U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Petroleum Exploration Plays and Resource Estimates, 1989, Onshore United States-- Region 7, Mid-Continent

By

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PETROLEUM EXPLORATION PLAYS AND RESOURCE ESTIMATES, 1989, ONSHORE UNITED STATES-- REGION 7, MID-CONTINENT

Richard B. Powers, *Editor*

INTRODUCTION

By Richard B. Powers

This report, one of a series, provides brief discussions of the petroleum geology, play descriptions, and resource estimates of 20 individually assessed exploration plays in 12 onshore geologic provinces in assessment Region 7 within the continental United States. These 12 provinces were among 80 onshore provinces, including 220 plays, that were assessed in connection with the determination of the Nation's estimated undiscovered resources of oil and gas in 1989. The report is an outgrowth of, and is based on, studies that led to the publication of "Estimates of undiscovered conventional oil and gas resources in the United States--A part of the Nation's energy endowment" (Mast and others, 1989). That report, a cooperative effort by the USGS (U.S. Geological Survey) and MMS (Minerals Management Service), presented estimates of undiscovered conventionally recoverable oil and gas for both the onshore and offshore petroleum provinces of the Nation. The data sources, assumptions, and methodologies used in the development of these estimates are summarized in Mast and others (1989) and described in more detail in a joint USGS-MMS Working Paper, U.S. Geological Survey Open-File Report 88-373 (1988). The plays discussed in this present report are those that are located exclusively within the onshore United States, as assessed by the USGS. All estimates of undiscovered oil and gas resources are as of January 1, 1987; additional data received after that date were not incorporated into the assessment.

In the 1989 National appraisal of undiscovered oil and gas resources, plays were the basic unit for quantitative estimates; this report presents not only the play estimates, but also the framework and petroleum geology for each of these basic units. Play discussions here summarize the open-file reports which were prepared by the geologists assigned to each assessment area. We are presenting the resource estimates and narrative descriptions at this basic play level because of the great interest shown by the public, State Geological Surveys, the oil and gas industry, and workers involved in oil and gas appraisal.

Sources of information for province studies included published and purchased data, data from USGS studies in progress, data from previous resource assessments, data from State Geological Surveys, and analysis of geological, geochemical, and geophysical data from various sources utilized in developing and defining plays. Computerized drilling and well completion data from oil and gas exploratory and development wells came from PI WHCS (Petroleum Information Corporation's Well History Control System). In addition, data on oil and gas fields were obtained from the "Significant oil and gas fields of the United States" file of NRG Associates, Inc. of 1986, and from the PI PDS (Petroleum Information Corporation's Petroleum Data System) computerized file of 1986. Additional statistical information on field production and reserves was obtained from yearly publications of various State oil and gas commissions, or their equivalents.

Uncertainties are inherent in estimating undiscovered quantities of oil and gas. Play estimates presented here are judgmental and are based upon a variety of geologic data, records of exploration successes and failures, production histories, assumptions of economic and technical conditions, and appraisal methods. Methodologies were developed to aid in making decisions under conditions of uncertainty, and the results are presented as ranges of values with associated

probabilities of occurrence. The estimates should be viewed as indicators, not absolutes, of the petroleum potential of the plays. The plays range from those in mature, established producing basins, to highly speculative, frontier-type plays in provinces that have experienced scant exploration or wildcat drilling.

COMMODITIES ASSESSED

Commodities assessed in this study are crude oil, natural gas, and natural gas liquids that exist in conventional reservoirs. Terms defined here are standard usage of the the oil and natural gas industry and resource estimation.

Undiscovered recoverable resources.--Resources in undiscovered accumulations, analogous to those in existing fields, which are producible with current recovery technology and efficiency, but without reference to economic viability. These resources occupy the area of the heavily framed box in figure 1.

Conventional resources.--Resources included in this category are crude oil, natural gas, and natural gas liquids that exist in reservoirs or in a fluid state amenable to extraction techniques employed in traditional development practices. They occur as discrete accumulations. They do not include oil occurring within extremely viscous and intractable heavy oil deposits, tar deposits, or oil shales, or gas from low-permeability "tight" sandstone and fractured shale reservoirs having *in situ* permeabilities to gas of less than 0.1 millidarcy, coal bed methane, gas in geopressured shales and brines, or gas hydrates.

AREAS OF STUDY

The primary organization of this study is by region as defined in figure 2 and as used in Mast and others (1989). Discussion of the Mid-Continent, Region 7, begins with a description of its geologic framework, modified from Mast and others (1989). Discussion of provinces in the region follows; the format for each province includes an introduction covering the geologic setting, exploration history, age of sediments, and a generalized stratigraphic chart. (No stratigraphic chart is provided for a province where no individual plays were assessed; a map of the province is substituted, because no specific stratigraphy is discussed in that province.) Following each province introduction is a systematic discussion of its individual plays. The play format includes the play name, narrative discussion and two illustrations, (1) a province map with the area of the play emphasized, and (2) a tabular form showing the original input data for the play appraisal.

Regions are basically geographic in character; however, their outlines are an attempt to group individual provinces along broad geologic lines. Provinces are constructed around natural geologic entities and may include a single dominant structural element, or a number of contiguous elements; they are named for structural or geographic features within their boundaries. These boundaries, following State and county lines, wherever possible, facilitate the use of production, reserves, and other reported data. A play is named after the most dominant feature or characteristic of a structural, stratigraphic, or geographic nature that best identifies it. Its name can also apply to a concept. Many plays described herein are recognized from their titles by the petroleum industry, but play titles are in no way formal geologic or stratigraphic names.

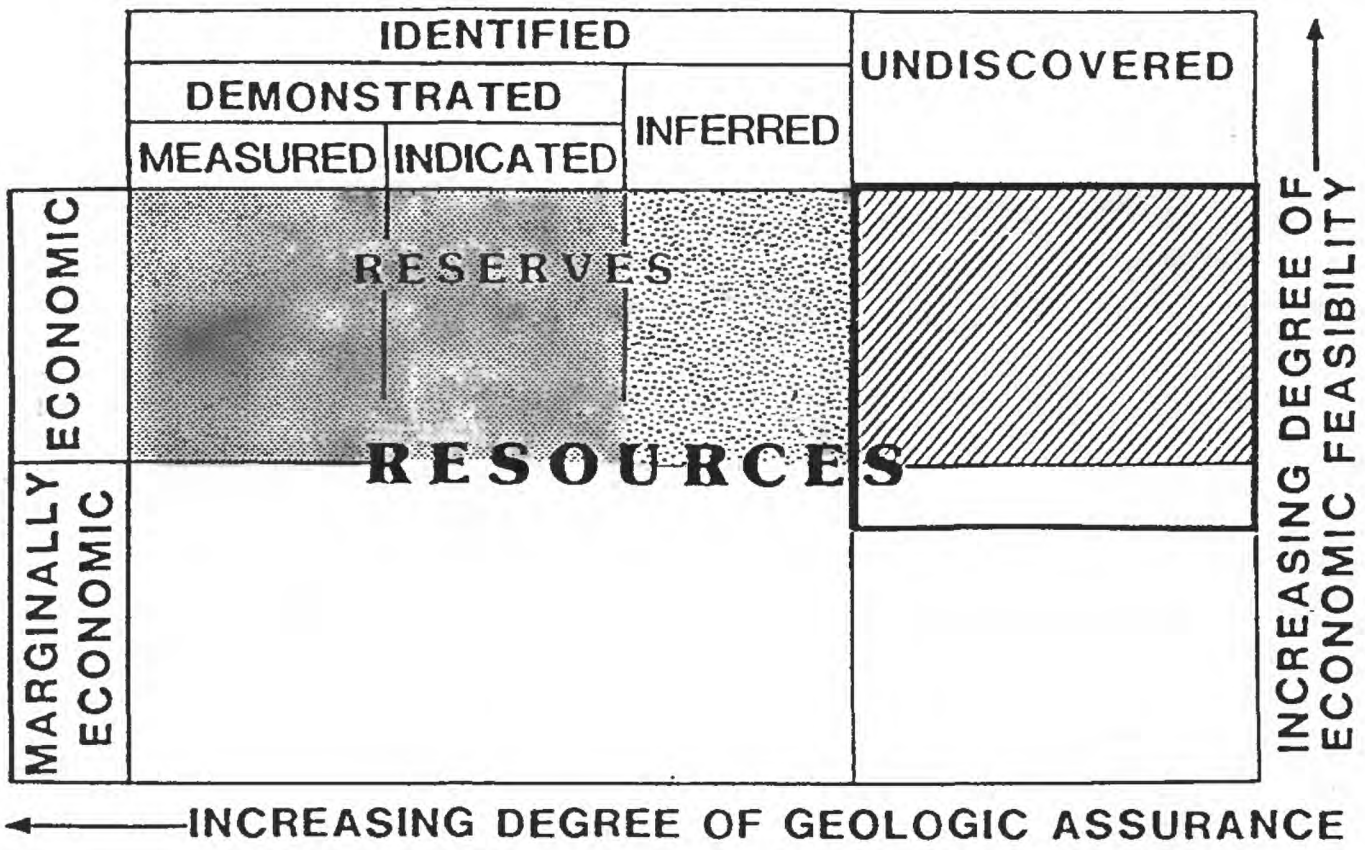

Figure 1. Diagrammatic representation of petroleum resource classification (Mast and others, 1989) representing conventional oil and gas resources. Area with heavy frame on upper right represents undiscovered recoverable resources estimated in this study.

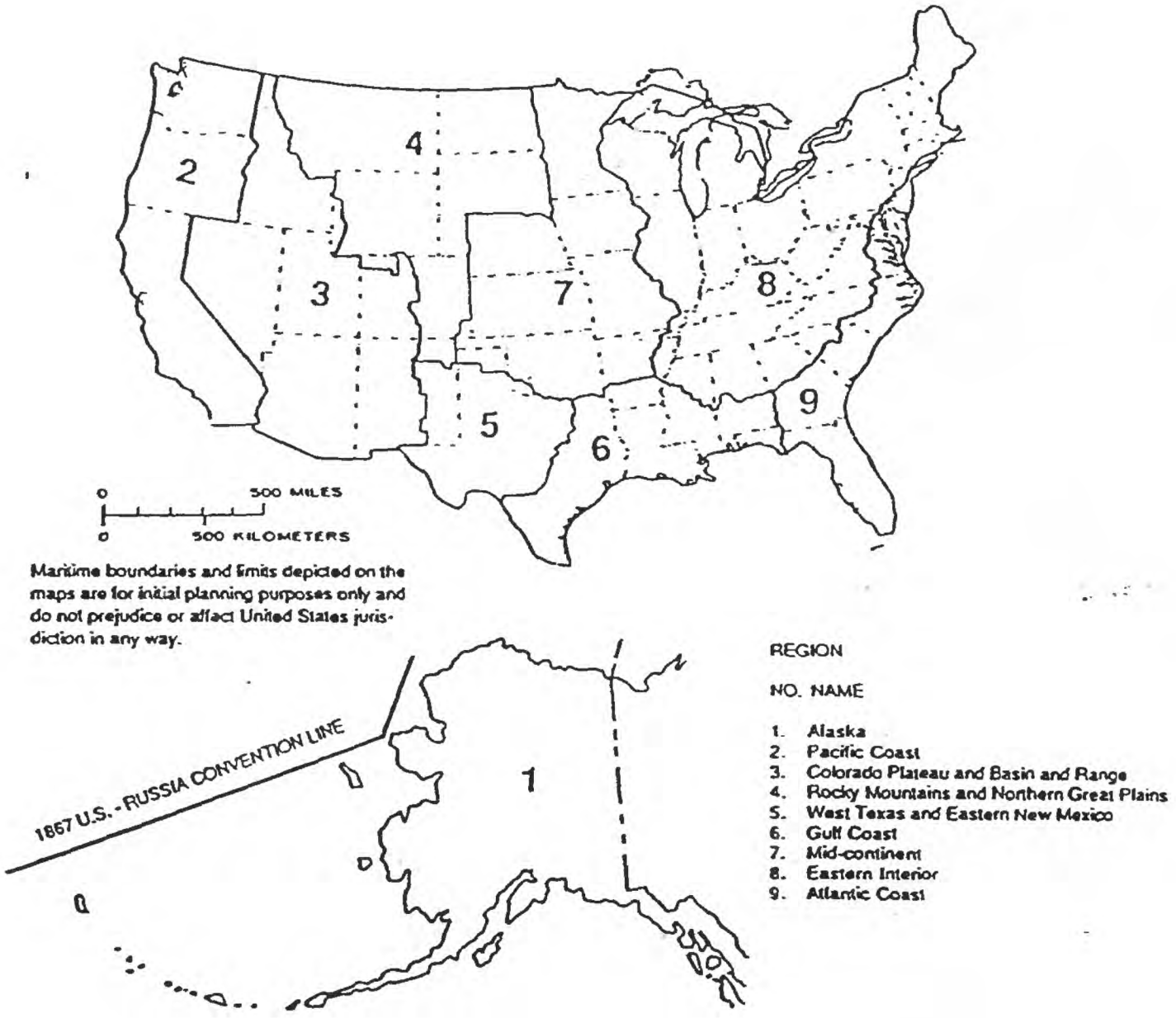

Figure 2. Map showing petroleum regions assessed in this study. Heavy lines are region boundaries, dotted lines are State boundaries.

PLAY DISCUSSION FORMAT

Individual plays described and assessed in this report include only those that were estimated to have undiscovered accumulations greater than 1 MMBO (million barrels of oil) or 6 BCFG (billion cubic feet of gas). Plays judged to have undiscovered accumulations that fell below that threshold were assessed separately for the provinces as a whole, and are not described in the report. A play is defined as a group of geologically related known or undiscovered accumulations and(or) prospects having similar characteristics of hydrocarbon source, reservoir, trap, and geologic history.

In order to achieve some degree of consistency in narrative discussions of a great number and variety of plays, a topical outline based on the definition of an exploration play has been used. Each play discussion notes the play characteristics, followed by descriptions of (1) reservoirs, (2) source rocks and related geochemistry, (3) timing of generation and migration of hydrocarbons, (4) traps (types, sizes, seals, and drilling depths), (5) exploration status (history, discovered volumes, field sizes, and hydrocarbon types), and (6) qualitative future hydrocarbon potential and factors limiting that potential. Although the discussions adhere to the order of the topical outline, it will be apparent that some inconsistency occurs in the amount of detail and coverage of each topic from one play to another. This is due to the relative abundance or lack of data pertinent to each play and is unavoidable in a report of this scope. Play discussions here are, of necessity, brief summaries. More detailed play information can be found in the province open-file reports, which are listed in the references at the end. Each play title is followed by a sequence number (for example, Frontal Wichita Play (060)), and these also appear on the table of resource estimates.

ASSESSMENT PROCEDURES AND METHODS

Assessments of undiscovered recoverable oil and gas in the individual plays in each province, and resources in small (< 1 MMBO or < 6 BCFG) accumulations were based upon review and analysis of the petroleum geology and exploration history of each province and incorporated geologic and geophysical information available as of January 1, 1987. In the National assessment, 220 plays covering the onshore and adjoiningState offshore areas were identified, and for each individual play, undiscovered oil and gas resources were estimated. Plays judged to contain more than 1 MMBO or 6 BCFG were individually assessed; plays judged to contain less than those amounts were treated differently, as described below. See Mast and others (1989) and USGS/MMS (1988) for a detailed discussion of this assessment, its assumptions, methods, and results.

In the play analysis method, geologic settings of oil and gas occurrence are modeled. The play is treated as a collection of accumulations (pools, fields) of similar geologic risk sharing common geologic characteristics that include reservoir and source rocks and known or suspected trapping conditions. A team of geoscientists made judgments as to the probability of the occurrence of those geologic factors necessary for the formation of hydrocarbon accumulations, and quantitatively assessed each factor as a play attribute; the team then estimated the numbers and sizes of accumulations as probability distributions, conditional on favorable play attributes. All of this information was entered on the play data input form which is included in each play discussion in this report. The information was then analyzed by a team who developed a computer program that performed the resource calculations on the basis of the assessment information in the input form, employing an analytical method based on probability theory. Final, undiscovered oil and gas estimates for each play, based on this method, are shown on Table 1 at the end of the report.

Probabilistic estimates of recoverable oil and gas in accumulations smaller than the established size cut-off (1 MMBO, 6 BCFG) were made separately. These estimates of small accumulations were based primarily on log-geometric extrapolations of numbers of fields into field-size classes smaller than the cut-offs. Estimates of undiscovered resources for these small fields were made for the province as a whole, rather than for the individual plays. These are shown in the table of estimates as: Oil < 1 MMB and Gas < 6BCF. In addition, minor plays and very mature, or nearly depleted plays not assessed individually are included in the table of estimates as: Other Occurrences > 1 MMBO and Other Occurrences >6 BCFG. Ratios of associated-dissolved gas to oil, and NGL (natural gas liquids) to gas, were estimated from historical production data and used for calculation of these components.

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GLOSSARY

Play.--A group of geologically related known or undiscovered accumulations and (or) prospects having similar characteristics of hydrocarbon source, reservoir, trap and geologic history.

Field.--A single pool or multiple pools of hydrocarbons grouped on, or related to, a structural or stratigraphic feature.

Prospect.--A geologic feature having the potential for trapping and accumulating hydrocarbons.

Crude oil.--A mixture of hydrocarbons present in underground reservoir rocks that is in a liquid state and remains in a liquid state as it is produced from wells.

Associated gas.--Free natural gas, occurring as a gas cap, in contact with and above an oil accumulation within a reservoir.

Dissolved gas.--Natural gas dissolved in crude oil within a reservoir.

Nonassociated gas. (*NA*)--Natural gas that is neither associated with nor in contact with crude oil within a reservoir.

Natural gas liquids (NGL).--Those portions of reservoir gas that are liquified at the surface in lease separators, field facilities, or gas processing plants. NGL is reported only in the tables of estimates in this report.

MMBO.--Millions (10^6) of barrels of oil (standard stock tank barrels of crude oil, 42 gallons per barrel).

BBO.--Billions (10^9) of barrels of oil.

BCFG.--Billions (10^9) of cubic feet of gas (standard cubic feet of gas at 14.73 pounds per in^2 and 60°F). Hydrocarbon gases only.

TCFG.--Trillions (10^{12}) of cubic feet of gas. Hydrocarbon gases only.

MMBOE.--Millions of barrels of oil equivalent (conversion factor utilized is 6,000 ft^3 of gas = 1 BOE).

REGION 7--MID-CONTINENT

GEOLOGIC FRAMEWORK

By Richard B. Powers

Region 7 is subdivided into 12 provinces, numbers 115-126 (fig. 3). The total number of individually assessed plays in the region is 20. Resources of the Mid-Continent Rift play, the area of which extends through the Sioux Uplift (124) and Iowa Shelf (125) provinces, were assessed in the latter province. However, both provinces are treated under one discussion. No individual plays were assessed in the Forest City Basin (119), Salina Basin (121), or Ozark Uplift (126) provinces.

This region occupies a large part of the Central Stable Interior and contains two major deep basins, the Anadarko (115) on the west and the Arkoma (116) on the east, both containing very thick sequences of Paleozoic rocks. A series of shallow basins that are separated by broad uplifts occurs along the northern margin. The region is bounded along its southern margin by the strongly deformed Marathon-Ouachita thrust belt and by a complex of major mountain uplifts and associated basins.

Oil in this region is concentrated in the States of Kansas and Oklahoma. Traps are structural, stratigraphic, or a combination of both, and reservoirs are sandstones and carbonates of Paleozoic age. Over half the oil in Kansas occurs on a regional high, the Central Kansas uplift. The major gas field, the Hugoton-Panhandle field, largest in the lower 48 states, occupies parts of Kansas, Oklahoma, and Texas and is on the western side of the Anadarko basin. Large gas resources have also been found in the Pennsylvanian sandstones of the Arkoma basin in Arkansas and Oklahoma. Oklahoma's major oil-producing areas include the Anadarko basin and the shelf areas and uplifts bordering it to the north and east. Significant undiscovered resources are believed to exist in the region largely in lesser explored areas, such as the deep Anadarko basin.

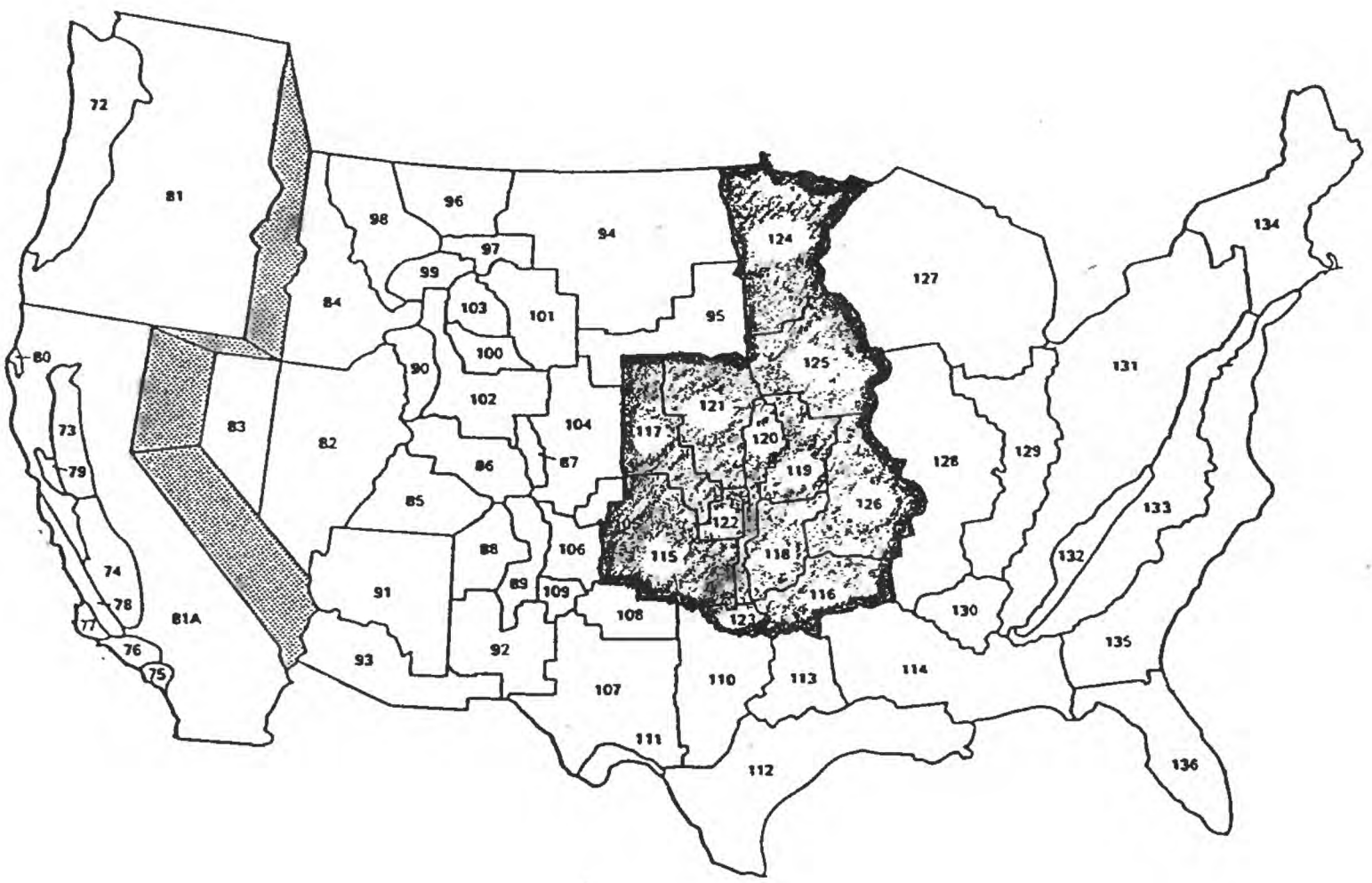

Figure 3. Index map of lower 48 states showing provinces assessed in Region 7(shaded).

Names of provinces are listed by number in table of estimates.

ANADARKO BASIN PROVINCE (115)

By Mitchell E. Henry, Mahlon M. Ball, and Sherwood E. Frezon

INTRODUCTION

The province includes parts of southwestern Kansas, northwestern Oklahoma, the northernmost part of the Texas Panhandle, and 2 counties in southeastern Colorado; it covers a total area of about 58,000 mi^2. The Anadarko basin is an asymmetric syncline bounded on the west by the Sierra Grande uplift, on the northwest by the Las Animas arch, on the north by the Central Kansas uplift and Pratt anticline, and on the east by the Nemaha uplift. From a broad shelf to the north and northwest (Hugoton embayment), mainly Paleozoic sediments thicken southward into a northwest trending depocenter where they are locally more than 40,000 feet thick (fig. 4). Immediately south of the depocenter, the symmetry of the syncline is terminated abruptly against the uplifted basement block of the Amarillo-Wichita uplift. The Anadarko basin has been actively explored for over 70 years since the discovery of oil in 1917. Seven plays were defined and individually assessed in the province: Pennsylvanian (020), Mississippian, (030), Springer-Morrow (040), Post-Morrow (050), Frontal Wichita (060), Deep Structural (070), and Hunton Paleotopographic (080).

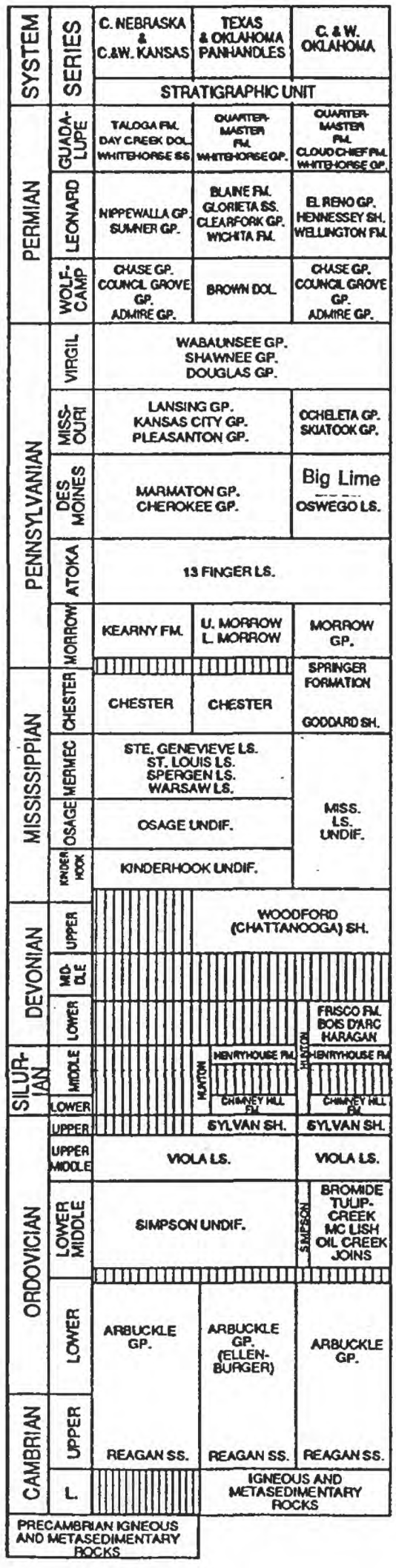

Figure 4. Generalized stratigraphic columns, Anadarko Basin province.

PENNSYLVANIAN PLAY (020)

The play covers an area of about 18,200 mi^2 and is characterized by oil and non-associated gas in stratigraphic traps in limestones of post-Atoka age which were deposited in the northern shelf of the basin in northern Oklahoma and in the Hugoton embayment as parts of cyclic depositional sequences (fig.5). As a result, the southern distribution of limestone is determined by the position of the basin slope. Principal reservoir rocks are the Big Lime and Oswego Lime of the Desmoinesian Marmaton Group and the Missourian age Lansing Group; these are generally less than 150 ft thick. Traps are stratigraphic and are formed by intercrystalline, vuggy, and fracture porosity with seals provided by overlying shales. Depths to reservoirs are generally in the 2,000 to 5,000 foot range.

Probable source rocks are dark marine shales within the Pennsylvanian section. In the Hugoton embayment and across northernmost Oklahoma these source rocks were probably never buried deep enough to reach the oil window of maturation. To the south, however, rocks of Desmoinesian age were within the oil window by the end of Permian time, and overlying rocks of Missourian age were within the oil window by the end of Triassic time. Hydrocarbons migrating updip, therefore, filled available limestone reservoirs.

Exploration in the play has resulted in the discovery of 7 oil fields, which have an estimated ultimate recovery of 23.2 MMBO, and 4 gas fields which have an estimated ultimate recovery of 60.4 BCFG. The largest oil field, Farnsworth North, with 8 MMBO ultimate recovery, was discovered in 1965, and the largest gas field, Coldwater Creek, with an ultimate recovery of 26.8 BCFG, was discovered in 1975. A relatively minor amount of oil and non-associated gas was produced during a 21-year period between 1960 and 1980 despite active exploration for deeper targets. The future potential of the play is fair for oil, and moderate for gas.

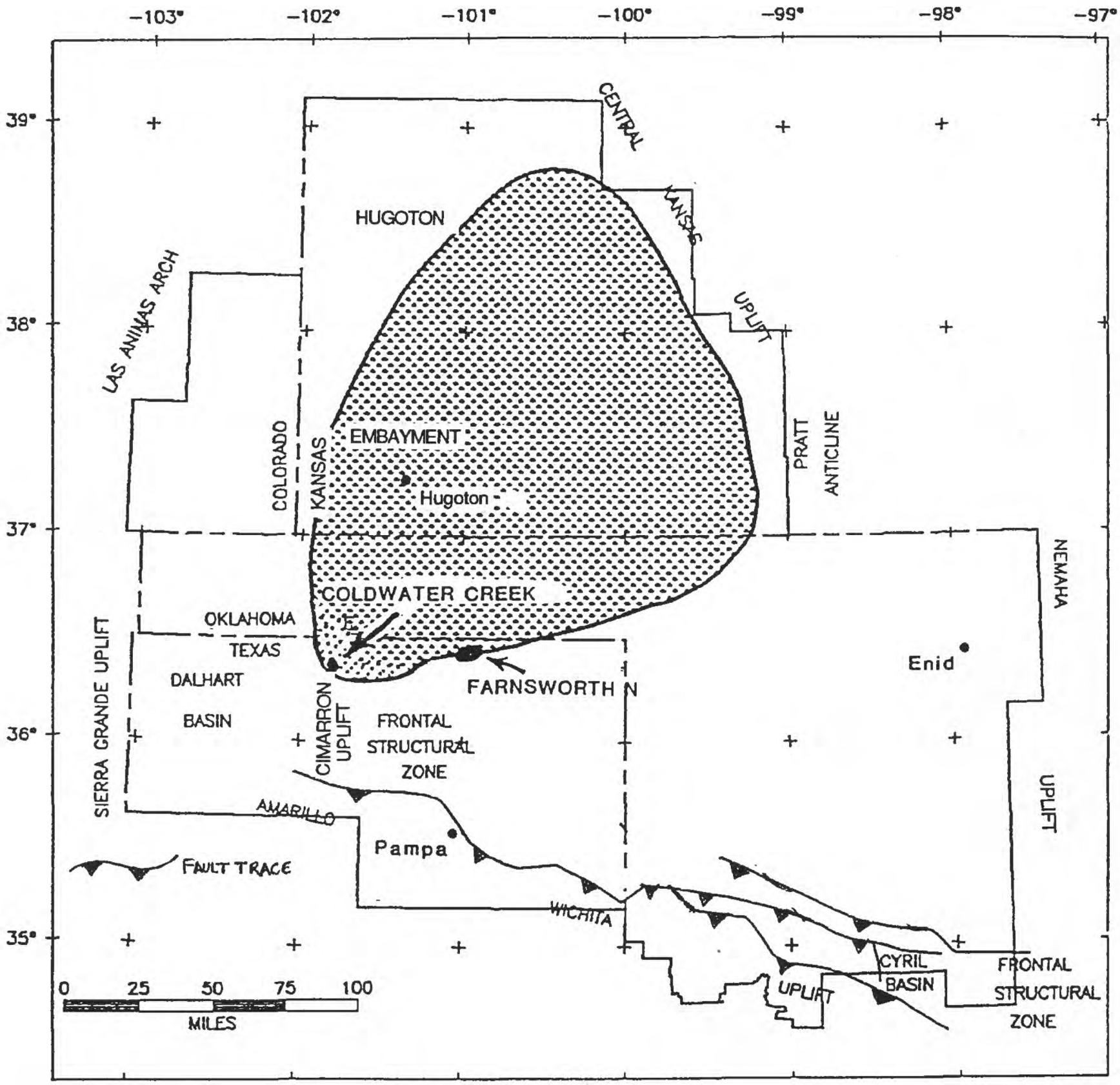

Figure 5. Map of Pennsylvanian play.

OIL AND GAS PLAY DATA

PLAY **PENNSYLVANIAN**
PROVINCE **ANADARKO BASIN** CODE **07-115-020**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	
Carbonate rocks	**X**
Other	

Hydrocarbon type	
Oil	**0.65**
Gas	**0.35**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.1**	**1.7**	**2.7**	**4**	**7**	**9**
Gas (x 10^9 CFG)	**6**	**6.5**	**8.6**	**12**	**18**	**30**	**36**
Reservoir depth (x10^3 ft)							
Oil	**2.5**			**8**			**14**
Gas (non-associated)	**7.5**			**14**			**17**
Number of accumulations	**35**	**37**	**41**	**45**	**50**	**58**	**70**

Average ratio of associated-dissolved gas to oil (GOR)	**1000**	CFG/BBL
Average ratio of NGL to non-associated gas	**25**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

MISSISSIPPIAN PLAY (030)

The play is charaacterized by oil and non-associated gas fields in stratigraphic and combination traps in Mississippian carbonates beneath a major unconformity at the base of overlying Pennsylvanian rocks. The play covers an area of about 40,000 mi^2 (fig. 6). Reservoirs occur in Osagian (informally known as Mississippi chat and solid), Meramecian (Warsaw and St. Louis Limestones) and Chesterian (Manning zone) age rocks that are generally limestones, but include dolomite and sandstone. Reservoir thicknesses range up to 400 feet in oil fields and 225 feet in gas fields. Oil accumulations occur in interstitial porosity traps associated mainly with small structures. Gas occurs in stratigraphic traps where porosity variations localize reservoirs. Depths to the top of oil reservoirs range from 3,500 to 13,500 feet and depths to the top of gas reservoirs range from 3,500 to 22,000 feet. The greater of both depth ranges may be excessive because Mississippian rocks are likely to be non-reservoir shale in deeper parts of the play.

Geochemical studies indicate that the source of oil and gas is probably the Mississippian-Devonian Woodford Shale. Burial of the Woodford in the deeper basin placed it in the oil window in Early Pennsylvanian time. In northern Oklahoma, at about the latitude of the southern line of the Oklahoma panhandle (36° 30'), the Woodford entered the oil window in Late Triassic time. Post-Mississippian erosion, followed later by Pennsylvanian deposition, sealed reservoir rocks in the play that coincided with the time frame of oil generation in the Woodford.

From 1960 to 1980, 23 oil fields were discovered with an estimated total ultimate recovery for all fields of about 68.1 MMBO. The largest field, Richland North, was discovered in 1973, and has an estimated ultimate recovery of 13.6 MMBO. The discovery rate in the play is relatively low; in the first 10 years (end of 1969) 28.3 MMBO, or 42 percent of the total, had been found. In the same time period, 28 non-associated gas fields were discovered with an estimated total ultimate recovery of 1,014 BCFG. The largest of these fields, Hooker Southwest, was discovered in 1960, and has an estimated ultimate recovery of 353 BCFG. The discovery pattern for undiscovered resources of both oil and gas is not expected to change dramatically with additional exploration. The overall future resource potential is fair to good.

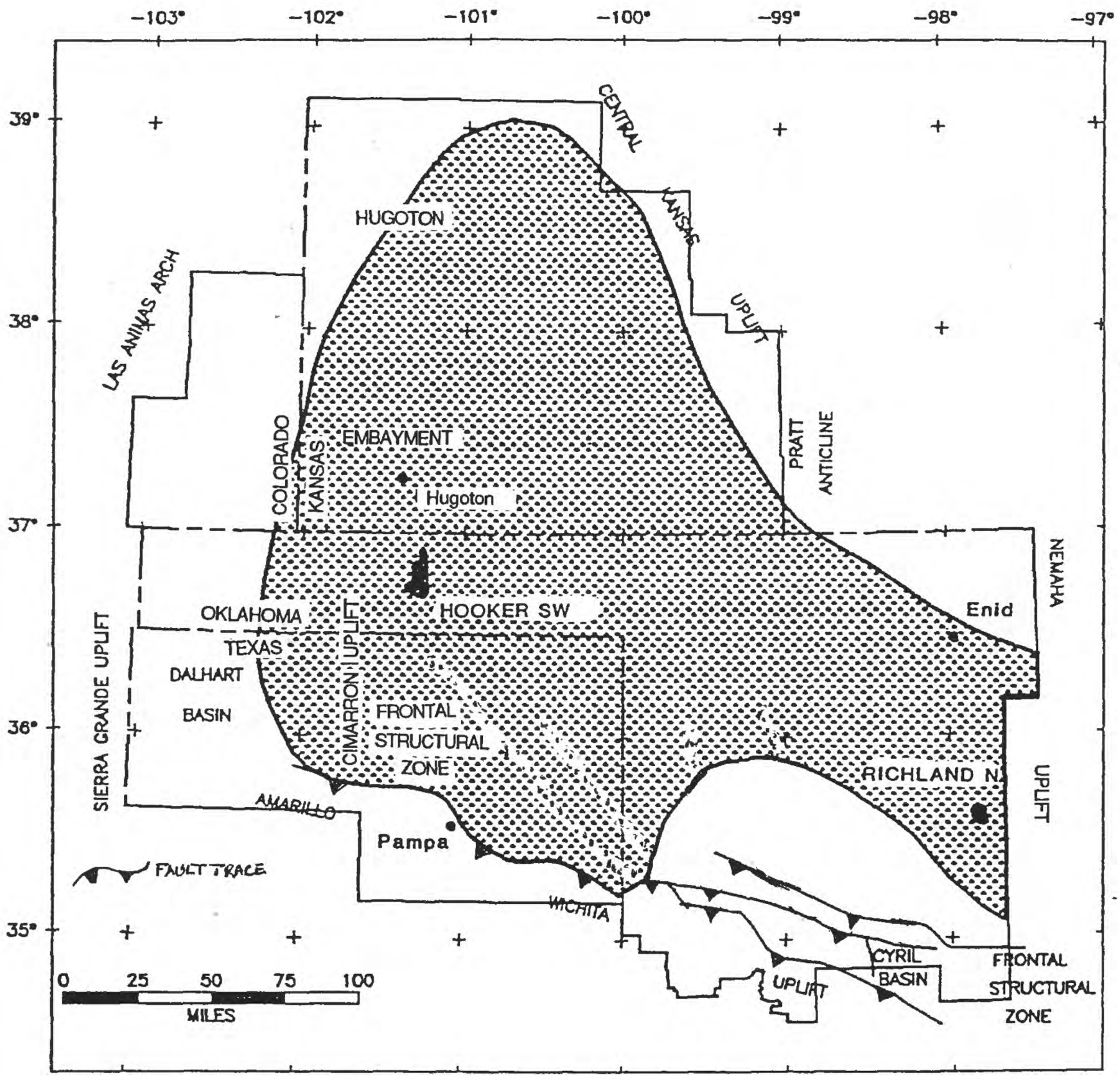

Figure 6. Map of Mississippian play.

OIL AND GAS PLAY DATA

PLAY **MISSISSIPPIAN**
PROVINCE **ANADARKO BASIN** CODE **07-115-030**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	**X**
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**0.5**
Gas	**0.5**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.1**	**1.4**	**2**	**3.4**	**9**	**26**
Gas (x 10^9 CFG)	**6**	**7.2**	**12**	**19**	**32**	**57**	**72**
Reservoir depth (x10^3 ft)							
Oil	**3**			**18**			**22**
Gas (non-associated)	**3**			**6**			**13.5**
Number of accumulations	**35**	**40**	**50**	**60**	**75**	**95**	**125**

Average ratio of associated-dissolved gas to oil (GOR)	**3000**	CFG/BBL
Average ratio of NGL to non-associated gas	**20**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

SPRINGER-MORROW PLAY (040)

The play is characterized by gas and oil production from sandstones in stratigraphic and combination stratigraphic-structural traps in the Mississippian-Pennsylvanian Springer Formation and Pennsylvanian Morrow Group. The boundary of the play corresponds to the area of the known presence of the Morrow Group in the province and covers about 40,000 mi^2. However, the Springer is present only in the deeper part of the basin in Oklahoma (fig. 7).

Reservoirs in the Springer are sandstone bodies that have lateral porosity and permeability variations and are encased in shale. In a few fields these sandstone stratigraphic traps are associated with anticlinal structures. Generally, reservoir porosities range between 5 and 10 percent and permeabilities are less than 1 millidarcy. Reservoirs are as deep as 23,000 feet, and produce sweet gas along with small quantities of natural gas liquids. Springer production is found primarily in the deep southeastern part of the basin and in a northwest-oriented Pennsylvanian age trend (about 75 miles long) in the eastern part of the play. Reservoirs are difficult to complete and to maintain production in, especially in the deeper basin, because heaving shales are frequently encountered during drilling. In addition, poor consolidation of reservoir sandstones makes production of high pressure gas difficult.

Morrow Group reservoirs produce oil and natural gas from sandstones present mainly at the base of the section in the deeper basin, and at the base and top of the section to the north and northwest. These sandstones were deposited as a sequence of onlapping and offlapping lacustrine, deltaic, and near-shore marine deposits. Morrow sandstone reservoir traps are dominantly stratigraphic, but some occur on structures. The sandstones range up to 250 feet in thickness and their porosity and permeability permit conventional completion practices. Drilling depths are as great as 21,500 feet in the deeper part of the basin.

Sources of gas and oil are probably organic-rich marine shales within the Springer and Morrow; these shales have a high hydrocarbon generating potential. The Springer had completely entered the oil window in the deep part of the basin by the end of Pennsylvanian time. Traps in the Springer and Morrow could have accumulated hydrocarbons as early as Late Pennsylvanian time. The Morrow-Springer section entered the oil window by Early Permian time. With traps in place from the time of deposition, it is assumed that hydrocarbons were migrating into them by Middle Permian time.

During a 20-year period between 1960 and 1980, 51 gas fields were discovered in the play with a total ultimate recovery of 3,077 BCFG. During the same period, 11 oil fields were discovered that have an estimated total ultimate recovery of 27 MMBO. Earlier estimates of ultimate recoveries for gas wells producing from the Springer were as high as 20 to 100 BCF per well, which were later reduced to 5-10 BCF per well, and many wells have not reached even this expectation. The future potential of the play for oil is only moderate, but excellent for gas.

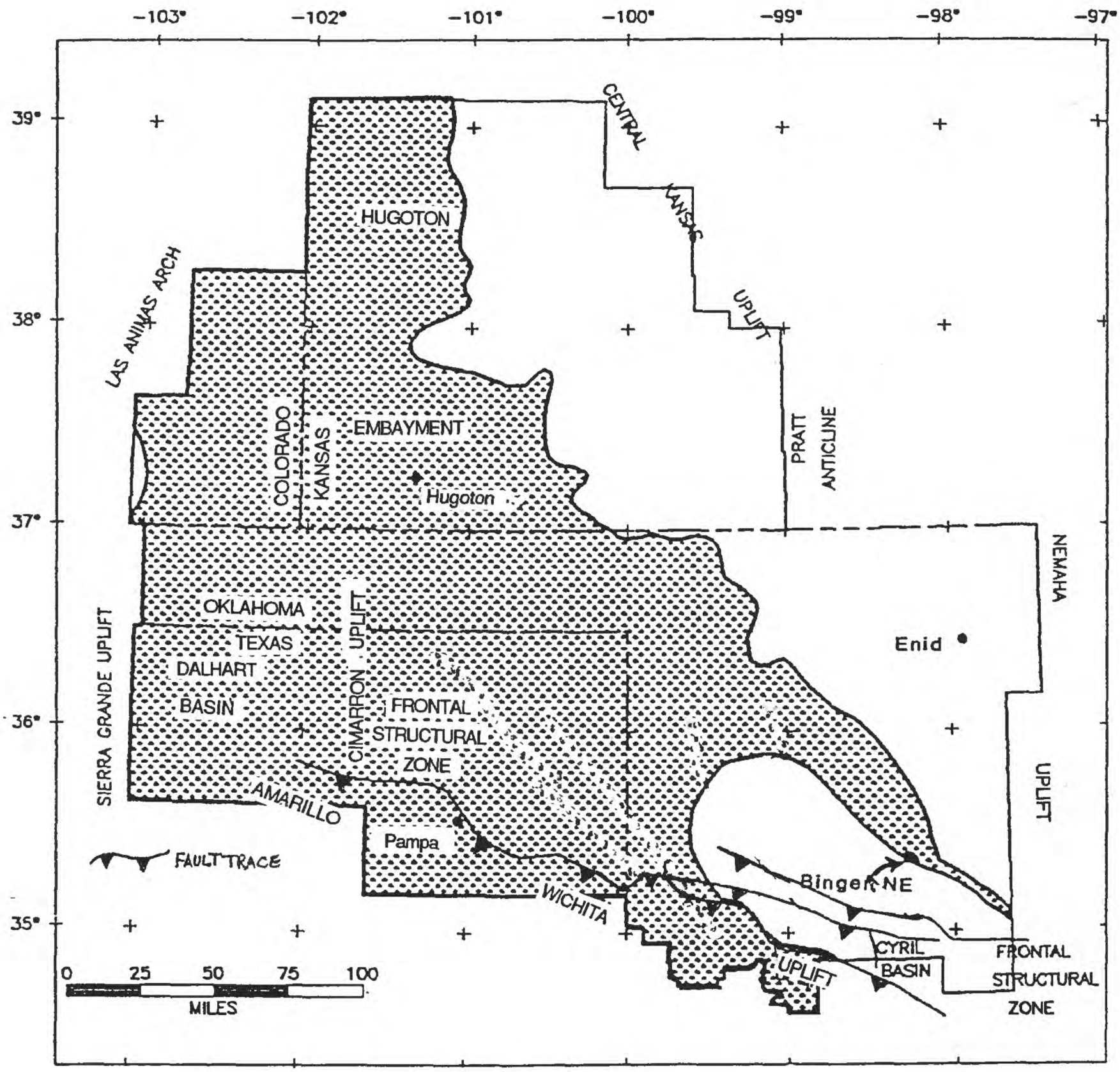

Figure 7. Map of Springer-Morrow play.

OIL AND GAS PLAY DATA

PLAY **SPRINGER-MORROW**
PROVINCE **ANADARKO BASIN** CODE **07-115-040**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	**X**
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	**0.15**
Gas	**0.85**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.03**	**1.2**	**1.6**	**2.4**	**5**	**14**
Gas (x 10^9 CFG)	**6**	**7.2**	**15**	**30**	**64**	**200**	**620**
Reservoir depth (x10^3 ft)							
Oil	**4**			**14**			**22**
Gas (non-associated)	**4**			**14**			**22**
Number of accumulations	**75**	**85**	**100**	**110**	**125**	**145**	**160**

Average ratio of associated-dissolved gas to oil (GOR)	**1500**	CFG/BBL
Average ratio of NGL to non-associated gas	**2**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

POST-MORROW PLAY (050)

The play is characterized by oil and non-associated gas production from sandstones of post-Morrowan age, such as undivided Atokan, Desmoinesian (Bartlesville sand, Red Fork sand and Skinner sand), Missourian (Cleveland sand, Layton sand) and Virgilian age (Tonkawa sand), in stratigraphic traps. The play boundary actually outlines the presence of these rocks within the province and encloses an area of about 36,500 mi^2 (fig. 8). These sandstones were derived from southern and northern source areas. The former are distal, fine-grained rocks derived from uplifted crystalline rocks of the Amarillo-Wichita uplift. The latter were transported south across the northern shelf and deposited as off shelf marine deposits, and some as lacustrine and shelf sandstones.

Reservoirs are sandstones of mainly Missourian and Desmoinesian age, and some of Atokan age. Reservoirs range up to 400 feet in thickness and depths to these reservoirs range from 2,000 to 14,000 feet. Traps are primarily stratigraphic, composed of sandstone bodies with lateral and vertical porosity variations and shale seals. Source rocks are shales interbedded within the overall Pennsylvanian section. It is probable that hydrocarbons migrated updip from the south to fill reservoirs to the north in shallower areas of the basin.

This play is the largest in the Anadarko basin in terms of ultimately recoverable oil, non-associated gas, and number of producing fields. During the period from 1959 to 1980, 29 oil fields, having an estimated total ultimate recovery of 133 MMBO, were discovered. The largest oil field, Chickasha Northwest, with an estimated ultimate recovery of 59 MMBO, was discovered in 1969. Over the same time period, 89 gas fields, with an estimated total ultimate recovery of 3,811 BCFG of gas, were discovered. The largest field (Mendota Northwest) was discovered in 1962, and has an estimated ultimate recovery of 249 BCFG. During this 22-year period the number of fields discovered each year ranged from 1 to 11. It is believed that the future potential of this play is good for oil and excellent for gas, and that undiscovered accumulations will probably exceed the amounts already discovered.

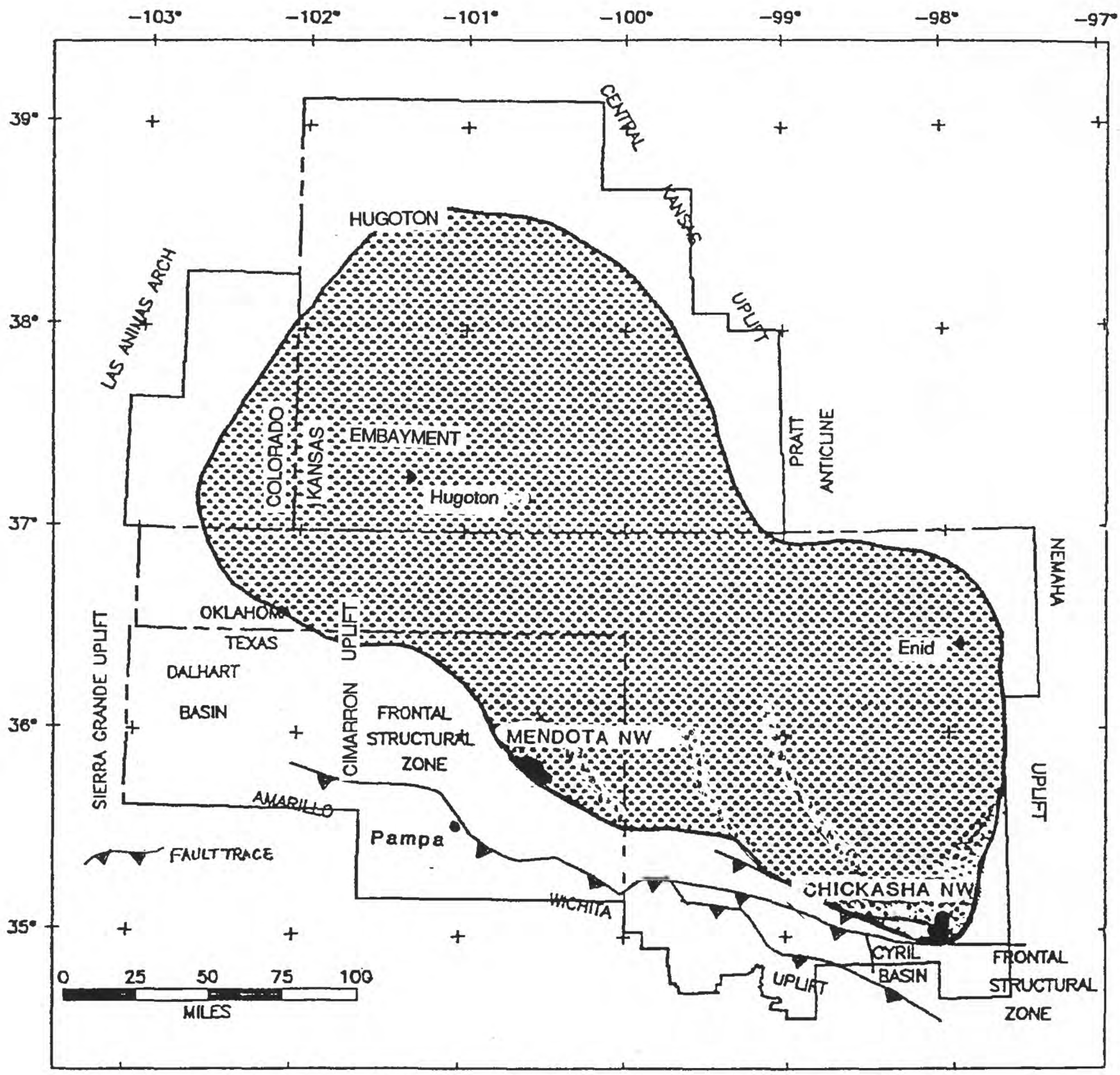

Figure 8. Map of Post-Morrow play.

OIL AND GAS PLAY DATA

PLAY **POST-MORROW**
PROVINCE **ANADARKO BASIN** CODE **07-115-050**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	**X**
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	**0.25**
Gas	**0.75**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.07**	**1.4**	**2.2**	**4.2**	**16**	**75**
Gas (x 10^9 CFG)	**6**	**7.8**	**16**	**30**	**60**	**120**	**250**
Reservoir depth (x10^3 ft)							
Oil	**2**			**10**			**14**
Gas (non-associated)	**2**			**10**			**14**
Number of accumulations	**60**	**80**	**105**	**125**	**155**	**195**	**225**

Average ratio of associated-dissolved gas to oil (GOR)	**1500**	CFG/BBL
Average ratio of NGL to non-associated gas	**25**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

FRONTAL WICHITA PLAY (060)

This play covers an area of about 5,900 mi^2 and is defined by production from conglomerate reservoirs of Pennsylvanian-Permian age on and immediately north of the Amarillo-Wichita uplift, along the southern part of the province (fig. 9). The southern boundary is formed by the Amarallo-Wichita uplift; the northern boundary is formed by the pinchout of these rocks; the western boundary generally coincides with the Cimarron uplift, and the eastern boundary is near the province boundary. The Amarillo-Wichita uplift was the source of conglomerates that were deposited as fanglomerates onshore, and as deltas and laterally distributed clastic sediments offshore. On the north side of the uplift the conglomerates occur as a more or less continuous body, but farther northward they tongue-out into finer grained rocks representing a broad span of time from late Morrowan to Wolfcampian.

Reservoirs are commonly referred to as "washes." There are three types of washes resulting from three stages of erosion on the Amarillo-Wichita uplift. The oldest, composed of chert and limestone, was derived from the erosion of Mississippian-age rocks, and is generally regarded as late Morrowan. This was followed and overlain by dolomite wash derived from older dolomites of the Arbuckle Group, and is estimated to be of lower Atokan age. The youngest wash is composed of a wide range of materials from boulder conglomerates to arkosic sandstones derived from Precambrian crystalline rocks. These washes range from moderate to high quality as reservoirs and, in many instances, are productive as shallower "bailout zones" when deeper exploration targets have been unproductive. Traps are primarily stratigraphic (depositional facies) but many are associated with anticlines or anticlinal noses. This is especially true of oil fields; five of the six discovered oil fields are combination traps. Oil reservoir rocks range up to 100 feet in thickness and depths to the reservoirs range from about 1,000 to 16,000 feet. Gas reservoir rocks range up to 700 feet in thickness and depths to these reservoirs also range from about 1,000 to 16,000 feet.

Source rocks are probably Pennsylvanian marine shales in the deep basin, immediately north of the Amarillo-Wichita uplift, and Devonian-Mississippian shales. The Woodford Shale may have been the source for some hydrocarbons, but younger shales seem a more likely source because of their proximity to reservoir rocks. Traps were present when the source rocks entered into the oil window.

Six oil fields in the play account for an ultimate recovery of 202 MMBO; the largest field (Cement) was discovered in 1917 and has an ultimate recovery of 114.5 MMBO, representing 57 percent of the discovered oil in the play. The other 43 percent of the oil is in 4 fields which have ultimate recoveries of 45.2, 23.4, 10.6, 7.3 and 1.1 MMBO, respectively. The first non-associated gas field in the play was discovered in 1952 and only 12 additional fields were discovered in the following 18 years. Estimated ultimate recovery in all 13 gas fields in the play is 863 BCFG of gas. By the end of 1953 the largest field, Hansford, with an ultimate recovery of 504 BCFG (nearly 60 percent of the total for the play) was discovered. Future potential of this play is expected to be poor for oil and fair to good for gas.

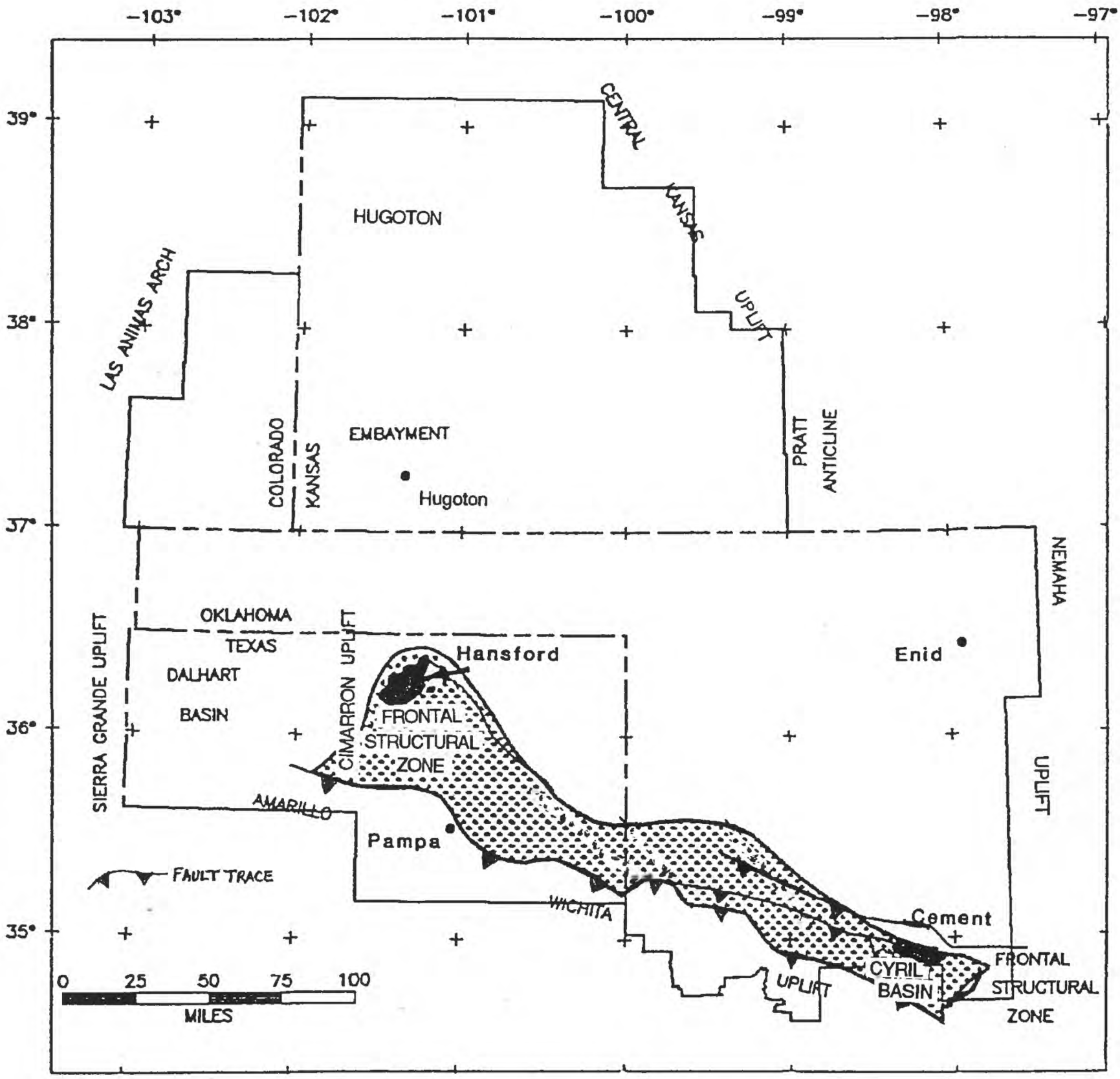

Figure 9. Map of Frontal Wichita play.

OIL AND GAS PLAY DATA

PLAY **FRONTAL WICHITA**
PROVINCE **ANADARKO BASIN** CODE **07-115-060**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	**X**
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**0**
Gas	**1**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Gas (x 10^9 CFG)	**6**	**6.6**	**11**	**18**	**30**	**66**	**120**
Reservoir depth (x10^3 ft)							
Oil	**0**			**0**			**0**
Gas (non-associated)	**10**			**18**			**23**
Number of accumulations	**5**	**12**	**22**	**30**	**40**	**52**	**60**

Average ratio of associated-dissolved gas to oil (GOR)	**0**	CFG/BBL
Average ratio of NGL to non-associated gas	**5**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

DEEP STRUCTURAL PLAY (070)

The play is defined by gas production from anticlines and faulted anticlines in Silurian-Devonian Hunton and Cambrian-Orodovician Arbuckle carbonate reservoirs at depths greater than 15,000 feet, and covers an area of about 11,200 mi^2 (fig. 10). Current production is localized to the area where rocks are dolomitized. The play is outlined mainly by a 15,000-foot structure contour, which defines the northern boundary of the play, and it is bounded to the south by the Amarillo-Wichita uplift (fig. 10). Although the productive structures involve all rocks of pre-Woodford age, reservoir rocks of the Hunton and Arbuckle Groups are the chief targets in the play.

Reservoirs are primarily dolomite beds in the Hunton and Arbuckle Groups. However, Ordovician Simpson Group reservoirs also have some minor production. Dolomite reservoirs are the product of diagenetic alteration of limestones, but the dolomization process was not pervasive, either areally or vertically, in the two groups. Limestones are not productive in the play and are not considered to be potential reservoirs. In the deepest part of the play the Hunton is more than 750 feet thick, and the Arbuckle is more than 6,500 feet thick, however, in this deeper area rocks in both the Arbuckle and Hunton are dominately limestone. Dolomite with intercrystalline porosity and fractures occurs in the most productive reservoirs.

Structural traps are formed in the Arbuckle and Hunton Groups by lateral and vertical porosity variations in the dolomite, and all gas accumulations apparently have a down-dip gas-water contact in the structures. These structures (fig. 10) are the result of orogeny and uplift that occurred at the end of Hunton time and before deposition of the Woodford. Where production occurs at and near the top of the Arbuckle, the overlying Simpson forms the seal; where production is near the top of the Hunton, the Woodford Shale forms the seal. Drilling depths in the play range from 15,000 to 27,500 feet.

There are probably two main sources of hydrocarbons. Gas in the Arbuckle is probably from source shales within the Upper Ordovician Sylvan Shale, and possibly from the more organic-rich portions of limestones in the Arbuckle. Gas in the Hunton may have some of its source in the underlying Sylvan Shale and most certainly much of its source in the overlying Woodford Shale. Geochemical studies show that Ordovician rocks are generally low (<1%) in total organic carbon content and that the Woodford is consistantly richer (>2%) in total organic carbon. Structures were formed before Woodford deposition and were in place when these source rocks entered the zone of thermal maturation in the deep part of the basin.

The northern half of the Carter-Knox gas field of the adjoining Southern Oklahoma Province (123) extends into the extreme southeastern part of this play, and is credited as the initial deep basin discovery in 1956; it produces gas from Simpson Group reservoirs at a depth of more than 15,000 feet. Between 1964 and 1975 16 gas fields were discovered, mainly in Texas and Oklahoma, which have a total estimated ultimate recovery of 2,560 BCFG. The largest field, Buffalo Wallow, was discovered in 1967 and has an estimated ultimate recovery of more than 450 BCFG. The World's deepest wildcat well (Lone Star No. 1 Bertha Rogers) was drilled in the western part of the play area. At a total depth of 31,441 feet, about 200 feet below the top of the Arbuckle, the drill encountered molten sulfur with a bottom hole temperature estimated at about 500°F.

Although key factors discussed above (presence of structures, selective areas of dolomite, and great drilling depths to reservoirs) are important constraints, the undiscovered gas potential of the play is felt to be highly significant. However, the quality of deep natural gas may be questionable, based on the Lone Star well experience.

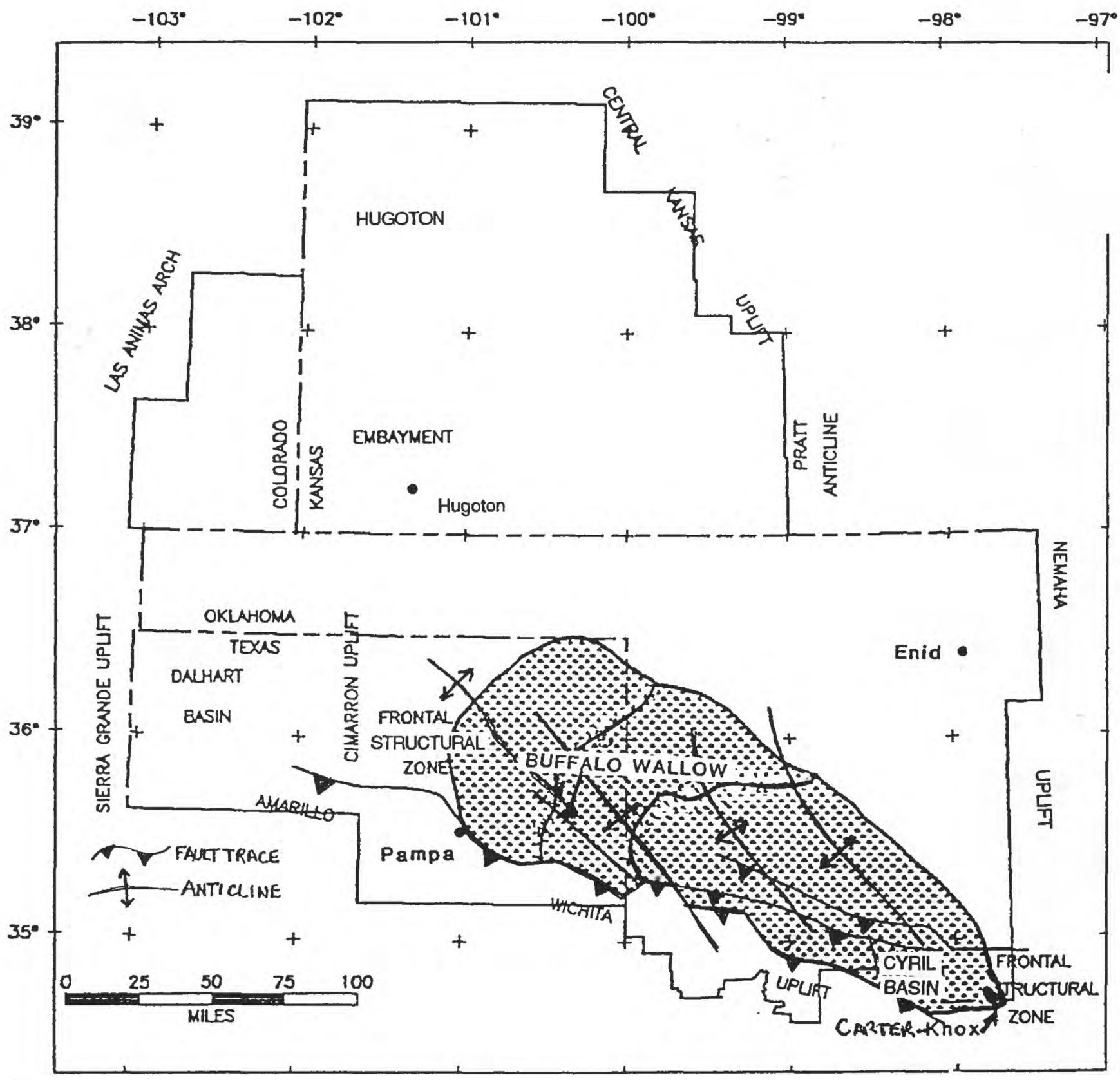

Figure 10. Map of Deep Structural play.

OIL AND GAS PLAY DATA

PLAY **DEEP STRUCTURAL**
PROVINCE **ANADARKO BASIN** CODE **07-115-070**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	**X**
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**0**
Gas	**1**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Gas (x 10^9 CFG)	**6**	**7**	**12**	**24**	**60**	**310**	**3500**
Reservoir depth (x10^3 ft)							
Oil	**0**			**0**			**0**
Gas (non-associated)	**14**			**20**			**27.5**
Number of accumulations	**20**	**22**	**30**	**35**	**42**	**50**	**60**

Average ratio of associated-dissolved gas to oil (GOR)	**0**	CFG/BBL
Average ratio of NGL to non-associated gas	**5**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

HUNTON PALEOTOPOGRAPHIC PLAY (080)

This play is defined by fields that produce oil and gas from various Hunton Group reservoirs (Frisco, Bois d'Arc, Henryhouse Formations and Chimneyhill Limestone) in stratigraphic traps and covers an area of about 16,600 mi^2. The northern boundary of the play is based on the trace of the erosional edge of the Hunton and the southern boundary is an indeterminate arc that is based on the belief that depth of burial here has destroyed porosity and permeability (fig. 11).

Reservoirs are limestone and dolomite beds in the Hunton Group. Hunton rocks thicken southward from the erosional edge and are more than 900 feet thick in the deepest part of the basin. Individual gas reservoirs range in thickness from about 5 to 300 feet and oil reservoirs range from 5 to 40 feet.

The Woodford Shale contains the source rocks of hydrocarbons found in the Hunton. It immediately overlies the Hunton and is a proven, high quality, prolific source for oil and associated/dissolved gas. Thermal maturity of the Woodford varies widely; it is overmature in the deepest parts of the play and immature on the shelf to the north. Between these two extremes, the Woodford is probably generating oil today in some parts of the basin. Because source beds overlie and seal the Hunton reservoirs, simple vertical migration of hydrocarbons could account for accumulations. The post-Hunton, pre-Woodford orogeny (discussed in the Deep Structural play (070)) that produced the structures culminated with a broad uplift of the entire province, which resulted in the erosion and subsequent development of topographic features on the exposed Hunton surface and porosity enhancement beneath the erosional surface. Although the original porosity in Hunton rocks may have been diagenetically altered when covered by the Woodford, the remaining porosity was present for charging by hydrocarbons as they were being generated.

Traps in the play are stratigraphic, are formed by paleotopography, and defined by lateral and vertical reservoir limits within the carbonates. Trapping is controlled by porosity and permeability decreases in limestones and dolomites at the top of and within the Hunton. Traps at the very top of the Hunton, at the erosion surface, are sealed by the Woodford Shale. Drilling depths range from about 5,500 feet to possibly 27,500 feet.

During a 20-year period from 1960 to 1980, 12 gas fields were discovered in the play with an estimated total ultimate recovery of 254 BCFG. The largest field, Vici, was discovered in 1970 and has an estimated ultimate recovery of 46 BCFG of gas. During the same period, 6 oil fields with an estimated total ultimate recovery of 19 MMBO were discovered. The largest of these fields, Yukon Northwest, was discovered in 1974 and has an estimated ultimate recovery of 8.2 MMBO. The play is estimated to be in the early stage of exploration. The down-dip (south) extent of the play is controlled by porosity and permeability limits that are functions of depth of burial; the greater number of discoveries will probably be made above 18,000 ft, although drilling depths could extend down to an estimated floor of gas occurrence at 27,500 ft. The potential for undiscovered oil is moderate, but is excellent for gas.

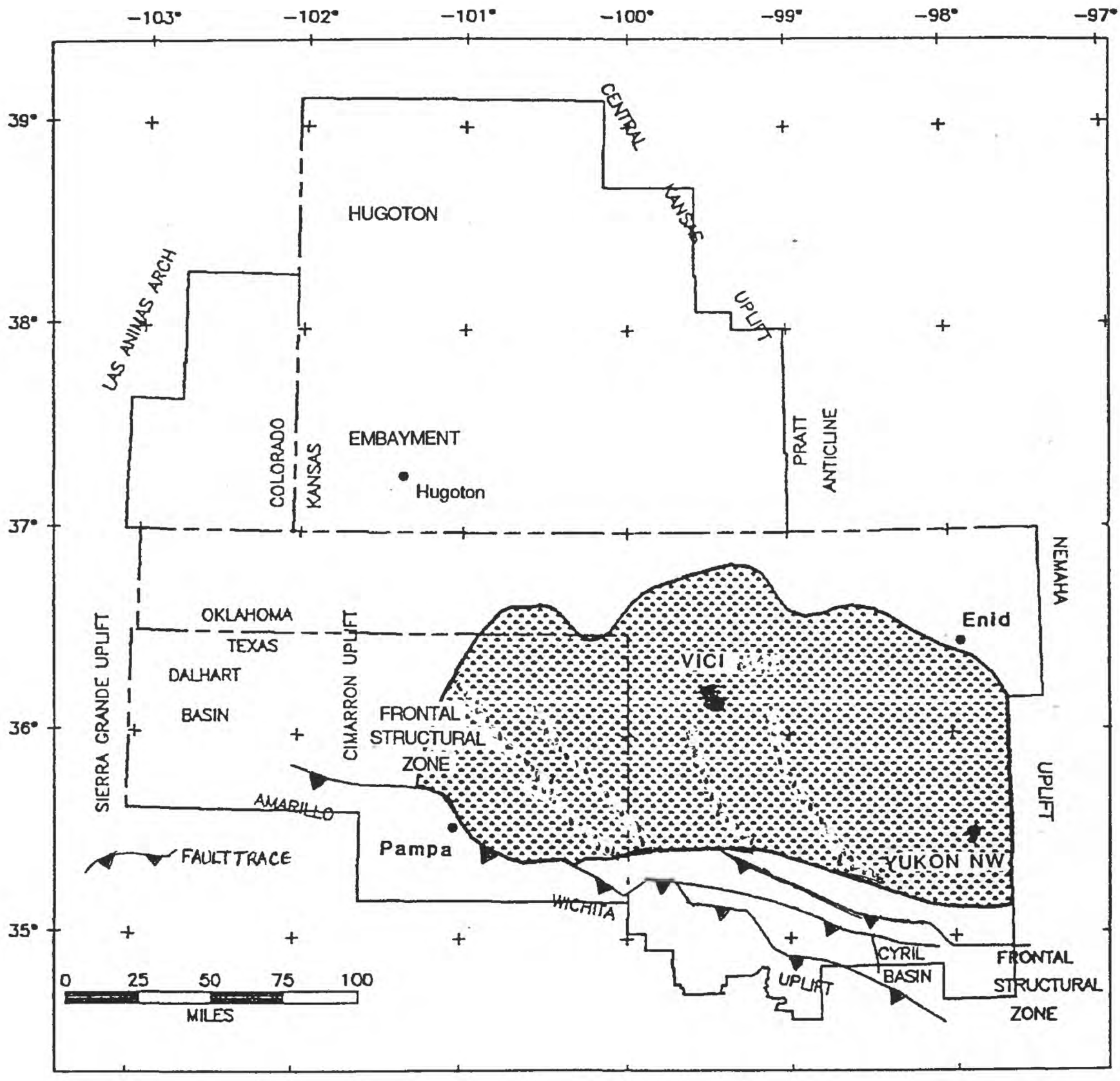

Figure 11. Map of Hunton Paleotopographic play.

OIL AND GAS PLAY DATA

PLAY **HUNTON PALEOTOPOGRAPHIC**
PROVINCE **ANADARKO BASIN** CODE **07-115-080**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**0.25**
Gas	**0.75**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.1**	**1.6**	**2.5**	**4.5**	**12**	**30**
Gas (x 10^9 CFG)	**6**	**6.6**	**11**	**18**	**33**	**80**	**180**
Reservoir depth (x10^3 ft)							
Oil	**8**			**18**			**27.5**
Gas (non-associated)	**8**			**11**			**13.5**
Number of accumulations	**50**	**60**	**80**	**100**	**125**	**165**	**200**

Average ratio of associated-dissolved gas to oil (GOR)	**1500**	CFG/BBL
Average ratio of NGL to non-associated gas	**15**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

ARKOMA BASIN PROVINCE (116)

By William J. Perry, Jr., and Sherwood E. Frezon

INTRODUCTION

The Arkoma Basin province includes portions of west-central Arkansas and southeastern Oklahoma and covers a total area of about 33,500 mi^2. The maximum length of the province is about 315 mi, east-west, and the maximum width is about 175 mi, north-south. In Arkansas, the province is bounded on the north by the Ozark uplift, and in Oklahoma it is bounded on the north by the Cherokee platform. The northern part of the province is a major foreland basin, the Arkoma basin, developed in front of and north of the Ouachita fold and thrust belt. The exposed part of this belt forms the southern part of the province. The Arkoma basin is characterized by down-to-the-south normal faults which affect Early Pennsylvanian and older rocks. The Ouachita folded sequence consists primarily of deepwater siliciclastic turbidites and radiolarian cherts. Sedimentary rocks in the Arkoma basin range in thickness from 3,000 to 30,000 ft and consist primarily of pre-Mississippian carbonate shelf deposits, organic-rich Mississippian marine shales and Pennsylvanian fluvial deposits. Nearly all the Early and Middle Pennsylvanian section is represented in the basin (fig. 12). Three plays were defined and individually assessed in the province; Basin Pennsylvanian (020), Pre-Woodford (030), and Frontal Ouachita (050). Producing fields on the northwestern edge of the province are included in the Cherokee Platform province (118).

SYSTEM	SERIES	STRATIGRAPHIC UNIT: ARKOMA BASIN — OKLAHOMA	STRATIGRAPHIC UNIT: ARKOMA BASIN — ARKANSAS	STRATIGRAPHIC UNIT: OUACHITA FOLD AND THRUST BELT
PENNSYLVANIAN (PART)	DESHOINES	Boggy Fm. Hartshorne Ss.	Boggy Fm. Hartshorne Ss.	Atoka Fm.
	ATOKA	Atoka Fm. ('Spiro' Ss.)	Atoka Fm.	
	MORROW	Wapanucka Ls. Game Refuge Ss.	Bloyd Fm. Hale Fm.	Johns Valley Sh. Jackfork Ss.
MISSISSIPPIAN		Springer Grp. Caney Sh.	Pitkin Ls : Boone Fm.	Stanley Sh.
DEVONIAN		Woodford Sh.	Chattanooga Sh.	Arkansas Novaculite
		Hunton Group	Penters Chert	
SILURIAN			Lafferty Ls. : Brassfield Dol.	Blaylock Ss.
ORDOVICIAN		Sylvan Sh. Viola Ls. Simpson Grp. Arbuckle Grp.	Cason Sh. : Gasconade Dol.	Polk Creek Sh. : Collier Shale
CAMBRIAN		Honey Creek Dol. Reagan Ss	Eminence Dol. : Lamotte Ss.	[No older rocks exposed or drilled]
PRECAMBRIAN		METAMORPHIC ROCKS		

(VERTICAL DOTS INDICATE NUMEROUS STRATIGRAPHIC UNIT NAMES OMITTED)

Figure 12. Generalized stratigraphic columns, Arkoma Basin province.

BASIN PENNSYLVANIAN PLAY (020)

The play consists of gas accumulations in sandstone reservoirs. It is predominately a stratigraphic play of Morrowan, Atokan, and early Desmoinesian age, but production is predominantly from Atokan rocks. The northwestern boundary of the play overlaps slightly into the Cherokee Platform province (118). The southern limit of the play is just north of the Choctaw thrust fault along the frontal zone of the Ouachita fold and thrust belt. The play is approximately 230 mi long, east-west, and as much as 50 mi wide, north-south (fig. 13).

Reservoirs are predominantly Atokan in age and consist mainly of fluvial, deltaic and nearshore marine sands. Reservoir thickness varies generally from 10 to 100 ft and is commonly about 35 ft. Traps are stratigraphic, although they may have a minor structural component. A lack of pressure drawdown in adjacent wells in certain fields has been observed, providing abundant evidence of limited horizontal transmissability for natural gas. For this reason, reservoir quality is only fair. Because of these numerous permeability barriers, infill drilling at 1/2 mile (320 acre) spacing is expected to yield additional reserves. Average areal reservoir size is about 5,000 acres, ranging from 640 to 92,160 acres. Drill depths range generally from 2,000 to 9,200 ft.

Source rocks probably include organic-rich Pennsylvanian shales as well as the Devonian and Mississippian Chattanooga-Woodford Shale. Source rock quality is considered to be very good. Gases are thermogenically altered oils, and tar residues are present in most of the Pennsylvanian sandstones. Relatively short-distance vertical migration is felt to have been the dominant mode of emplacement. Lateral permeability barriers within and between sandstone bodies as well as enveloping and overlying shales form seals for hydrocarbon accumulations.

The play is characterized by abnormally low reservoir pressures and no water/gas contact. Little or no water has been produced from the more than 11,000 wells drilled to date in the play. These two factors, low formation pressures and ubiquitous natural gas, appear to be the result of a high thermogenic event which occurred in Late Pennsylvanian to Early Permian time. Field limits are defined primarily by stratigraphy and permeability barriers.

The play is in a mature stage of exploration. Approximately 10.7 TCF of ultimately recoverable gas has been discovered in fields greater than 6 BCFG in size. Between 1910 and 1920, 7 gas fields were discovered, with an average field size of 528 BCF, and between 1920 and 1930, 5 fields were discovered, with an average field size of 290 BCF. Between 1960 and 1970, 18 fields were discovered, with an average field size of 41 BCF. Between 1970 and 1980, 10 fields were discovered with a average field size of 20 BCF. This decreasing field size distribution suggests that in the future, only small to medium-size fields remain undiscovered in the play.

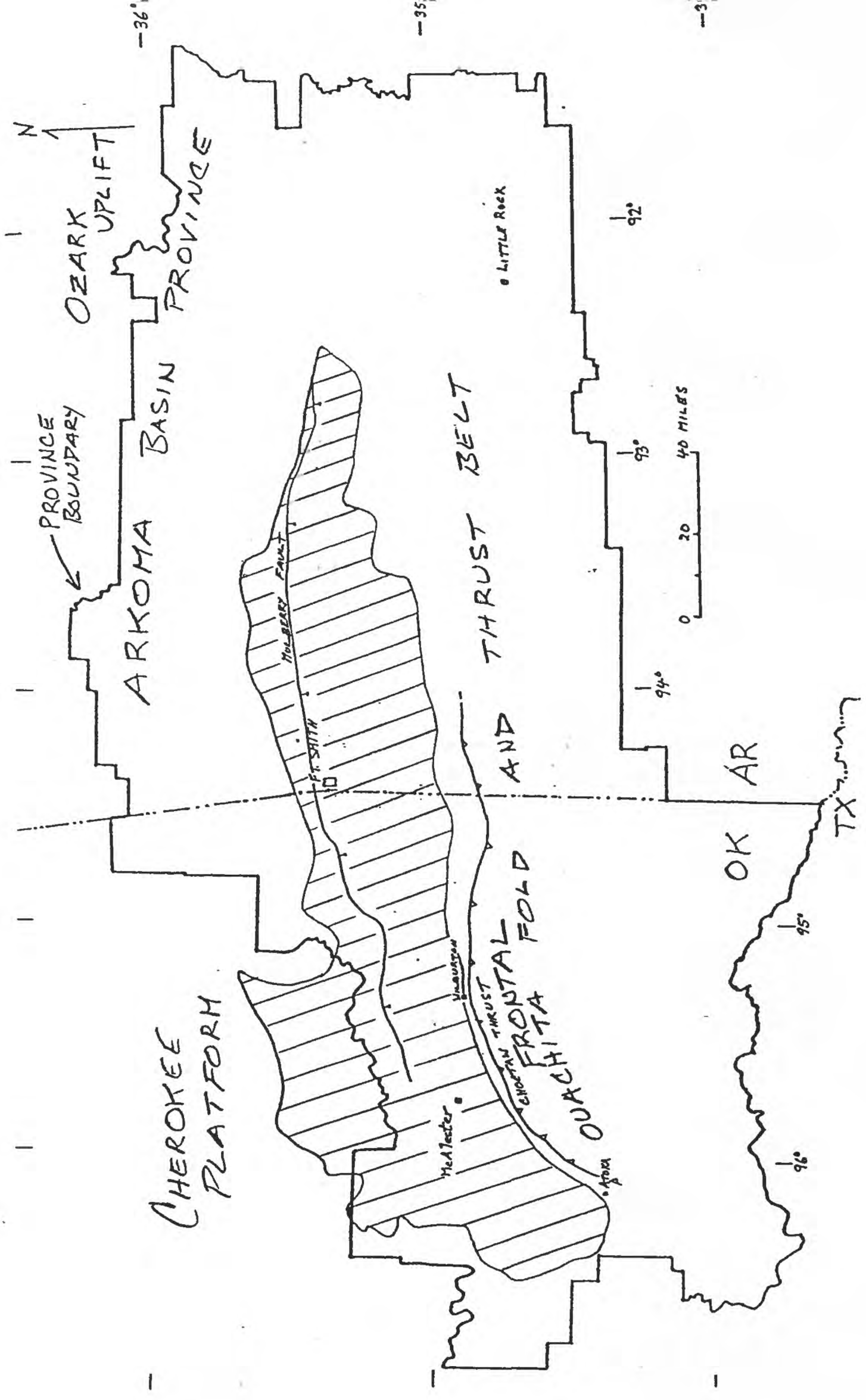

Figure 13. Map of Basin Pennsylvanian play.

OIL AND GAS PLAY DATA

PLAY **BASIN PENNSYLVANIAN**
PROVINCE **ARKOMA BASIN** CODE **07-116-020**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	**X**
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	**0**
Gas	**1**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Gas (x 10^9 CFG)	**6**	**7**	**12**	**20**	**35**	**70**	**120**
Reservoir depth (x10^3 ft)							
Oil	**0**			**0**			**0**
Gas (non-associated)	**3**			**7**			**12**
Number of accumulations	**15**	**18**	**24**	**30**	**38**	**54**	**75**

Average ratio of associated-dissolved gas to oil (GOR)	**0**	CFG/BBL
Average ratio of NGL to non-associated gas	**0**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

PRE-WOODFORD PLAY (030)

The play is predominately structural in character, involving Cambrian though Lower Devonian shelf rocks underlying Pennsylvanian rocks beneath and north of the front of the Ouachita fold and thrust belt. These rocks are involved in predominately down-to-the-south faulting of Atokan and older age. The northern boundary of the play is the Mulberry fault and the southern limit is locally south of the Choctaw thrust fault (Fig.14). The eastern limit is approximately 70 miles east-southeast of Ft. Smith, Arkansas, and the western limit approximately 10 miles west of McAlester, Oklahoma (Fig. 14). The eastern boundary is based on secondary porosity reduction by late Paleozoic calcite vein emplacement that filled fractures and remnant primary porosity. This is attributed to high levels of hydrothermal activity, associated pressure solution and recrystallization. The play is nearly 160 mi long, parallel to the Mulberry and Choctaw faults (ENE), and as much as 47 mi wide (NNW).

Reservoirs are predominately Arbuckle and Hunton carbonate rocks, but may include some Simpson sandstones. No data is available concerning the quality or thickness of reservoirs. Secondary porosity due to dolomitization and lateral porosity variations are inferred. Source rocks include the Woodford Shale and possibly the Ordovician Sylvan (Cason) Shales, although data on source rock quality are unknown. Depths to reservoirs are 5,800 to more than 14,000 ft. Timing of hydrocarbon generation and migration is believed to have occurred as early as the late Atokan and possibly continued through much of the Desmoinesian.

Traps are believed to be mainly structural, but of indeterminate size within paleostructures, and most likely include fault blocks bounded by steep down-to-south normal faults, or paleotopography at the top of the Hunton Group. Possible seals are overlying Ordovician and Mississippian shales.

Exploration drilling below the top of the Hunton Group was very limited until recently, when a major Arbuckle gas discovery, the Wilburton deep field, led to a significant increase in deep gas exploratory drilling (depths of more than 20,000 ft). Until the recent discovery of the Wilburton deep field in December, 1987 (which postdates this assessment), only two fields were known to have produced from pre-Woodford rocks. The play is estimated to have no oil potential and a moderate to good undiscovered gas potential.

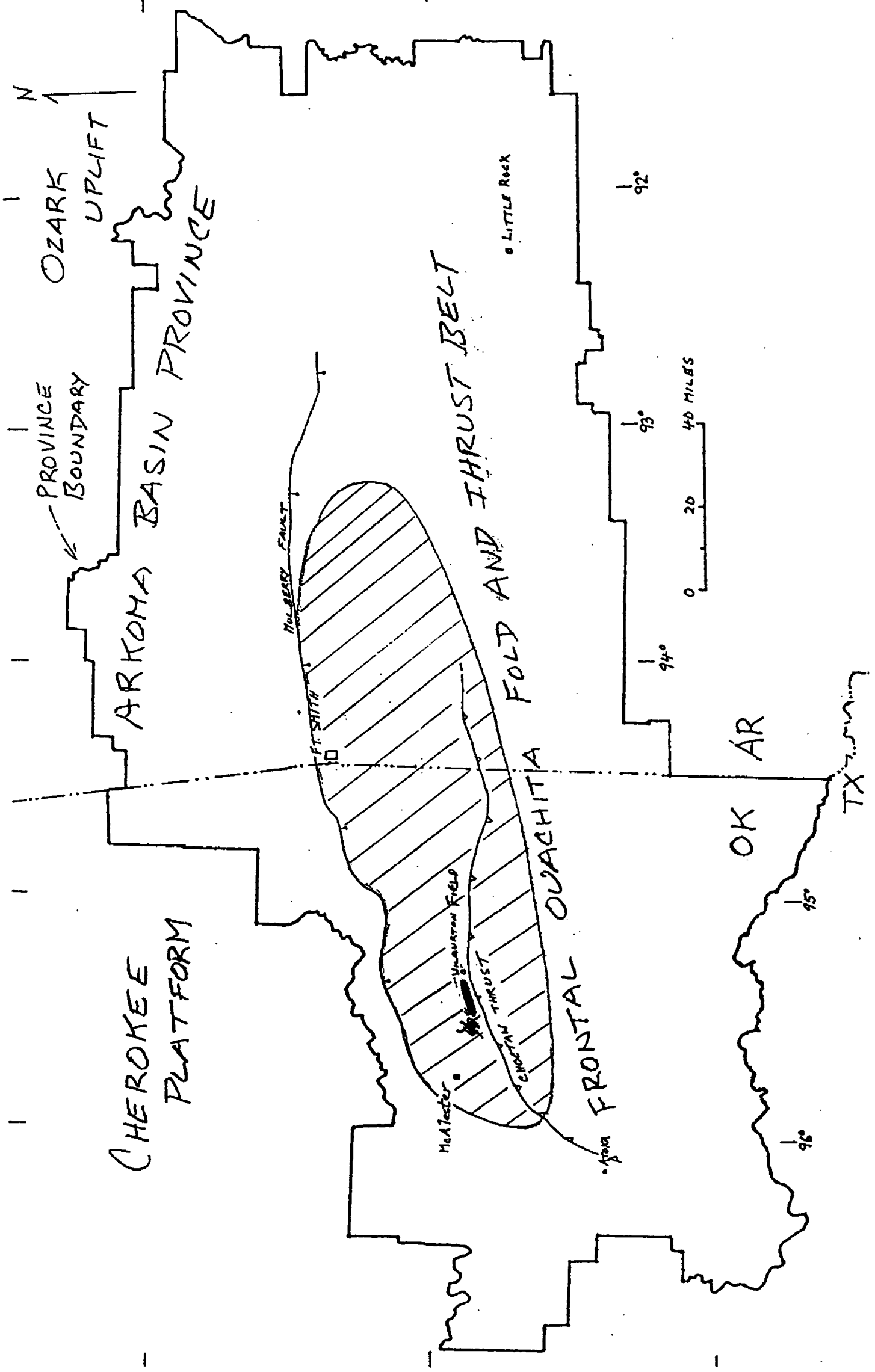

Figure 14. Map of Pre-Woodford play.

OIL AND GAS PLAY DATA

PLAY **PRE-WOODFORD**
PROVINCE **ARKOMA BASIN** CODE **07-116-030**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	**X**
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**0**
Gas	**1**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Gas (x 10^9 CFG)	**6**	**6.2**	**7**	**9**	**13**	**25**	**50**
Reservoir depth (x10^3 ft)							
Oil	**0**			**0**			**0**
Gas (non-associated)	**1.5**			**6.5**			**15**
Number of accumulations	**5**	**7**	**11**	**15**	**19**	**23**	**25**

Average ratio of associated-dissolved gas to oil (GOR)	**0**	CFG/BBL
Average ratio of NGL to non-associated gas	**0**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

FRONTAL OUACHITA PLAY (050)

The play is characterized by probable gas accumulations in Mississippian and Pennsylvanian sandstone and carbonate reservoirs in thrust faulted structural traps. It underlaps (extends northward beneath the southern part of) the Basin Pennsylvanian play (020). The northern limit of the play is the approximate northern limit of anticipated major thrust-faulted closures, in part, north of the Choctaw thrust (Fig. 15). The play extends westward and southwestward to a major upthrown block eroded to Precambrian basement, which projects southward into the Ouachita fold and thrust belt in the subsurface beneath Cretaceous rocks near the southwestern margin of the Arkoma basin province. The southeastern limit of the play is the approximate margin of the complexly deformed core of the Ouachita Mountains. The eastern limit is placed in western Arkansas. Here, rocks of the Ouachita belt have undergone eastward-increasing high paleotemperatures and hydrothermal alteration in late Paleozoic time, leading to tight cementation by calcite and quartz with consequently very low intergranular porosities. In addition, dickite and other clay minerals, as well as calcite and quartz, appear to plug fault and fracture zones in the eastern part of the frontal Ouachita thrust belt, reducing the effectiveness of possible fracture porosity. Depths to reservoirs are less than 100 ft to more than 14,000 ft.

Reservoirs include Pennsylvanian and Mississippian sandstones and carbonates, particularly the Stanley and Jackfork Sandstones, and Mississippian chert down to and including the Chattanooga (Woodford) Shale equivalent rocks of the upper Arkansas Novaculite. Source rocks include shales in the Johns Valley Formation, Jackfork Sandstone, Stanley Shale and Arkansas Novaculite. These source rocks are now overmature with respect to oil generation, but oil generated has been thermogenically converted to gas, following primary migration. Numerous gas shows have been encountered in various Mississippian and Pennsylvanian formations, and small quantities of oil and asphaltite deposits occur within the Stanley Formation.

Generation and migration of liquid hydrocarbons appears to have taken place during structural growth of the Ouachita Mountains, chiefly during early Desmoinesian time. Because undeformed upper Desmoinesian rocks overlap deformed lower Desmoinesian rocks in the northern part of the play, it is believed that deformation was over by the start of late Desmoinesian time. Deformation started earlier to the south, possibly as early as late Atokan time. Such deformation probably raised source-rock temperatures by allowing circulation of hot aqueous fluids from deep within the orogenic belt to source-rock sites. Therefore, northward, updip migration of hydrocarbons generated in the south, may have occurred in late Atokan time. Structural and combination traps are inferred beneath and south of the Choctaw thrust. Seals are probably overlying shales and lateral porosity variations. Tar plugs, resulting from an earlier phase of hydrocarbon generation, form updip seals in shallow Stanley Shale oil accumulations.

Although structurally trapped gas in thrust-faulted closures was first discovered near Wilburton, Oklahoma, in 1929, exploration has been intensified since late 1987, with the discovery of major new gas reservoirs beneath the Choctaw thrust in thrust-faulted closures in the Lower Pennsylvanian sandstone sequence. The size of these structurally trapped accumulations has not been made public, however, the future potential is felt to be moderate.

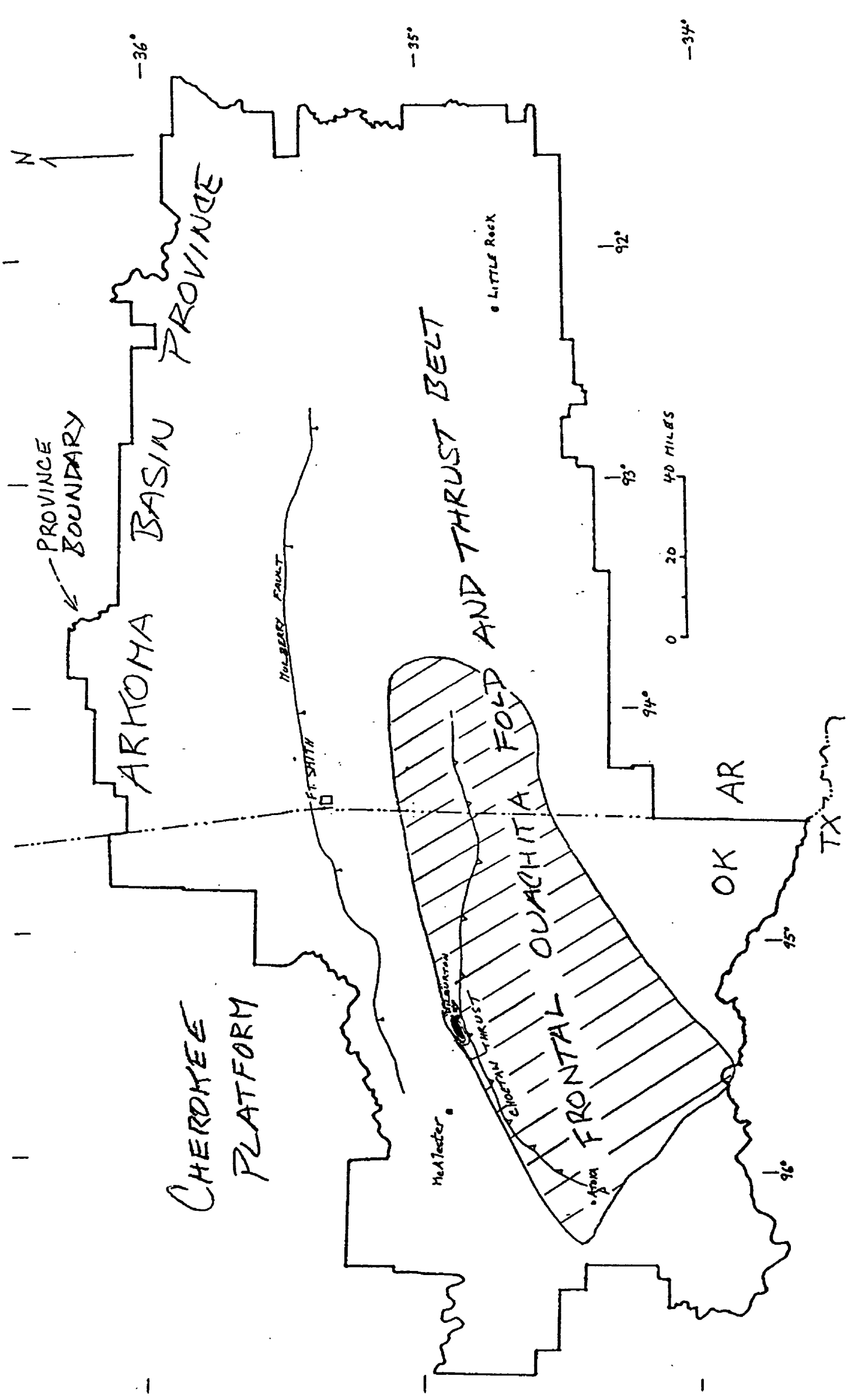

Figure 15. Map of Frontal Ouchita play.

OIL AND GAS PLAY DATA

PLAY **FRONTAL OUACHITA**
PROVINCE **ARKOMA BASIN** CODE **07-116-050**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**0.60**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	**X**
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**0.5**
Gas	**0.5**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.3**	**2.5**	**5**	**10**	**26**	**60**
Gas (x 10^9 CFG)	**6**	**8**	**15**	**30**	**60**	**156**	**360**
Reservoir depth (x10^3 ft)							
Oil	**1**			**6.5**			**12**
Gas (non-associated)	**1**			**13**			**25**
Number of accumulations	**2**	**3**	**5**	**6**	**9**	**15**	**25**

Average ratio of associated-dissolved gas to oil (GOR)	**500**	CFG/BBL
Average ratio of NGL to non-associated gas	**0**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

CAMBRIDGE ARCH-CENTRAL KANSAS UPLIFT PROVINCE (117)

By Debra K. Higley

INTRODUCTION

The province covers about 37,000 mi^2 in west-central Nebraska and Kansas, and is named after its two largest tectonic features; the gently-dipping Cambridge arch and Central Kansas uplift which trend northwest-southeast across the province. Oil and gas production is concentrated along the flanks of these structures. More than 2.6 BBO and 250 BCFG have been produced from mainly Paleozoic strata in the province. The geologic history of the Cambridge arch-Central Kansas uplift includes periods of uplift and erosion during Paleozoic and Mesozoic time, and repeated Paleozoic marine transgressions and regressions which resulted in deposition of cyclical platform sediments (fig. 16). Erosion during the Late Mississippian-Early Pennsylvanian, in particular, created a variety of topographic features and stratigraphic conditions favorable for trapping of hydrocarbons. Two plays were individually assessed in the province, Arbuckle-Reagan (020) and Pennsylvanian (070).

SYSTEM	STAGE	GROUP
Permian (part)	Wolfcampian	Chase Council Grove Admire
Pennsylvanian	Virgilian	Wabaunsee Shawnee Douglas
	Missourian	Pedee Lansing Kansas City Pleasanton
	Desmoinesian	Marmaton
	Atokan	Cherokee
	Morrowan	MORROW
Mississippian	Chesterian	CHESTERIAN
	Meramecian	MERAMECIAN
	Osagean	OSAGEAN
	Kinderhookian	KINDERHOOKIAN
Devonian		Hunton
Silurian		
Ordovician	U	SYLVAN SH
	M	VIOLA LS Simpson
	L	Arbuckle
Cambrian	U	REAGAN SS
Precambrian		

Figure 16. Generalized stratigraphic column, Cambridge Arch-Central Kansas Uplift province.

ARBUCKLE-REAGAN PLAY (020)

The play involves oil accumulations in dolomite reservoirs in various formations of the Cambrian-Ordovician Arbuckle Group and sandstone reservoirs in the Cambrian Reagan Sandstone in combination structural and stratigraphic traps. The play is present over about 20,600 mi^2 in Kansas and southernmost Nebraska (fig. 17). The Arbuckle stratigraphic section is as much as 600 ft thick, averaging 15 ft. Production is mainly oil, from depths of 3,200 to 4,700 ft. The Arbuckle section is bounded by unconformities, with Precambrian granite at the base and Middle Ordovician to Pennsylvanian age strata at the upper boundary (fig. 16). The Central Kansas uplift is the major structural control on the play; much of the oil is produced from small structures proximal and parallel to this feature. Uplift during Late Mississippian to Early Pennsylvanian time resulted in the creation of structural traps. Paleorelief or compaction may have also influenced the formation of hydrocarbon traps.

Potential carbonaceous source rocks in the play area are generally considered to be thermally immature for oil generation. Oil probably migrated northward into the play area from the Anadarko basin. The timing of oil migration ranges from Permian to Pennsylvanian.

Reservoir properties of Arbuckle dolomites were enhanced by influx of meteoric water down the flanks of the Central Kansas uplift, which resulted in increased porosity and permeability. The average porosity of Arbuckle reservoirs is 12% and average net pay thickness is 15 ft.

The first producing well in the play occurred in 1919; however, the first field discovered was the Gorham field in 1928 (fig. 17). Ninety-seven percent of the production is Arbuckle oil, and more than 1,400 MMBO have been produced (to 1984). The primary limiting factor to the future potential is the already extensive development of the play in the most favorable area, proximal to the Central Kansas uplift in Kansas. Also, most of the oil produced from this province is from stripper wells; average well production is about 4 barrels of oil per day. However, this low rate is offset by the economy of shallow drill depths, and therefore, the future potential is low to moderate.

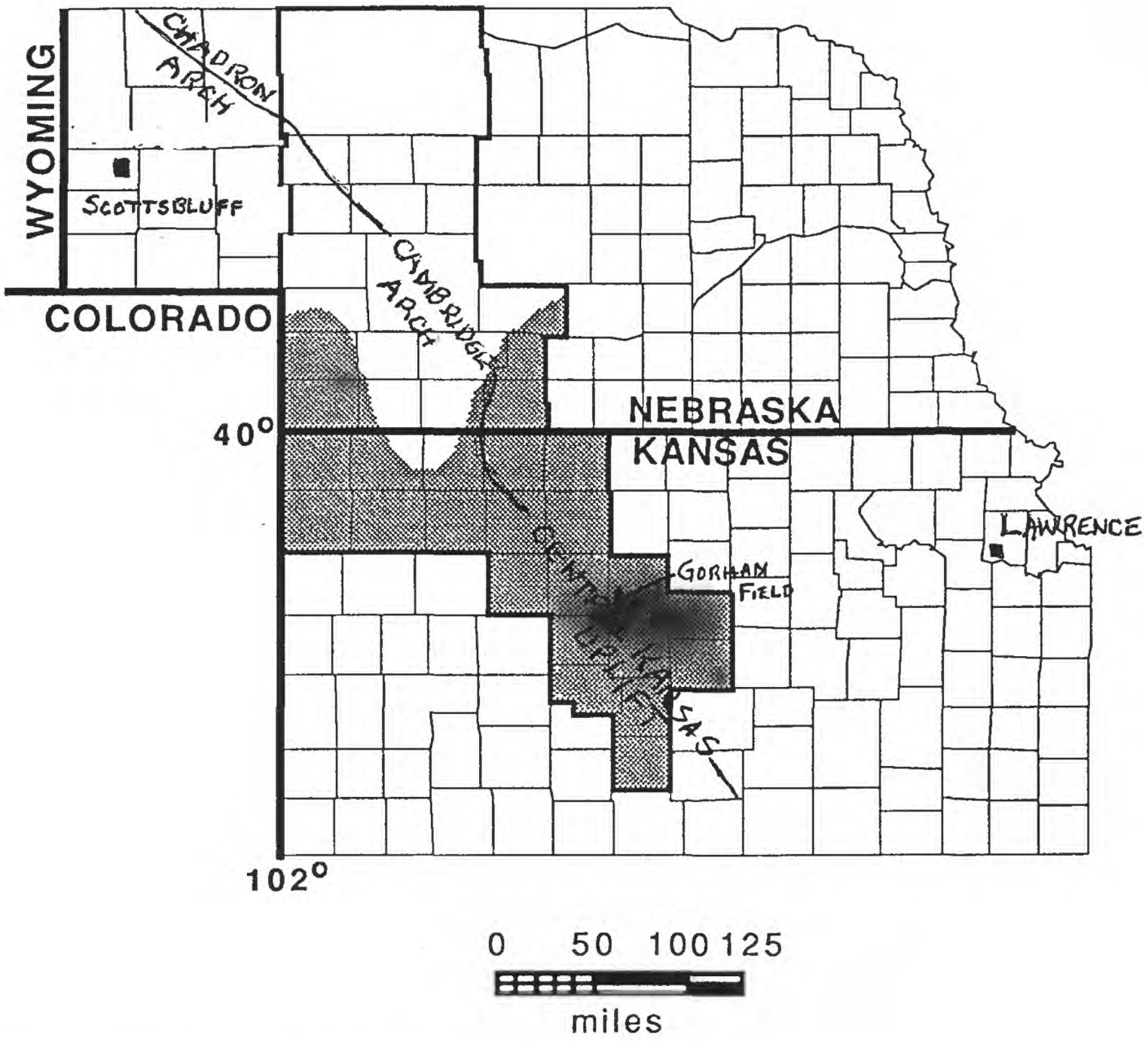

Figure 17. Map of Arbuckle-Reagan play.

OIL AND GAS PLAY DATA

PLAY **ARBUCKLE-REAGAN**
PROVINCE **CAMBRIDGE ARCH-CENTRAL KANSAS UPLIFT** CODE **07-117-020**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	**X**
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**1**
Gas	**0**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.03**	**1.2**	**1.5**	**2.2**	**5**	**14**
Gas (x 10^9 CFG)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Reservoir depth (x10^3 ft)							
Oil	**3**			**4**			**5**
Gas (non-associated)	**0**			**0**			**0**
Number of accumulations	**6**	**8**	**10**	**12**	**15**	**21**	**24**

Average ratio of associated-dissolved gas to oil (GOR)	**10**	CFG/BBL
Average ratio of NGL to non-associated gas	**0**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

PENNSYLVANIAN PLAY (070)

The play involves mainly oil reservoirs within cyclical limestone-shale-sandstone strata of Pennsylvanian age in both structural and stratigraphic traps. Groups and formations included in the play are the Wabaunsee, Shawnee, Douglas, Lansing, Kansas City, Marmaton, and Cherokee, as well as the "Penn" Sandstone and "Penn" conglomerate (fig. 16). These units are evaluated together because of similarities in stratigraphy and trapping mechanisms. The play covers about 26,500 mi^2 in the Central Kansas Uplift-Cambridge Arch province (fig. 18).

Hydrocarbon traps are primarily low relief structural noses and combinations of structure and updip porosity and permeability pinch-out. Stratigraphic traps within sandstones are also present. Hydrocarbons are produced from multiple pay zones in limestone, dolomite, and to a lesser extent, sandstone reservoirs.

Reservoir depth ranges from approximately 3,000 to 4,500 ft; net pay thickness averages about 15 ft and ranges up to 250 ft. Creation of structural traps and enhancement of reservoir porosity through influx of meteoric water are both closely associated with the formation of the Central Kansas uplift and subsequent erosion of strata on the structure.

Potential carbonaceous source rocks are generally considered to be thermally immature for oil generation. Oil probably migrated northward into the play from the Anadarko basin. The timing of oil migration ranges from Permian to Pennsylvanian.

The first oil discovery was in 1923 at the Fairport field. Ninety-three percent of the production from this play is oil, with 4 percent gas and 2 percent oil and gas. The primary limiting factor to future discoveries is the extensive drilling in the most favorable areas, near the Central Kansas uplift. However, shallow drill depths and the possibility of multiple producing formations enhances the moderate future resource potential of this play. Because the Pennsylvanian section thins to a few hundred feet in Central and Northern Nebraska, and Pennsylvanian units have fewer effective trapping mechanisms, there is only minor potential in the northern third of the play.

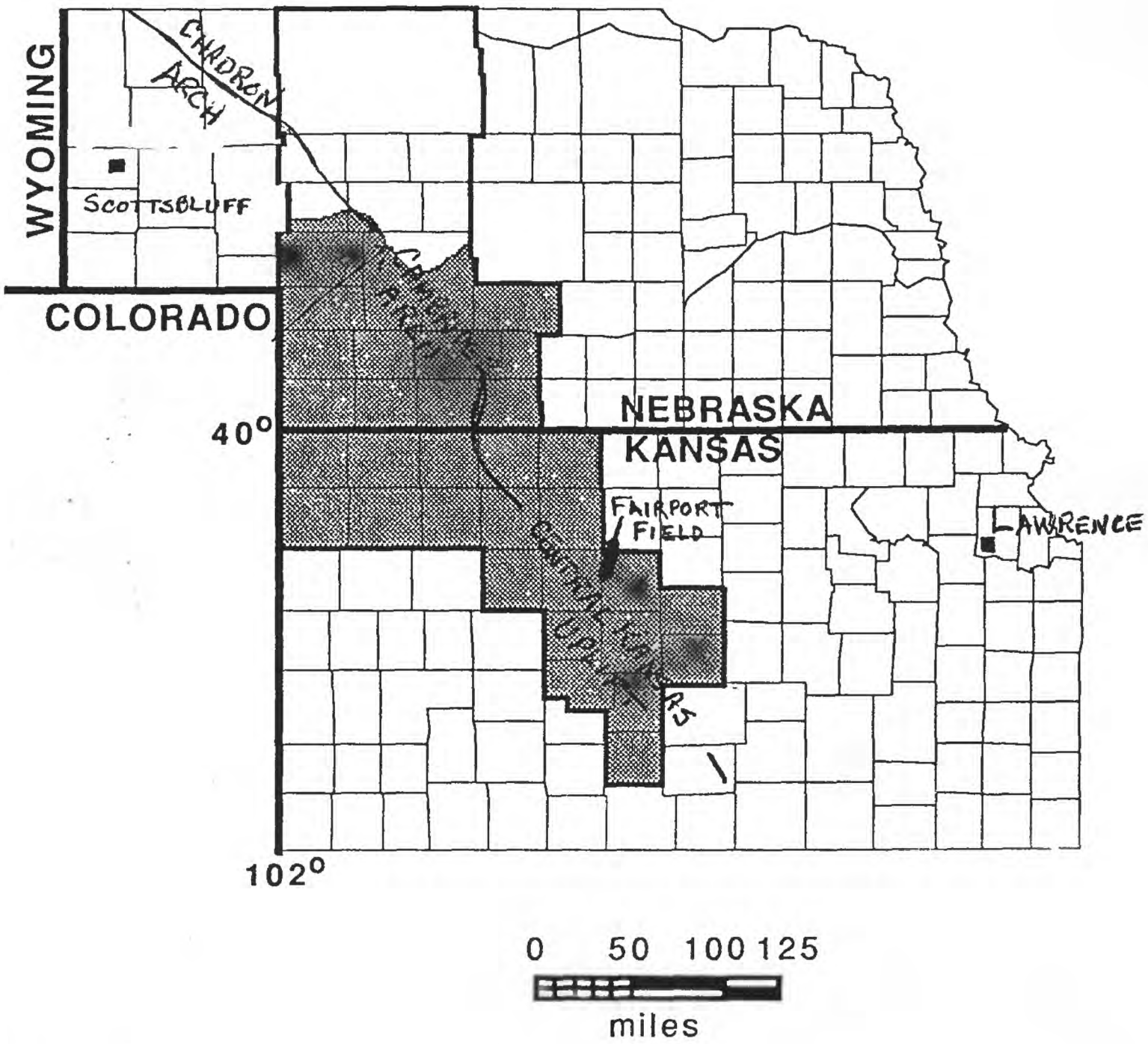

Figure 18. Map of Pennsylvanian play.

OIL AND GAS PLAY DATA

PLAY **PENNSYLVANIAN**
PROVINCE **CAMBRIDGE ARCH-CENTRAL KANSAS UPLIFT** CODE **07-117-070**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	**X**
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**1**
Gas	**0**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.03**	**1.2**	**1.5**	**2.2**	**5**	**14**
Gas (x 10^9 CFG)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Reservoir depth (x10^3 ft)							
Oil	**3**			**3.7**			**4.5**
Gas (non-associated)	**0**			**0**			**0**
Number of accumulations	**20**	**28**	**38**	**45**	**52**	**62**	**70**

Average ratio of associated-dissolved gas to oil (GOR)	**300**	CFG/BBL
Average ratio of NGL to non-associated gas	**0**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

CHEROKEE PLATFORM PROVINCE (118)

By Ronald R. Charpentier

INTRODUCTION

The Cherokee Platform province includes portions of northeastern Oklahoma, southeastern Kansas, and western Missouri. The province is about 225 mi north-south by 210 mi east-west, with an area of 25,987 mi^2, and is bounded by the Ozark uplift to the east, the Bourbon arch to the north, the Nemaha uplift to the west, and the Arkoma basin to the south. This part of the Mid-Continent region is one of the oldest oil and gas producing areas of the United States. Minor production of oil in the southeastern Kansas portion of the province dates back to the 1860's. The first major field discovery was the Dewey-Bartlesville field in 1897, followed later by the multipay Cushing field in 1912. Sandstone reservoirs of Pennsylvanian age have been the most important oil productive units in the province followed by Ordovician Simpson Group reservoirs (fig. 19). Two plays were individually assessed in the province; Pennsylvanian (020) and pre-Pennsylvanian (030).

SYSTEM	STRATIGRAPHIC UNIT
PERMIAN	CIMMARONIAN STAGE
	GEARYAN STAGE
PENNSYLVANIAN	VIRGILIAN STAGE
	MISSOURIAN STAGE
	DES MOINESIAN STAGE
	ATOKAN STAGE
	MORROWAN STAGE
MISSISSIPPIAN	CHESTERIAN STAGE
	MERAMECIAN STAGE
	OSAGIAN STAGE
	KINDERHOOKIAN STAGE
DEVONIAN	CHATTANOOGA SHALE
SILURIAN	HUNTON GROUP
ORDOVICIAN	MAQUOKETA SHALE
	VIOLA LIMESTONE
	SIMPSON GROUP
	ARBUCKLE GROUP
CAMBRIAN	BONNETERRE DOLOMITE
	LAMOTTE SANDSTONE
PRECAMBRIAN	

Figure 19. Generalized stratigraphic column, Cherokee Platform province

PENNSYLVANIAN PLAY (020)

The play is characterized by oil and gas fields in stratigraphic traps mainly in sandstone reservoirs of Desmoinesian age sealed by encasing shales. The play area is approximately 200 by 100 mi in size and covers nearly the entire province. The eastern boundary is at the outcrop edge of Pennsylvanian rocks and the southern boundary is marked by the approximate southern limit of oil production (fig. 20).

Reservoirs are dominantly marine sandstones in offshore bars ("shoestring sandstones") and nearshore marine sheet sandstones of Atokan-Desmoinesian age. These rocks range in overall thickness from zero at their outcrop edge along the eastern play boundary to more than 1,500 ft in northeastern Oklahoma. Individual reservoirs range in thickness from 3 to 100 ft, and average about 20 ft. Porosity of these reservoir sandstones is on the order of 20 percent and permeability is nearly 100 millidarcies. Minor reservoirs include thin algal limestones in the Desmoinesian section (Marmaton Group) and in the Missourian-Virgilian section (fig. 19). Drill depths to reservoirs range from 500 to 9,000 ft and average about 3,000 ft.

Source rocks for oil are considered to be mainly indigenous, highly organic-rich shale which makes up about 85 percent of the Atokan-Desmoinesian section. Thermal maturity of these shales within the play ranges from immature to marginally mature, however, in the deeper Arkoma basin to the south these rocks are mature and the Arkoma is probably the most likely source area. Generation and migration of hydrocarbons into traps began possibly as early as Late Pennsylvanian time and continued well into the Cenozoic.

Traps are dominantly stratigraphic, some formed by eastward updip facies change from sandstone to shale. Minor accumulations are also found in stratigraphic traps that have anticlinal components. Some of the larger traps cover up to 50,000 acres in areal size and have ultimate recoveries exceeding 500 MMBO.

Exploration in the play dates to the early 1860's and it is estimated that more than 3.5 BBO have been produced from Pennsylvanian rocks. Shallow wells drilled during the early period of exploration produced small quantities of oil and gas mostly for local markets until the discovery of the giant Glenpool field in 1905 (325 MMBO ultimate recovery). The largest field discovery was Burbank in 1920, with an estimated ultimate recovery of 540 MMBO. The most recent discovery of appreciable size was the Pershing field in 1957 with an estimated recovery of 21.8 MMBO (fig.20). There has been a steep decline in the discovery rate of oil since 1959, however. The two most recent discoveries in 1979 and 1982 found an estimated 7 MMBO. The future potential for the play is estimated to be fair for small size accumulations.

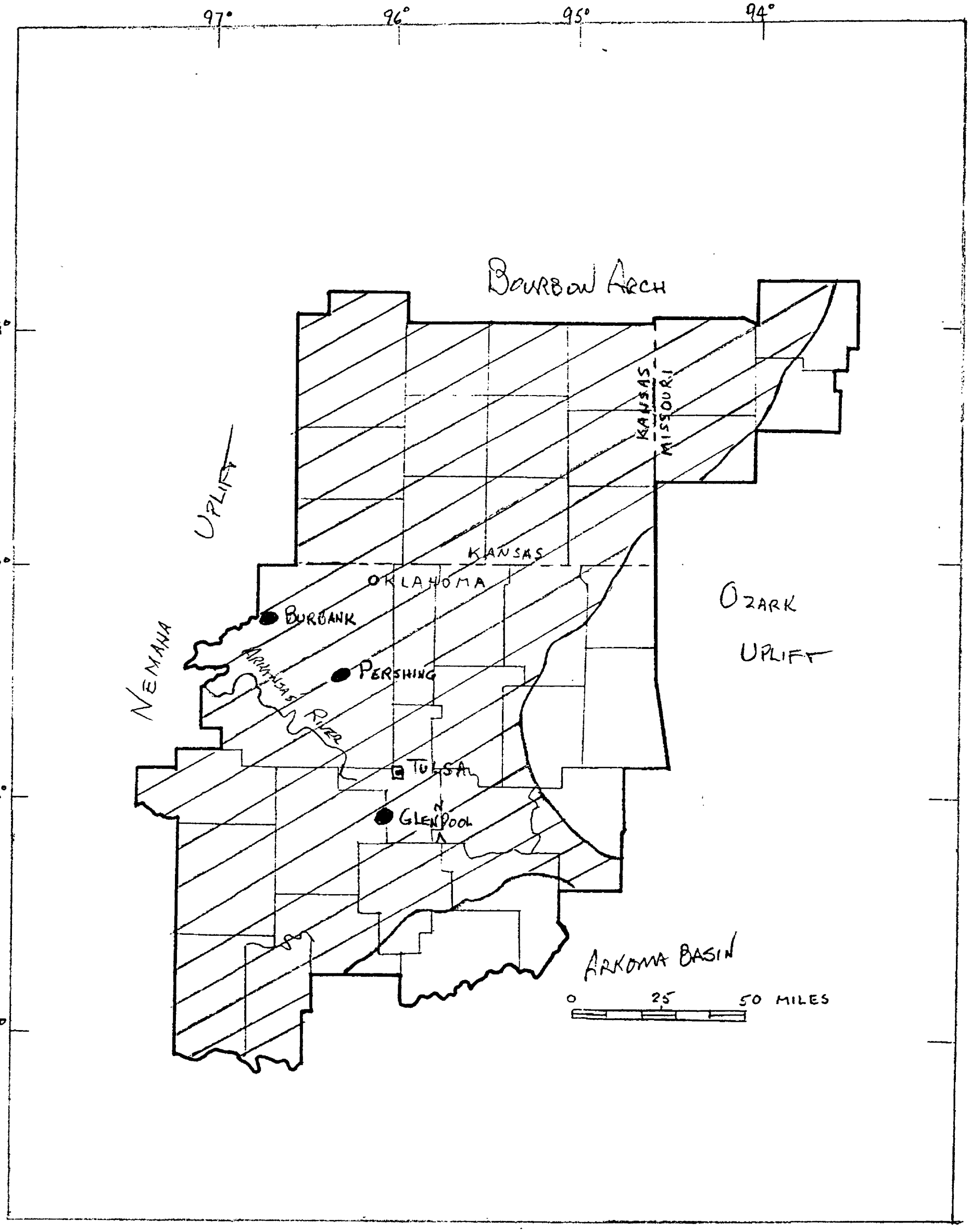

Figure 20. Map of Pennsylvanian play.

OIL AND GAS PLAY DATA

PLAY **PENNSYLVANIAN**
PROVINCE **CHEROKEE PLATFORM** CODE **07-118-020**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	**X**
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	**1**
Gas	**0**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.05**	**1.3**	**1.75**	**2.8**	**7**	**20**
Gas (x 10^9 CFG)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Reservoir depth (x10^3 ft)							
Oil	**0.5**			**2.5**			**5**
Gas (non-associated)	**0**			**0**			**0**
Number of accumulations	**7**	**11**	**15**	**18**	**21**	**25**	**30**

Average ratio of associated-dissolved gas to oil (GOR)	**1500**	CFG/BBL
Average ratio of NGL to non-associated gas	**0**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

PRE-PENNSYLVANIAN PLAY (030)

The play includes oil and gas trapped in rocks of Cambrian to Mississippian age, below the Mississippian-Pennsylvanian unconformity, and covers an area of 22,000 mi^2 (Fig.21). Eastern parts of the play are considered to be less prospective because of truncation of potential reservoirs on the Ozark uplift. Major reservoirs are sandstones in the Middle Ordovician Simpson Group, but the Middle Ordovician Viola Limestone, Silurian-Devonian Hunton Group dolomites, and the Devonian-Mississippian Chattanooga Shale (Sylamore Sandstone Member) also contribute some production. Traps are primarily truncations below the pre-Chattanooga unconformity, with the Chattanooga Shale itself being both the source and seal. Some anticlinal traps exist both below the Chattanooga and within Mississippian rocks. Drilling depths average about 2,000 feet.

The Chattanooga Shale and equivalents are the most likely source rocks, but the Upper Ordovician Maquoketa Shale may have also provided some hydrocarbons. Oil generation from the Chattanooga-equivalent Woodford Shale probably began as early as Mississippian time in the deeper part of the Anadarko basin, to the southwest, and much of the Cherokee Platform oil may have migrated from the deep Anadarko.

Drilling in the pre-Pennsylvanian rocks began in the 1860's, and is presently at a very mature stage of exploration for most of the play. The eastern part of the play is more sparsely drilled because of truncation of reservoir beds on the Ozark uplift. Little deep drilling has taken place into the Cambro-Ordovician Arbuckle Group; common practice is to drill just into the top few feet of this thick dolomite unit. Because of the advanced stage of drilling in the play, only minimal potential exists for new field discoveries of at least 1 MMBOE in size. The potential for new gas accumulations in the Arbuckle Group are lessened because of fresh-water lenses from recharge areas in the Ozark uplift.

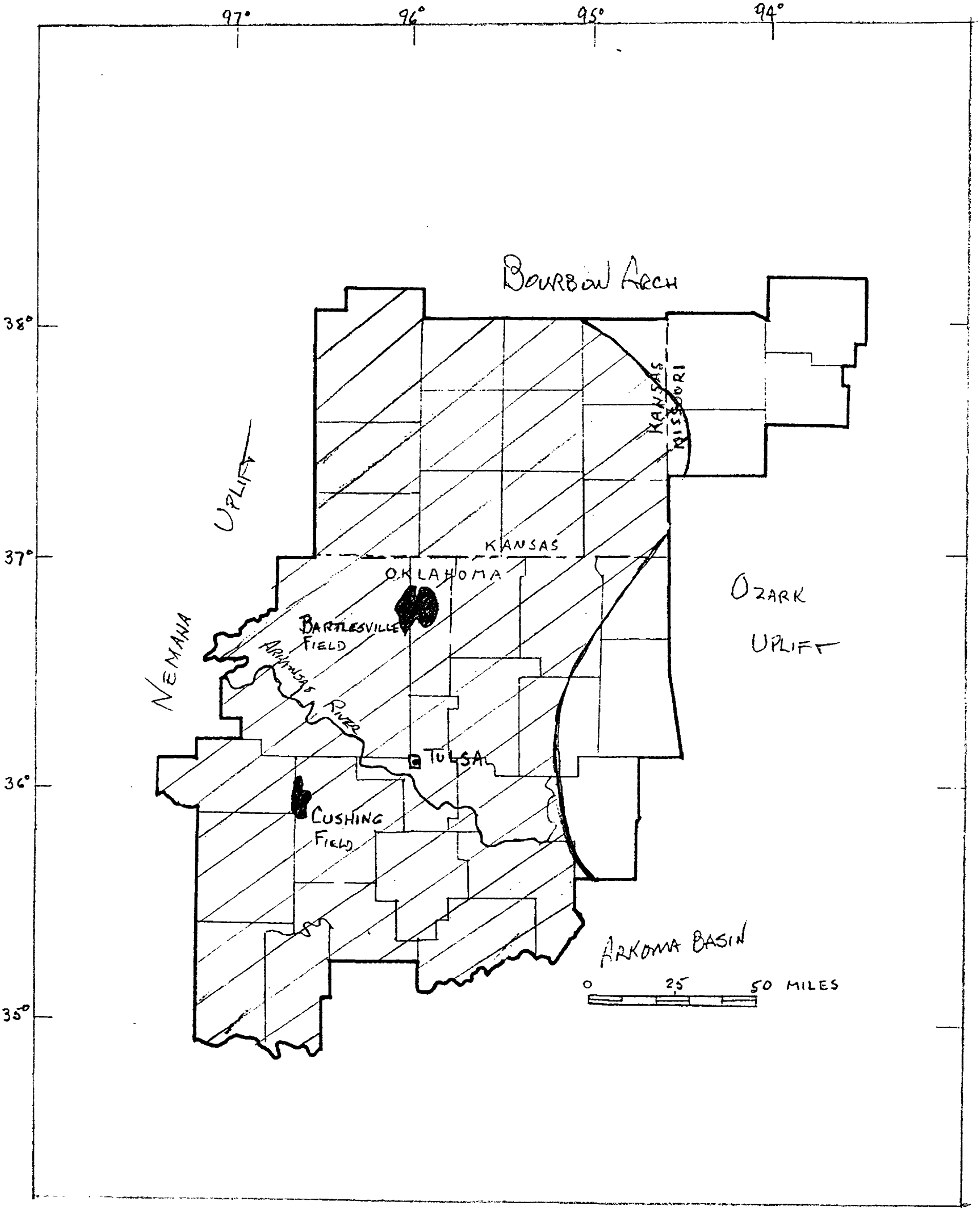

Figure 21. Map of Pre-Pennsylvanian play.

OIL AND GAS PLAY DATA

PLAY **PRE-PENNSYLVANIAN**
PROVINCE **CHEROKEE PLATFORM** CODE **07-118-030**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	**X**
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**1**
Gas	**0**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.04**	**1.2**	**1.5**	**2**	**3.2**	**4.6**
Gas (x 10^9 CFG)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Reservoir depth (x10^3 ft)							
Oil	**3**			**4.5**			**6**
Gas (non-associated)	**0**			**0**			**0**
Number of accumulations	**1**	**2**	**3**	**5**	**8**	**12**	**20**

Average ratio of associated-dissolved gas to oil (GOR)	**800**	CFG/BBL
Average ratio of NGL to non-associated gas	**0**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

FOREST CITY BASIN PROVINCE (119)

By Mahlon M. Ball

The Forest City basin is a shallow, intracratonic basin located in southwestern Iowa, northeastern Kansas, and northwestern Missouri. The basin contains Paleozoic sedimentary rocks with a maximum thickness of 5,200 feet in southwestern Iowa. The western border follows the basin's junction with the Nemaha uplift from the province's southwest corner to the Kansas-Nebraska state line. At this point, the boundary jogs east along the State line to the Missouri River and follows the river as it forms the boundary between Nebraska and Missouri, and then Iowa and Nebraska to the province's northwest corner. On the north and northeast, the boundary marks the separation of the Forest City basin and the Iowa Shelf province (125) (fig. 22). Total area of the province is approximately 25,000 mi^2.

Two exploration areas have traditionally dominated the Forest City basin. The first is a linear trend of anticlines that overlie high blocks in the Humboldt fault zone marking the steep, eastern face of the Nemaha uplift and its junction with the Forest City basin (fig. 22). Important productive reservoirs in this trend are Middle Ordovician Simpson sandstones, Viola Limestone, and Silurian-Devonian Hunton Group dolomites. For purposes of the National assessment, this trend was included in the Nemaha Uplift Province (120), and the two associated southeastern-most Nebraska counties and one Kansas county were shifted from province 119 to province 120 to facilitate this inclusion. The second area consists of a broad swath of numerous old, shallow oil fields dominated by the Paola field complex contained in Desmoinesian and Missourian sandstone reservoirs (fig. 22). Trap configurations for these fields are primarily stratigraphically controlled, although some combination structural-stratigraphic traps do occur. The area has produced approximately 100 MMBO since the initial discovery in the Paola field in 1860; 80 percent of this amount was produced from Pennsylvanian rocks, but production is now limited to stripper operations. No plays were individually assessed in the province.

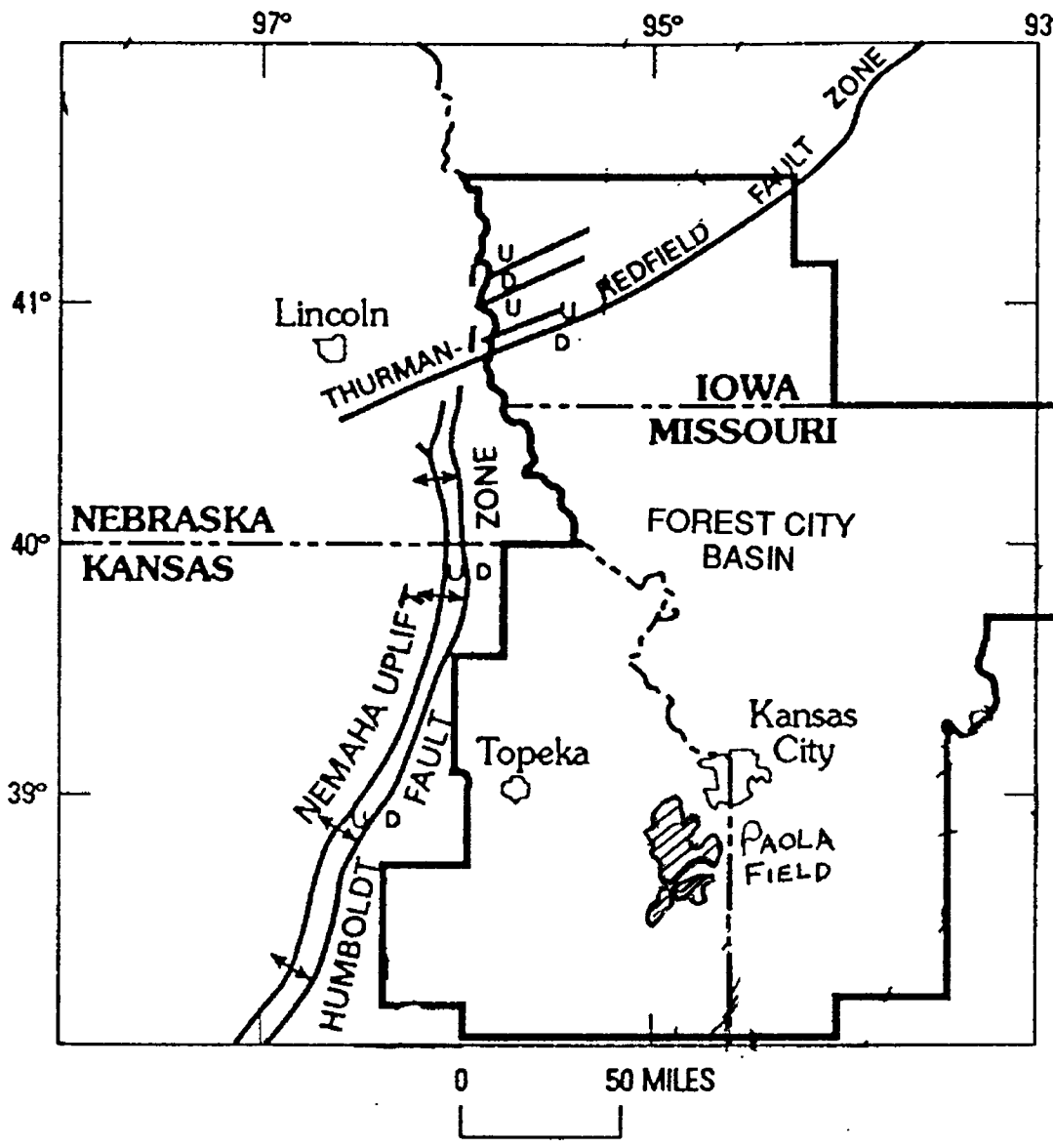

Figure 22. Map of Forest City Basin province.

NEMAHA UPLIFT PROVINCE (120)

By Gordon L. Dolton and Thomas M. Finn

INTRODUCTION

The Nemaha uplift is a regional paleostructural feature extending from southeast Nebraska to central Oklahoma. It is narrow, being little more than 80 mi at its widest in the north, and approximately 500 mi in length. Structurally, the uplift separates the Cherokee platform of northeastern Oklahoma and the Forest City basin of Kansas and Missouri, from the Anadarko, Sedgwick and Salina basins to the west. To the south, it extends obliquely across the broad arch or platform which separates the Arkoma and Anadarko basins and bounds the eastern end of the Anadarko basin. It has been productive of oil and gas from rocks ranging in age from Cambrian to Permian (fig. 23). The province area encompasses approximately 22,500 mi^2.

The uplift is a compound feature, composed of many separate fault blocks and structural culminations. It is bounded on the east by a major fault system, the Humboldt fault zone, which impinges upon the Thurman-Redfield fault zone of the Mid-Continent rift to the north, and by faults which intersect the Pauls Valley uplift and Arbuckle Mountains uplift to the south. Structural relief on the surface of the Precambrian basement across the arch locally exceeds 3,000 feet and generally diminishes to the south. In contrast, only very gentle structural relief is shown in the overlying younger rocks.

Pre-Pennsylvanian rocks (fig. 23) were folded, faulted, uplifted, and deeply eroded in late Mississippian or early Pennsylvanian time, during the Ouachita orogeny. Their truncated surfaces were onlapped by Desmoinesian strata and completely buried by Missourian time. In places, the oldest sedimentary rocks have been entirely stripped from old high-standing basement blocks.

The first successful drilling in the Nemaha uplift province resulted in the discovery of gas in shallow Permian and uppermost Pennsylvanian sandstones, mostly on anticlinal features. Deeper drilling on structures resulted in the discovery of large amounts of oil in older rocks. By 1945, a series of major oil and gas fields had been found, including the Oklahoma City field. In addition, Pennsylvanian Cherokee Group sandstones have produced modest amounts of oil and gas in smaller accumulations. Altogether, more than 160 fields greater than 1 MMBO in size have been discovered in the province and the total amount found is more than 2.8 BBO, along with substantial amounts of gas. The province is now in a very mature stage of development.

Three plays were recognized in the province, the Permian-Pensylvanian structural play, which was considered virtually exhausted, the Cherokee Sandstone play, which was assessed with the contiguous Cherokee Platform province (118), and the Paleostructure play (020). Only the latter was separately assessed.

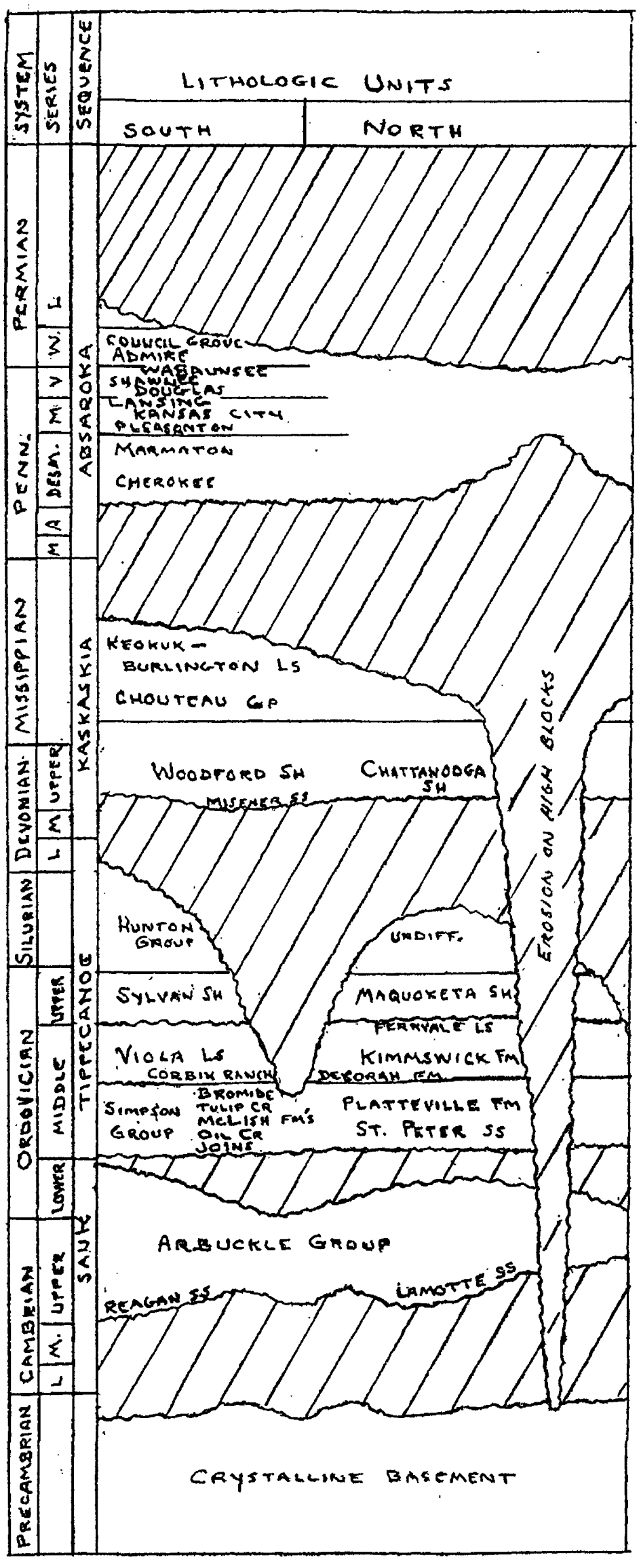

Figure 23. Generalized stratigraphic columns, Nemaha Uplift province.

PALEOSTRUCTURE PLAY(020)

This play involves the occurrence of oil and dissolved gas in Cambrian through Mississippian reservoir rocks in anticlinal traps and in truncation traps of high blocks beneath the Late Mississippian-Early Pennsylvanian unconformity on the Nemaha uplift. The overall play encompasses virtually the entire province area and limited contiguous areas (fig. 24).

Principal reservoirs are in the Arbuckle, Simpson, and Hunton Groups and Viola Limestone, including both sandstone and carbonate rocks. Dolomites and limestones of the Cambrian-Ordovician Arbuckle Group are the oldest of the major objective formations. Ordovician sandstone reservoirs, which rest unconformably on the Arbuckle Group, include the St. Peter Sandstone and, to the south, sandstones of the traditional formational breakdown of the Middle Ordovician Simpson Group of southern Oklahoma.

The Middle Ordovician Viola Limestone is generally a secondary reservoir and only infrequently produces alone. Production is generally from vuggy, porous dolomite reservoirs beneath the Pennsylvanian unconformity. The Silurian-Lower Devonian Hunton Group is an important carbonate reservoir where dolomitization and fracturing provide adequate porosity. The Devonian Misener sandstone is a secondary objective.

The Mississippian sequence is the youngest of the pre-Pennsylvanian reservoirs. Many fields produce relatively small amounts of oil from "chat", a weathered residual chert or bedded chert at the top of the Mississippian, and from porous zones within the carbonate section near the overlying basal Pennsylvanian unconformity. As a result of truncation, these rocks are largely limited to flank areas of the Nemaha uplift. Multiple pays are common and communication is sometimes present between reservoirs.

Source rocks are primarily the Devonian-Mississippian Woodford Shale and Ordovician Simpson and Decorah shales. Only on deeply buried elements of the uplift or in adjoining basinal areas have organic-rich rocks been sufficiently buried to have reached temperatures adequate for maturation. Some oil migrated into structures on the Nemaha uplift, such as Oklahoma City field (fig. 24), prior to mid-Pennsylvanian and was lost through surface leakage of exposed reservoirs before Pennsylvanian reburial and a second phase of migration and accumulation. Ordovician and Devonian rocks have been suggested as sources for this early-migrated oil but the uplift's maturation history requires lateral migration out of the adjoining basins.

Ordovician organic-rich rocks, including shales in the Simpson, Decorah, and perhaps Sylvan, are presently mature in the deeper elements of the Nemaha uplift, in the Forest City basin, and in the adjoining Anadarko and Arkoma basins, and are situated in a position to allow migration onto and along the uplift. The Devonian-Mississipppian Woodford Shale is in the upper part of the oil generation window at several points along the southern Nemaha uplift and is clearly mature in deeper parts of the adjoining basins. Progressing northward on the uplift, Woodford and younger rocks are not generally within the maturation window and lateral migration of oil from the areas of thermal maturity is required. Principal hydrocarbon generation and expulsion probably occurred as a result of burial in Pennsylvanian and Permian time.

Traps consist of ancient buried anticlines where porous zones of beveled older Paleozoic reservoirs lie within closed anticlines or in truncation traps on high blocks beneath and sealed by the Late Mississippian-Early Pennsylvanian unconformity. Structures are, in some cases, "bald headed" anticlines or uplifts wherein beds of Late Pennsylvanian age lie on rocks as old as Precambrian and reservoirs occupy flank positions. Where overlain by Woodford, the Hunton also may provide paleotopographic stratigraphic trapping potential similar to that of the Anadarko basin. Drilling depths range from about 2000 ft to more than 10,000 ft.

The discovery of major accumulations in Ordovician reservoirs at the Augusta field in 1914 (52 MMBO) and in Ordovician and Silurian rocks at El Dorado field in 1915 (280 MMBO) marked the beginning of intensive exploration of this play and resulted in the discovery of a series of major oil and gas fields, including the Oklahoma City field (approximately 750 MMBO). To date, more than 126 fields larger than 1 MMBO have been found in the play and account for more than 2.4 BBO. However, most major fields were discovered prior to 1945 and the last field greater than 10 MMBO was discovered in 1969. The play is in a mature stage of development and future potential will be mostly in subtle and small traps.

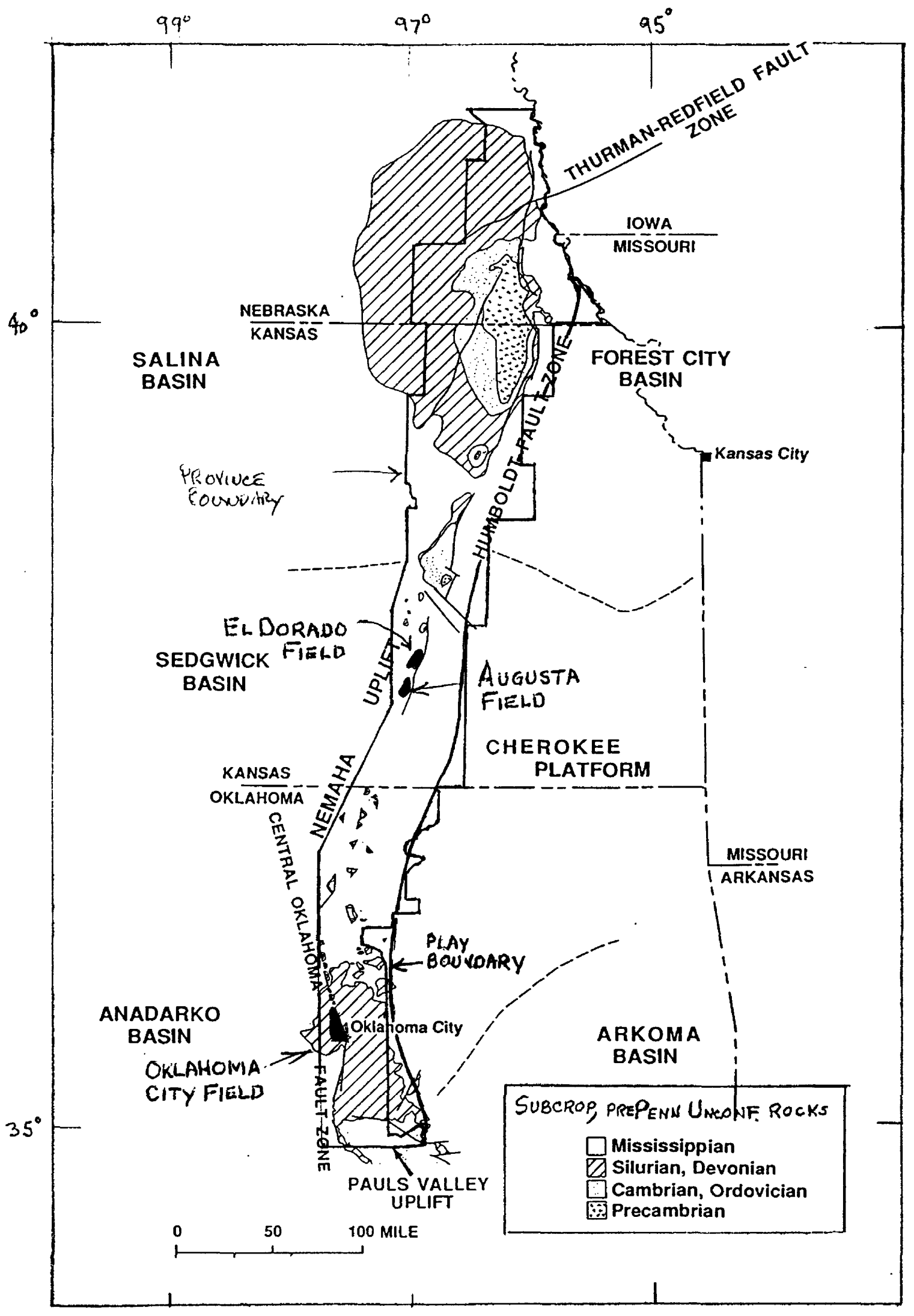

Figure 24. Map of Paleostructure play.

OIL AND GAS PLAY DATA

PLAY **PALEOSTRUCTURE**
PROVINCE **NEMAHA UPLIFT** CODE **07-120-020**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	**X**
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**1**
Gas	**0**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.03**	**1.2**	**1.5**	**2.2**	**5**	**14**
Gas (x 10^9 CFG)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Reservoir depth (x10^3 ft)							
Oil	**1.5**			**5**			**13**
Gas (non-associated)	**0**			**0**			**0**
Number of accumulations	**2**	**3**	**5**	**7**	**9**	**12**	**15**

Average ratio of associated-dissolved gas to oil (GOR)	**1000**	CFG/BBL
Average ratio of NGL to non-associated gas	**0**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

SALINA BASIN PROVINCE (121)

By Steven E. Prensky

The Salina basin province covers an area of 46,000 mi^2, within boundaries defined by county lines, consisting of the eastern half of Nebraska and the north-central portion of Kansas (fig. 25). The basin lies between the Central Kansas uplift on the west, the Nemaha uplift to the east, the Sioux arch to the north, and a poorly-defined structural saddle separating the Salina basin and the Sedgewick basin to the south. In addition to structural boundaries, the basin is further defined by the zero isopach of Mississippian rocks.

Exploration in the Salina basin is in a mature stage. Although only about 600 wells were drilled in the Nebraska portion of the basin, the lack of an organic-rich source rock facies and sufficient burial depths, or heat source in thermally immature rocks indicates little hydrocarbon potential. Within the structural boundaries of the basin there are 14 fields, 5 with cumulative production exceeding 1 MMBO, that produce from Ordovician rocks. There are 54 fields, 10 of which have cumulative production exceeding 1 MMBO, producing from Mississippian reservoirs.

The basin contains rocks extending from Precambrian basement to Quaternary alluvium. However, Paleozoic rocks (Ordovician through Pennsylvanian) represent the bulk of the stratigraphic section and contain the known hydrocarbon reservoirs. As of 1984 fewer than 600 wells were drilled in the Nebraska portion of the basin (36,200 mi^2) while 2,000 wells had been drilled in the Kansas portion (9,800 mi^2). Based on the distribution of potential reservoir rocks relative to structural features within the basin, two minor hydrocarbon plays were defined in Ordovician and Mississippian rocks; both were assessed in the aggregate, however, no individual plays were assessed. Some minor oil potential may exist in undrilled areas along the southern margin of the basin.

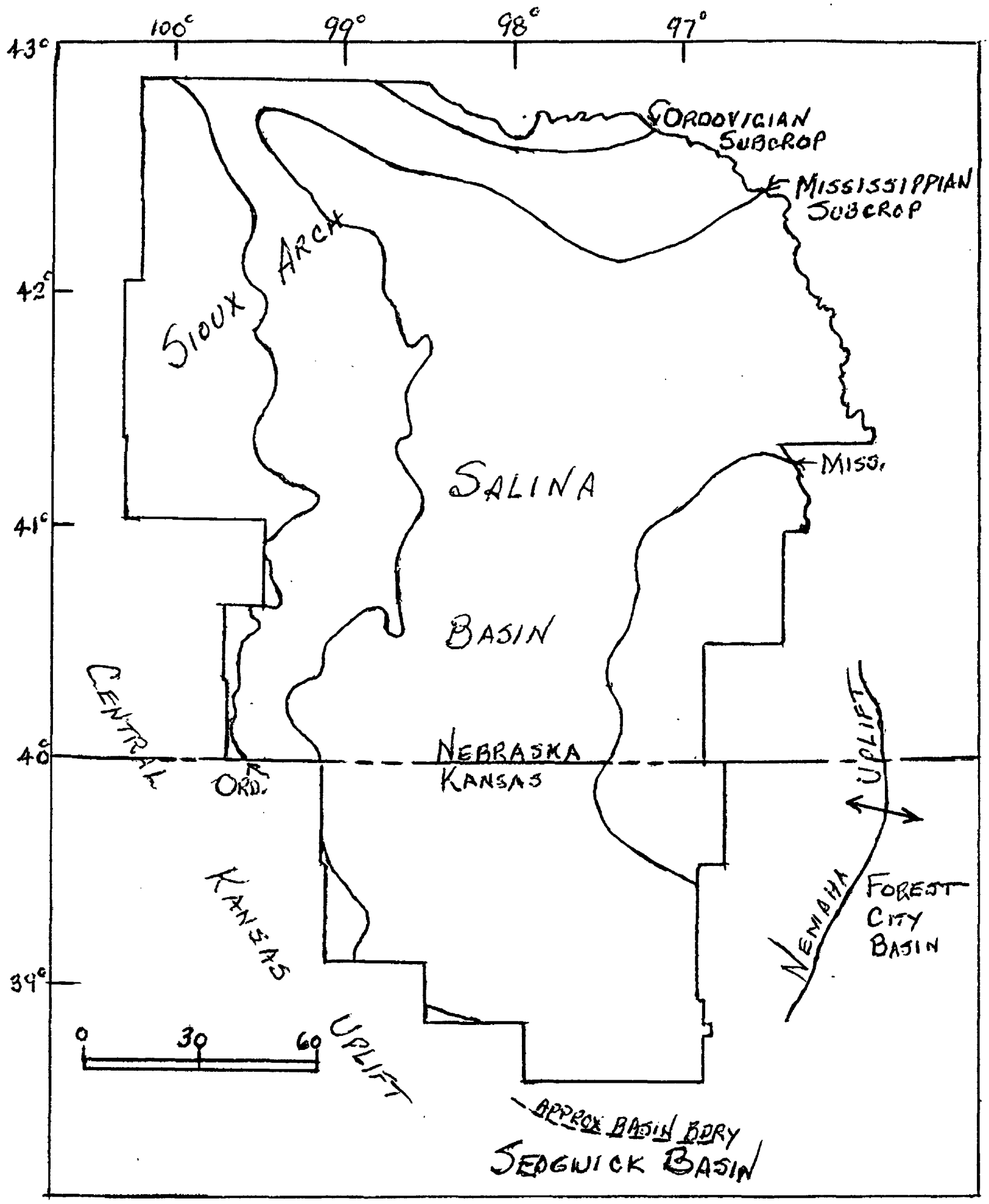

Figure 25. Map of Salina Basin province.

SEDGWICK BASIN PROVINCE (122)

By Ronald R. Charpentier

INTRODUCTION

The Sedgwick Basin province consists of nine counties in south-central Kansas, an area of about 8,456 mi^2, and is bounded on the east by the Nemaha uplift, on the south by the Anadarko basin, on the west and northwest by the Central Kansas uplift, and on north by the Salina basin. The northern structural margin of the province is an unnamed structural high between the Sedgwick and Salina basins. Sedimentary rocks in the province range from Cambrian through Tertiary and are approximately 6,000 ft thick (fig. 26). Only one play was formally assessed, the Paleozoic play (020).

SYSTEM	STAGE – FORMATION
TERTIARY	OGALLALA FORMATION
CRETACEOUS	DAKOTA FORMATION
	KIOWA FORMATION
	CHEYENNE SANDSTONE
PERMIAN	CUSTERIAN STAGE
	CIMMARONIAN STAGE
	GEARYAN STAGE
PENNSYLVANIAN	VIRGILIAN STAGE
	MISSOURIAN STAGE
	DESMOINESIAN STAGE
	ATOKAN STAGE
	MORROWAN STAGE
MISSISSIPPIAN	CHESTERIAN STAGE
	MERAMECIAN STAGE
	OSAGIAN STAGE
	KINDERHOOKIAN STAGE
DEVONIAN	CHATTANOOGA SHALE
SILURIAN	HUNTON GROUP
ORDOVICIAN	MAQUOKETA SHALE
	VIOLA LIMESTONE
	SIMPSON GROUP
	ARBUCKLE GROUP
CAMBRIAN	BONNETERRE DOLOMITE
	LAMOTTE SANDSTONE
PRECAMBRIAN	

Figure 26. Generalized stratigraphic column, Sedgwick Basin province.

PALEOZOIC PLAY (020)

The play consists of hydrocarbon accumulations in mainly Mississippian, Pennsylvanian, and pre-Mississippian reservoirs in stratigraphic and structural traps. Included are all known fields and potential accumulations in the play except for those in the area on the eastern edge of the province where producing fields are more appropriately associated with the Nemaha Uplift province (120). Mississippian limestones, dolomites, and cherts are the most important reservoirs, with additional contributions from reservoirs in Pennsylvanian limestones and sandstones, Simpson Group (Middle Ordovician) sandstones, Viola (Middle Ordovician) limestones, and Hunton Group (Silurian-Devonian) limestones and dolomites. Other, minor, reservoirs exist in rocks ranging in age from Ordovician to Permian. Traps in the Simpson, Viola, and Hunton are dominantly structural with some stratigraphic control by depositional facies variations. Traps in the younger Mississippian and Pennsylvanian rocks are dominantly stratigraphically controlled by facies changes, with a lesser degree of anticlinal control. Seals are mostly shales throughout the section. Expected drilling depths are 3,500 to 6,500 feet.

Because potential source beds in the play are thermally immature, much of the oil in the Sedgwick basin probably migrated from the deep part of the Anadarko basin to the south. The Chattanooga Shale and its correlatives are probably the major source rocks. Oil generation from the Chattanooga equivalent Woodford Shale in the deep Anadarko basin probably began in Mississippian time. Other possible source beds in the deep Anadarko basin include Ordovician shales and shales within the Mississippian-Pennsylvanian section.

Exploration in this play is at a very mature stage, having begun in the 1860's. Over 5,500 exploratory wells have been drilled in the play. The largest discovered field is Spivey-Grabs-Basil with ultimate recovery of about 65 MMBO and 700 BCF of ultimately recoverable gas. Fields mainly contain both oil and gas, but some are individual oil or gas fields. Because of the maturity of exploration, potential exists for a moderate number of new fields of 1 MMBOE or greater in size. Most of the remaining potential is in the older, pre-Mississippian rocks, which have been less thoroughly explored than the Mississippian and Pennsylvanian section.

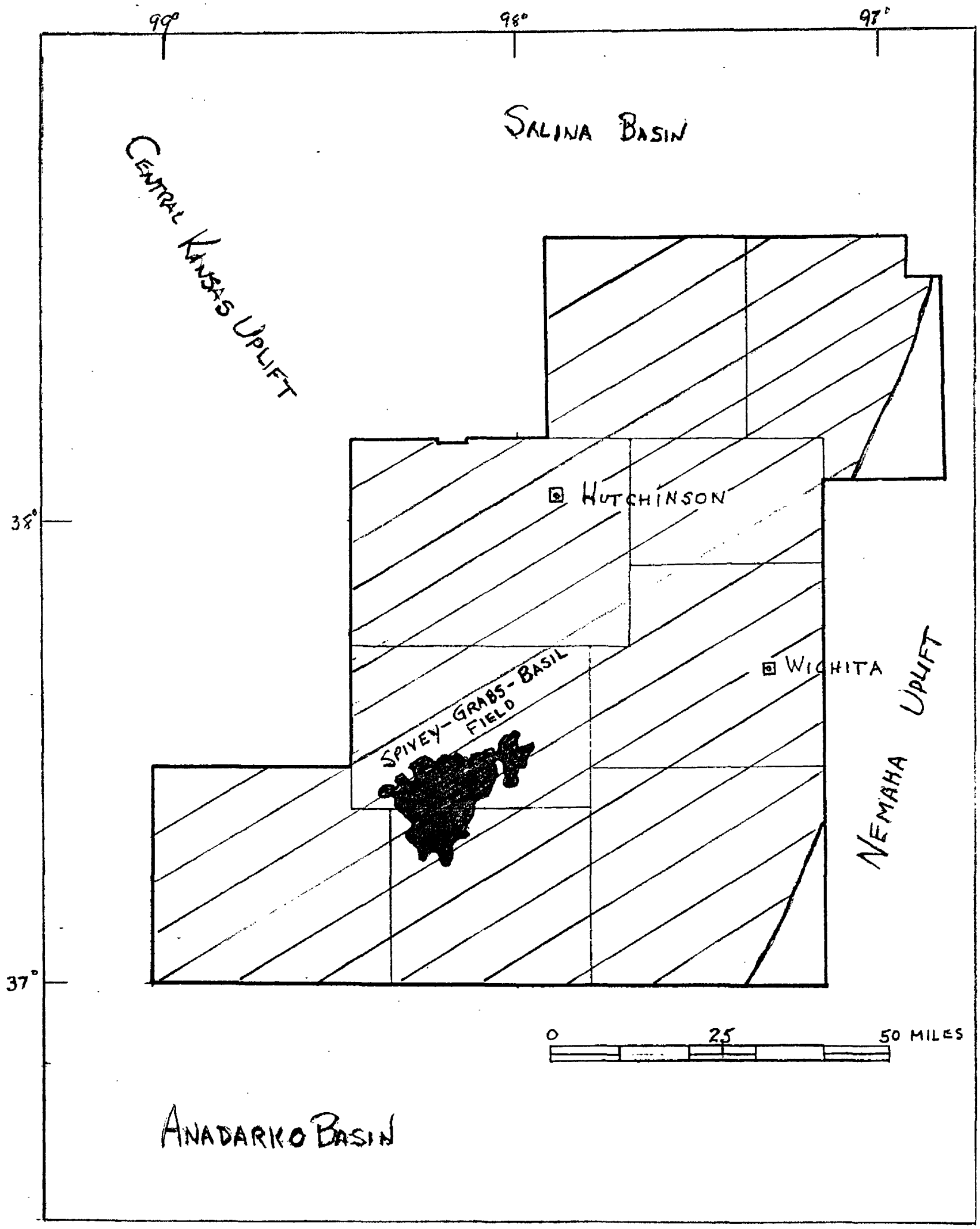

Figure 27. Map of Paleozoic play.

OIL AND GAS PLAY DATA

PLAY **PALEOZOIC**
PROVINCE **SEDGWICK BASIN** CODE **07-122-020**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	**X**
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**0.6**
Gas	**0.4**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.01**	**1.1**	**1.2**	**1.4**	**2**	**3.5**
Gas (x 10^9 CFG)	**6**	**6.1**	**6.6**	**7.2**	**8.4**	**12**	**21**
Reservoir depth (x10^3 ft)							
Oil	**3.5**			**5**			**6.5**
Gas (non-associated)	**3.5**			**5**			**6.5**
Number of accumulations	**35**	**37**	**41**	**45**	**52**	**68**	**85**

Average ratio of associated-dissolved gas to oil (GOR)	**2000**	CFG/BBL
Average ratio of NGL to non-associated gas	**30**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

SOUTHERN OKLAHOMA PROVINCE (123)

By Mitchell E. Henry

INTRODUCTION

The Southern Oklahoma province is located within ten counties in south-central Oklahoma and covers about 7,100 mi^2. Sedimentary rocks range in age from Cambrian to Quaternary, with Paleozoic rocks comprising the bulk of the stratigraphic section, and occur in thicknesses of well over 20,000 ft (fig. 28). Many of the units contain high-quality reservoir and source rocks. The province lies in the eastern portion of the southern Oklahoma aulacogen and much of the oil and gas production is related to its tectonic history. Major structural elements were formed during late Paleozoic time by breakup of the Anadarko basin into smaller basins and highs. Large scale faulting placed rocks as young as Pennsylvanian in contact with rocks as old as Cambrian and provided avenues for petroleum migration. Folding has produced local highs that were partially eroded and leached, increasing reservoir porosity and permeability, and has also produced many anticlinal features suitable for trapping of hydrocarbons. Hydrocarbon production is present in every county in the province, occurring primarily in combination traps, but structural and stratigraphic traps are also present.

Oil and gas are produced primarily from upper Paleozoic rocks. Gas is abundant and is often associated with the oil. Known fields in the province have produced about two BBO and over two TCFG. Ultimate recoveries from these fields are estimated to be over 2.3 BBO and 2.6 TCFG. The province is well explored, with over 25,000 oil and gas wells having been drilled, resulting in an average drilling density of more than three wells per mi^2. Three plays were identified and individually assessed: Older Paleozoic Carbonate (020), Simpson (030), and Pennsylvanian Structural (040).

SYSTEM	GROUP		STRATIGRAPHIC UNIT
Quaternary			
Tertiary			
Cretaceous			
Permian	Hennessey		Garber Sandstone
	Pontotoc		Wellington
Pennsylvanian	Hoxbar		Ada
			Vamoosa
	Deese		?
	Dormick Hills		
Mississippian			Springer
			Goddard
			Delaware Creek
			Sycamore Limestone
			Woodford Shale
Devonian	Hunton		Frisco
			Haragan-Bois D'Arc
			Henryhouse
Silurian		Chimneyhill Sub-group	
			Sylvan Shale
Ordovician	Viola		
	Simpson		Bromide Tulip Creek McLish Oil Creek Joins
	Arbuckle		
Cambrian	Timbered Hills		
	Igneous rocks, intrusive and extrusive		
Precambrian	Igneous and metasedimentary rocks		

Figure 28. Generalized stratigraphic column, Southern Oklahoma province.

OLDER PALEOZOIC CARBONATE PLAY (020)

The play is characterized by oil and gas accumulations in combination structural and stratigraphic traps involving porous carbonate rocks of Cambrian to Devonian age. The play covers nearly the entire province and extends for about 145 mi in an east west direction and about 70 mi in a north south direction (fig. 29).

Reservoir rocks include carbonates of the Cambrian-Ordovician Arbuckle Group, Ordovician Viola Limestone and Ordovican-Devonian Hunton Group (fig. 28). Reservoirs within the Arbuckle Group are primarily dolomites that have well developed secondary porosity probably related to fracture controlled solution. The Arbuckle Group may attain a total thickness of over 8,000 ft, however, known oil and gas accumulations are generally restricted to the upper few hundred feet and are generally associated with structural highs and fault traps. Porous zones are probably related to a post-Arbuckle unconformity that exists over much of the play. The Viola Limestone is about 1,500 ft thick and generally productive from porous zones developed in a dolomite within the lower part of the formation. The Hunton Group attains a thickness of over 500 ft and contains reservoir rocks in the Chimneyhill, Bois d' Arc and Frisco Limestones in which porosity is related primarily to post-Hunton uplift and erosion. Potential reservoir rocks are found in outcrop and at depths of over 20,000 ft. Total maximum thickness of rocks that contain reservoirs is in excess of 10,000 ft.

The most important potential source rocks are probably black Pennsylvanian shales that are believed to be in fault contact with Arbuckle reservoirs in several fields. Ordovician Simpson Group shales also contain probable source rocks, and where they directly overlie, or are in fault contact with, Arbuckle reservoir rocks, they are considered to be a secondary source. Because of its excellent characteristics, the Devonian-Mississippian Woodford Shale is an attractive source rock, however, the Woodford is absent over much of the southern part of the play. Potential source rocks have reached thermal maturity levels necessary to generate hydrocarbons and various studies suggest that these levels may have been reached as long ago as Late Pennsylvanian time.

The relationship between hydrocarbon generation, migration and trap formation has been favorable as evidenced by the numerous fields that produce in the play. Migration probably occurred along numerous faults, notably adjacent to and within uplifted blocks that resulted from Pennsylvanian and Permian orogenic activity. Known traps generally are, and undiscovered traps are expected to be, combination types, such as secondary porosity development related to lithology and structure, with hydrocarbon localization related to structural highs. Seals are probably formed by relatively non-porous overlying beds such as the Joins Formation for Arbuckle reservoirs, the Ordovician Sylvan Shale, or tight zones of the Viola Limestone for Viola reservoirs, and the Woodford Shale for reservoirs within the Hunton Group.

About 900 wildcat wells have been drilled in the play as of 1986. Sixteen known fields have estimated ultimate recoveries of greater than 1 MMBO. The Healdton field (320 MMBO) was discovered in 1913, and the most recent discovery (but not included in this National assessment), is the Cottonwood Creek field (possibly 20 MMBO in size), discovered in late 1987. Future potential of the play is considered to be low.

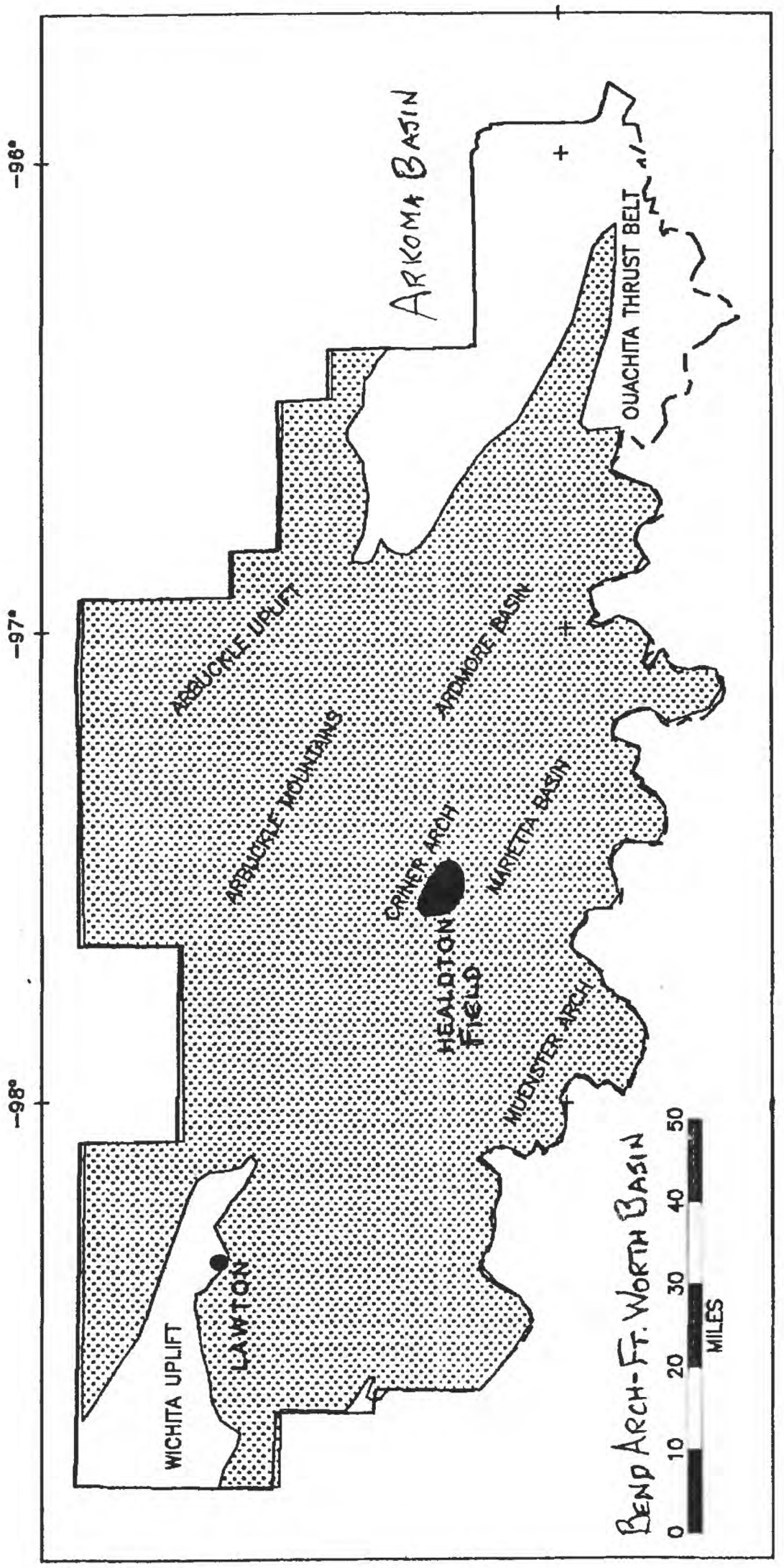

Figure 29. Map of Older Paleozoic Carbonate play.

OIL AND GAS PLAY DATA

PLAY **OLDER PALEOZOIC CARBONATE**
PROVINCE **SOUTHERN OKLAHOMA** CODE **07-123-020**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	
Carbonate rocks	**X**
Other	
Hydrocarbon type	
Oil	**1**
Gas	**0**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.2**	**2**	**3.5**	**6.2**	**13**	**24**
Gas (x 10^9 CFG)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Reservoir depth (x10^3 ft)							
Oil	**2**			**7**			**15**
Gas (non-associated)	**0**			**0**			**0**
Number of accumulations	**1**	**2**	**3**	**4**	**5**	**7**	**10**

Average ratio of associated-dissolved gas to oil (GOR)	**1000**	CFG/BBL
Average ratio of NGL to non-associated gas	**0**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

SIMPSON PLAY (030)

The play is primarily structural, involving anticlines and fault related traps that resulted from the juxtaposition of Ordovician Simpson Group sandstone reservoir rocks with interbedded Simpson source shales. The play area covers about one half of the province and trends generally in a northwesterly direction (fig. 30). Play boundaries are drawn to enclose the area where the majority of wildcat wells were drilled into Simpson rocks, and to reflect the area of the expected presence of these rocks. The play area extends for approximately 140 mi northwest-southeast and for about 75 mi northeast-southwest. Known reservoir rocks include the Joins, Oil Creek, McLish, Tulip Creek and Bromide Formations of the Simpson Group (fig. 28). The Joins Formation is generally a limestone, and although it is productive it is not a significant producer. The Oil Creek Formation is productive from a lower sandstone and an upper limestone which are separated by about 800 ft of green shale. The overall thickness of the Oil Creek may exceed 1,000 ft. The McLish Formation is more than fifty percent limestone, contains a lower and an upper sandstone, and reaches a thickness of 500 ft. It is absent over major uplifts in the province (fig. 30). The Tulip Creek is similar in distribution to the McLish, and contains a basal sandstone that reaches a thickness of 178 ft. The Bromide Formation consists of a lower sandstone, a green shale and an upper dense limestone, and reaches a total thickness of about 220 ft. Total maximum thickness of Simpson reservoir rocks is about 1,000 ft and porosity and permeability in reservoir sandstones are good to excellent. Simpson rocks outcrop in the play and may occur at depths greater than 16,000 ft.

Source rocks are probably the Devonian-Mississippian Woodford Shale and shales that lie between the major Simpson sandstone reservoirs. The Woodford is an excellent source rock and could have charged Simpson reservoirs where the two are in fault contact . However, Simpson shales may have been the major source of oil in some of the Simpson reservoirs. Migration of oil probably occurred along faults that formed structural traps. If some of the Simpson oils were derived from Simpson shales, large migration distances would not be required. Timing of hydrocarbon generation and migration relative to trap formation was favorable in the play, as evidenced by the past production record. Known and anticipated traps are primarily structural with a few combination type traps. Seals are present as shale beds that separate sandstone reservoir rocks, and in addition, acted as barriers that may have been placed adjacent to reservoirs by faulting. Drilling depths may range to more than 20,000 ft.

Eighteen fields, each with estimated ultimate recoveries of greater than 1 MMBO, or greater than 6 BCFG have been discovered. Total estimated ultimate recoveries for these fields are in excess of 380 MMBO and 800 BCFG. The Hewitt field (236 MMBO) was discovered in 1919 and the most recent significant discovery was the Davis Southwest field (15 MMBO) in 1975. Over 770 wildcat wells have been drilled in the play. Historically, the play has been an excellent producer, but it is lightly explored at drilling depths greater than 10,000 ft. The future potential of the play is considered to be moderate for both oil and gas in small to medium-size fields.

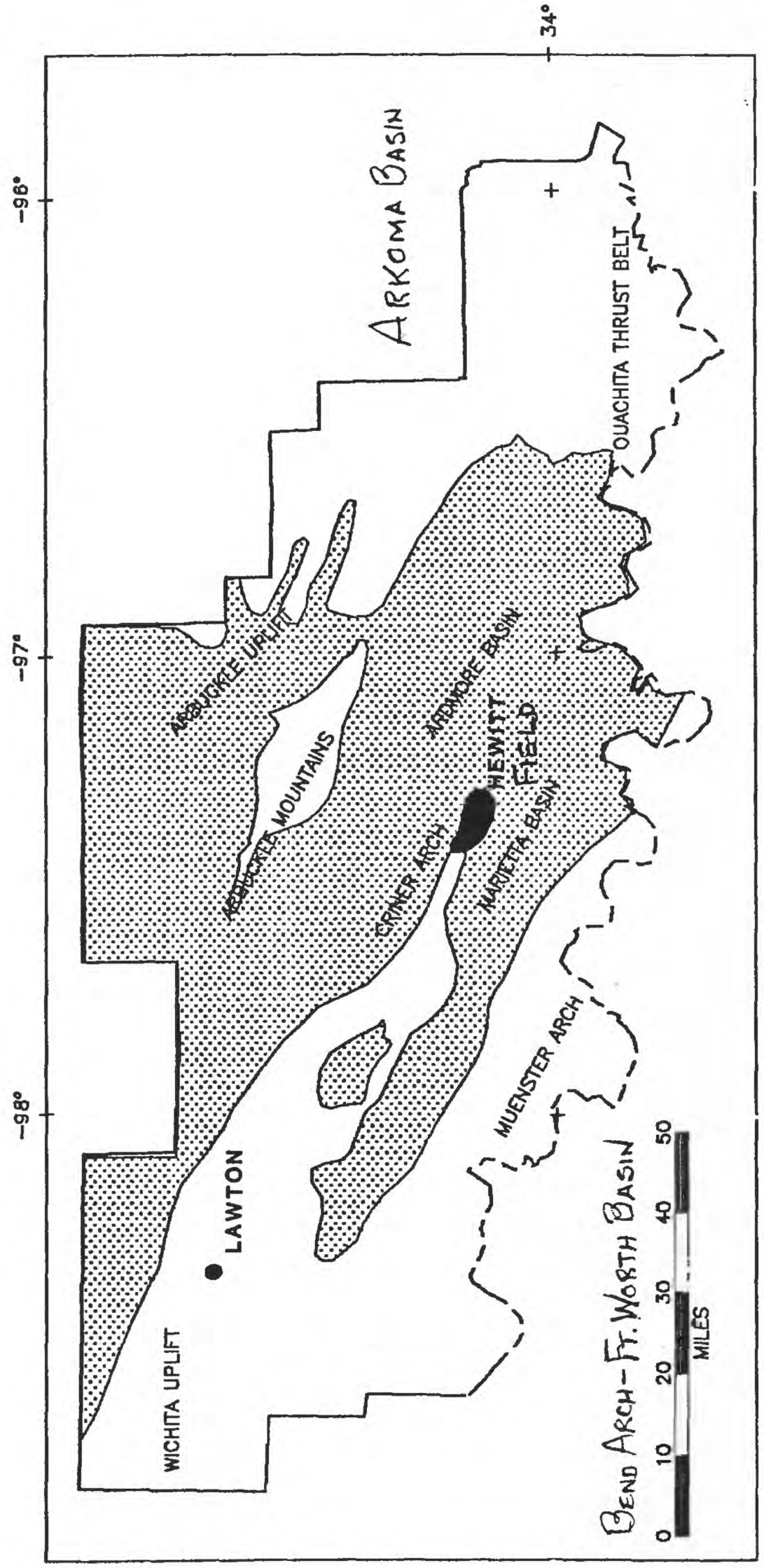

Figure 30. Map of Simpson play.

OIL AND GAS PLAY DATA

PLAY **SIMPSON**
PROVINCE **SOUTHERN OKLAHOMA** CODE **07-123-030**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	**X**
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	**0.6**
Gas	**0.4**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.3**	**2.5**	**5**	**10**	**25**	**60**
Gas (x 10^9 CFG)	**6**	**6.6**	**10**	**17**	**35**	**90**	**240**
Reservoir depth (x10^3 ft)							
Oil	**2**			**12**			**15**
Gas (non-associated)	**2**			**12**			**15**
Number of accumulations	**5**	**5**	**6**	**7**	**8**	**9**	**10**

Average ratio of associated-dissolved gas to oil (GOR)	**1500**	CFG/BBL
Average ratio of NGL to non-associated gas	**55**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

PENNSYLVANIAN STRUCTURAL PLAY (040)

The play is primarily a combination structural and stratigraphic play with the majority of fields producing from combination traps in the Mississippian-Pennsylvanian Springer Formation and Pennsylvanian Deese Group sandstone reservoirs. The play covers most of the western two-thirds of the province and extends for about 115 mi in an east-west direction and 50 to 70 mi in a north-south direction (fig. 31). Play boundaries are drawn to generally exclude areas in or near the Wichita and Arbuckle Mountains, and the western edge of the Quachita thrust belt.

Known reservoir rocks occur primarily in the Springer Formation and the Deese Group (fig. 28). The Springer contains three to five relatively porous and permeable sandstone units composed of fine- to medium-size, angular quartz grains. The Deese Group contains five sandstone reservoir units, all of which are productive. These units are composed of fine- to medium-size angular to subangular quartz gains, however, some of these rocks are graywacke and have poorer reservoir qualities than the cleaner sandstones. Total thickness of rocks containing reservoirs may exceed 15,000 ft and the total thickness of sandstone intervals probably exceeds 2,300 ft.

Source rocks for the larger oil and gas fields, in order of decreasing importance, are probably dark gray to black Pennsylvanian shales, Devonian-Mississippian Woodford Shale, shales of the Ordovician Simpson Group, and the Mississippian Goddard Formation. Numerous faults provided migration pathways for hydrocarbons. Pennsylvanian shales and Goddard shales may directly overlie or underlie reservoir beds. The source shales probably also form seals for traps in the play.

Known and expected traps are primarily structural-stratigraphic combination types, but anticlinal traps and traps formed by wedgeout or truncation of sandstone bodies are also common. Seals are present below and within the thick Pennsylvanian section in the form of shale. Drilling depths to Pennsylvanian rocks range from surface to probably greater than 20,000 ft.

Hydrocarbons were discovered at least as early as 1904 at the Sho-Vel-Tum field, which has an estimated ultimate recovery of greater than 1.2 BBO. The most recent, significant discovery was the Keller field (ultimate recovery of greater than 10 MMBO) in 1970. Pennsylvanian reservoir rocks are estimated to contain over 75 percent of the ultimately recoverable hydrocarbons in the overall province, however, more than one half of that comes from the giant Sho-Vel-Tum field. There are 40 oil and 11 gas fields with ultimate recoveries of greater than 1 MMBO and 6 BCFG of gas. More than 1,600 wildcat wells have been drilled in the play which is in a mature stage of exploration. The play is well explored to depths of less than 10,000 ft, but not explored significantly at greater depths. It is anticipated that the play will not contain undiscovered hydrocarbons of the magnitude already found, but with continued exploration it should contain important undiscovered resources in smaller fields.

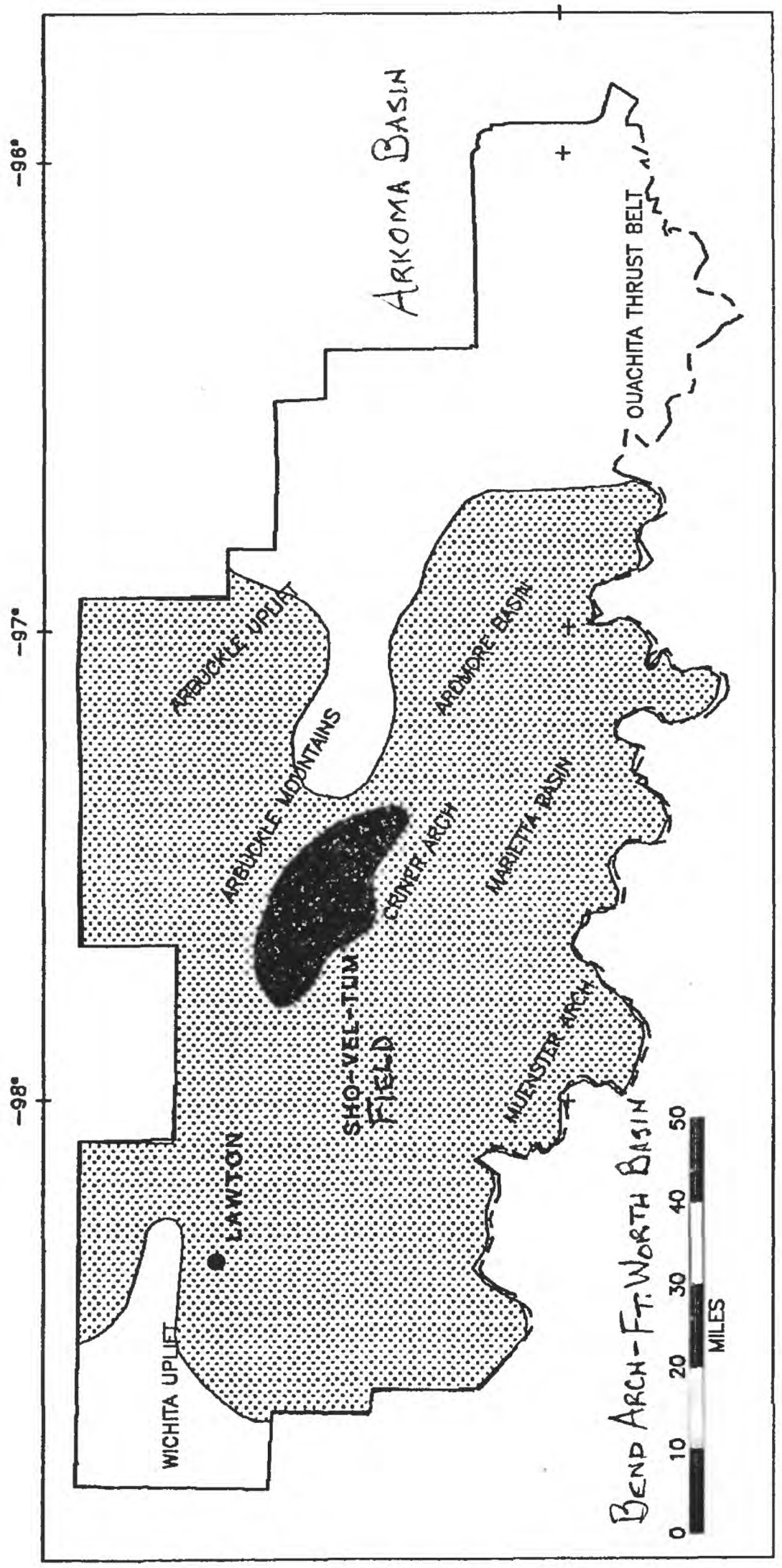

Figure 31. Map of Pennsylvanian Structural play.

OIL AND GAS PLAY DATA

PLAY **PENNSYLVANIAN STRUCTURAL**
PROVINCE **SOUTHERN OKLAHOMA** CODE **07-123-040**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**1.00**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**1.00**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**1.00**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	**X**
Carbonate rocks	
Other	

Hydrocarbon type	
Oil	**0.9**
Gas	**0.1**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**1**	**1.03**	**1.2**	**1.5**	**2.2**	**5**	**15**
Gas (x 10^9 CFG)	**6**	**6.2**	**7.2**	**10**	**13**	**30**	**90**
Reservoir depth (x10^3 ft)							
Oil	**2**			**10**			**12**
Gas (non-associated)	**2**			**10**			**12**
Number of accumulations	**3**	**5**	**6**	**7**	**8**	**9**	**10**

Average ratio of associated-dissolved gas to oil (GOR)	**635**	CFG/BBL
Average ratio of NGL to non-associated gas	**36**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

SIOUX UPLIFT PROVINCE (124)
IOWA SHELF PROVINCE (125)

By Joseph R. Hatch

INTRODUCTION

The Sioux Uplift province includes all of the state of Minnesota except 14 counties in the southeastern corner. The Iowa Shelf province includes these 14 southeastern Minnesota counties and all of the State of Iowa except 12 counties in the southwest corner. In northern and central Minnesota, surface bedrocks are Precambrian age rocks of the Canadian Shield, whereas, in southern Minnesota, surface bedrock consists of younger (<570 MYBP) Paleozoic and Cretaceous age sedimentary rocks. Surface bedrock in the Iowa Shelf province is primarily of Paleozoic age, with Cretaceous rocks restricted to an area in western and northwestern Iowa (fig. 32). Nearly 90 percent of the bedrock in the Sioux Uplift and Iowa Shelf provinces is now covered by unconsolidated glacial and postglacial debris.

The only known hydrocarbons found in either province came from a single well, now abandoned, (Flynn P-1) in southeastern Iowa, which produced approximately 400 barrels of oil from Middle Ordovician rocks. One speculative play common to both the Sioux Uplift and Iowa Shelf provinces was identified and individually assessed, the Mid-Continent Rift play (020). Although parts of the play extend northeast and southwest into four other provinces, outside the areas of the two subject provinces, the play is discussed here (including assessment of its undiscovered resources) because the majority of the play area lies within the Sioux Uplift and Iowa Shelf provinces.

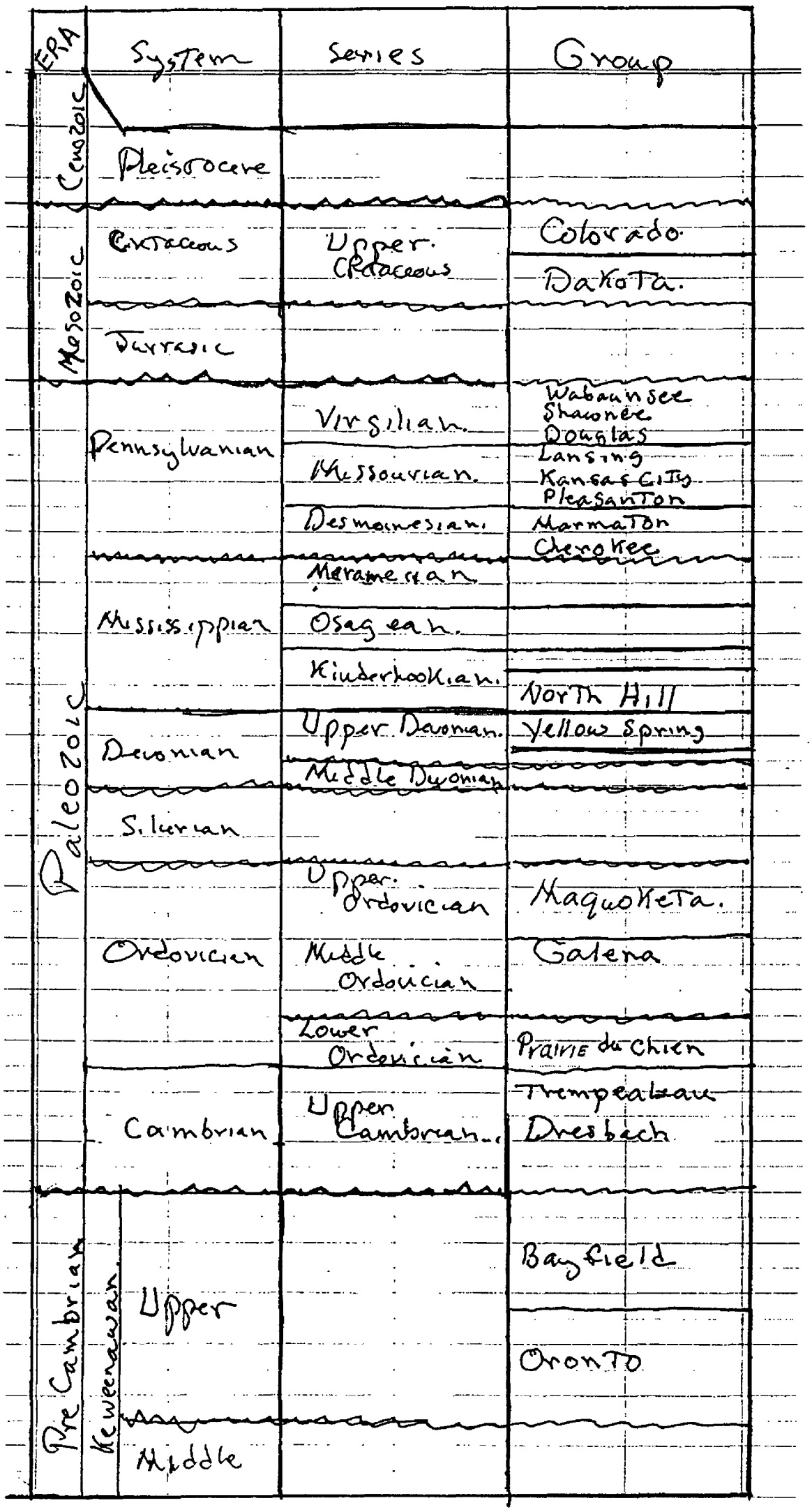

Figure 32. Generalized stratigraphic column, Sioux Uplift province and Iowa Shelf province.

MID-CONTINENT RIFT PLAY (020)

This speculative play involves prospective sandstone reservoir rocks of Precambrian Keweenawan age in regional structural traps in basins flanking a central horst within the Mid-Continent rift system. This system, a failed rift that developed approximately one billion years ago, extends in a NE-SW trend, approximately 850 miles in length, from the central Lake Superior area to east-central Kansas (fig. 33). The play trends northeastward into the Michigan Basin province (127) and southwestward into the Forest City Basin (119), Nemaha Uplift (120), and Salina Basin (121) provinces. It ranges from 35 to 200 miles in width. The play is based on comparisons with the hydrocarbon potential of other rift basins (e.g., Rhine Graben), and on the occurrences of organic-matter-rich lithologies and oil seeps in Oronto Group rocks (Nonesuch Formation) in northern Wisconsin and the Upper Peninsula of Michigan. Mid-Continent rift sedimentary rocks (Oronto and Bayfield Groups and equivalents; fig. 32) outcrop in northeastern Minnesota, northern Wisconsin, and northern Michigan. Elsewhere, the Mid-Continent rift is defined by a continuous linear gravity anomaly. The positive part of the anomaly originates from dense mafic volcanic rocks, whereas, the flanking negative anomalies result from contrasting lower density sedimentary rocks. There has been no oil or gas production from Upper Keweenawan rocks in the play.

Hydrocarbon source-rock characterizations of Mid-Continent rift sedimentary rocks give mixed results. Analyses of core samples from the Oronto (Nonesuch Formation) in northern Wisconsin and the Upper Peninsula of Michigan show that: 1) organic carbon contents are generally less than 0.3 percent; some thin shale intervals, however, contain 0.5 to 2.2 percent; 2) in mineralized areas, the Nonesuch has no significant source-rock potential; 3) in nonmineralized areas, organic matter is marginally mature, and in these areas, thin shale intervals in the Nonesuch may have moderate to good source-rock potential. In southeastern Minnesota and southwestern Iowa, Oronto Group equivalent rocks are organic-matter lean and thermally post mature with respect to oil and gas generation. These rocks have minimal potential for producing additional hydrocarbons, and thermal maturation of the organic matter probably took place relatively early (about 900 MYBP), and any hydrocarbons that might have been generated were probably lost. No organic-matter-rich intervals were encountered in 8,500 ft of Upper Keweenawan volcanic and sedimentary rocks drilled in northeastern Kansas.

Since oil and gas have not been produced from Upper Keweenawan sedimentary rocks in the play, information on reservoir lithologies or the nature of traps is speculative. If hydrocarbons are to be found, however, the most likely reservoirs for hydrocarbons are the more porous and permeable sandstone intervals, as other Keweenawan lithologies (arkose, subarkose, feldspathic sandstone) are compositionally immature and likely to have unfavorable porosity and permeability. Porosity measurements on Upper Keweenawan sandstones are limited, and the few published measurements generally show low porosity. As examples: 1) porosities of sandstones in Oronto Group equivalent rocks in southwestern Iowa, range between 1 and 6 percent and average 2.3 percent. "Better" porosities (3.5-6.0 percent) appear to correlate with higher percentages of plagioclase feldspar; 2) porosities of arkosic sediments present in northeastern Kansas average 2 percent; and 3) in east-central Minnesota, the Bayfield Group rocks (Hinckley Sandstone) are medium to coarse grained, poorly to moderately sorted, contain >95 percent quartz, and are weakly to strongly cemented by silica.

Throughout the play, regional structures in the basins flanking the central horst appear gently homoclinal, but local flexures and fault structures possibly exist. Upward bending of strata adjacent to the major faults may have produced suitable structural traps. The potential for undiscovered non-associated gas, due to less than favorable gas-prone source rocks, however, is thought to be minimal.

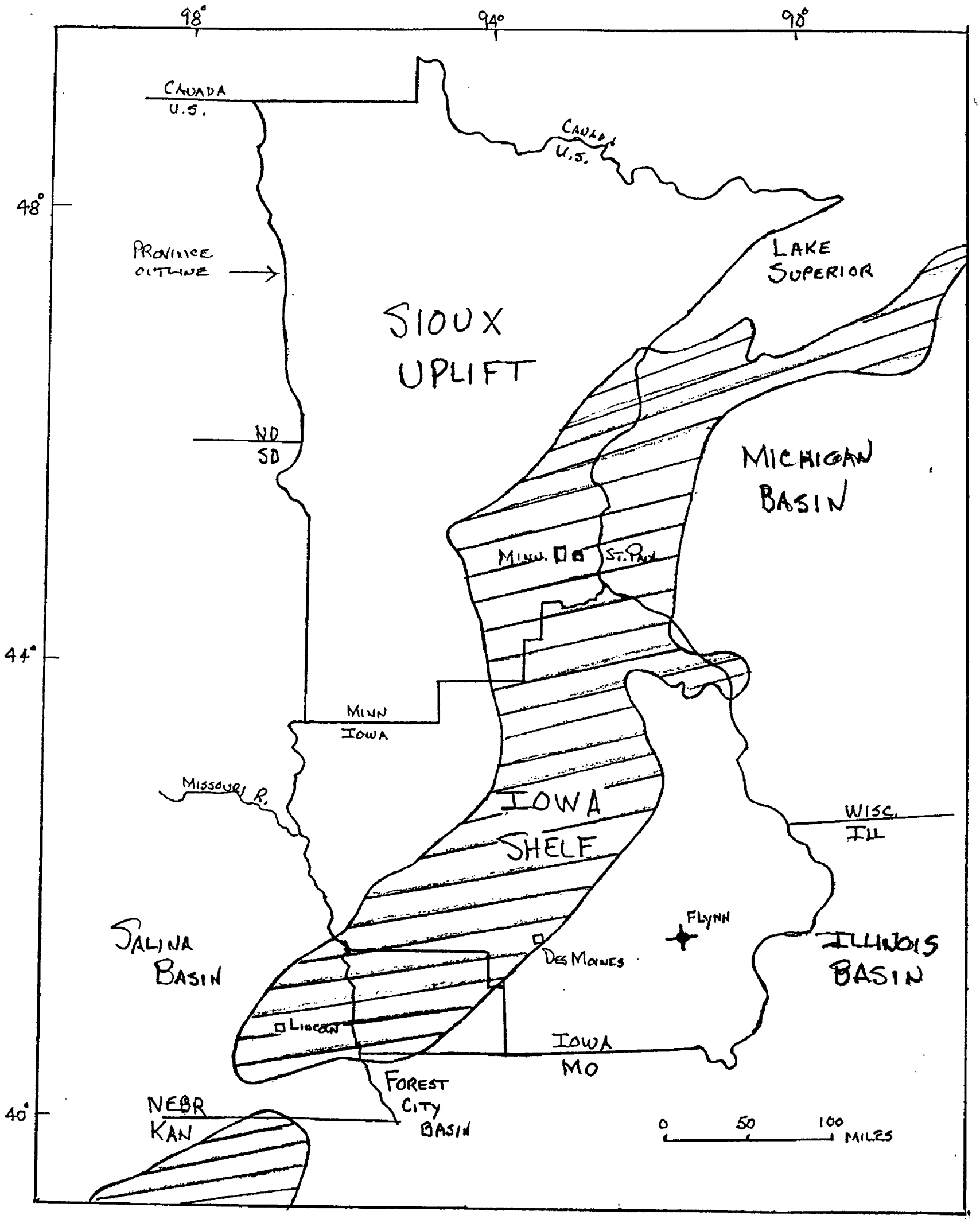

Figure 33. Map of Mid-Continent Rift play.

OIL AND GAS PLAY DATA

PLAY **MID-CONTINENT RIFT**
PROVINCE **SIOUX UPLIFT & IOWA SHELF** CODE **07-125-020**

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	**0.30**
Timing (T)	**1.00**
Migration (M)	**1.00**
Potential reservoir-rock facies (R)	**1.00**
Marginal play probability (MP) (S x T x M x R = MP)	**0.30**

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	**0.10**

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	**X**
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	**0**
Gas	**1**

	Fractiles * (estimated amounts)						
Fractile percentages * ----	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Gas (x 10^9 CFG)	**100**	**250**	**550**	**1000**	**1800**	**3000**	**5000**
Reservoir depth (x10^3 ft)							
Oil	**0**			**0**			**0**
Gas (non-associated)	**5**			**12**			**25**
Number of accumulations	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Average ratio of associated-dissolved gas to oil (GOR)	**0**	CFG/BBL
Average ratio of NGL to non-associated gas	**10**	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	**0**	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

OZARK UPLIFT PROVINCE (126)

By Ronald R. Charpentier

The Ozark Uplift province includes most of the State of Missouri, except for the northwestern part of the State, most of which lies within the Forest City Basin province (119), and the southeastern part of the State, which is in the Illinois Basin province (128). The province also includes the northern tier of counties in Arkansas, and overall, covers approximately 53,000 mi^2 (fig. 34). The major structural element in the province is the domal Ozark uplift which has had a long history of repeated uplift. It is flanked by basins and platforms which include the Illinois basin, Arkoma basin, Cherokee platform, Forest City basin and Iowa shelf (fig. 34). Because of repeated periods of uplift, much of the sedimentary cover has been stripped away, leaving Precambrian granite exposed in the core area. The remaining sedimentary cover averages only about 2,000 ft in thickness, most of which is Cambrian and Ordovician in age. The only production in the entire province is from the small Florissant field in St. Louis County which produced minimal amounts of oil from Middle Ordovician rocks. The thin sedimentary cover, abundant fresh water aquifers and total lack of any additional discoveries makes the province largely unprospective for hydrocarbons.

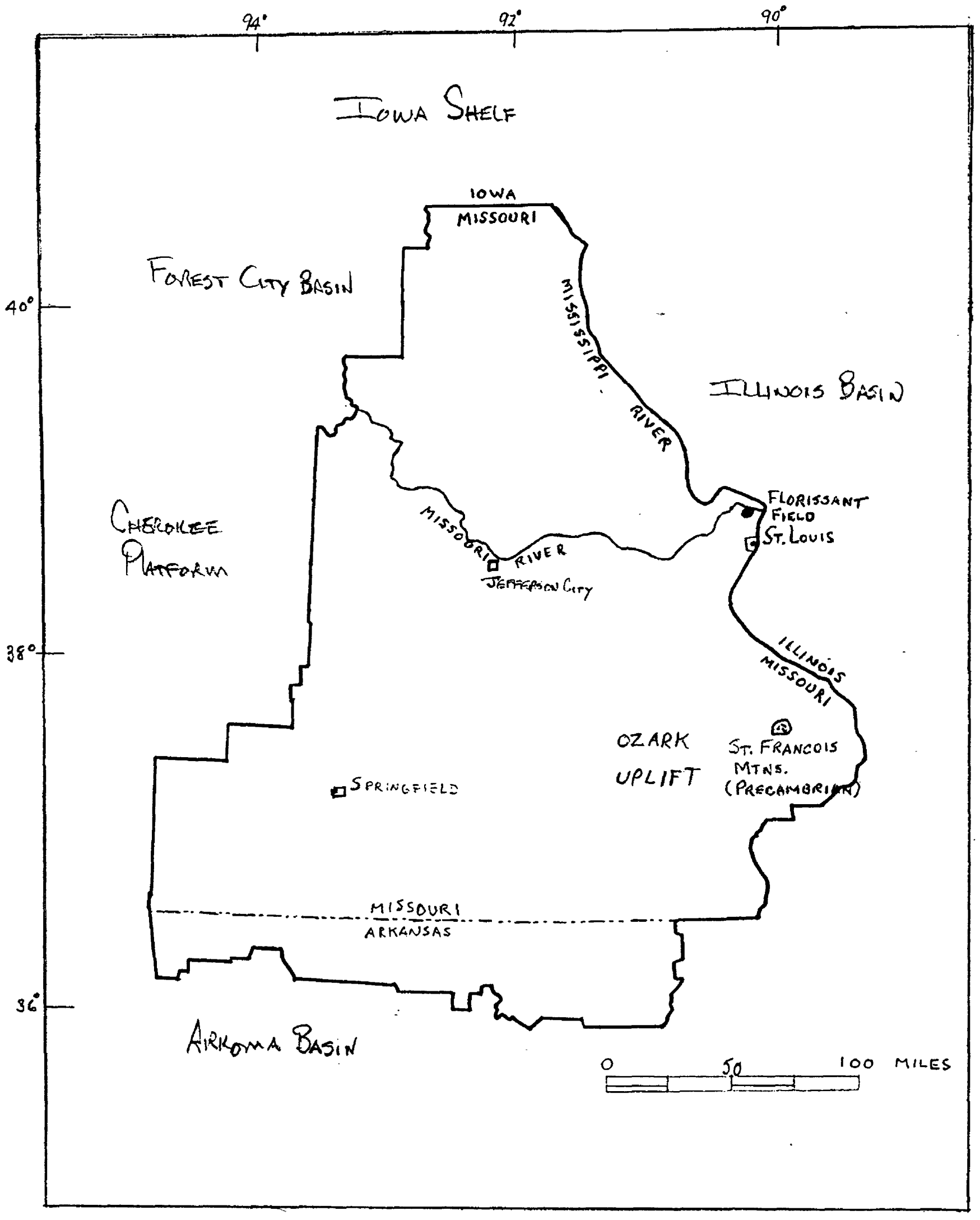

Figure 34. Map of Ozark Uplift province.

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(125) Iowa shelf
Hatch, J.R., 1990, Review of the geology of the Sioux Uplift and Iowa Shelf provinces as a basis for estimates of undiscovered hydrocarbon resources: U.S. Geological Survey Open-File Report 88-450V, 20 p.

TABLE 1.--Region 7 Mid-Continent. Estimates of undiscovered recoverable conventional oil gas, and natural gas liquids (NGL) in onshore provinces by play. Province and region totals are given.

Mean value totals may not be equal to the sums of the component means because numbers have been independently rounded. Fractile values (F_{95}, F_5) are not additive and represent estimates with a 19 in 20 chance and a 1 in 20 chance, respectively, of at least these tabulated estimates. Gas includes both nonassociated and associated-dissolved gas. Negl., negligible quantity; -, no estimate.]

			Crude Oil (Millions of Barrels)			Total Gas (Billions of Cubic Feet)			NGL (Millions of Barrels)		
			F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
115	Anadarko Basin										
	020	Pennsylvanian	65.8	133.0	95.7	227.9	455.3	329.3	6.9	13.0	9.7
	030	Mississippian	57.7	189.7	111.7	645.0	1,761.7	1,116.9	15.8	43.1	27.4
	040	Springer-Morrow	21.2	65.1	39.4	4,356.3	9,047.8	6,435.0	108.9	226.2	160.9
	050	Post-Morrow	86.4	352.0	191.0	2,909.9	7,562.6	4,893.0	87.3	226.9	146.8
	060	Frontal Wichita	0.0	0.0	0.0	364.1	1,449.5	793.4	7.3	29.0	15.9
	070	Deep Structural	0.0	0.0	0.0	1,917.2	11,035.0	5,298.9	28.8	165.5	79.5
	080	Hunton Paleotopographic	55.1	206.9	115.8	1,391.4	4,114.7	2,526.3	19.3	57.8	35.3
	320	Oil <1 MMB	205.6	579.6	362.8	349.5	985.3	616.7	8.7	24.6	15.4
	330	Gas <6 BCF	0.0	0.0	0.0	1,958.2	4,608.6	3,107.5	49.0	115.2	77.7
		Province Total	487.9	1,526.0	916.3	13,767.0	41,041.0	25,117.0	325.7	901.5	568.6
116	Arkoma Basin										
	020	Basin Pennsylvanian	0.0	0.0	0.0	451.5	1,593.5	912.9	0.0	0.0	0.0
	030	Pre-Woodford	0.0	0.0	0.0	88.0	301.5	174.7	0.0	0.0	0.0
	050	Frontal Ouachita	0.0	70.1	19.1	0.0	442.9	124.2	0.0	0.0	0.0
	320	Oil <1 MMB	3.0	8.6	5.4	1.5	4.3	2.7	0.0	0.0	0.0
	330	Gas <6 BCF	0.0	0.0	0.0	565.3	886.1	714.4	0.0	0.0	0.0
		Province Total	3.3	74.2	24.5	1,013.5	3,240.3	1,928.9	0.0	0.0	0.0
117	Cambridge Arch-Central Kansas Uplift										
	020	Arbuckle-Reagan	13.7	50.2	28.4	0.1	0.5	0.3	Negl.	Negl.	Negl.
	070	Pennsylvanian	62.5	151.6	101.0	18.8	45.5	30.3	0.5	1.1	0.8
	320	Oil <1 MMB	159.9	261.1	206.6	32.0	52.2	41.3	0.8	1.3	1.0
	330	Gas <6 BCF	0.0	0.0	0.0	24.3	68.2	42.8	0.2	0.7	0.4
		Province Total	234.0	462.2	335.9	74.6	166.2	114.7	1.5	3.1	2.2

TABLE 1.--Region 7 Mid-Continent. Estimates of undiscovered recoverable conventional oil gas, and natural gas liquids (NGL) in onshore provinces by play. Province and region totals are given--Continued

			Crude Oil (Millions of Barrels)			Total Gas (Billions of Cubic Feet)			NGL (Millions of Barrels)		
			F95	F5	Mean	F95	F5	Mean	F95	F5	Mean
118	Cherokee Platform										
	020	Pennsylvanian	27.0	84.3	50.7	40.5	126.5	76.0	1.0	3.2	1.9
	030	Pre-Pennsylvanian	2.9	22.3	9.7	2.3	17.9	7.8	0.1	0.4	0.2
	320	Oil <1 MMB	154.7	267.1	206.1	216.6	374.0	288.6	5.4	9.3	7.2
	330	Gas <6 BCF	0.0	0.0	0.0	106.5	218.2	156.1	1.1	2.2	1.6
		Province Total	181.3	373.3	266.5	362.3	735.9	528.5	7.5	15.1	10.9
119	Forest City Basin										
	320	Oil <1 MMB	2.1	4.3	3.1	2.1	4.3	3.1	0.0	0.0	0.0
	330	Gas <6 BCF	0.0	0.0	0.0	6.2	10.9	8.4	0.0	0.0	0.0
		Province Total	2.1	4.3	3.1	8.4	15.2	11.5	0.0	0.0	0.0
120	Nemaha Uplift										
	020	Paleostructure	5.7	31.0	15.2	5.7	31.0	15.2	0.1	0.8	0.4
	320	Oil <1 MMB	62.7	153.3	101.8	62.7	153.3	101.8	1.6	3.8	2.5
	330	Gas <6 BCF	0.0	0.0	0.0	53.5	92.8	71.5	0.5	0.9	0.7
		Province Total	67.6	184.3	117.0	120.2	276.9	188.4	2.2	5.5	3.6
121	Salina Basin										
	300	Other Occurrences >1 MMBO	0.0	9.7	4.1	0.0	1.9	0.8	0.0	Negl	Negl.
	320	Oil <1 MMB	8.1	13.1	10.4	1.6	2.6	2.1	Negl.	0.1	0.1
		Province Total	8.3	23.0	14.5	1.7	4.6	2.9	Negl.	0.1	Negl.
122	Sedgwick Basin										
	020	Paleozoic	25.0	56.5	38.8	154.7	331.6	232.6	2.8	7.1	4.7
	320	Oil <1 MMB	31.8	52.7	41.5	63.7	105.4	82.9	0.0	0.0	0.0
	330	Gas <6 BCF	0.0	0.0	0.0	102.4	222.0	155.0	3.1	6.7	4.7
		Province Total	56.6	109.2	80.2	320.3	658.7	470.5	5.9	13.8	9.3

TABLE 1.--Region 7 Mid-Continent. Estimates of undiscovered recoverable conventional oil gas, and natural gas liquids (NGL) in onshore provinces by play. Province and region totals are given--Continued

			Crude Oil (Millions of Barrels)			Total Gas (Billions of Cubic Feet)			NGL (Millions of Barrels)		
			F95	F5	Mean	F95	F5	Mean	F95	F5	Mean
123	Southern Oklahoma										
	020	Older Paleozoic Carbonate	6.2	41.5	18.9	6.2	41.5	18.9	0.2	1.0	0.5
	030	Simpson	10.3	79.5	34.9	50.9	283.7	137.7	1.8	13.7	6.0
	040	Pennsylvanian Structural	6.0	24.9	13.4	4.0	44.7	17.5	0.1	1.5	0.5
	320	Oil <1 MMB	36.1	59.3	46.8	43.3	71.2	56.2	1.1	1.8	1.4
	330	Gas <6 BCF	0.0	0.0	0.0	61.5	82.4	71.5	2.5	3.3	2.9
		Province Total	53.4	205.8	114.0	150.5	524.3	301.8	4.8	21.4	11.3
124	Sioux Uplift (Incl. in 125)										
125	Iowa Shelf										
	020	Mid-Continent Rift	0.0	0.0	0.0	0.0	0.0	39.4	0.0	0.0	0.4
	330	Gas <6 BCF	0.0	0.0	0.0	0.0	151.3	21.0	0.0	1.5	0.2
		Province Total	0.0	0.0	0.0	0.0	311.9	60.3	0.0	3.1	0.6
126	Ozark Uplift		-	-	-	-	-	-	-	-	-
		REGION TOTAL	1,208.8	2,727.0	1,871.9	16,232.0	45,986.0	28,724.5	352.1	953.1	606.4