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BULLETIN 77

OIL AND GAS IN EASTERN KANSAS

with special reference to developments from 1944 to 1948

BY JOHN MARK JEWETT

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OIL AND GAS IN EASTERN KANSAS

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by JOHN MARK JEWETT

ABSTRACT

Eastern Kansas as the term is used in this report includes 43 counties that lie wholly east of the 6th Principal Meridian, the line of division between east and west ranges in Kansas. Oil and gas were discovered in Kansas in 1860, in Miami County. It was not until 1923 that oil was found in western counties. The State first produced more than a million barrels of oil in 1904. Peak production in eastern Kansas, amounting to more than 45½ million barrels, was reached in 1918. In 1948 the eastern counties produced 22,892,329 barrels of oil and more than 2,110,882 thousand cubic feet of gas. Oil was produced in 31 counties.

The exposed consolidated rocks in eastern Kansas are Cretaceous, Permian, Pennsylvanian, and Mississippian in age. In general the exposed rocks dip gently to the west. Subsurface geologic conditions are complex because of the presence of several structural elements of which the Nemaha anticline is the most prominent. Subsurface conditions are shown diagrammatically in four north-south cross sections.

Each of the 43 counties is treated separately. Brief descriptions of the surface and subsurface geology are included and oil and gas developments are discussed. Tables show annual oil production in the various counties and yearly production in the fields during the period 1944 through 1948. In part this report is a revision of "Oil and Gas in Eastern Kansas," which was published in 1945 as State Geological Survey of Kansas Bulletin 57.

INTRODUCTION

Eastern Kansas, regarded a few years ago as of minor importance as an oil producing area, is now receiving somewhat extraordinary attention by oil producers. The reason for the change may be attributed to two major factors: the increased price of oil that has prevailed for the past few years and the introduction of improved methods of recovery in fields that have been nearly depleted by primary producing practices. There is considerable interest and activity in searching for undiscovered pools both in the more or less shallow Pennsylvanian rocks and in the deeper pre-Pennsylvanian beds. During the last few years several new pools have been found in eastern Kansas (Table 1). Production of oil in eastern Kansas counties is shown in Tables 2 and 2a.

TABLE 1.—*Oil and gas discoveries in eastern Kansas, 1944 through 1948*

County	Field	Discovery well	Location of discovery well	Producing zone	Initial daily production
		1944 discoveries			
Cowley	Rahn Southwest (Silverdale)	Gralapp et al. No. 1 Dunn	NE cor. SE 28-34-5E	"Bartlesville"	10 bbls.
Leavenworth	Lawrence North	J. M. Huber No. 1 Mohler	Cen. NW NE 22-12-20E	"Squirrel"	627 M cu. ft. gas
		1945 discoveries			
Butler	Hanna North	K. T. Weidemann No. 1 Hoard	NE SW SW 28-29-8E	"Miss. lime"	25 bbls.
Cowley	Seacat	Ben Gralapp No. 1 Seacat	NW cor. NW 26-33-4E	"Miss. lime"	153 bbls.
do	Winfield South	Marylyn Oil No. 1 Wise	SE cor. NW 1-33-4E	"Hoover sand"	200 bbls.
do	Rainbow Bend Northeast	B. B. Blair No. 1 Byrd	SE SW SW 15-33-3E	"Bartlesville"	25 bbls.
Dickinson	Lost Springs North	International Oil No. 2 Doyle	SW NW SE 22-16-4E	"Miss. lime"	50 bbls.
Leavenworth	Fairmont	John Kelley et al. No. 1 Krohne	Cen. SW NW 6-10-23E	Cherokee	200 M cu. ft. gas
		1946 discoveries			
Butler	Hickory Creek	Kewanee No. 1 Crowley	SW SW SE 11-28-5E	"Bartlesville"	98 bbls.
do	Salter	J. P. Gaty No. 1 Showalter	NE NW SW 23-28-3E	Simpson	40 bbls.
do	Dixon	Eckland No. 2 Dixon	NE NW SW 12-27-6E	K. C.-Lans.	75 bbls.
do	Shinn	K. T. Weidemann No. 7 Shinn	NW NW NE 19-29-8E	"Miss. lime"	20 bbls.
Greenwood	Ferrell North	K. T. Weidemann No. 2 Youngmeyer	NW NW NW 15-28-8E	"Miss. lime"	15 bbls.
Marion	Lehigh	Anderson-Pritchard No. 1 Warkenton	SE SE NW 27-19-1E	"Miss. lime"	28 bbls.
Woodson	Silver City	Bisagno-Lane No. 1 Spencer-Campbell	SE SE SE 19-26-15E	"Bartlesville"	30 bbls.
		1947 discoveries			
Butler	Womack	J. M. Huber No. 1 Womack	NE NW NE 19-28-6E	"Bartlesville"	2,000 M cu. ft. gas
do	Kramer-Stern South	J. M. Huber No. 1 Gardiner	SW SE NW 15-28-6E	Viola	35 bbls.
do	Semisch	Dunn & Strait No. 1 Semisch	SW SE SW 4-29-6E	"Bartlesville"	75 bbls.
do	Allen North	Rex & Morris No. 1 Robinson	NW NE NW 36-25-3E	"Miss. chert"	25 bbls.
do	Joseph	Cox & Burns No. 1 Joseph	SE SE NE 18-24-5E	"Basal Penn."	15 bbls.
Cowley	Combs	Kewanee Oil No. 1 Combs	NE NE SE 5-30-5E	"Bartlesville"	50 bbls.

do	School Creek	Veeder Supply No. 1 Reidy	NE NW NW 15-32-7E	"Bartlesville"	20 bbls.
do	Doane	McNeish-Gralapp No. 1 Doane	NE NE NW 36-33-6E	"Miss. lime"	25 bbls.
Dickinson	Lost Springs Northeast	International Oil No. 1 Schlesner	NE NE SW 26-16-4E	"Miss. lime"	100 bbls.
Lyon	Rock Creek	Murphey et al. No. 1 Keyes	NW NW NE 32-21-11E	"Bartlesville"	35 bbls.
Marion	Antelope	Leiker et al. No. 1 Henke	SW SE SW 33-18-4E	"Miss. chert"	25 bbls.
do	Lost Springs South	Saco et al. No. 1 Mazret	NE NE SW 16-18-4E	"Miss. chert"	35 bbls.
do	Wenger	Goering-Branine No. 1 Wenger	NW NW SW 11-21-3E	"Hunton"	50 bbls.
do	Elbing North	E. H. Adair No. 1 Jensen	SW SW NE 27-22-4E	"Miss. chat"	100 bbls.
Woodson	Teichnor	King et al. No. 1 Teichnor	SE SE SE 24-23-15E	"Miss. lime"	1,000 M cu. ft. gas

1948 discoveries

Butler	Guyot	Shawver-Graham No. 1 Guyot	NE NE SE 5-29-5E	"Bartlesville"	30 bbls.
do	Combs Northeast	Westgate-Greenland No. 1 Hampton	SE SE SW 27-29-5E	"Bartlesville"	50 bbls.
do	Towanda	Rex, Morris, & Adair No. 1 Rice	SE SE NE 5-26-4E	Viola	40 bbls.
Cowley	Enterprise	Sinclair-Prairie No. 1 McMichael	NW SE SW 35-33-3E	"Bartlesville"	40 bbls.
do	Box	K. T. Weideman No. 1 Hayden-Smith	SW NW NW 28-30-7E	"Miss. lime"	7 bbls.
do	Turner North	Wolf Creek & General Exploration No. 1 Bynum	SW SW SE 18-32-6E	"Layton"	15 bbls.
Marion	Antelope North	Leiker et al. No. 1 Holub	SW SE SW 28-18-4E	K.C.-Lans.	35 bbls.
do	Lost Springs Southeast	Monroe No. 1 Lueker	NE NE NW 10-18-4E	"Miss. lime"	12 bbls.
Nemaha	Strahm	Carter Oil No. 1 Strahm	SW SW NW 27-2-14E	"Hunton"	75 bbls.

Purpose and scope of the report.—Because several previous publications that describe the geology of eastern Kansas are out of print and in order to make this report more comprehensive, it contains a brief resume of the geology of eastern Kansas and less general descriptions of the geology of oil and gas in each of the 43 counties that lie east of the 6th Principal Meridian, the line of separation between east and west land ranges in the State. Figure 1 shows the part of Kansas that is regarded as "eastern Kansas." Because statistics of oil and gas production for the years 1944, 1945, and 1946 in the various counties and oil and gas fields of eastern Kansas have not been published previously, these pro-

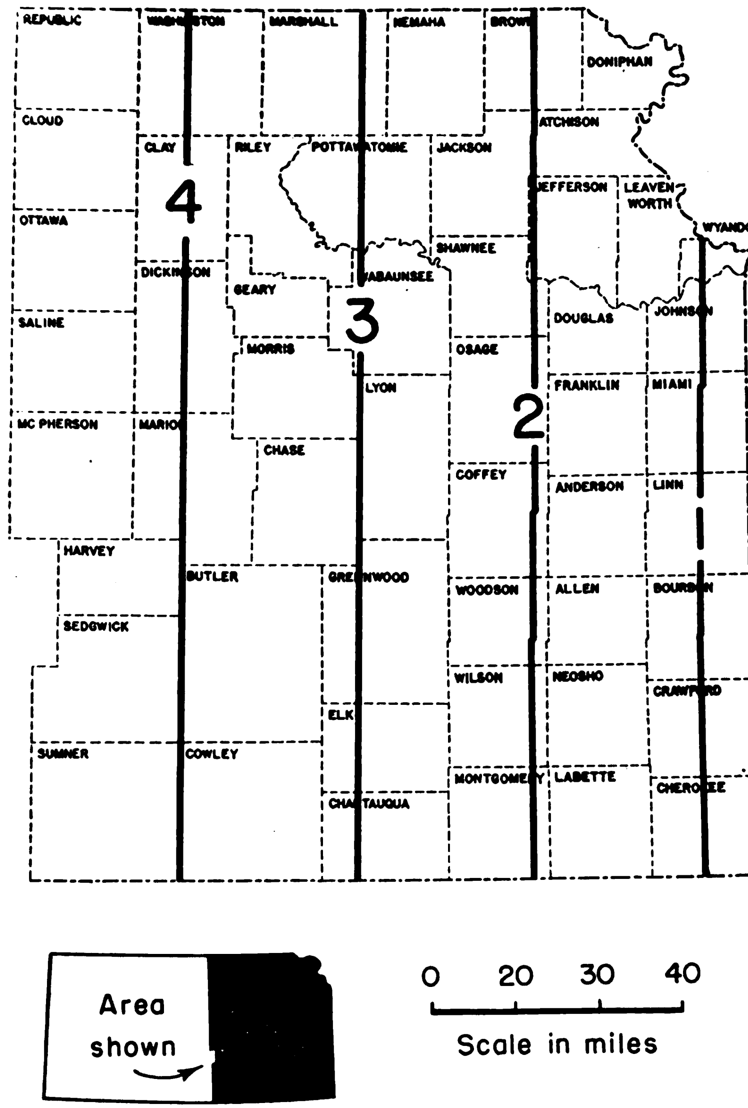

FIG. 1.—Index map of eastern Kansas showing locations of "eastern Kansas" counties and locations of cross sections (Pls. 1, 2, 3, and 4).

duction statistics are included in this report, along with statistics for 1947 (included in Ver Wiebe and others, 1948) and for 1948.

Four north-south geologic cross sections prepared by Virginia N. Perkins are included. These supplement four east-west cross sections that are a part of a former report (Jewett and Abernathy, 1945, pls. 1 to 4).

This report, a contribution from the Geological Survey's Division of Stratigraphy and Paleontology, may be regarded in part as a revision of the report, "Oil and Gas in Eastern Kansas" (Jewett and Abernathy, 1945).

Previous publications.—For many years the State Geological Survey has published reviews of oil and gas developments and descriptions of petroleum geology of Kansas. Oil and gas production statistics were included in a series on the "Mineral Resources of Kansas" which were published for the years 1897 to 1903 inclusive (Haworth, 1898, 1899, 1901, 1902, 1903, 1904). The first comprehensive Survey publication on oil and gas was issued in 1908 as Volume 9 of the Survey publications (Haworth, 1908). The development of shallow oil and gas in eastern Kansas was greatly facilitated by the publication of Bulletin 3, in 1917 (Moore and Haynes). This was followed by Bulletin 6, also called oil and gas resources of Kansas; five parts were published during the interval from 1920 to 1927 (Moore, 1920, 1920a; Moore and Elledge, 1920; Moore and Boughton, 1921; Charles, 1927).

More recently the Survey has published a more continuous series of reviews of oil and gas developments in the State. The first of these was prepared by L. W. Kesler and was published in 1928 as Mineral Resources Circular 1. The second was written by Anthony Folger for 1928 and 1929 and Roy H. Hall for 1930 and was issued in 1933 as Mineral Resources Circular 2. Edward A. Koester (1934) is the author of Mineral Resources Circular 3. These three reports review oil and gas developments in all of Kansas. Since 1938, Walter A. Ver Wiebe has prepared annual data for Survey publications on oil and gas developments in western Kansas counties (Ver Wiebe, 1938, 1939, 1940, 1941, 1942, 1943a, 1944, 1945, 1946). Ver Wiebe's latest report (1947) was published as Bulletin 68.

Bulletin 57, Oil and Gas in Eastern Kansas (Jewett and Abernathy, 1945) reviews oil and gas developments in eastern Kansas counties up to 1943. Bulletin 75 (Ver Wiebe and others, 1948), treats oil and gas developments in the entire State during 1947, and it is planned to continue publishing yearly bulletins on oil and gas developments in Kansas.

Oil and gas in several individual eastern Kansas counties have been discussed in several Survey publications. Three parts of Bulletin 6 are county oil and gas reports. Counties treated are: Allen and Neosho (Moore and Elledge, 1920) Wilson and Montgomery (Moore and Boughton, 1921) and Anderson (Charles, 1927). Bulletin 7, "The Geology of the Eldorado Oil and Gas Field" (Fath, 1921), and Bulletin 12, "The Geology of Cowley County, Kansas, with special reference to the occurrence of oil and gas" (Bass, 1929), are important contributions and were especially comprehensive at the time of publication. A later series of county oil and gas reports with maps showing locations and stratigraphic depths of drill holes includes reports for Labette County (Abernathy, 1939), Linn County (Jewett, 1940a) and Montgomery County (Abernathy, 1940).

In 1935 the State Geological Survey published Bulletin 20, "Subsurface Studies in Northeastern Kansas" (Ockerman, 1935), which contains results of studies of samples and logs and information on oil and gas possibilities in Atchison, Brown, Doniphan, Douglas, Jackson, Jefferson, Johnson, Leavenworth, Shawnee, Wabaunsee, and Wyandotte Counties.

Cooperative investigations of the State Geological Survey and the Mineral Fuels Division of the Federal Geological Survey under the supervision of Wallace Lee have yielded several very important contributions to the knowledge of oil and gas geology in eastern Kansas. Of these, Bulletin 38, part 10 (Lee, 1941) is a preliminary report of the McLouth oil and gas field, Jefferson and Leavenworth Counties. A more extensive report on the same area is contained in Bulletin 53 (Lee and Payne, 1944). Bulletin 51, "Stratigraphic and Structural Development of the Forest City Basin" (Lee, 1943), is especially valuable for understanding the geology of northeastern Kansas and surrounding regions.

Special attention is called also to United States Geological Survey Oil and Gas Investigations, Preliminary Map 48 (Lee and others, 1946) which shows the geologic development of the Forest City Basin chiefly by means of maps showing thicknesses of various stratigraphic units.

There are many important papers on the geology of eastern Kansas oil fields in various publications other than those of the Geological Survey. References are made elsewhere in this paper to several of them and other titles are in the list of references at the end of this report.

Other mineral resources of eastern Kansas.—In addition to oil and gas in eastern Kansas there are the lead and zinc deposits of the Tri-State district which includes part of Cherokee County; practically all of the State's minable coal beds (Whitla, 1940; Bowsher and Jewett, 1943; Shoewe, 1944; Abernathy, 1944, 1946; Abernathy, Jewett, and Schoewe, 1947); raw materials for cement manufacture which are utilized in several plants; large supplies of ceramic raw material; virtually unlimited supplies of limestone, sand, and gravel; gypsum mined and processed in Marshall County; and fairly large reserves of asphalt rock in several counties (Jewett, 1940). The larger stream valleys contain abundant shallow ground water, and large supplies of fresh water are available in deep rocks in the southeast part of the State (Moore, 1940; Jewett and Schoewe, 1942; Abernathy, 1943, 1948; Fishel, 1948).

Acknowledgments.—Thanks are expressed to the large number of oil and gas operators who for many years have voluntarily cooperated with the Kansas Geological Survey. As a result of this logs of a large percentage of the wells that have been drilled in Kansas and drill cuttings and cores from a large number of wells are in the Survey files. Logs of more than 75,000 wells are in the files of the Survey.

I have access to the records of oil runs in the files of the Conservation Division of the State Corporation Commission. The very valuable cooperation of Mr. T. A. Morgan, J. P. Roberts, D. C. Lilley, and H. A. Beverlin of that organization is acknowledged.

Wallace Lee has been especially generous in supplying data concerning pre-Pennsylvanian rocks. Frequent discussions with Mr. Lee on many problems have been of much value.

Special thanks are expressed to officials of the following organizations who are supplying the Geological Survey with monthly reports of oil purchases in the various eastern Kansas counties and fields: Cities Service Oil Company, Continental Oil Company, Cooperative Refinery Association, The El Dorado Renfing

Company, Joplin Refining Company, K.B. Oil and Gas Co
The Kanotex Refining Company, Kansas City Testing
tories, Layton Oil Company, Lynde, Walter, and Darby,
Oil Refining Company, Sinclair Prairie Oil Company, Sk
Company, Stanolind Oil Purchasing Company, Stekoll Pe
Company, Vance Rowe, and White Eagle Purchasing C
Inc.

Alfred C. Walker and Christine Notari of the State G
Survey efficiently assembled many data on water-floodi
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HISTORY OF OIL AND GAS DEVELOPMENT EASTERN KANSAS

In 1860, the year following the discovery of oil in nort
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a barrel. In 1886 or soon afterward a small refinery

[illegible]																
Greenwood	....															
Labette	....								10	14	12	[illegible]				
Linn	....			1	5	15	13	15	41	62	49	85	160	155	128	153
Lyon	.... Production prior to 1922 included with Greenwood County													14	23	21
Marion	....											3	6	5,363	3,267	2,333
Miami	33	30	28	31	44	115	129	283	502	540	420	630	540	236	226	225
Montgomery	560	500	554	650	834	1,365	1,248	1,500	1,727	1,675	1,310	1,520	1,422	786	765	1,117
Morris	....															
Neosho	125	110	116	147	353	700	630	690	1,046	1,070	840	1,120	995	394	362	300
Wilson	33	30	30	43	53	80	70	76	208	290	220	350	305	147	110	99
Woodson	.... Included with Greenwood County															

Company, Joplin Refining Company, K.B. Oil and Gas Company, The Kanotex Refining Company, Kansas City Testing Laboratories, Layton Oil Company, Lynde, Walter, and Darby, Sinclair Oil Refining Company, Sinclair Prairie Oil Company, Skelly Oil Company, Stanolind Oil Purchasing Company, Stekoll Petroleum Company, Vance Rowe, and White Eagle Purchasing Company, Inc.

Alfred C. Walker and Christine Notari of the State Geological Survey efficiently assembled many data on water-flooding projects and other statistical material for this report.

HISTORY OF OIL AND GAS DEVELOPMENTS IN EASTERN KANSAS

In 1860, the year following the discovery of oil in northwestern Pennsylvania, oil was discovered near Paola in Miami County, Kansas. It is believed that the first well drilled for the purpose of obtaining oil in Kansas was a 4-inch hole drilled near Paola during June 1860 to a depth of 100 feet. A second 100-foot well was put down on Wea Creek about 8 miles to the south. The third well drilled in 1860 is reported to have discovered oil. It was known as the David Lykins well, in the SW¼ sec. 15, T. 17 S., R. 23 E., and was bored to a depth of 275 feet. According to Haworth (1908, p. 25), "It was supposed that it would yield one barrel of oil per day." The advent of the Civil War halted oil-drilling activities in Miami County and near-by areas. However, several wells that yielded small amounts of both oil and gas were put down near Mound City in Linn county soon after the first drilling near Paola. During the 1860's gas and probably some oil were found in Wyandotte County within the present city limits of Kansas City, and it is recorded that prospecting was done in Bourbon, Shawnee, and Cherokee Counties.

In 1873, a diamond-drill hole 737 feet deep was put down at Iola in Allen County. Gas from this well was used to light a sanatorium in which salt water from the same well was used. In 1884, Paola was supplied with gas piped from a newly opened field about 7 miles east of town, and an area nearly surrounding the town was being drilled. The heavy dark oil that was produced was sold as lubricating oil at a price ranging from $3.00 to $5.00 a barrel. In 1886 or soon afterward a small refinery was erected at Paola, and it is reported that in 1889 the Paola oil field yielded 500 barrels of oil. At about the same time gas produced in the vicinity of Fort Scott was utilized in that city. Gas was discovered in the vicinity of Independence, Montgomery County, as early as 1881, and in 1884 both oil and gas were found in a coal prospect hole at Independence. Development did not follow immediately. Wells drilled in Kansas City during this period produced gas for 20 years.

In the last decade of the last century and the first decade of the present century the oil and gas industry developed rapidly in eastern Kansas. An oil well near Neodesha in Wilson County was the first well "shot" in Kansas. The event took place on July 4, 1894, on the same day that natural gas piped into Neodesha from a near-by field was first ignited. Several oil wells were completed in the Neodesha field during that year, and the first oil conservation law in Kansas was enacted at about that time. The Iola gas field was opened in 1893 or early in 1894.

Gas development advanced rapidly in Montgomery County in 1892 and 1893. Gas was piped into Coffeyville in the fall of 1892 and into Independence and Cherryvale the following year. In 1894 or 1895 gas was piped into the village of Peru in Chautauqua County from a few near-by wells. In 1897 a number of gas wells were drilled in the area west of Humboldt in Allen County, and in August of the same year gas was piped into Humboldt.

Several oil wells were drilled in the Neosho River Valley east of Chanute in 1899, and the operator of the Chanute field began shipping oil to Omaha and Kansas City in 1900. Many oil wells were drilled in the Neosho River Valley in the vicinity of Chanute and Humboldt during the next three years. The Chanute district produced 165,000 barrels of oil in 1902, and it is reported that much more could have been marketed if there had been sufficient pipe lines. By 1903 Chanute had become an important oil and gas center and oil and gas fields extended in various directions for several miles. Gas was piped into Erie in Neosho County in 1903. In that year a local company reported that they had drilled 35 wells, of which 14 were gas wells, 7 were oil wells, and 14 were dry holes. Oil was discovered near Bolton in Montgomery County in 1903 and within two years this field, containing some wells that flowed at the rate of 1,000 barrels of oil a day, became the most important oil district in the State (Haworth, 1908, p. 37). There

Table 2.—*Oil production in eastern Kansas counties, in thousands of barrels*
(Courtesy of Albert E. Sweeney, Jr., Director, Secondary Recovery Division, Interstate Oil Compact Commission)

County	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908
Allen					3	6	7	15	10	9	8	9	25	30	90	220	185	170	150	125
Anderson																25	30	40	40	30
Bourbon																				
Butler																				
Chautauqua												3	11	20	140	800	700	600	550	450
Coffey																				
Cowley																				
Crawford																				
Dickinson																				
Douglas																				
Elk														10	60	150	130	120	110	80
Franklin																40	60	80	70	55
Greenwood																				
Labette																				
Linn																				
Lyon																				
Marion																				
Miami	½	½	½	1	2	5	6	12	10	8	8	8	8	10	20	100	85	80	70	50
Montgomery					1	3	4	8	7	6	6	6	71	192	472	2,406	2,076	1,650	1,050	782
Morris																				
Neosho					2?	6	6	15	10	8	9	10	26	30	100	330	280	280	250	180
Wilson		½	1	4	10	20	21	63	44	40	38	38	38	40	50	100	85	80	70	50
Woodson																				

County	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924
Allen	80	72	93	122	228	450	398	495	650	695	540	730	645	550	507	427
Anderson	25	23	21	20	19	18	17	17	45	50	50	170	240	371	391	630
Bourbon									10	15	12	30	26	46	47	35
Butler						5	110	8,155	31,269	36,069	24,060	23,535	21,787	17,733	14,221	10,822
Chautauqua	300	269	348	492	756	1,323	1,207	1,460	1,769	1,720	1,300	1,886	1,520	1,138	1,013	936
Coffey						5	7	7	7	7	6	10	30	Incl. Greenwood Co.		
Cowley						15	14	18	29	26	22	60	70	243	629	2,266
Crawford									Unrecorded production started in 1917							
Dickinson																
Douglas																
Elk	70	63	58	54	49	46	43	46	99	105	130	405	470	284	245	268
Franklin	38	33	30	32	34	107	123	278	497	545	420	635	545	208	229	237
Greenwood								2	78	390	275	380	710	3,376	6,939	9,383
Labette									10	14	12	30	26	23	21	23
Linn				1	5	15	13	15	41	62	49	85	160	155	128	153
Lyon				Production prior to 1922 included with Greenwood County										14	23	21
Marion												3	6	5,363	3,267	2,333
Miami	33	30	28	31	44	115	129	283	502	540	420	630	540	236	226	225
Montgomery	560	500	554	650	834	1,365	1,248	1,500	1,727	1,675	1,310	1,520	1,422	786	765	1,117
Morris																
Neosho	125	110	116	147	353	700	630	690	1,046	1,070	840	1,120	995	394	362	300
Wilson	33	30	30	43	53	80	70	76	208	290	220	350	305	147	110	99
Woodson							Included with Greenwood County									

TABLE 2.—*Oil production in eastern Kansas counties, in thousands of barrels, concluded*

County	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940
Allen	556	298	241	220	187	169	187	157	187	157	161	155	165	167	222	230
Anderson	824	1,161	832	661	583	567	329	335	329	323	281	270	265	263	260	278
Bourbon	13	7	7	5	7	22	19	11	19	13	7	5	5	5	9	14
Butler	9,659	10,377	10,518	9,691	9,272	9,099	7,769	6,684	6,461	7,213	6,712	6,161	5,989	5,694	5,063	5,045
Chase	....	....	3	9	6	....	....	....	....	....	....	....	....	....	....	....
Chautauqua	864	894	872	820	998	991	579	540	579	582	560	670	825	815	867	910
Coffey	Incl. Greenwood		103	100	90	93	29	49	29	24	35	21	20	18	15	Green
Cowley	7,039	3,943	3,304	2,284	2,065	2,015	1,885	2,743	1,147	1,681	1,622	1,804	1,963	2,318	2,131	272
Crawford	........Unrecorded production started in 1917........															
Dickinson	........Included with Marion County........															
Douglas	....	....	24	....	....	....	....	....	....	....	....	....	....	....	....	....
Elk	513	15	895	757	716	626	757	557	344	592	581	490	400	279	245	303
Franklin	208	194	165	156	135	112	103	100	100	85	78	80	83	80	70	68
Greenwood	13,360	16,739	12,664	9,873	7,577	7,266	5,564	4,864	4,313	4,184	4,089	4,000	4,007	4,114	3,793	3,227
Labette	15	10	12	9	7	9	3	....	....	....	....	6	7	9	10	12
Linn	103	89	87	74	71	51	59	60	39	34	39	34	39	40	35	30
Lyon	56	680	715	382	323	255	155	113	95	87	81	139	133	127	121	115
Marion	1,662	1,382	1,155	1,312	1,399	1,166	874	663	538	536	509	410	348	320	377	547
Miami	186	163	753	709	365	406	389	433	403	272	284	210	230	215	213	213
Montgomery	1,136	721	579	538	545	488	312	537	412	334	280	290	340	315	305	303
Morris	........Included with Marion County........															
Neosho	277	255	222	185	183	179	176	184	170	158	177	285	430	490	630	788
Wilson	126	94	84	74	64	56	58	74	60	62	89	120	145	135	130	122
Woodson	........Included with Greenwood County........															

TABLE 2a.—*Oil production in eastern Kansas counties, in barrels, 1941 through 1948*

County	1941	1942	1943	1944	1945	1946	1947	1948
Allen	312,900	284,088	379,240	285,665	389,196	319,678	284,240	284,561
Anderson	336,304	501,768	486,603	374,535	289,674	318,041	325,390	371,131
Bourbon	3,897	6,912	45,354	35,595	16,107	24,692	31,660	11,188
Brown				969	21,684	18,195	9,630	5,671
Butler	5,304,450	4,864,103	4,540,224	4,684,021	4,741,500	5,149,226	5,611,484	5,911,373
Chase			Included with Greenwood and Lyon Counties					19,685
Chautauqua	952,916	959,751	926,320	884,507	635,616	794,334	830,535	832,965
Coffey	20,956	19,968	17,912	15,836	15,286	14,258	12,970	85,172
Cowley	2,816,706	2,865,952	2,738,228	2,614,388	2,583,650	2,717,746	2,812,928	2,592,991
Crawford	36,309	26,942	26,207	34,249	31,661	49,829	60,792	67,059
Dickinson			3,047	21,489	14,242	11,520	34,398	23,449
Douglas	7,020	5,760	3,054	5,000	5,000	5,000	5,110	4,000
Elk	367,889	213,592	226,607	263,639	275,057	217,391	220,021	211,926
Franklin	85,319	159,400	142,745	131,658	133,942	196,078	188,185	233,325
Greenwood	3,263,647	3,362,191	3,324,714	3,547,828	3,730,234	3,890,119	4,149,372	4,776,611
Jefferson	19,672	78,824	162,371	56,609	92,192	94,941	120,902	108,652
Johnson		1,127	1,321					
Labette	14,820	13,071	12,896	3,624	3,723	4,681	6,958	6,528
Leavenworth	13,020	22,964		2,742	1,009	3,594	2,795	1,266
Linn	26,195	24,529	38,845	56,169	70,758	85,368	73,163	60,201
Lyon	108,287	106,278	133,287	189,739	159,660	141,450	135,480	187,948
Marion	840,640	979,397	815,358	818,980	773,640	613,603	524,063	643,137
Miami	199,185	235,402	218,898	197,510	241,599	338,721	290,806	327,326
Montgomery	311,523	377,376	367,332	317,815	362,328	815,013	890,426	945,616
Morris	Previous production included in Marion County					1,320	390	407
Nemaha								1,000
Neosho	722,859	703,408	674,037	343,020	343,976	374,855	435,158	484,753
Wilson	106,247	86,157	55,714	75,745	79,088	90,356	77,281	69,976
Woodson	287,081	263,830	253,263	352,777	314,672	412,085	404,026	441,771
Miscellaneous				33,722	44,062			34,639
Total	16,157,842	16,162,790	15,593,577	15,347,831	15,369,556	16,702,094	17,538,160	18,744,327

were about 200 wells in the field in 1905, but the larger producers had declined to about 40 barrels of oil per day. At the end of 1903 there were 151 producing oil wells in the Peru field in Chautauqua County. Kansas oil production in 1904 exceeded 4 million barrels.

By 1910, 50 years after the discovery of oil in the mid-continent region at Paola, wells had been drilled in the majority of eastern Kansas counties and many shallow oil and gas fields had been developed. The oil and gas territory extended from Miami County on the north to the Oklahoma line in Montgomery and Chautauqua Counties. Gas had been discovered farther west in eastern Kansas at Longton, Elk Falls, Moline, Dexter, Winfield, Arkansas City, Augusta, and Elmdale in the first few years after 1900. There were oil refineries in Coffeyville, Neodesha, Chanute, and several other places, and many miles of pipe lines for both oil and gas had been laid. Many towns and cities were using natural gas, and the abundance of cheap gas had led to the establishment of numerous industries in southeastern Kansas. Gas was being used in cement plants, brick and tile plants, zinc and lead smelters, glass factories, and other industries.

During the first half century of Kansas oil and gas development, production was largely from rocks of Pennsylvanian age. Permian rocks, however, yielded significant quantities of gas in fields near Elmdale in Chase County; Dexter, Winfield, and Arkansas City in Cowley County; and Augusta in Butler County. The occurrence of oil seeps in Miami and northern Linn Counties attracted early prospecting for oil in the vicinity of Paola. After discoveries near these seeps, test holes were put down in nearly every county; and in the early part of the 20th century the eastern Kansas oil and gas territory, except the Nemaha anticline area, was more or less completely outlined. The first important application of structural geology to oil and gas finding in Kansas was probably that of Erasmus Haworth, J. W. Beede, and John Bennett, who worked in the early part of the present century. The relationships of oil and gas occurrence to lenticular sand bodies and to anticlinal structures were explained by Haworth (1908, pp. 161-79). After the finding of large amounts of oil and gas in anticlines and domes in the Nemaha anticline area in Butler County in 1914 and 1915, surface structure mapping led to the drilling of many wells.

The discovery of oil and gas in the El Dorado and Augusta fields in 1914 marked the beginning of large-scale oil and gas production in Kansas. Henceforth production of oil was measured in tens of millions of barrels, and gas production in tens of billions of cubic feet. The discovery of oil and gas in condemned pre-Pennsylvanian rocks and the acquisition of evidence demanding drastic revision of the earlier ideas of subsurface structure in eastern Kansas made the opening of the El Dorado field an important event. Its effect on Kansas oil production is shown by the increase in oil production during the period from 1915 to 1918. In 1915 oil output in Kansas was 2,823,487 barrels; in 1916 it was 8,783,077 barrels; in 1917 it was 36,536,125 barrels; and in 1918 it reached 45,451,017 barrels.

The discovery well in the El Dorado field is the Wichita Natural Gas Company No. 1 Stapleton, in the NE¼ SE¼ sec. 29, T. 25 S., R. 5 E. Commercial production estimated at 50 to 200 barrels per day was found in sandstone between 660 and 678 feet. The discovery well was later deepened and the "Stapleton pay zone"* was found at 2,465 feet. About 600 wells were producing in the El Dorado field at the end of 1916; most of them produced from the 660-foot sand. That year the daily output of the field was estimated at more than 12,000 barrels of oil (Fath, 1921, p. 21). During 1917 the productive limits of the field were fairly well outlined and in September the daily production exceeded 100,000 barrels of oil. During 1917 and 1918, 309 "Stapleton" gushers having initial capacities of more than 500 barrels were brought in; 205 of these had initial daily capacities of more than 1,000 barrels, and five had initial daily capacities of more than 15,000 barrels. The Gypsy Oil Company No. 5 Shumway well, in the SW¼ NW¼ sec. 11, T. 26 S., R. 4 E., flowed at the rate of 19,000 barrels per day; the Empire Gas and Fuel Company No. 3 Shriver well in the NW¼ sec. 14, T. 26 S., R. 4 E., was reported to have flowed at the rate of 23,000 barrels of oil per day (Fath, 1921, p. 23). In the El Dorado field large quantities of gas were found in five "sands" in Shawnee and Douglas rocks on the higher parts of the domes.

Soon after the El Dorado oil and gas fields were opened, important "Bartlesville sand"* shoestring pools were found in areas

* **For explanation of** oil field names of subsurface formations, see pages 63-76.

not far east of the Nemaha trend. The Smock-Sluss, Weaver, and Fox-Bush pools of Butler County and the Sallyards pool of Greenwood County were discovered in 1917 (Bass, 1936, p. 60). Many oil and gas pools were found in eastern Kansas in the 1920's. Mississippian, Viola, "Wilcox" (St. Peter), and Arbuckle production became established, and the importance of subsurface geologic studies became evident.

Acidizing of limestone reservoir rocks was practiced and greatly increased production in areas of limestone production in eastern Kansas, especially in the late 1920's and early 1930's. Repressuring by air and application of vacuum were widely employed as means of increasing oil recovery.

Water Flooding

Repressuring of oil sands by water injection is now being practiced widely in eastern Kansas. This method of supplying energy to move oil into wells is reported to have been first practiced in Kansas in 1935 (Grandone, 1944, p. 1) but small water-flooding projects were in operation long before that time.

Water-flood projects were started in Greenwood, Chautauqua, and Linn Counties in 1935, the year in which the Kansas legislature enacted a law authorizing water flooding. Water was injected into Pennsylvanian "shoestring sands" at depths ranging from 400 to 1,950 feet.

The first beneficial water floods in Kansas were accidental as they had been earlier in New York and Pennsylvania. It was noticed that when water leaked from old wells through corroded casing into oil sands, near-by wells showed an increase in oil production. This led to purposeful floods 30 or more years ago. One of the earliest projects was in the Stanton field, Miami County, where the producing sand is still being repressured by water.

In the late 1930's interest in water flooding spread rather rapidly through the old stripper fields (Fancher and Barnes, 1936; Weirich, 1937) but this means of repressuring may be regarded as still having been in the experimental stages then. A few years later, however, rather extensive studies of the engineering and geologic problems involved were taking place. Several engineers, experienced in Pennsylvania water-flooded oil fields, came to eastern Kansas.

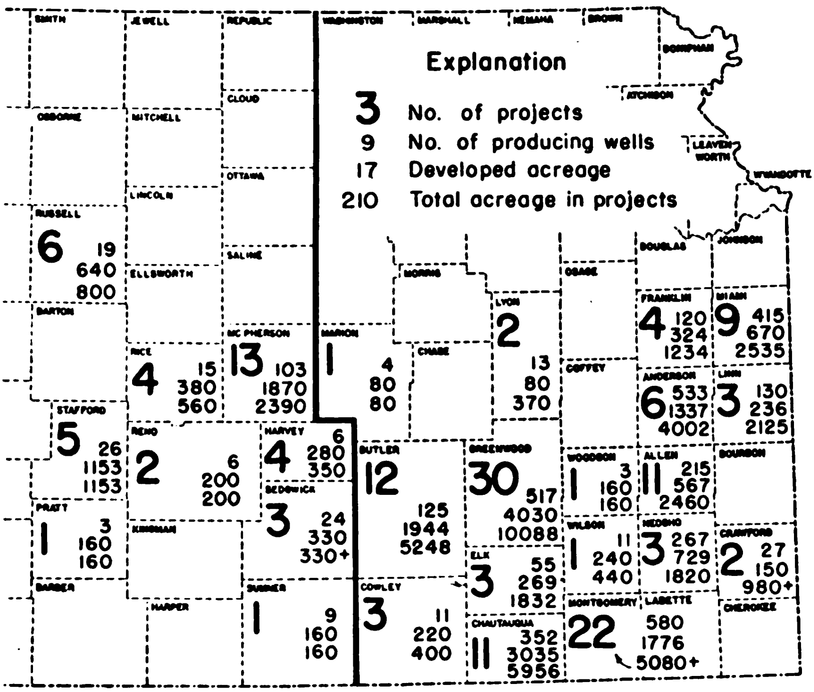

FIG. 2.—Map showing distribution of water-flooding projects.

At about the beginning of World War II successful water-flood projects were in operation in nearly all the oil-producing counties in eastern Kansas. Some of the fields in which water was injected had been drilled in the early 1900's and most of these earliest organized projects are still active.

Of secondary oil recovery methods (which include repressuring by air, natural gas, nitrogen, and vacuum) water flooding alone is being widely practiced in eastern Kansas. In counties in which oil production is largely or wholly from Pennsylvanian sandstones a large part of the yield is produced by water flooding and it is predicted that more and more acres in old fields will be repressured. Attention is called to the maps in this report of various counties showing outlines of oil fields and, in several places, the relatively small areas in which oil was produced last year. Few water-flood projects have been abandoned and most of the seemingly abandoned fields and parts of fields may be regarded as potential areas of repressuring.

Repressuring by water consists of injecting fresh or salt water through injection wells into oil-bearing formations. Water is forced into the rocks under sufficient pressure to dislodge oil from the pores in the rock and to drive it into producing wells. The oil wells may be pumped or water pressure may be sufficient to cause the oil wells to flow. Many operators expect the average life of water-flooding projects in eastern Kansas to be about 15 years, and it is believed that the amount of oil recovered by this means in most fields will be about the same as that produced by primary methods.

Successful water flooding requires the solution of engineering problems but geological information is essential. Water-flooding projects and some of the problems associated with them have been discussed recently in several trade journals. Water flooding in Kansas has been discussed by Weirich (1937), Grandone (1944), Abernathy and Jewett (1946), Abernathy (1948), Jewett (1948), Sweeney (1948, 1949), and Ver Wiebe and others (1948, pp. 21-27).

In the greater number of Kansas projects salt water obtained from deep formations, especially Mississippian limestones and Ordovician (Arbuckle) dolomites, is used. Other sources of water supplies include shallow fresh water wells in stream valley fills, comparatively shallow wells in Pennsylvanian sandstones, streams, ponds, and municipal water supplies. In some places water produced with oil from oil wells is utilized. Treatment of water that is injected is carefully controlled in accordance with laboratory data. Users of salt water from deep aquifers are not faced with seasonal fluctuations in quantity and quality of water. In general brines from deep rocks have fixed chemical composition and therefore the treatment required before injection does not need to be varied after it has been developed. Some Kansas operators inject salt water through closed systems and no chemical treatment is necessary.

Some water-flood operators inject water under pressure of 900 or more pounds per square inch at the well head; others are not increasing pressures due to gravity. Characteristics of the reservoir rocks and of the overburden, obviously, are factors. In some projects higher pressures are obtained in order to make oil wells flow.

Cores of oil-bearing formations commonly are studied in the laboratory before a lease is put under water flood. Data obtained are used in computing oil content in barrels per acre, oil and water saturation, porosity, and permeability.

Grandone (1944, p. 19) has mentioned that the most important item affecting the cost of water flooding usually is that of drilling the required number of wells. Uniform spacing of wells is necessary for maximum oil recovery and ordinarily wells are arranged in the five-spot pattern of squares, each square having an oil well at each corner and a water input well in the center. A development consists of alternate rows of oil wells and water input wells, the number of wells of each kind being about equal. Although this five-spot pattern is approximated in Kansas, the natural pattern of pools, many of which are "shoestrings," does not everywhere permit geometrically perfect well arrangements.

The importance of production of oil by secondary recovery methods in Kansas is demonstrated in Figure 2, which shows distribution of projects according to a recent survey. Table 3 shows data concerning reported projects in eastern Kansas counties.

GEOLOGY OF EASTERN KANSAS

Stratigraphy

For the purpose of this report the rocks of eastern Kansas can be conveniently placed in seven units. Although these units contain in several instances rocks assigned to more than one system, they are characterized by uniformity of structural attitude and similarity of lithology. Four of these units crop out at the surface. They are Quaternary-Tertiary, Cretaceous, Permian-Pennsylvanian, and Mississippian. The other three units, which in Kansas are known only through information obtained by deep drillings, are Devonian-Silurian, Ordovician-Cambrian, and Pre-Cambrian.

TABLE 3.—*Data on secondary recovery projects in eastern Kansas*

County	Field	Producing zone	Developed acreage	No. wells	Date started	Injection medium
Allen	Elsmore Shoestring	"Bartlesville"	50	40	1941	Fresh water
	do	do	60	35	1941	do
	do	do	15	10	1943	do
	do	do	15	8	1948	do
	do	....	70	12	1944	Salt water
	do	"Bartlesville"	160	13	1940	"Miss. lime" water
	Humboldt-Chanute	....	97	53	....	Fresh & salt water
	do	"Bartlesville"	20	10	1945	Salt water
	do	do	10	4	1945	do
	do	do	40	20	1942	do
	do	do	30	10	1941	do
Anderson	Bush City Shoestring	....	315	145	1944	do
	do	....	237	104	1939	do
	do	....	170.5	73	1941	do
	Garnett Shoestring	....	296	169	1936	Garnett city water
	Kincaid	"Bartlesville"	259	42	1946	Salt water
	Selma	do	60	......	1941	do
Butler	El Dorado	Admire	26	9	1947	Salt water
	do	Ordovician	680	45	1947	do
	do	Viola	40	3	1947	do
	Fox-Bush	....	120	11	1944	Fresh water
	do	"Bartlesville"	20	10	1947	....
	do	....	48	2	1944	Fresh water
	do	"Bartlesville"	360	15	1942	Salt water
	do	do	360	10	1948	do
	do	....	120	6	1945	Fresh water
	do	"Bartlesville"	140	13	1929	Residue gas
	Kramer-Stern	"Leon lime"	50	4	1937	Salt water
	Seward	Kansas City	40	3	1945	do
	Young	Kansas City	80	7	1946	do
Chautauqua	Elgin	"Peru"	160	6	1940	Salt water
	do	do	300	53	1940	do
	do	"Redd"	140	53	1940	do
	Peru-Sedan	"Peru"	600	38	1935	do
	do	do	420	42	1939	do
	do	do	420	58	1938	do
	do	do	25	5	....	do
	do	do	220	30	1938	do
	do	do	20	3	1944	do
	do	do	640	49	1938	do
	do	do	90	15	1938	do
Cowley	Eastman	"Bartlesville"	370	23	1930	Residue gas
	Hittle	"Layton"	100	3	1945	Salt water

	Murphy	"Bartlesville"	80	5	1946	do
	Rainbow Bend	"Burbank"	1,300	95	1933	Gas
	Weathered	"Stalnaker"	40	3	1946	Salt water
Crawford	McCune	....	......	....	1941	do
	Walnut	"Bartlesville"	150	27	1941	Salt & fresh water
Elk	"Gardner"	"Longton"	40	9	1947	Fresh water
	New Albany	New Albany	113	0	1937	do
	do	do	116	46	1943	Fresh & salt water
Franklin	Paola-Rantoul	....	212	83	1944	Marais des Cygne River water
	do	....	22	17	1944	do
	do	....	50	12	1948	Fresh & salt water
	do	....	40	8	....	Salt water
Greenwood	Burkett	"Bartlesville"	665	88	1939	do
	Demalorie-Souder	....	20	8	1946	do
	Fankhouser	"Bartlesville"	30	6	1944	do
	Hamilton	do	200	27	1946	Fresh & salt water
	do	do	40	3	1938	do
	Lamont	do	70	0	1942	Salt water
	do	do	90	8	1943	do
	do	do	100	8	1943	do
	Pixlee	do	220	20	1947	do
	Sallyards	....	10	31	1946	do
	Scott	....	95	43	1945	do
	Seeley-Wick	"Bartlesville"	23	2	1942	do
	do	do	147	25	1946	do
	do	do	540	60	1943	do
	do	....	89.5	25	1943	do
	do	"Bartlesville"	123	14	....	do
	do	do	280	20	1947	do
	do	do	50	5	1947	do
	do	do	30	3	1947	do
	Teeter	do	100	13	1947	do
	do	....	160	13	1944	do
	Thrall-Aagard	"Bartlesville"	84	10	1944	do
	do	....	100	13	1944	do
	do	....	44.5	5	1946	do
	do	....	43.5	5	1945	do
	do	....	110	17	1942	do
	do	....	8	2	1945	do
	do	....	47.5	5	1937	do
	do	"Bartlesville"	30	5	1943	do
	Virgil	"Miss. lime"	480	33	1946	do
Linn	Centerville	"Squirrel"	94	50	1936	Fresh water
	Goodrich-Parker	....	119.6	67	1944	Salt water
	LaCygne	....	22.5	13	1942	do

TABLE 3.—*Data on secondary recovery propects in eastern Kansas, concluded*

County	Field	Producing zone	Developed acreage	No. wells	Date started	Injection medium
Lyon	Atyeo	"Bartlesville"	50	4	1948	do
	Fankhouser	do	30	9	1943	do
Marion	Lost Springs	"Chat"	80	4	1943	do
Miami	Paola-Rantoul	"Peru"	37.5	21	1947	do
	do	....	113	27	1944	Fresh & salt water
	do	"Peru"	60	40	1941	Fresh water
	do	"Big Lake"	55	200	1945	Salt water
	do	....	70	26	1941	Fresh water
	do	....	102	24	1944	Salt water
	do	....	113	26	1945	do
	do	"Peru"	120	18	1938	Fresh water
	do	do	....	33	1939	do
Montgomery	Coffeyville-Cherryvale	"Peru"	40	17	1946	do
	do	do	60	22	1948	Arbuckle lime water
	do	....	....	....	1948	"Miss. lime" water
	Jefferson-Sycamore	....	....	2	1945	Salt water
	do	"Wayside"	60	30	1944	Fresh water
	do	"Bartlesville"	400	66	1945	H_2S water
	do	do	60	8	1945	Fresh water
	do	do	60	12	1943	"Miss. lime" water
	do	....	800	180	1943	Fresh & salt water
	do	....	....	30	1944	do
	Sorghum Hollow	....	....	2	1944	Salt water
	Wayside-Havana	....	....	15	1941	do
	do	....	....	25	1946	Fresh water
	do	"Wayside"	75	27	1942	Fresh & salt water
	do	do	20	10	1945	do
	do	"Wayside" & "Weiser"	40	15	1945	do
	do	"Wayside"	25	14	1944	do
	do	do	20	18	1945	do
	do	do	40	19	1948	do
	do	do	56.25	29	1938-39	do
	do	....	....	25	1940	do
	do	....	20	14	1945	Salt water
Neosho	Erie	....	30	11	1947	Fresh water and produced salt water
	Humboldt-Chanute	....	679	250	1937	Fresh water
	do	"Bartlesville"	20	6	1941	do
Wilson	Vilas	"Bartlesville"	240	11	1943	do
Woodson	Yates Center	Mississippian	160	3	....	do

SURFACE ROCKS

The geologic map of Kansas (Moore and Landes, 1937) shows the areal distribution of outcropping rocks in Kansas. Classification and brief description of these rocks are given by Moore, Frye, and Jewett (1944). Diagrammatic representations of outcropping rocks in eastern Kansas are shown in Figures 3, 4, 5, and 6.

Quaternary and Tertiary deposits.—Glacial drift, lake deposits, wind-blown clay and silt, and alluvial material, mostly unconsolidated, occur as the mantle rock in much of eastern Kansas. Glacial drift, comprising materials ranging in size from clay particles to huge boulders, is confined to the northeastern part of the State, but outwash material was deposited at an undetermined distance south of the generally recognized "drift border." Ice sheets invaded Kansas in an area bounded on the west by a line a few miles west of Big Blue River, and on the south by a line several miles south of Kansas River. The glacial deposits consist of clay, sand, silt, gravel, and boulders of quartzite of various colors, granite, and other igneous rock. Glacial deposits do not form a continuous cover for there are numerous outcrops of Permian and Pennsylvanian rocks in the glaciated area.

Alluvium of Recent and Pleistocene age is found in the main stream valleys. These stream-laid deposits have a maximum thickness of 85 feet or more and consist of clay, silt, sand, and gravel. Sand and gravel predominate in the larger stream valleys. Flint gravels of probable Tertiary age occur as thin upland deposits at many localities. This material was deposited by eastward-flowing streams over wide valley floors before elevation that brought about the present erosion cycle. Similar flint deposits of a somewhat younger age constitute alluvial terraces along some of the streams, especially in southeastern Kansas. The thickness of the upland flint deposits is generally less than 20 feet, but greater thicknesses are encountered locally.

Cretaceous rocks.—Cretaceous rocks of Gulfian and Comanchean age, chiefly clays and quartz sandstone, are present at the surface in Washington, Marion, Clay, Dickinson, Riley, and Marshall Counties. The thickness ranges from a featheredge to approximately 300 feet. Cretaceous rocks overlie beveled Permian beds that dip more steeply to the west than do the Cretaceous deposits.

Igneous rocks.—In Riley County there are three outcrops of pluglike masses of basic igneous rock of probable Cretaceous age. These locations are shown on the geologic map of Kansas and on the map of Riley and Geary Counties (Jewett, 1941, pl. 1). A granite dike of post-medial Pennsylvanian age cropping out in Woodson County is shown on the geologic map of Kansas (Moore and Landes, 1937). There is some doubt that the granite exposed there represents an igneous body that extends to depth in the locality. It has been reported that several holes drilled a few years ago in the vicinity of the outcrops revealed only the common Pennsylvanian sediments below the surface. Basic igneous or metamorphic rock crops out and occurs below sedimentary rocks at shallow depths in another area in Woodson County, known as Silver City, a few miles southwest of the granite exposures.

Permian and Pennsylvanian rocks.—Although regarded as belonging in different geologic systems, the Pennsylvanian and Permian rocks in eastern Kansas are here treated together. The rock layers are essentially parallel and the Permian rocks are separated from the underlying Pennsylvanian beds by an unconformity that is conspicuous in only a few places. About 1,000 feet of Permian rocks classed as the lower part of the Sumner group (Middle Permian) and the Chase, Council Grove, and Admire groups (Lower Permian) (Fig. 3) are the surface consolidated rocks east of the Cretaceous outcrop in the western part of eastern Kansas. These rocks are largely marine shales and limestones. Detailed descriptions of these strata were given by Fath (1921), Bass (1929, 1936), Jewett (1941a), and Moore, Frye, and Jewett (1944).

An area of Pennsylvanian outcrops occupies the approximate eastern one-fourth of Kansas and is continuous with an area of exposures of the same beds in Oklahoma, Missouri, Nebraska, and Iowa. The beds dip gently outward from the Ozark uplift in Missouri, and in eastern Kansas the direction of dip of the Pennsylvanian beds is generally westward. These rocks are composed largely of shale, sandstone, limestone, and coal beds. The total thickness of Pennsylvanian rocks is about 2,000 feet.

Outcropping upper Pennsylvanian rocks in Kansas comprising the Wabaunsee, Shawnee, and Douglas groups belong to the Virgilian Series; those comprising the Pedee, Lansing, Kansas City, and Pleasanton groups belong to the Missourian Series.

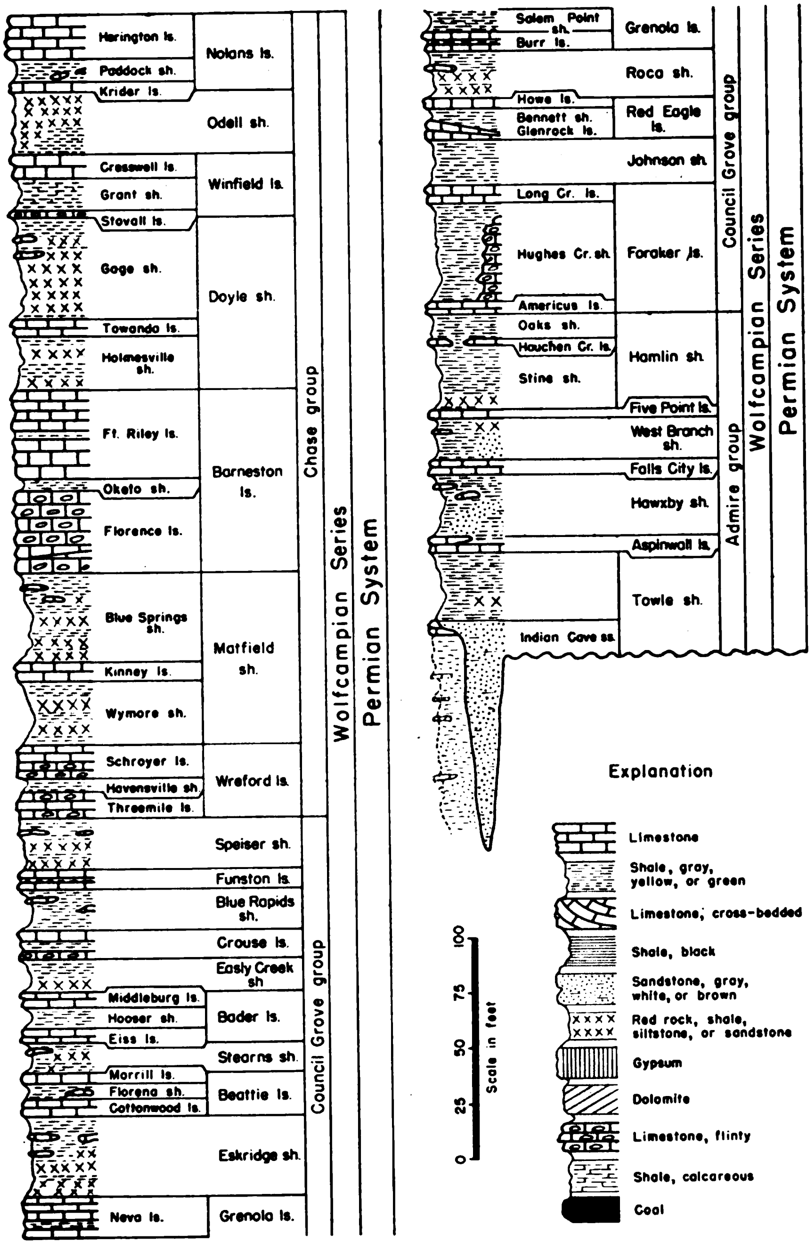

FIG. 3.—Generalized section of outcropping lower Permian rocks in Kansas.

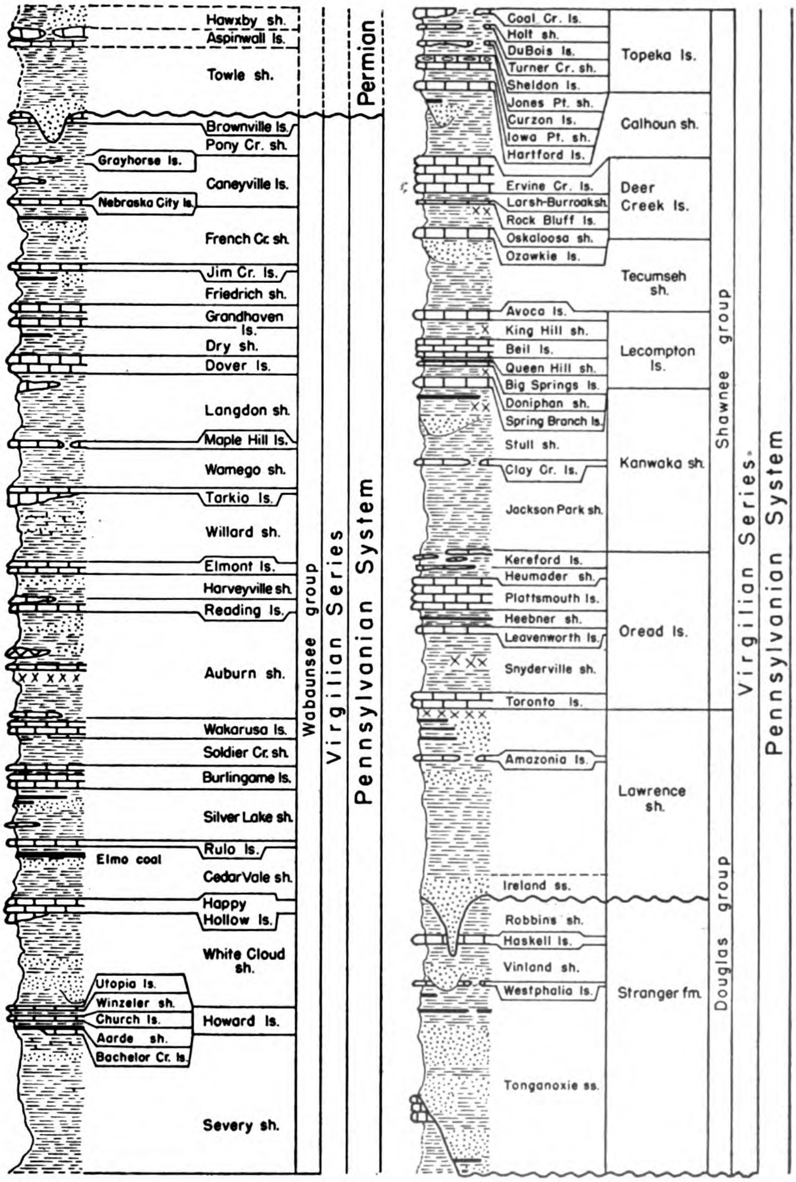

FIG. 4.—Generalized section of outcropping Virgilian rocks in Kansas. For explanation and scale see Fig. 3 or 5.

The Desmoinesian Series in Kansas includes the Marmaton and Cherokee groups (Figs. 4, 5, 6). The series boundaries are marked by important regional unconformities, but the beds of the various stages are essentially parallel. Detailed descriptions of Pennsylvanian rocks are given by Moore (1936) and by Moore, Frye, and Jewett (1944). The outcropping rocks in the various counties are named and described briefly in the section treating individual counties.

Moore and Thompson (1949) have proposed division of Pennsylvanian rocks into three series—Kawvian (Upper), Oklan (Middle), and Ardian (Lower). Units designated above as series are called stages by them. The classification used in this report is in accordance with the interstate agreement adopted by the May 1947 conference.

In Kansas, Permian and Pennsylvanian limestones, shales, and coal beds are generally persistent. These strata include many key beds suitable for structural mapping. A regional unconformity separates Pennsylvanian and underlying rocks. Throughout most of eastern Kansas Pennsylvanian strata lie upon various Mississippian formations; however, along the Nemaha uplift the beveled edges of older rocks, including Pre-Cambrian, are overlain by Pennsylvanian deposits.

Mississippian rocks.—Mississippian limestones of Osagian, Meramecian, and possibly Chesteran age crop out in the southeastern corner of Kansas (Fig. 6). The total thickness of exposed Mississippian limestones is about 50 feet.

BURIED ROCKS

Rocks of Quaternary and Tertiary age constitute only a thin discontinuous mantle in eastern Kansas. The glacial deposits and deposits of alluvium in the river valleys obscure the more firmly consolidated rocks at many localities.

Cretaceous rocks.—Eastern Kansas counties in which Cretaceous rocks occur are Washington, Marion, Clay, Dickinson, Riley, and Marshall. These rocks have a maximum thickness of about 600 feet in the eastern Kansas area. No oil or gas has been found in them in eastern Kansas.

Permian and Pennsylvanian rocks.—The uppermost consolidated rocks encountered in drilling in much of eastern Kansas

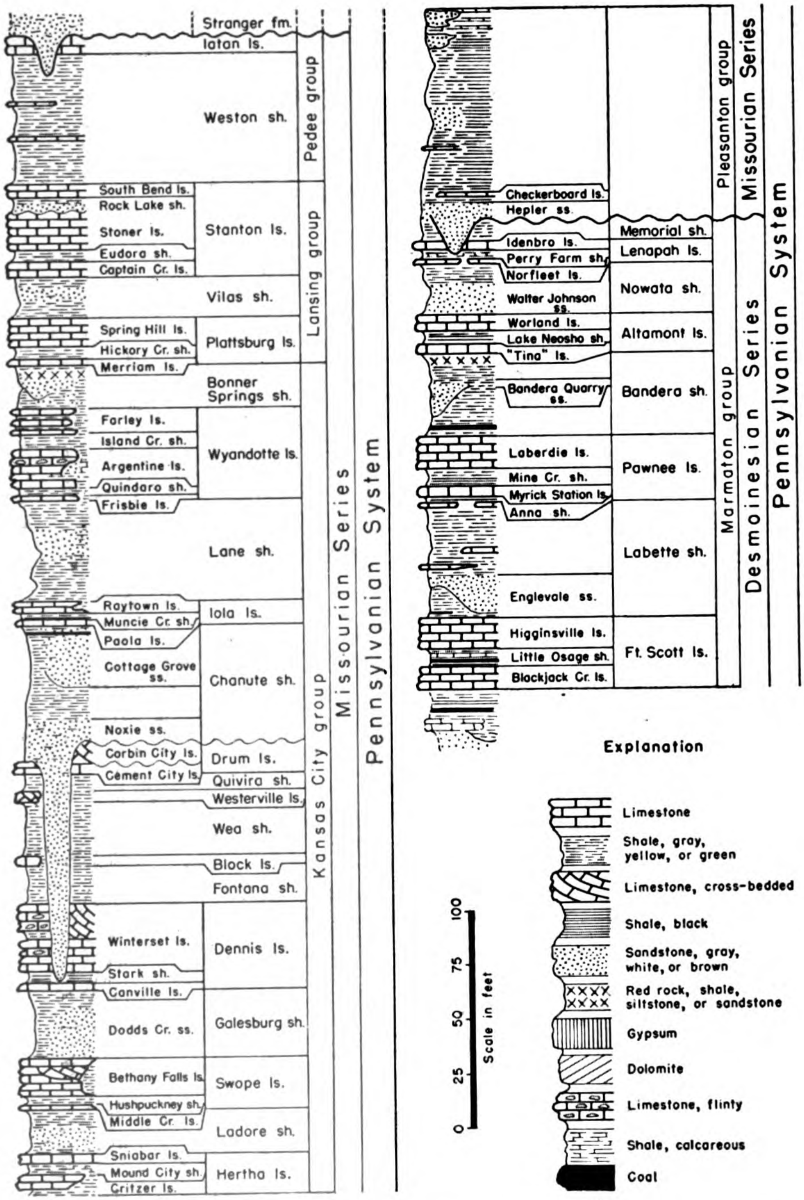

Fig. 5.—Generalized section of outcropping Missourian and upper Desmoinesian rocks in Kansas.

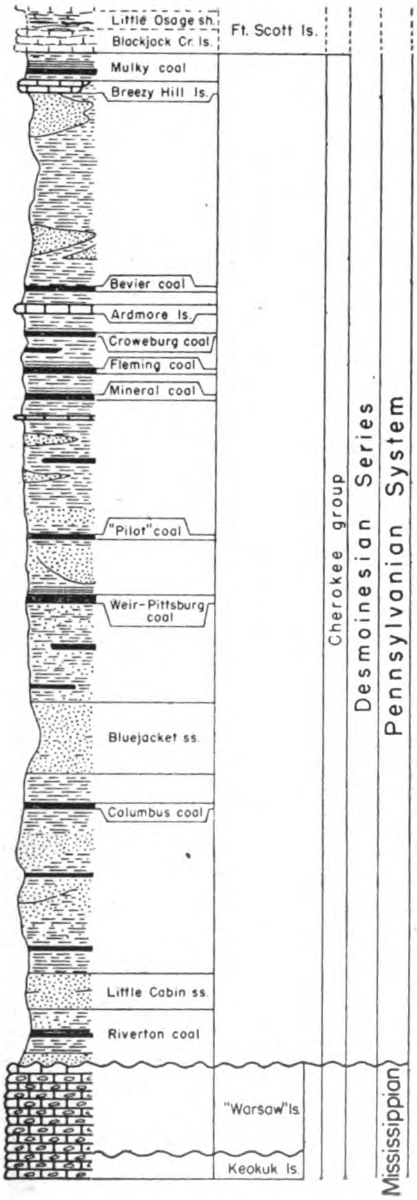

Fig. 6.—Generalized section of outcropping Cherokee rocks in Kansas. For explanation and scale see Fig. 3 or 5.

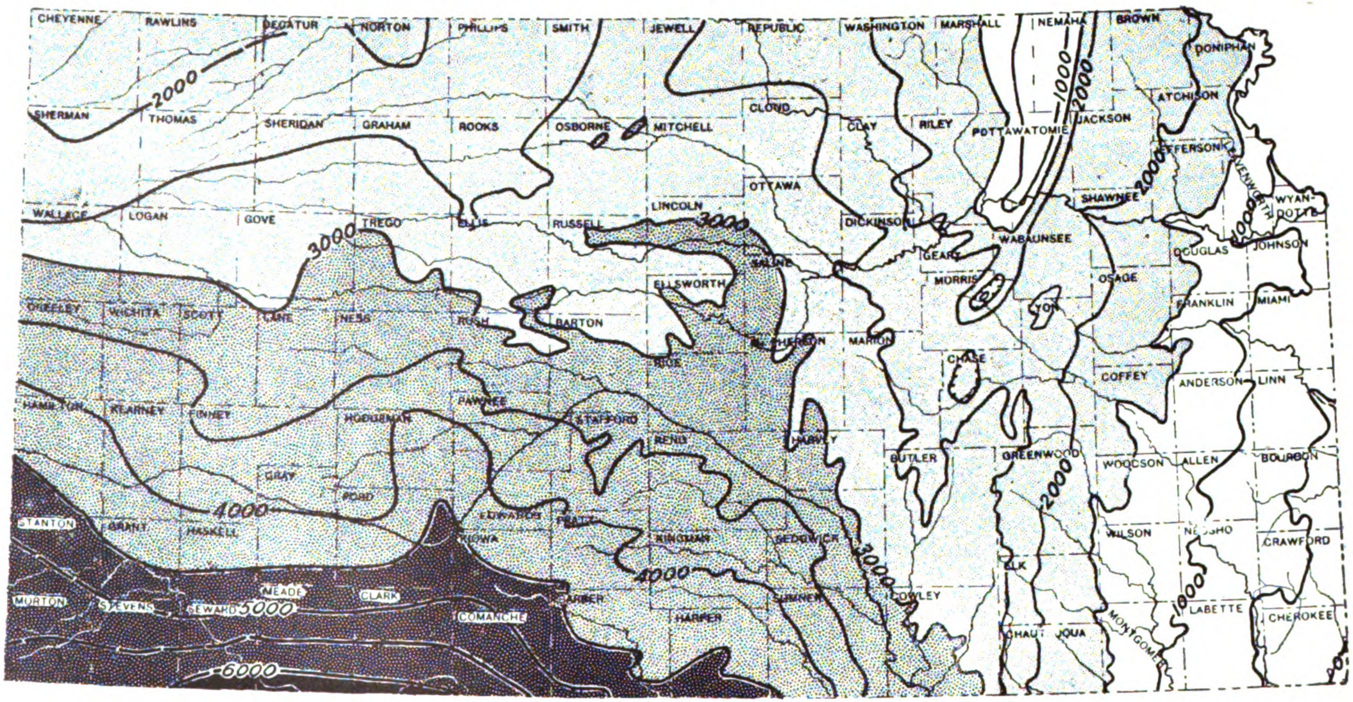

FIG. 7.—Map of Kansas showing thickness of Pennsylvanian and Permian rocks. (From Moore and Jewett, 1942).

are either Permian or Pennsylvanian in age. The thickest section of Permian and Pennsylvanian rocks in eastern Kansas is in southwestern Cowley County where they are more than 3,000 feet thick (Fig. 7). Permian rocks do not occur east of a line extending roughly from the north-central part of Brown County southward to the southeast corner of Cowley County. The geologic map of Kansas is a guide to the identification of the uppermost rocks in various places.

Permian rocks in eastern Kansas are classified as belonging to the Leonardian and Wolfcampian Series. Rocks of these two series are considered to be conformable and the boundary between them is regarded as being at the top of the Herington limestone member of the Nolans formation. The Leonardian Series includes the Nippewalla and Sumner groups, but the Nippewalla group and the upper part of the Sumner group are not present anywhere in the counties described in this report. The Sumner group includes the Ninnescah shale (absent in eastern Kansas) and the Wellington formation. The Wellington formation lies below the more commonly red Permian sediments and above the Herington limestone. It is chiefly gray shale, but contains some red and green shale, thick salt deposits in central and western Kansas, impure limestone, anhydrite, and gypsum beds. The thickness of the Wellington is about 750 feet.

Lower Permian rocks (formerly called Big Blue) are remarkably persistent in thickness and lithology both in the area of their outcrop in eastern Kansas and in the subsurface. The series is about 750 feet thick and contains light-gray limestones, several of which are flinty, highly colored shales and siltstones, and a little sandstone in the lower part. These rocks yield gas in Cowley, Morris, and Chase Counties, and oil in Butler County. The Chase, Council Grove, and Admire groups comprise the Wolfcampian Series.

The Chase group includes the Nolans limestone, the Odell shale, Winfield limestone, the Doyle shale, the Barneston limestone, the Matfield shale, the Wreford limestone. Flint is abundant in the Stovall member of the Winfield limestone, in the Florence member of the Barneston limestone, and in the Wreford limestone. The shale formations are highly colored; reds, chocolate colors, and greens are prominent. The general thickness of the Chase group is approximately 370 feet.

The Council Grove group includes the Speiser shale, the Funston limestone, the Blue Rapids shale, the Crouse limestone, the Easly Creek shale, the Badger limestone, the Sterns shale, the Beattie limestone, the Eskridge shale, the Grenola limestone, the Roca shale, the Red Eagle limestone, the Johnson shale, and the Foraker limestone. Individual limestone formations and members are thinner than those in the Chase group. Flint is less plentiful, although there is much flint in the Red Eagle formation in the southern part of the State. The shale formations are somewhat more somber in color, but reds and greens are conspicuous. Fusulines are abundant in both limestone and gray calcareous shale. It should be noted, however, that fusulines range upward into the Barneston limestone of the Chase group. The Council Grove rocks have a fairly uniform thickness of about 320 feet.

The important oil and gas "sands" of eastern Kansas are included within the Pennsylvanian rocks. Four north-south cross sections (Pls. 1-4) show subsurface relations and thicknesses of the Pennsylvanian groups and other rock units. The group and series boundaries as recognized in outcropping Pennsylvanian rocks can be more or less exactly identified from drillers' logs and by studies of well cuttings.

The uppermost series of the Pennsylvanian is the Virgilian, which includes the Wabaunsee, Shawnee, and Douglas groups. The top of the Wabaunsee group, which is also the top of the Pennsylvanian System, is not readily identified in some drillers' logs. However, the clastic basal Permian Admire contrasts somewhat with the more limy Wabaunsee rocks. Locally the Indian Cave sandstone in the basal part of the Permian marks the boundary, and locally a transitional zone at the Permian-Pennsylvanian contact consists of red shales. The average thickness of the Wabaunsee group in eastern Kansas is about 500 feet. Shale is the most common rock, but sandstone, which occurs in the thicker shale formations, and limestones are also important. In northeastern Kansas the Tarkio limestone, characterized by large fusulines, is a fairly easily recognized marker bed about 175 feet below the top of the Wabaunsee but the Tarkio is thin or absent farther south. Other easily recognized rocks are the Burlingame limestone, at about the middle of the Wabaunsee, and the Howard limestone, about 75 feet above the base.

The Shawnee group is easily identified in well logs because it contains relatively thick limestone formations in the upper and lower parts and it is overlain and underlain by more clastic rocks. The average thickness of the group is about 350 feet. Throughout most of eastern Kansas the Shawnee group is a fairly compact unit consisting of four limestones and three separating shales. The limestone formations, including their shale members, range from about 30 to more than 50 feet in thickness. Lenticular and locally thick sandstone bodies are common in the upper parts of the shale formations. This group is thicker and contains less limestone in southern Kansas than in northern Kansas. The Topeka limestone occurs at the top and the Oread limestone at the base of the Shawnee group.

The Douglas group, consisting principally of shale, sandstone, and minor amounts of limestone and coal, underlies the Shawnee group. The thickness of the group, from the base of the Oread limestone to the regional disconformity that separates Virgilian and Missourian rocks, ranges from about 75 to 350 feet in the subsurface in eastern Kansas. A disconformity of wide extent occurs within the group and separates the Lawrence formation from the underlying Stranger formation. The basal part of the Lawrence formation is distinguished by the Ireland sandstone which consists of lenticular sand bodies. A similar series of lenticular sandstone bodies, the Tonganoxie sandstone, occurs in the lower part of the Stranger formation. Locally the upper part of the Lawrence shale is silty and sandy and in many places the name Tonganoxie is applied to two sandstone beds separated by several feet of shale. Conglomerates occur locally in the basal parts of the sandstone deposits.

The Haskell limestone occupies a position near the top of the Stranger formation. Because of the erosional disconformity at the base of the Virgilian rocks, Douglas deposits are in contact with Missourian formations ranging downward from the Pedee group to the upper part of the Lansing group.

Sandstone comprises an important part of the Douglas (lowermost Virgilian) and a lesser part of the Pedee (uppermost Missourian) beds. An erosional break separates deposits of the two stages and locally lower Virgilian sandstones fill channels cut into upper Missourian deposits. Hence two sandstones may be in direct contact or Virgilian sandstone may be in contact with Lansing beds.

The Missourian Series occurs below the Virgilian and includes the Pedee, Lansing, Kansas City, and Pleasanton groups. The Pedee group is locally absent, due to pre-Virgilian erosion, but in many places it is about 200 feet thick. It consists chiefly of clastic sediments that lie above the Stanton limestone and below the disconformity at the base of the Stranger formation. The Iatan limestone, about 10 feet thick, is the uppermost formation of the group. The Weston shale, the basal formation of the group, consists chiefly of gray clay shale. It is probable that locally a few feet of shale occurs above the Iatan limestone and below the post-Missourian disconformity. Pedee rocks are difficult or impossible to detect in many drillers' logs.

The Lansing group is 75 to 275 feet thick in eastern Kansas and consists largely of limestone. It includes the Stanton limestone, the Vilas shale, and the Plattsburg limestone. In southeastern Kansas this group is thicker than farther north and contains more shale and sandstone. A few feet of black platy shale in the Eudora shale member of the Stanton limestone is a marker bed. In some areas it is difficult to differentiate the Plattsburg limestone from the Wyandotte limestone, in the upper part of the Kansas City group. South of T. 30 S., both the Lansing and upper part of the Kansas City group are largely clastic and consist of clayey and sandy shales and thin limestone beds.

The Kansas City group is composed of beds between the base of the Plattsburg (lowermost Lansing) limestone and the base of the Hertha limestone. The group is divided into three subgroups called Zarah, Linn, and Bronson (Moore, 1948). The Iola limestone (uppermost formation of the Linn subgroup) is identified rather easily in drillers' logs in much of eastern Kansas. In some reports the lower part of this unit, comprising the Winterset to Hertha limestones, inclusive, is assigned to the "Bronson group" (Moore, 1932; Moore, 1936; Jewett, 1932, 1933, 1937, 1940a; Jewett and Newell, 1935; Moore, Frye, and Jewett, 1944; Jewett and Abernathy, 1945). The Bronson rocks now are regarded as a subgroup in the lower part of the Kansas City group.

The Kansas City group, like the Lansing, throughout much of eastern Kansas is largely limestone and the two groups are differentiated with some difficulty. South of T. 30 S., the upper two subgroups consist almost entirely of shale, silty and sandy shale, siltstone, and sandstone. Limestones in the Bronson subgroup, however, are more persistent southward. Flinty and oölitic limestones are characteristic of the Bronson rocks. Two thin black shale beds, one in the Dennis and one in the Swope formation, are subsurface marker beds in the Bronson rocks. The base of the Kansas City group (base of the Hertha limestone) is an excellent subsurface marker in most of eastern Kansas.

The Kansas City group is about 160 feet thick in the northern part of eastern Kansas and about 585 feet thick in the southern part. The thickness of the combined two upper subgroups ranges from about 75 to 385 feet and of the Bronson subgroup from about 85 to 200 feet. Southward thickening is due chiefly to increasing thicknesses of the clastic formations. It is convenient to group together the Lansing and Kansas City groups in much of eastern Kansas; the combined thickness ranges from about 250 to about 700 feet.

The relatively thick Pleasanton assemblage of shale, sandstone, and very thin limestone beds lies below the Kansas City rocks and above the pre-Missourian and post-Desmoinesian disconformity. In eastern Kansas the thickness ranges from about 100 to 225 feet. "Big shale" is the drillers' common term for the Pleasanton shale, and the term "Bourbon shale" has been used in some reports for the same rocks. In northeastern Kansas lenticular sandstone bodies in the upper part, called Knobtown sandstone, locally yield oil. The more persistent Hepler sandstone in the basal part of the group yields oil in Miami County. In some places, as in eastern Miami County, the disconformity at the base of the Bourbon rocks brings the Hepler sandstone in contact with rocks as low as the Bandera shale. The Checkerboard limestone, a well-known surface and subsurface marker in northeastern Oklahoma, extends into southern Kansas as a thin limestone a few feet above the Hepler sandstone.

The Hepler sandstone, which is the northern extension of the upper part of the Seminole formation of northeastern Oklahoma, is absent, very thin, or perhaps only very locally present in eastern Kansas a few miles down dip from its persistent outcrop. Hence, Pleasanton beds cannot be differentiated from shale in the upper part of the Desmoinesian section in most of eastern Kansas, and the uppermost Desmoinesian limestone that is present commonly is the uppermost rock that can be differentiated from the Pleasanton.

Because the lower limestones of the Kansas City group are absent in southern Kansas, the term Coffeyville formation is used to designate beds between the base of the Dennis limestone (Hogshooter) and the Checkerboard limestone. The Coffeyville formation is stratigraphically equivalent to rocks that comprise most of the Bronson subgroup and the Pleasanton group. It may be noted, however, that at outcrops in southern Kansas the Pleasanton shale part of the Coffeyville formation is differentiated from the upper or Bronson part.

"Layton" and "Cleveland sands" are widely used terms for sandstone bodies in the Coffeyville formation. These, although broadly lenticular, are locally more or less sheetlike deposits of probable deltaic origin. The "Layton sand" at about 2,300 feet, yields oil in the Turner and Winfield fields, Cowley County. The name "Layton" is used in some places for one or more sandstones that are somewhat higher stratigraphically than Coffeyville rocks. The usage of these names is discussed more fully on subsequent pages of this report.

The Desmoinesian Series, comprising a total thickness of about 600 feet, includes the oldest Pennsylvanian rocks of eastern Kansas. The Marmaton group, consisting of about 250 feet of shale and limestone formations, is the uppermost group of the Desmoinesian. Along the outcrop of Marmaton rocks, which extends from Linn County southwestward to Labette and Montgomery Counties, the limestone formations are well developed and are differentiated into limestone and shale members (Jewett, 1941a). Because of the occurrence of important oil and gas reservoir rocks in this group and in the underlying Cherokee shale, identification of Marmaton formations in the subsurface is important. The group includes the Memorial shale, the Lenapah limestone, the Nowata shale, the Altamont limestone, the Bandera shale, the Pawnee limestone, the Labette shale, and the Fort Scott limestone.

The Lenapah limestone is about 30 feet thick in the southern part of eastern Kansas; elsewhere it is thin or locally absent because of local post-Desmoinesian erosion. The Nowata shale contains sandstone lenses, including the "Wayside sand," an important oil reservoir in southeastern Kansas and northeastern Oklahoma. The Altamont limestone, commonly less than 20 feet thick, occurs about 30 feet below the Lenapah limestone. The Bandera shale, consisting of gray and yellow clay shale and sandstone, occurs below the Altamont and includes the "Weiser sand." This formation ranges in thickness from 20 feet or less to about 100 feet. The Pawnee limestone is a persistently conspicuous pinkish limestone that ranges in thickness from about 20 to 60 feet in the subsurface in eastern Kansas. Two or more limestone members can be differentiated in many drillers' logs. The Labette shale ranges in thickness from about 25 to 100 feet except in most of Cowley County and locally in Chautauqua County where only a few feet of this shale lies between the Pawnee and Fort Scott limestones. The Labette consists of gray and black clay shale and gray silty and sandy shale, sandstone, thin beds of limestone, and thin coal beds. "Peru sand" is the common term for sand bodies in the Labette shale in the subsurface. The Fort Scott limestone is the lowermost Marmaton formation and immediately overlies the Cherokee shale. In most wells in eastern Kansas two limestones and a separating shale member can be identified; in some parts of southern Kansas four or more limestones are present. The thickness of the Fort Scott limestone ranges from about 25 to 100 feet. Many wells in eastern Kansas produce gas from black shale associated with the Fort Scott limestones. Production from this zone is often referred to as "Oswego" production.

The Cherokee shale, which includes important oil and gas reservoirs in eastern Kansas, comprises beds below the Fort Scott limestone (lowermost Marmaton) and above the pre-Pennsylvanian rocks. The Cherokee shale is not of Early Pennsylvanian age, but it is the oldest Pennsylvanian rock in eastern Kansas. It lies on Mississippian limestone formations in most parts of eastern Kansas, but it overlies pre-Mississippian rocks in the Nemaha anticinal area. The thickness of Cherokee rocks ranges from a few feet along the Nemaha uplift to about 800 feet in the Forest City basin. The common thickness in eastern Kansas is about 350 or 400 feet.

The Cherokee consists of dark and light-colored clayey and silty shales, some important sandstones, and a minor amount of limestone and coal. The upper few feet is commonly black platy shale and this zone is an important "shale gas" reservoir in several eastern Kansas counties. Sandstone beds, called "Squirrel sand," commonly occur in the upper part of the Cherokee shale. These sandstones are gas and oil reservoirs in several eastern Kansas counties, especially Franklin, Linn, and Miami. The "Squirrel sand" where present is generally about 30 feet below the Fort Scott limestone. The thickness is as much as 80 feet (Lee, 1943, p. 83). The Ardmore limestone, commonly about 4 feet thick, is a convenient marker bed in the upper middle part of the Cherokee shale. In drilling it is generally encountered 80 to 100 feet below the top of the Cherokee.

"Burbank sand" is a term applied locally to sandstone in the middle part of the Cherokee, and the name "Bartlesville sand" is applied commonly to sand bodies in the middle and lower parts of the Cherokee. Sandstone that lies on or a few feet above the Mississippian limestone is called "Burgess sand." Sandstone in similar position in some areas is called "Tucker."

Usage of names for sandstone bodies or for sandstone zones in the Cherokee rocks generally are well understood locally but of the several names in current usage most or all of them are applied to different formations. "Cattleman sand" is applied to sandstone bodies in Greenwood County that occur in the upper-middle part of the Cherokee section, 50 to 75 feet above what there is called "Bartlesville sand." The "Cattleman" occurs in more or less isolated lenses in a zone that may be correlative with that of the "Burbank sand" as the name is used in near-by places. It is probable that in many places in eastern Kansas "Bartlesville sand" is applied to sandstones somewhat younger than the productive sandstone that is called Bartlesville in the Bartlesville-Dewy oil field (Washington County, Oklahoma).

The Cherokee shale in eastern Kansas has not been studied sufficiently. Outcrop studies, chiefly by Abernathy (1937) show that sandstone and sandy shale, although discontinuous, occur in definite stratigraphic positions in the lower parts of cyclical units and that there are 15 cycles in the outcrop area. Twelve or more contain sandy zones at outcrops (Fig. 6). It is probable that a part of most of the stone that is called "Bartlesville" in eastern Kansas is the Bluejacket sandstone.

Names that are in common usage for various sandstones in Cherokee and other rocks are explained on pages 63 to 76.

Mississippian rocks.—Various Mississippian limestone formations ranging in age from Osagian or Kinderhookian through Meramecian are present throughout most of eastern Kansas (Lee, 1939; 1940; 1943, pp. 66-79). These rocks were removed by late Mississippian or early Pennsylvanian erosion from a large area along the northern part of the Nemaha anticline northward from the northern part of Chase County and from higher parts of the anticline northward as far south as Augusta in Butler County (Lee, 1939, pl. 1). The thickness of the Mississippian limestone formations in eastern Kansas ranges from a featheredge to more than 450 feet. Various kinds of limestone and dolomite are present and chert is characteristic of some of the formations. The distribution of various Mississippian formations in Kansas is shown by Lee (1940, pl. 8).

In most parts of eastern Kansas the Mississippian limestones are underlain by the Chattanooga shale of early Mississippian or late Devonian age. The Chattanooga shale and some younger beds (Northview shale and Compton limestone) were deposited above an extensive peneplain which had been developed on previously deformed rocks. The maximum thickness of the Chattanooga shale is about 260 feet, but the thickness commonly is not more than 50 feet. The Chattanooga shale is dark gray or black in southeastern Kansas, but it is lighter and greenish gray in the northern part. Sandstone is included in the basal part in some areas. Generally the Chattanooga contains plant spores and locally it is silty. In southeastern Kansas the Northview shale, which has a maximum thickness of about 28 feet, and the Compton limestone, which has a maximum thickness of about 60 feet (Lee, 1940, p. 31), occur comformably above the Chattanooga shale. The Northview and Compton are correlative with the Chouteau limestone of Missouri.

Devonian and Silurian rocks.—The terms "Siluro-Devonian" (Ockerman, 1935, p. 30 pl. 1) and "Hunton" limestone are commonly used to designate formations in eastern Kansas that occupy a position below the Chattanooga shale and above the Ordovician rocks. These are convenient names, but Lee (1943, pp. 43-59, fig. 3) has shown that there is an angular unconformity between Silurian and Devonian rocks in eastern Kansas and that several formations that crop out in Missouri and Oklahoma can be identified in the subsurface in Kansas. According to Lee (1943, p. 52), undifferentiated limestones and dolomites of Late Devonian age and the Cooper limestone, of Middle Devonian age, occur in eastern Kansas, and the Silurian rocks of the area consist of the Brassfield and Edgewood limestones which are correlative with the Chimneyhill limestone of Oklahoma (Lee, 1943, p. 45). Silurian and Devonian rocks are represented separately in the cross sections shown on Plates 1, 2, 3, and 4 of this report.

Devonian and Silurian rocks occur in eastern Kansas east and west of the northern part of the Nemaha anticline, and a small area in the southeastern part of Marion County is underlain by these rocks (McClellan, 1930; Ockerman, 1935, fig. 2). With the exception of the Nemaha anticlinal area, Devonian and Silurian rocks are present north and west of a line extending in a general east-west direction in or near T. 15 S. According to Lee (1943, pp. 45, 47), the greatest known thickness of Devonian rocks in eastern Kansas is about 250 feet and that of Silurian rocks is about 150 feet. The rocks are chiefly limestone and dolomite.

Ordovician and Cambrian rocks.—Maquoketa shale, Kimmswick limestone, Decorah shale, Plattin limestone, St. Peter sandstone, undifferentiated Cotter and Jefferson City dolomites, Roubidoux formation, undifferentiated Gasconade and Van Buren dolomites, and Gunter sandstone of Ordovician age have been identified in eastern Kansas. The Eminence and Bonneterre dolomites and the Lamotte sandstone of Cambrian age have been identified. The rocks between the St. Peter sandstone and the Lamotte sandstone are commonly called Arbuckle or may be referred to as "Siliceous lime." Lee (1943, pp. 19-20), however, has pointed out that the Bonneterre dolomite does not properly belong in the Arbuckle assemblage. It is recognized that the Arbuckle rocks, with or without the inclusion of the Bonneterre dolomite, constitute a convenient grouping of formations of Late Cambrian and Early Ordovician age. Late Devonian or Early Mississipian rocks rest directly on Arbuckle rocks in the Chautauqua arch area. Oil has been discovered in Arbuckle rocks in eastern Kansas in Elk, Wilson, Chautauqua, Montgomery, Labette, Cowley, and Marion Counties.

Lee (1943) has made known many data concerning the stratigraphy and structure of older Paleozoic rocks in the Forest City basin. Keroher (in Jewett, 1941, pp. 107, 110) interpreted drillers' logs of several wells in Riley and Geary Counties, but he did not make separations within the Arbuckle rocks. Keroher also studied cuttings of pre-Mississippian rocks from a well in Linn County in the northern part of the Chautauqua arch area (Jewett, 1940a, pp. 12-14) and subdivided these rocks. Abernathy (1943) studied samples from the Jayhawk Ordnance Works deep water well in northeastern Cherokee County, and identified the Cotter dolomite, the Jefferson City dolomite, the Roubidoux formation, and the Gasconade dolomite. This well, which is near the crest of the Chautauqua arch, reached 20 feet into the Gasconade dolomite. Early Mississippian (Kinderhookian) beds lie on Cotter dolomite in this area.

The Maquoketa shale occurs east and west of the Nemaha anticline in northeastern Kansas (McClellan, 1930; Ockerman, 1935, fig. 2; Lee, 1943, fig. 12, pp. 40-42). It was originally deposited throughout northeastern Kansas and probably across the Chautauqua arch (Lee, 1943, p. 42). Pre-Devonian erosion removed it and some older and younger rocks from large areas in southeastern Kansas and Missouri. Near the end of Mississippian time, the Maquoketa was eroded generally from the northern part of the Nemaha anticline. According to Lee (1943, p. 41), the formation is separable roughly into an upper and a lower part. Genrally the upper zone is silty impure dolomite, and the lower zone is dolomitic silty dark shale. In general, the Maquoketa shale is gray and greenish gray, and ranges from a featheredge to about 80 feet in thickness.

The Kimmswick limestone has been eroded from the northern part of the Nemaha anticline and from the Chautauqua arch. The formation is largely dolomite in northeastern Kansas but it changes to limestone toward the south in Johnson, Douglas, and adjacent counties (Lee, 1943, p. 36). Chert is characteristic of the middle part of the formation. The thickness ranges from a featheredge to about 180 feet. Lee has identified the Decorah shale and the Plattin limestone in cuttings from several northeastern Kansas wells. The Decorah shale is characterized by sandy dolomite interstratified with dark and gray-green shale (Lee, 1943, p. 32). Later, Leatherock (1945) correlated the "Plattin" limestone with the Platteville limestone. The Decorah shale is believed to be more generally present than is the Platteville limestone. The thickness of the formations east of the Nemaha anticline ranges from a few feet to about 85 feet. About 300 feet of Viola limestone occurs in Clay and other counties in the northwestern part of eastern Kansas. The Kimmswick limestone, the Decorah shale, and the Platteville limestone are often correlated with the Viola limestone of Oklahoma. However, Lee believes that only the Decorah shale and the Kimmswick limestone correspond in age to the Viola limestone, and according to Leatherock (1945) the Platteville (Plattin of Lee) limestone and the St. Peter sandstone are of Simpson age.

The St. Peter sandstone occurs generally between the Viola and Arbuckle rocks, but it is separated from younger and older rocks by important disconformities. In northeastern Kansas it oversteps all older Ordovician and Cambrian rocks and in the northwestern part of eastern Kansas it lies on Pre-Cambrian granite (Lee, 1943, pp. 29-30, fig. 5, pl. 1). Lee has found that in most northeastern Kansas wells that have been drilled into these rocks, the Decorah shale lies upon the St. Peter sandstone, but in the deeper part of the North Kansas basin limestone tentatively identified as Plattin overlies the St. Peter sandstone.

The St. Peter sandstone and younger pre-Chattanooga rocks were eroded from the Chautauqua arch before deposition of the Chattanooga shale. Immediately before the beginning of Chattanooga deposition the St. Peter sandstone was exposed in a narrow belt extending from a point near the northeast corner of Johnson County southwestward to Sumner County. This line is used commonly to mark the boundary of the Chautauqua arch. Arbuckle rocks were exposed south and east of the St. Peter exposure; younger Ordovician, Silurian, and Devonian formations were exposed west and north of the St. Peter outcrop. South and east of this line the Chattanooga shale, or locally Mississippian limestones, now lie upon Arbuckle rocks. The St. Peter sandstone and other rocks were removed from the northern part of the Nemaha anticline before Pennsylvanian deposition. The St. Peter formation is chiefly white sandstone composed of well-rounded grains but it includes a minor amount of green shale. The thickness of the St. Peter in eastern Kansas ranges from a featheredge to more than 400 feet; the common thickness is between 50 and 85 feet. St. Peter sandstone is sometimes called "Wilcox sand."

In eastern Kansas the St. Peter sandstone oversteps older Ordovician and Cambrian rocks from the east (Lee, 1943, fig. 5). That is, the Cotter-Jefferson City dolomites and older rocks were beveled before burial under the St. Peter sandstone. Undifferentiated Cotter and Jefferson City dolomites are absent in the Forrester and others No. 1 Hummer well in Shawnee County, but they are 106 feet thick in the Duffens and others No. 1 Stanley well in Douglas County. Keroher (Jewett, 1940a, pl. 2B) identified 168 feet of tan and gray oölitic cherty dolomite as undifferentiated Cotter-Jefferson City in the Holeman and Edwards No. 9 Pollman well in Linn County. Abernathy (1943, fig. 2) identified 105 feet of Cotter dolomite, including a few feet of Swan Creek sandstone in the basal part, and 300 feet of Jefferson City dolomite in the Jayhawk Ordnance Works water well in Cherokee County. An inconspicuous unconformity is believed to occur between the Cotter and Jefferson City formations in eastern Kansas.

The Roubidoux formation is present throughout a wide area in eastern Kansas (Keroher, in Jewett, 1940a, pl. 2B; Abernathy, 1943, p. 85, fig. 2B; Lee, 1943, pp. 25-26, fig. 5). It comprises sandy gray dolomite and sandstone. Recorded thicknesses are 175 feet in Shawnee County, 167 feet in Douglas County, 145 feet in Linn County, and 155 feet in Cherokee County.

Undifferentiated Gasconade-Van Buren formations are believed to occur throughout eastern Kansas except in the northern part of the Nemaha anticline area. Lee (1943, fig. 5) reported 90 feet in the Hummer well in Shawnee County and 206 feet in the Stanley well in Douglas County. Both figures include a few feet of Gunter sandstone in the basal part. Keroher (in Jewett, 1940a, pl. 2A) reported that these formations, including a few feet of Gunter sandstone, are 135 feet thick in the Pollman well in Linn County. The Jayhawk Ordnance Works well in Cherokee County was drilled 20 feet into the upper part of the Gasconade dolomite (Abernathy, 1943, fig. 2B). The undifferentiated Gasconade-Van Buren formations are chiefly cherty dolomite.

The Eminence dolomite underlies the Gunter sandstone in most parts of eastern Kansas, but it is not present in the northwestern part of the Forest City basin (Lee, 1943, p. 23, fig. 5). Recorded thicknesses are 90 feet in Shawnee County, 175 feet in Douglas County, and 150 feet in Linn County. The formations consist chiefly of light crystalline dolomite. Lee has pointed out that the Potosi dolomite may be present in easternmost Kansas as a thin wedge between the Eminence and Bonneterre dolomites. The Bonneterre dolomite is commonly present in eastern Kansas unconformably below the Eminence dolomite and unconformably above the Lamotte sandstone. The thickness ranges from a featheredge to 100 feet or more. In many areas in eastern Kansas several feet of sandstone lies next above the Pre-Cambrian floor. This sandstone is probably equivalent to the Lamotte sandstone of Missouri and it commonly is called Lamotte. The Reagan sandstone which is exposed in the Arbuckle Mountains in southern Oklahoma, occupies a stratigraphic position similar to that of the Lamotte sandstone. The Lamotte in eastern Kansas is coarse-grained and arkosic sandstone ranging in thickness from a featheredge to 40 feet or more.

In a recent publication Keroher and Kirby (1948) have shown results of studies of Upper Cambrian and Lower Ordovician rocks in Kansas. Descriptions and photographs of acid-insoluble residues included in their report are useful in identifying units in the Arbuckle and lower rock section. Formations studied include in descending order: (1) undifferentiated Cotter and Jefferson City dolomites, (2) Roubidoux dolomite, (3) undifferentiated Gasconade and Van Buren formations of early Ordovician age, (4) the Eminence dolomite, (5) the Bonneterre dolomite, and (6) Lamotte sandstone.

Pre-Cambrian rocks—Many wells in eastern Kansas have been drilled completely through the Paleozoic rocks into the more crystalline basement rocks. Some early wells were continued into granite or metamorphic rocks because it was not recognized that these rocks are Pre-Cambrian in age and are generally believed not to contain oil or gas. Pre-Cambrian rocks in Kansas are everywhere buried by sediments; hence they are known only from well cuttings or cores. They consist chiefly of granite, gneiss, and schist; quartzite, other metamorphic rocks, and igneous rocks of various kinds are also included.

According to Landes (1927), most of the "granite wells" east of the Nemaha anticline encountered granite or gneiss, but schist is not uncommon. Gneiss is a metamorphic rock in which the various minerals occur in more or less distinct bands. Some gneisses cannot be distinguished readily from granite in well cuttings. Schist is rather easily mistaken for shale. Wells that have been drilled through the sedimentary rocks in the area of the Nemaha anticline have chiefly revealed granite or gneiss in contact with the overlying Paleozoic rocks. It is reasonable to believe that in eastern Kansas beyond the flanks of the Nemaha anticline great thicknesses of metamorphic rocks lie between rocks of Paleozoic age and deeply buried granite or other igneous rocks. In fact, a well in Marshall County penetrated nearly 2,000 feet of schist and other Pre-Cambrian rock, and a well in Greenwood County was drilled into 650 feet of schist that was logged as shale (Landes, 1927, p. 822). The log of a well drilled at Iola, Allen County, indicates that 1,280 feet of metamorphic rocks was penetrated.

The upper surface of the eastern Kansas Pre-Cambrian rocks is an ancient irregular surface which was subjected to erosion for a long time before it was buried under younger rocks. The approximate configuration of the Pre-Cambrian rock surface in Kansas is shown in Figure 8. Sedimentary rocks ranging in age from Pennsylvanian to Cambrian directly overlie Pre-Cambrian rocks in Kansas (Pls. 1-4). Pre-Cambrian rocks in Kansas are nearest the surface in Nemaha County on the crest of the Nemaha anticline where the cover of Pennsylvanian rocks is about 600 feet thick. The crest of the crystalline rock ridge in the core of the Nemaha anticline slopes southward. It is about 2,700 feet below the land surface near El Dorado, in Butler County, and it is deeper southwest of El Dorado. The Pre-Cambrian floor is generally more than 2,000 feet lower just east of the Nemaha anticline than it is on the crest of the granite core. Thence the surface of contact between crystalline and sedimentary rocks rises to the east.

It is commonly believed that the Pre-Cambrian floor marks the lower limit of oil and gas occurrence. However, both oil and gas have been found in Pre-Cambrian rocks in Rice and Russell Counties, Kansas. The oil and gas there occur in stratigraphic traps in metamorphic rocks lying immediately below sediments of Pennsylvanian age.

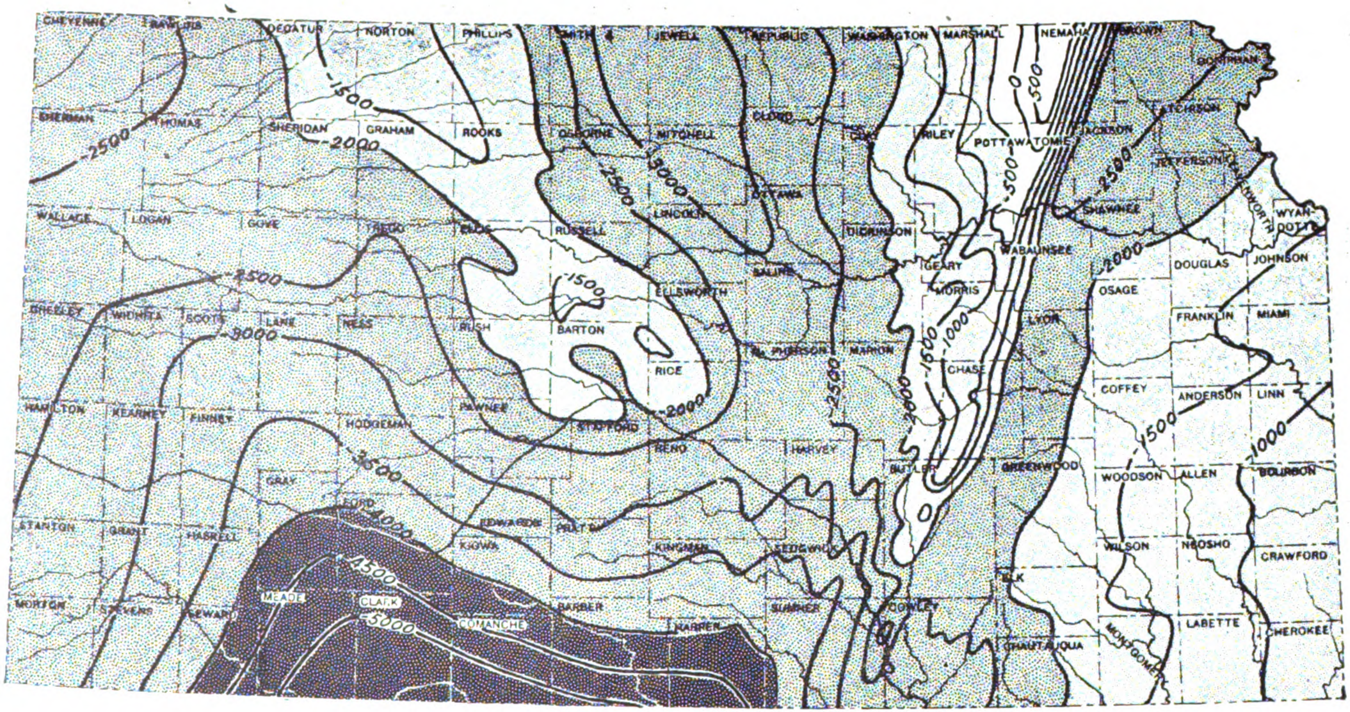

FIG. 8.—Map of Kansas showing approximate configuration of the Pre-Cambrian rock surface. Contour lines are drawn on sea level datum. (From Moore and Jewett, 1942).

Major Structural Features in Eastern Kansas

A map designed to show the major structures in eastern Kansas is somewhat misleading inasmuch as in some places uplifts now occur in former basins, or basins now occupy areas of former uplifts. As examples, the southeastern counties of Kansas are in the Cherokee basin and also on the Chautauqua arch, and the Nemaha uplift crosses the area of the North Kansas basin. The Cherokee basin is the northern part of a shallow basinlike area that existed in a part of Pennsylvanian time, and the Chautauqua arch is the Kansas part of an earlier elevated area. In general, basins are areas in which sections of rock of some particular age span are thicker than rocks of the same age in surrounding areas, and uplifts are areas in which certain rocks, although present in neighboring areas, are absent (Pls. 1-4).

PRE-CHATTANOOGA STRUCTURES

The unconformity lying next below the Chattanooga shale (uppermost Devonian or lowermost Mississippian) is an important and convenient datum horizon in subsurface studies in eastern Kansas. Pre-Mississippian structures can be separated readily from those of later origin. Devonian and Silurian rocks occur next below the pre-Chattanooga unconformity in a large area in northeastern Kansas. Elsewhere different formations of Ordovician age lie next below the Chattanooga shale or, in places where the Chattanooga is absent, next below Mississippian limestone. Several southeastern Kansas counties lack Devonian, Silurian, and Upper and Middle Ordovician rocks, and there the strata next below the pre-Mississippian unconformity are classified as belonging to the "Arbuckle group," of early Ordovician or late Cambrian age. The major pre-Mississippian structural features in eastern Kansas are the Chautauqua arch and the North Kansas basin (Fig. 9).

Chautauqua arch.—In southeastern Kansas there is a broad area in which Arbuckle rocks, flanked on the northwest by bands of successively younger Ordovician formations, lie next below the pre-Chattanooga unconformity (Fig. 10). This situation is due to early uplift and erosion of the westward extension of the Ozark uplift. The ancestral Ozark dome was undergoing differ-

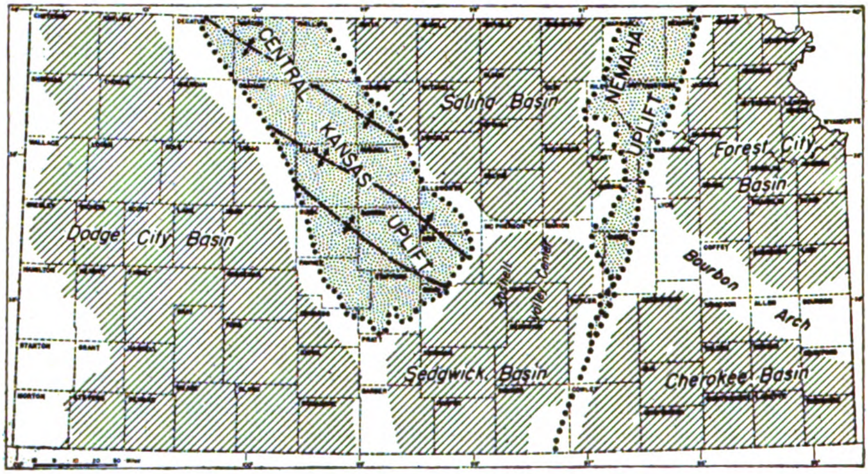

Fig. 9.—Sketch map showing main structural elements in Kansas during Mississippian time. (From Moore and Jewett, 1942).

ential elevation in Ordovician and Cambrian time and probably earlier. Before burial under the Chattanooga shale, the area was partly peneplaned; hence the Chattanooga sediments overstep various formations along the flanks of the dome.

In Kansas the Chautauqua arch occupies the area south and east of a line extending from about the southeast corner of Miami County to a point near the northwest corner of Sumner County (Fig. 9). Such a line approximately coincides with the line of pre-Mississippian outcrop of the contact between the Arbuckle rocks and the overlying St. Peter formation. The St. Peter sandstone, along with other pre-Chattanooga rocks, dips outward from the Chautauqua arch.

North Kansas basin.—The North Kansas basin is a large area north of the Chautauqua arch which was covered by Silurian and Devonian seas and which was the site of extensive sedimentation during Mississippian time (Fig. 9). In eastern Kansas the area north and west of a diagonal line extending from a point near the southeast corner of Miami County southwestward to a point near the northwest corner of Sumner County is included in the North Kansas basin. Devonian and Silurian strata, rocks of late

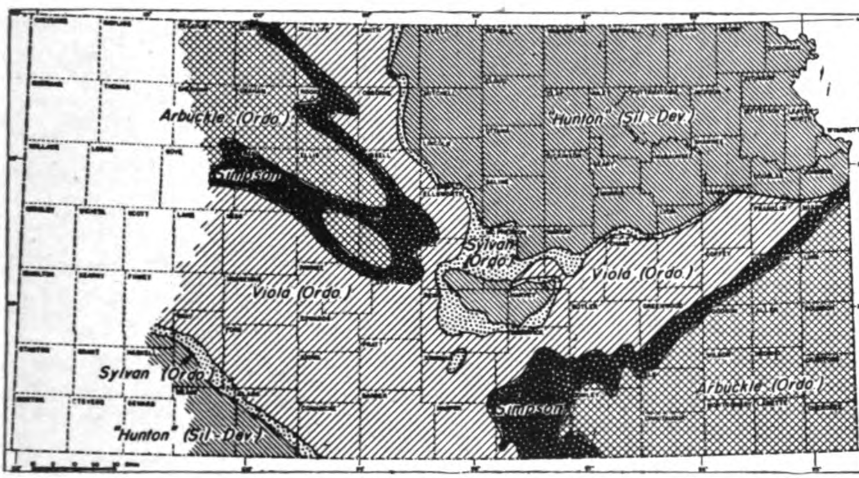

Fig. 10.—Map of Kansas showing inferred post-Devonian pre-Mississippian areal paleogeology. (From Moore and Jewett, 1942).

and medial Ordovician age, and the St. Peter sandstone, all of which are absent in the Chautauqua arch area, lie between the Chattanooga shale and the Arbuckle rocks in the North Kansas basin. Lee (1943, pp. 101-114) has thoroughly discussed the deformation that occurred in this area before Chattanooga time.

MISSISSIPPIAN AND LATER STRUCTURES

Lee (1943, p. 115) has shown that movements of minor importance took place along the axis of the present Nemaha anticline during Mississippian time. However, deformations that occurred during early Pennsylvanian time produced the present main subsurface structural elements in eastern Kansas (Fig. 11). These structures include the Nemaha anticline and small parallel folds such as the Voshell anticline, the Cherokee and Forest City basins, and the low Bourbon arch between the two basins. Farther west and extending into western Kansas are the Salina and Sedgwick basins.

Nemaha anticline.—The Nemaha anticline, whose buried crystalline core is often referred to as the Nemaha mountains or granite ridge, trends south-southwest across Kansas from Nemaha

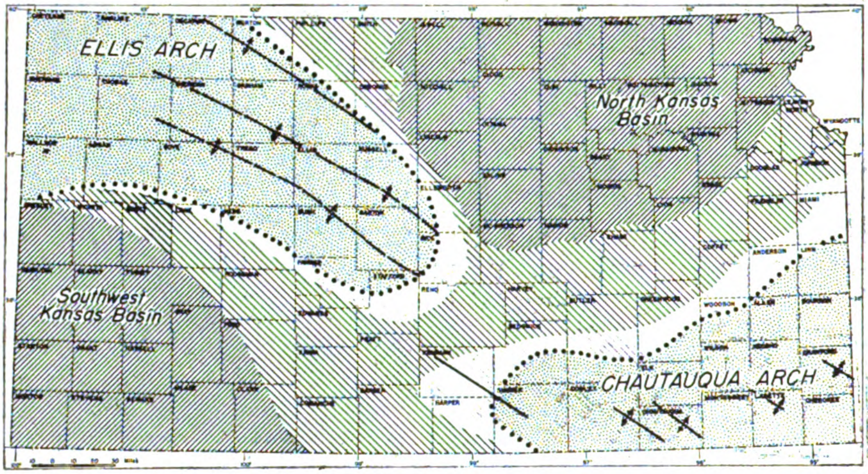

FIG. 11.—Sketch map showing early Pennsylvanian structural provinces in Kansas. (From Moore and Jewett, 1942).

County to Sumner County. Mississippian and older rocks are tilted and eroded on the flanks of this uplift. Pennsylvanian sediments on the anticline overstep and overlap rocks ranging in age from Pre-Cambrian to Mississippian. Pennsylvanian strata lie upon Pre-Cambrian rocks in a belt extending in a northeastward-trending direction from a point in T. 11 S., R. 10 E., and in isolated areas farther south. The extreme northern part of the ridge of Pre-Cambrian granite in the Nemaha anticline was not covered by Pennsylvanian sediments until Virgilian time. Older Pennsylvanian beds overlap and overstep Pre-Cambrian and Paleozoic rocks along the southern part of the axis of the ridge.

Forest City basin, Bourbon arch, and Cherokee basin.—Thinning of Cherokee sediments in a narrow area extending northwestward from Bourbon County to Lyon County indicates that briefly eastern Kansas was separated into two depositional basins, the Forest City basin in the north and the Cherokee basin in the south. The low separating structure expressed in pre-Pennsylvanian rocks is known as the Bourbon arch (Lee, 1943, fig. 2). The Forest City basin extends into northwestern Missouri, southeastern Nebraska, and southwestern Iowa. Pennsylvanian sedimentation seemingly began earlier in the Forest City basin than in the Cherokee basin. The Cherokee basin, however, is the northern or Kansas part of a sedimentation area that extended across eastern Oklahoma, and Pennsylvanian rocks older than any known in the Forest City basin occur in northeastern Oklahoma.

Salina basin.—The Salina basin (Fig. 11) lies between the Nemaha anticline and the Central Kansas uplift. The greatest thickness of Mississippian rocks there is in the western part adjacent to the Central Kansas uplift. Pennsylvanian sediments were laid down in the Salina basin after Mississippian strata had been peneplaned. Washington, Clay, and Dickinson Counties in eastern Kansas are in the Salina basin. Detailed studies of stratigraphic and structural conditions in the Salina basin have been made by Lee, Leatherock, and Botinelly, (1948).

Sedgwick basin.—A basinal area southeast of the Central Kansas uplift and west of the Nemaha anticline is called the Sedgwick basin (Moore and Jewett, 1942, p. 7). It is differentiated from other structural provinces partly because it is more or less separated geographically from northward and westward continuations of other basinal areas and partly because of the general nature of geologic structure and oil and gas occurrence in the region. Large amounts of oil and gas are produced in the Sedgwick basin area, mainly from anticlinal folds on trends generally parallel to those of the Nemaha anticline. Marion County and western Butler County in eastern Kansas are in the Sedgwick basin.

Prairie Plains monocline.—In eastern Kansas and part of neighboring states, outcropping Permian and Pennsylvanian rocks dip gently in a general westward direction. This regional dip, which generally is about 20 feet per mile, is modified locally, especially in the area of the Nemaha anticline. Because of this regional dip, the area is called the Prairie Plains monocline. Outcropping Pennsylvanian rocks dip gently outward from the Ozark dome, and Permian beds, whose strike is more nearly directly north-south, dip westward into a Mesozoic basin. Hence the so-called monocline is a large, more or less indefinitely limited tectonic element. It is chiefly post-Permian in age. Overstep of Cretaceous rocks on beveled Permian beds in eastern Kansas and on beveled Pennsylvanian rocks in southeastern Nebraska and southwestern Iowa indicates pre-Cretaceous age for the Prairie Plains structure.

Minor Structural Features

The regional westward dip of Pennsylvanian and Permian rocks in eastern Kansas is modified by small more or less local anticlines, synclines, domes, and basins. There are many places in which dips to the east, north, or south amount to several feet per mile. Structural maps compiled from altitudes measured on limestones or other key beds and covering an area of a few square miles almost invariably show these structures. Many of them are known to contain oil or gas or both. However, a great amount of oil production in eastern Kansas is from lenticular sand bodies that in most cases are called shoestring sands. In other words this oil accumulation in Pennsylvanian rocks in eastern Kansas was localized by changes in porosity of the strata. A combination of porosity changes and anticlinal structures is responsible for the oil and gas accumulations. It is well to note also that in eastern Kansas and elsewhere rock layers do not lie in parallel planes. Because of lateral changes in thickness of units, especially thicker shales, dips measured on a certain rock bed are not the same as those of lower or higher beds. Observations of outcrops in eastern Kansas show that thicknesses of some shale units, for example the Labette shale (Jewett, 1945, p. 27), vary several feet within a mile. Locally oil and gas have accumulated in curved parts of shoestring sands that lie in a relatively high position due to regional dip of the beds (Rich, 1926, p. 579). Rich found that accumulation in the Bush City Shoestring and the Colony-Welda gas field in Anderson County was probably due to this relationship. Rich wrote:

> In the case of the Colony-Welda gas pool, the sand, which southwest of Colony carries water, extends diagonally up the regional dip out of the water; turns north along the strike for several miles, filled with gas all the way; and finally turns northwestward down the regional dip and again runs into water.

Geologic Cross Sections

The geologic cross sections which are included as Plates 1, 2, 3, and 4 in this report, were made by Virginia N. Perkins. Mrs. Perkins acknowledges the help of Wallace Lee of the Federal

Geological Survey. Mr. Lee was especially helpful in dealing with problems concerning pre-Pennsylvanian rocks.

These north-south sections, which show diagrammatically the positions of rock units in eastern Kansas, supplement four east-west sections that were published as Plates 1, 2, 3, and 4 of Bulletin 57 (Jewett and Abernathy, 1945). It is believed that they are useful generalized pictures of the subsurface geology of eastern Kansas.

Plate 1 shows the subsurface geology along a line between Rs. 23 and 24 E. (Fig. 1) from Wyandotte County to Cherokee County. Attention is called to (1) the southward increase in thickness of Upper Cambrian and Lower Ordovician rocks (Lamotte sandstone to Jefferson City dolomite); (2) the beveling of the St. Peter sandstone, Decorah-Platteville formations, the Kimmswick limestone, and rocks of Devonian age along the northern flank of the Chautauqua arch in Miami County; (3) the absence of the Chattanooga shale in the southern part of the cross section; (4) the beveling of the Spergen and St. Louis limestones of Mississippian age in Linn and Miami Counties; and (5) the thin section of Cherokee shale at about the Linn-Miami County line.

Plate 2 shows subsurface geology along the line between Rs. 16 and 17 E., from Brown County to Montgomery County. Attention is called to (1) the general absence of the Lamotte sandstone between Shawnee and Wilson Counties; (2) the beveling of Arbuckle rocks in the northern part of the section where the Jefferson City-Cotter sequence is absent; (3) the beveling of the St. Peter sandstone in the central part; (4) the beveling of the Decorah-Platteville formations in Jackson County and their absence farther south; (5) the beveling of the Kimmswick limestone and the Maquoketa shale in Osage County and their absence farther south; (6) the beveling of Silurian rocks in Jefferson County and their absence southward; (7) the beveling of Devonian rocks in Osage County; (8) the increased thickness of the Chattanooga shale in the northern part; and (9) the beveling of Mississippian formations below Cherokee rocks.

Plate 3 shows subsurface geologic conditions along the line between Rs. 9 and 10 E. from Marshall County to Chautauqua County. The section crosses the Nemaha anticline in T. 10 S. The northern part of the section pictures conditions west of the anticline where Arbuckle rocks are absent north of T. 6 S., and deposits lie on Pre-Cambrian rocks. Beveled beds in the Simpson formation, Kimmswick limestone, Maquoketa shale, and the Silurian System are in contact with overlying Pennsylvanian sediments. East of the anticline the Cambrian section is thin and locally absent. The Roubidoux formation and the Jefferson City-Cotter dolomites are beveled below the Simpson formation in Wabaunsee, Lyon, and Morris Counties; the Simpson is thickest in Chase and Lyon Counties and is beveled below the Kimmswick limestone and the Chattanooga shale in Greenwood and Chase Counties. Attention is called to the beveling of Silurian rocks below the thin wedge of Devonian deposits in Wabaunsee County. The Chattanooga shale is absent in the extreme southern part of the the section and is thickest near the Nemaha anticline on the east side of the "granite ridge." The Cherokee shale is believed to overstep Mississippian, Devonian, Silurian, Ordovician, and Cambrian rocks on the flank of the Nemaha anticline and is in contact with various Mississippian formations along the line of the cross section southward from Wabaunsee County.

Plate 4 shows geological conditions from Washington County to Sumner and Cowley Counties, along the line between Rs. 2 and 3 E. (Fig. 1). The section is along the east flank of the Salina and Sedgwick basins, except in the extreme southern part where the line of section is slightly east of the crest of the Nemaha anticline. North of T. 19 S. the Bonneterre dolomite lies on Pre-Cambrian rocks but farther south the Bonneterre is absent. The Van Buren-Gasconade sequence is absent north of T. 26 S. (the Roubidoux dolomite being the lowermost Paleozoic formation between Ts. 18 and 26 S.). Arbuckle rocks are absent in the northern part of the line of section, but these Arbuckle rocks, especially the Jefferson City-Cotter dolomites, thicken rather rapidly southward. The Simpson formation is believed to be present throughout the line of section except on the Nemaha anticline where the Chattanooga shale lies on Arbuckle rocks. The Kimmswick limestone is absent, in the line of section, south of T. 26 S., and the Maquoketa shale is absent south of T. 21 S. The thin edge of the wedgelike section of Silurian rocks is near the south side of T. 18 S., and the edge of the Devonian wedge is near the south side of T. 16 S. The Chattanooga shale oversteps Simpson rocks, Kimmswick limestone, Maquoketa shale, and Silurian and Devonian rocks, and the beveled edge of the Chattanooga is in the northern part of the section. Many details in the Mississippian limestone are shown. The thin edge of the wedge of Mississippian limestones is in T. 6 S. In the northern part of the line of section Pennsylvanian deposits lie on the Chattanooga shale.

INDEX OF OIL FIELD NAMES FOR PRODUCING ROCKS

During the many years of oil and gas discoveries and developments in eastern Kansas a large number of names designating the producing formations have come into more or less general usage. Some of these names are recognized stratigraphic terms that appear commonly on geologic sections and in the texts of scientific publications. Others are names that were given to subsurface rocks before correlation with formations that have formal names had been established. In several cases two or more names have been applied to the same or equivalent formations. In other cases two or more formations are known in different places by the same name.

The names that are listed here are those that one hears in the oil fields and frequently some of them occur in reports of various kinds. Some are officially recognized scientific terms, but others are "local names." Because of their more or less common usage, however, they are well established as part of our language, although they are somewhat confusing except to those people who have become accustomed to local usage.

Although the original usages of some of these names and the correlations of some of the deposits to which they are applied are discussed here, these remarks primarily do not constitute an argument for or against the adoption or for discarding of the terms by people who find them useful. An attempt has been made to explain the usage.

Names that are listed in United States Geological Survey Bulletin 896, Lexicon of Geologic Names of the United States (Wilmarth, 1938) are starred in this index.

Arbuckle*—Arbuckle limestone or dolomite is the common designation for Lower Ordovician and Upper Cambrian rocks in eastern Kansas. The term "Siliceous lime" is used locally for Arbuckle rocks and in some areas they are known as "Wilcox." "Wilcox," however, more commonly designates the Simpson or

St. Peter sandstone which occurs stratigraphically above the Arbuckle.

The Arbuckle rocks in Kansas comprise the Cotter and Jefferson City dolomites, the Roubidoux formation, the Gasconade and Van Buren dolomites, and the Gunter sandstone of Ordovician age; and the Eminence dolomite of Cambrian age. The name "Arbuckle," however, is applied often to the sequence between the St. Peter sandstone (above) and the Lamotte sandstone (below); hence, including in its span in addition to the formations named above, the Bonneterre dolomite.

Bartlesville Sand*.—This name is in common use for several sandstones in eastern Kansas and in northern Oklahoma, and according to Powers (1926, pp. 14-15) it has been applied to Ordovician rocks.

The name "Bartlesville sand" is in common use as a name for productive sandstone in all eastern Kansas counties that are important as oil producers. It is applied to sandstone in the middle and lower parts of the Cherokee shale section. In some areas sandstone about 100 feet below the top of the Cherokee rocks is called "Bartlesville." In places there are a "Lower" and an "Upper Bartlesville." In some places the "Bartlesville" is the lowermost sandstone of the local Pennsylvanian section. The name is applied to "shoestring sand" bodies and to more sheetlike deposits. The term "True Bartlesville" of authors seemingly has little significance.

"Bartlesville" was used first as a subsurface stratigraphic term in the northern mid-continent area to designate a productive formation in the Bartlesville-Dewey oil field, Washington County, Oklahoma. The "Bartlesville sand" there lies 365 feet below the top of the "Oswego" (Fort Scott) limestone (Mills-Bullard, 1928, p. 50). It is probable that it is younger than most of the beds that are called Bartlesville in Kansas.

As used now the name "Bartlesville" may mean any of several sandstone bodies that occur in the Kansas Cherokee section below the Ardmore limestone.

Big Lake Sand.—This name is used in Miami County to designate shallow sandstone that is productive in the "Big Lake" field, a part of the Paola area. In part the "Big Lake" seemingly comprises two sandstone bodies, the Hepler sandstone which is the basal deposit of the Pleasanton group, and the Bandera Quarry sandstone, in the Bandera shale. The two locally are in contact because of disconformable relationships. Probably most but not all the oil and gas production in the Big Lake area is from the Bandera Quarry sandstone, which elsewhere in Miami County often erroneously is called "Wayside." "Weiser sand," however, is the more commonly used name for subsurface sandstone bodies in the Bandera shale but Bandera Quarry sandstone is the formal name. "Wayside" according to its original and more common usage designates sandstone in the Nowata shale.

Big Lime.—The term "Big lime" is used to designate the Pawnee limestone in the subsurface in eastern Kansas. The name "Pink lime" is used for the same rocks.

Big Salt Sand.—This name is used for sandstone in the Douglas group in southern Kansas. The "Big Salt sand" may be Ireland or Tonganoxie sandstone or both. Probably sandstone in the Pedee group also is called "Big Salt." The Tonganoxie sandstone is called also "Layton" and "Stalnaker."

Big Shale.—This name is used extensively in eastern Kansas to designate the rock section below the Hertha limestone and the locally uppermost Marmaton limestone (commonly the Lenapah). Hence the term is applied essentially to the Pleasanton group but the section may include at its base the Memorial shale (uppermost formation of the Marmaton group) or in places where the Lenapah limestone is absent or inconspicuous the name may be applied to rocks as low as the basal part of the Nowata shale. The Knobtown sandstone occupies a position in the upper part of the "Big shale" and the Hepler sandstone (included in part in the "Big Lake sand") is the basal formation of the Pleasanton group. Locally the Hepler is in contact with the Lenapah limestone or lower Marmaton formations.

Brown Lime.—This name is used to designate the Higginsville limestone (upper member of the Fort Scott formation) in southern Kansas, especially in Montgomery County. "Oswego" and "First Lime" are local names for the same rock.

Burbank Sand*.—The name "Burbank" is used somewhat commonly for sandstones in the Cherokee shale in eastern Kansas that lie below the Ardmore limestone and above deposits in the same areas that are called "Bartlesville." Seemingly deposits that are called "Burbank" in some places are called "Bartlesville" or "Upper Bartlesville" elsewhere.

The term "Burbank" was first used as a subsurface stratigraphic name for a producing sandstone in the Burbank oil field, Ts. 26 and 27 N., Rs. 5 and 6 E., Osage and Kay Counties, Oklahoma. The "Burbank sand" there lies about 275 to 290 feet below the "Oswego" (Fort Scott) limestone (Mills-Bullard, 1928, p. 28). According to Beckwith (1928, p. 44) the "Burbank" and "Bartlesville sands" of Osage County, Oklahoma, and the "Rainbow Bend" and "Fox Bush" sands in Kansas are seemingly about stratigraphically equal; and the "Bartlesville" is a blanket formation but the other three are more lenticular. According to Mills-Bullard (1928, p. 180) who seemingly made distinction between lenticular and blanketlike deposits, the "Burbank is not Bartlesville but is found at that horizon."

Burgess Sand*—The name "Burgess" is used rather widely to designate sandstone in the Cherokee shale in eastern Kansas that lies next above or almost in contact with Mississippian limestone (Jewett, 1940a; Jewett and Abernathy, 1945). Similar usage for basal Pennsylvanian sandstone in Oklahoma is common (White and others, 1922, p. 184, pls. 3, 28, 31). However Mills-Bullard (1928, p. 180) lists the "Burgess" in Oklahoma as Mississippian in age.

It is probable that in most places in eastern Kansas the deposit that is called "Burgess" is younger than rocks to which the name commonly has been applied in northern Oklahoma. "Basal Pennsylvanian sandstone" is perhaps better usage in eastern Kansas. In some parts of eastern Kansas "Burgess" and "Tucker" are used interchangeably, but as shown in this index "Tucker" seems to have been applied only to Ordovician rocks. However, "Tucker" in Oklahoma is used commonly for a Pennsylvanian sandstone below the "Bartlesville" and above the "Burgess" (White and others, 1922, p. 184).

Bush-Denton Sand.—This name is used for the highest of three productive sandstones that occur in the Lane-Vilas shale (Lansing group) in Elk and Montgomery Counties. It is known also as the "Ferguson sand."

Cattleman Sand*.—This name is used for a productive sandstone in Greenwood County, as in the Wiggins field. It is from 50 to 75 feet above the rock that is there called "Bartlesville sand" and lies about 110 feet below the top of the Cherokee shale.

Chat.—The term "chat" is used widely in eastern Kansas for deposits of fragmentary chert and other debris overlying Mississippian limestone. It is common to speak of the "Mississippian chat," but most of the so-called deposits probably are only slightly older than the overlying Pennsylvanian sediment and probably all or most all of them are of Pennsylvanian age. The chert generally is much weathered and deeply stained by iron oxide and the fragments are intermingled with deeply oxidized ferruginous clayey material. The chert is residual or transported from chert-bearing Mississippian limestones. The "chat" is an oil-bearing deposit in several eastern Kansas fields.

Cleveland Sand*.—The name "Cleveland sand" is used in some eastern Kansas areas for sandstone bodies in the Coffeyville formation. The names "Layton" and "Cleveland" are used more or less interchangeably, but in the Cleveland oil field, Pawnee County, Oklahoma, the "Layton" is 400 feet above the "Cleveland" (Mills-Bullard, 1928, p. 35), and in Kansas the name "Layton" is used more commonly for sandstone in the upper part of the Kansas City group.

Colony Sand*.—This name has been used for a gas-producing sandstone in several Anderson County fields (Charles, 1927; Jewett and Abernathy, 1945, pp. 57-58). The name originated in the Colony gas field. The sandstone called "Colony" occurs in the upper middle part of the Cherokee shale and more commonly is called "Bartlesville."

Dennis Sand.—This name, not to be confused with the Dennis formation in the upper part of the Bronson subgroup, is applied to a gas-bearing sandstone in the Bandera shale in Labette County (Jewett and Abernathy, 1945 p. 153). The term "Weiser" is used more commonly for subsurface sandstone bodies in the Bandera shale but Bandera Quarry sandstone is the more acceptable term.

Eight Hundred Foot Sand.—This name has been used for sandstone deposits in the Cherokee group in Anderson County about 200 feet below the top of the Cherokee section (Charles, 1927, pl. 1).

Encill Sand.—This name is used for the lowest of three sandstones that occur in the Lane-Vilas shale (Lansing group) in Elk and Montgomery Counties. It occurs at a depth of about 1,300 feet in the central part of the county.

Ferguson Sand.—This name is used for the highest one of three productive sandstones that occur in the Lane-Vilas shale (Lansing group) in Elk and Montgomery Counties. It is known also as the "Bush-Denton sand."

First Break.—The term "First break" is used often for a porous zone in the upper part of the Mississippian limestone. It may be applied to a part of any one of several formations.

First Lime.—This term is used to designate the Higginsville limestone (upper member of the Fort Scott formation) in southern Kansas, especially in Montgomery County. "Oswego" and "Brown lime" are local names for the same rock.

Forty Foot Lime.—This name is used to designate the Pawnee limestone in southern Kansas, especally in Montgomery County. "Pink lime" and "Big lime" are used as names for the same rock.

Garnett Sand.—This name is used in Anderson County for sandstone in the upper part of the Cherokee section. It is known also as the "800-foot sand."

Hancock Shale.—This name is used to designate the Little Osage shale member of the Fort Scott formation in the subsurface in Chautauqua County, Kansas, where it bears gas.

Heck Sand.—This name is applied to the middle one of three sandstones that occur in the Lane-Vilas shale in northwestern Montgomery County, Kansas. It is known also as the "Longton" and as the "Webb sand."

Hoover Sand.—This name is used in southeastern Kansas for sandstone believed to be equivalent or nearly equivalent to the Elgin sandstone of the Kanwaka formation. However, according to Mills-Bullard (1928, p. 180) the "Hoover series" lies between the Grayhorse limestone and the Elgin sandstone. In the Burbank oil field, Osage and Kay Counties, Oklahoma, the "Hoover" lies at a depth of 990 feet.

Hunton Limestone*.—"Hunton" is used to designate undifferentiated Silurian and Devonian limestones and dolomites in the subsurface in northeastern Kansas. The term Siluro-Devonian has been used by some geologists for these same rocks that lie between the Chattanooga shale and the Sylvan shale of Ordovician age. In northeastern Kansas Silurian and Devonian rocks are separated by an angular disconformity and comprise undifferentiated limestone and dolomite of late Devonian age, the Cooper limestone of middle Devonian age, and the Brassfield and Edgewood limestones of Silurian age which are correlatives of the Chimneyhill limestone of Oklahoma (Lee, 1943, pp. 43-59).

The name Hunton was introduced as a stratigraphic term by Taff (1902). The name is from a former townsite in Coal County, Oklahoma. According to Reeds (1911, pp. 256-268) the Hunton as defined by Taff includes in descending order, the Bois d'Arc limestone (Oriskany age), the Haragan shale (New Scotland age), and the Henryhouse limestone (Niagaran age), all of Devonian age and the Chimneyhill limestone (Alexandrian age) of Silurian age.

Kansas City*-Lansing*.—In areas where the shale formations in the Lansing and Kansas City groups (Missourian Series) are thin and the section is chiefly limestone, the rocks of the two groups often are designated as "Kansas City-Lansing."

Knobtown Sandstone*.—Sandstone near the top of the Pleasanton group in eastern Kansas and western Missouri is called Knobtown (Greene, 1933, p. 13). The type exposure is in sec. 22, T. 48 N., R. 3 W., Jackson County, Missouri. In eastern Kansas, at outcrops, the Knobtown locally is in contact with the Hertha limestone which overlies it. Gas has been produced from the formation in Johnson County, Kansas (Jewett and Abernathy, 1945, p. 148).

Lansing Limestone (Lansing Group*).—In areas where the rocks of the Lansing group (Upper Missourian Series, Pennsylvanian) are largely limestone, the term "Lansing limestone" or "Lansing lime" is used to designate the combined Plattsburg and Stanton limestones and the interlying Vilas shale (if present).

Layton Sand*.—The name "Layton" designates sandstones in the Kansas City group in southern Kansas, as in the Slick-Carson, Countryman, and Graham fields, Cowley County.

The name had its origin from the Layton farm in the Cleveland field, sec. 2, T. 20 N., R. 8 E., Pawnee County, Oklahoma. The sandstone that is called Layton in the Cleveland field has been assigned to the upper part of the Coffeyville formation (Wilmarth, 1938, p. 1,159).

It is probable that the sandstone that is most commonly called "Layton" in southern Kansas is in the Chanute formation and is correlative with the Cottage Grove sandstone.

Longton Sand.—This name is used for the middle one of three productive sandstones that occur in the Lane-Vilas shale (Lansing group) in Elk and Montgomery Counties. It is known also as the "Webb sand" and the "Heck sand."

McLouth Sandstone.—McLouth sandstone is the name of an oil-producing rock in the McLouth field, Jefferson County. It lies near the base of the Cherokee shale section in the McLouth area. Exact correlation with outcropping rocks has not been established.

Misener Sand*.—This term is used to designate sandstone deposits at the base of the Chattanooga shale immediately above the pre-Chattanooga disconformity in southeastern Kansas.

Mississippi Lime.—This name is applied to limestone of Missippian age. In the Kansas subsurface the Mississippian limestones comprise several formations.

New Albany Sand.—This name is used for sandstone in the Nowata shale in some parts of Eastern Kansas. It was first applied in the New Albany oil field in northeastern Elk County. Wayside is the more common term for sandstones in the Nowata shale which collectively are known as Walter Johnson sandstone.

Nine Hundred Foot Sand.—This name has been used for sandstone deposits in the Cherokee group in Anderson County about 300 feet below the top of the Cherokee section (Charles, 1927 pl. 1).

Old Red Sand.—This name is used for oil-producing sandstone that occurs in the Nowata shale in southern Kansas, as in Chautauqua County. In several parts of eastern Kansas sandstone in the same stratigraphic position is called "Wayside." The term "Red" is used by some operators for the same beds. Lenticular sandstone deposits in the Nowata shale collectively have the name Walter Johnson sandstone.

Oswego Lime (Oswego Limestone*).—"Oswego lime" is a common designation of the Fort Scott limestone in eastern Kansas. Some operators restrict the term to the Higginsville limestone, the upper member of the Fort Scott formation. Others apply it to the lower member of the formation which is the Blackjack Creek limestone or they may apply it to the Breezy Hill limestone which is a lenticular limestone in the upper part of the Cherokee group a few feet below the Fort Scott limestone.

Peacock Sand*.—This name is used to designate the principal producing formation in the Peacock oil field, Cowley County, Kansas. According to Bass (1929, p. 135) the "Peacock sand" is a zone in the lower part of the Shawnee group about 150 feet above the Oread limestone.

Peru Sand*.—"Peru sand" is the common name for subsurface sandstone bodies in the Labette shale, which occurs below the Altamont limestone and above the Pawnee limestone. The name is used widely but in some areas it is misapplied to higher and lower beds. The name originated in the Peru oil-producing area (Peru-Sedan field), Montgomery County. Englevale sandstone is the term applied in State Geological Survey reports to sandstone bodies in the Labette shale.

Pink Lime.—The term "Pink lime" is used for the Pawnee limestone in the subsurface in eastern Kansas. The name "Big lime" is used in the same sense.

Potwin Chat.—This name is used for detrital chert deposits at the top of the Mississippian limestone in the Potwin field, Butler County, Kansas.

Prue Sand*.—The name "Prue" designates sandstone in the upper part of the Cherokee group in southern Kansas and northern Oklahoma. The name originated in the Prue field, T. 21 N., R. 10 E., Osage County, Oklahoma, where it is about 150 feet below the top of the "Oswego" (Fort Scott) limestone (Mills-Bullard, 1928, p. 128). According to Mills-Bullard (1928, p. 180) the "Prue" is correlative with the "Squirrel," "Bixler," and "Perryman sands."

Red Sand.—"Red sand" is used to designate sandstone in the Nowata shale in some eastern Kansas areas. The name "Old Red sand" is used somewhat more widely, but "Wayside sand" is the more common term used by drillers and operators for sandstones in the Nowata shale, which collectively are known as the Walter Johnson sandstone.

Redd Sand*.—This name is used in southern Kansas for one or more sandstones that occur above the "Wayside sand." Probably it is most often applied to sandstone in the upper part of the Coffeyville formation, and is used as the name of the same deposit that is called "Cleveland."

Red Fork Sand*.—The term "Red Fork" is used for sandstone in the upper part of the Cherokee group in some places in eastern Kansas but commonly for deposits that are lower than what locally is called "Squirrel sand." According to Mills-Bullard (1928, p. 180) the "Skinner" and "Red Fork sands" are equivalent. The name originated in the Red Fork oil field, Tulsa County, Oklahoma, where the "Red Fork" lies about 675 feet below the top of the "Oswego" (Fort Scott) limestone and about 45 feet above the "Bartlesville."

Second Break.—This term has been used, as cited by Charles (1927, p. 28) for the Chattanooga shale and some higher rocks in Anderson County.

Second Lime.—This name is used to designate the second limestone from the top of the Fort Scott formation in southern Kansas. Generally the term is applied to the Blackjack Creek limestone but it may be applied to the lower part of the Higginsville limestone where separated from the upper part by a shale bed.

Siliceous Lime.—This name is applied to limestones and dolomites of the Arbuckle group. Hence, it may be used for any one of several formations.

Properly the Arbuckle rocks in Kansas comprise the Cotter and Jefferson City dolomites, the Roubidoux formation, the Gasconade and Van Buren dolomites, and the Gunter sandstone of Ordovician age, and the Eminence dolomite of Cambrian age.

Simpson*.—Rocks of Simpson age (Lower and Middle Ordovician) in northeastern Kansas comprise the Platteville limestone and the St. Peter sandstone. Frequently the St. Peter alone is called "Simpson sand."

Six Hundred Foot Sand.—This name has been applied to sandstone in the Bandera shale in Anderson County, Kansas (Charles, 1927, p. 25). This sandstone, however, more commonly is called "Weiser" and is the Bandera Quarry sandstone.

Skinner Sand*.—This name is used in some places for sandstone in the upper part of the Cherokee shale but commonly for deposits that are lower than what locally is called "Squirrel sand."

Squirrel Sand*.—The name "Squirrel sand" is widely used in eastern Kansas for sandstone bodies in the upper part of the Cherokee group. Seemingly the term is acceptable to many oil field operators and drillers for any sandstone body that occurs in the Cherokee group above the Ardmore limestone, or in the upper approximate 100 feet of the Cherokee section. According to Mills-Bullard (1928, p. 180) the "Squirrel" is equivalent to the "Prue," "Perryman," and "Bixler sands" but is higher than the "Skinner" or "Red Fork."

Stalnaker Sand*.—Seemingly this name is used for sandstone that occurs both above and below the disconformity that separated Virgilian and Missourian rocks; however, it may be more commonly applied to sandstone in the Lansing group. The term "Tonkawa" is also used to designate lower Virgilian sandstone in southern Kansas.

Stapleton Zone*.—This is the name that was applied to highly productive rocks found next below Pennsylvanian sediments in the El Dorado field. It is a porous zone of beveled Ordovician rocks that lies immediately below Pennsylvanian beds. The zone includes weathered pre-Pennsylvanian outcrops of the Viola limestone, St. Peter sandstone, and Arbuckle rocks. The term "Varner" is used in essentially the same sense.

Suitcase Sand*.—This name is used by some operators in southern Kansas. According to Wilmarth (1938, p. 2,082) this sandstone lies in the Ochelata formation and is lower than the "Tonkawa" and higher than the "Layton sand." According to Mills-Bullard (1928, p. 28) the "Suitcase sand" is about 390 feet above the "Layton" in the Burbank field, Osage County, Oklahoma.

Third Lime.—In southern Kansas, especially in Montgomery County, where the Fort Scott limestone seemingly comprises three or four limestones, the terms "First, Second, and Third limes" are used. Probably the Breezy Hill limestone is called "Third lime" or in other cases the "Third lime" may be the Blackjack Creek limestone.

Tonkawa Sand*.—This name is used for the Tonganoxie sandstone, and seemingly also for sandstone in the upper part of Missourian rocks. The name "Stalnaker" is used in the same ways. "Tonkawa" as a subsurface stratigraphic name originated in the Tonkawa field, Kay and Nobel Counties, Oklahoma (Mills-Bullard, 1928, p. 160) where it is about 30 feet thick and lies about 520 feet above the "Layton sand."

Tucker Sand*.—This name is used in a few eastern Kansas districts for sandstone that occurs in the lower part of the Cherokee shale immediately or a few feet above its base and in contact with or almost in contact with Mississippian limestone. The names "Burgess" and "Tucker" are used interchangeably in some areas. Seemingly this usage of "Tucker" deviates greatly from the original application of the term. According to Wilmarth (1938, p.

2,190) the "Tucker sand" in Oklahoma is lower than the "Bartlesville" and higher than the "Burgess" and is of early Pennsylvanian age; references are not cited. However, according to Powers (1926, pp. 14, 15) the "Tucker" sand was found in the Cleveland field in 1912 and is entirely of Ordovician age, in part representing the "Wilcox sand" and in part the "Siliceous lime." Seemingly at the time of original use of the term the rocks called Tucker were believed to be in the basal part of the Pennsylvanian section of the region, but it was found later that the name had been applied to a zone of beveled Ordovician rocks. In some reports the "Tucker" is shown as the higher of two sandstones in the basal part of the northern Oklahoma Cherokee section; the lower is called "Burgess" (White and others, 1922, p. 184, pls. 3, 28, 31). According to Mills-Bullard (1928, p. 180) the "Tucker" is of Pennsylvanian age and is the first producing formation below the "Bartlesville."

Varner Sand.—This name seems to have very local application. An example is its use as the name of a producing formation in the Douglass field, Butler County (Berg and Page, 1948, table 1B). In the Douglass field the "Varner" lies at a depth of about 2,835 feet.

According to Berry and Harper (1948, p. 215, footnote) the term "Varner sand" was used in the Augusta field, Butler County, for Simpson sandstone and Arbuckle dolomitic limestone, either singly or collectively. The usage is essentially the same as that of "Stapleton zone."

Viola Limestone*.—The term Viola is often used to include the Kimmswick limestone, Decorah shale, and Platteville limestone in eastern Kansas. However, it is probable that only the Decorah shale and Kimmswick limestone in eastern Kansas correspond in age to the Viola limestone (Middle Ordovician) in Oklahoma. The Kimmswick limestone in eastern Kansas is a partial equivalent of the Viola limestone of Oklahoma.

Wayside Sand*.—The name "Wayside" is used commonly for sandstone in the Nowata formation. The name originated in the Wayside oil field (now Wayside-Havana) in Montgomery and Chautauqua Counties, where sandstone in the Nowata formation is one of the principal reservoir rocks. Hence this sandstone lies below the Lenapah limestone and above the Altamont limestone. In some reports (McQueen and Greene, 1938; Clair, 1943) the term "Wayside" is used to designate sandstone that seemingly lies in the basal part of the Pleasanton group. The "Wayside sand," as the name is used commonly, is correlated with the Walter Johnson sandstone. Sandstone in the basal part of the Pleasanton group is the Hepler sandstone. In some places the "Wayside sand" is called "New Albany."

Webb Sand.—This is the name used for the middle one of three productive sandstones that occur in the Lane-Vilas shale (Lansing group) in Elk and Montgomery Counties. It is known also as the "Longton sand" and as the "Heck sand."

Weiser Cap or Weiser Lime.—The names "Weiser cap" and "Weiser lime" are used to designate the Altamont limestone in southern Kansas.

Weiser Sand*—The term "Weiser sand" is used to designate sandstone in southeastern Kansas that occurs in the Bandera shale. This sandstone occurs below the Altamont limestone and above the Pawnee limestone. An example of usage is its application to sandstone in the Wayside-Havana oil-producing area, Montgomery County, Kansas, where it is about 120 feet below the "Wayside sand" and lies at a depth of about 700 feet. In the Elk City gas field the "Weiser" lies from 70 to 90 feet below the "Wayside" (Boughton, 1920, p. 14).

Sandstone that occurs in the Bandera shale is known as the Bandera Quarry sandstone.

Wilmarth (1938, p. 2,296) lists "Weiser sand" as a synonym of "Wiser," named from the Wiser Hill oil field, Osage County, Oklahoma. Boughton (1920, p. 15), however, stated that the "Weiser sand" was named for a Mr. Weiser who first encountered it in Montgomery County, Kansas.

Wilcox Sand*.—"Wilcox" is used for two oil-producing zones in eastern Kansas. In some areas as in the McCollough field, Butler County, the term is used for the St. Peter sandstone in the upper part of the Simpson group of Upper Ordovician age (White, 1926). Elsewhere, as in the Coleman field, Montgomery County, the name is used to designate uppermost Arbuckle rocks. "Wilcox" was first applied to a subsurface formation in the northern midcontinent region in 1914. The name then was used for the Simpson sandstone to which it still is generally applied. First usage was in the Bixby field, Tulsa County, Oklahoma, when a well was completed by H. F. Wilcox in sec. 3, T. 16 N., R. 13 E. The

Bixby field had been opened a few months earlier in 1916, however, and the sand had been found to be productive in sec. 29, T. 17 N., R. 12 E. as early as 1908 (Powers, 1926, pp. 14-15). For many years the "Wilcox" had been called "Sapulpa" or "Mounds sand."

Wiser Sand*.—The term "Wiser sand" is used to designate oil-bearing sandstone in the upper part of the Cherokee section in southeast Kansas, as in the Wiggam oil field in Chautauqua County. The "Wiser sand" there is at a depth of about 1,600 feet. Sandstone in that part of the stratigraphic section more commonly is called "Squirrel." The name as used in Kansas probably is of local derivation and was not a correlation with the "Wiser sand" of northern Oklahoma.

According to Wilmarth (1938, p. 2,357) the "Wiser sand" in northern-central Oklahoma is correlated with a part of the Oologah formation. The Oologah limestone is, at least in part, equivalent to the Pawnee limestone in Kansas.

ALLEN COUNTY

The geology and oil and gas resources of Allen County have been discussed briefly by Moore and Elledge (1920). The early report by Moore and Elledge is comprehensive of early development and should be of interest to operators of water-flood and other projects.

During 1948 Allen County produced 284,561 barrels of oil. Production figures for preceding years are shown in Tables 2 and 2a. Table 4 shows the production in the various fields[1] from 1944 through 1948. There are 11 reported water-flood projects in the county.

Locations of the Allen County oil and gas fields and areas of 1948 oil production are shown in Figure 12.

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[1] In this report the term oil field is used in accordance with the definition in Webster's Collegiate Dictionary, 5th ed., 1943: "A natural area yielding some particular, especially mineral, resource." Hence an oil field is an area of land that yields oil. It may contain any number of oil wells. An oil pool is regarded as a geologic entity, a body or mass of oil in the earth. It may be convenient to regard two or more superposed but disconnected masses of oil as constituting a single pool, especially if they are in strata that comprise a single structural element.

Geology

SURFACE ROCKS

The surface rocks in Allen County consist of alternating beds of limestone, shale, and some sandstone. The consolidated rocks exposed in the county belong to the Lansing, Kansas City, and Pleasanton groups (Moore and Landes, 1937) of Pennsylvanian age. Lansing rocks in the county are about 90 feet thick and are exposed in the western part. Of these the Stanton limestone is exposed in the northwestern part and the Plattsburg limestone caps uplands in a broad belt east of the Stanton outcrops. All the rocks of the Kansas City group (including the Bronson group of some reports, now regarded as a subgroup) are exposed in the eastern part of Allen County. Rocks of the Bronson subgroup are the surface rocks in most of the southeastern part of the county, but the upper part of the Pleasanton group is exposed in the northern part of T. 26 S., R. 31 E. Several feet of chert gravel deposits of probable Tertiary age mantle the bedrocks in several places in the western part of the county and constitute terraces along Neosho River. Thick alluvial deposits in the valley of the river and its larger tributaries are composed principally of sand and gravel and bear considerable water. Pennsylvanian rocks exposed in the county are represented diagrammatically in Figure 5.

SUBSURFACE ROCKS

Pennsylvanian rocks.—In Allen County the Pleasanton group is about 100 feet thick and consists principally of shale. It is the "Big shale" of drillers and is easily recognized in drill holes as the first thick shale section after the Hertha and higher limestones have been drilled. Rocks of the Marmaton group are about 165 feet thick in the county. They consist of alternating beds of limestone and shale, some sandstone, and a few thin beds of coal. The Cherokee group in Allen County is about 340 feet thick. These rocks are chiefly light and dark shale, sandy shale, sandstone, and a few thin limestone and coal beds. Lenticular sandstones in the Cherokee section yield oil and gas. The "Bartlesville sand" is the most important of these.

Mississippian rocks.—The Mississippian rocks in Allen County consist of limestone (some cherty or dolomitic) and shale. The

"Warsaw," Burlington, Sedalia, and Chouteau limestones and the Chattanooga shale (probably of Mississippian age) (Lee, 1940, pl. 3) are present in the county. The total thickness of Mississippian limestones in the county averages about 300 feet (Lee, 1939, pl. 1). The Chattanooga shale is less than 50 feet thick. Oil is produced from a porous zone in the upper part of the Mississippian limestone (Cowley formation) in what is known as the "first break" in the northwestern part of Allen County in the extension of the Neosho Falls field.

Ordovician and Cambrian rocks.—The Arbuckle limestone of Ordovician and Cambrian age lies immediately below the Chattanooga shale in Allen County. In a well drilled at Iola about 750 feet of rock was encountered between the Chattanooga shale and rocks of Pre-Cambrian age. Studies by Keroher and Kirby (1948) indicate that the Cotter-Jefferson City sequence in Allen County has an average thickness of about 350 feet, it being somewhat less than 300 feet in the northeastern part and more than 400 feet in the southwestern part; the Roubidoux dolomite ranges in thickness from slightly less than 100 feet in the northwestern part to about 150 feet in the southeastern part; the Van Buren-Gasconade sequence ranges from about 100 feet in the northwestern part of the county to about 150 feet in the southwestern part; the Eminence dolomite has an average thickness of about 50 feet, increasing eastward; the Bonneterre dolomite is somewhat more than 100 feet in thickness; the Lamotte sandstone is believed to be absent in the northwestern approximate half of the county.

Pre-Cambrian rocks.—The record of a well drilled at Iola indicates that Pre-Cambrian metamorphic rock was reached at 2,160 feet. The well was drilled to a total depth of 3,440 feet. Seemingly granite was not found in this well.

Oil and Gas Developments

Gas was discovered at Iola in 1873 and within a short time several wells were drilled in the vicinity and a gas field large enough to supply the city was developed. For many years the Iola gas field was one of the leading ones in Kansas. Several industrial plants made use of the abundant cheap fuel. Oil and gas were found near Humboldt in 1894 and 1895 but the area was not well developed until about 1903.

In later years oil and gas were found in many parts of Allen County and now areas as indicated in Figure 12 are defined as oil and gas fields. However, small amounts of oil and gas have been found in areas not shown as fields on the map and comparatively small areas now produce oil.

The **Bayard** oil and gas field is no longer active. Few logs of wells are available. Oil and gas were produced probably from the "Bartlesville sand."

The **Bronson-Zenia** oil and gas field extends from eastern Allen County into Bourbon County. Oil is produced from the "Bartlesville sand" at a depth of about 700 feet. During 1948 the Allen County part of the field yielded 12,899 barrels of oil. Most of the oil was produced by water-flooding methods.

The **Colony West** oil and gas field extends into northeastern Allen County from Anderson County. In 1948, the Allen County part of the field produced 6,771 barrels of oil. The Allen County part of the **Davis-Bronson** field produced 33,237 barrels of oil in 1948.

The **Elsmore** field lies above a shoestring sand about 2 miles east of Elsmore. It is about one-half mile wide and more than 5

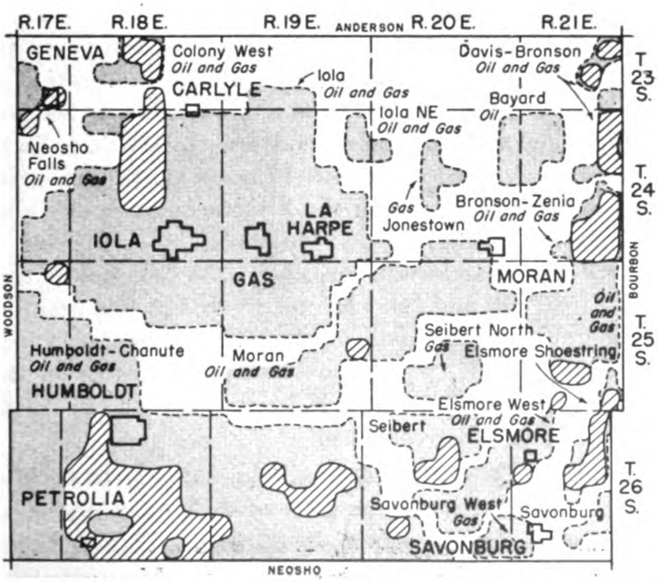

Fig. 12.—Map of Allen County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

miles long. The "Bartlesville sand" is about 55 feet thick in this field. It lies at a depth of about 550 feet and is about 160 feet below the Fort Scott limestone. In 1948 the field, which extends eastward into Bourbon County, produced 41,727 barrels of oil. The **Elsmore West** oil and gas field produced 7,954 barrels of oil in 1948. Production is from the "Bartlesville sand" at a depth of about 775 feet.

The southwestern part of Allen County is included in the large **Humboldt-Chanute** oil and gas field, which covers adjacent parts of Montgomery, Neosho, Wilson, and Woodson Counties. The chief producing formation is the "Bartlesville sand." In 1948 the Allen County part of the field produced 119,680 barrels of oil.

The **Iola** oil and gas field is a large area covering most of T. 24 S., Rs. 18 and 19 E., and smaller parts of adjacent townships. Oil is produced now in a small area in the northwestern part of the field. Probably much more could be repressured profitably by water. In the early part of the century there were important gas fields in this area in the vicinities of Iola, Gas City, and La Harpe. Oil occurs in the "Bartlesville sand" at an average depth of about 850 feet. According to Lane and Garton (1943, table 3), oil from the Iola field has a specific gravity of 19.2° A.P.I.

In the **Iola Northeast** field the "Bartlesville sand" is at a depth of about 1,000 feet. The field was developed several years ago but is not now active. The **Jonestown** gas field, in the central part of T. 24 S., R. 20 E. produced gas from a depth of about 500 feet.

The **Moran** oil and gas field extends west of Moran to La Harpe, east to the county line, and about 10 miles north and south. Oil and gas occur in this area in the "Bartlesville sand," which is about 25 feet thick and lies at a depth of about 680 feet. In the Moran area the "Bartlesville" is about 235 feet below the Fort Scott limestone. Oil and gas were discovered in this area in 1903. Water flooding to increase oil production was begun in this area in 1937 (Landes, 1937, p. 5); the subsequent history of the secondary recovery project has not been recorded. In 1948, four wells produced 1,173 barrels of oil.

The **Neosho Falls** oil and gas field extends from Woodson County into the northwestern part of Allen County. The field was extended as far as sec. 26, T. 23 S., R. 17 E. late in 1947. Production is from the "first break" in the Mississippian limestone (Cowley formation) at a depth of about 1,200 feet. During

TABLE 4.—*Oil production in Allen County, 1944 through 1948*

Field	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Bronson-Zenia[1]	32,166	12+	26,791	7+	20,804	55+	11,183	40+	12,899
Colony West[2]	6,729	17+	4,824	31	6,562	30	7,035	35	6,771
Davis-Bronson[3]	32,569		36,370		41,596	21+	32,019	4+	33,237
Elsmore Shoestring[1]	36,657	6+	27,574	6+	30,160	8+	32,921	16+	41,727
Elsmore West	6,394	23	4,654	23	6,619		5,118		7,954
Humboldt-Chanute[4]	115,386	411+	123,927	400+	148,536	5+	135,449		119,680
Iola	51,891	1+	48,184	3+	56,775	182+	56,471	103+	47,707
Moran	3,564		114,130		8,495	14	2,114	4	1,173
Neosho Falls[5]			2,669			2	1,432	10	5,343
Savonburg		See Bourbon County							
Seibert	309		73		131		385		478
Miscellaneous							113	3+	7,592
Totals	285,665	470+	389,196	470+	319,678	317+	284,240	215+	284,561

[1] Field extends into Bourbon County. Years 1944 and 1946 include Bourbon County production.
[2] Field extends into Anderson County.
[3] Field extends into Bourbon and Anderson Counties. Year 1945 includes Bourbon County production.
[4] Field extends into Neosho, Wilson, and Woodson Counties.
[5] Field extends into Woodson County.

1948, 5,343 barrels of oil were produced in 10 wells in the Allen County part of the field.

The **Savonburg** oil and gas field lies east of Savonburg and extends eastward into Bourbon County. Oil production is from the "Bartlesville sand." Oil production in 1948 amounted to 3,250 barrels from the entire field.

The **Savonburg West** gas field produces from the "Bartlesville sand" at a depth of about 750 feet. The **Seibert** oil and gas field produces oil from a depth of about 625 feet. Gas was found in the field in the "Squirrel sand" at a depth of about 400 feet. In 1948 the field produced 478 barrels of oil. The **Seibert North** gas field produces from the "Bartlesville sand" at a depth of about 760 feet. Several years ago the No. 1 Anderson well, SW¼ SW¼ sec. 23, T. 25 S., R. 20 E., tested pre-Pennsylvanian formations in this field to a depth of 1,553 feet.

ANDERSON COUNTY

Anderson County has been a producer of oil and gas since the first years of the present century. Gas was discovered near Garnett in 1904 and oil was found in the same part of the county a few years later. Secondary recovery by water drive is now an important phase of production.

The geology and oil and gas resources of Anderson County were described by Charles (1927). Carefully made observations were recorded by Charles and his conclusions should be considered by anyone interested in developing untested areas and in increasing production by secondary recovery methods.

During 1948 Anderson County produced 371,131 barrels of oil. Production figures for the preceding years are shown in Tables 2 and 2a. Table 5 shows the production in the various oil fields in the county from 1944 through 1948. Locations of the Anderson County oil and gas fields and the areas of 1948 production are shown in Figure 13. Most of the oil is being produced by water flooding. There are six reported projects operating in the county.

Geology

SURFACE ROCKS

With the exception of unconsolidated surficial beds of sand and gravel which range in age from Recent to Tertiary, the outcropping rocks of Anderson County belong to the Shawnee, Douglas, Pedee, Lansing, and Kansas City groups of the Pennsylvanian System (Moore and Landes, 1937). The oldest rocks crop out in the southeastern part of the county and the youngest Pennsylvanian rocks are exposed in the northwestern part. The youngest exposed Pennsylvanian rock is the Plattsmouth limestone member of the Oread formation and the oldest exposed rock is the Bethany Falls limestone member of the Swope formation.

The Oread limestone, which caps hills in the northwestern part of the county, is the only formation of the Shawnee group present in Anderson County. All recognized units of the Douglas group, with the possible exception of the Robbins shale, are believed to be exposed in the county. The Williamsburg coal and the Ireland sandstone are rather persistent units of the Lawrence shale. There is some sandstone included in the Vinland shale. The thickness of the Douglas group in the county is about 300 feet. The Westphalia limestone occurs about 60 feet from the base, and the Haskell limestone 60 or 75 feet higher. It is difficult to separate the Stranger formation from the underlying Weston shale at some exposures and on soil-covered slopes, and it is nearly impossible to separate them in the subsurface by means of drillers logs.

The Pedee group is the uppermost group in the Missourian Series. It is limited at the top by a regional disconformity which separates it from the overlying Virgilian rocks. The Iatan limestone is not known to occur in Anderson County. Probably it and the upper part of the Weston shale were removed by erosion before deposition of the overlying rocks of Virgilian age. Based on surface and subsurface observations, the Weston shale in Anderson County ranges in thickness from a featheredge to about 30 feet.

The total thickness of the Lansing group (Fig. 5) in Anderson County is about 110 feet. The units vary in thickness. The thickness of the Stanton limestone is generally about 50 feet. At outcrops the Vilas shale ranges from less than 2 to about 30 feet. The Plattsburg limestone in the shallow subsurface is about 50 feet thick, but where exposed its thickness is generally somewhat less. Thin shales are included in the Stanton and Plattsburg formation. The most prominent escarpments in the county are capped by the Stanton and Plattsburg limestones. Cliffs of Plattsburg limestone are especially noticeable. The lines of outcrop extend in a general north-south direction across the east-central part of the county. The Stanton limestone, covered only by thin residual soil or by deposits of gravel, underlies the surface in a wide area west of its outcrop.

Rocks of the Kansas City group (Fig. 5) are exposed in the eastern part of Anderson County. The Wyandotte limestone seems to be represented only by calcareous sandy shale and very thin limestone beds. The Westerville limestone is believed to be absent in the county. Hence, the rocks of the upper part of the Kansas City group, whose total thickness is about 250 feet, crop out in an area characterized by the prominent Iola limestone escarpment and the thick Wea-Fontana and Lane-Bonner Springs shale sections.

The Bronson subgroup of limestones and shale (Fig. 5) is approximately 100 feet thick in Anderson County. No single exposures showing the whole group are known in the county. The upper part of the Winterset limestone (upper member of Dennis formation) is generally eroded from the top of the Bronson escarpment, and rocks below the Bethany Falls limestone (upper member of the Swope formation) are not exposed. These rocks in Anderson County are characterized by flinty and oölitic limestones in the Winterset and Bethany Falls limestones and by black platy shale in the Stark shale member of the Dennis formation. These rocks crop out only in the southeastern part of the county.

SUBSURFACE ROCKS

Hundreds of wells, most of which did not reach Mississippian rocks, have been drilled in Anderson County. Several wells have penetrated Mississippian or deeper strata, however. The following discussion of rocks older than Mississippian is based largely on data obtained from the record of the Lambert and others No. 1 Wiggins well, in the SE¼ NE¼ sec. 12, T. 23 S., R. 17 E., which was drilled to a total depth of 2,303 feet.

Pennsylvanian rocks.—The Pleasanton shale has an average thickness of about 175 feet in Anderson County. Lenticular sandstones occur in its upper part. Marmaton rocks are about 175 feet thick in the county. They include shale, limestone, and sandstone. All formations and most members known from surface exposures of the Marmaton can be recognized in most drillers logs. Care must be taken in using the base and top of the Marmaton rocks as subsurface markers. Locally the Fort Scott limestone is underlain by a lenticular limestone in the upper part of the Cherokee shale, and locally the upper limestone formation of this group, the Lenapah, is absent. Sandstone in the Bandera shale formation commonly called "Wayside sand," has yielded some oil in the county. This is the Bandera Quarry sandstone; it is called "Weiser" in several parts of eastern Kansas. The sandstone that is more commonly called "Wayside" occurs in the Nowata shale.

The average thickness of the Cherokee rocks in Anderson County is about 400 feet. The Cherokee is composed principally of dark shale containing sandstone lenses and thin limestone and coal beds. The Ardmore limestone is a persistent marker in the upper part of the Cherokee rocks. Lenticular sandstones near the top of the Cherokee shale are called "Squirrel sand" by drillers. The "Bartlesville sand" or "Colony sand" lies in the upper middle part of the Cherokee, and thicker lenticular sandstones occur in the basal part. The Cherokee shale lies on the eroded Mississippian limestone surface and is conformably overlain by the Fort Scott limestone.

Mississippian rocks.—Mississippian limestones lie next below the Cherokee shale. Their total thickness is about 300 feet. Drillers commonly report shaly zones in the lower part and sandstone in the middle part. The latter is the "first break" of drillers. Cherty limestone is characteristic of the "Mississippi lime" in eastern Kansas. Lee (1939, 1940) has studied carefully the subsurface Mississippian rocks in Kansas and has shown several disconformities within them. Lee (in Jewett, 1940a, fig. 2B) has shown that rocks of Meramecian, Osagian, and Kinderhookian ages are present in Linn County, and it is probable that sample studies would show the presence of the same subdivisions in Anderson County.

Shale assigned to the Chattanooga formation, about 40 feet thick and seemingly conformable with the overlying Mississippian limestone, is believed to underlie all Anderson County.

Ordovician rocks.—The Chattanooga shale lies upon Ordovician rocks in a large triangular area in southeastern Kansas and extends into Missouri and Oklahoma (McClellan, 1930; Ockerman, 1935, fig. 2; Lee, 1940, fig. 1); therefore, rocks representing a long interval of Silurian and Devonian time are absent there. McClellan (1930) has shown that the Simpson (St. Peter) sandstone dipping under younger Ordovician rocks to the northwest is present in the northwestern corner of Anderson County. This indicates that the overlying Chattanooga shale oversteps various Ordovician strata. This condition resulted from erosion on the Chautauqua arch before the Chattanooga shale was deposited. The Chattanooga shale lies on slightly upturned and intensely eroded Ordovician strata that in Anderson County dip to the northwest away from the ancient Chautauqua arch. Because of this condition there is a possibility of stratigraphic oil traps in Ordovician rocks.

Cambro-Ordovician rocks.—The Arbuckle rocks include about 700 feet of strata, mostly dolomite but containing some shale in the lower part and perhaps some sandstone. Keroher (in Jewett, 1940a, pp. 12-14, pl. 2A) was able to differentiate Cambrian and Ordovician strata and to subdivide rocks of each system in the Holeman and Edwards No. 9 Pollman well, in the SE¼ sec. 35, T. 19 S., R. 24 E., Linn County. It is probable that a study of well cuttings from Anderson County would reveal a sequence of Arbuckle rocks similar to that in Linn County. Available data indicate a rather uniform total thickness for the Arbuckle rocks in the two counties.

Cambrian rocks.—About 30 feet of sandstone in Anderson County lying on granite is correlated with the Lamotte sandstone of Missouri.

Oil and Gas Developments

The first well in Anderson County of which we have record was drilled in about 1885 in the SW¼ sec. 6, T. 20 S., R. 20 E. A good show of oil was reported, but because gas was being sought the well was not completed as an oil well. Another early well was drilled in the SE¼ sec. 19, T. 20 S., R. 20 E. A small flow of gas was encountered, but the well was abandoned at about 500 feet. During the next several years only a few scattered wells were drilled. Gas was discovered a mile southeast of Garnett in 1904. An important field which supplied gas to the City of Garnett was soon developed. As drilling continued to the northeast, both oil and gas were discovered in a narrow discontinuous belt between Garnett and Greeley. Gas was discovered near Colony in the summer of 1921. Rapid development followed and in less than 2 years an unbroken strip of oil and gas producing territory 12 miles long was opened between Colony and Mount Ida (Charles, 1927, p. 14). Oil was discovered about 1 mile southeast of Garnett in September 1921. This opened the Garnett Shoestring which extends westward into sec. 2, T. 21 S., R. 19 E. and south and west to sec. 14, T. 21 S., R. 19 E.

Although several deep tests have been drilled in Anderson County, all oil and gas production has been from Pennsylvanian rocks. Production is from sandstone in the Bandera shale and from sandstones in the Cherokee rocks. The shoestring type of sandstone body is the common form.

The oil and gas fields in Anderson County as designated by the Oil Field Nomenclature Commitee of the Kansas Geological Society are indicated in Figure 13 and are discussed briefly in the following paragraphs.

The **Blue Mound** oil and gas field lies chiefly in southeastern Linn County but extends into Anderson County in Ts. 22 and 23 S., R. 21 E. Oil and gas were produced from several Pennsylvanian sandstones and several years ago a small amount of oil was produced in the Linn County part of the field from a deeply weathered zone at the top of the Mississippian limestone.

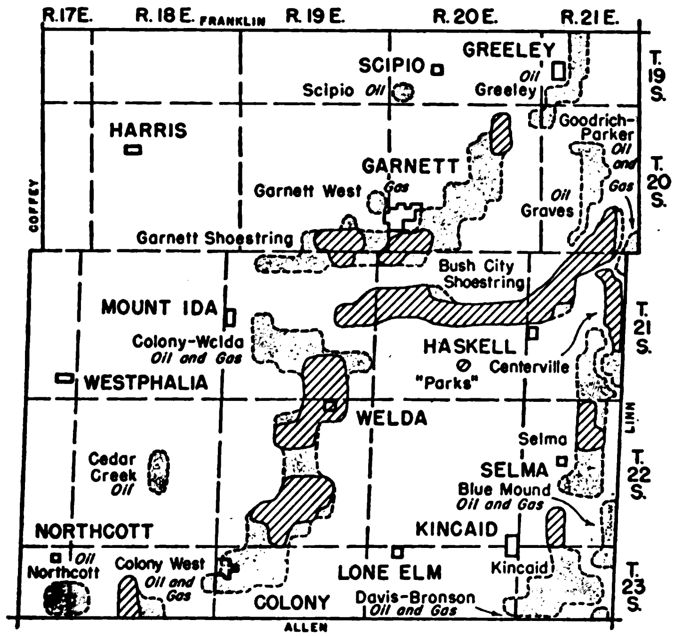

Fig. 13.—Map of Anderson County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

The **Bush City Shoestring** oil field is narrow, being 13 miles long and averaging about one-quarter of a mile in width. It seemingly is a continuation of the Goodrich Shoestring in Linn County. Production is from an elongated sand body called "Squirrel" that lies 20 to 40 feet below the top of the Cherokee shale. This sand body is at approximately the same horizon as is the sand body underlying the Pottawatomie Valley from southwest of Garnett to Greeley. Charles (1927, p. 44) believed these sand bodies to be channel fillings. The specific gravity of oil from the field is reported as 33.6° (Lane and Garton, 1943, table 3).

The **Cedar Creek** gas field is no longer active. Gas was formerly produced from the Bandera Quarry sandstone at a depth of about 750 feet.

The Anderson County part of the **Centerville** oil and gas field is the northern part of an area in which oil and gas occur in a "Bartlesville shoestring sand." The area has been known as the **Schimmerhorn-Selma-Kincaid** oil and gas producing area that extends as far south as sec. 9, T. 23 S., R. 21 E. Oil occurs in the north and south ends of the shoestring and gas and oil in the middle part. According to Lane and Garton (1943, table 3) oil from the Kincaid shoestring has a specific gravity of 35.2° A.P.I.

Because of the presence of continuous oil and gas producing territory from the vicinity of Mount Ida southward to Colony, the area has been designated the **Colony-Welda** oil and gas field. Oil is now produced in areas as are shown in Figure 13. Individual smaller "fields" merit separate consideration.

The **Colony** gas pool is at the southern end of the Colony-Mount Ida trend. The pool is centered in the town of Colony. This field was drilled out rapidly and great quantities of gas were wasted. Closely spaced drilling on town-lot locations resulted in many wells being exhausted after a few weeks. The first wells were drilled in 1921. The field is now nearly abandoned. Production is from the "Colony sand," which is the same formation that is known locally as "Bartlesville."

In the **Polkinghorn** oil and gas producing area gas has been produced from three zones: a sandstone in the Bandera formation, a sandstone near the top of the Cherokee shale, and the "Bartlesville" or "Colony sand." Most of the gas has been produced from the "Colony sand," which has a maximum thickness of more than 100 feet. The largest gas well is reported to have had an initial flow of 32 million cubic feet. The maximum open flow of the field is estimated to have been 250 million cubic feet. The original rock pressure was 280 pounds per square inch (Charles, 1927, p. 61). Oil was found in small disconnected areas in the "Squirrel sand." Initial daily productions of the wells ranged from 25 to 125 barrels.

The **Welda** oil and gas producing area produces oil from the "Squirrel sand." A small amount of gas has been produced from sandstone in the Bandera formation, and gas is produced from the "Colony sand."

The **Colony West** oil and gas field extends into Allen County. Oil production is from a sandstone in the upper part of the Cherokee shale at a depth of about 825 feet. During 1948, the Allen County part of the field produced 26,610 barrels of oil.

The **Davis-Bronson** oil and gas field, chiefly in Bourbon County, extends into the southeast corner of Anderson County. No oil was produced from the Anderson County part of the field in 1948.

TABLE 5.—*Oil production in Anderson County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Bush City Shoestring	84+	118,079	87+	113,619	94+	162,860	78+	202,475	47+	224,801
Centerville[1]		7,093		3,283		5,204		4,370		1,830
Colony-Welda	161+	19,610	160+	13,646	185+	12,099	158+	12,314	147+	11,338
Colony West[2]	25	10,629	23	8,650	42	15,355	30	22,708	43	26,610
Davis-Bronson[3]						115		102		
Garnett Shoestring	18+	185,767	18+	126,873	23+	97,769	18+	56,511	18+	53,846
Kincaid		12,892		14,327		13,743	12+	19,158		36,375
"Parks" (27-21-20)										547
Selma		20,465		9,276		10,896		7,661		10,784
Miscellaneous								91		
Totals	288+	374,535	288+	289,674	344+	318,041	296+	325,390	255+	371,131

[1] Field extends into Linn County.
[2] Field extends into Allen County.
[3] Field extends into Allen and Bourbon Counties.

The chief producing sand in the **Garnett Shoestring** oil field is a part of the same shoestring which produces in the Greeley field. The primary development in the Garnett Shoestring took place between 1921 and 1923. Water-flooding operations were started in the field in December 1936 by the Brundred Oil Corporation. Specific gravity of oil produced in the Garnett Shoestring field from the "Squirrel sand" is reported as 35.6° A.P.I., and 32.8° from the "Garnett sand."

The **Garnett West** gas field was developed several years ago. Gas was produced from a Marmaton sandstone at a depth of about 650 feet.

The **Graves** oil and gas field may be regarded as the northward extension of the Bush City field. Gas was found in this area in December 1929 in the Monitor No. 1 Graves well, NW¼ NW¼ sec. 20, T. 20 S., R. 21 E. in a sandstone in the Cherokee shale at a depth of about 760 feet. Production records are not available, but oil is reported to have been produced in sec. 32 from the "Squirrel sand" at a depth of about 600 feet.

The **Greeley** oil pool, now abandoned, is in secs. 29 and 31, T. 19 S., R. 21 E. This is in the northeast extension of the "Pottawatomie Valley field" of Charles' report (1927, p. 49). Oil was produced from sandstone near the top of the Cherokee shale. This sandstone is a shoestring that extends the entire length of the "Pottawatomie Valley field" and beyond. It is locally known as "the 800-foot sand."

The **Kincaid** oil field is east and southeast of Kincaid (Fig. 13). Oil is being produced from a "Bartlesville shoestring sand" which extends as far northward as the Anderson County part of the Centerville field. In 1948 the field produced 36,375 barrels of oil.

The **Northcott** gas field was developed several years ago. Production records are not available but gas was reported in drillers' logs as occurring in several sandstones ranging in depth from about 470 feet (Knobtown sandstone) to about 1,000 feet ("Bartlesville"). A deep test well in the SE¼ NE¼ sec. 12, T. 23 S., R. 17 E. is reported to have reached granite at 2,100 feet.

The **Scipio** oil field is no longer active. Production data are not available, but oil probably was produced from the "Bartlesville sand" which lies at a depth of about 750 feet.

The **Selma** oil and gas field produces oil from the "Bartlesville sand." The sand body seemingly is a part of a shoestringlike body extending northward from the vicinity of Kincaid on the south to the northern part of T. 21 S., R. 21 E. In 1948 the field produced 10,784 barrels of oil.

ATCHISON COUNTY

Oil and gas in commercial quantities have not been found in Atchison County. Testing, especially of deeper formations, has not been sufficient to disprove the area as potential oil and gas territory. Atchison County is in the Forest City basin and on the eastern margin of the North Kansas basin. The outcropping bedrocks are of Pennsylvanian age, and glacial drift occurs in thick deposits.

Geology

SURFACE ROCKS

Outcropping Pennsylvanian rocks in Atchison County include those from near the top of the Pennsylvanian System (Pony Creek shale) to the upper part of the Douglas group (Fig. 4).

SUBSURFACE ROCKS

Subsurface geologic conditions along the western border of Atchison County are shown in Plate 2. Depths to some key stratigraphic horizons are listed in Table 6.

TABLE 6.—*Depths to some key horizons in the Wakefield et al. No. 1 National Life well, sec. 17, T. 6 S., R. 20 E., Atchison County*

Horizon	Depth, feet
Base of the Oread limestone (top of Douglas group)	350
Top of Stanton limestone	555
Base of Hertha limestone (top of Pleasanton group)	875
Base of Fort Scott limestone (top of Cherokee group)	1,085
Top of Mississippian (Ste. Genevieve) limestone	1,665
Top of Chattanooga shale	2,060
Top of Devonian limestone	2,150
Top of Maquoketa shale	2,425
Top of Viola limestone	2,502
Top of Decorah shale	2,657
Top of St. Peter sandstone	2,675
Top of Arbuckle limestone	2,750

275

Pennsylvanian rocks.—Pennsylvanian rocks are about 2,500 feet thick in the northwestern part of Atchison County where nearly the whole section is present.

Mississippian rocks.—According to Lee (1939, pl. 1), the total thickness of Mississippian limestone formations in Atchison County ranges from less than 200 feet in the northwestern part to slightly more than 400 feet in the southeastern part. The Ste. Genevieve limestone is the uppermost Mississippian formation that has been identified in the county. It lies next below Pennsylvanian rocks in the eastern and northeastern parts of the county (Lee and Payne, 1944, fig. 17). West of the area of the Ste. Genevieve limestone, Pennsylvanian sediments overstep the St. Louis and Spergen limestones and in the western part of the county they lie on the "Warsaw" limestone. The "Warsaw," Burlington-Keokuk, and Gilmore City limestones are believed to be present throughout the county.

The thickness of the Chattanooga shale in Atchison County ranges from slightly more than 50 feet in the southeastern part to nearly 200 feet in the northwestern part (Lee, 1943, fig. 14).

Pre-Chattanooga rocks.—According to Lee (1943, fig. 12), the thickness of rocks between the base of the Chattanooga shale and the top of the Maquoketa shale ranges from about 200 feet in the southeastern corner of Atchison County to 400 feet in the northwestern corner. In the Wakefield et al. No. 1 National Life well, in sec. 17, T. 6 S., R. 20 E., 275 feet of Devonian limestone was found between the Chattanooga shale and the Maquoketa shale (Lee, 1943, fig. 7). The thickness of rocks between the top of the St. Peter sandstone and the Pre-Cambrian floor ranges from

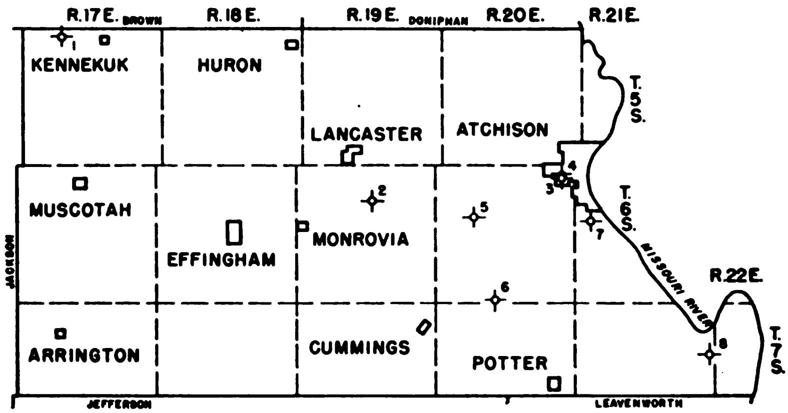

Fig. 14.—Map of Atchinson County showing location of wells listed in Table 7.

about 400 feet in the northwestern part of the county to about 700 feet in the northeastern part (Lee, 1943, fig. 9).

Oil and Gas Exploration

A few years ago when there was increased interest in oil possibilities in the Forest City basin area, much geologic work was done in Atchison and other northeastern Kansas counties, but few test wells have been drilled in Atchison County. Data on eight wells of which the Geological Survey has records are given in Table 7. Locations of the eight wells are shown on Figure 14.

Table 7.—*Data on wells drilled for oil and gas in Atchison County*

No. on map	Name of well	Location	Total depth, feet	Remarks
1	Scroggins No. 1 Duff	Cen. SE¼ NE¼ 5-5-17E	1,800?	No log available
2	Carter Oil Co. No. 3 Stratigraphic test	Cen. NE¼ NW¼ SW¼ 10-6-19E	2,941	Top Arbuckle 2,894 feet
3	Bailor Mfg. Co. No. 1 Argol Plant	NE ¼ SE¼ NW¼ 1-6-20E	643	Stopped in Pleasanton sh.
4	Bailor Mfg. Co. No. 2 Argol Plant	SE¼ NE¼ NW¼ 1-6-20E	1,405	Stopped in Cherokee rocks
5	Wakefield et al. No. 1 National Life	Cen. NW¼ NE¼ 17-6-20E	2,789	Depths to some horizons given in Table 6
6	Atchison No. 1 Martin	NE ¼ SW¼ SW¼ SE¼ 33-6-20E	1,280	Stopped in upper Cherokee rocks
7	Citizens of Atchison No. 1 Atchison	SW cor. NE¼ 18-6-21E	1,352	Diamond drill hole; top Mississippian rocks 1,300 feet
8	Indian Mound Oil Co. No. 1 Oak Mills	NE cor. NE¼ 13-7-21E	3,085?	Pre-Cambrian rocks at 2,900 feet

BOURBON COUNTY

As early as 1906 there were eight oil wells and six gas wells in Bourbon County, and it is reported that some gas was produced in the vicinity of Fort Scott many years earlier. The Walnut-Hepler pool in the southwestern part of the county was discovered in 1917. Gas was discovered near Mapleton in 1918. Oil was found near Bronson in 1919. Production of oil and gas in Bourbon County is almost entirely from sandstones in the Cherokee shale.

During 1948 Bourbon County produced 11,188 barrels of oil. Production figures for preceding years starting with 1917 are shown in Tables 2 and 2a. Table 8 shows the production in the various oil fields in the county for 1944 through 1948.

Locations of the Bourbon County oil and gas fields and the areas of production in 1948 are shown in Figure 15.

Geology

SURFACE ROCKS

The surface rocks of Bourbon County consist of alternating beds of shale, limestone, and sandstone. All outcropping consolidated rocks are of Pennsylvanian age.

The youngest outcropping Pennsylvanian formation is the Chanute shale in the Kansas City group (Fig. 5) which crops out in the northwestern part of the county. Rocks of the Bronson subgroup crop out in a narrow band along the Bourbon-Allen County line and on the uplands between Marmaton and Little Osage Rivers in the northwestern part of Bourbon County. They consist of alternating beds of limestone and shale and some thin beds of sandstone. The three limestone formations of the Bronson subgroup crop out along a steep winding escarpment. The Dennis limestone is present below an extensive dip slope west of the escarpment. The Bronson rocks have a total thickness of about 110 feet in the county. The Pleasanton group consists of beds of shale and sandstone and a few thin beds of limestone; the Hepler sandstone is a thin but persistent sand deposit at the base. The total thickness of the Pleasanton is about 150 feet in Bourbon County. It is separated from the underlying Marmaton rocks by a disconformity. The Marmaton rocks consist of alternating beds of limestone and shale and some beds of sandstone and thin coal. The thickness of the Marmaton rocks in Bourbon County is about 180 feet. The Marmaton formations are well exposed along Marmaton River between Fort Scott and Uniontown, and along smaller streams in the eastern part of the county.

The Cherokee shale (Fig. 6) is the oldest outcropping rock in Bourbon County. It is exposed in the eastern part of the county in the valleys of Little Osage and Marmaton Rivers and in the southeastern part of the county. The Cherokee consists of beds of shale and sandstone, a few thin beds of limestone, and several beds of coal. Some of the shale is sandy, and part of the sandstone contains shale. The total thickness of the Cherokee shale in Bourbon County is about 350 feet. Only the upper part is exposed.

SUBSURFACE ROCKS

Subsurface geologic conditions in the central part of Bourbon County are shown in Plate 1. Depths to some stratigraphic horizons in the Oklahoma Natural Gas Company No. 1 Stevenson well, in sec. 16, T. 26 S., R. 24 E., are given in Table 9.

Pennsylvanian rocks.—Pennsylvanian rocks in Bourbon County have an average thickness of about 500 feet. The Cherokee shale, of which only the upper part crops out, is about 350 feet thick. The "Squirrel sand," about 20 feet thick, lies a few feet below the top of the Cherokee shale. The "Bartlesville sand" is about 180 feet below the top of the Cherokee and ranges from a few feet to 40 feet in thickness. The "Burgess sand" occurs in the basal part of the Cherokee and is about 10 feet thick.

Mississippian rocks.—The total thickness of Mississippian rocks in Bourbon County ranges from about 300 to 350 feet (Lee, 1939, pl. 1). Mississippian formations present in the county in-

TABLE 8.—*Oil production in Bourbon County, 1944 through 1948*

Field	1944 Bbls. oil	1945 Bbls. oil	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Bronson-Zenia[1]	Allen Co.	479	Allen Co.	4	397	4	375
Davis-Bronson[1]	17,244	Allen Co.	14,477	62+	23,059	7+	6,452
Elsmore Shoestring[1]	Allen Co.	1,305	Allen Co.	12	1,092	Allen Co.	
Hepler					715		1,111
Savonburg[2]	18,351	14,323	10,215	11	6,397	5	3,250
Totals	35,595	16,107	24,692	89+	31,660	16+	11,188

[1] Field extends into Allen County.
[2] Includes Allen County production. Areas of production not definitely located.

TABLE 9.—*Depths to some stratigraphic horizons in the Oklahoma Natural Gas Company No. 1 Stevenson well in the SW¼ SW¼ sec. 16, T. 26 S., R. 24 E., Bourbon County*

Horizon	Depth, feet
Top of Labette shale	35
Top of Cherokee shale	130
Top of "Warsaw" limestone	490
Top of Burlington-Keokuk limestone	600
Top of St. Joe limestone	790
Top of Sedalia (?) limestone	803
Top of Northview shale	818
Top of Compton limestone	845
Top of Chattanooga shale	900
Top of Sylamore sandstone	913
Top of Cotter-Jefferson City dolomite	915
Top of Roubidoux formation	1,200
Top of Gasconade-Van Buren formation	1,280
Top of Gunter sandstone	1,451
Top of Proctor dolomite	1,476
Top of Eminence dolomite	1,533
Top of Bonneterre dolomite	1,658
Top of Lamotte sandstone	1,760
Top of Pre-Cambrian rocks	1,810

clude the "Warsaw," Keokuk, Burlington, Reeds Spring, and St. Joe limestones, the Northview shale, and the Compton limestone. The Chattanooga shale is less than 50 feet thick (Lee, 1940, pl. 3). It overlies beveled Ordovician rocks and is seemingly conformable with the overlying Compton limestone.

Ordovician rocks.—Studies of a deep well drilled in sec. 16, T. 26 S., R. 24 E. show the thickness of the Ordovician rocks to be 660 feet. The units identified are the Cotter-Jefferson City dolomite, the Roubidoux formation, the Gasconade and Van Buren dolomites, and the Gunter sandstones.

Cambrian rocks.—The thickness of Cambrian rocks in Bourbon County is about 300 feet. The Eminence-Potosi dolomite, the Bonneterre dolomite, and the Lamotte sandstone have been identified. They are separated from Ordovician rocks by an unconformity and rest on Pre-Cambrian rocks.

OIL AND GAS DEVELOPMENTS

Oil and gas have been found chiefly in the western part of Bourbon County. Several fields lie along the western border and extend into Allen County. A large number of wells, mostly of shallow depths have been drilled in the county.

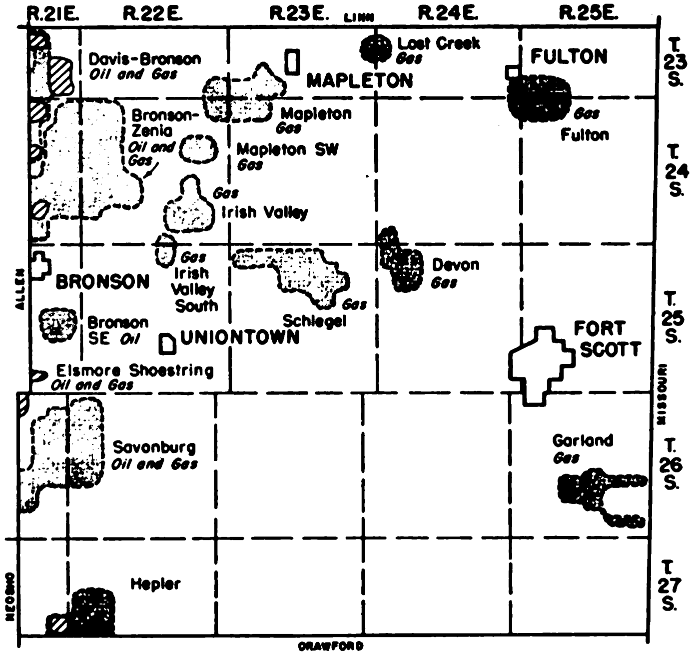

Fig. 15.—Map of Bourbon County showing oil and gas fields. Areas of 1948 oil production are cross hatched. Oil production in Savonburg field is not definitely located.

produced 39,689 barrels of oil. Of this amount 6,452 barrels came from the Bourbon County part of the field. Oil production is from

The Oil Field Nomenclature Committee of the Kansas Geological Society has designated oil and gas fields in Bourbon County as shown in Figure 15. The fields are described briefly below.

The **Bronson Southeast** oil field is no longer active. Production data are not available, but some oil was produced from the "Bartlesville sand" which is reported to be about 18 feet thick in the area, and which occurs at a depth of about 718 feet.

The **Bronson-Zenia** oil and gas field covers most of the western part of T. 24 S., R. 22 E. and extends southwestward across T. 24 S., R. 21 E. into Allen County. Oil production is from the "Bartlesville sand" which has an average thickness of about 20 feet and lies at a depth of about 665 feet. In 1948, 375 barrels of oil were produced in the Bourbon County part of the field.

The **Davis-Bronson** oil and gas field extends into Allen County (Fig. 12) and into Anderson County (Fig. 13). In 1948 the field the "Bartlesville sand." Several gas wells in sec. 35, T. 23 S., R. 21 E. are recorded as having produced gas from the "Bartlesville sand" at a depth of about 560 feet.

Few data on the **Devon** gas field are available. Gas was produced from a depth of about 455 feet. One well, in the SW cor. sec. 31, T. 24 S., R. 24 E., was reported as having had an initial daily production of 1 million cubic feet of gas.

The **Elsmore** oil and gas field extends into Bourbon County from Allen County. Oil production is from a "Bartlesville shoestring sand" about 50 feet thick and at a depth of about 550 feet. In 1948 the field produced 41,727 barrels of oil.

The **Fulton** gas pool was opened in 1943. Production is from the "Bartlesville sand" which there has an average thickness of about 20 feet and lies at a depth of about 450 feet. Wells were reported to have had an initial open flow of 150,000 cubic feet of gas and rock pressure of 225 pounds.

Almost no data on the **Garland** gas field are available. Gas was produced there from shallow wells. The **Hepler** oil field recently has been reactivated after temporary abandonment. In 1948 the field produced 1,111 barrels of oil. Production is from the "Bartlesville sand."

Few data on the **Irish Valley, Irish Valley South, Lost Creek, Mapleton,** and **Mapleton Southwest** gas fields are available. In the Irish Valley South area gas has been produced at depths between 700 and 800 feet. It is probable that the "Bartlesville sand" is the principal reservoir rock in the fields.

The **Schlegel** gas field was developed many years ago. Principal gas production was from the "Bartlesville sand" at a depth of about 600 feet, but gas was encountered at several shallower horizons.

BROWN COUNTY

Much information on the stratigraphy and structural geology of Brown and other northeastern Kansas counties has been made available by Lee (1943). Brown County is in the northwestern part of the Forest City basin and on the eastern margin of the North Kansas basin. The deepest part of the Forest City basin is in this county (Lee, 1943, fig. 1). Devonian rocks truncate northwestward-dipping Silurian rocks in this area.

TABLE 10.—*Oil production in the Livengood field, Brown County, 1944 through 1948*

Year	No. wells	Production, Bbls.
1944	1	969
1945	2	21,684
1946	2	18,195
1947	1	9,630
1948	2	5,671

Late in 1944 oil was discovered in the Gall No. 1 Livengood well in the NE¼ NW¼ SW¼ sec. 3, T. 1 S., R. 15 E.

Brown County produced 5,671 barrels of oil in 1948. Production figures for the years 1944 to 1948 inclusive are shown in Table 10.

GEOLOGY

SURFACE ROCKS

The exposed consolidated rocks in Brown County are Permian and Pennsylvanian in age. Thick deposits of glacial drift cause difficulty in outcrop studies.

Permian rocks.—Permian rocks of the Council Grove and Admire groups (Fig. 3) crop out in the western half of Brown County. There are few exposures because of the presence of glacial drift.

Pennsylvanian rocks.—Pennsylvanian rocks extending from the uppermost part of the system to the upper part of the Severy shale (Fig. 4) are exposed in Brown County. These rocks crop out in the approximate eastern half of the county. Like the Permian rocks, the Pennsylvanian beds are exposed in relatively few places. From outcrop studies and data from shallow drilling, it is evident that both Permian and Pennsylvanian rocks in Brown County are similar to equivalent formations farther south where they are more completely exposed.

SUBSURFACE ROCKS

Depths at which some key stratigraphic horizons were reached in the Gall No. 1 Livengood well are given in Table 11.

Pennsylvanian rocks.—In western Brown County, where the entire Pennsylvanian section is present under Permian beds, the Pennsylvanian strata have a total thickness of about 2,000 feet.

TABLE 11.—*Depths to some key horizons in the Gall No. 1 Livengood well in the NE¼ NW¼ SW¼ sec. 3, T. 1 S., R. 15 E., Brown County*

Horizon	Depth, feet
Top of Tarkio limestone	311
Top of Howard limestone	590
Top of Topeka limestone	650
Base of Oread limestone (top of Douglas group)	919
Top of Lansing group	1,018
Base of Hertha limestone (top of Pleasanton group)	1,335
Top of Mississippian rocks	2,215
Base of Mississippian limestones	2,314
Top of "Hunton" limestone	2,579
Total depth	2,590

Mississippian rocks.—The total thickness of Mississippian limestone formations in Brown County ranges from about 50 feet in the northwestern corner to about 225 feet in the southeastern corner (Lee, 1939, pl.1). According to Lee and Payne (1944, fig. 4), the St. Louis limestone is the uppermost Mississippian limestone formation. It lies next below Pennsylvanian deposits in southeastern Brown County. Successively the Spergen limestone and the "Warsaw" limestone are overstepped to the west, and in the western part of the county undivided Burlington and Keokuk limestone lie next below Pennsylvanian rocks.

The Chattanooga shale ranges in thickness from about 150 feet in the northeastern part of the county to slightly more than 250 feet in the western part (Lee, 1943, fig. 14). Lee identified 231 feet of Chattanooga shale in the Carter No. 4 Stratigraphic test well in sec. 24, T. 4 S., R. 16 E. (Lee, 1943, fig. 7). In the Gall No. 1 Livengood well, in sec. 3, T. 1 S., R. 15 E., rocks in the upper part of the 264-foot interval (Table 11) between the base of Mississippian limestones and the top of the "Hunton" limestone may be post-Chattanooga in age.

Devonian and Silurian rocks.—Lee (1943, fig. 7) identified 163 feet of Devonian limestone and 263 feet of Silurian limestone in the Carter No. 4 Stratigraphic test well. In the Wakefield et al. No. 1 National Life well in sec. 17, T. 6 S., R. 20 E., Atchison County, no Silurian rocks were found and Devonian rocks lie on a reduced thickness of Maquoketa shale.

Ordovician rocks.—In the Carter No. 4 Stratigraphic test well, Lee (1943, fig. 7) identified 135 feet of Maquoketa shale, 130 feet of Kimmswick limestone, and 95 feet of undivided Decorah-Plattin limestone. The St. Peter sandstone, 25 feet thick, lies on

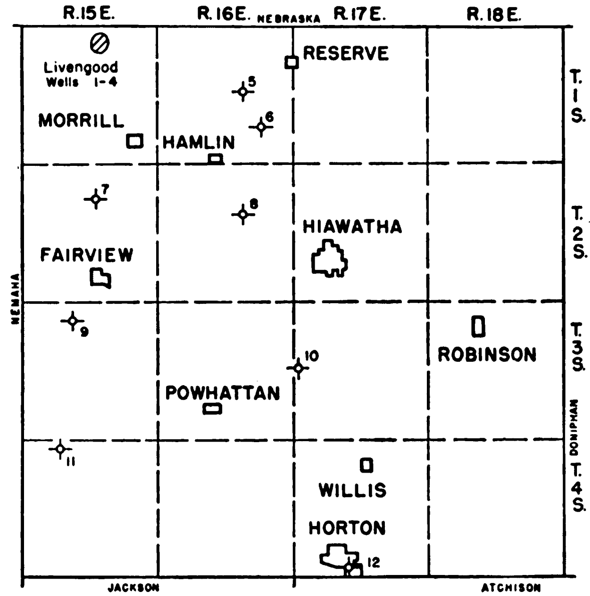

FIG. 16.—Map of Brown County showing the Livengood oil pool and location of wells listed in Table 12.

Arbuckle rocks. The maximum thickness of rocks between the top of the St. Peter sandstone and the Pre-Cambrian floor in Brown County is about 400 feet (Lee, 1943, fig. 9).

OIL AND GAS DEVELOPMENTS

The first test for oil and gas in Brown County of which we have record is a diamond drill hole that was put down at Horton in sec. 33, T. 4 S., R. 17 E., to a depth of 1,105 feet. This well did not reach Mississippian rocks. More recently several wells were drilled in the county (Table 12).

Oil was discovered late in 1944 in the Gall No. 1 Livengood well in the NE¼ NW¼ SW¼ sec. 3, T. 1 S., R. 15 E. Production is from the upper part of the "Hunton" limestone at a depth of 2,579 feet. The initial production was approximately 85 barrels of oil per day. Three oil wells have been drilled in the **Livengood** field, which is the only oil field in Brown County.

The second producing well in the field is the R. S. Tomer No. 1 "B" Livengood, NE¼ SW¼ SW¼ sec. 3, T. 1 S., R. 15 E. This

TABLE 12.—*Data on wells drilled for oil and gas in Brown County*

No. on map	Name of well	Location	Completion date	Total depth, feet	Remarks
1	Clifton Gall No. 1 Livengood	SE¼ NW¼ SW¼ 3-1-15E	10-16-44	2,590	85 bbl. oil well; see Table 11
2	Stout & Hahn No. 1 Livengood	SW¼ NE¼ SW¼ 3-1-15E	1-24-48	2,612	Top Kansas City ls. 1,028 feet; Mississippian ls. 2,224 feet; base Mississippian ls. 2,401 feet; top "Hunton" 2,605 feet; 40 bbl. oil well
3	R. S. Tomer No. 1 "B" Livengood	NE¼ SW¼ SW¼ 3-1-15E	4-28-45	2,635	Top "Hunton" 2,617 feet; 80 bbl. oil well
4	R. S. Tomer No. 1 Warner	NE¼ SE¼ NE¼ 4-1-15E	6-16-45	2,701	Top Mississippian ls. 2,275 feet; "Hunton" 2,650 feet
5	Ohio Oil Co. No. 1 Peck	SE cor. SE¼ 15-1-16E	3-26-44	2,880	Top "Hunton" 2,780 feet
6	Gall & Towle No. 1 Allerton	Cen. SW¼ NE¼ 26-1-16E	7- 6-43	2,785	Top Kansas City ls. 923 feet; Mississippian ls. 2,272 feet; base Mississippian ls. 2,472 feet; top "Hunton" 2,684 feet
7	Stanolind Oil & Gas Co. No. 1 Wikle	NW cor. SW¼ 10-2-15E	11-12-46	3,433	Top Mississippian ls. 2,592 feet; Kinderhookian 2,755 feet; "Hunton" 3,036 feet
8	Nichols-Neff-Stearns No. 1 Yaussi	Cen. N. line NE¼ NE¼ 15-2-16E	11- 8-41	2,766	Top "Hunton" 2,658 feet
9	McAlpine et al. No. 1 Tyler	NE¼ SW¼ SW¼ 4-3-15E	7-27-41	1,250	
10	Gall & Towle No. 1 Amann	Cen. SW¼ SW¼ 18-3-17E	5-24-43	2,732	
11	Towle & Gall No. 1 Dillaplain	Cen. SW¼ NE¼ 5-4-15E	10-8-43	3,066	Top Kansas City 1,237 feet; Mississippian ls. 2,561 feet; base Mississippian ls. 2,695 feet; top "Hunton" 2,995 feet
12	Diamond Drill Hole at Horton	33-4-17E		1,105.9	Stopped in lower Kansas City rocks

well was drilled to a depth of 2,635 feet. The top of the "Hunton" was reached at 2,617 feet. The initial production of the well which was completed April 28, 1945, was reported as 80 barrels of oil per day. The third oil well, the Stout and Hahn No. 1 Livengood, was completed January 25, 1948, in the SW¼ NE¼ SW¼ sec. 3. The initial daily production was estimated as 40 barrels per day. The total depth of the well is 2,612½ feet; the "Hunton" was reached at 2,605 feet; and saturation from 2,607½ feet to 2612½ feet was reported. The Livengood oil field and dry wildcat wells drilled in the county to date are shown on Figure 16.

BUTLER COUNTY

According to Fath (1921), shallow gas wells were drilled in the vicinity of Augusta as early as 1906. Oil was discovered near Augusta in June 1914; the first commercial production was in

1915. The discovery of oil in Ordovician rocks near El Dorado in 1915 was one of the most outstanding events in the history of the mid-continent oil industry. Production from Butler County in 1918, the peak year, was 36,069,670 barrels. Of this amount 28,807,680 barrels came from the El Dorado field. A comprehensive report on the El Dorado field was written by Fath (1921), and later Bass (1936) discussed the origin of the shoestring sands of Butler County. The Augusta field was described by Berry and Harper (1948).

Butler is by far the most important oil producing county in eastern Kansas and its El Dorado field has yielded more than twice as much oil as any other Kansas field. Cumulative production of El Dorado at the end of 1948 was 198,508,809 barrels. During 1948 the county produced 5,911,373 barrels of oil. Oil production figures for the years 1915 to 1948 inclusive are shown in Tables 2 and 2a. Table 13 shows production in the various fields in the county for 1944 through 1948 and cumulative production to the end of 1948 in fields where available. Water flooding is being practiced in the county in 12 projects; there is one gas injection project (Table 3). One new oil field was opened in the county in 1945; four oil fields in 1946, four oil and one gas in 1947; and three oil fields in 1948. Almost no gas was produced commercially in 1948.

Locations of the Butler County oil and gas fields and the areas of oil production during 1948 are shown in Figure 17.

Geology

SURFACE ROCKS

The consolidated rocks exposed in Butler County belong to the Sumner, Chase, and Council Grove groups of the Permian System (Fig. 3). The youngest rocks crop out along the western boundary of the county; the oldest rocks are exposed in the extreme eastern part.

Only the lower part of the Wellington shale is present in Butler County. It is underlain by the Herington limestone member of the Nolans formation. The maximum thickness of the rocks of the Sumner group in the county is about 65 feet. The Chase group has a maximum thickness of about 340 feet in Butler County. The Fort Riley and Florence limestone members of the Barneston formation are the surface rocks throughout most of central and eastern Butler County. Their combined thickness ranges from about 80 to 90 feet. The upper part of the Council Grove group is exposed in extreme eastern Butler County. Strata slightly older than the Neva limestone member of the Grenola limestone are the oldest rocks exposed. The total thickness of rocks of the Council Grove group is about 310 feet.

SUBSURFACE ROCKS

Subsurface rocks in Butler County are modified by two major structural features, the Nemaha anticline and the older Chautauqua arch. The northwestern flank of the Chautauqua arch underlies the southern part of the county (Fig. 9). In this area the Chattanooga shale rests upon rocks ranging in age from Devonian (Kimmswick limestone) to Ordovician (Cotter dolomite). Along the Nemaha anticline (Fig. 11), which crosses the county from the north to the southwest, Pennsylvanian rocks rest upon the upturned edges of formations ranging in age from Mississippian to Ordovician. Subsurface geologic conditions along the western side of Butler County are shown diagrammatically on Plate 4.

Permian rocks.—The Admire group has an average thickness of about 190 feet in Butler County. It consists of shale and thin limestones. The Permian rocks are slightly arched over the granite ridge and there are several smaller domes and basins on the flanks of the Nemaha anticline which are expressed in outcropping rocks.

Pennsylvanian rocks.—Pennsylvanian rocks in Butler County consist of about 2,100 feet of limestone, sandstone, and shale. The Wabaunsee group consists largely of shale and contains a few thin beds of coal, minor amounts of sandstone, and some thin beds of limestone. It is about 495 feet thick. The Shawnee group in Butler County consists of about 375 feet of interbedded limestones and shales and contains four sandstones that produce gas (Fath, 1921, p. 43). The Douglas group is about 250 feet thick in Butler County. It is chiefly shale and contains a few thin limestone and sandstone beds. A disconformity separates the Douglas and Pedee groups, but it is difficult to differentiate them in drillers' logs.

The Lansing group is about 150 feet thick in Butler County. It is composed chiefly of limestone. The Kansas City group consists of shale, thick beds of limestone, and thin beds of sandstone. A sandstone called "Layton" which lies near the top of the group yields gas. The Kansas City group is about 340 feet thick. The Pleasanton shale is about 125 feet thick. The Marmaton group, which consists of beds of limestone and shale, is about 165 feet thick.

The Cherokee shale in Butler County consists of light and dark shale, lenses of sandstone, a few thin beds of limestone, coal, and red shale. Shoestring sandstone lenses ("Bartlesville sand") in the lower part of the Cherokee yield oil. The average thickness of the Cherokee shale in this county is about 340 feet.

Mississippian rocks.—The Mississippian limestones are about 400 feet in total thickness in Butler County; they are mostly cherty. The "Warsaw" probably is the uppermost Mississippian formation in most of the county. Porous zones in Mississippian limestones yield oil. The common thickness of the Chattanooga shale in the county is about 100 feet; locally the Chattanooga is absent.

Ordovician and Cambrian rocks.—The Chattanooga shale or Mississippian limestone lies unconformably on Ordovician rocks. Silurian and Devonian rocks are absent. The Viola limestone and the Simpson sandstone are believed to be present in most of Butler County (Jewett and Abernathy, 1945, pl. 3). The combined thickness is about 100 feet. According to Keroher and Kirby (1948, figs. 6, 8, and 9) thicknesses of lower Ordovician and upper Cambrian formations in Butler County are: Jefferson City-Cotter, 300 feet in the north part of the county to 550 feet in the southwest corner; Roubidoux, 100 to 200 feet; Van Buren-Gasconade, present in the southern approximate half of the county, ranging from a featheredge in the central part to about 175 feet in the southwest corner. They (Keroher and Kirby, 1948, fig. 3) found the Roubidoux dolomite in contact with Pre-Cambrian rocks in the northern part of Butler County and Van Buren-Gasconade dolomites first above the basement rocks in the southern part.

Oil and Gas Developments

The locations of oil and gas producing areas in Butler County are shown in Figure 17. A list of the oil and gas fields of the county, their locations, and other data are given in Table 13.

The **El Dorado** oil and gas field was discovered in 1915, and became the greatest field ever developed in Kansas. It was the leading field in the United States in 1918; the production in that year was 28,807,680 barrels. On September 29, 1915, the Wichita Natural Gas Company started drilling on the Stapleton farm in the SE¼ sec. 29, T. 25 S., R. 5 E. Commercial production, estimated at 50 to 200 barrels per day, was found in a sandstone in the Admire group of Permian rocks at a depth of 660 feet. Late in 1915 deeper drilling found commercial production in the "Stapleton zone" at a depth of 2,465 feet. The discovery well was drilled 46 feet into the pay zone; the initial production of this well was 175 barrels per day. The field was extended to the east by drilling on the Wilson farm in the E½ sec. 27, T. 25 S., R. 5 E., 2½ miles east of the discovery well. In this well the "Stapleton zone" was encountered nearly 200 feet lower than the same zone in the discovery well.

Other developments rapidly extended this field. By the end of 1916 there were 600 producing wells having a total daily production of about 12,000 barrels. In the early part of 1917 several 500 barrel wells were drilled to the "Stapleton zone." In June 1917, the first gusher was completed. Production of this well was estimated to be from 6,000 to 24,000 barrels per day. Many other gushers were soon drilled; production in all of these was from the "Stapleton zone."

The "Stapleton" is a porous zone of beveled Ordovician rocks which lies immediately below Pennsylvanian rocks. These Ordovician rocks include the Viola limestone, the St. Peter sandstone, and the Arbuckle dolomite. The accumulation of oil in them is the result of anticlinal concentration in a porous zone at the angular disconformity immediately below Pennsylvanian rocks. This anticline, which has a structural relief of about 1,400 feet, is typical of the granite ridge of which it is a part. Most of the folding is confined to pre-Pennsylvanian rocks. However, the field was discovered on the basis of surface structural mapping.

The El Dorado field now has about 1,500 producing oil wells. Oil occurs in the Admire group at a depth of about 600 feet; in the lower part of the Douglas group at about 1,550; at the top of the Lansing group at about 1,700 feet; in the upper part of the Kansas City group at about 2,000 feet; and in the "Stapleton zone" which ranges in depth from 2,350 to 2,750 feet. Gas is pro-

TABLE 13.—*Oil production in Butler County, 1944 through 1948*

Field	Discovery year	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil	Cumulative	Producing horizon	Depth, feet
Allen		1+	3,563	1+	2,820	1+	5,666	1+	98,555		82,990			
Allen North	1947								710		36,454	37,164	"Miss. chert"	
Augusta	1914	138+	217,405	145+	204,259	135+	196,173	128+	248,252	141+	349,476	35,609,165	Lansing	1,700
													Bronson	2,000
													Marmaton	2,200
													Ordovician	2,445
													Arbuckle	2,600
Augusta North	1914	63	102,271	68	91,454	67	89,286	65	84,317	65	82,592	14,125,270	Lansing	1,650
													Bronson	1,950
													Ordovician	2,380
													Arbuckle	2,410
Bausinger		4	5,883	4	5,010	4	4,830	4	4,950	4	5,531		Ordovician	3,050
Benton		2	4,338	2	1,680	1	2,010	1	2,070	1	1,605		Mississippian	2,765
Blankenship[1]		85	66,948	86	68,760	85	66,960	82	68,460	25+	43,700	598,828	"Bartlesville"	2,650
Brandt-Sensebaugh	1936	54	172,641	60	150,420	61	136,964		101,790	1+	60,238	1,576,880	Miss. chat	2,692
Combs[4]	1947						See Cowley County							
Combs Northeast[2]	1948													
DeMoss		22	56,105	22	47,970	53	76,107	4+	32,079	4+	29,951		"Bartlesville"	2,700
													"Burgess"	2,732
Dixon (Eckel West)	1946					1	1,290		2,300		1,846	5,436	Kansas City	
Douglass		33	33,851	31	35,096	32	33,364	29	20,592	30	13,848		Lans.-K.C.	1,790
Dunns Mill		1	12,709	1	5,998	1	2,988	1	2,089	1	933	53,018	Arbuckle	2,951
Eckel		3	4,483	3	4,950	3	4,331		3,271		3,279	51,336		
Elbing[3]	1918	74	290,621	87	267,926	71	258,198	61	224,026	59	260,683	1,341,454	Viola	2,530
Elbing East		1	0	1	0	1	0		0		0			
El Dorado	1917	1,588+	2,680,652	1,639+	2,596,989	1,662+	2,628,032	1,755+	2,736,863	1,482+	3,011,660	198,508,809	Admire	600
													Lansing	1,700
													Bronson	2,000
													Viola	2,500
													Simpson	2,510
													Arbuckle	2,550
Ferrell[5]	1939	11	66,741	18	128,220	27	132,884	30	99,652	41	95,259	711,839	"Miss. lime"	2,647
Fox-Bush	1917	121	147,184	123	201,090	124	300,486	80+	313,134	74+	304,948	1,650,842	"Bartlesville"	2,730
Garden	1928	31	47,762	31	41,820	33	40,197	28+	38,916	8+	40,315		"Bartlesville"	2,760

Gelwick		2	7,292	2	7,980	2	3,660	1	1,800	1	864			
Guyot[2]	1948													
Hanna[4]	1945			1	748	1	614	1	318	3	2,915		"Miss. lime"	
Haverhill	1927	71	138,629	73	98,310	73	109,991	60+	86,626	43+	71,596	4,120,402	"Bartlesville"	2,700
Hickory Creek	1946					1+	119,970	14	154,740	8+	164,401	439,111	"Bartlesville"	
Joseph	1947							1	270	1	998	1,268	"Basal Penn."	
Keighley	1925	56	55,188	55	54,480	50	49,920	36+	37,440	12+	27,397		"Bartlesville" Simpson	2,650 3,148
Kramer-Stern	1928	33+	141,375	33+	200,340	41+	216,743	34+	236,944	33+	221,643		Ordo.	3,030-3,088
Kramer-Stern South								2	990	1	179	1,169	Viola	
Leon	1926	18	22,200	17	22,680	17	24,420	18	27,360	20	24,172	2,361,832	"Chat" Viola	2,660 3,050
Lucas								1	3,690	2	2,704	6,394		
McCullough	1929	5	10,575	5	9,990	5	9,387		7,624		3,302	480,094	Ordovician	3,169
Pierce		2	2,439	2	15,030	4	111,360	21	133,200	26	132,658			
Powell								1	150	Abandoned				
Potwin	1921	96	190,267	95	170,040	94	155,700	93	164,596	78	140,896	7,005,499	Bronson "Miss. lime"	2,550 2,660
Potwin South		1	1,057	....	0		0		0		0			
Reynolds-Schaffer	1926	23	64,303	21	48,540	21	58,443	11	79,540	6+	77,456		"Miss. lime"	2,780
Salter	1946					1	10,126	21	100,183	21	201,989	312,298	Simpson	
Semisch	1947							1	4,260		10,566	14,826	"Bartlesville"	
Seward		14	10,022	14	8,310	14	8,970	14	7,620	4+	7,696	1,014,108	"Bartlesville"	2,650
Shinn	1946					1	3,214	3	79,842	10	127,201	210,257	"Miss. lime"	
Smock-Sluss	1918	43	54,153	43	93,240	49	90,390	61	161,245	13+	98,208		"Bartlesville" Ordovician	2,700 3,000
Snowden-McSweeney	1930	2	6,077	2	3,180	1	2,940		3,054	1+	3,551		Mississippian	2,833
Steinhoff	1926	2	3,414	2	4,560	2	3,990	2	3,300	2	3,073		Mississippian	2,803
Towanda	1948									4	39,876	39,876	Viola	
Weaver	1929	5	2,159	5	1,650	5	1,882		1,927		622		"Bartlesville"	2,690
Young	1919	30+	61,714	31+	147,960	48+	187,740	74+	232,739	28+	122,102		Kansas City Mississippian	2,190 2,650
Totals		2,636+	4,684,021	2,742+	4,741,500	2,792+	5,149,226	2,739	5,611,484	2,253+	5,911,373			

[1] Field extends into Greenwood County. Years 1944, 1945, 1946, and 1947 include Greenwood County production.
[2] Production not recorded.
[3] Includes Marion County production.
[4] Field extends into Cowley County.
[5] Field extends into Elk County.

duced from rocks of the Admire, Shawnee, and Douglas groups which range in depth from 900 to 1,500 feet.

The **Augusta** oil and gas field is in southwestern Butler County. The maximum width is about 4 miles. Gas was discovered in the area in 1906 or earlier, and oil was found in the Wichita Natural Gas Company No. 1 Varner, NW¼ NE¼ NW¼ sec. 21, T. 28 S., R. 4 E. in 1914, in the "Varner sand" (Ordovician), at 2,466 feet. Initial production was about 150 barrels. The **Augusta North** pool was discovered by the McMann Oil and Gas Company No. 1 Kramer well, SE¼ sec. 28, T. 27 S., R. 4 E. This well had an initial production of 504 barrels of oil per day from the Simpson sandstone and Arbuckle limestone ("Varner zone"). Peak production in the Augusta area took place in 1917 when more than 1 million barrels per month was produced. The geology of the Augusta field has been described comprehensively by Berry and Harper (1948). According to Berry and Harper two anticlines are separated by a narrow northeast-southwest trough that passes through the City of Augusta. Closure, measured in surface rocks amounts to about 40 feet in the north structure and about 60 feet in the south anticline. Lower rocks of Pennsylvanian age are folded more steeply. Ordovician rocks are still more steeply folded and probably are faulted along the east side of the main Nemaha fold, of which the Augusta domes are parts. Non-inflammable gas, containing nitrogen and helium, was found in rocks of the Wabaunsee group at depths ranging from 450 to 550 feet in the Augusta field. Much of the gas that has been produced in the area has come from sandstone and overlying shale and limestone assigned to the Douglas group. This gas-producing zone is 100 feet thick and is reached at about 1,400 feet. Open flow from this zone was as much as 30 million cubic feet of gas per day (Berry and Harper, 1948, p. 220). Oil is produced from the upper part of the Lansing section in the southwest part of the Augusta field. Oil is produced from Lansing rocks at depths ranging from 1,700 to 1,750 feet. One well, NE¼ NW¼ SE¼ sec. 20, T. 28 S., R. 4 E. is reported to have had an initial production of 2,050 barrels of oil per day. Both fields have produced considerable oil from rocks in the upper part of the Kansas City group. Initial production ranged from a few to 500 barrels of oil per day. According to Berry and Harper (1948, p. 222) approximately 775 wells in the Augusta fields have produced oil from Ordovician

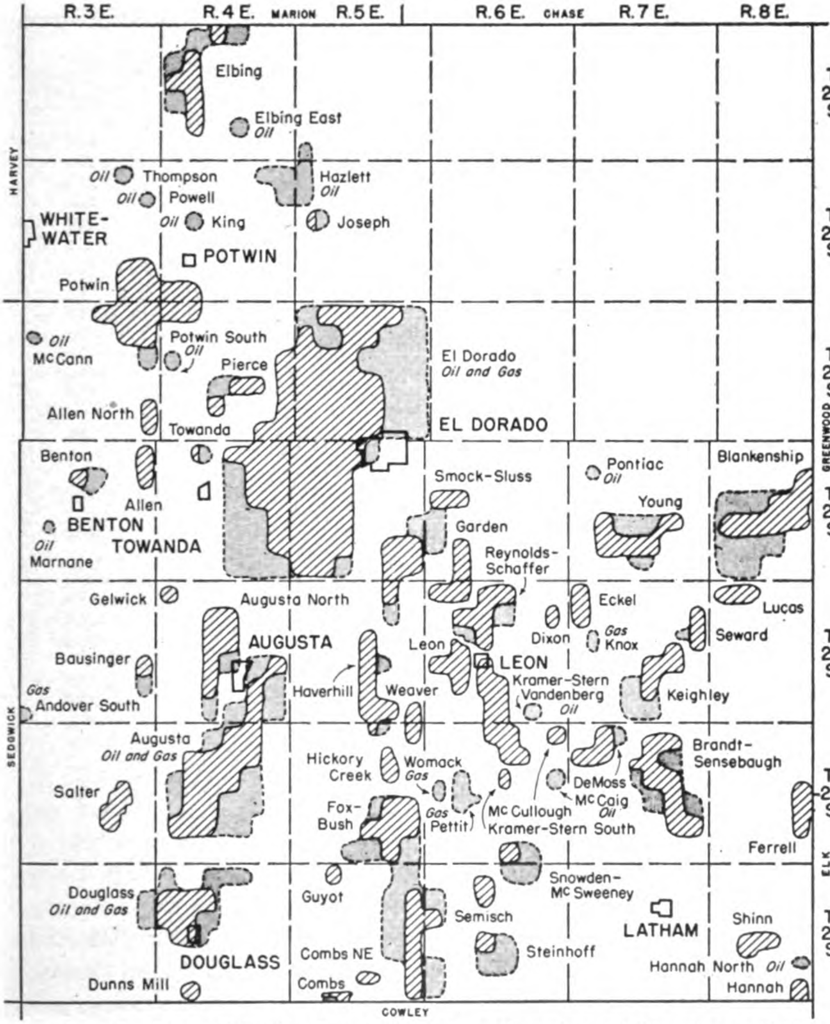

FIG. 17.—Map of Butler County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

rocks. Ordovician gushers were common during the early life of the field. One well, the Empire Oil and Gas Company No. 9 Scully, SW¼ NE¼ NW¼ sec. 28, T. 27 S., R. 4 E., flowed 525 barrels of oil per hour and 5,000-barrel wells were not uncommon. The average Ordovician well in the Augusta field was 200 barrels and in the Augusta North 350 barrels initially. Simpson production gen-

Table 14.—*Gravity of some samples of crude oil from fields in Butler County* (Data from U. S. Bureau of Mines)

Field	Producing zone	Depth to producing zone, feet	Gravity of oil, degrees A.P.I.
Augusta	Arbuckle limestone	2,480-2,495	32.8
do	"Wilcox sand"	2,557-2,566	33.8
Douglass	Lansing-Kansas City	1,778-1,800	41.4
Elbing	"Hunton" limestone	2,372	35.4
El Dorado	Admire rocks	627-648	36.6
do	Lansing limestone	1,663-1,754	36.8
do	Kansas City limestone	1,936-1,990	36.0
do	Viola limestone	2,401-2,417	37.4
do	Arbuckle limestone	2,395-2,483	38.2
do	"Wilcox" sandstone	2,566-2,630	36.6
Gelwick	Viola limestone	2,921	25.4
Haverhill	"Burbank sand"	±2,250 (composite)	39.4
do	"Burbank sand"	2,769	38.6
Hazlett	Mississippian limestone	2,470	40.4
Keighley	"Burbank sand"	2,632-2,658	30.0
do	"Burbank sand"	±3,100 (composite)	40.2
Leon	"Burbank sand"	2,700	38.8
Peabody	Viola limestone	2,504	35.0
Potwin	"Chat"	2,756	44.7
Reynolds-Schaffer	"Burbank sand"	2,754	34.4
Rosalie	Kansas City limestone	2,785	32.3
Seward	"Burbank sand"		39.4
Smock-Sluss	"Burbank sand"	2,750	38.6
do	"Burbank sand"	±2,750 (composite)	40.2
Snowden-McSweeney	Mississippian limestone	2,877	39.4
Steinhoff	Kansas City limestone	2,217	34.6
Yates	"Burbank sand"	2,722	39.6

erally was less than Arbuckle production. The field is now believed to be about 95 percent depleted for primary production.

In the **Potwin, Ferrell, Snowden-McSweeney, Steinhoff, Leon, Schaffer, Stern,** and **Young** pools production is from the Mississippian limestone, on the flanks of the granite uplift. In the **Blankenship, DeMoss, Fox-Bush, Garden, Keighley, Seward,** and **Smock-Sluss** pools, in the central and eastern parts of the county, production is from the "Bartlesville sand" at depths ranging from 2,650 to 2,800 feet. In some of the pools near the eastern boundary of the county production is from shoestring sand bodies which are extensions of the "Golden Lanes" of Greenwood County.

Additional data on oil and gas fields in Butler County are given in Table 13.

The gravity of some samples of crude oil from Butler County fields as reported by the U.S. Bureau of Mines (Lane and Garton, 1943) is shown in Table 14.

TABLE 15.—*Dry wildcat tests drilled in Butler County during 1948*

Company and farm	Location	Depth to top of Lansing, feet	Depth to top of Mississippian, feet	Total depth, feet
Shell Oil Co., Inc. No. 1 Henley	SE cor. SW¼ 7-24-8E	1,686	2,718	2,730
Shell Oil Co., Inc. No. 1 Vestring	SE cor. Lot 20 19-24-8E	1,710	2,725	2,778
Aladdin Oil Corp. No. 1 Joseph	SE¼ SW¼ NE¼ 3-25-4E	2,297*	2,749	3,073
Shell Oil Co., Inc. No. 1 "A" Brown	NE¼ SE¼ SE¼ 23-25-6E	1,794	2,780	2,795
Shell Oil Co., Inc. No. 1 Brown	SW cor. SE¼ 24-25-6E	1,764	2,756	2,784
Shell Oil Co., Inc. No. 1 Mattock	NE¼ NW¼ SW¼ 26-25-6E	1,760	2,730	2,745
Shell Oil Co., Inc. No. 1 Mueller	NW cor. SE¼ 35-25-6E	1,779	2,758	2,768
Shell Oil Co., Inc. No. 1 Williams	NW cor. SW¼ 4-25-7E	1,747	2,761	2,778
Shell Oil Co., Inc. No. 1 Grant	SW cor. SW¼ 5-25-7E	1,737		2,750
W. L. Hartman No. 1 Swindell	NW cor. NW¼ 19-26-4E	1,880	2,702	3,074
Shell Oil Co., Inc. No. 1 Taliaferro	SE¼ NW¼ SE¼ 5-26-6E	1,804	2,752	2,765
D. R. Lauck No. 1 Skaer	NW cor. SW¼ 21-27-3E	2,333*	2,802	3,165
Herman Kaiser No. 1 Stein	NW¼ NE¼ NW¼ 25-27-6E	1,780	2,770	3,209
Dilworth S. Hager No. 1 Metzger	SE¼ NW¼ NW¼ 10-28-3E	2,342*	2,860	3,153
The Derby Oil Co. No. 1 Ramp	NW¼ SW¼ SE¼ 29-28-7E	1,783	2,835	2,855

*Kansas City

Recent discoveries.—Recent discoveries in Butler County (Table 1) resulted in opening several new fields. In 1945, "Mississippi lime" production was found in sec. 28, T. 29 S., R. 8 E., where the **Hanna North** field was opened. In 1946, (1) the **Hickory Creek** field was established when production in the "Bartlesville sand" was found in sec. 11, T. 28 S., R. 5 E.; (2) the **Salter** field, with Simpson production in sec. 28, T. 28 S., R. 3 E.; (3) the **Dixon** field, with "Mississippi lime" production in sec. 12, T. 27 S., R. 6 E.; and the **Shinn** field was opened in sec. 19, T. 29 S., R. 8 E. with production from the "Mississippi lime." Five new fields were opened in the county in 1947. They are: (1) **Womack** gas, sec. 19, T. 28 S., R. 6 E., where the initial daily production from the "Bartlesville sand" was 2 million cubic feet; (2) **Kramer-Stern South,** the discovery well in sec. 15, T. 28 S., R. 6 E. having an initial daily production of 35 barrels of oil from the Viola limestone; (3) the **Semisch,** opened when the discovery well in sec. 4, T. 29 S., R. 6 E., found 75 barrels daily production in the "Bartlesville"; (4) the **Allen North,** with 25 barrels daily production from

TABLE 16.—*Data on pool wells drilled in Butler County during 1947 and 1948*

Field	1947 Producing wells and formation		1947 Dry	1947 Total	1948 Producing wells and formation		1948 Dry	1948 Total
Allen	3	Mississippian ls.	1	4	1	Mississippian ls.	7	8
Allen North			1	1	8	Mississippian ls.	3	11
Augusta	1	Kansas City ls.			1	Kansas City ls.		
	1	"Wilcox"			1	"Wilcox"		
	6	Simpson			1	"Bartlesville"		
	11	Arbuckle	4	23	11	Simpson		
					14	Arbuckle	8	36
Augusta	3	Kansas City ls.			1	Kansas City ls.		
North	1	Simpson	2	6	2	Arbuckle	2	5
Blankenship			0	0	1	"Bartlesville"	0	1
Combs	2	"Bartlesville"			3	"Bartlesville"	3	6
	2	Mississippian ls.	2	6				
Combs North-			0	0	1	"Bartlesville"		
east					1	Mississippian ls.	3	5
De Moss			0	0			2	2
Douglass			0	0			1	1
Dunn's Mill			0	0			3	3
Elbing	1	Arbuckle	0	1	3	Kansas City ls.		
					1	Mississippian ls.		
					1	Viola	4	9
Elbing East			0	0			1	1
El Dorado	1	Douglas			9	Douglas		
	1	Kansas City			5	Kansas City		
	1	"Bartlesville"			6	Marmaton		
	15	Mississippian ls.			17	Mississippian ls.		
	8	Viola			21	Viola		
	2	Simpson			9	Simpson		
	31	Arbuckle	20	79	39	Arbuckle		
					4	Salt water disposal	13	123
Fairview			0	0			1	1
Ferrell	2	Mississippian ls.	0	2	2	Mississippian ls.	1	3
Fox-Bush	4	"Bartlesville"			5	"Bartlesville"		
	1	Mississippian ls.	2	7	1	Mississippian ls.	6	12
Garden	1	Viola	3	4			1	1
Gelwick			0	0	1	Viola	0	1
Guyot			0	0	2	"Bartlesville"	1	3
Haverhill			0	0			1	1
Hazlett			0	0			1	1
Hickory Creek	2	"Bartlesville"	3	5	1	Mississippian ls.	0	1
Joseph	1	Mississippian ls.	0	1			1	1
Kughley (Keighley)			0	0			1	1
King			0	0			1	1
Kramer-Stern	2	Mississippian ls.			2	Mississippian ls.		
	1	Viola			2	Viola		
	1	Simpson	2	6	1	Arbuckle	1	6
Pierce	3	Mississippian ls.	2	5	9	Mississippian ls.	4	13
Pontiac			0	0			1	1
Potwin	2	Mississippian ls.	2	4	1	Mississippian ls.	2	3
Reynolds-			0	0	1	Mississippian ls.		
Schaffer					1	Viola	0	2
Rock North			0	0			2	2
Salter	6	Simpson	4	10	10	Simpson	3	13
Semisch	1	"Bartlesville"	0	1	4	"Bartlesville"		
					1	Mississippian ls.	2	7

Shinn	2	Mississippian ls.	1	3	1	Mississippian ls.	0	1
Smock-Sluss	3	"Bartlesville"	2	5	3	"Bartlesville"	2	5
Snowden-McSweeney			2	2	2	Mississippian ls.	1	3
Towanda			0	0	1	Mississippian ls.		
					5	Viola	5	11
Weaver			1	1			1	1
Young			2	2			1	1
Wildcats			10	10			15	15

"Mississippian chert" in the discovery well in sec. 36, T. 25 S., R. 3 E.; and (5) the **Joseph,** whose discovery well is in sec. 18, T. 25 S., R. 5 E. Discoveries in 1948 opened: (1) The **Guyot** field, sec. 5, T. 29 S., R. 5 E., with initial daily production of 30 barrels from the "Bartlesville"; (2) the **Combs Northeast,** whose discovery well, sec. 27, T. 29 S., R. 5 E., produced 50 barrels of oil daily from the "Bartlesville"; and (3) the **Towanda,** opened by a 40-barrel oil well in the Viola limestone in sec. 5, T. 26 S., R. 4 E.

Data on dry wildcat wells drilled in Butler County in 1948 are given in Table 15. Table 16, giving data on pool wells in Butler County drilled in 1947 and 1948, indicates the activity in the county.

CHASE COUNTY

Oil has been found in the southeastern corner of Chase County. The Teeter field has been extended into Chase County from Greenwood County and the Atyeo field has been extended westward from northwestern Greenwood and southwestern Lyon Counties. Production is from the "Bartlesville sand." Several gas pools have been found in the county. Gas production is from lower Permian and Pennsylvanian rocks.

In 1948, 1,074 barrels of oil were produced in the Chase County part of the Atyeo field; and 18,611 barrels in the part of the Teeter field that is in Chase County. Production in previous years is included in tables showing production in Greenwood and Lyons Counties. Locations of oil and gas fields in the county are shown in Figure 18.

Geology

SURFACE ROCKS

The consolidated surface rocks of Chase County are of Permian age. They include the lower part of the Sumner group, the Chase and Council Grove groups, and the upper part of the Admire group.

The youngest Permian rocks in Chase County comprise several feet of shale and thin limestone beds belonging to the lower part of the Wellington shale, the lowermost formation of the Sumner group. Rocks of the Chase group (Fig. 3) in Chase County are about 350 feet thick. Strata of this group are well exposed in the county in Flint Hills slopes. Numerous limestones are useful key beds in structural mapping. This group is characterized by flinty massive limestones and by gray, red, green, and chocolate-colored shales. The Fort Riley limestone member of the Barneston limestone, occurring as massive beds forming a rim near the tops of many slopes, underlies a dip slope which is extensive in the southwestern quarter of the county. The general thickness of the Council Grove group (Fig. 3) in Chase County is about 300 feet. Shale constitutes more than two-thirds of the total thickness. This group is characterized by highly colored shales in the Johnson and overlying shale formations and by thin limestones of various lithologies. Fusulines are common fossils in the limestones and in some of the shales.

The upper few feet of rocks of the Admire group are exposed along Cottonwood River in eastern Chase County and near the head of Verdigris River in the southeastern part of the county.

SUBSURFACE ROCKS

Pennsylvanian rocks.—Pennsylvanian rocks in Chase County are not greatly different from rocks of the same age in neighboring counties. The Wabaunsee and Shawnee groups are characterized by shale and relatively thin limestone beds. The thickness of the Wabaunsee section is about 475 feet and of the Shawnee about 500 feet. The Oread limestone, the basal formation of the Shawnee group, is about 75 feet thick. The Douglas group is almost entirely clastic material, but there is a persistent limestone approximately 100 feet below the top. This is probably the Haskell limestone. The thicknesses of Douglas rocks differ from place to place, which indicates that 50 or more feet of Missourian rocks was eroded locally before deposition of Douglas sediments. Sandstone, ranging from about 200 to 250 feet in thickness, commonly occurs in the basal part of the Douglas section. In places where the Douglas rocks are relatively thin, 30 feet or more of rocks identified as belonging to the Pedee group is present. The combined Lansing and Kansas City groups comprise approximately 400 feet of nearly solid limestone. The Pleasanton shale is approximately 100 feet thick and the underlying Marmaton group is about 130 feet thick. Slightly more shale than limestone is present in the Marmaton section. About 350 feet of Cherokee shale is present in most of Chase County. The Cherokee is thin or absent in the Nemaha anticline area. Pennsylvanian beds lie upon Pre-Cambrian rocks in the vicinity of Elmdale. Lee, Leatherock, and Botinelly (1948, pl. 13) show in detail the graph of Permian and Pennsylvanian rocks in the Aladdin Petroleum Corporation No. 1 Drummond well, sec. 15, T. 20 S., R. 7 E,

Mississippian rocks.—Mississippian limestone formations and the Chattanooga shale have been removed by post-Mississippian erosion from the Nemaha anticline area in the northwestern part of Chase County (Lee, 1939, pl. 1; 1940, Lee, Leatherock, and Botinelly, 1948, pl. 13, and Jewett and Abernathy, 1945, pl. 3). The total thickness of Mississippian limestones in the county ranges from a featheredge to slightly more than 400 feet. The maximum thickness of the Chattanooga shale is about 150 feet.

Pre-Chattanooga rocks.—The "Hunton" limestone and the Maquoketa shale are seemingly absent from most of Chase County. The Viola limestone and other rocks as old as some part of the Arbuckle limestone have been eroded from most of the Nemaha anticline in the county (McClellan, 1930; Ockerman, 1935, fig. 2). Lee, Leatherock, and Botinelly (1948, pl. 13) show the pre-Chattanooga section in Chase County east of the Nemaha anticline as comprising (1) Kimmswick limestone, (2) Simpson formation, (3) Arbuckle dolomite, and (4) Lamotte sandstone. Bonneterre dolomite and Lamotte sandstone were found high on the upthrown side of the Nemaha fault in the Drummond well, sec. 15, T. 20 S., R. 7 E. Keroher and Kirby (1948, fig. 3) did not recognize Lamotte sandstone in Chase County but show Roubidoux dolomite occurring next above the Pre-Cambrian surface except in the northeast part of the county where Bonneterre dolomite is shown as being in contact with the basement rocks. Accoring to Keroher and Kirby (1948, figs. 4, 8, and 9) the Jefferson City-Cotter section ranges from about 125 to 400 feet in thickness in the county; the Roubidoux dolomite ranges from slightly less than 100 to more than 150 feet in thickness; and the Bonneterre dolomite is present only in the northeastern part of the county where its maximum thickness is less than 50 feet.

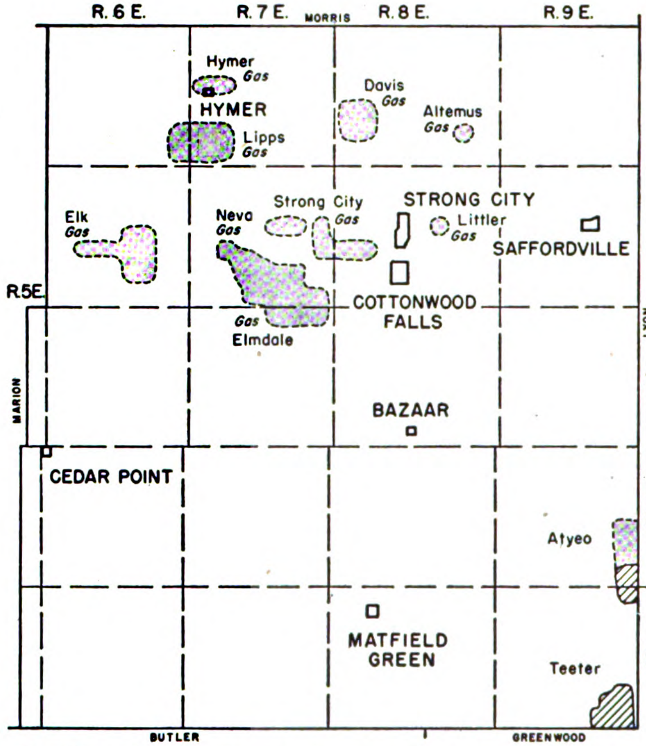

FIG. 18.—Map of Chase County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

Wallace Lee (personal communication) interpreted cuttings and logs of the Anderson et al. No. 1 Diggs well, sec. 13, T. 18 S., R. 9 E. Some of the results of his studies are shown in Table 17.

Oil and Gas Developments

Several wells have been drilled into Pre-Cambrian rocks in the Nemaha anticline in Chase County, but largely the county is poorly tested. One important exploratory well was drilled in 1948. It is the K. D. Anderson et al. No. 1 Diggs, SE¼ SE¼ NE¼ sec. 13, T. 18 S., R. 9 E., which was completed in June 1948 and is reported to be the only wildcat well drilled in the county during the year. It was abandoned in Arbuckle dolomite at 3,340 feet.

Early in 1949 four dry wildcats were drilled in Chase County and a fifth test is being drilled (March 1949) on the east flank of the Elmdale dome, a high on the Nemaha fold.

TABLE 17.—*Depths to some stratigraphic horizons in the K. D. Anderson et al. No. 1 Diggs well, SE¼ SE¼ NE¼ sec. 13, T. 18 S., R. 9 E., Chase County*

Horizon	Depth, feet
Top of Mississippian limestone	2,490
Top of Chattanooga shale	2,805
Top of Devonian limestone	2,925
Top of Viola dolomite	3,020
Top of Simpson group	3,090
Top of Arbuckle dolomite	3,170
Total depth of well	3,340

Locations of oil and gas producing areas in Chase County are shown in Figure 18. The **Teeter** oil pool extends north into Chase County from Greenwood County. The **Atyeo** pool extends from Lyon County into Chase County. Oil production in these pools is from the "Bartlesville sand."

The **Davis** gas field produces from Lower Permian rocks at depths from 350 to 400 feet. The **Elk** gas field produces from Lower Permian rocks at an average depth of about 500 feet. The **Elmdale** gas field produces from Lower Permian rocks also.

The **Lipps** gas field produces gas from a sandstone in the Lawrence shale at a depth of about 1,150 feet. The **Neva** field yields gas from Lower Permian rocks at depths ranging from 200 to 450 feet. The **Strong City** gas field produces from Lower Permian rocks at about 200 feet.

CHAUTAUQUA COUNTY

Oil was discovered in the Peru field in Chautauqua County in 1900. Later large continuous areas in the vicinities of Sedan, Peru, and Chautauqua have been developed into oil and gas fields.

During 1948 Chautauqua County produced 832,965 barrels of oil. Natural gas production for 1948 is not available. Oil produc-

TABLE 18.—*Oil production in Chase County during 1948*

Field	No. of wells	Bbls. oil
Atyeo[1]	1	1,074
Teeter[2]		18,611
Totals	1	19,685

[1] Field extends into Lyon and Greenwood Counties; production for 1944 through 1947 given under Lyon County.
[2] Field extends into Greenwood County; production for 1944 through 1947 given under Greenwood County.

tion statistics in the county during the years 1900 to 1948 inclusive are shown in Tables 2 and 2a. Table 19 shows production in the various oil fields in the county for 1944 through 1948. Water flooding is an important phase of the development in the county (Table 3; Fig. 2). There were 11 projects operated in 1948.

Figure 19 shows locations of oil and gas fields in Chautauqua County and the areas of oil production during 1948.

Geology

SURFACE ROCKS

The consolidated surface rocks of Chautauqua County consist of alternating beds of limestone and shale and some sandstone. The rocks exposed belong to the Council Grove and Admire groups of Permian age and the Wabaunsee, Shawnee, Douglas, Pedee, and Lansing groups of Pennsylvanian age. The youngest consolidated rocks, those of the Council Grove group, are in the northwestern part of the county in Ts. 30 and 31 S., R. 8 E.; the oldest outcropping rocks, those of the Lansing group, are at the surface in the southeastern part in T. 34 S., R. 13 E. (Moore and Landes, 1937).

Permian rocks.—The lower part of the Eskridge shale, Council Grove group (Fig. 6), is the youngest consolidated rock in Chautauqua County. The total thickness of the Council Grove group in the county is about 150 feet. Rocks of the Admire group, which are chiefly clastic materials, have a total thickness of about 90 feet.

Pennsylvanian rocks.—The Wabaunsee group (Fig. 4) comprises shale, sandstone, and thin beds of limestone. The total thickness of these rocks in Chautauqua County is about 550 feet. The Shawnee group consists of shale, sandstone, and limestone. The limestones are generally thicker than those of the Wabaunsee group. The average thickness of the Shawnee group is about 450 feet in Chautauqua County. The Douglas and Pedee groups, consisting chiefly of clastic materials, are about 300 feet thick. The Stanton limestone is the only formation of the Lansing group that crops out in the county. The upper part of the Stanton is exposed in the southeastern part of the county.

SUBSURFACE ROCKS

Pennsylvanian rocks.—The Lansing group is about 150 feet thick in Chautauqua County. The Kansas City group consists largely of limestone and contains some shale and sandstone. The sandstone in the upper part of this group is called "Layton sand." The total thickness of the Kansas City group in the county is about 450 feet. The Bronson subgroup of the Kansas City section is almost entirely limestone. The Pleasanton shale in the county has an average thickness of about 50 feet.

The Marmaton group consists of about 320 feet of alternating beds of limestone and shale and some sandstone. Important producing sandstones in the Marmaton are the "Old Red" or "Wayside" in the Nowata shale, the "Weiser" in the Bandera shale, and the "Peru" in the Labette shale.

The Cherokee shale is composed chiefly of shale (partly sandy), sandstone, and a few thin beds of limestone and coal. Its thickness in Chautauqua County ranges from 250 to 450 feet. The "Bartlesville sand" occurs as lenticular bodies lying at a depth of about 180 feet below the top of the Cherokee shale. The "Burgess sand" is the basal part of the Cherokee and fills depressions on the surface of the Mississippian limestone.

Mississippian rocks.—The Mississippian limestone in Chautauqua County ranges in thickness from less than 150 to more than 350 feet (Lee, 1939, pl. 1). The Mississippian section is thinnest over the axis of the Longton anticline in the northeastern part of the county and thickest in the west-central part. The "Warsaw," Reeds Spring, and St. Joe limestones, the Northview shale, and the Compton limestone are present in the eastern part of Chautauqua County. The Chattanooga shale is about 35 or 40 feet thick in eastern Chautauqua County. The "Warsaw" limestone and the Cowley formation, which lies directly on pre-Chattanooga rocks, are present in the western part of the county. Large quantities of oil and gas are produced in Chautauqua County from a porous zone in the upper part of the Mississippian limestone.

Ordovician and Cambrian rocks.—The total thickness of lower Ordovician and upper Cambrian rocks in the Sinclair Prairie No. 9 Brown well, in sec. 26, T. 34 S., R. 11 E., is 875 feet. Oil is produced from a porous zone in the upper part of the Cotter dolomite (upper part of the Arbuckle) of Ordovician age. This zone

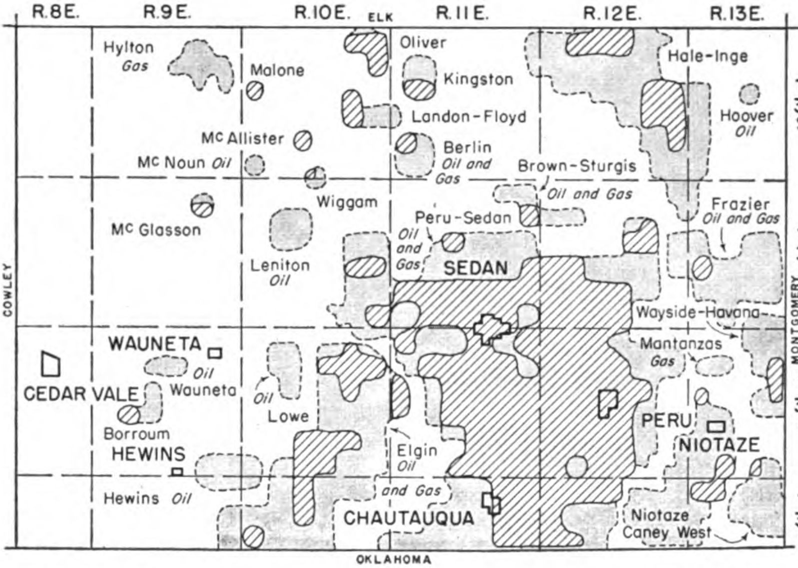

Fig. 19.—Map of Chautauqua County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

is locally called the "Siliceous lime" and sometimes is erroneously designated as "Wilcox."

Keroher and Kirby (1948, pl. 6) made the following identifications from the cuttings of the Brown well: Jefferson City-Cotter dolomite, 447 feet; Roubidoux dolomite, 165 feet; Van Buren-Gasconade, 143 feet; Eminence dolomite, 15 feet; Bonneterre dolomite and Lamotte sandstone, 26 feet. The top of the Arbuckle rocks (Cotter dolomite) was encountered at 2,208 feet in this well. The well was drilled a few feet into Pre-Cambrian rocks, which occur next below the Lamotte sandstone.

Oil and Gas Developments

Oil and gas are produced in Chautauqua County from the "Wayside sand" in the Nowata shale (known locally as the "Old Red sand"); from the "Peru sand," in the lower part of the Marmaton group; from the Little Osage shale (locally called "Hancock") member of the Fort Scott limestone; from the "Bartlesville sand" in the middle part of the Cherokee shale; from the "Burgess sand" in the basal part of the Cherokee shale; from the upper part of the Mississippian limestone; and from the upper part of the Cotter dolomite of Ordovician age.

Oil and gas have been found in every township in Chautauqua County except in those along the western edge (Fig.19). The largest oil-producing areas are near Sedan, Chautauqua, and Elgin. Most of the oil wells in the county are small producers but are noted for their long life; some of the wells have produced for as long as 35 years.

The Peru, Sedan, Monett, and Chautauqua areas have been extended and now form one large area. This is called the **Peru-Sedan** field and covers most of the south-central part of the county. The **Hale-Inge** gas and oil field is in the northeastern part of the county; it extends northward into Elk County. The **Elk City** gas field of southeastern Elk County extends southward into Chautauqua County.

In 1935, oil was discovered in the Arbuckle dolomite at a depth of 2,300 feet in the **Oliver** pool in secs. 1 and 2, T. 32 S., R. 10 E. Later oil was discovered in the Arbuckle dolomite in the vicinity of **Monett** and in the **McAllister** area. The dolomite was encountered at a depth of 1,790 feet in the Monett area. Gas and oil are also produced in these areas from the upper part of the "Mississippi lime." Oil and gas in the "Mississippi lime" and in the Arbuckle dolomite accumulated in anticlinal structures. Oil and gas accumulations in Pennsylvanian sandstones were controlled by changes in porosity and by minor structural elements. The oil and gas fields, as defined by the Nomenclature Committee of the Kansas Geological Society, are shown on Figure 19. Table 19 gives oil production in the various fields for 1944 through 1948.

The **Berlin** oil and gas field produces oil from the "Mississippian chat" according to available logs. Gas was found in this field in several sandstones in the Kansas City and Marmaton groups. Oil production in the **Borrum** oil and gas field is chiefly from the lower part of the Marmaton rocks at a depth of about 1,780 feet. Gas, according to available logs, occurs principally in the upper part of Mississippian limestone at a depth of about 2,120 feet.

The **Caney West** oil and gas field extends into southeastern Chautauqua County from Montgomery County. Oil occurs in the "Peru sand" and in sandstone in the middle and basal parts of the Cherokee group.

Elgin is a large oil and gas field. Oil is produced from the "Peru sand." The **Frazier** gas field is reported to be abandoned. Gas was found at a depth of about 550 feet, in lower Marmaton rocks at about 1,275 feet, and in the upper part of the Mississippian limestone.

The **Hale-Inge** oil and gas field is in northeastern Chautauqua County and southeastern Elk County. Oil production is from the "Peru sand." Gas was found in this field in the "Peru sand," the "Oswego lime," and upper part of Mississippian rocks. The **Hewins** field is no longer producing. Gas and oil were found in upper Lansing or Pedee rocks at a depth of about 1,100 feet.

The **Hoover** field had no reported oil production in 1948. Former production probably was from the "Burgess sand" at a depth of about 1,550 feet.

The **Hylton** gas field is in the northwestern part of Chantauqua County. Gas was found in this area in rocks of the Kansas City group at a depth of about 1,300 feet. The **McGlasson** oil field is described in the same area.

Production in the **Kingston** field is reported to be from "Mississippian chat" at a depth of about 1,750 feet. One dry hole was reported in the field in 1948.

The **Landon-Floyd** oil field yielded 39,627 barrels of oil in 1948. The field is one of the more important ones of the county, having 31 producing wells. The **Leniton** oil field is no longer producing. Former production was from the "Peru sand." The **Lowe** field had no oil production reported in 1948. Production was from the "Peru sand."

The **Malone** oil field has been reactivated. Logs of the wells are not available to the writer. Logs of the producing wells in the **Mantanzas** gas field are not available. Gas probably occurs in "Chat" at the top of Mississippian rocks.

The **McAllister** field yields oil from the Arbuckle dolomite. The **McGlasson** oil field is within the area of the Hylton gas field. Three oil wells were drilled in the field in 1948. The **McNoun** field is inactive. Available records show that wells were plugged in 1928 and 1933. The **Niotaze** oil and gas field is in southeastern Chautauqua County. Production chiefly is from the "Peru sand" at a depth of about 825 feet. The **Oliver** oil field extends into Elk County. Production is from Arbuckle rocks.

TABLE 19.—*Oil production in Chautauqua County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Berlin	1	6,094	1	6,036	1	5,549	1	3,166	1	2,130
Borroum	5	4,810	5	4,608	10	4,276	5	4,275	5	4,019
Brown-Sturgis	4	490	4	503	4	230	4	885	5	521
Caney West	17	1,801	17	991	17	958	17	1,433	17	4,156
Elgin	5+	43,894	5+	34,600	5+	31,787		40,611		37,792
Frazier										424
Hale-Inge[1]	62	27,997	63	21,299	61	20,134	65	17,094	69	15,695
Kingston		13,655		14,033		2,778		4,149		2,799
Landon-Floyd	23	45,228	25	50,167	28	47,999	27	38,511	31	39,627
McAllister	3	8,315	4	11,553	6	13,426	6	11,070	6	9,100
McGlasson										5,236
Malone			1	973	1	643	1	615	1	388
Niotaze	10+	834	9+	448	9+	351	10+	420	12+	890
Oliver[1]	18	19,902	18	17,691	18	15,674	18	12,990	18	12,511
Peru-Sedan	1,108+	705,668	1,163+	468,099	1,127+	646,825	1,158+	690,291	1,106+	691,698
Wayside-Havana[2]	14	2,386	14	1,950	17	1,912	16	1,978	21+	3,454
Wiggam	8	2,324	8	2,021	8	1,792	6	1,713	6	1,399
Miscellaneous	11+	1,049	11	644			13+	1,334	1+	1,126
Totals	1,289+	884,507	1,348+	635,616	1,312+	794,334	1,347+	830,535	1,299+	832,965

[1] Field extends into Elk County.
[2] Field extends into Montgomery County.

The **Peru-Sedan** oil and gas field covers a large area in south-central Chautauqua County, much of which is active oil-producing territory (Fig. 19). Oil production chiefly is from the "Peru sand" at an average depth of about 1,000 feet. Five new oil wells were reported in the field in 1948. The area includes more than 1,100 wells which produced 691,698 barrels of oil in 1948.

The **Wayside-Havana** oil and gas field extends into Chautauqua County from Montgomery County. Oil and gas in this field occur in several Pennsylvanian sandstones, especially the "Wayside sand." Gas occurs in Mississippian rocks; wells having an initial production of 6 million cubic feet of gas per day have been reported. In the **Wiggam** oil field production is from sandstone in upper part of the Cherokee group at a depth of about 1,600 feet. The sandstone locally is called "Wiser."

CHEROKEE COUNTY

Cherokee County is the only county in southeastern Kansas where commercial quantities of oil and gas have not been discovered. However, a few wells in this county have supplied small quantities of gas for many years. The producing zone is the "Bur-

TABLE 20.—*Depths to some stratigraphic horizons in two Cherokee County wells*

Horizon	Glower et al. No. 1 Forkner, NE¼ SE¼ sec. 17, T. 33 S., R. 23 E.	Jayhawk Ordnance Works water well, NW cor. SE¼ NE¼ sec. 4, T. 34 S., R. 25 E.
Top Spergen limestone	316	
Top "Warsaw" limestone	331	
Top Burlington-Keokuk limestone	393	22
Top Reeds Spring limestone	528	157
Top St. Joe limestone	660	285
Top Northview shale	675	307
Top Compton limestone	680	312
Top Cotter dolomite	685	314
Top Jefferson City dolomite	792	419
Top Roubidoux formation	1,065	719
Top Gasconade dolomite	1,262	874
Top Eminence formation	1,496	
Top Bonneterre dolomite	1,617	
Top Lamotte sandstone	1,806	

gess sand" in the basal part of the Cherokee shale, which ranges in depth from a few feet to about 300 feet. Oil shows have been reported from the "Bartlesville sand" and from pre-Pennsylvanian rocks (probably Mississippian).

GEOLOGY

SURFACE ROCKS

Surface rocks in Cherokee County are Pennsylvanian and Mississippian in age. Cherokee is the only county in the State where Mississippian rocks are exposed.

Pennsylvanian rocks.—The Labette shale of the Marmaton group (Fig. 5) is the surface rock in the extreme northwestern part of Cherokee County where it lies beneath northwestward-trending dip slopes. The Fort Scott limestone crops out in a narrow belt to the south and east.

The Cherokee shale (Fig. 6) crops out in Cherokee County in a broad northeastward-trending belt 18 to 27 miles wide covering the entire county except the extreme northwestern and southeastern parts. The Cherokee consists of light to dark-gray and black shale, sandstone, numerous coal beds, and a few thin beds of limestone. Its maximum thickness is about 500 feet. It increases in thickness to the southwest. The increase occurs principally in beds below the Ardmore limestone, which lies about

100 feet below the base of the Fort Scott limestone. Sandstone occurs in several different zones but most of these sandstone beds are not persistent. Some of them are shoestring sands, which are elongated channel fillings or bars. The Cherokee shale is not readily divisible into formations unless cyclic units (cyclothems) are regarded as formations.

Mississippian rocks.—Rocks of Mississippian age (Fig. 6) are exposed in a small area in the southeastern part of Cherokee County. They consist of light-gray cherty limestones, medium to coarse in texture. They probably include a few feet of Spergen limestone of Chesterian age. The Warsaw limestone of Meramecian age and the Keokuk limestone of Osagian age comprise most of the exposed section. The total thickness of outcropping Mississippian rocks in Cherokee County is about 50 feet.

SUBSURFACE ROCKS

Many lead and zinc test holes have penetrated Mississippian rocks in Cherokee County. Many wells in this and adjoining counties have penetrated the uppermost part of the Arbuckle rocks. Water wells in this area have encountered the Roubidoux sandstone or deeper beds, but only a few wells have reached Pre-Cambrian rocks.

Subsurface geologic conditions in the central part of Cherokee County are shown in Plate 1. Depths to some stratigraphic horizons in two deep wells in Cherokee County are given in Table 20.

Mississippian rocks.—The divisions of the Mississippian in Cherokee County are the Spergen, "Warsaw," Keokuk-Burlington, Reeds Spring, and St. Joe limestones, the Northview shale, and the Compton limestone. The Spergen limestone is thin and is of local occurrence. The thickness of the Mississippian rocks in the county ranges from about 335 to 380 feet. Numerous sinkholes have been formed in the northeastern part of the county by subsidence of the roofs of solution caverns in a zone near the top of the Mississippian limestone. The Chattanooga shale is not known to be present.

Ordovician rocks.—In Cherokee County all Ordovician rocks younger than the Cotter dolomite were removed by erosion before deposition of Mississippian sediments. Ordovician formations in the county are the Cotter dolomite, including the Swan Creek sandstone member at its base; the Jefferson City dolomite; the Roubidoux formation; and the Gasconade and Van Buren dolomites (undifferentiated), including the Gunter sandstone member at the base. The thickness of the Cotter dolomite in Cherokee County ranges from about 70 to 140 feet. Its thickness is not uniform because of the erosional disconformity below Mississippian rocks. The Cotter dolomite is locally absent about 4 miles north of Cherokee County in Crawford County. The Jefferson City dolomite ranges in thickness from 275 to 300 feet in Cherokee County. The Roubidoux formation consists of sandstone and dolomite. Some of the dolomite is sandy. The Roubidoux has an average thickness of about 170 feet. The formation includes two sandstone members which bear large quantities of water. The upper member, in the middle part of the formation, is about 15 feet thick; the lower member, in the basal part of the formation, is about 25 feet thick. The depth to the Roubidoux formation ranges from about 715 feet in the eastern part of the county to about 1,200 feet in the western part. The undifferentiated Gasconade and Van Buren dolomites range in thickness from about 100 to 265 feet. The Gunter sandstone ranges in thickness from about 5 to 20 feet. An unconformity separates the Gunter sandstone from underlying Cambrian rocks.

Cambrian rocks.—The Cambrian rocks in Cherokee County consist of the Eminence and Potosi dolomites (undifferentiated), Bonneterre dolomite, and Lamotte sandstone. The undifferentiated Eminence and Potosi dolomites have an average thickness of about 150 feet. The rocks between the top of the Cotter dolomite and the base of the Potosi dolomite are conveniently termed Arbuckle. The Bonneterre dolomite is about 175 feet thick in four wells. The Bonneterre is transitional into the underlying Lamotte sandstone. The Lamotte has an average thickness of about 65 feet in three wells. In some wells in Cherokee and adjoining counties a zone of detrital igneous material is found at the base of the Lamotte sandstone. Interpretation of cuttings from the Ordovician and Cambrian sections of two wells in Cherokee County were shown by Keroher and Kirby (1948, pl. 6).

Pre-Cambrian rocks.—Pre-Cambrian rocks are about 1,900 feet below the surface in the western part of Cherokee County and about 1,800 feet below the surface in the eastern part. Pre-Cambrian rocks are encountered about 875 feet below sea level at Columbus, Kansas, and their top is nearly level from Columbus to Carthage, Missouri, about 30 miles to the east. A deep well 12 miles west of Columbus reached Pre-Cambrian rocks at about 1,087 feet below sea level. This is 212 feet lower than the top of the Pre-Cambrian rocks at Columbus.

CLAY COUNTY

A small amount of oil was produced several years ago in sec. 21, T. 9 S., R. 4 E. in Clay County. The oil was found in the "Mississippian chat" at a depth of 1,774 feet.

Geology

SURFACE ROCKS

Cretaceous rocks.—Cretaceous sandstone, shale, and clay having a maximum thickness of approximately 250 feet are present in the western part of Clay County. These sediments overlap Permian rocks. Plummer and Romary (1942) have made preliminary studies of Cretaceous rocks in this part of Kansas.

Cretaceous rocks belonging to the Dakota and Kiowa formations have been identified in Clay County. Dakota sandstones and shales commonly lie on the Kiowa shale; locally they overstep the Kiowa and rest on Permian rocks. Massive sandstones are conspicuous in the Dakota formation, but the amounts of clay and sandstone are about equal. The maximum thickness of the Dakota in the county is approximately 200 feet. The Kiowa shale has a maximum observed thickness of about 50 feet. It consists almost entirely of dark rather fissile shale.

Permian rocks.—Permian sediments, including the lower part of the Sumner group and the upper part of the Chase group, crop out in the southeastern half of Clay County. The oldest well-exposed bedrock is the Fort Riley limestone. Rocks of the Chase group (Fig. 3) in Clay County are about 350 feet thick. Massive limestones, some of which are flinty, and bright-colored shales are characteristic. The Wellington formation consists chiefly of red and gray shales and thin impure limestones.

SUBSURFACE ROCKS

Clay County is in the central part of the North Kansas basin and on the eastern flank of the Salina basin. Subsurface geologic

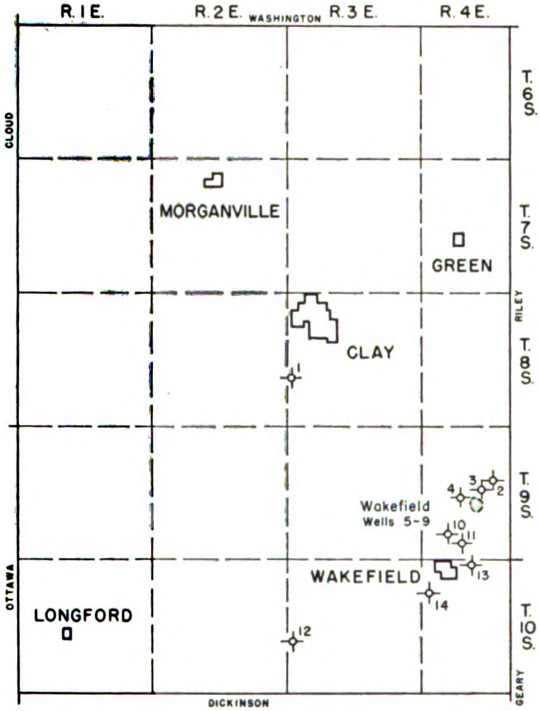

Fig. 20.—Map of Clay County showing location of wells listed in Table 22.

conditions in the central part of the county are shown diagrammatically on Plate 4.

Depths at which some key stratigraphic horizons were reached in the J. F. Boggess et al. No. 1 Younkin well, in the SW¼ SE¼ sec. 21, T. 9 S., R. 4 E., are given in Table 21.

Table 21.—*Depths to some key horizons in the J. F. Boggess et al. No. 1 Younkin well, SW¼ SE¼ sec. 21, T. 9 S., R. 4 E., Clay County*

Horizon	Depth, feet
Base of Wreford limestone	125
Top of Shawnee group	1,050
Base of Oread limestone	1,335
Top of Lansing group	1,390
Base of Bronson subgroup (Hertha limestone)	1,755
Top of Mississippian limestones	1,890
Top of Kinderhookian rocks	2,002
Top of Siluro-Devonian rocks	2,194
Top of Maquoketa shale	2,545
Top of Viola limestone	2,585
Top of St. Peter sandstone	2,745
Total depth	2,792

TABLE 22.—*Data on wells drilled for oil and gas in Clay County*

No. on map	Name of well	Location	Completion date	Total depth, feet	Remarks
1	Nebraska Oil Co. No. 1 Fevier	SW¼ SW¼SW¼ 19-8-3E	12-16-31	2,860	Show of oil in "chat" 2,198-2,213 feet; no log from 2,700-2,860 feet
2	Derby Oil Co. No. 1 McNeil	Cen. SW¼ NW¼ 15-9-4E	4-10-29	2,156	Show of oil in "chat" at 1,895 feet
3	Skow Bros., Ritchey, & Wentworth No. 1 Gates	SE cor. SW¼ 15-9-4E	9-29-29	2,662	Light show oil at 1,825 feet; in "chat"; well stopped in St. Peter ss.
4	J. F. Boggess et al. No. 1 Bradbury	NE¼ NE¼ 20-9-4E	4- 8-24	1,855	Top Mississippian ls. 1,787 feet
5	Roth & Faurot No. 1 Bradbury	SE¼ SW¼ SE¼ NW¼ 21-9-4E	9-20-28	1,777	50 bbls. initial daily prod. from "chat" at 1,774 feet
6	Veeder Supply & Devel. Co. No. 1 Glace	Cen. N. line 21-9-4E	1-29-46	1,850	Top Mississippian ls. 1,787? feet; show of oil 1,787½ feet
7	J. F. Boggess et al. No. 1 Younkin	SW cor. SE¼ 21-9-4E	11-23-23	2,792	Stratigraphic data in Table 19
8	Siedl Bros. No. 1 Younkin	Cen. S. line SE¼ NW¼ 21-9-4E	7-24-35	1,778	600 feet of oil in hole at 1,777 feet; top "chat" 1,772 feet
9	Henderson & Holden & Skow Bros. No. 2 Younkman	Cen. NW¼ SE¼ 21-9-4E	9-22-25	1,952	Show of heavy oil at 1,887-1,892 feet; top "chat" 1,880 feet
10	Nelson Synd. No. ? Peter Yarrow	SW¼ SW¼ 29-9-4E	?	2,443	Show of oil 1,820 feet; top Mississippian ls. 1,790 feet
11	J. F. Boggess No. 1 Fleming	SE cor. NE¼ NE¼ 32-9-4E	?	1,890	Top Mississippian ls. 1,770 feet
12	Derby Oil Co. No. 1 Neimoller	Cen. NW¼ SW¼ 19-10-3E	1-5-30	3,110	Stopped in St. Peter ss.; top Mississippian ls. 2,227 feet
13	H. M. Rizor No. 1 Myers	NE¼ NW¼ NW¼ 4-10-4E	9-12-35	1,860	Oil & gas show 1,620 feet in Pleasanton gr.; top Mississippian ls. 1,760; stopped in Kinderhookian
14	Henderson & Holden No. 1 Faidley	SE cor. NW¼ 7-10-4E	?	2,070	Well stopped in Kinderhookian

OIL AND GAS DEVELOPMENTS

Oil was produced several years ago from the Roth and Faurot No. 1 Bradbury well in sec. 21, T. 9 S., R. 4 E., which was completed in December 1928. Oil was found in "Mississippian chat" at a depth of 1,774 feet, and it is reported that 3,600 barrels of oil was produced in 2 years.

Some data on wells that have been drilled in Clay County are given in Table 22. Locations of the wells are shown in Figure 20.

COFFEY COUNTY

Oil was first discovered in Coffey County, near Le Roy, in 1903, but important production did not start in the county until 1916. Oil fields are confined to the southern and southwestern parts of the county. Oil is produced from lower Pennsylvanian and Mississippian rocks.

During 1948, Coffey County produced 85,172 barrels of oil. Table 23 shows oil production in the county from 1944 through 1948. Total production figures for Coffey County for the years 1914 to 1948, inclusive, are shown in Tables 2 and 2a.

Oil fields and areas of 1948 oil production in Coffey County are differentiated in Figure 21.

Geology

SURFACE ROCKS

Much of the upland surface of Coffey County is mantled with relatively coarse flint gravel of probable Tertiary age. Recent and Pleistocene alluvium partly fills the valleys of Neosho River and smaller streams. Surface bedrocks of Pennsylvanian age belong to the Virgilian and Missourian Series. The oldest exposed Pennsylvanian rocks occur in the southeastern part of Coffey County. However, the wide trench of Neosho River in this area causes difficulty in stratigraphic studies. The youngest bedrock is the White Cloud shale and the oldest exposed rock is the Stanton limestone.

Rocks in the lower part of the Wabaunsee group (Fig. 4) are present in the northwestern part of Coffey County. Several feet of White Cloud shale is exposed. This is underlain by the Howard limestone, which is about 15 feet thick. The Nodaway coal bed is a short distance below the most prominent part of the Howard limestone. The thickness of the Severy shale, lowest formation of the Wabaunsee group, is about 65 feet.

Rocks of the Shawnee group (Fig. 4) are well exposed in many places in Coffey County. These rocks are characterized by scarp-forming limestones, light and dark shales, and lenticular sandstones. The total thickness of the group is about 400 feet. The Oread limestone lies below an extensive dip slope which ranges in width from about 5 to 15 miles and extends from the northeastern to the southwestern part of Coffey County. Other limestones in the group lie below narrower dip slopes. Various members of the limestone formations are easily recognized key beds.

Rocks of the Douglas group (Fig. 4) are chiefly shales and sandstones; in Coffey County this group ranges in thickness from about 200 to 275 feet. The group comprises the Lawrence and Stranger formations, which are separated locally by a disconformity. The Lawrence shale includes a local limestone, the Amazonia?, about 25 feet below the top of the formation, and the Williamsburg coal bed, a few feet above the Amazonia? limestone. Local unconformities occur in the Lawrence shale. Subsurface studies indicate that much cutting and filling took place during the time of deposition of the upper part of the Lawrence rocks. Throughout Kansas and in neighboring states, the Douglas rocks are separated from underlying older rocks by a major erosional unconformity.

A few feet of Weston shale, lowermost formation of the Pedee group (Fig. 5) crops out at the surface in the southeastern part of Coffey County. Locally in the subsurface a maximum thickness of about 20 feet of Iatan limestone and about 40 feet of Weston shale are present. The Weston shale includes several feet of sandstone in its middle and upper parts. Well records show that Douglas rocks rest on Stanton limestone and that Pedee rocks were removed by pre-Douglas erosion in much of the county.

Dip slopes of the upper limestone members of the Stanton formation of the Lansing group extend into southeastern Coffey County. Exposures of these rocks are rather poor. The Lansing rocks are about 90 feet thick in the subsurface. About 10 feet of shale separates the Stanton and Plattsburg limestones.

SUBSURFACE ROCKS

Coffey County lies on the northwestern flank of the Chautauqua arch. Ordovician rocks dipping to the northwest were beveled by erosion and are buried under Mississippian sediments. The subsurface section includes Pennsylvanian, Mississippian, Ordovician, Cambrian, and pre-Paleozoic rocks. Geologic conditions in the eastern part of Coffey County are shown on Plate 2.

Pennsylvanian rocks.—The thickness of rocks of Pennsylvanian age from the base of Oread limestone, which crops out in the southeastern part of Coffey County, to the base of the Cherokee shale is about 1,300 feet. Douglas rocks range from about 200 to 300 feet in thickness in the county. This difference in thickness is due to differential erosion of Lansing rocks before deposition of Douglas sediments. Lower Douglas rocks lie on formations which range downward from the Iatan limestone to the Stanton limestone. Rocks of the Lansing and Kansas groups are similar in Coffey and adjacent counties. The combined thickness of these groups is about 430 feet. Because of the irregular surface upon which Pleasanton rocks lie, the thickness of the Pleasanton shale in the county ranges from about 100 to 150 feet. The Marmaton rocks range in thickness from about 150 to 200 feet. Locally, Pleasanton rocks lie upon a surface near the top of the Altamont limestone. In other places, however, all of the Marmaton formations are present. Cherokee rocks are about 375 feet thick in Coffey County.

Mississippian rocks.—The Mississippian limestone formations in Coffey County range in total thickness from slightly less than 300 feet to a little more than 350 feet (Lee, 1939, pl. 1). The Chattanooga shale is about 50 feet thick. It is somewhat sandy in the middle part.

Pre-Chattanooga rocks.—Rocks of Devonian age (unless the Chattanooga shale is in part Devonian) and of Silurian age are absent from Coffey County. The Viola limestone and the St. Peter sandstone (Ordovician) are absent from the southeastern part of the area. The maximum thickness of the Viola limestone is about 50 feet, and the St. Peter sandstone has about the same thickness. Arbuckle rocks underlie the St. Peter sandstone and rest directly on Pre-Cambrian rocks. The average thickness of the Arbuckle is probably about 550 feet.

According to Keroher and Kirby (1948, figs. 3, 4, 5, 6, 8, 9) the Cotter-Jefferson City sequence ranges from about 200 feet in the northern part of Coffey County to more than 400 feet in the southwest part; the Roubidoux dolomite less than 100 feet; the Van Buren-Gasconade sequence from about 25 to 100 feet; the Eminence dolomite from a featheredge to 50 feet; the Bonneterre between 50 to 100 feet. They indicate that the Bonneterre dolomite lies on Pre-Cambrian rocks.

Oil and Gas Developments

The **Dunaway** and **Virgil North** pools extend from Greenwood County into southwestern Coffey County, and the **Winterscheid**

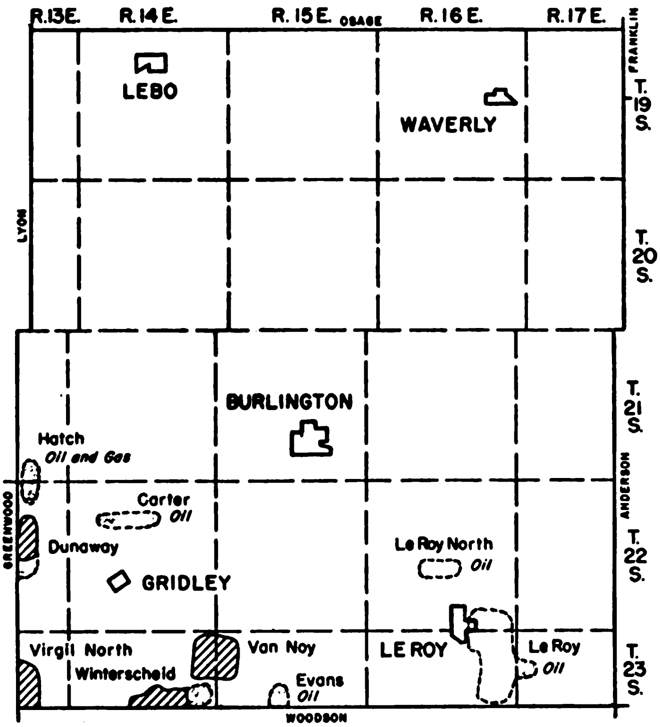

Fig. 21.—Map of Coffey County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

pool extends into Coffey County from Woodson County. Oil is produced in these pools from the "Bartlesville sand."

In 1928 the Union Gas Corporation No. 1 Carter well in sec. 8, T. 22 S., R. 14 E., was completed. An initial flow of 1,178,650 cubic feet of gas was reported at 1,355 feet. The producing formation is a sandstone in the upper part of the Cherokee shale. The pool is known as the **Carter** gas pool.

The **Hatch** pool was discovered in 1930, when oil was found in a basal Pennsylvanian sandstone ("Burgess") at a depth of about 1,825 feet. The discovery well, the Prairie Oil and Gas Company No. 1 Hatch in the NW¼ SE¼ sec. 35, T. 21 S., R. 13 E., had an initial daily production of 80 barrels. In the same year a 15-barrel oil well was completed in the SW¼ NE¼ of the same section, and in 1935 a gas well having a reported initial flow of 300,000 cubic feet of gas per day was drilled at the Cen. S. line NE¼ SE¼ of the section.

TABLE 23.—*Oil production in Coffey County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Dunaway[1]				See Greenwood County					7+	8,528
LeRoy[4]										
Van Noy	30	15,836	24	15,286	33	14,258	19	12,970	23	14,499
Virgil North[2]				See Greenwood County						47,542
Winterscheid[3]				See Woodson County						14,603
Totals	30	15,836	24	15,286	33	14,258	19	12,970	30+	85,172

[1] Field extends into Greenwood County.
[2] Field extends into Greenwood and Woodson Counties. Some of production estimated.
[3] Field extends into Woodson County.
[4] No production recorded.

Oil in the **Van Noy** pool was found in the upper part of the Mississippian limestone at depths of about 1,540 feet. Two wells were reported to have had an initial production of 100 barrels of oil per day. Smaller production was found in other wells. Although oil was discovered here earlier, most of the drilling was done in 1935 and 1936. It is reported that in the Van Noy field there is some production from the "Peru sand." There were 23 producing oil wells in this field in December 1948.

Many shallow wells have been drilled in Coffey County but much of the county is untested for stratigraphic traps in older rocks. In 1948 seven small oil wells and one dry hole were drilled in the Dunaway field; two oil wells were drilled in the Van Noy field. Two dry wildcats were drilled near Gridley and some drilling was reported in the old Le Roy field. Early in 1949 a well was being drilled in the Hatch field.

COWLEY COUNTY

Cowley County has been an important producer of oil and gas for many years. Gas was found near Winfield as early as 1902. Natural gas discovered near Dexter in 1905 attracted much interest because of its helium content; a plant for the extraction of the helium was built at Dexter in 1927. Although oil was discovered near Dexter in 1914, the first important oil field in the county, the Peacock, was opened in 1916. Extensive developments took place in the 1920's. The geology and oil and gas resources of the county have been described comprehensively by Bass (1929). Recently subsurface conditions in western Cowley County have been interpreted in a cross section from Marion County, Kansas, to Osage County, Oklahoma, by Lukert (1949).

In 1948 Cowley County produced 2,592,991 barrels of oil. Natural gas production during the year was approximately 100 million cubic feet. Peak production of oil in the county was attained in 1925, when the county produced 7,038,874 barrels of oil. Nearly four million barrels came from the Rainbow Bend field that year. Since 1925, production has been declining gradually; in 1926 it had dropped to 3,943,061 barrels; and in 1941 to 2,861,706 barrels.

Oil production in Cowley County during the years 1914 to 1948 inclusive is shown in Tables 2 and 2a. Production in the county's various fields for 1944 through 1948 is shown in Table 24. Table 25 shows the gravity of some samples of oil from Cowley County fields as reported by the U. S. Bureau of Mines (Lane and Garton, 1943).

Figure 22 shows the locations of oil and gas fields in Cowley County and areas that produced gas in 1948. Three water-flooding and two gas injection projects are being operated in Cowley County. During 1945 four new oil fields were opened; three in 1947, and two in 1948 (Table 1).

Geology

SURFACE ROCKS

The geology of Cowley County with special reference to the occurrence of oil and gas was described by Bass (1929). Flint gravels, Recent to Tertiary (?) in age and 20 feet or less in thickness, are present at the surface in many parts of Cowley County and are commercially important in several localities. The exposed bedrocks in Cowley County belong to the Sumner, Chase, Council Grove, and Admire groups of the Permian System and the Wabaunsee group of the Pennsylvanian System.

Permian rocks.—The youngest bedrock in Cowley County is the lower part of the Wellington shale which is present in most of the westernmost tier of townships. The rocks of the Chase group (Fig. 3) average about 375 feet in thickness and they occupy about half the surface of the county. The Herington limestone member of the Nolans formation is about 30 feet thick. Its basal part consists of about 5 feet of fossilferous limestone; the remainder is dolomitic and less fossiliferous. It is a useful key bed. The Barneston limestones are especially conspicuous. The Florence member lies below extensive dip slopes and the Fort Riley member crops out in wall-like cliffs near the top of Flint Hills slopes. The Council Grove group has an average thickness of about 150 feet in the county. Some of the Council Grove limestones are thicker in Cowley and Butler Counties than in counties farther north. Flinty limestone is characteristic of some of the beds. The Admire group in Cowley County has a total thickness of about 40 feet; it consists chiefly of shale.

Pennsylvanian rocks.—The Burlingame limestone of the Wabaunsee group (Fig.4), the oldest rock exposed in Cowley County, crops out in a very small area in the eastern part of T. 34 S., R. 8 E. Younger Pennsylvanian shales and limestones are exposed in a narrow band in the southeastern part of the county (Bass, 1929, pl. 1).

SUBSURFACE ROCKS

Subsurface geologic conditions along the west side of Cowley County are shown in Plate 4. The subsurface rocks of this county dip to the southwest at an average rate of about 22 feet per mile. Three parallel northeast-trending anticlines are the most pronounced structural features of the county. They are the Nemaha anticline in the extreme northwestern part of the county, the Winfield anticline in the west central part, and the Dexter anticline in the southeastern part.

Pennsylvanian rocks.—The Wabaunsee group has an average thickness of about 400 feet in Cowley County. The Shawnee group has an average thickness of about 650 feet and consists of interbedded shale and limestone and some sandstone. The Douglas group consists of about 350 feet of shale, sandstone, limestone, and red beds. The Lansing group comprises about 400 feet of shale and minor amounts of sandstone and limestone. The sandstone yields oil and gas. The Kansas City group consists largely of shale and sandstone and some limestone. It averages about 200 feet in thickness. Sandstone beds in the upper part of this group are known as the "Layton sand." In the northern part of the county the Kansas City group is composed largely of gray limestone. Various beds in this group yield oil and gas.

The thickness of the combined Bronson, Bourbon, and Marmaton groups in Cowley County is about 300 feet. This part of the section is thickest in the southeastern part of the county. Shale, sandstone, and relatively thin beds of limestone are included. Oil and gas are produced from numerous zones between the

Lansing and Cherokee rocks. The Cherokee shale ranges in thickness from slightly less than 300 feet in the eastern part of Cowley County to about 115 feet in the northwestern part (Bass, 1929). Local variations in thickness are common. The Cherokee shale is thin above the granite ridge, in the Dexter anticline, and locally above other structural highs in pre-Pennsylvanian rocks. The Cherokee is composed of shale, sandstone, and a few thin beds of limestone. Coal is frequently found associated with sandstone. Sandstone beds in the Cherokee are important oil and gas bearing zones. Studies by Bass and others (1937) indicate that the "Burbank" and "Bartlesville" sandstones are zones composed of numerous lenses of sandstone which occurs within narrow trends in the Cherokee shale. The "Burbank sand" lies 50 to 100 feet above the "Bartlesville sand." Shoestring sand bodies in the lower part of the Cherokee shale in Cowley County are called "Bartlesville sand" by geologists and drillers. The "chat," consisting of weathered fragments of chert, lies on Mississippian rocks.

Mississippian rocks.—Mississippian rocks in Cowley County range in total thickness from 225 to 450 feet; they consist chiefly of limestone. Thinning of Mississippian beds in structural highs and thickening of the beds in structural lows in the county have been pointed out by Bass (1929) and by Lee (1939). There is a close relation between thinning of Mississippian rocks and occurrence of oil and gas in anticlines. Oil occurs in Mississippian limestones in porous zones most of which are in the upper 100 feet. Oil is produced in the Mississippian rocks in the Dexter, Geuda Springs, and Murphy pools.

The Chattanooga shale underlies the Mississippian limestones. Locally the Chattanooga was removed by erosion before deposition of younger rocks. Its maximum thickness in Cowley County is about 200 feet.

Ordovician and Cambrian rocks.—Undifferentiated Ordovician and Cambrian rocks, known as the Arbuckle limestone, underlie the Chattanooga shale (or the Mississippian limestone where the Chattanooga is absent) in all of Cowley County except a small area in the northwestern and southwestern corners where rocks of the Simpson formation underlie the Chattanooga. Many wells have penetrated several hundred feet of strata below the Mississippian rocks. The Arbuckle rocks consist of alternating beds of thick limestone and shale. Well records indicate that the maximum thickness of these Ordovician and Cambrian rocks in Cowley County is about 670 feet. Oil and gas are produced from a porous zone near the top of the Arbuckle rocks.

A recent report by Keroher and Kirby (1948, fig. 3, 6, 8, 9,) indicates that (1) the Jefferson City-Cotter sequence in Cowley County ranges in thickness from about 450 to more than 650 feet, increasing from the northeast to the southwest; (2) the Roubidoux dolomite's thickness range is from slightly less than 100 feet in the northern part to about 150 feet in the southwestern part of the county; (3) the Van Buren-Gasconade sequence ranges from slightly more than 100 to more than 200 feet in thickness, increasing toward the southwest; (4) the Bonneterre dolomite is not present in the northern and western parts of the county, and has a maximum thickness in the county of about 50 feet in the southeast part. It is believed that the Van Buren-Gasconade dolomite lies on Pre-Cambrian rocks in the northern and western parts of Cowley County and that the Bonneterre dolomite is the first formation above the basement rocks in the eastern and southern parts.

Oil and Gas Developments

Oil and gas wells are widely distributed in Cowley County, but most of the producing pools are in the western half (Fig. 22). The Rainbow Bend, Hittle, Carson, Graham, Eastman, Weathered, and Rock pools are the most important. Most of the oil and gas in the county occurs in structural highs, although some of the most pronounced structures are barren. Gas is produced from a shallow sand in the lower part of the Permian, from sandstones in the Kansas City and Lansing groups, from shoestring sand bodies in the Cherokee shale locally called "Bartlesville," from some porous zones in the upper part of the Mississippian limestone, and from porous zones in the upper part of the Ordovician limestone. The Graham No. 1 well in the NE¼ sec. 9, T. 33 S., R. 3 E., which was completed in July 1924 and had an initial production of 900 barrels per day, was the first commercial producer from the Ordovician (Siliceous") limestone in the county.

Gas was discovered in the **Arkansas City** area in 1906. Much gas was produced from a sandstone in the Admire shale encountered at depths ranging from 650 to 850 feet. Some of the gas

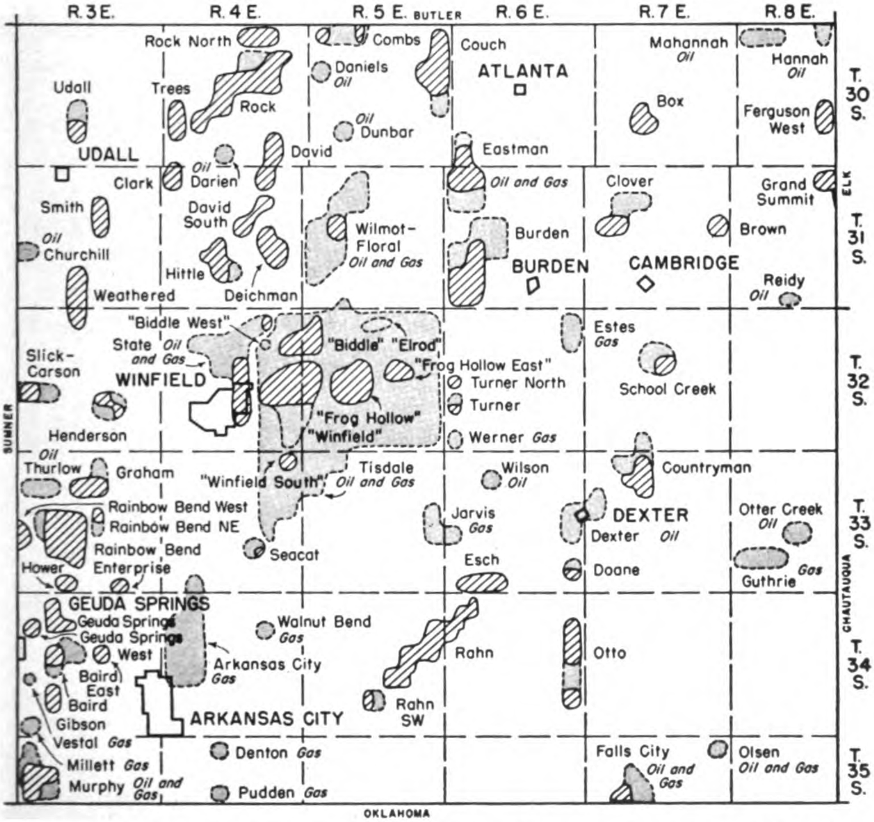

Fig. 22.—Map of Cowley County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

wells in this area had a maximum open flow of about 8 million cubic feet of gas a day. These wells were abandoned in 1920. Gas has also been produced southeast of Arkansas City in sec. 4, T. 35 S., R. 4 E. from a sandstone in the Kansas City group.

The **Box** field was opened in 1948 when Mississippian limestone production was found in sec. 28, T. 30 S., R. 7 E. During the year 17,392 barrels of oil were produced from 10 wells.

The **Combs** field was opened in 1945; the discovery well, sec. 5, T. 30 S., R. 5 E., had an initial daily production of 50 barrels of oil from the "Bartlesville sand." In 1948 the field, which extends into Butler County, yielded 117,981 barrels of oil from 13 wells.

TABLE 24.—*Oil production in Cowley County, 1944 through 1948*

Field	Discovery date	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil	Cumulative	Producing horizon	Depth, feet
Baird		2	2,454	2	1,620	2	1,680	2	1,590	2+	11,628		"Bartlesville"	
Baird East	1940	1	2,440	1	2,280	1	2,400	1	2,490	1	2,460		"Bartlesville"	3,200
Biddle		20	28,047	20	25,500	20	20,460	19	25,470	26	35,597		"Stalnaker" Kansas City Admire	2,300 2,000 600
Box	1948									10	17,392	17,392	"Mississippi lime"	
Brown	1922	1	6,562	2	6,900	2	6,505		5,695		5,208	238,195	Kansas City	
Burden	1926	32	38,194	31	35,220	31	32,760	30	30,420	27	28,408		"Bartlesville"	2,800
Clark	1914	4	9,024	5	8,610	5	9,600	5	9,330	5	10,031		"Bartlesville"	2,800
Clover		1	9,024	1		1			442	1	1,233	17,715		
Combs[1]	1947							9	32,490	13	117,981	150,471	"Bartlesville"	2,823
Couch	1940	22	186,598	22	126,480	22	220,342	21	235,824	22+	165,555	1,515,885	"Bartlesville"	2,800
Countryman		4	7,762	4	6,210	4	19,631		33,154		25,161		"Layton"	1,950
Darien	1939	5	26,416	4	9,636	3	3,646	Abandoned				265,138	Arbuckle	3,300
David	1935	25	65,268	26	55,680	26	51,900	26	45,780	24+	50,963	998,976	"Bartlesville"	2,900
David South	1938	5	7,876	5	6,810	5	6,330	5	5,910	5	5,775	143,344	Arbuckle "Bartlesville"	3,463 3,000
Deichman	1941	8	88,944	8	86,160	9	100,650	13	148,560	22	144,982	654,628	"Bartlesville"	2,800
Dexter	1914			1	2,340	1	1,487		1,500				Mississippian	2,750
Doane	1947							1	1,650	2	3,752	5,402	"Mississippi lime"	
Eastman	1924	27	48,866	25	36,300	25	33,916	24	43,681	21+	45,631		"Bartlesville"	2,800
Enterprise	1948									1	876	876	"Bartlesville"	
Esch								2	1,590	5	105,713			
Falls City	1919	8	11,973	8	10,920	8	9,243		6,890		6,208	1,254,994	"Stalnaker"	2,000
Ferguson West	1934	10	6,362	10	6,764	20	5,683	17	4,705	6	4,566		Bronson	2,000
Frog Hollow	1937	43	395,744	43	404,295	43	388,260	44	367,233	50	341,746	3,407,120	"Bartlesville"	3,000
Frog Hollow East	1941	5	34,340	5	29,700	15	22,680	7	24,570	6	19,912	204,736	"Bartlesville"	3,000
Geuda Springs	1936	12	25,902	11	26,820	11	27,480	11	21,990	3+	16,942	464,076	"Bartlesville"	
Geuda Springs West				1	120	1	810	1	720	1	456			
Gibson	1941	8	44,401	8	36,660	8	31,890	9	29,910	9	35,945	287,991	"Bartlesville"	3,300
Graham	1924	9	24,350	9	21,630	9	19,440	7	16,167	8	16,011	2,638,410	Arbuckle "Layton"	 3,518
Grand Summit[2]	1926	See Elk County		2	1,721	6	1,643	2	642	6	1,398		Kansas City	2,000
Hanna				1	758	2	5,346	2	4,033					
Henderson	1942	4	21,464	4	16,980	4	27,090	7	15,090	6	8,799	115,802	Kansas City Arbuckle	2,690 3,419
Hittle	1926	65	663,034	67	619,505	62	580,235	74	617,856	59	489,242	7,779,872	Kansas City Arbuckle	2,400 3,280

Hower	1935	4	7,597	4	7,410	4	6,780	4	6,000	3	5,635	57,535	
Mahannah	1918	1	155		Abandoned							47,686	"Burgess" 2,730
Murphy[1]	1933	12	28,334	22	105,510	22	175,140	27	170,760	23	110,911		Miss. "chat" 3,300
Olsen	1922	4	2,625	4	2,370	4	900						Marmaton 2,375
													Lansing 1,700
Otter Creek	1943	3		2	630	2		2				3,733	Lansing-K.C.
Otto								1	540	1+	5,686		"Chat" 3,017
Rahn	1939	18	177,382	28	231,210	30	303,761	28	304,121	25+	165,900	1,268,613	"Bartlesville" 2,900
Rahn Southwest (Silverdale)	1944	1	483	1	630	1	270	1	750	1	590	2,723	"Bartlesville" 3,019
Rainbow Bend	1923	114	221,559	114	227,880	115	224,340	82	230,218	68	216,127	14,963,770	"Burgess" 3,200
Rainbow Bend Northeast	1945					1	5,970	1	4,020	1	2,495	12,485	"Bartlesville"
Rainbow Bend West[3]		3	11,296	3	9,150	3	7,290	3	5,418	3	4,710		"Burgess"
													Arbuckle 3,500
Rock	1937	46	144,347	53	159,137	53	132,391	54	100,709	24+	105,501	2,854,235	"Bartlesville" 2,800
Rock North	1937	5	8,180	5	5,666	5	8,083	5	7,292	5	5,895	120,609	"Bartlesville" 2,800
Seacat	1945			2	4,050	2	2,709		1,774		1,703	10,236	"Miss. lime"
School Creek	1947							1	2,040	1	1,196	3,236	"Bartlesville"
Slick-Carson[3]	1925	16	39,804	16	32,700	16	29,040	16	33,870	15	39,012	3,388,326	"Layton" 2,700
													Arbuckle 3,450
Smith	1917	7	4,765	7	4,500	7	3,870	7	3,510	7	3,330		"Bartlesville" 3,000
State	1926	19	42,824	19	38,134	22	34,714	19	30,464	11+	36,036		Arbuckle 3,500
													"Layton" 2,300
Thurlow						1	930		Abandoned				
Trees	1934	10	21,311	10	19,080	10	17,940	10	15,660	11	13,756		"Bartlesville" 2,975
Turner	1937	4	15,424	4	13,710	4	10,890	4	8,790	4	7,230	258,693	"Layton" 2,332
Turner North[4]													
Udall				1	2,250	1	1,950	1	2,250	1	1,710		
Weathered	1935	25	57,778	23	56,040	23	55,230	20	58,200	14	48,447	2,554,719	Arbuckle
													Mississippian
													Lans.-K.C.
													"Stalnaker"
Wilmot-Floral											552		
Winfield	1914		75,389	56	77,884	55	64,441	57	91,160	58	94,678		Admire 600
													Arbuckle 3,300
													"Bartlesville" 3,050
													"Layton" 2,300
													"Peacock" 1,400
Winfield South	1945									1	2,320	2,320	"Hoover"
Totals		613	2,614,388	700	2,583,650	727	2,717,746	688	2,812,928	618+	2,592,991		

[1] Includes Butler County production.
[2] Field extends into Elk County.
[3] Field extends into Sumner County.
[4] Production not recorded.

The **Darien** pool, discovered in June 1939 is in sec. 33, T. 30 S., R. 4 E. Five wells produced oil from the Arbuckle, which is about 3,300 feet below the surface. No production was reported from this field during 1947 or 1948. In 1946, 3,646 barrels of oil were produced from three wells.

Shallow gas was discovered near Dexter in 1903 (Haworth, 1905, p. 191). The shallow gas wells had open flows of 3 to 6 million cubic feet of gas and rock pressures of 110 pounds (Bass, 1929, p. 167). Oil was discovered in Cowley County near Dexter in 1914. The **Dexter** oil field has been abandoned. Production was from Mississippian limestone at a depth of 2,750 feet. The **Doane** pool, which produces from "Mississippi lime," was discovered in 1947. The initial daily production of the discovery well was reported as 25 barrels. In 1948, 2 wells produced 3,752 barrels of oil.

The **Dunbar** oil pool was discovered in 1938. In 1943 one well produced from Kansas City-Lansing rocks. This pool was abandoned in 1944. The **Eastman** oil pool was discovered in January 1924. Large amounts of gas were produced with the oil during the first few years after discovery of the pool. One well is reported to have had an initial open flow of 35 million cubic feet. Production is from the "Bartlesville sand" at a depth of about 2,800 feet. The "Bartlesville" has a maximum thickness of 100 feet and is separated from the Mississippian limestone by about 100 feet of shale. The producing formation is a shoestring sand about one-half mile wide and 1½ miles long. The production from this pool in 1948 was 45,631 barrels.

The **Enterprise** field was opened in 1948, with a "Bartlesville sand" well in sec. 35, T. 33 S., R. 3 E. During the year 876 barrels of oil were produced from the discovery well. The **Esch** oil field has five wells that produced 105,713 barrels of oil in 1948.

Gas was discovered in the **Falls City** field in January 1916. The first well had an initial open flow of 7 million cubic feet of gas from a sandstone at a depth of 1,480 feet. The first oil well was drilled in January 1919. Eight wells are now producing oil from the "Stalnaker sand" at a depth of about 2,000 feet. The production from the Falls City oil pool in 1948 was 6,208 barrels.

The **Graham** oil pool was discovered in August 1924 when a well was drilled to the Arbuckle at a depth of 3,518 feet. This well had an initial daily production of 1,000 barrels. By the end of 1925, 38 wells had been drilled in the field; 21 were producing

TABLE 25.—*Gravity of some samples of oil from fields in Cowley County*
(Data from U. S. Bureau of Mines)

Field	Producing zone	Depth, feet	Gravity of oil, degrees A.P.I.
Burden	"Peru sand"	2,296	40.0
do	"Burbank sand"*	2,923	39.2
Clark	"Burbank sand"	2,851	39.4
Couch	"Burbank sand"	....	41.1
Daniels	"Burbank sand"	....	41.1
Graham	Kansas City ls.	2,541-2,554	35.6
do	Arbuckle ls.	3,485-3,535	38.6
Hittle	"Stalnaker sand"	2,431	39.8
Rainbow Bend	"Burbank sand"	3,228	42.3
Rooks	"Bartlesville sand"	2,830	38.2
do	"Cattleman sand"	....	38.6
Shaffer	"Burbank sand"	....	39.4
Udall	"Hoover sand"	1,860	34.2
Winfield	"Peacock sand"	1,400-1,492	38.4
do	"Layton sand"**	2,380	38.0
do	Kansas City ls.	2,568-2,577	36.4
do	"Burbank sand"	3,002-3,037	40.2
do	Arbuckle limestone	3,300	34.8

* "Burbank sand" is also called "Bartlesville."
** "Layton sand" is also called "Peru."

from the Arbuckle, 12 were producing from the "Layton sand," and 4 were dry holes. The field now has 8 wells which produced 16,011 barrels of oil in 1948.

In the **Grand Summit** field, discovered in 1926, gas was found at a depth of about 1,800 feet in the upper part of the Kansas City rocks, and oil was found about 200 feet lower, also in the Kansas City group. The wells had initial daily productions of about 5 million cubic feet of gas and about 25 barrels of 42° Bé. gravity oil. In 1948 the field had six wells which produced 1,398 barrels of oil. No gas is now being produced.

Oil was discovered in the **Olsen** field in 1922. Initial productions between 50 and 75 barrels a day were obtained from a sandstone in the Marmaton group at a depth of about 2,375 feet. Some wells produced as much as 18 million cubic feet of gas from a sandstone in the Lansing group at a depth of about 1,700 feet. In 1946 four wells produced 900 barrels of oil but no production was reported in 1947 or 1948.

Oil in the **Otto** oil and gas field was found in the Lewis and Hollis No. 1 Day well in the NW¼ sec. 25, T. 34 S., R. 6 E., in the "chat" at a depth of 3,017 feet. Gas was found in several wells at depths ranging from about 1,100 to 1,450 feet. Some of the gas contains helium. Production in 1948 was 5,686 barrels.

TABLE 26.—*Dry wildcat wells drilled in Cowley County during 1948*

Company and farm	Location	Depth to top of Kansas City, feet	Depth to top of Mississippian, feet	Total depth, feet
K. T. Weidemann No. 1 Lenier	SW¼ NE¼ SW¼ 4-30-7E		2,881	2,986
K. T. Weidemann No. 1 Haworth	NW cor. SW¼ 7-30-7E	2,180	2,887	2,912
H. H. Blair Drilling Co. No. 1 De Vore	SW cor. NW¼ 10-33-5E			3,252
Morrison Producing Co. No. 1 Brandenberg	NE cor. SE¼ 8-34-5E	2,619	3,183	3,642
Aladdin Oil Corp & Harbar Drilling Co. No. 1 Brandenberg	SE cor. NE¼ 3-35-3E		3,458	3,510
Kingery & Patterson No. 1 Shepard	SE ¼ NE¼ SE¼ 2-35-6E		2,990	3,034

The **Rainbow Bend** field was discovered by a well drilled on the Johnson farm, in sec. 20, T. 33 S., R. 3 E. in December 1923. It came in as a flowing well having an initial production of about 337 barrels per day. Production is from the "Burgess sand" in the basal part of the Cherokee shale. The "Burgess" ranges in thickness from 5 to 35 feet and lies at a depth of about 3,200 feet. The producing sand occurs in a structural high which conforms generally with the structure of the underlying Mississippian limestone. The Mississippian limestone is about 100 feet thinner on the axis of the fold than on the flanks. In 1948 the pool had 68 producing oil wells and the production was 216,127 barrels.

The **Rainbow Bend Northeast** field was opened in 1945. The discovery well is in sec. 15, T. 33 S., R. 3 E. Production is from the "Bartlesville sand." In 1948, one well produced 2,495 barrels of oil.

The **Rainbow Bend West** field, a westward extension of the Rainbow Bend pool, has three wells; production is from the "Burgess sand" and from the Arbuckle dolomite at a depth of about 3,500 feet. The production in 1948 was 4,710 barrels.

TABLE 27.—*Data on pool wells drilled in Cowley County during 1947 and 1948*

Field	1947 Producing wells and formation	1947 Dry	1947 Total	1948 Producing wells and formation	1948 Dry	1948 Total
Baird	1 Mississippian ls.	1	2		2	2
Biddle	2 "Layton"	0	2	3 "Layton"	1	4
Box		0	0	5 Mississippian ls.	2	7
Burden		1	1	1 "Bartlesville"	2	3
Clover	1 Kansas City				2	2
	1 Mississippian ls.	0	2			
Combs	2 "Bartlesville"	4	6	2 "Bartlesville"		
				2 Mississippian ls.		
				1 Salt water disposal	2	7

Couch	2	"Bartlesville"	1	3			2	2
Countryman	2	Mississippian ls.	1	3	2	Mississippian ls.	2	4
Daniels	1	"Bartlesville"	0	1			1	1
David			2	2	3	"Bartlesville"	1	4
Deichman	3	"Bartlesville"	1	4	1	"Bartlesville"		
					1	Mississippian ls.	0	2
Doane	1	Mississippian ls.	0	1	1	Mississippian ls.	0	1
Dunbar			0	0			1	1
Elrod			0	0	1	"Layton"	0	1
Enterprise			0	0	1	"Bartlesville"	2	3
Esch	1	"Bartlesville"	0	1	5	"Bartlesville"	1	6
Falls City			0	0			1	1
Frog Hollow	2	"Bartlesville"	2	4	4	"Bartlesville"	1	5
Gibson			0	0	1	"Bartlesville"		
					3	Mississippian ls.	0	4
Graham			1	1	1	Salt water disposal	0	1
Murphy	2	"Bartlesville"					1	1
	1	Mississippian ls.	1	4				
Olsen			0	0			1	1
Otto			1	1	1	"Layton"		
					1	Mississippian ls.	0	2
Pudden			0	0			1	1
Rainbow Bend			0	0			1	1
Rock			1	1	5	"Bartlesville"	4	9
School Creek			1	1			1	1
Smith			0	0			1	1
State			1	1	1	Kansas City	3	4
Tisdale	2	"Layton"					3	3
	1	"Bartlesville"						
	1	Unidentified sand	5	9				
Turner North			0	0	1	"Layton"	0	1
Walnut Bend			0	0			3	3
Weathered			0	0	1	Kansas City	2	3
Wilmot-Floral			1	1			2	2
Wilson			0	0			1	1
Winfield			0	0	1	Sandy lime		
					1	"Bartlesville"		
					2	Unidentified sand		
					2	Salt water disposal	6	12
Wildcats			11	11			6	6

The **School Creek** pool, which produces oil from the "Bartlesville sand," was found in 1947. The initial daily production of the discovery well was reported as 20 barrels. In 1948, one well produced 1,196 barrels of oil. The **Seacat** pool was discovered in 1945. Production is from the "Mississippi lime." In 1948, 1,703 barrels of oil were produced in the field. The **Turner North** field was opened in 1948 with a "Layton sand" well in the SW cor. SE¼ sec. 18, T. 32 S., R. 6 E. Initial production was reported as 15 barrels of oil per day. The **Wilmot-Floral** field is nearly abandoned. In 1948, 552 barrels of oil were produced on a lease in sec. 19, T. 31 S., R. 5 E.

The **Winfield** pool was opened in November 1914. Haworth (1903, pp. 37-38) reported that gas was discovered about a quarter of a mile east of Winfield in 1902. The Winfield field comprises 5,000 acres. Oil is produced from a sandstone in the Admire group at a depth of about 600 feet, from the "Peacock sand" at about 1,400 feet, from the "Layton sand" at a depth of about 2,300 feet, from the "Bartlesville sand" at about 3,050 feet, and from the Arbuckle limestone at about 3,300 feet (Ver Wiebe, 1943, p. 351). Much gas is produced from the "Peacock sand." In 1948, 94,678 barrels of oil were produced from this field.

The **Winfield South** pool was discovered in 1945 in sec. 1, T. 33 S., R. 4 E. Production is from the "Hoover sand." In 1948, one well produced 2,320 barrels of oil.

Some significant data on other Cowley County fields are listed in Table 24, which shows production in the various fields for 1944 through 1948. Data concerning dry wildcat wells drilled in Cowley County in 1948 are given in Table 26. Data on pool wells drilled in the county in 1947 and 1948 are given in Table 27. Eleven dry wildcat wells were drilled in the county in 1947 and six in 1948.

CRAWFORD COUNTY

There are several small oil and gas pools in the western part of Crawford County. Oil and gas are produced from the "Bartlesville sand" which ranges in depth from 300 feet in the southwestern part of the county to 600 feet in the northwestern part. Oil was discovered in the northwestern part of Crawford County in 1917. Gas has been produced for many years in the vicinities of Walnut, Monmouth, and McCune.

Crawford County produced 67,059 barrels of oil in 1948. Natural gas production during the year is estimated as approximately 357 thousand cubic feet. The amount of early oil production in the county is unrecorded; production figures for the years 1941 to 1948 inclusive are given in Table 2a. Production in the various fields in Crawford County for 1944 through 1948 is given in Table 28.

Two reported water-flooding projects are operating in Crawford County (Fig. 2, Table 3). Figure 23 shows the locations of oil and gas fields in Crawford County as they have been defined

TABLE 28.—*Oil production in Crawford County, 1944 through 1948*

Field	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Fair Oak	1,915	26	1,545	26	1,269		1,641		1,163
"Green Elm" (McCune)							2,444		2,215
McCune	28,497	165	24,443	73	42,224		49,418		55,831
St. Paul-Walnut[1]	653	11	531	8	528		516		999
Walnut Southeast[2]	3,184		5,142		5,808	27	6,594	9	6,297
Miscellaneous							179		554
Totals	34,249	202	31,661	107	49,829	27	60,792	9	67,059

[1] Field extends into Neosho County.
[2] Areas of production not definitely located.

by the Nomenclature Committee of the Kansas Geological Society. Areas of 1948 oil production are indicated on the figure.

GEOLOGY

SURFACE ROCKS

The consolidated rocks exposed in Crawford County belong to the Pennsylvanian System. They consist of alternating beds of limestone and shale, about 15 beds of coal, and several beds of sandstone. The rocks have an average westerly dip of about 12 feet per mile. The Hertha limestone, which crops out in the extreme northwestern part of the county, is the youngest consolidated rock in Crawford County. The Cherokee shale which crops out in the southeastern part of the county is the oldest exposed rock.

The Pleasanton shale (Fig. 5) is exposed in the northwestern part of Crawford County. It consists of about 75 feet of shale, some very thin limestone, and a sandstone 3 or 4 feet thick in the basal part. Marmaton rocks are exposed in Crawford County and are about 250 feet thick. Shale ranging in color from light gray through bluish and dark gray to black is the predominant rock of the Cherokee shale (Fig. 6). It is clayey, silty, micaceous, sandy, or carbonaceous. There are several sandstones, a few thin limestones, and 15 beds of coal. The Bluejacket sandstone, locally called the "Columbus" sandstone, ranges in thickness from 20 to 50 feet and is underlain by the Columbus coal. Measured thicknesses of the Cherokee shale in Crawford County range from 316 to 455 feet.

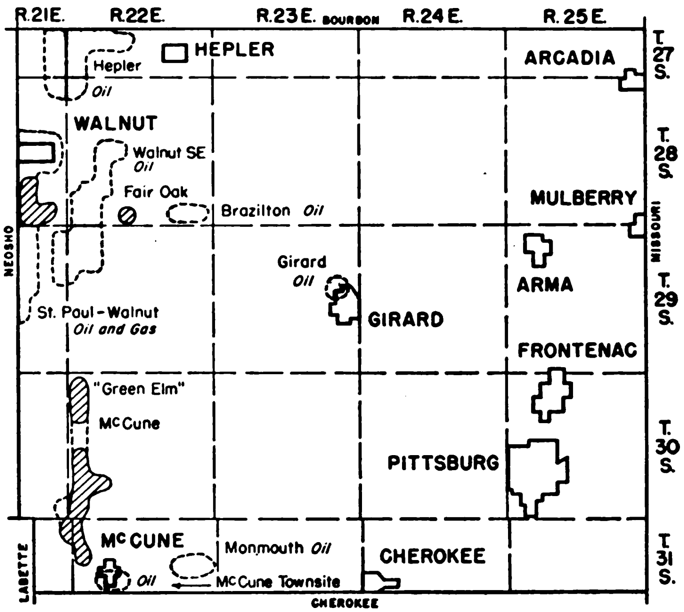

FIG. 23.—Map of Crawford County showing oil and gas fields. Areas of 1948 oil production are cross hatched. Oil producing areas in the Walnut-Southeast field are not definitely located.

SUBSURFACE ROCKS

Subsurface geologic conditions in the central part of Crawford County are shown diagrammatically on Plate 1. Depths at which some stratigraphic horizons were reached in the LaSalle Oil Company No. 1 Gable well, in the SE¼ NW¼ sec. 20, T. 28 S., R. 25 E., are given in Table 29.

Mississippian rocks.—The Mississippian rocks in Crawford County are composed of limestone, some of which is flinty, and shale. The "Warsaw," Burlington-Keokuk, Reeds Spring, and St. Joe limestones, the Northview shale, and the Compton limestone are present in the county. The Chattanooga shale, which commonly lies at the base of the Mississippian, is very thin or is locally absent in Crawford County. The Mississippian rocks range in thickness from 300 to 400 feet. They lie unconformably on Ordovician rocks.

Ordovician rocks.—Silurian, Devonian, and the upper part of Ordovician rocks are absent in Crawford County. Deep wells have

TABLE 29.—*Depths to some key horizons in the La Salle Oil Company No. 1 Gable well, SE¼ NW¼ sec. 20, T. 28 S., R. 25 E., Crawford County*

Horizon	Depth, feet
Top of "Warsaw" limestone	350
Top of Burlington-Keokuk limestone	425
Top of Reeds Spring-St. Joe limestone	550
Top of Northview shale	660
Top of Compton limestone	705
Top of Cotter-Jefferson City dolomite	725
Top of Roubidoux formation	950
Top of Gasconade-Van Buren formation	1,150
Top of Gunter sandstone member	1,380
Top of Eminence dolomite	1,410
Top of Bonneterre dolomite	1,500
Top of Lamotte sandstone	1,700
Top of Pre-Cambrian granite	1,838

penetrated a thick section of interbedded limestone and sandstone of Ordovician age. The formations of the Ordovician present in the county are the Cotter dolomite, the Jefferson City dolomite, the Roubidoux sandstone, and the Gasconade-Van Buren dolomites, including the Gunter sandstone. The Cotter dolomite is absent in the eastern part of the county. The total thickness of Ordovician rocks ranges from about 685 feet in the northeastern part of the county, where the Cotter is absent, to 800 feet in the southwestern part, where the Cotter is about 100 feet thick. The Roubidoux sandstone has an average thickness of about 175 feet and is an important fresh water-bearing sandstone.

Cambrian rocks.—Cambrian rocks have a total thickness of about 430 feet in the northeastern part of Crawford County and about 340 feet in the southwestern part. Cambrian formations present in the county are the Eminence and Bonneterre dolomites and the Lamotte sandstone.

Pre-Cambrian rocks.—Cuttings from wells that have penetrated Pre-Cambrian rocks in Crawford County seem to consist of hard red unaltered granite. The average depth to Pre-Cambrian rocks in the county is about 2,000 feet.

OIL AND GAS DEVELOPMENTS

Many gas wells have been drilled in Crawford County. All commercial wells are in the extreme western part of the county. Oil is produced from narrow elongated lenses of "Bartlesville sand." The sandstone ranges from 20 to 40 feet in thickness and lies at a depth of about 600 feet in the Walnut area in the northwestern part of the county and at a depth of about 300 feet in the McCune area in the southwestern part.

The **McCune** pool was discovered in 1932. The first wells produced gas, but oil was soon found. The oil is produced from the "Bartlesville sand" at a depth of about 300 feet. The "Bartlesville," which has an average thickness of about 25 feet, is about 180 feet below the Fort Scott limestone and about 180 feet above the Mississippian limestone. The McCune pool is a shoestring type pool and has several hundred producing oil wells, some of which had initial productions of 100 barrels per day. The production declined rapidly to 10 or 12 barrels per day.

The Engle water-flooding project, in sec. 7, T. 30 S., R. 22 E., in the McCune field, was started in September 1937 (Grandone, 1944, pp. 67-69). The first increase in the rate of oil production was in November 1937. Twenty acres were flooded; there were 16 oil recovery wells. The cumulative oil production was 862 barrels per acre. Flooding was discontinued in August 1939.

DICKINSON COUNTY

Oil has been found in three areas in Dickinson County. The Lost Springs field was extended into the southeastern part of the county several years ago and the Bonaccord pool was discovered in 1943. The Lost Springs North pool was discovered in 1945.

Dickinson County produced 23,449 barrels of oil during 1948. Production in the county during the years 1943 to 1948 inclusive is shown in Table 2a. Table 30 shows production in the various fields during the years 1944 to 1948, inclusive. Figure 24 shows the location of oil fields in Dickinson County and 1948 producing areas.

Geology

SURFACE ROCKS

Cretaceous rocks crop out in a small area in the northwestern corner of Dickinson County. The consolidated bedrock at the surface in the remainder of the county is Permian in age. The exposed Permian section extends from the lower part of the Wellington shale of the Sumner group to the lower part of the

Barneston limestone of the Chase group (Fig. 3). The valley of Smoky Hill River contains a rather thick fill of alluvium, and dune sand covers a few square miles a short distance west of Abilene on the north side of the river.

SUBSURFACE ROCKS

Subsurface geologic conditions in the central part of Dickinson County are shown in Plate 4. Lee, Leatherock, and Botinelly (1948, pl. 14) have shown in detail subsurface geology as revealed by two Dickinson County wells: the Franks No. 1 Huffman, sec. 11, T. 13 S., R. 1 E.; and the Empire Oil and Refining Co. No. 1 Duffey, sec. 3, T. 12 S., R. 3 E.

Pennsylvanian rocks.—The top of Pennsylvanian rocks in Dickinson County is about 600 feet below the base of the Barneston limestone. The Wabaunsee group, consisting chiefly of shale and relatively thin limestone beds, is about 350 feet thick. Lenticular sandstones occur in the basal part, lying on or a few feet above the Topeka limestone. The Shawnee group, about 350 feet thick, is composed largely of limestone, especially in the lower part. The Douglas group is about 100 feet thick in the county. One or more lenticular sandstone bodies occur in the Douglas section, which in some wells consists entirely of sandstone and in others entirely of shale. The thickness of the combined Lansing and Kansas City groups, which are composed chiefly of limestone, is about 550 feet. A rather persistent thin shale about 225 feet from the top of the Lansing group probably marks the top of the Kansas City group. The basal part of the Linn subgroup (base of the Kansas City group of some reports) is probably marked by a persistent zone of sandstone and conglomerate approximately 420 feet below the top of the Shawnee group. The Pleasanton shale in Dickinson County is about 35 feet thick, and the Marmaton and Cherokee rocks range from about 60 to 150 feet in thickness. About 35 feet of shale which occurs locally above the Mississippian limestone is probably Cherokee shale.

Pennsylvanian rocks in Dickinson County overlap and overstep Mississippian limestone beds, as indicated by the thicker lower Pennsylvanian and Mississippian section in the western part of the county.

Mississippian rocks.—The Mississippian limestones in Dickinson County range from about 100 to 150 feet in total thickness.

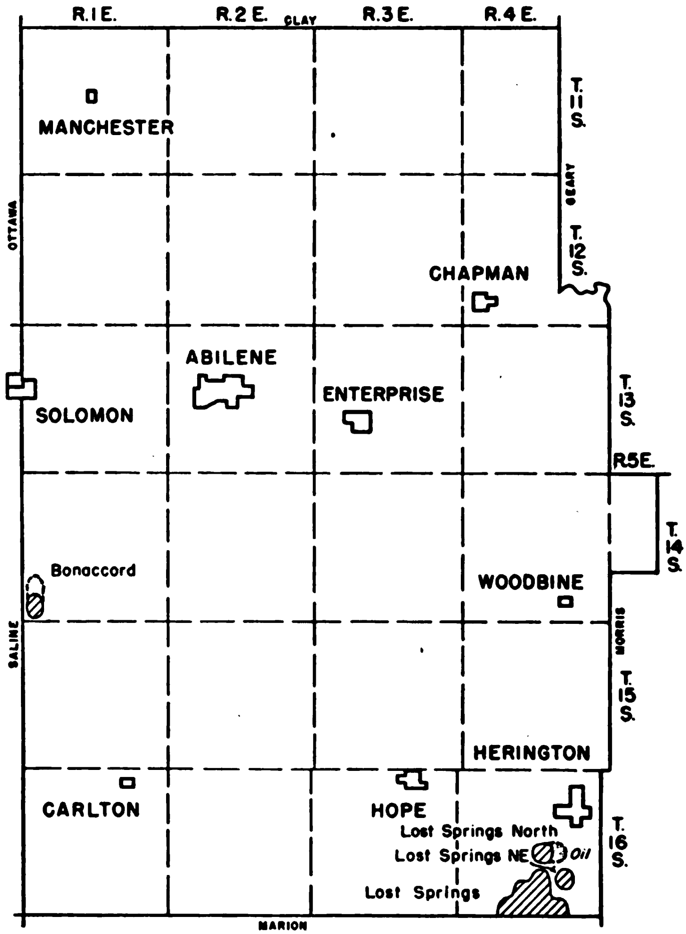

FIG. 24.—Map of Dickinson County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

The Keokuk and Burlington limestones, Gilmore City limestone, and Sedalia dolomite have been identified (Lee, Leatherock, and Botinelly, 1948, pl. 14). They are underlain by about 150 feet of Chattanooga shale.

Pre-Chattanooga rocks.—About 165 feet of "Hunton" limestone seemingly underlies all of Dickinson County. The Maquoketa shale is about 75 feet thick in the county. It is underlain by about 100 feet of Viola limestone. About 90 feet of sandstone, gray and red shale, and limestone occur below the Viola lime-

TABLE 30.—*Oil production in Dickinson County, Kansas, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Bonaccord		8,377		6,142				2,208	1	2,818
Lost Springs				See Marion County						
Lost Springs North		13,112	3	8,100	4	11,520	7	32,190	5	20,321
Lost Springs Northeast									1	310
Totals		21,489	3	14,242	4	11,520	7	34,398	7	23,449

stone and above the Arbuckle rocks. These rocks are correlated with the St. Peter (Simpson) formation. It is probable, however, that the St. Peter sandstone comprises only the approximate lower half. The undifferentiated Arbuckle rocks in Dickinson County consist of about 250 feet of limestone and dolomite.

OIL DEVELOPMENTS

An active drilling campaign took place in Dickinson County in 1919 and 1920 but all tests were unsuccessful. Later the Lost Springs field was extended from Marion County into southeastern Dickinson County. In 1943 the Bonaccord oil pool was discovered, and the Lost Springs North pool was found in 1945.

The **Bonaccord** oil field is in secs. 30 and 31, T. 14 S., R. 1 E. The discovery well, which was completed late in August 1943, is in the Cen. S½ SE¼ SW¼ sec. 30, T. 14 S., R. 1 E. A daily potential production of 223 barrels was reported. Oil was found in the "Burgess sand," the top of which was encountered at 2,483 feet. Later two additional producing wells were drilled in the NE cor. NW¼ sec. 31, T. 14 S., R. 1 E. and in the SW¼ NE¼ SW¼ sec. 30, T. 14 S., R. 1 E. Smaller initial productions were reported for the later wells. During the last 5 months of 1943, 3,047 barrels of oil was produced.

The **Lost Springs** oil field extends from Marion County into secs. 27, 28, 33, 34, and 35, T. 16 S., R. 4 E., Dickinson County. Production is from the "chat" in the upper part of the Mississippian limestone.

The **Lost Springs North** field is in sec. 22, T. 16 S., R. 4 E. The pool was discovered in 1945. Production is from the upper part of the Mississippian limestone or "chat." Two oil wells were drilled in 1945, one in 1946, and three in 1947. During 1948 the field produced 20,321 barrels of oil.

TABLE 31.—*Data on pool wells drilled in Dickinson County during 1947 and 1948*

Field	1947				1948			
	Producing wells and formation		Dry	Total	Producing wells and formation		Dry	Total
Lost Springs	11	Mississippian ls.	3	14	18	Mississippian ls.	6	24
Lost Springs North	3	Mississippian ls.	2	5			2	2
Lost Springs Northeast	1	Mississippian ls.	0	1			0	0

The **Lost Springs Northeast** field was opened in 1947. The discovery well is the International Oil Company No. 1 Schlesner, NE¼ NE¼ SW¼ sec. 26, T. 16 S., R. 4 E. Initial daily production was about 100 barrels of oil. The upper part of the Mississippian limestone or "chat" is the producing rock. Four dry holes, two by the El Dorado Refining Company, one by the Midwest Petroleum Company, and one by the Hutchinson Oil and Gas Company, were drilled in the same section during the year.

Data on wells drilled in 1947 and 1948 in the Lost Springs and Lost Springs North fields are listed in Table 31.

DONIPHAN COUNTY

Oil and gas in commercial quantities have not been found in Doniphan County. As in other northeastern Kansas Counties, not enough wells have been drilled into deeper rocks to condemn the area.

GEOLOGY

SURFACE ROCKS

Glacial drift covers much of the surface of Doniphan County. All the consolidated rocks that are exposed or are present immediately below the drift are of Pennsylvanian age. The outcropping Pennsylvanian rocks in the county include beds from the Reading limestone in the Wabaunsee group to the upper part of the Lawrence shale in the Douglas group (Fig. 7). Their total thickness is about 630 feet.

SUBSURFACE ROCKS

Pennsylvanian rocks.—The Pennsylvanian section in the western part of Doniphan County is about 2,000 feet thick; in the eastern part, where the surface rocks are older, the total thickness of Pennsylvanian rocks is about 1,500 feet.

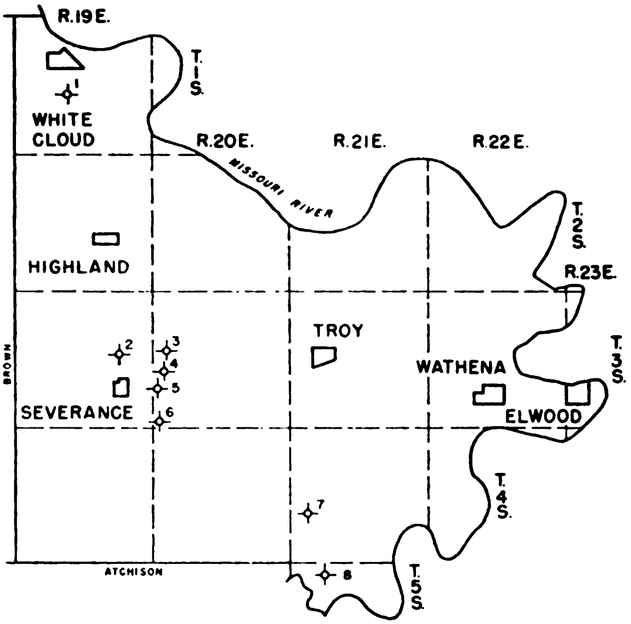

FIG. 25.—Map of Doniphan County showing location of wells listed in Table 32.

Mississippian rocks.—The total thickness of Mississippian limestone formations in Doniphan County ranges from about 250 feet in the northwestern corner to more than 300 feet in the southeastern part (Lee, 1939, pl. 1). According to Lee and Payne (1944, figs. 7 and 17), the Ste. Genevieve limestone lies next below Pennsylvanian rocks throughout most of the area. The rock next below the Pennsylvanian in a narrow north-south belt in the west-central part of the county is believed to be the St. Louis limestone. Spergen limestone is the uppermost Mississippian formation in the northwestern part of the county. The "Warsaw," Burlington, Gilmore City, Sedalia, and Chouteau limestones are believed to comprise the remainder of the Mississippian limestone section in the county (Lee, 1940, pl. 8; Lee and Payne, 1944, fig. 17).

According to Lee (1943, fig. 14), the thickness of the Chattanooga shale in Doniphan County increases westward from about 100 feet to more than 150 feet.

TABLE 32.—*Data on wells drilled for oil and gas in Doniphan County*

No. on map	Name of well	Location	Total depth, feet	Remarks
1	Valley Petroleum Co. No. 1 Mann	SE¼ NW¼ 21-1-19E	2,315	Top Mississippian rocks at 1,975 feet; Chattanooga sh. 2,205 feet; "Hunton" ls. 2,281 feet; stopped in "Hunton"
2	Doniphan Oil & Gas Co. No. 1 Albers	Cen. SW¼ SE¼ 14-3-19E	1,725	Top Mississippian ls. 1,715 feet
3	Gall et al. No. 1 Caudel	NW¼ NW¼ SE¼ 18-3-20E	2,090	Stopped in "Hunton" ls.
4	.... No. 1 Stout	19-3-20E	1,500	Stopped in Cherokee sh.
5	.... No. 2 Stout	SW¼ NE¼ NW¼ 30-3-20E	2,120	Top Mississippian ls. 1,775 feet; Chattanooga sh. 2,010 feet; stopped in Chattanooga sh.
6	Garden Construction Co. No. 1 Elliott	SE¼ SW ¼ 31-3-20E	2,950	Top Arbuckle ls. 2,898 feet
7	Southwest Oil & Gas Co. No. 1 Nity	SE cor. 19-4-21E	1,571	Stopped in Cherokee rocks
8	Diamond Prospecting Co. Doniphan	5-5-21	998	Diamond drill hole drilled in 1878; stopped in Cherokee sh.

Pre-Chattanooga rocks.—According to Lee (1943, fig. 12), the interval between the base of the Chattanooga shale and the top of the Maquoketa shale in Doniphan County ranges from about 300 feet in the southeastern part to nearly 550 feet in the northwestern part. The interval from the top of the Maquoketa shale to the top of the St. Peter sandstones ranges from about 275 to 350 feet. The increase in thickness is toward the northwest (Lee, 1943, fig. 11). The thickness of rocks between the top of the St. Peter sandstone and Pre-Cambrian rocks ranges from about 450 feet in the northwestern part of the county to 650 feet or more in the eastern part (Lee, 1943, fig. 9).

Oil and Gas Exploration

Doniphan County has been very inadequately tested for oil and gas. Data on eight wells in the county are given in Table 32. Locations of the wells are shown in Figure 25.

DOUGLAS COUNTY

Small quantities of oil and gas have been produced in Douglas County for a number of years; the Baldwin oil pool was discovered in 1919. Oil production is from the "Squirrel sand" and is restricted to the Baldwin area in the southeastern part of the

TABLE 33.—*Approximate oil production in the Baldwin field, Douglas County, 1944 through 1948*

Year	Barrels of oil
1944	5,000
1945	5,000
1946	5,000
1947	5,110
1948	4,000

county. The "Squirrel sand" is in the upper part of the Cherokee shale and is about 800 feet below the surface in southeastern Douglas County. Early developments in the county were discussed by Ockerman (1935, pp. 48-50).

The estimated amount of oil production in Douglas County in 1948 is 4,000 barrels. There are about 20 producing wells. The oil is used locally as fuel oil.

Early oil production in Douglas County is mostly unrecorded. In 1927, the county is reported to have produced approximately 24,000 barrels (Table 2). Yearly production during the period 1941 to 1948 inclusive is shown in Table 2a.

Table 33 shows the estimated production in the Baldwin pool in the years 1944, 1945, 1946, 1947, and 1948. Figure 26 shows locations of oil and gas fields as defined by the Nomenclature Committee of the Kansas Geological Society, areas of oil production in 1948, and locations of wells that have been drilled in the county outside the fields.

GEOLOGY

SURFACE ROCKS

The exposed consolidated rocks in Douglas County are of Pennsylvanian age, and belong to the Shawnee, Douglas, Pedee, and Lansing groups. The youngest of these is the Topeka limestone and the oldest is the Plattsburg limestone or perhaps a few feet of the Bonner Springs shale. Glacial drift is attenuated in the northern part of the county. The valleys of Kansas River and Wakarusa Creek are filled with sand and gravel to depths as great as 80 feet or more, and several alluvial terraces border their flood plains.

The Deer Creek and Oread limestones of the Shawnee group (Fig. 4) cap prominent escarpments. Lenticular sandstones are common in the upper parts of the Calhoun, Tecumseh, and Kanwaka shales. Several limestones are useful key beds for surface or shallow subsurface structural mapping in the western part of the county. The thickness of the Shawnee group in Douglas County is about 300 feet. The Douglas group is composed chiefly of shale and sandstone. The Haskell limestone, in the middle part of the Douglas section, is a useful key bed. Thick lenticular sandstones occur both above and below the Haskell limestone. A disconformity below the Ireland sandstone cuts out the Haskell limestone in the southeastern part of the county. The thickness of the Douglas group in the county ranges from about 200 to 270 feet.

Post-Missourian erosion removed Pedee rocks (Fig. 5) from the northeastern part of Douglas County, but about 60 feet of shale lying between the Stanton limestone and the Tonganoxie sandstone in the southeastern part of the county is correlated with the Weston shale of the Pedee group. In the same area a thin limestone is believed to be the Iatan. Rocks of the Lansing group are exposed in the northeastern part of the county in the vicinity of Eudora and eastward along the south side of Kansas River Valley. The Stanton limestone is well exposed there. The thickness of Lansing rocks in Douglas County is about 100 feet.

SUBSURFACE ROCKS

Douglas County lies on the southeastern flank of the North Kansas basin. The Chattanooga shale oversteps Devonian rocks, the Maquoketa shale, and the upper beds of the Kimmswick limestone from the northwest (Lee, 1943, fig. 7, wells 5 and 6). Depths to some key stratigraphic horizon in six wells in Douglas County are shown in Table 34.

Pennsylvanian rocks.—Pennsylvanian rocks in Douglas County older than those of the Lansing group are known only through study of well logs and cuttings. The total thickness of the Lansing and Kansas City groups in the county is about 350 feet. The thickness of the Pleasanton-Marmaton-Cherokee section ranges from about 700 feet in the eastern part of the county to slightly more than 800 feet in the northwestern part.

Mississippian rocks.—The total thickness of Mississippian limestone formations in Douglas County ranges from about 250 feet to slightly more than 400 feet (Lee, 1943, fig. 16). The Spergen

TABLE 34.—*Depths to some stratigraphic horizons in six Douglas County wells*

Horizon	Smith et al. No. 1 Smith, SW cor. SE¼ sec. 28, T. 12 S., R. 19 E.	Volcanic Oil Co. No. 1 Jackman, NE¼ SE¼ sec. 34, T. 12 S., R. 19 E.	Skelly Oil Co. No. 1 Middlekauff, SW¼ NE¼ NE¼ sec. 21, T. 13 S., R. 19 E.	Landsprecht & Baker No. 1 Griffin, Cen. NW¼ SE¼ sec. 4, T. 14 S., R. 18 E.	Pure Oil Co. No. 1 Leuf, NW cor. SE¼ sec. 31, T. 14 S., R. 19 E.	R. F. Duffens No. 1 Stanley, NW¼ NE¼ NW¼ sec. 3, T. 14 S., R. 21 E.
Top Douglas group	68			58		
Top Lansing group	358			370	340	
Top Pleasanton group	695	708		734	765	392
Top Cherokee group	913	955		962	1,025	
Top Mississippian ls.	1,498	1,465	1,263	1,540	1,493	1,074
Top Kinderhookian rocks	1,802	1,804	1,539	1,797	1,732	1,492
Top "Hunton" limestone		1,902	1,596	1,850	1,762?	
Top Viola limestone	1,890	1,929	1,685			
Top Simpson sandstone	2,025	2,025		2,032	1,919	1,663
Top Arbuckle rocks	2,134	2,080	1,842	2,100	1,975	1,711
Top Lamotte sandstone						2,456
Pre-Cambrian rocks						2,463
Total depth	2,382	2,210	1,855	2,116	2,110	2,503

(?), "Warsaw," Burlington, Sedalia, and Chouteau formations are believed to be present in the county (Lee, 1940, pl. 4). The Chattanooga shale ranges in thickness from about 50 feet in the southeastern and southwestern parts of Douglas County to about 100 feet in the northwestern part (Lee, 1943, fig. 14).

Devonian rocks.—In the Smith et al. No. 1 Smith well, sec. 28, T. 12 S., R. 19 E., 70 feet of Devonian limestone was identified, but in the Duffens et al. No. 1 Stanley well, sec. 3, T. 14 S., R. 21 E., the Chattanooga shale lies on the Kimmswick limestone (Middle Ordovician).

Ordovician and Cambrian rocks.—Rocks of Silurian age are believed to be absent in Douglas County and the Maquoketa shale (Upper Ordovician) is present only in a small area in the northwestern part of the county (Lee, 1943, fig. 11). In the Smith et al. No. 1 Smith well 115 feet of Kimmswick limestone was penetrated, and in the Duffens No. 1 Stanley well 104 feet of Kimmswick (including probably some Decorah at the base) was identified. The Smith well was drilled through 10 feet of Decorah shale and 75 feet of St. Peter sandstone. A thickness of 54 feet of St. Peter sandstone was found in the Stanley well. Thicknesses of units of the Arbuckle identified in this well are: undifferenti-

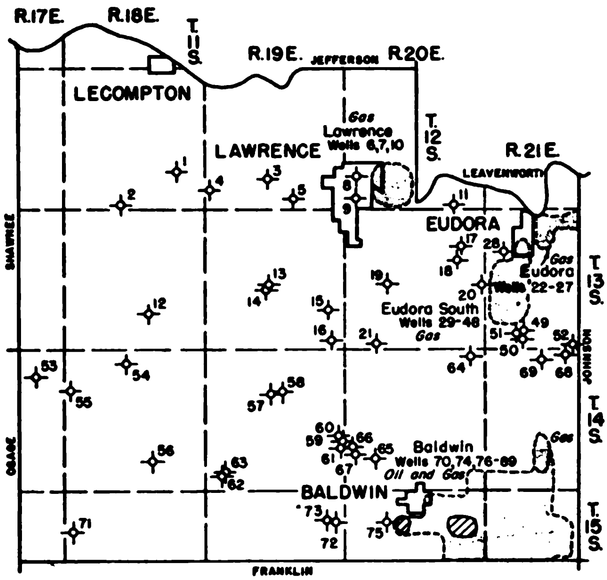

FIG. 26.—Map of Douglas County showing oil and gas fields and location of wells listed in Table 35.

ated Cotter and Jefferson City dolomites, 106 feet; Roubidoux formation, 167 feet; undivided Gasconade and Van Buren dolomites, including a slight thickness of Gunter sandstone in the basal part, 206 feet; Eminence dolomite, 175 feet; and Bonneterre dolomite, 91 feet (Lee, 1943, fig. 5). Seven feet of Lamotte sandstone lies on Pre-Cambrian crystalline rocks in this well.

OIL AND GAS DEVELOPMENTS

Although several deep test wells have been drilled in Douglas County, oil and gas have not been found in rocks older than the Cherokee shale. Known structural conditions in rocks older than the Chattanooga shale, however, suggest the probability that stratigraphic traps may exist in the Devonian or Kimmswick rocks. Data on Douglas County wells, records of which are available, are given in Table 35.

The **Baldwin** oil pool extends from southeastern Douglas County into Franklin County. Oil production is from the "Squirrel sand" about 800 feet below the surface. The pool was discovered in 1919. The discovery well was drilled in sec. 12, T. 15 S., R. 20 E.

Wells were reported to have had average initial production of about 20 barrels of oil per day although in some daily production as high as 220 barrels was reported. Peak production is reported

TABLE 35.—*Data on some wells drilled for oil and gas in Douglas County,*

No. on map	Name of well	Location	Completion date	Total depth, feet	Remarks
1	Volcanic Oil Co. No. 1 Gorrill	SE cor. NE¼ 26-12-18E	11-14-45	2,146	Top Miss. ls. at 1,516 feet; top Hunton ls. 1,968 feet; top of Simpson ss. 2,130 feet
2	.... No. 1 Wulfkuhle	SE¼ SE¼ SW¼ 33-12-18E		1,320	Stopped in basal part of Cherokee rocks
3	Smith et al. No. 1 Smith	SW cor. SE¼ 28-12-19E	8-4-27	2,382	See Table 34
4	Sagamore Oil & Gas Co. No. 1 David Williams	Cen. NW¼ NW¼ 31-12-19E	6-16-42	1,680	Top Miss. ls. 1,528 feet
5	Volcanic Oil Co. No. 1 Jackman	NE¼ NE¼ SE¼ 34-12-19E	11-7-45	2,208	See Table 34
6	Kerlyn Oil Co. No. 1 Wise	Cen. SE¼ SW¼ 28-12-20E	5-28-40	1,588	
7	J. M. Huber Corp. No. 1 Hickman	Cen. SE¼ SE¼ 29-12-20E	10-23-44	742	
8	....	.... 30-12-20E	9-?-1887	1,380	Near old A.T. & S.F. freight depot, Lawrence; reported to have flowed salt water
9	....	.... 31-12-20E	3-?-1887	600	Near Lykin's Mill on New Hampshire St., Lawrence
10	J. M. Huber Corp. No. 1 Community	NW cor. NW¼ 33-12-20E	1-3-45	1,813	108 M gas; discovery well
11	Forrester et al. No. 1 Altenborn	SW¼ SE¼ 35-12-20E	12-41-40	1,605	
12	Russell et al. No. 1 John Harrel	SW cor. NE¼ 27-13-18E	10-8-29	1,200	Stopped in Cherokee gr.
13	Skelly Oil Co. No. 1 Middlekauff	SW¼ NE¼ NE¼ 21-13-19E	6-7-44	1,855	See Table 34
14	Skelly Oil Co. No. 2 Middlekauff	NE¼ SW¼ NE¼ NE¼ 21-13-19E	7-6-44	1,271	Top Miss. ls. 1,267 feet
15	Apperson et al. No. 1 Howard	Cen. SE¼ NW¼ 25-13-19E	6-24-41	1,205	Top Miss. ls. 1,195 feet
16	.... No. 1 C. W. Wells	36-13-19E	?	1,030	
17	Douglas Oil & Gas Synd. No. 2 Gage	SE¼ NE¼ NE¼ SE¼ 11-13-20E	11-1-40	1,120	Top Miss. ls. 1,102 feet
18	Reynolds & Eaton No. 1 Gage	NW cor. NE¼ NE¼ 14-13-20E	12-6-33	760	Stopped in Cherokee gr.
19	Kerlyn Oil Co. No. 1 Whedon	Cen. NE¼ NE¼ 20-13-20E	6-26-40	719	Stopped in Cherokee gr.
20	Baysinger et al. No. 1 Grosdidier	SE¼ NE¼ NE¼ 24-13-20E	12-13-39	845	Stopped in Cherokee gr.
21	.... Doolittle	SE¼ NE¼ SW¼ 32-13-20E	?	1,300	"Much gas" reported between 900 and 1,300 feet
22	.... No. 1 Flagger	NE¼ SE¼ 3-13-21E	?	575	Oil show at 555 feet; gas at 568 feet
23	T. A. Goff No. 1 Henry Kurtz	SE cor. NE¼ 3-13-21E	?	644	Gas reported at 622 feet
24	T. A. Goff No. 1 McCoy	Cen. SW¼ NE¼ 3-13-21E	11-15-41	623	
25	T. A. Goff No. 1 Neis	Cen. NW¼ SW¼ 3-13-21E	6-16-40	577	Gas well; gas from 570 to 577 feet
26	R. F. Duffens No. 1 Lothholtz	Cen. NE¼ NW¼ SW¼ 4-13-21E	6-13-41	801	Dry hole; stopped in Cherokee gr.
27	.... No. 2 Moll	SW cor. SW¼ 4-13-21E	?	344	

TABLE 35.—*Data on some wells drilled for oil and gas in Douglas County, concluded*

No. on map	Name of well	Location	Completion date	Total depth, feet	Remarks
28	Goff Oil & Gas Co. No. 1 Gerstenberger	SE cor. SE¼ 7-13-21E	10-6-36	885	Stopped in Cherokee gr.
29	Goff Oil & Gas Co. No. 1 Gage	NW cor. NW¼ 8-13-21E	6-21-37	880	Stopped in Cherokee gr.
30	.... No. 1 Oberholtzer	8-13-21E	?	385	
31	.... No. 2 Oberholtzer	8-13-21E	?	383	Gas reported at 363 feet
32	.... No. 1 Pilla	8-13-21E	?	411	
33	.... No. 1 Chas. Richards	8-13-21E	?	342	
34	.... No. 1 J. Rotherger	NW cor. 8-13-21E	8-7-05	360	
35	Utilities of Kansas No. 1 Ott	SW cor. SE¼ SW¼ 17-13-21E	3-12-30	1,220	Top of Miss. ls. 1,070 feet
36	J. M. Edwards No. 1 Rosenau	Cen. SW¼ SW¼ 17-13-21E	7-26-42	787	Stopped in Cherokee gr.
37	J. M. Edwards No. 1 Durr	Cen. SE¼ NE¼ 18-13-21E	6-2-42	830	Stopped in Cherokee gr.
38	J. M. Edwards No. 2 Durr	SE¼ NE¼ SE¼ 18-13-21E	10-15-42	900	Stopped in Cherokee gr.
39	Hannan et al. No. 1 Adir	NE cor. SE¼ 19-13-21E	10-3-29	692	350 M gas from 682 to 692 feet
40	Hannan et al. No. 1 Bartz	NW cor. NW¼ 20-13-21E	11-8-29	685	180 M gas from 662 to 672 feet
41	.... No. 1 McBride	SE cor. SW¼ SW¼ 21-13-21E	?	766	Gas from 655 to 670 feet
42	Hannan et al. No. 2 McBride	SW cor. SW¼ 20-13-21E	10-6-29	511	550 M gas from 493 to 511 feet
43	Goff Oil Co. No. 3 Emilie Genter-barger	SW¼ NE¼ NW¼ 29-13-21E	7-31-37	734	Dry hole; stopped in Cherokee gr.
44	.... No. 1 Gerstenberger	NW¼ NW¼ 29-13-21E	?	678	Gas well; abd.; gas from 655 to 674 feet
45	.... No. 2 Gerstenberger	Cen. E. line SE¼ NW¼ 29-13-21E	-03?	1,104	Gas reported at 839 feet; top Miss. ls. 1,075 feet
46	John S. Holmes No. 1 Griffin	SW¼ SW¼ SE¼ 29-13-21E	commenced 8-15-42	703	Dry hole; stopped in Cherokee gr.
47	J. M. Edwards et al. No. 1 H. Bohnsack	NE cor. NE¼ 30-13-21E	9-25-41	786	Gas well; plugged back to 696 feet
48	Reynolds & Eaton No. 1 Faust	Cen. NE¼ NE¼ 30-13-21E	12-10-33	710	Dry hole; stopped in Cherokee gr.
49	Holmes et al. No. 1 Gabriel-Woodard	NE¼ NW¼ NE¼ 32-13-21E	11-3-42	358	Gas well
50	.... No. 2 Gerstenberger	32-12-21E	?	600	Gas reported from 347 to 353 feet; gas and oil from 476 to 481 feet; gas and oil from 590 to 600 feet
51	Conholbar et al. No. 1 Chas. Schohror	NE¼ NE¼ NW¼ 32-13-21E	7-10-42	712	Gas well; gas from 709½ to 712 feet
52	Kaw Valley Devel. Co. No. 1 Samuel Stanley	SE¼ SE¼ 34-13-21E	?	902	Stopped in Cherokee gr.
53	Wm. Lorenzen No. 1 Geo. Sullivan	NE¼ NE¼ 11-14-17E	5-8-37	677	
54	Landsprecht & Baker No. 1 Griffin	Cen. NW¼ SE¼ 4-14-18E	9-5-39	2,116	See Table 34
55	Kinney Oil & Refg. Co. No. 1 Losey	NW cor. SW¼ SW¼ 7-14-18E	-18	1,000	Log not available; oil show reported
56	W. H. Hazlett et al. No. 1 Featherston	Cen. SE¼ SE¼ 27-14-18E	9-7-32	1,337	Stopped in Cherokee gr.

57	S. W. Forrester et al. No. 1 Ice	SW¼ SE¼ SE¼ 9-14-19E	8-15-40	935	Tools lost in hole
58	W. H. Hazlett et al. No. 1 Wm. Churchbaugh	Cen. SW¼ SW¼ 10-14-19E	4-5-33	1,276	Stopped in Cherokee rocks
59	.... No. 1 Pardee	SE cor. SE¼ 24-14-19E	?	1,238	Stopped in Cherokee rocks
60	.... No. 2 Pardee	SE¼ SE¼ 24-14-19E	?	1,235	
61	.... No. 1 Pardee	NE cor. NE¼ 25-14-19E	?	1,022	Gas well; 1,000 M from 992 to 1,000 feet
62	Pure Oil Co. No. 1 Leuf	NW cor. SE¼ 31-14-19E	9-27-32	2,110	See Table 34
63	Sperry Oil & Gas Co. No. 1 Rappard	SE cor. N½ NE¼ 31-14-19E	?	1,070	Stopped in Cherokee gr.; tools left in hoie?
64	Conholbar Synd. No. 1 Stout	NE cor. NW¼ 1-14-20E	6-13-42	527	Dry hole
65	Hayhurst, Rich, & Lloyd	Cen. NE¼ SW¼ 29-14-20E	9-17-27	1,204	Dry hole; stopped in Cherokee gr.
66	.... No. 1 Tucker	NW¼ 30-14-20E	?	978	750 M gas from 969 to 978 feet
67	.... No. 2 Tucker	NE¼ SE¼ NW¼ 30-14-20E	?	1,005	Show of gas 999 to 1,005 feet
68	R. F. Duffens No. 1 Stanley	NW¼ NE¼ NW¼ 3-14-21E	7-20-41	2,503	See Table 34
69	Sagamore Oil & Gas Co. No. 1 Freund	Cen. SE¼ NW¼ 4-14-21E	7-17-42	853	Dry hole; stopped in Cherokee rocks
70	.... No. 1 Dwyer	SE¼ 33-14-21E	?	876	Dry hole; Stopped in Cherokee rocks
71	L. L. Russell No. 1 Dodder	Cen. N. line SW¼ 7-15-18E	5-25-32	1,333	Stopped in "Bartlesville sand"
72	Frank Hill No. 1 Butell	NE cor. SW¼ NE¼ 12-15-19E	-27?	1,430	Heavy oil reported from 945 to 950 feet; top Miss. ls. 1,345 feet
73	Sterline Synd. No. Butell	Cen. SE¼ NW¼ NW¼ 12-15-19E	?	1,170	Stopped in Cherokee rocks
74	Hemminger No. 1 Lancaster	NW¼ NE¼ NW¼ 2-15-20E	6-24-36	762	Stopped in Cherokee rocks
75	Russell Hays No. 1 Eichman	SE cor.NE¼ 8-15-20E	7-23-40	880	Stopped in Cherokee rocks
76	Stearns & Streeter No. 2 Smith	Cen. NW¼ SW¼ 9-15-20E		869	
77	Webster, Sterns et al. No. 1 Smith	NE¼ NW¼ SW¼ 9-15-20E	12-21-21	847	
78	Webster & Stearns No. 2 Smith	SE cor. NW¼ 9-15-20E	-21	857	
79	C. T. Edwards et al. No. 1 Webster	SW¼ SE¼ NW¼ 9-15-20E	?	845	Gas reported at 605 feet
80	.... No. 4 Webster	NE¼ SW¼ SE¼ NW¼ 9-15-20E	10-28-37	829	
81	Russell Hays No. 5 Webster	SE¼ SW¼ NW¼ 9-15-20E	7-8-39	847	Initial daily production 5 bbls. oil from 826 to 847 feet
82	Russell Hays No. 1 Jordan	NW cor.SE¼ 10-15-20E	8-5-37	860	Dry hole
83	Russell Hays No. 2 Jordan	Cen. NW¼ 10-15-20E	9-15-37	860	Dry hole
84	F. G. Hill No. 1 Finety	Cen. S½ SE¼ 11-15-20E	9-18-35	900	Dry hole
85	.... No. 3 Howard	N½ SE¼ 11-15-20E	?	887½	Oil sand from 842 to 877½ feet
86	.... No. 1 S. L. Preston	SE¼ SW¼ NW¼ 12-15-20E	?	842½	Oil sand from 827½ to 842½ feet
87	J. H. Lemon No. 1 Lidikey	SE¼ NW¼ SE¼ 4-15-21E	4-18-36	810	Dry hole
88	J. H. Lemon No. 2 Lidikey	Cen. N. Line SE¼ SW¼ 4-15-21E	5-27-36	750	Dry hole
89	Russell Hays No. 1 Hays	SW¼ NE¼ SW¼ 6-15-21E	5-22-37	884	Dry hole

to have been reached in 1927, when the field yielded 23,900 barrels of oil. Production during 1948 is estimated as 4,000 barrels of oil. Gas was discovered east and north of Baldwin, and a field was developed about 20 years ago. Initial daily production from the "Squirrel sand" was as high as 1 million cubic feet.

The **Eudora** gas pool is in T. 13 S., R. 21 E. The **Eudora East** gas pool extends into Johnson County in T. 13 S., R. 21 E. Production in these pools is from the "Squirrel sand" at a depth of about 700 feet.

The **Lawrence** gas-producing area lies northeast of Lawrence and extends into Leavenworth County. Gas was discovered in 1944 in the Huber No. 1 Community well in the NW¼ sec. 33, T. 12 S., R. 20 E. The "Squirrel sand" at a depth of 670 feet yields this gas. The well was gauged at 85,000 cubic feet of gas per day.

ELK COUNTY

The first gas well in Elk County was completed on the Johnson farm near Elk Falls on July 4, 1901. Oil was discovered near Longton in 1902, and oil and gas are still produced in this area. Production in Elk County has been relatively important since about 1921. Most of the gas has been produced in the southern half of the county. The southwestern part of the county is the principal oil-producing area.

Elk County produced 211,926 barrels of oil in 1948. Production in the county during the years 1902 to 1948 inclusive is shown in Tables 2 and 2a. Table 36 gives the production of the various oil fields for 1944 through 1948. Oil and gas fields and areas of 1948 oil production in Elk County are shown in Figure 27. Three water-flooding projects are operating in the county (Fig. 2, Table 3).

Peak oil production in Elk County was attained in 1927, when nearly 900,000 barrels was produced. In 1935 production had declined to 580,556 barrels.

Geology

SURFACE ROCKS

The youngest consolidated rocks exposed in Elk County belong to the Chase group. They crop out in the western part of

TABLE 36.—*Oil production in Elk County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Bush-Denton	40	28,806	47	20,933	51	26,041	45	28,010	46	29,241
Collyer	8	15,143	11	12,680	13	12,800	11	12,781	11	12,107
Dory	3	2,631	3	2,250	3	1,769	1	78	3	1,746
Dunkleberger	20	29,413	29	26,277	29	24,840	29	24,340	28	27,390
Ferguson East	1	2,105	2	3,218	2	2,868	2	2,365	1	1,205
"Gardner"								1,505		
Grand Summit[1]	13	18,410	10	14,402	10	11,778	11	10,875	12	14,463
Hale-Inge[2]			18	2,226	27	6,511	22	3,720	22	5,035
Longton										870
Love							4	7,527	4	4,515
Mills	4	1,905								
Moline	15	5,937	13	9,541	13	7,539	13	11,060	12	5,463
New Albany		84,104		103,887		44,121		31,144		22,100
Porter	11	12,012	12	10,008	12	7,677	13	13,354	10	4,609
Rettig			3	2,093	1	1,157	1	420		
Schrader									2	25,036
Severy				See Greenwood County						
Starr			2	963	2	1,111	6	10,496	6	5,266
Walker	3	1,889	1	1,703	2	1,453	2	1,597	2	1,456
Webb	75	58,943	65	63,861	80	67,726	78	60,683	70	50,873
Youngmeyer	1	2,341	1	1,015						
Miscellaneous								66		551
Totals	194	263,639	217	275,057	245	217,391	238	220,021	229	211,926

[1] Field extends into Cowley County.
[2] Field extends into Chautauqua County.

the county. The oldest rocks exposed belong to the Douglas group and crop out in the eastern part of the county.

Permian rocks.—Only the lower formations of the Chase group (Fig.3), the Matfield shale and the Wreford limestone, are present in Elk County. They cap the hills in the western part of the county. The Council Grove group in Elk County consists of about 125 feet of limestone and shale. Rocks of the Admire group consist of shale, thin beds of limestone, and some coal. They have a total thickness of about 90 feet.

Pennsylvanian rocks.—The Wabaunsee group (Fig. 4) consists of shale, sandstone, and thin beds of limestone; it has a total thickness of about 300 feet in Elk County. The average thickness of the Shawnee group in the county is about 425 feet. The Douglas group consists chiefly of shale and sandstone, and includes thin beds of limestone and some coal. The Douglas rocks have a total thickness of about 300 feet in Elk County. Only the upper part of the group crops out.

SUBSURFACE ROCKS

Subsurface geologic conditions in the west-central part of Elk County are shown diagrammatically in Plate 3. Depths to some stratigraphic horizons as shown by the log of the Halstead and Company No. 1 Osborne well, NW¼ NW¼ sec. 8, T. 31 S., R. 11 E., are given in Table 37.

Pennsylvanian rocks.—The total thickness of rocks between the top of the Pedee group and the base of the Cherokee shale is about 1,300 feet in Elk County. The Lansing group has a total thickness of about 150 feet. It consists of two limestones and a shale. Oil and gas are produced from three sandstones in the Vilas shale. The upper of these sandstones is known as the "Bush-Denton" or "Ferguson," the middle as the "Longton" or "Webb," and the lower as the "Encill sand." The Kansas City group has a thickness of about 440 feet in the county and consists chiefly of limestone and shale. A sandstone in the upper part of the group, known as "Layton," yields oil and gas. The Pleasanton rocks consist chiefly of shale and sandy shale and are about 60 feet thick.

The Marmaton group in Elk County is about 250 feet thick and consists of alternating beds of limestone and shale and includes some sandstone and coal beds. The "Old Red sand" in the Nowata shale, the "Weiser sand" in the Bandera shale, and the Little Osage shale member of the Fort Scott limestone yield oil and gas in Elk County. The Cherokee shale consists chiefly of shale, sandstone, and a few thin beds of limestone and coal. Its total thickness in the county is about 300 feet. The "Bartlesville sand," about 180 feet below the Fort Scott limestone, and the "Burgess sand," near the base of the Cherokee shale, yield oil and gas.

Mississippian rocks.—The total thickness of Mississippian limestones in Elk County ranges from 150 to 350 feet (Lee, 1939, pl. 1). The formations are the "Warsaw," Keokuk, Burlington, Reeds

TABLE 37.—*Depths to some key horizons in the Halstead and Company No. 1 Osborne well, SW¼ NW¼ NW¼ sec. 8 ,T. 31 S., R. 11 E., Elk County*

Horizon	Depth, feet
Base of Kansas City group (top of Pleasanton)	1,355
Base of Marmaton group (top of Cherokee)	1,610
Top of Mississippian limestone	1,904
Top of Chattanooga shale	2,157
Top of Cotter dolomite (Arbuckle)	2,200
Top of Pre-Cambrian rocks	2,960
Total depth of well	2,987

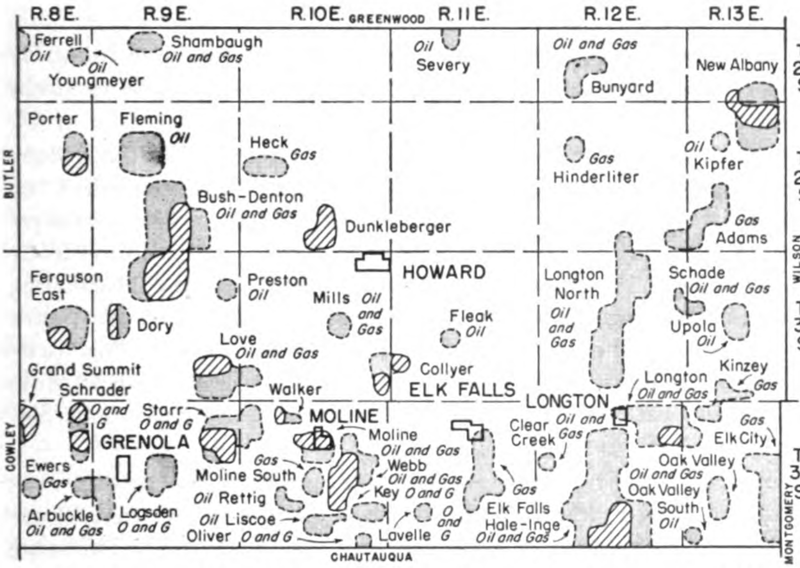

FIG. 27.—Map of Elk County showing oil and gas fields. Areas of 1948 oil production are cross hatched. Oil-producing areas in the Severy field are not definitely located.

Spring, and St. Joe limestones and Northview-Compton formations (undivided shale and limestone) (Lee, 1940). Lee (1939, pl. 1) has shown that the Mississippian rocks are thinner over anticlinal structures. Examples are the Dexter-Otto anticline, which extends into the northwestern part of Elk County, and the Longton anticline in the eastern part of the county. Oil and gas are produced from a weathered zone in the upper part of the Mississippian. The thickness of the Chattanooga shale in Elk County is about 50 feet (Lee, 1940, pl. 3).

Ordovician and Cambrian rocks.—The Ordovician and Cambrian rocks in Elk County have not been completely subdivided. The Cotter dolomite, which lies directly below the Chattanooga shale, is the youngest Ordovician rock in the county. Oil and gas are produced from a porous zone in the upper part of the Cotter. The thickness of the Ordovician and Cambrian rocks ranges from about 750 feet to 1,165 feet.

Pre-Cambrian rocks.—Pre-Cambrian rocks were penetrated at a depth of 2,950 feet in the Halstead and Company No. 1 Osborne well in the NW¼ NW¼ sec. 8, T. 31 S., R. 11 E.

Oil and Gas Developments

Oil and gas accumulations in Elk County have been found to be due to the presence of anticlinal structures. No shoestring sands are known.

Important gas-producing areas are Longton and Elk City. Most of the gas is produced from the "Encill sand" in the Kansas City group, the "Burgess" and "Bartlesville" sands in the Cherokee group, and the Mississippian limestone. Some production is from the "Peru," "Wayside," and "Weiser" sands in the Marmaton group. The average depth to the "Encill sand" in the central part of the county is about 1,300 feet. The maximum open flow production of some gas wells in these areas was more than 90 million cubic feet per day. The initial rock pressure was about 550 pounds.

A part of the **Longton** area has been used as a gas storage reservoir. Gas was stored in a sandstone near the top of the Kansas City group in an area of 1,150 acres in T. 32 S., R. 12 E. The sand has an average thickness of about 34 feet and lies at a depth of about 660 feet. The pool had produced a total of 3 billion cubic feet of gas. The initial rock pressure was 260 pounds. The total initial open flow from 25 wells was 30 million cubic feet.

The total production from the **Elk City** pool, in T. 31 S., R. 13 E., has been about 21½ billion cubic feet of gas. The producing formation is the "Burgess sand," which has an average thickness of about 33 feet and is at a depth of about 1,360 feet. The "Bartlesville sand" in this area has a thickness of about 30 feet and lies at an average depth of about 1,330 feet. The total open flow from 70 producing wells was 1¾ billion cubic feet. The open flows ranged from 15 to 90 million cubic feet. The initial rock pressure was 520 pounds.

The "Wayside sand" at a depth of about 560 feet is the producing horizon in the **New Albany** area. The **Webb** and **Bush-Denton** oil fields are important; they also yield some gas. Oil was produced from the Arbuckle limestone ("Siliceous lime") in the **Key** and **Shambaugh** pools. Both of these pools are now abandoned. Additional data on Elk County oil fields are included in Table 36.

FRANKLIN COUNTY

Franklin County has been producing oil and gas for more than 40 years. The oil fields lie generally in the eastern half of the county in the vicinities of Rantoul, Peoria, and Wellsville. There are scattered gas fields near Ottawa and in the northwestern part of the county. All oil and gas production has been from rocks of Pennsylvanian age. The producing rocks lie at an average depth of about 750 feet.

Franklin County produced 233,325 barrels of oil in 1948. Oil production in the county during the years 1904 to 1948, inclusive, is given in Tables 2 and 2a. Table 38 shows the production in the various producing areas for 1944 through 1948. Four water-flooding projects are operating in the county (Fig. 2, Table 3).

In 1947, 14 gas wells in Franklin County were reported as producing a total of 27,397 thousand cubic feet of gas. The 1948 production was about the same. Most of the gas comes from a small area in the northeastern part of T. 18 S., R. 21 E. and near-by sections.

The oil and gas fields and areas of 1948 oil production in Franklin County are shown in Figure 28.

Geology

SURFACE ROCKS

The consolidated outcropping rocks in Franklin County are of Pennsylvanian age. There are some unconsolidated surficial beds ranging in age from Tertiary (?) to Recent on the uplands and in the stream valleys. The youngest bedrocks in Franklin County are the Lecompton limestone and a few feet of the overlying Tecumseh shale (Fig. 4). These rocks are exposed in the northwestern part of the county. The oldest exposed rocks are along stream valleys in the southeastern part of the county.

The Douglas group (Fig. 5) consists chiefly of clastic material, including a large amount of sandstone. The Ireland sandstone member of the Lawrence shale is more fully developed in Franklin County than in counties farther north. The Douglas rocks in Franklin and neighboring counties have been described recently by Bowsher and Jewett (1943). The Weston shale of the Pedee group (Fig. 5) ranges in thickness from a featheredge to 75 feet or more in Franklin County. The Iatan limestone is not known to be present. There is an exposure of the Weston shale at the southeast corner of sec. 15, T. 17 S., R. 19 E.

The Stanton limestone of the Lansing group (Fig. 5) comprises about 45 feet of limestone and shale. The Rock Lake shale member near the top consists largely of sandstone, and the Eudora shale, near the base of the formation, is chiefly black platy shale. The Stoner limestone member, middle part of the Stanton formation, forms rather prominent bluffs and is generally less than 20 feet thick. The Vilas shale, which ranges in thickness from 2 to 10 feet or more, contains thin limestone beds in places where it is thickest. The Plattsburg limestone in Franklin County ranges from about 16 to 24 feet or more in thickness and is composed largely of massive limestone which is buff when weathered. The lower unit, the Merriam limestone member, although generally thin or even absent, locally is thicker than the upper member, the Spring Hill limestone.

The oldest exposed rocks in Franklin County are those in the upper part of the Kansas City group (Fig. 5). Rocks older than the Chanute shale are not exposed in the county and the Westerville limestone is seemingly absent. The upper few feet of the Chanute shale, the Iola limestone, the Lane shale, the Wyandotte limestone, and the Bonner Springs shale are exposed along streams in the southeastern part of the county. Rocks of this group are characterized by the thick Lane and generally thick Bonner Springs shales and by the conspicuous scarp-making Wyandotte limestone. The Bonner Springs shale ranges in thickness from as little as 5 feet in sec. 1, T. 19 S., R. 21 E. to 56 feet or more. The Bonner Springs formation contains much sandstone. The Wyandotte limestone, about 30 feet thick, is somewhat variable in lithology but consists mostly of irregularly bedded light-colored fossiliferous limestone.

SUBSURFACE ROCKS

Pennsylvanian rocks.—Pennsylvanian rocks below the base of the Oread limestone are about 1,300 feet thick in Franklin County. The presence locally of as much as 100 feet of Weston shale presents a situation somewhat different from that in some near-by areas. This condition is due to the difference in the amount of material removed by erosion from the top of Missourian rocks before deposition of Douglas beds. Lansing, Kansas

City, Pleasanton, and Marmaton rocks in Franklin County are not different particularly from the same rocks in near-by counties. Cherokee rocks are about 350 feet thick in Franklin County. The "Squirrel sand," in the upper part of the Cherokee section, is the most prolific oil and gas reservoir that has been found in Franklin County.

Mississippian rocks.—The total thickness of Mississippian limestones in Franklin County is about 300 feet. The "Warsaw" limestone is believed to be the uppermost Mississippian formation present in most of the county, but the Spergen limestone has been identified in the northeastern part (Lee and Payne, 1944, fig. 17). In the central-western part of the county, post-Mississippian erosion reached the upper part of the Burlington-Keokuk section. According to Lee (1940, pl. 8), the Chouteau and Sedalia limestones underlie all of Franklin County.

The Chattanooga shale, of late Devonian or early Mississippian age, is believed to be present under all of Franklin County. The thickness is about 50 feet. In most of Franklin County, the Chattanooga shale is in contact with the Viola dolomite. The Viola is absent in the southeastern part of the county, however, and the Chattanooga lies on the St. Peter formation. The St. Peter is believed to be absent in the extreme southeastern corner of the county and the Chattanooga rests upon Arbuckle rocks in this area (Fig. 4).

Older Paleozoic rocks.—Devonian and Silurian rocks are believed to be absent in most of Franklin County, but a few feet of Devonian limestone has been identified in the northern part of the area. The Kimmswick and Decorah formations (Middle Ordovician) are present in all but the southeastern part of the county. The greatest thickness of these rocks is about 100 feet. Except in the southeastern part of the county, the St. Peter sandstone is covered by younger Ordovician rocks. The extreme southeastern corner of the county seems to be high enough on the Chautauqua arch for the St. Peter sandstone to have been removed before burial under the Chattanooga shale. The thickness of the St. Peter sandstone ranges from a few feet to about 50 feet. Arbuckle rocks thicken eastward in Franklin County, a condition that was brought about by pre-St. Peter beveling of the upper formations. The thickness of Arbuckle rocks ranges from about 450 to about 800 feet.

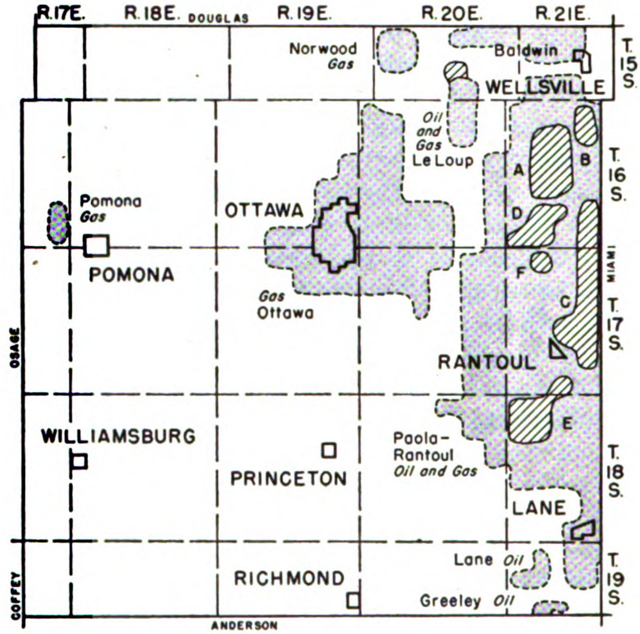

FIG. 28.—Map of Franklin County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

According to Keroher and Kirby (1948, figs. 3, 5, 6, 8, 9) the (1) Jefferson City-Cotter dolomite sequence in Franklin County ranges in thickness from 150 feet in the northeastern corner of the county to about 275 feet in the southwestern corner; (2) the Roubidoux dolomite is less than 100 feet thick; (3) the Van Buren-Gasconade sequence ranges in thickness from 100 feet in the southwestern corner of the county to 200 feet in the northeastern corner; (4) the Eminence dolomite ranges from 50 feet in the southwestern corner to slightly more than 150 feet in the northeast; (5) the Bonneterre has an average thickness of about 100 feet and lies on Pre-Cambrian rocks except in the northeastern part of the county where the Lamotte sandstone is believed to be present.

Oil and Gas Developments

Oil and gas were first produced commercially in Franklin County about 1904. In 1905, 55 oil wells and 4 gas wells were

TABLE 38.—*Oil production in Franklin County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Baldwin	See Douglas County. Franklin County part not producing at present.									
LeLoup	Production included in Douglas County estimate								3	400
Norwood		683								
Paola-Rantoul[1]										
A	121	16,172	118	15,991	122	20,276	116	17,842	115	15,327
B	13	1,123	18	986	13	1,207	18	913	13	1,112
C	283	101,886	281	104,336	283	161,889	285	155,472	282	204,977
D	54	4,364	52	3,761	52	4,246	52	4,659	46	4,081
E	25	6,565	29	8,087	31	7,676	29	8,308	29	6,671
F	4	565	4	481	4	560	4	743	4	757
Miscellaneous		300	4	300	4	224	16	248		
Totals	500	131,658	506	133,942	509	196,078	520	188,185	492	233,325

[1] Field extends into Miami County.

completed. The first production was near Rantoul. Peak production was reached in 1926.

Most of the oil and gas production in Franklin County is from an area that is included in the **Paola-Rantoul** field as designated by the Oil Field Nomenclature Committee of the Kansas Geological Society. This area includes most of the eastern half of Franklin County and a large part of Miami County. Some gas is produced from scattered pools in the western part of Franklin County. Production of both oil and gas is chiefly from the "Squirrel sand" in the upper part of the Cherokee shale but other Pennsylvanian sandstones, including the "Prue" and "Bartlesville," are productive.

Many wells were drilled in Franklin County in the early 1920's, but little attention was given to geologic conditions and there were many dry holes, but initial daily production of some wells was as high as 250 barrels. Peak oil production was attained in 1926 when 78,053 barrels was produced.

Recent activities in Franklin County have been almost entirely in connection with water-flooding operations in the Paola-Rantoul field.

GEARY COUNTY

Neither oil nor gas has been discovered in Geary County, but there has not been sufficient testing to prove the area barren. This county has an area of 407 square miles, but according to available records only 13 test holes have been drilled. The geology of Geary County has been described in a report by Jewett (1941).

Geology

SURFACE ROCKS

With the exception of loess (?), alluvium, and other unconsolidated surficial deposits of probable Pleistocene and Recent age, the surface rocks in Geary County are of early Permian (formerly called Big Blue) age. The youngest Permian rock in the county is the Winfield limestone or perhaps the lower few feet of the Odell shale. The oldest exposed bedrock is the Eskridge shale which crops out along Deep Creek in the northeastern part of the county.

The Winfield limestone of the Chase group (Fig. 3) occurs only in the northwestern and southwestern parts of Geary County. The total thickness of rocks of the Chase group in the county is about 350 feet. Approximately the lower 300 feet is well exposed at numerous places in the slopes of the Flint Hills. In Geary County, as elsewhere along the outcrop line of Wolfcampian beds in Kansas, rocks of the Chase group are characterized by highly colored shales and thick flinty limestones. Limestone beds in the lower part of the Fort Riley member of the Barneston formation form a very noticeable natural "rim rock" near the crest of the Flint Hills in a large part of the county.

Rocks of the Council Grove group (Fig. 3) have an aggregate thickness of approximately 300 feet in Geary County. Rocks in the upper part of this group are well exposed in the slopes of the Flint Hills. Rocks older than the Eskridge shale do not crop out in the county. The Council Grove rocks are characterized by highly colored shales and by limestones that weather light to nearly white in color and contain little or no flint. The individual limestone members do not exceed 10 feet in thickness.

SUBSURFACE ROCKS

Geary County lies on the west flank of the Nemaha anticline. Studies by Lee (1943, figs. 15, 16) indicate that the Mississippian limestone formations and the Chattanooga shale were removed from the extreme northeastern part of the county by pre- or early Pennsylvanian erosion. In most of the county the Chattanooga shale is believed to lie on the "Hunton" limestone, but in the extreme eastern part the Chattanooga or younger rocks lie on the Viola limestone. Lee, Leatherock, and Botinelly (1948, pl. 14)

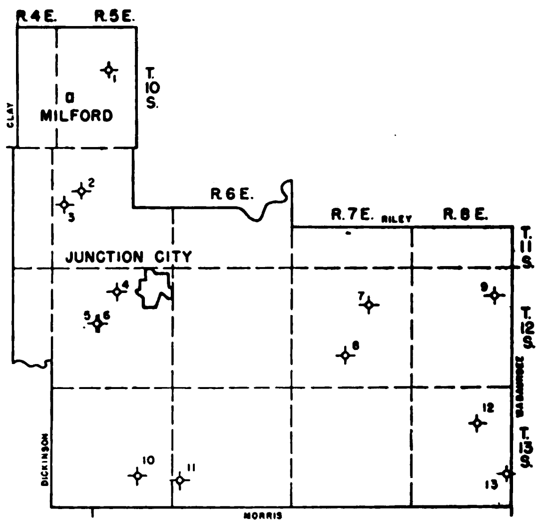

FIG. 29.—Map of Geary County showing location of wells listed in Table 39.

TABLE 39.—*Test wells drilled for oil and gas in Geary County*

No. on map	Name of well	Location	Comple- tion date	Total depth, feet	Lowest formation penetrated[1]
1	Brinkley et al. No. 1 Fawley	NW cor. NE¼ 16-10-5E	8- 9-27	2,501	Maquoketa
2	Wright et al. No. 1 Younkin	CNL NE¼ NW¼ 17-11-5E	9-24-30	3,240	Pre-Cambrian
3	Kerby & Wright No. 1 Kurtze	CNL SW¼ SE¼ 18-11-5E	6- 4-27	2,652	Hunton
4	Carter Oil No. 1 Munson	NE¼ NW¼ NW¼ 10-12-5E	9-28-05	1,930	Mississippian
5[2]	Junction City Mining & Drilling Co.	SE¼ NE¼ SW¼ 16-12-5E	about 04	1,700	
6[2]	Junction City Mining & Drilling Co.	SE¼ NE¼ SW¼ 16-12-5E	about 04		
7	Pioneer Petroleum Co. No. 1 Chase Ranch	SE cor. SE¼ 10-12-7E	1-15-29	3,638	Pre-Cambrian
8	Pioneer Petroleum Co. No. 1 Zumbrum	SW cor. NE¼ 28-12-7E		1,895	Cherokee
9	Scheu & Teague No. 1 Aye	NW¼ SW¼NW¼ 10-12-8E	8- 2-39	2,239	Maquoketa
10	Manhattan Oil No. 1 Foster	SW¼ NE¼ NW¼ 26-13-5E	8- 2-27	2,382	Hunton
11	Liberty-Texas Co. No. 1 Foster	NE cor. SW¼ 30-13-6E	8-24-26	2,412	Marmaton?
12	Empire Gas & Fuel No. 1 Stellwagen	NE¼ SE¼ SW¼ 9-13-8E	4-27-17	2,763	Hunton?
13	L. E. Dornes et al. No. 1 Fechner	Cen. SE¼ NE¼ 27-13-8E	11-15-33	1,220	Douglas group

[1] Determined by R. P. Keroher (in Jewett, 1941a, p. 110).

[2] Data from F. R. Newsome, Junction City, Kansas; two wells are about 300 feet apart.

have shown geologic conditions in the northwest part of Geary County as inferred from studies of cuttings from wells in adjoining counties. The cross section prepared by those geologists shows Cherokee shale overstepping beveled Mississippian formations.

Permian and Pennsylvanian rocks.—The maximum thickness of Permian rocks in Geary County is about 750 feet. The total thickness of Permian and Pennsylvanian rocks ranges from about 1,500 feet in the extreme northeastern part of the county to about 2,250 feet in the southwestern part (Moore and Jewett, 1942, fig. 2).

Mississippian rocks.—According to Lee and Payne (1944, fig. 17), the total thickness of Mississippian limestone formations in Geary County ranges from a featheredge to more than 100 feet. According to Lee, Leatherock, and Botinelly, (1948, pl. 14) the "Warsaw" (?), Gilmore City, and Sedalia limestones are the Mississippian limestone formations that are probably present in the northern part of the county. The Chattanooga shale ranges in thickness from a featheredge to more than 200 feet (Lee, 1943, fig. 14).

Pre-Chattanooga rocks.—In Geary County the "Hunton" limestone has an average thickness of about 300 feet. The Maquoketa shale is about 85 feet thick and is underlain by about 120 feet of Viola dolomite. The Simpson (St. Peter) sandstone includes a few feet of greenish shale in the upper part, a sandstone, and about 45 feet of red shale in the lower part. The total thickness of the Simpson is about 75 feet. About 10 feet of sandstone overlying granite in the Pioneer Petroleum No. 1 Chase Ranch well, in the SE cor. SE¼ 10, T. 12 S., R. 7 E., is believed to be the Lamotte sandstone.

Two wells in Geary County have been drilled into Pre-Cambrian rocks. The Pioneer Petroleum No. 1 Chase Ranch well reached granite at 2,925 feet. The Wright et al. No. 1 Younkin well, at the Cen. N. line NE¼ NW¼ sec. 17, T. 11 S., R. 5 E., reached granite at 2,940 feet.

Oil and Gas Exploration

Neither oil nor gas has been discovered in Geary County. Table 39 gives data on test drilling for oil and gas in Geary County.

Figure 29 shows the locations of 13 test wells in the county of which the Geological Survey has records.

GREENWOOD COUNTY

Many wells were drilled in Greenwood County in 1918, but oil production did not become important until 1921. The geology and development of the shoestring oil fields of Greenwood County have been discussed by Cadman (1927) and Bass (1936).

Greenwood County produced 4,776,611 barrels of oil in 1948. Natural gas production during the year was approximately 45 million cubic feet. The gas came from the Tucker field, secs. 14 and 15, T. 26 S., R. 11 E. Oil production in the county during each year from 1916 to 1948 is shown in Tables 2 and 2a. Table 40 gives production in the various fields for 1944 through 1948. Table 41 gives the gravity of some samples of oil from Greenwood County fields. Data are from Lane and Garton (1943, table 3). Figure 30 is a map of Greenwood County showing locations of oil and gas fields as defined by the Nomenclature Committee of the Kansas Geological Society and locations of areas that yielded oil in 1948.

Secondary recovery of oil by water injection is an important phase of the oil industry in Greenwood County. Thirty water-flooding projects are being operated in the county (Table 3, Fig. 2).

Geology

SURFACE ROCKS

Permian rocks.—The Florence flint, Matfield shale, and Wreford limestone in the lower part of the Chase group (Fig. 3) crop out in the extreme northwestern part of Greenwood County. The thickness of these rocks is about 175 feet. The Council Grove group has an average thickness of about 300 feet in the county, and the Admire group is about 150 feet thick.

Pennsylvanian rocks.—The average thickness of the Wabaunsee group (Fig. 4) in Greenwood County is about 420 feet. The Shawnee group has an average thickness of about 425 feet. The upper part of the Lawrence shale of the Douglas group is exposed in the extreme southeastern part of the county.

TABLE 40.—*Oil production in Greenwood County, 1944 through 1948*

Field	Discovery date	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil	Producing horizon	Depth. feet
Atyeo[1]		See Lyon County								11+	15,962		
Beaumont		30	126,441	29	70,890	28	68,880	28	60.030	24	53,177		
Beaumont South		Included with Beaumont											
Blackwell		3	1,803	3	1,710	3	720	11	3,854		1,594		
Blankenship[2]		See Butler County								9+	8,846		
Brinegar		27	5,330	24	5,721	23	7,058	20	6,059	20+	6,276		
Browning		90+	145,547	99+	132,045	99+	125,763	99+	129,851	99+	125,686	"Bartlesville"	2,314
Burkett		102+	610,193	101+	778,200	103+	714,270	100+	589,950	128+	504,344	"Bartlesville"	2,000
Climax					11,672				13,011		16,521	Mississippian	1,900
Demalorie-Souder	1924	125	254,066	125	226,440	125	208,770	125	183,900	2+	178,760	"Bartlesville"	2,150
Dunaway[3]		44	53,452	42	50,370	40	46,770	39	44,400		40,920	"Bartlesville"	1,800
Eureka		11	2,848	11	19,988	8	26,280	12	31,410	5+	29,245		
Fankhouser[4]		See Lyon County								7+	35,398		
Gaffney		3+	10,173	1+	9,968	3+	9,210	3+	8,880		8,934		
Gilroy										2	906		
Hamilton	1929	89+	94,074	85+	86,645	84+	83,237	82+	92,421	55+	418,719	"Bartlesville"	1,765
Hinchman		10	10,690	10	7,740	8	8,250	8	7,001	1+	5,800		
Hollis		2+	3,173			2+	2,970	2+	3,023	2+	3,023		
Jackson		2	1,586	2	1,560	2	1,500	2	1,530	2	1,396		
Jobes		2	3,103	1	540	1	450	1	480	1	380		
Lamont		106+	103,589	101+	100,489	104+	95,573	106+	128,880	48+	121,434		
Madison	1921	103+	129,414	105+	130,573	105+	117,060	105+	110,370	90+	100,317	"Bartlesville"	1,800
Petterson		1	582	3	3,690	4	3,394	2	485	1	2,072		
Pixlee	1923	43	41,606	43	34.950	43	34,078	43	41,280	37	67,795	"Bartlesville"	2,327
Polhamus		44	25,122	44	23,880	44	23,760	44	25,050		34,561		
Quincy[5]	1926	19	14,357	20	9,464	4	8,233	19	8,735	19	8,666	"Bartlesville"	1,420
Reese		26	27,401	24	21,330	22	19,650	22	23,220	19	22,179		
Sallyards	1921	130	115,616	131	115,500	130	114,150	130	157,440	50+	227,157	"Bartlesville"	2,350

Scott		66	74,451	66	69,296	66	60,215	66	69,039	66	70,728		
Seeley-Wick	1922	319	422,034	319	450,390	319	514,230	219	898,320	229+	1,462,496	"Bartlesville"	1,930
Severy[6]		41+	25,980	38+	29,587	38+	20,880	32+	19,954		16,176		
Severy North					1,884				1,402				
Teeter[7]	1922	193+	208,413	192+	200,070	190+	192,060	190+	212,557	128+	158,147	"Bartlesville"	2,400
Teichgraber		18	15,886	18	15,330	18	14,700	17	13,980	17	13,288		
Thrall-Aagard		252	464,287	255	539,680	256	754,762	251	649,200	29+	508,540		
Toronto[8]		7	6,403	2	4,767	7	3,461	7	2,316	10	2,530		
Virgil	1916	93+	100,394	108+	145,266	149	177,519	118+	178,017	43+	167,921	"Bartlesville" "Miss. lime"	1,550 1,700
Virgil North[9]		284	403,785	299	382,241	310	372,477	307	376,771	6+	286,670		
Wiggins		45	33,585	45	32,010	44	35,205	41	27,600	41	25,770		
Wilkerson		13	7,455	13	13,830	13	21,540	13	16,560	13	14,659		
Willard		3	4,989	2	2,518	2	3,044	3	3,781	2	5,827		
Miscellaneous									8,615		791		
Totals		2,346+	3,547,828	2,361+	3,730,234	2,397+	3,890,119	2,267+	4,149,372	1,216+	4,776,611		

1 Field extends into Chase and Lyon Counties.
2 Field extends into Butler County.
3 Field extends into Coffey County. Years 1944, 1945, 1946, and 1947 include Coffey County production.
4 Field extends into Lyon County.
5 Field extends into Woodson County.
6 Includes Elk County production. Areas of production are not definitely located.
7 Field extends into Chase County. Years 1944, 1945, 1946, and 1947 include Chase County production.
8 Includes Woodson County production.
9 Field extends into Coffey and Woodson Counties. Years 1944, 1945, 1946, and 1947 include some or all of Coffey and Woodson Counties production. Some of production estimated.

SUBSURFACE ROCKS

Subsurface geologic conditions in the western part of Greenwood County are shown diagramatically in Plate 3.

Pennsylvanian rocks.—The Douglas group includes beds of shale, sandstone, and thin limestone, and is about 300 feet thick in Greenwood County. The Pedee group consists of shale and some sandstone and is unconformably overlain by sandstone and shale of the Douglas group. It is convenient to designate the combined Douglas and Pedee rocks as Douglas-Pedee where the boundary cannot be recognized. The Lansing group consists of about 360 feet of shale and limestone. The Kansas City group consists largely of limestone but includes some shale and sandstone, especially in the upper part; the lower part, the Bronson subgroup, consists almost entirely of limestone. Its average thickness is about 450 feet. The Pleasanton shale has an average thickness of about 60 feet. The Marmaton group consists of about 250 feet of alternating limestone and shale. The Cherokee shale consists of light and dark-gray shale, black shale, lenses of sandstone, and a few thin beds of limestone and coal. Sandstone lenses occur locally near the top of the Cherokee. Sandstone lenses called "Cattleman" occur 50 to 75 feet above the top of the "Bartlesville shoestring sands," which are about 100 feet above the base of the Cherokee. Common thicknesses of the "Bartlesville" are between 50 and 100 feet. Locally the "Bartlesville" rests on Mississippian rocks (Bass, 1936, p. 23). In the eastern part of the county a sandstone is present at the base of the Cherokee shale. It is separated from the overlying "Bartlesville sand" by shale.

Mississippian rocks.—Mississippian limestones in Greenwood County range from about 250 to 400 feet in total thickness (Lee, 1940). They consist of limestone, cherty limestone, and shale. The "Warsaw," Keokuk, Burlington, Reeds Spring, and St. Joe limestones and the Northview-Compton shale have been identified in a well in sec. 33, T. 25 S., R. 10 E. (Lee, 1940). The Mississippian limestones are underlain by the Chattanooga shale which ranges in thickness from about 40 to 100 feet. The Chattanooga rests unconformably on Ordovician rocks.

Ordovician and Cambrian rocks.—Ordovician and Cambrian rocks have not been completely subdivided in Greenwood County. These rocks have a total thickness of about 700 to 1,000 feet and overlie Pre-Cambrian rocks. The Chattanooga shale is directly

TABLE 41.—*Gravity of some samples of oil from Greenwood County*

Field	Producing zone	Depth to producing zone, feet	Gravity of oil, degrees A.P.I.
Aagard	"Burbank sand"*	2,146-2,190	39.6
Browning	"Burbank sand"		41.1
Burkett	"Burbank sand"	±2,100	37.8
Demalorie-Souder	"Burbank sand"	2,240	42.3
Fankhouser	"Burbank sand"	±1,850	40.9
Hamilton	"Bartlesville sand"	1,700-1,708	38.2
Johnson	"Bartlesville sand"		40.0
Lamont	"Bartlesville sand"		38.6
Madison	"Burbank sand"	±1,900	39.8
Polhamus	"Burbank sand"	2,170-2,199	39.8
Quincy	"Burbank sand"	1,436-1,450	40.9
Sallyards	"Burbank sand"	2,394-2,458	39.4
Teeter	"Burbank sand"		41.5
Wick	"Burbank sand"		41.1
Wiggins	"Cattleman sand"	1,860-1,870 composite sample	40.2

* "Burbank sand" is called also "Bartlesville sand."

underlain by Viola limestone. The Viola limestone and Arbuckle rocks are separated by the St. Peter (Simpson) sandstone. Arbuckle rocks consist of massive beds of dolomite, limestone, and sandstone which are commonly referred to as "Siliceous lime."

Keroher and Kirby (1948, pl. 6, log 15) studied well cuttings from the Burg, Trott et al. No. 1 Breitkrutz well, sec. 4, T. 24 S., R. 10 E. They identify 475 feet of undifferentiated Jefferson City-Cotter dolomite, 72 feet of Roubidoux dolomite, and 17 feet of Bonneterre dolomite. The Bonneterre was found to be lying on Pre-Cambrian rocks. They (Keroher and Kirby, 1948, fig. 10) inferred that westward from a point a short distance west of the well whose cuttings were studied, the Roubidoux dolomite lies on Pre-Cambrian rocks, and that the Van Buren-Gasconade dolomites, the Gunter sandstone member of the Van Buren, and the Eminence dolomite pinch out in places southeast of the well.

Oil and Gas Developments

Most of the oil produced in Greenwood County is from elongated lenses of sand in the lower part of the Cherokee shale at an average depth of about 2,000 feet. The individual lenses are arranged approximately end to end, separated by narrow gaps, so that they form collectively long narrow systems, each 20 to 50 miles long and only a half mile to 1½ miles wide. These elongated sand bodies are commonly referred to as shoestrings. The sand lenses are not at one stratigraphic horizon, but all are confined

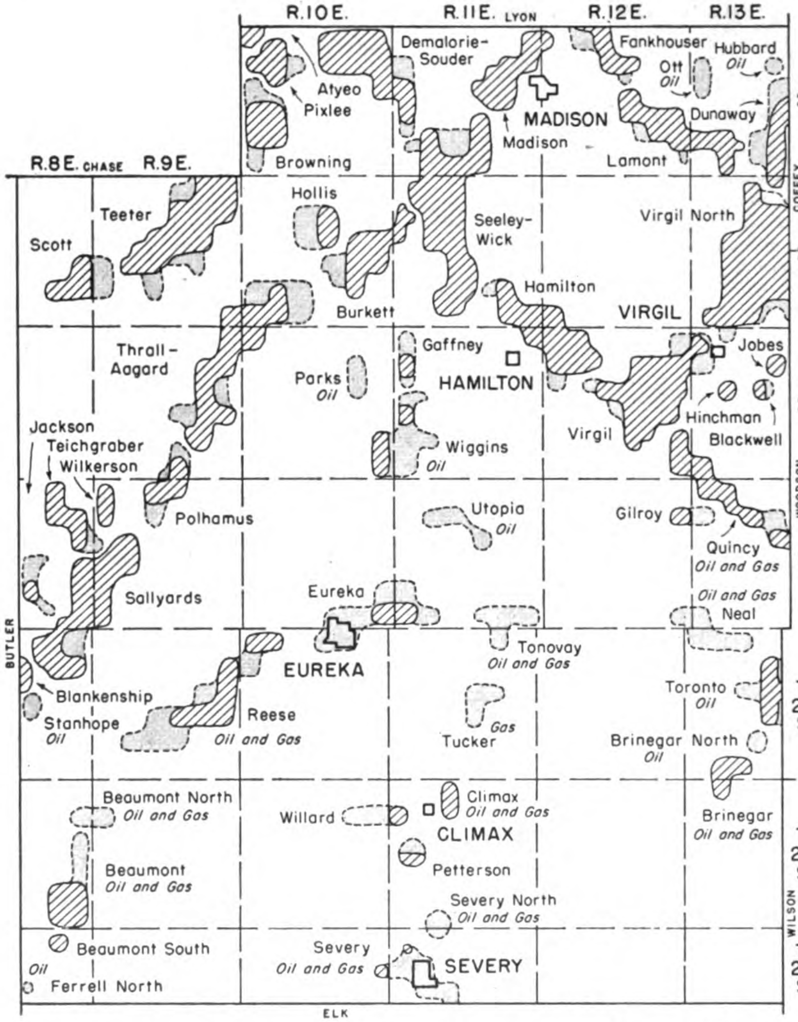

Fig. 30.—Map of Greenwood County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

to a restricted stratigraphic zone. Some oil is produced in the county from the Mississippian limestone.

The only commercial gas production in Greenwood County is in secs. 14 and 15, T. 26 S., R. 11 E., in the **Tucker** field. Gas is produced from sandstone in the Douglas rocks at a depth of about 645 feet. The field was drilled about 18 years ago and has been yielding about 40 or 50 million cubic feet of gas annually for the last seven years.

The **Sallyards** pool was discovered in 1917 (Bass, 1936, p. 60). A few years later other pools were opened in rapid succession—the **Teeter** and Aagard in 1921 and the **Seeley, Burkett,** and **Browning** in 1922 (Loomis, 1923). The Sallyards, **Polhamus,** Thrall-Aagard, Burkett, **Seeley-Wick,** and **Madison** pools form a field 30 miles in length and a mile or less in width. This productive area is called the **"Golden Lanes."** Another sand trend about 15 miles long is parallel to the "Golden Lanes" and about 5 miles northwest of them. Two other trends, about 8 miles apart, cross these main trends in a direction nearly at right angles. These sandstones have an average thickness of about 30 feet, and are in the "Bartlesville sand" zone at depths of 2,000 to 2,500 feet. Repressuring has been in progress in the Madison pool since 1937.

The **Virgil** field was one of the first to produce oil from the Mississippian limestone in Kansas. The discovery well in this field, the Cosden Oil and Gas Company No. 1 Wyaham in the SE¼ sec. 14, T. 24 S., R. 12 E., was completed on October 12, 1916. The initial production was about 15 barrels. By 1929, 193 oil wells and 10 gas wells were producing in this field. The average initial production of the oil wells was about 28 barrels per day. Some production is from the "Bartlesville sand" but the important production is from a porous zone at or near the top of the Mississippian limestone at a depth of about 1,700 feet. The Virgil field is located on a surface structure having a closure of more than 60 feet. There were more than 43 producing wells in this field in 1948 and the production in that year was 167,921 barrels.

The **Aagard** pool, later found to be connected with the **Thrall,** was discovered in 1924 and oil was produced by primary methods until 1930, when a gradual increase in the oil production rate was caused by water infiltration from abandoned oil wells. This accidental flood caused an increase in oil production from a daily average of 17 barrels to 61 barrels. The controlled water-flooding project was started in March 1937; the first oil increase was in August 1937 and the rate of oil production reached a peak during the latter part of that year. The productive zone is the "Bartlesville sand" which has an average thickness of about 50 feet and is encountered at a depth of about 2,100 feet.

Table 40 gives additional data on the oil pools in Greenwood

TABLE 42.—*Data on pool wells drilled in Greenwood County during 1947 and 1948*

Field	1947				1948			
	Producing wells and formation		Dry	Total	Producing wells and formation		Dry	Total
Beaumont			0	0			2	2
Burkett	1	"Bartlesville"	1	2	2	"Bartlesville"	1	3
Demalorie-Souder			0	0	2	"Bartlesville"	0	2
Dunaway			0	0	1	Mississippian ls.	0	1
Eureka	4	Mississippian ls.	0	4	10	Mississippian ls.	4	14
Fankhouser	1	"Bartlesville"					1	1
	1	Viola	0	2				
Gilroy			0	0	3	"Squirrel"	1	4
Hamilton			3	3	1	"Bartlesville"		
					7	Salt water disposal		
					1	Water input	2	10
Lamont	4	"Bartlesville"	3	7	1	"Bartlesville"		
					1	Mississippian ls.		
					4	Salt water disposal	1	7
Madison			0	0			2	2
Pixlee			0	0	2	Mississippian ls.	0	2
Polhamus	1	"Bartlesville"	0	1	2	"Bartlesville"	0	2
Quincy	1	Mississippian ls.	2	3	3	"Bartlesville"		
					1	Mississippian ls.	1	5
Reece	1	Mississippian ls.	0	1	1	Mississippian ls.	0	1
Seeley-Wick			4	4	8	"Bartlesville"		
					3	Salt water disposal		
					1	Water input	1	12
Virgil	1	Mississippian ls.	1	2	7	Mississippian ls.	3	10
Virgil North	1	"Bartlesville"			1	"Bartlesville"		
	3	Mississippian ls.	3	7	4	Mississippian ls.	3	8
Teeter			1	1	4	"Bartlesville"	2	6
Thrall-Aagard			0	0	1	"Bartlesville"		
					1	Mississippian ls.	1	3
Toronto			0	0	2	"Squirrel"		
					1	"Burgess"	3	6

County. Table 42 is a summary of the pool wells drilled in the county during 1947 and 1948.

JACKSON COUNTY

Neither oil nor gas in commercial quantities has been produced in Jackson County. Several wells have been drilled. Porosity in Mississippian and "Hunton" rocks has been reported, and a show of oil was reported in the upper part of the "Hunton" limestone in a well in sec. 27, T. 7 S., R. 15 E.

GEOLOGY

SURFACE ROCKS

Glacial deposits, some of which are several feet thick, occur in all parts of Jackson County. Consolidated bedrocks of Permian and Pennsylvanian ages are exposed. The youngest Permian rocks in the county are beds in the lower part of the Chase group and the oldest outcropping Pennsylvanian rock is the White Cloud shale.

Permian rocks.—The Wreford limestone caps hills in the northwestern part of Jackson County. Older Permian rocks (Fig. 3) crop out in most of the western two-thirds of the county. The Cottonwood limestone underlies an extensive dip slope in an area east of the Wreford-capped hills. Permian rocks in this county are similar in thickness and lithology to the same strata in near-by counties.

Pennsylvanian rocks.—Pennsylvanian rocks crop out in the eastern and southern parts of Jackson County. The oldest well-exposed rock is the Burlingame limestone (Fig. 4). The Tarkio and Burlingame limestones are the most prominent limestones among the outcropping Pennsylvanian beds.

SUBSURFACE ROCKS

Subsurface geologic conditions along the eastern side of Jackson County are represented diagrammatically in Plate 2. The county lies in the Forest City basin immediately east of the Nemaha anticline. Depths to some key horizons in five wells in the county are given in Table 43.

Pennsylvanian rocks.—Rocks of Pennsylvanian age in Jackson County have a maximum total thickness of about 2,250 feet. The section is thickest in the northern part of the county which is nearer the deepest part of the Forest City basin. The northward increase in thickness is chiefly in lower Pennsylvanian rocks. In the southwestern part of the county the interval between the base of the Bronson subgroup and the Mississippian rocks is about 800 feet, but the same interval is nearly 1,000 feet in the northern part.

Mississippian rocks.—The total thickness of the Mississippian limestones ranges from less than 100 feet in the northwestern corner of Jackson County to more than 300 feet in the northeastern corner (Lee and Payne, 1944, fig. 17). The Spergen limestone is the uppermost Mississippian limestone formation that has been identified in the county. It lies next below Pennsylvanian rocks in the northeastern part. Westward the Pennsylvanian sedi-

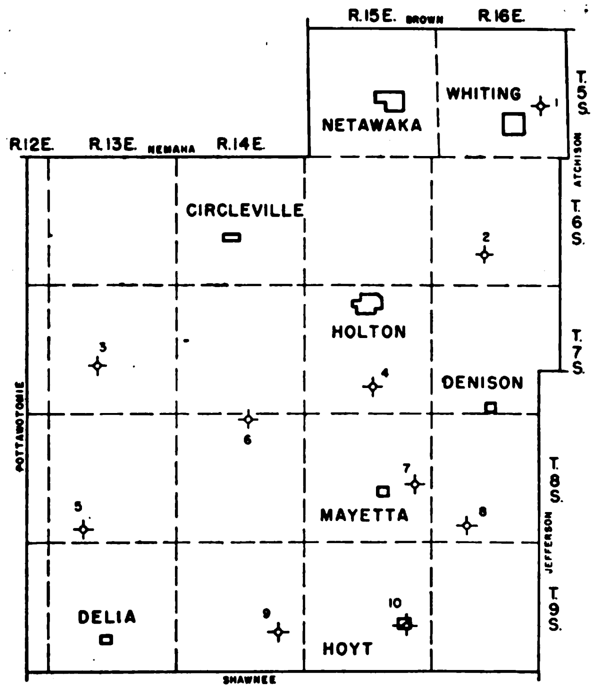

FIG. 31.—Map of Jackson County showing location of wells listed in Table 44.

ments overstep the "Warsaw" limestone onto the undifferentiated Burlington-Keokuk formations, the uppermost Mississippian rock in most of the county (Lee and Payne, 1944, figs. 4 and 17).

The Chattanooga shale in Jackson County ranges in thickness from slightly more than 150 feet in the southeastern part to more than 250 feet in the western part (Lee, 1940, fig. 14).

Pre-Chattanooga rocks.—The "Hunton" limestone in Jackson County increases in thickness to the northwest toward the deeper part of the North Kansas basin. According to Lee (1943, fig. 12), the thickness range is from about 150 feet in the southeast corner to about 450 feet in the northwest corner. Lee (1943, fig. 13) has shown that Silurian rocks (lower part of the "Hunton" limestone) range in thickness from about 100 feet in the southeastern corner to about 300 feet in the northeastern corner.

The interval between the top of the Maquoketa shale (uppermost Ordovician) and the top of the St. Peter sandstone in Jack-

TABLE 43.—*Depths to some key horizons in five wells in Jackson County*

Horizon	Rogers No. 1 Lincoln Liberty Life, SE¼ SE¼ sec. 23, T. 5 S., R. 16 E.	Garvin et al. No. 1 Lutz, SW¼ NW¼ SW¼ sec. 27, T. 7 S., R. 15 E.	Goens No. 1 Wabense, NE¼ NW¼ sec. 3, T. 8 S., R. 14 E.	McLaughlin & Sons No. 1 Kelly, SW¼ NE¼ sec. 24, T. 8 S., R. 15 E.	Haverbach et al. No. 1 Uhl, NE cor. NE¼ sec. 26, T. 9 S., R. 14 E.
Top Shawnee group		490	700	345	
Top Douglas group		800	1,060	650	740
Top Lansing group		1,015	1,260	888	1,015
Base Kansas City group		1,365	1,590	1,215?	1,595
Base Fort Scott limestone		1,555	1,800	1,500	1,915?
Top Mississippian rocks..	2,080	2,180	2,400	2,115	2,125
Top Chattanooga shale	2,330	2,475	2,592	2,275	2,365
Top "Hunton" limestone	2,533	2,635	2,832	2,480	2,680
Top Maquoketa shale					2,815
Top Viola limestone					2,880

son County is believed to range from less than 200 feet in the southern and southeastern parts to about 300 feet in the northwestern corner (Lee, 1943, fig. 11). The thickness of rocks between the top of the St. Peter sandstone (upper part of Lower Ordovician) and Pre-Cambrian rocks probably ranges from less than 100 feet in the northwestern part to about 500 feet in the

TABLE 44.—*Data on wells drilled for oil and gas in Jackson County*

No. on map	Name of well	Location	Completion date	Total depth, feet	Remarks
1	L. B. Rogers No. 1 Lincoln Liberty Life	Cen. NE¼ SE¼ SE¼ 23-5-16E	4-14-42	2,718	Stratigraphic data given in Table 43
2	Charles Wheeler	28-6-16E	?	1,200	
3	Stanolind Oil & Gas Co. No. 1 Stratigraphic test	SW cor. 21-7-13E	11-4-43		Log not available
4	Garvin et al. No. 1 John Lutz	SW¼ NW¼ SW¼ 27-7-15E	?	2,774	Stratigraphic data given in Table 43
5	"Well at Adrian"	SW cor. NE¼ 32-8-13E	?	1,000	Incomplete log
6	Goens et al. No. 1 Wabense	NE¼ NW¼ 3-8-14E	8-15-28	2,953	Stratigraphic data given in Table 43
7	McLaughlin Sons Co. No. 1 Kelly	Cen. SW¼ NE¼ 24-8-15E	3-24-44	2,538	Stratigraphic data given in Table 43
8	D. W. McLaughlin No. 1 Allen	SW¼ NW¼ NE¼ 32-8-16E	4-10-45	3,068	Top Mississippian ls. 2,143 feet; "Hunton" ls. 2,515 feet; Viola ls. 2,730 feet; Simpson 2,915 feet; Arbuckle 3,025 feet
9	Haverbach et al. No. 1 Uhl	NE cor. NE¼ 26-9-14E	8-1-38	2,905	Stratigraphic data given in Table 43
10	"Hoyt well"	SE cor. SE¼ 33-9-15E	?	1,246½	

southeastern part (Lee, 1943, fig. 9). The thickness of the St. Peter sandstone is probably much less than 100 feet. In the southern part of the county a few feet of Lamotte sandstone probably lies on the Pre-Cambrian floor.

Oil and Gas Exploration

Figure 31 is a map of Jackson County showing locations of wells drilled for oil or gas. Data on all wells on record in the Geological Survey files are given in Table 44.

JEFFERSON COUNTY

Oil and gas production became important in Jefferson County in 1940 when the McLouth pools were discovered. The geology of the McLouth area and the development of the McLouth field have been thoroughly discussed by Lee (1941) and by Lee and Payne (1944).

Jefferson County produced 108,652 barrels of oil in 1948. Yearly production in the county during 1941 to 1948 inclusive is shown in Table 2a. Table 45 shows the yearly production in the three fields of Jefferson County for 1944 through 1948.

Gas production in the county for 1941 through 1948 is given in Table 46. The locations of oil and gas fields and areas of oil production in 1948 are shown in Figure 32.

Geology

SURFACE ROCKS

Glacial drift is attenuated in all parts of Jefferson County, but in most of the area consolidated Pennsylvanian bedrocks are well exposed. The youngest Pennsylvanian rock in the county is the Reading limestone (Fig. 4) or a slightly higher bed which is present in the northwestern part of the county; the oldest ex-

Table 45.—*Oil production in Jefferson County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Banker's Life	5	13,259	5	14,850	5	52,861	7	11,200	7	11,843
McLouth	8	38,970	15	71,763	4	37,977	19	101,874	19	94,881
McLouth North	5	4,380	10	5,579		4,103	6	7,828	6	1,928
Totals	18	56,609	30	92,192	9+	94,941	32	120,902	32	108,652

TABLE 46.—*Estimated natural gas production in Jefferson County, 1944 through 1948*

Year	Thousand cu. ft. gas
1944	60,000
1945	60,000
1946	60,000
1947	100,000
1948	100,000

posed rocks are the upper beds of the Douglas group which crop out in the southeastern part. The Tarkio and Burlingame limestones cap prominent escarpments east of the Reading limestone exposures. The Shawnee group is well exposed in Jefferson County. Its thickness is about 300 feet. The Ervine Creek and Plattsmouth limestones are the thickest limestones and are the most prominent cliff-making ledges. The upper part of the Lawrence shale, in the Douglas group, is the oldest exposed rock in the county.

SUBSURFACE ROCKS

Jefferson County lies in the Forest City basin and on the northeastern flank of the North Kansas basin. Subsurface geologic conditions along the northern boundary of Jefferson County are shown in Plate 2. Depths to some key horizons in a well in the McLouth area are given in Table 47.

Pennsylvanian rocks.—In the northwestern part of Jefferson County, where the youngest Pennsylvanian rocks are present, the thickness of the Pennsylvanian section is slightly more than 2,000 feet. In the southeastern part of the county Pennsylvanian rocks are slightly more than 1,000 feet thick. As elsewhere in this part of Kansas, the base of the Oread limestone and the base of the Hertha limestone are convenient subsurface marker beds. Rocks between the base of the Hertha limestone and the Mississippian rocks in Jefferson County range in thickness from about 700 feet in the central-eastern part of the county (the McLouth field) to nearly 900 feet in the northwestern part (Lee, 1943, fig. 17A).

Mississippian rocks.—Limestones of Mississippian age in Jefferson County range in total thickness from about 250 feet in the northwestern part of the county to about 350 feet in the northeastern part (Lee, 1943, fig. 16). The St. Louis limestone has been identified as the youngest Mississippian formation in the county (Lee and Payne, 1944, figs. 4, 17). This limestone lies next below

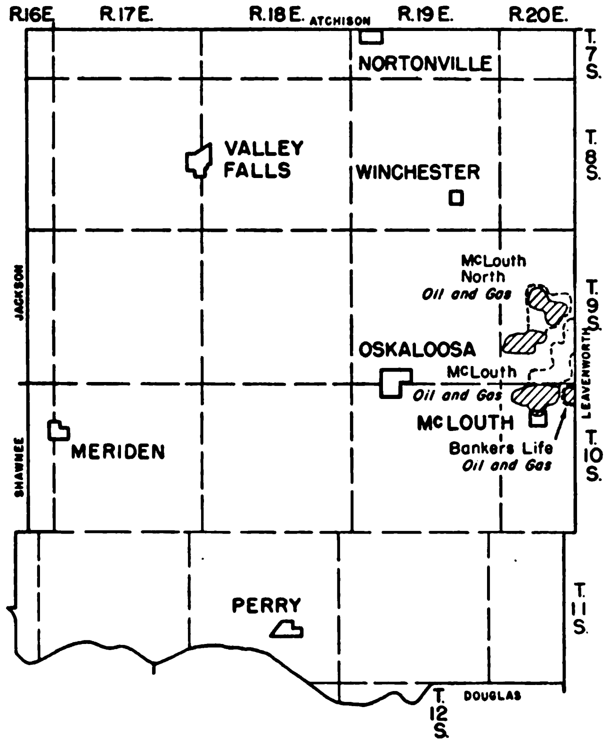

FIG. 32.—Map of Jefferson County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

Pennsylvanian beds in the northeastern part of the county and occurs as pre-Pennsylvanian outliers in the central part. West of the area in which the St. Louis limestone is next below the Pennsylvanian deposits, the Spergen and Warsaw formations are overlain by Pennsylvanian rocks. In the southwestern part of the county Pennsylvanian rocks lie on the Burlington-Keokuk limestones.

The Chattanooga shale ranges in thickness from about 75 feet in the southeastern part of Jefferson County to more than 150 feet in the northwestern part (Lee, 1943, fig. 14).

Pre-Chattanooga rocks.—Devonian rocks are 173 feet thick in the McLouth field (Lee, and Payne, 1944, p. 48). The thickness increases toward the northwest and decreases toward the southeast. In the McLouth area Lee and Payne (1944, p. 47, fig. 3) found 15 to 20 feet of sandstone in the basal part of the Devonian

TABLE 47.—*Depths to some key horizons in the J. B. Apperson et al. No. 1 Bower well, SE¼ SE¼ NE¼ sec. 5, T. 10 S., R. 20 E., Jefferson County* (Data from Lee and Payne, 1944, table 27)

Horizon	Depth, feet
Top Mississippian limestone	1,440
Top of "Warsaw" limestone	1,450
Top Burlington-Keokuk porous zone	1,580
Top of Chattanooga shale	1,781
Top of Devonian rocks	1,829
Top of Maquoketa	2,002
Top of Kimmswick limestone	2,009
Top of Decorah shale	2,158
Top of St. Peter sandstone	2,165
Top of Arbuckle	2,233
Total depth	2,288

section. A few feet of Maquoketa shale was found immediately below Devonian rocks. In a part of the area the Maquoketa shale and about 20 feet of the Kimmswick limestone were removed by erosion. The Kimmswick limestone was found to range in thickness from 125 to 150 feet (Lee and Payne, 1944, pp. 48-49). It lies disconformably on the St. Peter sandstone which is about 70 feet thick in the McLouth area. The Arbuckle rocks (Ordovician and Cambrian) are about 700 feet thick in the McLouth area. The thickness increases toward the southeast and decreases toward the northwest.

OIL AND GAS DEVELOPMENTS

The **McLouth** field has been discussed thoroughly by Lee (1941) and by Lee and Payne (1944). Three stratigraphic zones yield oil or gas: the McLouth sand in the basal part of the Cherokee shale, a zone at the top of Mississippian rocks, and a dolomitic zone in the Burlington-Keokuk limestone about 150 feet below the top of Mississippian rocks. The McLouth area extends into Leavenworth County.

The **McLouth North** gas pool yields gas from the McLouth sand and oil is found in the same rock on the north and south margins of the area (Lee and Payne, 1944, pl. 3). The McLouth gas pool occupies a larger area. The gas is produced from the McLouth sand. Oil was found in the Mississippian dolomite in the McLouth oil pool in secs. 4 and 5, T. 10 S., R. 20 E., and oil was found in the McLouth sand in sec. 3, T. 10 S., R. 20 E. in the **Bankers Life** pool, Leavenworth County. As commonly divided the

McLouth area in Jefferson County includes the Bankers Life, McLouth, and McLouth North fields (Fig. 32).

One dry wildcat well was reported in Jefferson County in 1948. It is the Inland Producing Company and E. F. Jackman No. 1 Browning well in the SW¼ SE¼ SW¼ sec. 16, T. 9 S., R. 17 E. Early in 1949 a well was reported being drilled in the NW¼ sec. 21, T. 9 S., R. 17 E.

JOHNSON COUNTY

Oil and gas are being produced in small amounts in several parts of Johnson County. Productive sandstones are found in the Marmaton and Cherokee groups. A report on the geology of Johnson and Miami Counties (Newell, 1935) includes areal geologic maps and describes in detail the outcropping rocks in the two counties. The subsurface geology of Johnson County has been discussed by Ockerman (1935) and Lee (1943) in papers on the subsurface rocks in northeastern Kansas.

The last reported production of oil in Johnson County took place a few years ago when a few barrels were produced in the county in the "Gardner" field.

In 1947 Johnson County produced 66,109 thousand cubic feet of gas. The 1948 production is estimated to have been about the same. Recorded production is in the Olathe, Olathe North, and Gardner South fields. Locations of oil and gas producing areas are shown in Figure 33.

Geology

SURFACE ROCKS

Pennsylvanian rocks crop out in all parts of Johnson County except where concealed by glacial drift or other surficial deposits. Pennsylvanian groups present include the Douglas, Pedee, Lansing, and Kansas City (Figs. 4, 5). The youngest Pennsylvanian rock in the county is the Tonganoxie sandstone which crops out on the uplands in the western part of the county; the oldest outcropping rock is the Winterset limestone member of the Dennis formation which crops out in the valley of Indian Creek along the eastern edge of the county and in the bed of Turkey Creek in northeastern Johnson County.

A large part of Johnson County is immediately underlain by the Stanton limestone. The Plattsburg and Wyandotte limestones crop out in many places along the valley walls of streams which have cut into the upland that is floored by the Stanton limestone. There are several useful key beds in the outcropping rocks. Among the more easily identified beds are black platy and fissile shale in the Eudora shale member of the Stanton limestone; the Merriam limestone, basal member of the Plattsburg formation; and the Paola limestone, basal member of the Iola formation.

SUBSURFACE ROCKS

Subsurface geologic conditions in the central part of Johnson County are shown diagramatically in Plate 1. Depths to some stratigraphic horizons in four wells in Johnson County are shown in Table 48.

Pennsylvanian rocks.—The average thickness of Pennsylvanian rocks in Johnson County is about 1,000 feet. The thickness of the Pennsylvanian section from the top of the Lansing group, which includes the surface rocks over a large part of the county, to the top of the Mississippian limestones is about 1,050 feet.

TABLE 48.—*Depths at which some key horizons were reached in four wells in Johnson County*

(Data in part from Lee and Payne, 1944, fig. 7)

Horizon	McCain No. 1 Doane, SE¼ NW¼ SW¼ sec. 34, T. 12 S., R. 22 E.	G. L. Smith No. 1 Pretz, SW¼ SE¼ NW¼ sec. 1, T. 14 S., R. 22 E.	Seminole Oil Company No. 1 Harrington, NE¼ cor. SW¼ sec. 12 T. 14 S., R. 22 E.	Adolf Thurow No. 1 Green, Cen. SW¼ sec. 25, T. 14 S., R. 22 E.
Base of Hertha limestone	312	345	340	401
Base of Fort Scott limestone	568	......	753	652
Top of Mississippian limestone	1,000	1,009	1,025	1,038
Top of Chattanooga shale	1,387	1,412	1,395	1,447
Top of Devonian limestone	1,429	......	......	1,528
Base of Devonian limestone	1,465	......	......	1,543
Top of Kimmswick (Viola) limestone	1,465	1,450	1,435	1,543
Top of Decorah and Plattin limestone	1,578	......	......	1,567
Top of St. Peter sandstone	1,605	1,555	1,535	1,587
Top of Arbuckle limestone	......	......	1,598	1,654
Top of Pre-Cambrian rocks	......	......	2,400	......

Mississippian rocks.—The total thickness of Mississippian limestone formations in Johnson County ranges from about 350 feet in the northwestern part to slightly more than 450 feet (Lee, 1943, Fig. 13). The average thickness of the Chattanooga shale in the county is somewhat less than 50 feet (Lee, 1943, Fig. 14).

Pre-Chattanooga rocks.—A thin section of Devonian rock is believed to underlie all of Johnson County. Lee (1943, fig. 7) identified 36 feet of Cooper and undifferentiated limestones in the McCain No. 1 Doane well in sec. 34, T. 12 S., R. 22 E., and 15 feet of Devonian sandstone in the Adolf Thurow No. 1 Green well in sec. 25, T. 14 S., R. 22 E. Fifteen feet of Devonian sandstone was found in a well in Missouri a few miles east of the southern corner of Johnson County.

Silurian rocks, the Maquoketa shale, and a part of the Kimmswick limestone were removed by erosion from this area before the time of deposition of Devonian sediments. The Kimmswick limestone was found to be 113 feet thick in the Doane well and 24 feet thick in the Green well. Twenty-seven feet of Decorah shale was found in the Doane well and 20 feet was found in the Green well.

The St. Peter sandstone underlies Johnson County. The thickness everywhere probably is less than 100 feet. The Arbuckle limestone is 802 feet thick in the Seminole Oil Company No. 1 Harrington well in sec. 12, T. 14 S., R. 22 E. The Arbuckle rocks increase in thickness to the southeast. Lee (1943, fig. 5) has shown that pre-St. Peter rocks in Johnson County probably include Cotter dolomite, Jefferson City limestone, Roubidoux formation, Gasconade and Van Buren dolomites, Gunter sandstone, Eminence and Bonneterre dolomites, and Lamotte sandstone. There probably is a thin wedge of Potosi dolomite between the Eminence and Bonneterre dolomites in the eastern part of the county.

Pre-Cambrian rocks were reached at 2,400 feet in the Seminole Oil Company No. 1 Harrington well.

Oil and Gas Developments

Gas has been produced for several years in the **Craig-Monticello** gas fields in T. 12 S., R. 23 E. For the last few years, however, a part of the field has been used for underground gas storage. Production in this field is from sandstones in the Pleasanton,

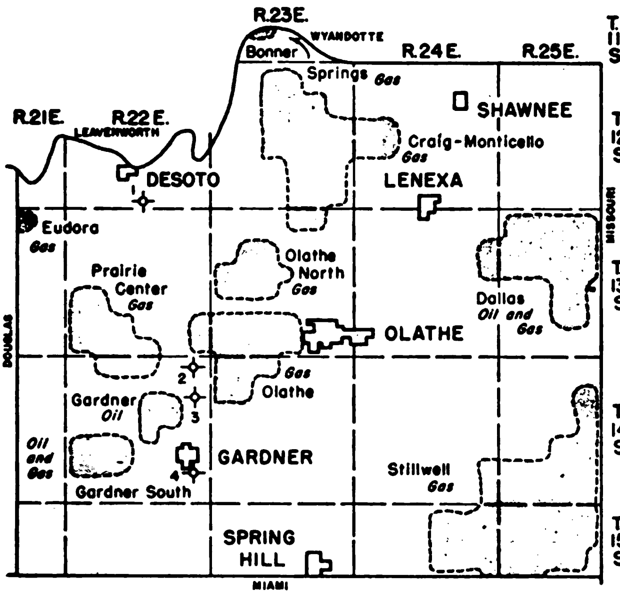

FIG. 33.—Map of Johnson County showing oil and gas fields and location of wells listed in Table 48.

Marmaton, and Cherokee groups. The principal production came from upper Cherokee rocks. In sec. 15, T. 12 S., R. 23 E., small gas wells were developed in the Knobtown sandstone in the upper part of the Pleasanton shale, a few feet below the Hertha limestone at depths ranging from about 200 to 300 feet. The Reid No. 1 Hodge well, in the SW¼ SW¼ sec. 15, T. 12 S., R. 23 E., yielded gas from the Knobtown "sand" and upper Cherokee sandstone. The Webb No. 1 fee well, in the NE¼ SE¼ of the same section, found gas in the same two zones. Gas was found in Pleasanton sandstone and in an upper Cherokee sandstone in T. 12 S., R. 23 E., and smaller amounts of gas were found in the "Peru sand" in some locations. In a part of this field, especially in secs. 25, 26, and 27, a gas-bearing sandstone as much as 60 feet thick was reported in the lower part of the Pleasanton shale.

Gas is produced from several zones in the northeastern part of T. 12 S., R. 25 E. The "Bartlesville sand" at a depth of 692 feet is reported to have yielded an initial flow of 331,000 cubic feet of gas in a well in the NW¼ NE¼ NE¼ sec. 9, T. 12 S., R. 25 E.

Gas has been found in the Knobtown sandstone in the **Dallas** area. Most of the wells were drilled in about 1938. Several wells are producing at the present time. The Knobtown in this field lies at depths ranging from about 100 to less than 200 feet. The Dallas oil field is now abandoned. Oil was produced from upper Cherokee sandstone between depths of 400 and 500 feet.

Scattered gas production, chiefly from the "Squirrel sand," is found in the southern part of Johnson County (Fig. 33). Initial production as high as 500,000 cubic feet has been reported.

The **Prairie Center** gas field (the Sunflower Ordnance Works now includes the site of the old town Prairie Center) is the newest gas field in the county. This field was drilled in 1942, and is being extended to the south. Production is from Pleasanton, Marmaton, and upper Cherokee rocks. Wells having initial productions of about 500,000 cubic feet have been reported.

The Denton and Cooper No. 2 Wood well, drilled in the fall of 1928 in sec. 14, T. 14 S., R. 22 E., was reported to have had an initial production of 100 barrels of oil daily. Production came from a Marmaton sandstone. In 1939 several oil wells having reported initial daily productions ranging from 5 to 100 barrels were drilled in sec. 15, T. 14 S., R. 22 E., in the **Gardner** field.

The Eudora East gas field extends from Douglas County into the northwestern corner of Johnson County.

A large number of wells, mostly shallow, have been drilled in Johnson County. Shallow rocks have been tested in most parts but the deeper rocks are largely untested.

On Dec. 8, 1948, the G. L. Smith No. 1 Pretz well, SW¼ SE¼ NW¼ sec. 1, T. 14 S., R. 22 E., was completed with a total depth of 1,560 feet (Table 42). Initial daily gas production was reported as 500 thousand cubic feet. Gas was found in a zone between 628 and 645 feet.

A few other wells have been drilled in Johnson County in recent years. The R. E. Andrews No. 1 Davis well in the NE¼ NE¼ SW¼ NW¼ sec. 2, T. 15 S., R. 24 E. was completed in June 1948 at a total depth of 903 feet. No production was reported.

LABETTE COUNTY

Oil and gas have been produced in Labette County for many years. The Wilmoth gas field, in sec. 9, T. 35 S., R. 19 E., was discovered in November, 1917. Large quantities of gas have been produced in the southeastern part of the county since 1921. Oil and gas are produced from the Bandera shale, the Fort Scott limestone, the Cherokee shale, the Mississippian limestone, and the Arbuckle dolomite. An oil and gas exploration map of Labette County was published by the Geological Survey (Abernathy, 1939) ten years ago. It was remarkably complete in showing the locations of wells and their stratigraphic depths. Many wells, however, have been drilled since the map was prepared.

Labette County produced 6,528 barrels of oil in 1948. Production in the county each year from 1917 to 1948 inclusive is shown in Tables 2 and 2a. Table 49 gives the production in the various fields in the county for 1944 through 1948.

Natural gas production in Labette County in 1948 is estimated as approximately 198,619 thousand cubic feet.

Figure 34 shows the locations of oil and gas fields in Labette County, as defined by the Nomenclature Committee of the Kansas Geological Society, and the locations of areas that produced oil in 1948.

Geology

Surface Rocks

All exposed consolidated rocks in Labette County are of Pennsylvanian age. The youngest consolidated rock is the Chanute shale in the Kansas City group (Fig. 5). It is exposed in the northwestern part of the county. The Bronson subgroup and the Pleasanton group crop out in a broad belt across the northwestern part of the county. The eastern boundary of the outcrop of Pleasanton rocks is at a point north of Parsons on the Neosho County line. Because the limestones in the Kansas City group become thin and inconspicuous southward, it is convenient to use the northern Oklahoma classification in the southern half of western Labette County. This classification includes the Chanute shale, Drum limestone, Cherryvale shale, Dennis limestone, Coffeyville shale, and Seminole (Hepler) sandstone.

The Marmaton group (Fig. 5) crops out in a broad band across the northeastern and southern parts of Labette County. The outcrop in the northern part of the county extends from the vicinity of Parsons to the Crawford County line, and in the southern part of the county it extends from a point south of Chetopa to the southwestern corner of the county on the Oklahoma line. The shale formations of this group underlie broad plains, whereas the limestone formations make more or less prominent escarpments across the regional dip slope of the beds. The Fort Scott limestone (locally called "Oswego," crops out in a narrow band across the southeastern corner of Labette County from the vicinity of Oswego to Bartlett. The outcrop makes a prominent escarpment in most places. The escarpment of the Pawnee limestone is relatively inconspicuous, although it is prominent farther south in Nowata County, Oklahoma. The Altamont limestone makes a prominent escarpment and the Lenapah makes a weak bench; these cross the county a little to the west of the Pawnee outcrop.

The Cherokee shale (Fig. 6) is the surface rock in the southeastern corner of Labette County. The western limit of its outcrop is a line running northeast and southwest through Oswego. Shale is predominant in the Cherokee. The area of Cherokee outcrop in Labette County is, therefore, a lowland plain floored with residual soil in which there are few rock exposures.

SUBSURFACE ROCKS

Pennsylvanian rocks.—The Lenapah limestone is about 30 feet thick in the subsurface in the western part of Labette County. The Nowata shale consists of about 40 feet of clay and sandy shale. The Altamont limestone consists of two beds of light-gray limestone, each about 10 feet thick, separated by about 4 feet of black fissile shale. The Bandera shale is about 122 feet thick. It includes sandy shale and sandstones. The Pawnee limestone, locally known as the "Pink" limestone, ranges in thickness from about 22 to 34 feet. The Labette shale ranges in thickness from 55 feet in the northwestern part of the county to 90 feet in the southwestern part. A thin bed of coal occurs in the upper part of the Labette shale and a thin limestone lies near the base of the shale. In the northeastern part of Labette County the Fort Scott limestone consists of two limestones separated by black shale. The upper limestone is about 20 feet thick and the lower limestone is about 8 feet thick. The black shale is about 5 feet thick. In the southwestern part of the county three or more limestones seemingly constitute the Fort Scott limestone. These limestones and separating shales have a maximum thickness of about 100 feet.

The upper limestone has a maximum thickness of 41 feet, the middle limestone has a maximum thickness of 34 feet, and the lower limestone has a thickness of 15 feet. The upper black shale is about 4 feet thick and the lower black shale is about 8 feet thick.

The Cherokee shale ranges in thickness from 395 to 560 feet. The shale thickens regularly toward the southwest in Labette County, but local variations in thickness are common. Sandstone commonly occurs in thin lenticular beds, and it is present in the lower part of the Cherokee in thick and massive beds. These beds include the "Bartlesville," Bluejacket ("Columbus"), and Little Cabin ("Burgess") sandstones. The most persistent limestone in the Cherokee shale is the Ardmore, which occurs about 80 feet below the base of the Fort Scott limestone in the eastern part of the county and about 40 feet below the Fort Scott in the western part. The Ardmore is a single bed of fossiliferous limestone about 3 feet thick.

Mississippian rocks.—About 350 feet of Mississippian rocks overlie the Chattanooga shale in Labette County. As pointed out by Lee (1939), these rocks were deposited on the nearly flat surface of the Chattanooga shale and later were gently folded and elevated. Subsequent erosion removed part of the Mississippian rocks from the elevated areas. The Mississippian formations in Labette County include the Spergen, "Warsaw," Keokuk-Burlington, Reeds Spring, and St. Joe limestones, the Northview shale, and the Compton limestone. The Chattanooga shale has an average thickness of about 20 feet; locally it ranges from 2 to 50 feet. The top of the Chattanooga is about 800 feet below the surface in the southeastern part of the county, and the depth increases to 1,340 feet in the northwestern part. The Chattanooga shale lies unconformably on Ordovician rocks.

Ordovician and Cambrian rocks.—Ordovician rocks in Labette County include the Cotter and Jefferson City dolomites, the Roubidoux formation, the Gasconade dolomite, and the Van Buren formation. Cambrian rocks include the Eminence and Bonneterre dolomites and the Lamotte sandstone.

Inferred geologic conditions in pre-Chattanooga rocks in Labette County are shown by Keroher and Kirby (1948, figs. 3, 4, 5, 6, 8, 9, and 11).

Oil and Gas Developments

Oil and gas are widely distributed over Labette County. Producing wells have been drilled on about 167 square miles of the county whose total area is about 637 square miles. It is estimated that more than 2,000 wells have been drilled in the county; about half of them have produced oil or gas.

Oil and gas are produced in Labette County from the Bandera shale, the Fort Scott limestone, and the Cherokee shale, of Pennsylvanian age; the "Warsaw" limestone of Mississippian age; and the Arbuckle limestone of Cambro-Ordovician age.

Much gas has been produced in the vicinity of Dennis from a sandstone in the Bandera shale known locally as the "Dennis sandstone." The "Dennis" lies about 340 feet below the surface. About 125 wells have been drilled to the "Dennis sandstone." According to the records, only 10 of these were dry holes. Black shales in the Fort Scott limestone yield gas in Labette County. In a total of 136 holes penetrating the Fort Scott limestone, 84 produced gas and 52 were dry holes. No oil is known to have been produced from this formation in the county.

Much oil and gas is produced from the "Bartlesville sand" in the Cherokee shale in Labette County. Gas is produced locally from coal beds in the Cherokee shale. Some areas of "Bartlesville" production are arranged in definite trends. The thickness of the "Bartlesville sand" ranges from about 2 to 50 feet. This sandstone zone is separated from the Mississippian limestone by 40 to 100 feet of shale. Gas has been produced from the Cherokee shale in more than 300 wells and oil has been produced from the Cherokee in about 75 wells.

A producing zone occurs in the "chat" that lies on Mississippian limestone. This "chat" is composed largely of fragments of chert; it is restricted in its occurrence to the flanks of "Mississippi lime" hills. The upper part of the Mississippian limestone contains porous beds that have yielded large amounts of gas.

Oil is produced from siliceous limestone in the upper part of the Arbuckle rocks. This zone has been penetrated by 63 wells in Labette County. Many of these wells had a "showing" of oil or gas; commercial quantities of oil were found in 15 or more wells.

Oil and gas fields as defined by the Nomenclature Committee of the Kansas Geological Society are indicated in Figure 34. Some smaller "fields" are discussed. Oil was first produced in the **Price** field in 1917. The reservoir rock is the "Bartlesville sand" at a depth of about 600 feet. Initial daily productions of the wells ranged from 10 to 50 barrels. More than 60 producing wells were drilled in this pool. In 1948, the field produced 2,236 barrels of oil.

The **"Kincaid"** part of the **Coffeyville-Cherryvale** field has yielded much oil. No records are available as to the date of discovery or the amount of production. About 40 wells produced oil from the "Bartlesville sand" at a depth of about 750 feet. All these wells were abandoned several years ago.

Oil has been produced since 1909 in the **"Benham"** part of the **Coffeyville-Cherryvale** field. Several wells in this pool have produced oil from the "Bartlesville sand" at a depth of about 675 feet. Initial daily productions ranged from 10 to 40 barrels. Fifteen wells in the Coffeyville-Cherryvale field are producing and yielded 4,006 barrels of oil in 1948.

The most recently discovered oil pool in Labette County is the **Chetopa.** The discovery well, the Remington No. 3, was drilled in sec. 36, T. 34 S., R. 20 E. by the Chetopa Oil and Gas Company in March 1936. This pool now is not producing. Production was from the Arbuckle limestone, which lies about 850 feet below the surface. The producing zone is a soft siliceous limestone about 3 feet thick which lies just below a hard brown limestone caprock. Only two dry holes were drilled in the pool. Daily initial productions ranged from 30 to 120 barrels per well.

Gas was first produced in the **Dennis** field in 1914. The producing sand, known as the "Dennis," lies in the Bandera shale at a depth of about 340 feet and ranges in thickness from 12 to 50 feet. More than 100 wells have been drilled in this area. Initial daily productions ranged from 100,000 to 500,000 cubic feet. The field is now abandoned.

The small **Oswego** gas pool is now abandoned. Most of the wells were drilled in 1930. The producing zone was the top of the Mississippian limestone at a depth of about 580 feet. The pool had eight gas wells; initial productions of these wells ranged from 100,000 to 150,000 cubic feet per day.

The **Lush** gas-producing area, west of Altamont and a part of the **Altamont** field, has yielded gas since 1930. The producing formations are the Fort Scott limestone, the "Bartlesville sand," and the Mississippian limestone. The Fort Scott limestone is about

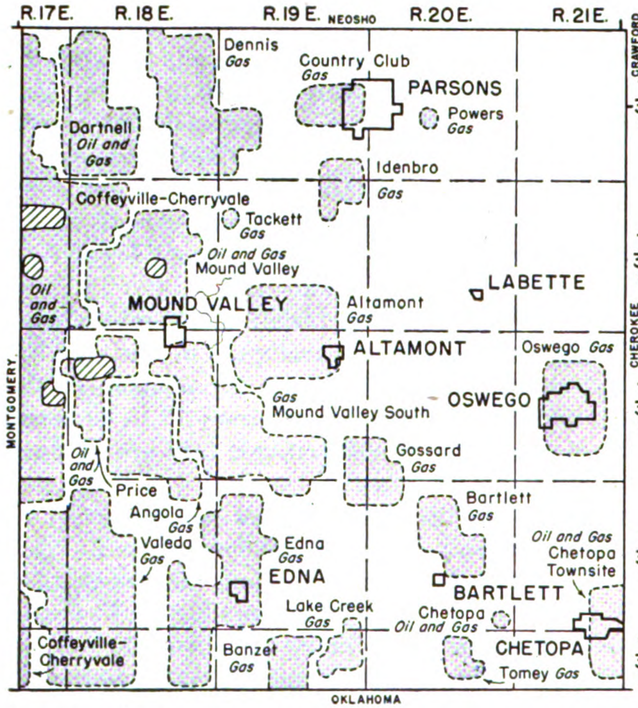

FIG. 34.—Map of Labette County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

270 feet below the surface, the "Bartlesville sand" about 540 feet, and the Mississippian limestone about 775 feet. The "Bartlesville sand" ranges in thickness from 12 to 60 feet. The initial flow of gas in the wells ranged from 40,000 to 500,000 cubic feet. Seventeen wells have been drilled in this area, nine to the "Bartlesville sand" and eight to the Mississippian limestone. One of the latter wells was dry in the "lime," but it was plugged back and gas was produced from the Fort Scott limestone.

The **Mortimer** gas-producing area is a part of the large **Coffeyville-Cherryvale** field. The date of discovery is not known; however, much drilling was done in 1913 and activity continued until 1927. The area is now abandoned as a gas field. Gas was produced from the Fort Scott limestone at a depth of about 600 feet, the "Bartlesville sand" at a depth of about 840 feet, and the Mississippian limestone at a depth of about 1,020 feet. In this area

42 holes were drilled to the "Bartlesville sand"; 22 of these were dry. One dry hole was drilled to the Arbuckle limestone in the NW¼ sec. 11, T. 31, R. 17 E.

The **Dack** gas area is a part of the **Dartnell** field. In this area 25 or more wells have been drilled; 3 produced oil, and 7 were dry holes. No records of the other 9 wells are available. Most of the wells were drilled in 1927. The producing formations are the Fort Scott limestone, about 935 feet below the surface, and the Mississippian limestone at a depth of about 1,080 feet.

The **Timber Hills** gas area is in the **Coffeyville-Cherryvale** field. Gas was discovered in this area in 1905; however, production did not begin until 1910. For many years Cherryvale, in Montgomery County, was supplied with large quantities of gas from this area in which more than 200 wells have been drilled. Production is from the Fort Scott limestone, the "Bartlesville sand," and the top of the Mississippian limestone. The depth to the Fort Scott limestone in these wells ranges from 575 to 675 feet, the "Bartlesville sand" from 705 to 860 feet, and the Mississippian limestone from 880 to 890 feet.

Mound Valley is the largest gas-producing area in Labette County. Gas has been produced here since 1905. More than 125 wells have been drilled to the "Bartlesville sand"; only 15 of these were dry holes. The thickness of the "Bartlesville" in this area ranges from 6 to 60 feet. Some well logs record two sandstones, separated by about 30 feet of shale. Both of these sandstones, known as "Upper Bartlesville" and "Lower Bartlesville," may be productive. The initial flows of gas ranged from 100,000 to 4,500,000 cubic feet per day; the rock pressure was about 250 pounds. Gas is still being produced in some of the wells. Seventeen wells were drilled to the top of the Mississippian limestone. Three of these yielded gas but they are now abandoned. Oil production in the Mound Valley field in 1948 was 286 barrels.

The discovery well of the **Chetopa** gas pool, the Chetopa Oil and Gas Company No. 1 Wright, was drilled in December 1935. Ten gas wells have been drilled; initial daily productions ranged from 100,000 to 500,000 cubic feet. The rock pressure was about 225 pounds. Gas-producing zones are in the upper part of the Mississippian limestone and in porous rock about 20 feet below the top of the "lime." The top of the Mississippian limestone is about 500 feet below the surface. This pool is on a closed structure.

The **Gossard** gas pool, discovered in 1906, produces from the "Bartlesville sand" which lies at a depth of about 450 feet and ranges in thickness from about 17 to 61 feet. Initial daily productions of wells ranged from 100,000 to 1,000,000 cubic feet. A total of 21 gas wells and 3 dry holes have been drilled. One of the dry holes penetrated the Arbuckle limestone and was drilled to a total depth of 1,075 feet.

The **Traxon** gas-producing area is a part of the **Valeda** gas field. About 45 wells, 20 of which were dry holes, have been drilled in this area. The gas-producing zones are in the Fort Scott limestone, the "Bartlesville sand," and the upper part of the Mississippian limestone. Five deep tests, all of which were dry, were drilled to the Arbuckle limestone in sec. 30, T. 34 S., R. 18 E. The Fort Scott limestone is about 360 feet below the surface in this area, the "Bartlesville sand" about 600 feet, the top of the Mississippian limestone about 825 feet, and the Arbuckle limestone about 1,200 feet.

The **Edna** oil and gas producing area has supplied the town of Edna with gas for several years. Most of the drilling has been done since 1921. About 40 holes have been drilled, 12 of which were dry. Production was found in the Fort Scott limestone, the "Bartlesville sand," and the upper part of the Mississippian limestone. Most of the gas is produced from the "Bartlesville sand," and oil was produced from this sand in four wells. Gas was found in the upper part of the Mississippian limestone in two wells, from the Fort Scott limestone in two wells, and from the "Bartlesville sand" in eight wells. Oil and gas are still produced in this area. The Fort Scott limestone is about 300 feet below the surface, the "Bartlesville sand" about 580 feet, and the top of the Mississippian limestone about 800 feet.

TABLE 49.—*Oil production in Labette County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Coffeyville-Cherryvale[1]	7	1,276	8	1,216	15	1,415	15	3,735	15+	4,006
Mound Valley										286
Price		2,348	11	2,507	11	3,266		3,223		2,236
Totals	7	3,624	19	3,723	26	4,681	15	6,958	15+	6,528

[1] Field extends into Montgomery and Wilson Counties.

LEAVENWORTH COUNTY

The extension of the McLouth oil and gas producing area into Leavenworth County has made that county somewhat important in the production of oil and gas. Gas had been produced in scattered areas for several years before the discovery of the McLouth pools. In December 1944 the Lawrence gas-producing area was extended from Douglas County into Leavenworth County.

The geology and development of the McLouth gas and oil field have been described in detail by Lee (1941) and by Lee and Payne (1944).

Leavenworth County produced 1,266 barrels of oil during 1948. Oil production in the county during the years 1941 to 1948 inclusive (except 1943, when the production is not separated from that of Jefferson County) is shown in Table 2a. The amount of natural gas produced in Leavenworth and Wyandotte Counties during 1948 is estimated as 50 million cubic feet. Of this amount 10 million cubic feet was produced in Leavenworth County and 40 million cubic feet in the Roberts-Maywood field, partly in Wyandotte County.

Table 50 shows production in the Ackerland field for 1944 through 1948.

Figure 35 shows the locations of Leavenworth County oil and gas fields and areas of 1948 oil production.

Geology

SURFACE ROCKS

Outcropping consolidated rocks in Leavenworth County are of Pennsylvanian age. The youngest of these formations is the Deer Creek limestone or possibly the lower part of the Tecumseh shale, and the oldest is the Wyandotte limestone. Much of the county is mantled with glacial drift.

Table 50.—*Oil production in the Ackerland field, Leavenworth County, 1944 through 1948*

Year	No. of wells	Barrels of oil
1944	1	2,742
1945	1	1,009
1946	1	3,594
1947	1	2,795
1948	1	1,266

Pennsylvanian rocks.—The soil on the surface of more than half the area of Leavenworth County is immediately underlain by rocks of the Douglas group (Fig. 4). This area of rolling topography is east and south of the sinuous escarpment capped by the Oread limestone. The outcrop line of the Oread extends from the northeastern corner of the county along Missouri River to the vicinity of Leavenworth and northwestward to the southwest corner of the county. West of the Oread escarpment is a less conspicuous line of hills capped by the Lecompton limestone. Hills capped by Deer Creek limestone are in the northwestern part of the county. Rocks older than those of the Douglas group are exposed in the county along Kansas and Missouri Rivers. The oldest exposed bedrock in the county crops out along Kansas River near Lenape and Loring. The Shawnee group in the county is about 350 feet thick, and the Douglas group ranges from about 180 to 280 feet.

Rocks of the Pedee group (Fig. 5) are well exposed in the vicinity of Leavenworth where the Weston shale and the thin overlying Iatan limestone have a combined thickness of about 45 feet. Locally the entire Pedee section and in some places older rocks have been removed by erosion that preceded Douglas deposition. In those places the Tonganoxe sandstone lies on some part of the Stanton limestone. The Lansing group in the county is about 80 feet thick. Strata in the upper part of the Kansas City group show unusual development along Kansas River in the vicinity of Lenape and Loring. Shale units several feet thick become only a few inches thick in short lateral distances, and limestones, particularly the Farley limestone, change abruptly in thickness and lithology.

SUBSURFACE ROCKS

Leavenworth County is in the Forest City basin and on the southeastern margin of the North Kansas basin. The Chattanooga shale oversteps beveled Devonian rocks from the northwest (Lee, 1943, fig. 7, wells 13-15). The Maquoketa shale is believed to be absent except in the northwestern part of the county (Lee, 1943, figs. 11, 12).

Pennsylvanian rocks.—The average thickness of the Pennsylvanian section in Leavenworth County is about 1,000 feet. The thickness of rocks between the Hertha limestone and the top of Mississippian rocks ranges from a little less than 700 feet to slightly more than 800 feet.

Mississippian rocks.—According to Lee and Payne (1944, fig. 17), the Mississippian limestone formations in Leavenworth County have an average total thickness of about 400 feet. The thickness of the Chattanooga shale in the county ranges from about 50 to 75 feet (Lee, 1943, fig. 7).

Pre-Chattanooga rocks.—Depths to some key horizons in deeper rocks in the McLaughlin and Sons No. 1 Thorpe well, in the Cen. NE¼ NE¼ sec. 27, T. 10 S., R. 20 E., are given in Table 51. Data are from Lee (1943, fig. 7).

According to Lee (1943, fig. 12), the interval between the base of the Chattanooga shale and the top of the Maquoketa shale in Leavenworth County ranges from about 100 to 225 feet. The Maquoketa shale is present only in the northwestern part of the county. Lee's studies (1943, fig. 11) indicate that the average thickness of the rocks between the top of the Maquoketa shale and the top of the St. Peter sandstone in northwestern Leavenworth County is about 200 feet, and the thickness of rocks between the top of the St. Peter sandstone and the Pre-Cambrian ranges from about 650 feet in the northwestern part of the county to about 800 feet in the southeastern part.

Oil and Gas Developments

Gas has been produced in Leavenworth County for several years. The **Six Corners** gas field (Ockerman, 1935, p. 57) was put into use as a subsurface gas storage project in 1927. The practicability of gas storage in rock formations demonstrated in the Six Corners field is said to have been inductive to the more or less

Table 51.—*Depths to some key horizons in the McLaughlin and Sons No. 1 Thorpe well, Cen. NE¼ NE¼ sec. 27, T. 10 S., R. 20 E. Leavenworth County*

Horizon	Depth, feet
Top of Mississippian limestone	1,397
Top of Chattanooga shale	1,734
Base of Chattanooga shale and top of Devonian rocks (Cooper limestone)	1,794
Base of Devonian rocks and top of Kimmswick (Viola) limestone	1,953
Top of Decorah shale	2,067
Top of St. Peter sandstone	2,093
Top of Arbuckle rocks	2,154

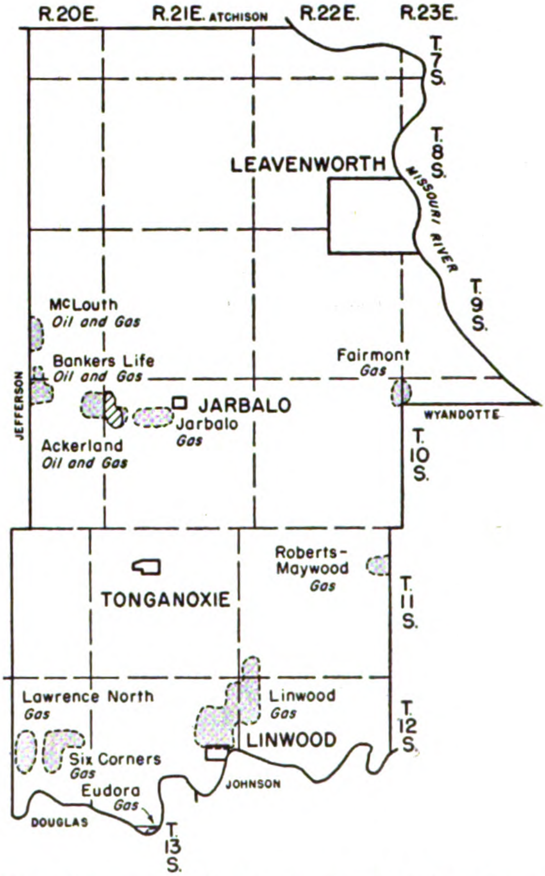

FIG. 35.—Map of Leavenworth County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

common practice of storing gas in porous rocks. Producing gas wells in the Six Corners field averaged about ½ million cubic feet of gas per day when they were brought in. Production was from the "Squirrel sand," at a depth of about 750 feet and about 20 feet thick.

On November 30, 1944, the J. H. Huber Corporation No. 1 Huber well in the Cen. NW¼ NE¼ sec. 22, T. 12. S., R. 20 E., was completed with reported daily production of 627,000 cubic feet of gas. This well was regarded as opening the **Lawrence North** field (Kansas Geological Society's list of oil and gas fields in

Kansas as of February 6, 1945) but might be regarded as an extension of the Six Corners field. The Huber well found gas in the "Squirrel sand" at 705 feet. Some gas has been reported from the "Knobtown sand" in the Six Corners area.

The **Bankers Life** oil pool was discovered in May 1941. Production was from the McLouth sand which lies near the base of the Cherokee shale. No oil was reported from the Leavenworth County part in 1948. The discovery of gas in October 1941 in the NE¼ sec. 12, T. 10 S., R. 20 E., opened the **Ackerland** gas pool. Gas is produced from the McLouth sand. Oil is produced from the McLouth sand in secs. 6 and 7, T. 10 S., R. 21 E. in the Ackerland oil pool, which is slightly east of the Ackerland gas pool. The **McLouth** gas pool extends into Leavenworth County from Jefferson County. Production is from the McLouth sand. The **Jarbalo** gas pool produces from the "McLouth sand" at a depth of about 1,270 feet.

The Roberts gas pool is included in the **Roberts-Maywood** gas-producing area of Leavenworth and Wyandotte Counties. Production is from the "Squirrel sand."

The **Linwood** pool produces gas from the "Squirrel sand"; some gas has been reported from the Knobtown sandstone.

A prospect well was drilled in 1887 at Leavenworth to a depth of 2,116 feet. No gas or oil shows were reported. In this well the top of the Mississippian limestone was reached at 1,175 feet; the top of Ordovician rocks at 1,650 (?) feet; the top of the St. Peter sandstone at 1,710 feet; and the top of the Arbuckle at 1,870 feet.

Numerous other wells have been drilled in Leavenworth County but most of them tested only Pennsylvanian rocks.

LINN COUNTY

Three wells were drilled in Miami County in 1860, and a short time later several wells were drilled north of Mound City in Linn County. Small amounts of oil and gas were produced from these wells. Important amounts of oil and gas have been produced in Linn County for many years. The oil production in 1926 was 89,208 barrels. Production has declined from this maximum, but many wells have been especially long-lived. Because of the increased importance of water flooding, the production of oil in 1943 was more than 50 percent greater than in 1942 and now production is nearly 100 percent above that of 1943 (Table 2a). Gas is widespread in the county. A small amount of oil has been produced from near the top of the Mississippian limestone. All other production is from Pennsylvanian rocks. Deep tests in the county have been unsuccessful.

The oil and gas resources of Linn County have been described by Jewett (1940a) in a report which contains a map showing locations of known wells as of 1940 and gives the stratigraphic depths of many wells.

Linn County produced 60,201 barrels of oil during 1948. Production in the county during the years 1912 to 1948 inclusive is given in Tables 2 and 2a. Table 52 shows oil production in the various fields in Linn County for 1944 through 1948. Three waterflooding projects are being operated in the county.

Figure 36 shows the oil and gas producing areas, and areas of 1948 oil production in Linn County.

Geology

SURFACE ROCKS

With the exception of a few feet of unconsolidated deposits of Recent, Pleistocene, and Tertiary (?) age, the surface rocks of Linn County are of Pennsylvanian age. The youngest consolidated rock is the Plattsburg limestone, basal formation in the Lansing group (Fig. 5), which underlies a small area in the extreme northwestern part of the county. The oldest exposed rock is the upper part of the Labette shale.

The upper part of the Kansas City group in Linn County includes shales and comparatively thin limestones. The total thickness of the Zarah and Linn subgroups is about 210 feet. These rocks crop out in the western part of the county, and are charac-

TABLE 52.—*Oil production in Linn County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Blue Mound[1]						4,200	9	3,703	18	2,640
Centerville[1]	103	40,837	108	29,879	114	23,466	113	16,858	107+	10,803
Goodrich-Parker[1]	44+	9,404	39+	30,841	55+	38,710	59+	36,133	46+	32,435
LaCygne-Cadmus	64+	5,928	66+	10,038	66+	18,992	65+	16,469	65+	14,323
Totals	211+	56,169	213+	70,758	235+	85,368	246+	73,163	236+	60,201

[1] Field extends into Anderson County.

terized by thick, more or less sandy, gray and yellow shales. There is a persistent sandstone in the Chanute shale, and a bed of coal occurs below the sandstone. The average thickness of the Bronson subgroup in the county is slightly more than 200 feet. Limestone constitutes more than half the thickness. The rocks of this subgroup form the boldest escarpments in the county, and the upper formation (Dennis limestone) lies immediately below the soil in a large area. These rocks are characterized by flinty and oölitic limestones in the Dennis and Swope formations and by black platy shale in the lower parts of the same formations. There are several key horizons which are useful in mapping surface structures.

The Pleasanton group ("Big shale" of drillers) in Linn County ranges in thickness from about 80 to 200 feet. Massive sandstone occurs locally in the upper part of the Pleasanton, and locally there are several feet of alternating thin beds of shale and dark limestone. This upper part constitutes the Knobtown sandstone in the central part of the county. The Hepler sandstone, lying at the base of the Pleasanton group, ranges from about 2 to 25 feet in thickness.

The Marmaton group of limestone and shale is about 200 feet thick at outcrops in Linn County. Locally the upper three formations have been partly or entirely removed by erosion before deposition of the overlying Pleasanton shale. The lower part of the Labette shale and the Fort Scott limestone do not crop out in the county. The other formations of this group (Fig. 5) are present at the surface in the eastern and southeastern parts of the county. The Bandera and Labette formations contain lenses of sandstone.

SUBSURFACE ROCKS

Hundreds of wells, most of which did not reach the oldest Pennsylvanian rocks of the region, have been drilled in Linn County. However, several wells have penetrated older rocks and eight wells are known to have reached rocks older than those of Mississippian age. Depths to some key horizons in the Holeman and Edwards No. 9 Pollman well are given in Table 53. Linn County lies in the northern part of the area of the Chautauqua arch. Subsurface geologic conditions in the central part of the county are shown in Plate 1.

TABLE 53.—*Depths to some key stratigraphic horizons in the Holeman and Edwards No. 9 Pollman well, SE¼ sec. 35, T. 19 S., R. 24 E., Linn County*

Horizon	Depth, feet
Top of Mississippian limestone	460
Top of Chattanooga shale	812
Base of Chattanooga shale and top of Arbuckle rocks (Cotter-Jefferson City dolomites)	822
Top of Roubidoux formation	990
Top of Gasconade and Van Buren dolomites	1,135
Top of Proctor and Eminence dolomites	1,275
Top of Bonneterre dolomite	1,425
Total depth	1,515

Pennsylvanian rocks.—Subsurface Marmaton rocks are about 250 feet thick and consist of limestone, shale, and sandstone. Gas is produced from the Bandera and Labette formations and oil from the Bandera formation. The Cherokee shale includes five or more gas and oil producing zones which are chiefly lenticular sandstones that are known as the "Squirrel," "Upper Bartlesville," "Lower Bartlesville," and "Burgess" ("Tucker") sandstones. "Shale gas" is produced from black platy shale in the upper few feet of the Cherokee section in several parts of Linn County.

Mississippian rocks.—Mississippian rocks in Linn County were discussed by Lee (in Jewett, 1940a, pp. 14-17). Depths to Mississippian rocks range from less than 450 feet below valleys in the eastern part of the county to about 1,000 feet on the uplands in the western part. The average thickness of Mississippian rocks is slightly more than 350 feet in the northwestern part and 390 feet in the southeastern part. The Mississippian rocks are slightly less than 300 feet thick in some areas in the central part of the county. The Mississippian section includes Meramecian rocks comprising the St. Louis limestone, the Spergen or "Upper Warsaw" limestone, and the "Warsaw" limestone, having a total thickness of about 155 feet; Osagian rocks, including the undifferentiated Keokuk and Burlington limestones and the Sedalia (?) limestone, having a total thickness of about 150 feet; and Kinderhookian rocks, including the Chouteau limestone, about 100 feet thick. The Chattanooga shale, also probably of Kinderhookian age, has an average thickness of about 20 feet.

In Linn County the Chattanooga shale lies on rocks of early Ordovician age. It is probable that younger Ordovician, Silurian, and Devonian rocks were deposited and later eroded from this part of the Chautauqua arch area.

Ordovician rocks.—According to Keroher (in Jewett, 1940a, pp. 12-14), who studied cuttings from the Holeman and Edwards No. 9 Pollman well in the SE¼ sec. 35, T. 19 S., R. 24 E., Ordovician rocks in Linn County include 168 feet of undifferentiated Cotter and Jefferson City dolomites; 145 feet of Roubidoux formation; and 135 feet of undifferentiated Gasconade and Van Buren dolomites and Gunter sandstone.

Cambrian rocks.—We have no record of wells in Linn County that have penetrated the full thickness of Cambrian rocks. The Holeman and Edwards No. 9 Pollman well was drilled through 150 feet of undifferentiated Proctor and Eminence dolomites and 90 feet into the Bonneterre dolomite (Jewett, 1940a, pl. 2). From studies of cuttings from wells in near-by areas, it is believed that the Bonneterre dolomite in Linn County is about 125 feet thick and that the Lamotte sandstone is probably about 40 feet thick.

Oil and Gas Developments

The shallower rocks in Linn County have been explored extensively for oil and gas, but deeper rocks, especially those of Ordovician age, have been tested inadequately. Several years ago a small amount of oil was found in the weathered upper part of the Mississippian limestone in the southwestern part of the county near Blue Mound, but elsewhere production has come from Pennsylvanian rocks. Oil or gas or both have been found in the Bandera formation, the upper few feet of the Cherokee shale, the "Squirrel sand,' the "Bartlesville sand," the "Tucker sand" (in the basal part of the Cherokee shale), and the upper part of the Mississippian limestone. Oil discoveries have been restricted generally to the northern and western parts of the county. There are gas wells in many parts of the county; therefore, it is difficult to divide the county into definite fields or producing areas. Areas of greater concentration are discernible, however (Fig. 36).

The **Beagle** oil field extends into Linn County from Miami County. The area has been abandoned for several years.

The **Blue Mound** oil field extends westward into Anderson County. A small amount of oil was produced about 10 years ago from the top of the Mississippian limestone at a depth of about

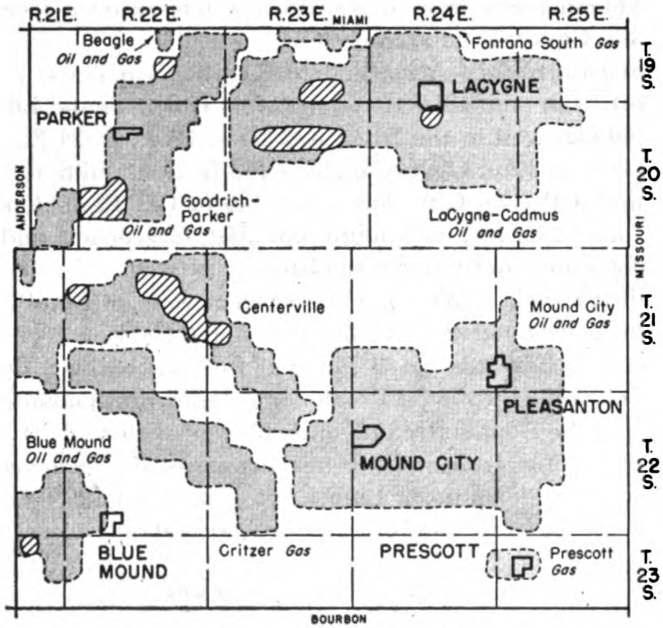

FIG. 36.—Map of Linn County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

800 feet in sec. 19, T. 22 S., R. 22 E. Most of the production has come from Pennsylvanian rocks at shallower depths. The field produced 2,640 barrels of oil from 18 wells in 1948.

The **Centerville** field produces oil chiefly from the "Squirrel sand." In 1935 the Texas Company started a water-flooding project in secs. 13, 14, and 24, T. 21 S., R. 22 E. in the Centerville area. The entire property was yielding 8 barrels of oil per day when water flooding was begun. A notable increase in production took place 12 months later. Between December 6, 1935, and November 1, 1942, 84,189 barrels of oil were produced as the result of injecting 739,913 barrels of water (Grandone, 1944, pp. 91, 92). There were 59 oil wells at that time. The project is still in operation and 12,633 barrels of oil were produced during 1948. Fresh water is injected.

The **Critzer** gas field is a large elongated area. Most of the wells have been abandoned. Gas was produced chiefly from sandstone in the basal part of the Cherokee section, called "Tucker sand."

The **Fontana South** gas field extends into Linn County. Gas occurs in the uppermost part of the Cherokee section in black shale that lies a few feet below the base of the Fort Scott limestone. Gas from these rocks is commonly called "shale gas."

The **Goodrich-Parker** oil-producing area is a "shoestring" about 7 miles long and one-half to 1 mile wide. Oil production is from the "Squirrel sand." The Bradford Producing Company is operating a water-flooding project in the field. Salt water is being injected.

The **Cadmus-LaCygne** area produces oil chiefly from sandstone in the Bandera formation. The Wallace Oil Company began a water-flooding project on the Laura Lee lease in the NW¼ sec. 10, T. 20 S., R. 23 E. in December 1940. It is reported that before water flooding was started, the lease had been depleted of oil recoverable by primary methods. To November 1, 1942, the lease produced 1,617 barrels of oil from seven wells as the result of injecting 55,415 barrels of water (Grandone, 1944, p. 95). Sloan and Zook are now operating a water-flooding project in the area. Salt water is injected; the project was started in 1942.

In the **Mound City** oil and gas field as shown in Figure 36 gas is found in sandstone in the Bandera shale and in the Labette shale ("Weiser" and "Peru sands" of several eastern Kansas fields); in dark shale in the upper part of the Cherokee section; in the "Squirrel sand"; in the "Upper and Lower Bartlesville sands"; and in the "Tucker sand." Oil has also been produced from the "Upper Bartlesville."

The smaller Mound City oil pool, in the "Squirrel sand," is on a structural dome that is rather large in comparison to most eastern Kansas structures. Seemingly the apex of the dome, which caused the accumulation of large quantities of oil and gas in Pennsylvanian rocks, lies a short distance north and east of Mound City. Structural mapping showing the exact form of the fold, however, is not available to me. This was one of the first oil pools discovered in Kansas. The wells were pumped intermittently for many years, but the field is now inactive.

The Evans et al. No. 1 Charles Cook well in the SE¼ SE¼ NW¼ sec. 4, T. 22 S., R. 24 E., was drilled on the Mound City structure in 1938. The total depth of the well is 800 feet. The top of Mississippian limestone was encountered at 455 feet; the top of Kinderhookian (?) rocks at 700 feet; and the top of the Arbuckle at 745 feet. A strong show of oil was found in the top of the Mississippian limestone.

The **Prescott** gas field is in the southeastern part of Linn County. Gas is found there in the "Upper and Lower Bartlesville sands."

Pennsylvanian rocks in Linn County have been tested relatively thoroughly for oil and gas but older rocks mostly are untested. In 1948 several new gas wells were drilled in an area northwest of Pleasanton.

LYON COUNTY

Oil is produced in the extreme southern part of Lyon County. Production at present is from the "Bartlesville" shoestring sandstones. According to Landes (1937, p. 57) oil was discovered in the county in the Bradfield pool, in Ordovician sandstone, in 1922. One well in the Bradfield field is reported to have had an initial daily production of 1,100 barrels of oil. The rock that yielded oil is probably the Kimmswick limestone. The field is no longer active. The Richey-Moore pool formerly yielded oil from the upper part of the Mississippian limestone.

Lyon County produced 187,948 barrels of oil in 1948. Oil production in the county for 1922 through 1948 is given in Tables 2 and 2a. Production for 1944 through 1948 in the various fields is given in Table 54. Two water-flooding projects are operating in Lyon County (Fig. 2, Table 3).

Locations of oil fields and areas of oil production during 1948 are shown in Figure 37.

Geology

SURFACE ROCKS

Surficial deposits in Lyon County include several feet of flint gravel, principally on the uplands, and finer alluvium in the stream valleys. The flint gravel beds, which are especially abundant in the southern part of the county, are probably of Tertiary age.

Permian rocks.—Permian rocks (Fig. 3) of Wolfcampian age crop out in the western part of Lyon County. About 600 feet of lower Permian strata are exposed. The Florence limestone or a few feet of overlying sediments is the uppermost Permian rock

TABLE 54.—*Oil production in Lyon County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Atyeo[1]	11+	81,323	50+	65,880	50+	63,150	50+	66,780	33+	159,527
Fankhouser[2]	3+	108,416	60+	93,780	60+	78,300	58+	64,260		22,877
Rock Creek							4	4,440	4	5,544
Totals	14+	189,739	110+	159,660	110+	141,450	112+	135,480	37+	187,948

[1] Field extends into Chase and Greenwood Counties. Years 1944, 1945, 1946, and 1947 include production from Chase and Greenwood Counties.
[2] Field extends into Greenwood County. Years 1944, 1945, 1946, and 1947 include Greenwood County production.

in the county. In several exposures in Lyon County basal Permian rocks are seemingly conformable with the underlying Brownville limestone. Elsewhere in Kansas local unconformities occur between rocks of the Permian and Pennsylvanian Systems.

About 150 feet of rocks of the Chase group is exposed in western Lyon County. These rocks are characterized by bright-colored shales and massive limestones. The Florence and Wreford limestones contain abundant nodules of flint. In Lyon County, as in several other eastern Kansas counties, rocks assigned to the Council Grove group have a total thickness of about 300 feet. The percentage of limestone in this division is much larger than in the underlying Admire group. Highly colored shales similar to those in the overlying Chase group are characteristic of the Council Grove group, especially in its upper part. The Cottonwood and Neva limestones are the most easily recognized limestones. The thickness of the Admire group in Lyon County is about 150 feet. These rocks are chiefly gray and yellow shale but the Towle shale is partly red. They contain limestones commonly less than 2 feet thick and minor amounts of sandstone.

Pennsylvanian rocks.—Upper Pennsylvanian sediments, including rocks of the Wabaunsee group and the upper part of the Shawnee group, crop out in the eastern part of Lyon County. The thickness of exposed Pennsylvanian rocks in the county is approximately 500 feet. Most of the named units of the Wabaunsee group (Fig. 4), especially the limestones, are fairly easily recognized at their outcrops. The Tarkio limestone, however, one of the most readily determined strata farther north, has not been identified in Lyon County. Fairly light-colored limestones only a few feet thick and clayey and sandy shales are characteristic of Wabaunsee rocks in this part of the State. Fusulines are abundant in Wabaunsee rocks. The Topeka limestone and the upper part of the Calhoun shale are exposed in a small area in T. 20 S., R. 13 E. along a tributary to Neosho River. Elsewhere in Lyon County these rocks are buried beneath younger bedrock.

SUBSURFACE ROCKS

Subsurface geologic conditions along the western boundary of Lyon County are shown in Plate 3. Depths to some stratigraphic horizons in the Bird, Hanley, and Sheedy No. 1 Welch well, sec. 31, T. 20 S., R. 10 E. are shown in Table 55.

Pennsylvanian rocks.—The thickness of Pennsylvanian rocks in Lyon County varies from place to place because of slight lateral changes in thicknesses of rock units and because Pennsylvanian rocks that are present in the western part of the county have been removed from the eastern part by erosion. The westward-dipping surface rocks have been beveled by erosion. The average thickness of rocks from the top of the Topeka limestone to the base of the Pennsylvanian section is about 1,650 feet. Pennsylvanian rock groups in Lyon County are not greatly different in thickness and lithology from those of neighboring counties. Oil is produced in the southern part of the county from the "Bartlesville sand," in the lower part of the Cherokee group.

Mississippian rocks.—The total thickness of Mississippian limestone formations in Lyon County ranges from about 300 feet in the northwestern corner to slightly more than 450 feet in the central-eastern part (Lee, 1943, fig. 6). The Chattanooga shale has an average thickness of about 100 feet (Lee, 1940, pl. 3).

Pre-Chattanooga rocks.—In most of Lyon County the Chattanooga shale is believed to lie on the Viola limestone (Ockerman

TABLE 55.—*Depths to some stratigraphic horizons in the Bird, Hanley, and Sheedy No. 1 M. F. Welch well, SW cor. NE¼ sec. 31, T. 20 S., R 10 E., Lyon County*

Horizon	Depth, feet
Top of Topeka limestone (top of Shawnee group)	810
Top of Lawrence shale (top of Douglas group)	1,180
Top of Lansing group	1,465
Top of Kansas City group (top of Bonner Springs shale)	1,495
Top of Pleasanton group (base of Kansas City group)	1,870
Top of Marmaton group	2,015
Top of Cherokee group	2,040
Top of Mississippian limestone (Keokuk and Burlington limestone)	2,482
Total depth of well	2,555

1935, fig. 2). In the northern part of the county the "Hunton" limestone underlies the Chattanooga shale and the pre-Chattanooga outcrops of the "Hunton" and Viola limestones were separated by a narrow band of Maquoketa shale. In the northern part of the county the interval between the base of the Chattanooga shale and the top of the Maquoketa shale is about 100 feet (Lee, 1943, fig. 12). The total thickness of rocks between the top of the Maquoketa shale and the top of the St. Peter sandstone is probably less than 100 feet everywhere in the county (Lee, 1943, fig. 12) and the interval from the top of the St. Peter sandstone to the Pre-Cambrian floor ranges from about 300 to 800 feet.

Keroher and Kirby (1948, figs. 4, 6, 8, and 9) estimated that the thickness of the Jefferson City-Cotter sequence in Lyon County ranges from about 100 feet in the northwest part of the county to about 375 feet in the southeast part; the Roubidoux dolomite less than 100 feet in the southeast part to slightly more than 150 in the northwest part; the Van Buren-Gasconade sequence—believed to be absent in the western half of the county—ranges from a featheredge to a thickness less than 50 feet in the eastern part; the Bonneterre dolomite from a featheredge in the southeast corner to a maximum of more than 100 feet in the northeast part.

Oil and Gas Developments

The **Atyeo** oil field is in Lyon, Chase, and Greenwood Counties. The field was extended into Lyon County in 1926. Production in this pool is from the "Bartlesville sand." The depth to the "Bartlesville" is about 2,200 feet. The Lyon County part of the field produced 159,527 barrels of oil in 1948.

The **Fankhauser** oil field extends into Greenwood County. The field was extended into Lyon County in 1926. The Lyon County part of the field produced 22,877 barrels of oil during 1948. The Phillips Petroleum Company operates a water-flooding project in the field. Oil production is from the "Bartlesville sand."

The extension of the Atyeo and Fankhauser fields into Lyon County resulted in an increase of oil production in the county from 27,515 barrels in 1925, to 625,931 barrels in 1926 (Landes, 1937, p. 57).

The **Rock Creek** oil pool was discovered in 1947, when the Murphy et al. No. 1 Lee well found oil in the "Bartlesville sand" in sec. 32, T. 21 S., R. 11 E. Initial daily production of the discovery

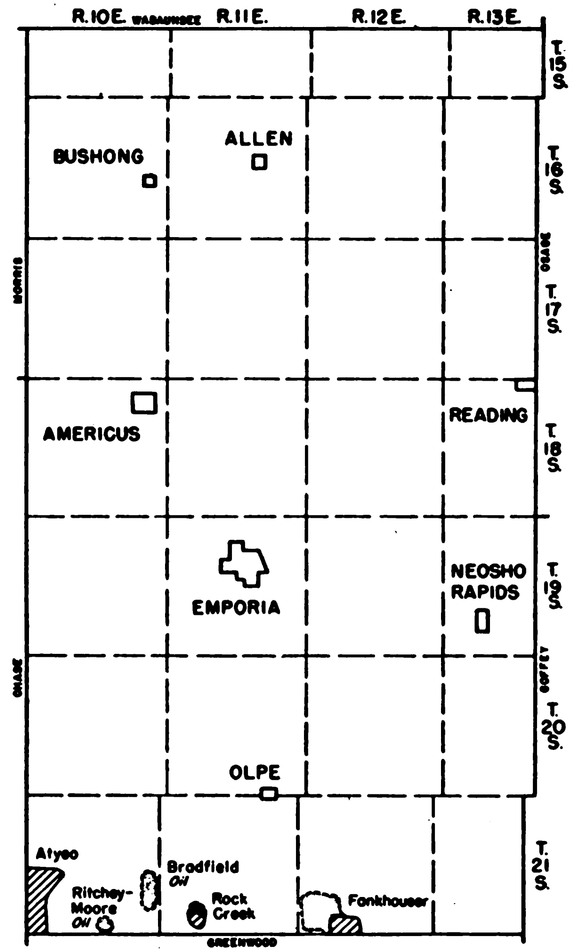

FIG. 37.—Map of Lyon County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

well was reported to be 35 barrels. Three more wells were completed in 1947 and the field yielded 4,440 barrels of oil that year. In 1948, 4 wells produced 5,544 barrels of oil.

In the **Bradfield** pool, in secs. 24 and 25, T. 21 S., R. 10 E., oil was produced from the Kimmswick limestone probably at depths ranging from about 2,200 to 2,600 feet. The Kimmswick is believed to lie next below the Chattanooga shale in that area. The field yielded 27,516 barrels of oil in 1925, and is reported to

TABLE 56.—*Data on wells in the Bradfield oil field, secs. 24 and 25, T. 21 S., R. 10 E., Lyon County*

Name of well	Location	Completion date	Total depth, feet	Initial daily production, bbls. of oil
McCulloch No. 1 L. E. Bradfield	NW½ NE¼ NW¼ sec. 25	commenced 1-21-26	2,596	1,100
.... No. 1 Rossillon	Cen. W. line SE¼ SE¼ sec. 24	3- 2-26	2,600	oil
McCulloch No. 1 Babinger	SE cor. SW¼ SE¼ SW¼ sec. 24	commenced 5- 7-26	2,602	200
Pryor & Lockhart No. 1 Babinger	Cen. NW¼ NE¼ ? sec. 24	7-29-26	2,580	250
McCulloch No. 2 Hattie Bradfield	SW cor. NW¼ NE¼ sec. 25	commenced 7-29-26	2,864	?
Richey & Moore No. 1 Bradfield	NW cor. SE¼ NE¼ sec. 25	11- 7-26	2,589	2,200 feet oil in hole in 2½hrs.
Jackson & Wise No. 1 Bradfield	NE¼ SE¼ NW¼ sec. 25	11-12-26	2,543	500
McCulloch No. 1 Harvey Bradfield	NW cor. SE¼ sec. 25	12- 5-26	2,210	800
McCulloch No. 2 Lewis Bradfield	SE cor. NE¼ NW¼ sec. 25	1-27-27	2,575	500
Richey & Moore No. 2 Bradfield	SE¼ SW¼ SE¼ sec. 25	2-18-27	2,256	50
McCulloch No. 1 Alice Bradfield	NE¼ NE¼ SW¼ sec. 25	3-26-27	2,735	Dry
Jackson & Wise No. 2 Bradfield	SE cor. NW¼ sec. 25	5-11-27	2,864	Dry
Becker Bros. No. 1 Rossillon	Cen. E. line SW¼ SE¼ sec. 24	12-26-34	2,608	150
Octave Leblanc et al. No. 1 Bradfield	NE¼ SE¼ NW¼ sec. 25	4-13-43	1,505	Dry
.... No. 1 Rossillon	NE¼ NE¼ sec. 24	?	2,600	Oil
W. R. Talbot et al. .... Bradfield	NW cor. NE¼ sec. 25	?	2,587	300

have been discovered in 1922. Several additional wells were drilled in 1926 and 1927. The field now is inactive.

Oil pools in Ordovician rocks in eastern Kansas, especially as far east as Lyon County, merit special attention. The McCulloch No. 1 L. E. Bradfield well in the NW¼ NE¼ NW¼ sec. 25, T. 21 S., R. 10 E., the largest well drilled in the Bradfield field, had a reported 1,100 barrels initial daily production in "sandy chat" at 2,592 to 2,596 feet. Data on this and other wells that were drilled in the field are given in Table 56.

The **Richey-Moore** field formerly produced oil from the upper part of the Mississippian limestone. The Richey-Moore No. 1 Pixlee, SE cor. SW¼ sec. 34, T. 21 S., R. 10 E., found oil between 2,170 and 2,194 feet. Several dry holes have been drilled in the same section.

Numerous dry holes, mostly shallow, have been drilled in Lyon County. The list of wells, logs of which are in the Geological Survey files, is too long to be included in this report. Four dry

TABLE 57.—*Data on pool wells drilled in Lyon County during 1947 and 1948*

Field	1947 Producing wells and formation	1947 Dry	1947 Total	1948 Producing wells and formation	1948 Dry	1948 Total
Atyeo		0	0	1 Salt water disposal	2	3
Bradfield		0	0		1	1
Fankhouser		1	1		0	0
Rock Creek	2 "Bartlesville"	1	3		6	6
Wildcats		4	4		2	2

wildcat wells were reported in the county in 1947. Two dry wildcats were drilled in 1948.

Data on wells drilled in 1947 and 1948 in the various fields in Lyon County are listed in Table 57.

MARION COUNTY

Oil and gas is produced in Marion County in widely scattered areas although oil fields are chiefly confined to approximately the eastern half of the county in the northwestern part of the Sedgwick basin or on the west flank of the Nemaha anticline. Chief oil production is from Ordovician and Mississippian rocks. The geology of the southern part of Marion County and the northern part of Butler County was discussed several years ago in papers by Thomas (1927, 1929). Recently Lukert (1949) has interpreted subsurface conditions in southern Marion County.

Soon after the discovery of oil in the Elbing pool in Butler County, the Elbing field was extended into Marion County and the Peabody, Covert-Sellers, and Florence-Urschel pools were discovered. These oil fields lie above rather low surface anticlines. Oil occurs in Ordovician rocks at an average depth of about 2,400 feet. Inasmuch as the oil occurs in eroded Ordovician dolomites that are overstepped by Pennsylvanian and Mississippian rocks, it is proper to say that the oil is in stratigraphic traps as well as in anticlines. Important production has also been found in "Mississippian chat." One field, the Wenger, produces from the "Hunton" limestone.

One pool, the Lehigh, was discovered in Marion County in 1946; four, the Antelope, Lost Springs South, Wenger, and Elbing North, in 1947; two, the Antelope North and Lost Springs Southeast in 1948.

During 1948 Marion County produced 643,137 barrels of oil. Oil production during each year from 1922 to 1948 inclusive is shown in Tables 2 and 2a. Production from the various oil fields in the County during the years 1944 to 1948 inclusive is shown in Table 58. The county produced approximately 670,710 thousand cubic feet of gas during 1948. One water-flooding secondary oil recovery project is in operation in the county. Figure 38 is a map of Marion County showing locations of oil and gas fields and areas of oil production during 1948.

Geology

SURFACE ROCKS

Cretaceous sandstone and shale (Dakota and Kiowa) occupy small areas at the surface in western Marion County. Permian rocks crop out in the remaining part of the county. Exposed Permian rocks include those between the lower part of the Wellington shale and the strata a few feet below the base of the Barneston limestone (Fig. 3). The Carlton limestone, in the lower part of the Wellington shale, crops out in a narrow band a few miles east of the eastern border of Cretaceous rocks. Limestones in the upper part of the Chase group crop out in steep escarpments in the eastern part of the county.

SUBSURFACE ROCKS

Marion County is on the west flank of the Nemaha anticline and on the margins of the Salina and Sedgwick basins. The northern part of the county is on the southern margin of the North Kansas basin (Figs. 9 and 11). Geologic conditions in the west-central part of Marion County are shown in Plate 4.

Permian and Pennsylvanian rocks.—The average thickness of Permian and Pennsylvanian rocks in Marion County is about 2,500 feet. This section is thicker in the western part of the county and thinner in the eastern part.

Mississippian rocks.—Mississippian limestone formations seemingly are absent in the eastern part of T. 18 S., R. 5 E. and the east half of T. 19 S., R. 5 E. in extreme northeastern Marion County (Lee, 1939, pl. 1). The thickness of Mississippian limestone in the county, as shown by Lee's studies, ranges from a featheredge to slightly more than 300 feet in the extreme southwestern part.

The Chattanooga shale is believed to be absent in approximately the same area in Marion County in which Mississippian limestones are absent. The Chattanooga shale ranges in thickness from a fraction of a foot to about 250 feet. The greatest thickness is in the west-central part of the county (Lee, 1940, pl. 3).

Pre-Chattanooga rocks.—In Marion County the Chattanooga shale where present, is in contact with the "Hunton" limestone, Maquoketa shale, and Viola limestone (McClellan, 1930; Ockerman, 1935, fig. 2). The "Hunton" is represented by Silurian rocks (Pl. 4). In the northeastern part of the county where the Chattanooga shale is absent, Pennsylvanian rocks are believed to truncate underlying rocks as old as the upper part of the Arbuckle limestone. The thickness of the Silurian limestone ranges from a featheredge to about 100 feet. It is believed to underlie only the northern part of the county. The maximum thickness of the Maquoketa shale in the county is believed to be about 100 feet and the greatest thickness of the Viola limestone is about the same. The maximum thickness of the St. Peter sandstone is perhaps less than 50 feet, and the average thickness of Arbuckle rocks is believed to be about 400 feet.

Ranges of thicknesses of pre-St. Peter rocks in Marion County as inferred by Keroher and Kirby (1948, figs. 4, 8, and 9) are Jefferson City-Cotter sequence, about 150 to 350 feet, increasing southwestward; Roubidoux dolomite, mostly less than 200 feet; and Bonneterre dolomite, a featheredge to 150 feet in the northwest part.

Oil and Gas Developments

The **Antelope** oil pool was discovered early in 1947 (Jewett, 1947, table 1). The discovery well, the Leiker et al. No. 1 Henke well, SW¼ SE¼SW¼ sec. 33, T. 18 S., R. 4 E., was rated at 22 barrels of oil per day. Production is from Mississippian "chat" at about 2,380 feet. Two wells produced in 1947. During 1948 the field produced 579 barrels of oil from one well.

The **Antelope North** pool was discovered early in 1948. The discovery well, the Schlageck No. 1 Holub well, SE¼ SW¼ sec. 28, T. 18 S., R. 4 E., was rated at 35 barrels of oil per day. Production is from the Kansas City limestone at about 1,840 feet. The field produced 650 barrels of oil during the year.

TABLE 58.—*Oil production in Marion County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Antelope							2	90	1	579
Antelope North									1	650
Covert-Sellers			16	32,490	13	37,500	13	31,260		2,393
Elbing[3]			See Butler County							
Elbing North							1	450		4,242
Fanska	3	29,605	3	63,540	9	68,576	8	36,437	9	23,640
Florence	4+	15,602	10	12,930	10	12,210	9	10,824	5	7,112
Hillsboro	8	37,716	9	35,610	10	32,777	9	26,881	8	25,637
Lehigh							2	17,621	6	18,604
Lost Springs[1]		709,175	166	607,650	174	442,380	174	379,470	181	528,119
Lost Springs East		348			2	930	2	960	1	986
Lost Springs South							1	540	1	957
Lost Springs Southeast[2]										
Peabody	3	26,534	11	21,420	11	19,230	2	16,770	3	19,144
Wenger							1	2,760	1	11,074
Totals	18+	818,980	215	773,640	229	613,603	224	524,063	217	643,137

[1] Includes Dickinson County production.
[2] Production not recorded.
[3] Field extends into Butler County

The **Covert-Sellers** oil pool was discovered in March 1920, when the Ward and Wilhoit No. 1 Covert well, in the SW¼ NE¼ NW¼ sec. 28, T. 21 S., R. 4 E., encountered oil in the Viola limestone. In 1948 the total production was 2,393 barrels of oil.

The **Doles Park** gas field extends into Marion County from McPherson County. The pool was discovered early in 1947, by the W. C. McBride No. 1 Waln well, sec. 12, T. 19 S., R. 1 W. The initial daily production from Mississippian limestone was established at 283,600 cubic feet of gas.

The **Elbing** oil field is chiefly in Butler County, but was extended into T. 22 S., R. 4 E. in southern Marion County in 1920.

The **Elbing North** pool was discovered in November 1947 (Ver Wiebe and others, 1948, p. 133). The discovery well, the E. H. Adair Oil Company No. 1 Jansen well, found production in Mississippian "chat" at 2,439 feet. The well was rated at 100 barrels of oil per day, and yielded 450 barrels of oil in the year. In 1948 the field produced 4,242 barrels of oil.

The **Fanska** oil pool, in sec. 6, T. 17 S., R. 1 E., was discovered in June 1943. Production is from lower Pennsylvanian rocks at a depth of about 2,680 feet. Production from the field in 1948 amounted to 23,640 barrels of oil from 9 wells.

The **Florence** oil pool was discovered in 1920 by the Robinson and Loreau No. 1 Hupp-Greely well, in the SW¼ SE¼ sec. 18, T.

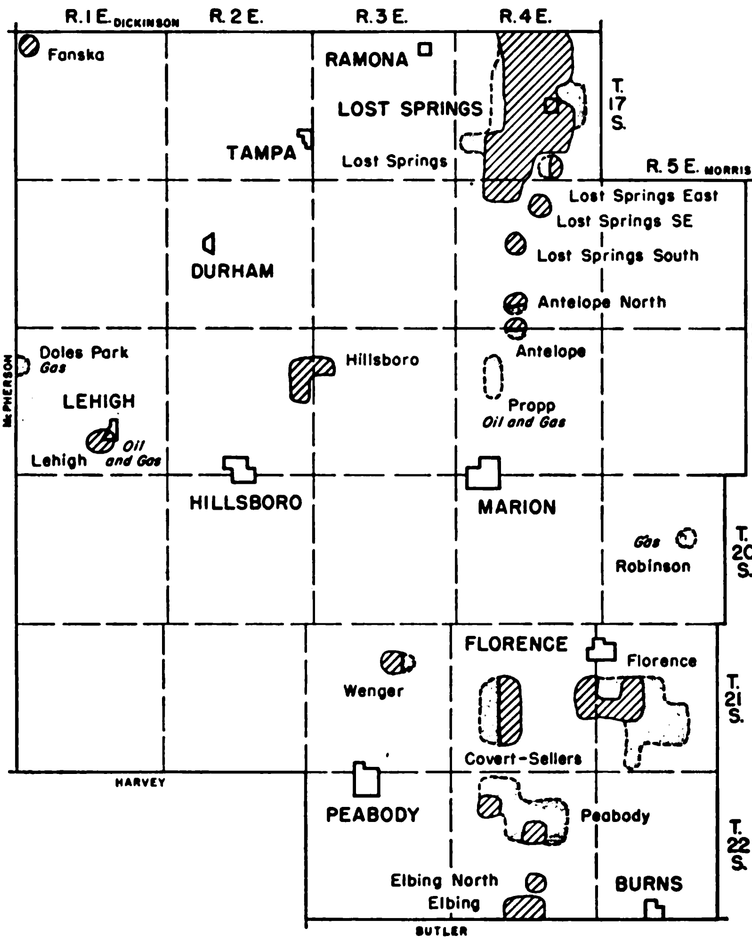

FIG. 38.—Map of Marion County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

21 S., R. 5 E. Oil was found in the Viola limestone. During 1948 the Florence field produced 7,112 barrels of oil from 5 wells.

The **Hillsboro** oil pool was discovered in October 1928. The discovery well, the Davis No. 1A Weins well in the NW¼ sec. 7, T. 19 S., R. 3 E., produces oil from the Viola limestone; it is reported that this well produced 332 barrels of oil from the "Mississippi lime" before it was deepened to the Viola. The average depth to the top of the producing zone in the Viola in this area is about 2,820 feet. Initial production of some wells was as

TABLE 59.—*Dry wildcat wells drilled in Marion County in 1948*

Company and farm	Location	Depth to top of Kansas City, feet	Depth to top of Mississippian, feet	Total depth, feet
Ingling & Maguire No. 1 Jost	SW¼ NE¼ SW¼ 22-19-2E		2,568	3,010
E. H. Adair Oil Co. No. 1 Buckley	SW cor. NE¼ 24-19-3E	1,805*	2,413	2,708
A. J. Stormfeltz et al. No. 1 Larkin	NE¼ NW¼ SE¼ 34-19-5E	1,665*		2,602
H. J. Uhl et al. No. 1 Duerksen	SE cor. SW¼ 14-20-1E	2,135*	2,829	3,216
J. Pasternak & I. W. Seige No. 1 Schmidt	SW cor. SW¼ 26-20-1E	2,204	2,820	3,280
A. J. Stormfeltz No. 1 Stephens	SE cor. SE¼ 1-21-3E	1,855	2,381	2,718
Branine & Goering No. 1 Lathrop	NE cor. SE¼ 26-21-3E	1,910	2,476	2,769

*Kansas City

high as 400 barrels of oil per day. The total production of 8 wells in 1948 was 25,637 barrels of oil.

The **Lehigh** oil and gas field was opened in 1946. The discovery well is the Anderson-Prichard Oil Corp. No. 1 Warkentine Unit, SE cor. sec. 27, T. 19 S., R. 1 E. Production is from the Mississippian limestone. Initial daily production of the discovery well was reported as 28 barrels of oil, 75 barrels of water, and 3 million cubic feet of gas. Other wells that have been drilled in the field include (1) the Anderson-Prichard No. 1 Weyand, SE¼ NW¼ SW¼ sec. 27, completed on November 9, 1946, with an initial daily production of about 340 barrels of oil and 1 percent water; (2) the Weyand No. 2, in the NW¼ NE¼ SW¼, completed December 12, 1946, with a potential of about 206 barrels of oil and 9 percent water; (3) the Warkentine No. 2, SE¼ SW¼ NW¼, completed December 31, 1946, with an estimated daily production of 2 million cubic feet of gas; and (4) the Esau No. 1, Cen. N½ SW¼ SW¼, completed March 29, 1947, with daily production estimated as 3½ million cubic feet of gas and 5 barrels of oil. A disposal well, the Esau 1-A was drilled in June 1947. In 1948 the field yielded 18,604 barrels of oil.

The **Lost Springs** oil pool, discovered in 1926, is in the northeastern part of Marion County, and extends into Dickinson County. Production is from the Mississippian limestone, the top of which is encountered at an average depth of about 2,365 feet. Average initial production was about 135 barrels of oil per day and the maximum initial production was about 1,000 barrels. In 1948 the production from 181 wells was 52,119 barrels of oil.

TABLE 60.—*Data on pool wells drilled in Marion County in 1947 and 1948*

Field	1947 Producing wells and formation		1947 Dry	1947 Total	1948 Producing wells and formation		1948 Dry	1948 Total
Antelope North			0	0	1	Kansas City	0	1
Bitikofer			0	0			1	1
Covert-Sellers			0	0	10	Viola	4	14
Elbing North			1	1	3	Mississippian ls.	2	5
Florence			0	0	1	Viola	3	4
Lehigh	1	Mississippian ls.	0	1	1	Mississippian ls.	1	2
Lost Springs	4	Mississippian ls.	5	9	4	Mississippian ls.	5	9
Lost Springs East			0	0	2	Mississippian ls.	2	4
Lost Springs South			1	1			1	1
Lost Springs Southeast			0	0	1	Mississippian ls.	0	1
Peabody			0	0	1	Viola	1	2
Wenger			0	0	10	"Hunton"	11	21
Wildcats			12	12			7	7

The **Lost Springs East** pool is in secs. 34 and 35, T. 17 S., R. 4 E. Production is from the top of Mississippian rocks or "chat." During 1948, one well in sec. 35 produced 986 barrels of oil.

The **Lost Springs South** pool was discovered in 1947. The discovery well, the Saco No. 1 Navrat, sec. 16, T. 18 S., R. 4 E., was rated at 35 barrels of oil per day from the top of the Mississippian limestone. The amount of produced water was about equal to the oil. In 1948, one well produced 957 barrels of oil. The **Lost Springs Southeast** field is in sec. 10, T. 18 S., R. 4 E.

The **Peabody** oil pool was discovered in 1920 by the Elmhurst Investment Company No. 10. Jolliffe well, in the SE¼ SE¼ sec. 9, T. 22 S., R. 4 E. The Viola limestone is the producing rock. In 1948 the total production from three wells was 19,144 barrels of oil.

The **Propp** gas pool was discovered in April 1926. Initial production of the discovery well was 4 million cubic feet of gas per day. Production is from the "chat," in the upper part of the Mississippian limestone.

The **Robinson** gas pool is in sec. 15, T. 20 S., R. 5 E. The discovery well, the Tom Palmer No. 1 Robinson, SW cor. NW¼ sec. 15, was drilled in 1930. Initial daily production was estimated as 1½ million cubic feet of gas. Production is from Cherokee rocks at a depth of 2,095 feet. Dry holes had been drilled previously in the SW¼ NW¼ sec. 15. In 1941, the Dexter et al. No.

1 Robinson was rated as having an initial daily production of 1 million cubic feet of gas from a depth of 2,073 feet.

The **Wenger** oil pool was discovered in 1947. The discovery well, the Goering and Branine No. 1 Wenger, NW¼ NW¼ SW¼ sec. 11, T. 21 S., R. 3 E., found oil in the "Hunton" limestone at 2,771 feet. Initial rating of the well was 50 barrels of oil per day. In 1948, one well produced 11,074 barrels of oil.

During 1948, 72 wells were drilled in Marion County. Two of the nine wildcats discovered oil. Four of the 16 wildcat wells drilled during 1947 discovered oil. Data on dry wildcat wells drilled in 1948 are given in Table 59. Data on pool wells drilled in Marion County during 1947 and 1948 are given in Table 60.

MARSHALL COUNTY

Neither oil nor gas in commercial quantities has been found in Marshall County. The county lies in an area where regional structural conditions are such that one might expect to find structural oil traps in the more deeply buried rocks.

Geology

SURFACE ROCKS

In most of Marshall County the exposed rocks are of Permian age. A small area in the western part of the county is occupied by outcrops of Cretaceous sediments and a few feet of late Pennsylvanian rocks crop out in the eastern part of the county.

Cretaceous rocks.—A small upland area in T. 2 S., R. 6 E. and in the extreme northwest corner of T. 3 S., R. 6 E. in western Marshall County is underlain by Dakota sandstone and shale.

Permian rocks.—In most of Marshall County the soil is immediately underlain by Permian rocks that embrace the section between the lower part of the Wellington shale and lowermost Permian (Fig. 3). Several limestones of lower Permian age are useful key beds for surface structural mapping. Outcropping Permian rocks in the county are similar to the same strata in Riley County and are more completely discussed in the part of this paper in which Riley County is discussed.

Pennsylvanian rocks.—The Dover limestone (Fig. 4) and a few feet of other upper Pennsylvanian rocks crop out in eastern and southeastern Marshall County (Moore and Landes, 1937).

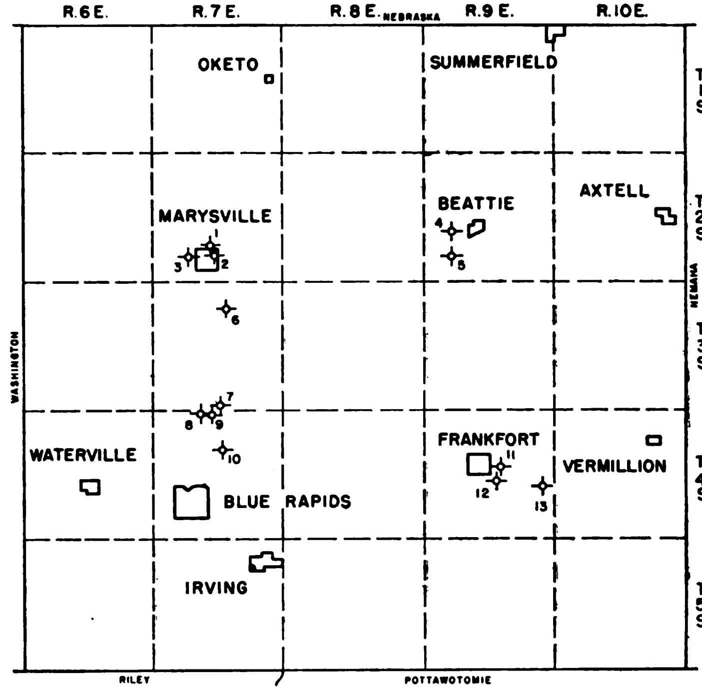

FIG. 39.—Map of Marshall County showing location of wells listed in Table 62.

SUBSURFACE ROCKS

Marshall County lies on the west flank of the Nemaha anticline. Subsurface geologic conditions in the east-central part of the county are shown on Plate 4. Recent studies by Lee, Leatherock, and Botinelly (1948) on the stratigraphy and structural development of the Salina basin should be of interest in exploration for oil and gas in Marshall County.

Permian and Pennsylvanian rocks.—The combined thickness of Permian and Pennsylvanian rocks in Marshall County ranges from less than 1,000 feet to more than 2,000 feet. The thinner section is in the eastern part of the county where Permian rocks have been eroded. Marshall County lies on the west flank of the Nemaha anticline where the Pennsylvanian section is much thinner than it is east of the anticline. West of the anticline the older Pennsylvanian section is reduced in thickness, but Pennsylvanian rocks above the base of the Kansas City group have

TABLE 61.—*Depths to some stratigraphic horizons in the Blair No. 1 Cox well, Cen. SW¼ SW¼ sec. 10, T. 4 S., R. 7 E., Marshall County* (Data in part from Lee, Leatherock, and Botinelly, 1948)

Horizon	Depth, feet
Top of Topeka limestone	810
Top of Devonian limestone (Base of Pennsylvanian)	1,445
Top of Silurian limestone	1,478
Top of Maquoketa shale	1,757
Top of Kimmswick limestone	1,814
Top of Platteville limestone	2,047
Top of St. Peter sandstone	2,117
Top of Pre-Cambrian rocks	2,157
Total depth	2,175

about the same thickness on both sides of the anticline. Redbeds are characteristic of the lowermost Pennsylvanian rocks.

Mississippian limestones and the Chattanooga shale are probably absent in all parts of Marshall County.

Pre-Chattanooga rocks.—In Marshall County Pennsylvanian rocks overstep from the west the "Hunton" limestone, the Maquoketa shale, the Viola limestone, and the Simpson formation (St. Peter-Decorah). Arbuckle rocks are probably absent from

TABLE 62.—*Data on wells drilled for oil and gas in Marshall County*

No. on map	Name of well	Location	Completion date	Total depth, feet	Remarks
1	"Well near Marysville"	SE¼ NW¼ NE¼ 28-2-7E	?	1,644	Stopped in Cherokee rocks
2	Carter No. .... Marysville	NE¼ SE¼ SE¼ 28-2-7E	?	1,700	Stopped in Cherokee rocks
3	Schnell & Mildeen No. 1 Marysville	NE cor. SE¼ SE¼ 29-2-7E	5-9-08	1,700	Top "Hunton" 1,692 feet
4	Vermillion Oil & Gas Co. No. 1 Fitzgerald	SW¼ 20-2-9E	11-13-22	1,271	Top Pre-Cambrian 1,265 feet
5	.... No. 1 Beatty	SW¼ 29-2-9E	?	3,000	Oil & gas show at 1,182 feet; top Pre-Cambrian 1,420 feet
6	Blazier et al. No. 1 Cooper	NE cor. NW¼ 10-3-7E	8-21-29	2,325	Stopped in St. Peter ss.
7	Aladdin-Thrifty-Leiker et al. No. 1 Rombeck	NW¼ SW¼ SW¼ 34-3-7E	11-10-48	1,915	Top "Hunton" 1,632 feet
8	H. J. Uhl et al. No. 1 Marvin	NE¼ NE¼ NW¼ 4-4-7E	4-4-48	1,875	Stopped in "Hunton"
9	Marshall County Synd. No. 1 Catherine Finn	NW cor. NE¼ NE¼ 4-4-7E	5-23-29	3,953	Top "Hunton" 1,520 feet; St. Peter ss. 2,148 feet; Pre-Cambrian 2,265 feet
10	B. B. Clair No. 1 Cox	Cen. SW¼ SW¼ 10-4-7E	1-21-44	2,175	Some stratigraphic data given in Table 61; stopped in Pre-Cambrian rocks
11	.... No. 1 Geo. Sharer	15-4-9E	?	850	Oil show 750-755 feet; 100 M gas at 790 feet; stopped in Kansas City gr.
12	Swicker & Simcox No. 1 Dowrimple	Cen. N½ NW¼ 22-4-9E	12-18-29	1,245	St. Peter ss. on Pre-Cambrian rocks at 1,225 feet
13	Dalton J. Woods No. 2 Geo. Sharer	21-4-9E	8-7-47	1,365	Pre-Cambrian rocks at 1,340 feet

all parts of the county. The Marshall County Syndicate No. 1 Catherine Finn well, NW¼ NW¼ NE¼ sec. 4, T. 4 S., R. 7 E., was drilled 1,770 feet into Pre-Cambrian rocks, all of which probably comprise metamorphased sediments. Wells in Marshall County have reached Pre-Cambrian rocks at depths ranging from 1,225 to 2,265 feet. Depths to some key horizons in a well in sec. 10, T. 4 S., R. 7 E. are given in Table 61.

Oil and Gas Exploration

The Geological Survey has records of 13 wells that have been drilled in Marshall County. Locations and other data concerning the wells are shown in Table 62. From logs it seems that one well stopped in the Kansas City rocks; two wells were stopped in the Cherokee shale; three in the "Hunton" limestone; one in the St. Peter sandstone; and six in Pre-Cambrian rocks. Location of wells listed in Table 62 are shown in Figure 39.

MIAMI COUNTY

Miami County was one of the first counties in Kansas to produce oil and gas. Three wells drilled by Dr. G. W. Brown near Paola in 1860 were the first test wells drilled in the State. The first two wells were abandoned as dry holes at depths of about 100 feet (Haworth, 1908, p. 22). The third well was drilled deeper and the discovery of oil was reported. Natural gas was piped to Paola from a field 7 miles to the east as early as 1884. This was the first city in Kansas to be supplied with natural gas.

The early exploration for and the discovery of oil and natural gas in Miami County near Paola have been described in several publications (Haworth, 1908, p. 22; Forbes, 1942, pp. 9-10; Moore and Jewett, 1942; Jewett and Abernathy, 1945, pp. 179, 181-192).

Water flooding has become a very important factor in oil production in Miami County. Repressuring by air also has been practiced. There are now nine water-flooding projects in operation (Table 3, Fig. 2).

All the oil and gas that has been found in Miami County occurs in Pennsylvanian rocks. In the eastern part of the county depths to oil- and gas-bearing formations range from about 325 or less to 400 feet; depths in the western part of the county are as much as 700 feet.

During 1948 Miami County produced 327,326 barrels of oil. Production in the county for 1889 through 1948 is given in Tables 2 and 2a. Table 63 shows production in the various fields for 1944 through 1948. In 1947, Miami County produced 184,339 thousand cubic feet of natural gas; 1948 production is estimated as about the same. Production is reported from about 40 scattered wells, with the larger ones being in the Block field. The oil and gas fields and areas of 1948 oil production are shown in Figure 40.

Geology

SURFACE ROCKS

The surface geology of Miami County has been described by Newell (1935). His report contains an areal geologic map of the county and detailed descriptions of outcropping rocks.

With the exception of a few feet of unconsolidated deposits of Recent, Pleistocene, and Tertiary (?) age, the surface rocks of Miami County are of Pennsylvanian age. They include most of the Lansing group, all the Kansas City group, and most of the Pleasanton shale (Fig. 5). The upper part of the Stanton limestone of the Lansing group has not been identified in the county, although the entire formation is probably present under soil cover in the northwestern part of the county. The thickness of the exposed part of the Stanton limestone ranges from about 26 to 36 feet, the thickness of the Vilas shale from about 6 to 20 feet,

Table 63.—*Oil production in Miami County, 1944 through 1948*

	1944		1945		1946		1947		1948	
Field	No. wells	Bbls. oil	No. wells	Bbls. oil	No. wells	Bbls. oil	No. wells	Bbls. oil	No. wells	Bbls. oil
Louisburg	34	2,644	34	2,241	29+	2,211	20+	1,431	40	3,834
Paola-Rantoul[1]										
"Paola A"	9	337	9	259	9	340	9	297		
"Paola B"	32	17,180	30	13,645	38	15,926	58	11,818	49	15,345
"Paola C"	63+	12,239	63+	11,646	62+	12,685	53+	18,267	63+	30,902
"Paola D"	9	4,135	9	2,445	9	1,431	9	1,508	9	1,212
"Paola E"	12	2,815	12	2,810	12	3,265	12	2,793	12	3,235
"Big Lake"	265	76,115	261	98,416	263	133,825	258	98,401	251	77,743
"Osawatomie"	77+	10,728	59+	8,040	136	49,005	85+	40,337	88+	67,297
"Pressonville"	230+	11,085	230+	16,515	372+	59,030	286+	48,245	209+	81,211
"Rantoul"	12	513	12	256	12	340	12	149	12	255
"Stanton"	144+	48,578	124+	74,284	76+	60,663	135+	67,485	117+	46,292
Miscellaneous	144	11,141	114	11,042				75		
Totals	1,031+	197,510	957+	241,599	1,018+	338,721	937+	290,806	850+	327,326

[1] Field extends into Franklin County.

and the thickness of the Plattsburg limestone from about 10 to 22 feet. These rocks are exposed in the northwestern part of the county.

Rocks of the Kansas City group, whose total thickness is about 255 feet, crop out in areas characterized by the prominent Wyandotte limestone escarpment and by the thick Lane shale section in the western part of the county. The Iola limestone escarpment is less conspicuous. The Wyandotte limestone is the formation next below the soil on the uplands in all the county except the southeastern and northwestern parts. The Westerville limestone seemingly is absent in Miami County. The total thickness of rocks of the Bronson subgroup in the county is about 80 feet. Limestone is the dominant rock of this assemblage, which is characterized by oölitic cross-bedded flinty limestones and thinner black platy shales. These rocks crop out in the southern and southeastern parts of the county.

The thickness of the Pleasanton shale in Miami County is approximately 140 feet, but only about the upper 90 feet is exposed. The exposures of these rocks are along Hushpuckney Creek, Marais des Cygnes River, Middle Creek, and Sugar Creek in the southern and southeastern parts of the County.

SUBSURFACE ROCKS

Subsurface geologic conditions in the central part of Miami County are shown in Plate 1.

TABLE 64.—*Depths to some stratigraphic horizons encountered in five deep wells in Miami County*

Horizon	McDonald No. 1 Lee SW¼ SW¼ SW¼ sec. 16., T. 16 S., R. 23 E.	Breisch No. 1 Ringer, NW¼ NE¼ NW¼ sec. 3 T. 17 S., R. 23 E.	No. 1 Brown sec. 12, T. 17 S., R. 21 E.	Clark No. 1 Vaughn, SE¼ SW¼ sec. 28, T. 17 S., R. 22 E.	"Osawatomie," NE¼ NW¼ sec. 12, T. 18 S., R. 22 E.
Base of Hertha limestone	195	195	380	315	95
Base of Fort Scott limestone	445	475	?	615	428
Top of Mississippian limestone	852	888	1,055	981	770
Top of Chattanooga shale	1,278	1,272	1,410	1,385	1,195
Top of Viola limestone	1,435?	1,415?	1,465	1,428	1,255
Top of St. Peter sandstone	?	1,493	1,510	1,460	1,535
Top of Arbuckle limestone	?	1,533	1,538		1,634
Top of Pre-Cambrian rocks	2,283				

Table 64 gives depths to some stratigraphic horizons in five wells in Miami County.

Pennsylvanian rocks.—The thickness of Pennsylvanian rocks in Miami County ranges from slightly more than 1,000 feet in the northwestern part to about 600 feet in the southeastern part. All oil and gas production in the county is from Pennsylvanian rocks, and numerous producing zones ranging from the Pleasanton shale to the lower part of the Cherokee shale are known. The Pleasanton rocks are easily recognized in well logs, and comprise strata that are referred to as the "Big shale." In the subsurface, the Hepler sandstone is locally in contact with the "Big Lake" sandstone in the Bandera shale. Because of this relationship, the "Big Lake" sandstone in some places comprises two sandstones, the Hepler sandstone at the base of the Pleasanton shale and the Bandera Quarry sandstone in the upper part of the Marmaton group. A part of the oil and gas produced in the Big Lake area is from the Hepler sandstone. The common thickness of Pleasanton rocks in the county is about 200 feet. The Marmaton group is about 150 feet thick, and the Cherokee shale ranges in thickness from about 350 feet to 450 feet.

Mississippian rocks.—The total thickness of Mississippian limestone formations in Miami County ranges from about 350 feet to slightly more than 450 feet. The Chattanooga shale is believed to be less than 50 feet thick in all parts of the county.

Pre-Chattanooga rocks.—Miami County lies on the northern flank of the Chautauqua arch. Ordovician rocks, including Viola dolomite, St. Peter sandstone, and Arbuckle dolomite, are overstepped by the Chattanooga shale. The Viola and St. Peter are believed to be present only in the approximate northwestern half of the county. Elsewhere the Chattanooga shale is in contact with Arbuckle dolomite. The thickness of the Viola dolomite ranges from a featheredge to about 200 feet. The maximum thickness of the St. Peter sandstone is probably not much greater than 100 feet. Arbuckle rocks in the county have an average thickness of perhaps 850 feet. The Lamotte sandstone, having a maximum thickness of about 100 feet, probably underlies most or all of the county.

Keroher and Kirby (1948) estimated that the Jefferson City-Cotter sequence in Miami County ranges from less than 100 feet in the northeast part to something more than 200 feet in the south-

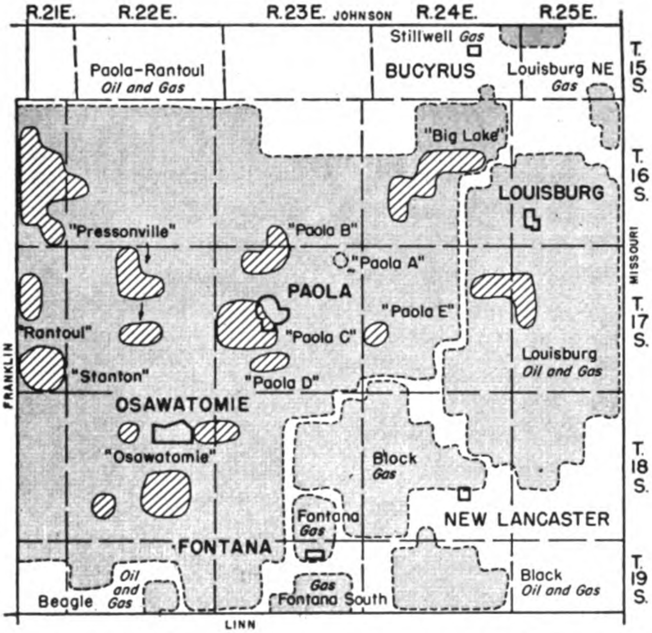

Fig. 40.—Map of Miami County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

western part; the Roubidoux dolomite from about 100 feet in the southwest corner to a lesser amount in the northeastern part; the Van Buren-Gasconade sequence from 150 feet in the southwest corner to less than 200 feet in the northeastern part; the Eminence dolomite from an amount slightly greater than 100 feet in the southwest corner to an amount of more than 150 feet in the northeastern part; the Bonneterre dolomite from about 100 feet in the northwest corner to a somewhat greater amount in the southeastern part of the county.

Oil and Gas Developments

In 1884 gas was piped into Paola from wells about 7 miles east of town, and then, and perhaps earlier, oil was sold locally as lubricating oil. In about 1886 a small refinery was erected in Paola, and oil was shipped from there to Omaha and Kansas City. In 1889 the Paola field is reported to have yielded 500 barrels of oil. Until 15 years ago the leading districts were in the western half of the county where the Paola, Osawatomie, and Rantoul fields are located. Wells in these fields generally had initial production of less than 100 barrels of oil per day, and their productions soon declined to a few barrels. In the autumn of 1926 the Big Lake pool was discovered. The discovery well in this field was drilled in sec. 20, T. 16 S., R. 22 E. This discovery resulted in an increase in the county's production from 13,153 barrels of oil in 1925 to 752,102 barrels in 1927. Much prospecting in the eastern half of the county followed. The Big Lake field was extended and several smaller fields were opened. In this part of the county producing wells range in depth from about 325 to 400 feet. In the western part, wells are as deep as 750 feet.

Oil and gas wells are distributed so widely in Miami County that it is not deemed practicable to divide the county into small fields. Gas is produced in nearly all parts of the county and wells have been drilled wherever locations are convenient to pipe lines or for domestic use. Many farmers have their own gas wells or one or more wells serve a few farms. The amount of natural gas that enters commercial pipe lines is much less than the total production.

Most of the area of Miami County lies within the area designated as the **Paola-Rantoul** oil and gas field (Fig. 40). The **Louisburg** oil and gas field, as designated also by the Oil Field Nomenclature Committee of the Kansas Geological Society (Jewett and Abernathy, 1945, table 67) is a smaller area covering much of the eastern part of the county.

Inasmuch as at present oil is produced in isolated areas and from pools that have well-established names, such as Big Lake, Pressonville, and Stanton, it seems advisable to segregate oil production as is shown in Table 63 and Figure 40. The discovery well of the **Big Lake** oil-producing area was drilled on the Big Lake lease in sec. 20, T. 16 S., R. 24 E. in November 1926. The producing formation is a shoestring sandstone having a northeast-southwest trend. The wells range in depth from about 325 to 400 feet. Initial daily productions ranged from about 20 barrels to more than 250 barrels of oil. The producing sandstone is known as the "Big Lake sand"; it is correlated in part with the Bandera Quarry sandstone that lies between the Altamont and Pawnee limestones. In most of the area, however, the Altamont limestone is absent and the Hepler sandstone is seemingly locally in contact with the lower sandstone, the Bandera Quarry. Until more detailed studies are made, it is not deemed possible to determine whether production is chiefly from the Hepler sandstone or from the Bandera Quarry sandstone. The maximum known thickness of the "Big Lake sand" in the area is slightly more than 55 feet. Repressuring by air was practiced for many years before water flooding was initiated recently. In 1948, 77,743 barrels of oil were produced from about 250 wells in the Big Lake area.

The **Pressonville** shoestring oil-producing area extends into Franklin County. This area in Miami County is about 12 miles long and ranges from about a quarter of a mile to 2 miles or more in width. Oil production is chiefly from the "Squirrel sand" at depths ranging from about 500 feet in the eastern part to about 750 feet in the western part of the area. The thickness of the "Squirrel sand" ranges from a few feet to about 50 feet. In 1948, the area produced 81,211 barrels of oil, chiefly by water flooding.

The **Paola** oil-producing area includes pools that lie north, south, and southwest of Paola. Oil production in this part of the county is chiefly from the "Wayside sand" (in the Nowata shale), but some production seemingly is from the Hepler sandstone. Disconformable relations at the base of the Hepler cause it to be in contact with various upper Marmaton rocks. The Lenapah limestone is thin and locally absent, and it is difficult to differentiate the Hepler and "Wayside sand" in many logs. Some oil and frequent oil shows have been reported in the Knobtown sandstone in the area. Gas is produced in the Paola area from the Hepler sandstone, "Wayside sand," sandstone in the Bandera shale, "Peru sand," black shale in the upper few feet of the Cherokee shale, and "Bartlesville sand." Gas production is not as completely confined to definite areas as is oil production, and there is almost an unbroken gas field extending from Paola northwestward about 14 miles, eastward about 10 miles, southeastward, southward, and westward to the county boundaries and beyond.

Scattered wells in all directions make exact delineation of the **Stanton** oil pool boundary uncertain. Production seemingly is chiefly from the Hepler sandstone, which is about 15 feet thick and occurs between 350 and 450 feet below the surface. The "Squirrel sand" also is productive in a part of the area, and gas is produced from several zones. Water flooding has been practiced in this area for many years.

Oil production in the **Osawatomie** area is principally from a sandstone locally called "Wayside sand," but seemingly the reservoir rock is the Bandera Quarry sandstone which occurs in the Bandera shale. Water flooding has been practiced in the Osawatomie area for several years.

A few years ago a shaft was driven to a depth of 230 feet into oil bearing sandstone on the Hugh Whiteford farm, SW¼ sec. 9, T. 19 S., R. 24 E. It is reported that 14 radial holes with a total footage of more than 7,000 feet were drilled horizontally into the sand (Abernathy and Jewett, 1945). This project, which was the first oil-mining venture in Kansas, was developed by Frank C. Thomas of Thomas and Thomas mining operators, St. Louis, Missouri. Seemingly there has been no commercial production from the mine. This project was in the Black oil and gas field (Fig. 40).

MONTGOMERY COUNTY

Gas was discovered in Montgomery County in 1881 and oil was discovered in 1903 in the Bolton pool. The geology and oil and gas resources of Montgomery County were described by Moore and Boughton (1921) and by Abernathy (1940). Abernathy's report includes a map showing locations of most of the wells that had been drilled before the time of the report's publication and the stratigraphic depths of many of the wells are indicated.

Repressuring oil sands by water injection has become a very important phase of the petroleum industry in Montgomery County. Twenty-two projects were in operation in 1948 (Table 3, Fig. 2).

During the year 1948 Montgomery County produced 945,616 barrels of oil. The yield of natural gas was 568,283 thousand cubic feet. Oil production in the county for 1893 through 1948 is given in Tables 2 and 2a. Table 65 gives the production in the county's various fields for 1944 through 1948. Figure 41 shows the locations of oil and gas fields and the areas of oil production in 1948.

Geology

SURFACE ROCKS

Pennsylvanian rocks including those of the Douglas, Pedee, Lansing, Kansas City, Pleasanton, and Marmaton groups (Figs.

4, 5) crop out in Montgomery County. Beds in the lower part of the Douglas group are exposed in the western and northwestern parts of the county. The oldest exposed rock in the county is the Altamont limestone of the Marmaton group, which crops out in the southeastern corner.

The Tonganoxie sandstone is the caprock of prominent hills in the area of Douglas outcrops, and the Weston shale in the Pedee group underlies a broad area south of Elk River in the western part of Montgomery County. The outcrop belt of these rocks north of the river is much narrower. Most of the limestones in the Lansing and Kansas City groups are thin and inconspicuous in this part of the State and several of them pinch out before reaching the Kansas-Oklahoma line. Marmaton limestones, however, are thicker than farther north.

Because of lateral changes in rocks of the Missourian Series it is convenient to apply the classification commonly applied to equivalent rocks in northeastern Oklahoma to these rocks south of T. 33 S. In this classification the Ochelata group includes rocks between the base of the disconformity at the base of the Tonganoxie sandstone (Virgilian-Missourian boundary) and the disconformity at the base of the Noxie sandstone. The Ochelata group is about 200 feet thick in Montgomery County. It consists chiefly of shale and sandstone. These rocks crop out in the county in the west-central and north-central parts. The Skiatook group includes rocks between the disconformity below the Noxie sandstone and the disconformity at the base of the Missourian Series, which is overlain by the Hepler (Seminole) sandstone. These rocks are slightly more than 200 feet thick in Montgomery County. The Drum limestone (Kansas City group) is 50 feet or more thick in the vicinity of Independence, but it is not present in the southern part of the county where it is seemingly cut out by the disconformity below the Ochelata rocks. The Dennis (Hogshooter) limestone is persistent across the county. The Swope limestone pinches out in the vicinity of Liberty, or is present southward as a thin zone of limy shale. The Hertha limestone also pinches out before reaching the state line. The Checkerboard limestone, in the lower part of the Skiatook group, crops out in Coffeyville and vicinity. Upper Marmaton rocks are exposed in the southeastern part of Montgomery County. The oldest rock exposed in the county is the Altamont limestone or a few feet of the Bandera shale.

SUBSURFACE ROCKS

Subsurface geologic conditions in the eastern part of Montgomery County are shown in Plate 2. The county is in the area of the Chautauqua arch, where the Chattanooga shale lies on lower Ordovician rocks.

Pennsylvanian rocks.—The average total thickness of Marmaton rocks in Montgomery County is about 390 feet. A bed of sandstone 20 to 50 feet thick, known as the "Weiser sand," occurs locally in the upper part of the Bandera shale. The thickness of the Bandera ranges from about 60 to 150 feet. The Pawnee limestone ranges in thickness from about 22 to 50 feet. It is chiefly dense, hard, light-gray, fossiliferous limestone, locally consisting of two beds of limestone separated by a few feet of black shale. It is locally designated by drillers as the "Pink lime" or "40-foot limestone." The thickness of the Labette shale ranges from about 40 to 100 feet, and the average is about 70 feet. There is a thin bed of coal in the upper part of the Labette shale in southeastern Montgomery County, and a bed of sandstone, called the "Peru sand," occurs locally. The total thickness of the Fort Scott limestone (including the Breezy Hill? limestone) ranges from about 75 to 100 feet in the county. Three limestone members (locally four or five) are included. The upper limestone, which is very hard and dense, is called "Oswego," "Brown lime," or "First lime" by some drillers and operators. The middle and lower limestones, called the "Second lime" and "Third lime," commonly are not as hard as the upper limestone and are impure in most places. The black shale beds separating the limestones range in thickness from 2 to 20 feet.

The Cherokee shale in Montgomery County ranges in thickness from about 304 to 495 feet. It consists of gray and black shale, a few lenses of sandstone, several thin beds of coal, and a few thin beds of limestone. A sandstone in the upper part of the Cherokee is known as the "Squirrel sand." The Ardmore limestone is massive, fossiliferous, and dark gray, and ranges from 3 to 5 feet in thickness. It is persistent and commonly lies about 30 to 70 feet below the Fort Scott limestone. A similar bed about 40 feet below the Ardmore occurs locally. Sandstone lenses about

140 to 200 feet above the base of the Cherokee are called "Bartlesville sand." Some of these sandstone bodies are more than 100 feet thick. A conglomerate composed principally of chert and smaller amounts of limestone and pyrite occurs in the basal part of the Cherokee. In some places the "Burgess sand" directly overlies the conglomerate. Black shale, 40 to 90 feet in thickness, commonly lies on the "Burgess sand" in Montgomery County. If the sandstone and conglomerate are not present, the black shale lies on the Mississippian limestone.

Mississippian rocks.—The Mississippian rocks in Montgomery County have an average thickness of about 300 feet. Anticlines are generally marked by thin sections of Mississippian rocks (Lee, 1939, p. 12, pl. 1). The minimum thickness recorded is about 225 feet. The upper part of the Mississippian rocks was weathered and made porous before deposition of the overlying Pennsylvanian rocks, and most of the oil produced from Mississippian rocks is from this porous zone. The Mississippian rocks include the Warsaw limestone, Cowley formation, Keokuk limestone, Burlington limestone, Reeds Spring limestone, St. Joe limestone, Northview shale, and Compton limestone. The Chattanooga shale, which is black or gray and fissile, has an average thickness of about 40 feet in Montgomery County. It lies on Ordovician rocks.

Ordovician rocks.—Ordovician rocks in Montgomery County include the Cotter and Jefferson City dolomites, the Roubidoux formation, and the undifferentiated Gasconade dolomite and Van Buren formation. The total thickness of these rocks in the County is about 725 feet.

Cambrian rocks.—The Cambrian rocks in Montgomery County are the Eminence and Bonneterre dolomites and the Lamotte sandstone. The total thickness of Cambrian rocks in the County is about 350 feet.

Pre-Cambrian rocks.—Well logs indicate that red granite was reached at a depth of 2,155 feet in the J. B. Miller well in sec. 33, T. 33 S., R. 17 E., and at 2,536 feet in the Hydraulic Oil Company No. 1 Beal well in sec. 12, T. 33 S., R. 14 E.

Oil and Gas Developments

Montgomery was one of the first counties in Kansas to produce large quantities of oil and gas. Gas was found in small quantities at several places in the county as early as 1881. Larger supplies of gas were found near Cherryvale in 1889 and near Coffeyville about a year later. Gas was piped to Coffeyville in 1892; that city was one of the first towns in southeastern Kansas to use natural gas. The largest gas field in the county, the Independence field reached its peak of production in 1904. At that time it had an open-flow capacity exceeding 700 million cubic feet. Gas wells having initial daily productions of 10 to 20 million cubic feet were common; the largest well was reported to have had an initial production of 93 million cubic feet per day. During the early history of the gas industry, gas was produced from well-defined areas, such as the Elk City, Independence, Jefferson, Cherryvale, and Coffeyville areas. At the present time gas is produced from widely distributed wells in the county, and development has been so widespread that any one field is almost continuous with other fields. Gas is produced chiefly from the "Bartlesville sand"; the lowest gas-producing rock is the Arbuckle limestone.

Oil was first produced in Montgomery County in 1903, the year in which the Bolton pool southwest of Independence was discovered. Initial productions of wells in that pool ranged from 10 to 1,000 barrels per day. Subsequently oil pools were found in nearly all parts of the county. Oil production in Montgomery County reached its peak in 1925 when 1,136,654 barrels were produced. Water flooding of partly depleted oil-bearing formations was practiced in the county as early as 1920, and modern systematic water flooding started in 1939.

Oil and gas are produced in Montgomery County from the Lane-Vilas, Bandera, Labette, and Cherokee shales, and the Fort Scott, Mississippian, and Arbuckle limestones.

Gas is produced in the northwestern part of the county from at least three sandstones in the Lane-Vilas shale. The upper sandstone is locally called "Bush-Denton" or "Ferguson"; the middle sandstone is called "Longton," "Webb," or "Heck"; and the lower sandstone is called "Encill." Oil is produced from the "Wayside sand" in the Nowata shale; this sandstone ranges in thickness from 10 to 30 feet. A sandstone in the Bandera shale, known as the "Weiser sand," yields oil and gas; it ranges in thickness from 20 to 60 feet. The "Weiser" has been very prolific; during the more active stages of development a large percentage of the wells drilled into it were producers.

There are three important oil and gas producing zones in the Cherokee shale in Montgomery County. The "Squirrel sand," which occurs locally in the upper part of the Cherokee shale, yields small amounts of gas and some oil. It is separated from the Fort Scott limestone by 10 to 80 feet of shale. The "Bartlesville sand," which occurs as lenses 10 to 100 feet in thickness and 40 to 100 feet above the base of the Cherokee, yields both oil and gas. The "Burgess sand," at or near the base of the Cherokee shale, yields much gas.

Gas occurs in the upper part of the Mississippian rocks both in porous limestone and in beds of fragmental chert, called "chat." The "chat" is restricted in its distribution to the flanks of "Mississippi lime" hills.

Seven oil pools and one gas pool have been discovered in Arbuckle rocks of Ordovician age in Montgomery County. The oil occurs in a siliceous limestone zone in the upper part of the Arbuckle. The Arbuckle pools are in small but well-defined anticlinal folds. Arbuckle rocks have been penetrated in at least 222 wells in Montgomery County. Commercial quantities of oil have been produced from at least 87 of these wells and gas has been produced from 6 of them.

Because of the widespread occurrence of oil and gas in Montgomery County it is difficult to delineate fields in a satisfactory manner. However Figure 41 shows locations of rather large areas designated as fields by the Nomenclature Committee of the Kansas Geological Society (Jewett and Abernathy, 1945, pp. 192-193). In Table 65 production of oil in the county is assigned to fields as shown in Figure 41. Some smaller "fields" and pools are mentioned in the following discussion.

The **Brewster** oil and gas field produces from the "Bartlesville sand." In 1948 the field produced 2,624 barrels of oil. Production was limited to a small part of the area.

The **Caney** field is mostly a gas producing area. Gas occurs in basal Pennsylvanian sandstone called "Burgess." Oil is produced from a part of the area from the "Bartlesville sand." In 1948, 25 wells yielded 7,008 barrels of oil.

The **Coffeyville-Cherryvale** oil and gas field covers practically all of the eastern part of Montgomery County. Oil production at present is limited to small areas. The smaller "Cherryvale" oil and gas field was developed in 1904 (Abernathy, 1940, p. 26). The

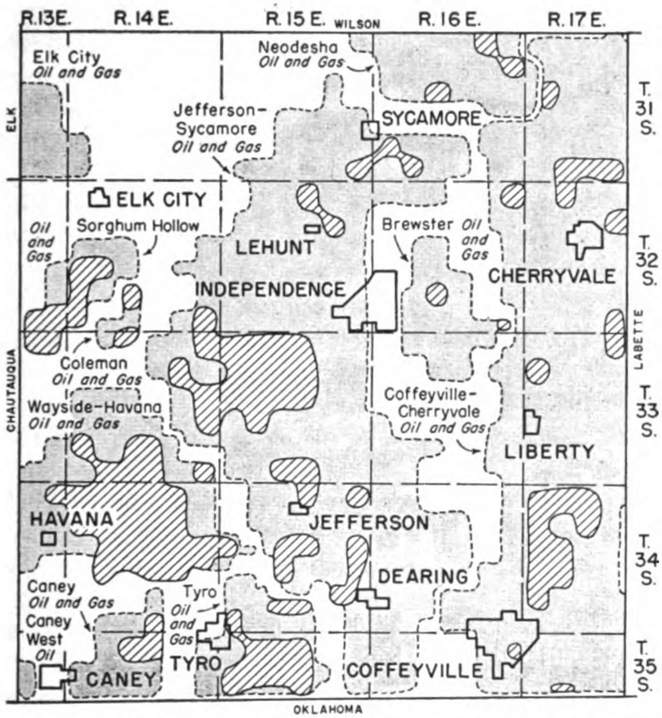

Fig. 41.—Map of Montgomery County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

chief producing formation is the "Bartlesville sand." The "Coffeyville" field is one of the oldest fields in Kansas. The three producing zones are the "Wayside sand" at about 400 feet, the lower part of the Fort Scott limestone at about 600 feet, and the "Bartlesville sand" at about 1,000 feet.

Three Arbuckle dolomite (Jefferson City) oil pools have been found in the Coffeyville-Cherryvale area. They are the Alloway, the Ballairs, and Thompson pools. The **Bellairs** pool, secs. 3 and 4, T. 33 S., R. 17 E., was discovered in 1921 (Abernathy, 1940, p. 26). Oil was found in the upper part of the Arbuckle limestone at depths ranging from about 1,250 to 1,300 feet. At least 25 oil wells were completed in the pool. Some of the wells flowed initially 220 barrels of oil per day. Gas was found in the same area in Pennsylvanian and Mississippian rocks. The oil has a very low gasoline content. A small amount of oil is being produced now from the field. The **Alloway** pool, secs. 8 and 17, T. 35 S., R. 17 E., was developed in 1924. The initial production from more than 40 wells ranged from 25 to 220 barrels of oil per day. Oil occurs in the upper few feet of the Arbuckle dolomite at a depth of about 1,200 feet. The **Thompson** pool, secs. 12 and 13, T. 33 S., R. 16 E., was discovered in 1924. The discovery well is the Kors and Wilkinson No. 2 Thompson, SW¼ SW¼ sec. 12. This pool also contains oil of small gasoline content.

The **Coleman** oil pool produces from the upper part of the Jefferson City dolomite (top of Arbuckle). Two wells are producing oil. The field was opened on July 1, 1921, when the Red Bank Oil Company No. 1 Coleman well in the SW cor. SE¼ sec. 28, T. 32 S., R. 14 E. found Arbuckle oil at a depth of about 1,700 feet. Initial daily production of the discovery well was reported to have been 4,100 barrels of oil by natural flow. Several other wells were drilled and the field extended into sec. 33. The Coleman pool is producing oil from two wells, one on the Haines farm, sec. 33, T. 32 S., R. 14 E., and one drilled in February 1948 on the Holden farm in the NW¼ sec. 4, T. 33 S., R. 14 E. The Holden well is reported to have had an initial daily production of 200 barrels of oil and is to be regarded as having extended the field.

A small amount of oil (268 barrels) was produced in the **Elk City** field in 1947. Several years ago the Elk City field was regarded as a well-defined gas field, with production from the upper part of the Mississippian limestone. Later, however, gas wells have been drilled so widely in Montgomery County that this and other fields have almost lost their identities. Now the field may be regarded as a small abandoned oil field in secs. 30 and 31, T. 31 S., R. 14 E. The oil producing rock is the "Weiser sand" in the Bandera formation.

The **Jefferson-Sycamore** field (the former Bolton and Jefferson-Sycamore fields combined) is a large area covering the central part of Montgomery County. Oil production is limited now to isolated areas. Oil production chiefly is from the "Bartlesville sand." The **Bolton** oil pool was the first to be discovered in Montgomery County. The discovery well was drilled in 1902 by McBride and Bloom in the SW¼ sec. 18, T. 33 S., R. 15 E. Initial production of this well was about 40 barrels of oil per day but as the field was developed many wells exceeded 1,000 barrels per day (Abernathy, 1940, p. 25). The producing formation, the "Bartlesville sand," lies at depths ranging from 1,150 to 1,200 feet. The **Laramer-Sycamore** pool was discovered in 1920, with production from the "Bartlesville" at a depth of about 1,000 feet. According to Lane and Garton (1943, table 3) the gravity of oil from the Bolton field is 35.2° A. P. I. In 1948, the field produced 721,815 barrels of oil.

The **Neodesha** oil and gas field extends from Wilson County into Montgomery County. Oil occurs in the "Bartlesville sand." Oil production in the Montgomery part of the field in 1948 amounted to 2,086 barrels. Production in the **Sorghum Hollow** field is from the "Weiser sand." In 1948 the field yielded 8,379 barrels of oil.

The **Wayside-Havana** oil-producing area is in the southwestern part of Montgomery County, where oil was discovered in 1904; more than 500 wells in this area have produced oil. A small amount of high-grade oil having a paraffin base and a specific gravity of 36 to 38° A. P. I. (Moore and Boughton, 1921, p. 25) is still produced. The "Wayside sand" in the Nowata shale, which occurs at an average depth of about 575 feet, is the uppermost productive rock in this area. The "Weiser sand," about 120 feet below the "Wayside," also yields oil. The third producing zone is the "Bartlesville sand" which lies at an average depth of about 1,200 feet and ranges from about 15 to 50 feet in thickness. In 1948, the Montgomery County part of the field produced 141,773 barrels of oil.

TABLE 65.—*Oil production in Montgomery County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Bolton	Combined with Jefferson-Sycamore									
Brewster	10	237	4	770	10	2,478		3,491		2,624
Caney	3	632	5	2,035	9	6,127	9	4,017	25	7,008
Coffeyville-Cherryvale[1, 2]	206+	35,287	158+	28,600	162+	29,932	170+	22,011	165+	30,174
Coleman	13	2,069	13	2,138	13	1,550	20	2,278	13+	431
Elk City								268		
Jefferson-Sycamore	375+	85,658	412+	159,376	500+	546,968	419+	671,462	265+	721,815
Neodesha[2]	9+	2,995	14+	794	14+	2,384	10+	874	20+	2,086
Sorghum Hollow	61	7,596	60	6,564	61	7,556	60	7,389	50	8,379
Tyro	10	26,956	12	10,723	14	70,462	13	29,011	13+	30,063
Wayside-Havana[3]	970+	152,261	1,015+	150,146	1,036+	147,556	1,003+	147,847	882+	141,773
Miscellaneous	84	4,124	33	1,182				1,778		1,263
Totals	1,741+	317,815	1,726+	362,328	1,819+	815,013	1,704+	890,426	1,433+	945,616

[1] Field extends into Labette County.
[2] Field extends into Wilson County.
[3] Field extends into Chautauqua County.

The **Tyro** pool, discovered in 1904, yields oil and gas from the "Bartlesville sand" which ranges in thickness from 20 to 60 feet and has an average depth of 1,250 feet.

MORRIS COUNTY

Oil is produced in the Nelson field in the southeastern part of Morris County a few miles east of the Lost Springs field in Marion County. Gas discoveries have been more widespread. Oil production is from the "chat," fragmentary flint deposits derived by erosion from the Mississippian limestones. Like other basal detrital deposits, the "chat" is of different ages in various places. Gas production is from the Indian Cave sandstone, other zones in lower Permian rocks, and the Willard shale, Lawrence shale, and Lansing group of Pennsylvanian age. Depths to gas production range from 450 to 1,450 feet.

During 1948 the Nelson field of Morris County produced 407 barrels of oil. Oil production in the county during 1946, 1947, and 1948 is given in Tables 2a and 66.

Figure 42 shows locations of oil and gas fields in Morris County.

Geology

SURFACE ROCKS

The outcropping bedrocks in Morris County are Permian in age. Approximately the lower 100 feet of the Sumner group, the Chase group, and nearly all of the Council Grove group are exposed (Fig. 3). The total thickness of exposed Permian rocks is about 700 feet. Alluvium in the valleys of recent streams and upland gravel deposits are similar to surficial deposits in other eastern Kansas counties.

A thickness of 100 feet or more of the Wellington shale in the Sumner group is present at the surface in the western part of Morris County. The Chase group occupies an outcrop belt about 20 miles wide. This group is characterized by massive limestones, several of which are flinty, and by highly colored shales; it is about 350 feet thick in Morris County. Included in these rocks are several excellent key horizons for structural mapping. The Florence limestone lies below the most extensive dip slope in the area. The upper surface of the Florence, however, should be used as a datum plane only in places where it is protected by overlying shale beds. Council Grove rocks crop out along Neosho River in the southeastern part of the county. The lowest well-exposed unit is the Grenola limestone (which includes the Neva limestone member).

SUBSURFACE ROCKS

Subsurface geologic conditions along the eastern border of Morris County are shown diagrammatically in Plate 4. The Nemaha anticline extends through the county. In the buried Nemaha fault scarp, rocks as old as the Arbuckle limestone are believed to be in contact with basal Pennsylvanian deposits.

Permian and Pennsylvanian rocks.—The average thickness of Permian and Pennsylvanian rocks in Morris County is about 2,000 feet. The Shawnee group includes much more limestone than shale, and the Lansing and Kansas City groups are chiefly limestone. Higher rocks and those of the Douglas group are similar to equivalent strata farther east in the State. The thickness of combined Pleasanton, Marmaton, and Cherokee groups is about 650 feet in the eastern part of the county, but as little as 150 feet or less in the western part.

Mississippian rocks.—On the eastern side of the Nemaha anticline in Morris County the total thickness of Mississippian limestone formations ranges from a featheredge to approximately 350 feet, and on the western side to slightly more than 150 feet. These rocks are absent from a large area (Lee, 1939, pl. 1). The thickness of the Chattanooga shale in the county ranges from a featheredge to about 150 feet (Lee, 1940, pl. 3).

Pre-Chattanooga rocks.—The "Hunton" limestone is believed to have been eroded from a large part of Morris County in the area of the Nemaha anticline. The maximum thickness is probably not more than 200 feet. The Maquoketa shale is believed to be present in the county on both sides of the Nemaha fault; its maximum thickness is probably less than 100 feet. The Viola limestone has a maximum thickness of probably not more than 200 feet. The thickness of the St. Peter sandstone ranges from a featheredge to about 50 feet or more. Pre-Pennsylvanian areal geology in Morris County is shown by Lee, Leatherock, and Botinelly (1948, pl. 8). It is important to note that rocks included in the section between the base of Mississippian limestone and the base

TABLE 66.—*Oil production in the Nelson field, Morris County, 1946 through 1948*

Year	No. wells	Production, bbls.
1946	1	1,320
1947	1	390
1948	1	407

of the St. Peter sandstone were beveled by pre-Pennsylvanian erosion in a band extending from the southeastern part to the northeastern part of the county. The greatest thickness of Arbuckle rocks in the county is believed to be about 400 feet. In the Alta Vista Oil Company No. 1 Helen Taylor well, in the NE¼ SW¼ sec. 5, T. 14 S., R. 8 E., Pre-Cambrian rock was reached at 2,480 feet.

OIL AND GAS DEVELOPMENTS

Oil and gas producing areas in Morris County are shown in Figure 42. Oil production is confined to the southwestern part of the county—the Nelson field. This area may be regarded as a part of the Lost Springs area which is chiefly in Marion County.

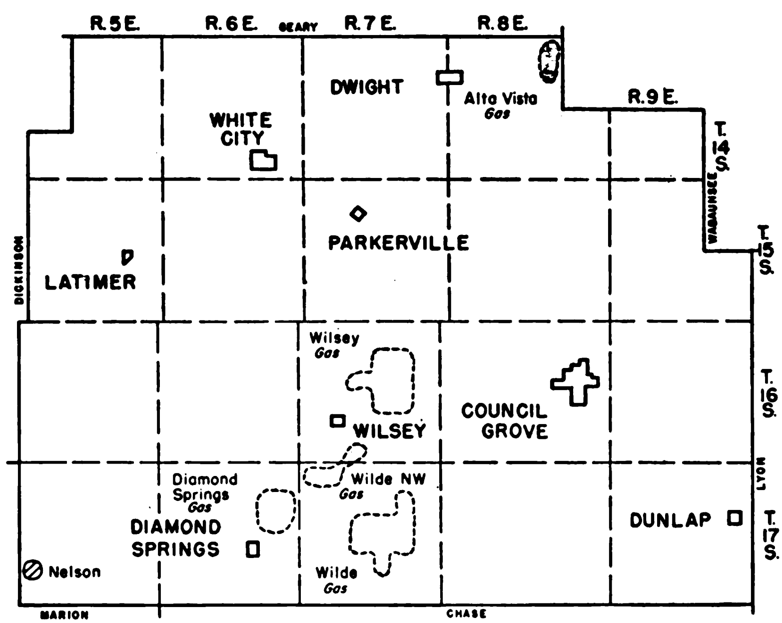

FIG. 42.—Map of Morris County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

Oil production is from the Mississippian "chat." The Gilliland Oil Company No. 1 Nelson well, NE cor. SE¼ sec. 30, T. 17 S., R. 5 E., the discovery well, was drilled in March 1928. Oil was found at a depth of 2,295 feet. Initial daily production was reported as 40 barrels of oil. It was not until 1945 that two additional producings wells were drilled in the field after two dry holes had been drilled in the same section in 1942, and one in 1944.

The **Alta Vista** gas producing area produces from several zones in lower Permian rocks at a depth of about 500 feet. Gas in the **Heigle** pool was discovered in the General Utilities No. 1 Heigle well in the SW¼ SE¼ sec. 11, T. 16 S., R. 7 E., in May 1928 in upper Lansing rocks at a depth of about 1,440 feet. Initial daily production was reported as 1½ million cubic feet of gas. Gas was found in the same rocks in other wells in secs. 10 and 15. Later gas was found in the Indian Cave sandstone at depths of about 440 feet in secs. 15 and 22.

The **Diamond Springs** gas producing area is in T. 17 S., R. 6 E. Gas was discovered in the **Wilde** pool in this area in 1929. Producing zones include the Willard shale at about 600 feet, the Lawrence shale at about 1,200 feet, and Lansing rocks at about 1,400 feet.

A rather large number of wildcat wells have been drilled in Morris County, but most have tested only Pennsylvanian rocks.

NEMAHA COUNTY

Oil was discovered in the "Hunton" limestone in Nemaha County, September 13, 1948, in the Carter Oil Company No. 1 Mamie Strahm well, Cen. SW¼ SW¼ NW¼ sec. 27, T. 2 S., R. 14 E. Initial daily production was reported as 54 barrels of oil. During the remainder of the year about 1,000 barrels of oil were produced.

Geology

SURFACE ROCKS

Exposed consolidated rocks in Nemaha County are Permian and Pennsylvanian in age. The oldest outcropping formation is the Topeka limestone, and the youngest consolidated formation is the Wreford limestone. In Nemaha and neighboring counties the Nemaha anticline and the syncline that borders it on the east

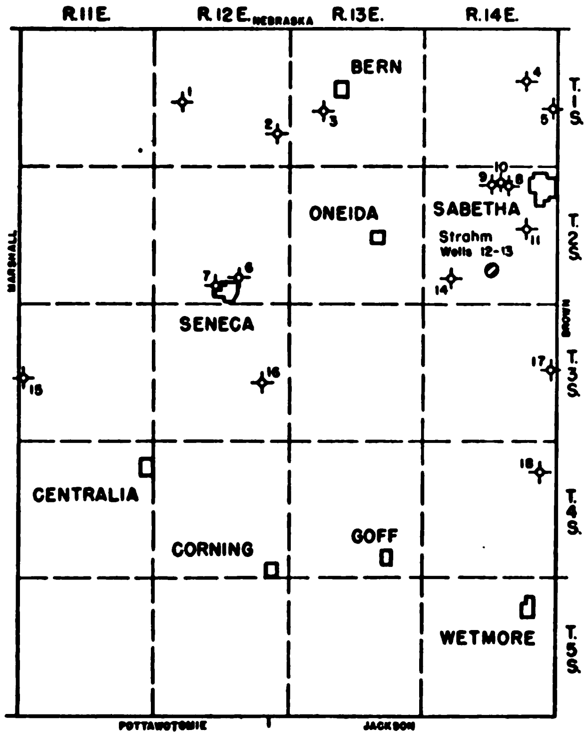

FIG. 43.—Map of Nemaha County showing location of wells listed in Table 67.

have brought about structural conditions that are unique in Kansas. In the western part of the county is a band of exposed Pennsylvanian rocks bordered both on the east and the west by Permian beds.

The Wreford limestone underlies an area in the eastern part of T. 1 S., R. 13 E. and the western two-thirds of T. 1 S., R. 14 E. The Topeka limestone is exposed along Nemaha Creek in sec. 2, T. 1 S., R. 12 E. Glacial drift occurs in comparatively thick deposits in all parts of Nemaha County and the country rock is concealed in many places.

SUBSURFACE ROCKS

Pre-Cambrian rocks are nearer the land surface in Nemaha County than elsewhere in Kansas. Crystalline rocks are about 600 feet deep in the highest part of the buried granite ridge of

TABLE 67.—*Data on wells drilled for oil and gas in Nemaha County*

No. on map	Name of well	Location	Completion date	Total depth, feet	Remarks
1	Partman & McKenna No. 1 Sudbeck	SW¼ NW¼ NW¼ NW¼ 20-1-12E	7-11-34	490?	
2	Rock Island R. R. Co.	25-1-12E	?	550	Stopped in Douglas-Pedee rocks
3	.... No. 1 Wittmer	20-1-13E	?	1,880	Pre-Cambrian rocks at 1,295? feet
4	Carter Oil Co. No. 1 Dennis Kesler	NW¼ NW¼ NE¼ 14-1-14E	12-29-48	2,773	Top "Hunton" 2,681 feet
5	Clifton Galle & Towle No. 1 Mills	Cen. SE¼ NE¼ 24-1-14E	11-3-34	2,946	Stopped in "Hunton" ls.
6	.... No. 1 Williams	SE cor. SE¼ 27-2-12E		1,100	
7	"Seneca well"	SW¼ NE¼ NE¼ 33-2-12E	1914	736	Pre-Cambrian rocks at 571? feet
8	Fred D. Culpepper No. 1 Lamparter	Cen. W½ SW¼ SE¼ 3-2-14E	12-1-44	2,900	Top "Hunton" 2,830 feet
9	Ohio Oil Co. No. 1 Lamparter	Cen. NE¼ SW¼ 3-2-14E	3-24-44	3,947	Pre-Cambrian rocks at 3,938 feet
10	Stout and Hahn No. 1 Lamparter	NW¼ NE¼ SW¼ 3-2-14E	9-22-48	2,910	Top "Hunton" 2,828 feet
11	Carter Oil Co. No. 1 Gilbert-Landbank	NW¼ NW¼ SE¼ 14-2-14E	1-26-49	3,228	Stopped in Silurian rocks
12	Carter Oil Co. No. 1 Strahm	SW¼ SW¼ NW¼ 27-2-14E	9-13-48		54 bbls. oil initial daily production in "Hunton" ls.
13	Carter Oil Co. No. 1 Koch-Ramsom	SW¼ NE¼ SE¼ 28-2-14E	2-16-49	2,970	Stopped in "Hunton" ls.
14	Shelly No. 1 Sabetha	SW¼ NE¼ SW¼ SW¼ 29-2-14E	4-20-1876	521	
15	Nemaha Oil & Gas Co. No. 1 Seneca	NW cor. NW¼ 19-3-11E	3-20-29	3,256	Poor log; Pre-Cambrian rocks 750? feet
16	.... No. 1 Noll	SE¼ SE¼ NE¼ 23-3-12E	?	2,190	Very poor log
17	Carter Oil Co. No. 1 Draney Heirs	SE¼ SE¼ SE¼ 13-3-14E	3-49	3,152	
18	Ladd et al. No. 1 Achlen	Cen. S½ SE¼ NW¼ 12-4-14E	11-25-41	3,130	Stopped in "Hunton" ls.

the Nemaha anticline. About 3,500 feet of sedimentary rocks overlie the Pre-Cambrian floor east of the buried fault escarpment of the anticline.

Permian and Pennsylvanian rocks.—The maximum thickness of Permian and Pennsylvanian rocks in Nemaha County is about 2,000 feet. About 600 feet of Pennsylvanian rocks is present over the crest of the buried crystalline core of the anticline (Jewett and Abernathy, 1945, pl. 1).

Mississippian rocks.—Mississippian rocks are absent in Nemaha County in the area west of the buried fault escarpment of the Nemaha anticline, but the Mississippian limestone formations have a total thickness of about 150 feet in the southeastern part of the county. Undifferentiated Burlington-Keokuk limestone is believed to be the uppermost Mississippian limestone in the county.

It is probably underlain by the Gilmore City and Chouteau formations.

Pre-Chattanooga rocks.—According to Lee (1943, fig. 12), the thickness of rocks between the base of the Chattanooga shale and the top of the Maquoketa shale in Nemaha County ranges from a featheredge to about 650 feet. The interval between the top of the Maquoketa shale and the top of the St. Peter sandstone ranges from a featheredge to about 400 feet (Lee, 1943, fig. 11). The maximum thickness of the rocks from the top of the St. Peter sandstone to the Pre-Cambrian floor is about 200 feet (Lee, 1943, fig. 9). Probably the Roubidoux dolomite, Bonneterre dolomite, and Lamotte sandstone are present in the county and possibly a small thickness of rocks of the Van Buren formation is present in the extreme southeastern part.

Oil and Gas Developments

Figure 43 is a map of Nemaha County showing locations of the **Strahm** oil field and of dry test wells that have been drilled in the county. Data on 15 Nemaha County wells, records of which are in the Geological Survey files, are given in Table 67.

Early in 1949 wells were drilled in Nemaha County in these locations (Table 67): NW¼ SE¼ sec. 14, T. 2 S., R. 14 E.; NE¼ SE¼ sec. 28, T. 2 S., R. 14 E.; and SE¼ SE¼ sec. 13, T. 3 S., R. 14 E.

NEOSHO COUNTY

Oil and gas have been produced in Neosho County for many years. The first active prospecting in the county was in the northeastern part in the vicinity of Humboldt in about 1893 or 1894 when both oil and gas were discovered. The geology and oil and gas resources of Neosho County have been described by Moore and Elledge (1920).

During 1948, 484,753 barrels of oil were produced in Neosho County. Production in the County for 1894 to 1948 is given in Tables 2 and 2a. Three water-flooding projects are operating in Neosho County. Approximately 108,365 thousand cubic feet of gas were produced in the county in 1948.

Oil production in the various fields in Neosho County for 1944 through 1948 is given in Table 68.

Figure 44 is a map of Neosho County showing locations of oil and gas fields and areas of 1948 oil production in Neosho County.

Geology

SURFACE ROCKS

The surface rocks of Neosho County consist of alternating beds of limestone and shale and locally some beds of sandstone. With the exception of sand and gravel deposits of Recent age, the exposed rocks of Neosho County belong to the Kansas City, Pleasanton, and Marmaton groups of Pennsylvanian age.

Rocks of the Kansas City group (Fig. 5) crop out in the western and central parts of Neosho County. The Lane-Bonner Springs shale is the youngest consolidated rock and is exposed in the area west and north of Chanute. The middle and lower parts of the Kansas City group section are modified by a local disconformity in the area east of Chanute. Sandstone in the Chanute shale, which lies next above the disconformity, rests on strata ranging in age from the Drum limestone to the basal part of the Dennis limestone. The rocks of the Bronson subgroup consist of thick beds of limestone separated by thin beds of shale. Where the entire Bronson section is present, its thickness is about 150 feet. The Pleasanton group in Neosho County is about 100 feet thick and consists chiefly of shale. It contains a persistent sandstone, the Hepler, a few feet thick in the basal part and a few thin beds of limestone, one of which probably is the Checkerboard limestone. Rocks of the Marmaton group (Fig. 5), which are the oldest exposed Pennsylvanian rocks in the county, crop out in the southeastern part and are about 250 feet thick.

SUBSURFACE ROCKS

Pennsylvanian rocks.—The Cherokee shale is about 420 feet thick in Neosho County. It consists of light and dark shale, sandstone lenses, and thin beds of limestone and coal. Sandstone lenses about 50 feet below the top of the Cherokee shale are called "Squirrel sand." The "Squirrel" is well developed in the central part of the county. The Ardmore limestone, an excellent key bed, lies about 80 feet below the top of the Cherokee. The "Bartlesville sand," which occurs about 100 feet below the top of the Cherokee, is the most productive oil sand in the Cherokee shale. It may be noted that this so-called "Bartlesville sand" is stratigraphically higher and younger than the "Bartlesville sand" in northern Oklahoma and parts of southern Kansas. The Cherokee lies unconformably upon the eroded surface of Mississippian limestone.

Mississippian rocks.—Mississippian rocks in Neosho County consist dominantly of limestone, some of which is cherty or dolomitic. They have a total thickness of about 300 feet. The formations present in the county are the "Warsaw," Keokuk, Burlington, Reeds Spring, and St. Joe limestones, the Northview shale, and the Compton limestone. The Chattanooga shale is less than 50 feet thick (Lee, 1940, pl. 3).

Ordovician and Cambrian rocks.—Very little information pertaining to Ordovician and Cambrian rocks in Neosho County is available. The drillers log of one deep well in Neosho County, the Arnett No. 1 in sec. 34, T. 30 S., R. 18 E., shows 927 feet of limestone, sandstone, and shale between Mississippian and Pre-Cambrian rocks.

From studies of cuttings from wells in neighboring counties, Keroher and Kirby (1948) estimated that (1) the thickness of the Jefferson City-Cotter sequence ranges from about 325 feet in the northeastern part of the county to about 475 feet in the southwestern part; (2) the average thickness of the Roubidoux dolomite is about 150 feet; (3) the thickness of the Van Buren-Gasconade sequence ranges from an amount less than 150 feet in the northeastern part to one slightly in excess of 200 feet in the southwestern part; (4) the Eminence dolomite has an average thickness of about 50 feet; and (5) the Bonneterre dolomite ranges from 100 to 150 feet in thickness in the county. The Lamotte sandstone is believed to be present throughout the county.

Pre-Cambrian rocks.—Pre-Cambrian rocks underlie Neosho County at a depth of about 2,000 feet. The drillers log of a deep well in the southeastern part of the county records these rocks as granite. Samples of the Pre-Cambrian rocks from a deep well west of Chanute are red granite composed of red feldspar, quartz, mica, and hornblende.

Oil and Gas Developments

Gas was first discovered in Neosho County near Humboldt in 1894. Guffey and Galey drilled a number of dry holes in the vicinity of Chanute a short time later. Oil was discovered in the Chanute field in 1899. The greatest development of oil and gas has been in the northwestern part of the county where production is from sands in the Cherokee shale. In the Erie pool, in the east-central part of the county, oil is produced from the "Bartlesville sand" at a depth of about 550 feet. This pool has been extended to the southeast, and more recent drilling has extended the shoestring trend to a point northeast of St. Paul. In the Island district, a part of the St. Paul-Walnut area, gas is produced from the "chat" at the top of the Mississippian limestone. Some wells in this area reported a daily open flow of 5 million cubic feet of gas. Oil and gas wells are so widespread in the northeastern part of the county that it is difficult to differentiate the pools. Oil and gas fields as they have been defined by the Nomenclature Committee of the Kansas Geological Society are listed and described briefly below. Their locations are shown in Figure 44.

The **Altoona East** oil and gas field extends into Neosho County. The Neosho County part of the field is now inactive. The **Canville Creek** gas field is in the southwestern part of T. 27 S., R. 20 E. Logs of wells in this field are not available.

The **Dennis** gas field (now abandoned) extends into Neosho County in the south-central part of T. 30 S., R. 18 E. Gas was produced from sandstone in the Bandera formation.

Oil was discovered in the **Erie** oil and gas-producing area in 1903. Later the field was extended to the southeast. Oil and gas are produced from the "Bartlesville sand" at a depth of about 650 feet. The field is now largely abandoned, with the exception of some areas that are being water flooded. The wells were initially producers and yield low-gravity oil (much of it below 25° Be.). The average initial production was about 20 barrels of oil per day and after a few months production decreased to 4 to 8 barrels per day.

The **Galesburg** gas field is in the northwestern part of T. 30 S., R. 19 E. Logs of the wells are not available. Gas was reported at depths of 220 and 982 feet in the log of a nonproducing well in the NW¼ sec. 6. The log shows Mississippian limestone at 973 feet.

Oil and gas formerly were produced in the **Hertha** field in the southwestern part of T. 29 S., R. 20 E. Gas was produced from Cherokee rocks at a depth of about 570 feet and from the Missis-

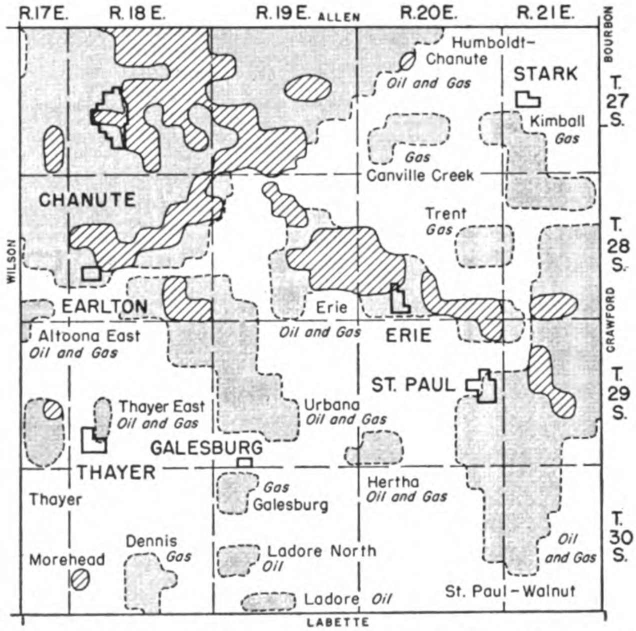

Fig. 44.—Map of Neosho County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

sippian limestone at a depth of about 825 feet. Few logs are available. Oil production probably was from "Bartlesville sand" at about 570 feet.

The **Humboldt-Chanute** oil and gas field is one of the oldest in the State. It is, as now defined, a large area covering entirely the northwestern part of Neosho County and extending northward well into Allen County (Fig. 12) and westward into Wilson County (Fig. 51). Development in the Neosho County part of the field took place largely in the late 1890's. Drilling activity was renewed in 1903 and the area was redrilled in 1937 for water flooding. Oil production in this area is from the "Bartlesville sand" which has an average depth of about 700 feet and an average thickness of about 40 feet. The "Bartlesville sand" here is a broadly lensing deposit and hence unlike the "Bartlesville shoestring sands" of Montgomery County. It is probable, however, that the "Bartlesville sand" of the Humboldt-Chanute area is somewhat younger than is the sandstone farther south that is called "Bartlesville."

TABLE 68.—*Oil production in Neosho County, 1944 through 1948*

Field	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Erie	29,639	166	26,503	163	25,132	36+	22,037	36+	24,092
Humboldt-Chanute[1]	306,576	425	307,582	386	335,668	231+	398,380	241+	445,468
Morehead							442		1,615
St. Paul-Walnut[2]	2,552	19	2,350	19	7,612	1+	8,664		9,853
Thayer							239		351
Urbana	4,253	11	7,541	11	6,443		5,396		3,002
Miscellaneous								4+	372
Totals	343,020	621	343,976	579	374,855	268+	435,158	281+	484,753

[1] Field extends into Allen, Wilson, and Woodson Counties.
[2] Field extends into Crawford County.

The **Kimball** gas field, in the northern part of Neosho County, was developed chiefly about 20 years ago. Gas was produced at depths ranging from about 280 to 350 feet. Black shale in the Fort Scott formation probably is the chief reservoir rock.

The **Ladore** oil field, now abandoned, is in the southern part of Neosho County. Logs of the wells are not available to me. The **Ladore North** field, abandoned also, is in the north-central part of T. 30 S., R. 19 E. Logs of the wells are not available. The **Morehead** oil and gas field, sec. 30, T. 30 S., R. 18 E., yielded 442 barrels of oil in 1947 and 1,615 barrels in 1948.

In the **St. Paul-Walnut** oil and gas-producing area oil production is from the "Bartlesville sand" which occurs as a "shoetring" in the northwestern part of the area. Gas production is from the "Bartlesville sand" and the Fort Scott limestone. The "Bartlesville sand" has an average thickness of about 30 feet and lies at a depth of about 550 feet.

The **Thayer** oil field yielded 239 barrels of oil in 1947 and 351 barrels in 1948. Logs of the wells are not available. The **Thayer East** field is no longer active. Logs of former producing wells are not in the Geological Survey files. However, sandstones in the Cherokee shale at depths of about 800 and 1,000 feet probably are the reservoir rocks.

The **Trent** gas field has yielded gas from shale in or just below the Fort Scott formation at a depth of about 330 feet and probably from the "Bartlesville sand" at a depth of about 530 feet. Logs of most of the wells in the area are not available.

Production in the **Urbana** oil-producing area is from the "Bartlesville sand" which has an average thickness of about 20 feet and lies at a depth of about 750 feet. The area has had several gas wells, but all are now abandoned. In 1947 the field produced 5,396 barrels of oil; in 1948, 3,002 barrels.

Wells that have yielded small amounts of gas have been drilled in several parts of Neosho County in areas not shown as fields in Figure 44. Small amounts of gas have been reported from the upper part of the Mississippian limestone in sec. 35, T. 30 S., R. 17 E. in the southwest corner of the county.

OSAGE COUNTY

Oil and gas in commercial quantities have not been reported from Osage County. The Pomona gas pool, in Franklin County, however, is a short distance east of the Osage-Franklin County line. In that area gas was found in the "Squirrel sand" in the upper part of the Cherokee shale. About 40 wells have been drilled in Osage County searching for oil but most of them did not test rocks lower than the Cherokee shale or the upper few feet of Mississippian limestone.

Geology

SURFACE ROCKS

Like other eastern Kansas Counties, scattered surficial deposits of alluvial material are widespread in Osage County. Flint gravel beds a few feet thick are present on the uplands, especially in the southern part of the county. Outcropping consolidated rocks include the lower few feet of the Admire group (Permian), the Wabaunsee and Shawnee groups, and the upper part of the Douglas group (Pennsylvanian). The thickness of the exposed Pennsylvanian rocks is about 850 feet.

Permian rocks.—The lower few feet of the Towle shale (Fig. 3) lowermost Permian formation in Kansas, crops out in the extreme northwestern part of Osage County.

Pennsylvanian rocks.—Wabaunsee rocks (Fig. 4) are well exposed in western and especially northwestern Osage County. The Church limestone member of the Howard formation lies below an extensive dip slope in the west-central part of the county. The thickness of Wabaunsee sediments in the county is about 500 feet. Thin fusuline-bearing limestones and drab clayey and sandy shales are charactristic of the group. The formations of the Shawnee group are well exposed and their total thickness is

TABLE 69.—*Depths at which some stratigraphic horizons were reached in two wells in Osage County*

Horizon	Elmhurst Investment Co. No. 1 Badger, NW¼ sec. 4, T. 15 S., R. 16 E.	Gulf Oil Corp. No. 1 Peterson, SW¼ SE¼ SW¼ sec. 20, T. 15 S., R. 16 E.
Base of Oread limestone	230	
Top of Lansing limestone	628	460
Base of Hertha limestone	1,010	845
Top of Mississippian limestone	1,700	1,531
Top of Chattanooga shale	1,978	1,831
Top of "Hunton" limestone		1,928
Top of Viola limestone	2,070	1,972
Top of St. Peter sandstone	2,240	2,047
Top of Arbuckle limestone	2,290	2,079
Top of Pre-Cambrian rocks	2,838	
Total depth	3,015	2,217

about 350 feet. The belt of outcrop of these rocks covers the approximate eastern half of the county. Rocks of the Shawnee group are characterized by clayey and sandy shales ranging from a few feet to 25 feet or more in thickness and by limestones generally less than 20 feet thick. Many of the limestones contain abundant fusulines.

SUBSURFACE ROCKS

Subsurface geological conditions in the eastern part of Osage County are shown diagrammatically in Plate 2.

Pennsylvanian rocks.—The maximum thickness of Pennsylvanian rocks in Osage County is about 2,250 feet.

Mississippian rocks.—Mississippian limestone formations in Osage County range from less than 300 feet to more than 400 feet in total thickness (Lee, 1939, pl. 1). The Chattanooga shale ranges in thickness from about 50 feet to nearly 150 feet (Lee, 1943, fig. 14). The greatest thickness is in the northwestern part of the county.

Pre-Chattanooga rocks.—The Chattanooga shale oversteps the upper part of the "Hunton" limestone, the Maquoketa shale, and beveled beds of the Viola limestone in the northwestern part of Osage County. The Viola limestone immediately underlies the Chattanooga in most of the county. Devonian rocks are present only in the northwestern part. Their thickness ranges from a featheredge to less than 100 feet. Silurian rocks are believed to be absent in Osage County (Lee, 1943, fig. 13). A small thickness

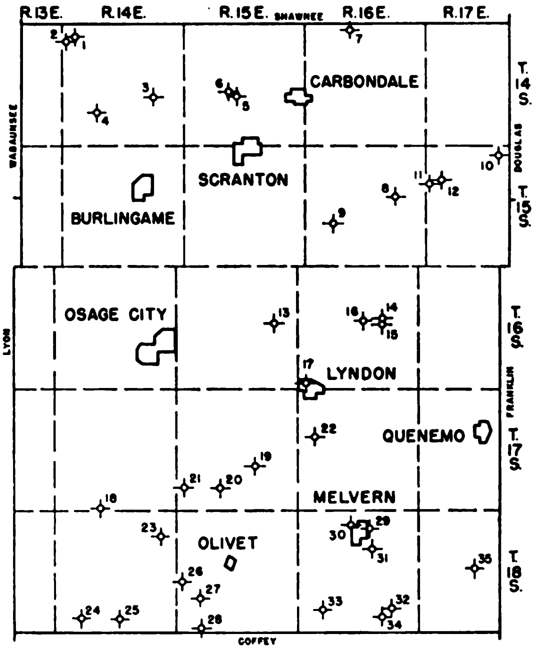

FIG. 45.—Map of Osage County showing location of wells listed in Table 70.

TABLE 70.—*Data on wells drilled for oil and gas in Osage County*

No. on map	Name of well	Location	Completion date	Total depth, feet	Remarks
1	R. G. Gillespie No. .... W. W. Lyttle	6-14-14E	7-18-24	2,458	
2	R. G. Gillespie No. 1 Wylie	SW¼ SW¼ 6-14-14E	?	2,452	
3	.... Mills	23-14-14E	?	3,125	
4	Hibbomae Oil No. 1 Stevenson	SW cor. NE¼ 29-14-14E	1929?	1,705	
5	J. M. Edwards No. 1 Deitrich	Cen. NW¼ SE¼ 21-14-15E	11-15-39	1,638	
6	Briggs & Smith No. 1 Woods	Cen SE¼ NW¼ 21-14-15E		2,627	
7	Elmhurst Investment Co. No. 1 Badger	NW¼ 4-14-16E	commenced 7-13-20	3,015	Pre-Cambrian rocks at 2,745 feet (See Table 69)
8	Red Line Oil & Gas Co. No. 1 Weil	14-15-16E	?	1,618	Stopped at top of Mississippian ls.
9	Gulf Oil Corp. No. 1 Peterson	SW¼ SE¼ SW¼ 20-15-16E	6-18-42	2,217	See Table 69
10	.... No. 1 Bryson	3-15-17E	1925	1,610	
11	.... No. 1 Daniels	SW¼ NW¼ SW¼ SW¼ 7-15-17E	5-18-17	1,625	Top Mississippian ls. 1,570 feet
12	.... No. 2 Daniels	S½ SE¼ 7-15-17E	?	751	
13	Orlando Petr. Co. No. 1 Hyde	SE cor. SE¼ 14-16-15E	6-8-21	3,408	

14	McMahon & Leonard No. 1 Kraft	Cen. NW¼ SW¼ 14-16-16E	?	1,950	Show oil 1,504-1,512 feet; 1,572 feet; Top Mississippian ls. 1,565 feet; "Wilcox sd." 1,880 feet; Arbuckle 1,883½ feet
15	Anderson et al. No. 1 Woodward	SE cor. SW¼ SW¼ 14-16-16E	9-5-44	1,610	Top Mississippian ls. 1,523 feet; strong show oil 1,524-1,561 feet
16	.... Bailey	NE cor. SW¼ 15-16-16E	1929?	1,309	
17	"Lyndon well"	NW¼ SE¼ SW¼ 31-16-16E	10-1894	1,007	
18	John Starke No. 1 Barnett	SE¼ SW¼ 33-17-14E	commenced 7-1-27	1,817	
19	.... No. 1 Justice	SE¼ SE¼ 22-17-15E	?	2,200	
20	Goebel, Bending & Mendenhall No. 1 Bartee	Cen. SW¼ SW¼ 28-17-15E	9-7-29	2,240	
21	G. C. McBride et al. No. 1 Jenkins	Cen. SE¼ SW¼ 30-17-15E	9-12-27	2,204	
22	.... Carmen Bros.	SE¼ NE¼ 18-17-16E	?	1,078	
23	Wentworth Bros. No. 1 Booth	NE¼ SW¼ NW¼ 12-18-14E	commenced 11-8-24	2,184	
24	J. V. McMahon No. .... Rogers	Cen. SE¼ NW¼ 32-18-14E	4-5-26	1,765	Top Mississippian ls. 1,738 feet
25	Papoose Oil Co. No. 1 Evans	SW cor. NW¼ 34-18-14E	3-19-29	1,781	Top Mississippian ls. 1,702 feet
26	York State Oil Co. No. 1 Jones	SE¼ SW¼ NW¼ 19-18-15E	12-5-28	2,118	Top Mississippian ls. 1,666 feet
27	.... George et al.	SW¼ NW¼ 29-18-15E		1,781	Top Mississippian ls. 1,698 feet
28	Empire Gas & Fuel Co. No. .... Woodbury	SW¼ 32-18-15E	9-18-23	2,290	Top Mississippian ls. 1,708? feet
29	Shanner et al. No. .... Hallem	SW cor. SW¼ SE¼ 3-18-16E	?	1,430	
30	.... No. 1 Brink	NW cor. SW¼ SE¼ 4-18-16E	?	1,435	
31	W. W. Trigg No. .... Van Buskirk	SW cor. SE¼ 10-18-16E	?	1,840	
32	.... No. 1 Fisher	SW cor. SE¼ 26-18-16E	?	1,553	
33	Bert Young et al. No. 1 Catlin	SE cor. SW¼ SW¼ 29-18-16E	7-23-27	2,081	
34	Tross & Orlando Oil Co. No. 1 Minnie Wells	Cen. S½ NW¼ NW¼ 35-18-16E	?	2,410	
35	Shaie and Smith No. 1 Varnsdell (C. D. Miller)	SE¼ SW¼ SE¼ 16-18-17E	?	1,603	

of Maquoketa (uppermost Ordovician) shale is present in the northwestern part. The average thickness of the Viola limestone is about 175 feet. The interval between the top of the St. Peter sandstone and Pre-Cambrian rocks ranges from about 450 feet in the northwestern corner of the county to nearly 800 feet in the southeastern corner.

Depths at which some stratigraphic horizons were reached in two wells in Osage County are given in Table 69.

Studies by Keroher and Kirby (1948) indicate that (1) the thickness of the Jefferson City-Cotter sequence in Osage County ranges from about 100 feet in the northwest corner of the county to an amount slightly in excess of 250 feet in the southern part, (2) the Roubidoux dolomite has an average thickness about 100 feet, (3) the Van Buren-Gasconade sequence ranges in thickness from about 25 feet in the western part to about 125 feet in the northeast corner of the county, (4) the Eminence dolomite is absent in the southwestern part of the county, and ranges in thickness from a featheredge to about 50 feet, with maximum thickness in the northeast corner of the county, and (5) that the Bonneterre dolomite has a thickness of about 75 feet, and is in contact with Pre-Cambrian rocks in all parts of Osage County.

Oil and Gas Exploration

Data on wells that have been drilled in Osage County and records of which are in the files of the Geological Survey are shown in Table 70. Locations of the wells are shown in Figure 45.

POTTAWATOMIE COUNTY

Oil and gas in commercial quantities have not been found in Pottawatomie County. This county is in the northern part of the Nemaha anticlinal area.

Geology

SURFACE ROCKS

Outcropping consolidated rocks in Pottawatomie County include strata from the Barneston limestone of Permian age (Fig. 3) to about the horizon of the Reading limestone of Pennsylvanian age (Fig. 4). Glacial drift conceals the bedrock in some areas.

Permian rocks.—Permian rocks of Wolfcampian age crop out in most of Pottawatomie County. The exposed Permian section is about 650 feet thick.

Pennsylvanian rocks.—Exposed Pennsylvanian rocks in Pottawatomie County include the Brownville limestone (uppermost Pennsylvanian formation in Kansas) and about 250 feet of older rocks. The oldest rock exposed is the Reading limestone or the upper part of the Auburn shale.

SUBSURFACE ROCKS

Plate 3 shows diagrammatically the subsurface geological conditions in the central part of Pottawatomie County.

Permian and Pennsylvanian rocks.—About 1,000 feet of Pennsylvanian rock is present in the Nemaha anticline area in Pottawatomie County. In the western part of the county, where there are both Permian and Pennsylvanian rocks, the combined thickness is about 2,250 feet.

Mississippian rocks.—Mississippian limestone formations are absent in Pottawatomie County west of the buried fault escarpment of the Nemaha anticline (Lee, 1943, fig. 16). The total thickness of limestones of Mississippian age in the eastern part of the county ranges from a featheredge to more than 200 feet. The western edge of Mississippian limestones crosses the northern boundary of the county near the northwest corner of T. 6 S., R. 12 E., and it crosses the southern boundary near the center of the south line of T. 10 S., R. 10 E. The Chattanooga shale also is absent in Pottawatomie County west of the fault escarpment of the Nemaha anticline. The thickness of the Chattanooga shale in the eastern part of the county ranges from a featheredge to about 250 feet (Lee, 1940, pl. 3; 1943, fig. 14).

Pre-Chattanooga rocks.—"Hunton" limestone (Devonian-Silurian) is present in Pottawatomie County east of the Nemaha fault escarpment; there is a thin wedge of silurian limestone between Pennsylvanian rocks and the Sylvan (Maquoketa) shale in the extreme western part of the county (Pl. 1) (Ockerman, 1935, fig. 2). According to Lee (1943, fig. 12), the thickness of rocks between the base of the Chattanooga shale and the top of the Maquoketa shale in eastern Pottawatomie County ranges from about 225 feet in the southeastern corner to about 450 feet in the northeastern part. The thickness of rocks between the top of the Maquoketa shale and the top of the St. Peter sandstone (interval including the Maquoketa shale and Viola limestone) in both eastern and western Pottawatomie County ranges from about 200 to 300 feet (Lee, 1943, fig. 11); these rocks are absent in the Nemaha anticline. The St. Peter sandstone is believed to be present in all of Pottawatomie County except in the northern part of the Nemaha anticline area (Lee, 1943, fig. 9). The thickness of the St. Peter sandstone probably does not exceed 100 feet

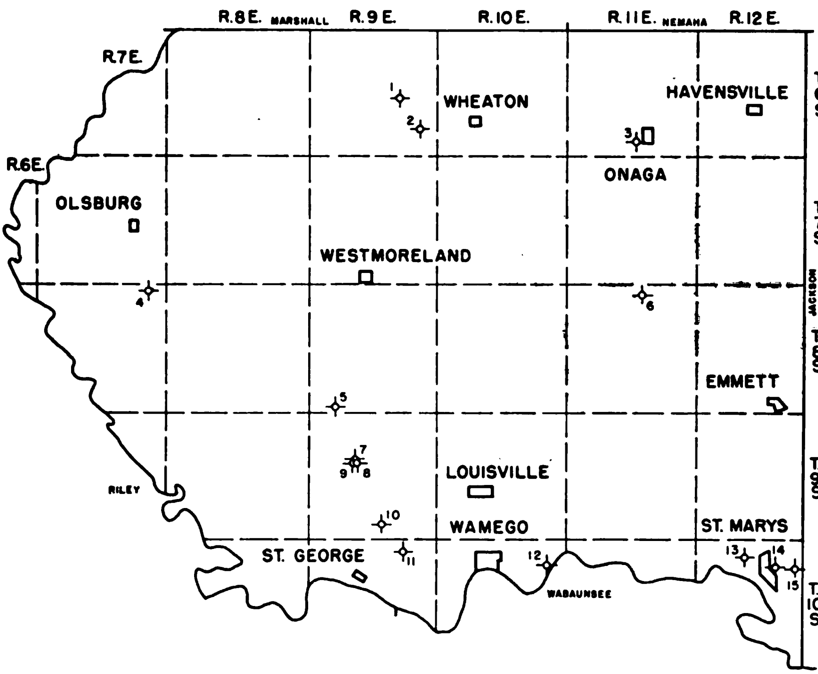

FIG. 46.—Map of Pottawatomie County showing location of wells listed in Table 71.

except in the southeastern part of the county; it is more than 200 feet in the extreme southeastern part. In the Turner No. 1 Umscheid well, in sec. 32, T. 8 S., R. 9 E., the St. Peter sandstone is 20 feet thick and is separated from Pre-Cambrian rocks by 20 feet of Bonneterre dolomite and 5 feet of Lamotte sandstone (Lee, 1943, fig. 5). The St. Peter sandstone is believed to lie on Pre-Cambrian rocks in much of western Pottawatomie County. About 200 feet is the greatest vertical distance between the top of the St. Peter sandstone and the Pre-Cambrian rocks in the eastern part of the county (Lee, 1943, fig. 9).

Oil and Gas Exploration

A register of the wells drilled in Pottawatomie County of which the Geological Survey has record is given in Table 71. Two tests were drilled in 1947, the D. J. Woods No. 1 Meeham well in sec. 25, T. 6 S., R. 9 E., and the D. J. Woods No. 2 Umscheid well

TABLE 71.—*Data on wells drilled for oil and gas in Pottawatomie County*

No. on map	Name of well	Location	Completion date	Total depth, feet	Remarks
1	Tri-State No. 1 Pierce	Cen. NW¼ NW¼ 23-6-9E	?	1,773	Pennsylvanian rocks on Maquoketa sh. at 1,425? feet; Pre-Cambrian at 1,770? feet
2	D. J. Woods No. 1 Meeham	NW¼ NW¼ SW¼ 25-6-9E	2-27-47	1,755	Pre-Cambrian rocks at 1,753 feet
3	Empire Oil & Rfg. Co. No. 1 Rokes	Cen. SW¼ NW¼ 34-6-11E	2-1-17	1,735	Pre-Cambrian rocks at 975? feet
4	Olson & McCole No. 1 Anderson	NW¼ SW¼ NW¼ 1-8-7E	1-7-42	1,095	Incomplete log
5	Turner et al. No. 1 Umscheid	Cen. NE¼ SW¼ 32-8-9E	11-9-38	1,985	Pre-Cambrian rocks at 1,975 feet
6	....	3-8-11E		1,734	Incomplete log
7	Lashelle Oil Co. No. 1 Umscheid	Cen. NW¼ NW¼ 16-9-9E	11-21-43	2,075	Top "Hunton" 1,292 feet; Simpson ss. 1,944 feet; Plattin ls. 1,984 feet; St. Peter ss. 2,002 feet; "Basal sd." 2,065 feet
8	D. J. Woods et al. No. 1 Umscheid	NW¼ SE¼ NW¼ 16-9-9E	1-14-48	1,500	Top "Hunton" 1,251 feet
9	D. J. Woods No. 2 Umscheid	SW¼ NW¼ NW¼ 16-9-9E	12-17-47	1,500	
10	Crawford No. 1 Hoofer	NE¼ SE¼ NW¼ 34-9-9E	?	2,225	Pre-Cambrian rocks at 1,850 feet
11	....	2-10-9E	1905	895	No log available
12	Wamego Coal Hole	Cen. NW¼ 12-10-10E	1887	930	
13	Crawford No. 1 Doyle	Cen. S. line SE¼ SE¼ SW¼ 4-10-12E	?	2,635	
14	St. Marys Coal, Oil & Gas No. 2 St. Marys College	NE¼ NE¼ 10-10-12E	5-9-08	1,700	Stopped in upper part of Mississippian ls.
15	Crawford No. 1 St. Marys	Cen. W. line SW¼ NE¼ 11-10-12E	?	2,190	Incomplete log

in the SW¼ NW¼ NW¼ sec. 16, T. 9 S., R. 9 E. Only one test was completed in 1948; this was the D. J. Woods et al. No. 1 Umscheid well in the NW¼ SE¼ NW¼ sec. 16, T. 9 S., R. 9 E. The recorded wells drilled to the end of 1948 are shown on Figure 46.

RILEY COUNTY

Neither oil nor gas has been discovered in Riley County, but there has not been sufficient drilling to prove the county barren of petroliferous materials. Because of favorable structural conditions, it is expected that oil or gas or both may be discovered there. Twelve wells have been drilled in the county which has an area of about 600 square miles. The geology of Riley County was described by Jewett (1941).

Geology

SURFACE ROCKS

With the exception of glacial drift, loess (?), and alluvium, the outcropping sedimentary rocks in Riley County are chiefly early Permian to late Pennsylvanian in age. A few feet of Cretaceous sandstone is present on the uplands in the extreme northwestern part of the county. There are three outcrops of basic igneous rock of probable Cretaceous age. The oldest exposed rock is the Auburn shale of the Wabaunsee group.

Cretaceous and younger rocks.—A few feet of Dakota sandstone caps the uplands in a small area in northwestern Riley County. This rock is coarse-grained ferruginous quartz sandstone. Unconsolidated deposits of doubtful classification, commonly called loess, cover much of the upland area of the county. Some easily identified glacial drift is present, and probably some of the material that has been called loess is deeply weathered drift.

Permian rocks.—Permian strata, about 800 feet thick, are exposed in Riley County. The youngest of these is the lower part of the Wellington shale, which consists of about 5 feet of silty limestone underlain by about 45 feet of highly colored shale. The combined thickness of rocks of the Chase group (Fig.6) in Riley County is about 350 feet. Massive limestones, some of which are flinty, and bright-colored shales are characteristic rocks. Flint is abundant in the lower member of the Winfield limestone, in the Florence limestone, and in the Wreford limestone.

Rocks assigned to the Council Grove group (Fig. 3) have a total thickness of slightly more than 300 feet in Riley County. The Cottonwood limestone member of the Beattie formation and the Neva limestone member of the Grenola formation are easily recognized and traced along their lines of outcrop. The Americus limestone member of the Foraker formation at the base of the group is a conspicuous marker bed. Highly colored shales are the characteristic rocks.

With the exception of rocks in the three upper formations, the Admire group (Fig. 3) is fairly well exposed in eastern Riley County. The combined thickness of rocks in this group is about 170 feet. The group is characterized by yellow and gray shales and thin limestones. The Falls City limestone, locally the thickest limestone, has a maximum thickness of about 3 feet. The Indian Cave sandstone member of the Towle shale, the lowermost Permian rock known in Kansas, ranges in thickness from a featheredge to about 75 feet. This sandstone lies disconformably on beds of the Wabaunsee group ranging from the Brownville limestone to the lower part of the Langdon shale (Jewett, 1941, pl. 5).

Pennsylvanian rocks.—Pennsylvanian rocks assigned to the Wabaunsee group (Fig. 4) crop out in the valley of Deep Creek in the eastern part of Riley County. Rocks older than the Auburn shale are not exposed in the county, and rocks between the upper part of the Pony Creek shale and the lower part of the French Creek shale are concealed by mantle deposits or removed by intraformational erosion. The Tarkio limestone is the most easily recognized exposed stratum in the Wabaunsee group. It is about 12 feet thick, massive, weathers to a deep brown color, and contains myriads of large fusulines which resemble large wheat grains. Individual fusulines are smaller and less numerous in other Wabaunsee limestones. Other limestones in the group are much thinner and generally are light gray where weathered. The Wabaunsee rocks in Riley County have a total thickness of about 575 feet. Approximately the upper 175 feet is exposed.

SUBSURFACE ROCKS

Permian rocks.—Logs of wells in the western part of Riley County indicate much lateral variation in the shallow subsurface, and detailed study of cuttings is necessary before definite statements can be made about these shallow Permian rocks. The same is true of the upper part of the Pennsylvanian section.

Pennsylvanian rocks.—Pennsylvanian rocks which are probably no older than late Desmoinesian (Marmaton) overstep older Paleozoic rocks and overlap pre-Paleozoic rocks. Pennsylvanian rocks in this area are about 1,500 feet thick. They consist chiefly of limestone and gray shale and include a small thickness of sandstone and red shale or siltsone. Although the Permian-Pennsylvanian contact can be readily recognized at the surface, it is not so easily identified in the subsurface. However, studies of drill cuttings should allow such identification.

Mississippian rocks.—Limestone of Mississippian age ranging in thickness from a featheredge to about 100 feet is present in

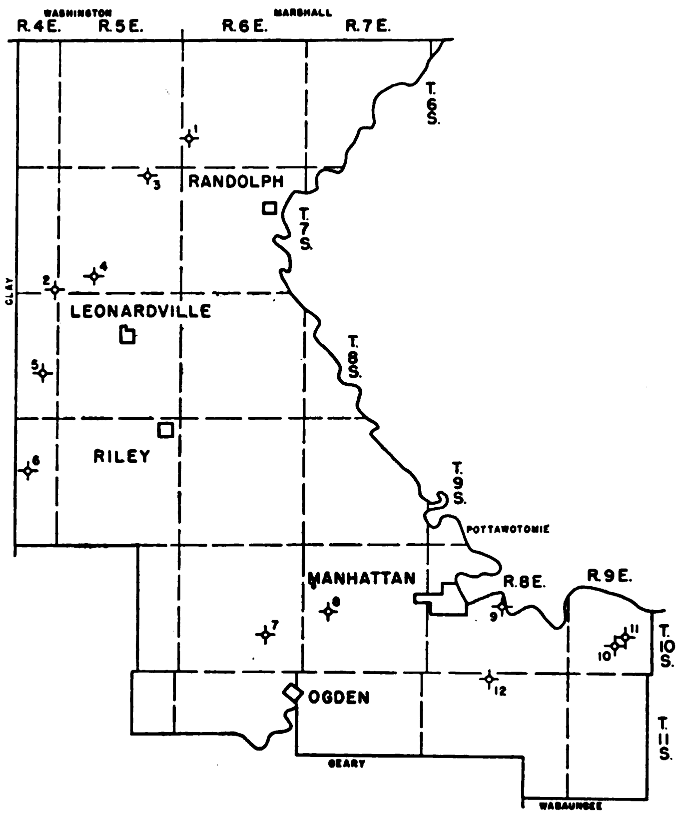

FIG. 47.—Map of Riley County showing location of wells listed in Table 72.

the western part of Riley County. Shale about 150 feet thick believed to be of Kinderhookian age and probably correlative with the Chattanooga shale is the oldest rock assigned to the Mississippian System. This rock has been identified in the western part of the county.

Pre-Chattanooga rocks.—The "Hunton" limestone lies next below Mississippian and younger rocks in most of Riley County (McClellan, 1930, fig. 2; Lee, 1939, pl. 1). The "Hunton" has a maximum thickness in this area of about 400 feet and lies unconformably between the Chattanooga and Maquoketa shales. It consists of limestone and dolomite.

The Maquoketa shale, the Viola limestone, and the Simpson sandstone are present in Riley County. The Maquoketa, which

TABLE 72.—*Data on wells drilled for oil and gas in Riley County*
(Compiled by R. P. Keroher)

No. on map	Name of well	Location	Completion date	Total depth, feet	Lowest rocks tested
1	General Utilities et al. No. 1 Hay	NE cor. SW¼ 30-6-6E	11-23-29	2,535	Arbuckle
2	C. Gentler et al. No. 1 Doyle	SE cor. SE¼ 36-7-4E	8-1-24	2,601	Maquoketa
3	Gypsy Oil Co. No. 1 Droll	SE¼ SW¼ NW¼ 2-7-5E	6-30-17	3,520	Pre-Cambrian
4	Derby Oil Co. No. 1 Lindstrom	NE cor. NE¼ 32-7-5E	10-9-29	2,226	"Hunton"?
5	Arkansas Fuel Co. No. 1 Martin	SE¼ NE¼ SW¼ 24-8-4E	1-11-30	2,942	Pre-Cambrian
6	Empire Oil & Refg. No. 1 Woodbury	SW cor. NE¼ 14-9-4E	4-29-25	2,804	Pre-Cambrian
7	Pawnee Oil and Gas No. 1 Marks	NE¼ SW¼ NW¼ 26-10-6E	12-22-23	1,853	Mississippian?
8	F. J. Heeley et al. No. 1 Thier	NW¼ NE¼ NW¼ 20-10-7E	5-23-29	2,965	Pre-Cambrian
9	Coronado Oil No. 1 Parks	Cen. SE¼ SE¼ 16-10-8E	7-28-38	1,989½	Pre-Cambrian
10	Cain Bloom No. 1 Zeandale	NW cor. SW¼ 28-10-9E	1914	1,020	Pre-Cambrian
11	Parker Oil Co. No. 1 Bardwell	SW¼ NE¼ 28-10-9E		1,093	Pre-Cambrian
12	W. R. Wilson et al. No. 1 Rannels	SE¼ SW¼ NW¼ 4-11-8E	9-12-28	2,310	"Hunton"

consists chiefly of shale but contains some sandstone, has a maximum thickness of about 100 feet; the Viola has an average thickness of perhaps 150 feet; and the Simpson is probably not more than 40 or 50 feet thick. These rocks are separated by unconformities. The Simpson sandstone is believed to overstep older rocks, including Pre-Cambrian, in Riley County. The overstep is toward the east; that is, the Simpson extends across the Arbuckle limestone and the Lamotte (?) sandstone and lies on granite in the eastern part of the county. Paleozoic rocks older than those of some part of the Missourian Series are not continuous over the buried Nemaha fault escarpment, the crest of which lies below the extreme eastern part of Riley County. Very little definite information about older Paleozoic rocks in this county is available. It is believed, however, that in the western part the Lamotte (?) sandstone and the Arbuckle limestone range in thickness from a featheredge to 150 feet or more. The Lamotte (?) sandstone is not known to be more than 85 feet thick in this area.

Because of the presence of the Nemaha uplift, the surface of the Pre-Cambrian floor in this part of Kansas is very irregular, having a relief in Riley County of 2,000 feet or more. The Pre-

Cambrian rocks are igneous and metamorphic and are believed to be chiefly granite and schist. Younger rocks ranging in age from Middle Pennsylvanian to Late Cambrian lie on the surface of the crystalline rocks. According to available records, the Cain Bloom No. 1 Zeandale well, in the NW cor. SW¼ sec. 28, T. 10 S., R. 9 E., reached granite at a depth of 928 feet. The Parker Oil Company No. 1 Bardwell well, in the SW¼ NE¼ sec. 28, T. 10 S., R. 9 E. is reported to have reached granite at 950 feet. The oldest Paleozoic rock encountered in this well is probably of Bronson age. The Empire Oil and Refining Company No. 1 Woodbury well, in the SW¼ NE¼ sec. 14, T. 9 S., R. 4 E., reached granite at 2,760 feet. In this well, the Simpson sandstone lies next above the Pre-Cambrian granite. The Arkansas Fuel Company No. 1 Martin well, in the SE¼ NE¼ SW¼ sec. 24, T. 8 S., R. 4 E., reached granite at about 2,938 feet. About 168 feet of limestone next above the granite is believed to be of Arbuckle age.

Oil and Gas Exploration

According to records in the files of the State Geological Survey of Kansas, 12 wells have been drilled in Riley County. Seven of these are reported to have reached Pre-Cambrian rocks. However, Pennsylvanian rocks lie on the granite in two of these; hence only Pennsylvanian rocks were tested. Table 72 lists the wells that have been drilled in Riley County and shows the lowest formation reached in each well. All wells were dry holes. Locations of the wells are shown in Figure 47.

SHAWNEE COUNTY

Neither oil nor gas is produced in Shawnee County. Several test wells have been drilled, but the county is very inadequately explored for oil and gas.

Geology

Surface Rocks

Rocks of Permian age are exposed in two small areas in the southwestern part of Shawnee County. The exposed bedrocks elsewhere in the county are Pennsylvanian in age. Thin deposits of glacial till and outwash material are found in all the county except the southwestern part.

Pennsylvanian rocks.—Outcropping Pennsylvanian rocks in Shawnee County extend from uppermost Pennsylvanian strata to beds in the upper part of the Douglas group (Fig. 4). Several limestones cap conspicuous escarpments that cross the county in a general north-south direction. The most prominent are those of the Topeka, Deer Creek, Lecompton, and Oread limestones of the Shawnee group.

SUBSURFACE ROCKS

Pennsylvanian rocks.—In southwestern Shawnee County where the uppermost Pennsylvanian rocks are present the total thickness of these rocks is about 2,000 feet.

Mississippian rocks.—According to Lee (1943, fig. 16), the total thickness of the Mississippian limestones in Shawnee County ranges from slightly less than 200 feet to slightly more than 350 feet. The youngest Mississippian formation that has been identified in the county is the "Warsaw" limestone, which is believed to lie next below the Pennsylvanian deposits in all parts of the county (Lee and Payne, 1944, fig. 17). In the McBride and Goens No. 1 Shirley well, in sec. 21, T. 12 S., R. 14 E., Lee (1940, pl. 6) identified 50 feet of "Warsaw" limestone. In the same well 25 feet of Keokuk limestone was found overlying 47 feet of Burling-

TABLE 73.—*Depths at which some key stratigraphic horizons were reached in three wells in Shawnee County*

Horizon	Forester et al. No. 1 Hummer, sec. 14, T. 11 S., R. 16 E.	McKnab No. 1 Fritz, sec. 4, T. 12 S., R. 14 E.	Green et al. No. 1 Ripley, sec. 12, T. 12 S., R. 16 E.
Top Mississippian limestone	1,785	1,893	1,930
Top Chattanooga shale	2,040	2,139	2,052
Top Devonian ("Hunton" limestone)	2,160	2,292	2,140
Top Silurian limestone	2,245	2,348	
Top Maquoketa shale	2,260	2,430	2,255
Top Kimmswick (Viola) limestone	2,330	2,492	2,275
Top Decorah shale	2,450	2,599	
Top St. Peter sandstone	2,465	2,631	2,405
Top Arbuckle rocks	2,535	2,680	2,475
Top Gasconade dolomite	2,710		
Top Eminence dolomite	2,800		
Top Bonneterre dolomite	2,890		
Top Lamotte sandstone	2,980		
Top Pre-Cambrian rocks	3,008		
Total depth	3,023	2,720	3,320

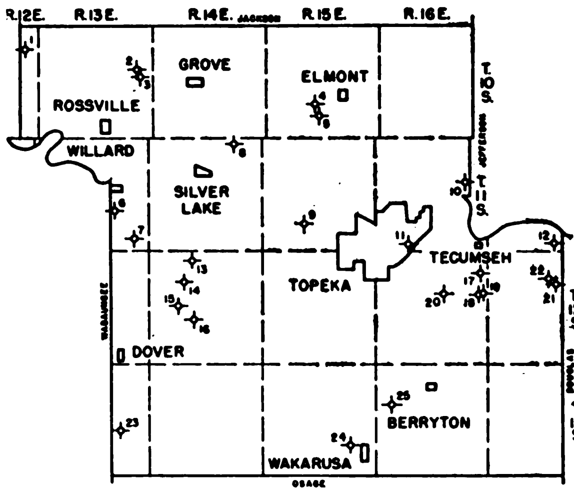

Fig. 48.—Map of Shawnee County showing location of wells listed in Table 74.

Table 74.—*Data on wells drilled for oil and gas in Shawnee County*

No. on map	Name of well	Location	Comple- tion date	Total depth, feet	Remarks
1	St. Marys Coal, Oil & Gas Co. No. 1 St. Marys College	SW¼ NW¼ NW¼ 12-10-12E	1-18-08	1,892	Top Mississippian ls. 1,871 feet
2	Adanác Oil & Refg. Co. No. 1 Adanac	SW¼ NW¼ 13-10-13E	6-21-20	2,700	Top Mississippian 2,115 feet; Chattanooga sh. 2,316 feet; "Hunton" ls. 2,563 feet
3	Skelly Oil Co. No. 1 Wallace	NW¼ SE¼ SW½ 13-10-13E	6-25-44	3,147	Top Mississippian rocks 2,094 feet; "Hunton" ls. 2,523 feet; Arbuckle 3,069 feet
4	Jenkins & Scott No. 1 Asherman	NW¼ NE¼ 28-10-15E	6-18-30	862	Stopped in Kansas City-Lansing rocks
5	C. W. Murchison No. 1 Federal Land Bank	SE cor.SE¼ 28-10-15E	7-31-43	2,885	Top Arbuckle rocks 2,735 feet
6	Barnsdall No. 1 Stacey	SW¼ 23-11-13E	4-?-18	1,951	Stopped in Cherokee rocks
7	Holl et al. Werner	SE cor. NW¼ 36-11-13E	10-10-26	2,006	Top Mississippian rocks 1,990 feet?; stopped in upper part of Mississippian
8	Jones, Davisson, et al. No. 1 Allen	SE¼ NE¼ NW¼ 2-11-14E	9-14-29	2,471	Top Mississippian rocks 2,080 feet; top Chattanooga sh. 2,305 feet; "Hunton" ls. 2,450 feet; stopped in "Hunton"
9	Corbett et al. No. 1 Security Benefit Assoc.	SW cor. SE¼ NW¼ 28-11-15E	9-1-40	2,170	Top Mississippian rocks 1,776 feet; Chattanooga sh. 1,955 feet ?; "Hunton" ls. 2,119 feet; stopped in "Hunton"
10	Forrester et al. No. 1 Hummer	SW¼ SE¼ NE¼ 14-11-16E	3-10-30	3,023	See Table 73
11	....	NW¼ NE¼ SE¼ 32-11-16E	1886	1,638	Stopped in Cherokee rocks

12	....	SW¼ SW¼ NE¼ 34-11-17E	?	1,435	Stopped in Cherokee rocks
13	McKnab No. 1 Fritz	SW¼ SE¼ NW¼ 4-12-14E	5-6-39	2,720	See Table 73
14	Jenkins & Scott No. 1 Hayden	NE cor. SE¼ 8-12-14E	8-21-29	2,693	Drillers log is similar to that of McKnab No. 1 Fritz; stopped in St. Peter ss.
15	Rinker No. 1 Flickinger	SW cor. SE¼ 17-12-14E	?	1,880	Stopped in Cherokee rocks
16	McBride & Givens No. 1 Shirley	NE¼ SW¼ 21-12-14E	10-?-27	2,469	Top Mississippian ls. 2,050 feet; Chattanooga sh. 2,306 feet; stopped in Chattanooga sh.
17	Green et al. No. 1 Ripley	NW cor. NE¼ 12-12-16E	8-4-23	3,320	See Table 73
18	....	NE¼ 13-12-16E	?	552	Incomplete log
19	Goodwin et al. No. 1 Decker	NW¼ SE¼ NE¼ NE¼ 13-12-16E	?	1,435	Log not available
20	.... Bahnmeier	NE¼ 15-12-16E	11-?-05	1,310	Incomplete log; stopped in Cherokee rocks?
21	Sterling Drilling Co. No. 1 Milliken	Cen. W. line NW¼ SE¼ 10-12-17E	4-18-44	2,511	Top Mississippian 1,714 feet; Arbuckle ls. 2,409 feet
22	Jenkins & Scott No. 1 Milliken	SE cor. NW¼ 10-12-17E	?	550	No log available
23	.... No. 1 Marshall	23-13-13E	?	1,812	Top Mississippian rocks reported 1,765 feet
24	Wapeka Oil Co. No. 1 Neal	Cen. SW¼ NE¼ 26-13-15E	6-22-17	2,430	
25	Milliken, Trott, et al. No. 1 Zeidler	NE cor. NE¼ 18-13-16E	11-10-46	2,278	Top Mississippian rocks 1,820 feet; Chattanooga sh. 2,081 feet

ton limestone. This is underlain by 29 feet of limestone of Fern Glen age. The Sedalia limestone, which is 13 feet thick, occurs next below. In the basal part of the Mississippian section, 60 feet of Gilmore City limestone was identified. The thickness of the Chattanooga shale ranges from less than 100 feet in the southeastern part of the county to slightly less than 250 feet in the southwestern part (Lee, 1943, fig. 14).

Pre-Chattanooga rocks.—Table 73 shows the depths at which some key pre-Chattanooga horizons were reached in three Shawnee County wells. Data are from studies made by Lee (1943, figs. 5, 7). Lee's studies indicate that the Silurian limestone and the Maquoketa shale have been removed from southeastern Shawnee County. The maximum thickness of rocks between the base of the Chattanooga shale and the top of the Maquoketa shale is about 250 feet (Lee, 1943, fig. 12). The interval from the top of the Maquoketa shale to the top of the St. Peter sandstone is not more than 200 feet (Lee, 1943, fig. 11), and the interval from the top of the St. Peter sandstone to Pre-Cambrian rocks ranges from about 200 to 600 feet (Lee, 1943, fig. 9).

Oil and Gas Exploration

Much of Shawnee County is untested or inadequately tested for oil and gas. Data on 25 wells in the county are given in Table 74. These wells are shown on Figure 48.

WABAUNSEE COUNTY

Oil was discovered in Wabaunsee County in April 1949. Several test wells had been drilled previously. It is reported that 44,000 cubic feet of helium gas was produced from a sandstone between 266 and 276 feet in a well in sec. 9, T. 12 S., R. 10 E. (Ockerman, 1935, p. 71). Subsurface structural conditions are favorable for the accumulation of oil in stratigraphic traps in pre-Pennsylvanian rocks.

Geology

SURFACE ROCKS

Both Permian and Pennsylvanian rocks crop out in Wabaunsee County. The exposed Permian section is about 750 feet thick, and the exposed Pennsylvanian section is about 200 feet thick. Surficial deposits of unconsolidated sediments include alluvium in the valleys of Kansas River and other streams, attentuated glacial drift, and scattered gravel beds. The youngest bedrock in the county is the Doyle shale near the top of the Wolfcampian Series. The Willard shale (Wabaunsee group) is the oldest surface rock of the country. That shale and the overlying Tarkio limestone are exposed along Kansas River in the northwestern part of the county.

Permian rocks.—Outcrops of rocks of the Chase group (Fig. 3) occupy most of the western part of Wabaunsee County. The Fort Riley and Florence limestone members of the Barneston formation, the Wreford limestone, and several highly colored shales are easily identified. Rocks of the Council Grove group crop out in a belt extending in a general northeast direction from the southwest corner of the county. The outcrop belt ranges from about 6 to 20 miles in width. As in other eastern Kansas counties, the thickness of the Council Grove rocks is about 300 feet. Rocks of the Admire group crop out in the eastern half of the county. Exposures along Mill Creek are especially well adapted to study.

The basal Admire deposit in Wabaunsee and neighboring counties is a sandstone (Indian Cave member of the Towle formation) that lies above a disconformity. This disconformity locally reaches 135 feet or more below the youngest Pennsylvanian rocks of the region. The Indian Cave sandstone is especially well exposed in the SW¼ NW¼ sec. 3, T. 13 S., R. 13 E. Its base in this area is a few feet above the Maple Hill limestone (Wabaunsee) (Moore and others, 1936, fig. 30). The Admire rocks are chiefly clastic and the limestones are only a few feet thick.

Pennsylvanian rocks.—The thickness of the Wabaunsee group (Fig. 4) along the outcrop in Kansas shows little variation, although the thicknesses of the formations are quite variable. In Wabaunsee County and elsewhere in the State, the thickness of the group is about 500 feet. Clayey and sandy shales, light-colored limestones, and minor amounts of sandstone characterize this rock division. Only the upper part of the group, the Willard shale and higher formations, is exposed in the county. These rocks crop out in the northwestern part of the county.

SUBSURFACE ROCKS

The subsurface geological conditions along the border of Wabaunsee County are shown diagrammatically in Plate 3. The crest of the buried crystalline core of the Nemaha anticline underlies the western part of the county. Rocks of Marmaton age

TABLE 75.—*Depths to some key horizons in four wells in Wabaunsee County*

Horizon	Amerada Petr. Co. No. 1 Willig, sec. 5, T. 11 S., R. 10 E.	Ramsey Petr. Co. No. 1 Kaul, sec. 2, T. 11 S., R. 11 E.	Empire Oil & Gas Co. No. 1 Schwalm, sec. 19, T. 12 S., R. 11 E.	Williams et al. No. 1 Henderson, sec. 15, T. 13 S., R. 12 S.
Top Shawnee group	473	560	900	525
Top Douglas group		970	1,255	915
Top Lansing group	981	1,170	1,495	1,305
Top Bronson subgroup		1,525	1,850	1,505
Base Marmaton group		1,748	2,070	1,705
Top Mississippian rocks		2,240	2,485	2,230?
Top Chattanooga shale	1,545	2,375	2,805	2,453
Top "Huron" limestone	1,752	2,585	2,990	2,727
Top Maquoketa shale			3,215	2,822
Top Viola limestone	2,180		3,285	2,895
Top St. Peter sandstone	2,337		3,400	3,040
Top Arbuckle limestone	2,438			3,130
Top Pre-Cambrian rocks	2,475			3,428?
Total depth	2,489	2,830	3,431	3,652

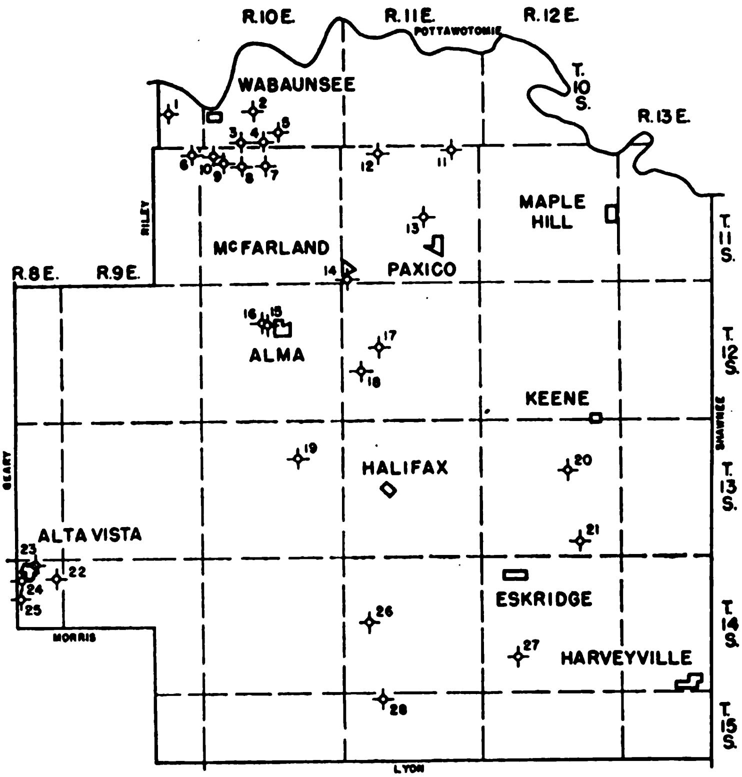

FIG. 49.—Map of Wabaunsee County showing location of wells listed in Table 76.

TABLE 76.—*Data on wells drilled for oil and gas in Wabaunsee County*

No. on map	Name of well	Location	Completion date	Total depth, feet	Remarks
1	Parker Oil Co. No. 2 Bardwell	26-10-9E		1,093	Pennsylvanian rocks on Pre-Cambrian rocks at 958 feet
2	Amerada Petr. Corp. No. 1 Morton	SW¼ SW¼ NW¼ 28-10-10E	12-1-48	1,918	Top Kinderhookian 1,350 feet; "Hunton" 1,537 feet; Sylvan sh. 1,867 feet
3	Amerada Petr. Corp. No. 1 Bolton	SW cor. SE¼ 32-10-10E	8-24-48	1,720	Top Marmaton rocks 1,161 feet; "Hunton" 1,280 feet; Sylvan 1,350 feet; Viola 1,445 feet; Simpson 1,475 feet; Arbuckle 1,670 feet; Pre-Cambrian 1,698 feet
4	Amerada Petr. Corp. No. 1 Adelaide Enlow	SW cor. SE¼ 33-10-10E	10-13-48	2,705	Top Mississippian 1,784 feet; top Viola 2,441 feet; top Pre-Cambrian 2,690 feet
5	Amerada Petr. Corp. No. 1 Stewart	SE¼ SW¼ NW¼ 34-10-10E	12-15-48	2,371	Top Kansas City-Lansing 1,342 feet; top Mississippian 2,338 feet

6	Empire Oil & Gas Co. No. 1 Root	SW¼ NE¼ 1-11-9E	?	2,000	Pennsylvanian rocks on Pre-Cambrian rocks at 1,180 feet
7	Amerada Petr. Corp. No. 1 Elizabeth Enlow	SE cor. SE¼ 4-11-10E	11-10-48	2,575	Top Topeka ls. 790 feet; Oread ls. 1,094 feet; Lansing ls. 1,342 feet; Mississippian 2,347 feet; Kinderhookian 2,502 feet
8	Amerada Petr. Corp. No. 1 Willig	SE cor. SE¼ 5-11-10E	9-22-48	2,489	See Table 75
9	Amerada Petr. Corp. No. 2 Willig	NW cor. SW¼ 5-11-10E	10-27-48	1,523	Pre-Cambrian rocks at 1,508 feet
10	Amerada Petr. Corp. No. 1 Mertz	SW cor. NE¼ 6-11-10E	8-19-48	1,234	Top Kansas City-Lansing 770 feet; top Pre-Cambrian 1,224 feet
11	Ramsey Petr. Co. No. 1 Kaul	NE¼ NE¼ 2-11-11E	9-29-25	2,830	See Table 75
12	Kansas Oil Assoc. No. 1 Wille	SW¼ NE¼ 5-11-11E	8-5-18	2,700	Top of Mississippian 2,295 feet; Chattanooga sh. 2,480 feet
13	.... No. 1 Newbury	NW¼ NE¼ 22-11-11E	?	500	
14	Bullock No. 1 McFarland (City)	SW¼ 31-11-11E	10-?-1892	2,006	Stopped in upper Cherokee rocks
15	American Petr. Co. No. 1 Smidt	SE¼ SE¼ 9-12-10E	11-2-27	2,339	Top of Mississippian rocks 2,270 feet
16	Coleman-Edgerton No. 1-B Smith	NE¼ SE¼ SE¼ 9-12-10E	3-22-29		Produced 44 M cu. ft. helium-bearing gas between 266 and 276 feet
17	Cosden No. 1 Renker	SW¼ SE¼ 17-12-11E	11-21-16	1,880	Stopped in Cherokee rocks
18	Empire Oil & Gas Co. No. 1 Schwalm	SE cor. SE¼ 19-12-11E	1-25-28	3,431	See Table 75
19	Manhattan Oil Co. No. 1 Steinmeyer	NE cor. NW¼ SW¼ 11-13-10E	5-28-27	2,405	Top of Mississippian rocks 2,340 feet
20	Williams et al. No. 1 Henderson	NE¼ 15-13-12E	?	3,652	See Table 75
21	Pinnacle Oil Co. No. 1 Martin	Cen. S. line SE¼ NW¼ 35-13-12E	7-11-19	3,640?	Drillers log similar to Williams et al. No. 1 Henderson
22	Zinn No. 1 Langvardt	NW¼ SW¼ SE¼ 1-14-8E	6-2-37	625	Stopped in Lower Permian rocks
23	Rose No. 1 Hartraft	Cen. NE¼ 2-14-8E	10-10-34	618	Stopped in Lower Permian rocks
24	Rose No. 2 Stice	SW cor. SW¼ 2-14-8E	11-10-33	700	Slight show of gas in Lower Permian rocks at 431 feet
25	Rose No. 1 Stice	SW¼ NW¼ 11-14-8E	4-14-32	604	Show of gas in Lower Permian rocks at 485 feet
26	Benedum Trees No. 1 Lockhart	SW cor. SW¼ 17-14-11E	?	2,665	Stopped in Cherokee rocks
27	Holborne Oil Co. No. 1 Stevenson	SW cor. NE¼ 29-14-12E	5-15-26	2,510	Top of Mississippian rocks 2,405 feet
28	.... No. 1 Wilson	NE¼ SW¼ NE¼ 5-15-11E	?	1,052	

are believed to lie on Pre-Cambrian crystalline rocks in this area, and a little farther east the Cherokee shale oversteps the upturned and beveled edges of Mississippian limestone formations, the Chattanooga shale, and older rocks.

Depths to some key horizons in three wells in Wabaunsee County are give in Table 75.

Pennsylvanian rocks.—The average thickness of Pennsylvanian rocks in Wabaunsee County is about 2,000 feet. The section is thinner in the western part of the county in the area of the Nemaha anticline.

Mississippian rocks.—According to Lee (1939, pl. 1; 1943, fig. 16), Mississippian limestone formations in Wabaunsee County have a total thickness ranging from a featheredge to slightly more than 350 feet. The greatest thickness is in the southeast corner of the county. These rocks are absent in the extreme western part. The Chattanooga shale ranges in thickness from a fraction of a foot to more than 150 feet (Lee, 1943, fig. 14). It was removed by post-Mississippian erosion west of a line from the northern boundary of Wabaunsee County at about the middle of R. 10 E. to the southern boundary at about the middle of R. 9 E.

Pre-Chattanooga rocks.—Lee's studies (1943, fig. 7) indicate that a well in sec. 19, T. 12 S., R. 11 E. was drilled through 41 feet of Devonian limestone, and that 179 feet of Silurian limestone was penetrated. Lee also identified 72 feet of Maquoketa shale, 103 feet of Fernvale (?) and Kimmswick limestone, 23 feet of Decorah shale and Plattin limestone, and 19 feet of St. Peter sandstone. Arbuckle rocks lie below the St. Peter sandstone. Pre-Cambrian rocks are 958 feet below the surface in sec. 26, T. 10 S., R. 9 E., and 3,625 feet below the surface in sec. 15, T. 13 S., R. 12 E. The difference in elevation of the Pre-Cambrian floor between these two places is approximately 2,400 feet. The well in which granite was found at the shallow depth is near the crest of the Nemaha anticline, where Pennsylvanian rocks are in contact with the Pre-Cambrian.

Oil and Gas Exploration

Oil was found in the Viola limestone at a depth of 3,199 feet in the Carter Oil Company No. 1 Davis well, SW¼ SE¼ SW¼ sec. 33, T. 13 S., R. 10 E. in April 1949.

Wabaunsee County has been very inadequately tested for oil and gas. Table 76 gives data on wells drilled in the county to the end of 1948. These wells are shown on Figure 49. Eight test wells were drilled in the county during 1948.

WASHINGTON COUNTY

Oil and gas have not been found in Washington County. The county is on the eastern margin of the Salina basin and in the northern part of the Kansas part of the North Kansas basin. Studies recently completed by Lee, Leatherock, and Botinelly (1948) of the stratigraphy and structural history of the Salina basin in Kansas are especially valuable in evaluating oil possibilities in Washington and other Salina basin counties.

Geology

SURFACE ROCKS

Cretaceous rocks.—The youngest exposed rock in Washington County is a part of the Carlile shale which caps hills in the northwestern part of the county. Older Cretaceous rocks exposed include the Greenhorn limestone, the Graneros shale, the Dakota formation, and probably the Kiowa shale. Sandstones of the Dakota formation crop out in a large part of the area.

Permian rocks.—Outcropping Permian rocks in Washington county extend from the lower part of the Wellington shale to the upper part of the Matfield shale (Fig. 3).

SUBSURFACE ROCKS

Younger Paleozoic rocks.—The average thickness of Permian and Pennsylvanian rocks in Washington County is about 2,000 feet (Moore and Jewett, 1942, fig. 2). Geologic conditions in the central part of Washington County are shown diagrammatically in Plate 4. Data pertaining to rocks older than Pennsylvanian were furnished chiefly by Wallace Lee.

The Chattanooga shale is believed to underlie Pennsylvanian rocks in the southwestern part of the county (Lee, 1943, fig. 14). A thin wedge of Mississippian limestone is believed to separate Pennsylvanian and Chattanooga rocks in the western part of

TABLE 77.—*Depths to some key horizons in the Gulf Oil Company No. 1 Baker well, NW¼ SE¼ SE¼ sec. 1, T. 1 S., R. 2 E., Washington County*

Horizon	Depth, feet
Base of Pennsylvanian rocks and top of Devonian ("Hunton") rocks	2,185
Top of Silurian rocks	2,340
Top of Maquoketa shale	2,600
Top of Kimmswick (Viola) limestone	2,655
Top of Simpson formation	2,770
Top of Bonneterre dolomite	3,105
Total depth	3,152

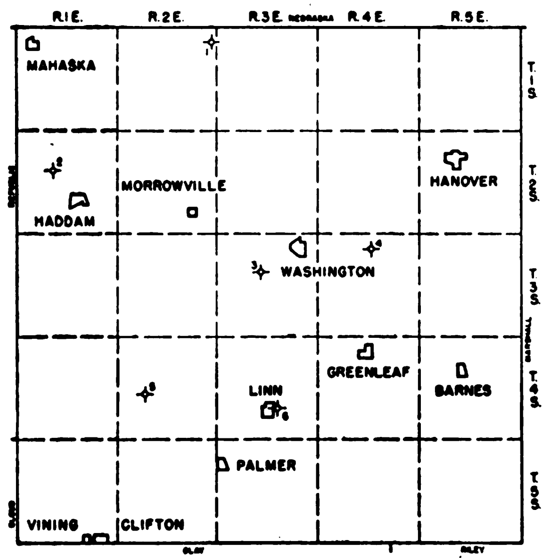

FIG. 50.—Map of Washington County showing location of wells listed in Table 78.

the county. The maximum thickness of the Chattanooga shale is slightly more than 200 feet.

Pre-Chattanooga rocks.—The "Hunton" limestone, which has an average thickness of about 400 feet, is believed to be present in all parts of Washington County. The Sylvan (Maquoketa) shale probably underlies all the county. Its thickness probably does not exceed 75 feet. The Viola limestone probably is present in all parts of the county; its average thickness is believed to be about 400 feet. A small thickness of Simpson (St. Peter) sandstone probably lies between the Viola limestone and Pre-Cambrian rocks in most of the county. There is a thin wedge of Arbuckle (or Bonneterre) dolomite below the Simpson sandstone in the western part.

Depths at which some stratigraphic horizons were reached in a well in sec. 1, T. 1 S., R. 2 E. are given in Table 77. Data were supplied by Constance Leatherock of the United States Geological Survey.

OIL AND GAS EXPLORATION

Data on wells that have been drilled in Washington County and of which the Geological Survey has records are given in Table

TABLE 78.—*Data on wells drilled for oil and gas in Washington County*

No. on map	Name of well	Location	Completion date	Total depth, feet	Remarks
1	Gulf Oil Corp. No. 1 Baker	NW¼ SE¼ SE¼ 1-1-2E	7-25-42	3,152	See Table 77
2	Westfield Oil & Gas Corp. No. 1 Canfil	SW cor. NW¼ 16-2-1E	-23	4,085	Pre-Cambrian rocks at 3,321 feet?
3	Sincox No. 1 Penwell	NE cor. NW¼ SE¼ NE¼ 16-3-3E	1-20-23	1,720	
4	Elder & Ward No. 1 Stamm	SW cor. SW¼ 3-3-4E	2-26-25	3,400	Pre-Cambrian rocks at 3,005 feet?
5	Phillips Petroleum Co. No. 1 Helms	Cen. SE¼ NE¼ 20-4-2E	10-14-43	3,027	Top of Viola ls. 2,730 feet; Simpson 2,730 feet; St. Peter 2,959 feet; Arbuckle 2,998 feet
6	McCole et al. No. 1 Swartzfoyer	NW cor. NE¼ 27-4-3E	2-19-30	3,167	Stopped in St. Peter ss.?

78. These wells are shown on Figure 50. As far as we know, no tests have been drilled since 1943.

WILSON COUNTY

Oil and gas have been producéd in every township in Wilson County. Oil was first discovered in the county near Neodesha in 1890 (Haworth, 1908, p. 24). Neodesha was supplied with gas on July 4, 1894. More than 40 wells were producing gas in this area by the close of 1894. Oil and gas were produced near the towns of Fredonia, Benedict, and Buffalo in 1900. Neodesha, Altoona, Fredonia, Buffalo, and Vilas are nearly surrounded by producing areas. The oil and gas resources of Wilson County were described by Moore and Boughton (1921); and the subsurface geology of the county was described by Stryker (1925). These reports are useful both in reference to early developments and in possibilities of new discoveries or in reference to water flooding in present fields.

In 1948, 69,976 barrels of oil were produced in Wilson County. Oil production for 1890 through 1948 is given in Tables 2 and 2a. Production for 1944 through 1948 in the various Wilson County fields is given in Table 79.

GEOLOGY

SURFACE ROCKS

The surface rocks in Wilson County consist of alternating beds of shale, limestone, and sandstone. The Oread limestone of the

Shawnee group (Fig. 4) is the youngest consolidated rock exposed in the county. It crops out in the extreme northwestern part. The Douglas group, which consists of thick massive or cross-bedded sandstones, shaly sandstones, and sandy shales, is about 230 feet thick in the county. Pedee rocks (Fig. 5) have a thickness of about 60 feet, Lansing rocks are about 165 feet thick, and Kansas City rocks are about 250 feet thick.

SUBSURFACE ROCKS

Pennsylvanian rocks.—Rocks of the Bronson subgroup are about 100 feet thick in Wilson County. The Pleasanton rocks are mostly silty to sandy shale; their thickness in the county is probably about 100 feet. The Marmaton group of rocks consists of about 250 feet of shale, sandstone, and limestone and a minor amount of coal. The Cherokee shale ranges in thickness from about 200 feet in the central part of Wilson County to about 425 feet in the east-central part (Bass, 1936, pl. 1). It is composed principally of light and dark shale containing sandstone lenses and thin beds of limestone and coal. The "Bartlesville sand" is separated from the underlying Mississippian limestone by about 100 feet of shale. A sandstone occurs locally in the basal part of the Cherokee shale.

Mississippian rocks.—The total thickness of the Mississippian rocks in Wilson County ranges from 150 to 300 feet (Lee, 1939, pl. 1). The identified Mississippian rocks and their thicknesses in a well in sec. 22, T. 30 S., R. 15 E., are: "Warsaw" limestone, 97 feet; Keokuk limestone, 44 feet; Burlington limestone, 54 feet; Reeds Spring limestone, 121 feet; St. Joe limestone, 5 feet; Northview shale, 7 feet; Compton limestone, 5 feet; and Chattanooga shale (Mississippian or Devonian), 17 feet. The Chattanooga shale lies unconformably on the Ordovician rocks.

Ordovician and Cambrian rocks.—The drillers log of a well in sec. 10, T. 29 S., R. 15 E. records 979 feet of rocks that are probably Arbuckle and other Lower Paleozoic rocks. According to this log, granite was penetrated at a depth of 2,214 feet. Keroher and Kirby (1948) indicated that the Jefferson City-Cotter sequence has an average thickness of 450 feet in Wilson County; the Roubidoux about 150 feet, the Van Buren-Gasconade about 200 feet. Their studies show that the Eminence dolomite is present only in the eastern and southeastern parts of the county and is less than 50 feet thick. The average thickness of the Bonneterre is about 100 feet.

Oil and Gas Developments

Pennsylvanian rocks in Wilson County have been thoroughly tested for oil and gas by extensive drilling which has been carried on for many years. The county is more important as a gas producer than as an oil producer. In 1935 more than 8,000 gas wells were reported in the county. Most of the productive sands are lenticular bodies in the Cherokee shale. Some production is from the top of the Mississippian limestone and from the top of the Ordovician ("Siliceous lime.)"

Figure 51 shows the distribution of the oil and gas producing areas in Wilson County as defined by the Nomenclature Committee of the Kansas Geological Society. Gas and perhaps some oil has been produced in interlying areas also.

The **Altoona** oil and gas field is in the east-central part of Wilson County. Oil production is from the "Bartlesville sand." In 1948 the field produced 2,019 barrels of oil. Gas has been produced from the "Bartlesville" and higher Pennsylvanian rocks. The **Altoona East** oil and gas field along the central part of the eastern border of Wilson County extends into Neosho County. In 1948 the field produced 3,876 barrels of oil.

The **Benedict** oil and gas field in the central part of the county produces from sandstone in Cherokee rocks at a depth of about 975 feet. In 1948 the field yielded 1,246 barrels of oil.

The **Buffalo** oil and gas field is a large area in the northeastern part of Wilson County (Fig. 51). Oil and gas were found chiefly in the "Bartlesville sand" at a depth of about 1,025 feet. Some oil has been produced from sandstone near the base of the Cherokee section. Some gas wells were reported to have had an initial daily production of 5,000 thousand cubic feet. In 1948, the field yielded 5,223 barrels of oil.

The **Buxton** gas field is in the southwest part of Wilson County. Logs of gas wells are not available, but production probably comes from a sandy body nearly 100 feet thick at a depth of about 1,100 feet. The top of Mississippian rocks in this area is about 1,225 feet below the surface.

The **Coffeyville-Cherryvale** oil and gas field chiefly in Montgomery County extends into the southeast corner of Wilson

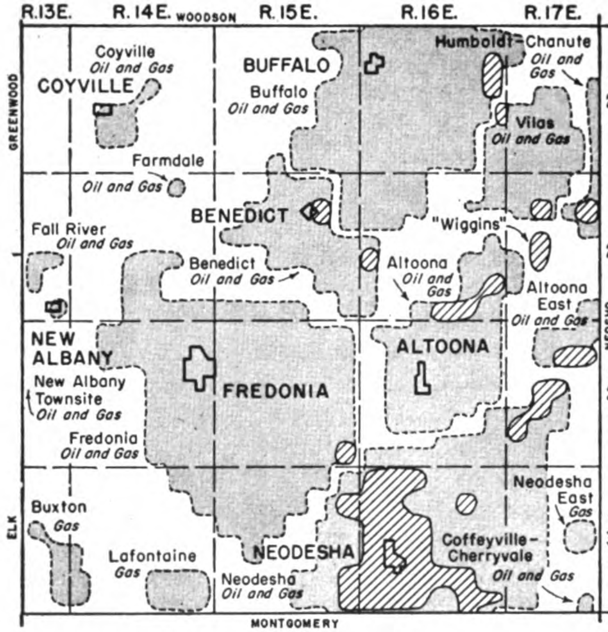

Fig. 51.—Map of Wilson County showing oil and gas fields. Areas of 1948 oil production are cross hatched. Oil-producing areas in the Coyville field are not definitely located.

County. No oil production has been reported for the Wilson County part of the field in the last few years.

The **Coyville** oil and gas field produced only 40 barrels of oil in 1948. Gas and oil have been reported in several Pennsylvanian formations. Production was chiefly from sandstone in the lower part of the Cherokee rocks or from the upper part of Mississippian limestone.

The **Fall River** oil and gas field has not produced oil for several years. Former production was from sandstone in the lower middle part of the Cherokee section. Logs of producing wells in the **Farm Dale** oil and gas field, sec. 2, T. 28 S., R. 14 E., are not available. No oil production has been reported from the field during the last few years.

The **Fredonia** oil and gas field covers a large area in the southwestern and central part of Wilson County. Oil and gas were found chiefly in a thick sandstone in the lower part of the Cherokee group. Some gas has been produced from higher rocks es-

TABLE 79.—*Oil production in Wilson County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Altoona		565	2	2,399	2	1,888		1,711		2,019
Altoona East[5]		6,848	34	5,456	34	4,232		3,325		3,876
Benedict		2,670	8	2,744	3	1,249		923		1,246
Buffalo[1]		357	3	974	3	2,205		5,297		5,223
Coyville[2]										40
Fredonia		246	1	191	1	5,319		6,563		6,647
Humboldt-Chanute[3]		653		789		788		1,590		1,500
Neodesha[4]	126+	46,507	197+	46,495	265+	54,933	188+	41,225	175+	36,466
Vilas		8,340	10	11,313	10	12,072		11,382	1+	8,668
"Wiggins		9,559	53	8,727	53	7,670		5,205		4,291
Miscellaneous								60		
Totals	126+	75,745	308+	79,088	371+	90,356	188+	77,281	176+	69,976

[1] Field extends into Woodson County.
[2] Areas of production not definitely located.
[3] Field extends into Allen, Neosho, and Woodson Counties.
[4] Field extends into Montgomery County.
[5] Field extends into Neosho County.

pecially in the Fort Scott formation. Many wells in the area were drilled a few feet into Mississippian rocks. The area was developed largely in the late 1920's.

The **Humboldt-Chanute** oil and gas field chiefly in Allen and Neosho Counties, extends into Wilson County. In 1948, 1,500 barrels of oil were produced in the Wilson County part of the field. The **Lafontaine** oil and gas field is in the southeastern part of T. 30 S., R. 14 E. Few logs are available. Oil and gas have been reported from sandstone in the upper part of the Cherokee section and gas from Mississippian limestone.

The **Neodesha** oil and gas field is a large area covering most of the southeastern part of Wilson County. Oil production has been chiefly from sandstone in the Cherokee group at depths ranging from about 825 to 850 feet. In 1948 oil was produced in isolated parts of the field; 1948 production from the field amounted to 36,466 barrels of oil.

The **Neodesha East** gas field produced gas from sandstones in the lower and middle parts of the Cherokee shale. In 1926, a deep test, the Wilson No. 1 Birk well, SE¼ SE¼ NW¼ sec. 21, was drilled to a total depth of 2,310 feet. This well stopped probably a few feet above Pre-Cambrian rocks. The **New Albany Townsite** field, sec. 36, T. 28 S., R. 13 E., is no longer active. Logs of producing wells are not available.

The **Vilas** oil and gas field, in northeastern Wilson County, yields oil in small areas and ranks second in importance in oil production in the county. In 1947, 11,382 barrels of oil were produced, and 8,668 barrels were produced in the area in 1948. The **"Wiggins"** oil field in the central part of T. 28 S., R. 17 E. yielded 5,205 barrels of oil in 1947, and 4,291 barrels in 1948.

WOODSON COUNTY

There are many scattered oil and gas producing areas in Woodson County. The largest oil production comes from the west-central part. Most of the oil and gas is produced from the "Bartlesville sand" and the upper part of the Mississippian limestone.

In 1948, 441,771 barrels of oil were produced in Woodson County. Approximately 5 million cubic feet of gas was produced the same year. Yearly oil production in Woodson County is shown in Tables 2 and 2a. Oil production in the county's various fields for 1944 through 1948 is shown in Table 80. Figure 52 is a map of Woodson County showing locations of oil and gas fields as defined by the Nomenclature Committee of the Kansas Geological Society and areas in which oil was produced in 1948.

Geology

SURFACE ROCKS

Granite is exposed at the surface in sec 13, T. 26 S., R. 15 E. in a small anticline known as Rose dome. Quartzitic sandstone and other metamorphic rocks, believed to have been formed by hydrothermal action, occur at the surface in sec. 32, T. 26 S., R. 15 E. in another small anticline, the Silver City dome.

Pennsylvanian rocks.—Surface rocks of Woodson County include the Shawnee, Douglas, Pedee, and Lansing groups. The Topeka limestone of the Shawnee group is the surface rock in the northwestern part of the county. The oldest exposed rock is the Plattsburg limestone of the Lansing group which is the surface rock in the southeastern part.

The thickness of the Shawnee group in Woodson County is about 300 feet. The Douglas group consists chiefly of shale, sandy shale, and sandstone and some thin beds of limestone and coal. These rocks are about 300 feet thick and occupy a broad band of prominent sandstone hills about 6 miles wide which trends in a northeast-southwest direction across the middle of the county. Pedee rocks crop out in eastern Woodson County in a narrow band immediately east of the broad outcrop of Douglas rocks. The total thickness of the Lansing group is about 90 feet.

SUBSURFACE ROCKS

Rose dome, a small anticline in sec. 13, T. 26 S., R. 15 E., is one of the few places in the State where igneous rocks seem to be intruded into sedimentary rocks. Occurrence of coarse-grained granite at the surface there has been interpreted as an igneous dike (Moore and Landes, 1937). A well drilled on the east flank of Rose dome penetrated igneous rocks, which were reported by Knight and Landes (1932) as "apparently an altered dike rock." Samples of a well south of Rose dome in sec. 19 were studied by Twenhofel and Bremer (1928, p. 758). They reported peridotite between 1,151 and 1,253 feet. "Silver City" as noted above is another area with geologic conditions unusual for Kansas. Very firmly cemented sandstone is underlain there by metamorphic sediments and perhaps some igneous rock. The drillers log of the McGinns No. 1 Hill well, in the SW¼ SE¼ sec. 32, T. 26 S., R. 15 E. on the flank of the Silver City dome, records "red rock and mica," "shale and mica," and "mica" between depths of 775 and 840 feet.

Pennsylvanian rocks.—The Kansas City group has an average thickness of about 420 feet in Woodson County and consists chiefly of limestone and shale. Gas is produced near Neosho Falls from a porous zone in the Dennis limestone in the Kansas group at a depth of about 325 feet. The Pleasanton shale consists chiefly of clayey and sandy shale and is about 120 feet thick in the county. The Marmaton rocks consist of alternating beds of shale, limestone, and sandstone; they are about 210 feet thick.

The Cherokee rocks in Woodson County have an average thickness of about 330 feet. They are composed chiefly of clayey and sandy shale, sandstone, and thin beds of limestone and coal. The "Bartlesville sand" lies in the upper middle part of the Cherokee, and thick lenses of sandstone occur near the base. The "Bartlesville" yields both gas and oil in the Iola-Humboldt area which extends into southeastern Woodson County from Allen County.

Mississippian rocks.—The total thickness of Mississippian limestones in Woodson County ranges from 250 to 350 feet (Lee, 1939, pl. 1). Formations present are the "Warsaw" limestone; the Keokuk limestone which is absent in the northeastern one-third of the county; the Burlington limestone; the Reeds Spring limestone; the St. Joe limestone which is absent in the northeastern corner of the county; the Sedalia limestone which is absent in the western and southwestern parts; the Northview shale; the Compton limestone; and the Chattanooga shale (Mississippian or Devonian). Oil is produced from a porous zone in the upper part of the Mississippian limestones in the Neosho Falls and Yates Center area.

Ordovician and Cambrian rocks.—Woodson County lies on the Chautauqua arch; the Chattanooga shale lies on the Arbuckle limestone there. The thickness of Lower Ordovician and Upper Cambrian rocks in Woodson County is about 700 feet. These rocks are chiefly limestone and dolomite. Keroher and Kirby (1948) indicate thicknesses of Lower Ordovician and Upper Cambrian rocks in the county as follows. (1) The Jefferson City-Cotter sequence about 400 feet; (2) the Roubidoux dolomite about 100 feet; (3) the Van Buren-Gasconade sequence about 100 feet; (4) the Eminence dolomite, present only in the eastern part, ranging from a featheredge to about 25 feet; and (5) the Bonneterre about 100 feet. The Bonneterre dolomite probably lies on Pre-Cambrian rocks in all parts of the county.

Oil and Gas Developments

Most of the oil and gas pools that are known in Woodson County were discovered nearly 30 years ago. Much drilling was done in the county in 1919. In April of that year a well in the SW¼ sec. 22, T. 25 S., R. 15 E. in the Yates Center field, which had come in at more than 5 million cubic feet of gas, started flowing oil at a rate estimated at 200 barrels per day. At about that time 23 drilling rigs were in operation and several fairly large producers were completed.

The important Neosho Falls pool, in Mississippian rocks, however, was not found until 1928. Later discoveries resulted in extending the Quincy field into Woodson County from Greenwood County and the opening of the Sheedy field in 1932. The Evans field was opened in 1938. The Silver City oil pool was found in 1946, and the Teichnor gas pool in 1947.

Oil and gas fields in accordance with their present definition (Fig. 52) are described briefly below. Table 80 gives the production in the various fields for 1944 through 1948.

Oil in the **Batesville** field is produced from the "Bartlesville sand." Probably the field should be regarded as an extension of the Quincy. The discovery well is the Saco Oil Company No. 1 Hassenpflug well in sec. 34, T. 25 S., R. 14 E., drilled in October 1934. Gravity of the oil is reported to be 38.6° A. P. I. (Lane and Garton, 1943). No producton has been recorded since 1945.

The **Big Sandy** oil and gas field produces oil from the "Bartlesville sand" at a depth of about 1,230 feet. The top of Mississippian rocks in the area is reached at about 1,400 feet. In 1947, the field yielded 53,428 barrels of oil; in 1948, 45,495 barrels.

The **Buffalo** oil and gas field extends from Wilson County into the southern part of T. 26 S., R. 16 E. In 1948, 1,942 barrels of oil were produced in the Woodson County part of the field. The producing formation is the "Bartlesville sand."

The **Evans** oil field is in sec. 16 (Coffey County) and sec. 21 (Woodson County), T. 23 S., R .15 E. In 1948, the Woodson County part of the field yielded 1,758 barrels of oil. The discovery well is the Phil-Han Oil Company No. 1 Evans well, NE cor. SW¼ sec. 21, which was drilled in June 1938. Production is from the upper part of the Mississippian limestone at a depth of about 1,540 feet.

In the **Halligan** oil field, now inactive, oil was produced from sandstone at a depth of about 770 feet. Logs of the wells are not available. The **Hoagland** field yields oil from the upper part of the Mississippian limestone at a depth of about 1,635 feet. In 1948, 15,399 barrels of oil were produced in the field. Most of the wells in the field had initial daily productions of 30 or less barrels of oil. However, the OKO Oil Company No. 2 Hoagland well, in the SW¼ NE¼ NE¼ sec. 2, T. 24 S., R. 14 E., was reported to have had an initial production of 135 barrels of oil per day.

The large **Humboldt-Chanute** oil and gas field extends into the southeastern part of Woodson County from Neosho County.

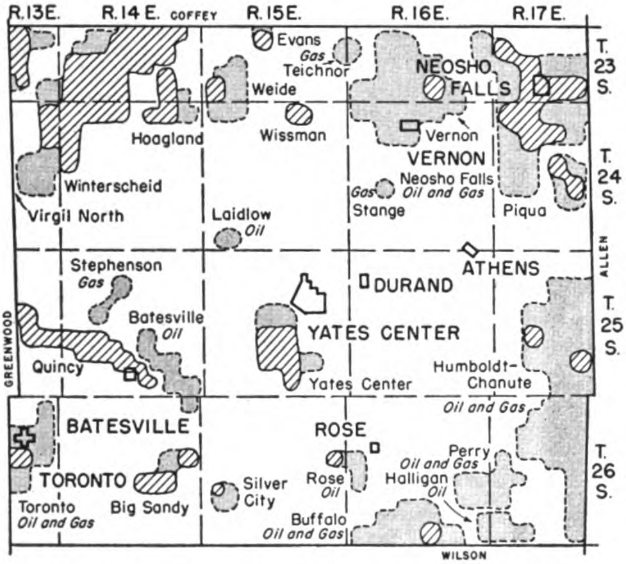

Fig. 52.—Map of Woodson County showing oil and gas fields. Areas of 1948 oil production are cross hatched.

Oil was produced in the Woodson County part of the field in 1948 in areas as shown in Fig. 52. Production, which is from the "Bartlesville sand," amounted to 2,644 barrels of oil last year. The **Laidlow** field is inactive. Logs of the oil wells are not available. Production is reported to have been from the "first break" in the Mississippian limestone.

Oil is produced in the **Neosho Falls** field from the "first break" in the Mississippian limestone (Cowley formation) at an average depth of about 1,200 feet. The discovery well was drilled in sec. 31, T. 23 S., R. 16 E. in 1928. The average initial daily production of wells has been about 20 barrels of oil. Daily production usually declines to about 10 barrels or less within the first year. Gas is produced in this area from a sandy zone in the Winterset limestone at a depth of about 325 feet. The accumulation of oil and gas seems to be controlled by changes in porosity and by structure. The field has been gradually extended and now reaches as far northeastward as sec. 26, T. 23 S., R. 17 E., Allen County. In 1948, 17,458 barrels of oil were produced in the Woodson County part of the field.

Oil is not being produced in the **Perry** oil and gas field at the present time. Former production probably was from the same

TABLE 80.—*Oil production in Woodson County, 1944 through 1948*

Field	1944 No. wells	1944 Bbls. oil	1945 No. wells	1945 Bbls. oil	1946 No. wells	1946 Bbls. oil	1947 No. wells	1947 Bbls. oil	1948 No. wells	1948 Bbls. oil
Batesville	1	8,272	1	1,285			1			
Big Sandy			18+	19,640	19+	41,990	18+	53,428	1	45,495
Buffalo[1]		2,203	10	2,730	10	2,685		2,304		1,942
Evans[6]	2	2,534	9	12,143	9	10,609	10	9,203	1	1,758
Hoagland	15	15,223	16	16,231	18	14,881	18	13,159	21	15,399
Humboldt-Chanute[2]		3,261	1+	1,376		1,988	4+	2,207	4+	2,644
Neosho Falls[3]	9+	26,115		19,440		26,650	39	17,372	53	17,458
Piqua							16	8,081	25	4,230
Quincy[4]	81+	109,753	80+	99,935	80+	92,237	78+	89,854	79+	124,688
Rose						1,700	2+	4,500	2+	2,100
Silver City						200	1+	1,000	1+	979
Toronto[4]				See Greenwood County						
Vernon						3,414	2+	942	2	907
Virgil North[5]	See Greenwood Co.		1+	3,421	1+	3,957	4	5,940	5+	35,579
Weide	4	4,102	4	3,314	4	3,588	4	3,361	4	3,511
Winterscheid[6]	16+	159,231	22+	115,737	218+	190,037	215+	176,836	18+	165,652
Wissman									8	5,209
Yates Center		19,222	17	19,420		18,149		15,714		12,754
Miscellaneous	4	2,861						125		1,406
Totals	132+	352,777	179+	314,672	359+	412,085	412+	404,026	224+	441,771

[1] Field extends into Wilson County.
[2] Field extends into Allen, Neosho, and Wilson Counties.
[3] Field extends into Allen County.
[4] Field extends into Greenwood County.
[5] Field extends into Greenwood and Coffey Counties. Some of production estimated.
[6] Field extends into Coffey County. Years 1944, 1945, 1946, and 1947 include Coffey County production.

sandstone that yielded oil in the Halligan field. The **Piqua** field perhaps should be regarded as the southeast extension of the Neosho Falls field. Production is from the upper part of the Mississippian limestone. In 1948, 25 wells in the field produced 4,230 barrels of oil.

The **Quincy** is a shoestring oil pool that was extended into Woodson County from Greenwood County in 1932. The extension well, near the Cen. sec. 14, T. 25 S., R. 13 E., had an initial production of about 100 barrels of oil per day from the "Bartlesville sand" at a depth of about 1,500 feet. In 1948, 124,688 barrels of oil were produced in the Woodson County part of the field.

The **Rose** oil and gas field yielded 4,500 barrels of oil in 1947, and 2,100 barrels in 1948. Logs of producing oil wells are not available. The **Sheedy** oil field was discovered in December 1932. The discovery well had an initial daily production of about 400 barrels of oil from the "Bartlesville sand" at a depth of about 1,420 feet. The field now is inactive.

The **Silver City** oil pool was discovered in 1946. The discovery well, the Bisagno et al. No. 1 Campbell well, SE¼ SE¼ SE¼

TABLE 81.—*Data on pool wells drilled in Woodson County during 1947 and 1948*

Field	1947 Producing wells and formation		1947 Dry	1947 Total	1948 Producing wells and formation		1948 Dry	1948 Total
Batesville			0	0			5	5
Big Sandy	1	"Bartlesville"	1	2	1	"Bartlesville"	3	4
Hoagland			0	0			1	1
Neosho Falls			0	0			2	2
Virgil North	2	Mississippian ls.	1	3	3	Mississippian ls.	2	5
Teichnor			0	0			1	1
Winterscheid	2	Mississippian ls.	7	9	20	Mississippian ls.	6	26
Wildcats			3	3			2	2

sec. 19, T. 26 S., R. 15 E., was reported as having initial production of 30 barrels of oil per day. The **Stephenson** gas field found gas in the "Bartlesville sand" at a depth of about 1,425 feet. The **Strang** pool was opened by the Oklahoma Natural Gas Company No. 1 Strang well, NE¼ NW¼ NE¼ SE¼ sec. 20, drilled in September 1938. Initial daily production was 887 thousand cubic feet of gas. Gas was found in Marmaton and Cherokee rocks.

The **Teichnor** gas pool was discovered early in 1947 (Jewett, 1947, table 1). The discovery well, the King et al. No. 1 Teichnor, SE¼ SE¼ SE¼ sec. 24, T. 23 S., R. 15 E., had a reported initial production from Mississippian rocks of 1 million cubic feet of gas per day. The **Toronto** oil and gas field extends from the central part of T. 26 S., R. 13 E. into Greenwood County. This is a "Bartlesville shoestring sand" pool. It formerly yielded much oil.

The **Vernon** field now produces oil from small areas. Oil production is from the upper part of the Mississippian limestone at a depth of about 1,420 feet. The **Virgil North** field extends into Greenwood and Coffey Counties. In 1948, 35,579 barrels of oil were produced in the Woodson County part of the field. Production is from the "Bartlesville sand" and the upper part of the Mississippian limestone.

The **Weide** oil field was opened by the Ward McGinnis No. 1 Weide well in the SW¼ NE¼ NE¼ SE¼ sec. 31, T. 23 S., R. 15 E. in January 1937. Oil was found about 28 feet below the top of the Mississippian limestone at 1,571 feet. Initial production of the well was 30 barrels of oil per day. In 1948 the field yielded 3,511 barrels of oil.

The **Winterscheid** field covers a comparatively large area in the northwestern part of Woodson County and is the most important field in the county. The field extends into Coffey County. In 1948, 165,652 barrels of oil were produced in the Woodson County part of the field. The **Wissman** oil field has been inactive for several years previous to 1948. Oil occurs in the upper part of the Mississippian limestone at an average depth of about 1,520 feet.

Oil production in the **Yates Center** field is from the upper part of the Mississippian limestone at an average depth of about 1,480 feet. In 1947, the field yielded 15,714 barrels of oil and in 1948, 12,754 barrels.

Three dry wildcat wells were reported in Woodson County in 1947 and two in 1948. Data on pool wells drilled in 1947 and 1948 in Woodson County are listed in Table 81.

WYANDOTTE COUNTY

Gas was discovered in Wyandotte County soon after the first drilling for oil in Miami County. Comparatively small amounts of gas have been produced in the county for many years and a small amount of oil is reported to have been taken from at least one or two wells.

The geology of Wyandotte County was described by Jewett and Newell (1935). Their report includes a description of outcropping rocks and areal and structural geologic maps. The subsurface geology of Wyandotte and other northeastern Kansas counties was discussed by Ockerman (1935). More recent studies of the Forest City basin by Lee (1943) and by Lee and Payne (1944) are of interest in regard to oil and gas possibilities in Wyandotte County. Studies of the ground water in the Kansas City area by Fishel (1948) are important to industrial developments of all kinds.

Geology

SURFACE ROCKS

Deposits of glacial drift in Wyandotte County are fairly thin and are scattered. However, much of the county is covered by deposits of loess—accumulations of clay and silt which are believed to have been deposited by wind. The trenches of Missouri and Kansas Rivers are partly filled with gravel, sand, and silt. The maximum thickness of valley-fill deposits is about 100 feet.

The outcropping consolidated rocks in Wyandotte County are of Pennsylvanian age. The youngest of these is the Tonganoxie sandstone member of the Stranger formation and the oldest is the Bethany Falls limestone member of the Swope formation. The Tonganoxie sandstone, which comprises the basal part of the Douglas group, is the surface rock in the upland areas in the western part of Wyandotte County. It consists of sandstone and shale and commonly a limestone conglomerate in the basal part. The maximum thickness is about 30 feet. A regional disconformity separates the Tonganoxie sandstone from underlying rocks. A few feet of the Weston shale of the Pedee group is locally present in the county between the disconformity and the Stanton limestone, but in most of the area the sandstone or conglomerate lies on the Stanton limestone. Locally in the northwestern part of the county the disconformity cuts well into or through the Stanton formation.

The Lansing group in Wyandotte County is about 75 feet thick. The outcrops of the Stanton limestone in Wyandotte County are near the uplands capped by the Tonganoxie sandstone, but the Plattsburg limestone lies below a dip slope 5 miles or more in width in the north-central part of the county. Rocks of the Kansas City group are not entirely exposed in the county, but the thickness of the Zarah and Linn subgroups (Fig. 5) ranges from about 160 to 225 feet. The range in thickness is due to abrupt lateral changes, particularly in the shale units. Limestones that show abrupt lateral changes in lithology and to a lesser degree in thickness include especially the Farley limestone member of the Wyandotte formation and the Westerville limestone. The Dennis limestone, Galesburg shale, and most of the Swope limestone of the Bronson subgroup are exposed in a quarry about one-half mile east of Morris in the W½ sec. 27, T. 12 S., R. 24 E. These rocks are less prominent eastward along the valley wall of Kansas River.

SUBSURFACE ROCKS

Pennsylvanian rocks.—The base of the Hertha limestone is a convenient datum horizon in Wyandotte County, as elsewhere in eastern Kansas. The average thickness of rocks between the Hertha limestone and the Missssippian rocks in Wyandotte County is about 700 feet.

Mississippian rocks.—The average total thickness of Mississippian limestone formations in Wyandotte County is about 450 feet (Lee, 1939, pl. 1). According to Lee and Payne (1944, figs. 12-17), the St. Louis limestone is the uppermost Mississippian limestone formation in the county. Lee's studies (1943, fig. 14) of wells in Wyandotte and surrounding counties indicate that the maximum thickness of the Chattanooga shale in the county is slightly more than 50 feet and that the thickness decreases to the east.

Devonian rocks.—Lee (1943, fig. 7, pp. 53, 55) concluded that Devonian limestone underlies all parts of Wyandotte County. He identified 36 feet of Cooper and undifferentiated limestone in the McCain No. 1 Doane well, in sec. 34, T. 12 S., R. 22 E., Johnson County, about 11 miles southwest of the southwest corner of Wyandotte County. Lee (1943, p. 53) points out that about 200 feet of Devonian limestone is present in Clay and Platte Counties, Missouri.

Ordovician and Cambrian rocks.—Silurian and Upper Ordovician rocks (Maquoketa shale and some older beds) are believed to be absent in Wyandotte County (Lee, 1943, figs. 6, 11, 13). The uppermost Ordovician rock in the county is believed to be the Kimmswick (Viola) limestone. Its maximum thickness is probably about 100 feet. A few feet of Decorah and Plattin limestones is probably present in all parts of the county. The St. Peter sandstone probably is less than 100 feet thick in the county. According to Lee (1943, fig. 9), the thickness of rocks between the top of the St. Peter sandstone and the top of Pre-Cambrian rocks in Wyandotte County ranges from slightly less than 800 feet to slightly more than 900 feet. The thickness of rocks between the top of the Roubidoux formation and the top of the Lamotte sandstone ranges from slightly more than 600 feet to more than 700 feet (Lee, 1943, fig. 10). Formations older than the St. Peter sandstone in Wyandotte County are believed to include Cotter and Jefferson City dolomites, Roubidoux formation, Gasconade and Van Buren dolomites, Gunter sandstone, Eminence dolomite, Potosi dolomite (?), Bonneterre dolomite, and Lamotte sandstone.

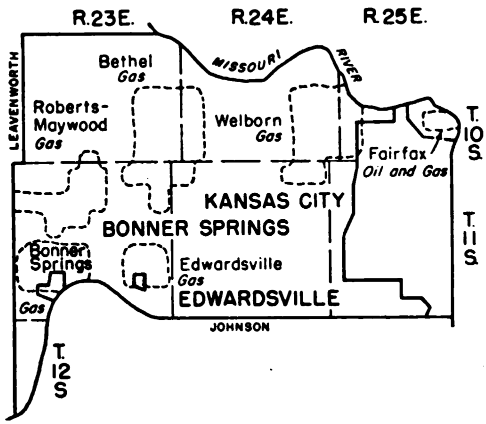

FIG. 53.—Map of Wyandotte County showing oil and gas fields.

OIL AND GAS DEVELOPMENTS

Gas was discovered in Wyandotte County soon after the first drilling for oil in Miami County. The first wells were within the present Kansas City area. For many years small amounts of gas have been produced in several areas (Jewett and Abernathy, 1945, pp. 237-238). Shows and small amounts of oil have been reported in several Pennsylvanian sandstones in Wyandotte County. In 1904, a well drilled near Argentine is said to have produced about one barrel of oil in 24 hours from a depth of 139 feet. About 20 years ago a small amount of oil was produced from a well in the SE¼ sec. 1, T. 11 S., R. 23 E; and a few years ago some oil was bailed from the "Peru sand" and used as fuel when a well in sec. 33, T. 10 S., R. 23 E. was being drilled. Late in 1948 a well in the same section was reported to be yielding oil.

In Wyandotte County there are several gas fields that are abandoned except for a few wells that supply gas for local use. The **Fairfax** field which was in the present Fairfax industrial district of Kansas City was opened in 1931. There were about 40 wells, some of which had initial daily productions as high as 2 million cubic feet. The average was slightly less than 1 million. Gas in this field was found in a zone 225 to 275 feet below the land surface, and in the "Peru sand" at a depth of 350 to 400 feet. The "Peru" sandstone has an average thickness of about 30 feet. Some years ago the **Bethel** gas field contained 60 or more producing wells. The Marmaton and the "Squirrel" sandstones were the reservoir rocks.

The **Roberts-Maywood** area in the northwestern part of T. 11 S., R. 23 E., and the northeastern part of T. 11 S., R. 22 E. (partly in Leavenworth County) is now the most important gas producing area in the county. Production is from a Marmaton sandstone, locally called "Peru," and from the "Squirrel sand." Several wells were drilled in this field during 1947. Gas production in the entire field in 1948 was 40 million cubic feet. Gas fields in Wyandotte County as defined by the Nomenclature Committee of the Kansas Geological Society are designated in Figure 53.

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