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Oil Exploration and Production in Kansas:
Present Activity, Future Potential

by

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The comments in this paper are confined to oil production and exploration in Kansas. Nevertheless, natural gas, certainly an important commodity, has recently experienced significant setbacks in production in Kansas which will also affect immediate exploration activity. To adequately discuss both oil and gas activities would require a much more lengthy articulation. The goal of this paper is to provide a perspective on oil in Kansas, where the industry has been and is now today, highlighting developments that have made Kansas an exciting petroleum province, particularly in the last few years. We share a guarded optimism for the immediate future, calling on several promising drilling trends that have and should continue to generate serious interest by the petroleum industry.

Annual oil production in Kansas peaked in 1956 at 124.5 million barrels.[1] 8006 wells were drilled in that year, only 10% of which were exploratory wells. Through 1956 annual oil production had increased between 35 and 40 million barrels per year. It was a time of rapid development drilling of many large and several giant oil fields.

Following this peak year of 1956, drilling, exploration, oil production and reserves in Kansas began to decline. Production fell 5 to 10% per year until 1975. Many major oil companies directed their exploration endeavors to areas outside of Kansas. Drilling in recent years has found fewer large fields and many more small ones, following the general trend that large oil fields are usually discovered early in the exploration of a province. During the last 30 years the paucity of new, large fields has limited the ability to replace reserves and maintain production levels. Nevertheless, significant increases in drilling since 1977 have stabilized both.

There has been a strong, positive surge in the drilling activity since 1979. If we examine the last few years of the production curve, we see that the decline has stopped and an increase is under way at a rate comparable to that of the past (Table 1 below).[1] Since 1979 oil production in Kansas has, in fact, increased 25%.

REVERSAL OF CRUDE OIL PRODUCTION DECLINE IN KANSAS

	Million bbls	Percent Change
1977	57.50	-1.7
1978	56.59	-1.6
1979	57.00	+0.72
1980	60.15	+5.5
1981	65.80	+9.4
1982*	~70.5	+7.4 (U.S. 1.4%)

*Latest (March 1983) report of pipeline runs by the Kansas Corporation Commission.

The number of exploration and production wells began a modest increase in 1974.[2] In 1979, exploratory wells began a strong rise while development drilling increased spectacularly in Kansas.

Well completions reported to API in 1982 were an all-time record 34% over those of 1981. There were 9199 production, exploratory, and service completions reported in 1982 compared to the 8006 wells during the previous peak year of 1956. This upward trend that began in 1979 is the first major increase in 23 years (Table 1). 66% of the development wells were successful in 1982; one in five exploratory wells were completed as producers. These exploration wells consisted of both extensions and new-field wildcats. The effect of this surge in drilling on oil production was immediate.

33% of the land area in Kansas is estimated now to be under lease for oil and gas (around 17 million acres) including 7.6 million producing acres and 9.4 million undeveloped lease acres. On the producing acreage oil is being extracted from nearly 43,000 active wells. The average well produces 4.25 barrels of oil per day. Of these oil wells 29,400 are stripper wells (wells that produce less than 10 BOPD), which account for an important 68% of the total number. Stripper wells contributed over 45 million bbls in 1981, 68% of all production.

In 1981 total oil produced on leases with secondary recovery in Kansas was reported as 17 million barrels or 26% of the annual production.[1] Over 10 million barrels of this recovered oil was attributed to secondary methods, mostly waterflooding. Secondary recovery affected 16,400 producing wells or over 40% of all oil-producing wells in Kansas. Many stripper wells are tapping nearly depleted reservoirs that are under a strong water drive where no secondary methods of recovery are anticipated. It is not unusual to have water cuts in excess of 95% in many of these older, stripper wells.

There are now 400 abandoned fields in Kansas that produced in excess of 10,000 barrels each. These once-operating fields account for over 53 million barrels of cumulative oil production in Kansas. During 1982, 85 fields previously abandoned are again producing as a result of renewed drillin g. Nevertheless, these abandoned fields may provide additional oil production through tertiary oil recovery.[2]

Kansas is certainly a mature oil- and gas-producing province with a long history of petroleum production going back to 1870's. Proven oil reserves still remain around 370 million bbls, stabilizing in the late 70's as a result of the drilling surge (Figure 3). Over 5 billion barrels of oil have been produced from the original oil in place, estimated to have been 16.6 billion barrels. 11.6 billion barrels then remain as a resource.[3] Estimates of this resource potentially recoverable by tertiary recovery range from around 1 billion barrels following guidelines in a recent publication on improved oil recovery by Exxon[4] to possibly 2.2 billion barrels for present EOR technology using figures by Geffen[5] as originally applied by Ebanks[6] to Kansas in an earlier paper published in proceedings of this conference.

The causes of the recent drilling surge are more apparent than the reasons for the latest precipitous slow-down. The predictions for the future remain speculative at best. Since the 1973 oil embargo and the formation of OPEC, the domestic petroleum industry has gone through a series of major adjustments and is still doing so as the price for oil continues to fluctuate. The following is a brief discussion of some of the causes of latest drilling rise and decline.

Figure 4 illustrates the trends taken by the intents to drill filed in Kansas with the Conservation Division, Kansas Corporation Commission and the monthly Hughes Rig count between 1970 and January 1983 versus the average monthly domestic wellhead price for crude oil.[7]

Drilling activity in Kansas closely followed the price of crude oil with very little lag time. The recent decline in rig count and intents to drill is continuing at present. 702 intents were filed and an average of 122 rigs were estimated by Hughes to be active during February 1983, down 18% and 15% from January 1983 and 29% and 42% from one year earlier. Nevertheless, the price of oil has only declined 7% between February 1982 to February 1983. Factors in addition to price must be affecting drilling activity. Furthermore, the decline in the prospects for oil price increases in the immediate future, strongly inferred from the present decline in price, has cut assets and trimmed anticipated return on investment.

A survey published in the January 1983 issue of the American Oil and Gas Reporter queried the independent oil and gas operators regarding the major incentives for drilling. The availability of investment capital and crude-oil prices were their two top responses. Obviously, when oil prices went from $3.39 a barrel in 1973, which was less than the price of oil in 1920, to nearly $40.00 in January 1981, a significant increase in the number of wells drilled would be anticipated. Kansas, in fact, experienced a 340% increase in number of wells drilled per year in 1982 over 1973, an all time record.

The high record level of drilling was reached because of the availability of new sources of investment capital. Steward-Gorden in a February 1, 1982 article in World Oil concluded that these high levels were sustained by new people getting involved in the oil industry.[9] He estimated that as much as $7 billion of nontraditional financing found its way into the domestic (U.S.) oil industry between the end of 1979 and the middle of 1982. Limited partnership drilling funds increased substantially after 1978 to a peak of nearly $2 billion in 1981 alone, according to a recent Oil and Gas Journal article.[10] Money in public drilling funds, though, has fallen precipitously, some 45% in 1982 alone, as these drilling investments "lost some of their magic." This loss of capital was caused by more than just the drop in the price for oil. The recession and tax-law changes that affected investors across the country diverted their money away from these investments and in turn helped to bring on the cash-flow problem in the petroleum industry. A recent article in the AAPG Explorer states that investment capital will be the critical, major issue for the 1980's.[11]

The price for domestic crude oil has dropped around 20% since 1979. Drilling across the country has dropped 40% during the same time period, again suggesting that the declining prices are only part of the problem that the industry faces today. If prices were the total cause of this decline in drilling, the recent drop in drilling should have been less than proportional to the price decline, particularly with the buffer of the windfall profits tax, according to the scenario presented by Merklein and Asner.[12] Alternately, recent declines in the cost of money and driling have continued to improve the economics of prospective sites for exploration and development drilling. Also, many leases have now become available. While investment remains a problem, other factors should make drilling more lucrative even though oil prices may be flat for the immediate future.

Investment in drilling and exploration based on $80-$90 per barrel of oil in the 1990's is a little unreasonable with today's world developments, thus the readjustment in investment strategy. Nevertheless, the cash-flow-generating potential of exploration and production remains most attractive for companies, according to a recently published analysis by a senior editor of the Oil and Gas Journal.[13] Companies will need to streamline their operations, though, to generate the necessary capital for drilling. 1981 was an extraordinary year for drilling and completions in Kansas, but another repeat soon is not anticipated. 1983 and 1984 though will probably be more in line with the gradual growth experienced in previous years proceeding 1973 up through 1980.

The last several years have been very exciting times for the oil industry in Kansas. Money was available in abundance to drill wells to find new fields and to replace reserves that were being consumed. This is exactly opposite of the situation during the late 60's and early 70's when the Kansas oil industry was more or less slowly going out of business, when the price of oil barely, if at all, covered its replacement cost, while reserves and production declined. The surge in drilling and its success in halting the reserve decline suggests that there still are opportunities for further successful drilling, and for even more important new trends for exploration.

A major concentration of Kansas oil production is closely associated with the Central Kansas uplift, also along the western flanks of this uplift in the Hugoton Embayment, the Nemaha uplift including both crestal areas in the south and along its west and eastern flanks. Oil fields are also concentrated in the Cherokee and Sedgwick basins (Figure 5).

The Central Kansas uplift is the most densely drilled geological province in the U.S., according to Petroleum Information (Figure 6).[14] The Sedgwick Basin ranked number four in the country. The maturity of much of this area as a producing region is obvious.

New exploratory wells reported as discoveries in 1982 are concentrated on the Central Kansas uplift, the Hugoton Embayment, Sedgwick basin, Cherokee basin, and portions of the Nemaha uplift (Figure 5 and 7). Most of the exploratory drilling was close to existing production on established trends. During 1981 successful exploratory drilling in the Hugoton embayment was higher than in 1982, probably a reflection of the effect of prices stabilized to decreasing oil prices on deeper drilling in Kansas. The wells reported in 1982 reflect many wells actually drilled in late 1981. The pie chart in Figure 8 depicts the division of the oil discoveries for geological province (see Figure 5) for 1981 and 1982. The Hugoton Embayment is a close second to the Central Kansas uplift in number of discoveries in these two years. Together they contain over two-thirds of the discoveries in the State.

The Lansing and Kansas City Groups of Pennsylvanian age dominated the oil discoveries in 1981 and 1982 (Figure 9). The Mississippian carbonates were a close second, followed by the many other producing zones of Kansas. Notice that the Pennsylvanian interval accounts for over one half of the discoveries. Of course, numbers like these do not reveal the significance of a particular discovery and its relationship to potential development in the future. We will now examine some of the established producing areas and, then, where new exploration and development trends are coming to life.

Although discoveries today in the Arbuckle Group do not rank in the upper echelon, 47% of the original oil in place (OOIP) in Kansas is from Ordovician-age rocks, primarily from the carbonates of the Arbuckle Group. Present production concentrated on the Central Kansas uplift is indicated in Figure 10 by the distribution of producing oil and gas wells.

36% of the OOIP is associated with reservoirs of Pennsylvanian age representing primarily a split between the Lansing-Kansas City (L-KC) carbonates (Figure 11) and the Cherokee sandstones (Figure 12). The L-KC production is concentrated on the crest of the Central Kansas uplift, yet much of the new and successful activity is taking place west of the uplift. The Cherokee Group is noted for its oil and gas from southeastern Kansas, the location of and the strata from which oil was first produced in Kansas. Nevertheless, the Cherokee along the western flanks of the Central Kansas uplift offer excellent opportunities for good sandstone reservoir development. Both the L-KC and Cherokee zones remain as intervals with important new discoveries. A key factor that still makes them viable, prospective zones is the geological conditions that have produced subtle traps for oil accumulation. Improved technology and geologic interpretation are required in exploration to reduce the inherent risks.[15,16]

16% of the OOIP in Kansas is estimated to reside in Mississippian-age carbonate reservoirs. Mississippian oil and gas reservoirs flank the Central Kansas uplift and an area in the Hugoton Embayment along trends where layers of these rocks are truncated beneath a regional buried Pennsylvanian-age erosion surface. Of those units shown, the Warsaw is oldest and the Chester is the youngest Mississippian rock. These layers dip gently to the southwest (Figure 13). Subdued traps of hydrocarbons have been documented in this interval and this area offers future possibilities for finding additional accumulations of oil.[17]

Approximately 4% has been added to the State's total original oil in place since 1977 and historically this addition reflects a rather successful period of development. As previously mentioned, this development has also kept pace in replacing the reserves depleted by production during this same period. Attention is now focused on several promising drilling trends in the State.

Some of the oldest reservoirs have probably generated the most excitement and a lot of publicity. Articles written two decades ago expected the Forest City Basin to be actively drilled back then, some predicting 25 to 50 wildcats per year. Interest in this area though, has fluctuated through the years as has drilling and, until most recently, interest was quite limited. Pendleton, Petro Lewis, Energy Management Corporation, and Stone Petroleum Corporation drilled a discovery in the Forest City Basin in December 1981, the #1 McClain in Nemaha County, Kansas. This changed the complexion of the area. The discovery well was 10 miles north of a 1979 discovery by Cities Service Company, the #1 Beck in Corning Field.

The McClain field now has 14 development wells that lie within an apparent fault block within the Humboldt fault zone (Figure 14). Initial potentials generally exceeded 100 BOPD from the Simpson Group and Viola Limestone. It was reported in the Oil and Gas Journal that several wells had capacities that exceeded 100 barrels per day. A strong water drive is indicated.[18]

Seismic interpretation will probably be important in locating similar traps along the Nemaha uplift. Structurally, simple anticlinal (dip) closure characterizes some other Lower Paleozoic oil fields lying in the Forest City basin near the Nemaha uplift, such as Davis Ranch and John Creek fields. Stratigraphic traps similar to Lost Springs may also be found as drilling continues (see Figure 14).

A few more discoveries similar to this should change the once-negative attitude about this area. An assessment of the availability, generative potential, and maturation of source rocks and regional correlation and mapping of all available control will also help to evaluate this area. To this end, a structural-stratigraphic-geochemical investigation of the Forest City and Salina basins is under way at the Kansas Geological Survey to assist explorationists in the evaluation of this area. Several recently published reports and map sets are available covering the Forest City basin.[19,20,21]

Another prominent interval hosting a series of recent significant oil discoveries is the Mississippian age sediments, predominately carbonate and chert reservoirs. Recent wildcatting has followed trends near the buried truncated edges of the Ste. Genevieve and St. Louis limestones in southwest Kansas. Several trend-setting oil fields have been found. These accumulations found are generally again subtle, having a strong stratigraphic component in their trapping mechanism.

In 1976 the Ingalls field was discovered (Figures 13, 15). It is a combination structural-stratigraphic oil accumulation with 19 wells and a cumulative production of over 1/2 million barrels.[1] Discovery was made by Gear Petroleum and development now includes the Slawson Companies.

In 1978 Gear drilled another discovery well in the St. Louis limestone three miles south and farther down the flanks of the same structural feature. The Ingalls South has produced over 50,000 bbls from two active wells. During 1982 seven additional wells were drilled and by the end of 1982 cumulative production had risen to over 130,000 barrels. Eight dry holes separate the two fields developed on essentially the same structure.

We would anticipate that many similar fields will be found along these northwest-trending parallel Mississippian subcrops in southwest Kansas, provided the economic climate is favorable to survey and drill for these deeper prospects.

The Lexington pool in Clark County is one of the many recent discoveries in the Morrow interval of the Pennsylvanian in Kansas. The sandstone reservoirs in the Morrow are limited to western Kansas in a wedge of sandstone and shale that is moderately deeply buried (generally below 5000 ft. in southwest Kansas).[16] The reservoirs of sandstone are thick, but are lenticular and therefore limited in areal extent. The Lexington pool, discovered by Mesa Petroleum, is no exception with a dominating stratigraphic component to the trap, one that is difficult to detect without such tools as high resolution CDP seismic.[17]

The oil- and gas-charged Morrowan sandstone reservoir in the Lexington field lies in a buried river valley system scoured into the ancient weathered Mississippian limestone surface. Paleodrainage was to the south toward an ancient sea in Oklahoma. The 27 producing wells in the Lexington field are confined to the channel cut into Mississippian limestone. Some wells had made initial potentials in excess of 1000 BOPD in this stratigraphic trap. Thus far 1.5 million bbls have been produced since its discovery in 1977.[1] Higher resolution and new seismic processing technology was understood to have been important in its discovery. Although this exploration decision was more costly, it paid for itself handsomely. More buried valley systems, river channels, and delta and marine sandstone deposits are probably available for further testing in southwest Kansas.

Although the Lansing-Kansas City has been a major contributor to oil production in Kansas for many years, it still leads in the number of oil discoveries in new trends. The interval continues to add a new dimension to the distribution of this pay zone in Kansas (Figure 11). In 1979 the Lemon Ranch pool was discovered by KRM Petroleum Corporation in Comanche County in southwest Kansas (now combined with Collier Flats). Of the several potential pay zones in the LKC, the Swope or K-Zone penetrated in the discovery well realized an IPP of 100 BOPD, a well located along the southerly plunging, structural nose (Figure 18). 22 wells have produced over 400,000 BO and the field has merged with the Collier Flats and C.F. South fields located immediately north. Their 32 wells have also produced in excess of 600,000 BO primarily from the K-Zone of the LKC.[1] The dry holes particularly updip from the accumulation in this area readily identify the importance again of the discontinuous reservoir development that has helped to provide the trap for oil in this field. Other examples of oil and gas developments during 1981 in Kansas are available in Reference 1.

Careful geology and engineering applied to these areas in the future should add significantly more to the oil reserves in Kansas. These are only a few examples of recent discoveries, each with its own subdued and complicated character that distinguishes it from the giant oil fields of the past. Yet, the opportunity is here for those companies with the trained staff and technology to competently handle the problem of finding these additional accumulations.

Kansas offers several attractions to explorationists, namely reasonable drilling depths, no significant drilling hazards, accessible land, minimal production problems, and a favorable market at least for oil.[22] We strongly concur with Daniels who, as a representative of industry, challenges others to accept the risk of the rank wildcats, with a drilling program in which holes are analyzed as completely as possible. Rank wildcatting is a significant risk and requires a solid commitment to a drilling program. Yet the reward can be high and mean a sustained, long term development program.

Certainly, tertiary oil recovery remains a key to acquisition of additional recoverable reserves in many maturly developed sandstone and carbonate reservoirs across Kansas. Again technology, trained staff, and economic incentives are necessary prerequisites for its success. With over 60% of our production in the stripper category from fields approaching exhaustion, only tertiary recovery offers any hope to revitalize these fields and potentially tap an additional 1-2 billion barrels of oil.

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CAPTIONS

1. Kansas annual crude-oil production 1935-1982. Data from American Petroleum Institute (API) and U.S. Department of Energy (DOE).
2. Annual well completions reported in Kansas illustrated here as separate curves for total development wells, successful production wells, total exploratory wells (which includes new pool, extension, and new field wildcats), and successful exploratory wells. Key years include the Arab oil embargo in 1973, the Iranian revolution in 1979, and the decontrol of domestic oil prices in January 1981; all increased the price paid for crude oil.
3. Annual estimates of proven crude oil reserves in Kansas illustrated for 1955-1982.
4. Active monthly rig count by Hughes Tool Company and monthly intents to drill filed with the Kansas Corporation Commission (KCC) compared to the average monthly and annual domestic wellhead price made available from DOE. Chart prepared by Dave Collins, Kansas Geological Survey.
5. Oil and gas field outlines on map of Kansas. Heavier straight lines outline geological provinces defined by Committee on Drilling Statistics (American Petroleum Institute and American Association of Petroleum Geologists).
6. Posting of wells that have wireline logs showing bottom-hole temperature data on file at the Kansas Geological Survey in Lawrence. Data compiled by Stavenz (1982).[23] Map shown to indicate drilling density. Note that logs with temperature data in eastern Kansas reflect only a fraction of the wells drilled there while the display of western Kansas closely reflects actual wells drilled in this region.

7. Map of Kansas illustrating new oil fields reported by county during 1982.

8. Oil discoveries reported for Kansas in 1981 and 1982 partitioned among geological provinces. Actual numbers for each province shown in parentheses.

9. Oil discoveries reported for Kansas during 1981 and 1982 partitioned among productive zone identified here by major stratigraphic interval.

10. Map of Kansas with posting of recent (1st quarter 1980) oil (solid dot) and gas wells (plus symbol) producing from the Arbuckle Group. Data from automated Well History File of Petroleum Information, Inc. Date of data and symbols are the same for Figures 11, 12, 13, and 16.

11. Posting of oil and gas wells producing from the Lansing and Kansas City groups of Pennsylvanian age.

12. Posting of oil and gas wells producing from the Pennsylvanian Cherokee Group. The few points in eastern Kansas in the Cherokee basin represent only a fraction of wells actually drilled in this area.

13. Posting of oil and gas wells producing from Mississippian-age reservoirs in Kansas. Bands of subcropping Mississippian strata identified in western Kansas modified from Goebel.[24] These bands are also developed in central and eastern Kansas, but are not shown here. Please refer to Merriam[25] for further information on the Mississippian in Kansas.

14. Map of northeastern Kansas illustrating major geological elements and exploration activity (Jan. 1980 through 1982). Map centers on Nemaha uplift identified as the region with the bands of gently westerly dipping truncated strata, the oldest of which is the

Precambrian situated on the crest of the uplift. The east side of the Nemaha uplift bordering the Forest City basin is a fault zone, the Humboldt fault zone consisting of several down-to-the-east faults. The contours represent the elevation of the basal Pennsylvanian unconformity. Significant dry holes and oil fields are noted, including McClain field in Nemaha County, within the Humboldt fault zone.

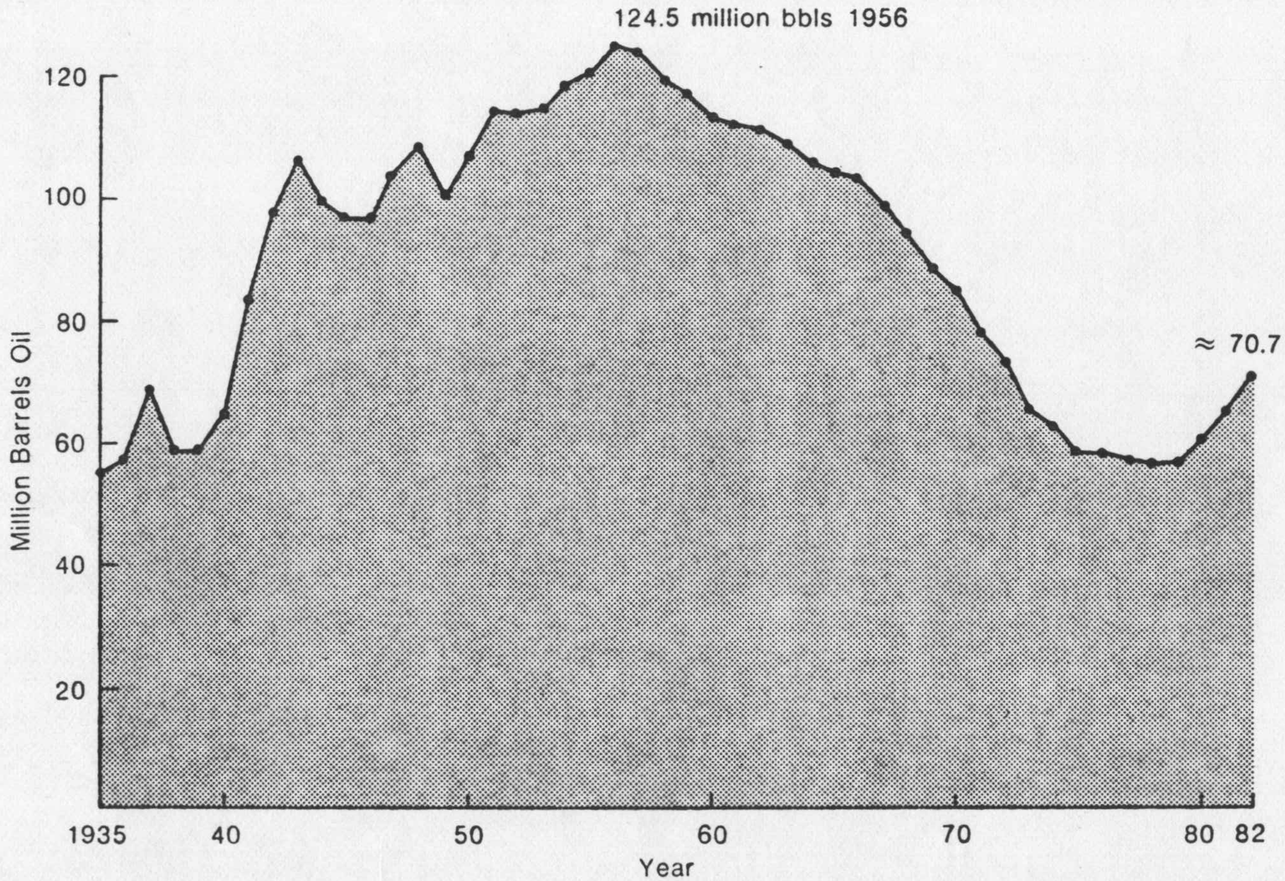
15. Structural contour map of the top of the St. Louis (Mississippian) in the vicinity of Ingalls and Ingalls South field in Gray County, Kansas (see Figure 13). Contour interval is 25 feet. Contours depict a southerly plunging anticline with oil wells of both Ingalls and Ingalls South fields near, but not directly over crestal areas of this structure.

16. Posting of oil and gas wells producing from Pennsylvanian Morrowan-age sandstones in southwestern Kansas. Heavy line represents approximate line of pinchout of the Morrow.

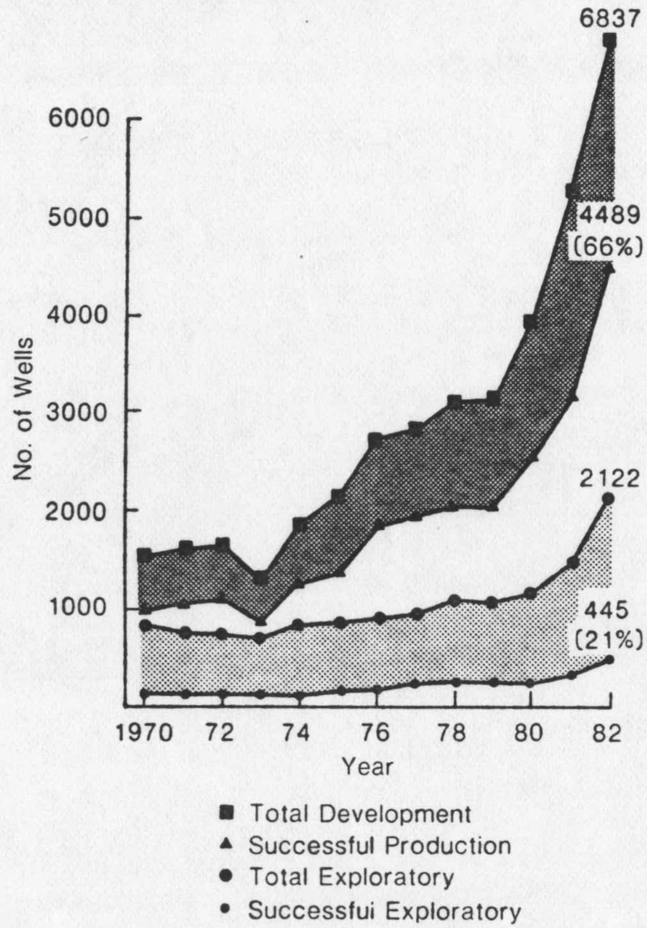
17. Configuration of the top of Mississippian surface in the vicinity of the Lexington field, Clark County, Kansas (see Figure 16). The Lexington field produces from Morrow sandstone located in the lower channel-like areas of the Mississippian surface. Mississippian oil and gas production is confined to the high regions of the Mississippian surface immediately east and west of the north-south-oriented trough.

18. Structural contour map of the top of the Swope Limestone (K-Zone) in the Kansas City Group in the vicinity of the Collier Flats field in Comanche County, Kansas (see Figure 11). All but two holes on this map penetrated the Swope. The contour interval is 25 feet.

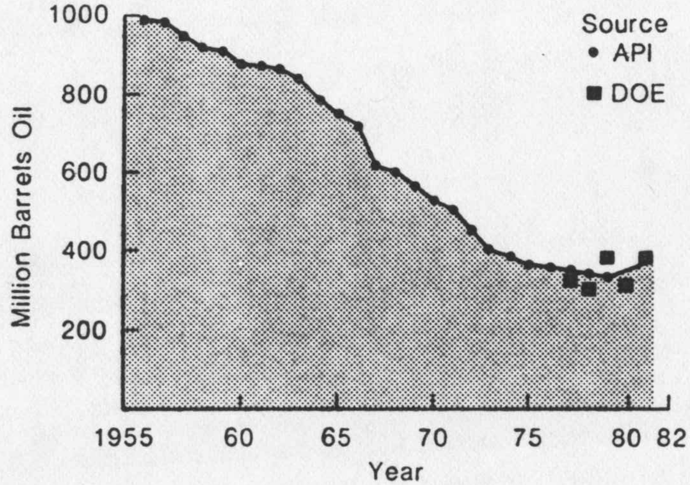
Oil wells closely correspond with the crest of a southerly plunging anticline. The northern edge of the Collier Flats field, on a higher crest of the anticline, is defined by dry holes.



124.5 million bbls 1956
≈ 70.7
120
100
80
60
40
20
Million Barrels Oil
1935
40
50
60
70
80
82
Year

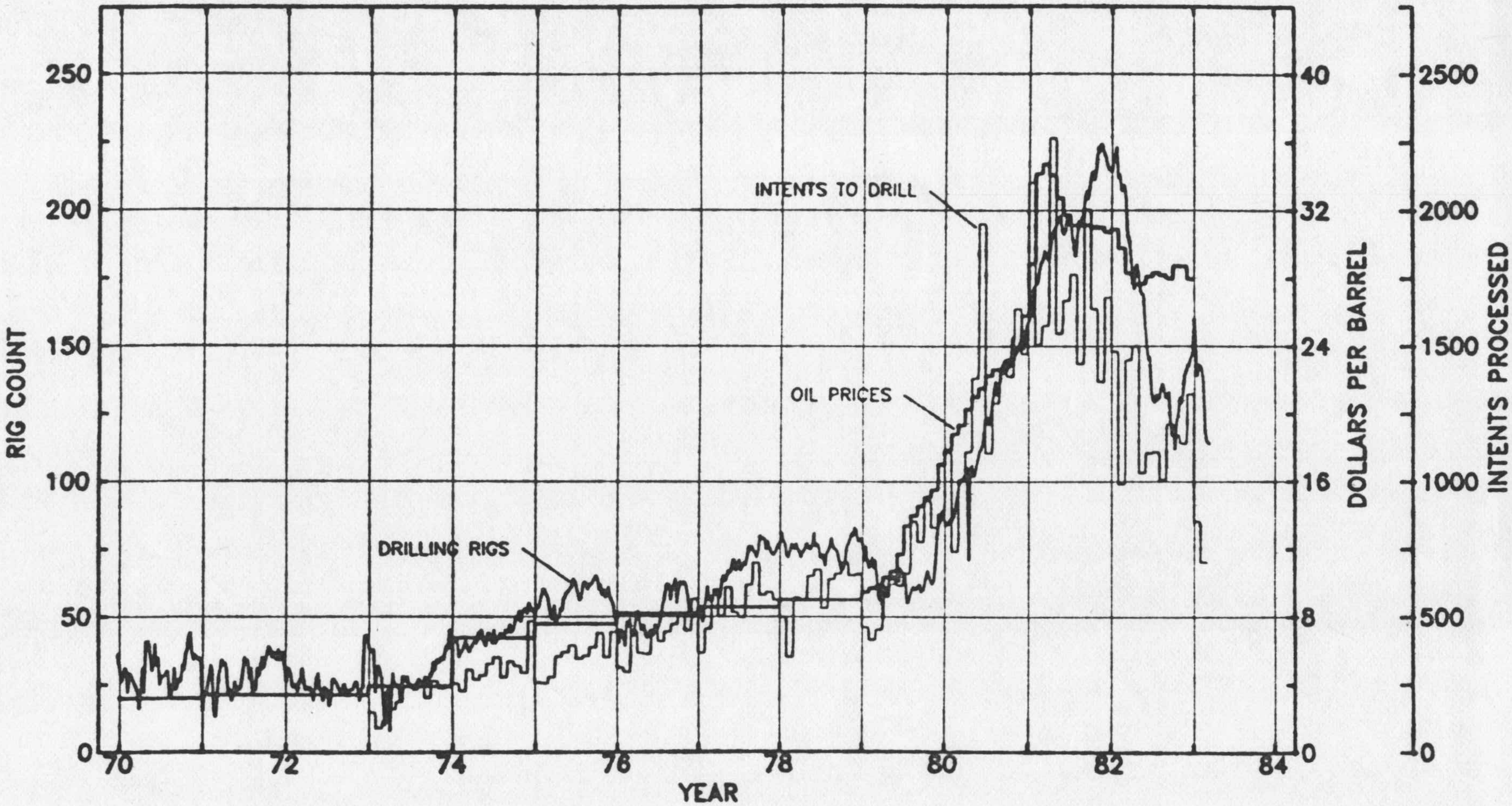


6837
4489
(66%)
2122
445
(21%)
6000
5000
4000
3000
2000
1000
No. of Wells
1970
72
74
76
78
80
82
Year
Total Development
Successful Production
Total Exploratory
Successfui Exploratory



1000
800
600
400
200
Million Barrels Oil
Source
• API
■ DOE
1955
60
65
70
75
80
82
Year

Drilling Rigs : Oil Prices : Intents to Drill

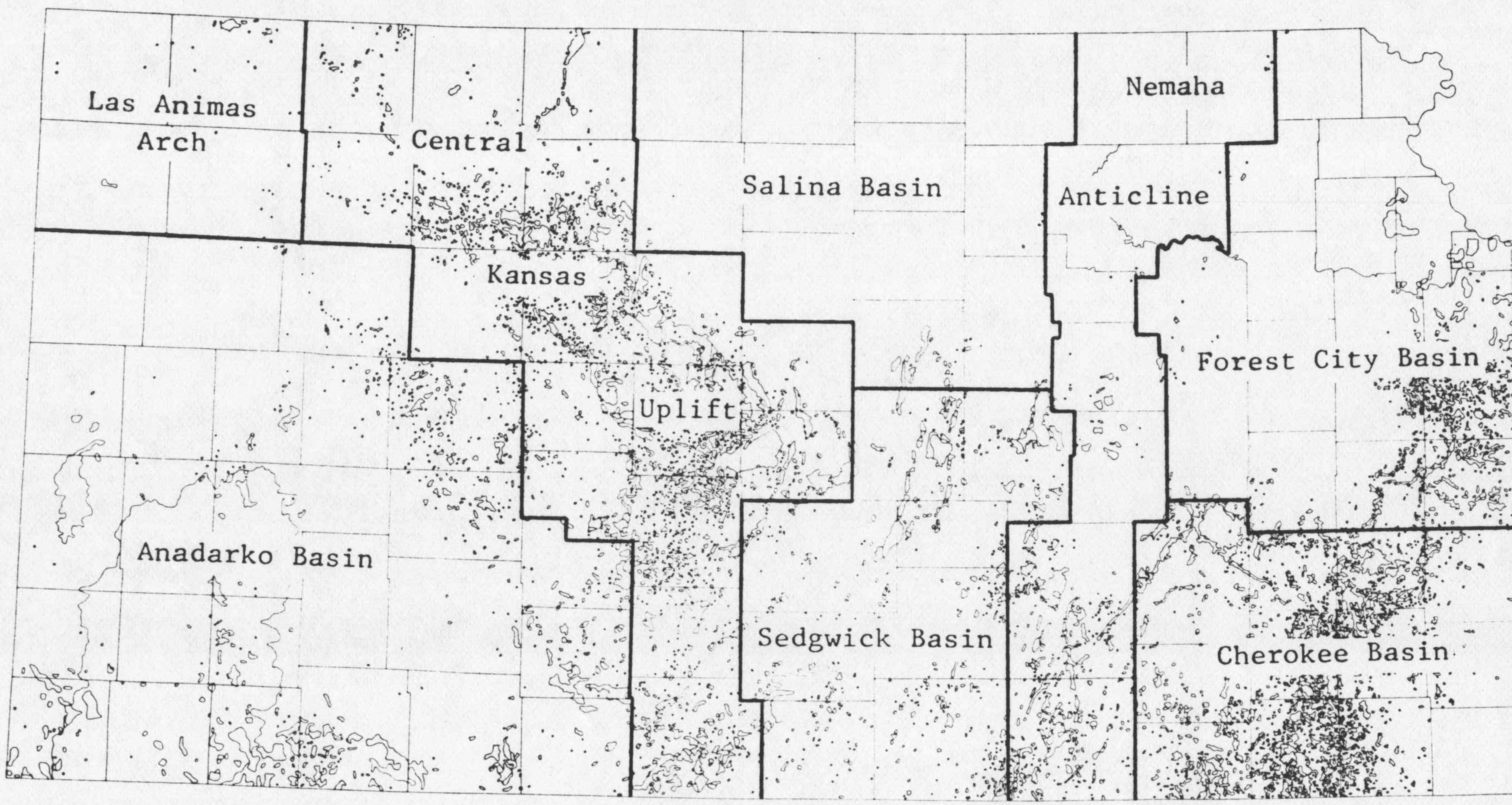


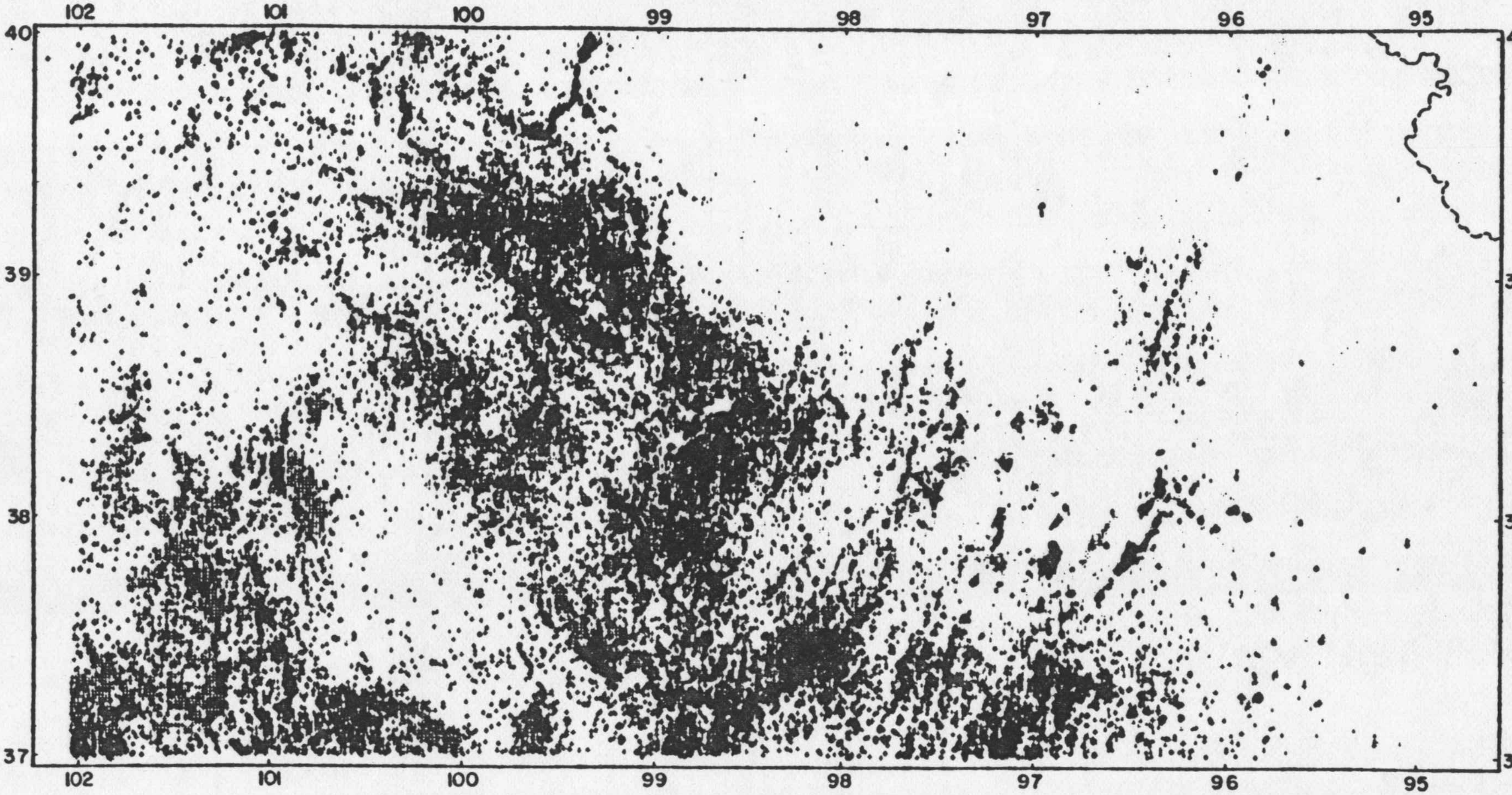
Definition of Data:

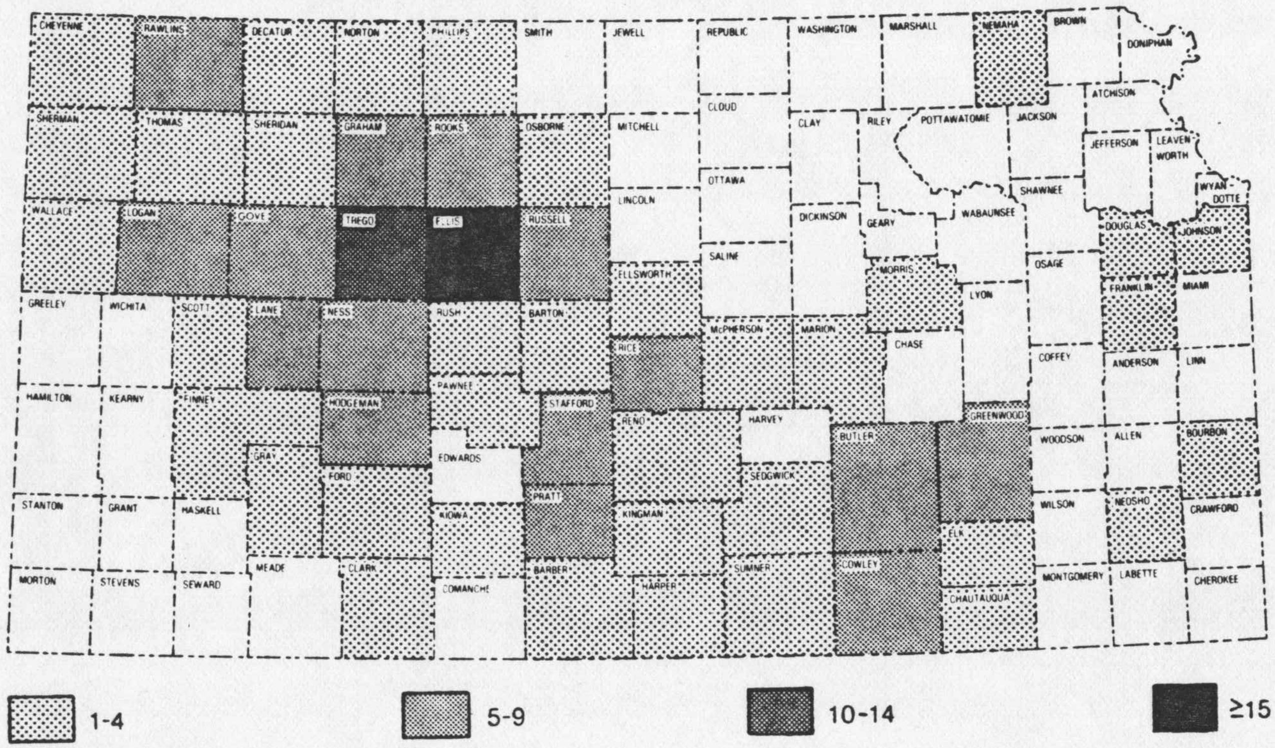
Drilling Rigs: Active rotary rigs in Kansas, counted by the Hughes Tool Company
OilPrices: Average wellhead price of crude oil in the United States
Intents to Drill: Intents processed monthly by the Kansas Corporation Commission

Data Sources:

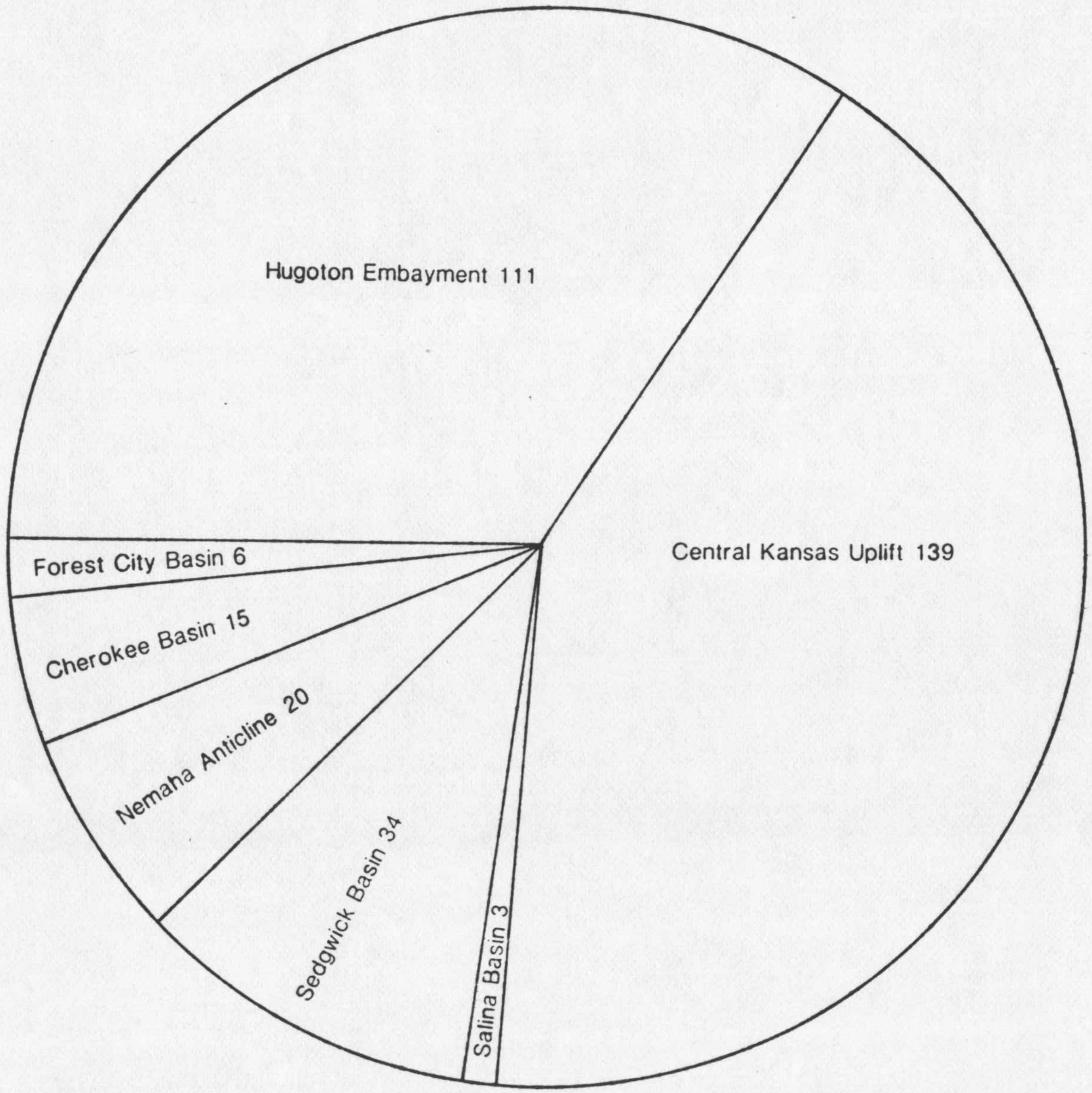
Drilling Rigs: Oil and Gas Journal
Oil Prices: Monthly Energy Review, U. S. Department of Energy
Intents to Drill: Kansas Corporation Commission


Las Animas
Arch
Central
Kansas
Uplift
Salina Basin
Nemaha
Anticline
Forest City Basin
Anadarko Basin
Sedgwick Basin
Cherokee Basin

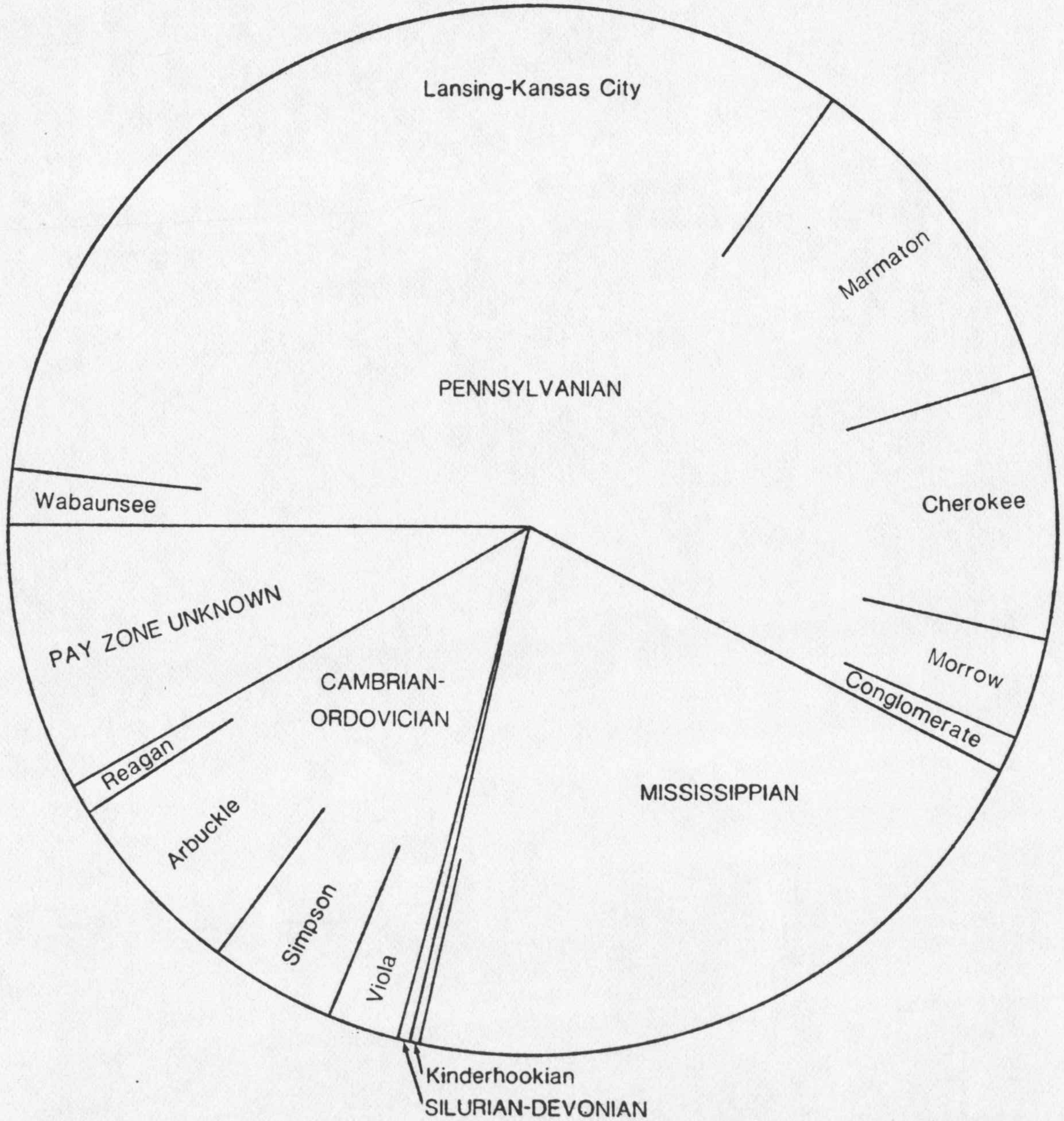

102
101
100
99
98
97
96
95
40
39
38
37

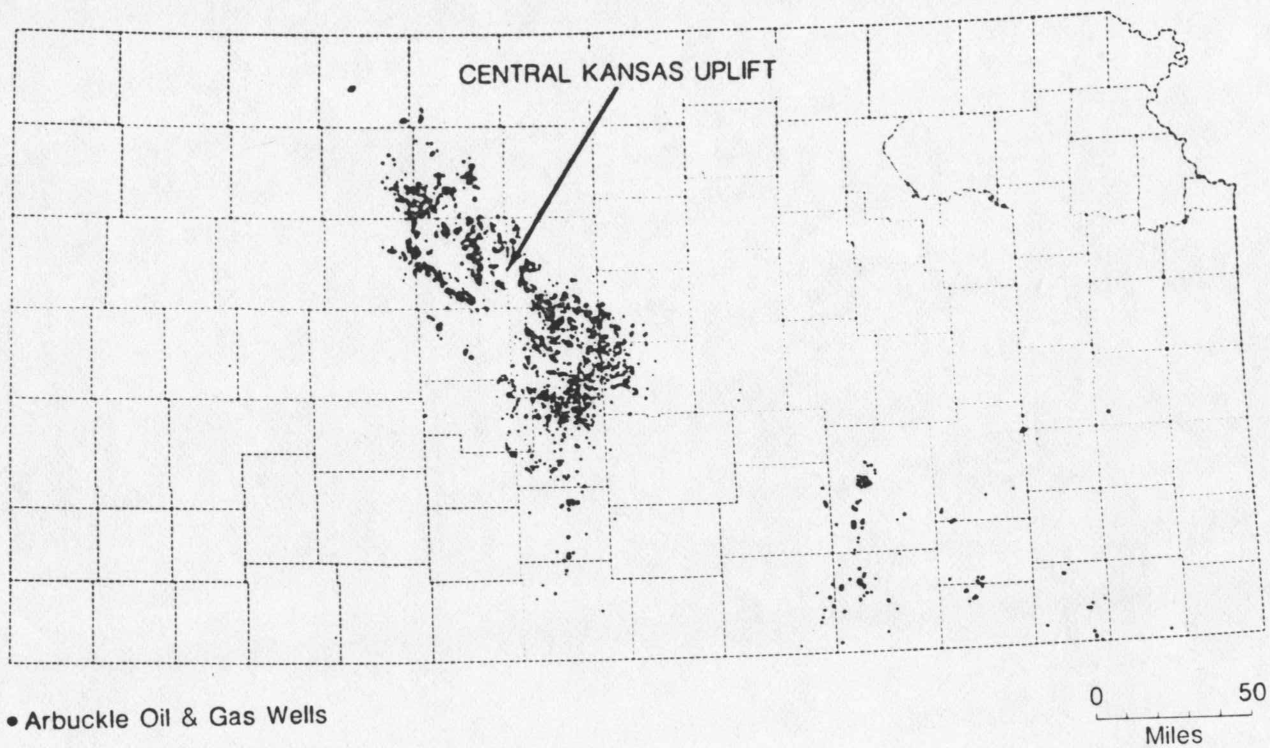


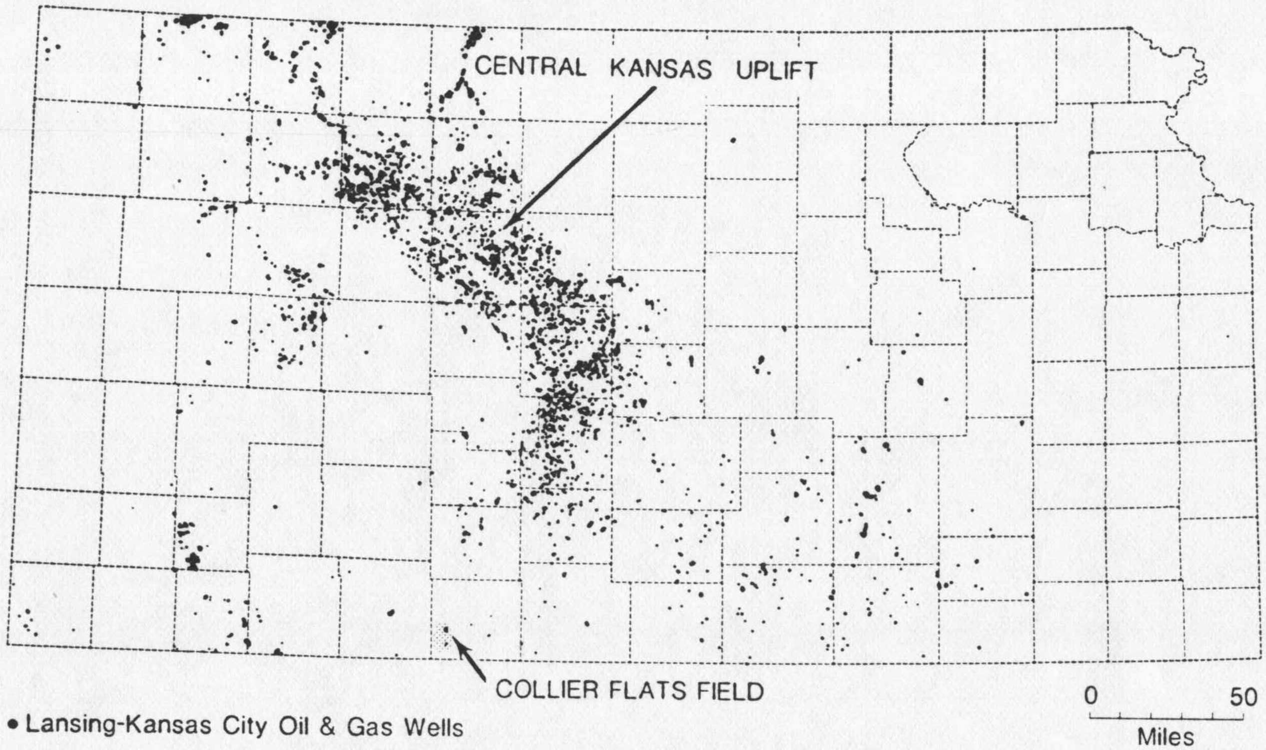
CHEYENNE
RAWLINS
DECATUR
NORTON
PHILLIPS
SMITH
JEWELL
REPUBLIC
WASHINGTON
MARSHALL
NEMAHA
BROWN
DONIPHAN
SHERMAN
THOMAS
SHERIDAN
GRAHAM
ROOKS
OSBORNE
MITCHELL
CLOUD
CLAY
RILEY
POTTAWATOMIE
JACKSON
ATCHISON
JEFFERSON
LEAVEN WORTH
OTTAWA
SHAWNEE
WYAN DOTTE
WALLACE
LOGAN
GOVE
TREGO
ELLIS
RUSSELL
LINCOLN
DICKINSON
GEARY
WABAUNSEE
DOUGLAS
JOHNSON
SALINE
ELLSWORTH
MORRIS
OSAGE
FRANKLIN
MIAMI
LYON
GREELEY
WICHITA
SCOTT
LANE
NESS
RUSH
BARTON
RICE
McPHERSON
MARION
CHASE
COFFEY
ANDERSON
LINN
HAMILTON
KEARNY
FINNEY
HODGEMAN
PAWNEE
STAFFORD
RENO
HARVEY
BUTLER
GREENWOOD
WOODSON
ALLEN
BOURBON
GRAY
EDWARDS
FORD
SEDGWICK
STANTON
GRANT
HASKELL
KIOWA
PRATT
KINGMAN
ELK
WILSON
NEOSHO
CRAWFORD
MORTON
STEVENS
SEWARD
MEADE
CLARK
COMANCHE
BARBER
HARPER
SUMNER
COWLEY
CHAUTAUQUA
MONTGOMERY
LABETTE
CHEROKEE
1-4
5-9
10-14
≥15



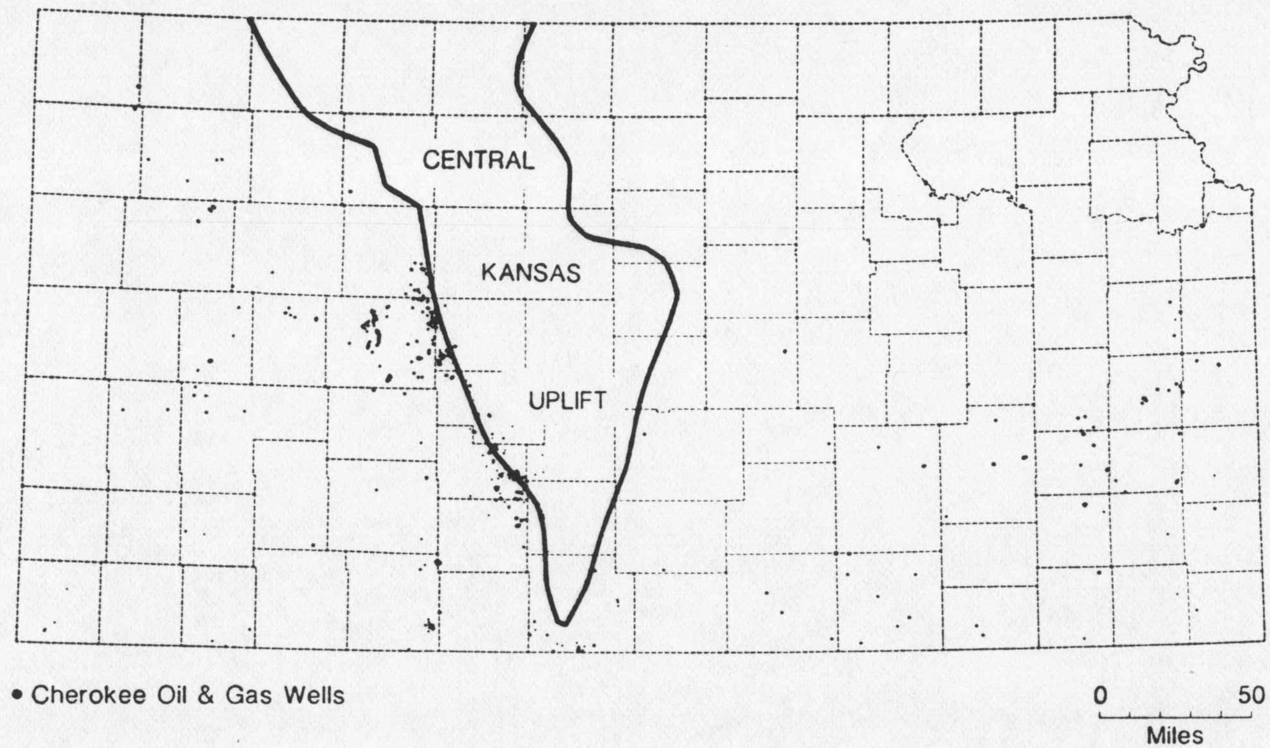
Hugoton Embayment 111
Central Kansas Uplift 139
Forest City Basin 6
Cherokee Basin 15
Nemaha Anticline 20
Sedgwick Basin 34
Salina Basin 3

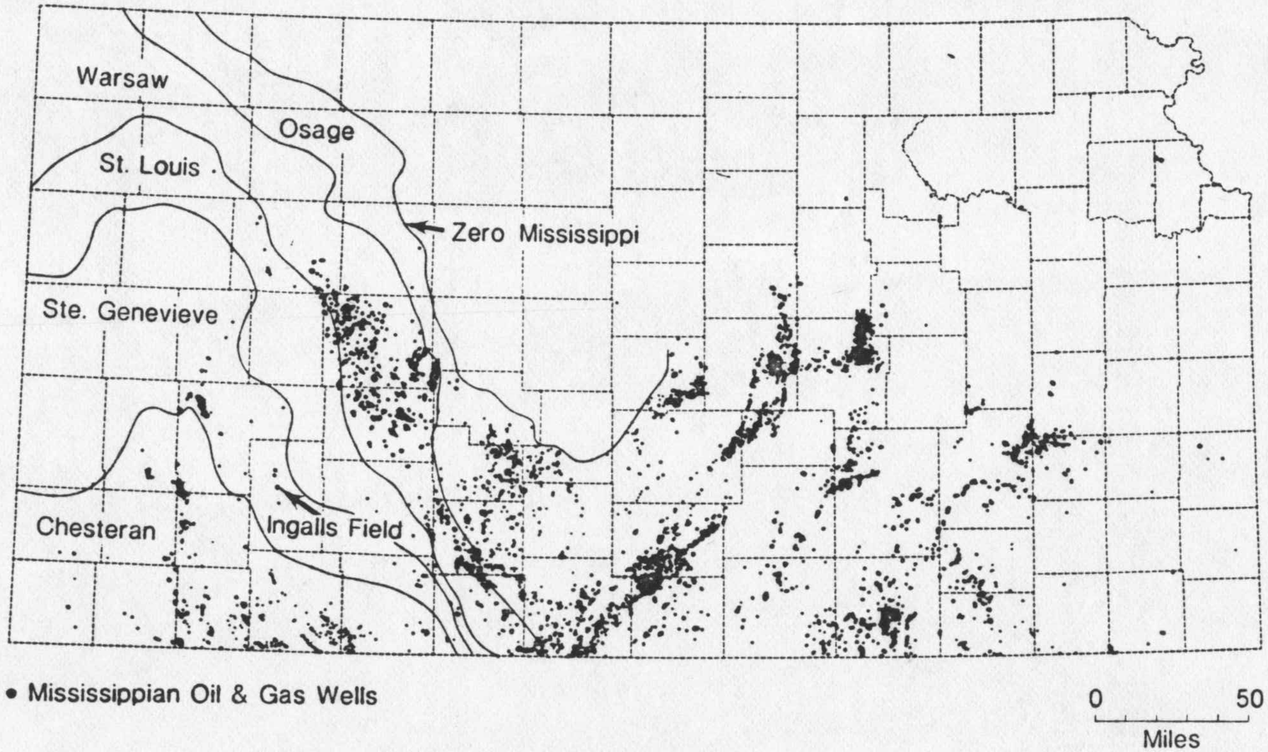

Lansing-Kansas City
Marmaton
PENNSYLVANIAN
Cherokee
Wabaunsee
PAY ZONE UNKNOWN
CAMBRIAN-
ORDOVICIAN
Morrow
Conglomerate
MISSISSIPPIAN
Reagan
Arbuckle
Simpson
Viola
Kinderhookian
SILURIAN-DEVONIAN

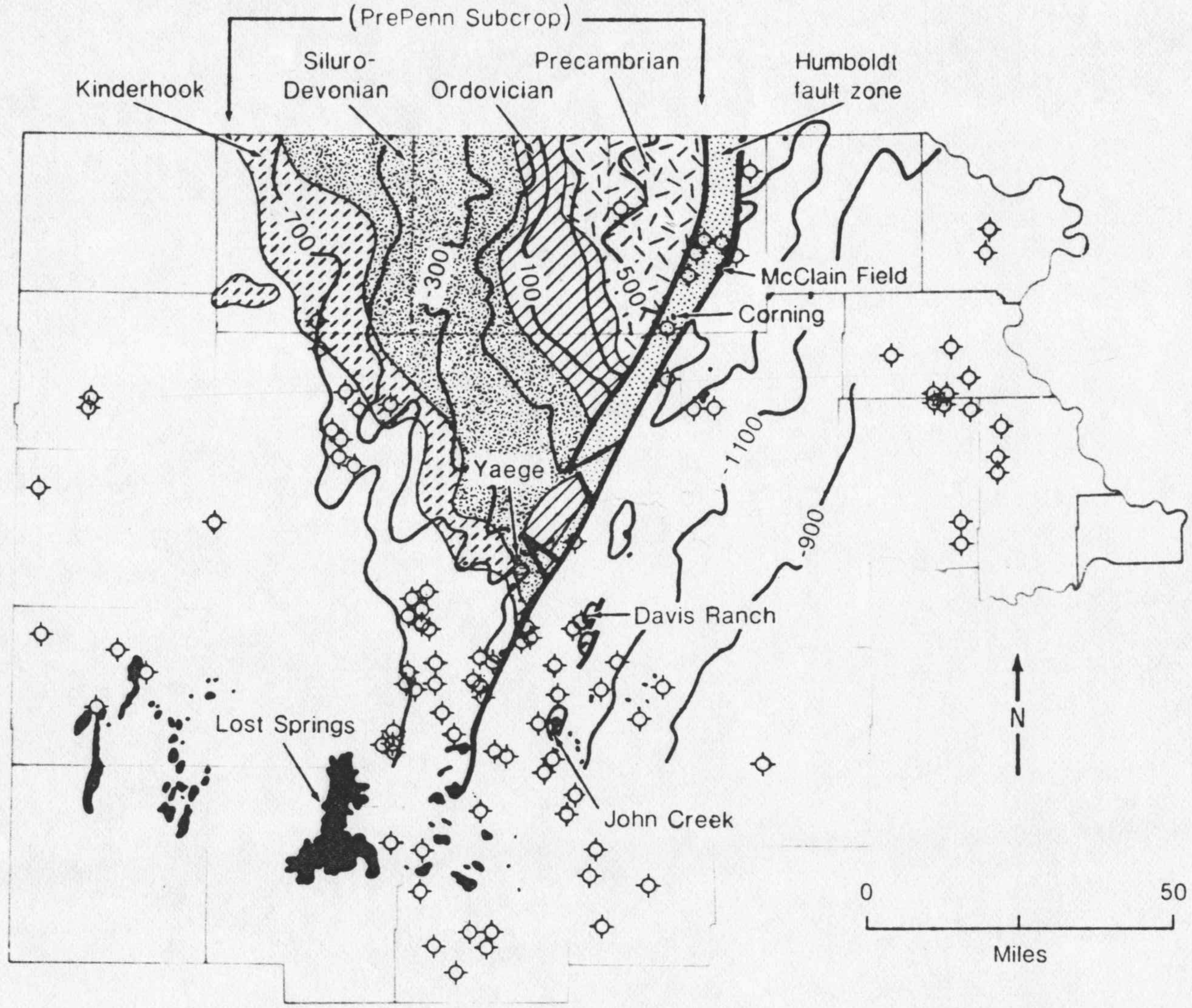

CENTRAL KANSAS UPLIFT
• Arbuckle Oil & Gas Wells
0
50
Miles



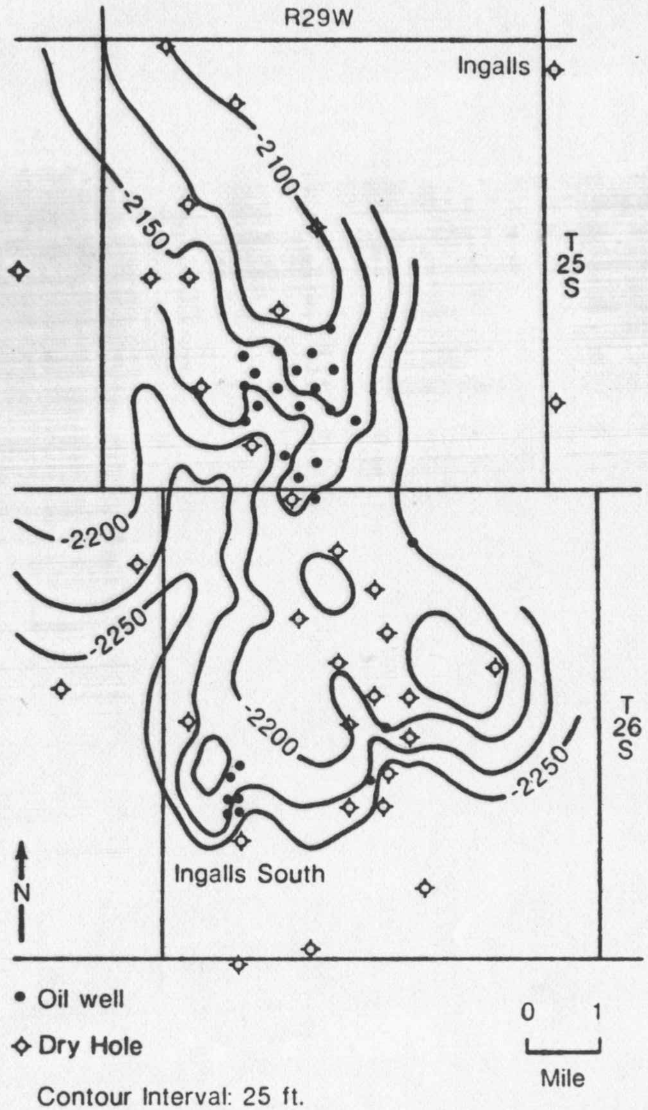
• Lansing-Kansas City Oil & Gas Wells

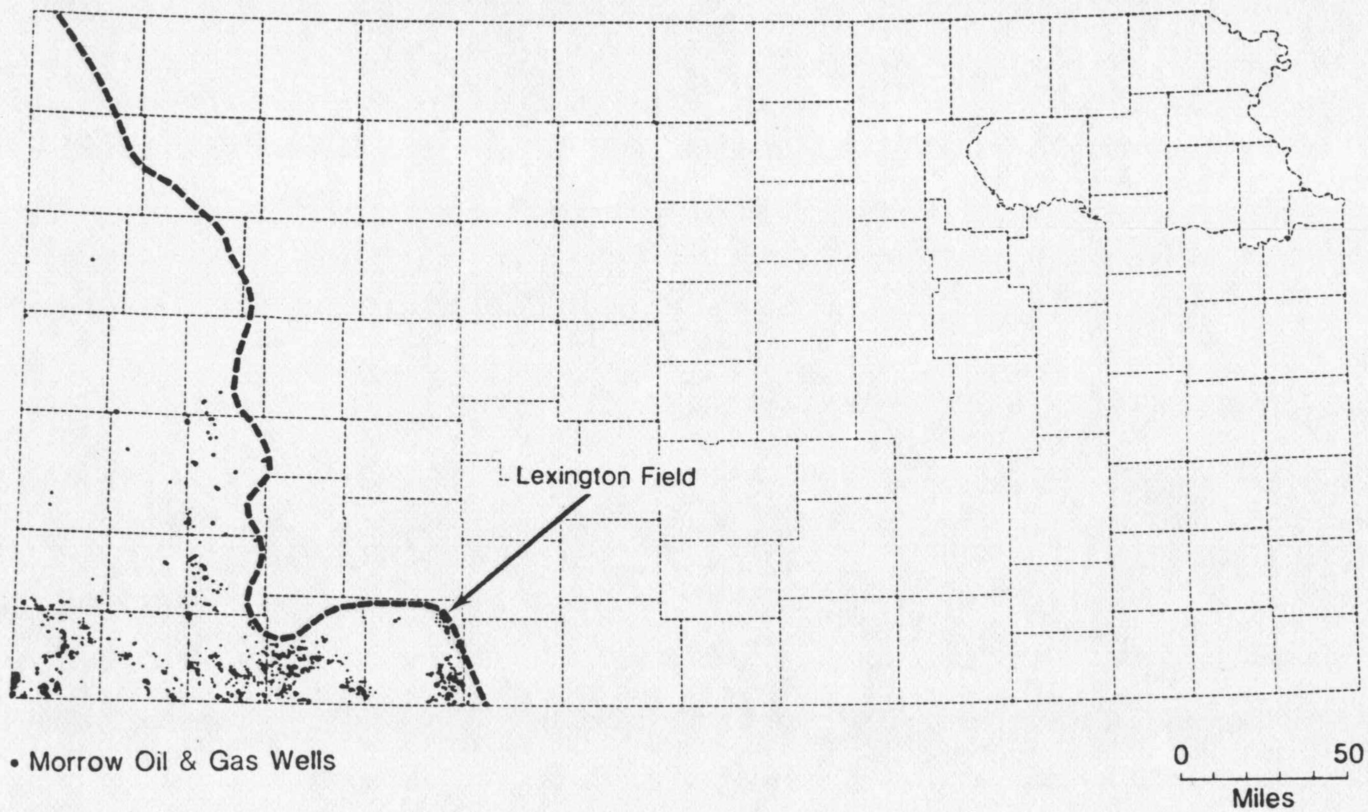

CENTRAL
KANSAS
UPLIFT
• Cherokee Oil & Gas Wells
0
50
Miles


Warsaw
Osage
St. Louis
Zero Mississippi
Ste. Genevieve
Chesteran
Ingalls Field
• Mississippian Oil & Gas Wells
0
50
Miles

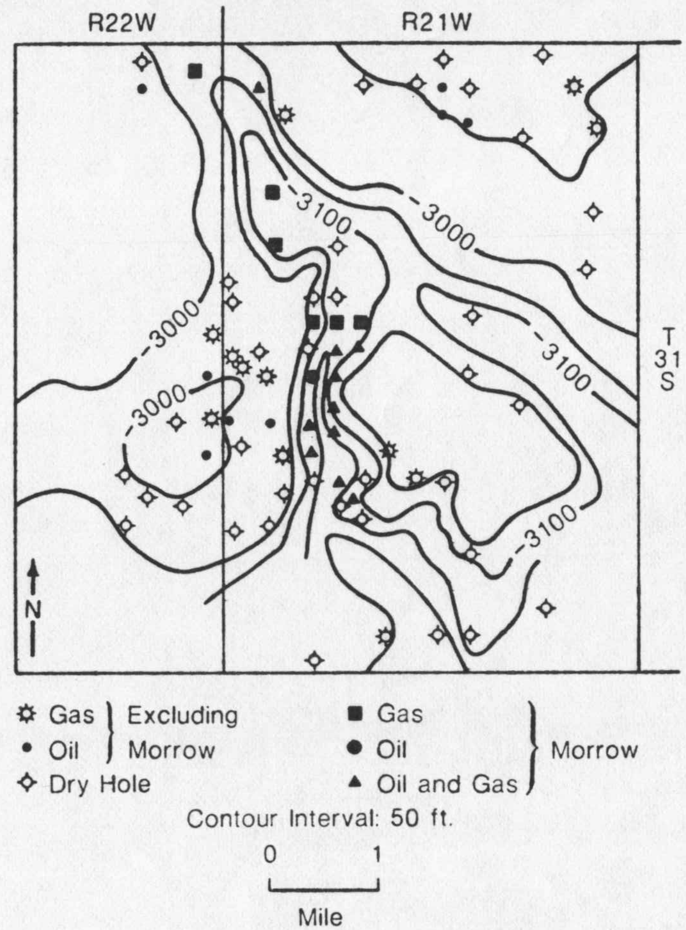


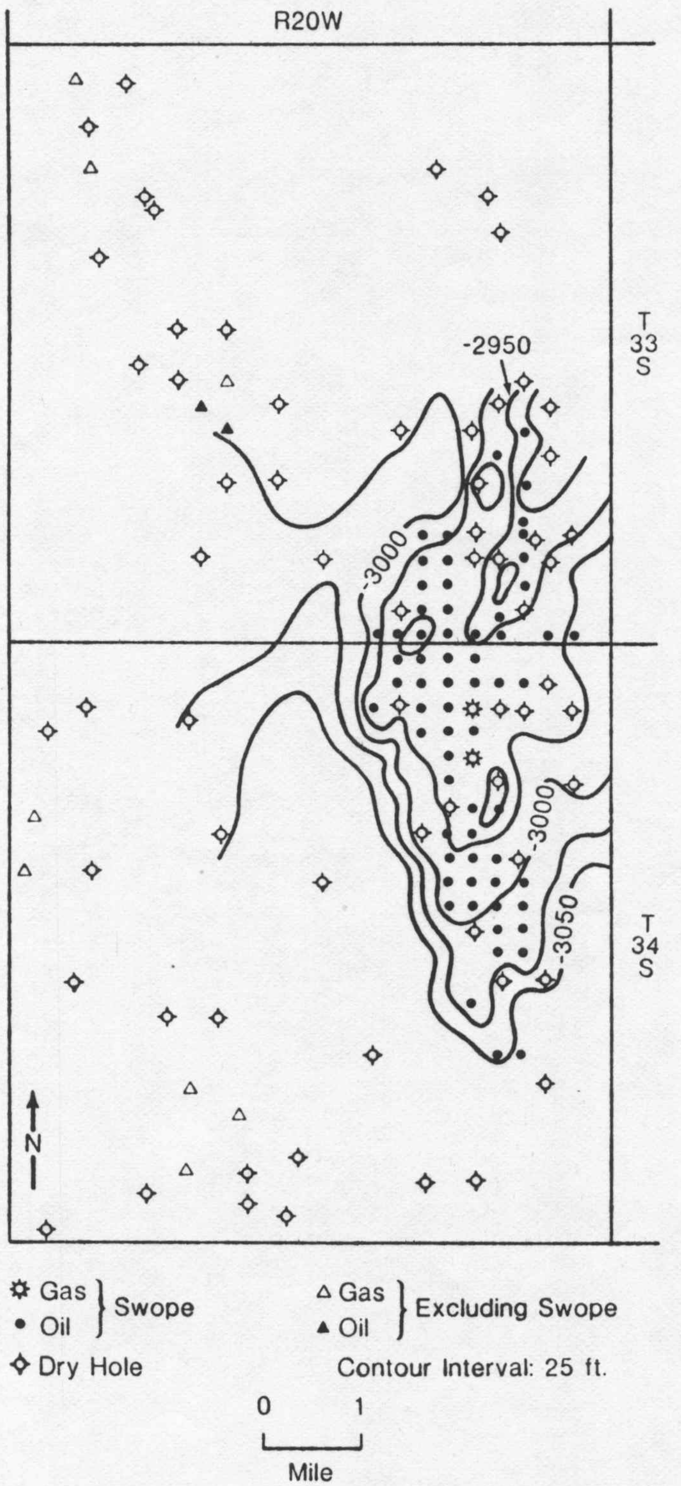
Significant dry holes — Structure contours, base Pennsylvanian — Contour interval: 200 ft.


R29W
Ingalls
T
25
S
-2100
-2150
-2200
-2250
T
26
S
-2200
-2250
Ingalls South
N
Oil well
Dry Hole
Contour Interval: 25 ft.
0
1
Mile



Lexington Field
• Morrow Oil & Gas Wells
0
50
Miles


R22W
R21W
T 31 S
3100
3000
3000
3000
3100
3100
N
Gas
Oil
Dry Hole
Excluding Morrow
Gas
Oil
Oil and Gas
Morrow
Contour Interval: 50 ft.
0
1
Mile


R20W
T 33 S
T 34 S
-2950
-3000
-3000
-3050
N
Gas
Oil
Swope
Dry Hole
Gas
Oil
Excluding Swope
Contour Interval: 25 ft.
0
1
Mile