lans.-K.C.	3,160
						Arbuckle	3,281
						Reagan	3,310
						Gorham	3,335
						Pre-Cambrian	
Kraft-Prusa Northeast (1941)	36-16-11W	260	23,837	319,250	7	Lans.-K.C.	3,250
						Arbuckle	3,351
Kramp (1952)	7-19-11W	80	1,581	1,581	2	Arbuckle	3,351
Lake Barton (1948)	21-18-13W		no report	6,861		Arbuckle	3,372
Lanterman (1934)	15-19-11W	860	29,096	895,963	11	Lans.-K.C.	3,109
						Arbuckle	3,235
Larkin (1951)	10-17-14W	200	25,732	57,439	5	Lans.-K.C.	3,280
Laudick (1948)	28-16-12W	Combined with Beaver South					
Leoville (1950)	7-17-14W	640	176,061	334,036	20	Lans.-K.C.	3,267
						Arbuckle	3,464
Liberty (1952)	23-20-14W		no report	none		Lans.-K.C.	3,341
Lott (1952)	26-16-12W	Combined with Beaver South					
Mary Ida* (1950)	31-18-10W	320	109,672	148,126	11	Lans.-K.C.	3,033
						Arbuckle	3,272
Mary Ida North (1952)	25-18-11W	40	241	241	1	Arbuckle	3,304
McCauley (1949)	34-17-13W	100	no runs	16,733	3	Lans.-K.C.	3,276
Meadowside (1949)	24-18-11W	100	32,532	122,569	4	Lans.-K.C.	3,079
						Arbuckle	3,284
Merten Northeast (1946)	36-18-15W	40	1,560	16,262	1	Arbuckle	3,494
Merten Southeast (1949)	12-19-15W	40	7,962	20,272	1	Reagan	3,567
Odin (1948)	3-17-12W	80	15,525	77,848	4	Arbuckle	3,321
Otis-Albert* (1935)	30-18-15W	7,000	360,235	4,361,659	105	Reagan	3,601
Pawnee Rock* (1936)	13-20-16W	500	2,532	207,000	6	Arbuckle	3,832
Pawnee Rock East (1941)	17-20-15W	40	1,244	25,489	1	Arbuckle	3,814
Peach (revived)(1952)	25-16-14W	40	1,289	1,289	1	Lans.-K.C.	3,373
Prairie View (1950)	20-19-11W	320	61,054	158,150	7	Lans.-K.C.	3,080
Pritchard (1944)	34-20-14W	1,280	185,795	1,891,415	29	Simpson	3,525
						Arbuckle	3,455
Putnam (1951)	7-17-13W	160	30,608	32,877	4	Lans.-K.C.	3,286
Putnam West (1951)	1-17-14W	80	14,080	15,255	2	Lans.-K.C.	3,225
Redwing (1950)	31-17-12W	320	43,860	86,265	9	Lans.-K.C.	3,083
						Arbuckle	3,335
Redwing South (1952)	6-18-12W	40	3,127	3,127	1	Arbuckle	3,325
Reif South (1950)	31-16-12W	80	7,672	20,494	3	Lans.-K.C.	3,172
Rick* (1936)	1-19-11W	900	61,698	993,633	19	Lans.-K.C.	3,106
						Arbuckle	3,355
Roesler (1943)	14-18-11W	40	2,700	40,733	1	Arbuckle	3,291
Roesler East (1950)	13-18-11W	640	117,394	233,696	14	Arbuckle	3,294
Rolling Green (1948)	36-20-13W	80	217	16,333	2	Lans.-K.C.	3,257
Rolling Green East (1949)	30-20-12W	80	1,304	7,955	2	Arbuckle	3,491
Rowland (1949)	32-17-13W	40	1,458	8,466	1	Arbuckle	3,323
Rusco (1950)	8-19-12W	40	1,279	6,424	1	Arbuckle	3,417
Sadie (1951)	12-18-11W	40	2,750	2,968	1	Arbuckle	3,276
St. Peter (1944)	5-19-11W	80	9,114	107,437	2	Lans.-K.C.	
						Arbuckle	3,387
Sandford (1951)	25-17-14W	160	12,945	21,437	4	Arbuckle	3,375

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Sandrock (1951)	21-20-13W	40	1,125	2,519	1	Lans.-K.C.	3,412
Sandrock South (1952)	28-20-13W	160	8,616	8,616	5	Lans.-K.C.	3,418
Silica South* (1935)	24-20-11W	3,000	1,992,828	21,903,700	140	Lans.-K.C.	3,035
						Arbuckle	3,268
Sunflower (1949)	8-17-12W		no report	1,969		Arbuckle	3,376
Sunny Valley (1949)	7-20-12W	200	40,016	257,525	6	Lans.-K.C.	3,230
Trapp* (1936)	23-15-14W	13,700	2,308,802	45,854,630	432	Shawnee	2,889
						Dodge	2,966
						Lans.-K.C.	3,062
						Arbuckle	3,252
Underwood (1950)	15-17-13W	80	1,502	7,537	2	Arbuckle	3,342
Unruh (1945)	24-20-15W	500	10,826	131,354	6	Lans.-K.C.	3,442
						Arbuckle	3,641
Walnut Creek (1952)	8-19-13W	40	2,180	2,180	1	Lans.-K.C.	3,347
Wearne (1951)	4-20-12W	40	2,739	5,192	1	Arbuckle	3,384
Werner-Robl (1951)	30-19-11W	120	35,769	61,330	5	Lans.-K.C.	3,106
						Arbuckle	3,364
Werner-Robl Northwest (1951)	24-19-12W	40	1,457	4,577	1	Lans.-K.C.	3,092
Werner-Robl South (1951)	30-19-11W	40	3,937	6,521	1	Arbuckle	3,347
Workman (1944)	33-20-12W	40	2,200	24,939	1	Arbuckle	3,407
Zink* (1950)	13-18-11W	320	51,974	59,128	8	Arbuckle	3,284
Pools or fields abandoned				155,557			
Total Barton County		106,000	16,959,379	234,310,513 recorded	3,018		
			BOURBON COUNTY				
Bronson-Xenia*	17-25-21E	700	37,443		10+	"Bartlesville"	665
Davis-Bronson*	23-21E	80			2+	"Bartlesville"	560
a			465				
b			99				
Hepler* (1917)	27-22E	400	18,977		5+	"Bartlesville"	
Total Bourbon County		1,180	56,984	697,937 recorded	17+		
			BROWN COUNTY				
Livengood (1944)	3-1-15E	640	5,001	84,124 recorded	1	"Hunton"	2,580
			BUTLER COUNTY				
Allen-Robison (1943)	1-26-3E	1,300	48,328		32	Mississippian	2,700
Augusta (1914)	21-28-4E	6,400	339,068	37,225,161	159	Lansing	1,700
						Kansas City	2,000
						Marmaton	2,200
						Ordovician	2,445
						Arbuckle	2,600
Augusta North (1914)	28-27-4E	1,200	107,918	14,540,469	63	Lansing	1,650
						Kansas City	1,950
						Ordovician	2,380
						Arbuckle	2,410
Bare (1952)	31-28-5E	80	1,332	1,332	2	"Bartlesville"	2,778
Bausinger (1929)	24-27-3E	80	5,206		2	"Wilcox"	3,050
Benton (1925)	26-3E	40	2,485		1	Miss. "chat"	2,965
Blankenship* (1921)	26-8E	1,200		1,760,208	87+	"Bartlesville"	2,650
a			568,040				
b			12,555				
c			16,651				

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Brandt-Sensenbaugh (1925)	22-28-7E	1,800		1,791,977	35	Miss."chat"	2,692
a			49,242				
b			4,630				
Brickley (1951)	2-27-7E	160	39,885	46,724	6	"Bartlesville"	2,636
Brickley Southwest (1952)	3-27-7E	40	1,705	1,705	1	"Bartlesville"	2,699
Butwick* (1949)	7-26-3E	320	12,848	67,109	5	Mississippian	2,860
Butwick Northeast (1949)	7-26-3E	40	306	4,269	1	Miss. "chat"	2,820
Combs* (1947)	5-30-5E	320	17,406		5	"Bartlesville"	2,820
						Mississippian	2,850
Combs Northeast (1948)	27-29-5E	100	4,149	24,823	3	"Bartlesville"	2,810
DeMoss (1934)	8-28-7E	600	21,522		22	"Bartlesville"	2,650
						"Burgess"	2,680
Dixon (1946)	12-27-6E	40	1,312	11,279	1	Kansas City	2,160
						Mississippian	
Douglass (1916)	21-29-4E	160	6,494		4	Lans.-K.C.	1,790
						Ordovician	3,000
Eckel (1940)	7-27-7E	80	1,135	59,288	3	Lans.-K.C.	2,190
Edgecomb (1951)	9-25-3E	60	4,603	5,478	2	Mississippian	2,759
Elbing* (1918)	18-23-4E	1,800		4,385,314	83	Kansas City	2,120
a			529,847			Mississippian	2,400
b			34,759			Viola	2,530
c			1,838				
Elbing East (1950)	27-23-4E	300	5,875	25,389	4	Lans.-K.C.	1,799
El Dorado (1915)	29-25-5E	16,500		211,333,902	1,853	Lansing	1,700
a			3,413,206			Kansas City	2,000
b			24,618			Viola	2,500
						Simpson	2,510
						Arbuckle	2,550
Ferrell (1939)	28-28-8E	1,000	130,051	1,119,010	37	Mississippian	2,647
Four Mile Creek (1951)	5-28-3E	320	33,340	79,511	9	Simpson	3,069
Fox-Bush (1917)	24-29-5E	6,500		2,709,829	107	"Bartlesville"	2,730
a			74,172				
b			212,890				
Garden (1925)	32-26-6E	800	46,605		25	"Bartlesville"	2,760
Guyot (1948)	5-29-5E	80	623	11,890	2	"Bartlesville"	2,800
Hannah (1936)	29-8E	40	2,814	14,162	1+	Kansas City	2,120
Hartenbower (1950)	16-29-6E	80	5,414	14,861	2	"Peru"	2,404
Hartenbower South (1951)	16-29-6E		no report	64		Lans.-K.C.	2,060
Haverhill (1927)	34-27-5E	1,600	49,751	4,366,307	55	"Bartlesville"	2,700
Hazlett	24-5E	1,800	304,014	875,360	89	Mississippian	2,480
Hickory Creek (1946)	11-28-5E	320	69,243	833,232	30	"Bartlesville"	2,685
						Mississippian	2,700
Joseph (1947)	18-24-5E	40	no report	4,069	1	Miss. "chat"	2,491
Keighley (1925)	22-27-7E	1,200	23,084		14	"Bartlesville"	2,650
						Simpson	3,148
Kramer-Stern (1926)	3-28-6E	1,900	304,554		71	Simpson	3,020
						Arbuckle	3,040
"Lanier"	35-26-7E	40	6,856		1+		
Leon (1922)	19-27-6E	800	28,853	2,463,610	23	Miss. "chat"	2,660
						Viola	3,050
Long (1949)	15-26-7E	80	2,859	11,833	2	Mississippian	2,780
Lucas (1946)	6-27-8E	80	5,231	22,065	3	"Bartlesville"	2,680
McCullough (1929)	1-28-6E	40	3,158	491,485	1	"Wilcox"	3,169
Muddy Creek (1950)	13-29-4E	600	74,505	131,722	10	"Bartlesville"	2,813
Murdock (1952)	23-25-3E	40	2,105	2,105	1	Mississippian	2,709
Parsley (1949)	3-26-3E	280	17,353	81,816	6	Mississippian	2,710
Pettit (1926)	17-28-6E		no report			"Wilcox"	3,180
Pierce (1926)	28-25-4E	700	94,864		29	Miss. "chat"	2,550
Pierce West (1951)	20-25-4E	180	7,551	12,846	4	Mississippian	2,515
Potwin (1917)	31-24-4E	5,200	193,797	7,712,199	111	Kansas City	2,550
						Mississippian	2,660
Reynolds-Schaffer (1922)	9-27-6E	1,860	107,960		37	Kansas City	2,375
						Mississippian	2,780
						Viola	3,141
Rombold (1949)	4-26-3E	180	6,409	23,318	3	Mississippian	2,770
Salter (1946)	23-28-3E	360	123,211	1,071,115	32	Simpson	3,000
Semisch (1947)	4-29-6E	640		503,289	52	"Bartlesville"	2,810
a			236,620				
b			56,607				

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Seward (1926)	27-27-7E	320	23,253	1,069,376	16	"Bartlesville"	2,650
Shinn (1946)	19-29-8E	640	48,643	490,847	9	Mississippian	2,766
Smock-Sluss (1917)	2-27-5E	1,900	85,413		56	"Bartlesville"	2,700
						Viola	3,000
Snowden-McSweeney (1930)	34-28-6E	640	105,112		8	Mississippian	2,833
Steinhoff (1926)	28-29-6E	80	2,247		2	Mississippian	2,803
Towanda (1948)	5-26-4E	320	263,393	1,050,754	31	Mississippian	2,400
						Viola	2,460
Whitewater (1949)	32-25-4E	320	53,933	224,660	3	Viola	2,625
Whitewater North (1951)	29-25-4E	40	1,874	6,020	1	Viola	2,700
Womack (1947)	19-28-6E	40	1,366		1+	"Bartlesville"	2,620
						Kansas City	2,190
Young (1920)	27-26-7E	980			45	Mississippian	2,650
a			65,105				
b			11,793				
Miscellaneous			619				
Total Butler County		64,660	8,164,208	379,831,847 recorded	3,304+		
CHASE COUNTY							
Atyeo* (1925)	30-21-10E	300	4,944		1+	"Bartlesville"	2,250
Bazaar (1951)	36-20-8E	160	257		1+	Lans.-K.C.	1,823
Teeter* (1920)	16-23-9E	900	25,428		23+	"Bartlesville"	2,500
Total Chase County		1,360	30,629	174,256 recorded	25+		
CHAUTAUQUA COUNTY							
Borroum (1926)	20-34-9E	80	3,953		1+	Marmaton	1,780
Brown-Sturgis	33-11E		no report				
Elgin	34-10E	3,000			20+	"Peru"	1,520
a			2,542				
b			368				
c			20,297				
d			1,614				
e			1,518				
f			8,991				
Frazier	33-13E	600			2+	"Peru"	1,520
a			708				
b			871				
Hale-Inge* (1907)	32-12E	1,300			2+	"Peru"	1,160
a			2,656				
b			6,744				
Hylton			no report				
Kingston (1926)	18-32-11E	320	1,394		1+	Miss. "chat"	1,850
						Arbuckle	2,176
Landon-Floyd (1936)	23-32-10E	800	22,955		5+	Mississippian	2,000
McAllister (1925)	28-32-10E	300	10,615		5+		
McGlassen (1947)	11-33-9E		no report				
Malone	18-32-10E	40	542		1+	Ordovician	2,340
Miotaze	34-13E	400	4,537		1+	"Redd"	690
						"Peru"	825
Oliver (1935)	32-11E	700	14,175		5+		
Peru-Sedan (1900)	34-11E	30,000			175+	"Peru"	1,200
a			362,889			Mississippian	2,000
b			82,248				
c			9,645				
d			1,238				
e			4,379				

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f			29,430				
g			119,046				
h			17,723				
i			7,280				
j			629				
k			32,931				
l			13,072				
m			774				
n			769				
o			2,467				
Wauneta	34-9E	320	2,252		2+	"Peru"	1,670
						Mississippian	2,100
Wayside-Havana* (1904)	34-13E	500			5+	"Wayside"	575
a			91			"Weiser"	700
b			462			"Bartlesville"	1,200
c			1,974				
Wiggam	34-32-10E	200	3,401		1+	"Weiser"	1,600
Miscellaneous			1,526				
Total Chautauqua County		38,560	798,706	43,115,477 recorded	226+		
			CHEYENNE COUNTY				
Judy (1951)	26-1-39W		no report	none		Marmaton	4,497
			CLARK COUNTY				
Ashland (1951)	35-32-23W	80	13,043	19,456	2	Viola	6,526
						Lans.-K.C.	4,673
			CLAY COUNTY				
Wakefield (1951)	21-9-4E		no runs			Mississippian	1,904
Wakefield Northeast (1951)	15-9-4E		no runs			Mississippian	1,793
			COFFEY COUNTY				
Dunaway* (1922)	34-22-13E	850	13,839		5+	"Burgess"	1,850
						Mississippian	1,878
						Ordovician	2,200
Leroy (1905)	35-22-16E	160			2+		
a			82				
b			1,086				
Van Noy (1917)	7-23-15E	800	10,015		5+	"Peru"	1,170
						Mississippian	1,540
Virgil North* (1920)	22-23-13E	1,200			20+	"Bartlesville"	1,585
a			44,143			Mississippian	1,838
b			248				
Winterscheid* (1920)	23-14E	600			10+	"Bartlesville"	1,630
a			4,738			Mississippian	1,750
b			9,357				
Miscellaneous			2,143		2+		
Total Coffey County		3,610	85,651	1,276,042 recorded	44+		
			COWLEY COUNTY				
Arkansas City West (1952)	23-34-3E	40	8,460	8,460	1	"Bartlesville"	3,291
Baird (1925)	17-34-3E	400	15,431		5	"Bartlesville"	3,285
						Mississippian	3,350
Baird East (1940)	15-34-3E	160	4,101		4	"Bartlesville"	3,200
Bergkamp (1952)	6-35-4E	460	90,512	90,512	13	"Bartlesville"	3,202
Bergkamp Northwest (1952)	6-35-4E	40	525	525	1	"Bartlesville"	3,208
Biddle (1922)	7-32-5E	500	15,052		16	Kansas City	2,000
						"Stalnaker"	2,300

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Table 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Bogner (1952)	24-31-5E	40	1,450	1,450	1	Mississippian	2,999
Box (1948)	28-30-7E	320	27,387	139,363	11	Mississippian	2,840
Brown (1922)	13-31-7E	80	1,474	246,000	2	Kansas City	2,100
Bruce (1950)	9-30-4E	80	11,835	24,195	2	Arbuckle	3,306
Burden (1926)	31-31-6E	700	25,615		34	"Bartlesville"	2,900
Cabin Valley (1952)	31-33-6E	80	2,725	2,725	2	"Layton"	2,188
Canfield (1952)	13-34-3E	40	3,137	3,137	1	"Bartlesville"	3,375
Clark (1914)	6-31-4E	180	7,807		6	"Bartlesville"	2,840
Clover	31-7E		no runs	19,355		Kansas City	2,200
						Mississippian	2,800
Combs* (1947)	5-30-5E	320	35,154	326,977	12	"Bartlesville"	2,823
						Mississippian	2,850
Copeland (1952)	5-35-4E	40	117	117	1	Mississippian	3,211
Couch (1937)	13-30-5E	800	77,196	1,873,221	50	"Bartlesville"	2,800
Countryman (1925)	4-33-7E	600	10,338		9	"Layton"	1,950
						Mississippian	2,870
David (1935)	35-30-4E	640	149,104	1,288,818	37	"Bartlesville"	2,900
David South (1934)	11-30-4E	300	17,531	210,900	6	"Bartlesville"	2,760
						Arbuckle	3,463
Deichman (1941)	24-31-4E	400	28,438	839,098	27	"Bartlesville"	2,900
						Mississippian	3,000
Dexter (1914)	33-6E	40	1,946		1	Mississippian	2,750
Doane (1947)	36-33-6E	80	817	11,225	1	Mississippian	2,878
						Arbuckle	3,140
Dutch Creek (1952)	35-31-4E	40	198	198	1	"Bartlesville"	2,924
Eastman (1924)	5-31-6E	800	46,583		26	"Bartlesville"	2,890
Elrod	4-32-5E	40	3,196		1	"Layton"	2,411
Enterprise (1948)	35-33-3E		no runs			"Bartlesville"	3,285
Enterprise Northeast (1952)	35-33-3E	160	6,071	6,071	3	"Bartlesville"	3,335
Esch (1928)	33-33-6E	40	11,900		1+	"Bartlesville"	2,900
Falls City (1916)	35-7E	320	2,644	1,272,687	7	"Layton"	2,000
Ferguson Northwest (1950)	16-30-8E	120	2,295	9,457	3	Kansas City	2,200
Ferguson West (1934)	21-30-8E	120	890		3	Kansas City	2,180
Frog Hollow (1937)	20-32-5E	1,000	147,681	4,272,963	45	"Bartlesville"	3,000
Frog Hollow East (1941)	15-32-5E	500	10,516	257,679	5	"Bartlesville"	3,000
Fussell (1952)	14-34-3E	40	240	240	1	"Bartlesville"	3,348
Geuda Springs	5-34-3E	500	31,181	554,498	18	"Bartlesville"	3,300
						Miss. "chat"	3,345
Gibson (1941)	29-34-3E	600	229,689	611,376	43	"Bartlesville"	3,350
						Mississippian	3,400
Gibson South (1952)	32-34-3E	Combined with Gibson					
Graham (1924)	3-33-3E	640	26,512	2,778,191	15	"Layton"	2,550
						Arbuckle	3,518
Grand Summit* (1926)	4-31-8E	160	400		9	Kansas City	2,000
Grouse Creek (1951)	16-30-7E	40	1,967	3,011	1	Mississippian	2,890
Harvey (1952)	23-34-3E	160		35,581	9	"Bartlesville"	3,278
a			3,672				
b			31,909				
Harvey Northwest (1952)	15-34-3E	160	5,061	5,061	7	"Bartlesville"	3,298
Henderson (1942)	26-32-3E	80	900	131,007	2	Kansas City	2,690
						Arbuckle	3,419
Hittle	28-31-4E	800	212,886	9,005,861	44	Kansas City	2,400
						Arbuckle	3,280
Hower (1935)	32-33-3E	300	5,909	78,958	4	"Bartlesville"	3,320
Jarvis	13-33-5E	40	218		1+		
McKay (1951)	17-35-4E	640	100,879	103,844	16	"Bartlesville"	3,314
Mansur (1949)	25-31-6E	400	14,814	66,309	7	"Layton"	2,170
Murphy* (1933)	7-35-3E	1,000	65,464		33	"Bartlesville"	3,450
						Miss. "chat"	3,500
Nigger Creek (1951)	22-34-3E	40	2,107	2,514	1	"Bartlesville"	3,281
"Priest"	7-33-6E	40	98	98	1		

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Otto (1927)	25-34-6E	200		13,560	4	Miss. "chat"	3,017
a			3,059				
b			3,095				
Rahm (1939)	13-34-5E	1,200	22,885	1,438,546	44	"Bartlesville"	2,900
Rahn Northeast (1949)	27-33-6E	80	12,859	48,789	5	"Bartlesville"	2,902
Rahn Southwest (1943)	28-34-5E		no report	3,790		"Bartlesville"	3,019
Rainbow Bend (1923)	20-33-3E	1,500	155,038	15,633,097	100	"Burgess"	3,200
Rainbow Bend Northeast (1945)	15-33-3E	160	7,022	31,680	3	"Bartlesville"	3,213
Rainbow Bend West*	19-33-3E	320	11,680		3	"Burgess"	3,200
						Arbuckle	3,550
Rock	15-30-4E	1,500	175,395	3,430,841	65	"Bartlesville"	2,800
Rock North (1937)	3-30-4E	160	9,747	149,425	5	"Bartlesville"	2,800
School Creek (1947)	15-32-7E	160	4,063	23,234	3	"Bartlesville"	2,800
Seacat (1944)	26-33-4E	40	1,542	16,650	1	Mississippian	3,100
Slick-Carson (1924)	19-32-3E	320	43,389	3,554,913	16	"Layton"	2,600
						"Bartlesville"	3,150
						Arbuckle	3,450
Smith (1917)	31-3E		no report			"Bartlesville"	3,050
State (1926)	15-32-4E	1,200	43,296		12	"Layton"	2,400
						Arbuckle	3,300
Stayton (1949)	32-32-4E	640	20,204	70,059	9	"Bartlesville"	3,100
Thurlow (1927)	8-33-3E	640	36,062		9	Simpson	3,500
Trees (1935)	19-30-4E	400	14,762		13	"Bartlesville"	2,875
Turner (1937)	30-32-6E	80	3,588	280,980	2	"Layton"	2,232
Turner North (1948)	18-32-6E	40	139	357	1	"Layton"	
Turner West (1952)	25-32-5E	40	2,204	2,204	1	Mississippian	3,054
Udall	30-3E	40	1,803		1	Arbuckle	2,850
Weathered (1935)	28-31-3E	600	32,402	2,709,245	17	"Stalnaker"	2,080
						Lans.-K.C.	2,480
						Mississippian	3,020
						Arbuckle	3,250
Winfield (1914)	32-5E	1,280	58,011		55	Admire	600
						"Peacock"	1,400
						"Layton"	2,300
						"Bartlesville"	3,050
						Arbuckle	3,300
Winfield South (1945)	1-33-4E	40	872	8,475	1	"Hoover"	1,400
Miscellaneous			355				
Total Cowley County		25,760	2,165,504	71,263,932 recorded	920		

CRAWFORD COUNTY

Fair Oak	33-28-22E	300	7,119		5+	"Bartlesville"	400
Hepler* (1917)	27-22E	40	59		1+	"Bartlesville"	
"Houston"	3-31-22E	40	120		1+		
McCune (1929)	30-22E	3,000	27,170		10+	"Bartlesville"	
"Steimel"	35-29-21E	40	222		1+		
St. Paul-Walnut*	28-21E	500	138		1+	"Bartlesville"	425
Walnut Southeast	28-22E				10+	"Bartlesville"	400
a		700	11,526				
b		40	593				
Miscellaneous			150		1+		
Total Crawford County		4,660	47,097	551,999 recorded	30+		

DECATUR COUNTY

Adell Northwest (1952)	34-5-27W	640	93,582	93,582	13	Lans.-K.C.	3,664
Feely (1952)	2-5-27W	160	17,799	17,799	3	Lans.-K.C.	3,590
Hardesty (1952)	22-5-27W	500	21,551	21,551	3	Lans.-K.C.	3,642
Jennings (1951)	25-4-27W	400	37,802	42,159	4	Wabaunsee	3,156
						Lans.-K.C.	3,478
Monaghan (1952)	15-2-27W	40	1,690	1,690	1	Lans.-K.C.	3,514
Total Decatur County		1,740	172,424	176,781	24		

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
DICKINSON COUNTY							
Bonaccord (1943)	30-14-1E	40	1,208	33,349	1	"Burgess"	2,483
Lost Springs*	16-4E	800	100,901		16	Miss. "chat"	2,300
Lost Springs North (1945)	22-16-4E	40	2,066	93,651	1+	Miss. "chat"	2,300
Lost Springs Northeast (1947)	26-16-4E	40	4,138	13,558	4+	Miss. "chat"	2,300
Total Dickinson County		920	108,313	696,185 recorded	22+		
DOUGLAS COUNTY							
Baldwin (1919)	12-15-20E	600	1,580	52,910 recorded	16	"Squirrel"	800
EDWARDS COUNTY							
Bradbridge (1948)	2-24-16W	120	23,810	57,507	3	Arbuckle	4,020
Pools or fields abandoned				102,496			
Total Edwards County		120	23,810	160,003	3		
ELK COUNTY							
Bush-Denton (1920)	4-30-9E	800	25,075		30	"Stalnaker"	1,060
						"Peru"	2,135
						"Burgess"	2,300
Collyer (1924)	30-30-11E	160	6,959		11	Kansas City	1,286
						Fort Scott	1,518
Dory	18-30-9E	80	2,130		2	Mississippian	2,570
Dunkleberger	34-29-10E	600	32,584		18	Kansas City	1,300
						Mississippian	1,970
Elk City	31-13E		no report				
Ferguson East	23-30-8E	40	1,113		1	Ordovician	2,900
Fleming (1950)	8-29-9E	40	506		1	Arbuckle	2,656
Grand Summit*	4-31-8E	40	8,118		1+	Kansas City	2,000
Hale-Inge* (1907)	31-12E	80				"Peru"	1,160
a			6,708		1+		
b			33		1+		
Kipfer	29-13E	40	59		1+		
Logsden	31-9E		no report				
Longton	31-12E	40	1,647		1+		
Love	30-9E	40	3,106		1	Mississippian	2,370
Moline (1928)	9-31-10E		no report			"Burgess"	2,000
						Mississippian	2,030
New Albany	29-13E	700	18,090		4+	"Wayside"	560
Oak Valley	31-13E	40	141		1+		
"Perkins"	1-30-9E	40	576		1+		
Porter (1923)	29-8E	40	1,828		1+	Kansas City	2,050
						Arbuckle	3,000
Schrader (1928)	12-31-8E	500	31,468		3+	Kansas City	1,520
Severy* (1922)	8-28-11E	40	206		1+	Kansas City	1,200
Starr (1937)	12-31-9E	40	1,963		1+	Mississippian	2,330
Walker (1927)	5-31-10E	40	1,230		1+	Kansas City	1,550
						Mississippian	2,225
Webb (1925)	23-31-10E	600	32,206		4+	Kansas City	1,300
						Fort Scott	1,650
						Mississippian	1,975
						Arbuckle	2,300
Total Elk County		4,000	175,746	13,893,905 recorded	86+		

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ELLIS COUNTY

Antonino (1947)	27-14-19W	200	8,033	86,308	4	Arbuckle	3,712
						Basal sandstone	3,726
Antonino Townsite (1949)	2-15-19W	80	6,549	31,242	2	Arbuckle	3,697
Antonino Townsite East (1952)	1-15-19W	40	3,010	3,010	1	Lans.-K.C.	3,344
Beeching (1943)	34-15-16W	500	9,658	229,719	6	Lans.-K.C.	3,156
Bemis-Shutts (1935)	16-11-17W	16,000	3,642,381	71,558,125	556	Arbuckle	3,380
Bielman (1952)	24-15-18W	40	2,913	2,913	1	Arbuckle	3,496
Blue Hill (1937)	14-12-16W	1,200	130,909	2,011,405	27	Topeka	3,030
						Lans.-K.C.	3,072
						Gorham	3,348
						Arbuckle	3,360
Brungardt* (1952)	35-10-17W	80	5,150	5,150	2	Lans.-K.C.	3,194
Burnett* (1937)	1-11-18W	7,000	2,524,449	41,684,603	274	Shawnee	2,967
						Lans.-K.C.	3,093
						Arbuckle	3,570
Burnett Northwest* (1946)	3-11-18W	800	283,690	2,199,894	28	Lans.-K.C.	3,450
						Arbuckle	3,617
Burnett Southwest (1946)	22-11-18W	1,600	492,130	3,400,650	79	Shawnee	3,074
						Lans.-K.C.	3,207
						Simpson	3,582
						Arbuckle	3,633
Canyons (1948)	11-12-17W	40	no runs	8,566	1	Lans.-K.C.	3,361
Catharine (1936)	3-13-17W	400	133,650	675,368	14	Lans.-K.C.	3,262
						Arbuckle	3,516
Catharine Northwest (1944)	4-13-17W	340	61,706	473,559	10	Lans.-K.C.	
						Arbuckle	3,590
Catharine South (1946)	15-13-17W	540	187,443	987,718	21	Arbuckle	3,555
Catharine Townsite (1949)	9-13-17W	40	5,576	17,797	1	Arbuckle	3,585
Chrisler (1949)	22-11-16W	40	3,856	22,785	1	Lans.-K.C.	3,100
Christina (1949)	22-12-16W	Combined with Emmeram Northeast					
Dechant (1950)	6-15-18W		no report	1,888		Arbuckle	3,670
Dreiling (1949)	21-14-16W	640	141,028	335,181	20	Lans.-K.C.	3,120
						Arbuckle	3,367
Ellis* (1942)	31-12-20W	1,000	112,373	884,761	17	Arbuckle	3,832
Emmeram (1937)	4-13-16W	160	8,245	245,433	5	Lans.-K.C.	3,262
Emmeram Northeast (1949)	27-12-16W	1,000	136,780	265,688	20	Lans.-K.C.	3,272
						Arbuckle	3,541
Emmeram Townsite (1952)	6-13-16W	40	485	485	1	Lans.-K.C.	3,291
						Arbuckle	3,520
Experiment (1952)	8-14-18W	40	2,791	2,791	1	Arbuckle	3,675
Fairport* (1923)	8-12-15W	1,050	294,995	2,881,497	41	Lans.-K.C.	2,950
						Gorham	3,211
						Arbuckle	3,312
						Reagan	3,350
Fort Hays State College (1950)	1-14-19W	40	no runs	1,203	1	Arbuckle	3,806
Giinther (1952)	17-11-19W	80	9,319	9,319	2	Lans.-K.C.	3,439
						Arbuckle	3,554
Haller (1936)	10-11-18W		no report	24,643		Topeka	3,045
Herl (1951)	28-14-17W	500	47,408	60,093	8	Lans.-K.C.	3,382
						Penn. congl.	3,453
						Arbuckle	3,476
Hertel (1952)	16-14-16W	40	6,385	6,385	1	Lans.-K.C.	3,134
Hertel Southwest (1952)	17-14-16W	40	3,560	3,560	1	Lans.-K.C.	3,215
Herzog (1940)	30-13-16W	470	100,653	1,131,356	13	Lans.-K.C.	3,232
						Arbuckle	3,450
Irvin (1946)	6-14-19W	1,500	159,290	525,053	27	Arbuckle	3,860
Irvin North (1951)	31-13-19W	Combined with Irvin					
Irvin Northeast (1951)	32-13-19W	Combined with Irvin					
Jacob (1951)	6-11-19W	40	5,845	5,845	1	Lans.-K.C.	3,542
Jensen (1952)	26-12-18W	160	32,052	32,052	4	Lans.-K.C.	3,531
						Arbuckle	3,621
Karlin (1951)	14-13-17W	320	64,560	92,347	8	Lans.-K.C.	3,348
Koblitz (1937)	23-12-18W	1,300	280,514	1,299,674	35	Lans.-K.C.	3,434
						Arbuckle	3,694

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Kraus (1936)	22-14-19W	100	3,080	130,486	2	Sooy	3,735
						Arbuckle	3,732
Krueger* (1948)	35-10-16W	640	172,980	589,537	20	Lans.-K.C.	3,552
Leiker (1943)	14-15-18W	100	90,211	199,144	2	Lans.-K.C.	3,292
						Arbuckle	3,591
Lookout Hollow (1950)	31-14-18W	40	no runs	1,080	1	Lans.-K.C.	
						Arbuckle	3,629
Mendota (1951)	5-11-20W	160	18,076	19,610	5	Lans.-K.C.	3,530
						Arbuckle	3,668
Nicholson (1945)	30-11-20W	250	41,300	311,814	6	Arbuckle	3,842
Nicholson North (1952)	19-11-20W	40	6,883	6,883	1	Lans.-K.C.	3,610
Penny-Wann (1936)	13-15-20W	80	8,060	167,440	2	Sooy	3,653
Pleasant (1944)	2-14-20W	1,000	147,005	1,184,893	18	Arbuckle	3,833
						Reagan	3,877
						Penn. congl.	
Pleasant North (1946)	26-13-20W		no report	2,168		Arbuckle	3,798
Pleasant Northwest (1952)	27-13-20W	120	10,386	10,386	3	Arbuckle	3,814
Pleasant Ridge (1950)	20-12-17W	640	74,420	467,599	8	Lans.-K.C.	3,408
						Arbuckle	3,683
Pleasant Ridge Southwest (1951)	19-12-17W	40	9,327	14,537	1	Arbuckle	3,673
Polifka (1948)	7-13-17W	40	2,948	31,886	1	Arbuckle	3,640
Raynesford (1952)	17-13-20W	40	3,901	3,901	1	Penn. congl.	3,870
Raynesford East (1952)	16-13-20W	40	no report	none	1	Arbuckle	3,861
Reed (1949)	5-13-17W	40	1,311	6,970	1	Lans.-K.C.	3,424
Riverview (1943)	19-11-18W	1,020	145,915	1,716,359	24	Arbuckle	3,610
Rome (1952)	27-13-17W	40	634	634	1	Arbuckle	3,525
Ruder (1935)	17-15-18W	640	49,379	1,186,546	9	Lans.-K.C.	3,422
						Arbuckle	3,572
Schmeidler (1944)	28-12-17W	1,000	69,148	426,354	18	Arbuckle	3,625
Schoenchen (1946)	21-15-18W	1,000	116,182	828,892	18	Arbuckle	3,569
Sessin (1952)	15-11-19W	160	49,934	49,934	4	Arbuckle	3,499
Solomon (1936)	28-11-19W	2,500	517,601	984,024	65	Arbuckle	3,629
Sugarloaf (1941)	17-13-17W	360	95,981	519,468	14	Arbuckle	3,645
Sugarloaf East (1950)	21-13-17W	80	2,679	9,164	2	Lans.-K.C.	3,391
Sugarloaf Southeast (1941)	28-13-17W	500	42,722	155,718	9	Lans.-K.C.	3,312
Sunnydale (1952)	1-14-20W	40	145	145	1	Arbuckle	3,850
Sweet William (1950)	10-12-20W	40	3,960	8,590	1	Lans.-K.C.	3,700
						Arbuckle	3,908
Toulon (1935)	3-14-17W	700	59,323	523,385**	10	Lans.-K.C.	3,298
						Arbuckle	3,512
Ubert (1936)	12-13-18W	80	10,275	290,233	2	Lans.-K.C.	
						Arbuckle	3,707
Ubert North (1951)	31-12-17W	280	33,774	36,728	6	Arbuckle	3,600
Ubert Northwest (1952)	1-13-18W	80	10,849	10,849	2	Arbuckle	3,592
Walter (1936)	2-12-18W	1,700	317,069	5,699,337	57	Topeka	3,160
						Lans.-K.C.	
						Arbuckle	3,619
Warren (1949)	12-11-20W	40	6,755	31,734	1	Lans.-K.C.	3,458
Weisner (revived)(1952)	36-12-20W	40	1,509	1,509	1	Penn. congl.	3,863
Wheatland (1949)	18-15-17W	200	10,569	18,875	5	Arbuckle	3,571
Younger (1944)	6-14-17W	400	28,722	234,719	8	Arbuckle	3,574
Pools or fields abandoned				197,683			
Total Ellis County		51,630	11,070,399	147,287,280	1,565		
ELLSWORTH COUNTY							
Andrews (1952)	4-17-8W	40	1,817	1,817	1	Arbuckle	3,302
Bloomer* (1936)	36-17-11W	2,850	803,569	12,460,436	92	Lans.-K.C.	3,044
						Arbuckle	3,257
Edwards* (1936)	3-18-8W	3,000	1,120,781	14,517,325	141	Simpson	3,157
						Arbuckle	3,278

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Edwards North (1950)	10-17-8W	Combined with Edwards					
Heiken (1930)	25-17-10W	160	18,082	65,490	4	Lans.-K.C.	2,974
						Arbuckle	3,269
Heiken North (1942)	24-17-10W	80	7,116	177,171	2	Arbuckle	3,212
Kraft-Prusa* (1937)	10-17-11W	900	144,722	899,306	17	Shawnee	2,885
						Lans.-K.C.	3,160
						Gorham	3,335
						Arbuckle	3,281
						Reagan	3,310
Kraft-Prusa East (1944)	18-17-10W	40	5,350	8,469	1	Arbuckle	3,309
Lorraine (1934)	13-17-9W	2,000	104,204	10,556,821	36	Lans.-K.C.	3,060
						Arbuckle	3,200
Maes (1952)	26-17-8W	500	103,315	103,315	15	Arbuckle	3,341
Palacky (1949)	31-16-10W	80	4,790	24,464	2	Lans.-K.C.	3,148
						Arbuckle	3,390
Stoltenberg (1931)	22-16-10W	13,900	1,467,911	34,838,349	357	Lans.-K.C.	3,260
						Arbuckle	3,333
Vacek (1944)	32-15-10W	640	51,582	229,523	7	Arbuckle	3,315
West (1951)	20-17-10W	80	10,394	10,611	2	Arbuckle	3,287
Wilkens Southeast (1942)	32-17-9W	300	12,872	424,833	6	Arbuckle	3,220
Total Ellsworth County		24,570	3,856,505	74,317,930	683		

FINNEY COUNTY

Beyer (1952)	24-26-33W	40	3,210	3,210	1	Lans.-K.C.	4,398
Damme (1951)	21-22-33W	160	37,458	44,663	4	Mississippian	4,626
Damme South (1952)	28-22-33W	40	no report	none	1	Mississippian	4,690
Nunn (1938)	27-21-34W	1,200	152,842	1,865,692	24	Kansas City	
						Marmaton	
						Cherokee	4,550
						"Miss. lime"	4,654
Sonderegger (1952)	21-22-31W	40	1,209	1,209	1	Mississippian	4,737
Stewart (1952)	6-23-30W	40	2,870	2,870	1	Mississippian	4,710
Total Finney County		1,520	197,589	1,917,644	32		

FORD COUNTY

Pleasant Valley (1951)	34-27-21W	40	1,938	9,339	1		

FRANKLIN COUNTY

LeLoup	15-20E	40	500+		1+	"Squirrel"	750
Paola-Rantoul* (1860)	17-21E	6,000			337+	Knobtown	300
a			17,474			Hepler	400
b			163,988			"Prue"	500
c			10,524			"Squirrel"	600
d			511			"Bartlesville"	700
e			26,995				
f			148,967				
g			1,139				
h			19,738				
Miscellaneous			16,892				
Total Franklin County		6,040	406,698	8,583,128 recorded	338+		

GOVE COUNTY

Beougher (1952)	8-13-30W	40	624	624	1	Lans.-K.C.	4,079
Coberly (1951)	15-14-29W	80	12,996	32,239	2	Marmaton	4,287
Gove (1951)	26-13-30W	80	3,047	3,047	2	Mississippian	4,547
Jasper (1951)	30-15-29W		no report	740		Lans.-K.C.	3,670
Lundgren (1952)	30-14-29W	80	2,324	2,324	2	Mississippian	4,306
Lundgren South (1952)	31-14-29W	40	3,929	3,929	1	Mississippian	4,277
Pyramids (1952)	9-15-31W	40	3,581	3,581	1	Marmaton	4,280
Total Gove County		360	26,501	46,484	9		

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
			GRAHAM COUNTY				
Alda (1944)	15-7-22W		no report	23,740		Lans.-K.C.	3,518
Alda West (1952)	16-7-22W	40	5,502	5,502	1	Lans.-K.C.	3,719
Bass (1950)	12-10-21W	Combined with Cooper					
Bass Southwest (1952)	14-10-21W	Combined with Cooper					
Cooper (1950)	11-10-21W	3,840	1,165,854	2,224,280	88	Lans.-K.C.	3,528
						Arbuckle	3,841
Crocker (1951)	18-10-21W	40	6,625	10,816	1	Arbuckle	3,916
Dorman (1952)	30-10-23W	40	4,282	4,282	1	Lans.-K.C.	3,921
Fargo (1950)	26-9-22W	120	12,226	39,290	3	Lans.-K.C.	3,622
Fargo West (1951)	34-9-22W	80	1,101	1,101	2	Lans.-K.C.	3,755
Faulkner (1945)	27-10-22W	160	9,786	181,163	4	Lans.-K.C.	3,629
Gettysburg (1941)	7-8-23W	80	4,163	58,221	2	Lans.-K.C.	3,725
Harmony (1951)	32-7-22W	160	29,591	30,508	4	Lans.-K.C.	3,597
Highland (1951)	20-8-22W	40	2,560	5,953	1	Lans.-K.C.	3,616
Houston (1947)	9-6-22W	40	1,874	18,485	1	Lans.-K.C.	3,506
Ironclad (1950)	23-9-22W	200	45,936	97,917	6	Lans.-K.C.	3,756
Laura* (1950)	30-10-20W	40	5,355	8,766	1	Arbuckle	3,706
Law (1951)	34-9-23W	900	188,084	269,178	15	Lans.-K.C.	3,922
						Penn. congl.	4,126
Mickleson (1952)	27-8-22W	40	1,736	1,736	1	Arbuckle	3,759
Millbrook (1951)	21-8-23W	40	8,660	10,150	1	Lans.-K.C.	3,761
Morel (1938)	15-9-21W	6,400	2,094,964	14,858,529	207	Sooy	3,712
						Arbuckle	3,718
Morel East (1949)	13-9-21W	360	58,993	213,436	6	Arbuckle	3,729
Morlan (1949)	23-10-21W	360	78,018	242,725	10	Arbuckle	3,778
Muilenburg (1949)	1-10-21W	80	4,659	18,637	2	Arbuckle	3,839
Noah (1952)	27-10-21W	120	12,628	12,628	3	Lans.-K.C.	3,651
						Arbuckle	3,786
Penokee (1940)	11-8-24W	130	22,345	196,737	6	Lans.-K.C.	3,750
Ray* (1949)	32-5-20W	40	217	967	1	Lans.-K.C.	3,297
						Arbuckle	3,575
						Reagan	3,540
Schmied (1952)	21-8-25W	160	14,203	14,203	4	Lans.-K.C.	3,740
Schmied North (1952)	16-8-25W	80	3,543	3,543	2	Lans.-K.C.	3,795
Schnebly (1952)	8-8-22W	40	4,094	4,094	1	Lans.-K.C.	3,507
Shiloh (1951)	1-9-25W	40	11,183	12,868	1	Lans.-K.C.	4,013
Smith-Denning (1950)	5-10-21W	400	78,818	214,993	9	Lans.-K.C.	3,530
						Arbuckle	3,818
Smith-Denning West (1951)	6-10-21W	160	19,825	22,686	4	Lans.-K.C.	3,851
						Arbuckle	3,880
White (1952)	25-10-21W	80	8,655	8,655	2	Arbuckle	3,716
Wild Horse Creek (1950)	16-9-22W	40	no runs	10,095	1	Arbuckle	3,944
Worcester (1951)	23-7-22W	40	4,817	6,876	1	Arbuckle	3,792
Pools or fields abandoned				12,765			
Total Graham County		14,390	3,910,297	18,845,525	392		
			GREENWOOD COUNTY				
Atyeo* (1925)	30-21-10E	300	102,969		16+	"Bartlesville"	2,250
Beaumont	27-8E	500	62,991		36	"Peru"	1,830
						Mississippian	2,445
						Arbuckle	2,740
Beaumont North	27-9E	40	7,803		1	Mississippian	2,477
						Ordovician	2,800
Beaumont South (1935)	2-28-8E	40	409		1	Mississippian	2,500
Blackwell (1925)	16-24-13E	160	2,113		4	Mississippian	1,650
Blankenship* (1921)	26-8E	300	21,994		5+	"Bartlesville"	2,650
Brinegar	26-13E	80	5,040		1+		
Browning (1924)	22-10E	1,200	105,482		70	"Bartlesville"	2,314

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Burkett (1923)	24-23-10E	1,800	275,860	86	"Bartlesville"	2,000
Burt (1949)	8-26-11E	40	1,609	1+	Mississippian	1,945
Climax (1925)	27-11E	180	14,789	2+	Mississippian	1,900
DeMalorie-Souder (1924)	22-10E	2,000	298,501	67	"Bartlesville"	2,150
Dunaway* (1922)	34-22-13E	1,800	55,262	30+	Mississippian	1,800
Eureka	31-25-11E	1,800	81,764	60	Fort Scott	1,750
					Mississippian	2,000
Fankhouser* (1926)	4-22-12E	800	197,687	37	"Bartlesville"	1,850
Gaffney (1926)	18-24-11E	160	6,465	3	"Bartlesville"	1,850
Gilroy (1928)	12-25-12E	40	202	1+	Mississippian	1,600
Hamilton (1925)	7-24-12E	3,000		33+	"Bartlesville"	1,650
a			158,343		Mississippian	1,800
b			4,044			
Hinchman (1927)	17-24-13E	160	5,470	4	Mississippian	1,615
Hollis (1927)	16-23-10E	40	1,629	1	"Bartlesville"	2,150
Honey Creek (1950)	32-26-11E		no report		Mississippian	1,871
Hubbard	22-13E	40	932	1		
Jackson	25-8E	160		2	"Bartlesville"	
a			3,186			
b			1,230			
Jobes	24-13E	40	5,947	1		
"Kimbal"	28-25-13E	40	1,442	1		
Lamont (1926)	29-22-13E	1,800	221,127	54	"Bartlesville"	1,700
Madison	14-22-11E	1,900	350,704	44	"Bartlesville"	1,800
"Mignot"	9-22-11E		no report			
Morris (1950)	28-24-13E		no report			
Parks	24-10E	40	719	1		
Pixlee (1923)	7-22-10E	900	40,877	26+	"Bartlesville"	2,350
					Mississippian	2,400
Polhamus (1922)	25-9E	700	442,124	34+	"Bartlesville"	2,180
Quincy* (1926)	31-24-12E	1,200		20+	"Bartlesville"	1,500
a			5,776		Mississippian	1,720
b			51,402			
Reece	24-26-9E	800		24	Kansas City	1,380
a			5,153		Mississippian	2,100
b			22,480			
Sallyards	25-8E	2,400		51+	"Bartlesville"	2,350
a			197,618			
b			2,547			
Scott (1925)	24-23-8E	1,000	78,245	39	"Bartlesville"	2,525
Seeley-Wick	28-23-11E	5,000		283	"Bartlesville"	1,930
a			1,266,540			
b			5,551			
Severy*	8-28-11E	900		3	Kansas City	1,200
a			3,471			
b			3,201			
Severy North	27-11E	40	972	1		
Stanhope	15-26-8E	160	19,346	10	Mississippian	2,450
Teeter* (1920)	16-23-9E	3,000	205,989	54	"Bartlesville"	2,400
Teichgraber	25-8E	600		18	"Bartlesville"	2,750
a			11,288	192	"Bartlesville"	2,170
b			472			
Thrall-Aagard	14-24-9E	4,200		192	"Bartlesville"	2,170
a			1,940,716			
b			4,752			
Tonovay	25-11E	40	2,145	1		
Tonovay North			no report			
Tonovay West (1950)	33-25-11E	40	516	1	Mississippian	1,948
Toronto* (1913)	16-26-13E	160	2,925	1	"Peru"	1,000
					"Bartlesville"	1,700
Tucker			no report			
Virgil (1916)	14-24-12E	3,600	150,888	100+	"Bartlesville"	1,550
					Mississippian	1,700
Virgil North* (1920)	22-23-13E	5,000	286,743	200+	"Bartlesville"	1,585
					Mississippian	1,840
Wiggins (1925)	30-24-11E	1,800	23,998	25+	"Bartlesville"	1,860
Wilkerson (1926)	6-25-9E	300	17,031	1+	"Bartlesville"	2,200
Willard	7-27-11E	400	39,448	13	Miss. "chat"	1,900

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Miscellaneous			6,290				
Total Greenwood County		50,700	6,834,217	184,543,957 recorded	1,660		
			HARPER COUNTY				
Bluff Creek (1952)	24-34-5W	40	1,088	1,088	1	Lans.-K.C.	3,938
Grabs (1949)	13-31-9W	200	14,054	32,077	4	Mississippian	4,400
Total Harper County		240	15,142	33,165	5		
			HARVEY COUNTY				
Burrton* (1931)	1-23-4W		Included with Reno County			Mississippian	3,266
						"Hunton"	3,583
Burrton Northeast (1942)	3-23-3W	200	1,651	7,607	4	"Chat"	3,224
						Mississippian	3,269
Graber* (1934)	32-21-1W	40	2,845	148,455	1	"Misener"	3,323
						"Hunton"	3,274
Halstead (1929)	36-22-2W	1,300	28,506	1,916,163	11	"Chat"	3,005
Hollow-Nikkel* (1931)	30-22-3W	2,000	114,423	20,802,888	40	"Chat"	3,195
			Includes McPherson County			"Hunton"	3,507
			production			Simpson	3,500
Jester Creek (1949)	3-24-1E		no report	1,202		Lans.-K.C.	2,687
Sperling (1935)	23-22-2W	300	11,861	599,286	5	"Hunton"	3,279
Pools or fields abandoned				123,238			
Total Harvey County		3,840	159,286	23,598,839	61		
			HODGEMAN COUNTY				
Jetmore (1950)	24-22-24W	80	14,212	47,520	2	Mississippian	4,580
Purdyville (1951)	3-24-24W	640	119,716	165,863	8	Penn. congl.	4,651
						Mississippian	4,663
Total Hodgeman County		720	133,928	213,383	10		
			JEFFERSON COUNTY				
McLouth (1939)	4-10-20E		no report			McLouth	1,450
						Mississippian	1,550
McLouth North (1941)	29-9-20E	150			2+	McLouth	1,450
a			1,318			Mississippian	1,500
b			176				
Total Jefferson County		150	1,494	875,083 recorded	2+		
			JOHNSON COUNTY				
Dallas	13-13-24E		no report				
			KEARNY COUNTY				
Patterson (1941)	23-22-38W	120	28,229	379,979	3	"Patterson sd"	4,748
			KINGMAN COUNTY				
Artesian Valley (1952)	22-27-10W	80	8,874	8,874	2	Viola	4,315
Bartholomew* (1948)	30-27-4W	240	7,572	57,668	6	"Miss. lime"	3,732
Broadway (1950)	21-28-5W	1,200	244,334	457,583	31	Mississippian	3,833
Casley (1952)	11-28-5W	40	1,055	1,055	1	Mississippian	3,794

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Cunningham* (1931)	7-28-11W	800	63,686	3,049,243	33	Lans.-K.C.	3,390
Dewey (1950)	9-28-5W	640	80,187	152,853	10	Mississippian	3,801
Dresden (1951)	13-27-10W	800	235,502	374,627	24	Mississippian	4,002
						Viola	4,270
Evan Mound (1951)	22-27-5W	40	5,554	10,030	1	Mississippian	3,800
Lansdowne North (1951)	4-28-5W	40	5,887	14,586	1	Mississippian	3,814
Pat Creek (1946)	20-28-9W	160	21,638	129,724	4	Viola	4,406
						Simpson	4,475
Spivey (1951)	23-30-8W	80	8,248	9,679	2	Mississippian	4,205
Pools or fields abandoned				27,000			
Total Kingman County		4,120	682,537	4,292,922	115		
			KIOWA COUNTY				
Brenham (1947)	29-28-17W	40	179	179	1	Miss."chert"	4,821
Exel (1948)	20-30-20W	40	7,040	39,624	1	"Miss. lime"	5,126
Total Kiowa County		80	7,219	39,803	2		
			LABETTE COUNTY				
Altamont	33-19E	40	72		1		
Banzet	35-19E		no report				
Chetopa	36-34-20W		no report				
Coffeyville-Cherryvale*	32-17E	600			1+	"Wayside"	400
a			1,024			Fort Scott	600
b			1,385			"Bartlesville"	1,000
c			42				
d			95				
Lake Creek	35-19E	40	1,276		1+		
Mound Valley	32-18E	40	344		1+	"U.Bartlesville"	630
						"L.Bartlesville"	700
						Mississippian	900
Price (1917)	33-18E	300			17+	"Bartlesville"	600
a			75				
b			2,100				
Miscellaneous			1,048				
Total Labette County		1,020	7,461	362,353 recorded	21+		
			LANE COUNTY				
North Fork (1952)	19-17-29W	40	2,954	2,954	1	Lans.-K.C.	4,333
			LEAVENWORTH COUNTY				
Ackerland (1941)	12-10-20E		no report			McLouth	1,370
Banker's Life (1941)	3-10-20E		no report			McLouth	1,450
Total Leavenworth County				81,050 recorded			
			LINN COUNTY				
Centerville* (1920)	10-21-22E	1,100			10+	"Squirrel"	480
a			780			"Bartlesville"	720
b			230				
c			15,304				
d			287				
Goodrich-Parker (1922)	25-20-21E	1,200			95+	"Squirrel"	600
a			477			"Bartlesville"	700
b			33,297				
LaCygne-Cadmus	20-24E	900			38+	Bandera	150
a			10,443			Labette	200
b			842				
c			476				
Total Linn County		3,200	62,136	684,822 recorded	143+		

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
			LYON COUNTY				
Atyeo* (1925)	30-21-10E	1,000	192,452		44+	"Bartlesville"	2,200
Bradfield	24-21-10E	40	4,148		1+		
Bushong (1950)	26-16-10E	40	3,691		1+	"Hunton"	2,950
Fankhouser* (1926)	4-22-12E	1,100	40,538		7+	"Bartlesville"	1,850
Ritchey-Moore	34-21-10E	40	21,168				
Rock Creek (1947)	32-21-11E	160	2,972		4	"Bartlesville"	1,900
Total Lyon County		2,380	264,969	6,126,455 recorded	57+		
			MCPHERSON COUNTY				
Battle Hill (1945)	24-18-1W	40	2,595	43,388	1	"Chat"	2,825
Battle Hill North (1948)	13-18-1W	40	13,917	53,008	1	"Miss. lime"	2,811
Bitikofer (1940)	1-20-1W	160	3,734	212,084	4	"Chat"	2,885
Bitikofer North (1946)	25-19-1W		no report	9,043		"Miss. lime"	2,892
Bonaville (1949)	33-17-2W	80	2,342	15,998	2	Simpson	3,557
Bornholdt* (1937)	30-20-5W	3,000	258,777	11,711,076	106	"Chat"	3,292
Burk (1948)	7-18-1W	120	11,215	82,854	3	Mississippian	2,781
Canton North (1936)	26-18-1W	540	36,269	613,614	12	"Chat"	2,803
Chindberg (1929)	18-19-2W	600	14,069	1,777,357	14	Lans.-K.C.	2,363
						"Chat"	3,007
Coons (1940)	13-19-1W	80	3,198	5,047	2		
Crowther (1942)	26-17-1W	1,500	129,368	2,866,278	45	"Chat"	2,778
Georob (1947)	31-17-1W	1,560	336,881	1,547,993	40	"Chat"	2,665
Graber* (1934)	32-21-1W	2,300	790,786	10,578,865	111	"Misener"	3,323
						"Hunton"	3,274
Gypsum Creek (1944)	4-17-1W	440	31,407	370,587	13	"Chat"	2,619
Henne (1940)	21-17-1W	800	39,058	1,427,824	16	"Chat"	2,658
Hollow-Nikkel* (1931)	30-22-3W		Included with Harvey County			"Chat"	3,195
						"Hunton"	3,507
						Simpson	3,500
Jenday (1944)	1-19-2W	1,000	39,727	804,448	27	"Chat"	2,984
Johnson (1932)	35-19-3W	920	52,889	3,332,759	9	"Chat"	3,032
Johnson South (1950)	11-20-3W	40	2,135	8,153	1	Mississippian	3,043
Lindsborg (1938)	8-17-3W	5,400	491,081	6,780,634	103	Viola	3,352
						Simpson	3,360
McPherson (1926)	29-18-2W	1,500	57,107	1,527,505	30	Lans.-K.C.	2,340
						"Chat"	2,967
						Viola	3,140
Maxwell (1948)	17-18-1W	160	5,409	23,655	4	"Miss. lime"	2,846
Paden (1943)	10-18-1W	640	238,016	2,439,851	42	"Chat"	2,752
						Viola	3,153
Paden South (1950)	21-18-1W	160	15,164	23,565	4	Mississippian	2,765
Reuben (1949)	17-18-2W	80	4,653	18,103	2	Simpson	3,675
Ritz-Canton (1929)	1-20-2W	12,000	451,334	42,641,170	177	"Chat"	2,935
						Viola	3,412
Roxbury (1938)	18-17-1W	1,000	80,655	3,007,970	29	"Chat"	2,684
						Simpson	3,278
Roxbury South (1942)	30-17-1W	240	10,339	313,977	4	"Chat"	2,658
Roxbury Southeast (1943)	20-17-1W	240	17,089	79,351	4	"Chat"	2,665
Voshell (1929)	9-21-3W	3,500	226,809	28,323,574	61	"Chat"	3,095
						Viola	3,301
Total McPherson County		38,140	3,366,023	120,639,731	867		
			MARION COUNTY				
Antelope (1947)	33-18-4E		no report			Miss. "chat"	2,380
Antelope North (1948)	28-18-4E	40	2,789		1	Kansas City	1,840

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Biscuit Hill (1952)	33-21-4E		no report			Mississippian	2,269
Cedar Creek (1950)	31-20-5E	40	283	1,898	1	Viola	2,563
Covert-Sellers (1920)	28-21-4E	1,200	142,841		47	Viola	2,400
Elbing* (1918)	18-23-4E	100	5,232		1+	Kansas City	2,120
						Mississippian	2,400
						Viola	2,530
Elbing North (1947)	27-22-4E	500	7,333	57,455	4	Miss. "chat"	2,439
Fanska (1943)	6-17-1E	40	4,826		6	Miss. "chat"	2,680
Florence (1920)	18-21-5E	700	11,020		8	Viola	2,300
Hillsboro (1928)	7-19-3E	500	23,129		8	Mississippian	2,470
						Viola	2,820
Lehigh (1946)	27-19-1E	160	7,711	87,963	3	Mississippian	2,800
Lost Springs* (1926)	22-17-4E	4,800	198,319		160	Mississippian	2,365
Lost Springs East (1942)	35-17-4E	40	1,569		1+	Miss. "chat"	2,350
Lost Springs Southeast (1948)	10-18-4E	160	2,567	6,956	3	Mississippian	2,345
Peabody (1920)	9-22-4E	1,000			20	Viola	2,500
a			16,400				
b		20,296	20,296				
c			74				
Propp	15-4E	160	7,751	20,220	5		
Shank (1952)	12-22-3E	40	7,841	7,841	1	Mississippian	2,474
Wenger (1947)	11-21-4E	800	106,979	549,164	23	"Hunton"	2,770
Miscellaneous			330				
Total Marion County		10,280	567,290	32,630,289 recorded	292+		
			MEADE COUNTY				
Adams Ranch (1948)	8-35-30W	40	90	1,362	1		
Adams Ranch East (1947)	36-34-30W	80	14,500	27,631	2	Marmaton	5,346
Bromwell (1952)	7-34-29W	40	2,878	2,878	1	Morrowan	5,901
McKinney (1950)	2-34-26W	250	3,596	3,596	6	Mississippian	5,762
Novinger (1951)	26-33-30W	1,800	181,948	206,611	26	Marmaton	5,270
						Morrowan	5,765
						Mississippian	5,803
Total Meade County		2,210	203,012	242,078	36		
			MIAMI COUNTY				
Block	18-24E	300	1,449		9+		
Louisburg	17-25E	500			2+	Knobtown	270
a			3,397			"Peru"	430
b			604			"Squirrel"	600
Paola-Rantoul* (1860)	17-23E	12,000			666+	Knobtown	300
a "Big Lake"			68,324			Hepler	400
b			12,164			"Peru"	500
c "Pressonville"			11,418			"Squirrel"	600
d "Pressonville"			1,667			"Bartlesville"	700
e "Pressonville"			312,281				
f Paola-Rantoul			3,132				
g			18,470				
h "Pressonville"			23,796				
i "Pressonville"			63,747				
j "Stanton"			21,291				
k "Osawatomie"			2,143				
l "Osawatomie"			31,990				
m "Osawatomie"			1,540				
Miscellaneous			13,740				
Total Miami County		12,800	591,153	13,945,296 recorded	677+		
			MONTGOMERY COUNTY				
Brewster	32-16E	700			50+	"Bartlesville"	900
a			4,129			Arbuckle	
b			117				

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
c			32,573				
d			48				
e			440				
Caney	35-14E	600	7,523		8+	"Bartlesville"	1,320
Coffeyville-Cherryvale* (1902)	33-17E	4,500			300+	"Wayside"	400
a			4,221			Fort Scott	600
b			157			"Bartlesville"	1,000
c			2,107			Arbuckle	1,300
d			56				
e			79				
f			2,456				
g			1,463				
h			556				
i			61				
j			333				
k			29,248				
l			12,987				
m			35				
n			53				
o			18				
p			1,018				
Coleman (1921)	28-32-14E	80			2+	Arbuckle	1,700
a			36				
b			346				
Jefferson-Sycamore (1903)	18-33-15E	5,000			400+	"Weiser"	800
a			336,326			"Bartlesville"	1,200
b			3,973				
c			299				
d			18,034				
e			289				
f			56				
g			15,932				
h			990				
i			804				
j			253				
k			55				
l			3,262				
m			1,643				
n			779				
o			33,122				
p			36				
Neodesha*	31-16E	800			10+	"Bartlesville"	950
a			284				
b			5,477				
c			1,006				
d			70				
"Scott"	18-31-15E	40	50				
Sorghum Hollow	32-14E	1,800	3,851		3+	"Weiser"	800
Tyro (1904)	13-35-14E	2,000			5+	"Bartlesville"	1,250
a			11,154				
b			1,219				
Wayside-Havana* (1904)	34-14E	6,000			149	"Wayside"	575
a			137,037			"Weiser"	700
b			1,060			"Bartlesville"	1,200
Miscellaneous			742				
Total Montgomery County		20,520	677,863	41,063,051 recorded	927+		
MORRIS COUNTY							
Burdick (1949)	15-17-5E	160	4,785	22,188	4	Mississippian	2,220

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Three Mile Creek (1950)	25-16-5E	600	17,648	63,359	4	Mississippian	2,208
Three Mile Creek South (1950)	35-16-5E	700	25,427	55,758	7	Mississippian	2,183
Total Morris County		1,460	47,860	141,305	15		
MORTON COUNTY							
Richfield (1948)	17-32-40W	40	no runs	829	1	Basal Penn. (Atokan)	4,990
NEMAHA COUNTY							
Sabetha (1950)	13-2-14E	320	8,912	21,684	4+	"Hunton"	2,826
Strahm (1948)	27-2-14E	320	25,311	75,152	4+	"Hunton"	2,879
						Viola	3,559
Total Nemaha County		640	34,223	96,836 recorded	8+		
NEOSHO COUNTY							
Erie (1903)	28-20E	3,600			17+	"Bartlesville"	650
a			261				
b			23,344				
c			4,016				
Canville Creek	27-20E	40	119		1		
Humboldt-Chanute*	27-18E	5,000			636+	"Bartlesville"	700
a			3,215				
b			2,315				
c			95,702				
d			597				
e			399,579				
f			6,773				
g			208				
h			10,829				
i			4,909				
Kimball	27-21E	40	1,970		1+		
Morehead	30-30-18E	100	1,732		1+	"Bartlesville"	850
St. Paul-Walnut*	29-21E	1,600			10+	"Bartlesville"	550
a			1,090				
b			7,567				
c			1,037				
d			416				
e			2,346				
Thayer	29-17E	40	75		1		
Trent	28-21E	40	626		1		
Urbana	28-18E	300	4,097		2+	"Bartlesville"	750
Miscellaneous			72,178				
Total Neosho County		10,960	645,001	21,752,509 recorded	670+		
NESS COUNTY							
Aldrich (1929)	7-18-25W	5,000	287,215	2,660,041	37	"Warsaw"	4,428
Arnold (1943)	22-16-25W	300	28,778	328,346	5	Fort Scott	4,436
						"Warsaw"	4,528
Kansada West (1950)	28-17-26W		no report	none		Mississippian	4,438
Manteno (1945)	31-19-25W	160	2,860	52,796	2	"Warsaw"	4,549
Pools or fields abandoned				7,581			
Total Ness County		5,460	318,853	3,048,764	44		
NORTON COUNTY							
Ray* (1940)	32-5-20W	340	40,506	246,425	6	Lans.-K.C.	3,297
						Arbuckle	3,575
						Reagan	3,540

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Ray West (1945)	26-5-21W	160	13,481	105,324	4	Arbuckle	3,650
Pools or fields abandoned				32,054			
Total Norton County		500	53,987	383,803	10		
OSBORNE COUNTY							
Ruggles (1952)	23-10-15W	640	73,200	73,200	12	Shawnee	2,986
						Lans.-K.C.	3,024
						Penn. congl.	3,394
PAWNEE COUNTY							
Ash Creek* (1947)	31-20-15W	400	2,361	240,495	3	Arbuckle	3,787
Ash Creek Southwest (1947)	11-21-16W	40	6,841	97,708	1	Arbuckle	3,779
Benson (1945)	30-23-15W	200	19,619	199,604	5	Lans.-K.C.	3,853
Benson South (1952)	30-23-15W	80	11,060	11,060	2	Lans.-K.C.	3,754
Benson Southeast (1946)	32-23-15W	200	31,213	31,213	5	Lans.-K.C.	3,709
Evers (1951)	1-22-16W	240	39,043	39,205	6	Lans.-K.C.	3,525
						Simpson	3,861
						Arbuckle	3,908
Garfield (1947)	17-23-17W		no report	7,309		Kinderhookian	4,276
Larned (revived) (1952)	28-21-16W	160	13,039	13,728	4	Arbuckle	3,877
Pawnee Rock* (1936)	13-20-16W	3,200	340,070	2,999,681	57	Arbuckle	3,832
Pawnee Rock West (1949)	23-20-16W	Combined with Pawnee Rock					
Rutherford (1946)	8-20-16W	300	18,576	249,111	6	Arbuckle	3,815
Rutherford East (1950)	4-20-16W	Combined with Ryan					
Ryan* (1945)	35-19-16W	400	44,843	443,415	8	Arbuckle	3,656
Ryan Southeast (1945)	12-20-16W	300	17,286	286,763	9	Arbuckle	3,688
Shady (1948)	35-22-16W	80	no runs	6,038	2	Arbuckle	4,067
Zook (1942)	16-23-16W		no report	7,016		Arbuckle	4,066
Total Pawnee County		5,600	543,951	4,632,346	108		
PHILLIPS COUNTY							
Beckman (1951)	3-4-19W	40	2,200	3,297	1	Lans.-K.C.	3,201
Bow Creek (1939)	25-5-18W	120	7,063	62,087	3	Lans.-K.C.	3,111
Dayton (1941)	26-2-19W	1,540	51,199	1,004,992	18	Lans.-K.C.	3,430
Fredericksburg (1952)	4-1-18W	40	3,267	3,267	1	Lans.-K.C.	3,457
Glenwood (1951)	21-1-17W	40	2,814	7,635	1	Lans.-K.C.	3,597
Hansen (1943)	14-5-20W	940	232,817	1,944,826	33	Lans.-K.C.	3,363
						Arbuckle	3,530
Hansen West (1952)	15-5-20W	40	458	458	1	Arbuckle	3,543
Huffstutter (1949)	6-2-18W	3,600	624,858	2,229,800	134	Lans.-K.C.	3,444
Huffstutter Southwest (1951)	23-2-19W	200	28,389	30,600	5	Lans.-K.C.	3,458
Kent (1951)	22-1-18W		no report	1,472		Lans.-K.C.	3,432
Logan (1945)	3-5-20W	420	42,132	346,783	12	Lans.-K.C.	3,149
						Arbuckle	3,381
Ray* (1940)	32-5-20W	4,200	1,583,886	14,355,929	158	Lans.-K.C.	3,297
						Arbuckle	3,575
						Reagan	3,540
Slinker (1951)	25-4-20W	160	25,570	32,580	4	Lans.-K.C.	3,215
Stuttgart (1950)	14-3-19W	640	80,587	135,226	14	Lans.-K.C.	3,146
Stuttgart South (1951)	23-3-19W	40	4,666	9,771	1	Lans.-K.C.	3,291
Pools or fields abandoned				1,596			
Total Phillips County		12,020	2,689,906	20,170,319	386		
PRATT COUNTY							
Blowout (1952)	8-27-14W	40	1,767	1,767	1	Lans.-K.C.	3,929

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Chance (1946)	4-27-13W	1,500	647,814	1,511,557	72	Mississippian	4,254
						Simpson	4,380
						Arbuckle	4,432
						Viola	4,250
Chance East (1952)	34-26-13W	160	14,779	14,779	4	Mississippian	4,138
						Viola	4,261
Chitwood (1943)	23-28-12W	1,700	506,371	6,932,232	74	Lans.-K.C.	
						Viola	
						Simpson	4,396
						Arbuckle	
Chitwood Northeast (1950)	13-28-12W	40	622	3,678	1	Viola	4,330
Clara* (1948)	36-29-14W	100	18,310	148,646	4	Simpson	4,472
Coats (1944)	24-29-14W	400	21,921	384,856	8	Simpson	4,402
						Arbuckle	
Cunningham* (1931)	7-28-11W	3,500	138,227	4,501,282	76	Lans.-K.C.	3,390
Frisbie (1943)	5-26-13W	400	18,933	322,803	4	Lans.-K.C.	3,947
Frisbie Northeast (1948)	4-26-13W	80	14,527	135,792	6	Lans.-K.C.	3,788
Iuka-Carmi (1937)	11-27-13W	7,600	1,250,142	12,417,840	183	Lans.-K.C.	4,104
						Viola	4,195
						Simpson	4,292
						Arbuckle	4,354
Jarboe (1952)	25-26-14W	40	126	126	1	Lans.-K.C.	3,834
Ludwick (1944)	4-29-13W	40	1,643	29,655	1	Simpson	4,490
Moore (1949)	1-26-14W	40	12,747	29,896	1	Simpson	4,348
Shriver (1944)	33-29-14W	300	70,012	615,774	7	Simpson	4,557
Stark (1941)	18-26-11W	600	10,303	841,814	6	Lans.-K.C.	3,601
						Viola	4,121
Stoops (1946)	7-29-12W	80	3,588	84,940	2	Viola	4,446
Stoops Southwest (1946)	24-29-13W	40	1,263	14,228	1	Viola	4,483
Total Pratt County		16,660	2,733,095	27,991,665	452		
			RENO COUNTY				
Abbyville (1927)	24-24-8W	1,100	33,410	831,133	16	Lans.-K.C.	3,540
Albion (1948)	14-26-6W	100	2,137	23,769	3	Lans.-K.C.	3,342
						"Chat"	3,654
Albion North (1950)	14-26-6W	40	no runs	767	1	Viola	3,997
Buhler (1938)	25-22-5W	1,000	117,192	860,714	13	Viola	3,890
						Simpson	3,897
Burrton* (1931)	1-23-4W	11,000	901,054	47,381,999	329	Mississippian	3,266
		Includes	Harvey County	production		"Hunton"	3,583
Haven (1951)	9-25-4W	80	7,397	7,397	2	Simpson	3,977
Hilger (1934)	16-26-4W	900	96,212	4,640,731	15	Viola	4,062
Keddie (1952)	26-23-10W		no report	none		Lans.-K.C.	3,299
Lerado Southwest (1944)	21-26-9W	40	3,991	126,590	1	Viola	4,177
Morton (1942)	17-24-8W	40	2,501	40,199	1	Lans.-K.C.	3,180
Morton Southeast (1951)	16-24-8W	40	2,980	4,727	1	Lans.-K.C.	3,423
Nicklaus (1952)	3-26-4W	40	1,010	1,010	1	Lans.-K.C.	3,249
Sankey (1951)	22-22-10W	80	10,364	15,426	2	Lans.-K.C.	3,187
Sankey Southwest (1952)	21-22-10W	40	6,682	6,682	1	Viola	3,548
Yoder (1935)	24-24-5W	160	no runs	93,285	3	"Chat"	3,450
Zenith-Peace Creek* (1941)	21-23-10W	10,000	288,432	17,619,008	136	Viola	3,773
Pools or fields abandoned				2,590,055			
Total Reno County		24,660	1,473,362	74,243,492	525		
			RICE COUNTY				
Bingham (1952)	35-19-9W	40	4,971	4,971	1	Simpson	3,278
Bloomer* (1936)	36-17-11W	1,500	867,040	13,041,846	80	Lans.-K.C.	3,044
						Arbuckle	3,257
Bornholdt* (1937)	30-20-5W	1,400	170,773	2,162,185	35	"Chat"	3,292
Bowman North (1948)	16-19-10W	40	89[illegible]	13,629	1	Arbuckle	3,331
Bredfeldt (1948)	7-18-9W	120	7,610	77,392	3	Arbuckle	3,226
Bredfeldt West (1939)	12-18-10W	40	1,098	60,098	1	Arbuckle	3,260
Calf Creek (1950)	28-18-10W	200	41,973	74,072	5	Pre-Cambrian	3,143
Calf Creek North (1952)	28-18-10W	40	1,451	1,451	1	Arbuckle	3,248

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Chase-Silica * (1931)	32-19-9W	34,500	3,893,023	93,453,311	769	Lans.-K.C.	2,942
						"Wilcox"	3,260
						Arbuckle	3,252
Click (revived) (1952)	3-18-7W	40	186	5,818	1	Lans.-K.C.	3,050
Click Southeast (1947)	11-18-7W	80	11,453	27,519	2	Lans.-K.C.	3,065
Edwards* (1936)	3-18-8W	600	75,824	177,712	7	Penn. congl.	3,214
						Arbuckle	3,278
Engelland (1949)	34-20-7W	40	1,661	8,091	1	Conglomerate	3,348
Fair (1952)	15-21-10W	40	1,670	1,670	1	Penn. congl.	3,358
Farmer (1952)	24-18-10W	240	25,374	25,374	6	Arbuckle	3,222
Frederick (1951)	10-18-9W	40	6,505	12,108	1	Penn. congl.	3,213
Galt (revived) (1952)	8-18-7W	40	6,622	22,694	1	Arbuckle	3,193
Gemeinhardt (1948)	18-18-10W	80	9,244	47,211	2	Arbuckle	3,293
Geneseo (1934)	25-18-8W	6,200	2,139,511	32,329,558	245	Lans.-K.C.	2,787
						Penn. congl.	3,222
						Arbuckle	3,132
Glen Sharrald (1950)	20-18-10W	120	6,393	23,160	3	Lans.-K.C.	3,118
Heinz (1938)	8-18-10W	300	24,231	277,992	7	Lans.-K.C.	3,000
						Arbuckle	3,254
Ixl (1950)	4-19-10W	640	45,634	53,944	8	Lans.-K.C.	3,068
						Arbuckle	3,308
Ixl South (1951)	9-19-10W	Combined with Ixl					
Keller (1943)	3-19-9W	40	1,699	42,375	1	Sooy	3,240
Lyons (1949)	14-20-8W	40	5,904	67,581	1	Lans.-K.C.	3,226
						Arbuckle	3,277
						"Misener"	3,315
						Penn. congl.	
Mary Ida* (1950)	31-18-10W	640	135,459	254,275	16	Lans.-K.C.	3,033
						Arbuckle	3,272
Munyon (1950)	34-18-10W	120	13,929	28,097	3	Sooy	3,270
						Arbuckle	3,275
Munyon South (1951)	3-19-10W	160	18,738	29,214	4	Arbuckle	3,300
Odessa (1949)	32-18-6W	400	76,596	171,177	11	Lans.-K.C.	3,092
Odessa South (1949)	9-19-6W	120	5,725	22,945	3	Lans.-K.C.	3,069
Orth (1932)	27-18-10W	1,600	186,266	2,516,546	52	Shawnee	
						Lans.-K.C.	2,915
						Sooy	3,187
						Pre-Cambrian	3,240
Orth West (1944)	21-18-10W	600	104,164	482,200	17	Shawnee	2,688
						Arbuckle	3,235
Ponce (1936)	28-21-7W	40	2,686	60,864	1	Sooy	3,388
Prosper (1948)	6-18-9W	40	584	9,456	1	Arbuckle	3,232
Prosper East (1950)	5-18-9W	200	42,165	117,236	6	Arbuckle	3,222
Raymond (1929)	21-20-10W	2,800	270,067	13,324,967**	78	Wabaunsee	2,285
						Lans.-K.C.	3,130
						Arbuckle	3,330
Rick* (1936)	1-19-11W	40	2,778	51,910	1	Lans.-K.C.	3,106
						Arbuckle	3,355
Rick Southeast (1947)	18-19-10W	100	9,521	67,077	3	Lans.-K.C.	3,026
						Arbuckle	3,334
Rickard (1935)	22-18-9W	200	6,523	188,752	4	Arbuckle	3,324
Ringwald (1949)	32-18-10W	500	97,854	315,762	13	Lans.-K.C.	2,947
						Pre-Cambrian	3,072
Schulz (1952)	15-18-10W		no report	none		Arbuckle	3,500
Silica South* (1935)	24-20-11W	500	133,670	1,118,723	18	Lans.-K.C.	3,035
						Arbuckle	3,268
Smyres (1942)	36-19-6W	1,600	366,470	2,447,643	50	"Chat"	3,339
Sterling (1951)	4-22-8W	40	309	759	1		
Union East (1950)	27-20-8W	280	22,730	40,317	7	Sooy congl.	3,305
Volkland (1943)	27-18-9W	400	43,649	638,842	7	Arbuckle	3,221
Welch (1924)	35-20-6W	2,900	361,946	6,248,595	87	"Chat"	3,370
Welch East (1941)	1-21-6W	80	2,354	35,215	2	"Chat"	3,341

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Welch North (1937)	23-20-6W	80	3,469	101,677	2	"Chat"	3,334
Welch West (1948)	6-21-6W	280	27,393	92,888	7	"Miss. lime"	3,498
Wherry (1933)	11-21-7W	7,100	176,238	11,172,087	67	Sooy	3,358
Wherry North (1947)	35-20-7W	1,000	90,700	440,018	16	Sooy	3,423
Zink* (1950)	13-18-11W	120	13,813	14,970	3	Arbuckle	3,284
Pools or fields abandoned				284,228			
Total Rice County		68,360	9,566,545	182,288,202	1,577		

ROOKS COUNTY

Amboy (1950)	16-10-20W	120	13,256	53,979	3	Arbuckle	3,813
Annon (1951)	27-10-20W	80	19,568	31,688	2	Arbuckle	3,711
Barry (1942)	11-9-19W	1,840	721,874	6,051,216	69	Lans.-K.C.	
						Arbuckle	3,435
Barry East (1947)	6-9-18W	400	83,788	482,316	10	Lans.-K.C.	3,280
						Arbuckle	3,489
Barry Southeast (1946)	13-9-19W	680	161,314	1,324,325	25	Arbuckle	3,479
Bartos (1952)	15-9-19W		no report	none		Arbuckle	3,544
Bassett (1951)	20-10-20W	40	397	1,982	1	Arbuckle	3,749
Bassett Southwest (1952)	29-10-20W		no report	none		Arbuckle	3,679
Baum (1942)	10-10-16W	40	1,620	19,148	1	Lans.-K.C.	3,057
Baumgarten (1950)	25-9-19W	240	33,638	80,765	6	Arbuckle	3,621
Baumgarten Northeast (1952)	30-9-18W		no report	none		Arbuckle	3,608
Belmont (1949)	28-7-19W	40	1,855	9,301	1	Lans.-K.C.	3,337
Berland North (1950)	31-9-19W	Changed to Marcotte North					
Berland South (1951)	31-10-19W	40	4,953	16,854	1	Lans.-K.C.	3,480
Berland Southwest (1949)	26-10-20W	440	53,919	184,813	12	Arbuckle	3,728
Brungardt* (1952)	35-10-17W	120	13,285	13,285	3	Lans.-K.C.	3,194
Burnett* (1937)	1-11-18W	640	138,975	1,174,290	22	Lans.-K.C.	3,093
						Arbuckle	3,570
Burnett Northwest* (1946)	3-11-18W	240	42,718	329,540	6	Lans.-K.C.	3,450
						Arbuckle	3,617
Chandler (1948)	14-9-19W	Combined with Jelinek					
Chandler West (1951)	15-9-19W	40	3,182	3,182	1	"Dodge"	3,248
						(Shawnee)	
Dancer (1952)	4-8-17W	40	4,675	4,675	1	Lans.-K.C.	3,140
Dopita (1934)	31-8-17W	700	76,651	872,389	19	Lans.-K.C.	3,212
						Arbuckle	3,409
Dopita East (1952)	29-8-17W	40	2,541	2,541	1	Lans.-K.C.	3,304
Dorr (1942)	20-9-16W	640	65,184	688,617	17	Lans.-K.C.	3,230
Eagle Creek (1949)	2-10-20W	Combined with Marcotte					
Elm Creek (1951)	19-8-17W	320	35,133	37,829	7	Arbuckle	3,400
Elm Creek West (1952)	24-8-18W	Combined with Elm Creek					
Erway (1941)	2-10-16W	200	17,624	92,253	5	Lans.-K.C.	3,136
Fehnel (1952)	16-10-19W	80	5,145	5,145	2	Lans.-K.C.	3,480
Finnesy (1947)	14-10-18W	80	5,446	22,829	2	Lans.-K.C.	3,419
Gick (1947)	30-9-19W	200	30,630	122,980	5	Arbuckle	3,578
Gra-Rook (1948)	30-9-20W	800	304,167	597,732	21	Penn. congl.	3,810
						Arbuckle	3,869
Grover (1950)	22-7-19W	400	40,731	60,157	9	Lans.-K.C.	3,272
						Arbuckle	3,408
Hayden (1949)	31-8-19W	360	106,383	349,131	13	Lans.-K.C.	3,289
						Arbuckle	3,513
Hillside (1952)	12-8-20W	40	4,164	4,164	1	Shawnee	3,206
Jelinek (1947)	23-9-19W	1,500	594,741	2,217,539	67	Shawnee	3,220
						Arbuckle	3,537
Kern (1950)	28-9-20W	200	59,084	143,660	5	Arbuckle	3,855
Krueger* (1948)	35-10-16W	300	73,796	272,173	10	Lans.-K.C.	3,552
						Arbuckle	
Kruse (1951)	3-10-16W	40	2,194	4,529	1	Lans.-K.C.	3,094
Laton (1927)	11-9-16W	4,100	174,897	4,111,476	100	Lans.-K.C.	3,228
Laura* (1950)	30-10-20W	40	5,918	16,504	1	Arbuckle	3,706
Laura Southeast (1952)	30-10-20W	120	4,830	4,830	3	Arbuckle	3,667
Locust Grove (1949)	8-7-19W	40	3,514	16,069	1	Arbuckle	3,450
Locust Grove Southeast (1951)	9-7-19W	40	1,666	4,525	1	Arbuckle	3,400
Lone Star (1948)	4-8-17W	600	42,364	64,146	9	Arbuckle	3,382
Lone Star Southwest (1951)	8-8-17W	80	5,387	10,049	2	Arbuckle	3,299

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Lynd (1951)	32-9-19W	320	80,214	114,260	8	Arbuckle	3,750
Lynd Southwest (1952)	5-10-19W	40	1,473	1,473	1	Arbuckle	3,759
McClellan (1945)	9-9-19W	40	5,111	56,097	1	Lans.-K.C.	3,343
McHale (1948)	8-9-18W	400	57,343	299,346	10	Lans.-K.C.	3,436
						Arbuckle	3,494
McHale South (1949)	17-9-18W		no report	4,663		Arbuckle	3,615
McMullen (1952)	33-8-17W		no report	none		Arbuckle	3,454
Marc (1948)	18-9-19W	80	1,398	14,916	2	Lans.-K.C.	3,370
Marcotte (1943)	15-10-20W	5,800	1,919,317	5,900,926	214	Lans.-K.C.	3,596
						Arbuckle	3,752
Marcotte North (1950)	31-9-19W	160	23,806	50,619	4	Arbuckle	3,770
Marcotte Northwest (1950)	9-10-20W	40	8,766	23,568	1	Arbuckle	3,722
Marcotte South (1951)	22-10-20W	40	10,240	18,169	1	Arbuckle	3,719
Marcotte Southwest(1951)	21-10-20W	80	12,072	12,072	2	Arbuckle	3,743
Mayhew (1951)	24-9-19W	80	9,781	9,781	2	Arbuckle	3,613
Medicine Creek (1952)	18-8-16W	120	7,735	7,735	3	Lans.-K.C.	3,054
Mt. Ayr (1952)	13-10-18W	40	2,077	2,077	1	Lans.-K.C.	3,554
Nettie (1948)	34-9-17W	800	196,191	370,697	28	Lans.-K.C.	3,243
						Simpson	3,499
						Arbuckle	3,513
Northampton (1948)	26-9-20W	940	418,254	1,945,089	34	Arbuckle	3,803
Nyra (1946)	16-9-17W	300	19,778	147,209	9	Lans.-K.C.	3,429
						Arbuckle	3,501
Palco (1943)	5-10-20W	1,020	312,824	1,482,604	40	Arbuckle	3,824
Palco Southeast (1949)	3-10-20W	600	106,708	297,298	12	Lans.-K.C.	3,728
						Arbuckle	3,827
Palco Southwest (1951)	7-10-20W	160	33,246	36,796	4	Arbuckle	3,858
Palco Townsite (1945)	20-9-20W	80	5,725	24,654	2	Arbuckle	3,847
Paradise Creek (1947)	21-9-18W	1,100	251,845	1,718,667	34	Arbuckle	3,576
Plainville (1948)	31-9-17W	80	5,054	16,166	2	Lans.-K.C.	3,477
						Arbuckle	3,613
Ray Southeast (1942)	9-6-20W	40	3,779	75,910	1	Reagan	3,600
Riffe (1951)	4-7-19W	80	7,444	12,970	2	Lans.-K.C.	3,230
Slate (1951)	31-6-19W	120	5,746	5,746	3	Lans.-K.C.	3,291
						Arbuckle	3,545
Stamper (1950)	28-8-17W		no report	910		Marmaton	3,394
Stockton (1937)	35-7-17W	300	11,675	121,999	6	Shawnee	2,692
						Lans.-K.C.	3,180
Sweet (1951)	18-8-18W	40	2,167	4,738	1	Arbuckle	3,423
Vohs (1945)	14-10-19W	900	273,237	1,565,449	21	Lans.-K.C.	3,365
Vohs Northwest (1947)	9-10-19W	80	4,991	76,980	2	Lans.-K.C.	3,446
Vohs South (1947)	23-10-19W	40	no runs	12,524	1	Lans.-K.C.	3,303
Webster (1946)	27-8-19W	1,800	249,432	2,045,913	54	Arbuckle	3,403
Westhusin (1936)	11-9-17W	1,600	177,186	1,948,238	41	Lans.-K.C.	3,231
						Arbuckle	3,408
Whisman (1950)	9-9-20W		no report	none		Lans.-K.C.	3,427
Yohe (1949)	4-9-18W	80	6,136	32,786	2	Lans.-K.C.	3,266
Zurich (1935)	26-10-19W	700	35,850	319,040	8	Shawnee	3,087
						Lans.-K.C.	3,340
Zurich Southwest (1952)	34-10-19W	40	494	494	1	Lans.-K.C.	3,385
Zurich Townsite (1944)	27-9-19W	360	58,830	346,483	8	Arbuckle	3,647
Pools or fields abandoned				155,447			
Total Rooks County		34,460	7,287,132	38,783,135	1,032		
RUSH COUNTY							
Big Timber (1952)	5-16-18W	40	452	452	1	Arbuckle	3,613
Hungry Hollow (1951)	6-16-17W	40	1,006	2,429	1	Lans.-K.C.	3,344
Otis-Albert* (1934)	10-18-16W	2,200	86,137	4,730,872**	35	Reagan	3,527
Rush Center (1947)	16-18-18W	40	2,157	10,873	1	Arbuckle	3,836
Ryan* (1945)	35-19-16W	2,400	174,274	1,608,728	70	Arbuckle	3,656

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Stegman (1952)	11-16-17W	40	196	196	1	Lans.-K.C.	3,376
Timken (1952)	28-16-17W	40	1,049	1,049	1	Arbuckle	3,729
Weitzel (1947)	1-16-20W	40	2,229	36,080	1	Gorham	3,674
Pools or fields abandoned				59,942			
Total Rush County		4,840	267,500	6,450,621	111		

RUSSELL COUNTY

Atherton (1935)	30-13-14W	2,100	197,377	2,817,579	56	Arbuckle	3,284
Atherton North (1945)	7-13-14W	40	6,436	66,766	1	Arbuckle	3,195
Beisel (1944)	15-14-12W		no report	18,617		Arbuckle	3,266
Boxberger (1935)	36-15-15W	160	4,747	227,929	3	Lans.-K.C.	3,147
Claussen (1944)	27-12-14W	200	14,125	41,300	4	Lans.-K.C.	2,855
Claussen North (1949)	22-12-14W	40	1,328	9,730	1	Lans.-K.C.	2,956
Claussen West (1949)	29-12-14W		no report	1,217		Lans.-K.C.	2,841
Coal Creek (1951)	22-15-11W		no report	none		Penn. congl.	3,178
Cook (1950)	26-13-15W	200	15,957	55,369	5	Lans.-K.C.	3,051
						Arbuckle	3,314
Davidson* (1930)	4-16-11W	160	11,490	197,440	4	Lans.-K.C.	3,016
						Sooy	3,317
						Arbuckle	3,314
Dillner Northwest (1947)	27-13-15W	40	no runs	9,640	1	Arbuckle	3,318
Donovan (1935)	10-15-15W	120	8,827	220,173	3	Lans.-K.C.	3,193
Dubuque (1935)	34-15-12W	750	101,010	956,301	19	Lans.-K.C.	3,275
						Arbuckle	3,330
Ehrlich (1951)	7-14-13W	Combined with Hall-Gurney					
Ely (1949)	15-15-13W	Combined with Trapp					
Eulert (1949)	35-11-15W	540	179,663	542,673	17	Arbuckle	3,316
Fairport* (1923)	8-12-15W	4,000	590,196	21,350,827	157	Lans.-K.C.	2,950
						Sooy	3,137
						Gorham	3,211
						Arbuckle	3,312
						Simpson	3,316
						Reagan	3,350
Fay (1952)	2-12-15W	40	1,643	1,643	1	Arbuckle	3,238
Gorham (1926)	32-13-15W	16,200	1,981,997	53,981,102	454	Shawnee	2,765
						Lans.-K.C.	2,908
						Gorham	3,152
						Arbuckle	3,289
						Reagan	3,299
Hall-Gurney*(1931)	30-14-13W	27,000	3,952,216	54,822,259	1,041	Indian Cave	1,985
						Wabaunsee	2,400
						Topeka	2,675
						Oread	2,813
						Lans.-K.C.	2,985
						Gorham	3,165
						Arbuckle	3,192
						Pre-Cambrian	3,156
Homer (1949)	17-14-13W	Combined with Hall-Gurney					
Homer Southeast (1949)	16-14-13W	Combined with Hall-Gurney					
Janne (1943)	24-15-12W	300	17,245	206,891	5	Lans.-K.C.	
						Arbuckle	3,319
Jerry (1942)	4-15-14W	40	2,730	58,387	1	Wabaunsee	
						Lans.-K.C.	2,985
						Arbuckle	
Kaufman* (1947)	33-15-12W	40	5,989	59,045	1	Arbuckle	3,311
Meier (1948)	30-15-12W	60	21,605	116,861	3	Arbuckle	3,325
Ney (1948)	31-15-12W	240	30,701	173,853	5	Lans.-K.C.	3,240
						Arbuckle	3,350
Parker (1948)	18-15-12W	340	35,342	234,898	7	Shawnee	2,957
						Arbuckle	3,259
Russell (1934)	22-13-14W	2,720	471,622	9,717,299	94	Lans.-K.C.	3,195
						Arbuckle	3,280
Russell East (1949)	25-13-14W	100	600	26,407	3	Arbuckle	3,273
Strecker (1943)	21-15-14W	120	2,536	49,284	2	Arbuckle	3,342

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Trapp* (1936)	23-15-14W	23,000	3,971,031	87,978,278	860	Tarkio	2,350
						Shawnee	2,889
						Dodge	2,966
						Lans.-K.C.	3,062
						Arbuckle	3,252
Trapp East (1949)	14-15-13W	80	8,911	39,270	2	Lans.-K.C.	3,146
						Arbuckle	3,277
Pools or fields abandoned				352,292			
Total Russell County		78,630	11,635,324	234,333,330	2,750		
SALINE COUNTY							
Bachofer (1951)	15-15-2W	160	11,660	16,765	4	Mississippian	2,799
Gypsum Creek North (1952)	33-16-1W	500	12,032	12,032	6	Mississippian	2,594
Holm (1951)	32-16-3W	160	29,773	34,222	5	Viola	3,406
Holm North (1952)	20-16-3W	600	9,170	9,170	5	Viola	3,427
Holm Southeast (1952)	32-16-3W	80	3,494	3,494	2	Viola	3,388
Hunter (1943)	20-16-1W	880	39,660	1,048,399	20	"Chat"	2,681
Hunter North (1948)	8-16-1W	320	41,775	140,583	8	"Miss. lime"	2,674
Mentor (1944)	13-15-3W	120	4,471	25,648	3	Viola	3,258
Olsson (1929)	10-16-3W	1,080	61,073	424,692	18	Viola	3,303
Salemsborg (1952)	5-16-3W	40	2,651	2,651	1	Viola	3,381
Salina (1943)	30-14-2W	1,700	80,720	838,324	28	Viola	3,223
Salina South (1946)	32-14-2W	300	18,656	141,439	7	Viola	3,246
Smolan (1950)	19-15-3W	3,200	754,036	1,096,768	95	Viola	3,386
Swenson (1950)	34-15-3W	40	2,351	8,920	1	Viola	3,353
Pools or fields abandoned				11,285			
Total Saline County		9,180	1,071,522	3,814,392	203		
SCOTT COUNTY							
Keystone (1950)	25-18-32W	120	43,519	60,586	3	Lans.-K.C.	4,001
Shallow Water (1935)	15-20-33W	900	28,076	1,821,855	8	Marmaton	4,286
						"Miss. lime"	4,660
						Ste. Genevieve	4,670
Total Scott County		1,020	71,595	1,882,441	11		
SEDGWICK COUNTY							
Bartholomew* (1948)	30-27-4W	1,800	462,222	1,380,985	63	"Miss. lime"	3,732
Butwick* (1949)	7-26-3E	40	1,939	1,939	1	Mississippian	2,860
Chambers (1948)	10-29-2W	120	10,616	42,591	3	"Miss. lime"	3,540
Clearwater (1944)	22-29-2W	200	11,145	106,077	5	Lans.-K.C.	2,913
Crestview (1952)	1-27-1E		no report	none		"Burgess"	2,982
Cross (1929)	27-25-1W	40	4,780	82,256	1	Lans.-K.C.	2,690
Curry (1947)	11-27-1W	440	79,382	401,555	15	Lans.-K.C.	2,715
						Simpson	3,400
Eastborough (1929)	19-27-2E	870	59,149	8,879,707	25	"Chat"	2,956
						Viola	3,238
Eastborough North (revived) (1952)	8-27-2E	80	5,939	10,339	1	Arbuckle	3,376
Fairview (1948)	8-26-2E	600	56,693	248,616	9	Lans.-K.C.	2,500
						"Burgess"	2,960
						Mississippian	2,991
Fairview North (1948)	5-26-2E	120	13,481	96,683	3	"Burgess"	2,971
Fairview South (1950)	17-26-2E	40	2,258	9,380	1	"Burgess"	2,945
Gehring-Rick (1952)	16-28-2E	80	1,505	1,505	2	Mississippian	2,950

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Goodrich (1928)	16-25-1E	780	74,378	4,647,607	25	Lans.-K.C.	2,614
						"Chat"	3,010
						Kinderhookian	3,334
						Arbuckle	3,339
Greenwich (1929)	14-26-2E	700	136,531	11,428,459	25	"Chat"	2,885
						Viola	3,321
Hinkle (1946)	1-27-1E		no report	10,153		"Burgess"	2,980
Hohn (1945)	22-27-1W	160	14,005	97,013	4	Lans.-K.C.	2,779
Kuske North (1951)	13-25-1E	200	15,754	19,567	5	"Burgess"	3,016
Luening (1951)	33-26-2E	80	3,968	5,547	2	Simpson	3,338
Minneha (1951)	11-27-2E	40	3,716	8,449	1	Arbuckle	3,247
Minneha Northwest (1951)	10-27-2E		no report	2,798		Simpson	3,300
Petrie (1945)	36-26-1W	80	12,557	92,190	1	Viola	3,387
Petrie Northwest (1951)	35-26-1W	40	17,033	20,882	1	Viola	3,445
Prairie Creek (1952)	25-25-2E	40	176	176	1	Mississippian	2,812
Robbins (1929)	20-28-1E	900	91,356	3,932,509**	47	"Miss. lime"	3,090
Schulte (1947)	7-28-1W	200	8,643	190,573	5	Mississippian	3,349
						Simpson	3,658
Valley Center (1928)	1-26-1W	1,800	66,749	21,963,695	34	Lans.-K.C.	2,860
						Kinderhookian	3,380
						Viola	3,366
White Cotton (1948)	30-26-2E	700	84,698	413,937	17	"Burgess"	2,957
Pools or fields abandoned				216,421			
Total Sedgwick County		10,230	1,238,673	54,311,609	297		
SEWARD COUNTY							
Kismet (1948)	23-33-31W		no runs	16,103		Marmaton	5,095
Kismet South (1952)	26-33-31W	40	7,041	7,041	1	Mississippian	5,770
Kneeland (1951)	23-34-31W	40	1,930	3,041	1	Marmaton	5,332
Liberal-Light (1951)	11-35-32W	240	45,371	62,975	3	Morrowan	6,005
Liberal Southeast (1947)	15-35-33W	120	7,120	61,807	3	Penn. sandstone	6,202
Liberal-White (1952)	35-34-32W	40	394	394	1	Morrowan	5,906
Light (1951)	11-35-32W	Changed to Liberal-Light					
Total Seward County		480	61,856	151,361	9		
SHERIDAN COUNTY							
Adell (1944)	11-6-27W	1,200	362,519	2,665,433	8	Lans.-K.C.	3,755
George (1952)	17-9-26W	40	6,304	6,304	1	Lans.-K.C.	4,023
Moss (1952)	2-8-30W	40	339	339	1	Lans.-K.C.	4,033
Studley (1943)	23-8-26W	340	20,748	379,653	6	Lans.-K.C.	3,810
Studley Southwest (1945)	32-8-26W	40	4,443	43,083	1	Lans.-K.C.	3,758
Total Sheridan County		1,660	394,353	3,094,812	47		
STAFFORD COUNTY							
Ahnert (1941)	26-22-13W	40	2,528	45,657	1	Arbuckle	3,784
Bart-Staff* (1951)	4-21-14W	120	48,283	73,318	3	Arbuckle	3,572
Bayer (1951)	16-21-14W		no report	1,505		Lans.-K.C.	3,543
Bedford (1940)	21-23-12W	900	64,266	1,555,051	16	Arbuckle	3,859
Brock (1944)	12-23-12W	640	17,249	347,528	10	Arbuckle	3,680
Brunselmeyer (1952)	2-22-13W	80	5,276	5,276	2	Arbuckle	3,652
Byron (1951)	9-21-12W	80	8,275	17,472	2	Arbuckle	3,459
Byron Southeast (1951)	10-21-12W	160	17,636	20,390	4	Arbuckle	3,500
Chase-Silica* (1931)	32-19-9W	400	44,582	175,092	9	Arbuckle	3,383
Cochlin (1951)	19-22-11W	80	10,416	13,363	2	Arbuckle	3,659
Crissman (1952)	16-23-14W	240	24,803	24,803	6	Lans.-K.C.	3,664
						Simpson	3,984
						Arbuckle	4,006
Crissman North (1952)	9-23-14W		no report	none		Lans.-K.C.	3,669
Curtis (1942)	6-22-13W	500	59,183	638,846	11	Lans.-K.C.	3,514
						Arbuckle	3,693
Curtis South (1951)	12-22-14W	40	674	1,741	1	Arbuckle	3,751
Curtis West (1952)	12-22-14W	200	28,539	28,539	5	Lans.-K.C.	3,570
						Arbuckle	3,744
Dell (1950)	7-21-13W	160	20,380	77,596	4	Lans.-K.C.	3,446

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Dell East (1951)	5-21-13W	400	69,689	94,474	11	Lans.-K.C.	3,471
Dell Northeast (1951)	5-21-13W	40	4,205	4,834	1	Arbuckle	3,612
Drach (1937)	12-22-13W	2,700	397,297	5,127,732	54	Arbuckle	3,690
Drach Northwest (1944)	11-22-13W	Combined with Gates South					
Drach West (1938)	14-22-13W	40	2,704	120,262	1	Arbuckle	
Duggan (1951)	30-21-11W	540	42,997	99,189	8	Lans.-K.C.	3,312
						Penn. congl.	3,479
						Simpson	3,505
						Arbuckle	3,514
Eden Valley (1950)	29-21-13W	400	82,298	115,198	10	Lans.-K.C.	3,496
						Arbuckle	3,748
Eric (1951)	8-21-13W	Combined with Dell East					
Farmington (1943)	34-24-15W	980	54,786	1,047,507	17	Kinderhookian	
						Arbuckle	4,417
Fischer (1938)	31-21-12W	200	20,504	369,758	5	Arbuckle	3,641
Fischer Northwest (1948)	36-21-13W	1,000	433,304	1,390,846	32	Lans.-K.C.	3,464
						Arbuckle	3,639
Frey (1950)	7-21-14W	700	136,274	344,804	11	Arbuckle	3,717
Gates (1933)	27-21-13W	1,200	280,670	2,639,324	44	Viola	3,635
						Arbuckle	3,679
Gates South (1949)	3-22-13W	800	111,616	255,971	18	Arbuckle	3,748
German Valley (1951)	4-22-12W	80	10,012	16,596	2	Arbuckle	3,648
Gray (1946)	11-24-13W	120	3,094	42,432	3	Lans.-K.C.	3,762
Grow (1949)	16-21-13W	640	98,289	284,405	13	Lans.-K.C.	3,463
						Arbuckle	3,705
Grow West (1952)	16-21-13W	Combined with Hazel West					
Grunder (1943)	11-25-15W	40	1,734	22,276	1	Lans.-K.C.	3,945
Happy Valley (1952)	15-23-13W	40	3,624	3,624	1	Arbuckle	3,810
Hart (1949)	36-22-14W		no report	14,204		Arbuckle	3,830
Harter (1950)	30-24-13W	80	9,823	64,951	4	Lans.-K.C.	3,767
						Simpson	4,167
						Arbuckle	4,181
Hazel (1942)	21-21-13W	840	114,804	510,921	21	Arbuckle	3,692
Hazel West (1950)	20-21-13W	800	149,072	306,636	16	Arbuckle	3,673
Helene (1952)	16-22-12W	40	2,272	2,272	1	Arbuckle	3,685
Heyen (1943)	24-22-12W	800	36,577	519,844	15	Arbuckle	3,652
Hickman (1951)	27-21-14W	700	198,460	343,692	21	Lans.-K.C.	3,522
						Simpson	
Hickman South (1952)	34-21-14W	40	2,152	2,152	1	Lans.-K.C.	3,567
Hudson (1952)	33-22-12W		no report	none		Lans.-K.C.	3,495
Hufford (1948)	33-21-13W	400	138,643	475,203	14	Lans.-K.C.	3,499
						Arbuckle	3,755
Jordan (1936)	15-25-14W	380	40,856	749,807	9	Lans.-K.C.	3,722
Kachelman (1950)	7-25-13W		no report	1,868		Viola	4,075
Kelly (1948)	35-23-12W		no report	5,204		Arbuckle	3,870
Kenilworth (1947)	15-22-13W	400	49,845	337,096	12	Lans.-K.C.	3,505
						Arbuckle	3,808
Kipp (1937)	27-25-14W	300	16,806	635,921	6	Lans.-K.C.	3,827
Kipp Northeast (1946)	23-25-14W	120	15,501	181,109	3	Lans.-K.C.	3,844
Knoche (1951)	8-24-12W	80	640	992	2	Viola	3,810
Koelsch (1952)	24-24-14W	80	5,000	5,000	2	Lans.-K.C.	3,750
Koelsch Southeast (1952)	25-24-14W	40	4,217	4,217	1	Arbuckle	4,187
Kowalsky* (1941)	32-20-11W	80	6,496	9,209	2	Lans.-K.C.	3,279
Kowalsky Southwest (1950)	6-21-11W	240	28,496	97,935	5	Arbuckle	3,424
Leesburgh (1938)	12-25-13W	700	51,222	2,439,835	14	Simpson	4,060
						Arbuckle	4,153
Leo (1950)	7-21-13W	80	23,432	36,041	3	Lans.-K.C.	3,475
						Arbuckle	3,636
Lincoln (1951)	29-21-14W	160	43,860	57,679	4	Lans.-K.C.	3,543
Lincoln Northwest (1952)	29-21-14W	40	1,344	1,344	1	Arbuckle	3,778

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McCandless (1944)	30-25-13W	340	134,191	606,192	13	Lans.-K.C.	3,863
						Simpson	4,251
McGinty (1950)	13-21-14W	40	2,327	8,480	1	Lans.-K.C.	3,503
McGinty Northwest (1951)	14-21-14W	40	6,181	16,339	1	Lans.-K.C.	3,483
Marie (1951)	30-21-12W	160	27,468	40,226	4	Lans.-K.C.	
						Arbuckle	3,639
Max (1938)	35-21-12W	4,480	686,255	5,005,059	78	Lans.-K.C.	3,356
						Simpson	3,615
						Arbuckle	3,570
Max South (1950)	15-22-12W	40	1,627	6,557	1	Lans.-K.C.	3,320
Merle (1949)	32-23-13W	380	40,363	262,400	13	Lans.-K.C.	3,669
Moon (1948)	4-22-13W	80	10,206	25,558	2	Lans.-K.C.	3,530
						Penn. congl.	3,643
Mt. View (1952)	29-22-13W	40	4,395	4,395	1	Lans.-K.C.	3,641
Mueller (1938)	29-21-12W	4,400	628,130	4,297,455	85	Lans.-K.C.	3,356
						Arbuckle	3,594
Mueller Northwest (1951)	12-21-13W	Combined with Mueller					
Mueller West (1949)	24-21-13W	120	10,982	16,259	3	Arbuckle	3,658
Nellie (1948)	28-22-14W	40	726	21,542	1	Lans.-K.C.	3,696
Neola (1948)	15-25-11W	80	3,636	23,347	2	Viola	3,921
North Star (1952)	27-24-12W	240	27,494	27,494	6	Viola	3,915
						Simpson	4,063
O'Connor (1948)	8-24-15W	120	3,971	17,333	3	Lans.-K.C.	3,768
Oscar (1949)	24-22-14W	340	30,722	116,108	8	Lans.-K.C.	3,503
						Viola	3,777
						Arbuckle	3,798
Oscar North (1951)	14-22-14W	300	55,389	66,116	7	Arbuckle	3,780
Oscar West (1952)	22-22-14W	120	15,912	15,912	3	Lans.-K.C.	3,593
Pleasant Hill (1951)	26-24-12W		no report	69		Lans.-K.C.	3,530
Pleasant Grove (1952)	26-22-12W	80	4,270	4,270	2	Lans.-K.C.	3,462
Prairie Home (1949)	2-21-13W	80	1,163	14,940	2	Arbuckle	3,514
Pritchard South (1951)	3-21-14W	40	6,780	6,997	1	Lans.-K.C.	3,483
Pundsack (1947)	19-21-13W	760	104,710	331,618	17	Lans.-K.C.	3,575
						Arbuckle	3,735
Pundsack North (1950)	18-21-13W	160	26,299	47,791	4	Arbuckle	3,674
Pundsack Northwest (1950)	24-21-14W	40	832	5,031	1	Lans.-K.C.	3,512
Rattlesnake (1938)	13-24-14W	160	13,790	177,030	4	Lans.-K.C.	3,608
Rattlesnake Southwest (1950)	14-24-14W	40	10,517	56,999	1	Lans.-K.C.	3,760
Rattlesnake West (1944)	11-24-14W	240	26,215	107,586	7	Lans.-K.C.	3,759
						Mississippian	4,025
Richardson (1930)	36-22-12W	1,400	553,534	11,789,577	67	Lans.-K.C.	3,264
						Arbuckle	3,537
Richland (1944)	27-24-14W	40	495	186,258	1	Mississippian	4,032
						Arbuckle	4,232
Riley (1940)	28-23-11W	80	4,485	137,177	2	Lans.-K.C.	3,323
Rose Valley (1952)	36-25-13W	40	4,898	4,898	1	Lans.-K.C.	3,824
Rothgarn (1943)	10-21-13W	440	33,365	272,899	10	Lans.-K.C.	3,369
						Arbuckle	3,569
Rothgarn Southeast (1950)	14-21-13W	120	26,390	43,635	3	Arbuckle	3,544
St. John (1935)	23-24-13W	840	45,624	2,567,157	16	Lans.-K.C.	3,588
						Arbuckle	4,075
St. John North (1952)	20-23-13W	40	2,231	2,231	1	Lans.-K.C.	3,603
St. John Northwest (1952)	20-23-13W	40	3,816	3,816	1	Lans.-K.C.	3,644
St. John Townsite (1944)	33-23-13W	400	25,477	384,422	10	Lans.-K.C.	
						Arbuckle	3,919
Sandago (1947)	12-21-12W	240	12,103	132,131	5	Arbuckle	3,480
Sand Hills (1944)	19-21-11W	40	3,735	53,437	1	Arbuckle	3,548
Saundra (1946)	14-21-12W	260	21,332	170,933	6	Lans.-K.C.	3,282
						Arbuckle	3,546
Shaeffer (1941)	3-21-13W	120	13,150	339,346	3	Lans.-K.C.	3,404
						Arbuckle	3,546
Shepherd (1951)	16-22-11W	280	61,971	104,201	7	Arbuckle	3,548
Silver Bell (1949)	10-22-13W	260	13,239	41,278	5	Lans.-K.C.	3,498
						Arbuckle	3,774
Sittner (1937)	33-21-12W	440	26,848	654,866	13	Lans.-K.C.	3,278
						Arbuckle	3,600
Sleeper (1951)	22-22-11W	80	2,697	14,796	2	Penn. congl.	3,581

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TABLE 66.—*Oil production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
Smallwood (1951)	2-22-14W	640	155,995	196,389	15	Lans.-K.C.	3,474
						Arbuckle	3,576
Snider (1936)	3-21-11W	80	20,262	444,330	2	Simpson	3,362
Snider South (1938)	16-21-11W	500	87,768	1,178,310	10	Simpson	3,402
						Arbuckle	
Spangenberg (1943)	21-22-12W	40	3,100	80,107	1	Arbuckle	3,691
Stafford (1940)	15-24-12W	1,280	197,426	3,376,242	33	Viola	3,836
						Arbuckle	3,945
Star (1950)	4-21-14W	40	1,669	9,755	1	Arbuckle	3,579
Strobel (1952)	9-22-14W	80	6,651	6,651	2	Lans.-K.C.	3,659
						Arbuckle	3,864
Strobel Northwest (1952)	8-22-14W	80	4,209	4,209	2	Simpson	3,852
						Arbuckle	3,874
Syms East (1947)	21-21-12W	40	2,253	9,840	1	Arbuckle	3,565
Syms Southeast (1952)	27-21-12W	40	2,356	2,356	1	Arbuckle	3,565
Taylor (1952)	15-21-14W	40	9,427	9,427	1	Simpson	3,688
Van Lieu (1943)	20-24-13W	120	4,523	202,385	3	Arbuckle	4,069
Van Winkle (1950)	23-21-14W	40	2,475	9,049	1	Lans.-K.C.	3,570
Van Winkle Southeast(1950)	26-21-14W	80	14,570	34,196	2	Lans.-K.C.	3,569
Wendelburg (1951)	19-23-11W	40	5,721	10,358	1	Arbuckle	3,729
Zenith-Peace Creek*(1937)	23-24-11W	6,000	159,885	20,348,398	78	Lans.-K.C.	3,481
						Viola	3,860
Pools or fields abandoned				50,827			
Total Stafford County		47,220	6,462,936	76,013,531	1,044		
			SUMNER COUNTY				
Alton (1949)	10-35-2W		no report	12,148		Simpson	4,711
Anness (1937)	2-30-4W	40	2,200	154,028	1	Simpson	4,394
Anson (1948)	35-30-2W	80	19,119	74,893	4	Lans.-K.C.	3,264
						"Miss. lime"	3,742
Bellman (1945)	15-30-1E	160	23,379	279,683	4	Simpson	3,798
Caldwell (1929)	17-35-3W	160	53,859	1,479,057	4	Simpson	4,765
Caldwell Northwest (1952)	8-35-3W	40	3,011	3,011	1	Simpson	4,835
Chandler (1942)	4-35-2E		no report	9,947		"Miss. lime"	3,450
Churchill (1926)	25-31-2E	720	70,345	16,402,411	26	"Stalnaker"	1,820
						Arbuckle	2,632
Corbin (1948)	23-34-2W		no report	37,286		Simpson	4,475
Fall Creek (1950)	3-35-3W	800	298,510	761,635	24	Simpson	4,746
Guelph (1951)	6-35-1E	640	184,067	209,247	20	Lans.-K.C.	3,028
						Simpson	3,854
						Arbuckle	3,969
Hunnewell (revived) (1952)	18-35-1E	40	838	838	1	Mississippian	3,602
Latta (1927)	9-30-2W	540	39,384	1,243,928	11	Lans.-K.C.	3,042
Lee (1951)	33-32-2E	300	28,579	38,402	6	Mississippian	3,349
Margaret (1946)	36-32-2E	40	2,489	108,423	1	Arbuckle	3,474
Metz (1951)	7-32-2E	40	5,706	17,160	1	Simpson	3,735
						Arbuckle	3,773
Murphy* (1933)	7-35-3E		See Cowley County				
Oxford (1927)	14-32-2E	800	106,325	16,132,151	25	Hoover	1,930
						"Stalnaker"	2,020
						"Layton"	2,510
						Arbuckle	2,890
Oxford West (1926)	17-32-2E	240	27,012	699,585	6	Simpson	3,681
						Arbuckle	
Padgett (1925)	12-33-2W	2,700	195,958	2,381,382	38	"Miss. lime"	3,474
						Simpson	3,744
Perth (1945)	12-33-2W	600	103,794	718,948	12	"Wilcox"	4,264
Portland (1950)	16-34-1E	160	50,928	100,472	5	Simpson	4,002
Rainbow Bend West* (1925)	24-33-2E		no report	453,000		Arbuckle	

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Slate Creek (1952)	9-33-2E	40	4,651	4,651	1	Lans.-K.C.	2,804
Tate (1950)	31-32-2E		no report	3,171		Simpson	3,726
Val Verde (1945)	23-33-2E	40	492	5,442	1	"Bartlesville"	3,280
Vernon North (1930)	15-35-2E	1,860	58,571	926,067	24	"Miss. lime"	3,443
Wellington (1929)	33-31-1W	3,000	216,097	7,943,111	142	"Chat"	3,655
Zoglmann (1951)	8-31-1W	40	5,905	14,101	1	Simpson	4,036
Zyba (1937)	7-30-1E	560	31,355	352,265	7	Simpson	3,866
Zyba Southwest (1944)	22-30-1W	600	178,676	717,691	14	Simpson	3,918
Pools or fields abandoned				126,475			
Total Sumner County		14,240	1,811,250	51,410,609	380		

THOMAS COUNTY

Mingo (1952)	19-9-32W	40	1,208	1,208	1	Mississippian	4,680

TREGO COUNTY

Cotton (1945)	15-12-21W	40	1,970	31,093	1	Arbuckle	3,958
Cotton East (1947)	14-12-21W	40	5,199	41,477	1	Arbuckle	3,942
Ellis* (1942)	31-12-20W	420	30,939	348,996	5	Arbuckle	3,832
Ellis Northwest (1944)	26-12-21W	160	8,279	172,878	4	Arbuckle	3,925
Ellis South (1952)	12-13-21W	40	1,420	1,420	1	Arbuckle	3,822
Groff (1952)	26-14-21W	40	1,387	1,387	1	Penn. congl.	3,822
Nieden (1952)	16-12-23W	40	6,210	6,210	1	Mississippian	3,850
Ogallah (1951)	26-12-22W	3,000	563,584	670,286	65	Arbuckle	3,961
Ogallah West (1951)	28-12-22W	Combined with Ogallah					
Ridgeway (1952)	26-12-21W	300	38,189	38,189	7	Arbuckle	3,896
Spring Creek (1951)	32-12-21W	40	120	340	1	Arbuckle	3,904
Sunny Slope (1952)	21-14-21W	300	33,190	33,190	7	Marmaton	3,848
Wakeeney (1934)	14-11-23W	640	21,898	819,097	5	Lans.-K.C.	3,619
Wakeeney East (1949)	13-11-23W	40	1,172	11,904	1	Lans.-K.C.	3,576
Walz (1950)	12-11-21W	640	88,088	166,485	10	Lans.-K.C.	3,428
						Arbuckle	3,666
Pools or fields abandoned				51,206			
Total Trego County		5,740	801,645	2,394,158	110		

WABAUNSEE COUNTY

Davis Ranch (1949)	33-13-10E	1,260	236,531	895,220	18	"Hunton"	2,929
						Viola	3,201
Mill Creek (1950)	2-13-10E	320	35,585	88,585	4	Viola	2,923
Newbury (1950)	11-11-11E	320	48,672	107,595	6	Viola	2,901
Wheat (1951)	10-15-11E	100	4,221	4,403	1	Simpson	3,230
Woodbury (1951)	11-15-10E	320	8,285	11,896	2	Viola	3,328
Pools or fields abandoned				7,599			
Total Wabaunsee County		2,320	333,294	1,115,298	31		

WILSON COUNTY

Altoona (1903)	10-29-16E	600			5+	"Squirrel"	650
a			31			"Bartlesville"	900
b			570				
c			547				
d			614				
e			78				
Altoona East	29-17E	300	3,635		1+	"Bartlesville"	900
Benedict	28-15E	40	518		1+	"Bartlesville"	1,000
Buffalo* (1924)	27-16E	1,000			3+	"Bartlesville"	1,025
a			5,298			Cherokee	1,150
b			234				
c			943				
Fredonia (1890)	29-15E	300			3+	"Burgess"	1,050
a			4,508				
b			120				
Humboldt-Chanute*	28-17E	200	3,116		1+	"Bartlesville"	850
Neodesha*	30-16E	3,600			10+	"Bartlesville"	950
a			8,899				

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TABLE 66.—*Oil production in Kansas during 1952, concluded*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, bbls.	Cumulative production to end of 1952, bbls.	No. producing wells	Producing zone	Depth to producing zone, feet
b			345				
c			448				
d			22,563				
e			677				
Neodesha East	30-17E	200	744		1+		
Vilas (1905)	27-17E	160			2+	"Bartlesville"	1,000
a			3,547				
b			2,769				
"Wiggins"	28-17E	600	7,067		5+	"Bartlesville"	850
Total Wilson County		7,000	67,271	5,343,146 recorded	32+		
WOODSON COUNTY							
Batesville (1934)	34-25-14E		no runs			"Bartlesville"	1,450
Big Sandy (1923)	23-26-14E	650	26,572		19	"Bartlesville"	1,230
Buffalo* (1924)	26-16E	200	2,301		1+	"Bartlesville"	950
						Cherokee	1,150
Evans (1938)	21-23-15E	300	3,613		5	Mississippian	1,540
Hoagland (1929)	2-24-14E	1,400	36,961		35	Mississippian	1,635
Humboldt-Chanute*	25-17E	600			2+	"Bartlesville"	900
a			2,659				
b			686				
Jobes	24-13E		no report				
Neosho Falls* (1928)	23-16E	2,200			19+	"Squirrel"	950
a			7,302			Mississippian	1,200
b			3,552				
c			14,627				
Perry	26-17E	500	15,194		5+		
Piqua (1938)	22-24-17E	100	127		1+	Mississippian	1,190
Quincy* (1932)	14-25-13E	1,800	197,029		200+	"Bartlesville"	1,500
Rose	7-26-16E		no report				
Silver City (1946)	19-23-15E		no report				
Steele (1952)	20-23-15E	40	1,050		1+	Mississippian	1,525
Vernon	23-16E	200	1,045		1+	Mississippian	1,420
Virgil North* (1920)	22-23-13E	600	20,779		10+	"Bartlesville"	1,585
						Mississippian	1,840
Weide (1937)	31-23-15E	900	23,815		22	Mississippian	1,570
Winterscheid*	23-14E	7,000	254,275		318	"Bartlesville"	1,630
						Mississippian	1,750
Wiseman (1936)	3-24-15E	300	2,993		1+	Mississippian	1,520
Yates Center	28-25-15E	1,000			2+	Mississippian	1,480
a			13,461				
b			360				
Miscellaneous			3,110				
Total Woodson County		17,790	631,511	5,219,172 recorded	642+		

* Field extends into adjacent county or counties.
** Corrected cumulative.

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TABLE 67.—*Gas production in Kansas during 1952*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, M cu. ft.	Cumulative production to end of 1952, M cu. ft.	No. producing wells	Producing zone	Depth to producing zone, feet
			ALLEN COUNTY				
Humboldt-Chanute	26-18E		140,065		33	"Squirrel"	740
						"Bartlesville"	850
Miscellaneous			245,618		80+		
Total Allen County			385,683		113 +		
			ANDERSON COUNTY				
Southeast part of Anderson County			919		1+		
			BARBER COUNTY				
Aetna (1935)	13-34-15W	500	67,778	975,284est.	1	Mississippian	4,850
						Viola	5,215
Boggs (1947)	8-33-12W	80	Included with Whelan			Simpson	4,824
Clara (1944)	2-30-14W	280	no report	717,792		Simpson	4,435
						Viola	4,509
						Arbuckle,	4,540
Cottonwood Creek (1948)	21-30-14W	160	no report	none		Simpson	4,582
Deerhead (1942)	26-32-15W	640	no report	1,693,763		Viola	4,931
DeGeer (1948)	2-33-15W	100	5,327	101,890	1	Viola	5,176
Donald (1946)	33-31-15W	160	no report	none		"Miss. lime"	4,697
Lake City (1945)	7-31-13W	40	Included with Skinner North				
Medicine Lodge (1927)	13-33-13W	7,200	3,505,008	144,823,371	40	"Chat"	4,455
Medicine Lodge Northeast (1945)	8-33-12W	300	Included with Medicine Lodge			"Douglas sd."	3,812
						Simpson	4,860
Nippawalla (1951)	13-33-12W	40	no report	none		"Douglas sd."	3,659
Skinner North	17-31-14W	5,200	609,299	22,380,135	10	Viola	4,630
Skinner South (1944)	32-31-14W	200	Included with Skinner North			"Douglas sd."	4,023
Whelan (1934)	32-31-11W	640	2,219,993	20,349,298	10	"Chat"	4,355
Total Barber County		15,240	6,407,405	191,041,533	62		
			BARTON COUNTY				
Adolph (1947)	16-20-15W		no report	none		Arbuckle	3,734
Ash Creek* (1948)	31-20-15W	200	175,300est.		2	Arbuckle	3,769
Behrens (1944)	6-20-15W	200	175,300est.		2		
Bergtal (1941)	22-20-15W	500	54,473	784,437	3	Arbuckle	3,689
Dundee (1945)	29-20-14W	600	278,244	1,749,092	5	Arbuckle	3,607
Eberhardt (1935)	14-19-11W	100	7,891	356,038	1		
Heizer Southwest (1952)	21-19-14W	40	11,837	11,837	1	Penn. congl.	3,496
Krier (1944)	30-16-11W	160	93,650	492,938	2		
			Within Kraft-Prusa pool				
Otis-Albert* (1930)	11-18-16W	7,000	1,009,489est.		22	Neva	
					est.	Reagan	3,507
Pawnee Rock* (1936)	19&20-15&16W	100	87,000		1		
Rick* (1941)	11-19-11W	60	no report	360,722		Arbuckle	3,355
Unruh (1945)	24-20-15W	400	794,119	10,707,752	4	Arbuckle	3,641
Total Barton County		9,360	2,687,303	14,462,816	43		
			BUTLER COUNTY				
Andover South*	31-27-3E		no report			"Stalnaker"	2,006
			CHASE COUNTY				
Altemus	26-18-8E		no report				

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TABLE 67.—*Gas production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, M cu. ft.	Cumulative production to end of 1952, M cu. ft.	No. producing wells	Producing zone	Depth to producing zone, feet
Davis'(1929)	18-8E	640	52,393		32	L. Permian	350-400
Elmdale	19-7E	300	12,752		8	L. Permian	500
						Wabaunsee	800
Hymer	18-7E		no report				
Lipps	32-18-7E		no report				
Neva	19-7E		no report				
Total Chase County		940	65,145		40		
CHAUTAUQUA COUNTY							
Miscellaneous			126,227		15		
CLARK COUNTY							
Ashland (1951)	35-32-23W	1,200	263,971	263,971	2		
Snake Creek (1952)	21-34-21W	640	no report	none		Morrowan	5,452
Theis (1951)	5-34-25W	1,600	no report	none		Mississippian	5,532
Total Clark County		3,440	263,971	263,971	2		
COFFEY COUNTY							
Miscellaneous			11,477		2		
COWLEY COUNTY							
Brown West (1951)	14-31-7E		no report				
"Cambridge Southeast"		40	116,920		1		
Estes			no report			Douglas	1,568
Frog Hollow	32-5E	40	4,235		1		
Gibson	34-3E	120	319,095		3		
New Salem (1949)	21-31-5E		no report				
Tisdale	32-5E	40	5,071		1		
Trees	30-4E	80	37,938		2		
Wilmot-Floral	31-5E	40	61,647				
Winfield			no report				
Total Cowley County		360	544,906		8		
CRAWFORD COUNTY							
Miscellaneous			29,270		19		
DOUGLAS COUNTY							
Eudora			no report				
Lawrence			no report				
EDWARDS COUNTY							
Belpre (1942)	8-25-16W	80	213,093	6,404,700	3	Lans.-K.C.	3,800
Bradbridge*(1948)	6-24-15W	200	no report	none		Arbuckle	4,020
Total Edwards County		280	213,093	6,404,700	3		
ELK COUNTY							
Bush-Denton (1920)	4-30-9E		no report				

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Schrader			no report				
Miscellaneous			292,081				
ELLSWORTH COUNTY							
Stoltenberg (1947)	18-17-9W	100	40,446	381,061	2	Shawnee	2,728
	Figure includes total county production as reported by Corporation Commission						
FINNEY COUNTY							
Hugoton*		See Hugoton Gas Area					
Nunn (1938)	27-21-34W	120	56,839	130,488	3		
FORD COUNTY							
Pleasant Valley (1938)	34-27-21W		no report	none		Mississippian	4,954
GRAHAM COUNTY							
Law (1951)	34-9-23W	400	11,225	11,225	4		
GRANT COUNTY (See Hugoton Gas Area)							
HAMILTON COUNTY (See Hugoton Gas Area)							
HARPER COUNTY							
Grabs (1949)	7-31-8W	120	74,971	176,919	3	Mississippian	4,385
Grabs Southeast (1950)	17-31-8W		no report	none		Mississippian	4,386
HARVEY COUNTY							
Burrton* (1930)	23-23-4W	640	506,071		10	Mississippian	3,298
			Includes Reno County production				
Burrton Northeast (1942)	3-23-3W		Included with Burrton			Mississippian	3,226
Sperling (1935)	23-22-2W	250	40,243	6,619,942	1	"Chat"	2,955
Wall (1951)	25-22-3W		no report	none		Mississippian	3,150
Total Harvey County		890	546,314	6,619,942	11		
HASKELL COUNTY (See Hugoton Gas Area)							
HUGOTON GAS AREA (Finney, Grant, Hamilton, Haskell, Kearny, Morton, Seward, Stanton, and Stevens Counties)							
Hugoton (1922)	3-35-34W	2,433,560	335,058,956	2,101,982,973	2,874	Herington Krider Winfield Fort Riley Florence	
JEFFERSON COUNTY							
McLouth		400	40,130		13		
JOHNSON COUNTY							
Miscellaneous			27,668		24		
KEARNY COUNTY (See Hugoton Gas Area)							
KINGMAN COUNTY							
Artesian Valley (1952)	22-27-10W	40	3,457	3,457	1		

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TABLE 67.—*Gas production in Kansas during 1952, continued*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, M cu. ft.	Cumulative production to end of 1952, M cu. ft.	No. producing wells	Producing zone	Depth to producing zone, feet
Broadway (1948)	21-28-5W	280	451,341	451,341	7		
Cunningham (1931)	7-28-11W	600	278,701est.		10 est.	Arbuckle Viola	4,094 4,278
Dewey (1950)	9-28-5W	900	591,416	1,278,596	5		
Total Kingman County		1,780	1,324,915	2,170,973	23		
			KIOWA COUNTY				
Alford (1944)	14-30-19W		no report	none		Spergen	5,040
Brenham (1947)	29-28-17W		no report	none		"Miss. chert"	4,841
Miscellaneous		200	33,714	69,165	2		
			LABETTE COUNTY				
Coffeyville-Cherryvale*	32-17E		no report				
Valeda			no report				
Miscellaneous			19,614		12		
			LEAVENWORTH COUNTY				
Linwood			no report				
Roberts-Maywood*		120	6,608		3		
			LINN COUNTY				
LaCygne-Cadmus	20-24E	40	1,600				
			MCPHERSON COUNTY				
Coons (1940)	13-19-1W	200	Included with McPherson			"Chat"	2,897
Doles Park (1947)	12-19-1W	160	Included with McPherson			"Chat"	2,843
Graber North (1951)	4-21-1W	40	no report	none		Mississippian	2,955
McPherson (1926)	29-18-2W	40	3,591		1	Lans.-K.C. "Chat" Viola	2,340 2,967 3,140
Ritz-Canton (1929)	12-20-2W	100	Included with McPherson		—	"Chat"	2,935
Total McPherson County		540	3,591		1		
			MARION COUNTY				
"Marion"			no report				
Propp	8-19-4E	160	69,180		4		
			MEADE COUNTY				
Adams Ranch (1945)	8-35-30W	500	71,772	249,406	2	Mississippian	5,850
Adams Ranch East (1947)	36-34-30W	2,500	no report	none		Morrowan Mississippian	5,874 5,094
Fringer (1952)	7-35-29W	1,800	no report	none		Morrowan	5,780
McKinney (1950)	2-34-26W	5,760	478,354	478,354	8	Mississippian	5,762
Stevens (1952)	32-32-30W	640	no report	none	—	Morrowan	5,560
Total Meade County		11,200	550,126	727,760	10		
			MIAMI COUNTY				
Miscellaneous			47,000				

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MONTGOMERY COUNTY

Coffeyville-Cherryvale*(1902)	33-17E		no report				
Neodesha*		40	32,569				
Miscellaneous		—	521,729				
Total Montgomery County		40	554,298				

MORRIS COUNTY

North part of county			1,613		1		
South part of county			43,960		16		
Total Morris County			45,573		17		

MORTON COUNTY

Greenwood (1951)	14-33-42W	640	no report	none		Morrowan	4,872
Hugoton*			See Hugoton Gas Area				
Richfield (1948)	17-32-40W	640	55,254	563,012	1	Basal Penn. (Atokan)	4,990
Total Morton County		1,280	55,254	563,012	1		

NEOSHO COUNTY

Miscellaneous			133,490		119+		

PAWNEE COUNTY

Ash Creek* (1948)	31-20-15W	100	175,300est.		2	Arbuckle	3,769
Benson Southeast (1946)	32-23-15W	600	100,278		6	Arbuckle	4,048
		Includes Benson and Benson South					
Evers (1951)	36-21-16W	100	469,445	469,445	2	Arbuckle	3,908
Larned (revived) (1952)	28-21-16W		no report			Arbuckle	3,877
Pawnee Rock* (1936)	19&20-15&16W	600	1,491,104est.		17		
Rutherford East (1950)	4-20-16W	Combined with Ryan					
Ryan*	35-19-16W	100	175,300est.		2		
Shady (1945)	34-22-16W	100	85,621	3,446,668	1	Arbuckle	4,063
Torrance (1947)	19-21-15W	100	19,154		1		
Zook (1942)	16-23-16W	320	470,746	9,822,083	4	Arbuckle	4,066
Total Pawnee County		2,020	2,986,948	13,738,196	35		

PRATT COUNTY

Barnes (1952)	25-27-12W	160	no report	none		Simpson	4,328
Chitwood (1943)	23-28-12W	800	722,273	8,405,741	19	Viola	4,340
Cunningham* (1931)	7-28-11W	3,000	836,136est.		29	Viola	4,278
		Includes Cairo pool production			est.	Arbuckle	4,094
Iuka-Carmi (1942)	29-26-12W	600	1,088,352	1,461,621	9	Viola	4,122
Shriver (1949)	27-29-14W	100	no report	93,073			
Stark (1941)	13-26-12W	50	no report			Viola	4,121
Ward (1941)	11-26-12W	160	no report			Viola	4,129
Total Pratt County		4,870	2,646,761	9,960,435	57		

RENO COUNTY

Burrton* (1930)	23-23-4W	450	Included with Harvey County			Mississippian	3,298
Lerado (1937)	10-26-9W	150	22,134	1,169,244	3		
Yoder (1935)	34-24-5W	200	98,600		3	"Chat"	3,402
Zenith-Peace Creek*(1937)	23-24-11W	100	no report		—	Viola	3,860
Total Reno County		900	120,734	1,169,244	6		

RICE COUNTY

Alden (1937)	22-21-9W	400	Included with Chase-Silica	13,801,113		"Misener"	3,317

TABLE 67.—*Gas production in Kansas during 1952, concluded*

Pool or field name and year of discovery	Location of discovery well	Area, acres	1952 production, M cu. ft.	Cumulative production to end of 1952, M cu. ft.	No. producing wells	Producing zone	Depth to producing zone, feet
Chase-Silica (1936)	6-19-9W	100	330,862	1,370,194	4	Arbuckle	3,192
		Includes miscellaneous Rice County production					
Lyons (1888)	35-19-8W	1,100	no report	12,332,332		Simpson Arbuckle	3,290 3,277
Orth (1933)	27-18-10W	160	119,986		1	Lans.-K.C.	2,906
Quivira (1947)	36-19-9W	300	Included with Chase-Silica	211,244		Tarkio	2,117
Union (1950)	28-20-8W	280	Included with Chase-Silica		4	Penn. congl.	3,275
Total Rice County		2,340	450,848	27,714,883	9		
RUSH COUNTY							
Otis-Albert* (1930)	11-18-16W	6,500	988,723est.		20 est.	Neva	
Ryan*	35-19-16W	300	964,200est.		11 est.	Reagan	3,507
Total Rush County		6,800	1,952,923 est.		31 est.		
RUSSELL COUNTY							
Miscellaneous		100	10,147	10,147	2		
SCOTT COUNTY							
Keystone (1950)	25-18-32W	40	40,307	40,307	1		
SEDGWICK COUNTY							
Andover South* (1950)	31-27-3W		no report	none		"Stalnaker"	2,006
Bartholomew* (1946)	30-27-4W	680	459,042		14	"Miss. lime"	3,732
Derby (1937)	32-28-2E	no longer productive; used for gas storage only				"Stalnaker" Lans.-K.C.	2,215 2,228
Schulte (1949)	7-28-1W	200	192,702	845,859	3		
Total Sedgwick County		880	651,744	845,859	17		
SEWARD COUNTY							
Hawks (1952)	18-35-31W	640	no report	none		Morrowan	5,927
Hugoton*		See Hugoton Gas Area					
Liberal-Light (1951)	11-35-32W	640	3,423,484	4,030,136	4		
Liberal Southeast (1947)	15-35-33W	860	1,117,068	7,686,613	3	Penn.sandstone	6,202
Liberal-White (1952)	35-34-32W	320	no report	none		Morrowan	5,906
Light (1951)	11-35-32W	Changed to Liberal-Light					
Total Seward County		2,460	4,540,552	11,716,749	7		
STAFFORD COUNTY							
Bradbridge* (1948)	6-24-15W	80	no report	none		Arbuckle	4,020
Farmington (1948)	27-24-15W	50	Included with Macksville	691,757		Mississippian	4,207
Farmington West (1952)	6-25-15W	50	no report	none		Penn. "sand"	4,164
Gates (1950)	26-21-13W	40	66,336	238,471	1	Lans.-K.C.	3,473
Hill (1952)	11-23-12W	40	no report	none		Lans.-K.C.	3,447
Knoche (1951)	8-24-12W	300	395,720	586,976	3	Viola	3,810
Macksville (1947)	3-24-15W	400	911,790	4,510,649	10	Lans.-K.C.	
O'Connor (1947)	16-24-15W	160	no report	none		Arbuckle	4,061

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Zenith-Peace Creek*(1937)	23-24-11W	200	no report			Viola	3,860
Total Stafford County		1,280	1,373,846	6,027,853	14		
			STANTON COUNTY (See Hugoton Gas Area)				
			STEVENS COUNTY (See Hugoton Gas Area)				
			SUMNER COUNTY				
Fall Creek (1950)	3-35-3W	40	no report			Simpson	4,746
Padgett (1924)	23-34-2E	640	no report			"Miss. lime"	3,474
Vernon North (1915)	15-35-2E	640	no report				
Wellington (1929)	33-31-1W	No longer productive; used for gas storage only				"Chat"	3,655
Total Sumner County		1,320	none reported				
			WILSON COUNTY				
Neodesha*	30-16E		no report				
Miscellaneous			185,316		15+		
			WOODSON COUNTY				
Miscellaneous			41,732		5		
			WYANDOTTE COUNTY				
Roberts-Maywood*	11-23E	120	4,920		3		

* Field extends into adjacent county or counties.

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