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STATE GEOLOGICAL SURVEY OF KANSAS

RAYMOND C. MOORE, State Geologist
KENNETH K. LANDES, Asst. State Geologist

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SUBSURFACE STUDIES
IN
NORTHEASTERN KANSAS

By JOHN W. OCKERMAN

BULLETIN 20

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PREFACE

A few changes have taken place in the stratigraphic nomenclature of Kansas since this report was prepared. The Admire, here classed as a formation at the top of the Wabaunsee group (uppermost Pennsylvanian), is now considered to be a group of formations at the base of the Big Blue series of Permian age.

RAYMOND C. MOORE, *State Geologist.*

Subsurface Studies in Northeastern Kansas

J. W. Ockerman
Kansas Geological Survey

INTRODUCTION

Purpose of the Report. This report was prepared in response to many inquiries for subsurface information concerning northeastern Kansas. It contains the results of studies of logs and samples of wells, together with information relative to oil and gas possibilities in the following counties: Atchison, Brown, Doniphan, Douglas, Jackson, Jefferson, Johnson, Leavenworth, Shawnee, Wabaunsee, and Wyandotte. The purpose is to present detailed subsurface information on the aforementioned counties, using all of the available well records, all published data relative to the area, and incorporating the results of detailed lithologic studies of the pre-Pennsylvanian formations that have been carried on by the State Geological Survey. Several subsurface cross-sections are included in order to correlate the stratigraphy of the several counties. Following the discussion of the general stratigraphy and structure of the region there is outlined for each of the counties the well records and subsurface correlations. This will make it possible for anyone desiring subsurface information in any part of the area to find it summarized by counties. The information can be supplemented by the more detailed lithologic descriptions presented under the heading "General Stratigraphy."

Earlier Reports. Little has been written about subsurface conditions in northeastern Kansas. In 1908 Erasmus Haworth[1] published a "Special Report on Oil and Gas" in which he included descriptions of numerous wells drilled in Kansas. Several of the old wells drilled in the northeastern part of the state were described, but no information was given as to the general structure or production in the various counties. Raymond C. Moore and Winthrop P. Haynes[2] in 1917 described the oil and gas developments in Kansas up to that date and included in their report not only a description of wells but also a county-by-county summary of oil and gas devel-

1. Kans. Univ. Geol. Survey, vol. IX, 1908.
2. Oil and gas resources of Kansas: Kans. Geol. Survey, Bull. 3, 1917.

opments and possibilities. All of the counties included in this report were discussed, but much information has become available through more extensive drilling since that time. Bulletin 13 of the Kansas Geological Survey[3] briefly indicates the oil and gas production of Kansas up to 1927, but includes very little subsurface information concerning northeastern Kansas. "Oil and Gas Resources of Kansas in 1927,"[4] by L. W. Kesler, describes the Linwood and Six Corners gas fields in Leavenworth county and the Craig Station-Monticello and Dallas fields of Johnson county. Fanny Carter Edson[5] describes the pre-Mississippian sediments of Kansas, and discusses the lithology and the paleontologic correlations of the rocks encountered in the Ramsey Petroleum Company well, Kaul No. 1, SW¼ NE¼ NE¼ sec. 2, T. 11 S., R. 11 E., Wabaunsee county, Kansas. Hugh McClellan[6] has recently described in detail the various pre-Pennsylvanian rocks in Kansas, and has outlined the major structures of the state. His contribution of knowledge is very valuable to subsurface workers in the eastern part of the state as well as in the central and western part.

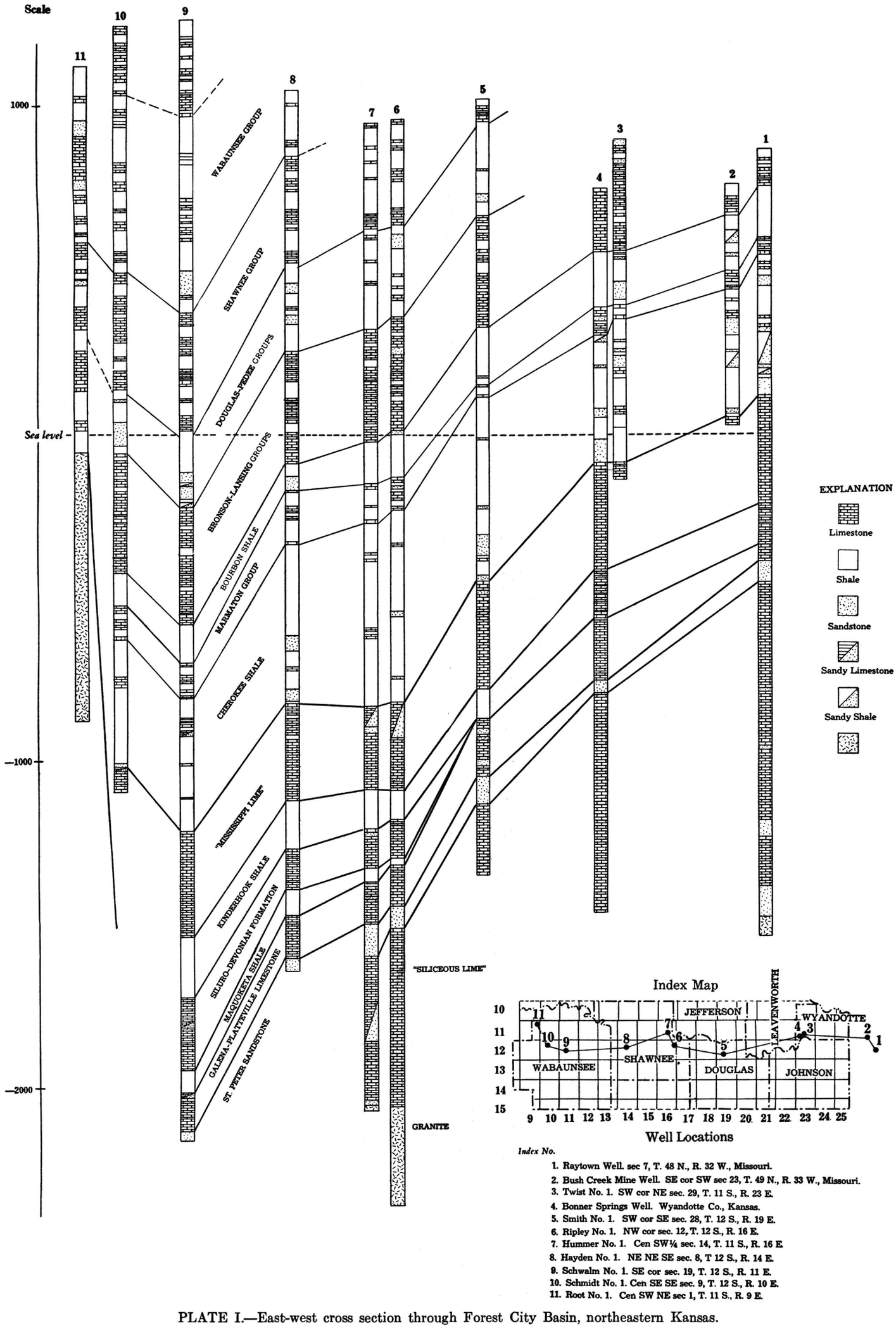
ACKNOWLEDGMENTS. The writer is indebted to oil and gas companies and independent oil and gas operators working in northeastern Kansas for the help they have given in the way of well cuttings and well logs. Mr. H. S. McQueen of the Missouri Bureau of Geology and Mines has aided the writer in connection with the insoluble residue studies of the pre-Pennsylvanian formations. The work on this report has been carefully supervised and directed by Dr. Raymond C. Moore of the Kansas Geological Survey.

REGIONAL STRUCTURE

Three major structures are found in eastern Kansas and are known as the Forest City Basin, the Nemaha Granite Ridge, and the Chautauqua Arch. Figure 1 shows the relative positions of these structural features. The counties discussed in this report are also indicated in figure 1 and it will be noted that they lie principally in the Forest City Basin.

The Forest City Basin lies in the extreme northeastern part of Kansas and extends northeastward into Missouri. The basin was named after Forest City, Missouri, where a deep well was drilled in

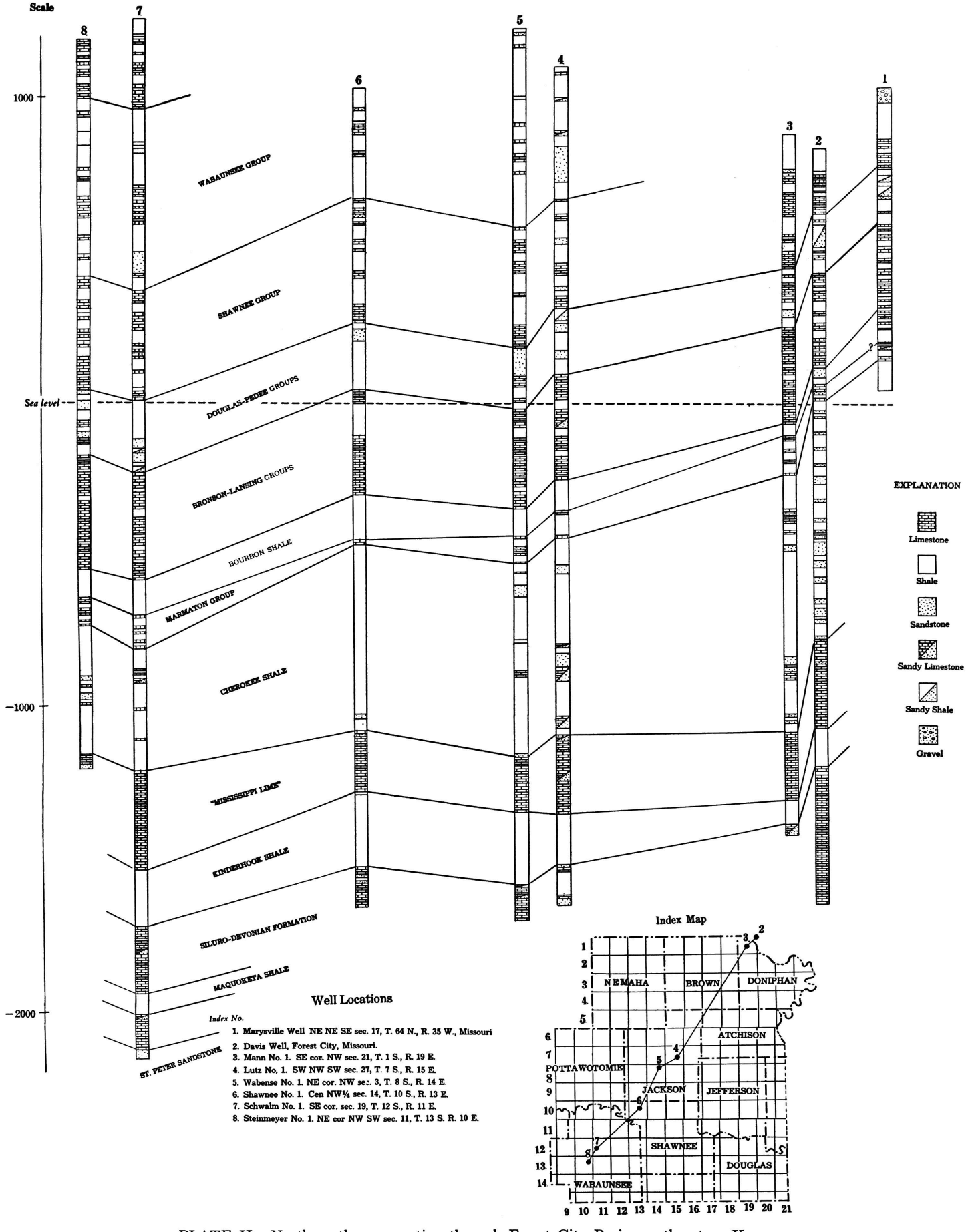
3. Moore, Raymond C., and Landes, Kenneth K.: Underground resources of Kansas, 1927.
4. Kans. Geol. Survey, Min. Resources Circ. 1, 1927.
5. Edson, Fanny Carter: Pre-Mississippian sediments in central Kansas. Am. Assoc. Petroleum Geologists Bull., vol. 13, No. 5, pp. 441-458, 1929.
6. McClellan, Hugh: Subsurface distribution of pre-Mississippian rocks of Kansas and Oklahoma. Am. Assoc. Petroleum Geologists Bull., vol. 14, No. 12, pp. 1535-1556, 1930.



Index No.

1. Raytown Well. sec 7, T. 48 N., R. 32 W., Missouri.
2. Bush Creek Mine Well. SE cor SW sec 23, T. 49 N., R. 33 W., Missouri.
3. Twist No. 1. SW cor NE sec. 29, T. 11 S., R. 23 E.
4. Bonner Springs Well. Wyandotte Co., Kansas.
5. Smith No. 1. SW cor SE sec. 28, T. 12 S., R. 19 E.
6. Ripley No. 1. NW cor sec. 12, T. 12 S., R. 16 E.
7. Hummer No. 1. Cen SW¼ sec. 14, T. 11 S., R. 16 E.
8. Hayden No. 1. NE NE SE sec. 8, T 12 S., R. 14 E.
9. Schwalm No. 1. SE cor sec. 19, T. 12 S., R. 11 E.
10. Schmidt No. 1. Cen SE SE sec. 9, T. 12 S., R. 10 E.
11. Root No. 1. Cen SW NE sec 1, T. 11 S., R. 9 E.

PLATE I.—East-west cross section through Forest City Basin, northeastern Kansas.



Well Locations

Index No.

1. Marysville Well NE NE SE sec. 17, T. 64 N., R. 35 W., Missouri
2. Davis Well, Forest City, Missouri.
3. Mann No. 1. SE cor. NW sec. 21, T. 1 S., R. 19 E.
4. Lutz No. 1. SW NW SW sec. 27, T. 7 S., R. 15 E.
5. Wabense No. 1. NE cor. NW sec. 3, T. 8 S., R. 14 E.
6. Shawnee No. 1. Cen NW¼ sec. 14, T. 10 S., R. 13 E.
7. Schwalm No. 1. SE cor. sec. 19, T. 12 S., R. 11 E.
8. Steinmeyer No. 1. NE cor NW SW sec. 11, T. 13 S. R. 10 E.

PLATE II.—North-south cross-section through Forest City Basin, northeastern Kansas.

1901. The correlation[7] of this well, as given by Ulrich, indicated that there is a basin, and subsequent drilling in Kansas has fairly well defined the boundaries and outline of the southern end of the basin in eastern Kansas. The general outline of the basin is marked by the distribution of the Hunton "lime" east of the Granite Ridge (Fig. 2). Figure 3, a reproduction of a relief model of the Nemaha Granite Ridge, reveals the general character of the basin. The Granite Ridge rises abruptly on the western side of the basin and the Chautauqua Arch rises more gradually on the southern and southeastern sides.

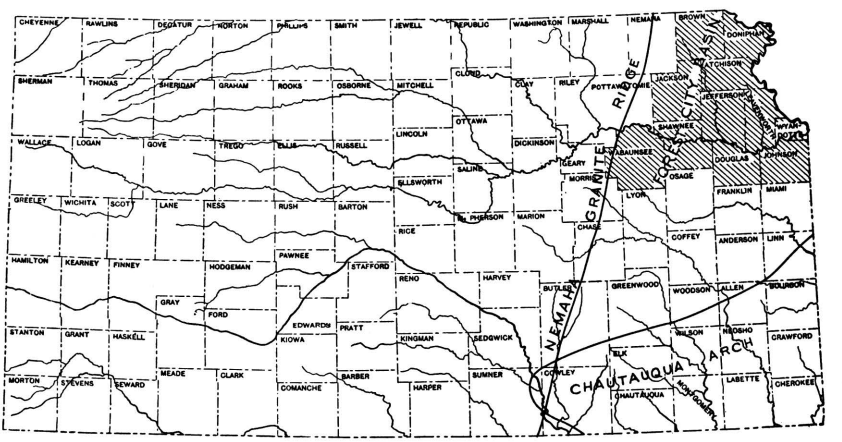


FIG. 1.—Index map and structural features of eastern Kansas.

Plates I and II give a picture of the basin and the formations that are found in it. The section of the Empire Oil and Gas Company's No. 1 Schwalm well in the SE cor. sec. 19, T, 12 S., R. 11 E., Wabaunsee county, is typical of the pre-Pennsylvanian geologic sequence in the basin. The following beds are recorded:

	Thickness in feet
MISSISSIPPIAN SYSTEM:	
"Missippi lime"	320
Kinderhook shale	185
DEVONIAN AND SILURIAN SYSTEMS:	
Limestone	222
ORDOVICIAN SYSTEM:	
Maquoketa shale	70
Galena-Platteville limestone	112
St. Peter sandstone	31+[8]

7. Hinds, Henry, and Greene, F. C.: The stratigraphy of the Pennsylvanian series in Missouri. Missouri Bur. Geology and Mines, vol. XIII, 2d ser., pp. 215-239, 1914.

8. Well was drilled 31 feet into St. Peter sandstone and abandoned.

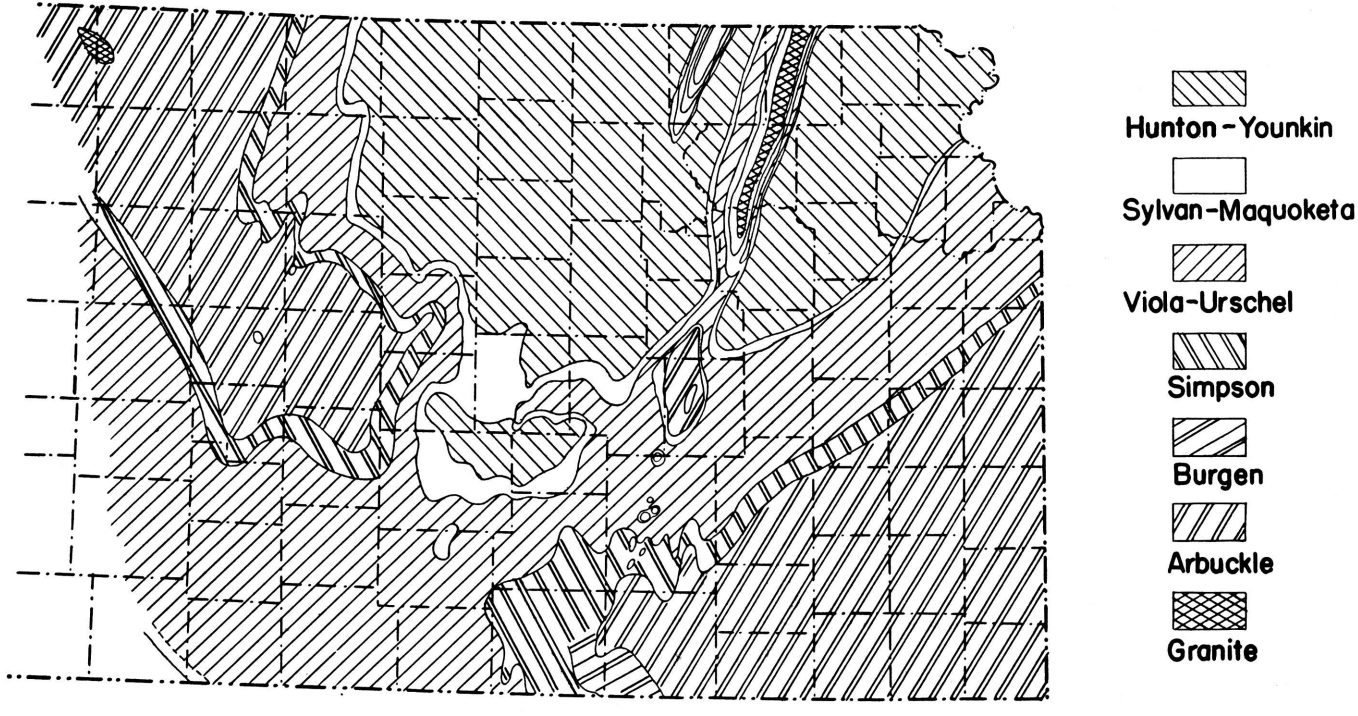


FIG. 2.—Areal distribution of pre-Mississippian in Kansas. From McClellan, Hugh W., Subsurface distribution of pre-Mississippian rocks of Kansas and Oklahoma; Am. Assoc. Petroleum Geologists, Bull., vol. 14, No. 12, pp. 1535-1556, Dec., 1930. Reprinted by courtesy of the American Association of Petroleum Geologists by whom the map is copyrighted.

The Nemaha Granite Ridge comprises the western border of the Forest City Basin in Kansas. The ridge extends from near Omaha, Nebraska, across Kansas between Nemaha county and eastern Sumner county, trending about N. 18° E., to Oklahoma City, Oklahoma. The top of the granite is about 500 feet below the surface in Nemaha county and about 3,000 feet deep in Sumner county. A model show-

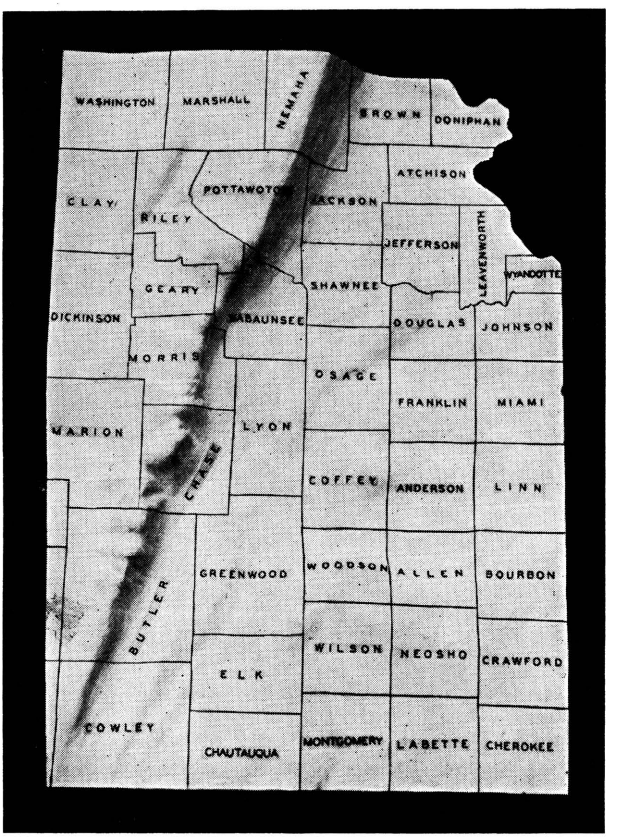


FIG. 3.—Photograph of relief model of Nemaha granite ridge.

ing the form of the Granite Ridge in Kansas, according to a map prepared by Dr. R. C. Moore, is shown in figure 3. It illustrates very well the position and magnitude of this feature.

The Chautauqua Arch is a part of the large uplift known as the Chautauqua-Barton Arch. The Chautauqua Arch is the pre-Mississippian extension of the Ozark uplift in southeastern Kansas and is separated from the Barton Arch to the northwest by a gentle

saddle. The crest of the arch contains Arbuckle limestone unconformably overlain by Mississippian and (locally) by Pennsylvanian rocks. It is evident that the other pre-Mississippian formations were either never deposited along the axis of the Chautauqua Arch or if they were once present they were eroded prior to deposition of the Mississippian beds. Figure 2 shows the relationship of this arch to the Forest City Basin and the distribution of the early formations on the crest and flanks of the arch.

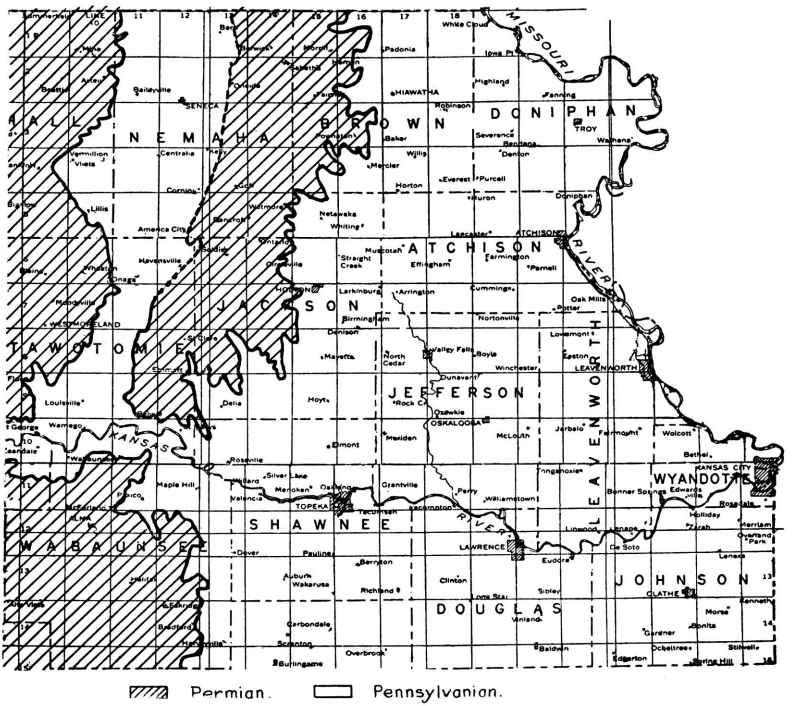


FIG. 4.—Distribution of Pennsylvanian rocks in northeastern Kansas.

STRATIGRAPHY

General

The surface formations of northeastern Kansas are Quaternary deposits, and Permian and Pennsylvanian strata. The unconsolidated Quaternary materials consist of Pleistocene glacial deposits, loess and alluvium. In the northern counties, especially Nemaha, Brown, Doniphan and western Atchison, Pleistocene glacial deposits and loess cover most of the bedrock so that exposures of the under-

lying Permian and Pennsylvanian rocks are scarce. Figure 4 shows the Permian and Pennsylvanian boundaries in northeastern Kansas.

Formations known to be present but not exposed are of Lower Pennsylvanian, Mississippian, Siluro-Devonian, Cambro-Ordovician and pre-Cambrian age. The pre-Pennsylvanian beds described in this report will be given names according to the Iowa classification because they can be traced by log correlation to the outcrop in Iowa. The Forest City Basin in Kansas is but the south extension of a large basin occurring in southwest Iowa and northeast Missouri. The lithologic and stratigraphic data relative to the correlation of the Kansas and Iowa beds will be given in the following discussions of the pre-Pennsylvanian systems.

Surface Stratigraphy

QUATERNARY DEPOSITS. The unconsolidated deposits occurring in northeastern Kansas are glacial drift, loess, lake deposits and alluvium. The glacial deposits of Pleistocene age are confined to the northeastern part of the state. Todd states: "Northeastern Kansas, including the area bounded on the east, south and west by the Missouri, Kansas, and Big Blue rivers, respectively, was invaded by the second, or Kansan, continental ice sheet."[9] Additional work by Schoewe has resulted in the relocation of the boundary of the Kansan drift area several miles south of the Kansas river.[10] The first, or Nebraskan drift, is thought to be present in Nebraska, but has not been identified in Kansas as yet.[11] The Kansan drift is composed of till, sand, gravel and erratic boulders. Associated with the drift are thick deposits of loess scattered over the northeastern counties of Kansas. The loess is a fine yellowish clay-like deposit which ranges up to 100 feet in thickness. Lake deposits consisting of fine sands and clays are found in northeastern Kansas. Kaw Lake was formed by the damming of the Kansas river, and occupied the area between Manhattan, in Riley county, and Wamego, in Pottawatomie county. Sands 100 feet thick, many erratic boulders and lacustrine silts and clays characterize the lake deposits. In the vicinity of Atchison, in Atchison county, is a succession of fine sands and silts averaging 30 feet, which were probably also deposited in a temporary lake created by ice damming. Alluvium of recent age is found in the valleys of the main streams. The alluvium consists of sands, silts, and gravels. The masking of the

9. Schoewe, W. H.: Glacial geology of Kansas. Pan-American Geologist, vol. XL, pp. 102-110, Sept., 1923.

10. Schoewe, W. H.: Evidence for a relocation of the drift border in eastern Kansas: Jour. Geology, vol. XXXVIII, No. 1, pp. 67-74, 1930.

11. Schoewe, W. H.: Personal communication.

bedrock by the Quaternary deposits and the consequent difficulty in locating structures favorable to the accumulation of oil and gas has been one of the important factors retarding the exploitation of oil and gas in this area.

PERMIAN. Figure 4 shows the area of Permian bedrock in northeastern Kansas. The Permian strata belong to the Council Grove and Chase groups of the Big Blue series. They are of marine origin and are shales and limestones for the most part. The important limestones of the Council Grove group are the Americus, Neva and Cottonwood. The Chase group is characterized by limestones and hard, resistant chert. The chert and limestone beds form prominent escarpments where exposed. The important ledge-forming beds are the Wreford limestone, Florence flint, Fort Riley limestone and Winfield limestone.

PENNSYLVANIAN. With the exception of the Marmaton and Cherokee, all of the Pennsylvanian groups outcrop in the area covered by this report. Figure 4 shows the general distribution of the Pennsylvanian formations in northeastern Kansas. The oldest of the exposed rocks belong to the Missouri series, which, as redefined by Moore, extends from the important unconformity below the Sniabar ("Hertha") limestone to another widely recognized unconformity above the Stanton limestone, or locally the Iatan limestone. The Lansing, Kansas City and Bronson groups outcrop in Johnson and Wyandotte counties and in southern Leavenworth and northeastern Douglas counties. The Douglas group outcrops over much of Douglas and Leavenworth counties, southern Jefferson county, and the eastern edge of Atchison and Doniphan counties. The Shawnee group occupies a belt extending through eastern Shawnee county, western Douglas county, and most of Jefferson, Atchison and Doniphan counties. The upper Shawnee beds are found in eastern Jackson and Brown counties. The Wabaunsee group occupies most of eastern Wabaunsee, Jackson and eastern Brown counties, and western Shawnee and Atchison counties. The lithology and thickness of the Pennsylvanian beds will be described in the section on subsurface stratigraphy.

Subsurface Stratigraphy

PENNSYLVANIAN SYSTEM

VIRGIL SERIES

WABAUNSEE GROUP. The Wabaunsee group as redefined by Moore includes the beds between the base of the Americus limestone and the top of the Topeka limestone. The Wabaunsee is a natural

Series.	Group.	Formation.
VIRGIL	Wabaunsee	Admire shale* Brownville limestone Pony Creek shale Caneyville limestone French Creek shale Jim Creek limestone Friedrich shale Grandhaven limestone Dry shale Dover limestone Table Creek shale Maple Hill limestone Pierson Point shale Tarkio limestone Willard shale Elmont limestone Harveyville shale Reading limestone Auburn shale Wakarusa limestone Soldier Creek shale Burlingame limestone Silver Lake shale Rulo limestone Cedar Vale shale Happy Hollow limestone White Cloud shale Howard limestone Severy shale
	Shawnee	Topeka limestone Calhoun shale Deer Creek limestone Tecumseh shale Lecompton limestone Kanwaka shale Oread limestone
	Douglas	Lawrence shale Haskell limestone Stranger formation
——UNCONFORMITY——		
MISSOURI	Pedee	Iatan limestone Weston shale
	Lansing	Stanton limestone Vilas shale Plattsburg limestone
	Kansas City	Bonner Springs shale Wyandotte limestone Lane shale Iola limestone Chanute shale Drum limestone Cherryvale shale
	Bronson	Dennis limestone Galesburg shale Swope limestone Ladore shale Hertha limestone
	Bourbon	Undifferentiated shale and limestone "Uniontown" limestone Unnamed shale Warrensburg channel sandstone
——UNCONFORMITY——		
DES MOINES	Marmaton	Lenapah limestone Nowata shale Altamont limestone Bandera shale Pawnee limestone Labette shale Fort Scott limestone
	Cherokee	Cherokee shale
——UNCONFORMITY——		

* Now included in Big Blue series

stratigraphic unit composed predominantly of shales gray to red in color. Thin but persistent limestones are also characteristic of this group. Some sandstone is found, usually in the lower part of the group.

The log of the Empire Oil and Refining Company No. 1 Schwalm well in the SE cor. sec. 19, T. 12 S., R. 11 E., Wabaunsee county, shows 605 feet of Wabaunsee beds. The strata logged in this well are as follows:

Empire Oil and Refining Co. No. 1 Schwalm, SE cor. sec. 19, T. 12 S., R. 11 E.

WABAUNSEE GROUP:	Thickness in feet	Depth in feet
Shale	115	295-410
Red rock	10	410-420
Shale	10	420-430
Red rock	15	430-445
Shale	60	445-505
Limestone	2	505-507
Shale	43	507-550
Limestone	5	550-555
Shale	10	555-565
Limestone	20	565-585
Shale	15	585-600
Limestone	5	600-605
Shale	15	605-620
Limestone	5	620-625
Shale	10	625-635
Limestone	25	635-660
Shale	10	660-670
Limestone	10	670-680
Shale	50	680-730
Sandy shale	40	730-770
Sand	75	770-845
Shale	2	845-847
Limestone	7	847-855
Shale	45	855-900

The section of Wabaunsee beds in the Manhattan Oil Company No. 1 Steinmeyer well in the NE cor. NW¼ SW¼ sec. 11, T. 13 S., R. 10 E., Wabaunsee county, is very similar to that of the Schwalm well. The total thickness of the Wabaunsee group in the Steinmeyer well is 590 feet. The lithologic description is given for comparison with the Schwalm section.

Manhattan Oil Co. No. 1 Steinmeyer, NE cor. NW¼ SW¼ sec. 11, T. 13 S., R. 10 E.

WABAUNSEE GROUP:	Thickness in feet	Depth in feet
Shale	45	195-240
Limestone	25	240-265
Shale	40	265-305
Red rock	45	305-350
Shale	70	350-420
Limestone	5	420-425
Shale	15	425-440

	Thickness in feet	Depth in feet
Limestone	5	440-445
Shale	20	445-465
Limestone	10	465-475
Shale	45	475-520
Limestone	25	520-545
Shale	5	545-550
Limestone	15	550-565
Shale	10	565-575
Limestone	15	575-590
Shale	60	590-650
Limestone	10	650-660
Shale	55	660-715
Limestone	15	715-730
Shale	55	730-785

SHAWNEE GROUP. This group, extending from the top of the Topeka limestone to the base of the Oread limestone, consists predominantly of limestone. The principal limestone formations, the Topeka, Deer Creek, Lecompton, and Oread, contain distinctive upper, middle and lower limestone members with intervening shale bodies where typically developed, and represent a cyclic type of sedimentation. This group ranges from 275 to 410 feet (averaging about 375 feet) in thickness in wells in various places in northeastern Kansas. The lithologic description of the Shawnee beds in the Goens et al. No. 1 Wabense, Cen. NE¼ NW¼ sec. 3, T. 8 S., R. 14 E., Jackson county, is fairly representative of this group. The thickness of the group as shown in this well is 355 feet.

Goens et al. No. 1 Wabense, Cen. NE¼ NW¼ sec. 3, T. 8 S., R. 14 E.

SHAWNEE GROUP:	Thickness in feet	Depth in feet
Topeka limestone (35 feet)—		
Soft gray dense limestone	35	705-740
Calhoun shale (30 feet)—		
Soft gray and greenish-gray shale	30	740-770
Deer Creek limestone (40 feet)—		
Gray dense to coarsely crystalline limestone	23	770-793
Soft gray shale	7	793-800
Gray dense to coarsely crystalline limestone	10	800-810
Tecumseh shale (65 feet)—		
Very soft greenish-gray shale	65	810-875
Lecompton limestone (39 feet)—		
Soft gray crystalline limestone	8	875-883
Soft dark-gray shale	17	883-900
Buff and gray crystalline limestone	14	900-914
Kanwaka shale (66 feet)—		
Soft gray shale	40	914-954
Buff crystalline limestone	3	954-957
Soft gray shale	23	957-980
Oread limestone (80 feet)—		
Gray to buff finely crystalline limestone	42	980-1,022
Soft gray shale	13	1,022-1,035
Gray sandy limestone, buff crystalline limestone	25	1,035-1,060

The Shawnee group is 375 feet thick in the Manhattan Oil Company No. 1 Steinmeyer well in the NE cor. NW¼ SW¼ sec. 11, T. 13 S., R. 10 E., Wabaunsee county, and the section is very similar to that in the Wabense well. The Steinmeyer section is given for comparison.

Manhattan Oil Co. No. 1 Steinmeyer, NE cor. NW¼ SW¼ sec. 11, T. 13 S., R. 10 E.

	Thickness in feet	Depth in feet
SHAWNEE GROUP:		
Topeka limestone (40 feet)—		
Limestone	40	785-825
Calhoun shale (40 feet)—		
Shale	40	825-865
Deer Creek limestone (60 feet)—		
Limestone	25	865-890
Shale	15	890-905
Limestone	20	905-925
Tecumseh shale (35 feet)—		
Shale	35	925-960
Lecompton limestone (55 feet)—		
Limestone	10	960-970
Shale	5	970-975
Limestone	10	975-985
Shale	10	985-995
Limestone	20	995-1,015
Kanwaka shale (35 feet)—		
Shale	35	1,015-1,050
Oread limestone (110 feet)—		
Limestone	60	1,050-1,110
Shale	5	1,110-1,115
Limestone	20	1,115-1,135
Shale	5	1,135-1,140
Limestone	20	1,140-1,160

PEDEE-DOUGLAS GROUP. The beds lying between the base of the Oread limestone and the top of the Stanton limestone belong to the Pedee-Douglas group. The Douglas group is composed predominantly of shales and sandstones and contains the Lawrence shale, Haskell limestone and Stranger formation. The Lawrence shale is often sandy and the Stranger formation is largely sandstone. The Haskell limestone is a thin limestone often mistaken for the Iatan. The Pedee group, where typically developed, is dominantly shale, and its members are the Hardesty shale, Iatan limestone, and Weston shale. The Pedee group lies between the pre-Virgil unconformity and the top of the Stanton limestone and in places is not present, the sandstones of the Stranger formation lying directly on the Stanton limestone.

The average thickness of the Pedee-Douglas beds in northeastern Kansas is about 225 feet, with a maximum of 290 feet in the Smith et al. No. 1 Smith well in the SW cor. SE¼ sec. 28, T. 12 S., R.

19 E., Douglas county, and a minimum of 175 feet in the Horton well, sec. 34, T. 4 S., R. 17 E., Brown county.

The lithology of the Pedee-Douglas groups in the Smith et al. No. 1 Smith well, SW cor. SE¼ sec. 28, T. 12 S., R. 19 E., is as follows:

Smith et al. No. 1 Smith, SW cor. SE¼ sec. 28, T. 12 S., R. 19 E.

	Thickness in feet	Depth in feet
PEDEE-DOUGLAS GROUP:		
Soft reddish-brown shale	5	68-73
Soft greenish-gray shale	141	73-214
Fine angular sandstone, buff limestone	5	214-219
Soft greenish-gray shale	71	219-290
Fine angular micaceous sandstone	25	290-315
Light-gray arenaceous shale	43	315-358

This is fairly representative of the Pedee-Douglas group as found in northeastern Kansas. The fine angular sandstone is usually present, or if not, a sandy shale is found. Thin limestone beds are usually present, but are often not recorded in the driller's log. The shale is characteristically greenish-gray in color and quite soft, but red shale is sometimes found in the upper part of the Lawrence shale. The red shale is useful as a horizon marker in subsurface work.

BRONSON-LANSING GROUP. The Bronson-Lansing group, including the Bronson, Kansas City, and Lansing groups, is a well-defined stratigraphic unit that is composed predominantly of limestone. This lime series, formerly designated as the Kansas City-Lansing, is very important in subsurface work because it can be easily recognized. The Lansing group is chiefly limestone, and its formations are the Stanton limestone, Vilas shale, and Plattsburg limestone. The Kansas City group is the shale and limestone unit which lies between the Lansing and the Bronson groups. Formations included are the Bonner Springs shale, Wyandotte limestone, Lane shale, Iola limestone, Chanute shale, Drum limestone, and Cherryvale shale. The Bronson group is composed dominantly of limestone and is made up of the Dennis limestone, Galesburg shale, and Swope limestone.

The lithology and general sequence of beds are fairly well shown in the description of cuttings of the Bronson-Lansing strata from the Anderson Drilling Company No. 1 Stines well in the NE cor. sec. 10, T. 11 S., R. 18 E., Jefferson county.

Anderson Drilling Co. No. 1 Stines, NE cor. sec. 10, T. 11 S., R. 18 E.

	Thickness in feet	Depth in feet
LANSING GROUP (80 feet):		
Stanton limestone (35 feet)—		
Gray, finely crystalline limestone, fine angular sandstone	4	537-541
Fine angular sandstone, gray limestone	6	541-547
Light-gray earthy limestone	15	547-562
Black fissile shale	5	562-567
Gray finely crystalline limestone	5	567-572
Vilas shale (18 feet)—		
Hard greenish-gray shale	18	572-590
Plattsburg limestone (27 feet)—		
Gray sandy limestone, gray shale	3	590-593
Buff, dense and oölitic limestone	24	593-617
KANSAS CITY GROUP:		
Bonner Springs shale (31 feet)—		
Fine angular micaceous sandstone	19	617-636
Greenish-gray shale	12	636-648
Wyandotte limestone (79 feet)—		
White to buff finely crystalline limestone	79	648-727
Lane shale (11 feet)—		
Medium hard gray shale	11	727-738
Iola (?) limestone (8 feet)—		
White chalky and buff-colored limestone	8	738-746
Chanute-Cherryvale shale (88 feet)—		
Hard greenish-gray shale	5	746-751
Hard white crystalline limestone, white chert	12	751-763
Medium hard gray shale	19	763-782
Gray and buff finely crystalline limestone, fine angular sandstone	3	782-785
Medium hard gray shale	5	785-790
Gray and buff finely crystalline limestone	2	790-792
Soft gray shale	3	792-795
Hard gray and brown crystalline limestone, brown chert	10	795-805
Hard dark-gray shale	2	805-807
Hard gray and brown crystalline limestone, brown chert	20	807-827
Dark-gray to black shale	7	827-834
BRONSON GROUP:		
Dennis limestone (20 feet)—		
Gray earthy and finely crystalline limestone	18	834-852
Black, fissile shale	2	852-854
Galesburg shale (1 foot)—		
Dark-gray shale	1	854-855
Swope to Hertha limestone (25 feet)—		
Mottled brown earthy limestone	22	855-877
Dark-gray to black shale	1	877-878
Mottled brown earthy limestone	2	878-880

A description of these beds as they occur at the outcrop is given in a report on Wyandotte county.[12] The thickness of the Bronson-

12. Newell, Norman D.: Mineral resources of Wyandotte county. Kansas Geol. Survey, Circ. 4, 1931.

Lansing group varies from 300 to 700 feet and averages about 350 feet.

Bourbon shale. This succession lies between the base of the Hertha formation and the pre-Missouri unconformity and is composed dominantly of undifferentiated shales and sandstones. In subsurface correlations the term Bourbon can be conveniently used for the shaly beds between the Hertha and limestones of the Marmaton group.

DES MOINES SERIES

MARMATON GROUP. The Marmaton group extends from the pre-Missouri unconformity above the Lenapah limestone to the base of the Fort Scott limestone. However, the sandstone marking the pre-Missouri unconformity is often not present or not recorded in drilling, so the unconformity cannot always be recognized. The top of the group of limestones in the Marmaton, generally the Altamont, will arbitrarily be used as the upper limit of the Marmaton group. The Marmaton and Bourbon beds will be discussed below as a unit. The Marmaton-Bourbon interval, as recognized in subsurface correlations, varies considerably in thickness. In the eastern part of the area the thickness reaches a maximum of 272 feet in the Universal Oil Company No. 1 Harrington well in the NE cor. SW¼ sec. 12, T. 14 S., R. 22 E., Johnson county, and averages about 245 feet in thickness. To the west the section is thinner. In the Jenkins and Scott well, No. 1 Hayden, NE¼ NE¼ SE¼ sec. 8, T. 12 S., R. 14 E., Shawnee county, these beds are only 165 feet thick. The average thickness in the western part of the area is about 200 feet. The section in the Anderson Drilling Company No. 1 Stines well in the NE cor. sec. 10, T. 11 S., R. 18 E., Jefferson county, is fairly typical.

Anderson Drilling Co. No. 1 Stines, NE cor. sec. 10, T. 11 S., R. 18 E.

MARMATON AND BOURBON GROUPS:	Thickness in feet	Depth in feet
Bourbon shale (98 feet)—		
Soft gray shale	20	880-900
Gray finely crystalline limestone (Uniontown limestone ?)	10	900-910
Fine angular sandstone	15	910-925
Gray to dark-gray shale	45	925-970
Gray shale	8	970-978
Altamont limestone (7 feet)—		
Gray to buff crystalline limestone	7	978-985
Bandera shale (55 feet)—		
Soft greenish-gray shale	55	985-1,040
Pawnee limestone (8 feet)—		
Buff finely crystalline limestone	8	1,040-1,048

	Thickness in feet	Depth in feet
Labette shale (23 feet)—		
Dark-gray shale	10	1,048-1,058
Soft greenish-gray shale	7	1,058-1,065
Black shale	6	1,065-1,071
Fort Scott limestone (7 feet)—		
Buff and gray finely crystalline limestone	7	1,071-1,078

The section in the Smith et al. No. 1 Smith well in the SW cor. SE¼ sec. 28, T. 12 S., R. 19 E., Douglas county, is given for comparison.

Smith et al. No. 1 Smith, SW cor. SE¼ sec. 28, T. 12 S., R. 19 E.

Marmaton and Bourbon Groups:	Thickness in feet	Depth in feet
Bourbon shale (155 feet)—		
Fine angular sandstone	11	695-706
Soft greenish-gray shale	136	706-842
Green and red shale	5	842-847
Dark-gray to black shale	3	847-850
Altamont limestone (5 feet)—		
Buff finely crystalline limestone	5	850-855
Bandera shale (20 feet)—		
Dark-gray shale	20	855-875
Pawnee limestone (5 feet)—		
Buff finely crystalline limestone	5	875-880
Labette shale (25 feet)—		
Greenish-gray shale	25	880-905
Fort Scott limestone (8 feet)—		
Buff dense and granular limestone	8	905-913

The Lenapah limestone is either absent or very thin in northeastern Kansas and did not show up in the two sections described above. An important gas sand in the Marmaton group is the Peru sand. This sand is found between the Altamont and Pawnee limestones and is usually lenticular, so that it varies greatly in thickness within a small area. The sand at the base of the Bourbon group is called "stray" sand in Wyandotte county and is an important gas horizon in many localities. It is erratic in thickness and distribution.

Cherokee shale. The rocks lying between the Marmaton group and the Mississippi "lime" are predominantly shale and sandstone. Thin limestone beds are sometimes present in the Cherokee shale, but are not important. Shale is by far the most predominant material. It varies from light-gray to black in color, and in a few places green and red streaks occur in the section. Lithologically the shale varies from fine clay shale to very sandy and micaceous shale. There are several sandstones in the Cherokee that are important as oil and gas reservoirs. These sandstones are lenticular and thicken and thin markedly in short distances, being absent in many wells. The up-

permost sandstone is the "Squirrel sand," which lies just below the Fort Scott limestone. This sand is one of the important gas sands in Wyandotte county. The Bartlesville sand or group of sands lies approximately in the middle of the Cherokee shale and is divided into the upper and lower Bartlesville in some areas. The thickness of the Bartlesville varies greatly and often it is represented by only one thin sandstone. It is recorded in some wells as being less than one foot and in others as much as 125 feet in thickness. The Bartlesville has not been productive in northeastern Kansas thus far. Oil and gas shows have been reported in a number of Bartlesville tests, however. The Bartlesville sand is fine and angular and usually carries much mica. The Burgess sandstone, at the base of the Cherokee shale immediately overlying the "Mississippi lime," is of varying thickness and is not found in all the wells. In the Smith well, west of Lawrence, it is 60 feet in thickness, but it is commonly 20 feet or less. The Burgess is generally coarser and less angular than the Bartlesville sand. The amount of sandstone in the Cherokee increases to the north. The log of the Forest City well, which follows, shows about 35 percent of the Cherokee shale as sandstone.

Davis Well, Forest City, Missouri[13]

PENNSYLVANIAN SYSTEM:	Thickness		Depth	
Cherokee shale (786 feet)—	Ft.	In.	Ft.	In.
Shale, black, thin layers of coal at bottom..	0	10	836	10
Clay shale	6	7	843	5
Limestone, gray, argillaceous	5	7	849	0
Clay, light-gray, calcareous	2	0	851	0
Shale	14	11	865	11
Limestone, dark-gray, fine-grained	2	0	867	11
Sandstone, dark bluish-gray, fine-grained	5	5	873	4
Shale, black, slaty	15	8	889	0
Coal, bony (Summit)	0	4	889	4
Sandstone	5	7	894	11
Shale, dark-gray, arenaceous	4	4	899	3
Limestone	8	9	908	0
Shale	11	10	919	10
Limestone, greenish, argillaceous	2	2	922	0
Shale, green, calcareous	4	2	926	2
Limestone, light-gray, argillaceous	2	3	928	5
Shale	8	2	936	7
Sandstone, fine-grained, argillaceous, pyritiferous	7	5	944	0
Shale	40	6	984	6
Limestone	1	8	986	2
Coal (Bedford)	0	4	986	6
Shale, gray, pyritiferous	6	9	993	3
Sandstone, micaceous	1	3	994	6
Coal, pyritiferous (Bevier)	1	2	995	8
Slate, bluish-gray, micaceous	1	4	997	0

13. Wilson, M. E.: Occurrence of oil and gas in Missouri. Missouri Bur. Geology and Mines, vol. XVI, 2d ser., pp. 196-201, 1922.

	Thickness Ft.	In.	Depth Ft.	In.
Sandstone, gray, soft, argillaceous	7	0	1,004	0
Shale	26	7	1,030	7
Limestone, greenish-gray, compact	0	8	1,031	3
Shale, slaty, calcareous	1	10	1,033	1
Limestone, dark, bituminous	0	11	1,034	0
Shale, black, slaty, carbonaceous	1	1	1,035	1
Limestone, brownish-black, compact	0	4	1,035	5
Shale, black, slaty, carbonaceous	1	9	1,037	2
Limestone, brownish-black, compact	0	8	1,037	10
Shale, black, slaty, carbonaceous	2	2	1,040	0
Coal (Tebo)	1	3	1,041	3
Clay	4	0	1,045	3
Sandstone, fine-grained, greenish	6	3	1,051	6
Shale	7	11	1,059	5
Coal	1	0	1,060	5
Shale, dark-gray, clayey	0	4	1,060	9
Sandstone, gray, fine-grained	4	0	1,064	9
Shale, black, slaty	5	8	1,070	5
Coal	0	9	1,071	2
Shale	11	4	1,082	6
Clay, brownish, very sandy	2	4	1,084	10
Sandstone	25	10	1,110	8
Shale	30	4	1,141	0
Coal, pyritiferous	0	9	1,141	9
Clay, gray, pyritiferous	4	3	1,146	0
Shale, brown, very hard	0	5	1,146	5
Sandstone, dark, argillaceous	1	2	1,147	7
Shale, dark	10	6	1,158	1
Clay, light-colored, sandy	1	11	1,160	0
Sandstone	8	2	1,168	2
Shale, dark-colored, arenaceous	2	6	1,170	8
Sandstone, light-colored, fine-grained	1	10	1,172	6
Shale	10	0	1,182	6
Sandstone, very argillaceous	0	6	1,183	0
Shale, dark-blue to black	3	4	1,186	4
Wasted core	2	2	1,188	6
Sandstone, brownish-black	2	3	1,190	9
Shale	23	5	1,214	2
Sandstone, light-gray	1	6	1,215	8
Shale, greenish-gray	0	10	1,216	6
Sandstone, greenish	1	4	1,217	10
Shale, greenish-gray	4	6	1,222	4
Sandstone, light bluish-gray	5	3	1,227	7
Shale, black, slaty, carbonaceous	2	0	1,229	7
Sandstone, gray	6	9	1,236	4
Shale	15	0	1,251	4
Coal	0	5	1,251	9
Clay, dark-gray, sandy	0	4	1,252	1
Sandstone, fine-grained	5	11	1,258	0
Shale, black	5	5	1,263	5
Coal, rotten	0	3	1,263	8
Sandstone, gray, fine-grained	5	10	1,269	6
Shale	2	6	1,272	0
Sandstone, argillaceous	6	4	1,278	4
Shale, black	3	0	1,281	4
Sandstone, banded, shaly	0	5	1,281	9
Shale	5	2	1,286	11
Sandstone, gray	4	9	1,291	8
Shale, dark brownish-black	10	0	1,301	8
Sandstone	42	1	1,343	9

	Thickness Ft.	In.	Depth Ft.	In.
Shale	12	10	1,356	7
Sandstone, brownish-black	1	0	1,357	7
Shale, dark brownish-gray	3	5	1,361	0
Sandstone	22	1	1,383	1
Shale, black	1	4	1,384	5
Coal	0	5	1,384	10
Clay, gray, sandy at top	2	6	1,387	4
Shale, black	2	9	1,390	1
Coal	0	10	1,390	11
Clay, gray, soft	1	1	1,392	0
Wasted core	1	4	1,393	4
Clay, gray to black	1	4	1,394	8
Shale, black	17	11	1,412	7
Sandstone	22	5	1,435	0
Shale, black	5	0	1,440	0
Clay shale, dark-gray	4	0	1,444	0
Sandstone, dark-gray	1	8	1,445	8
Shale, dark-gray	8	4	1,454	0
Sandstone, brown	0	3	1,454	3
Clay, dark-gray	3	6	1,457	9
Sandstone, brown, coarse	0	7	1,458	4
Shale	30	2	1,488	6
Sandstone, light-colored	4	8	1,493	2
Shale	2	4	1,495	6
Sandstone	11	2	1,506	8
Shale, black	11	6	1,518	2
Sandstone	11	10	1,530	0
Coal	0	2	1,530	2
Shale, dark	0	4	1,530	6
Sandstone	15	3	1,545	9
Shale, banded	6	2	1,551	11
Sandstone	5	4	1,557	3
Shale, black	2	10	1,560	1
Sandstone, light-colored	6	2	1,566	3
Shale, dark-gray to black	14	0	1,580	3
Sandstone, fine-grained	1	11	1,582	2
Shale, black	4	3	1,586	5
Sandstone, black	1	3	1,587	8
Shale	25	8	1,613	4
Sandstone, light-gray to white	4	10	1,618	2
Limestone, argillaceous, crystalline	0	7	1,618	9
Sandstone	3	2	1,621	11

The general stratigraphic and lithologic character of the Cherokee shale is well shown in the description of cuttings from Smith et al. No. 1 Smith well in the SW cor. SE¼ sec. 28, T. 12 S., R. 19 E., Douglas county.

Smith et al. No. 1 Smith, SW cor. SE¼ sec. 28, T. 12 S., R. 19 E.

Cherokee shale (558 feet)—	Thickness in feet	Depth in feet
Soft greenish-gray shale	37	913-950
Fine angular micaceous sandstone (Squirrel)	37	950-987
Soft, greenish-gray shale	38	987-1,025
Fine angular micaceous sandstone	8	1,025-1,033
Coal seam	3	1,033-1,036
Soft gray shale	34	1,036-1,070
Greenish-gray and reddish-brown shale	5	1,070-1,075
Black shale, fine sand	33	1,075-1,108
Soft, dark-gray shale	37	1,108-1,145
Reddish-brown shale, greenish-gray shale	2	1,145-1,147
Soft greenish-gray shale	18	1,147-1,165
Moderately hard dark-gray shale	55	1,165-1,220
Soft greenish-gray shale, fine angular sand	38	1,220-1,258
Moderately hard black shale, coal	19	1,258-1,277
Soft greenish-gray shale	18	1,277-1,295
Fine angular micaceous sandstone (Bartlesville sand)	4	1,295-1,299
Soft gray shale	26	1,299-1,325
Fine angular micaceous sandstone (Bartlesville sand)	5	1,325-1,330
Soft gray shale	68	1,330-1,398
Gray sandy limestone, coarse sand	6	1,398-1,404
Soft black shale	7	1,404-1,411
Coarse angular to rounded sand (Burgess sand)	60	1,411-1,471

Mississippian System

The Mississippian rocks of northeastern Kansas consist of the "Mississippi lime" and the Kinderhook shale. The Chattanooga shale, found in southwest Missouri and northeast Oklahoma, has been traced into Kansas as far north as Marion county but is not present in the Forest City Basin. *Sporangites huronense* is diagnostic of the Lower Mississippian shales.

"Mississippi lime" is the term commonly used to designate the cherty limestones of the upper part of the Mississippian in Kansas. These cherty limestones are probably Burlington-Keokuk in age, but since the correlation is not definite the name "Mississippi lime" will be used.

The classification of the lower part of the Mississippian system of the Mississippi Valley is as follows:[14]

14. Laudon, L. R.: Stratigraphy of the Kinderhook series of Iowa. Iowa Geol. Survey, vol. XXXV, p. 341, 1931.

Classification of Lower Mississippian of Mississippi Valley

System.	Series.	Formation.
MISSISSIPPIAN	Lower Chester	Paint Creek Yankeetown Renault Aux Vases St. Genevieve
	Meramec	St. Louis Spergen
	Osage	Warsaw Keokuk Burlington Fern Glen
	Kinderhook	Chauteau Hannibal Louisiana Chattanooga

The general classification of the Mississippian of Iowa[15] is given below.

General classification of the Mississippian of Iowa

System.	Series.	Formation.
MISSISSIPPIAN	Chester	Pella
	Meramec	St. Louis Spergen
	Osage	Warsaw Keokuk Burlington
	Kinderhook	Hampton English River Maple Hill

The Mississippian limestones found in deep wells in the Forest City Basin of southwestern Iowa have not been differentiated in most cases. In some of the wells[16] the Mississippian section has been divided into the Meramec, Osage, and Kinderhook series, but not into formations. It is probable that the upper part of the

15. Laudon, L. R., Op. cit., p. 341.
16. Norton, W. H.: Deep wells of Iowa. Iowa Geol. Survey, vol. 33, 1928.

Mississippian section is the St. Louis limestone of the Meramec series, and that the Burlington and Keokuk limestones constitute the major part of the "Mississippi limestone." The Kinderhook series contains limestones at the top, but these are usually included with the Osage and Meramec series, and the shale in the lower part of the Mississippian section is designated as Kinderhook shale.

The most accurate well by which to correlate the Mississippian of northeastern Kansas with that of southwestern Iowa is the Forest City well at Forest City, Missouri. The Mississippian system in this well is described and classified as follows:

Forest City Well, Forest City, Missouri

MISSISSIPPIAN SYSTEM:	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
St. Louis limestone (39 ft. 3 in.)—				
Limestone, gray to brownish-gray, cherty...	11	7	1,633	6
Limestone, gray, dense.....	9	10	1,643	4
Limestone, dark-gray, fine-grained.....	17	10	1,661	2
Warsaw shale (40 ft. 4 in.)—				
Limestone, light-gray, fine-grained.....	5	0	1,666	2
Dolomite, gray, soft, argillaceous.....	1	6	1,667	8
Shale, dark greenish-gray.....	4	5	1,672	1
Sandstone, blue-green, calcareous.....	1	3	1,673	4
Shale	5	1	1,678	5
Sandstone, light, argillaceous, calcareous....	1	7	1,680	0
Limestone, light-gray	10	11	1,690	11
Shale, dark greenish-gray.....	1	9	1,692	8
Limestone, fine-grained, very arenaceous....	5	4	1,698	0
Wasted core	2	0	1,700	0
Sandstone, very fine-grained, argillaceous....	1	6	1,701	6
Burlington and Keokuk limestones (119 ft. 7 in.)—				
Limestone, light to dark-gray, cherty.....	112	2	1,813	8
Wasted core	7	5	1,821	1
Kinderhook group (220 feet)—				
Dolomitic limestone, light-gray.....	16	0	1,837	1
Chert, light and dark-gray.....	1	9	1,838	10
Limestone, gray	75	1	1,913	11
Shale, blue-gray to greenish.....	39	6	1,953	5
Hematite, dark-red, flat oölites resembling typical "flaxseed" iron ore.....	4	1	1,957	6
Shale, bluish-gray, pyritiferous.....	83	7	2,041	1

The relation of the section in this well to our northeastern Kansas section can be seen in Plate II.

Barwick[17] in his paper on the Salina basin calls the "Mississippi lime" Unit 1 in his classification of pre-Pennsylvanian beds and states that it is a white to gray cherty limestone ranging from a few to 300 feet in thickness. He states further that studies by Van Tuyl

17. Barwick, J. S.: Salina Basin of north-central Kansas. Am. Assoc. Petroleum Geologists Bull., vol. 12, No. 2, pp. 177-199, 1928.

in Iowa and Buchanan in Oklahoma indicate that the Boone cherty limestone member of the Mississippian pinches out to the northwest in those states and that in the same direction the St. Louis cherty limestone member makes up the greater portion of the "Mississippi lime." McClellan[18] states that the upper part of the Mississippian in Kansas consists of cherty white to light-tan, fine crystalline limestone, which ordinarily shows evidence of prolonged weathering and concentration of chert at the top.

The foregoing discussions of the "Mississippi lime" apply in a general way to the Upper Mississippian limestones in central and western Kansas, but are applicable to those of northeastern Kansas, there being no marked difference between the "Mississippi lime" east and west of the Granite Ridge.

The "Mississippi lime" varies from 145 feet to 400 feet in thickness in the northeastern part of Kansas. The Mississippian beds seem to be unevenly eroded, for the thickness varies markedly in short distances. The "Mississippi lime" in the Ramsey et al. No. 1 Kaul well in sec. 2, T. 11, S., R. 11 E., is 145 feet thick, while in Kansas Oil Corporation's No. 1 Wille well in sec. 5, T. 11 S., R. 11 E., about three miles west, it is 280 feet thick. Similarly, in the Garvin et al. No. 1 Lutz well in sec. 27, T. 7 S., R. 15 E., the lime is 265 feet thick, while six miles away, in the Goens et al. No. 1 Wabense well in sec. 3, T. 8 S., R. 14 E., it is only 182 feet. There seems to be a general thinning of the Mississippian limestones to the west, but the lack of data coupled with the variable thicknesses makes the compilation of an isopach map of the "Mississippi lime" inadvisable.

The lithologic description of the samples from the "Mississippi lime" of the Empire Oil and Refining Company No. 1 Schwalm well in the SE cor. sec. 19, T. 12 S., R. 11 E., Wabaunsee county, is given as a typical section for northeastern Kansas.

Empire Oil and Refining Company No. 1 Schwalm, SE cor. sec. 19, T. 12 S., R. 11 E.

MISSISSIPPIAN SYSTEM:	Thickness in feet	Depth in feet
"Mississippi lime" (295 feet)—		
Gray dense limestone, dark shale	5	2,510
Gray granular limestone	25	2,535
Hard sandy dolomitic limestone	10	2,545
Hard white crystalline limestone, white chert	6	2,551
Soft gray coarsely crystalline limestone, white chert	14	2,565
Hard white chert, gray crystalline limestone	17	2,582
Hard white chert, gray dolomitic limestone	11	2,593

18. McClellan, Hugh: Subsurface distribution of pre-Mississippian rocks of Kansas and Oklahoma. Am. Assoc. Petroleum Geologists Bull., vol. 14, No. 12, p. 1547, 1930.

	Thickness in feet	Depth in feet
Buff colored dolomitic limestone, chert	17	2,610
White coarsely crystalline limestone, dolomite	15	2,625
Hard white dense chert, buff dolomitic limestone	12	2,637
Buff crystalline limestone, white chert	17	2,654
Dense white and brown chert, little limestone	51	2,705
White crystalline limestone	5	2,710
White crystalline limestone, dense white chert	25	2,735
Dark-gray shale	7	2,742
White coarsely crystalline limestone	14	2,756
Brown, dolomitic limestone	7	2,763
Soft white and buff earthy limestone	37	2,800

As can be seen in the above lithologic description, the "Mississippi lime" is predominantly a light-colored crystalline limestone associated for the most part with chert in varying amounts. Some parts of the section are predominantly chert. It is worthy of note that there are some dolomitic limestones found in the section.

The "Mississippi lime" section of the Smith et al. No. 1 Smith well in the SW cor. SE¼ sec. 28, T. 19 S., R. 12 E., Douglas county, is included here as it shows both the general characteristics of the lime section and the weathered chert zone at the top.

Smith et al. No. 1 Smith, SW cor. SE¼ sec. 28, T. 19 S., R. 12 E.

MISSISSIPPIAN SYSTEM: "Mississippi lime" (331 feet)—	Thickness in feet	Depth in feet
White weathered chert, coarse sand	19	1,490
Coarse subangular to rounded, frosted sand	8	1,498
White weathered chert, gray crystalline limestone	17	1,515
Coarse subangular to rounded, frosted sand	10	1,525
Light-gray, finely crystalline limestone, white chert	50	1,575
White coarsely crystalline limestone, white chert	27	1,602
Buff colored dolomitic limestone, white chert	12	1,614
Dead white chert, buff dolomitic limestone	16	1,630
Dull white chert, soft white crystalline limestone	20	1,650
Soft buff-colored crystalline limestone, white chert	20	1,670
Soft white coarsely crystalline limestone, white chert	20	1,690
Gray finely crystalline dolomitic limestone	25	1,715
White to brown chert, buff dolomitic limestone	10	1,725
Gray crystalline limestone, dull gray chert	20	1,745
Dull gray chert, gray limestone	10	1,755
Gray crystalline limestone, dull gray chert	25	1,780
Gray crystalline limestone	22	1,802

Kinderhook shale. The general classification of the Kinderhook series in the Mississippi Valley as given in the discussion of the "Mississippi lime" shows Chattanooga shale at the base. The classification of the Mississippian system of Iowa contains no Chattanooga shale in the Kinderhook series. The Kinderhook series, as it occurs in Iowa and Missouri, contains some limestone beds along with the shale, but these limestones are generally grouped with the "Mississippi lime" and the shale is designated as the Kinderhook

shale.[19] As previously mentioned in the text, the Chattanooga shale of Mississippian age is associated with the Kinderhook in southern Kansas and has been traced from Oklahoma as far north as Marion county, Kansas. North of that the Chattanooga has not been identified and has presumably pinched out leaving the Kinderhook shale occupying the entire shale series between the base of the "Mississippi lime" and the pre-Mississippian beds below. Barwick[20] calls this shale series unit 2 in his classification and suggests the name Skelton because of the uncertainty as to the exact age.

The Kinderhook shale ranges from 90 feet in thickness in the Smith et al. No. 1 Smith well in the SW cor. SE¼ sec. 28, T. 12 S., R. 19 E., Douglas county, to 240 feet in the Goens et al. No. 1 Wabense well in the Cen. NE¼ NW¼ sec. 3, T. 8 S., R. 14 E., Jackson county, and shows no regularity throughout the area under consideration.

The Kinderhook is predominantly shale, the shales usually being soft and of a gray and greenish-gray color. In the Ramsey et al. No. 1 Kaul well in the SE cor. NE¼ NE¼ sec. 2, T. 11 S., R. 11 E., Wabaunsee county, the upper 15 feet was light pinkish-gray shale,[21] but this is not usually found. It may be noted in Plate I that the Kinderhook becomes increasingly calcareous to the east. The presence of thin limestones within this interval makes it difficult to recognize.

Sporangites huronense, a small brown translucent plant spore, is very abundant in the Kinderhook shale as well as in the Chattanooga shale and makes an excellent criterion for their identification.

Silurian and Devonian System

Siluro-Devonian Formation. The limestone beds immediately underlying the Kinderhook shale in the central part of the Forest City Basin will be designated as the Siluro-Devonian formation in this report. The beds occupying the same position in southwestern Iowa have been considered as Silurian and Devonian, but not definitely correlated. There is considerable disagreement as to the exact correlation of these limestones. They have been called Hunton formation by some geologists because they occupy the same relative position with respect to the Mississippian and the Ordovician as does the Hunton formation in Oklahoma. However, Ulrich's cor-

19. The correlation of the Forest City well is an exception to this general practice and while the limestones of the Kinderhook are not named, they are included in the Kinderhook and not in the Burlington-Keokuk above.

20. Barwick, John S.: Op. cit.

21. Edson, F. C.: Op. cit.

relation of these beds in the Forest City well (given later in this discussion) is not in accord with the Hunton theory. Ulrich considers these beds to be Middle Silurian and Middle and Upper Devonian, whereas the members of the Hunton formation in Oklahoma are Lower Silurian and Lower Devonian in age. This disagreement led Barwick to suggest the name Younkin.[22] The name has been used by a few geologists, but is not commonly accepted. Barwick states that the lithology and position of this zone suggests a correlation with the Silurian and Devonian rocks penetrated by deep wells in southeastern Nebraska and southwestern Iowa.

The lower part of the Forest City well, Forest City, Missouri, was correlated by E. O. Ulrich as follows:[23]

Forest City Well, Forest City, Missouri

	Thickness		Depth	
DEVONIAN SYSTEM:	Ft.	In.	Ft.	In.
Limestone	15	8	2,056	9
Shale, dark bluish-gray	5	11	2,062	8
Upper Devonian Series—				
Limestone, light to dark gray	71	10	2,134	6
Middle Devonian Series—				
Dolomite	35	0	2,169	6
Limestone	10	10	2,180	4
Dolomite	52	3	2,232	7
Chert, partly decomposed and chalky	1	8	2,234	3
Dolomite, cherty in part	130	10	2,365	1
SILURIAN SYSTEM (Lockport group of Niagaran series):				
Dolomite, bluish-gray, crystalline to shaly	134	11	2,500	0

As can be seen in Plate II the Silurian and Devonian in the Forest City well correlates with the Siluro-Devonian of the northeastern Kansas wells.

Figure 2 shows the extent of the Siluro-Devonian (Hunton-Younkin) east of the Granite Ridge in the Forest City Basin.

The Siluro-Devonian formation has a maximum thickness of 459 feet in the Forest City well, Forest City, Missouri. The thickest reported section in eastern Kansas is 240 feet in the Ramsey et al. No. 1 Kaul well in the SE cor. NE¼ NE¼ sec. 2, T. 11 S., R. 11 E., Wabaunsee county. Empire Oil and Refining Company No. 1 Schwalm, SE cor. sec. 19, T. 12 S., R. 11 E., Wabaunsee county, logged 217 feet of Siluro-Devonian formation. The beds thin away from the axis of the Forest City Basin, three wells in Shawnee county showing about 120 feet of the formation.

22. Barwick, John S.: Salina Basin of north-central Kansas. Am. Assoc. Petroleum Geologists, Bull., vol. 12, No. 2, pp. 177-199, 1928.

23. Wilson, M. E.: Occurrence of oil and gas in Missouri. Missouri Bur. Geology and Mines, vol. XVI, 2d ser., p. 201, 1922.

The Siluro-Devonian formation consists of white, gray, and brown limestones and dolomites. Sand, ranging from fine to coarse, is present in parts of most sections, and chert in varying amounts is associated with the limestones and dolomites. The description of the samples from the Siluro-Devonian of the Empire Oil and Refining Company No. 1 Schwalm well in the SE cor. sec. 19, T. 12 S., R. 11 E., Wabaunsee county, is herewith given as typical of the formation.

Empire Oil and Refining Company No. 1 Schwalm, SE cor. sec. 19, T. 12 S., R. 11 E.

SILURO-DEVONIAN FORMATION:	Thickness in feet	Depth in feet
Brown coarsely crystalline dolomite, white crystalline limestone	20	3,015
Soft gray fissile shale	5	3,020
Brown coarsely crystalline dolomite	11	3,031
White finely crystalline limestone, white earthy chert	9	3,040
Brown coarsely crystalline dolomite, white earthy chert	13	3,053
Brown and white coarsely crystalline dolomite, coarse angular to frosted sand	11	3,064
White coarsely crystalline dolomite	38	3,102
White coarsely crystalline dolomite, coarse angular sand	23	3,125
Buff colored coarsely crystalline dolomite, coarse angular sand, white chert	30	3,155
White coarsely crystalline dolomite	17	3,172
White to buff coarsely crystalline dolomite, white earthy chert	13	3,185
Yellowish-brown coarsely crystalline dolomite	27	3,212

Very interesting and useful results have been obtained in the study of the insoluble residues[24] of the Siluro-Devonian formation and the Galena-Platteville limestone. A detailed report has been prepared by the writer[25] on this phase of subsurface work. The Siluro-Devonian formation is characterized by a white, finely dolocastic[26] chert that is found in several zones in the formation. This chert is usually of delicate structure, the casts being tiny and the walls very thin, giving the material a lace-like appearance. Another distinctive residue of the Siluro-Devonian is the soft green to greenish-gray shale which occurs in very friable thin flakes. This shale is usually without dolocasts, but a few fragments show fine dolocasts. In addition a small amount of oölitic chert is present which was not found in the Galena-Platteville residues. Granular or sucrose chert, both brown and white, and granular quartz are

24. McQueen, H. S.: Insoluble residues as a guide in stratigraphic studies. Missouri Bur. Geology and Mines, Appendix I, 56th Bien. Rep., 1931.

25. Insoluble residues of the Hunton and Viola limestones of Kansas. Jour. Sedimentary Petrology, vol. 1, No. 1, pp. 43-47, 1931.

26. Dolocast: Casts or impressions of dolomite crystals preserved in the insoluble chert, shale, glauconite, pyrite, limonite. By H. S. McQueen (op. cit.).

more abundant in the Siluro-Devonian residues than in the Galena-Platteville residues.

Because of the scarcity of fossils in this formation the use of insoluble residues will be a valuable aid and the results to date are excellent.

Ordovician System

Maquoketa Shale. Below the Siluro-Devonian formation is found the Maquoketa shale. This shale by its lithology and stratigraphic position has been correlated with the Sylvan shale of Oklahoma by some geologists. Barwick[27] suggested the name Engle shale for this shale interval, principally because of the fact that the Maquoketa shale is Upper Ordovician and the Sylvan is considered by some to be Lower Silurian. Gould,[28] however, classifies the Sylvan shale as Upper Ordovician (Richmond).

The greatest recorded thickness of the Maquoketa in eastern Kansas is 78 feet in the Jenkins and Scott No. 1 Hayden well in the NE¼ NE¼ SE¼ sec. 8, T. 12 S., R. 14 E., Shawnee county, and 70 feet was logged in the Empire Oil & Refining Co. No. 1 Schwalm well in the SE cor. sec. 19, T. 12 S., R. 11 E., Wabaunsee county.

Lithologically the Maquoketa shale is very similar to the Kinderhook shale, and when the Siluro-Devonian formation is not found between it is practically impossible to determine the contact between the two shales. The Maquoketa shale is in most cases gray and greenish-gray in color and quite soft.

Galena-Platteville Limestone. The limestone overlying the St. Peter sandstone correlates approximately with the Viola limestone of Oklahoma, but is dissimilar from the two members of the Viola present in northern Oklahoma. Correlations with deep wells in the northern part of the Forest City Basin in southwestern Iowa have led to assigning the name Galena-Platteville to this limestone. The Decorah shale, which lies between the Galena and Platteville, is not always present or recognizable. Barwick[29] considers the Galena-Platteville to be equivalent to a part of the Plattin-Kimmswick section of Missouri and the Galena-Platteville section of Iowa, and suggested the name Urschel for this limestone. McClellan[30] states that in Riley county, northern Kansas, there is about 30 feet of

27. Barwick, John S.: Salina Basin of north-central Kansas. Am. Assoc. Petroleum Geologists, Bull., vol. 12, No. 2, p. 184, 1928.

28. Gould, Chas. N.: Index to the stratigraphy of Oklahoma. Oklahoma Geol. Survey, Bull. 35, p. 16, 1925.

29. Barwick, John S.: Op. cit.

30. McClellan, Hugh: Subsurface distribution of pre-Mississippian rocks of Kansas and Oklahoma. Am. Assoc. Petroleum Geologists, Bull., vol. 14, No. 12, p. 1544, 1930.

light-brown dolomite overlying 20 feet with a coarsely crystalline phase, below which is 110 feet of both dense and finely crystalline cherty limestone, and that, if a correlation on the basis of lithology can be relied upon, this suggests that the upper bed and the Fernvale (coarsely crystalline phase) are thinning toward the north and an older bed, probably Galena in age, appears and thickens toward the north.

This idea is substantiated by the correlation of the limestone above the St. Peter (Simpson formation) in the Raytown well,[31] sec. 7, T. 48 N., R. 32 W., Jackson county, Missouri, as Joachim (?) by E. O. Ulrich. The Joachim is Lower Ordovician in age and is much older than the Viola of Oklahoma.

The records of the Bonner Springs well, sec. 20, T. 11 S., R. 23 E., Bonner Springs, Wyandotte county, show 190 feet of Galena-Platteville limestone, and the Smith et al. No. 1 Smith well in the SW cor. SE¼ sec. 28, T. 12 S., R. 19 E., Douglas county, logged 185 feet. The average thickness over the area under discussion is somewhat less, being about 110 feet.

The Galena-Platteville series consists of white to brown dolomite and limestone, very often cherty and in some instances sandy. The description of the Galena-Platteville in the Smith et al. No. 1 Smith well in the SW cor. SE¼ sec. 28, T. 12 S., R. 19 E., Douglas county, will serve to give the detailed lithology of these beds.

Smith et al. No. 1 Smith, SW cor. SE¼ sec. 28, T. 12 S., R. 19 E.

ORDOVICIAN SYSTEM:	Thickness in feet	Depth in feet
Galena-Platteville limestone (185 feet)—		
Gray and brown dense limestone	5	1,895
White to cream colored dense limestone, greenish shale	25	1,920
Coarse rounded frosted sand, white limestone	10	1,930
White to cream colored crystalline limestone	10	1,940
Coarse rounded frosted sand, fine angular sand	15	1,955
Hard bluish chert, dull white chert, white limestone	15	1,970
Brown translucent chert, brown dolomitic limestone	5	1,975
Brown coarsely crystalline dolomitic limestone, brown chert	35	2,010
Dense white chert, white crystalline dolomitic limestone	5	2,015
Brown coarsely crystalline dolomitic limestone, white chert	25	2,040
Brown coarsely crystalline dolomitic limestone	35	2,075

The Galena-Platteville limestone of the Empire Oil and Refining Company No. 1 Schwalm well in the SE cor. sec. 19, T. 12 S., R. 11 E., Wabaunsee county, is somewhat different and is recorded here to show the variations.

31. Wilson, M. E.: Occurrence of oil and gas in Missouri. Missouri Bur. Geology and Mines, vol. XVI, 2d ser., p. 143, 1922.

Empire Oil & Refining Company No. 1 Schwalm, SE cor. sec. 19, T. 12 S., R. 11 E.

ORDOVICIAN SYSTEM:

	Thickness in feet	Depth in feet
Galena-Platteville limestone (118 feet)—		
White very coarsely crystalline dolomitic limestone.....	18	3,300
Brown very coarsely crystalline dolomitic limestone.....	19	3,319
Brown translucent chert, brown dolomitic limestone.....	7	3,326
Brown coarsely crystalline dolomitic limestone, brown chert	14	3,340
Soft gray fissile shale.....	12	3,352
Cream colored to brown crystalline dolomitic limestone..	37	3,389
Soft gray fissile shale.....	7	3,396
Brown coarsely crystalline dolomitic limestone.....	4	3,400

The Galena-Platteville beds have been studied by means of insoluble residues. Their characteristic residues are brown mottled chert and brown and green dolocastic shales. The chert is abundant throughout the formation and ranges from light- to very dark-brown in color with a mottled appearance as a general rule. Some of the chert shows fairly coarse dolocasts widely spaced, giving the chert a pitted rather than a porous appearance. The shales are characteristically dolocastic, the casts being very fine and giving the shale a finely porous appearance. The shales are brown, green and gray in color and more compact than those found in the Siluro-Devonian residues. Granular quartzose cavity fillings are also distinctive in the Galena-Platteville residues.

St. Peter sandstone. Overlying the Siliceous limestone in northeastern Kansas is a sand series that has been variously called "Wilcox," Simpson, and St. Peter. The name "Wilcox" is not suitable because Edson[32] has shown by her petrographic work that the true "Wilcox" of the Simpson formation is not extensive in Kansas, probably not extending north of the El Dorado field in Butler county. McClellan[33] states: "Since the 'Wilcox' sand closely resembles several similar sands in the Simpson formation, the oil fraternity commonly applies the name to any Simpson sand. For this reason, would it not be well to abandon the name entirely?"

The name St. Peter is suggested by Barwick,[34] who states that this horizon is very similar lithologically to the St. Peter sandstone of Minnesota, Illinois, Iowa, Wisconsin, Missouri, Arkansas and northeast Oklahoma, and appears to occupy the same stratigraphic position. Correlation with wells in southwestern Iowa indicates

32. Edson, F. C.: Pre-Mississippian sediments in central Kansas. Am. Assoc. Petroleum Geologists, Bull., vol. 13, No. 5, pp. 449-452, 1929.

33. McClellan, Hugh: Subsurface distribution of pre-Mississippian rocks of Kansas and Oklahoma. Am. Assoc. Petroleum Geologists, Bull., vol. 14, No. 12, pp. 1540-1541, 1930.

34. Barwick, John S.: Salina Basin of north-central Kansas. Am. Assoc. Petroleum Geologists, Bull., vol. 12, No. 2, p. 185, 1928.

that the St. Peter sandstone extends into northeastern Kansas in the Forest City Basin.

The Simpson formation in northeastern Oklahoma was differentiated into the following three parts by White:[35] Burgen sand, Tyner formation, and "Wilcox" sand. McClellan's map[36] shows the Burgen pinching out before it reaches Kansas and the Tyner formation extending only into Cowley and Sumner counties, Kansas. Edson[37] made many heavy mineral analyses of the Simpson formation of Kansas. Her analyses show that the upper Simpson or "Wilcox" is very restricted in Kansas. She finds that the middle zone of the Simpson formation is the most extensive in this state. The middle zone is stratigraphically lower than "Wilcox" sand and is the zone called Tyner by White.[38] The lowest member of the Simpson formation, the so-called "Hominy" sand or the Burgen sand, was found by Edson in only a very few Kansas wells.

The St. Peter sandstone is composed of rounded to angular sand, often frosted. Minor amounts of green shale and gray dolomite occur in zones in the formation. Locally, thin beds of "oölitic" hematite are found. The sand is in general "Wilcox" type sand, a moderately coarse rounded frosted sand, and is usually easily recognized. It ranges from 60 to 100 feet in thickness in northeastern Kansas. The record of the Leavenworth well,[39] Leavenworth, Kansas, shows an abnormal thickness of St. Peter, 160 feet, and at the same time a subnormal thickness of Galena-Platteville limestone, 30 feet, which suggests that some of the Galena-Platteville dolomites may have been called sand and put in with the St. Peter sandstone.

Cambro-Ordovician

"Siliceous Lime." The thick dolomitic limestone series below the St. Peter sandstone is composed of beds that are Early Ordovician and Upper Cambrian in age. These dolomitic beds are also known as Arbuckle limestone after the Arbuckle Mountain section of southern Oklahoma, but that name will not be used here because of a closer relationship to the Early Ordovician and Upper Cambrian beds encountered in wells in northwestern Missouri and south-

35. White, Luther H.: Subsurface distribution and correlation of the pre-Chattanooga ("Wilcox" sand) series of northeastern Oklahoma. Okla. Geol. Survey, Bull. 40, vol. I, pp. 21-40, 1928.

36. McClellan, Hugh: Op. cit.

37. Edson, F. C.: Op. cit.

38. White, Luther H.: Op. cit.

39. Hinds, Henry, and Greene, F. C.: Geol. Atlas of the United States, Leavenworth-Smithville Folio (No. 206). U. S. Geol. Survey, 1917.

western Iowa. The classification of these lower beds in Iowa follows:[40]

Ordovician System:	Cambrian System:
Maquoketa	Jordan
Galena	St. Lawrence (Trempealeau, Franconia)
Decorah	Dresbach
Platteville	Eau Claire
Glenwood	Mt. Simon
St. Peter	
Prairie du Chien (Shakopee, New Richmond, Oneota)	

The classification of the Lower Ordovician and Cambrian beds in Missouri[41] is given for comparison with the Iowa classification.

Ordovician System:	Cambrian System:
St. Peter	Proctor
Everton	Eminence
Smithville	Potosi
Powell	Derby-Doerun
Cotter	Davis
Jefferson City	Bonneterre
Roubidoux	Lamotte
Gasconades	
Van Buren-Gunter	

The detailed study of the lithology of the "Siliceous lime" along with the study of the insoluble residues derived from them has led to the correlation of zones of the "Siliceous lime" with certain formations of the Missouri Cambro-Ordovician series. Mr. C. Brewer and the writer have examined the residues from all of the available "Siliceous lime" samples in northeastern Kansas and by comparison with McQueen's[42] descriptions of residues have correlated quite definitely three zones in the "Siliceous lime" with the Cotter, Roubidoux and Bonneterre of the Missouri section, respectively. The Cotter equivalent of the "Siliceous lime" is the upper part and is characterized by abundant chert, much of it oölitic. The Roubidoux equivalent is characterized by abundant quartz sand, and the Bonneterre equivalent (the basal portion of the "Siliceous lime") is marked by brown and green dolocastic shale. These correlations, based on insoluble residues, establish quite specifically the age of the "Siliceous lime" as Late Cambrian and Lower Ordovician. While the study of insoluble residues in the Kansas Cambro-Ordovician has been limited by lack of samples, it indicates that this method of

40. Norton, W. H.: Deep wells of Iowa. Iowa Geol. Survey, vol. XXXIII, p. 24, 1928.

41. McQueen, H. S.: Insoluble residues as a guide in stratigraphic studies. Missouri Bur. Geology and Mines, 56th Bien. Rep., 1931.

42. McQueen, H. S.: Op. cit.

correlation will prove to be of decided help in identifying the pre-Pennsylvanian limestones.

The "Siliceous lime" thins to the north and west and ranges from 760 feet in the Universal Oil Company No. 1 Harrington well in the NE cor. SW¼ sec. 12, T. 14 S., R. 22 E., Johnson county, to 450 feet in the Forrester et al. No. 1 Hummer well in the cen. SW¼ sec. 14, T. 11 S., R. 16 E., Shawnee county.

Lithologically the "Siliceous lime" consists of dolomitic limestones which are locally cherty, and thin beds of rounded quartz sand. The description of the section in the Forrester et al. No. 1 Hummer well in the cen. SW¼ sec. 14, T. 11 S., R. 16 E., Shawnee county, shows the detailed lithology of the beds.

Forrester et al. No. 1 Hummer, cen. SW¼ sec. 14, T. 11 S., R. 16 E.

CAMBRO-ORDOVICIAN: "Siliceous lime" (430 feet)—	Thickness in feet	Depth in feet
White and buff crystalline dolomite, chert, and sand	40	2,590
White crystalline dolomite	100	2,690
White crystalline dolomite, white chert	20	2,710
White crystalline dolomite, fine angular sand	25	2,735
White crystalline dolomite, white limestone	25	2,760
White and buff crystalline dolomite, white earthy chert	50	2,810
Gray crystalline dolomite, greenish shale	55	2,865
Gray and buff crystalline dolomite, greenish shale	25	2,890
Buff-colored crystalline dolomite	40	2,930
No sample	20	2,950
Gray coarsely crystalline dolomite, rounded frosted sand,	30	2,980

BASAL SAND. The majority of the wells that were drilled to granite in northeastern Kansas encountered a coarse, arkosic sand that has been called the basal sand by some and Reagan sand by others. It is apparently equivalent to the Reagan sand of Oklahoma and the Lamotte sand of Missouri. However, this correlation is only applicable when the "Siliceous lime" section is complete, and in places where Ordovician or younger rocks are immediately above the basal sand it can be much younger than Cambrian in age. In northeastern Kansas the lower part of the "Siliceous lime" appears to be present, thus making the basal sand Cambrian in age.

The sand is the product of the erosion of the pre-Cambrian rocks and is usually coarse and angular and often quite arkosic. It varies greatly in thickness throughout the state, but in northeastern Kansas it is comparatively thin. In the Green et al. No. 1 Ripley well in the NW cor. NE¼ sec. 12. T. 12 S., R. 16 E., Shawnee county, only 8 feet of basal sand was reported, and in the Universal Oil Company No. 1 Harrington well in the NE cor. SW¼ sec. 12, T. 14 S., R. 22 E., Johnson county, 35 feet of basal sand was penetrated before reaching the pre-Cambrian rocks.

Pre-Cambrian

Many of the wells drilled in northeastern Kansas reached the pre-Cambrian basement rocks and several were drilled into the crystalline rocks a considerable distance because of failure to recognize them as being pre-Cambrian in age.

In a report on the pre-Cambrian rocks of Kansas, Kenneth K. Landes[43] describes the various kinds of rocks making up the pre-Cambrian basement, and gives several cases of useless drilling into the crystalline rocks that resulted from insufficient knowledge of their texture and composition. Landes states that most of the wells east and west of the Granite Ridge struck granite or gneiss, but that schist is not uncommon. The Beattie well in Marshall county penetrated nearly 2,000 feet of pre-Cambrian schists and the Greitkreutz well in northern Greenwood county penetrated 650 feet of schist which was logged as shale. In addition to granite or gneiss and schist, quartz porphyry and quartzite are reported to have been found in wells that struck the pre-Cambrian.

The common conception is that the pre-Cambrian is granite and often when schist is encountered it is not recognized as being pre-Cambrian. The amount of drill-steel in the cuttings is often useful in this respect in that the pre-Cambrian rocks are usually hard to drill and as a consequence the percentage of drill-steel in the cuttings is usually higher than it is in cuttings from the sedimentary beds.

Atchison County

The oil and gas development in Atchison county has been very slow. This is probably due to the mantle of glacial drift and loess that covers most of the outcrops of the underlying rocks. Structures are extremely hard to map because of the lack of outcrops in the northeastern counties of Kansas. There have been only six wells drilled for oil or gas in Atchison county, two deep wells and four shallow wells. None of these have been productive, although shows of oil and gas were reported in the Oak Mills well in the NE cor. sec. 13, T. 7 S., R 21 E. The Oak Mills well was drilled by the Indian Mound Oil Company to a depth of 3,085 feet, although the log record is only to 2,890 feet. Mr. S. S. King, who furnished the log, reported about 7 feet of red rock below 2,890, 10 or 15 feet of black, dirty, sticky material, about 100 feet of what appeared to be rotten granite, and then 10 or 15 feet more of the black, dirty, sticky

43. Landes, Kenneth K.: A petrographic study of the pre-Cambrian of Kansas. Am. Assoc. Petroleum Geologists, Bull., vol. 11, No. 8, pp. 821-824, 1927.

material. From the description of beds below 2,890 by Mr. King, it appears that the granite was encountered at about 2,900 feet. The black material probably was schist. The stratigraphic record of the Oak Mills well is given below.

Indian Mound Oil Co. No. 1 Oak Mills, NE cor. sec. 13, T. 7 S., R. 21 E.

FORMATION:	Thickness in feet	Depth in feet
Pleistocene (35 feet)—		
Sand and loess	35	0-35
Pennsylvanian System—		
Bronson-Lansing groups	365	35-400
Marmaton-Bourbon groups	180	400-580
Cherokee shale	670	580-1,250
Mississippian System—		
"Mississippi lime"	410	1,250-1,660
Kinderhook shale	90	1,660-1,750
Silurian and Devonian Systems—		
Siluro-Devonian formation	170	1,750-1,920
Ordovician System—		
Maquoketa shale	3	1,920-1,923
Galena-Platteville limestone	192	1,923-2,115
St. Peter sandstone	80	2,115-2,195
Cambro-Ordovician System—		
"Siliceous lime"	635	2,195-2,830
Basal sand	60	2,830-2,890
Pre-Cambrian System—		
Granite and schist	185	2,900?-3,085 T.D.

As no samples were available from this well it is difficult to correlate the limestones between the base of the Kinderhook shale and the top of the St. Peter sandstone. The unusual thickness suggests that it cannot be entirely Galena-Platteville limestone. The upper 170 feet of the limestones are assigned to the Siluro-Devonian formation, the 3-foot shale is considered as representing the Maquoketa shale, and the lower 192 feet is regarded as Galena-Platteville limestone. Shows of gas were reported in the Oak Mills well at 574 feet, 1,400 feet, and 2,830 feet. A show of oil was reported in the basal sand at 2,830-2,890 feet.

The record of the diamond drill hole at Atchison, in the SW cor. NE¼ sec. 18, T. 6 S., R. 21 E., is given in Bulletin 3 of the Kansas Geological Survey.[44] Their correlations of this well are as follows:

44. Moore, Raymond C., and Haynes, Winthrop: Oil and gas resources of Kansas. Kansas Geol. Survey, Bull. 3, pp. 222-224, 1917.

Stratum:	Thickness in feet	Depth in feet
Clay and loose rock	18	18
PENNSYLVANIAN SYSTEM:		
Douglas formation—		
Lawrence shale:		
Shale, clayey	6	24
Sandstone	7	31
Shale, blue	33	64
Sandstone	1	65
Shale, blue	40	105
Iatan limestone (?):		
Limestone (?), conglomeratic	2	107
Weston shale:		
Shale, sandy	53	160
Sandstone	7	167
Shale, blue	9	176
Sandstone	3	179
Shale, sandy	11	190
Sandstone	34	224
Limestone	2	226
Shale, blue	8	234
Sandstone	2	236
Shale, sandy	3	239
Sandstone	5	244
Lansing formation—		
Stanton limestone:		
Limestone	20	264
Sandstone	4	268
Limestone	1	269
Vilas shale:		
Sandstone	12	281
Shale, blue	2	283
Plattsburg limestone:		
Limestone	8	291
Lane shale:		
Shale, sandy	35	326
Kansas City formation—		
Iola limestone:		
Limestone	11	337
Shale, blue	3	340
Limestone	9	349
Chanute shale:		
Shale, blue and black	4	353
Limestone	1	354
Shale, blue	9	363
Limestone	5	368
Shale	10	378
Limestone	5	383
Shale, with limestone	4	387
Limestone	1	388
Shale, blue	4	392
Drum limestone (?):		
Limestone	5	397
Cherryvale shale:		
Shale	11	408
Limestone	3	411
Shale, blue	1	412
Conglomerate	8	420

	Thickness in feet	Depth in feet
Shale, blue	7	427
Conglomerate	2	429
Limestone	6	435
Conglomerate	4	439
Winterset limestone:		
Limestone	15	454
Bethany Falls limestone:		
Shale, blue	8	462
Limestone	19	481
Shale, black	5	486
Hertha limestone:		
Limestone	16	502
Marmaton formation—		
Pleasanton shale:		
Shale	6	508
Sandstone, coal, 1 inch	5	513
Shale, sandy	6	519
Limestone	1	520
Walnut shale:		
Shale, sandy	42	562
Shale, blue, clayey	22	584
Sandstone	5	589
Shale, clayey	24	613
Limestone	1	614
Bandera shale:		
Shale, clayey	4	618
Sandstone	4	622
Shale, blue, clayey	5	627
Shale, black, soft	4	631
Pawnee limestone:		
Limestone	4	635
Shale, with limestone	8	643
Shale, blue	6	649
Shale and limestone	2	651
Shale, blue	2	653
Shale and limestone	5	658
Limestone	4	662
Labette shale:		
Shale, sandy, black	16	678
Limestone	2	680
Shale, black	2	682
Coal	1	683
Shale	2	685
Fort Scott limestone:		
Shale, limy	2	687
Limestone	5	692
Shale, limy	2	694
Limestone	3	697
Shale	10	707
Limestone	1	708
Shale and limestone	4	712
Limestone	1	713
Limestone and shale	3	716
Cherokee shale:		
Shale, black, and limestone	2	718
Shale	46	764
Coal, shale partings	1	765

	Thickness in feet	Depth in feet
Sandstone and shale	10	775
Shale, coal 2½ inches	3	778
Shale, sandy	15	793
Limestone, dark shaly	6	799
Coal, a little bony	1	800
Shale, with nodules	3	803
Limestone and shale	4	807
Shale, soft	3	810
Shale, sandy	9	819
No core	4	823
Limestone and shale	5	828
Shale	7	835
Coal	1	836
Shale	15	851
Sandstone	9	860
Shale, sandy	5	865
Sandstone	1	866
Shale	12	878
Coal	1	879
Shale (salty water)	7	886
Shale, sandy	3	889
Limestone and shale	3	892
Sandstone	11	903
Shale, sandy	6	909
Sandstone	49	958
Coal and shale partings, sandstone	17	975
Sandstone	45	1,020
Shale	23	1,043
Sandstone, light gray	20	1,063
Shale	7	1,070
Coal	2	1,072
Sandstone	6	1,078
Shale, light sandy	30	1,108
Shale, dark, carbonaceous	3	1,111
Sandstone, light gray	5	1,116
Shale, very dark	1	1,117
Sandstone and limestone, coal 1 inch	4	1,121
Sandstone, light colored	1	1,122
Coal	3	1,125
Sandstone	4	1,129
Shale, very dark	4	1,133
Coal	1	1,134
Sandstone	11	1,145
Shale, dark	3	1,148
Sandstone	2	1,150
Shale, coal	2	1,152
Sandstone	12	1,164
Shale, black, coal	1	1,165
Shale, carbonaceous	0	0
Shale, dark, fossiliferous	22	1,187
Coal	2	1,189
Shale, black	7	1,196
Coal, very brittle	2	1,198
Shale, dark	57	1,255
Coal	1	1,256
Sandstone, shaly	40	1,296
Shale, dark	2	1,298
Sandstone	16	1,314
MISSISSIPPIAN SYSTEM:		
Limestone, crystalline	38	1,352

There is no record of oil or gas shows in this well. The four shallow wells likewise were not productive of either oil or gas. Plate III shows the location of the wells drilled in Atchison county.

Brown County

The Upper Pennsylvanian beds, including parts of the Wabaunsee and Shawnee formations, and Permian beds (in the northwestern part of the county) occur in Brown county. Outcrops of the Pennsylvanian formations are not common, however, because of the mantle of loess and glacial drift. This is the main reason why so little is known regarding subsurface structures in Brown county. The result of this inability to determine and map the structures is that there has been very little geologic work done in the county and oil and gas development has been greatly retarded. One diamond drill hole was put down at Horton in sec. 33, T. 4 S., R. 17 E., to a depth of 1,108 feet. The detailed lithology is given in Bulletin 3 of the Kansas Geological Survey.[45] Only the Pennsylvanian beds are penetrated by this well. Their correlations are as follows:

Horton diamond drill hole, sec. 33, T. 4 S., R. 17 E.

Stratum	Thickness in feet	Depth in feet
Soil	37	37
PENNSYLVANIAN SYSTEM:		
Wabaunsee formation—		
Willard shale:		
Shale, soft	29	66
Limestone	5	71
Shale, gray, hard	14	85
Burlingame limestone:		
Limestone	3	88
Shale, black, slaty	3	91
Limestone	1	92
Shale, black, slaty	4	96
Limestone	4	100
Shawnee formation—		
Scranton and Severy shales:		
Shale, gray	3	103
Shale, sandy	7	110
Shale, clayey	18	128
Limestone, black, conglomerate	3	131
Coal	1	132
Shale, clayey	12	144
Conglomerate (?)	1	145
Shale, clayey	95	240
Topeka limestone (?):		
Limestone	2	242
Shale, clayey	18	260
Limestone	1	261

45. Moore, Raymond C., and Haynes, Winthrop: Oil and gas resources of Kansas. Kansas Geol. Survey, Bull. 3, pp. 228-229, 1917.

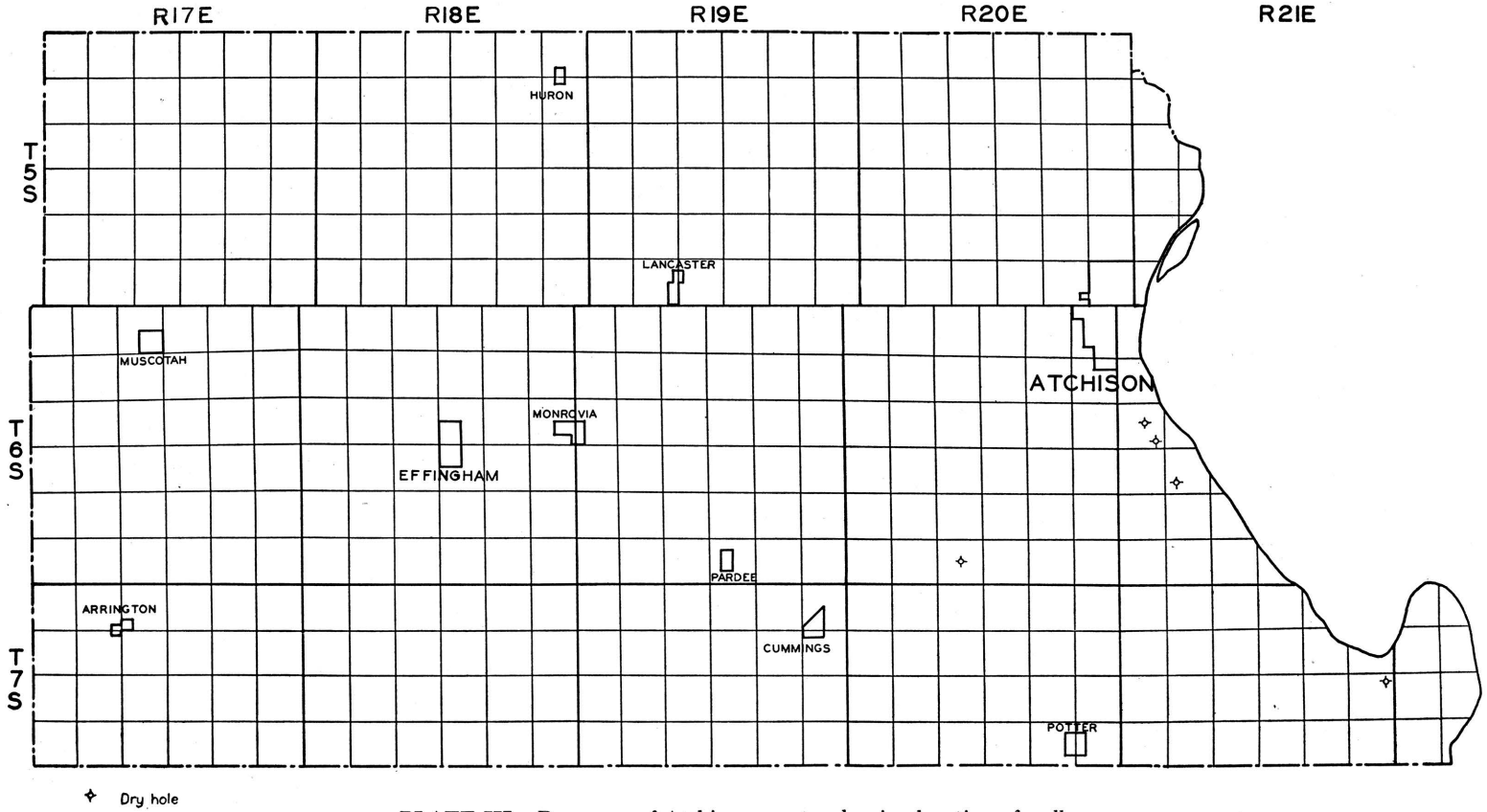


PLATE III.—Base map of Atchison county, showing location of wells.

Stratum	Thickness in feet	Depth in feet
Calhoun shale:		
Shale, sandy	30	291
Shale, clayey	8	299
Deer Creek limestone:		
Limestone	3	302
Shale, black, slaty	2	304
Limestone	5	309
Tecumseh shale:		
Shale, clayey	13	322
Lecompton limestone:		
Limestone	6	328
Shale, sandy	3	331
Limestone	3	334
Kanwaka shale:		
Shale, black, slaty	9	343
Shale, sandy	2	345
Shale, clayey	6	351
Douglas formation—		
Oread limestone:		
Limestone	28	379
Limestone, sandy	4	383
Lawrence shale:		
Shale, clayey	2	385
Sandstone (water)	6	391
Shale, micaceous	5	396
Shale, sandy	43	439
Shale, clayey	20	459
Iatan limestone:		
Limestone	15	474
Weston shale:		
Shale, black, slaty	4	478
Limestone	3	481
Shale, black, slaty	1	482
Limestone	4	486
Shale, hard	6	492
Shale, sandy (salt water)	8	500
Sandstone	13	513
Shale, hard	23	536
Limestone, conglomeratic	4	540
Shale, hard	16	556
Lansing formation—		
Stanton limestone:		
Limestone, sandy	2	558
Shale and limestone	2	560
Shale, hard	3	563
Limestone, conglomeratic	2	565
Limestone and shale	23	588
Vilas shale (?):		
Shale, black, slaty	9	597
Plattsburg limestone:		
Limestone	18	615
Lane shale:		
Shale, green	14	629
Shale, red	1	630
Shale, clayey	26	656
Sandstone	4	660

Stratum	Thickness in feet	Depth in feet
Shale, clayey	23	683
Shale, sandy	2	685
Shale, hard	23	708
Kansas City formation—		
Iola limestone:		
Limestone, blue	2	710
Shale, hard	2	712
Limestone, blue	6	718
Chanute and Cherryvale shales:		
Shale, red	8	726
Shale, sandy, micaceous	4	730
Shale, red	5	735
Shale, micaceous	31	766
Shale, clayey	34	800
Winterset limestone (?):		
Limestone	5	805
Galesburg shale (?):		
Shale, sandy, hard	13	818
Bethany Falls and Hertha limestones:		
Limestone, with sandy shale	49	867
Limestone	16	883
Marmaton formation (?)—		
Shale clay	16	899
Limestone	4	903
Shale	13	916
Limestone	9	925
Shale	12	937
Limestone	13	950
Shale	2	952
Shale, black, slaty	2	954
Limestone, conglomerate	2	956
Shale	7	963
Limestone	4	967
Shale	7	974
Limestone	13	987
Shale	10	997
Shale, slaty and limestone	99	1,096
Limestone	12	1,108

No oil and gas shows were reported in this well. Plate IV shows the location of the Horton well, Brown county.

Doniphan County

Doniphan county, in the extreme northeastern corner of Kansas, has not been tested to any extent for either oil or gas. This is probably due to two factors: First, that the structures are very difficult to map on the surface because of a thick mantle of glacial drift and loess, and secondly, that the few wells drilled were not productive and did not encourage further exploration. In 1887 a diamond drill hole was put down at Doniphan by the Diamond Prospecting Company. This well was dry and abandoned in the Cherokee shale at 998 feet. In 1917 the Southwest Oil and Gas Company drilled the

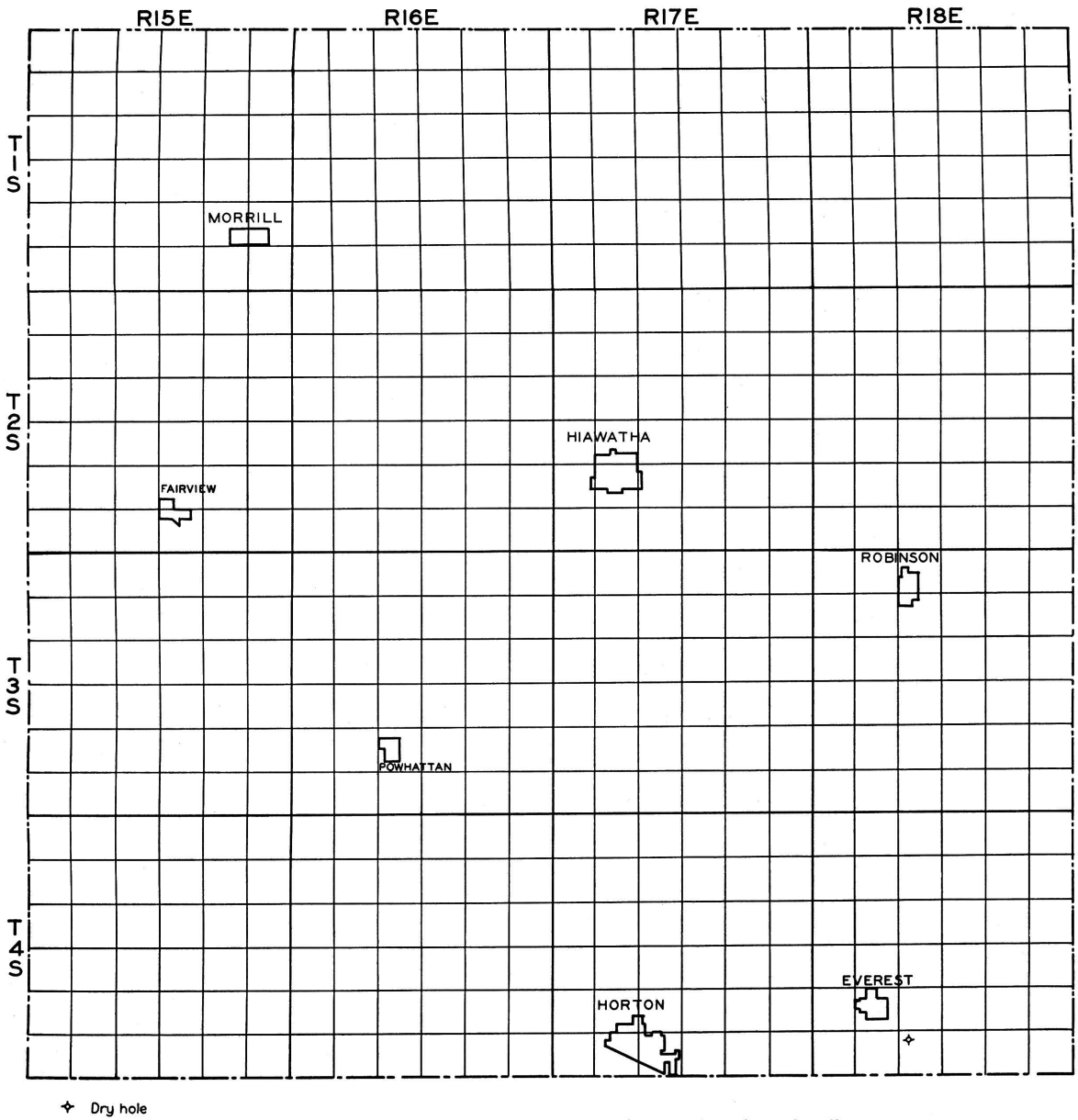


PLATE IV.—Base map of Brown county, showing location of wells.

Nity No. 1 well in the SE cor. sec. 19, T. 4 S., R. 21 E. This well did not reach the "Mississippi lime" as reported, but bottomed in the Cherokee shale at 1,571 feet. The Doniphan Oil and Gas Company drilled the Albers No. 1 well in the center of the SW¼ SE¼ sec. 14, T. 3 S., R. 19 E., to a depth of 1,725 feet in 1920 without success. The "Mississippi lime" is reported at 1,635 feet, but the limestone encountered is a limestone in the lower Cherokee and not the "Mississippi lime." A limestone hit at 1,715 may be the "Mississippi lime," but no samples are available and the determination cannot be checked.

The exact location of the Stout No. 1 well drilled in sec. 19, T. 3 S., R. 20 E., is not available, nor is the date of drilling. It was drilled to 1,500 feet and abandoned in the Cherokee shale. Stout No. 2 in the Cen. NW¼ sec. 30, T. 3 S., R. 20 E., was drilled to 2,120 feet and abandoned. The section it penetrated is given below:

Stout No. 2, Cen. NW¼ sec. 30, T. 3 S., R. 20 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Shawnee group	325	surface-325
Douglas-Pedee groups	125	325-450
Bronson-Lansing groups	375	450-825
Marmaton-Bourbon groups	180	825-1,005
Cherokee shale	770	1,005-1,775
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	235	1,775-2,010
Kinderhook shale	110	2,010-2,120 T.D.

The Valley Petroleum Company completed the John Mann well, SE¼ NW¼ sec. 21, T. 1 S., R. 19 E., in 1927. The well was dry and abandoned at 2,315 feet in the Siluro-Devonian formation.

Valley Petroleum Co. No. 1 Mann, SE¼ NW¼ sec. 21, T. 1 S., R. 19 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Shawnee group	440	surface-440
Douglas-Pedee groups	200	440-640
Bronson-Lansing groups	320	640-960
Marmaton-Bourbon groups	170	960-1,130
Cherokee shale	845	1,130-1,975
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	230	1,975-2,205
Kinderhook shale	76	2,205-2,281
SILURIAN AND DEVONIAN SYSTEMS:		
Siluro-Devonian formation	34	2,281-2,315 T.D.

Cuttings were not saved from this well, but the lithology of the formations is very similar to that in the W. F. Davis well near Forest City, Missouri. A complete lithologic and stratigraphic description of the Davis well is given in Volume 13 of the Missouri

Bureau of Geology and Mines.[46] The log of the Forest City well and the log of the Marysville well,[47] Marysville, Missouri, are included in the cross-section of northeastern Kansas, Plate II. The location of the wells drilled in Doniphan county is shown on Plate V.

Douglas County

The surface rocks of Douglas county belong to the Shawnee and Douglas groups of Upper Pennsylvanian age. The eastern portion of the county is underlain with beds of the Douglas group. The western portion is occupied by beds of the Shawnee group. The escarpment of the Oread limestone formation is prominent in Douglas county. The strata in Douglas county generally dip slightly to the west, but are almost horizontal in places. Oil and gas have been found in commercial quantities in eastern and southern Douglas county, but development has been slow.

For many years there has been sporadic drilling in Douglas county, but with the exception of the Baldwin area and the Eudora area, no commercial production has been found.

The Baldwin oil field, in secs. 2, 9, 11, 12, 13, and 14, T. 15 S., R. 20 E., was opened in 1919 by a well drilled in sec. 12, T. 15 S., R. 20 E. The oil was found in sand at a depth of about 800 feet. The wells have an average initial production of about 20 barrels per day. In some wells the initial production was as high as 220 barrels per day, but the decline was rapid. Because of the small size of the wells and the relatively heavy grade of oil, activity has not been great in the Baldwin field and no pipe lines have been built. Some of the oil is used in Baldwin. The oil is found in sand at about 800-830 feet in the top of the Cherokee shales. It is probably the Squirrel sand. It averages about 20 feet in thickness. Some gas is found in the Peru sand, in the top of the Marmaton group, but this is not very important. A typical section of the Baldwin oil wells is given below.

Webster No. 3, SE cor. NW¼ sec. 9, T. 15 S., R. 20 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Douglas-Pedee groups	190	0-190
Bronson-Lansing groups	375	190-565
Marmaton-Bourbon groups	232	568-800
Cherokee shale	59	800-859 T.D.
Squirrel sand	23	831-854

46. Hinds, Henry, and Greene, F. C.: The stratigraphy of the Pennsylvanian series in Missouri. Missouri Bur. Geology and Mines, vol. XIII, 2d ser., pp. 215-239, 1914.

47. Idem, pp. 230-244.

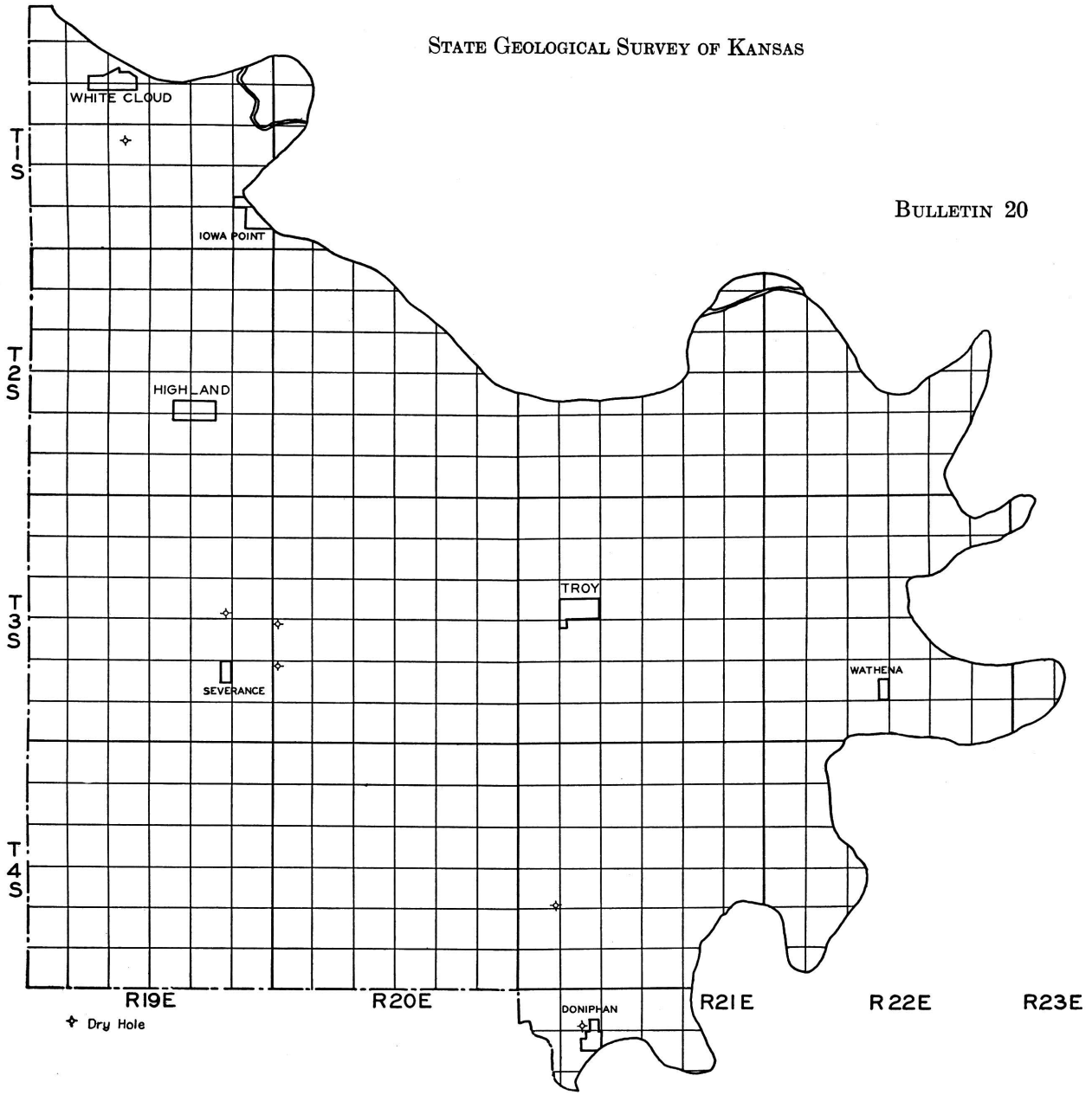


PLATE V.—Base map of Doniphan county, showing location of wells.

North and east of Baldwin a small gas field has been developed. The wells found gas in the Squirrel sand at about 820 feet and ranged up to 1,000,000 cubic feet of gas per day initial production. This area has never been of great importance, however.

In northeastern Douglas county, in the vicinity of Eudora, a number of gas wells have been drilled. There are two districts of gas production in the Eudora field, one on the east side of Eudora, and the other about three miles south of Eudora. The records of the wells at Eudora show that the gas is being produced from the Peru sand, in the upper Marmaton group, at a depth of 340 feet. The sand varies considerably in thickness, one well recording 70 feet, but it probably averages about 20 feet. The wells in the district south of Eudora have an average initial production of about 500,000 cubic feet of gas per day, with an initial rock pressure of about 210 pounds. The important gas horizon in this area is the Squirrel sand, found at a depth of 700 feet. The sand averages less than 20 feet in thickness. Some gas is found in the Peru sand at a depth of 340 feet. A typical section for this area is given below.

Hannan et al. No. 1 *Bartz, NW cor. sec.* 20, *T.* 13 *S., R.* 21 *E.*

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Bronson-Lansing groups	340	0-340
Marmaton-Bourbon groups	220	340-560
Cherokee shale	125	560-685 T.D.
Squirrel sand	10	662-672

There has been no recent drilling in this area, but further development can be expected as the region has not been thoroughly investigated and drilled.

Only one deep test has been drilled in Douglas county, the Al Smith et al. No. 1 Smith in the SW cor. SE¼ sec. 28, T. 12 S., R. 19 E. It was drilled to a total depth of 2,382 feet and was abandoned. An excellent set of cuttings was obtained from this well and has served to give an accurate stratigraphic description of the well.

Al Smith et al. No. 1 *Smith, SW cor. SE¼ sec.* 28, *T.* 12 *S., R.* 19 *E.*

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Shawnee group	68	0-68
Douglas-Pedee groups	290	68-358
Bronson-Lansing groups	337	358-695
Marmaton-Bourbon groups	218	695-913
Cherokee shale	558	913-1,471
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	331	1,471-1,802
Kinderhook shale	92	1,802-1,894

Formation	Thickness in feet	Depth in feet
ORDOVICIAN SYSTEM:		
Galena-Platteville limestone	187	1,894-2,081
St. Peter sandstone	74	2,081-2,155
CAMBRO-ORDOVICIAN SYSTEM:		
"Siliceous lime"	127	2,155-2,382 T.D.

This well is included in the east-west cross-section of the Forest City Basin, Plate I.

Recent work suggests the presence of a northwest-southeast pre-Pennsylvanian structural trend which J. V. Howell has called the Iola anticline. Plate VI shows the location of the fields in Douglas county.

Jackson County

Jackson county lies almost entirely within the belt of outcrop of the Wabaunsee group of the Pennsylvanian. As in the neighboring counties, however, these outcrops are masked in many places by glacial drift and loess deposits so that geologic work is difficult and exploration for oil and gas has been hindered. Two attempts to secure deep oil production were made in 1928 by the Garvin et al. No. 1 Lutz well in the SW¼ NW¼ NW¼ sec. 27, T. 7 S., R. 15 E., and the Goens et al. No. 1 Wabense well in the center NE¼ NW¼ sec. 3, T. 8 S., R. 14 E. Both wells were drilled to the Siluro-Devonian formation. The Lutz well was reported to have had a show of oil on top of the Siluro-Devonian formation at 2,639 feet, but neither well was productive of oil or gas. Three shallow wells have also been drilled in Jackson county, none of which reached the "Mississippi lime." The Charles Wheeler well, in sec. 28, T. 6 S., R. 16 E., found the Bronson-Lansing group at 775-1,095 feet and bottomed in the Marmaton at 1,200 feet. No shows of oil or gas were reported. The diamond drill hole at Hoyt, sec. 23, T. 9 S., R. 15 E., struck the Bronson-Lansing group at 978 and finished in it at 1,246 feet. The log of the well drilled to 1,000 feet at Adrian is not reliable and no definite correlation can be made for it.

The correlation of the formations penetrated by the Lutz well is given below.

Garvin et al. No. 1 Lutz, SW¼ NW¼ NW¼ sec. 27, T 7 S., R. 15 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Wabaunsee group	430	0-430
Shawnee group	370	430-800
Douglas-Pedee groups	215	800-1,015
Bronson-Lansing groups	350	1,015-1,365
Marmaton-Bourbon groups	190	1,365-1,555
Cherokee shale	655	1,555-2,210

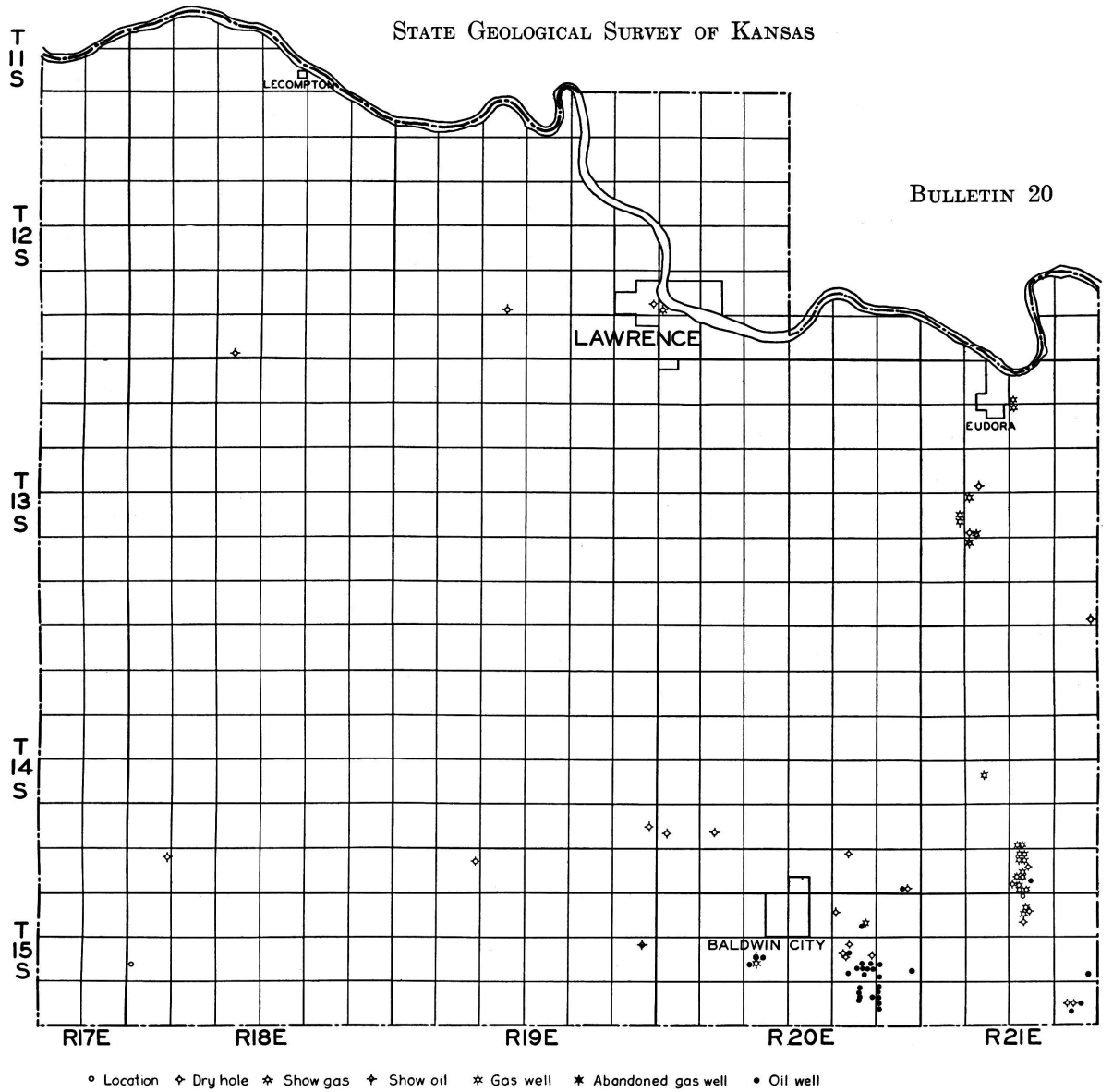


PLATE VI.—Base map of Douglas county, showing location of wells.

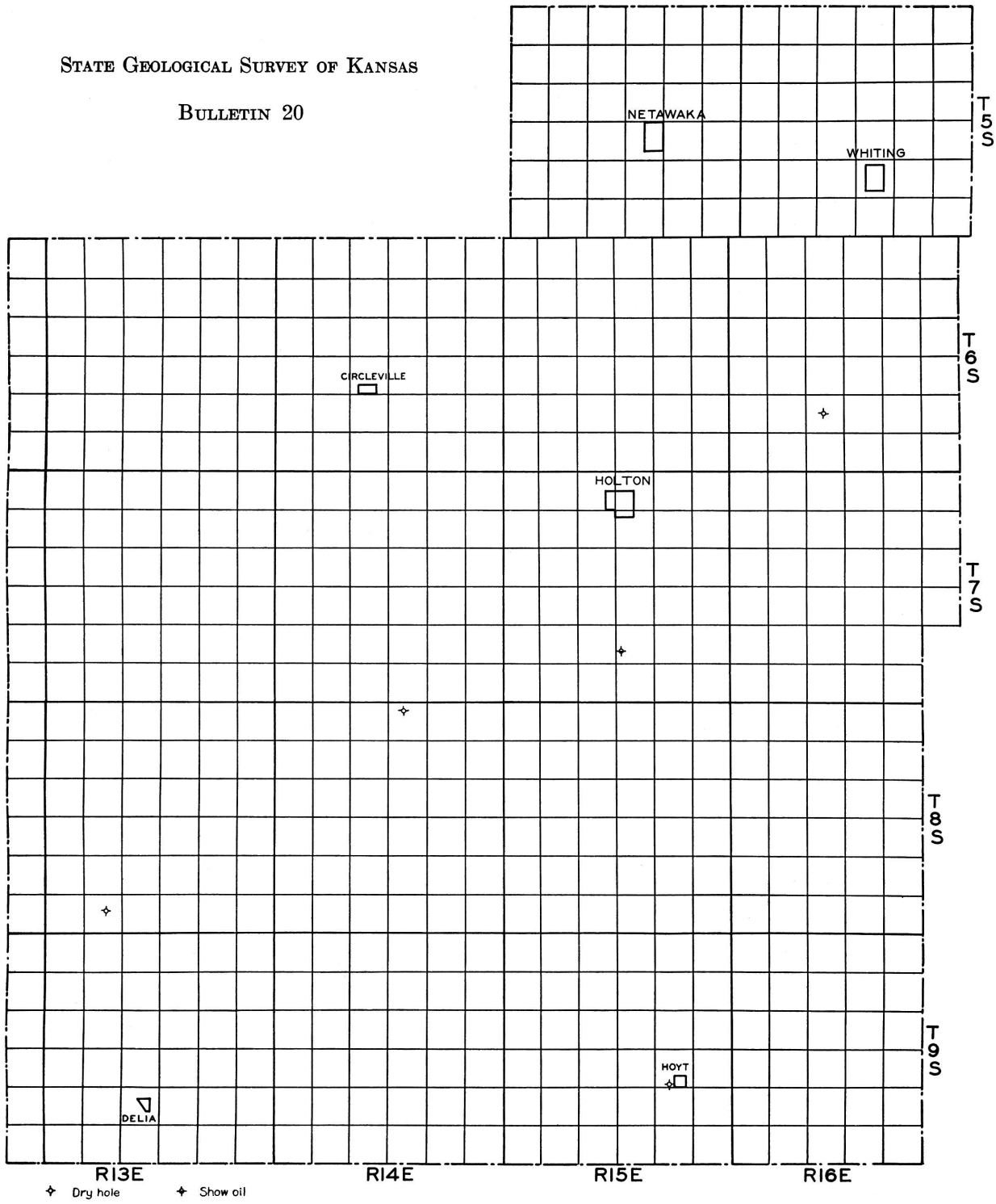


PLATE VII.—Base map of Jackson county, showing location of wells.

Formation	Thickness in feet	Depth in feet
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	265	2,210-2,475
Kinderhook shale	164	2,475-2,639
SILURIAN AND DEVONIAN SYSTEMS:		
Siluro-Devonian formation	135	2,639-2,774 T.D.

The section penetrated by the Wabense well is very similar to that of the Lutz well and is given here for comparison.

Goens et al. No. 1 Wabense, cen. NE¼ NW¼ sec. 3, T. 8 S., R. 14 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Wabaunsee group	655	0-655
Shawnee group	405	655-1,060
Douglas-Pedee groups	200	1,060-1,260
Bronson-Lansing groups	330	1,260-1,590
Marmaton-Bourbon groups	210	1,590-1,800
Cherokee shale	600	1,800-2,400
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	192	2,400-2,592
Kinderhook shale	240	2,592-2,832
SILURIAN AND DEVONIAN SYSTEMS:		
Siluro-Devonian formation	121	2,832-2,953 T.D.

Plate VII shows the location of the wells in Jackson county. It will be noted that there has been no systematic drilling in the county. Until further careful drilling has been done one cannot predict the oil and gas possibilities of this county. The Lutz well and the Wabense well are included in the north-south cross-section through the Forest City Basin, Plate II.

Jefferson County

Rocks of Upper Pennsylvanian age outcrop over Jefferson county, those of the Shawnee group occupying most of the county. There is considerable glacial material throughout the county, but the Pennsylvanian rocks are not covered as much as in the more northerly counties. Comparatively little structural mapping has been done in this county and oil and gas exploration has been very slow so that the oil and gas possibilities are uncertain as yet. The "Mississippi lime" has been tested by two wells with a reported showing of gas in one well. The pre-Mississippian rocks have not yielded oil or gas.

The earliest recorded well is the one at Valley Falls, located in the center of the SW¼ NE¼ sec. 19, T. 8 S., R. 18 E. It was drilled to a depth of 1,173 feet and abandoned. The record of this well is given in Bulletin 3,[48] in which it is correlated according to the old

48. Moore, Raymond C., and Haynes, Winthrop: Oil and gas resources of Kansas. Kansas Geol. Survey, Bull. 3, pp. 289-290, 1917.

Pennsylvanian classification. The section penetrated, according to the revised Pennsylvanian classification is as follows:

Valley Falls well, cen. SW¼ NE¼ sec. 19, T. 8 S., R. 18 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Wabaunsee group	13	17-40
Shawnee group	202	40-242
Douglas-Pedee groups	258	242-500
Bronson-Lansing groups	310	500-810
Marmaton-Bourbon groups	169	810-979
Cherokee group	194	979-1,173 T.D.

The John Freeland well, in sec. 27, T. 7 S., R. 17 E., was completed in 1921 at a depth of 1,594 feet as a dry hole. It is reported to have hit the "Mississippi lime" at 1,590 feet. No samples from this well are available to check this correlation, but it is the writer's opinion that the "Mississippi lime" is deeper than 1,590 feet at that location.

The Winchester well, drilled by the Northern Oil and Gas Company, in the NW cor. NW¼ sec. 13, T. 9 S., R. 19 E., was abandoned at 3,615 feet. Oil and gas shows were reported at 2,085-2,092 feet, in the St. Peter sandstone, and at 2,365-2,375 feet in the "Siliceous lime." The formations from 3,100 feet to 3,300 feet were reported to have been saturated with oil and also from 3,300 feet to 3,420 feet oil saturation and gas shows were reported. Samples from this well at 3,280, 3,390, and 3,420 feet were submitted to the Kansas Geological Survey. The cuttings from 3,280 and 3,390 feet were identified as igneous by Dr. K. K. Landes of the Survey. The sample from 3,420 was not identifiable because of its heterogeneous character. The writer believes that the pre-Cambrian surface was reached considerably above 3.280 feet. The dark "shales" and red "shales" below 3,016 strongly suggest schists of pre-Cambrian age, because the usual sequence below the "Siliceous lime" is a basal sand and then pre-Cambrian rocks. Putting the contact of the pre-Cambrian at 3,016 still leaves a very thick section of "Siliceous lime" in this well.

Northern Oil & Gas Co. No. 1 Winchester, NW cor. NW¼ sec. 13, T. 9 S., R. 19 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Shawnee group	245	0-245
Douglas-Pedee groups	235	245-480
Bronson-Lansing groups	340	480-820
Marmaton-Bourbon groups	205	820-1,025
Cherokee shales	595	1,025-1,620

Formation	Thickness in feet	Depth in feet
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	285	1,620-1,905
Kinderhook shale	70	1,905-1,975
ORDOVICIAN SYSTEM:		
Galena-Platteville limestone	110	1,975-2,085
St. Peter sandstone	35	2,085-2,120
CAMBRO-ORDOVICIAN SYSTEM:		
"Siliceous lime"	896?	2,120-3,016?
Pre-Cambrian	..	3,016?-3,615 T.D.

The Anderson Drilling Company recently completed two wells north of Perry, Kansas, the Stines No. 1 in the NE cor. of sec. 10, T. 11 S., R. 18 E., and the Gramse No. 1 in the SE¼ SE¼ sec. 4, T. 11 S., R. 18 E. The Stines No. 1 was drilled to 1,565 feet and reported an oil show in the Bartlesville sand at 1,405-1,440 feet. Correlation with the Gramse well showed that the reported "Mississippi lime" at 1,565 feet was a limestone in the lower part of the Cherokee shale about 70 feet above the top of the true "Mississippi lime." The stratigraphic section of the Stines well is given below.

Anderson Drilling Co. No. 1 *Stines, NE cor. sec.* 10, *T.* 11 *S., R.* 18 *E.*

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Shawnee group	279	0-279
Douglas-Pedee groups	256	279-535
Bronson-Lansing groups	345	535-880
Marmaton-Bourbon groups	198	880-1,078
Cherokee shale	487	1,078-1,565 T.D.

The Gramse well in the SE¼ SE¼ sec. 4, T. 11 S., R. 18 E., tested the St. Peter sandstone with no oil or gas in the pre-Mississippian formations. A strong flow of gas was reported on top of the "Mississippi lime" at 1,536 feet, but was not sufficient to be commercial. The well found water in the St. Peter sandstone and was abandoned. The section of the Gramse well is as follows:

Anderson Drilling Co. No. 1 *Gramse, SE¼ SE¼ sec.* 4, *T.* 11 *S., R.* 18 *E.*

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Shawnee group	173	0-173
Douglas-Pedee groups	252	173-425
Bronson-Lansing groups	355	425-780
Marmaton-Bourbon groups	194	780-974
Cherokee shale	562	974-1,536
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	334	1,536-1,870
Kinderhook shale	75	1,870-1,945
SILURIAN AND DEVONIAN SYSTEMS:		
Siluro-Devonian formation	142	1,945-2,087

Formation	Thickness in feet	Depth in feet
ORDOVICIAN SYSTEM:		
Maquoketa shale	47	2,087-2,130
Galena-Platteville limestone	124	2,130-2,254
St. Peter sandstone	70	2,254-2,324 T. D.

There has been an increasing interest in the oil and gas development and exploration in Jefferson county. Results have been encouraging in that gas and oil shows have been reported, but no commercial wells have been brought in. Plate VIII shows the location of the wells in Jefferson county.

Johnson County

The surface rocks of Johnson county belong to the middle part of the Pennsylvanian system. The Douglas group outcrops in upland areas in central and western Johnson county. Beds of the Lansing group are found in the valleys. The older beds outcrop to the east, the Wyandotte and Bronson formations in the lower areas, and the Stanton limestone in prominent escarpments in eastern and southern Johnson county.

Because of the proximity of Kansas City, attempts to find oil and gas in Johnson county were made at an early date. Out of this more or less widespread drilling two definite fields have been developed, the Craig Station-Monticello gas field, and the Dallas oil and gas field. Some gas has been found northeast of Spring Hill, but a field has not been developed.

The Craig Station-Monticello field, often called the Craig field, is located in north-central Johnson county in T. 12 S., R. 23 E. Over sixty wells have been drilled in the field, but only a few are producing at the present time. A survey of the field in 1931 showed eight wells producing gas. The production of the field for 1930 was 33,785,000 cubic feet of gas. The total production of the field up to July 1, 1931, was about 3½ billion cubic feet of gas. The rock pressure has declined from 188 pounds to 34 pounds. The estimated probable gas reserves for the Craig field are about 3½ billion cubic feet. The probable gas reserves are estimated as five times the proved reserves which are figured on the decline in pressure. The gas is found in two horizons, a sand in the upper part of the Marmaton group, probably the Peru sand, and a sand in the Upper Cherokee shale, about 50 feet below the Fort Scott limestone. This lower sand is probably the Squirrel sand. The wells that produce from the Peru sand range from 150 to 300 feet in depth and the sand varies from 10 to 30 feet in thickness. The deeper wells, producing from the Squirrel sand, are 550 to 650 feet in depth. The sand aver-

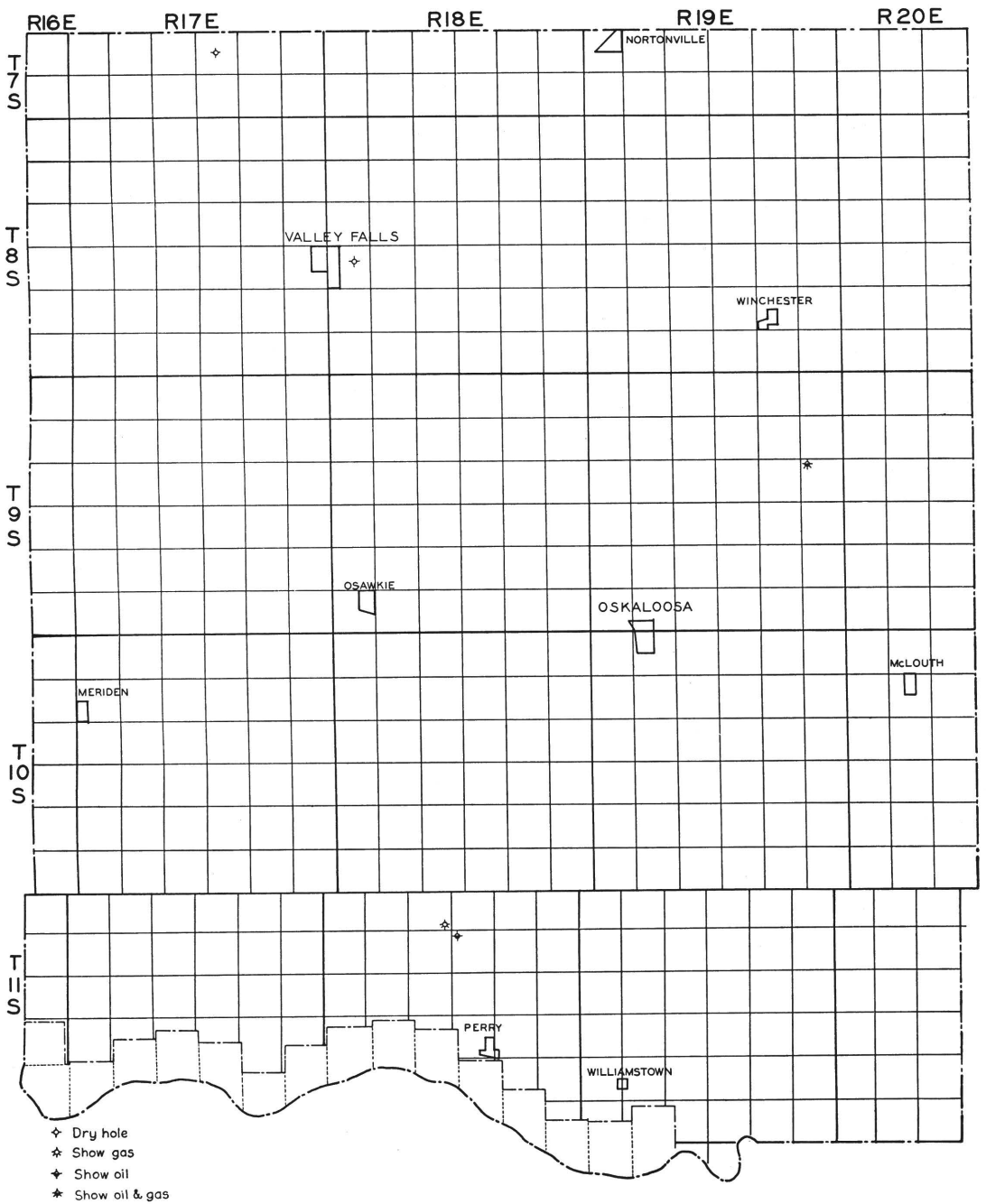


PLATE VIII.—Base map of Jefferson county, showing location of wells.

ages about 25 feet in thickness. A generalized section of a typical well in the area is given below.

Harlan et al. No. 1 Mettee, SE¼ SW¼ NW¼ sec. 22, T. 12 S., R. 23 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Bronson-Lansing groups	295	0-295
Marmaton-Bourbon groups	250	295-545
Gas sand (Peru)	10	305-315
Fort Scott limestone	13	532-545
Cherokee shale	105	545-650 T.D.
Gas sand (Squirrel)	25	570-595
Gas sand	35	615-650

The location of this field is shown in Plate IX.

The Dallas oil and gas field in T. 13 S., R. 25 E., had 75 active wells in 1927, the majority producing oil and the others gas. The wells are small and the field is of minor importance. The oil is produced from the Bartlesville sand, at a depth of about 500 feet. The sand is thick and averages about 60 feet. The gas is found in a sand in the Upper Marmaton group, probably the Peru sand. The gas is not an important product of the field. Little drilling has been done in this area during the last few years.

Some shallow gas wells were drilled in sec. 1, T. 15 S., R. 24 E., but the area has not been thoroughly exploited. The wells had an initial daily production of 200,000 to 300,000 cubic feet of gas from sand in the upper part of the Marmaton group. The sand is found at a depth of 270 feet and is 20 feet thick on an average. Several tests have been drilled in T. 15 S., R. 24 E., and T. 15 S., R. 25 E., to the "Mississippi lime," with no production from the "lime," but several shows of oil were reported in the Bartlesville sand. The generalized section of one of the wells is given as typical of this area of Johnson county.

Higgins et al. No. 1 Harrison, NW cor. sec. 6, T, 15 S., R. 25 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Bronson-Lansing groups	290	0-290
Marmaton-Bourbon groups	242	290-532
Gas sand (Peru)	5	320-325
Cherokee shale	390	532-922
Bartlesville sand	10	772-782
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	53	922-975 T.D.

Only two deep tests have been drilled in Johnson county, one in sec. 12, T. 14 S., R. 22 E., to the granite, and another in sec. 4, T. 14

S., R. 24 E., into the "Siliceous lime." The Harrington No. 1 well was drilled to a depth of 2,236 feet by the Seminole Petroleum Company and was completed at 2,421 feet by the Universal Oil and Gas Company. The well was dry and abandoned, but shows of oil and gas were reported at the following depths:

270-375	Show of gas	1,535-1,577	Show of gas
673-675	Show of gas	1,724-1,732	Show of gas
712-717	Show of oil	2,235-2,236	Show of oil and gas
1,433-1,435	Show of oil		

The stratigraphic record of the Harrington well is given below.

Universal Oil Co. No. 1 Harrington, NE cor. SW¼ sec. 12, T. 14 S., R. 22 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Bronson-Lansing groups	340	0-340
Marmaton-Bourbon groups	305	340-645
Cherokee shale	380	645-1,025
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	370	1,025-1,395
Kinderhook shale	40	1,395-1,435
ORDOVICIAN SYSTEM:		
Galena-Platteville limestone	100	1,435-1,535
St. Peter sandstone	63	1,535-1,598
CAMBRO-ORDOVICIAN SYSTEM:		
"Siliceous lime"	767	1,598-2,365
CAMBRIAN SYSTEM:		
Basal sandstone	35	2,365-2,400
PRE-CAMBRIAN GRANITE	21	2,400-2,421 T.D.

The Mahaffie well was drilled in sec. 4, T. 14 S., R. 23 E., to a depth of 1,785 feet. A small show of gas was reported at 660 feet in the Bartlesville sand. The section of the well follows:

Mahaffie No. 1, sec. 4, T. 14 S., R. 23 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Bronson-Lansing groups	235	0-235
Marmaton-Bourbon groups	265	235-500
Cherokee shale	410	500-910
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	405	910-1,315
Kinderhook shale	20	1,315-1,335
ORDOVICIAN SYSTEM:		
Galena-Platteville limestone	165	1,335-1,500
St. Peter sandstone	65	1,500-1,565
CAMBRO-ORDOVICIAN SYSTEM:		
"Siliceous lime"	220	1,565-1,785 T.D.

Johnson county will probably continue to witness intermittent drilling because of the results thus far and because of the close

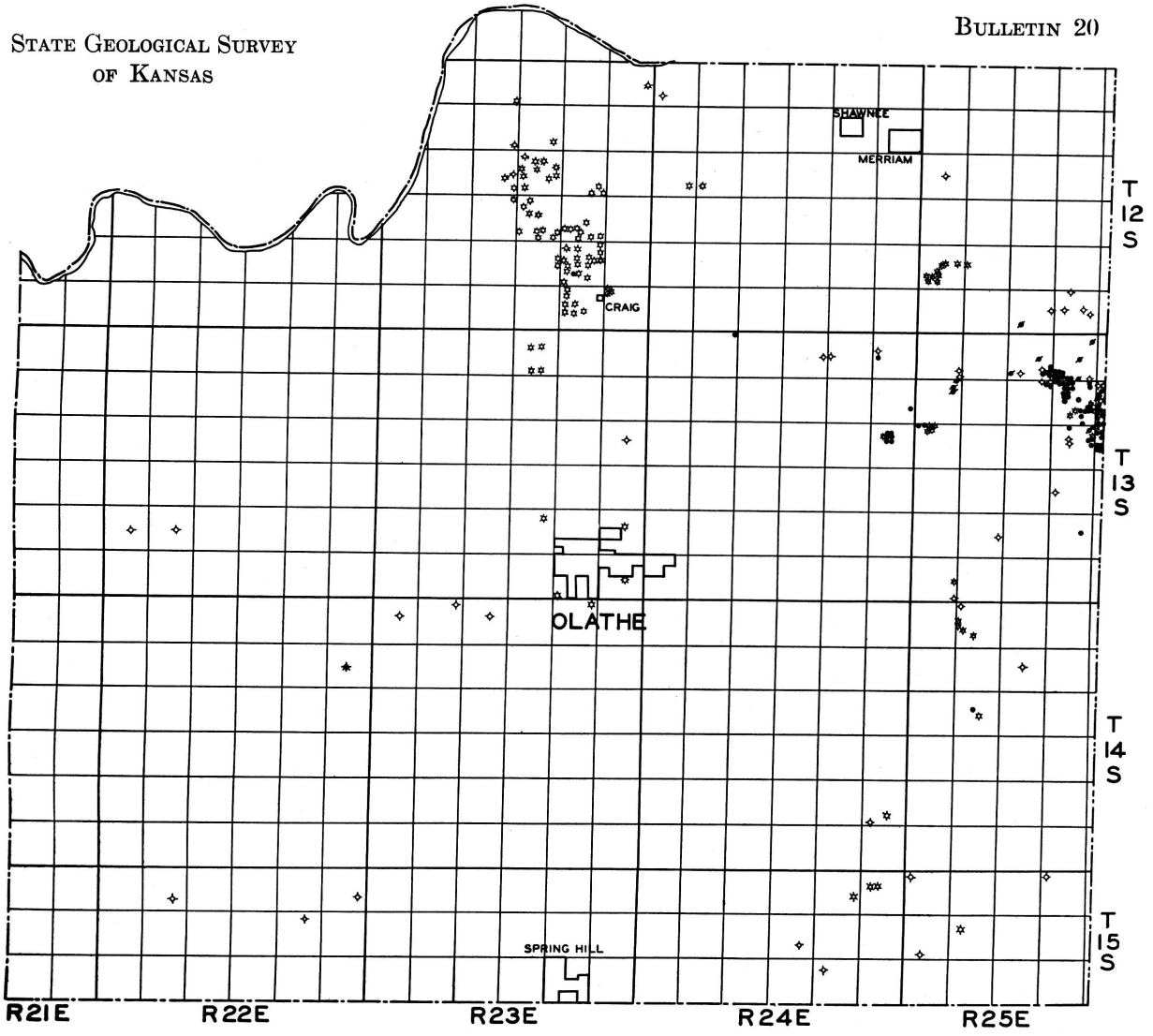


PLATE IX.—Base map of Johnson county, showing location of wells.

market Kansas City provides. Thus far attempts have failed to show any production in the pre-Pennsylvanian beds, but the few tests that have been put down are no criteria for the entire county. Plate IX shows the location of wells in Johnson county.

Leavenworth County

Pennsylvanian beds of Douglas and lower Shawnee age outcrop in Leavenworth county. Very little glacial drift obscures the outcrops of the Pennsylvanian rocks so that structures can be mapped fairly well throughout the county. The exploration for oil and gas has not been extensive in the northern part of the county, but there has been much mapping and gas development in southern Leavenworth county. Two gas fields have been developed in southern Leavenworth county, the Linwood gas field and the Six Corners gas field.

The Linwood gas field is located in sec. 31, T. 11 S., R. 22 E., sec. 6, T. 12 S., R. 22 E., and in secs. 11, 12, 13, and 14, T. 12 S., R. 21 E. The production comes from a sand about 50 feet below the Fort Scott limestone in the upper part of the Cherokee shale. It is generally known in northeastern Kansas as the Squirrel sand. The gas sand is about 700 feet below the surface and is about 20 to 30 feet in thickness throughout the field. In some of the wells the Peru sand in the upper Marmaton group produces some gas but is not as important as the Squirrel sand. The wells in this field averaged close to 1,000,000 cubic feet of gas per day, some ranging up to 2,000,000 cubic feet of gas. The initial rock pressure was 263 pounds. There has been very little development in the Linwood field the last few years and as the pressure decreased the wells were taken off the line and abandoned.

The Six Corners gas field, located in secs. 13, 14, and 23, T. 12 S., R. 20 E., was purchased in 1927 by the Empire Oil and Refining Company for experimentation in subsurface gas storage. The gas was pumped from the lines into the ground for storage. Upon withdrawal all of the gas pumped into the sands was recovered and the success in this area led to underground storage in other regions. The gas wells in the Six Corners field were smaller initially than those in the Linwood field, although the rock pressure was slightly greater. The wells average about 500,000 cubic feet of gas per day when brought in. The production is from the Squirrel sand just below the Fort Scott limestone as in the Linwood field. The gas zone is about 750 feet in depth and is about 20 feet in thickness. Development in this field has been at a standstill, as in the Linwood

area, but the prospects for increased activity in southern Leavenworth county are promising.

Two wells have been drilled to the Mississippian or deeper in Leavenworth county. A prospect well for oil and gas was drilled in 1887 at Leavenworth to a depth of 2,116 feet. No gas or oil shows were reported. The lithologic description of the well is given in the Leavenworth-Smithville folio[49] and is correlated as follows:

Record of well at Leavenworth, T. 9 S., R. 23 E.

Formation	Thickness in feet	Depth in feet
QUATERNARY SYSTEM:		
Loam and clay	20	0-20
PENNSYLVANIAN SYSTEM	1,155	20-1,175
MISSISSIPPIAN SYSTEM:		
Keokuk and Burlingame limestone	375	1,175-1,550
Kinderhook (?) group	130	1,550-1,680
ORDOVICIAN SYSTEM:		
Joachim (?) limestone	30	1,680-1,710
St. Peter sandstone	160	1,710-1,870
ORDOVICIAN AND CAMBRIAN	246	1,870-2,116 T.D.

Comparison with adjacent wells has led to a partial revision of this correlation.

Formation	Thickness in feet	Depth in feet
QUATERNARY SYSTEM	20	0-20
PENNSYLVANIAN SYSTEM:		
Bronson-Lansing groups	340	20-360
Marmaton-Bourbon groups	262	360-622
Cherokee shale	553	622-1,175
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	395	1,175-1,570?
Kinderhook shale	70	1,570?-1,650?
ORDOVICIAN SYSTEM:		
Galena-Platteville limestone	60	1,650?-1,710
St. Peter sandstone	160	1,710-1,870
CAMBRO-ORDOVICIAN SYSTEM:		
"Siliceous lime"	246	1,870-2,116 T.D.

The chief difference in the two classifications is in the Kinderhook shale. Shale only is assigned to the Kinderhook in the later classification, but since the Kinderhook is apparently becoming more limy to the east it may include some of the limestone beds as in the earlier correlation.

In 1930 Forrester et al. drilled No. 1 Yazel in the cen. E. L. SE¼ SE¼ sec. 18, T. 12 S., R. 22 E., in the Linwood district, to a depth

49. Hinds, Henry, and Greene, F. C.: Leavenworth-Smithville folio, Missouri-Kansas. U. S. Geol. Survey, Geol. Atlas of U. S., 1917.

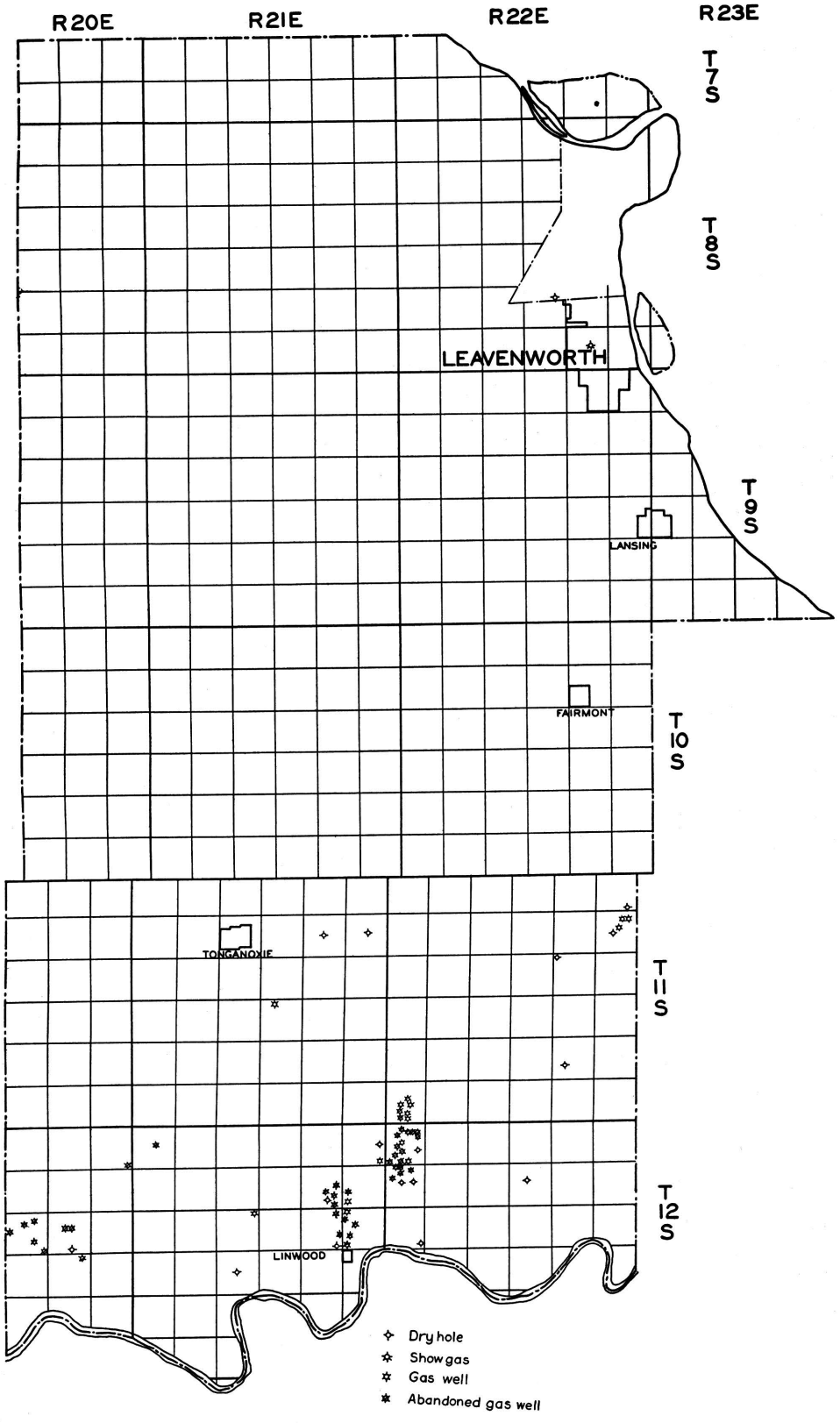


PLATE X.—Base map of Leavenworth county, showing location of wells.

of 1,546 feet where it was abandoned. The Squirrel sand, producing in that area, was absent in the Yazel well and only a few feet of Bartlesville sand were found. The stratigraphic section of the well is given below.

Forrester et al. No. 1 Yazel, cen. E. L. SE¼ SE¼ sec. 18, T. 11 S., R. 22 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Bronson-Lansing groups	260	62-322
Marmaton-Bourbon groups	210	322-532
Cherokee shale	456	532-988
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	402	988-1,390
Kinderhook shale	55	1,390-1,445
ORDOVICIAN SYSTEM:		
Galena-Platteville limestone	101	1,445-1,546 T.D.

Plate X gives the location of wells drilled in Leavenworth county and shows the location of the Linwood and Six Corners fields.

Shawnee County

The surface rocks in Shawnee county are Upper Pennsylvanian in age. The eastern part is occupied by the Shawnee group and the western part by the Wabaunsee group. The Topeka limestone of the Shawnee group and the Burlingame limestone of the Wabaunsee group form prominent escarpments.

The first test for oil or gas in Shawnee county was drilled in 1886 at Topeka. It was a diamond drill hole, and the section as recorded in Bulletin 3 of the Kansas Geological Survey[50] is given below. The well was drilled to a total depth of 1,638 feet and ended in lower Cherokee shale. It was a dry hole.

Record of well at Topeka

Stratum	Thickness in feet	Depth in feet
Soil	42	42
PENNSYLVANIAN SYSTEM:		
Shawnee formation—		
Sandstone, fine, gray	16	58
Sandstone, coarse	24	82
Calhoun shale:		
Shale, blue	19	101
Shale, clay, laminated, light blue	7	108
Deer Creek limestone:		
Limestone, dark conglomerate	3	111
Limestone, mixed with clay	12	123
Shale, blue	1	124
Limestone, dark	4	128

50. Moore, Raymond C., and Haynes, Winthrop: Oil and gas resources of Kansas. Kansas Geol. Survey, Bull. 3, pp. 339-341, 1917.

Stratum	Thickness in feet	Depth in feet
Tecumseh shale:		
Shale, blue	9	137
Shale, laminated	15	152
Shale, blue	2	154
Lecompton limestone:		
Limestone, hard, gray	2	156
Shale, blue	23	179
Limestone, gray, fossiliferous	5	184
Kanwaka shale:		
Shale, blue, laminated	1	185
Shale	17	202
Shale, laminated, light and dark	17	219
Shale, blue (water)	14	233
Douglas formation—		
Oread limestone:		
Limestone, gray	5	238
Shale, light	5	243
Limestone, gray	11	254
Limestone, light	1	255
Shale, black	7	262
Limestone, light	8	270
Shale	6	276
Limestone, gray	3	279
Shale, hard, black	6	285
Limestone, gray	2	287
Lawrence shale:		
Shale, sand and mud	124	411
Iatan limestone:		
Limestone, crystalline	2	413
Weston shale:		
Shale	41	454
Shale	30	484
Shale, laminated, with limestone	31	515
Shale, dark, compact	25	540
Lansing formation—		
Stanton limestone:		
Limestone, light to dark, some shale	52	592
Vilas shale—		
Shale, dark, laminated	17	609
Plattsburg limestone:		
Limestone, gray	18	627
Shale, black	3	630
Limestone, gray	6	636
Shale, blue	3	639
Limestone, gray	1	640
Shale, blue	1	641
Limestone, gray	1	642
Shale, blue	1	643
Limestone, gray	2	645
Shale, blue	3	648
Lane shale:		
Shale, blue	20	668
Kansas City formation—		
Iola limestone:		
Limestone, light	20	688
Shale, soft, and mud	11	699
Limestone, gray	13	712

Stratum	Thickness in feet	Depth in feet
Chanute shale:		
Shale, dark, clayey	12	724
Limestone, gray	7	731
Shale, hard, black	2	733
Limestone, gray	2	735
Shale, dark, laminated	12	747
Drum limestone:		
Limestone, gray	9	756
Cherryvale shale:		
Shale, dark	4	761
Limestone, light and dark	3	764
Shale, dark	10	774
Limestone, light	3	777
Shale, dark	11	788
Winterset limestone (?):		
Limestone, some shells	23	811
Shale, with limestone	4	815
Limestone, light to dark	14	829
Galesburg shale:		
Shale, laminated, dark	6	835
Limestone, conglomeratic	3	838
Shale, laminated	2	840
Limestone, conglomeratic, fossiliferous	1	841
Shale, laminated, and limestone	13	854
Bethany Falls limestone:		
Limestone, conglomeratic, fossiliferous	12	866
Shale, dark with limestone	5	871
Limestone, light gray	7	878
Ladore shale:		
Shale, black	5	883
Hertha limestone:		
Limestone	29	912
Marmaton formation—		
Pleasanton shale:		
Sandstone, gray	3	915
Shale, laminated, blue	8	923
Limestone, gray	11	934
Bandera shale:		
Shale, dark	6	940
Shale, blue	14	954
Shale, dark, clayey	32	986
———	8	994
Shale, bituminous	2	996
Limestone, conglomeratic	2	998
Shale, dark, clayey	2	1,000
Pawnee limestone:		
Limestone	3	1,003
Shale, laminated	8	1,011
Limestone	2	1,013
Labette shale:		
Coal	1	1,014
Shale, laminated	4	1,018
Sandstone, laminated	35	1,053
Shale, laminated	3	1,056
Fort Scott limestone:		
Limestone	2	1,058
Shale, laminated	5	1,063
Limestone	1	1,064

Stratum	Thickness in feet	Depth in feet
Cherokee shale:		
Shale	38	1,102
Sandstone, light	1	1,103
Shale	18	1,121
Coal	1	1,122
Shale, black to light	7	1,129
Coal	1	1,130
Shale, dark to light	10	1,140
Sandstone and shale	4	1,144
Shale, black	2	1,146
Coal	1	1,147
Shale and clay, some flint	50	1,197
Coal	1	1,198
Shale and sandstone, laminated	14	1,212
Coal	1	1,213
Clay	4	1,217
Shale	14	1,231
Sandstone, micaceous	11	1,242
Shale, blue	3	1,245
Limestone, porous (gas)	3	1,248
Shale	1	1,249
Sandstone, variegated	9	1,258
Sandstone and shale	1	1,259
Shale, dark	3	1,262
Shale, little coal	9	1,271
Limestone, dark	1	1,272
———	2	1,274
Shale, dark	2	1,276
Limestone, gray	1	1,277
Shale, black	1	1,278
Limestone	1	1,279
Shale, dark	5	1,284
———	3	1,287
Shale, blue	12	1,299
Shale with limestone	5	1,304
Shale	14	1,318
———	4	1,322
Shale, mixed with iron oxide	3	1,325
Sandstone	9	1,334
Shale, dark	6	1,340
Shale, black, little coal	10	1,350
Sandstone, little coal	1	1,351
Sandstone, hard	1	1,352
Shale, with limestone	8	1,360
Shale, clay, dark	9	1,369
Shale and sandstone	1	1,370
Sandstone, gray	2	1,372
Shale, some limestone	8	1,380
Shale, clayey, with mica sandstone	10	1,390
———	3	1,393
Sandstone	1	1,394
Shale, dark	24	1,418
Sandstone, gray	9	1,427
Limestone, light	1	1,428
Sandstone, shaly	6	1,434
Sandstone, gray	15	1,449
Shale, dark	2	1,451
Sandstone, gray	2	1,453
Shale	1	1,454
Sandstone, with shale bands	12	1,466
Shale, laminated, dark	34	1,500

Stratum	Thickness in feet	Depth in feet
Sandstone and shale	13	1,513
Limestone, light	7	1,520
Shale	9	1,529
Coal	1	1,530
Shale	67	1,597
Coal	2	1,599
Limestone, crystalline	3	1,602
Shale, dark	4	1,606
Coal	1	1,607
Sandstone and shale	3	1,610
Shale	11	1,621
Sandstone, white	4	1,625
Shale, dark	13	1,638

Since 1886 fourteen wells have been drilled, of which nine encountered pre-Pennsylvanian beds. All of the wells were dry and were abandoned. All of the earliest tests stopped before they reached the "Mississippi lime." The first test to reach the "Mississippi lime" was the Wapeka Oil Company's No. 1 Neil in the cen. SW¼ NE¼ sec. 26, T. 13 S., R. 15 E., drilled in 1917. It topped the "Mississippi lime" at 1,545 feet and was drilled to a total depth of 2,430 feet.

In 1920 the Advance Oil and Refining Company drilled No. 1 Shawnee in the SW¼ NW¼ sec. 14, T. 10 S., R. 13 E., to a depth of 2,700 feet. The stratigraphic section of this well is given below.

Advance Oil & Refining Co. No. 1 Shawnee, SW¼ NW¼ sec. 14, T. 10 S., R. 13 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Wabaunsee group	360	0-360
Shawnee group	410	360-770
Douglas-Pedee groups	220	770-990
Bronson-Lansing groups	345	990-1,335
Marmaton-Bourbon groups	165	1,335-1,500
Cherokee shale	615	1,500-2,115
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	200	2,115-2,315
Kinderhook shale	247	2,315-2,562
SILURIAN AND DEVONIAN SYSTEMS:		
Siluro-Devonian formation	138	2,562-2,700 T.D.

Sulphur water was found in the Siluro-Devonian formation and the well was abandoned. This well is included in the north-south section through the Forest City basin, Plate II.

Green et al. drilled the No. 1 Ripley well in the NW cor. NE¼ sec. 12, T. 12 S., R. 16 E., in 1923 and struck the pre-Cambrian granite at 3,015 feet, penetrating it for 305 feet to a depth of 3,320 feet. No shows of oil or gas were reported. The stratigraphic record of this well follows:

Green et al. No. 1 Ripley, NW cor. NE¼ sec. 12, T. 12 S., R. 16 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Shawnee group	325	0-325
Douglas-Pedee groups	275	325-600
Bronson-Lansing groups	350	600-950
Marmaton-Bourbon groups	240	950-1,190
Cherokee shale	590	1,190-1,780
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	270	1,780-2,050
Kinderhook shale	90	2,050-2,140
SILURIAN AND DEVONIAN SYSTEMS:		
Siluro-Devonian formation	120	2,140-2,260
ORDOVICIAN SYSTEM:		
Maquoketa shale	20	2,260-2,280
Galena-Platteville limestone	125	2,280-2,405
St. Peter sandstone	70	2,405-2,475
CAMBRO-ORDOVICIAN SYSTEM:		
"Siliceous lime"	530	2,475-3,005
CAMBRIAN SYSTEM:		
Basal sandstone	10	3,005-3,015
PRE-CAMBRIAN SYSTEM:		
Granite	305	3,015-3,320 T.D.

The Ripley well is one of the wells in the east-west section through the Forest City Basin, Plate I. It will be noted that, although the Siluro-Devonian formation and Maquoketa shale are present in the Ripley well, they are absent in the Smith et al. No. 1 Smith well to the east. These beds were truncated in the pre-Mississippian erosion interval.

The Onarch Oil and Gas Co. No. 1 Omar Allen well in the SE cor. NE¼ NW¼ sec. 2, T. 11 S., R. 14 E., was drilled in 1929 to the Siluro-Devonian formation, 2,450-2,471 feet, and found sulphur water. It was abandoned at 2,471 feet.

Two deep tests were drilled near Topeka and a third started but abandoned. Hummer No. 1 drilled by Forrester et al., in the center of the SW¼ sec. 14, T. 11 S., R. 16 E., was drilled to the granite and abandoned at 3,023 feet. Samples were carefully saved and the stratigraphic section was accurately determined.

Forrester et al. No. 1 Hummer, cen. SW¼ sec. 14, T. 11 S., R. 16 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Shawnee group	355	0-355
Douglas-Pedee groups	275	355-630
Bronson-Lansing groups	345	630-975
Marmaton-Bourbon groups	245	975-1,220
Cherokee shale	565	1,220-1,785

Formation	Thickness in feet	Depth in feet
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	255	1,785-2,040
Kinderhook shale	120	2,040-2,160
SILURIAN AND DEVONIAN SYSTEMS:		
Siluro-Devonian formation	120	2,160-2,280
ORDOVICIAN SYSTEM:		
Maquoketa shale	50	2,280-2,330
Galena-Platteville limestone	120	2,330-2,450
St. Peter sandstone	100	2,450-2,550
CAMBRO-ORDOVICIAN SYSTEM:		
"Siliceous lime"	440	2,550-2,990
CAMBRIAN SYSTEM:		
Basal sandstone	20	2,990-3,010
PRE-CAMBRIAN SYSTEM:		
Granite	13	3,010-3,023 T.D.

The Hummer well found a hole full of water in the Siluro-Devonian formation and in the St. Peter sandstone. The well is included in the east-west section through the Forest City Basin, Plate I.

The second deep test near Topeka was Jenkins and Scott No. 1 Hayden in the NE¼ NE¼ SE¼ sec. 8, T. 12 S., R. 14 E. This well reported showings of gas at 715, 1,180-1,225, and 1,665-1,710 feet, but no commercial quantities were found. The formations are relatively thick below the Pennsylvanian, showing a synclinal condition that did not favor oil accumulation in the pre-Pennsylvanian beds. The well was abandoned in the Simpson formation at 2,693 feet.

Jenkins and Scott No. 1 Hayden, NE¼ NE¼ SE¼ sec. 8, T. 12 S., R. 14 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Wabaunsee group	150	0-150
Shawnee group	382	150-532
Douglas-Pedee groups	263	532-795
Bronson-Lansing groups	345	795-1,140
Marmaton-Bourbon groups	170	1,140-1,310
Cherokee shale	565	1,310-1,875
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	295	1,875-2,170
Kinderhook shale	150	2,170-2,320
SILURIAN AND DEVONIAN SYSTEMS:		
Siluro-Devonian formation	125	2,320-2,445
ORDOVICIAN SYSTEM:		
Maquoketa shale	77	2,445-2,522
Galena-Platteville limestone	133	2,522-2,655
St. Peter sandstone	38	2,655-2,693 T.D.

The Hayden well is included in the east-west section across the Forest City Basin, Plate I. The thickening of the beds below the Pennsylvanian can readily be seen.

Jenkins and Scott started the Asherman well in the NE¼ NW¼ NE¼ sec. 28, T. 10 S., R. 15 E., but abandoned it at 862 feet.

Results in oil and gas exploration have been disappointing, but there is much territory in Shawnee county left for investigation. What the future for oil and gas development in Shawnee county is cannot be predicted, but the county cannot be condemned by the scattered drilling attempts up to the present time. Plate XI shows the location of the wells in Shawnee county.

Wabaunsee County

Pennsylvanian and Permian rocks appear at the surface in Wabaunsee county, the Lower Permian beds in the western and southwestern part of the county and Upper Pennsylvanian beds of the Wabaunsee group in the eastern and central part of the county. The general dip of the strata is westward, but anticlinal structures have been mapped in the county. The structure near Alma[51] is an anticline whose crest is 160 feet above the bottom of the adjacent shallow anticline to the east. This structure was tested by a diamond drill hole in the SW cor. of sec. 31, T. 11 S., R. 11 E., near McFarland, which did not show any oil or gas. The McFarland well stopped in the Cherokee shale at 2,006 feet. The Upper Pennsylvanian beds are hard to correlate from the record of this well, but the Douglas-Pedee groups can be identified from 880 to 1,151 feet, the Bronson-Lansing group from 1,151 to 1,536 feet, the Marmaton group from 1,536 to 1,842 feet, and the Cherokee shale from 1,842 to 2,006 feet.

Three wells drilled in Wabaunsee county reached the pre-Cambrian basement rocks. The Parker Oil Company drilled two wells on the Bardwell farm. The record of Bardwell No. 2, sec. 26, T. 10 S., R. 9 E., as given in Bulletin 3 of the Kansas Geological Survey,[52] follows:

Record of Bardwell well No. 2, Zeandale, Wabaunsee County

Stratum	Thickness in feet	Depth in feet
Soil and clay	10	10
Clay, soft	20	30
Sand, fine	10	40
Clay, blue	20	60

51. Moore, Raymond C., and Haynes, Winthrop P.: Oil and gas resources of Kansas. Kansas Geol. Survey, Bull. 3, p. 346, 1917.

52. Idem, p. 151.

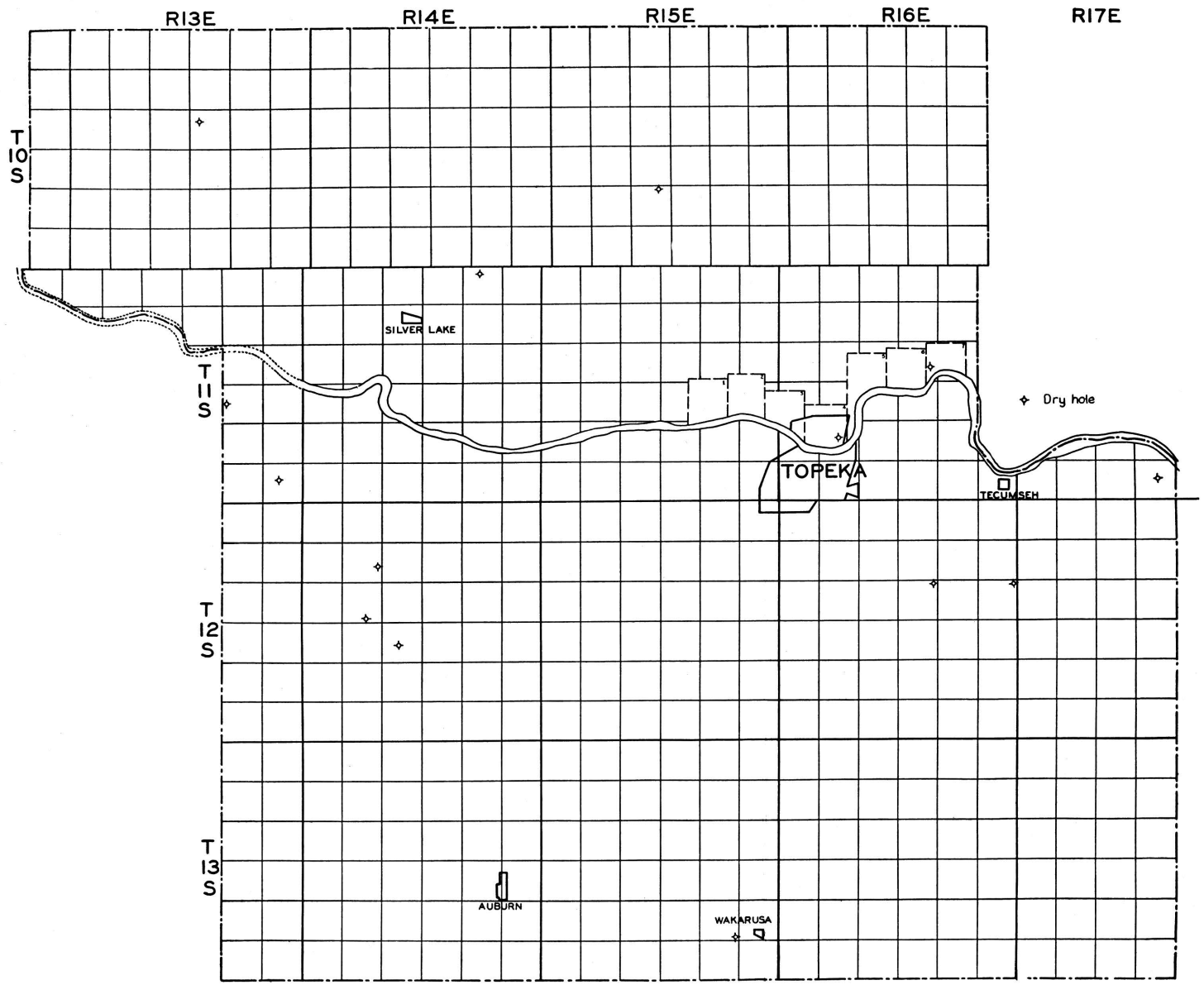


PLATE XI.—Base map of Shawnee county, showing location of wells.

Stratum	Thickness in feet	Depth in feet
Gravel, coarse	6	66
Clay, blue	17	83
Limestone	2	85
Shale, light blue	80	165
Limestone	4	169
Shale, blue	88	257
Limestone	26	283
Shale, light	12	295
Shale, sandy	10	305
Shale	15	320
Limestone	43	363
Shale	10	373
Limestone	5	378
Shale	12	390
Limestone	8	398
Shale, black	2	400
Limestone	25	425
Shale	50	475
Limestone	5	480
Shale, light	5	485
Limestone	24	509
Shale	1	510
Limestone	15	525
Clay	5	530
Limestone	4	534
Shale, blue	76	610
Limestone	5	615
Shale	5	620
Redrock	2	622
Shale	3	625
Limestone	8	633
Shale, light	25	658
Limestone	7	665
Shale	4	669
Limestone	1	670
Shale	2	672
Limestone	1	673
Shale	1	674
Limestone	19	693
Shale, blue	3	696
Limestone	1	697
Shale	3	700
Limestone	5	705
Shale	5	710
Limestone	18	728
Shale	3	731
Limestone	4	735
Shale, light	8	743
Limestone	40	783
Shale	1	784
Limestone	10	794
Shale	2	796
Limestone	26	822
Shale, light	4	826
Limestone	2	828
Shale	2	830
Limestone	35	865
Shale	4	869
Limestone	4	873
Shale	2	875

Stratum	Thickness in feet	Depth in feet
Limestone	8	883
Shale	2	885
Limestone	15	900
Shale	4	904
Limestone	49	953
Shale	5	958
Granite, gray	17	975
Granite, red	15	990
Shale	1	991
Granite, gray	102	1,093

The above record shows the top of the granite at 958 feet. The well was drilled to a depth of 1,093 feet and abandoned. Pink, medium to fine-grained granite and chlorite schists are reported to have been penetrated by the Bardwell well. This well is often known as the Zeandale well because of its location near Zeandale.

The Empire Oil and Refining Company No. 1 Root well in the cen. SW¼ NE¼ sec. 1, T. 11 S., R. 9 E., struck the granite surface at 1,180 feet and drilled 820 feet into it to a total depth of 2,000 feet. Pink, medium to fine-grained granite is reported from this well. A record of this well and a description of the granite cuttings are given in Bulletin 3 of the Kansas Geological Survey.[53] The record follows:

Record of well south of Wabaunsee, Wabaunsee County

Stratum	Thickness in feet	Depth in feet
Shale	90	90
Limestone	20	110
Shale, black	5	115
Shale, light	10	125
Shale, black	40	165
Sandstone	30	195
Sand (water)	23	218
Limestone	92	310
Shale	10	320
Limestone	30	350
Sandstone	30	380
Shale (little gas)	15	395
Limestone	26	421
Shale	39	460
Limestone	24	484
Shale	20	504
Limestone	2	506
Sandstone	16	522
Shale	20	542
Limestone	38	580
Shale	6	586
Limestone	6	592
Shale	36	628
Limestone	4	632
Redrock	20	652

53. Op. cit., pp. 150, 163.

Stratum	Thickness in feet	Depth in feet
Shale	6	658
Sandstone	17	675
Shale	60	735
Limestone	70	805
Shale	65	870
Limestone	102	972
Shale	13	985
Limestone	6	991
Shale and coal	95	1,086
Limestone	29	1,115
Shale	5	1,120
Shale and flint	60	1,180
Granite, red	200	1,380
Granite, gray	80	1,460
Granite, red	20	1,480
Granite, gray	510	1,990

Both the Root well and the Bardwell well were about on the crest of the Nemaha granite ridge. Figure 3 shows the location of the ridge and its relationship to the Forest City Basin to the east.

The Williams et al. No. 1 Henderson well in the cen. NE¼ sec. 15, T. 13 S., R. 12 E., begun in 1924 and finished in 1928, was drilled to a total depth of 3,652 feet and encountered granite at 3,625 feet. The steep eastward slope of the granite ridge is illustrated by these wells. The granite in the Root well is approximately 55 feet below sea level, while the granite in the Henderson well, 21 miles southeast of the Root well, is approximately 2,455 feet below sea level, a difference of 2,400 feet. The Henderson test is located well out into the Forest City Basin.

The Empire Oil and Refining Co. No. 1 Schwalm well in the SE cor. sec. 19, T. 12 S., R. 11 E., was drilled to a depth of 3,431 feet and an excellent set of cuttings was saved. A careful study of these cuttings has made accurate correlation possible. The section of the Schwalm well is, therefore, a very good type section for Wabaunsee county. The well is in the lowest part of the Forest City Basin for, in spite of its depth of 3,431 feet, it reached only the St. Peter sandstone. The section of the Schwalm well is given below.

Empire Oil & Refining Co. No. 1 Schwalm, SE cor. sec. 19, T. 12 S., R. 11 E.

Formation	Thickness in feet	Depth in feet
PERMIAN:		
Council Grove group	295	0-295
PENNSYLVANIAN SYSTEM:		
Wabaunsee group	605	295-900
Shawnee group	355	900-1,255
Douglas-Pedee groups	240	1,255-1,495
Bronson-Lansing groups	355	1,495-1,850
Marmaton-Bourbon groups	220	1,850-2,070
Cherokee shale	415	2,070-2,485

Formation	Thickness in feet	Depth in feet
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	320	2,485-2,805
Kinderhook shale	185	2,805-2,990
SILURIAN AND DEVONIAN SYSTEMS:		
Siluro-Devonian formation	225	2,990-3,215
ORDOVICIAN SYSTEM:		
Maquoketa shale	70	3,215-3,285
Galena-Platteville limestone	115	3,285-3,400
St. Peter sandstone	31	3,400-3,431

No shows of oil or gas were reported in this well. The Schwalm well is included in the east-west cross-section, Plate I.

The Ramsey Petroleum Company No. 1 Kaul well in the SW¼ NE¼ NE¼ sec. 2, T. 11 S., R. 11 E., was drilled to the Siluro-Devonian formation, but found no oil or gas. The well went to 2,830 feet. The section of this well is as follows:

Ramsey Petroleum Co. No. 1 Kaul, SW¼ NE¼ NE¼ sec. 2, T. 11 S. R. 11 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Wabaunsee groups	560	0-560
Shawnee group	410	560-970
Douglas-Pedee groups	200	970-1,170
Bronson-Lansing groups	355	1,170-1,525
Marmaton-Bourbon groups	223	1,525-1,748
Cherokee shale	492	1,748-2,240
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	135	2,240-2,375
Kinderhook shale	210	2,375-2,585
SILURIAN AND DEVONIAN SYSTEMS:		
Siluro-Devonian formation	245	2,585-2,830 T.D.

A discussion of the lower section is given by F. C. Edson,[54] in which the Kinderhook beds are described in detail. The top of the Kinderhook shale was a bed of soft, light pinkish-gray shale about 15 feet in thickness. Below this was a light greenish-gray shale which carried *Sporangites huronense* from 2,445 to 2,580 feet. Banded reddish-brown and greenish-gray shale at the base, 2,580-2,585 feet, carried these plant spores also. The dolomitic limestone below the Kinderhook shale, identified as Siluro-Devonian by the writer, was described by Edson as a cream-colored dolomitic limestone from 2,585 to 2,620 feet, passing into a 10-foot zone of white and gray semitranslucent chert, and then cream to buff finely crystalline pure dolomite. Edson describes the lowest sample which she examined, at 2,650 feet, as containing a small amount of irreg-

54. Edson, F. C.: Pre-Mississippian sediments in central Kansas. Am. Assoc. Petroleum Geologists, Bull., vol. 13, No. 5, pp. 442-443, 1929.

ular subangular, frosted sand. No age is assigned to this dolomite by Mrs. Edson.

Three other wells drilled in Wabaunsee county reached the "Mississippi lime." The Kansas Oil Association No. 1 Wille well in the cen. SW¼ NE¼ sec. 5, T. 11 S., R. 11 E., was drilled to 2,700 feet and reported a showing of oil and gas in sand at 2,000 to 2,024 feet, but was abandoned. The section of this well is as follows:

Kansas Oil Association No. 1 Wille, cen. SW¼ NE¼ sec. 5, T. 11 S., R. 11 E.

Formation	Thickness in feet	Depth in feet
PERMIAN SYSTEM:		
Council Grove group	290	0-290
PENNSYLVANIAN SYSTEM:		
Wabaunsee group	450	290-740
Shawnee group	385	740-1,125
Douglas-Pedee groups	200	1,125-1,325
Bronson-Lansing groups	370	1,325-1,695
Marmaton-Bourbon groups	180	1,695-1,875
Cherokee shale	420	1,875-2,295
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	185	2,295-2,480
Kinderhook shale	220	2,480-2,700 T.D.

The American Petroleum Corporation drilled a well on the Schmidt farm in the cen. SE¼ SE¼ sec. 9, T. 12 S., R. 10 E., to a depth of 2,339 feet and was abandoned. It penetrated the following formations:

American Petroleum Corporation No. 1 Schmidt, cen. SE¼ SE¼ sec. 9, T. 12 S., R. 10 E.

Formation	Thickness in feet	Depth in feet
PERMIAN SYSTEM:		
Council Grove group	270	0-270?
PENNSYLVANIAN SYSTEM:		
Wabaunsee group	490	270?-760
Shawnee group	350	760-1,110
Douglas-Pedee groups	200	1,110-1,310
Bronson-Lansing groups	365	1,310-1,675
Marmaton-Bourbon groups	200	1,675-1,875
Cherokee shale	395	1,875-2,270
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	69	2,270-2,339 T.D.

A well drilled in the NW¼ SE¼ SE¼ of sec. 9, T. 12 S., R. 10 E., the Coleman-Edgerton No. 1-B Smith, produced 44,000 cubic feet of helium gas in sand at 266 to 276 feet. This is very unusual and is the only recorded well in northeastern Kansas producing helium gas. No attempt has been made to develop this helium gas area by further drilling.

Another deep test in Wabaunsee county was the Steinmeyer No. 1 well drilled by the Manhattan Oil Company in the NE¼ NW¼ SW¼ sec. 11, T. 13 S., R. 10 E. This well was drilled to a depth of 2,405 feet and found a hole full of water in the "Mississippi lime." The record of this well is given below.

Manhattan Oil Company No. 1 Steinmeyer, NE cor. NW¼ SW¼ sec. 11, T. 13 S., R. 10 E.

Formation	Thickness in feet	Depth in feet
PERMIAN SYSTEM:		
Council Grove group	195	0-195
PENNSYLVANIAN SYSTEM:		
Wabaunsee group	590	195-785
Shawnee group	375	785-1,160
Douglas-Pedee groups	205	1,160-1,365
Bronson-Lansing groups	370	1,365-1,735
Marmaton-Bourbon groups	210	1,735-1,945
Cherokee shale	395	1,945-2,340
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	65	2,340-2,405 T.D.

The log of this well is included in the east-west cross-section in Plate I.

The exploration and development of oil and gas in Wabaunsee county has been slow up to the present time. This is due in a large part to the disappointing results of the wells that have been drilled. With the exception of a few shows of oil and gas, the only productive well is the Smith No. 1-B in sec. 9, T. 12 S., R. 10 E., which produced helium gas. Plate XII shows the location of the various tests in Wabaunsee county.

Wyandotte County

Wyandotte county has been surveyed by N. D. Newell and J. M. Jewett, and Circular 4[55] gives some of their findings. The surface beds in Wyandotte county are Lower Pennsylvanian, belonging principally to the Missouri series of the new Pennsylvanian classification. The Pennsylvanian beds are generally well exposed, although some are masked by glacial gravels and till.

Wyandotte county stands out prominently in northeastern Kansas as a gas-producing area. While gas is being produced over a large part of the county, there are two fairly distinct gas fields, the Fairfax field in sections 25, 26, 27, and 34, T. 10 S., R. 25 E., and the Bethel gas field in sections 24, 25, 26, 35, 37, T. 10 S., R. 23 E., 30 and 31, T. 10 S., R. 24 E., and 1 and 2, T. 11 S., R. 23 E. Two

55. Newell, Norman D.: Mineral resources of Wyandotte county, Kansas. Kansas Geol. Survey, Circ. 4, 1931.

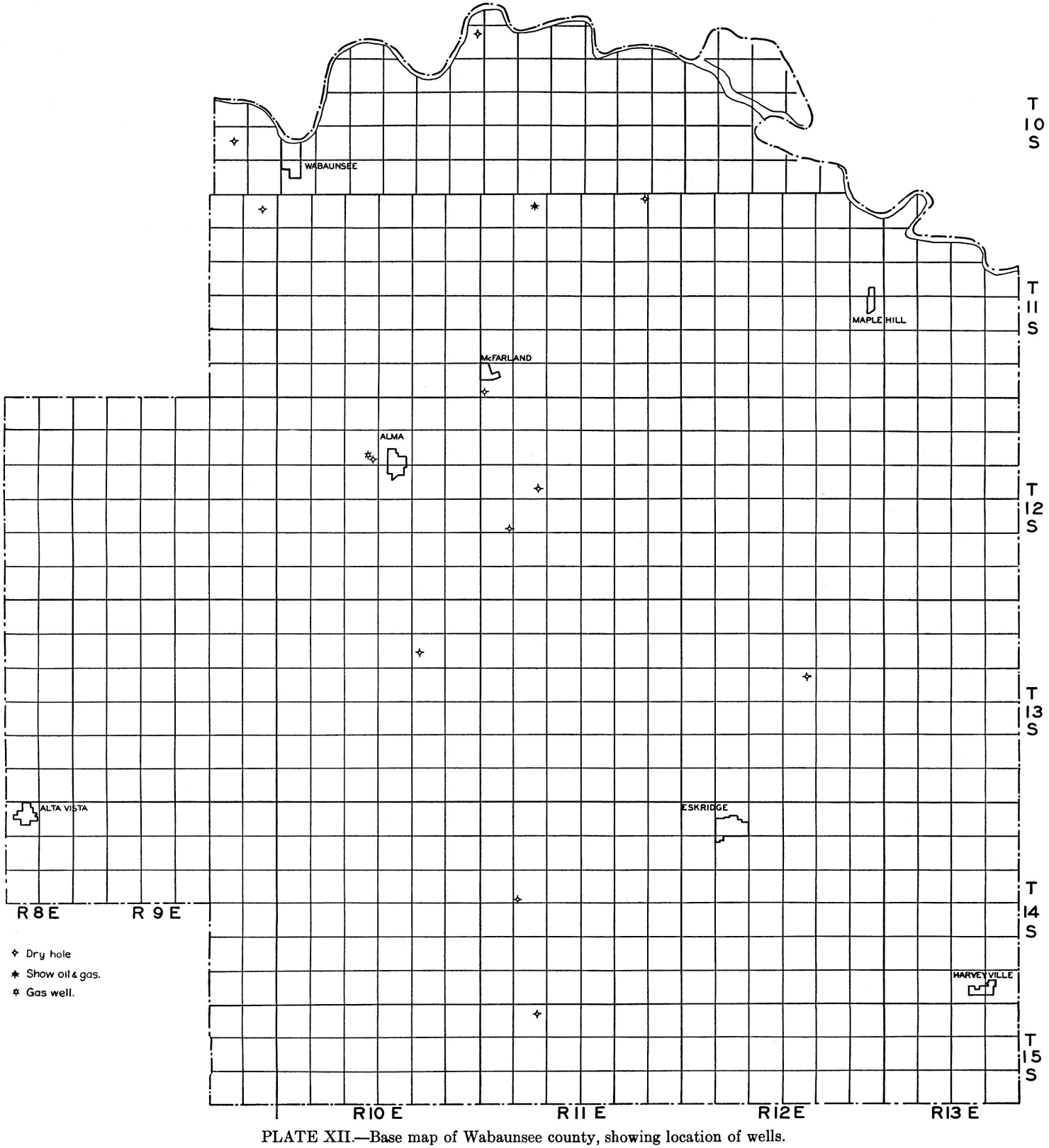


PLATE XII.—Base map of Wabaunsee county, showing location of wells.

smaller fields in Wyandotte county are the Welborn field, northeast of Welborn in sections 23, 24, 25, 35, T. 10 S., R. 24 E., and 19, T. 10 S., R. 25 E., and the Dunlap field in sec. 8, T. 11 S., R. 23 E.

All of the gas produced in Wyandotte county is found in the Marmaton group and Cherokee shale. The Squirrel sand near the top of the Cherokee shale is the most important gas zone. The Peru sand in the Pleasanton formation is the next most important gas zone. No gas or oil has been obtained in commercial quantities from the "Mississippi lime" wells drilled in Wyandotte county. Whether the unsuccessful tests in the "Mississippi lime" have been due to poor structural locations or lack of oil and gas in the "lime" is not known. It will require more careful study of structures and more drilling to ascertain whether the pre-Pennsylvanian beds underlying Wyandotte county are productive or not. It is more than likely that many of the structures apparent on the surface do not extend below the Pennsylvanian beds, but again only deep drilling can prove or disprove this supposition.

There have been wells producing gas for many years in Wyandotte county, but only in the last three years has there been active development. Both the Bethel and Fairfax fields were opened in 1930.

The Fairfax gas field, located in the industrial district north of Kansas City, Kansas, has about 40 wells producing from two horizons in the Marmaton group. The most important gas horizon is the Peru sand, found at about 350-400 feet below the surface. The other gas zone is a shale at about 225-275 feet below the surface. The Peru sand averages about 30 feet in thickness. The initial daily production ranges up to two and a quarter million cubic feet of gas, but the average for the field is less than one million cubic feet. The gas accumulation is due primarily to structure, but is locally affected by the lenticularity of the sand bodies. The sands thicken and thin locally and cause great variation in the production of the wells. The Bartlesville sand has been tested, but was not commercially productive. Likewise the Burgess sand and "Mississippi lime" were penetrated, but were not productive. The probable gas reserves, based on pressure decline curves, are about 700,000,000 cubic feet.

The Bethel gas field, west and northwest of Bethel, has about 60 gas wells producing from the Squirrel and Peru sands. The field was opened in November, 1930, and drilling has been active since that date. The Squirrel sand is the most important gas zone in this

field and is found at a depth of about 700 feet. The sand is 75 to 100 feet below the base of the Fort Scott limestone, or "Oswego lime" as it is often called. The Squirrel sand averages about 30 feet in thickness with a maximum recorded thickness of 81 feet. The Peru sand in the Bethel field is found at a depth of about 550 feet and is less than 20 feet thick on an average. Some wells have been drilled to the Bartlesville sand in this area, but little gas was found. The probable gas reserves of this field based on the pressure decline from 165 to 140 pounds are estimated at about six billion cubic feet.

The Welborn field, northeast of Welborn in secs. 23, 24, and 25, T. 10 S., R. 24 E., and sec. 19, T. 10 S., R. 25 E., has about 15 gas wells producing from the Squirrel and Peru sands. The rock pressure has declined quite rapidly in this field from 162 to 57 pounds and the reserves are not large.

The Dunlap field in sec. 8, T. 11 S., R. 23 E., on the Dunlap and McKee leases, is controlled by the Arrow Oil and Gas Company. There are about eight wells at present producing from the Squirrel and Peru sands, but they are not large wells, averaging less than half a million cubic feet daily production. The estimated probable reserves for this field, based on pressure decline from 136 to 112 pounds, are about one billion cubic feet.

Very few deep wells have been drilled in Wyandotte county. The deepest was the Bonner Springs Oil and Gas Company No. 1 Bonner Springs well in sec. 20, T. 11 S., R. 23 E., drilled to 2,200 feet. The section of the well is as follows:

Bonner Springs Oil & Gas Co. No. 1 Bonner Springs, sec. 20, T. 11 S., R. 23 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Bronson-Lansing groups	190	0-190
Marmaton-Bourbon groups	260	190-450
Cherokee shale	390	450-840
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	325	840-1,165
Kinderhook shale	150	1,165-1,315
ORDOVICIAN SYSTEM:		
Galena-Platteville limestone	190	1,315-1,505
St. Peter sandstone	35	1,505-1,540
CAMBRO-ORDOVICIAN SYSTEM:		
"Siliceous lime"	660	1,540-2,200 T.D.

This log is included in the east-west cross-section, Plate I.

Three wells were drilled to the "Mississippi lime" near Bonner Springs, in addition to the Bonner Springs No. 1, by the Bonner

Springs Oil and Gas Company. The wells are the No. 1 Twist in the SE cor. NE¼ sec. 29, T. 11 S., R. 23 E.; No. 1 Schubert in the SE cor. NE¼ sec. 30, T. 11 S., R. 23 E.; and No. 1 Kinahan in the SE cor. NW¼ sec. 21, T. 11 S., R. 23 E. The sections in the wells are very similar, and that of the Twist well, as given below, is typical for the area.

Bonner Springs Oil and Gas Company No. 1 Twist, SE cor. NE¼ sec. 29 T. 11 S., R. 23 E.

Formation	Thickness in feet	Depth in feet
PENNSYLVANIAN SYSTEM:		
Bronson-Lansing groups	340	0-340
Marmaton-Bourbon groups	205	340-545
Cherokee group	445	545-990
MISSISSIPPIAN SYSTEM:		
"Mississippi lime"	50	990-1,040 T.D.

This well is included in the east-west cross-section of northeastern Kansas, Plate I.

The future development of oil in Wyandotte county is problematical, but there seems to be room for considerable development

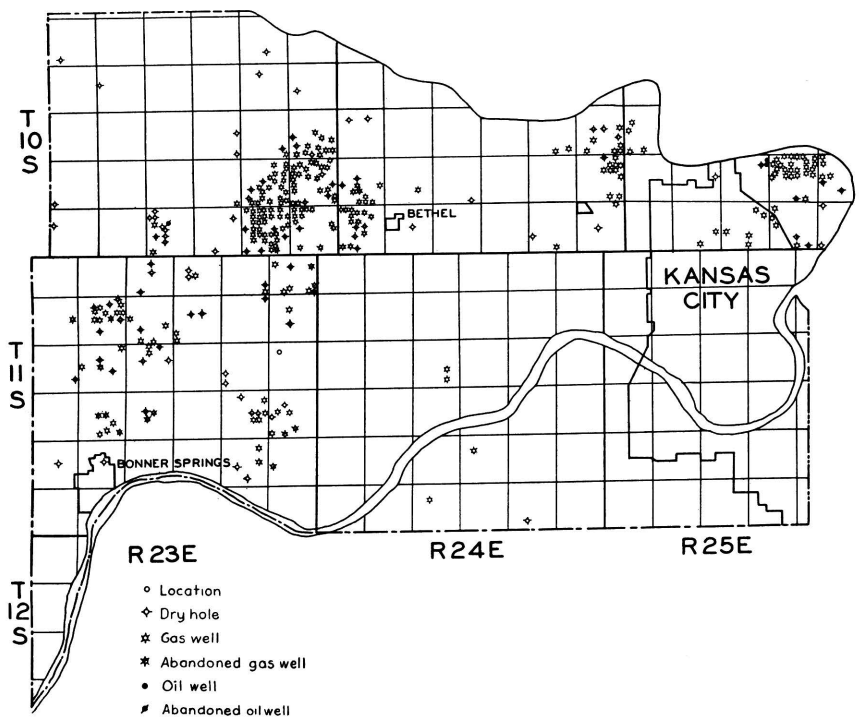


PLATE XIII.—Base map of Wyandotte county, showing location of wells.

of gas in the county. Much of the drilling has been done without careful geologic study and it seems likely that with detailed mapping new areas can be developed into good gas fields. Plate XIII shows the location of the several fields in Wyandotte county as well as scattered wells.

List of wells in northeastern Kansas drilled to "Mississippi lime" or deeper

Company	*Well*		*T. D.*
Valley Petroleum Co.....	Mann No. 1.....	SE¼ NW¼, sec. 21, T. 1 S., R. 19 E.....	2315
Valley Petroleum Co.....	Stout No. 2.....	Cen. NW¼, sec. 30, T. 3 S., R. 20 E.....	2120
Diamond drill hole.....	Atchison	SW¼ NE¼, sec. 18, T. 6 S., R. 21 E.....	1392
Garvin et al.....	Lutz No. 1.....	SW¼ NW¼ NW¼, sec. 27, T. 7 S., R. 15 E.....	2774
Indian Mound Oil Co....	Oak Mills No. 1....	NE cor. sec. 13, T. 7 S., R. 21 E.....	2890
Goens et al.....	Wabense No. 1.....	Cen. NE¼ NW¼, sec. 3, T. 8 S., R. 14 E.....	2953
Lansing coal shaft.....	.....	NE¼SE¼NE¼, sec. 27, T. 8 S., R. 22 E.....	2116
Northern O. and G. Co...	Winchester No. 1....	NW cor. sec. 13, T. 9 S., R. 19 E.....	3440
Parker Oil Co.....	Bardwell No. 1.....	Sec. 26, T. 10 S., R. 9 E.....	1093
Jennings Oil Co.....	Miller No. 1.....	NW¼ SE¼ SE¼, sec. 12, T. 10 S., R. 10 E.....	2015
Advance O. and R. Co....	Shawnee No. 1.....	SW¼ NW¼, sec. 14, T. 13 S., R. 10 E.....	2700
Empire O. and R. Co.....	Root No. 1.....	Cen. SW¼ NE¼, sec. 1, T. 11 S., R. 9 E.....	2000
Ramsey et al.....	Kaul No. 1.....	SE cor. NE¼ NE¼, sec. 2, T. 11 S., R. 11 E.....	2830
Kansas Oil Assoc.....	Wille No. 1.....	Cen. SW¼ NE¼, sec. 5, T. 11 S., R. 11 E.....	2700
Diamond Drilling	McFarland No. 1....	SW cor. sec. 31, T. 11 S., R. 11 E.....	2006
Hall et al.....	Werner No. 1.....	SE cor. NW¼, sec. 36, T. 11 S., R. 13 E.....	2006
Onarch O. and G. Co.....	Allen No. 1.....	SE cor. NE¼ NW¼, sec. 2, T. 11 S., R. 14 E.....	2471
Forrester et al.....	Hummer No. 1.....	Cen. SW¼, sec. 14, T. 11 S., R. 16 E.....	3055
Anderson Drilling Co.....	Gramse No. 1.....	SE¼ SE¼, sec. 4, T. 11 S., R. 18 E.....	2324
Bonner Springs O. and G.,	Bonner Springs No. 1,	Sec. 20, T. 11 S., R. 23 E.....	2200
Bonner Springs O. and G.,	Twist No. 1.....	SE cor. NE¼, sec. 29, T. 11 S., R. 23 E.....	1040
Bonner Springs O. and G.,	Schubert No. 1.....	SE cor. NE¼, sec. 30, T. 11 S., R. 23 E.....	1014
Bonner Springs O. and G.,	Kinahan No. 1.....	SE cor. NW¼, sec. 21, T. 11 S., R. 23 E.....	853
American Petroleum Co...	Schmidt No. 1.....	Cen. SE¼ SE¼, sec. 9, T. 12 S., R. 10 E.....	2339
Empire O. and R. Co.....	Schwalm No. 1.....	SE cor. sec. 19, T. 12 S., R. 11 E.....	3431
Jenkins and Scott.....	Hayden No. 1.....	NE¼ NE¼ SE¼, sec. 8, T. 12 S., R. 14 E.....	2693
McBride and Givens.....	Shirley No. 1.....	NE cor. SW¼, sec. 21, T. 12 S., R. 14 E.....	2469
Green et al.....	Ripley No. 1.....	NW cor. NE¼, sec. 12, T. 12 S., R. 16 E.....	3320
Smith et al.....	Smith No. 1.....	SW cor. SE¼, sec. 28, T. 12 S., R. 19 E.....	2382

Company	*Well*		*T. D.*
Forrester et al.....	Yazel No. 1.....	Sec. 18, T. 12 S., R. 22 E.....	1546
Manhattan Oil Co.....	Steinmeyer No. 1....	NE cor. NW¼ SW¼, sec. 11, T. 13 S., R. 10 E.....	2405
Williams et al.....	Henderson No. 1....	Cen. NE¼, sec. 15, T. 13 S., R. 12 E.....	3652
Wapeka Oil Co.....	Neal No. 1.....	Cen. SW¼ NE¼, sec. 26, T. 13 S., R. 15 E.....	2430
Wapeka Oil Co.....	Schwab No. 1.....	Sec. 30, T. 13 S., R. 22 E.....	2162
Ft. Scott Foundry Co....	Olathe well	SW¼ SW¼ NE¼, sec. 35, T. 13 S., R. 23 E.....	1522
Benedum-Trees	Lockhart No. 1.....	SW cor. sec. 17, T. 14 S., R. 11 E.....	2665
Universal Oil Co.....	Harrington No. 1...	NE cor. SW¼, sec. 12, T. 14 S., R. 22 E.....	2421
Universal Oil Co.....	Mahaffie No. 1.....	Sec. 4, T. 14 S., R. 23 E.....	1785
Stokes Co.	Seckinger No. 1.....	Cen. W½ SE¼, sec. 5, T. 15 S., R. 22 E.....	1036
Stokes Co.	Marshall No. 2.....	Cen. NW¼ NE¼, sec. 11, T. 15 S., R. 22 E.....	1086
Higgins	Harrison No. 1.....	NW cor. sec. 6, T. 15 S., R. 25 E.....	975
Higgins	Conboy No. 1.....	SE cor. SW¼, sec. 7, T. 15 S., R. 25 E.....	1012

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