Report to United States Department of Interior, National Park Service: Petroleum Geology and Oil and Gas Operations in Chase County with Emphasis on the Tallgrass Prairie National Preserve

Timothy R. Carr

Kansas Geological Survey
Open File Report 98-46

October 15, 1998

Summary

The petroleum geology of Chase County is dominated by the 20-km wide Nemaha uplift that extends in a north-northeast direction across the county and through the Tallgrass Prairie National Preserve. In Chase County, as elsewhere along the Nemaha uplift, Middle Pennsylvanian (Desmoinsian) sediments overlie rocks ranging from Precambrian to Mississippian. The uplift is the most important component in both structural and stratigraphic trapping of oil and gas in Chase County. The discovery in 1914 of prolific oil fields along the trend of the Nemaha uplift in Butler County, Kansas, set off a drilling boom that rapidly extended northward into Chase County. Many of the oil and gas fields in Chase County were discovered in the 1920's as part of this spurt of activity. On the Tallgrass Prairie National Preserve, gas production is from very shallow reservoirs (200 to 400 feet), and was developed by local efforts for use by surrounding ranches and cities. Until recently, reporting gas production from small non-prorated fields was not required. As a result, well locations, well production, and well history including final abandonment, are known only from scattered and incomplete records. Based on subsurface mapping, the potential for additional oil and gas reserves on the Tallgrass Prairie National Preserve is believed to be high. Cumulative oil and gas production for Chase County is estimated at 2,550 thousand barrels of oil (MBO) and 6,315 million cubic feet of gas (MMCF).

Introduction

Chase County and the area encompassing the Preserve have a long and very poorly documented history of oil and gas production. A general review of the published literature was combined with a preliminary search of digital and paper data located at the Kansas Geological Survey. A digital database was developed and used to generate a series of well location and structure maps. All products and data are available in digital form from the Survey. A more complete evaluation could be performed by searching for additional records in the files at the Kansas Geological Society, Conservation Division of the Kansas Corporation Commission, and local county and gas company records.

Structural Geology

The Nemaha uplift is a complex structural feature that extends 650-km across Kansas from Nebraska to Oklahoma (Moore and Haynes, 1917; Condra, 1927; Jewett and Abernathy, 1945; Jewett, 1951). The Nemaha uplift is coincident with the Midcontinent Geophysical Anomaly and Central North American rift system that extend from Minnesota to Kansas (Ocola and Meyer, 1973). The uplift consists of a series of asymmetric fault blocks with a relatively gently dipping western flank and steeper eastern flank. The Nemaha uplift developed mainly during the Pennsylvanian as a series of small asymmetric crustal blocks that were raised sharply along its axis. A major regional unconformity extends over much of Kansas, including Chase County. The unconformity separates Mississippian and older rocks from middle Pennsylvanian and younger strata (O'Connor and others, 1951; Merriam, 1963). A reproduction of an older cross-section across Chase County (Figure 1a, b) illustrates the subsurface structure and unconformity (O'Connor and others, 1951). At the crest of major uplifted blocks, Middle Pennsylvanian rocks overlie rocks ranging in age from Precambrian to Mississippian (Figure 1). Deformation along the Nemaha uplift is related to the Wichita and Ouachita orogenies (O'Connor and other, 1951; Merriam, 1963).

A number of gravity and magnetic lineaments are observed in Chase County (figures 2, 3). These lineaments are related to deeper basement faults that can be observed in structural maps up through the Permian and have been recognized at the surface (Prosser and Beede, 1904). Individual fault blocks can be recognized through subsurface mapping and gravity and magnetic lineaments (figures 2, 3). The blocks are typically 5 to 8 km wide and 8 to 32 km long. In northern Chase County the blocks are tilted to the northwest and bounded by major faults to the southeast (Huffman, 1959). A series of northwest trending faults provide accommodation between adjacent fault blocks. Some of these northwest trending faults have regional extent and define the structural grain of Kansas (Berendsen and Blair, 1986).

In Chase County, a number of structural features have long been recognized. These features include the Elmdale Dome, the Cedar Creek Syncline and associated Cedar Creek Fault, and the extension of the Walnut-Brownville Syncline (figures 2, 3). Both the Cedar Creek Syncline and the Elmdale Dome were

initially mapped using surface geology (Prosser and Beede, 1904). Structure maps on top of the Arbuckle Group show elevation differences is on the order of 2000', and 200 - 500' at the top of the Lansing Group (Berendsen and Blair, 1986; this report figures 9, 10). The Cedar Creek Fault that defines the southern boundary of the Cedar Creek Syncline appears to be part of a regional feature, which extends from McPherson County eastward to Greenwood County (Berendsen and Blair, 1986).

Major structural movement appears to be confined to the early and middle Pennsylvanian, but deformation due to differential compaction and minor basement movement appears to persist into the Permian.

Stratigraphic Distribution of Oil and Gas

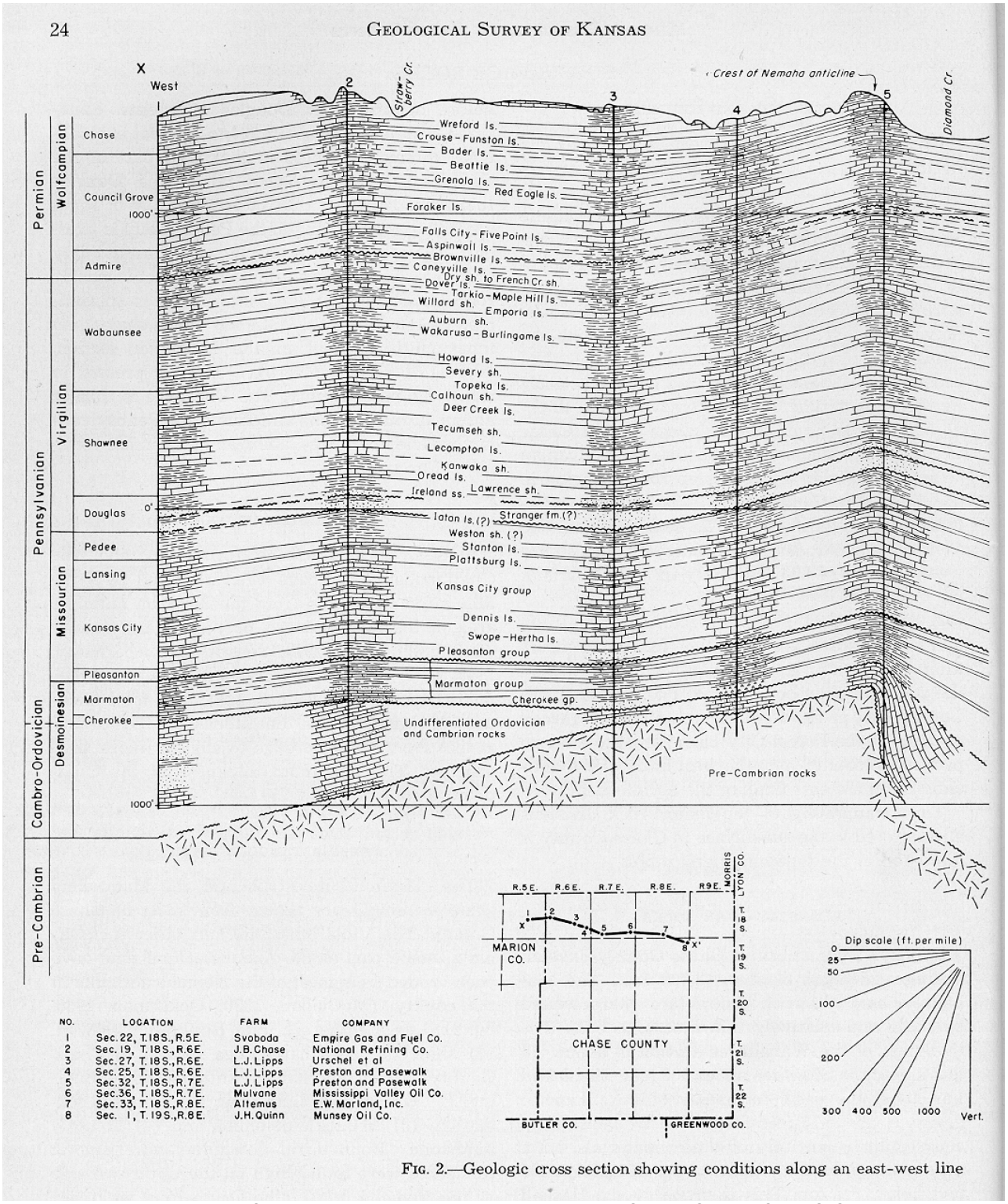
In Chase County, the most significant stratigraphic component in trapping oil and gas is the regional unconformity that separates Mississippian and older rocks from middle Pennsylvanian and younger rocks (O'Connor and others, 1951; Merriam, 1963). On the tops of major uplifted blocks, Middle Pennsylvanian rocks overlie rocks ranging in age from Precambrian to Mississippian. The result is a number of traps beneath the unconformity, and sands and conglomerates deposited along the flanks of the uplifted blocks.

In northwest Chase County, production has been reported from the Viola Limestone (Middle Ordovician) from a small number of wells (Koegboehn Field, Figure 2). Viola production in Kansas is from structural traps or unconformity traps across buried uplifted blocks beneath the Mississippian-Pennsylvanian regional unconformity.

In the southeast corner of the county, oil is produced from Mississippian carbonates, and sands and conglomerates in the Cherokee Group (Atyeo-Pixlee, Welch-Mohr SW, and Teeter-Scott fields). Mississippian (Osagian) peritidal carbonates and cherts produce from unconformity traps beneath the regional unconformity and represent a major reservoir interval in Kansas. The Cherokee Group (Pennsylvanian, Desmoinesian) consists of lenticular fluvial sands and local conglomerates that were deposited directly on the extensive Mississippian-Pennsylvanian erosion surface. The pinch out of Cherokee reservoir rocks on the flanks and across the crests of uplifted blocks resulted in the formation of numerous stratigraphic traps throughout Kansas.

The Lansing and Kansas City groups (Pennsylvanian, Missourian) are a sequence of alternating limestones and terrigenous clastics commonly combined in the subsurface and referred to as Lansing-Kansas City. The Lansing-Kansas City sequence of alternating limestones and terrigenous clastics extends upwards into overlying formations of the Douglas Group (Pennsylvanian, Virgilian). In northwest Chase County, recent development and extension in the Lipps and Diamond Creek fields from both the Lansing-Kansas City and Douglas (Ireland Sandstone) groups has significantly increased oil and gas production in the county (Figure 2).

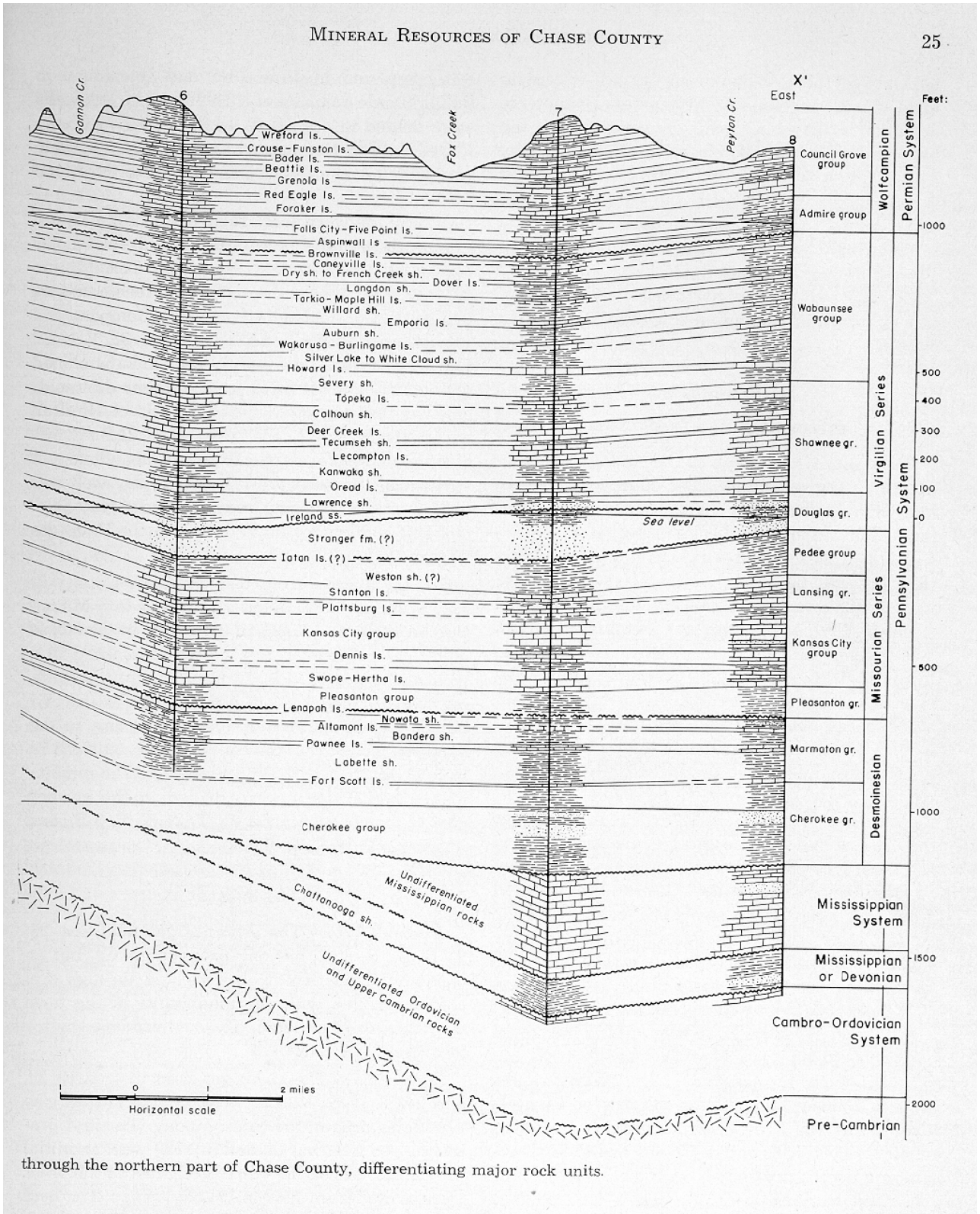
The shallowest producing interval in Chase County is the Permian Admire Group. Gas is produced from several sandstone intervals, most notably the Indian Cave Sandstone from a number of shallow (200 to 400') structural-stratigraphic traps in northwest Chase County (e.g., Davis, Elmdale, Vetter fields). At the present, the majority of this shallow gas production is inactive in Chase County.



NO.	LOCATION	FARM	COMPANY
1	Sec. 22, T. 18S., R. 5E.	Svoboda	Empire Gas and Fuel Co.
2	Sec. 19, T. 18S., R. 6E.	J. B. Chase	National Refining Co.
3	Sec. 27, T. 18S., R. 6E.	L. J. Lipps	Urschel et al
4	Sec. 25, T. 18S., R. 6E.	L. J. Lipps	Preston and Posewalk
5	Sec. 32, T. 18S., R. 7E.	L. J. Lipps	Preston and Posewalk
6	Sec. 36, T. 18S., R. 7E.	Mulvane	Mississippi Valley Oil Co.
7	Sec. 33, T. 18S., R. 8E.	Altemus	E. W. Marland, Inc.
8	Sec. 1, T. 19S., R. 8E.	J. H. Quinn	Munsey Oil Co.

FIG. 2.—Geologic cross section showing conditions along an east-west line

Figure 1a.- Reproduction of geologic cross section across northern Chase County from O'Connor and others (1951). Cross section passes just south of the Tallgrass Prairie National Preserve and shows the significant structural relief on the pre-Mississippian rocks. Cross section continues as Figure 1b.



through the northern part of Chase County, differentiating major rock units.

Figure 1b.- Continuation of geologic cross section across northern Chase County from O'Connor and others (1951). Cross section passes just south of the Tallgrass Prairie National Preserve and shows the significant structural relief on the pre-Mississippian rocks.

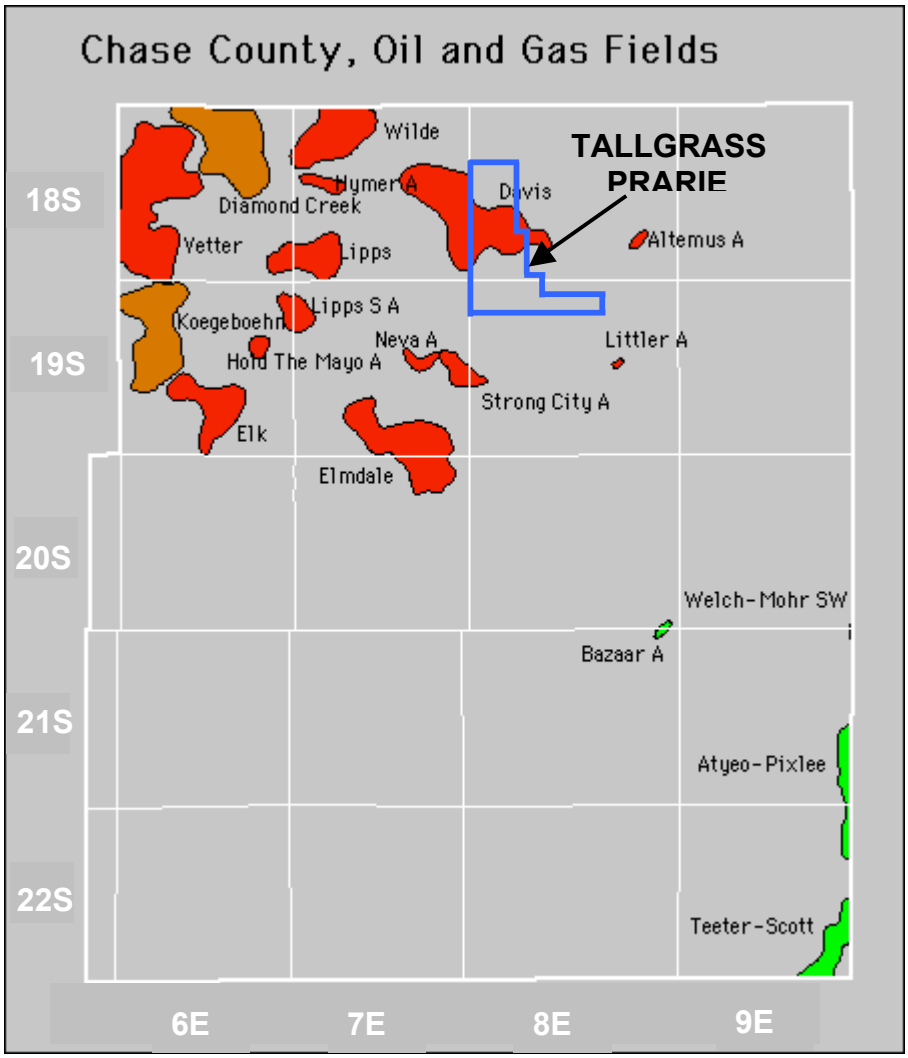


Figure 2.-Oil and Gas Fields of Chase County, Kansas. Image is modified from Kansas Geological Survey web site. The URL is http://www.kgs.ukans.edu/PRS/County/abc/chase.html.

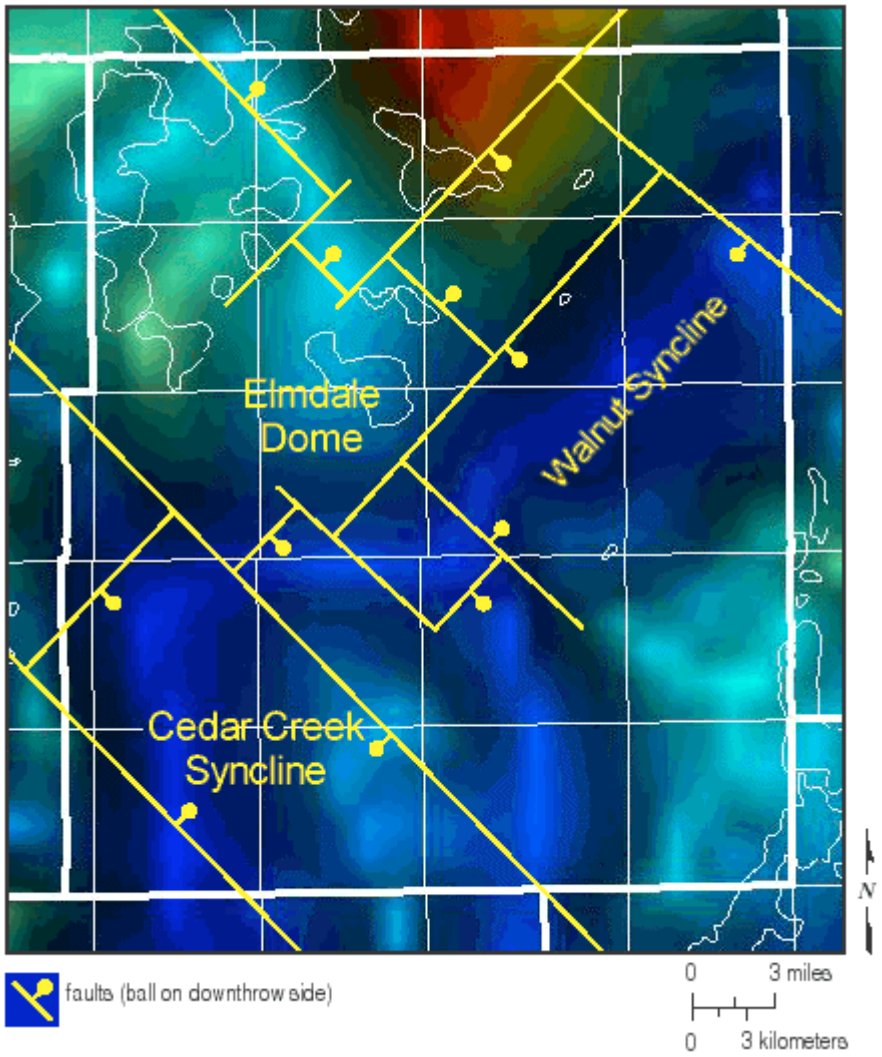


Figure 3.-Magnetic anomaly map of Chase County, Kansas, based on Kansas Geological Survey grid. Colored image is displayed with apparent relief created by vertical illumination. Blues represent lowest magnetic values; reds represent highest magnetic values. Darker shading indicates steeper gradients. Overlaid are outlines of oil and gas fields, structural features from the literature, and major fault boundaries as determined from potential fields lineaments and subsurface mapping. Image is modified from Kansas Geological Survey web site. The URL is http://www.kgs.ukans.edu/PRS/PotenFld/County/abc/chaseMagOg.html .

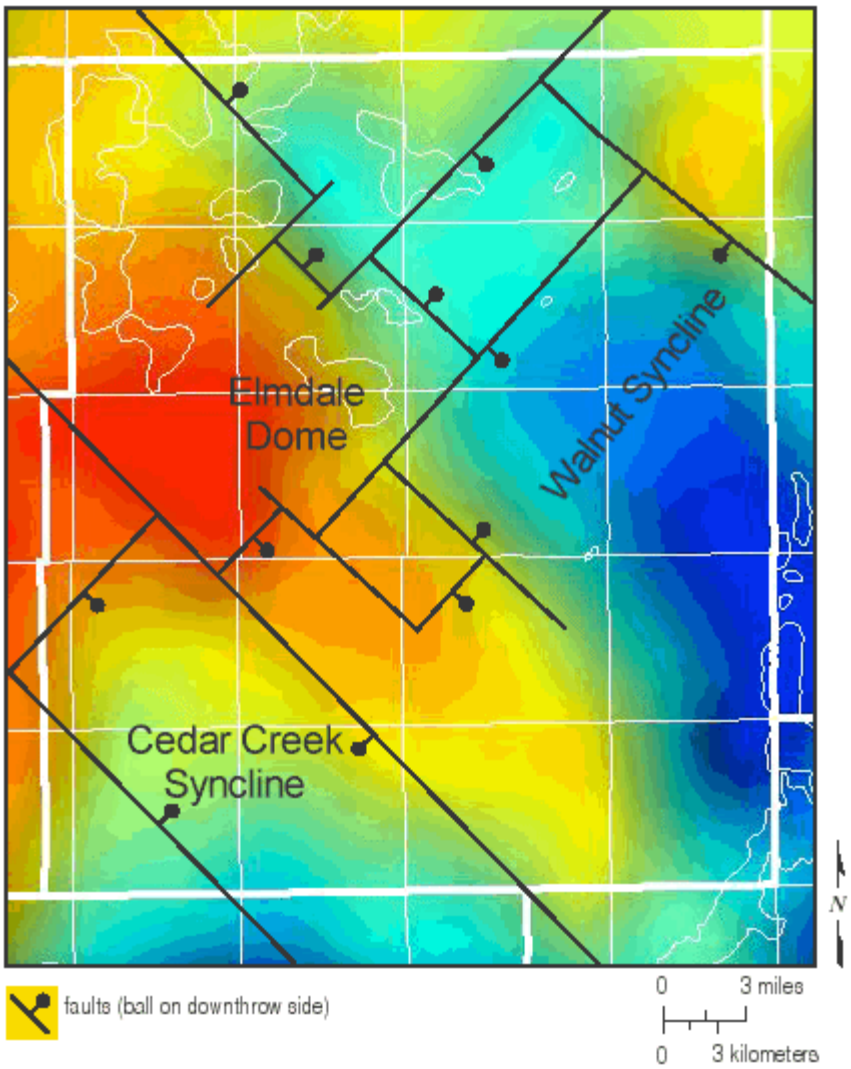


Figure 4.-Gravity anomaly map of Chase County, Kansas, based on Kansas Geological Survey data. Colored image is displayed with apparent relief created by vertical illumination. Colored image is displayed with apparent relief created by vertical illumination. Blues represent lowest residual Bouguer gravity values; reds represent highest residual Bouguer gravity values. Darker shading indicates steeper gradients. Overlaid are outlines of oil and gas fields, structural features from the literature, and major fault boundaries as determined from potential fields lineaments and subsurface mapping. Image is modified from Kansas Geological Survey web site. The URL is http://www.kgs.ukans.edu/PRS/PotenFld/County/abc/chaseGravOg.html.

Petroleum Geology

Chase County and the area encompassing the Tallgrass Prairie National Preserve have a long and very poorly documented history of oil and gas production. Cumulative oil and gas production for Chase County is estimated at 2,550 thousand barrels of oil (MBO) and 6,315 million cubic feet of gas (MMCF). The majority of the gas production is from the Permian Admire Groups and is very shallow (200 to 400 feet) and was developed by local efforts for use by surrounding ranches and cities. Until the early 1980's, gas production was not typically reported for small non-prorated fields. As a result, well locations, well production, and well history, including final abandonment, are known only from scattered and incomplete records.

The first production in Chase County was reported from the Elmdale Gas Field just southwest of the Tallgrass Prairie National Preserve. The Elmdale Gas Field was discovered sometime in the early 1920's, but the year is uncertain. Drilling was probably based on surface mapping of the Elmdale Dome (Prosser and Beede, 1904). According to available records, in September 1925, the Lipps Field on the northern end of the Elmdale Dome was discovered (Discovery well: Preston and Pasewalke #1 Lipps, sec. 32, T18S, R7E). Also in 1925, the Teeter and Atyeo oil fields were extended into the southeast corner of Chase County.

The Davis Gas Field extends over the present Tallgrass Prairie National Preserve. The field was named after one of the early owners of the ranch. The field covered large portions of sections 18, 19, 30 and 31 (figures 2, 5). The first producing well (sec. 30, T18S, R8E) in the Davis Gas Field was drilled in 1929 with an initial reported production of 681 MCF of gas per day. However, the majority of wells in and immediately surrounding the preserve were not drilled until the 1940's when oil was in short supply due to World War II. Producing horizons in the Davis Gas Field are the "Indian Cave Sandstone" of the Onaga Shale, and an unnamed sandstone in the Hamlin Shale Member of the Janesville Shale; both formations are part of the Lower Permian Admire Group (Zeller, 1968). Most of the wells were completed with an open hole across the producing formation, and depth to productive interval(s) ranges from 260 to 450 feet. Initial production appears to be in the range of 30 to 50 MCF/D, but rates up to 1 MMCF/D have been reported (O'Connor and others, 1951). In 1950, O'Connor and others (1951) reported 36 wells in the field. Three of the wells were abandoned gas wells and one was an abandoned oil well (only a couple of barrels reported prior to abandonment). The remaining wells produced gas that was piped for local use through a 6" pipe to Strong City and Cottonwood Falls. Production, insufficient during the winter months, was supplemented from a 26" pipeline that passed just north of Strong City. Both lines appear to have crossed the present Preserve boundaries. Approximate locations of gas lines and wells are shown on Figure 5 (O'Connor and others, 1951). The location and history of many early wells in the Davis Gas Field is known only from sketchy records or solely from well spots on a map (See Figure 5 a reproduction of a plate in O'Connor and others [1951] for one of the better maps). Production and plugging records for these early wells are at best incomplete and it would require significant manual effort to improve documentation. Well locations in the Davis Gas Field that were recorded in the files of the Kansas Geological Survey are show on the structure maps (figures 8-10) and are listed in Table 1.

During the period 1988 to 1990, the Davis Gas Field was extended to the west. A total of 43 wells were drilled on the Mulvane Ranch Lease along the eastern edge of T18S, R7E. Maximum production reached 100 MMCF per year in 1990 and then quickly declined (Figure 7). The lease is inactive and the last reported production was in 1997. Many of the wells on the Mulvane lease are located along the western edge of the Tallgrass Prairie National Preserve (Figure 8).

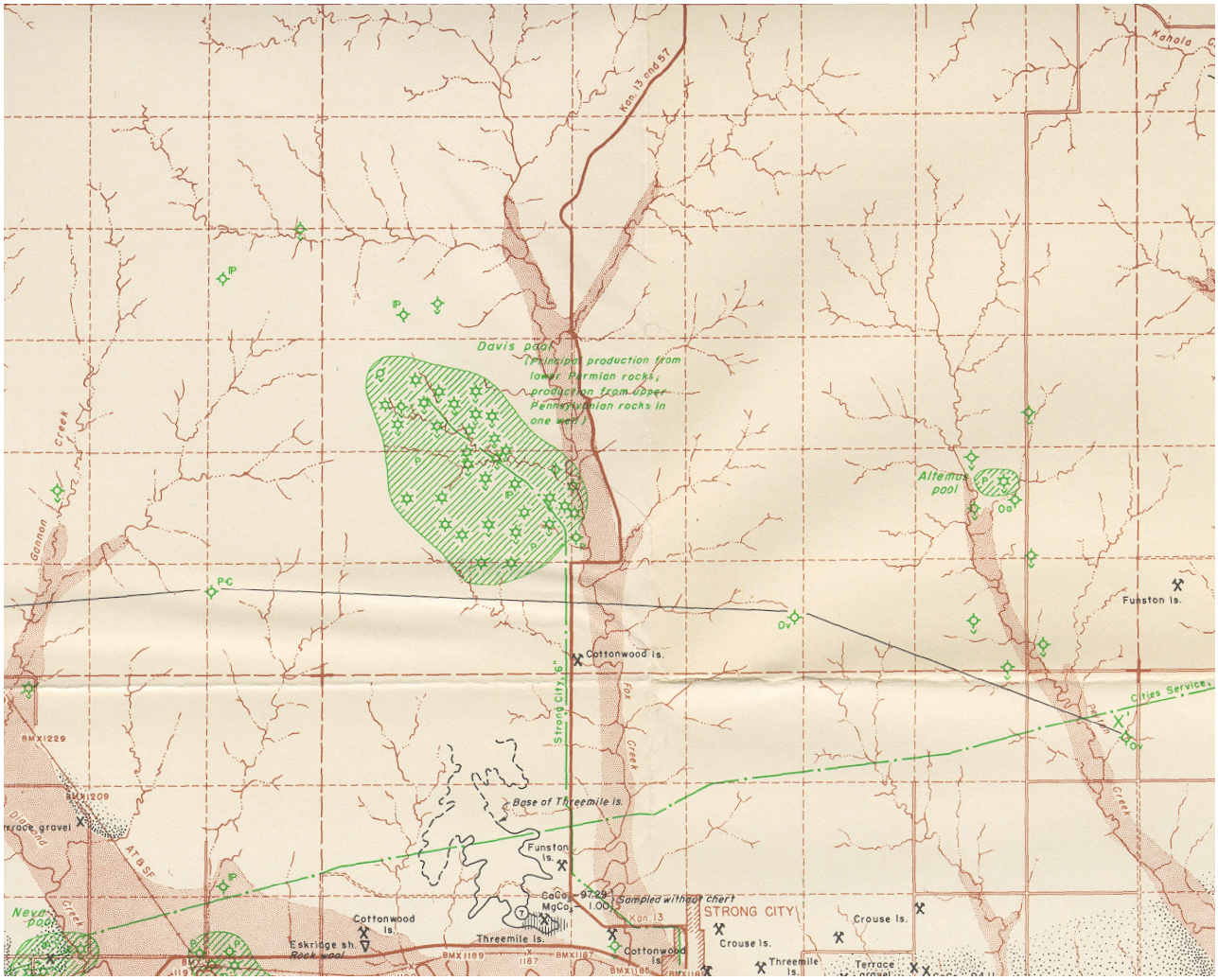


Figure 5.- Scanned image covering a portion of Plate 2 included in the report of O'Connor and others (1951). At the time of the report, the Davis Gas Field covered parts of sections 19 and 30 (T18S, R8E) and a 6" gas line extended to Strong City. Gas production is from sandstone horizons in the Permian Admire Group.

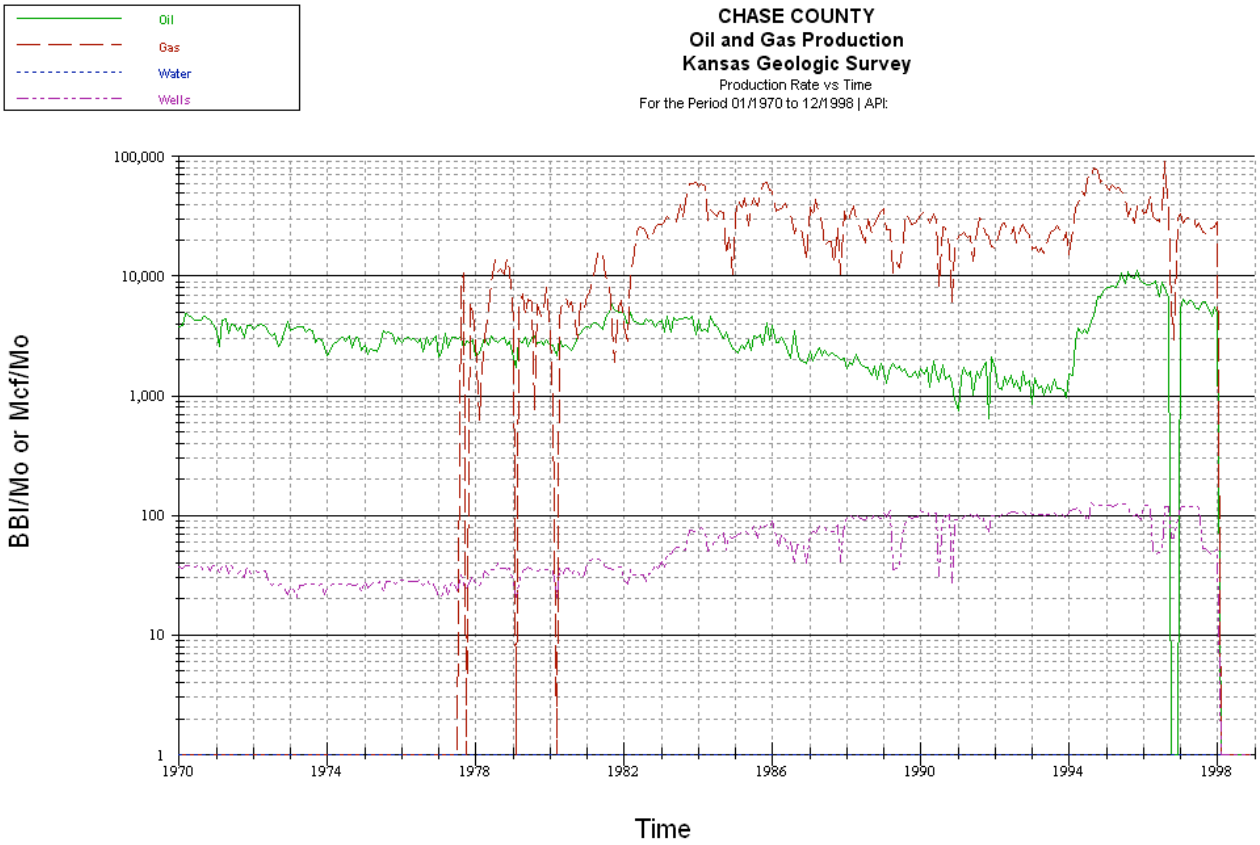


Figure 6.- Monthly production data for Chase County through January 1998. Gas production prior to 1978 is not available and is not reliable prior to 1982 due to absence of production reporting requirements. The increase in oil and gas production in 1994 is the result of the discovery of deeper production from the Lansing-Kansas City and Douglas groups at Lipps and Diamond Creek fields.

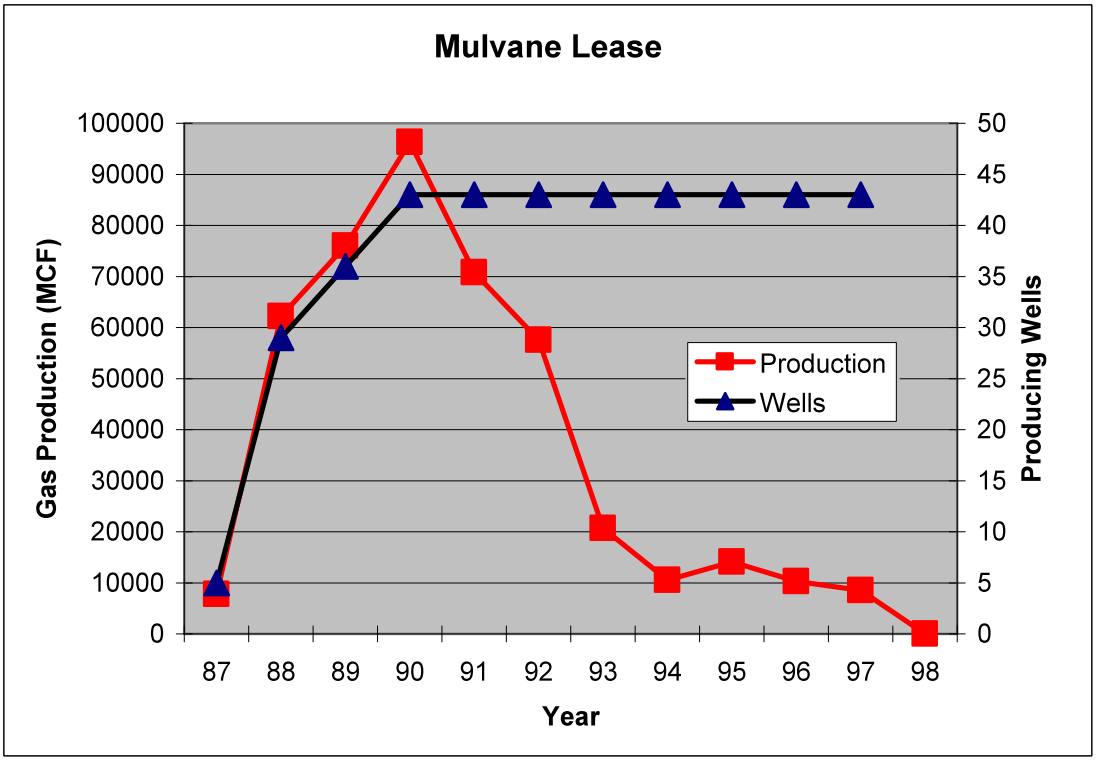


Figure 7.- Annual production data for the Mulvane Lease in the Davis Gas Field. The lease is inactive and the last reported production was in 1997.

Potential Oil and Gas Resources

The potential for additional oil and gas production on the Tallgrass Prairie National Preserve is believed to be high. The Admire shallow gas play is not fully developed on the Preserve. This is especially evident from the clustering of relatively new wells on the Mulvane Ranch lease just west of the Preserve, and the structure on top of the producing Admire interval (Figure 8). The western parts of sections 18, 19, and 30 are high potential infill targets. However, production from the Davis Ranch Field is from a relatively shallow reservoir, and its low pressure-low rate nature may make production uneconomic under present market scenarios. The potential for additional gas reserves within the boundaries of the Preserve from infill drilling that targets the Permian Admire Group is very high.

A second possible play would be relatively deeper oil and gas production from reservoirs within the Lansing-Kansas City and Douglas groups. This play has been a successful target for deeper pool extension in the Lipps and Diamond Creek fields located 6 miles west of the Preserve. Deeper production from these fields was discovered in 1994 and accounts for approximately 80 to 90% of present oil and gas production from Chase County (Figure 6). A structure map on the top of the Lansing Group (Figure 9) shows that production is, in part, controlled by a structural nose that is an extension of the Elmdale Dome. The Elmdale Dome and other Chase County structures have been interpreted as an uplifted basement structure with basement faulting continuing up through the Pennsylvanian (The stratigraphic component of Pennsylvanian production was not investigated). A similar structural nose, while poorly defined, runs across the northern parts of the Preserve. Pennsylvanian strata throughout Chase County deserve additional examination.

Finally, while more speculative, potential unconformity traps beneath the late Mississippian - early Pennsylvanian unconformity have not been fully evaluated in Chase County. A structure map on top of the Lower Ordovician Arbuckle Group is included (Figure 10). The nearest production from reservoirs beneath

the unconformity is approximately 15 miles southwest (Ordovician Viola Limestone production from Koegboehn Field, [Figure 2]). The potential for deeper production on structural highs beneath the unconformity has not been fully tested and remains a potential exploration target.

Oil and Gas Wells Located on the Preserve

Known well locations within the Tallgrass Prairie National Preserve are shown in figure 8-10 and listed in Table 1. A number of wells on the preserve were not in the Kansas Geological Survey records, but are shown on various maps (e.g., O'Connor and others, 1951). Other wells are not well documented to location (e.g., “toward west-side of section”). Many of these wells could be documented with further investigation of records in Wichita at the Survey Sample Library and the Kansas Geological Society Library and the Kansas Corporation Commission. The local Strong City Gas Company (if still in operation) may be another valuable information source. Complete digital data used to construct the attached maps is stored at the is stored at the Kansas Geological Survey in relational databases and in Geographix^{tm} compatible form.

References Cited

Berendsen, P. and K. P. Blair, 1986, Subsurface structural maps over the Central North American rift system (CNARS), central Kansas, with discussion: Kansas Geological Survey, Subsurface Geology Series 8, 16p.

Condra, G. E., 1927, The stratigraphy of the Pennsylvanian System in Nebraska: Nebraska Geological Survey, Bulletin 1, 291p.

Huffman, G. G., 1959, Pre-Desmoinsian isopachous and paleogeologic studies in central Midcontinent region: AAPG Bulletin 43:2541-2574.

Jewett, J. M., 1951, Geologic structures in Kansas: Kansas Geological Survey, Bulletin 90, part 6, p. 105-172.

Jewett, J. M. and G. E. Abernathy, 1945, Oil and gas in eastern Kansas: Kansas Geological Survey, Bulletin 57, 244p.

O’Connor, H. G., J. M. Jewett, and R. K. Smith, 1951, Geology, mineral resources, and ground-water resources of Chase County, Kansas; Part 2; Mineral resources of Chase County: Kansas Geological Survey, 11:16-28.

Merriam, D. F., 1963, The geologic history of Kansas: Kansas Geological Survey, Bulletin 162, 317p.

Moore, R. C and W. P. Haynes, 1917, Oil and gas resources of Kansas: Kansas Geological Survey, Bulletin 3, 391p.

Ocola, L. C., and R. P. Meyer1973, Central North American rift system 1, Structure of the axial zone from seismic and gravimetric data: Journal of Geophysical Research, v. 78, no.23, p. 5, 173-175, 194.

Prosser, C. S., and J. W. Beede, 1904, Description of the Cottonwood Falls quadrangle (Kansas): U. S. Geological Survey, Geologic Atlas Folio Series no. 109, 6p.

Zeller, D. E., 1968, The stratigraphic succession in Kansas: Kansas Geological Survey, Bulletin, 189, 81p.

Table1.- Wells in the Kansas Geological Survey files that are located within the boundaries of the Tallgrass Prairie National Preserve. Wells without designated API number were assigned an arbitrary number containing a “W”. Plugged date is from the plugged well file.

API NUMBER	OPERATOR	LEASE NAME	WELL No.	TWN	RGE	SEC	SPOT	PLUGGED DATE
15017000760000	REX & MORRIS	D N MERRILL		18S	8E	18	TWST	Oct-01-1959
15017200820000	BMG INC	Z-BAR CATTLE		18S	8E	18		
15017205840000	KNIGHTON OIL	DAVIS TRUSTS		18S	8E	18		
15017205840001	KNIGHTON OIL	DAVIS TRUSTS		18S	8E	18		
15017205860000	KNIGHTON OIL	DAVIS TRUSTS		18S	8E	18		
15017205860001	KNIGHTON OIL	DAVIS TRUSTS		18S	8E	18		
15017206670000	KNIGHTON OIL	DAVIS TRUSTS		18S	8E	18	SW SE NW	
15017207050000	KNIGHTON OIL	DAVIS TRUSTS		18S	8E	18	SW	
15017W00020000	STRONG CITY GAS CO.	DAVIS	40	18S	8E	18	4550W/450S/NEC	
15017W00030000	STRONG CITY GAS CO.	DAVIS	41	18S	8E	18	3600W/1800N/SEC	
15017W00040000	STRONG CITY GAS CO.	DAVIS	42	18S	8E	18	5050W/1395S/NEC	
15017W00050000	WATCHERN OIL & GAS CO.	PATTON	1	18S	8E	18	5750W/2000N/SEC	
15017W00550000	STRONG CITY GAS CO.	DAVIS NOLAND	47	18S	8E	18	NW	Sep-01-1966
15017205830000	KNIGHTON OIL	DAVIS TRUSTS		18S	8E	19		
15017W00060000	STRONG CITY GAS CO.	DAVIS	21	18S	8E	19		
15017W00070000	STRONG CITY GAS CO.	URASCH	1	18S	8E	19	4900W/300N/SEC	
15017W00560000	KNIGHTON OIL	DAVIS	4	18S	8E	19	3630W/330S/NEC	Aug-01-1989
15017W00580000	KNIGHTON OIL	DAVIS	5	18S	8E	19	1980N/4620W/SEC	Aug-01-1989
15017W00590000	KNIGHTON OIL	DAVIS	6	18S	8E	19	2310N/1970W/SEC	Oct-01-1989
15017W00600000	KNIGHTON OIL	DAVIS	7	18S	8E	19	3660N/990W/SEC	Oct-01-1989
15017W00610000	KNIGHTON OIL	DAVIS	8	18S	8E	19	2970W/330N/SEC	Aug-01-1989
15017W00620000	KNIGHTON OIL	DAVIS	25	18S	8E	19	3630W/990S/NEC	Aug-01-1989
15017W00630000	KNIGHTON OIL	DAVIS	26	18S	8E	19	2640N/2970W/SEC	Oct-01-1989
15017W00640000	KNIGHTON OIL	DAVIS	28	18S	8E	19	3300N/3300W/SEC	Oct-01-1989
15017000270000	FRANK STRAIT ET AL.	DAVIS-MERRELL	1	18S	8E	30	C NW	Aug-01-1958
15017W00110000	H. A. AMERINE ET AL.	DAVIS	13	18S	8E	30	2000W/1320S/NEC	
1501700120000	H. A. AMERINE ET AL.	DAVIS	14	18S	8E	30	2000W/1980S/NEC	
15017W00130000	H. A. AMERINE ET AL.	DAVIS	15	18S	8E	30	2000W/3300S/NEC	
1501700140000	STRONG CITY GAS CO.	DAVIS	9	18S	8E	30	1980S/5940W/NEC	Oct-01-1989
15017W00150000	STRONG CITY GAS CO.	DAVIS	10	18S	8E	30	3900W/50N/SEC	Oct-01-1989
1501700160000	STRONG CITY GAS CO.Y	DAVIS	11	18S	8E	30	2310N/2310W/SEC	
1501700170000	STRONG CITY GAS CO.	DAVIS	12	18S	8E	30	2310S/2310W/NEC	
15017W00650000	KNIGHTON OIL	DAVIS	14	18S	8E	30	2970N/2310W/SEC	Oct-01-1989
15017W00180000	H. A. AMERINE ET AL.	DAVIS	16	18S	8E	30	4450W/1650N/SEC	
15017W00190000	H. A. AMERINE ET AL.	DAVIS	17	18S	8E	30	4290W/330N/SEC	Oct-01-1989
15017W00200000	H. A. AMERINE ET AL.	DAVIS	18	18S	8E	30	5940W/1980N/SEC	
15017W00210000	STRONG CITY GAS CO.	DAVIS	19	18S	8E	30	1980S/7590W/NEC	Oct-01-1989
15017W00220000	STRONG CITY GAS CO.	DAVIS	44	18S	8E	30	1155W/1485N/SEC	
15017W00660000	KNIGHTON OIL	URSCHEL	3	18S	8E	30	2640N/2640W/SEC	Oct-01-1989
15017W00230000	CHASE CO. PIPELINE CO.	URACHELL	9	18S	8E	30	1155W/1155N/SEC	
15017W00240000	STRONG CITY GAS CO.	DAVIS	45	18S	8E	31	1760W/1430S/NEC	
15017W00670000	STRONG CITY GAS CO.	DAVIS	34	18S	8E	31	8250W/330N/SEC	May-01-1960
15017W00680000	STRONG CITY GAS CO.	DAVIS	35	18S	8E	31	4950W/330N/SEC	May-01-1960
15017W00260000	STRONG CITY GAS CO.	DAVIS	32	19S	8E	6	3300W/2020N/SEC	
1501700270000	STRONG CITY GAS CO.	DAVIS	33	19S	8E	6	5940W/3300N/SEC	Jul-01-1959
15017W00690000	STRONG CITY GAS CO.	DAVIS	31	19S	8E	7	NW/NW/SE	Aug-01-1958
15017W00700000	CHASE CO. PIPELINE CO.	MERILL	32	19S	8E	8	NW/SE	Aug-01-1958

Figure 8.- **(Attached Map)** Structure map for Chase County showing well locations and well control on top of the Admire Group (Permian). Tops listed for the Admire Group are subsea measurements. Data and contours are restricted to the northwest corner of the county. Oil and gas wells are coded by primary producing horizon. The approximate boundaries of the Tallgrass Prairie National Preserve are shown in yellow.

Figure 9.- (**Attached Map)** Structure map for Chase County showing well locations and well control on top of the Lansing Group (Pennsylvanian, Missourian). Tops listed for the Lansing Group are subsea measurements. Fault patterns are based on regional patterns, structure, and potential field data (gravity and magnetics). Oil and gas wells are coded by primary producing horizon. The approximate boundaries of the Tallgrass Prairie National Preserve are shown in yellow.

Figure 10.- **(Attached Map)** Structure map for Chase County showing well locations and well control on top of the Arbuckle Group (Lower Ordovician). Tops listed for the Arbuckle Group are subsea measurements. Fault patterns are based on regional patterns, Lansing structure, and potential field data (gravity and magnetics). Oil and gas wells are coded by primary producing horizon. The approximate boundaries of the Tallgrass Prairie National Preserve are shown in yellow.