GEOMETRY OF LATE PALEOZOIC THRUSTING,

WILBURTON AND DAMON QUADRANGLES,

ARKOMA BASIN,

SOUTHEAST OKLAHOMA

By

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GEOMETRY OF LATE PALEOZOIC THRUSTING

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CHAPTER I

INTRODUCTION

The Arkoma basin and the Ouachita Mountains were formed during the Ouachita Orogeny which is a belt of deformed Paleozoic rocks at the southern margin of the North American craton. The Orogeny occurred by continent-continent collision when a part of Gondwanaland collided with the North American craton. The collision created a variety of structural and tectonic features approximately 300 million years ago during the Pennsylvanian period.

The Arkoma basin is a foreland basin that developed as a result of contractional tectonics during the Ouachita Orogeny. The basin is bounded to the south by the frontal Ouachita belt defined by the trace of the Choctaw fault, and to the west by the Arbuckle Uplift (Fig.1). Its surface expression is a gently arching, elongated basin that extends from south-central Oklahoma to east-central Arkansas. It consists of a series of broad open folds, and normal faults in the northern portion .

In the southern part of the Arkoma Basin, rocks of Atokan age crop out. However, in the northern part of the basin, the Boggy, Savanna, and Hartshorne formations, rocks of Desmoinesian age crop out. At the surface, the top of the Hartshorne Formation is expressed by a coal seam.

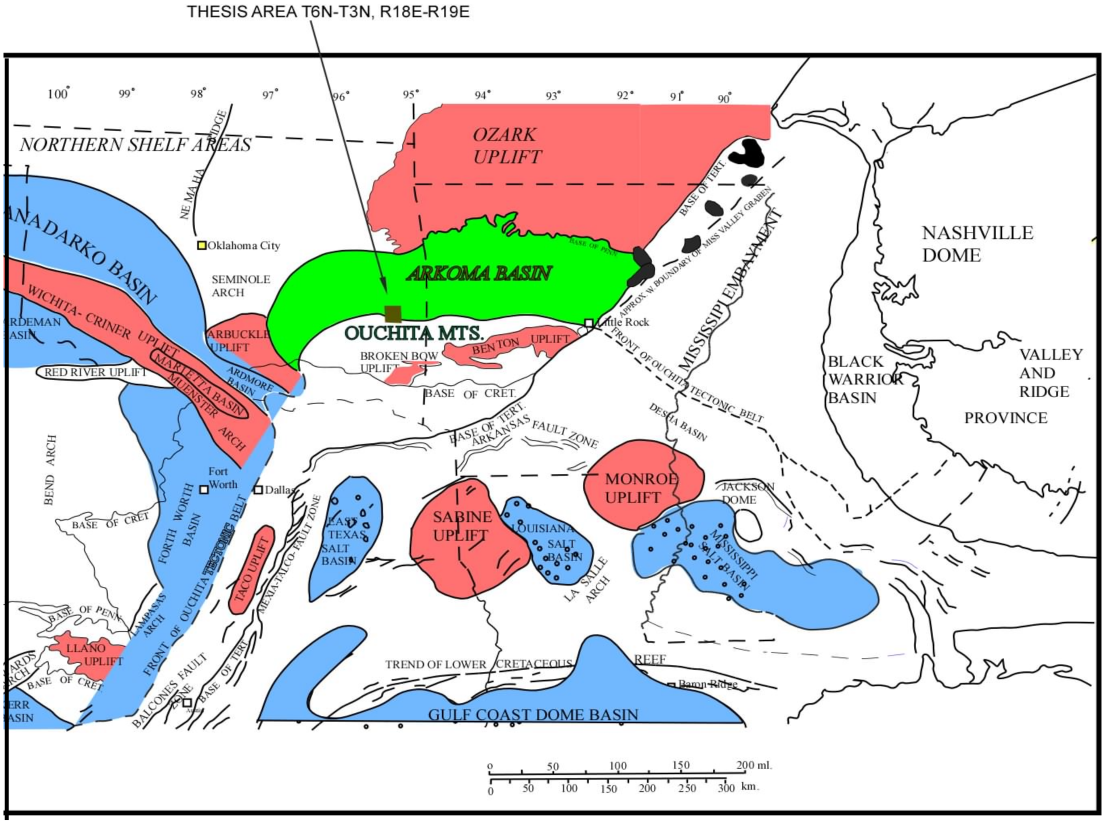

Figure 1. Major Geological Provinces of Oklahoma (Johnson, 1988, Modified from Cemen, 2003.) The arrow points to the study area.

The Ouachita Mountains are divided into three assemblages. They are from north to south: the frontal belt, the central belt, and the Broken Bow Uplift (Fig. 2).

The Broken Bow Uplift is located south of the Windingstair fault. The rocks outcropping are of Ordovician to Lower Mississippian deep-water deposits. The uplift is composed of several thrust faults and isoclinal folds (Suneson et al. (1990).

The Central Ouachitas is located between the Ti Valley and the Windingstair fault. It is distinguished by Mississippian and Lower Pennsylvanian turbidites that are exposed throughout the belt except for a window of pre-Mississippian rocks in

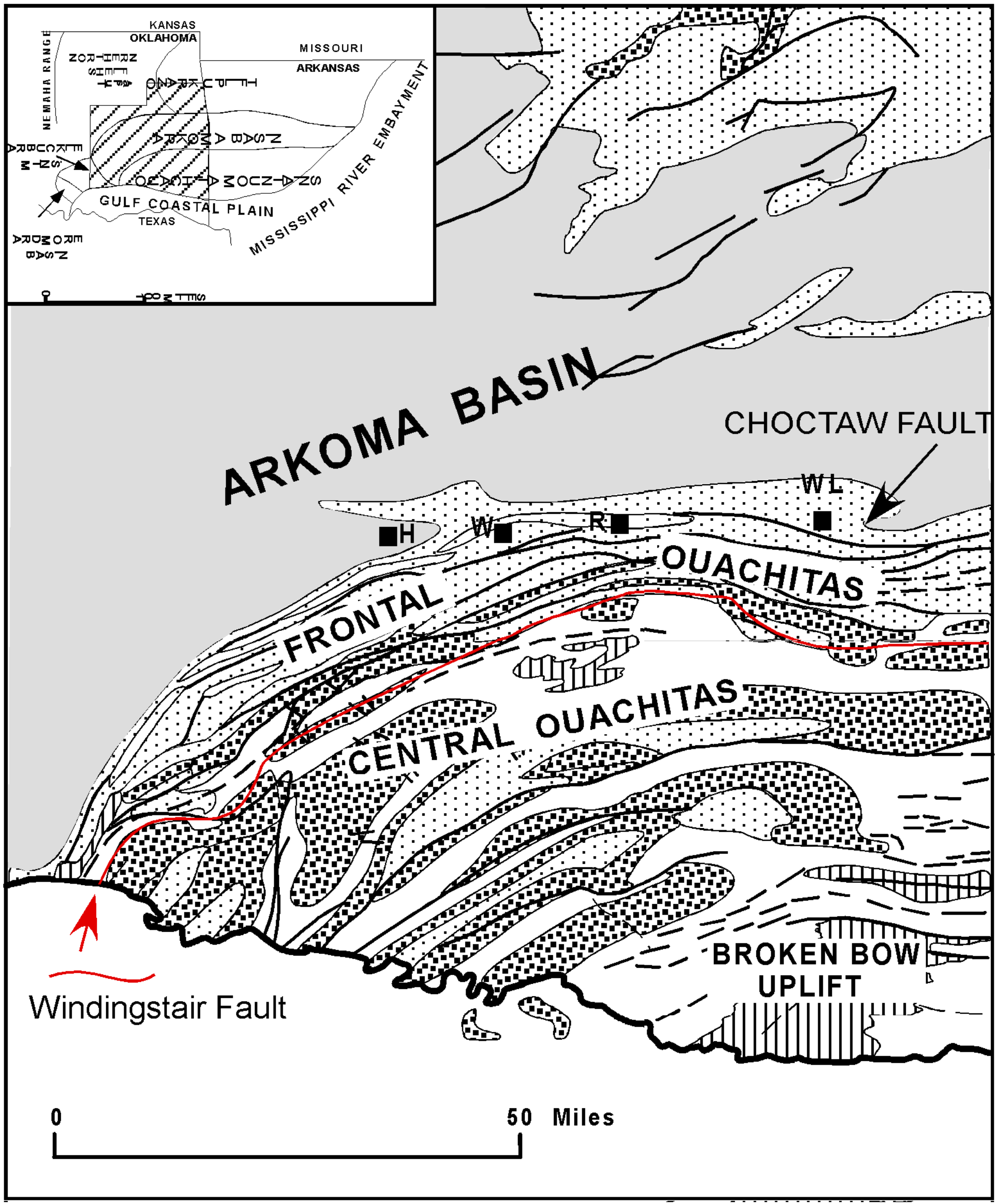

Figure 2. Geologic Provinces of the Ouachita Mountain modified from Arbentz (1989). The top map modified from Johnson (1988).

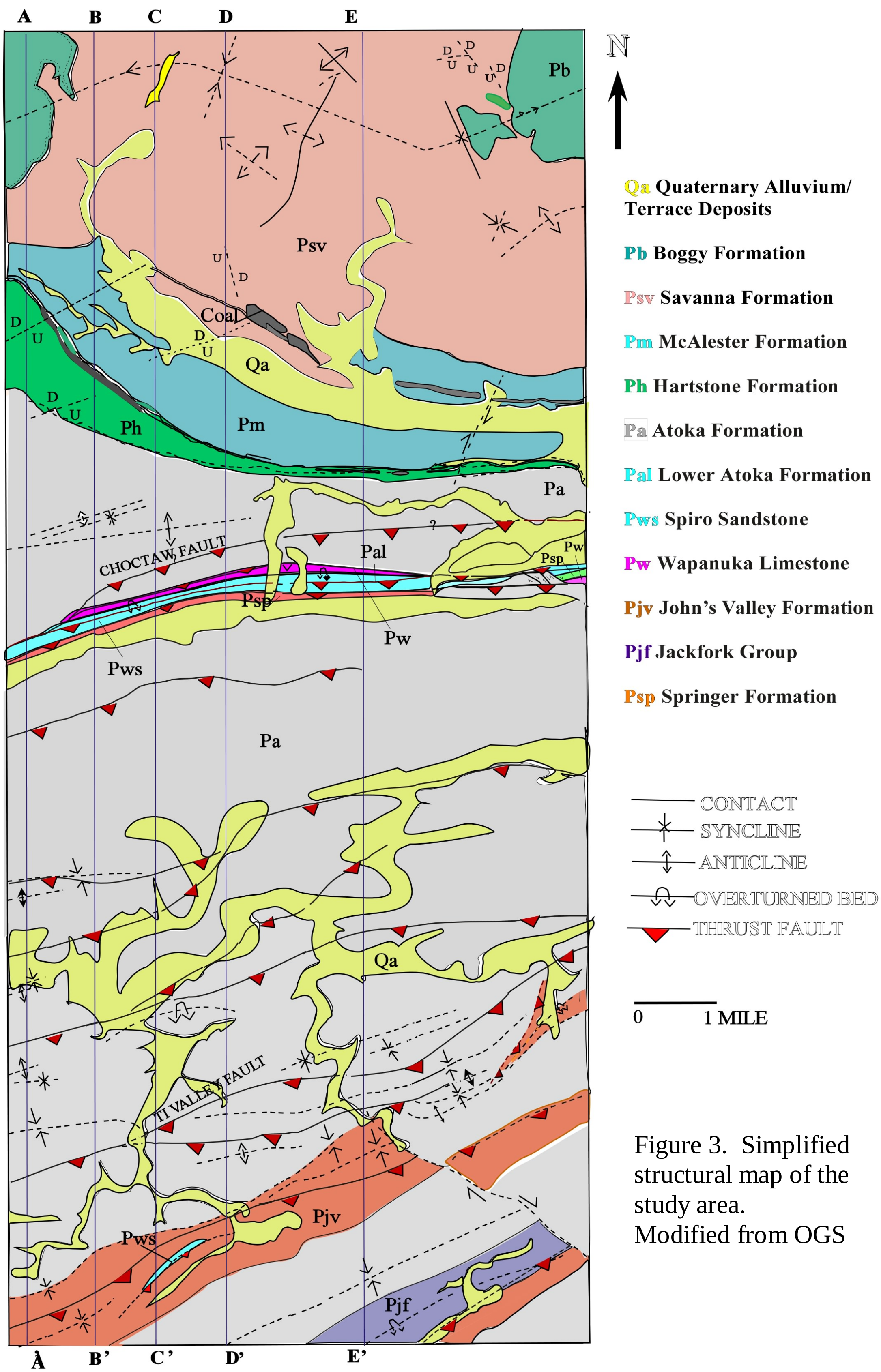

Figure 3. Simplified structural map of the study area. Modified from OGS

the Potatoe Hills area. Broad synclines alternating with tightly folded anticline are characteristic of the structural style of the central Ouachitas.

The Frontal belt is sandwiched between the Choctaw fault to the north, and the Windingstair fault to the south. It is distinguished by its Morrowan shallow-water sedimentary rocks to Atokan turbidites facies. Imbricately thrusted, folded, and tilted strata characterize the structural style of the Frontal belt (Cemen et al., 2001).

STATEMENT OF PURPOSE

The main purpose of this study is to delineate the subsurface structural geometry of the transition zone between the Arkoma Basin and the Frontal Ouachitas in the Wilburton and Damon Quadrangles in Latimer county, southeastern Oklahoma, from Sec. 14, T.6N, R.18E in the northwest corner to Sec 2, T.3N, R.19E in the southeast corner (Fig 3, 4, 5a, 5b, and 5c.) Since 1992, a Structural Research Group at the School of Geology of OSU supervised by Dr. Ibrahim Cemen has been constructing balanced structural cross-sections from the Wister Lake area to the western edge of the Wilburton Gas Field (Sagnak 1996, Akthar 1996, Evans 1997, Mehdi 1999, Ronk 1999 and McPhail 2000). Two papers summarized the structural geometry in these areas (Cemen, Sagnak, and Akthar, 2001) and (Cemen, Evans, and Sagnak, 2001). The group determined that a triangle zone exists in the Wilburton gas field area. The triangle zone is bounded by the Choctaw fault to the south and the Carbon fault to the north (Fig 5a, 5b, and 5c). Within the study area, the Carbon fault becomes a blind thrust, but the triangle zone is detected and delineated in the subsurface in the Red Oak oil field to the east (Evans 1997; Mehdi 1998; Cemen, Evans, and Sagnack 2001).

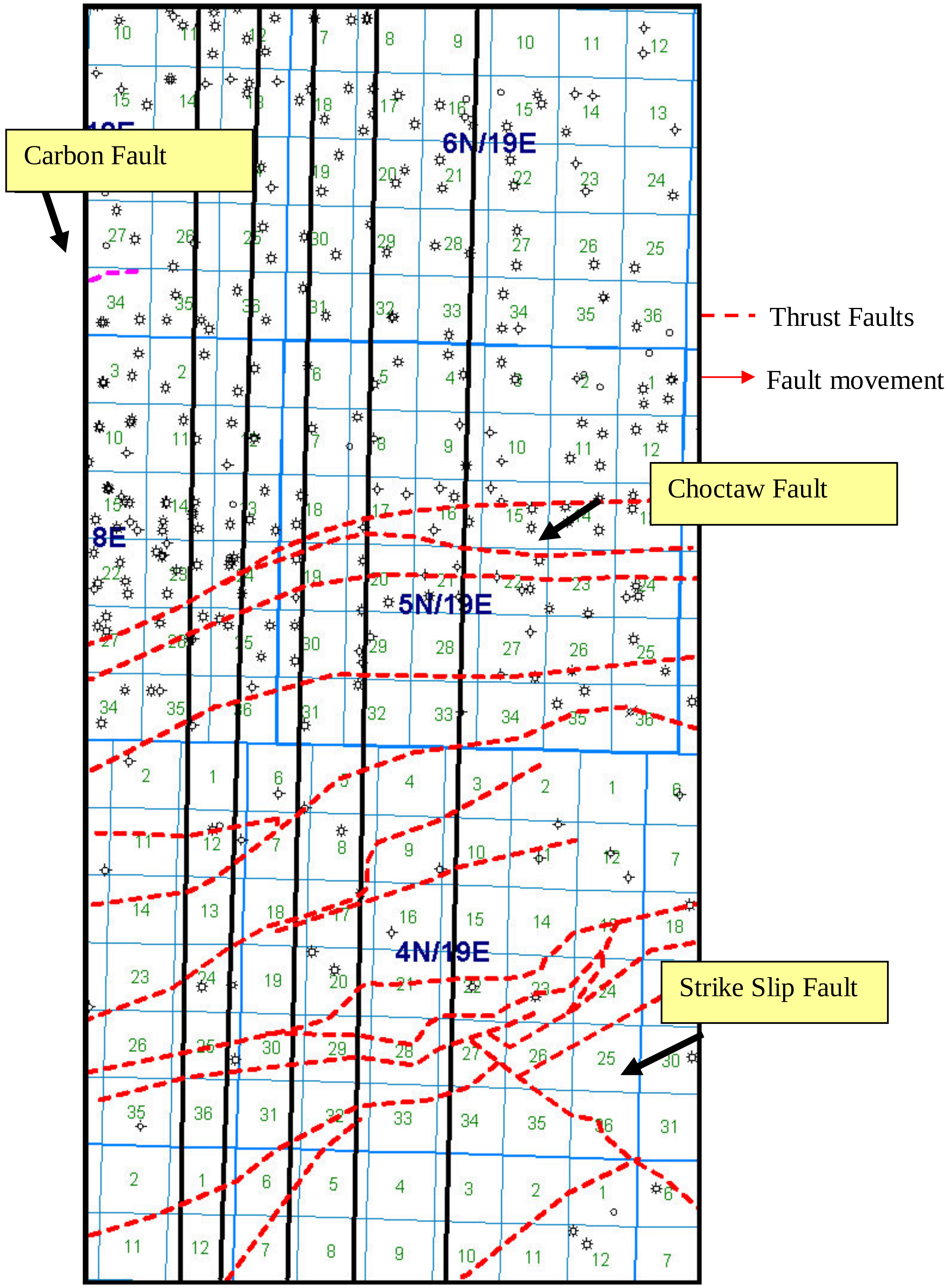

Figure 4. Map of the study area showing townships, ranges, well spots, and the location of the major faults.

In the early 2000's, the group extended their work to the southwest of the Wilburton Gas Field area (Kaldirim, 2004) and (Hadaway2004). A paper by Hadaway

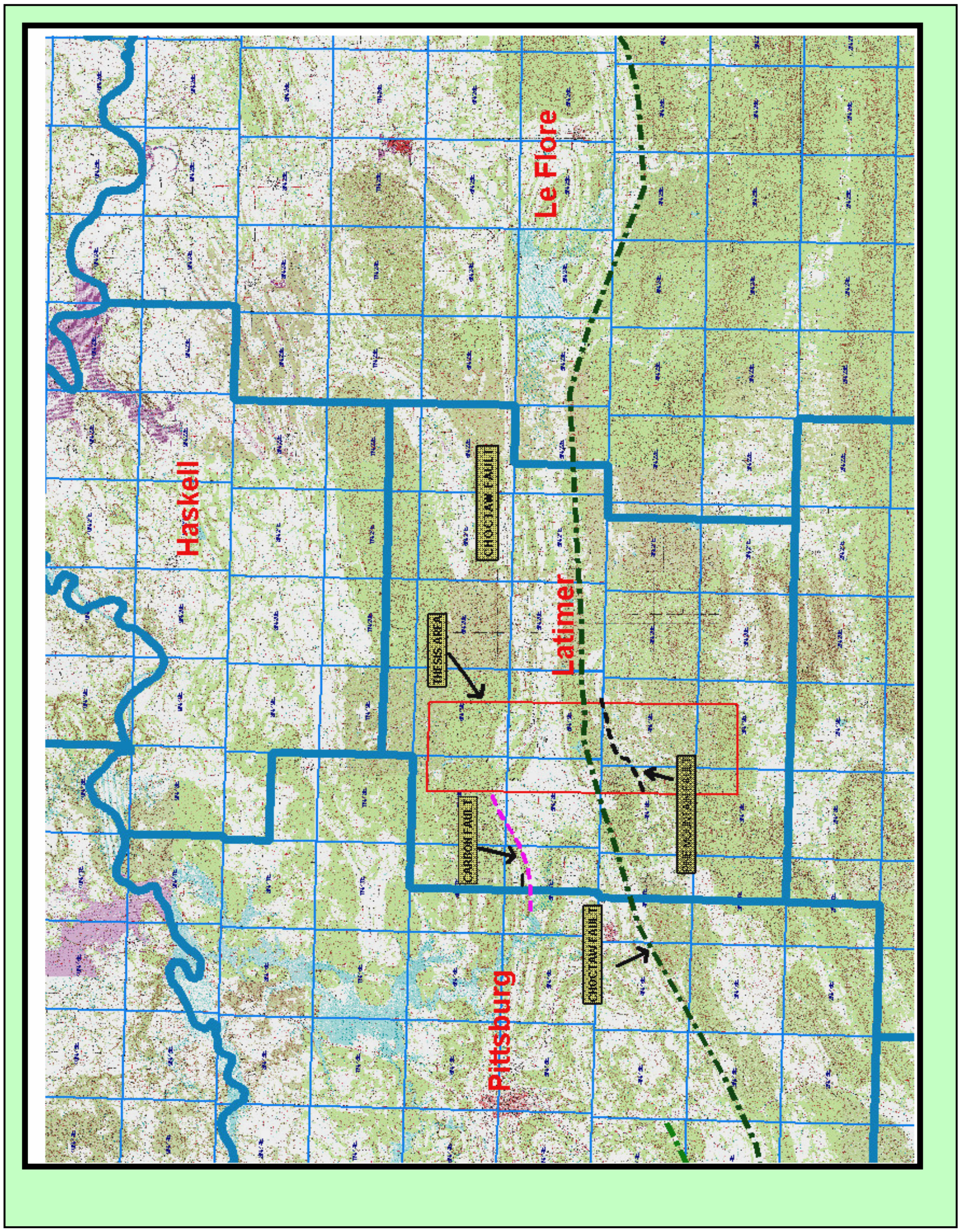

Figure 5. (a) Topographic map of the Arkoma Basin including Latimer county showing the thesis area, the Choctaw fault, and the Carbon fault.

and Cemen (2005) summarized the structural geology of the Hartshorne gas field and its implication for gas production.

This study is aimed at depicting the geometry of the northern end of the triangle zone as the carbon fault becomes a blind thrust.

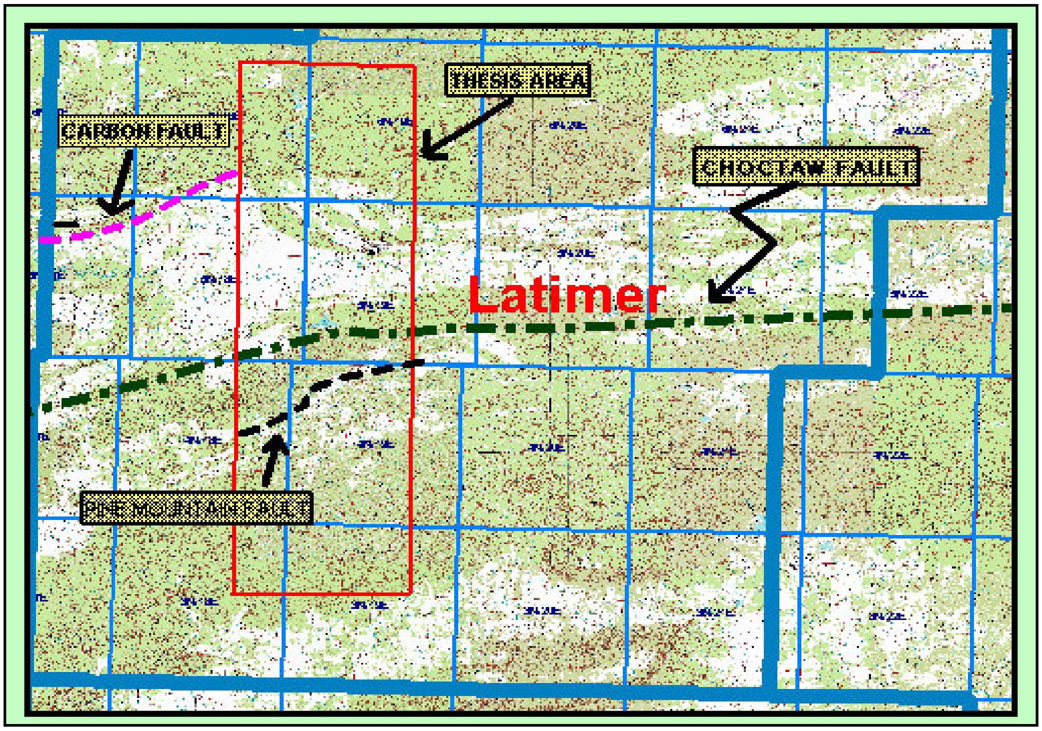

Figure 5. (b) Detailed topographic map of Latimer County and the thesis area.

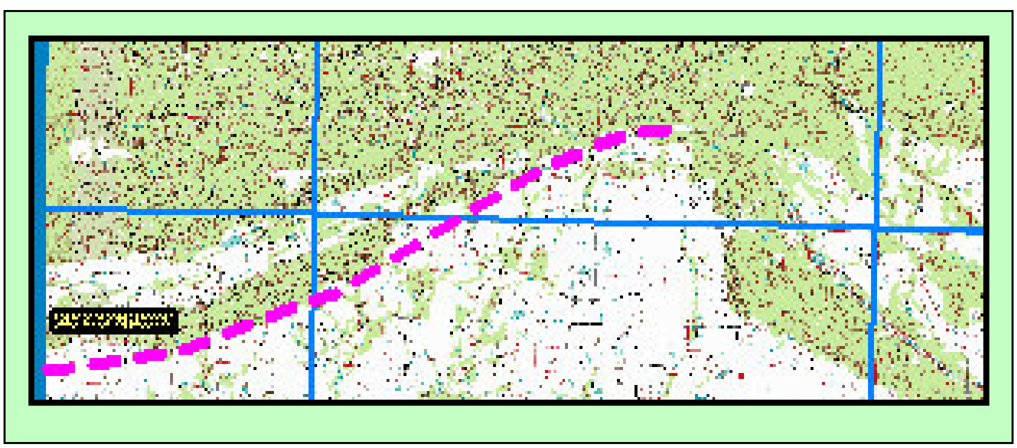

Figure 5. (c) Detailed topographic map showing a close up of the Carbon fault.

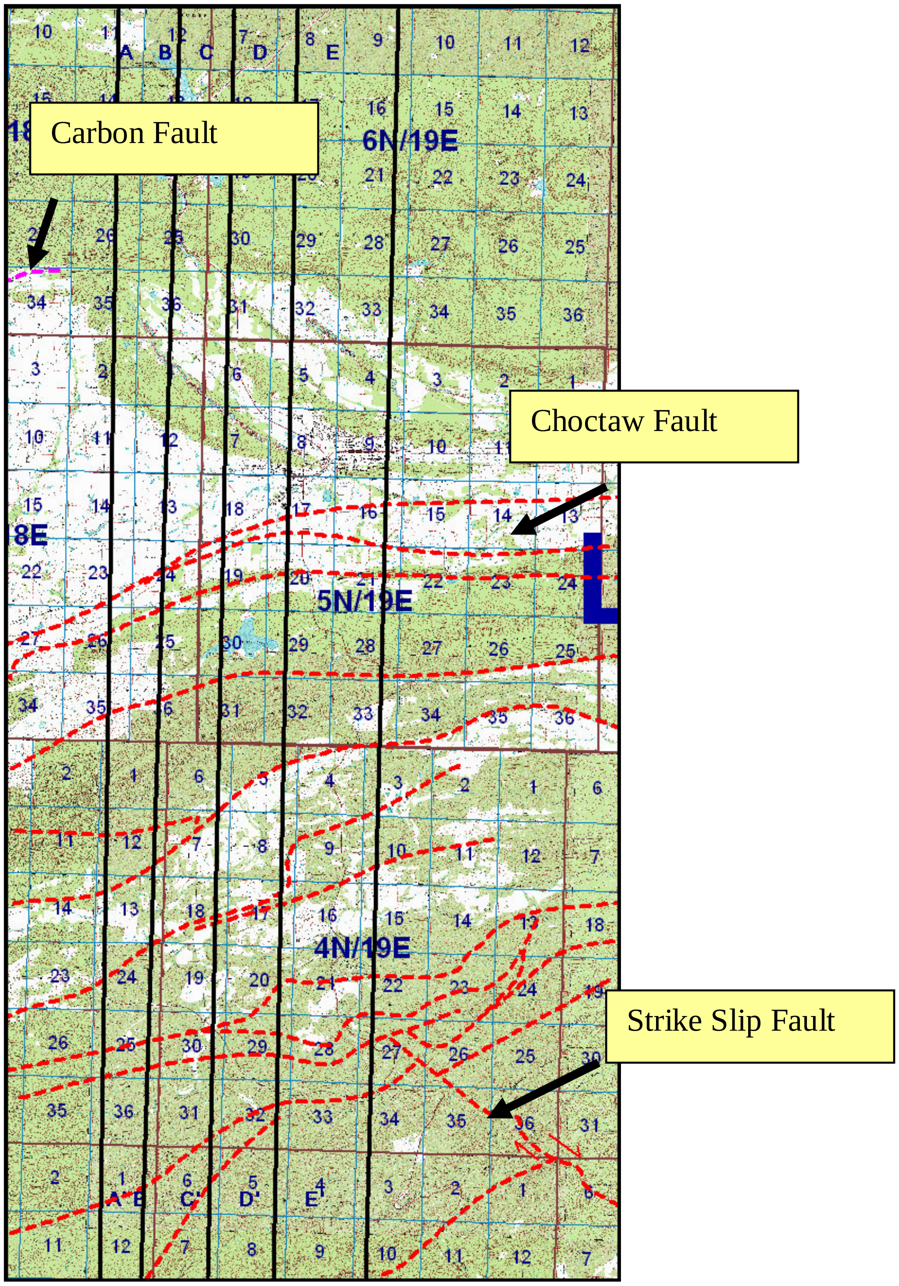

Figure 5. (d) Topographic map of the study area showing the major faults superimposed on the land grid system (Plate XI).

METHODS OF INVESTIGATION

In conjunction with the main purpose of this study, five cross-sections, two contour structural maps, and a bubble map were constructed to determine the geometry of thrusting in the Wilburton gas field area. Two seismic lines were interpreted to verify the cross sections. The amount of shortening was established by restoring the cross-sections using the key-bed method of restoration.

The following information and techniques were used to prepare the necessary maps and structural cross-sections:

1) Topographic and surface geological maps were obtained from the Oklahoma geological Survey (Suneson and Hemish, 1989).

2) A simplified geologic map of the area was prepared from the Oklahoma Geological Survey Maps (Figure 3, Plate I).

3) Copies of available well logs and scout tickets were obtained from the Oklahoma City Geological Library and used to locate the stratigraphic positions of the Boggy, Mc Alester, Savanna, Booch, Hartshorne, Red Oak, Panola, Brazil, Spiro, Wapanucka, Woodford, Springer and Arbuckle group (Appendix B Tables IV AND V).

4) Scout tickets were obtained from the Oklahoma City Geological Library and used to locate the position of some rock units based on the well log signatures of these rock units.

5) Digital copies of well logs were donated by Dwight's and downloaded into the Petra software program. This digital data was used to locate formation tops and generate maps.

6) The wells drilled in the area were assumed to be straight unless otherwise indicated by information provided in their completion cards or well surveys from Dwight's data. The surface and bottom hole location of deviated wells were determined using Boak's (1992) minimum curvature method (Fig. 6).

7) 2D seismic reflection profiles, provided by the Devon Energy Co. were examined to determine if the outcrop and well log based interpretation of subsurface geometry fit to the data in seismic profiles (Fig. 43).

8) Canvas drawing software was used to construct the structural cross-sections and to determine the amount of shortening caused by thrusting. The cross sections were restored using the key-bed restoration method.

9) Structure maps of the Spiro and the Red Oak sandstones were constructed using formation tops derived from well log interpretation, especially raster image logs using Petra and Geographix software (Fig. 41 to 42, Plates VIII to XIII.)

10) A gas production map was constructed using Dwight's data in Petra software (Fig. 11, Plate X).

11) A topographic map was generated with the location of the major faults using Geographix software (Fig.5d).

The five structural cross-sections were built perpendicular to the axes of the major structural features to yield the most accurate geometry. The orientation of the cross sections is parallel to the stress direction.

The scale used for the cross-sections was 1:24,000 horizontal scale and 1:12,000 vertical scale; thereby, having a vertical exaggeration of 2:1 (Plates III, IV, V, VI, VII, and Fig. 36-40).

Manual correlation of the stratigraphic units derived from the interpretation of the well log signatures was mainly used to construct the cross-sections.

Two dimensional seismic reflection profiles were studied to verify the structural interpretation of the cross sections based on the electric log signatures of the major Atokan sandstone units. Line drawings of the Spiro Sandstone were made using the Canvas software program. Duplex structures were identified by repeated Spiro beds reflected in the seismic profile. Normal faulting was identified by offsets of the Spiro reflector. Thrust faulting was clearly identified by the Spiro reflector as a line ramping up. Close to the Choctaw fault towards mid-section, the seismic profile was blurry and could not be used for proper tracing of the middle Atokan beds reflectors.

BOAK'S MINIMUM CURVATURE METHOD

Hadaway (2004) explained in detail the use of the Boak's method to plot the bottom hole locations and vertical depth of deviated wells by using simple geometry as seen in Figure 6. This method was used when there was not a directional well survey available. A true vertical depth was used; a kickoff point computed, and a circular arc below the Kickoff point assumed. A kickoff angle of 20 degrees and an angle of 40 degrees were assumed.

The formula used was:

$\Phi = \cos^{-1} [\cos \acute{\alpha}_{i-1} \cos \acute{\alpha}_i + \sin \acute{\alpha}_i \ \sin \acute{\alpha}_{i-1} \cos (B_{i-} (B_{\ i-1})]$ Where:

$\acute{\alpha}$= the inclination angle in degrees from the vertical

B= compass bearing in degrees clockwise from north

i= survey point number (I=0 at surface)

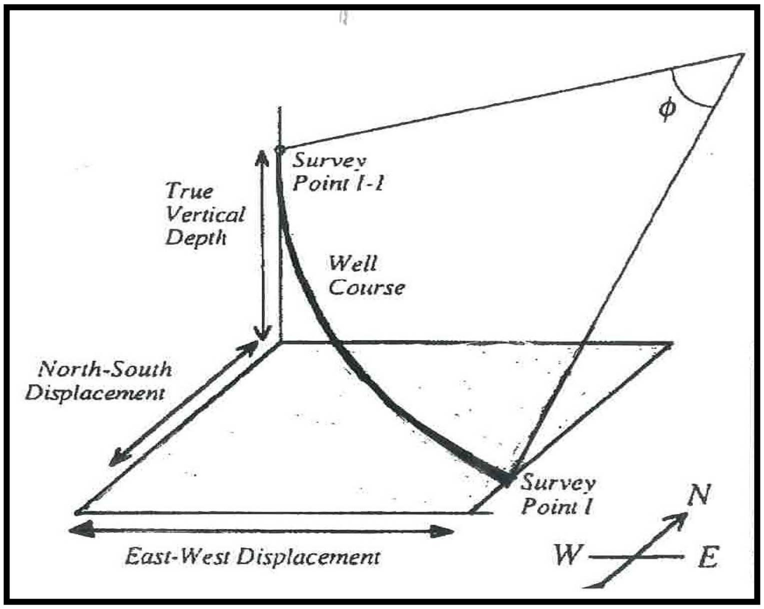

Figure 6. Boak's minimum curvature method (Boak, 1993)

TECTONICS OF THE OUACHITA SYSTEM

Many models have been suggested to explain the tectonic evolution of the Arkoma Basin (Keller and Cebull, 1973, Buchannan and Johnson, 1986). However, Houseknecht and Kacena in 1983 proposed a model using the previous researchers' work. This model is used to describe the tectonic features of the Ouachitas (Fig 7).

The Ouachita system is a major Paleozoic belt. It extends from Mississippi to northern Mexico.

During the late Proterozoic or early Cambrian, the North American craton was rifted away from the super continent Rodinia (Kruger and Keller, 1986). As the continent drifted, and the basin subsided, the proto-Atlantic ocean basin was formed. This ocean is also referred to as the Iapetus ocean.

The southern margin of the craton evolved into a passive Atlantic type margin with a shelf-slope-rise geometry until the early to middle Paleozoic. Sediments that were deposited along the shelf were mostly carbonates. Sediments deposited towards the slope were mostly shales, sandstones, and limestones showing characteristics of deep water origin. This can be evidenced in the Arbuckle facies of southern Oklahoma.

An eastward subduction complex beneath the southern continental mass of the craton began to form in the late Devonian. This is supported by the presence of widespread metamorphic rocks of lower Devonian, tuff and volcanoclastic sandstones in the Mississippian Stanley formation, and in the Sabine uplift (East Texas) volcanic rocks of Pennsylvanian Pre-Desmoinesian age. These volcanic rocks suggest that a magmatic arc formed as subduction was occurring.

From the Mississippian to early Atokan time as convergence continued leading to the closure of the remnant ocean, the shelf facies persisted. Limestone, shales, and sandstones were deposited in environments from shallow marine to non-marine. Basal Atokan Spiro sandstone was deposited in the Early Atokan time in such environments.

While the ocean basin was closing, the Appalachians were being uplifted. To the west of the southern Appalachians, the Ouachitas and the Wichita Mountains were also being uplifted. Sediments poured in large quantities into the southern ocean from the east, north, and west. During those time flysch was deposited forming the Stanley, Jackfork, Johns Valley, and the lowermost Atoka formations which are now the rock units south of the Choctaw fault. (Houseknecht and Kacena, 1983).

By the early to middle Atokan time, as the result of the collision of the two land masses, and the overriding of the subduction complex over the rifted continental margin, normal faults were created offsetting the crystalline basement and the overlying Cambrian rocks. This faulting lead to subsidence, an increase in sedimentation, and the creation of the Arkoma foreland basin (Fig. 8). The collapse of the shelf leads to the formation of deeper water environments. Submarine units such as the Red Oak Sandstone were deposited. Along the normal faults, the abrupt thickening of the sediments of Lower Atokan represents a transition between the passive margin sedimentation and foreland basin sedimentation.

By the late Atokan time, as the landmasses formed a supercontinent, foreland styles thrusting dominated. Shallow marine, deltaic, and fluvial sedimentation occurred in the basin.

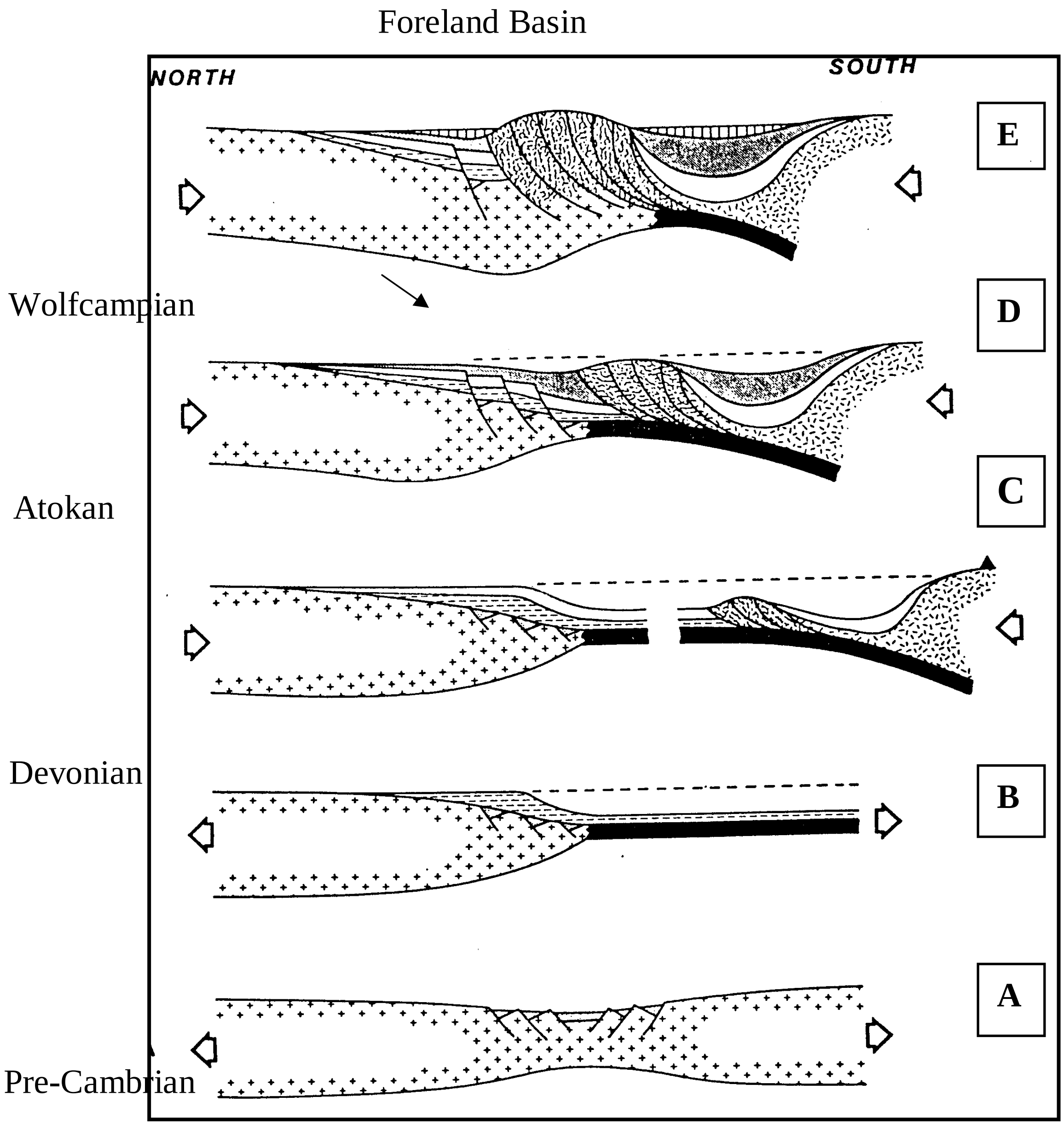

Figure 7. Tectonic evolution of the Ouachita Mountains and the Arkoma Basin from late Proterozoic to late Pennsylvanian (modified from Hadaway, 2005 and Houseknecht and Kacena, 1983). A. Normal Faulting B. Passive Margin C. Beginning Crustal Loading D: Normal Faulting E: End of Thrusting.

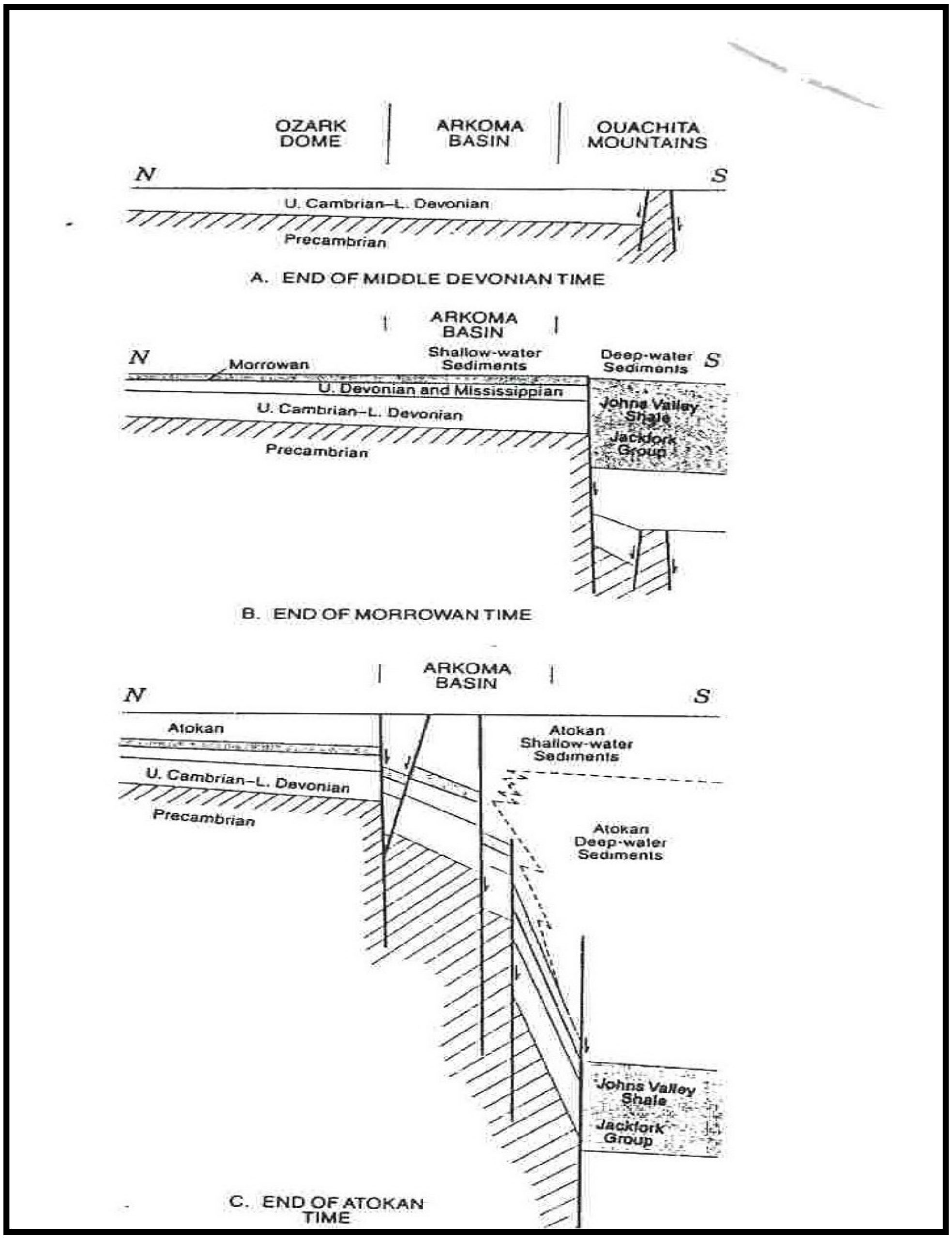

Figure 8. Generalized cross-sections showing the sedimentation in the Arkoma Basin- Ouachita Mountain area late Cambrian through Atokan time (From Johnson 1988).

A BRIEF HISTORY OF GAS EXPLORATION AND PRODUCTION IN THE ARKOMA BASIN

In March 1902, gas was first discovered in the Arkoma basin at Mansfield, Sebastian county, Arkansas, on the Hartford anticline (Branan, 1966). In the same year, a well was drilled to the Spiro Sandstone at a depth of 6,300 feet by the Red Bank Oil. This well was located in Sec. 23, T. 9N, R.24 E. It was the first deep gas well in the basin (Branan, 1966). The Spiro Sandstone, the reservoir rock, was to become a prolific natural gas reservoir in the Arkoma basin.

In 1959, Midwest Oil Corporation drilled a well into the deep Atokan Spiro Sandstone in Sec. 8 T. 6 N. R. 22E. This well was known as the Raymond F Orr 1. While drilling, at 7190ft they encountered the Red Oak Sandstone, which produced 6.3 mmcf of gas per day (and produced until 1998). Thereafter, the Arkoma Basin was to become the subject of intensive study in the quest for natural gas.

During the late 1980's and early 1990's gas exploration activity in the Arkoma Basin increased. At this time, the structural geology was still poorly understood. However, from 1992 to 1995, a group from Oklahoma State University with a grant from the Oklahoma Center for Advancement in Science and Technology (OCAST) began an extensive study of the structural geology of the Arkoma Basin and the transition zone, Cemen et al (1994), Al-Shaieb et al (1995), Sagnak (1996).

Following the funding of the OCAST project, subsurface mapping of the Arkoma basin was undertaken by additional graduate students at Oklahoma State University including Ronk (1997), Evans (1997), Mehdi (1998), Mc Phail (2001), Kaldirim (2004), and

Hadaway (2004). These studies helped to further the knowledge of the complex structural geometry of the Arkoma basin and frontal Ouachitas transition zone. Some of these M.S. thesis were summarized in articles by Cemen et al., (2001a and 2001b), Cemen, Sagnak, and Atkins (2001), Cemen, Evans, and Sagnak (2001), and Hadaway and Cemen (2005).

With a current gas production of 4.4 BCF per day, revenue in excess of $5 billion per year in Oklahoma (Oklahoma Geological Survey, 2005) and an increasing demand for energy worldwide, coupled with a lack of an alternative energy, the gas exploration is not likely to diminish. Therefore, the search for understanding and mapping complex structural areas such as the transition zone of the Ouachita Mountains and the Arkoma basin will continue as more sophisticated techniques such as seismic data become available.

In Latimer County alone, over 1700 wells produced gas starting in 1930. One hundred and five wells produced over 10 BCF during the course of their life; some are still producing. The major producing fields in Latimer county are the Wilburton, Kinta , and Panola gas fields (Fig. 9). In Ts. 6N and 5N, R. 18E and 19E, sixty wells have produced over 10 BCF (Dwight's data, Table II and III Appendix I). Some wells in the 1930's are known to have produced in the TCF range, but official data during those times were not well recorded. In the thesis area, the Spiro Sandstone has proven to be an excellent reservoir because of the chamosite coating of the sand grains, which preserves the primary porosity in the rocks. Fig. 10 represents the production from the Spiro Sandstone. The blue dots represent wells completed before 1980, the pink dots wells completed between 1980 and 1990, the yellow dots wells completed between 1990 and

1995, the purple dots completion of the wells between 1995 and 2000, and the green dots completion of the wells after the year 2000. Fig. 12 represents a Landsat image of the thesis area showing productive and dry Spiro wells.

Today the area is still very active (Appendix A, Table I to V). In August 2005, 7352 wells reported a production of 26 BCF of gas in the Arkoma Basin, and 1068 wells reported a production of 354.56 MMCF of gas in Latimer County. In calendar year 2005, 60 wells were drilled in Latimer County. The production of these wells totaled 13.67 BCF for the year 2005 (Table I Appendix I). As of January 2006, 14 rigs were drilling into the Desmoinesian, Atokan, and Ordovician strata in Latimer county with the deepest well projected to penetrate at a depth of 13, 600 feet (Dwight's data, 2006).

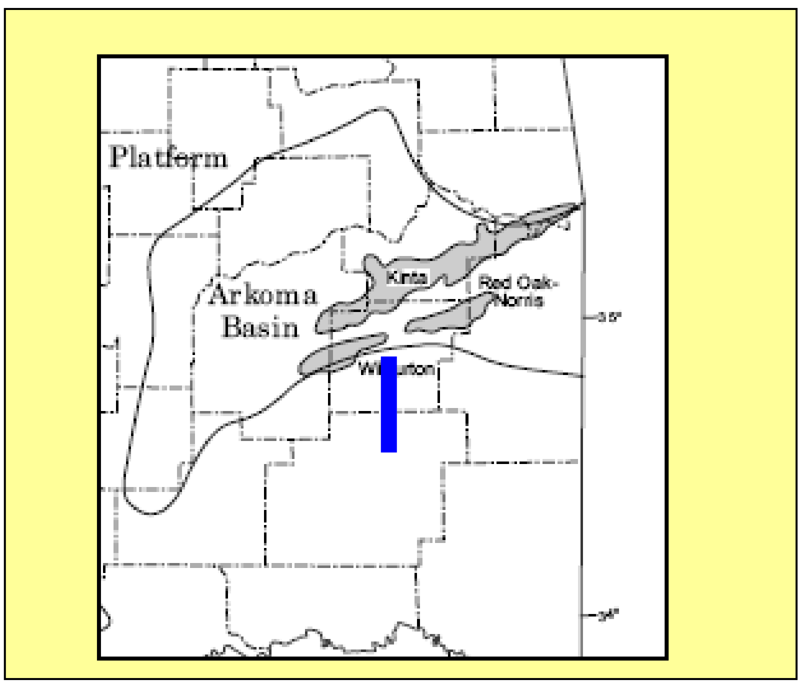

Figure 9 . The Kinta, Wilburton and Red Oak Norris gas field in Latimer County. The blue line represents the approximate area of the thesis. (OGS)

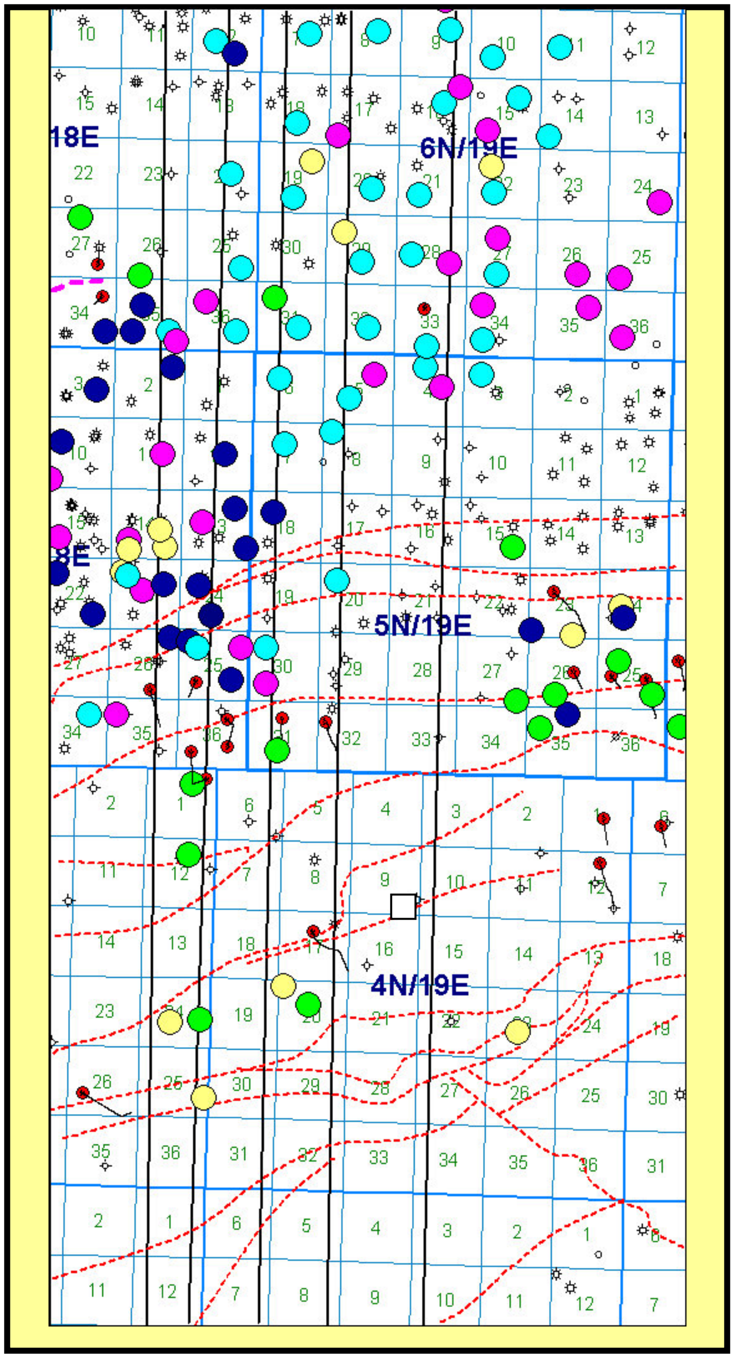

Figure 10. Cumulative gas production map of the Spiro sandstone. The light blue dots represent productive wells drilled before 1980, the pink dots between 1980 and 1990, the yellow dots between 1990 and 1995, the dark blue dots between 1995 and 2000, and the green dots after the year 2000.

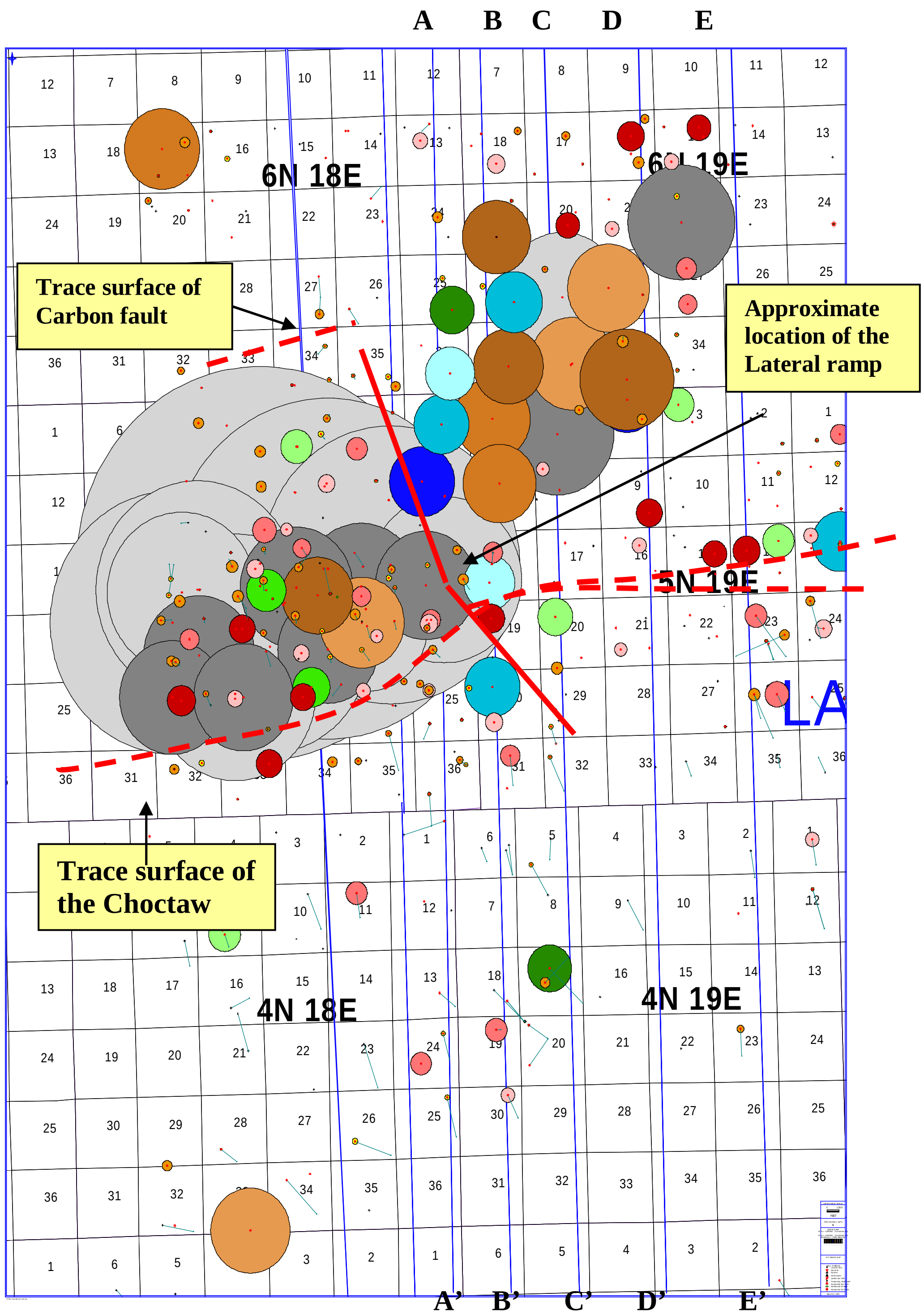

Figure 11 Cumulative gas production map of the Spiro Sandstone. The size of the bubble is an indication of the cumulative gas production of a well. Table II Appendix I give the cumulative production of the wells that have produced over 10 BCF.

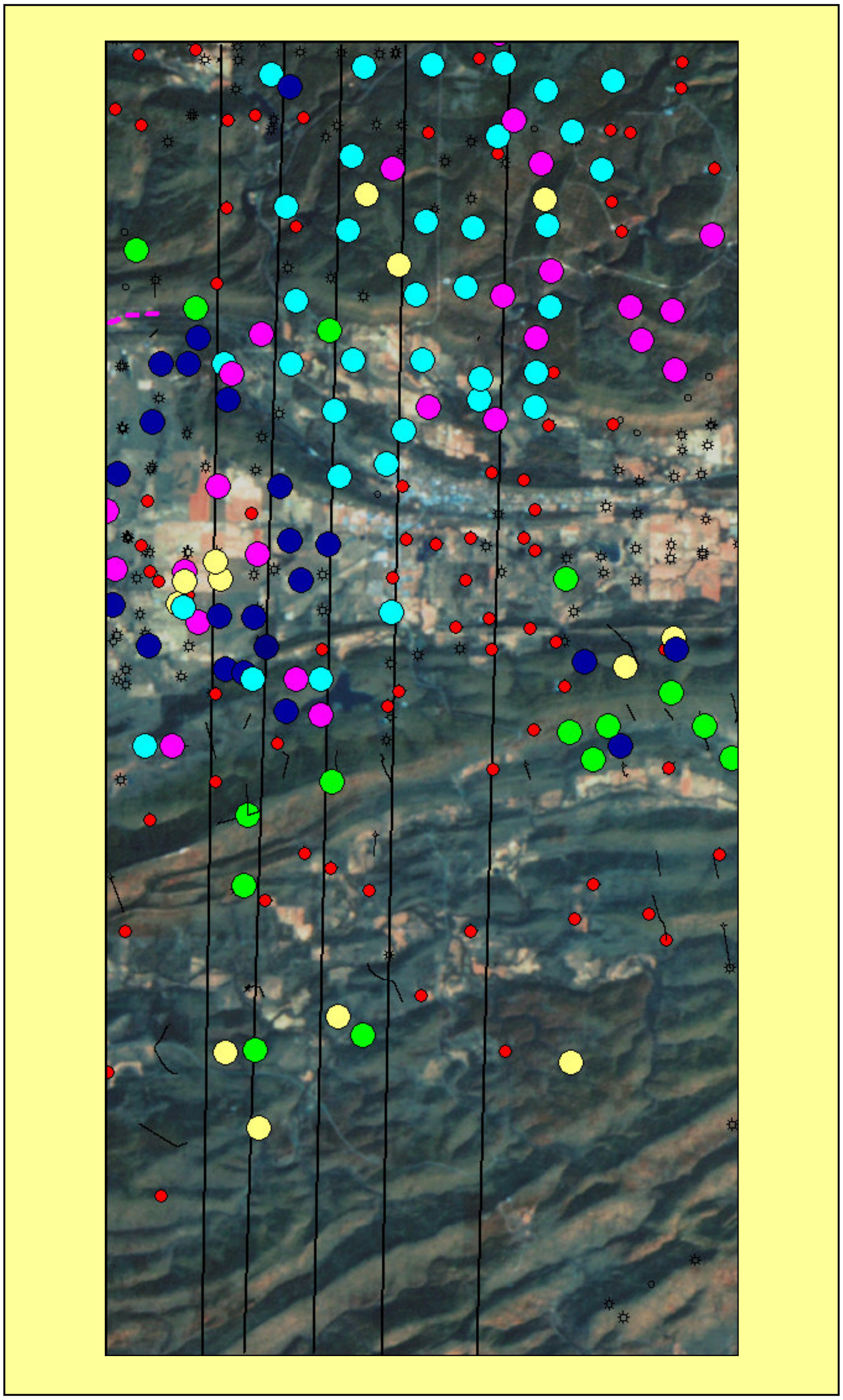

Figure 12. Landsat image of the thesis area with lines of the cross-sections. The colored circles represent areas of Spiro production. The red dots represent dry wells.

CHAPTER II

STRATIGRAPHY

PRE- PENNSYLVANIAN

The Arkoma Basin is composed of sequences of sedimentary rocks ranging from Cambrian to Pennsylvanian age that overly a crystalline basement of Proterozoic granite and rhyolite (Fig. 13). In the basin, the Cambrian through the Mississippian rocks have a relative normal thickness relative to areas adjacent to the Arkoma basin.

The oldest sedimentary unit in the basin is the Upper Cambrian Timbered Hills Group: The Reagan SS and the Honey Creek Ls which noncomformably overlies the crystalline basement. The Cambrian Arbuckle Group: the Fort Sill Ls., the Royer Dolomite, and the Signal Mountain Ls. overlies conformably the Timbered Hills Group.

The lower Ordovician contains the upper formations of the Arbuckle Group: The Butterly dolomite, the McKenzie Hill Fm., the Cool Creek Fm., the Kindblade Fm., and the West Spring Creek Fm. These formations represent deposition in a shallow marine environment, and contain a variety of normal marine fauna including trilobites, brachiopods, mollusks, and sponges.

The middle and upper Ordovician is composed of the Simpson Group, Viola Group, and the Sylvan Shale in an ascending order. The Simpson Group represents a change in depositional environment as it is composed of alternating sequences of skeletal calcarenites, skeletal carbonates, mudstones, sandstones, and shales. The Viola Group

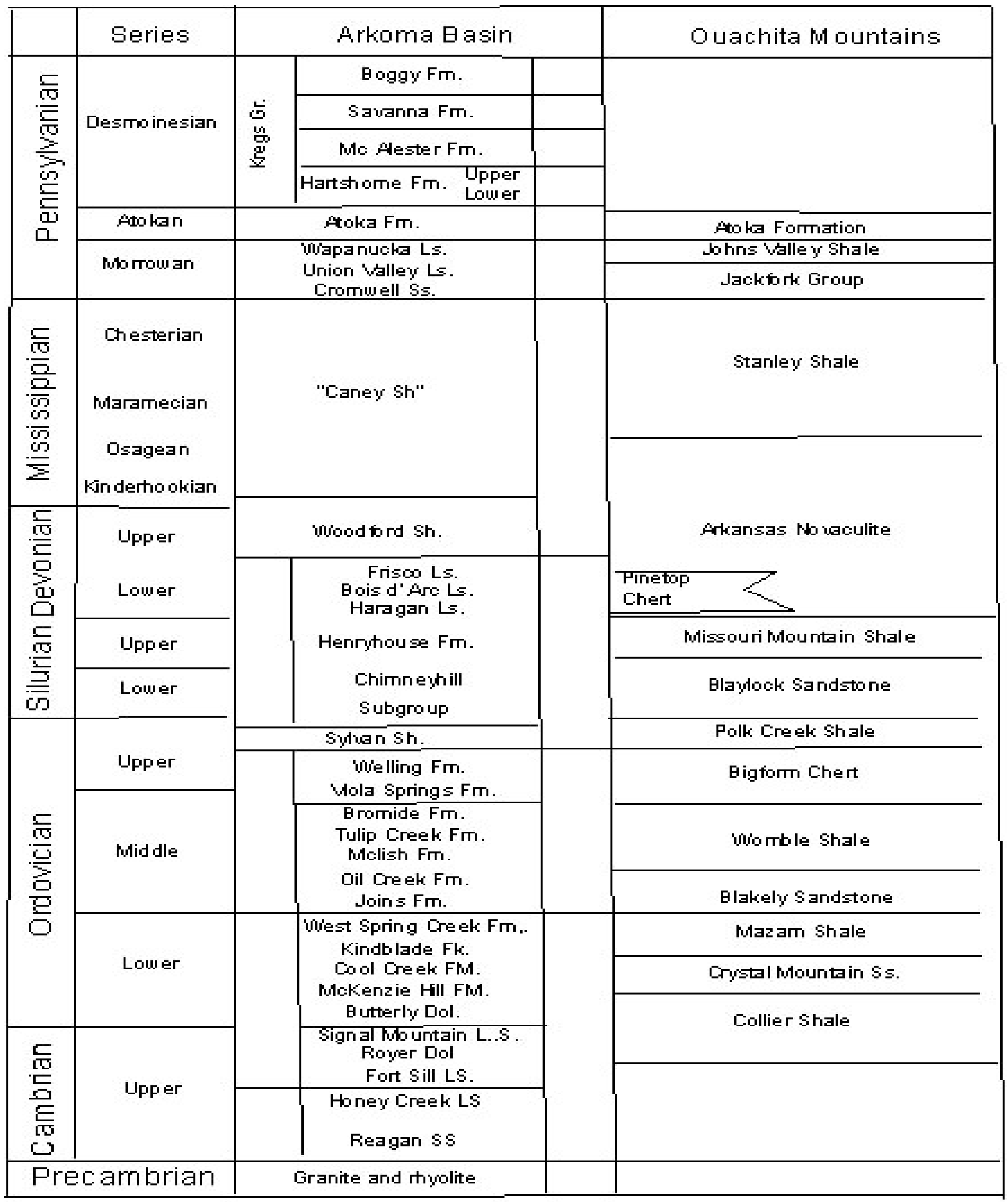

Figure 13. Stratigraphic chart for the Arkoma Basin and the Ouachita Mountain (from Johnson, 1988).

contains limestones including grainstones, packstones, wackestones, dolomitized wackestones, and nodular chert-rich mudstones. Super adjacent to the Viola Group, the Sylvan Shale is laminated and contains graptolites and chinozoans.

The Silurian and Devonian Periods contain the Hunton Group and the Woodford Shale. The top of the Hunton Group is mainly composed of skeletal mudstones and skeletal calcarenites. The basal Hunton Group is made up of oolites representing a change in sea level. The Woodford shale is composed of dark fissile shale with beds of vitreous and siliceous chert (Ham, 1978). In the frontal Ouachitas, the Woodford Shale hosts a main detachment fault and provides a gliding plane for thrusting. This detachment is called the Woodford detachment.

The Mississippian is represented by the Caney Shale. The Springer Shale is an informal unit similar to the Caney Shale of the upper Mississippi/lower Pennsylvanian. The Caney shale contains phosphate nodules. The Springer differs from the Caney by the appearance of siderite or clay-ironstone beds (Ham, 1978). The Springer shale is important to the Frontal Ouachita tectonics as it serves as gliding plane for the Springer detachment. A more detailed interpretation of the Pre-Pennsylvanian rocks is available by Johnson (1988), Ham (1978).

PENNSYLVANIAN

The Pennsylvanian formations are significant for this study because they provide outcrops used to help interpret deformation, and they contain the main gas producing reservoir rocks (Fig.14).

The Pennsylvanian is represented by the Morrowan, Atokan, and Desmoinesian series.

The Morrowan strata represent a shelf-like sedimentation in the basin . The sediments contain a significant amount of sand deposited between limestones and shale units as several series of transgressions and regressions occurred (Sutherland, 1988). The Morrowan rocks which are represented in the basin by the Cromwell Sandstone, the Union Valley Limestone, and the Wapanuka Formation, thicken southward in the basin. They are approximately 300 feet thick in the northern area, increasing to 1000 feet thick in the southern portion of the basin, and quickly expanding to 6000 feet thick in the Ouachita trough. Going southward towards the transition zone of the frontal Ouachitas and the deepest part of the basin, the Morrowan rocks grade into the Jackfork Group and Johns Valley Shale which are the deep marine flysch deposits (Johnson, 1988).

Near Wilburton, the Cromwell Sandstone is tightly cemented with calcite. It represents the lower Morrowan series and overlies the Mississippian Caney Shale. The Cromwell sandstone stratigraphically pinches out in the Frontal Ouachitas where 2400 feet of Union Valley overlies the Caney Shale (Springer shale).

The Wapanuka Formation of the upper Morrowan series is a sequence of various shoal limestones, spiculites, shales and sandstones. The formation is divided into four zones. They include in ascending order, (1) the Chickachoc Chert Member, (2) the lower limestone member, (3) the middle shale member, and (4) the upper sandstones/limestone member (Grayson, Jr., 1980).

At the top of the Wapanucka Formation lies the sub-Spiro shale. It is the uppermost Morrowan in age. The sub-Spiro shale is not laterally consistent. Where the sub-Spiro shale is absent, the Spiro sandstone is at the top of the Wapanucka formation.

The Wapanucka formation is exposed to the south of the Choctaw fault in the study area. Its thickness is approximately 300ft.

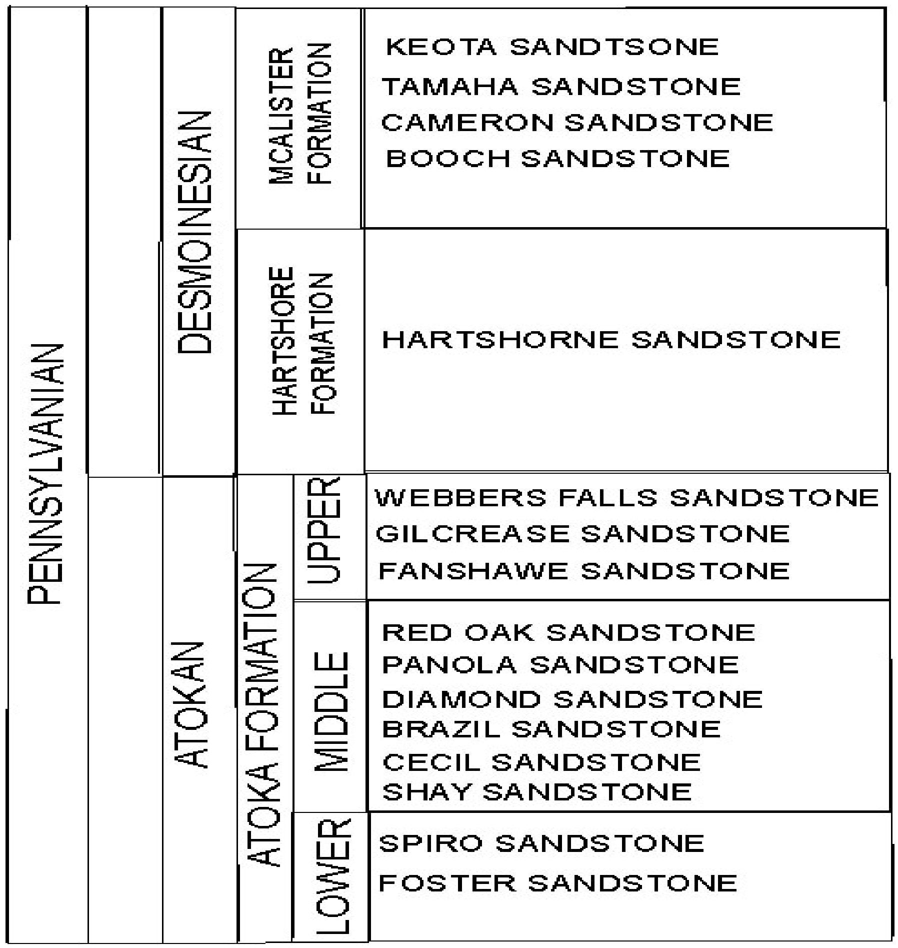

Figure14. Stratigraphic chart, Atokan strata and Desmoinesian strata, informal rock-stratigraphic units, Arkoma Basin (Modified from Sutherland, 1988).

The Atoka strata are divided into three units, the lower, middle, and upper Atoka. The division is based on the effects of syndepositional normal faults and the amount of sediment that accumulated in the Arkoma Basin. It is the thickest unit in the Arkoma Basin ranging from several hundreds to over 10,000 feet in the basin.

At the base of the Atoka Formation lies the Spiro Sandstone. The Spiro Sandstone can be subdivided into a lower and upper unit. The lower unit which is usually found north of the Choctaw fault, is interpreted as an incised-valley fill sandstone by Fritz and Hooker (1994). From cores studies, Hess (1992) determined that the Spiro is a very fine to fine-grained, silica cemented, well sorted sandstone. Chamosite clay coating is present in most places where primary porosity is preserved.

The upper unit of the Spiro Sandstone is composed of shallow marine sandstones and carbonates. Those beds are commonly found in the basin and in the frontal Ouachitas. The Spiro Sandstone is exposed along, and to the south of the Choctaw fault from T.5N, R.21E to T.1N, R.12E. Towards the east, the Spiro is a quartz sandstone. It grades to limestone in the west (Grayson and Hinde, 1993). In the study area, the Spiro exposed to the south of the Choctaw fault is a light brown to very pale orange, well sorted, porous, medium grained stratified quartz arenite. The beds are approximately 2cm to 1m thick of mostly parallel stratified sandstone with thin interbedded limestone beds (Sutherland, 1988).

The lower Atoka formation is exposed south of the Choctaw fault in the study area. Approximately 3750ft of the formation crop out. The unit contains shales and mudstones with thin beds of laminated siltstones and thick beds of sandstones. The beds vary in thickness from a few centimeters to a few meters. The sandstone beds are mostly fine-grained, poorly to moderately sorted, noncalcareous, and composed of about 95% quartz, 3% feldspar and lithic fragments. Those thicker beds are usually part of a Bouma turbidite sequence and indicative of deep water. Sole marks at the base of the units can be observed (Sutherland, 1988). (Fig.15a)

The middle Atokan is a flysch sequence of sandstones and shales of about 12,000 feet thick (Johnson, 1988) the result of normal faulting and subsidence of the land. The middle Atokan strata range from 300 feet in the north to over 10,000 feet in the southern part of the basin. In the study area, approximately 1,200 ft of the Atoka formation is exposed in the southern part of the basin north of the Choctaw fault. It is mostly composed of silty, brown to gray-black noncalcareous shale with discontinuous, ridge-forming, brown, fine-grained sandstones. The Red Oak Sandstone is a major hydrocarbon producing sand unit in part of the middle Atoka formation. The Upper Atokan units do not show thickening across the faults. They are mainly composed of shallow shelf and deltaic facies (Sutherland, 1988) this suggests that normal faulting stopped or lessened in its intensity in the late Atokan time (Fig. 15b).

The Krebs group of the lower Desmoinesian time is composed of the Hartshorne Sandstone, McAlester Formation, Savanna Sandstone and Boggy Formation. In the study area, the Krebs group crops out in the northern part of the basin. The Hartshorne Formation was deposited in high constructive tidally deltaic system. The McAlester and Boggy formations were deposited during a series of transgressions and regressions of sea level, and are comprised of rocks of fluvial/deltaic sedimentation. The Boggy Formation was deposited in a deltaic complex (Sutherland, 1988). In the study area, the surface trace of the Hartshorne marks the boundary of a coal seam.

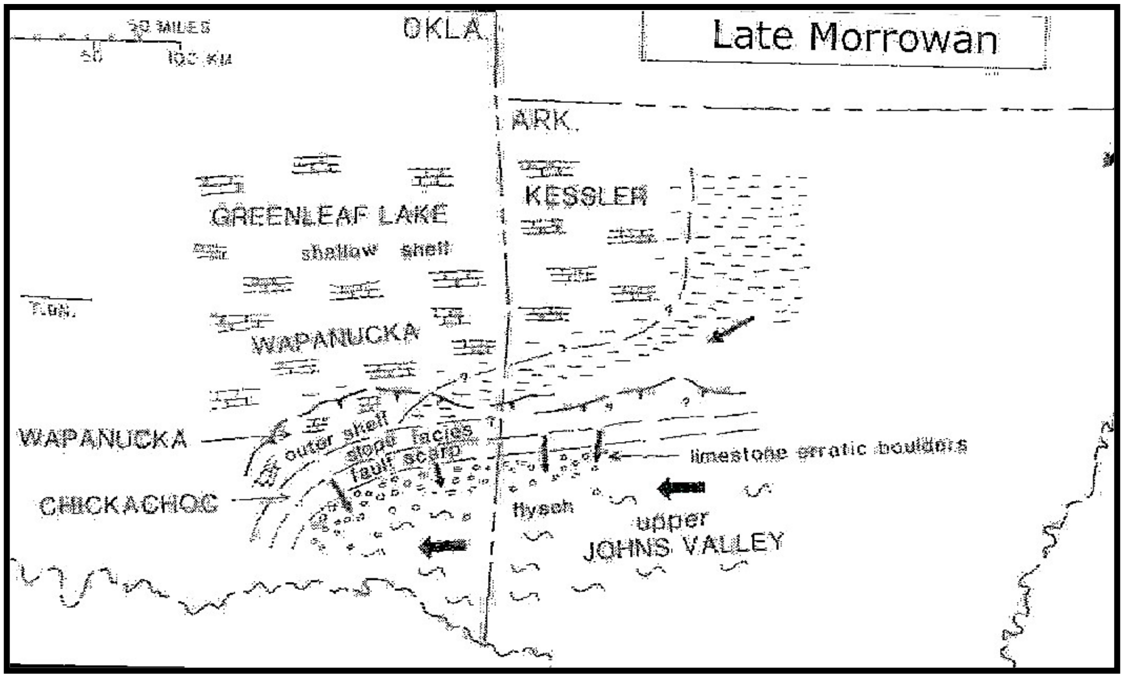

Figure 15 a. Late Morrowan depositional environment (from Sutherland, 1988).

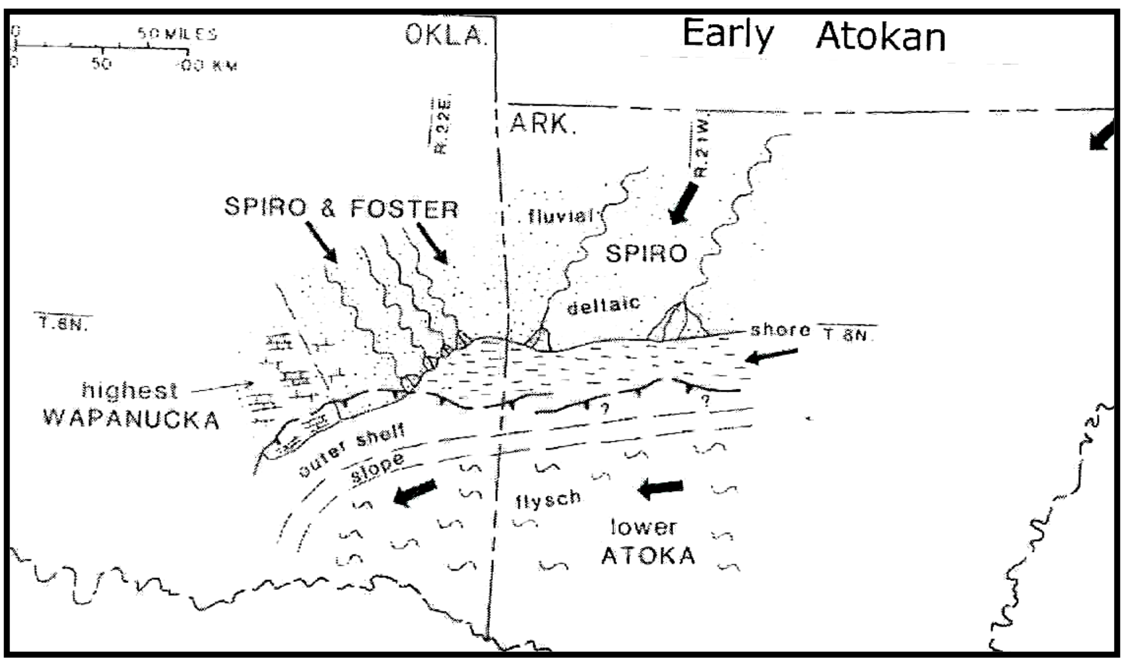

Figure 15 b. Early Atokan depositional environment (from Sutherland, 1988).

VERTICAL WELL LOG PROFILES SIGNATURES

Over two hundred vertical well log profiles were examined for correlation to construct the structural cross sections. The Spiro Sandstone is continuous throughout the study area. It is a clean sand and the gamma signature is low in the order of 15 API. It contains chamosite clay coating, and exhibit a high resistivity between 200 and 400 Ohms with peak of 500 Ohms. The Spiro usually overlies a thick sequence of the Wapanucka limestone formation unless a thin sub-Spiro shale is present. It is easy to identify because of its blocky look(Fig.16, 17, 18).

The gamma ray, induction logs were used primarily to identify the Spiro. However, in the Western part of the basin, towards the Wilburton gas field area, most wells were built before 1970. Sometimes, the only available wells logs were the SP with the Electrical logs (Fig. 19).

The middle Atokan Red Oak Sandstone is almost continuous within the study area. It is present in the northern part of the basin, but disappears towards the Choctaw fault. The Panola Sandstone lies beneath the Red Oak and is also almost continuous within the study area. It is not mapped in the cross-sections, but served as a marker bed to help confirm the position of the Red Oak in the stratigraphic succession.

The Red Oak Sandstone for correlation purposes is divided between a top, a middle, and a bottom part. The top part is about 100’ thick. It has a silty component, and a variable gamma ray. It is followed by a shaly unit which varies considerately. The middle is composed of a very thin sand alternating with silty shale, and the bottom part is very silty, and has a thickness of approximately 120’ (Fig. 20).

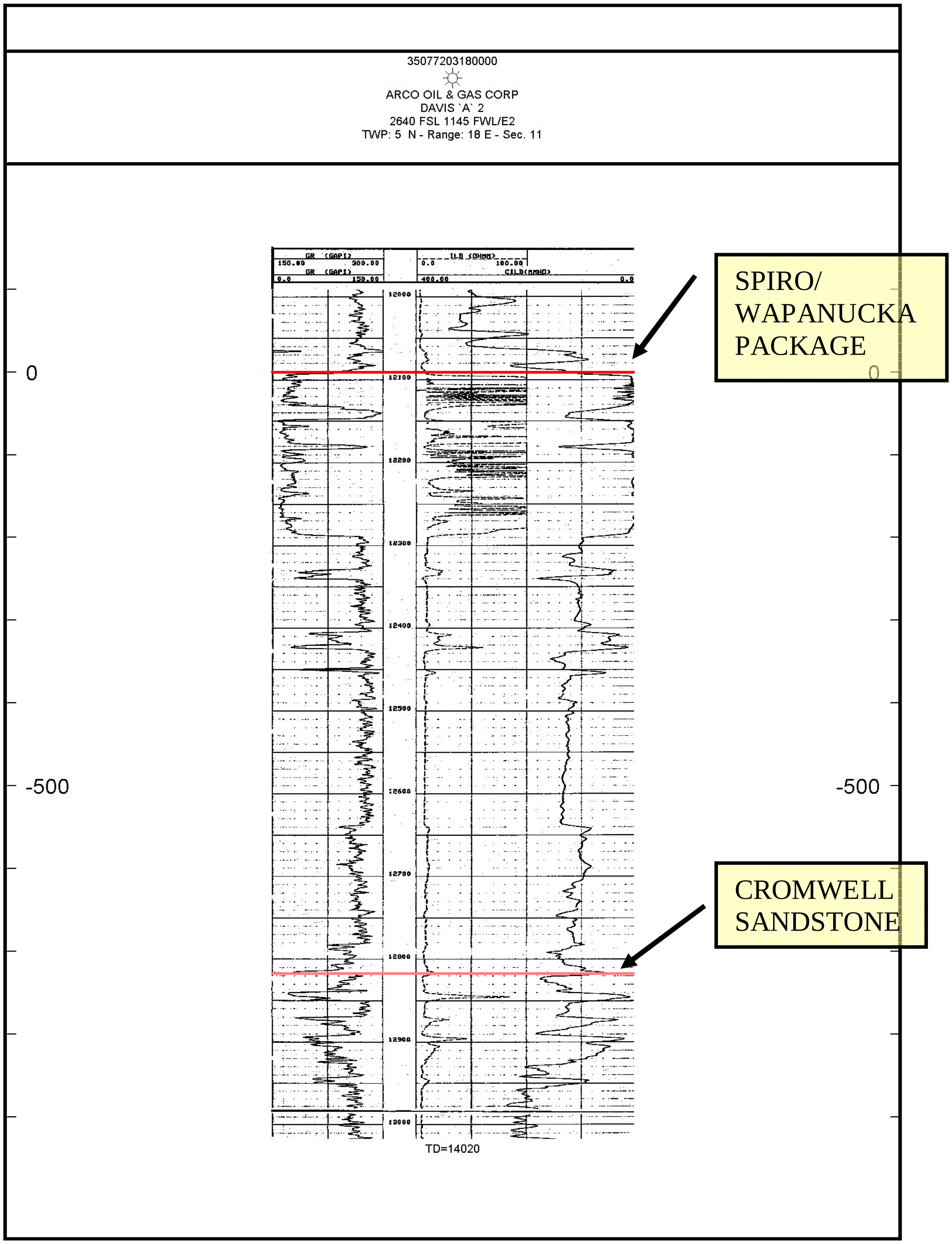

Figure 16. Gamma Ray well log signature of the Spiro Sandstone (Red line). The pink line represents the top of the Cromwell Sandstone. Arco Oil & Gas Corp. Davis 'A' 2 Sec. 11, T. 5N, R. 18 E.

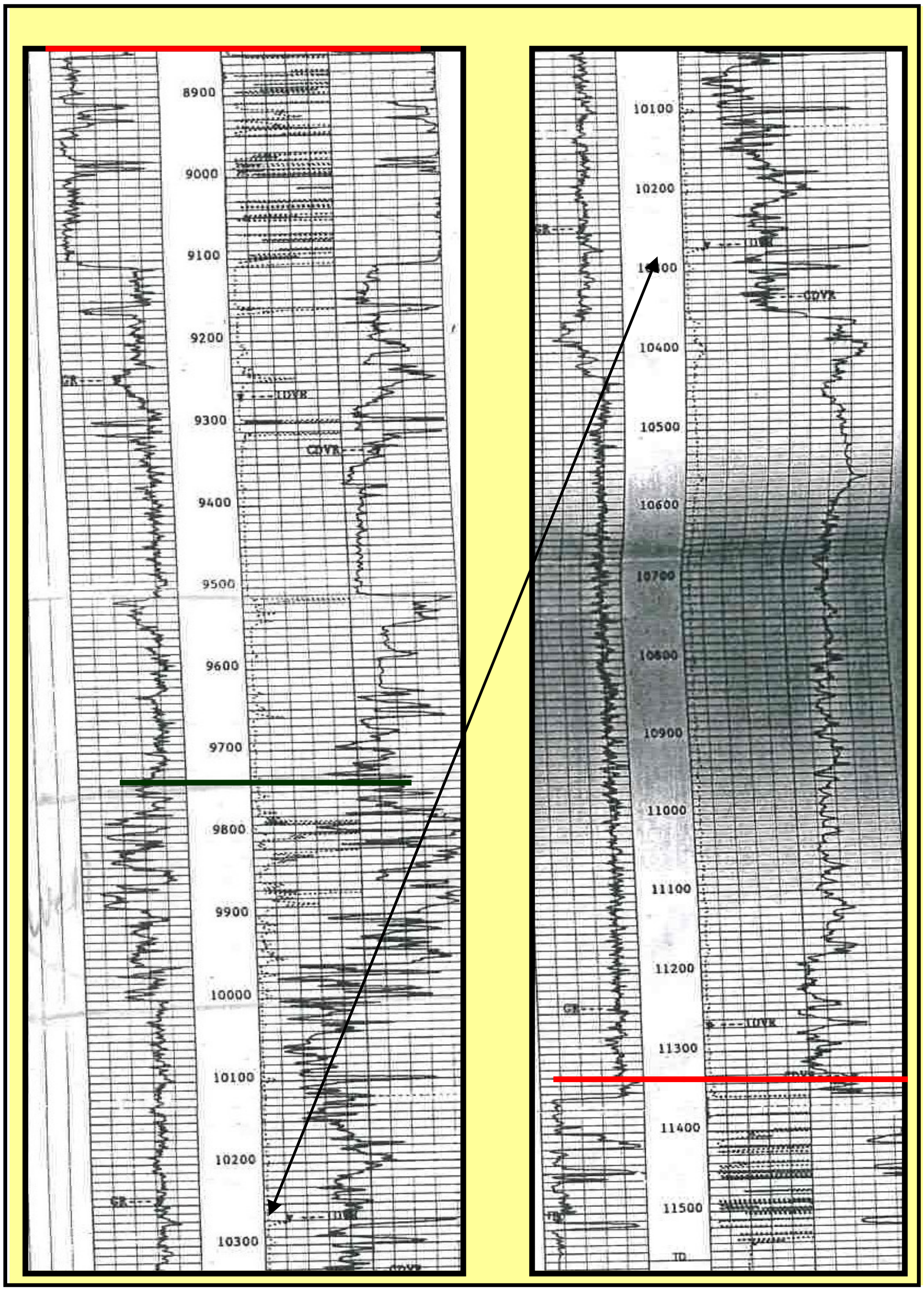

Figure 17. Gamma Ray well log signature of the Spiro Wapanucka package showing repetition, therefore thrusting. GHK Co. William 6-23, Sec. 23, T. 5N, R.18E. The red lines represent the top of the Spiro SS, the dark line represents the top of the Cromwell SS.

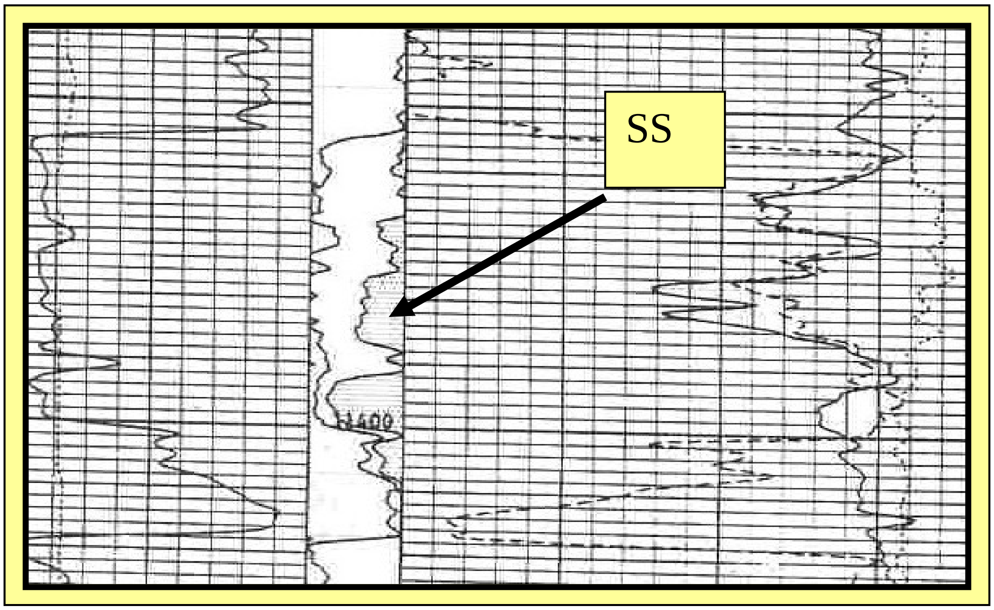

Figure 18 . Neutron Density log with lithology showing the formation as a sandstone

GHK Co. William 6-23, Sec. 23, T. 5N, R. 18E.

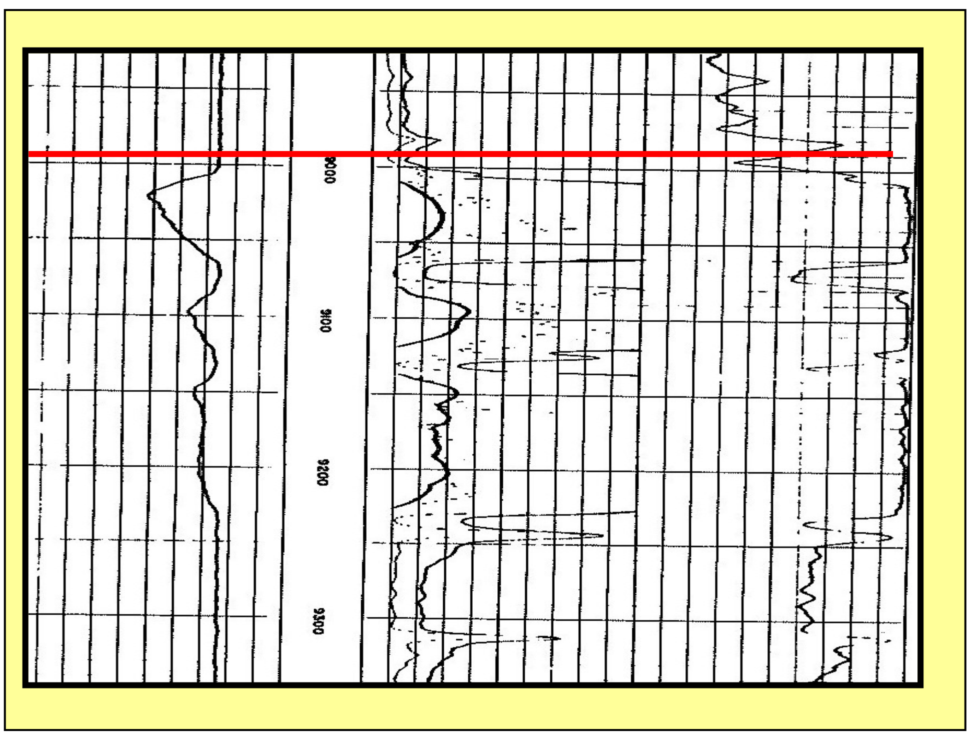

Figure 19. Electrical well log signature of the Spiro Sandstone SP and resistivity .

Skelly Oil Company- Guy Varnum no.1, T.5N, R. 19E.

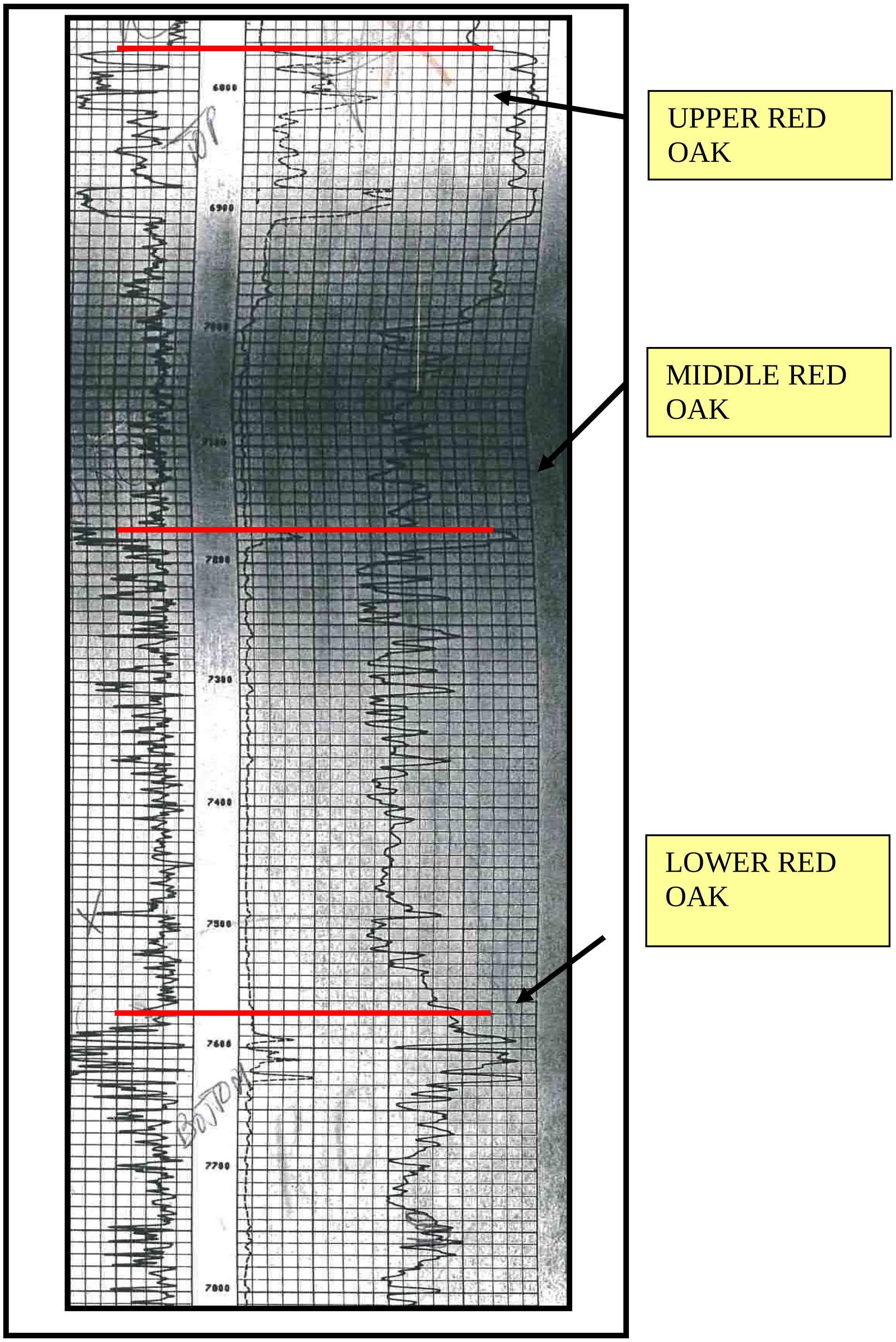

Figure 20 . Gamma Ray Signature of the Upper, Middle, and Lower Red Oak Sandstone. Oxley Petroleum Co. Weaver #3, Sec. 16, T. 6N, R. 19E.

The Fanshawe above the Red Oak was present in only a very small portion of the basin to the north area of the cross-sections area. Because it is stratigraphically located between the Harshorne, and the Red Oak, and has a distinct characteristic, it was easy to identify. Its gamma ray signature shows three sequences of silty sands interbedded with shales. However, although it helped confirm the position of the Red Oak Sandstone, because it was not consistent throughout the basin, it could not be used for the cross sections. (Fig 21) .

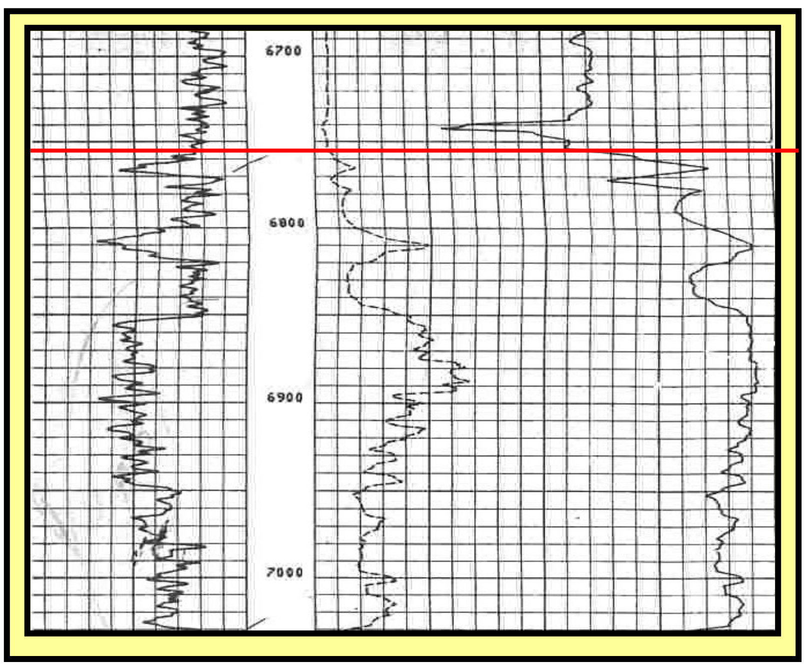

Fig 21. Gamma Ray well log signature of the Fanshawe sandstone. Samson Resources Co. Degnan, T.16N, R.19E

The Booch Sandstone of the Mc Alester Formation, and the Hartshorne Sandstone of the Hartshorne Formation were identified mainly using the surface geology.

The Booch Sandstone is stratigraphically divided into three sub-units. However for this thesis only the top part was used when wells were shallow enough to enable the subsurface correlation of these sands (Fig. 22).

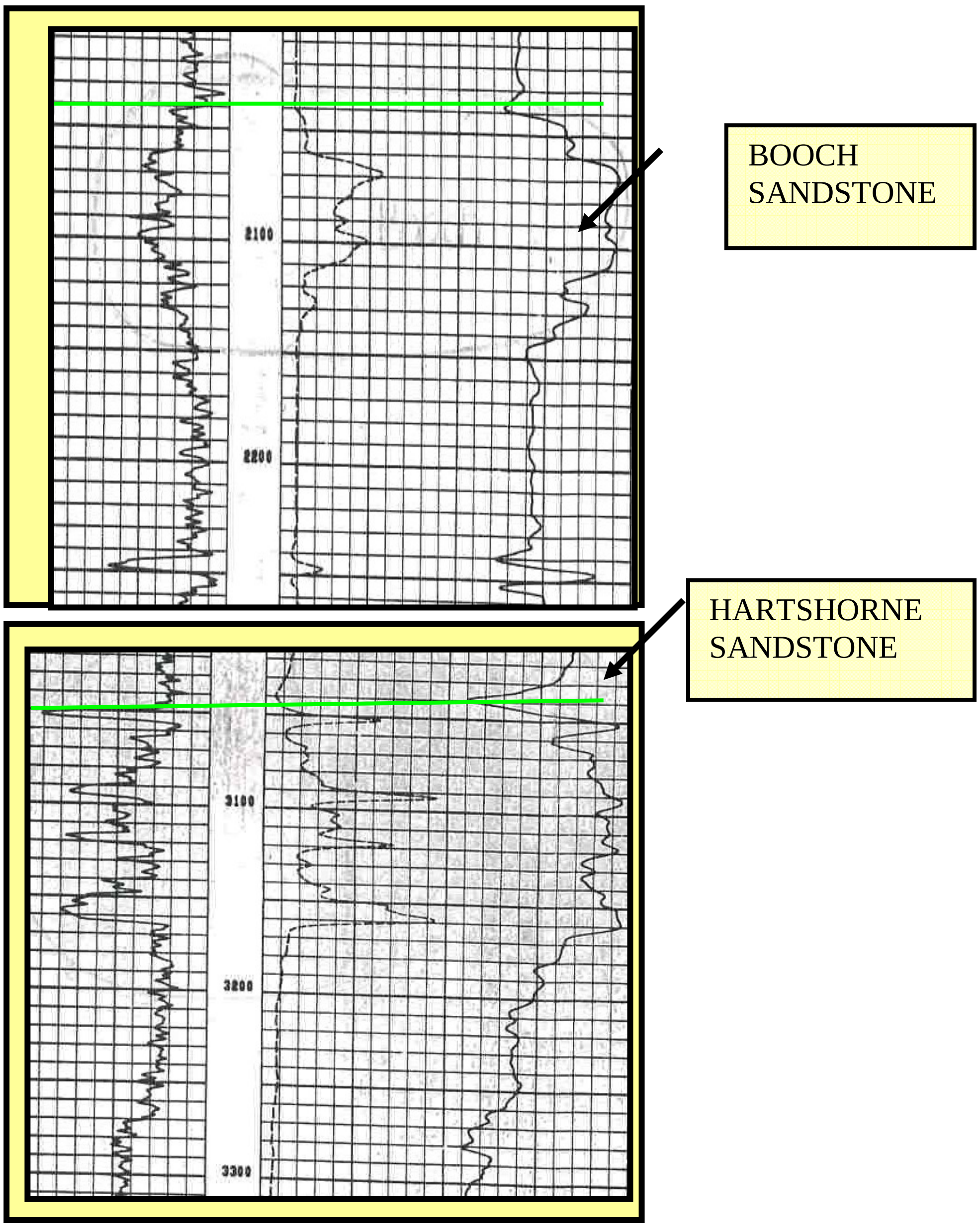

Figure 22. Gamma Ray well log signatures of the Booch and Hartshorne Sandstones. Samson Resources Co. Degan #1, Sec. 28, T. 6N, R. 19E.

CHAPTER III

GEOMETRY OF THRUST SYSTEM

The frontal Ouachitas is a classic example of a thrust system, which is an assemblage of thrust faults and thrusted sheets. In a thrust system, thrust faults branch out from a common thrust or basal shearing plane, which is also called a decollement surface or a detachment fault.

Boyer and Elliott (1982) provided the first comprehensive classification of structural features in thrust systems (Fig 24). The two main parts are imbricate fans and duplexes. Since this study contains well developed duplexes, only the geometry of duplexes will be briefly discussed. For imbricate fan geometry, the reader may refer to McClay (1992).

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DUPLEX STRUCTURES

A duplex structure refers to a thrust system with imbricate faults branching off a basal shearing plane, and connected to the top that forms another continuous fault (Fig. 23). The basal shearing plane is called the floor thrust; the upper fault is called the roof thrust. The rock bodies bounded on all sides by the floor thrust, the roof thrust, and two branching thrust faults are called horses (Marshak and Mitra, 1988).

Boyer and Elliot (1982) divided the duplex structures into three main types: hinterland dipping duplexes, antiformal stack, and foreland dipping duplexes Fig. 24) . Mitra (1988) also classified the duplexes into three types: independent ramp anticlines, true duplex, and overlapping ramp anticlines leading to antiformal stack. Boyer and Elliot (1982) used the terms hinterland and foreland in reference to the final attitudes of imbricate thrusts. Mitra (1988) used the same terms to define the attitude of the roof thrust at the contact between horses.

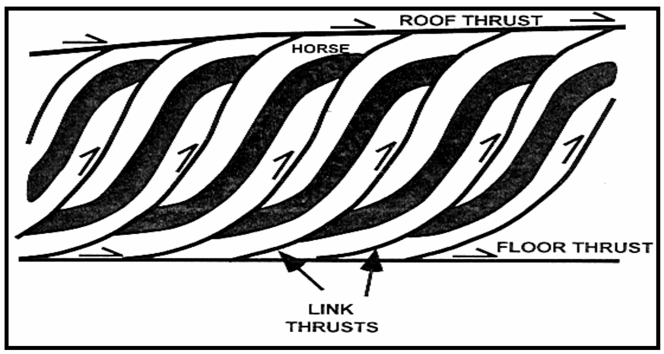


Figure 23. Duplex Terminology (McClay, 1992).

TYPES OF DUPLEXES

The difference between the amount of slip and the truncated bed length will determine the shape and geometry of a duplex. If the fault slip is less than the truncated bed length, a normal duplex will develop. If fault slip and truncated bed length are equal, an antiformal duplex will develop. If fault slip is approximately equal to the truncated beds, a forward dipping duplex will develop (McClay, 1992). (Fig. 24)

In a normal duplex, the horses dip gently backward towards the hinterland. In an antiformal duplex, the horses are slightly arched, and stacked up on top of each other.

This arrangement is due to undercutting of horses during a break backward sequence. In a foreland-dipping duplex, the horses are gently dipping forwards towards the foreland. (Fig. 24)

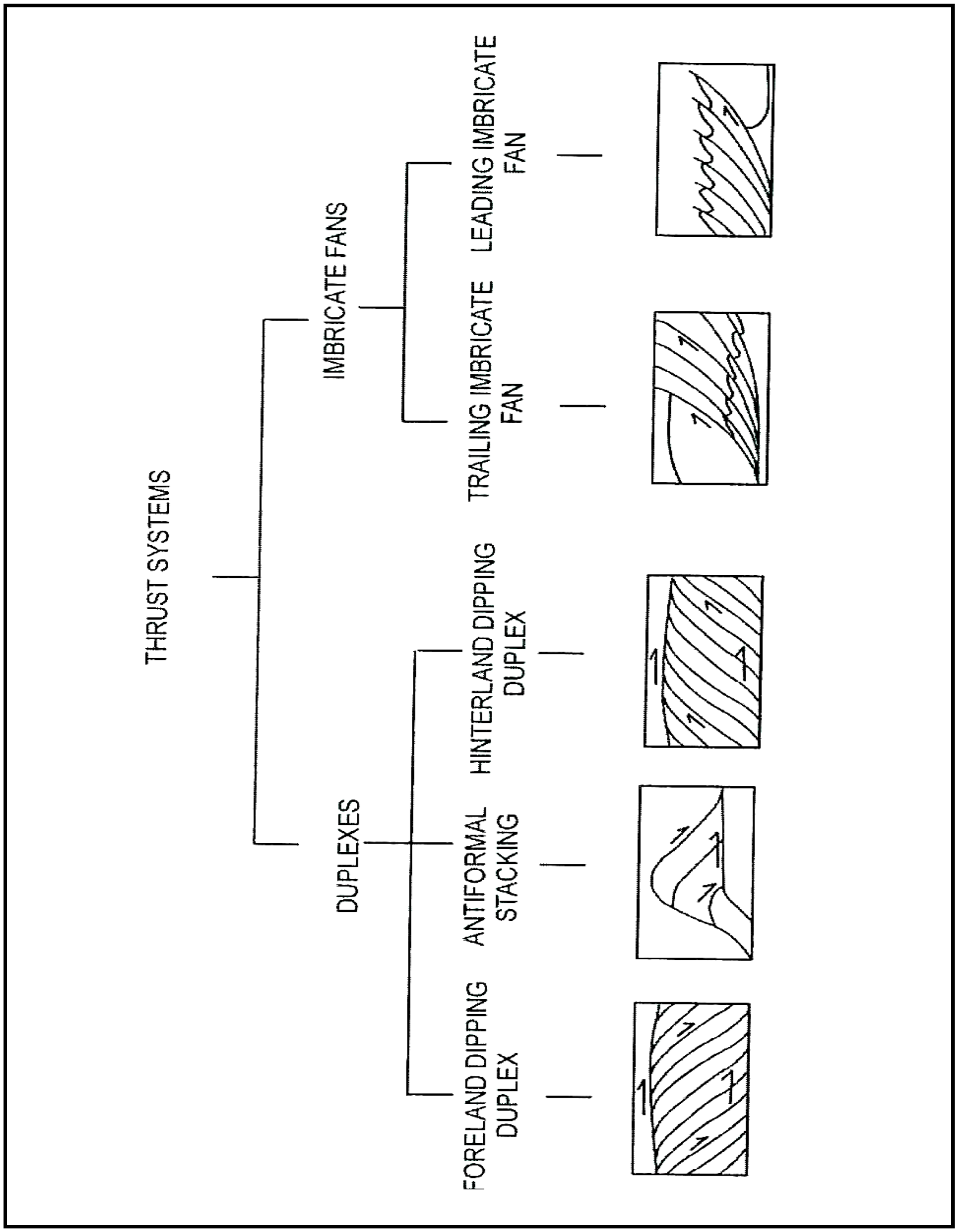


Figure 24. Classification of Thrust Systems (Modified from Boyer and Elliot, 1982).

LATERAL RAMPS

Rich in 1934 recognized the kinematics of thrusting. Harris and Suppe (1983) described a model to understand the structural geology of deformed strata in many thrust belts which is composed of ramps and flats.

Ramps can occur in a frontal, oblique or lateral position. Sometimes a ramp will cut up a section laterally before reassuming a flat geometry. In this case, the movement along the lateral ramp will be a strike-slip movement (Boyer and Elliot, 1982). (Fig. 25)

Frontal ramps are perpendicular to the displacement of the fault. Oblique ramps are at an incline to the displacement direction, and lateral ramps have a strike parallel to the displacement direction. The distinction between oblique and lateral ramps would be difficult to know unless one has three dimensional seismic data.

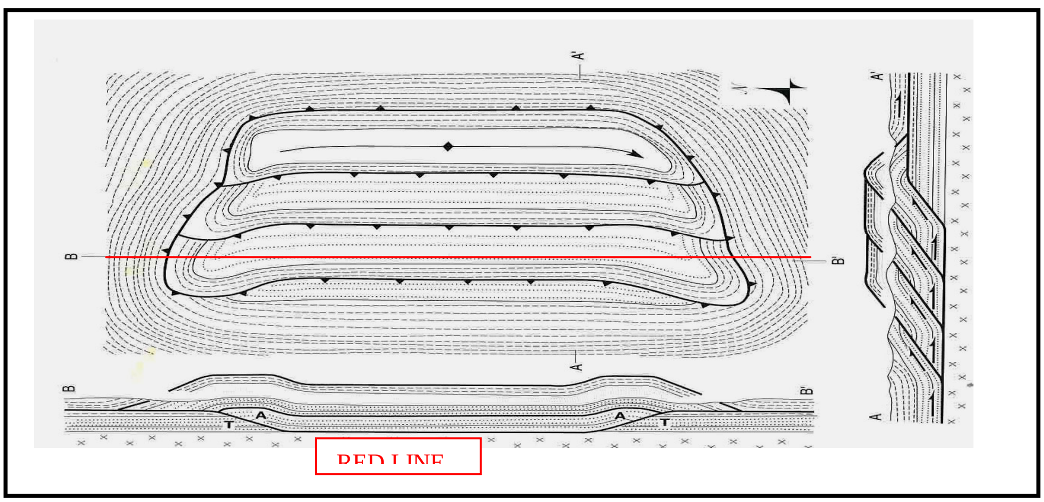


Figure 25. Geologic map and cross section of a lateral ramp. (From Boyer and Elliot, 1982). The lateral ramp is shown along the line of cross-section B-B'.

Lateral ramps have had many names in the literature. They have been called tear faults, strike slip fault-lineaments, Gwinn-type lineaments, transverse faults, cross-strike structural discontinuities, transverse decollements, and finally lateral ramps by Boyer and Elliot (1982), Butler (1982), Hossack (1983), and Coleman (1988). An extensive study of lateral ramps in the Appalachian mountains and the world, were provided by Thomas and others (1986), Thomas (1990) and (1991), and Howard A. Pohn (2000) . Those researchers have inferred the presence of lateral ramps from features in the surface that they linked to the subsurface. These features include a sudden change in wavelength or termination of folds (Fig. 26) a change in the frequency of mapped faults, straight river trends (Fig.26), zones of seismic activity, tectonic windows, igneous intrusions, giant landslides, and abrupt changes in sedimentary facies along strike. These features have been backed up by seismic profile evidence (Pohn, 2000).

In the Appalachian, and the studies of several lateral ramps, the basement faulting might contribute to the formation of lateral ramps. Lateral ramps could be caused by thrust sheet motion over the activation of ancient fracture systems (Pohn, 2000). (Fig. 27) Many frontal ramps are located above basement block faulting. In a normal ramp step up, as compressional stresses crowd the beds against those block faults, these stresses force the decollement to ramp upward to a higher stratigraphic level. By the same token, if a block fault is present and positioned to a slight angle to the maximum principal stress direction of the tectonic transport, then the compressive forces would cause the rocks adjacent to the fault to be uplifted along the fault trace. Therefore, it would produce an environment encouraging the formation of a lateral ramp.

Figure 26. Field example of the Susquehanna Lateral Ramp. An obvious discontinuity exists between the wavelength of the folds generally to the east of the Susquehanna river. Side looking airborne radar image. The heavy lines indicate the boundaries of the Susquehanna lateral ramp (Pohn, 2000.)

The steepness of the fault scarp would reflect the amount of ramping along the lateral ramp (Pohn, 2000). (Fig. 28)

Simplified models of the geometry of lateral ramps have been sketched (Fig. 29 . In these models, the ramps are connected to a horizontal decollement. They produce a smaller cross sectional area at their distal end except for the first model. Therefore, each of these last three geometry require a movement of compressed material along the strike perpendicular to tectonic transport (Pohn, 2000).

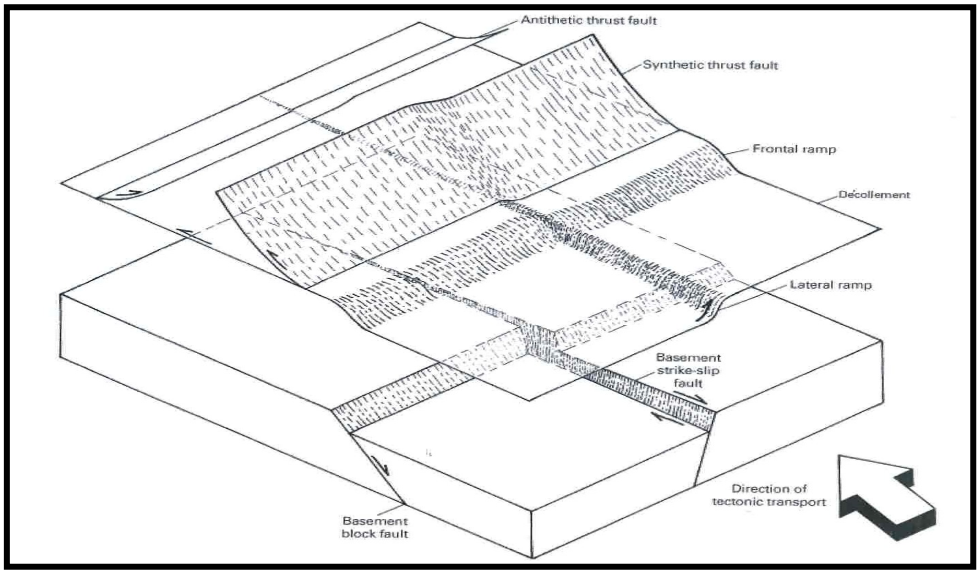


Figure 27. Block diagram showing relationship between basement block faults and frontal ramp and basement block faults and lateral ramps. Arrows indicate the relative movement of the thrusted sheet (Pohn, 2000).

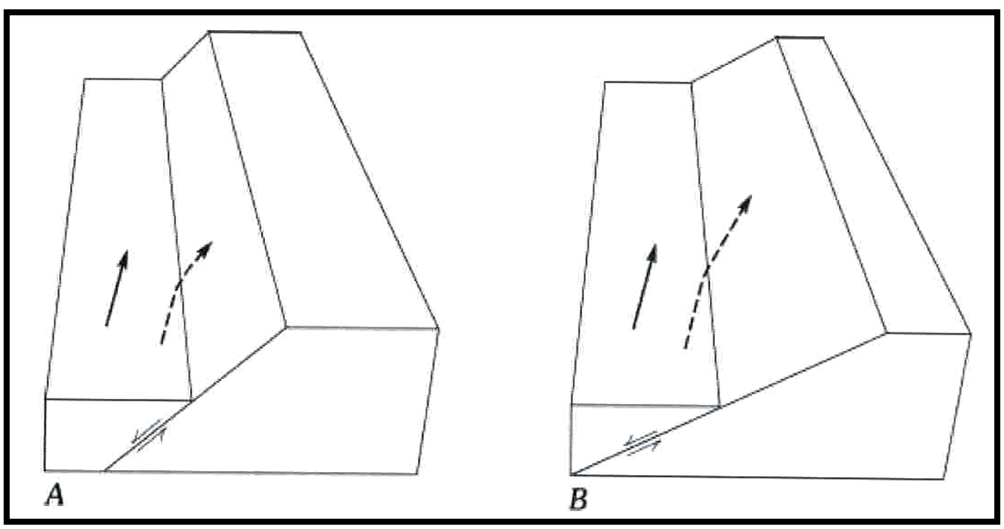


Figure 28. Block diagrams showing relationship of fault refraction to steepness of fault scarp. A. Steep faults refract steeply B. Shallow faults refract shallowly (Pohn, 2000).

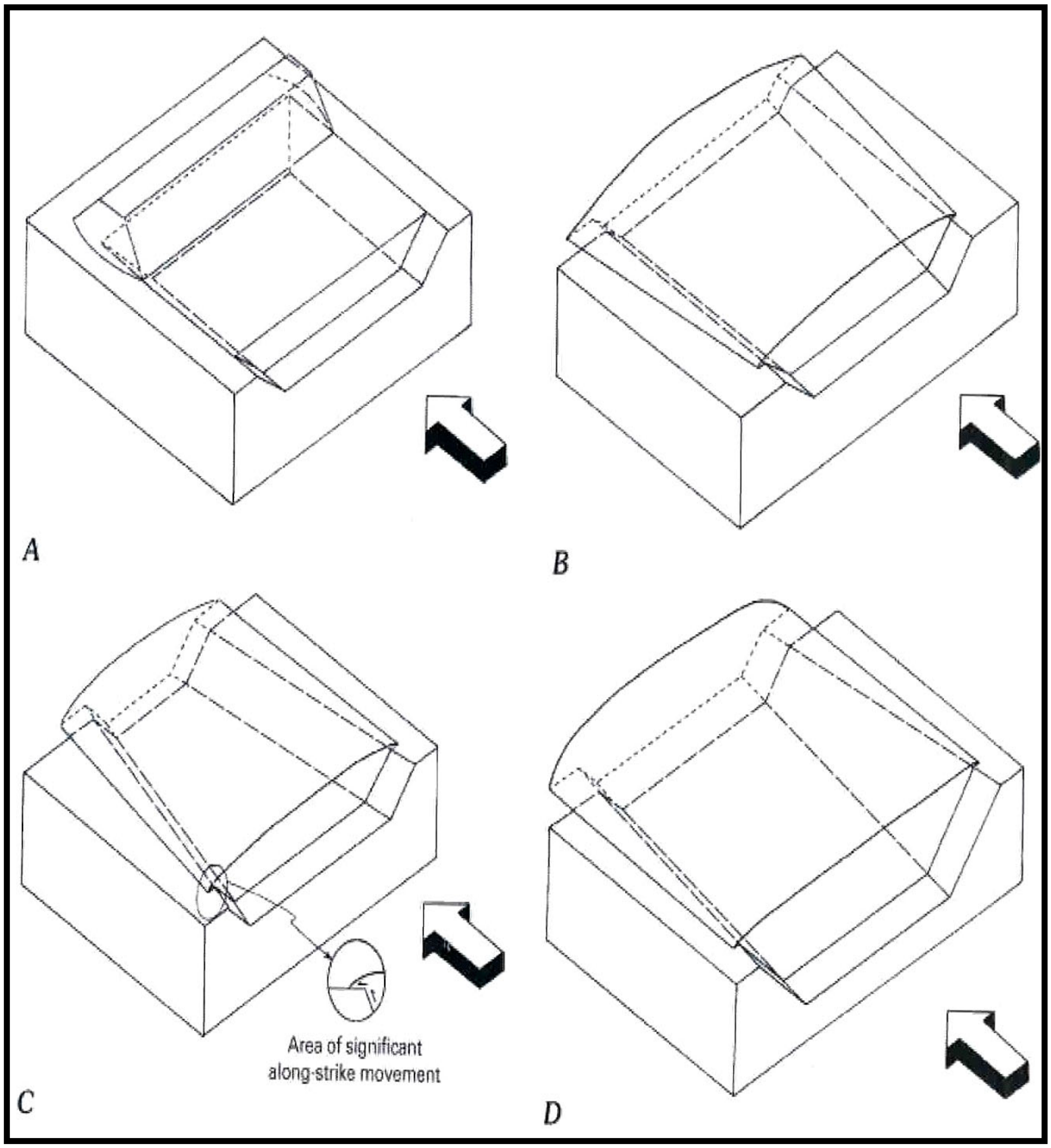
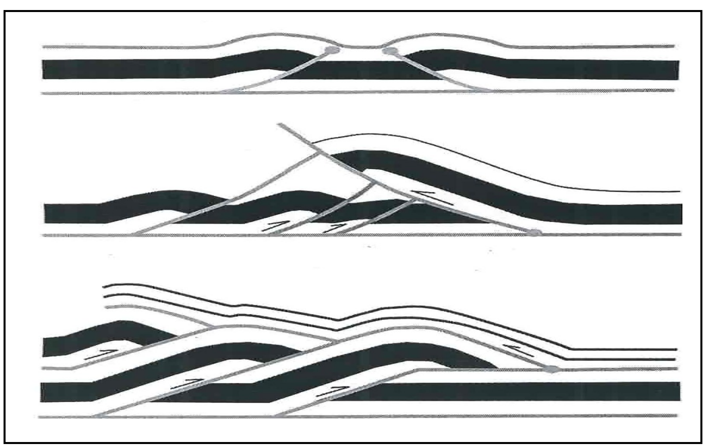


Figure 29. Simplified block diagrams of lateral ramps showing four basic geometric configurations. The arrows indicate the sense of movement. A. Parallel-sided lateral ramps connected to a horizontal decollement. B. Parallel-sided lateral ramps connected to a rising decollement. C. Convergent-sided lateral ramps connected to a horizontal decollement. D. Convergent sided lateral ramps connected to a rising decollement (Pohn, 2000).

TRIANGLE ZONES

A triangle zone is a zone formed by the opposing vergence of two thrust faults. The triangle zone is bounded by a floor thrust, and on the side by the two opposite dipping thrust faults forming the legs of the triangle. There are three basic types of triangle zones (Fig. 30). The first one consist of thrusts of opposite direction with a symmetrical distribution over a single detachment. The second one consists of asymmetrical distribution over a single detachment. The third one consists of opposing thrust with asymmetrical distribution and two levels of detachment faults. The reader is referred to Couzens and Wiltschko (1994) for a more in depth study of triangle zones (Fig. 25). The triangle mapped in this study project is the triangle zone defined in the Wilburton area by Cemen et al. (1994), Akthar (1995), Sagnak (1996), Cemen, Sagnak Author (2001a.). It is similar to type III triangle zone proposed by Couzens and Wiltschko (1994).



TYPE I

TYPE II

TYPE III

Figure 30. Three end member geometries for triangle zones (From Couzens and Wiltschko, 1994).

CHAPTER IV

PROPOSED STRUCTURAL GEOMETRY OF THE FRONTAL OUACHITAS

The Structural geometry of the transition zone along the frontal Ouachitas-Arkoma Basin have been studied by several researchers, A.&B. Arbentz (1984, 1989) (Fig. 31), Hardie (1988), Camp and Ratcliff (1989) (Fig. 33), Milliken (1988) (Fig. 33), Hardie and Reeves et al, (1988) (Fig. 32), Perry and Sunneson (1990) (Fig. 33), Wilkerson and Wellman (1993) (Fig. 34), Suneson (1995) summarized the models that were presented by the mid-1990's. Hadaway (2005) updated the summary by Suneson.

Arbenz (1984) (Fig. 31) recognized a deep decollement parallel to the bedding extending into the basin serving as the floor for a series of blind imbricate thrusts. He also recognized a triangle zone formed by a backthrust.

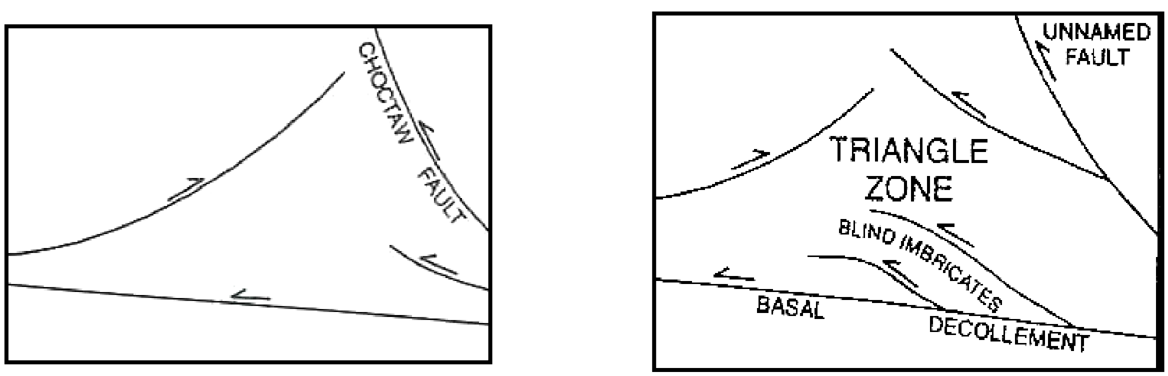


Figure 31. Sketch of subsurface geology: Arbentz (1984, 1989).

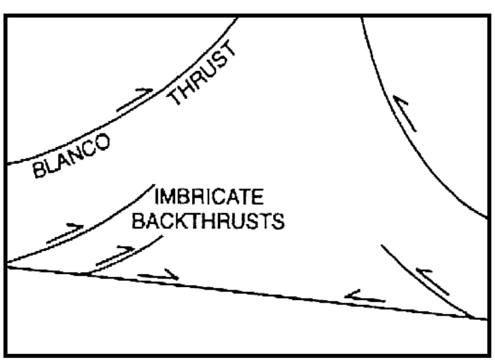
Hardie (1988) suggested the presence of blind imbricate thrusts to the north, and a series of backthrust, as well as a decollement extending into the basin (Fig. 32).

Milliken (1988) (Fig. 33a) suggested a north dipping imbricate thrust with a thin triangle zone. He suggested the “Carbon fault” joins a deep decollement and does not extend into the basin . Camp and Ratcliff (1989) (Fig. 33a) also identified a deep decollement with a thick triangle zone. The decollement is floored by imbricate thrusts faults and backthrusts Reeves and others (1990) (Fig. 33b) published a seismic section recognizing a deep and a shallow decollement. Two triangle zones were defined. One located above the shallow (Fig.33) decollement, the other with imbricate thrust between the shallow and deeper decollement.

Perry and Suneson (1990) proposed a triangle zone above a deep decollement extending into the basin. They identified several backthrusts (Fig 33b).

Wilkerson and Wellman (1993) described blind imbricate thrusts, tear faults and a thin triangle zone (Fig. 34).

In 1992, as part of an OCAST study (Oklahoma Center for Advancement in Science and Technology a group of students under the directions of Dr. Cemen started working on the geometry of the trust faulting along the frontal Ouachitas and Arkoma Basin. The study was undertaken because of the natural gas reservoirs in the Wilburton gas field area . The study aimed to determine the structural geometry of the area associated with thrust belts, as well as the nature of the gas traps.



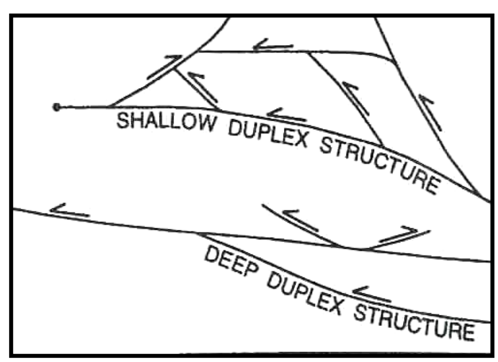


Figure 32.   Sketch of subsurface geology: Hardie (1988) and Reeves et al. (1990).

Seven master thesis and several papers were written based on the work since 1992. Two papers were written in 2001 summarizing that work. (Cemen, Sagnak and Akthar (2001) and Cemen, Evans, and Sagnak (2001).   Another paper by Hadaway and Cemen (2005,) deals with the structural geometry of thrust faults in the Hartshorne gas field area.

Cemen, Sagnak, and Akthar (2001) suggested a triangle zone made out of the Choctaw Fault to the south, and the Carbon fault to the north (Fig 35) . The triangle zone contains a lower detachment fault acting as the roof thrust of a duplex structure. The floor of the duplex is another detachment, the Springer detachment.   The duplex structure was interpreted as hinterland dipping duplex. They also suggested that imbricate thrust faults were formed in the hanging wall of the Choctaw fault.

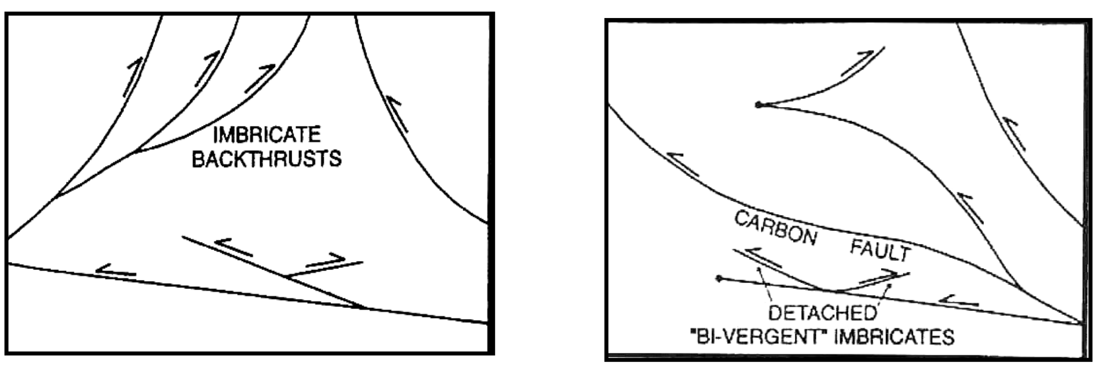


Figure 33 a) Sketch of subsurface geology : Camp and Ratliff (1989) and Milliken (1988).

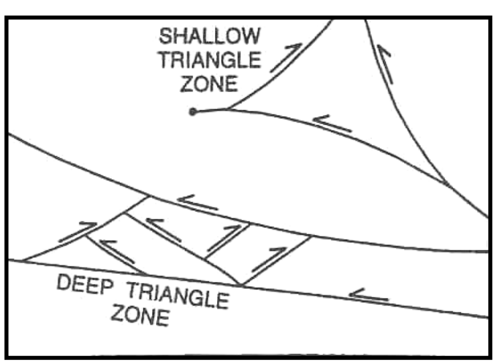


Figure 33. b)   Sketch of subsurface geology Perry and Sunneson (1990).

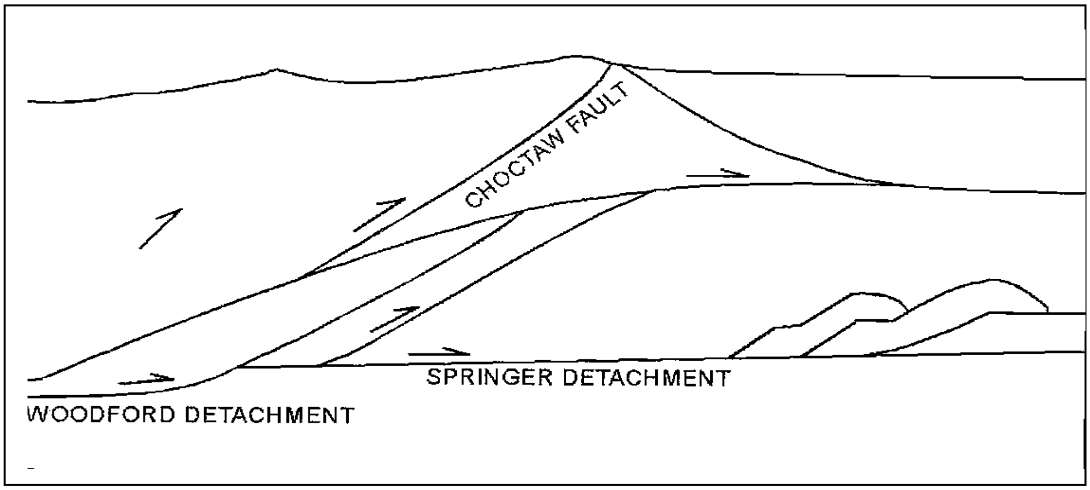


Figure 34. Sketch cross-section showing the geometry in the west of Wilburton gas field (From Wilkerson and Wellman, 1993).

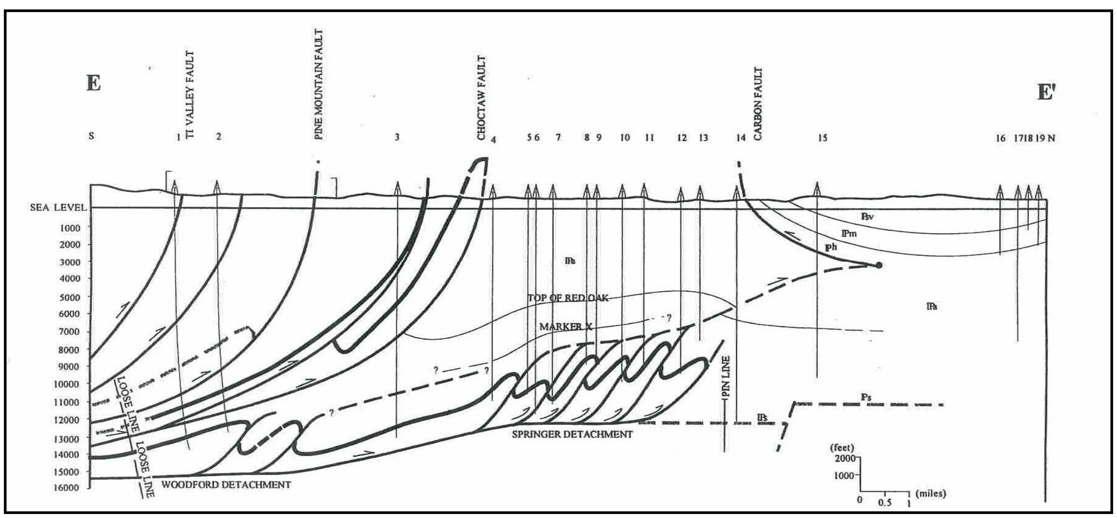


Figure 35. Cross Section from Cemen, Sagnak and Akthar’s (2001). Interpretation of subsurface geometry of the Frontal Ouachitas (Wilburton Gas Field).

CHAPTER V

STRUCTURAL GEOLOGY

In the study area, five cross sections and two structural contour maps were constructed to determine the geometry of the structural features. Contractional features dominate the frontal belt of the Ouachita mountains and Arkoma Basin transition zone. Within the study area, the northernmost thrust of the frontal Ouachitas is the Choctaw fault. The fault acts as a boundary that divides the basin into two distinct structural domains. The hanging wall of the Choctaw fault contains contractional structural features distinctly different than its footwall (Fig. 36-40). Significant gas reserves were found in multiple formations along the footwall of the Choctaw fault. Therefore, without ignoring the complex structure of the hanging wall, much of this study has been concentrated in the geometry of the footwall.

The cross-sections are based on the data obtained from the various types of logs of the drill holes to explore gas in the Spiro/ Wapanucka reservoirs. Auditable 2-D seismic lines are also examined to help cross-section construction. The structural contour maps of the Spiro, and the Red Oak Sandstones were constructed using Petra program. However, because the Spiro Sandstone is repeated three times in certain wells, only the top formation was used, using 50, 100, and 500 feet contour intervals. The 100 feet contour came out the best structurally drawn to include in this thesis. The method used to connect the features was triangulation and natural neighbor (Petra's instruction's manual.) The structural map was grided. Faults are apparent when the contours are bunched together. The maps were recontoured several times to verify the accuracy of the Petra program. Because of the thrusting, only the footwall was contoured. After the construction of the structural maps, the contour maps were compared to the cross sections (Fig.41-42).

Shortening of the crust was calculated using Canvas and Excel software programs. The length of all the segments of the Spiro Sandstone were measured and totaled. A pin line was put at the end of the northern most segment of the cross sections in the Spiro Sandstone where the strata is not deformed. Loose lines were inserted at the southernmost portion of the Cross Sections where the Spiro has been deformed. The total length of the Spiro after restoration is the original length of the strata. The lengths of the cross sections are the final lengths of the strata after deformation (Table I).

CHOCTAW FAULT

The Choctaw fault separates the Arkoma basin from the frontal Ouachitas, and is considered the leading edge thrust of the Ouachita fold thrust belt. The fault extends more than 120 miles within Oklahoma and trends west-southwest to east-northeast (Evans, 1995). At the northern part of the study area where the Choctaw fault crops out, it is dipping approximately seventy five degrees southward. It is flattening at depth. At the southern part of the study area the Choctaw fault is at approximately 12, 000 feet deep, and is almost horizontal. In the study area, a splay of the Choctaw fault crops out to the north , and forms a fault block basinward. It is called the Northern Choctaw fault. Previous studies Evans (1992), Ronck (1998), and Mehdi (1998) show that the fault block between the Choctaw and the northern Choctaw fault does not contain any Spiro Sandstone as opposed to the other fault blocks in the hanging wall. However, it does contain Red Oak and Panola middle Atokan sands that are only found in the footwall and in the Arkoma basin. It was confirmed in my cross sections. The Spiro Sandstone was not present in any wells located in this fault block. Therefore, the northern Choctaw is younger than the Choctaw fault (Fig. 36- 40).

HANGING WALL OF THE CHOCTAW FAULT

In the hanging wall of the Choctaw fault, they are several secondary thrusts that breaks to the surface (Fig. 36-40) . Some are major thrusts, others are splay faults that breaks off the major faults. These thrusts branch out from the Choctaw fault, making the Choctaw fault the main detachment surface for the thrusts. The geometry of this assemblage forms an imbricate fan structure.In the study area, the Ti Valley fault and the Pine Mountain faults are the main faults on the hanging wall of the Choctaw fault zone. The Ti Valley fault is the most southern fault. The Pine Mountain fault is located between the Ti Valley and Choctaw fault. The faults have a slight south-west to north-east orientation . Therefore, looking from the West to the East of the study area, the surface expression of the faults in each adjacent cross- section is moving further up to the north.

At the surface, to the south east of the Study area, across Sec. 1, T.3N, R.19E, Sec. 36, 35, 26, 27, T.4N, R.19E one fourth of a mile from the Cross-Section D-D', a strike –slip fault offsets the Atoka and John Valleys formations (Fig. 3 and 4). The offsets runs south east to north-east, and is approximately 1300, (OGS map, 1989). The fault seems to end and die in the Ti Valley splay. However, the trend could be continued to the Choctaw fault. There is a visible offsets in the faults making up the imbricate fans in Sections. 22, 21, 9, 10, 4, 5, T.4N, R.19E; Sec.30, T.5, R.19E; and Sec. 24, T.5N, R.18 (Fig. 36-40).

Blind thrusts are present in the hanging wall of the Choctaw fault. They do not crop out at the surface, but are physically expressed in the orientation of the bedding where dips of up to75 degrees can be seen (Fig. 36-40).

The Spiro sandstone of the lower Atokan series is present in the hanging wall of the Choctaw fault . However, the middle Atokan sands present in the northern part of the basin are absent. To the south of the study area, the Spiro sandstone crops out at the surface in Sections 5,6,31,32 of T. 3N and T4N, and R.18E and R.19E. Therefore, it must also be present in the northern thrusted sheets. However, it could not be seen because of the lack of well control, or because it was too broken up to be detected in the wire line well logs. In the cross sections where well control was not possible, the Spiro sandstone was projected from adjacent cross-sections (Fig.36-40).

FOOTWALL OF THE CHOCTAW FAULT

BASAL DETACHMENT

The major detachment of the Ouachitas to the south of the study area is the Woodford Detachment. Further to the north, the Woodford becomes the Springer detachment as it ramps up at the level of the Springer shale. The Springer detachment is at an approximate depth of 13000 feet. Normal faulting can be seen by the correlation of the late Paleozoic formations in well logs in cross section A-A' and B-B'. This normal faulting causes the Woodford detachment to ride on top of the fault and to step up to become the Springer detachment. This lower detachment branches off from the Woodford detachment and propagates northward in the basin (Fig. 36-40) .

To the north, the Springer detachment gently rises to approximately 30 degrees dip. It folds and bends the Spiro sandstone, and defines the northern end of a duplex structure. Both the Woodford and Springer detachment forms the floor thrust of the duplex structure.

DUPLEX STRUCTURE

In the duplex structure, a set of three horses containing the Spiro sandstone can be identified in both well data and seismic data (Fig. 43) . These horses are bounded by the floor thrust and the lower Atokan Detachment named LAD. This detachment was identified by Ahktar, Sagnack, and Evans (1997), and Cemen et al. (2001). There is a change in geometry between the Spiro sandstone located within the horse, and the middle Atokan Red Oak sandstone located above the horses. This geometry cause a difference in dips between the two formations. This is indicative of a barrier between the two formations (Evans, 1997) and evidence for a roof thrust.   The exact position of the floor thrust cannot be located but can be inferred from the seismic data and the well logs available.

In the study area, correlation of the Spiro sandstone between the wells and seismic data indicates three sets of horses. The Spiro sandstone was identified as a major reflector in the seismic sections (Fig. 46).   Their placement is shown in the well logs by the repeat of the Spiro sandstone two or three times in the same wells in cross-section A-A', B-B', C-C' (Fig. 36-38).   In cross-sections D-D'and E-E' (Fig 39, 40) the wells were not drilled deep enough to allow control of the data, so the horses were approximated using the data from the adjacent cross-sections.   The interpretation of a duplex structure matches the data for all the cross sections.   Above the set of horses, the Red Oak is deformed and folded (Fig. 36-40). It rises as an anticline. This is an indication of structural deformation from thrust faulting and shortening of the middle Atokan Rocks as the duplex was formed.

The duplex structures in cross-sections A-A', B-B', C-C' are structurally higher than cross-sections D-D' and E-E' because the Spiro Sandstone is located much lower in the last two cross-sections in sea level depth .   The Duplex structure seems to flatten out to the east of the cross-sections. (Fig 36-40). This could be an indication of a change in geometry, and a possible lateral ramp.

NORMAL FAULTING

Normal Faults are located to the north of the cross-sections A-A’ to E-E’ in the footwall of the Choctaw fault and below the duplex structure. The faults to the north of the duplex structures are evidenced by the breakdown of subsea elevations in the Spiro sandstone (Fig 36-40) There is an upward northern trend in the location of the Spiro sandstone. The Spiro Sandstone is stratigraphically located higher as indicated in cross sections A-A’ to E-E’. Those normal faults are interpreted to be formed before the thrusting due to the bending of the Pre-Pennsylvanian sedimentary section and basement of the foreland basin. Normal faulting is concentrated in the lower Atokan section, and does not affect the middle Atokan Red Oak sandstone.

The normal faults located below the duplex structure are evidenced by a change in depth between stratigraphic units older than Pennsylvanian. In the cross section A-A’ between wells #82 and #84, the Viola is displaced 2000’. The downthrown side of the fault is to the south. This normal fault is located beneath the duplex structure. This normal fault acted as a barrier and impeded the lateral propagation of the Woodford detachment. Instead, it served as a gliding plane and tectonic ramp to the detachment. This decollement, which was riding on top of the Woodford stepped up to the Springer formation and became known as the Springer detachment

STRIKE SLIP FAULTING AND LATERAL RAMP

Strike slip faulting in the thesis area was derived from observations of anomalies made by simple analysis of the cross sections and the maps produced in this thesis. The simplified structural map (Fig. 3) shows curvature of the main thrust fault and offsets of stratigraphic units which are ramping up in a north west trend. The structural contour map of the Spiro Sandstone (Fig. 41) shows a drop in subsea depth to the east of the thesis area. This drop is beneath the surface trace of the Choctaw fault where the duplex structure should be located. In the cross-sections, the duplex structure to the east (Fig 36-40) are flatter than the ones to the west and at a lower subsea level. In the cumulative gas production map (Fig. 11) there is an increase of the Spiro Sandstone production trending south east to north west which does not stay parallel to the Choctaw fault. As seen on Fig. 12, wells drilled into the Spiro Sandstone in the eastern part of the thesis area, next to the surface trace of the Choctaw fault are dry. The shortening calculations of cross- sections A-A', B-B', and C-C' are 10% more than the shortening calculations of cross- sections D-D' and E-E'. As seen on the topographic maps (Fig 5 a, 5b, and 5c) there are geomorphic discontinuities where the carbon fault dies out in sec. 26, T.6N, R.18E. These discontinuities are evidence for the presence of a lateral ramp in that area. From studies in the Appalachian mountain and around the world Pohn (2000) concluded that strike slip faulting is rarely apparent in the surface where a lateral ramp forms. In the Appalachian and worldwide, faulting in the basement rocks is thought to be responsible for the lateral ramps (Pohn, 2000). In the thesis area, faulting is evidenced from well data, and was projected to cross section A-A' and B-B' where the detachment fault ramps up on top of a normal fault from the Woodford detachment to a higher level. Therefore, the Paleozoic strata beneath the Pennsylvanian time could be responsible for the formation of a lateral ramp in the thesis area. Normal faulting could hinder the progression of a frontal lateral ramp and cause stratigraphic thickness in a localized area. In turn, the increase in stratigraphic thickness would have caused differential stress, and a change in the direction of that stress perpendicular to the transport direction. Seismic studies along the Choctaw fault show a very disturbed Paleozoic strata beneath the Atokan time (Fig 44).

From these observations, a strike slip fault or lateral ramp is believed to be present in the thesis area. The movement would be a left lateral movement, and the fault is trending southeast-northwest

TRIANGLE ZONE

From well log data, and the non repetition of formations of middle Atokan age, a triangle zone does not seem to have formed in the subsurface of the study area. If indeed it is the case, it would be compatible with the hypothesis of a lateral ramp. The fact that stress was transferred perpendicular to the direction of transport could have prevented a backthrust to form by minimizing the frontal stress. However, seismic data in Syed's thesis area (1996) showed the presence of the triangle zone in the subsurface to the east of the study area. Therefore, it could be concluded that the triangle zone has been displaced due to the lateral ramp. A further study of the area using 3-D seismic data could confirm or reject the location of a triangle zone. Fig. 45 is a diagram illustrating a possible geometry of the Carbon fault as a result of the lateral ramp.

RESTORED CROSS SECTIONS AND AMOUNT OF SHORTENING

The cross sections were restored using the key bed restoration method. The amount of shortening was calculated by measuring the length of the Spiro sandstone in each cross-section before shortening (lo) and after shortening (lf). The difference between the two gave us the shortening distance. The amount of shortening was then computed by using the ratio between the final length and the original length of the Spiro sandstone. The formula used was**:** (lf – lo)/ lo**.** The percent shortening was then computed by multiplying by 100 (Table III). In the study area, the Spiro sandstone in the footwall was used for restoration because it is the bed that was used to map the major structural features of the basin. Pin lines were located to the north of the duplex structure at the boundary where compressional forces are not present (Fig. 36-40) . The loose lines were located to the south of the cross section below the Choctaw fault in the footwall. Those pins marked the section within the cross- sections that were used to calculate the amount of shortening. The Spiro within the imbricate faults of the thrust system were not included. The shortening calculation for each cross-sections were done using excel software program (Table III). Cross section A-A' has a shortening of 35 %, cross section B-B' a shortening of 32%, C-C' a shortening of 39%, D-D' a shortening of 26%, and E-E' a shortening of 29%. The shortening calculations fit the hypothesis of a lateral ramp by the fact that if a lateral ramp is in fact perpendicular to the transport direction, and ramping eastward, shortening should be less towards the east.

SHORTENING CALCULATIONS					
FORMULA FOR CALCULATING SHORTENING = (lf-lo)/lo					
SCALE 1:24000					
MEASUREMENT IS IN FEET					
	Lo	**Lf**	**Lf-Lo**	**Shortening**	**Percentage**
CROSS-SECTION A-A'	95830.00	62595.00	-33235.00	-0.35	34.68%
CROSS-SECTION B-B'	97379.00	66610.00	-30769.00	-0.32	31.60%
CROSS-SECTION C-C'	92766.76	56374.98	-36391.78	-0.39	39.23%
CROSS-SECTION D-D'	92965.00	68817.00	-24148.00	-0.26	25.98%
CROSS-SECTION E-E'	96696.84	68639.31	-28057.53	-0.29	29.02%

Table III. Shortening calculations computed with Excel software program.

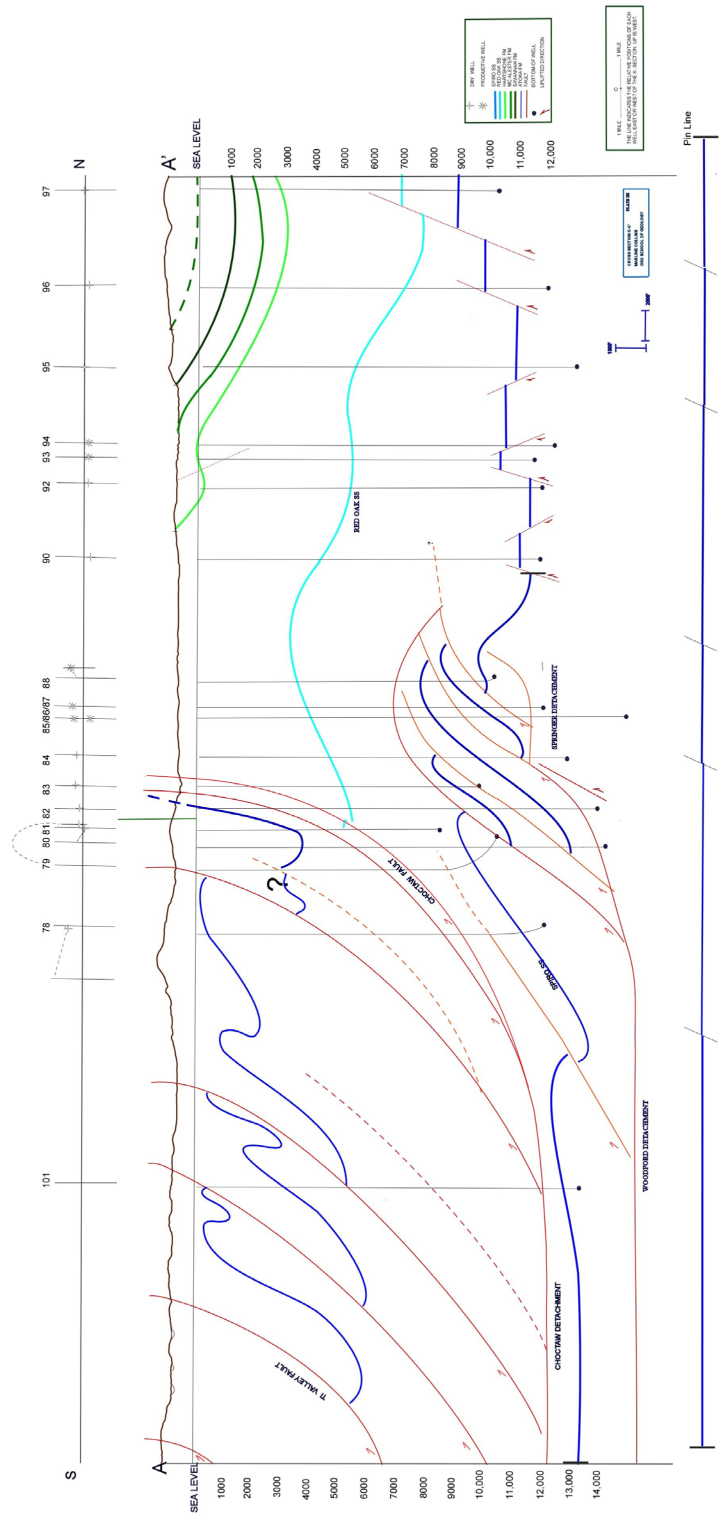


Figure 36 . Cross-Section A-A'

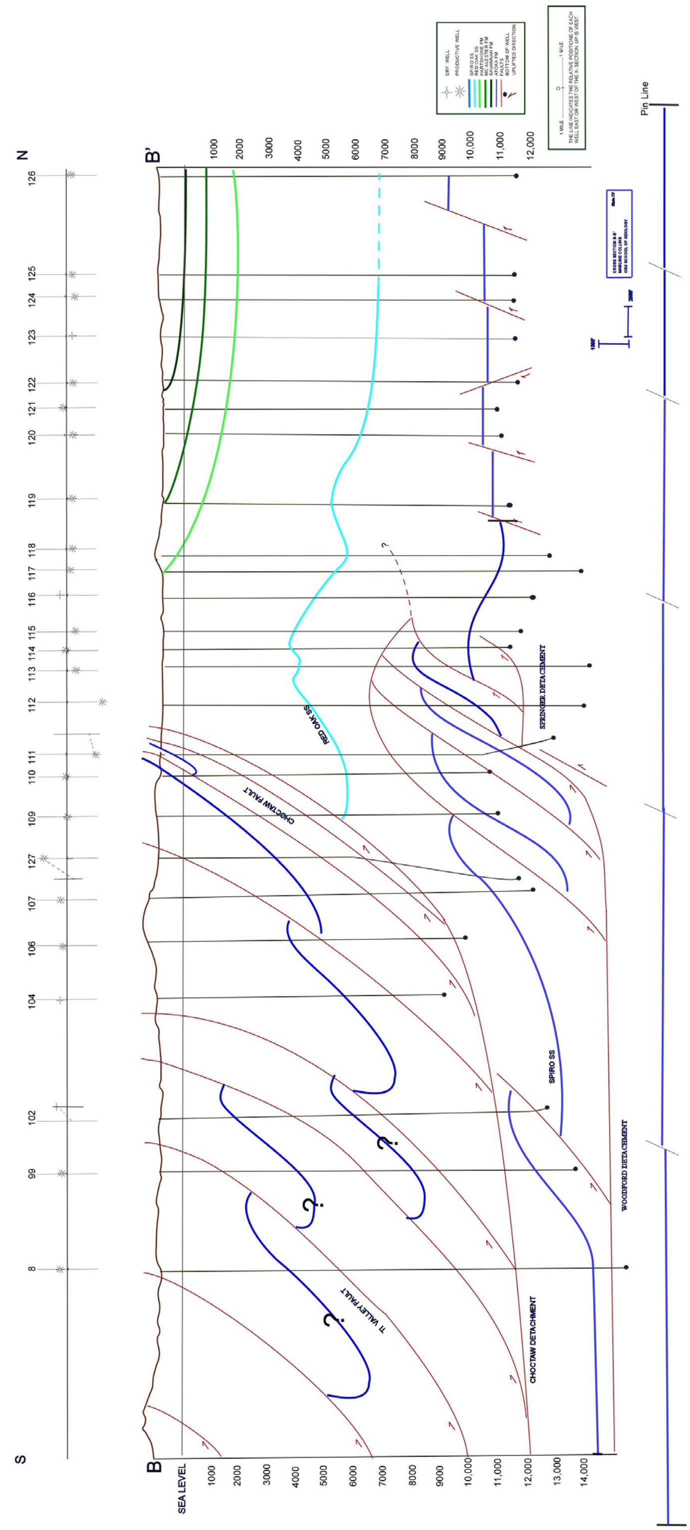


Figure 37 . Cross-Section B-B'

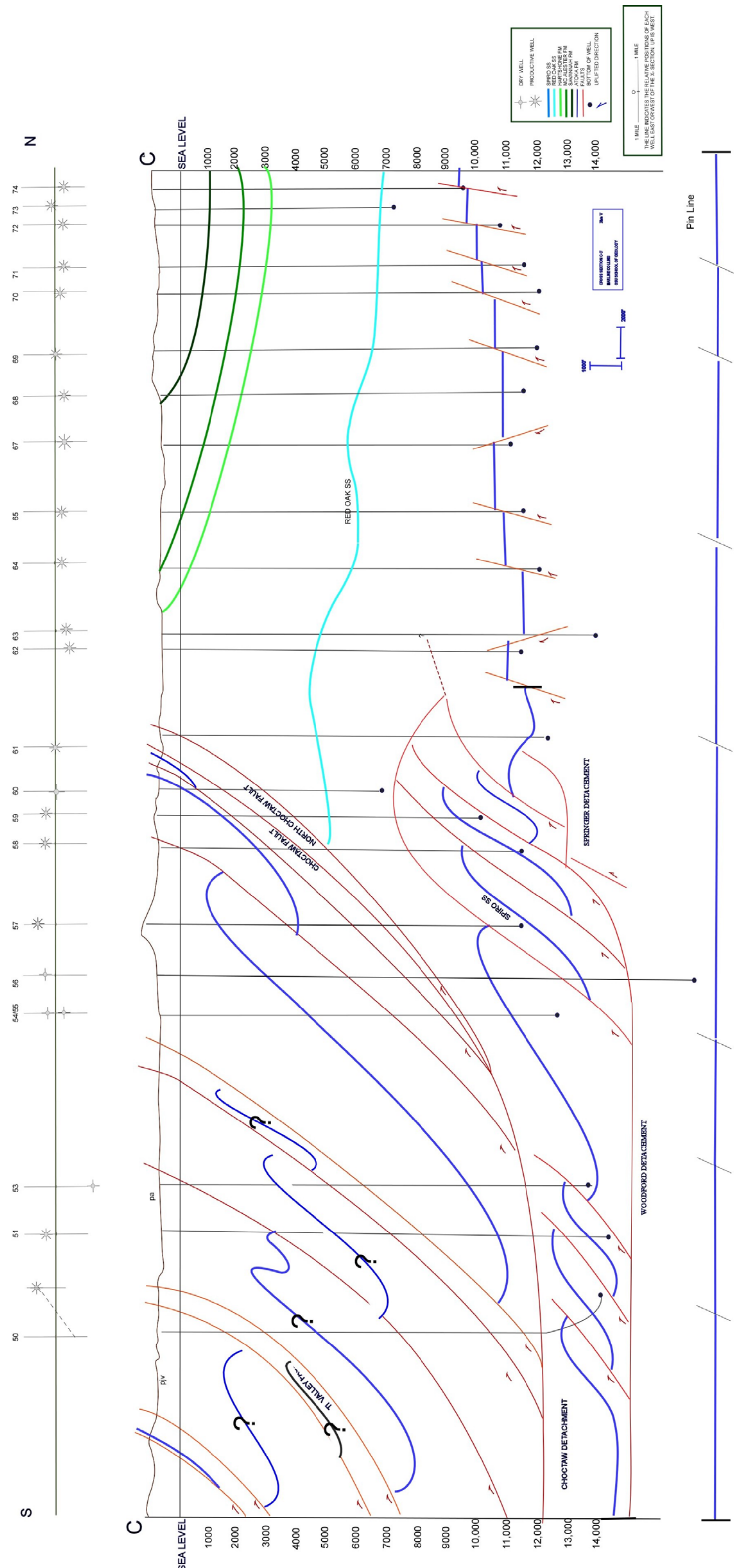


Figure 38 . Cross-Section C-C’.

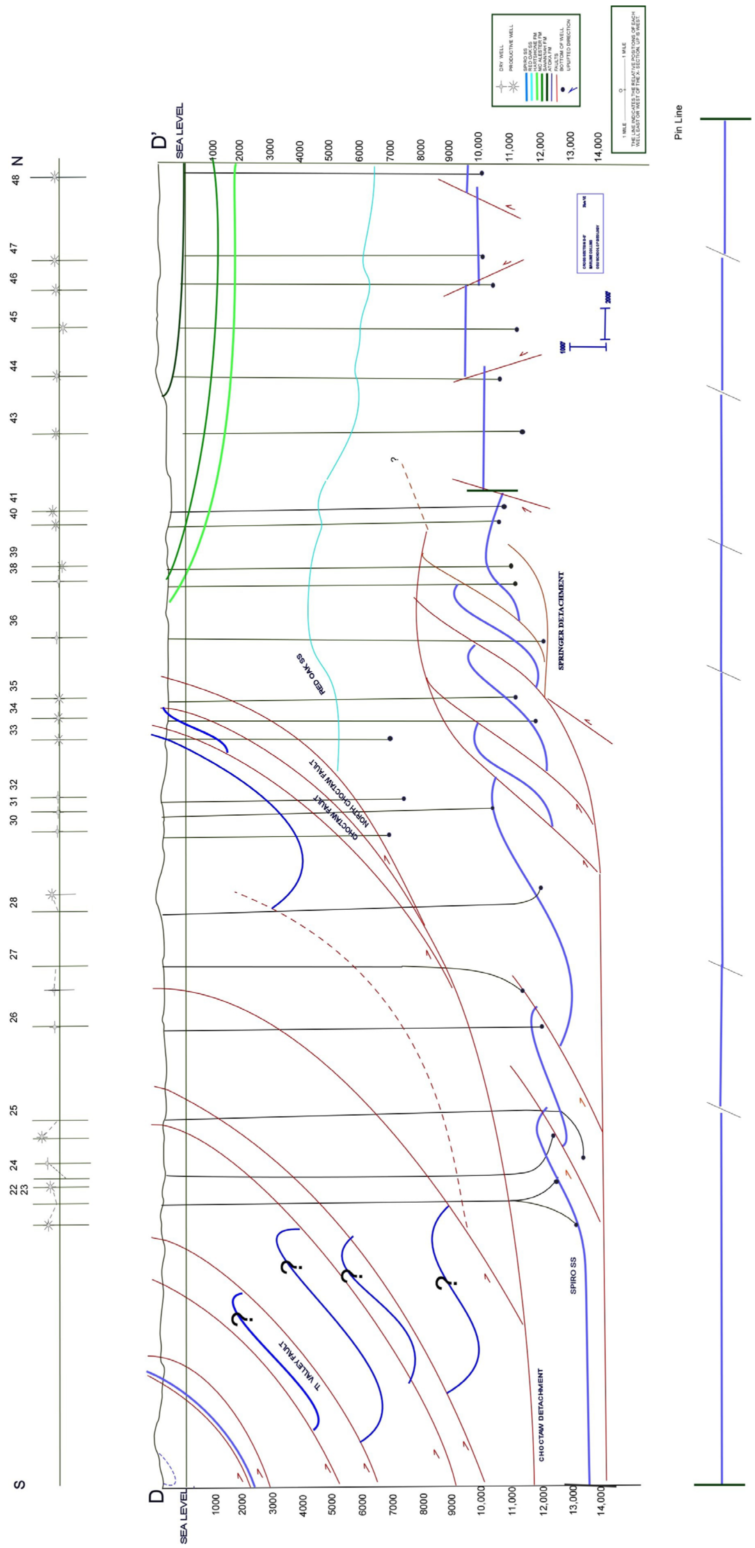


Figure 39. Cross-Section D-D'.

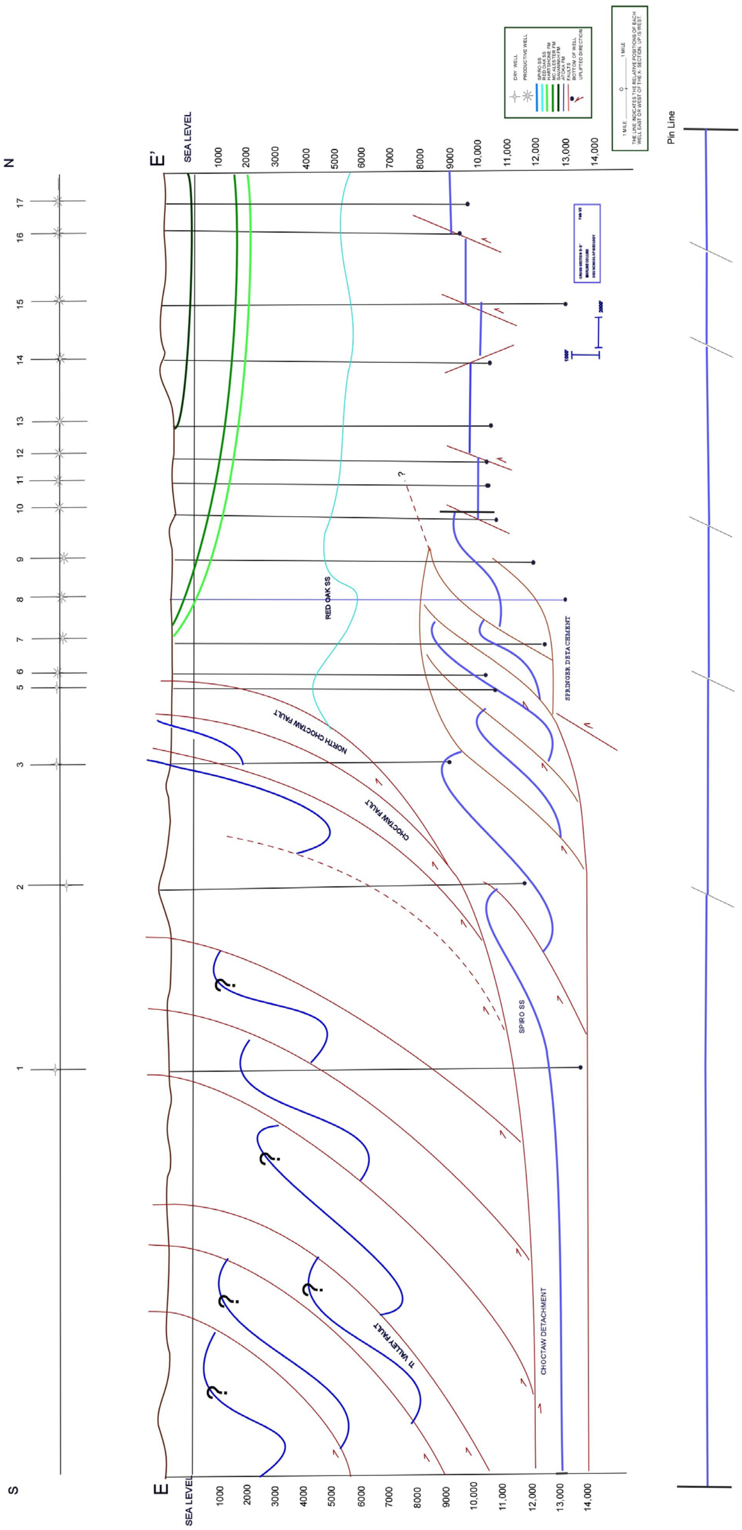


Figure 40 . Cross-Section E-E'.

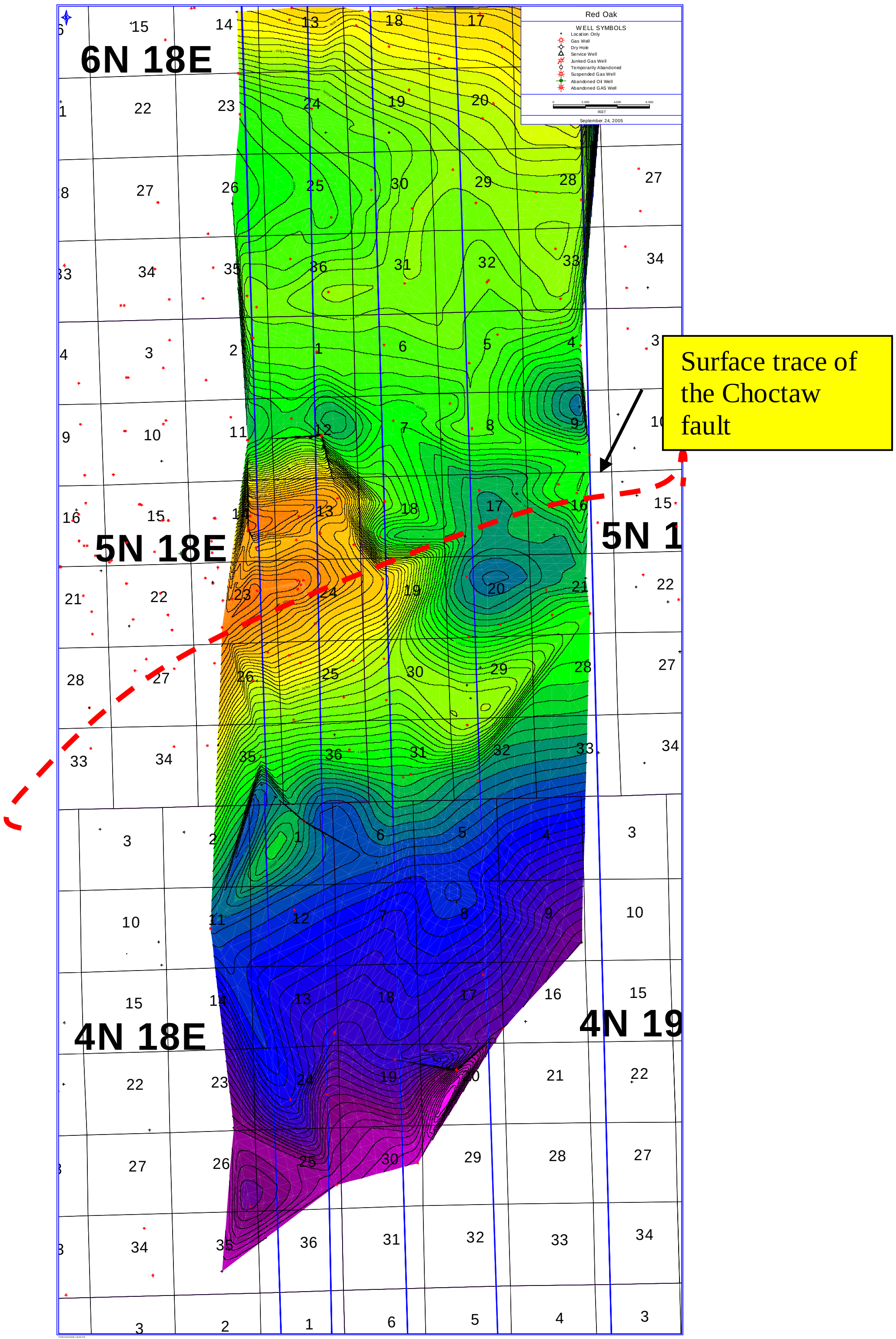


Figure 41 . Structural contour map of the Spiro Sandstone (100' contour interval)

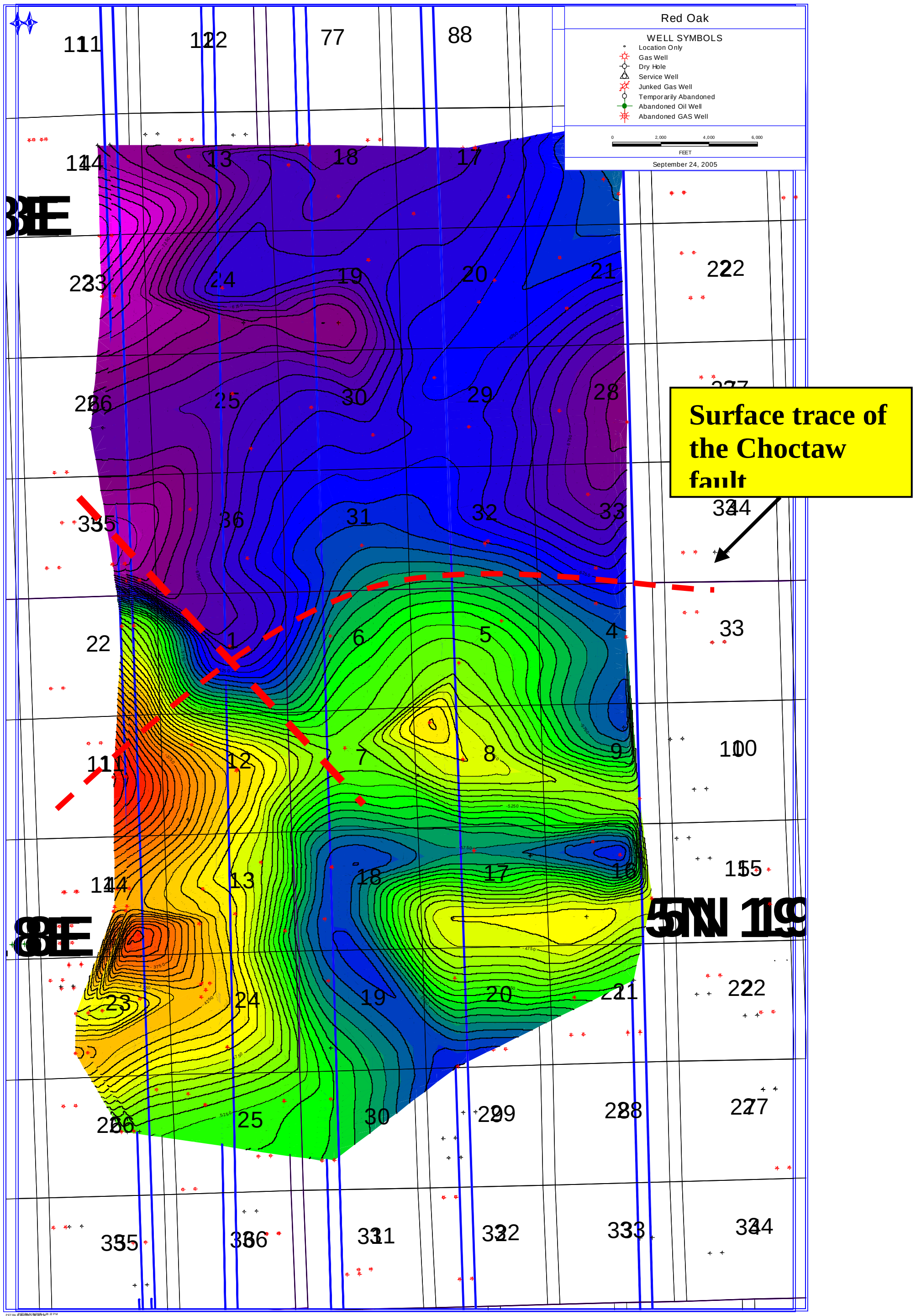


Figure 42 . Structure contour map of the Red Oak. (100 ‘ contour interval.)

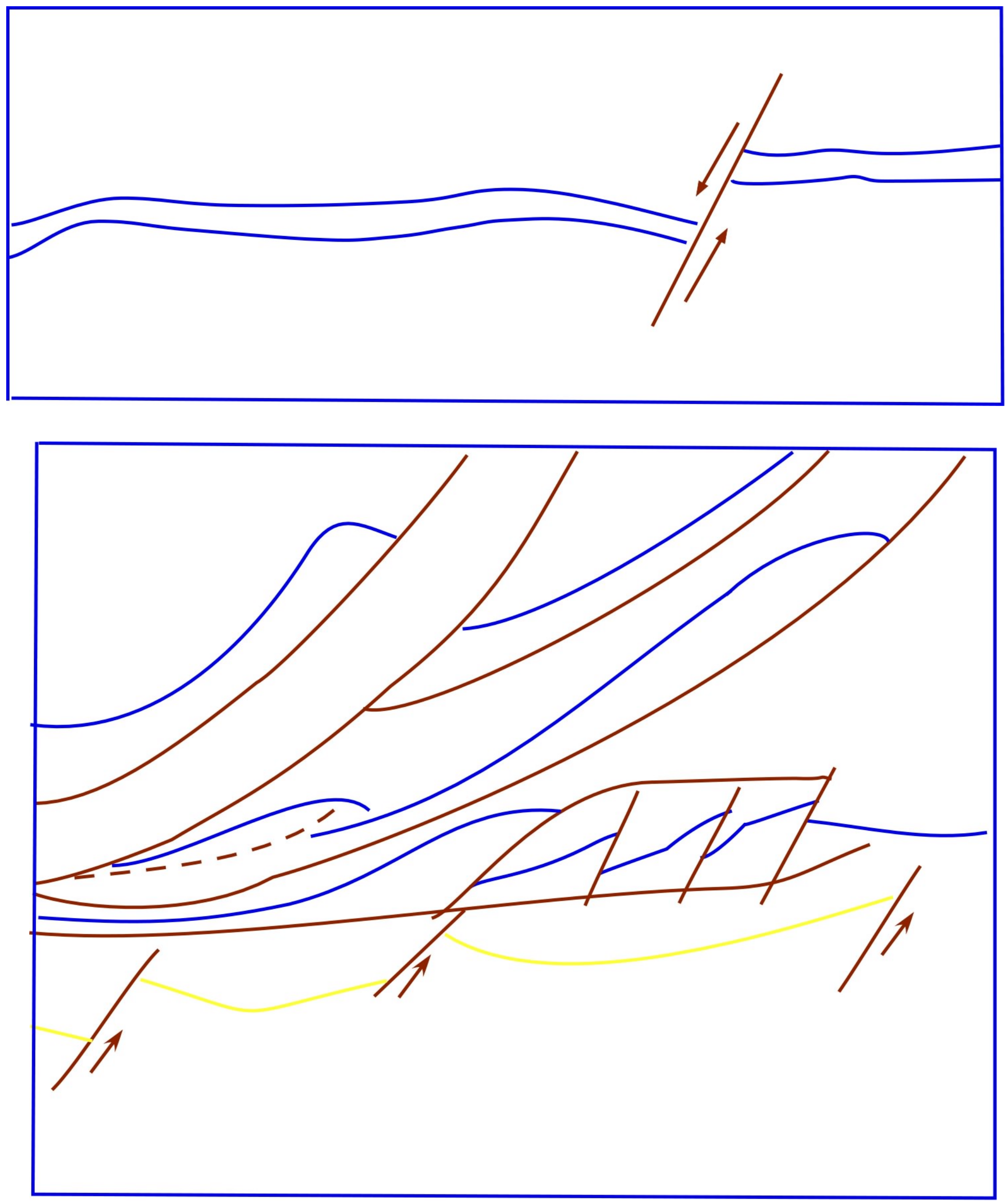


Figure. 43   Seismic data close to the thesis area. A. Normal Faulting in the northern area. B. Duplex Structure under the Choctaw fault. Interpretation of seismic lines donated by Devon Energy .

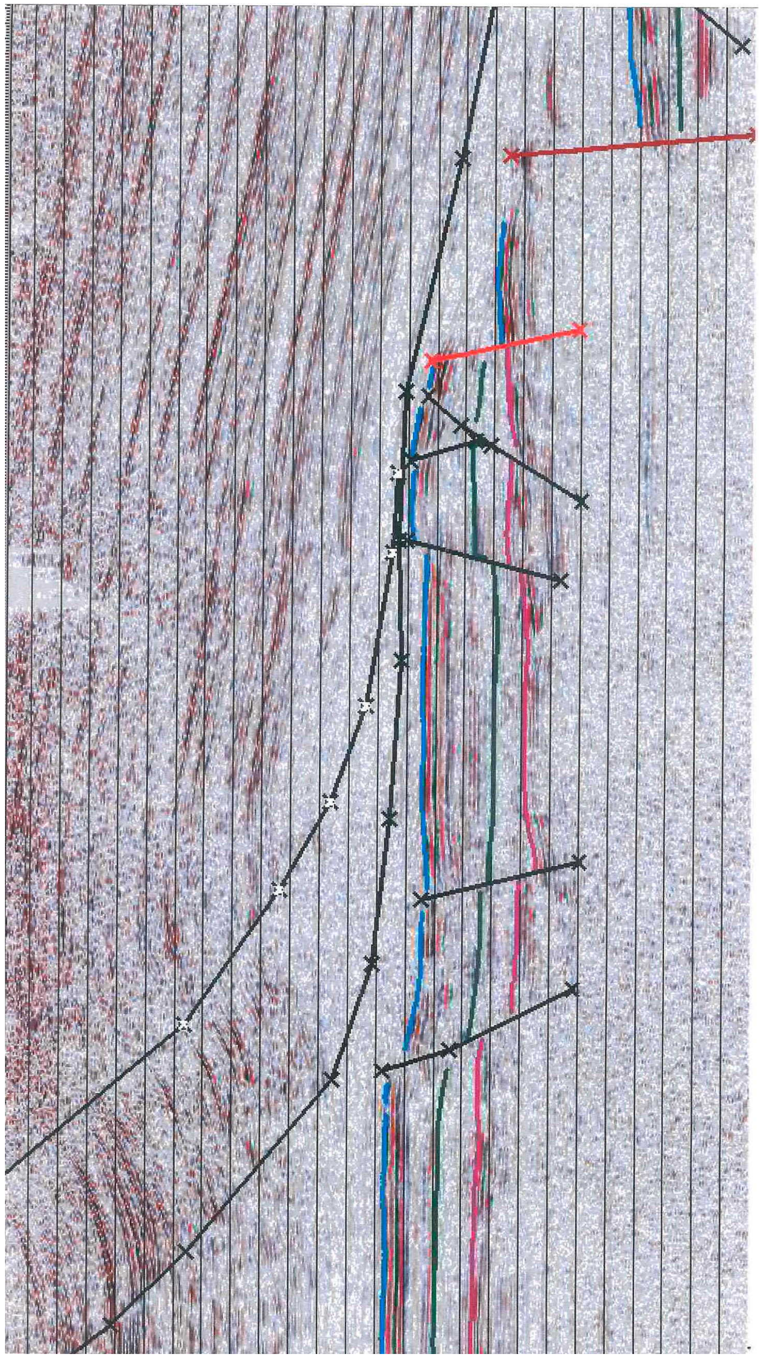


Figure 44 . Interpretation of faulted Paleozoic strata of late Atokan, Morrowan, Mississipian, Precambrian by Jim Vilbert, Continental Resources. Inc. Courtesy of X-Mark (trademark.) The seismic line is located south west of the thesis area.

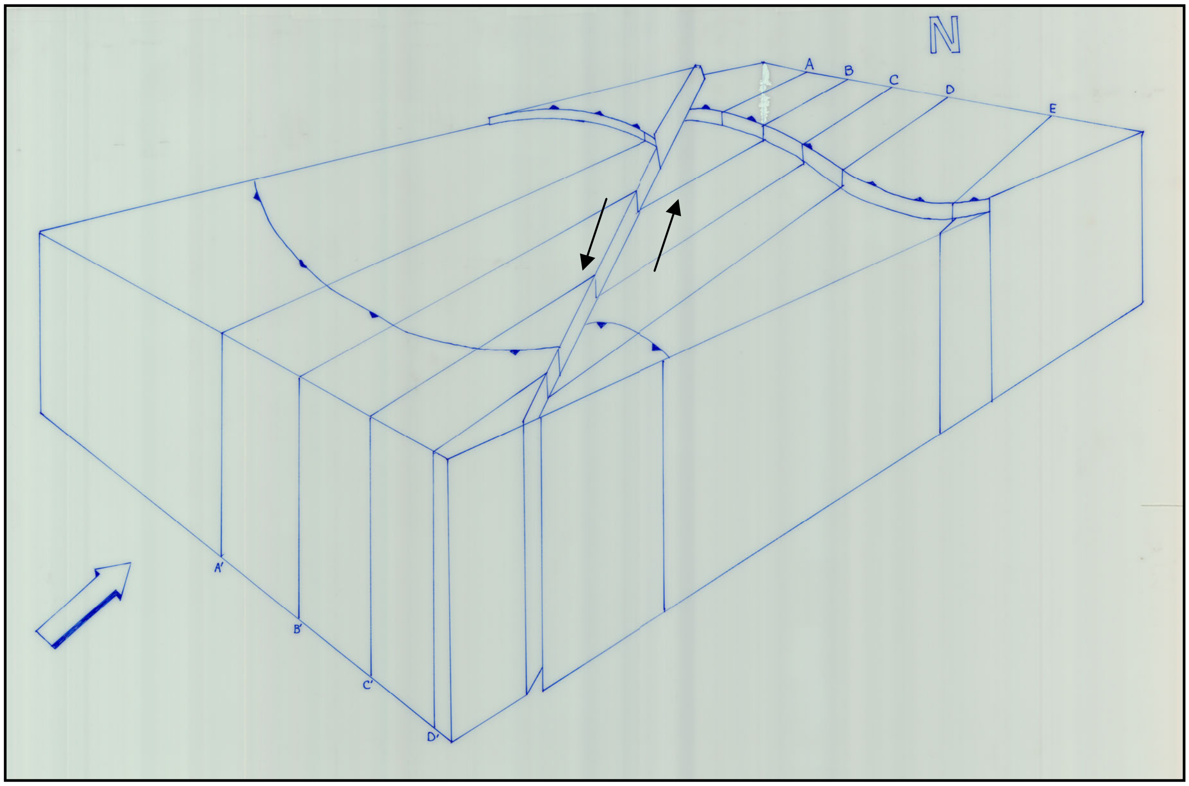


Fig. 45 - Diagram of strike slip faulting above the duplex structure at 5000' below sea level. Possible geometry of the Carbon fault due to a lateral ramp. The arrow to the left west corner represents the stress direction. The cross sections are labeled. Drawing by Tim Wehrle.

CONCLUSIONS

As a result of this investigation, the major conclusions for this thesis can be summarized as follow:

1. Imbricate fan structures are the main structural features in the hanging wall of the Choctaw fault.
2. A duplex structure with the Springer detachment riding on top of normal faulting is the floor thrust, and the Lower Atokan detachment is the roof thrust.
3. Three horses formed within the duplex structures. The horses flatten out in an easterly direction.
4. Strike slip faulting is cutting the Pennsylvanian strata in the subsurface.
5. A lateral ramp is formed where the carbon fault loses its surface expression.
6. A triangle zone does not seem to be apparent in this area from well log data. If a backthrust is present it is a blind thrust.
7. Shortening in the area ranges from 39% to 26% from west to east.
8. As the complex structural features of the Arkoma basin are revealed and mapped with the help of advanced technology, the search for petroleum in the basin is not about to stop.

REFERENCES

Akthar, Saleem, 1995. the Geometry of Thrust System in the Wilburton Gas Field and Surrounding, Latimer County, Oklahoma, M.S. thesis, Oklahoma State University, Stillwater, Ok..

Arbentz, J.K., 1989, Ouachita Thrust Belt and Arkoma Basin: in Hatcher, R.D., Jr., Thomas, W.A., and Viele, G.W., eds., The Geology of North America, vol. F-2, The Appalachian-Ouachita Orogeny in the United States, Geological Society of America, Boulder, Colorado, p. 621-634.

Boak, J., 1992, Conversion of Well Log Data to Subsurface Stratigraphic and Structural Information: Part 6, Geological Methods in Me 10: Development Geology Reference Manual, AAPG Special Publications, p. 289-293.

Boyer, S.E. and Elliot, D., 1992, Thrust Systems, American Association of Petroleum Geologists Bulletin, v 66, p. 1196-1230.

Branan, C. B., Jr., 1961, Tectonics of the Ouachita Mountains of Oklahoma and Arkansas, The Arkoma Basin, Proceedings of the Seventh Biennial Geological Symposium Held at the University of Oklahoma, Norman, March 7-8, 1961.

Branan, C.B. Jr., 1968, Natural Gas in Arkoma Basin of Oklahoma and Arkansas, Consulting Geologist, Oklahoma City, Oklahoma, Reprinted and Edited from AAPG Memoir 9, v 2, pp 1616-1635, Petroleum Geology of the Mid-continent Tulsa Geological Society, Special Publication 3.

Brown, A.R., 1999, Interpretation of Three-Dimensional Seismic Data, Fifth Edition, AAPG Memoir 42, SEG Investigations in Geophysics, No. 9.

Buchanan and Johnson, 1986, Bonanza Gas Field-A Model for Arkoma Basin Growth Faulting, in Cline, S.M., ed., Geology of the Western Arkoma Basin and Ouachita Mountains, Oklahoma City Geological Society Guidebook, p. 75-85.

Busby, Cathy J., and Ingersoll, R.V., 1995, Tectonics of Sedimentary Basins, Blackwill Science, Cambridge Massachusetts.

Butler, R.W.H, 1987, Thrust Sequences, Journal of the Geological Society of London, v 144, 1987, p. 619-634.

Camp, W.K. and Ratliff, R.A., 1989, Balanced Cross-Section Through Wilburton Gas Field, Latimer County, Oklahoma: Implications for Ouachita Deformation and Arbuckle Exploration in Arkoma Basin (Abstract): AAPG Bull, v.73, p. 1044.

Cemen, I., Al Shaieb, Z., Hess, F., Akthar, S., and Feller, R., 1995, Geometry and Thrusting in Wilburton Gas Field and Surrounding Areas, Arkoma Basin, Oklahoma, Implications for Gas Exploration in the Spiro Sandstone Reservoir; Abstract, AAPG Bull. v 79, no. 9, p. 1401.

Cemen, I., Al Shaieb, Z., Sagnak, A., Feller, R., and Akthar, S., 1997, Triangle Zone Geometry of the Frontal Ouachita in the Wilburton Area, Arkoma Basin, Oklahoma: Implications for Fault Sealing in the Wilburton Gas Field (Abstract) AAPG Annual Convention Program with Abstracts, p. A-19.

Cemen, I., Evans, J., and Sagnak, A., 2001, Eastern Continuation of the Wilburton Triangle Zone in the Red Oak Gas-Field Area, Frontal Ouachitas-Arkoma Basin Transition Zone, Southeastern Oklahoma, Oklahoma Geological Survey, Circular 106, p. 81-94.

Cemen, I., Kerr, D., Roberts, Suneson, N. Stratigraphic and Structure of the Arkoma Basin-Ouachita Mountains Transition one and Frontal-Belt Reservoir Facies: Implications for Exploration and Development, Oklahoma Geological Survey, guidebook 34.

Cemen, I., Sagnak, A. and Akthar, S., 2001, Geometry of the Triangle Zone and Duplex Structure in the Wilburton Gas Field Area of the Arkoma Basin, Southeastern Oklahoma, Oklahoma Geological Survey, Circular 104, p. 87-98.

Couzens, B.A. and Wiltschko, D. V., 1994, Some Constraints for Mechanical Models of Triangle Zones, Abstract, Western Canadian and International Expertise, Exploration Update, A Joint Convention of CSEG and CSPG, Calgary, Alberta, 1994, p. 370-371.

Dahlstrom, C.D.A., 1970, Structural Geology in the Eastern Margin of the Canadian Rocky Mountains, Bulletin of Canadian Petroleum Geology, 18, p. 332-406.

Davis, G. H., and Reynolds, S. J., 1984, Structural Geology of rocks and Regions, Jon Wiley and Sons, Inc., Canada.

Drover, D. H., and Sprat, D. A., 2000, Lateral Ramps and Leading Edge Folds – The Along-Strike Variation of the Quirk Creek Structure, Reservoir, v 27, Issue 3, p. 18.

Elmore, D.R., Sutherland, P.K., White, P.B., 1990, Middle Pennsylvanian Recurrent Uplift of the Ouachita Fold Belt and Basin Subsidence in the Arkoma Basin, Oklahoma, Geology, v. 18.,September, p. 906 –909.

Evans, Justin, Structural Geometry of Thrust Faulting in the Baker Mountain and Panola Quadrangles, Southeastern Oklahoma, M.S. Thesis, 1997, Oklahoma State University.

Feller, R., 1995, Characteristics of Abnormally-Pressurized Gas Compartments and Potential Sealing Mechanisms in the Spiro Sandstone, Arkoma Basin, Oklahoma, Abstract, Geological Society of American, v 27, Issue 3, p. 49

Flawn and others, 1961, The Ouachita System, Peter T. Flawn, August Goldstein, Jr., Phillip B. King, and C.E. Weaver, University of Texas, Publication Number 6120, October 15, 1961, Bureau of Economic Geology, The University of Texas, Austin, Peter T. Flawn, Director.

Frezon , 1962, Correlation of Paleozoic Rocks from Coal County Oklahoma to Sebastian County, Arkansas, Oklahoma Geological Survey, Circular 58.

Fritz, R.D., and Hooker, E.O., 1994, Stop 10, Spiro Sandstone, Oklahoma Geological Survey Guidebook 29, Geology and Resources of the Eastern Ouachita Mountains Frontal Belt and Southeastern Arkoma Basin Oklahoma.

Grayson, R.C. Jr., 1979, Stop Descriptions, 5th day, Oklahoma Geological Survey Guidebook 19, Ozark and Ouachita Shelf to Basin Transition, Oklahoma-Arkansas.

Grayson, R.C. Jr., and Hinde, L.K., 1993, Lower Atoka Group (Spiro Sand) Stratigraphic Relationships, Depositional Environments and Sand Distribution, Frontal Ouachita Mountains, Oklahoma, Oklahoma Geological Survey Circular 95.

Hadaway, S., 2004, Structural Geometry of Thrust Faulting in the Hartshorne Southwest Quadrangle, Arkoma Basin, southeast Oklahoma, M.S. Thesis, Oklahoma State University.

Hadaway, S., and Cemen, I., 2005, Tear Faulting and Compartments for Gas Production in southwest Hartshorne Gas Field, Arkoma Basin, Southeast Oklahoma, Shale Shaker, Oklahoma City Geological Society, January-February, 2005.

Ham, W.E ., 1978, Regional Geology of Arbuckle Mountains, Oklahoma, Oklahoma Geological Survey, Special Publication 73-3. p. 61.

Hardie, W, 1988, Structural Styles of the Frontal Thrust Belt of the Ouachita Mountains, Southern Pittsburg County, Oklahoma: Oklahoma Geology Notes, v 48, no.6, p. 232-246.

Hess, F. B., 1995, Sedimentology and Depositional Environments of the Lower Atokan Spiro Sandstone in the Wilburton, Red Oak, and Kinta Fields, Arkoma Basin, Oklahoma, M.S. , Oklahoma State University, Stillwater, OK.

Houseknecht, D.W. and Kacena, 1983, Tectonic - Sedimentary Evolution of the Arkoma Basin and Guidebook to Deltaic Facies, Hartshorne Sandstone, Houseknecht, and others, SEPM Mid-Continent section, Volume 1, October 1983- Tectonic and Sedimentary Evolution of the Arkoma Foreland Basin.

Johnson, K.S., 1988, General Geologic Framework of the Field-Trip Area, in Johnson, K.S. ed., Shelf to Basin Geology and Resources of Pennsylvanian Strata in the Arkoma Basin and Frontal Ouachita Mountain.

Johnson K.S., Northcutt, R. A., Hinshaw, G. C., Hines, K. E., 2005, Geology and Petroleum Reservoirs in Pennsylvanian and Permian Rocks of Oklahoma, Oklahoma Geological survey Circular 104, p. 1-19.

Kaldirim, Osman, 2004, Geometry of Late Paleozoic Thrust Faulting in Southwestern Hartshorne Gas Field, Arkoma Basin, Southeastern Oklahoma, M.S. Thesis, Oklahoma State University.

Keller, G.R., and Cebull, S.E., 1973, Plate Tectonics and Ouachita System in Texas, Oklahoma, and Arkansas, Geological Society of America Bulletin, v. 83.

Kruger and Keller, 1986, Kruger, J.M. and Keller G.R., 1986 Interpretation of Crustal Structure from Regional gravity Anomalies, Ouachita Mountains Area and Adjacent Gulf Coastal Plain, AAPG Bulletin, v 70 No.6 June 1986 P 667-689.

Lumsden, D.N., Pittman, E.D. and Buchanan, R.S., 1971, Sedimentation and Petrology of Spiro and Foster Sands (Pennsylvanian), McAlester Basin, Oklahoma; AAPG Bulletin 55, p. 254-266.

Maher Jr. H. D., Modeling a Fold Thrust Belt With a Sandbox. Department of Geography and Geology, University of Nebraska, Ohaha, Ne. Research University of Nebraska.

Marshak S., and Mitra, G., 1988, Basic Methods of Structural Geology. Prentice Hall, Englewood Cliffs, NJ.

McClay, K.R., ed , 1992, Glossary of Thrust Tectonic Terms, Thrust Tectonics, Chapman Hall, p. 447.

McPhail, 2001, Geometry and Structural evolution of the Thrust Faults in the Summerfield and LeFlore Southeast Quadrangles, Southeastern Oklahoma, M.S. Thesis, Oklahoma State University.

Mehdi, Syed, 1998, Structural Geometry of Thrust System in the Red Oak and Talihina Quadrangles, Latimer and Leflore Counties, Arkoma Basin Southeastern Oklahoma, M.S. Thesis. Oklahoma State University.

Milliken, J.V., 1988, Late Paleozoic and Early Mesozoic Geologic Evolution of the Arklatex Area: Rice University, Houston, Unpublished M.S. thesis.

Mitra , S., 1986, Duplex Structures and Imbricate Thrust Systems; Geometry, Structural Position and Hydrocarbon Potential, AAPG Bull, 70, p. 1087-1112.

Montgomery, S.D., 1989, Petroleum Frontiers, Drilling the Deep Arkoma, Petroleum Information Corporation.

Perry, W.J, Suneson, N.H, 1990, Preliminary Interpretation of a Seismic Profile Across the Ouachita Frontal Zone Near Hartshorne, Oklahoma, Geology and Resources of the Frontal Belt of the Western Ouachita mountains, Oklahoma, Oklahoma Geological Survey, Special Publication 90-1, p. 145-148.

Pohn, H. A., 2000, Lateral Ramps in the Folded Appalachians and in Overthrust Belts Worldwide- A fundamental Element of Thrust-Belt Architecture, U.S. Geological Survey Bulletin 2163, August 10.

Price, R. A, 1994, “Triangle Zones” as Elements in a Temporal and Spatial Spectrum of Tectonic Wedging and Delamination, (Abstract), Western Canadian and International Expertise, Exploration Update, a Joint Convention of CSEG and SCPG, Calgary, Alberta, p. 208.

Reeves and others, 1990, Reeves, D.L., Schriener, W.P. and Sheffield, T.M., New State Mountain, Geology and Resources of the Frontal Belt of the Western Ouachita Mountains, Oklahoma,, Oklahoma Geological Survey, Special Publication 90-1, p. 37-40.

Ricardon M, Ruben M., Salfity, J. Structural Complexities Associated with Lateral Ramps in the Eastern Cordillera, Central Andes of Argentina., Universitad Nacional Tucuman-Conicet, Argentina, Research.

Ronck, Jeff, 1997, Geometry and Structural Evolution of the Thrust Faults in the Blackridge and LeFlore 7.5 Quadrangles, LeFlore County. M.S. Thesis, Oklahoma State University.

Sagnak, Ata, 1996, Geometry of Late Paleozoic Thrusting between Wilburton-Hartshorne Area, Arkoma Basin, southeast Oklahoma, M.S. Thesis, Oklahoma State University.

Stone, C. G., LeBlanc, Sr., R. J., McFarland III, J. D, 1979, Oklahoma Geological survey Guidebook 19, Stop descriptions – Fourth Day, Ozark and Ouachita shelf to Basin Transition Oklahoma-Arkansas.

Suneson, N.H, Campbell, J.A., and Tilford, M.J., 1990, Geology and Resources of the Frontal Belt of the Western Ouachita Mountains, Oklahoma Geological Survey, Special Publication 90-1.

Suneson, N.H. ,1992 and 1995, Structural Interpretations of the Arkoma Basin Ouachita Mountains Transition Zone, Southeastern Oklahoma; A Review; in Johnson, K.S. ed., Structural Styles in the southern Mid-continent, 1992 Symposium; Oklahoma Geological Survey, Circular 97, p. 259-263.

Suneson, N. H., Cemen, I., Kerr, D., Roberts, M.l., Slatt, R. Stone, C., 2005, Stratigraphic and Structural Evolution of the Ouachita Mountains and Arkoma Basin, Southeastern Oklahoma and Western Arkansas: applications to Petroleum Exploration, Geological Survey, guidebook 34, p.1-4.

Suppe, J., 1983, Geometry and Kinematics of Fault Bend Folding, American Journal of Science, v 283, p. 684-721.

Sutherland, P.K., and Manger, W. L., 1979, Mississipian-Pennsylvanian Shelf to Basin Transition Ozark and Ouachita Regions, Oklahoma and Arkansas, GSA Bulletin, Guidebook 19, May 27-June 1, p.1-13.

Sutherland, P.K. ,1979 and 1988, Late Mississippian and Pennsylvanian Depositional History in the Arkoma Basin area, Oklahoma and Arkansas; GSA Bulletin, v. 100 no. 11, p. 1787-1802.

Twiss, R. J., and Moores, E. M., 1997, Structural Geology, W. H. Freeman and Company, New York.

Valderrama, M.,H., Nielsen, K. C., McMechan, G. A., 1996, Three-dimensional Seismic Interpretation from the Triangle Zone of the Frontal Ouachita Mountains and Arkoma Basin, Pittsburg County, Oklahoma. AAPG Bulletin, v 80, No.8, August, p. 1185-1202.

Walper, J.L., 1977, Paleozoic Tectonics of the Southern Margin of NorthAmerica, Trans Gulf Association of Geological Societies, v 27, p. 1082-1100.

Wilkerson, M.S., and Wellman, P.C., 1993, Three Dimensional Geometry and

Kinematics of the Gayle-Buckeye Thrust System, Ouachita Fold and Thrust Belt, Latimer and Pittsburg Counties, Oklahoma, AAPG Bulletin, V 77, no. 6, June 1993, p. 1082-1100.

Wickman J., Roeder, D. and Briggs, G., 1976, Plate Tectonics Models for the Ouachita Foldbelt, Geology, March 1976.

APPENDICES

APPENDIX A

PRODUCTION DATA

TABLE I

PRODUCTION DATA

LATIMER COUNTY WELLS DRILLED IN 2005

Well	Lease		First Gas	Last Gas	Producing Formation	MCF	MMCF
35077214640000	USA JACQUELINE ANDERSON	2/1	2/28/2005	8/31/2005	ABROF	43182	43.182
35077215170000	SMITH	1/29	11/30/2005	11/30/2005	AKSO	10000	10
35077214750000	MAXEY	1/3	3/31/2005	9/30/2005	AKSO	252203	252.203
35077214810000	JACKOWSKY	1/2	6/30/2005	9/30/2005	AKSPW	8472	8.472
35077213810000	COBLENTZ	1/9	7/31/2005	9/30/2005	AKURO	92777	92.777
35077215030000	MAXEY	1/4	9/30/2005	11/30/2005	ATOK	19995	19.995
35077215190000	NILAS	2/21	10/31/2005	12/31/2005	ATOK	163382	163.382
35077214930000	SCHARFF	1/4	6/30/2005	8/31/2005	ATOKL	1627983	***1627.983**
35077214660000	LIVELY	1/4	1/31/2005	9/30/2005	ATOKL	4524535	**4524.535**
35077214820000	LIVELY	1/5	5/31/2005	9/30/2005	ATOKL	1749129	**1749.129**
35077214960000	THORNTON	1/2	7/31/2005	8/31/2005	ATOKL	60273	60.273
35077300770001	MAB	1/4	2/28/2005	8/31/2005	ATOKM	30472	30.472
35077205030001	LAKE WAYNE	1/1	5/31/2005	8/31/2005	ATOKM	52520	52.52
35077215080000	BRANDT ELLIS	4/20	8/31/2005	12/31/2005	ATOKM	45439	45.439
35077213810001	COBLENTZ	1/9	7/31/2005	12/31/2005	AUFRO	162947	162.947
35077215010000	JOSEPH	1/27	11/30/2005	11/30/2005	BRTT	10301	10.301
35077214760000	MCFERRAN	2/26	1/31/2005	8/31/2005	BRZL	107972	107.972
35077214200001	LYONS	1/8	9/30/2005	10/31/2005	FHRO	19220	19.22
35077207530001	RAMER	1/4	8/31/2005	9/30/2005	FHRO	17385	17.385
35077215250000	HULSEY	1/11	12/31/2005	12/31/2005	FHRO	28364	28.364
35077214260000	GARRETT	1/6	5/31/2005	8/31/2005	FNPRK	180213	180.213
35077214670000	SMALLWOOD A	1/9	6/30/2005	8/31/2005	FNSH	215354	215.354

35077214610000	DOWC	1-2H	3/31/2005	8/31/2005	HRSR	3802	3.802
35077214610000	DOWC	1-2H	3/31/2005	8/31/2005	HRSR	3802	3.802
Well	Lease		First Gas	Last Gas	Producing Formation	MCF	MMCF
35077214970000	ELLIS	2/19	8/31/2005	9/30/2005	JKFK	218791	218.791
35077214710000	LYONS	2/1	4/30/2005	9/30/2005	JKFK	8003	8.003
35077214880000	WORRELL	1/24	5/31/2005	8/31/2005	JKFK	84015	84.015
35077214900000	FOSTER	2/15	6/30/2005	8/31/2005	PNOL	34468	34.468
35077214890000	JUANITA	1/1	6/30/2005	8/31/2005	PNOL	7021	7.021
35077214280000	HULSEY	9/18	4/30/2005	8/31/2005	RDOK	39978	39.978
35077214770000	SMALLWOOD A	1/10	5/31/2005	8/31/2005	RDOK	492223	492.223
35077214840000	RAMER	1/9	7/31/2005	8/31/2005	RDOK	26284	26.284
35077214980000	MYTON	1/11	7/31/2005	8/31/2005	RDOK	85659	85.659
35077214380000	NORRIS	1/9	6/30/2005	10/31/2005	RDOK	22405	22.405
35077215150000	BELL HEIRS	1/10	11/30/2005	11/30/2005	RDOK	44709	44.709
35077215160000	BELL HEIRS	1/11	12/31/2005	12/31/2005	RDOK	28709	28.709
35077215240000	RAMER	1/10	12/31/2005	12/31/2005	RDOK	22040	22.04
35077215260000	MABRY	1/8	12/31/2005	12/31/2005	RDOK	14064	14.064
35077215340000	HULSEY	1/12	12/31/2005	12/31/2005	RDOK	4923	4.923
35077214530000	ANDERSON	1/7	8/31/2005	12/31/2005	ROPBS	47837	47.837
35077214690000	MABRY	1/7	3/31/2005	8/31/2005	SMPS	405371	405.371
35077214830000	FAZEKAS	1/7	5/31/2005	8/31/2005	SMPS	150857	150.857
35077214920000	HAMPTON BUD	1/5	6/30/2005	8/31/2005	SMPS	349204	349.204
35077205170100	HAMPTON BUD	1/2	1/31/2005	8/31/2005	SMPS	516731	516.731
35077214730000	ORT MICKLE	1/1	5/31/2005	8/31/2005	SNHAM	177939	177.939
35077214780000	HARMON	1/7	4/30/2005	8/31/2005	SNSPO	538253	538.253
35077214860000	CHARNEY	1/8	9/30/2005	10/31/2005	SORK	50925	50.925
35077211970000	MORELAND	2/12	9/30/2005	10/31/2005	SPRO	6215	6.215
35077214940000	DOBSON	1/2	9/30/2005	10/31/2005	SPRO	39227	39.227
35077215110000	SIMON	1/3	12/31/2005	12/31/2005	SPRO	43859	43.859
35077215360000	MABRY	1/9	12/31/2005	12/31/2005	SPRO	7906	7.906
35077214790000	MABRY	12/4	3/31/2005	8/31/2005	SPRO	120585	120.585
35077214720000	WATTS B2	1/1	3/31/2005	8/31/2005	SPRO	55725	55.725
35077214910000	MCCASLIN	2/5	5/31/2005	7/31/2005	SPRO	159244	159.244
35077214850000	MATTHEW	1/18	5/31/2005	8/31/2005	SPRO	91282	91.282
35077214300000	MABRY RANCG	2/10	2/28/2005	8/31/2005	WAPRC	26065	26.065
35077214650000	ROWLAND	1/2	1/31/2005	8/31/2005	WSPAU	258521	258.521

*** The numbers highlighted in red represents production of over 1BCF.**

The “last gas” column represents the date at which the last production was reported (Dwight’s data.)

TABLE II

PRODUCTION DATA

PRODUCTION OF WELLS OVER 10 BCF IN LATIMER COUNTY

(SORTED BY PRODUCTION)

Lease Name	Well Number	Township: North	Range: East	Section	Comp Date	Field	Operator	Top Depth	TD	BCF
KILPATRICK G L	1/2	5	18 E	16	5/30/88	WILBURTON	ARCO OIL & GAS CORP	12853	13964	61
YOURMAN	1/2	5	18 E	15	6/17/88	WILBURTON	ARCO OIL & GAS CORP	13066	15391	52
COSTILOW	1/3	5	18 E	14	7/1/88	WILBURTON	ARCO OIL & GAS CORP	13113	14200	44
WHITE D	1/1	6	18 E	5	10/4/66	QUINTON SOUTH	SKELLY OIL COMPANY	7323	7550	43
SMITH UNIT	1/1	5N	18E	20	6/28/62	WILBURTON	AMBASSADOR OIL CORP	8504	8703	41
FAZEKAS STEVE	1/2	5	18 E	17	6/17/88	WILBURTON	ARCO OIL & GAS CORP	13002	15012	35
PASCHALL	1/2	5	18 E	21	12/11/88	WILBURTON	ARCO OIL & GAS CORP	13228	14278	30
PASCHALL	1/2	5	18 E	21	12/11/88	WILBURTON	ARCO OIL & GAS CORP	13692	14278	30
WHITE C	1/1	6	18 E	4	10/14/66	QUINTON SOUTH	SKELLY OIL COMPANY	4792	7220	26
WHITE C	1/1	6	18 E	4	10/14/66	QUINTON SOUTH	SKELLY OIL COMPANY	6799	7220	26
REUSCH UNIT	1/1	5	19 E	3	10/28/64	WILBURTON	PAN AMERICAN	11476	12300	21
REUSCH UNIT	1/1	5	19 E	3	10/28/64	WILBURTON	PAN AMERICAN	6956	12300	21
DOVIE WEAVER UNIT	1/1	6	19 E	6	10/5/66	KINTA	MOBIL OIL CORP	7057	10480	21
DOVIE WEAVER UNIT	1/1	6	19 E	6	10/5/66	KINTA	MOBIL OIL CORP	10384	10480	21
DOVIE WEAVER	1/1	6	19 E	6	10/5/66	KINTA	MOBIL OIL CORP	7340	10480	21

UNIT										
WILLIAMS `A`	3/23	5	18 E	23	3/25/89	WILBURTON	ANADARKO PET CORP	13538	15000	20
KILPATRICK	1/29	6	19 E	29	2/3/66	WILBURTON	SHELL OIL CO	11678	11783	20
COSTILOW	1/2	5	18 E	14	1/18/86	WILBURTON	SAMSON RESOURCES CO	9292	12440	20
FRANK GLENN `B` UT	1/1	6N	18E	18	8/9/67	QUINTON SOUTH	MOBIL OIL CORP	7050	7500	20
YOURMAN	1/3	5N	18E	15	7/15/88	WILBURTON	ARCO OIL & GAS CORP	9376	11250	19
USA-CHOCTAW TRIBE	1/1	6	19 E	5	9/2/65	WILBURTON NORTH	PAN AMERICAN	1193	11485	19
C O HARRISON UNIT	1/1	6	19 E	22	5/6/69	WILBURTON	MOBIL OIL CORP	10906	11050	18
DOBBS STATE UNIT	1/1	5N	18E	29	9/20/62	WILBURTON	AMBASSADOR OIL CORP	8707	8895	18
WHITE-B	1/1	6	18 E	3	9/6/66	QUINTON SOUTH	SKELLY OIL COMPANY	6995	7242	18
WHITE-B	1/1	6	18 E	3	9/6/66	QUINTON SOUTH	SKELLY OIL COMPANY	4897	7242	18
WHITE J	1/1	6	18 E	7	1/7/67	KINTA	SKELLY OIL COMPANY	7025	7300	17
MCALESTER R F	1/3	5	18 E	22	8/2/89	WILBURTON	ARCO OIL & GAS CORP	13568	14400	17
STATE `C`	1/2	5	18 E	28	10/27/89	WILBURTON	ARCO OIL & GAS CORP	13804	14100	17
ADAMS UNIT	1/1	6	19 E	33	9/30/65	WILBURTON NORTH	PAN AMERICAN	11030	11177	16
KENT HEIRS	B-1	5N	17E	14	4/19/82	WILBURTON	ARKOMA PROD OF CA	8747	9135	16
MAXEY UNIT A	1/2	6N	22E	10	4/18/87	RED OAK-NORRIS	AMOCO PROD CO	6704	7061	15
WHITE F	1/1	6	17 E	13	10/14/66	UNNAMED	SKELLY OIL COMPANY	7076	9982	15
QUAID UNIT B	1/1	6	19 E	32	2/10/66	WILBURTON	PAN AMERICAN	10991	11138	14
SMALLWOOD	1/1	6N	22E	15	1/10/63	RED OAK-NORRIS	MIDWEST OIL PROD	6393	7150	14
WM WILLIAMS UNIT	1/1	5N	18E	23	12/15/60	UNNAMED	AMBASSADOR OIL CORP	8811	9704	14
GARRETT & CO C	1/1	4N	18E	33	7/1/90	HARTSHORNE SOUTH	EXXON CORPORATION	14435	14840	14
YOUNG RANCH	1/28	6	19 E	28	5/10/66	WILBURTON	AUSTRAL OIL CO INC	11392	11492	14
USA-J W MCTIRNAN	1/1	5	19 E	6	3/18/65	WILBURTON	PAN AMERICAN	11325	11475	13
W ERLE WHITE-B UNIT	1/1	6N	18E	17	5/21/67	QUINTON SOUTH	MOBIL OIL CORP	7899	8335	13
QUAID UNIT	1/1	5	19 E	7	5/13/65	WILBURTON	PAN AMERICAN	11836	12000	12
EASTERN OKLA	1/1	6	19 E	31	9/18/65	WILBURTON	PAN AMERICAN	10990	11145	12
CAVE	1/1	6	19 E	19	4/22/69	WILBURTON	MONSANTO CO ETAL	11438	11550	12
HAMPTON BUD	1/2	5N	18E	18	1/6/90	WILBURTON	ARCO OIL & GAS CORP	14064	14600	11

BENNETT STATE	1/2	5N	18E	19	12/15/88	WILBURTON	ARCO OIL & GAS CORP	13836	14500	11
BENNETT STATE	1/2	5N	18E	19	12/15/88	WILBURTON	ARCO OIL & GAS CORP	13444	14500	11
FRED CLAWSON UNIT	1/1	6	19 E	9	10/31/68	KINTA	MOBIL OIL CORP	10040	10160	11
FRED CLAWSON UNIT	1/1	6	19 E	9	10/31/68	KINTA	MOBIL OIL CORP	6805	10160	11
CLAYTON BROWNE UNIT	1/1	6	19 E	10	4/30/69	KINTA	MOBIL OIL CORP	10367	10524	10
CLAYTON BROWNE UNIT	1/1	6	19 E	10	4/30/69	KINTA	MOBIL OIL CORP	7231	10524	10
KILPATRICK G L	1/3	5	18 E	16	12/17/88	WILBURTON	ARCO OIL & GAS CORP	8706	11200	10
KILPATRICK G L	1/3	5	18 E	16	12/17/88	WILBURTON	ARCO OIL & GAS CORP	10232	11200	10
KILPATRICK G L	1/3	5	18 E	16	12/17/88	WILBURTON	ARCO OIL & GAS CORP	10961	11200	10
MARY WHITE	1/2	6N	18E	8	3/31/78	KINTA	SNEE WILLIAM E	7083	7354	10
CLAYTON BROWNE UNIT	1/1	6N	19E	3	4/7/66	KINTA	HUMBLE OIL & REFG CO	10237	10360	10
JANKOWSKY	1/19	6N	18E	19	2/28/68	KINTA	SHELL OIL CO	7973	8570	10

Production data from Dwight's in Geographix.

TABLE III

PRODUCTION DATA

PRODUCTION OF WELLS OVER 10 BCF IN LATIMER COUNTY

(SORTED BY PRODUCING FORMATION)

SPIRO PRODUCTION										
Lease Name	Well Number	Township : North	Range: East	Section	Comp Date	Field	Operator	Top Depth	TD	Cum Gas volume BCF
REUSCH UNIT	1/1	5	19 E	3	10/28/64	WILBURTON	PAN AMERICAN	11476	12300	21
KILPATRICK	1/29	6	19 E	29	2/3/66	WILBURTON	SHELL OIL CO	11678	11783	20
COSTILOW	1/2	5	18 E	14	1/18/86	WILBURTON	SAMSON RESOURCES CO	9292	12440	20
USA-CHOCTAW TRIBE	1/1	6	19 E	5	9/2/65	WILBURTON NORTH	PAN AMERICAN	1193	11485	19
C O HARRISON UNIT	1/1	6	19 E	22	5/6/69	WILBURTON	MOBIL OIL CORP	10906	11050	18
ADAMS UNIT	1/1	6	19 E	33	9/30/65	WILBURTON NORTH	PAN AMERICAN	11030	11177	16
KENT HEIRS	B-1	5N	17E	14	4/19/82	WILBURTON	ARKOMA PROD OF CA	8747	9135	16
QUAID UNIT B	1/1	6	19 E	32	2/10/66	WILBURTON	PAN AMERICAN	10991	11138	14
WM WILLIAMS UNIT	1/1	5N	18E	23	12/15/60	UNNAMED	AMBASSADOR OIL CORP	8811	9704	14
GARRETT & CO C	1/1	4N	18E	33	7/1/90	HARTSHORNE SOUTH	EXXON CORPORATION	14435	14840	14
YOUNG RANCH	1/28	6	19 E	28	5/10/66	WILBURTON	AUSTRAL OIL CO INC	11392	11492	14
USA-J W MCTIRNAN	1/1	5	19 E	6	3/18/65	WILBURTON	PAN AMERICAN	11325	11475	13

EASTERN OKLA	1/1	6	19 E	31	9/18/65	WILBURTON	PAN AMERICAN	10990	11145	12
CAVE	1/1	6	19 E	19	4/22/69	WILBURTON	MONSANTO CO ETAL	11438	11550	12
FRED CLAWSON UNIT	1/1	6	19 E	9	10/31/68	KINTA	MOBIL OIL CORP	10040	10160	11
CLAYTON BROWNE UNIT	1/1	6	19 E	10	4/30/69	KINTA	MOBIL OIL CORP	10367	10524	10
CLAYTON BROWNE UNIT	1/1	6N	19E	3	4/7/66	KINTA	HUMBLE OIL & REFG CO	10237	10360	10
KILPATRICK G L	1/3	5	18 E	16	12/17/88	WILBURTON	ARCO OIL & GAS CORP	8706	11200	10
KILPATRICK G L	1/3	5	18 E	16	12/17/88	WILBURTON	ARCO OIL & GAS CORP	10232	11200	10
QUAID UNIT	1/1	5	19 E	7	5/13/65	WILBURTON	PAN AMERICAN	11836	12000	12
RED OAK - FANSHAWE- ATOKA MIDDLE SANDS PRODUCTION										
WHITE D	1/1	6	18 E	5	10/4/66	QUINTON SOUTH	SKELLY OIL COMPANY	7323	7550	43
SMITH UNIT	1/1	5N	18E	20	6/28/62	WILBURTON	AMBASSADOR OIL CORP	8504	8703	41
WHITE C	1/1	6	18 E	4	10/14/66	QUINTON SOUTH	SKELLY OIL COMPANY	4792	7220	26
WHITE C	1/1	6	18 E	4	10/14/66	QUINTON SOUTH	SKELLY OIL COMPANY	6799	7220	26
REUSCH UNIT	1/1	5	19 E	3	10/28/64	WILBURTON	PAN AMERICAN	6956	12300	21
DOVIE WEAVER UNIT	1/1	6	19 E	6	10/5/66	KINTA	MOBIL OIL CORP	7057	10480	21
DOVIE WEAVER UNIT	1/1	6	19 E	6	10/5/66	KINTA	MOBIL OIL CORP	10384	10480	21
DOVIE WEAVER UNIT	1/1	6	19 E	6	10/5/66	KINTA	MOBIL OIL CORP	7340	10480	21
FRANK GLENN \`B\` UT	1/1	6N	18E	18	8/9/67	QUINTON SOUTH	MOBIL OIL CORP	7050	7500	20
YOURMAN	1/3	5N	18E	15	7/15/88	WILBURTON	ARCO OIL & GAS CORP	9376	11250	19
DOBBS STATE UNIT	1/1	5N	18E	29	9/20/62	WILBURTON	AMBASSADOR OIL CORP	8707	8895	18
WHITE-B	1/1	6	18 E	3	9/6/66	QUINTON SOUTH	SKELLY OIL COMPANY	6995	7242	18
WHITE-B	1/1	6	18 E	3	9/6/66	QUINTON SOUTH	SKELLY OIL COMPANY	4897	7242	18
WHITE J	1/1	6	18 E	7	1/7/67	KINTA	SKELLY OIL COMPANY	7025	7300	17
MAXEY UNIT A	1/2	6N	22E	10	4/18/87	RED OAK-NORRIS	AMOCO PROD CO	6704	7061	15
WHITE F	1/1	6	17 E	13	10/14/66	UNNAMED	SKELLY OIL COMPANY	7076	9982	15
SMALLWOOD	1/1	6N	22E	15	1/10/63	RED OAK-NORRIS	MIDWEST OIL PROD	6393	7150	14
W ERLE WHITE-B UNIT	1/1	6N	18E	17	5/21/67	QUINTON SOUTH	MOBIL OIL CORP	7899	8335	13

FRED CLAWSON UNIT	1/1	6	19 E	9	10/31/68	KINTA	MOBIL OIL CORP	6805	10160	11
CLAYTON BROWNE UNIT	1/1	6	19 E	10	4/30/69	KINTA	MOBIL OIL CORP	7231	10524	10
KILPATRICK G L	1/3	5	18 E	16	12/17/88	WILBURTON	ARCO OIL & GAS CORP	10961	11200	10
MARY WHITE	1/2	6N	18E	8	3/31/78	KINTA	SNEE WILLIAM E	7083	7354	10
JANKOWSKY	1/19	6N	18E	19	2/28/68	KINTA	SHELL OIL CO	7973	8570	10

ARBUCKLE FORMATIONS - CROMWELL SS

Lease Name	Well Number	Township: North	Range: East	Section	Comp Date	Field	Operator	Top Depth	TD	Cum Gas volume BCF
FAZEKAS STEVE	1/2	5	18 E	17	6/17/88	WILBURTON	ARCO OIL & GAS CORP	13002	15012	35
PASCHALL	1/2	5	18 E	21	12/11/88	WILBURTON	ARCO OIL & GAS CORP	13228	14278	30
PASCHALL	1/2	5	18 E	21	12/11/88	WILBURTON	ARCO OIL & GAS CORP	13692	14278	30
WILLIAMS \`A\`	3/23	5	18 E	23	3/25/89	WILBURTON	ANADARKO PET CORP	13538	15000	20
SMITH	1/3	5	18 E	20	10/12/89	WILBURTON	ARCO OIL & GAS CORP	13334	14200	19
MCALESTER R F	1/3	5	18 E	22	8/2/89	WILBURTON	ARCO OIL & GAS CORP	13568	14400	17
STATE \`C\`	1/2	5	18 E	28	10/27/89	WILBURTON	ARCO OIL & GAS CORP	13804	14100	17
HAMPTON BUD	1/2	5N	18E	18	1/6/90	WILBURTON	ARCO OIL & GAS CORP	14064	14600	11
BENNETT STATE	1/2	5N	18E	19	12/15/88	WILBURTON	ARCO OIL & GAS CORP	13836	14500	11
BENNETT STATE	1/2	5N	18E	19	12/15/88	WILBURTON	ARCO OIL & GAS CORP	13444	14500	11
KILPATRICK G L	1/2	5		16	5/30/88	WILBURTON	ARCO OIL & GAS CORP	12853	13964	61
YOURMAN	1/2	5	18 E	15	6/17/88	WILBURTON	ARCO OIL & GAS CORP	13066	15391	52

APPENDIX B

WELL DATA

TABLE IV

WELL DATA (MD)

ID	Well Name	BOCK	HRSN	FNSH	RDOK	RDOK T	PNOL	DMND	BRZL	SPRO	SPRO2	SPRO3	SPRO H1	SPROH2
1	YOURMAN									14590				
2	EVANS													
3	HAMILTON						8040	8490	8890	11810			1105	
4	GIVENS				6000		7200	7660		12277			1782	
5	PACE				5200		6450	6900	7850	12242				
6	DENTON				5375		6700	7150	8050					
7	BURGER				6770		7820	8400	9230	11634	12447			
8	BULLARD				5600		6430		9700	11697				
9	WILBURTON TOWNSITE				6701	6701				12600				
10	USA-CHOCTAW TRIBE T		1744		6560		7200			11720				
11	USA-CHOCTAW TRIBE	900	1810		5658	6350	7350	7730	8920	11293				
12	ADAMS UNIT									11049				
13	ADAMS UNIT C				7692	8200				11146				
14	DEGNAN			6950	8090	8600	10500			11382				
15	DOVIE WEAVER E UNIT		3240	7094						11195				
16	WEAVER	2287	3300	6950	7392	7802	9730			10659				
17	WEAVER				7288	7718				10485				
18	WEAVER	2040	3150	6765	7170	7560	9315			10299				
19	OTHO ENIS													
20	ENIS OTHO													
21	IVEY													
22	BIG PRIZE									14367			8922	11922
23	BIG PRIZE									15228			8928	11928
24	JAMES									14430	9477	12243		
25	JOHNSON									15257				

26	CLEMONS									13048			2048	2948
27	GARY									13081			3481	7581
28	WALKER VIRGINIA									12646			6120	
29	NATION													
30	VFW													
31	CHURCH LAKE													
32	BABB UNIT												2164	
33	MCKEOWN				7064	7140	7449						1842	
34	J A RAY UNIT									12481				
35	POTEET				5300		6290		7930	12159				
36	J D HUMPHREY				6400		7560		8875	12239				
37	BOOGER RED													
38	D J BISHOP UNIT				5295	6200			8999	11390				
39	ESTRN OK ST COLLEGE				5106	5214				11612			650	
40	USA CHOCTAW TRIBE T									11344				
41	KILPATRICK													
42	KILPATRICK													
43	QUAID GAS UNIT B													
44	KILPATRICK	2194	2900		7543	7920				11651				
45	KILPATRICK	1500	3080	6150	7330	7820				11476			3300	
47	DOVIE WEAVER B UNIT	1968	2930	6850	6175	7730	9850			11175				
48	DOVIE WEAVER /D/ U		2960		7704					10453				
49	WOODS													
50	PINE CREEK									15460				
51	GAMBLER DEEP									13796				
52	SWINDLE												4106	9806
54	BURGER													
55	BURGER TRUST									13209				
56	HART									13018			7370	
57	MABRY									12664				
58	DIAMOND UNIT				6300	6600			9170	11282			3350	
59	DIAMOND UNIT				6371		6673		9000	11098			1911	
60	DRESSEN UNIT												2400	
61	CHARLES SPARKS UNIT									9860	12228			
62	COLLEGE UNIT				6700					11300				
63	COLLEGE UNIT				6700					11792				

I64	QUAID UNIT				5830				5815	11816				
65	R H LOWRY UNIT	623	1324											
66	USA-J W MCTIRNAN		482							11304				
67	EASTERN OKLA				6600	7200	7700			11040				
68	HACKNEY UNIT	1765	2728		7450	7820				11452				
69	HACKNEY UNIT	1920	2860		7490					11778				
70	CAVE				7930	8010				11432				
71	CAVE	2204	3125	7130	7462	7786				11029				
72	ROBBERS CAVE	2420	3161		7505	7561				10561				
73	ROBBERS CAVE			7090	7530	7840				10626				
74	ROBBERS CAVE			7154	7820	8056	9249			10392				
75	MABRY A J UNIT													
76	TONY MITCHELL													
78	MOSE									12856				
79	WANDERER									11708			3930	
80	WAGGONER				6000		6200		7150				890	1000
81	MABRY RANCH													
82	WATTS-JONES				6000		6200		7100	10647	10845	14045		
83	WATTS JONES						8100			9850				
84	WILLIAMS				4800		5100		6400	8890	9390	12390		
85	WILLIAMS \`A\`				5400	5700			7400	9070	9050			
86	WILLIAMS \`A\`				5350				7300					
87	WILLIAMS									8847	9510			
88	COSTILOW				3982					9582	10582			
89	PARKER E CASTILOW									9286	9581	11481		
90	COSTILOW				4750				7050	8800				
91	DAVIS \`A\`				3700				4600	12080				
92	DAVIS		2300		5750				6500	11450				
93	SUNFLOWER									11276				
94	CLAUDE WILSON UNIT				8050	8200	9200			11300				
95	DOREMUS UNIT		3193		7850					12254				
96	CARVER	3304	4180	7810	8610	8798				12163				
97	SCRUGGS		4268	8274	8430					10800				
98	ROBE \`A\`									15133				
99	9001 JV-P AMASON									13632				
100	FAZEKAS													

101	9001 JV-P AMASON									14590				
102	DOLLINS									13848				
103	JAMES UNIT			3800	4890				5700	9006				
104	MORELAND JV-P 9001												3810	
105	REVERE									13165				
106	PICARO									13287	13318			
107	CLAUDE WILSON									11528				
108	VARNUM GUY									11360				
109	GUY VARNUM													
110	JAMES									9786			3186	
111	JAMES UNIT MA			3800	4900				5620	9019	11005			
112	AUSTIN WAYNE									9804	645			
113	AUSTIN WAYNE				5203		4176		5900	9578	11063			
114	AUSTIN WAYNE				5507					9374				
115	9001 JV-P NEWELL				5500				6200	14885				
116	JUNIOR													
117	ROBINSON			4552						12031				
118	ROBINSON			4486	5000				7700	11675				
119	USA J ANDERSON				7278				7300	11400				
120	FEDERAL CHURCH UNIT									11034				
121	FEDERAL CHURCH									11405				
122	USA ANDERSN-PRCHRD		2174							11576				
123	USA-ANDERSON PRITCH				7480	7800				11712				
124	WILDLIFE			7078	7698	7992	8350			11396				
125	WILDLIFE		3462	8102	7300	7776				11504				
126	C L PEPPERS UNIT	2735	3462							10074				
127	9001 JV-P MABRY						8274			13118				
128	CARVER		4268	8274	9036	9172								
129	REUSCH UNIT													
130	COSTILOW													
131	GARRETT & CO UNIT A									14800				
132	ULYSSES									15515				

Formations: BOCK= Booch; HRSN = Hartshorne; FNSH = Fanshawe; RDOK = Red oak, T = top; DMND = Diamond; BRZL = Brazil, SPRO = Spiro; SPROH = Spiro in the hanging wall.
MD = Measured depth

TABLE V

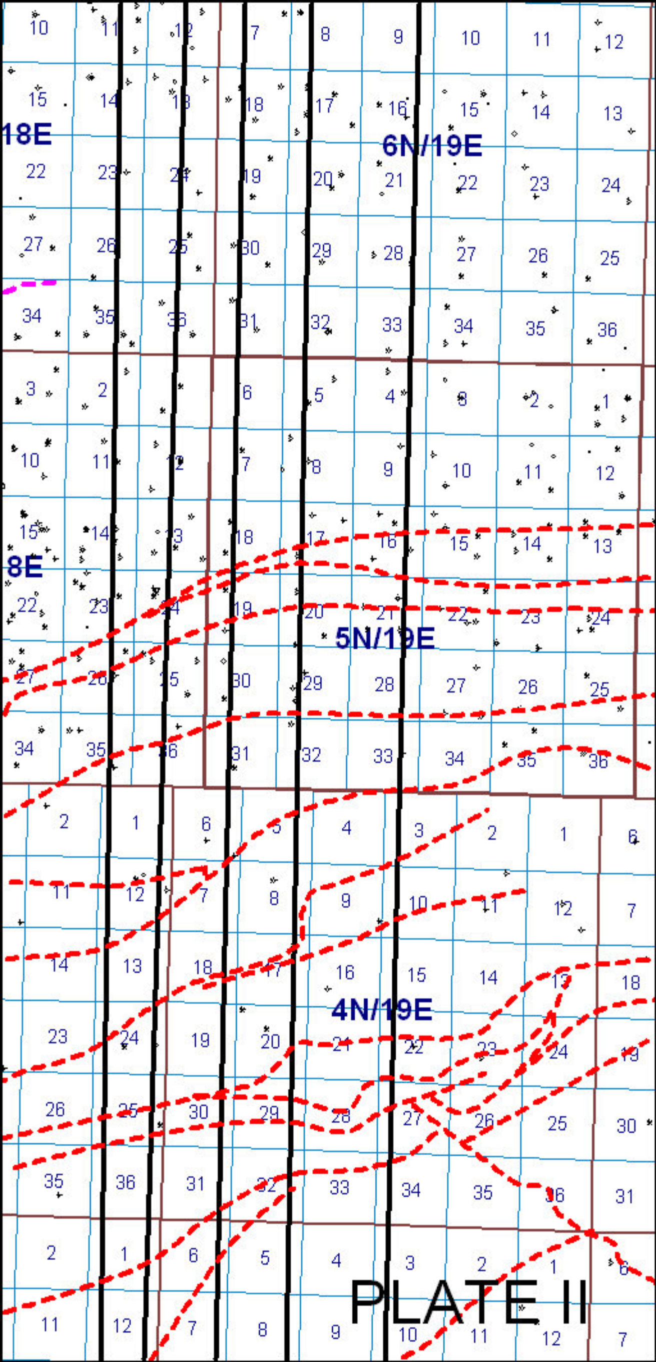
ID	T	R	S	Well Name	Well Number	Field Name	Operator	CUMGAS	ELEV_KB	TD	COMP_DATE
1	4N	19E	9	YOURMAN	1/1	WILDCAT	EXXON CORPORATION		775	14960	4/29/1991
2	5N	19E	33	EVANS	1/1	WILBURTON	EBERLY & MEADE INC		870	7678	5/22/1979
3	5N	19E	21	HAMILTON	1/21	WILBURTON	QUESTAR EXPLOR&PROD			11000	4/17/2001
4	5N	19E	21	GIVENS	1/1	WILBURTON	TEXAS O&G CORP			7800	4/14/1981
5	5N	19E	16	PACE	1/16	WILBURTON	SLAWSON DONALD C			11250	11/2/1984
6	5N	19E	16	DENTON	1/16	WILBURTON	CHAPARRAL ENERGY INCORPORATED	193846	655	10992	11/11/1985
7	5N	19E	16	BURGER	1/16	WILBURTON	KCS RESOURCES INCORPORATED	2429773		13247	7/4/1984
8	5N	19E	9	BULLARD	1/1	WILBURTON	WILLIFORD ENERGY COMPANY	4360864	697	13639	8/8/1981
9	5N	19E	9	WILBURTON TOWNSITE	1/1	WILBURTON	AMAREX INCORPORATED		701	12730	5/29/1980
10	5N	19E	4	USA-CHOCTAW TRIBE T	1/2	WILBURTON	CHESAPEAKE OPERATING INCORPORATED	1681492	634	12005	3/30/1987
11	5N	19E	4	USA-CHOCTAW TRIBE	1/1	WILBURTON NORTH	CHESAPEAKE OPERATING INCORPORATED	18833792		11485	9/2/1965
12	6N	19E	33	ADAMS UNIT	1/1	WILBURTON NORTH	CHESAPEAKE OPERATING INCORPORATED	15669523		11177	9/30/1965
13	6N	19E	33	ADAMS UNIT C	1/2	KINTA	CHESAPEAKE OPERATING INCORPORATED	1915657	869	12000	7/19/1985
14	6N	19E	28	DEGNAN	1/1	KINTA	SAMSON RESOURCES COMPANY	323625		12126	3/3/1987
15	6N	19E	21	DOVIE WEAVER E UNIT	1/1	WILBURTON	VASTAR RESOURCES INCORPORATED	2347390		11367	9/22/1967
16	6N	19E	16	WEAVER	1/2	KINTA	OXLEY PETROLEUM COMPANY	1877054	1459	10930	9/26/1985
17	6N	19E	16	WEAVER	1/1	KINTA	OXLEY PETROLEUM COMPANY	4567479	1385	10500	7/3/1969
18	6N	19E	16	WEAVER	1/3	KINTA	OXLEY PETROLEUM COMPANY	1431537		11100	2/16/1989
19	5N	19E	12	OTHO ENIS	1/12	PANOLA	WILLIFORD ENERGY COMPANY	424059	609	12350	1/17/1985
20	5N	19E	12	ENIS OTHO	1/12	PANOLA	WILLIFORD ENERGY CO			12350	10/30/1997
21	5N	19E	10	IVEY	1/10	WILBURTON	SLAWSON DONALD C			11420	11/27/1984
22	4N	19E	20	BIG PRIZE	1/20	WILBURTON SOUTH	AMOCO PRODUCTION COMPANY	388132		14700	10/8/2001
23	4N	19E	20	BIG PRIZE	2/20	WILBURTON	AMOCO PRODUCTION COMPANY	91987		15425	6/4/2002
24	4N	19E	17	JAMES	1/17	UNNAMED	AMOCO PRODUCTION COMPANY	7324284		15000	6/11/1991

25	6N	19E	15	JOHNSON	1/3	KINTA	OXLEY PETROLEUM COMPANY	372376		9678	11/17/1999
26	4N	19E	8	CLEMONS	1/1	WILDCAT	WILLIFORD ENERGY CO			13590	4/15/1983
27	4N	19E	5	GARY	1/3	WILBURTON	HELMERICH&PAYNE INC		781	13460	2/2/1991
28	5N	19E	32	WALKER VIRGINIA	1/1	WILBURTON	CHESAPEAKE OPERATING INCORPORATED	667274		13823	3/18/1991
29	4N	19E	8	NATION	5/1	UNNAMED	CHEVRON U S A INCORPORATED	751707		14640	9/17/1996
30	5N	19E	32	VFW	1/29	WILBURTON	CHAPARRAL ENERGY INCORPORATED	785345	898	12533	2/14/1991
31	5N	19E	29	CHURCH LAKE	1/1	WILBURTON	D-PEX OPERATING CO			13985	10/14/1989
32	5N	19E	29	BABB UNIT	1/1	WILBURTON	SUPERIOR OIL CO ETAL			7751	4/15/1968
33	5N	19E	20	MCKEOWN	1/1	WILBURTON	QUESTAR EXPLORATION & PRODUCTION	1953283	904	7558	3/13/1973
35	5N	19E	17	POTEET	1/17	WILBURTON	PROSPECTIVE INV&TRDN		659	12601	2/7/1979
36	5N	19E	17	J D HUMPHREY	1/1	WILBURTON	HUMBLE OIL & REFG CO			12713	4/21/1966
37	5N	19E	8	BOOGER RED	1/2	WILBURTON	HARDWICK DON&NORITA			2450	7/1/1988
38	5N	19E	8	D J BISHOP UNIT	1/1	WILBURTON	SINCLAIR			12550	3/31/1966
39	5N	19E	8	ESTRN OK ST COLLEGE	1/8	WILBURTON	SPESS OIL COMPANY	2168692	673	11720	3/23/1979
40	5N	19E	5	USA CHOCTAW TRIBE T	1/2	WILBURTON	CHESAPEAKE OPERATING INCORPORATED	1509707		11450	5/26/1987
41	5N	18E	16	KILPATRICK	2/A	UNNAMED	LIMESTONE O&G CO			2828	1/29/1941
42	5N	18E	16	KILPATRICK	1/2	UNNAMED	LIMESTONE O&G CO			2295	4/9/1940
43	6N	19E	32	QUAID GAS UNIT B	1/2	WILBURTON	AMOCO PROD CO		654	4101	8/2/1996
44	6N	19E	29	KILPATRICK	1/29	WILBURTON	SAMSON RESOURCES COMPANY	20202732	1231	11783	2/3/1966
45	6N	19E	29	KILPATRICK	2/1	KINTA	SAMSON RESOURCES COMPANY	1019281		12150	7/10/1990
47	6N	19E	20	DOVIE WEAVER B UNIT	1/1	WILBURTON	AMOCO PRODUCTION COMPANY	4001549		11296	1/28/1967
48	6N	19E	17	DOVIE WEAVER /D/ U	1/1	KINTA	CULPEPPER C W		1142	11092	4/26/1967
49	5N	18E	15	WOODS	1/3	UNNAMED	LIMESTONE O&G CO			2750	11/15/1943
50	4N	19E	30	PINE CREEK	1/30	VETERANS COLONY	AMOCO PRODUCTION COMPANY	2328498		15708	4/7/2001
51	4N	19E	19	GAMBLER DEEP	1/19	VETERANS COLONY	AMOCO PRODUCTION COMPANY	3686843		13902	11/17/1999
52	4N	19E	20	SWINDLE	1/17	WILBURTON SOUTH	WARD PETROLEUM CORP			12376	10/18/1996
54	4N	19E	6	BURGER	1-6A	WILBURTON	BARRETT RES CORP			13275	12/23/1997
55	4N	19E	6	BURGER TRUST	1/6	WILBURTON	HELMERICH&PAYNE INC		797	13650	2/8/1991
56	4N	19E	6	HART	1/1	WILDCAT	ARCO OIL & GAS CORP			18085	4/21/1989
57	5N	19E	31	MABRY	2/1	WILBURTON	CHESAPEAKE OPERATING INCORPORATED	110150		13300	5/23/2002
58	5N	19E	30	DIAMOND UNIT	1/2	WILBURTON	KERR-MCGEE OIL & GAS ONSHORE LLC	2935716		12316	7/2/1989
59	5N	19E	30	DIAMOND UNIT	1/30	WILBURTON	QUESTAR EXPLORATION & PRODUCTION	9248817	940	11203	11/1/1966
60	5N	19E	19	DRESSEN UNIT	1/1	WILBURTON	SAMSON RESOURCES CO			6720	10/12/1978
61	5N	19E	19	CHARLES SPARKS UNIT	1/1	WILBURTON	EXXON COMPANY U S A	4515096		12384	5/22/1964
62	5N	19E	18	COLLEGE UNIT	2/18	WILBURTON	BARRETT RES CORP			14250	4/19/1997
63	5N	19E	18	COLLEGE UNIT	1/1	WILBURTON	EXXON COMPANY U S A	8540359	675	12446	3/29/1963
64	5N	19E	7	QUAID UNIT	1/1	WILBURTON	CHESAPEAKE OPERATING INCORPORATED	12186909		12000	5/13/1965

65	6N	18E	33	R H LOWRY UNIT	1/1	WILBURTON	SINCLAIR OIL & GAS C			11646	2/10/1964
66	5N	19E	6	USA-J W MCTIRNAN	1/1	WILBURTON	CHESAPEAKE OPERATING INCORPORATED	12682840		11475	3/18/1965
67	6N	19E	31	EASTERN OKLA	1/1	WILBURTON	CHESAPEAKE OPERATING INCORPORATED	11665711		11145	9/18/1965
68	6N	19E	30	HACKNEY UNIT	1/1	WILBURTON	AMOCO PRODUCTION COMPANY	9468373	1052	11835	9/2/1966
69	6N	19E	30	HACKNEY UNIT	1/2	KINTA	AMOCO PRODUCTION COMPANY	936046		11937	12/13/1988
70	6N	19E	19	CAVE	1/1	WILBURTON	MERIT ENERGY COMPANY	11409634	887	7311	4/22/1969
72	6N	19E	18	ROBBERS CAVE	1/1	KINTA	UNIT PETROLEUM COMPANY	2989154		10700	8/29/1973
73	6N	19E	18	ROBBERS CAVE	1/4	KINTA	UNIT PETROLEUM COMPANY	151371		8350	4/23/2001
74	6N	19E	18	ROBBERS CAVE	1/3	KINTA	UNIT PETROLEUM CORPORATION	309669	977	10643	8/20/1996
75	5N	19E	31	MABRY A J UNIT	1/1	WILBURTON	CHESAPEAKE OPERATING INCORPORATED	3306697		13139	6/22/1990
76	6N	18E	32	TONY MITCHELL	1/1	WILBURTON	VASTAR RESOURCES INCORPORATED	1234871		11721	9/13/1963
78	5N	18E	35	MOSE	2A	WILBURTON	SAMSON RESOURCES CO			12250	7/22/2000
79	5N	18E	35	WANDERER	1/26	WILBURTON	AMOCO PRODUCTION COMPANY	1001974		11927	6/24/2000
80	5N	18E	26	WAGGONER	1/1	WILBURTON	FERGUSON OIL			8300	12/17/1973
81	4N	18E	1	MABRY RANCH	1/1	HOOKER EAST	VASTAR RESOURCES INC			14900	7/2/2000
82	5N	18E	26	WATTS-JONES	1/2	WILBURTON	AMOCO PRODUCTION COMPANY	159888		14100	4/3/1990
83	5N	18E	26	WATTS JONES	3/26	WILBURTON	AMOCO PRODUCTION COMPANY	1070830		10210	6/25/1998
84	5N	18E	23	WILLIAMS	5/23	WILBURTON	FUEL RESOURCES INCORPORATED	792838		13174	5/29/1995
85	5N	18E	23	WILLIAMS \`A\`	2/23	WILBURTON	FUEL RESOURCES INCORPORATED	2099975	689	12554	10/30/1986
86	5N	18E	23	WILLIAMS \`A\`	3/23	WILBURTON	HOUSTON EXPLORATION COMPANY THE	20161910	690	14990	3/25/1989
87	5N	18E	23	WILLIAMS	6/23	WILBURTON	FUEL RESOURCES INCORPORATED	274975		11555	9/21/1995
88	5N	18E	14	COSTILOW	5/14	WILBURTON	SAMSON RESOURCES COMPANY	700656	682	11254	9/3/1993
89	5N	18E	14	PARKER E CASTILOW	1/1	WILBURTON	ARCO PERMIAN	923524		10074	6/12/1962
90	5N	18E	14	COSTILOW	1/6	WILBURTON	SAMSON RESOURCES COMPANY	1230238		10940	7/21/1994
91	5N	18E	11	DAVIS \`A\`	1/2	WILBURTON	ARCO OIL & GAS CORP			14020	5/15/1986
92	5N	18E	2	DAVIS	1/2	WILBURTON	QUESTAR EXPLOR&PROD			11695	2/10/1999
93	6N	18E	35	SUNFLOWER	1/1	WILBURTON	SAMSON RESOURCES COMPANY	1588424		11600	5/10/1985
94	6N	18E	35	CLAUDE WILSON UNIT	1/1	WILBURTON	AMOCO PROD CO		777	12050	1/24/1972
95	6N	18E	26	DOREMUS UNIT	1/1	WILDCAT	PAN AMERICAN			13138	8/8/1963
96	6N	18E	23	CARVER	2/23	KINTA	CLEARY PETRO CORP		1176	12262	10/15/1976
97	6N	18E	14	SCRUGGS	1/1	KINTA	SNEE & EBERLY		1281	10800	5/23/1977
98	4N	18E	25	ROBE \`A\`	1/25	WILBURTON SOUTH	HOUSTON EXPLORATION COMPANY THE	848972		15550	9/25/1992
99	4N	18E	24	9001 JV-P AMASON	1/1	WILBURTON SOUTH	BTA OIL PRODUCERS	3515176	935	14090	9/1/1990
100	5N	18E	17	FAZEKAS	1/5	WILBURTON	AMOCO PRODUCTION COMPANY	341234		8742	2/22/1996
101	4N	18E	24	9001 JV-P AMASON	2/24	VETERANS COLONY	BTA OIL PRODUCERS	785661		14030	11/13/2001
102	4N	18E	13	DOLLINS	1/13	UNNAMED	ARCO OIL & GAS CORP			14195	7/27/1991
103	5N	18E	24	JAMES UNIT	1-A	WILBURTON	VASTAR RESOURCES INCORPORATED	3229482		10085	6/1/1962

104	4N	18E	12	MORELAND JV-P 9001	1/1	WILBURTON SOUTH	BTA OIL PRODUCERS	34519	961	10000	6/10/1991
105	4N	18E	1	REVERE	1/1	WILBURTON SOUTH	AMOCO PRODUCTION COMPANY	341486		13978	6/8/2000
106	4N	18E	1	PICARO	3/1	WILBURTON SOUTH	AMOCO PRODUCTION COMPANY	609195		13700	9/19/2001
108	5N	18E	25	VARNUM GUY	4/25	WILBURTON	AMOCO PRODUCTION COMPANY	532834		11524	11/28/2000
109	5N	18E	25	GUY VARNUM	1/1	WILBURTON	SAMSON RESOURCES COMPANY	2070988		10614	5/31/1966
110	5N	18E	24	JAMES	1/3	WILBURTON	VASTAR RESOURCES INC			12868	8/6/1997
111	5N	18E	24	JAMES UNIT MA	1/2	WILBURTON	AMOCO PRODUCTION COMPANY	2954797		14150	8/30/1990
112	5N	18E	13	AUSTIN WAYNE	1/5	WILBURTON	VASTAR RESOURCES INC			11594	12/18/1996
113	5N	18E	13	AUSTIN WAYNE	1/2	WILBURTON	AMOCO PRODUCTION COMPANY	25772631		14350	5/4/1989
114	5N	18E	13	AUSTIN WAYNE	1/4	WILBURTON	AMOCO PRODUCTION COMPANY	1450425	674	11900	2/22/1996
115	4N	18E	23	9001 JV-P NEWELL	1/23	WILDCAT	ARCO OIL & GAS CORP			15218	5/30/1991
116	5N	18E	12	JUNIOR	1/1	WILBURTON	SAMSON RESOURCES CO		675	13260	8/28/1987
117	5N	18E	12	ROBINSON	2/12	WILBURTON	AMOCO PRODUCTION COMPANY	153440	695	13875	12/12/1996
118	5N	18E	12	ROBINSON	3/12	WILBURTON	AMOCO PRODUCTION COMPANY	85330		4700	4/12/1997
119	5N	18E	1	USA J ANDERSON	1/1	WILBURTON	AMOCO PRODUCTION COMPANY	9174351		11525	7/17/1964
120	6N	18E	36	FEDERAL CHURCH UNIT	1/1	WILBURTON	KERR-MCGEE OIL & GAS ONSHORE LLC	8239297	652	11204	8/23/1966
121	6N	18E	36	FEDERAL CHURCH	1/2	WILBURTON	JMC EXPLORATION INCORPORATED	39448	679	11516	3/8/1989
122	6N	18E	25	USA ANDERSN-PRCHRD	1/1	WILBURTON	CHESAPEAKE OPERATING INCORPORATED	7408447		11750	6/26/1968
123	6N	18E	25	USA-ANDERSON PRITCH	1/2	KINTA	CHESAPEAKE OPERATING INCORPORATED	863919	783	11900	4/24/1987
124	6N	18E	24	WILDLIFE	1/2	KINTA	BHP PET(AMERICAS)INC		734	11769	4/24/1990
125	6N	18E	24	WILDLIFE	1/1	WILBURTON	MERIT ENERGY COMPANY	1727193		11685	8/10/1969
126	6N	18E	13	C L PEPPERS UNIT	1/1	WILDCAT	MOBIL OIL CORP			10558	1/28/1965
127	4N	18E	11	9001 JV-P MABRY	1/1	WILBURTON SOUTH	DMS OIL COMPANY	3582561	1055	14100	8/4/1990
128	6N	18E	23	CARVER	1/23	KINTA	SOUTHERN RESOURCES	60164		9265	8/23/1975
129	5N	19E	3	REUSCH UNIT	1/1	WILBURTON	CHESAPEAKE OPERATING INCORPORATED	5261384		12300	10/28/1964
130	5N	18E	14	COSTILOW	1/3	WILBURTON	AMOCO PRODUCTION COMPANY	43055276		14200	7/1/1988
131	4N	18E	26	GARRETT & CO UNIT A	1/1	WILBURTON SOUTH	CORTEZ OPERATING COMPANY	972918		15289	9/3/1990
132	4N	18E	35	ULYSSES	1/1	WILDCAT	ARCO OIL & GAS CORP		1032	17480	7/1/1990

A
B
C
D
E
N
Pb
Psv
Coal
Qa
Pm
Ph
D
U
Pa
CHOCTAW FAULT
Pal
Psp
Pw
Pws
TI VALLEY FAULT
Pjv
Pjf
A'
B'
C'
D'
E'
Qa Quaternary Alluvium/ Terrace Deposits
Pb Boggy Formation
Psv Savanna Formation
Pm McAlester Formation
Ph Hartstone Formation
Pa Atoka Formation
Pal Lower Atoka Formation
Pws Spiro Sandstone
Pw Wapanuka Limestone
Pjv John's Valley Formation
Pjf Jackfork Group
Psp Springer Formation
CONTACT
SYNCLINE
ANTICLINE
OVERTURNED BED
THRUST FAULT
0
1 MILE



18E
6N/19E
8E
5N/19E
4N/19E
PLATE II

S
N
101
78
79
80
81
82
83
84
85/86/87
88
90
92
93
94
95
96
97
A
A'
SEA LEVEL
1000
2000
3000
4000
5000
6000
7000
8000
9000
10,000
11,000
12,000
13,000
14,000
TI VALLEY FAULT
?
CHOCTAW FAULT
RED OAK SS
SPIRO SS
CHOCTAW DETACHMENT
SPRINGER DETACHMENT
WOODFORD DETACHMENT
DRY WELL
PRODUCTIVE WELL
SPIRO SS
RED OAK SS
HARTSHONE FM
MC ALESTER FM
SAVANNAH FM
ATOKA FM
FAULT
BOTTOM OF WELL
UPLIFTED DIRECTION
1000'
2000'
CROSS SECTION C-C'
PLATE III
MARLINE COLLINS
OSU SCHOOL OF GEOLOGY
1 MILE
O
1 MILE
THE LINE INDICATES THE RELATIVE POSITIONS OF EACH WELL EAST OR WEST OF THE X- SECTION. UP IS WEST.
Pin Line

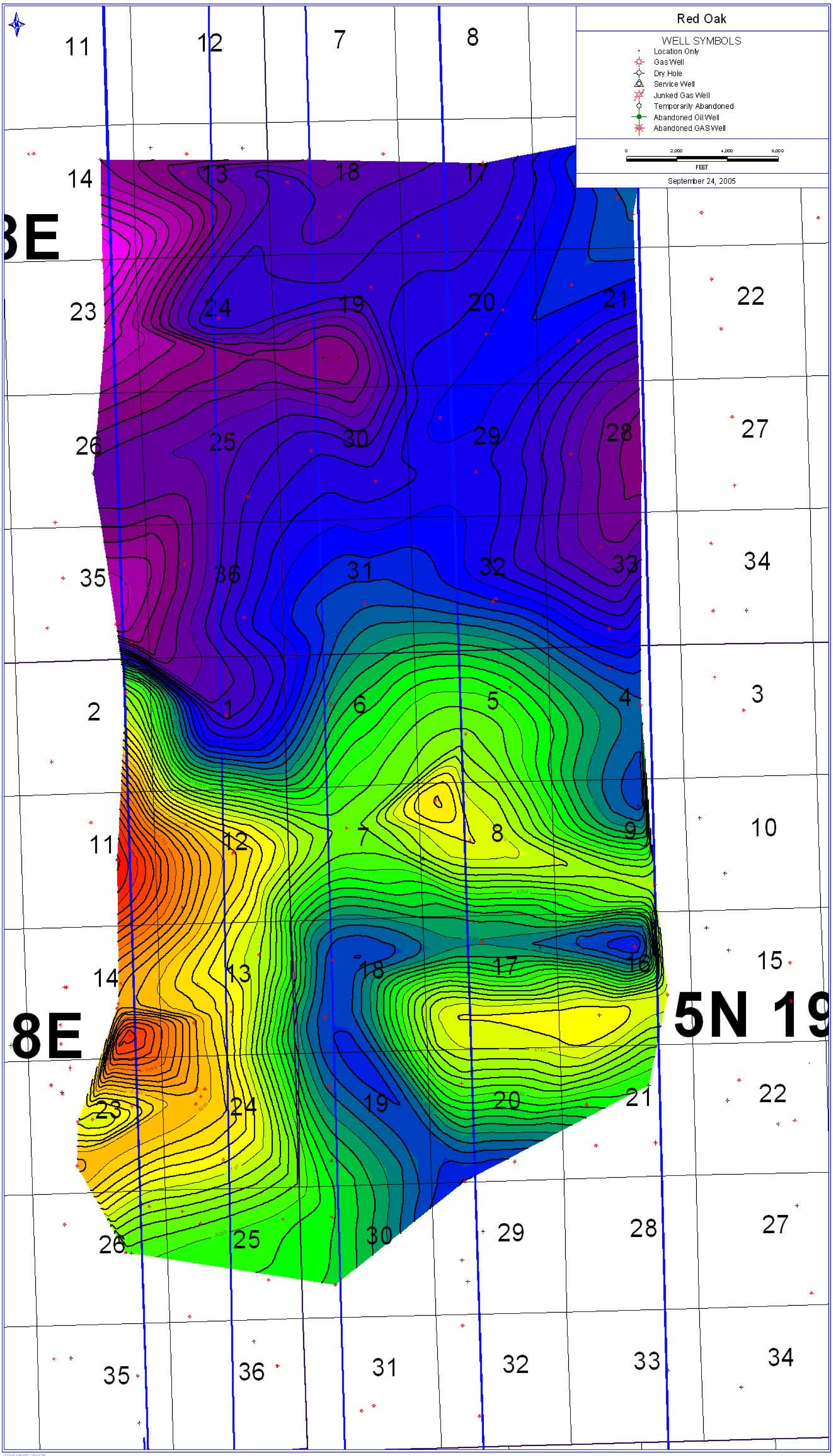

S
N
8
99
102
104
106
107
127
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
B
B'
SEA LEVEL
1000
2000
3000
4000
5000
6000
7000
8000
9000
10,000
11,000
12,000
13,000
14,000
TI VALLEY FAULT
CHOCTAW FAULT
RED OAK SS
CHOCTAW DETACHMENT
SPIRO SS
SPRINGER DETACHMENT
WOODFORD DETACHMENT
?
DRY WELL
PRODUCTIVE WELL
SPIRO SS
RED OAK SS
HARTSHONE FM
MC ALESTER FM
SAVANNAH FM
ATOKA FM
FAULTS
BOTTOM OF WELL
UPLIFTED DIRECTION
1 MILE
O
1 MILE
THE LINE INDICATES THE RELATIVE POSITIONS OF EACH WELL EAST OR WEST OF THE X- SECTION. UP IS WEST.
1000'
2000'
CROSS SECTION B-B'
Plate IV
MARLINE COLLINS
OSU SCHOOL OF GEOLOGY
Pin Line


S
N
50
51
53
54/55
56
57
58
59
60
61
62
63
64
65
67
68
69
70
71
72
73
74
C
C'
SEA LEVEL
1000
2000
3000
4000
5000
6000
7000
8000
9000
10,000
11,000
12,000
13,000
14,000
pjv
pa
TI VALLEY FAULT
CHOCTAW FAULT
NORTH CHOCTAW FAULT
RED OAK SS
SPIRO SS
CHOCTAW DETACHMENT
SPRINGER DETACHMENT
WOODFORD DETACHMENT
1000'
2000'
CROSS SECTION C-C'
Plate V
MARLINE COLLINS
OSU SCHOOL OF GEOLOGY
DRY WELL
PRODUCTIVE WELL
SPIRO SS
RED OAK SS
HARTSHONE FM
MC ALESTER FM
SAVANNAH FM
ATOKA FM
FAULTS
BOTTOM OF WELL
UPLIFTED DIRECTION
1 MILE
O
1 MILE
THE LINE INDICATES THE RELATIVE POSITIONS OF EACH WELL EAST OR WEST OF THE X- SECTION. UP IS WEST.
Pin Line


S
N
22
23
24
25
26
27
28
30
31
32
33
34
35
36
38
39
40
41
43
44
45
46
47
48
D
D'
SEA LEVEL
SEA LEVEL
1000
2000
3000
4000
5000
6000
7000
8000
9000
10,000
11,000
12,000
13,000
14,000
TI VALLEY FAULT
CHOCTAW FAULT
NORTH CHOCTAW FAULT
RED OAK SS
CHOCTAW DETACHMENT
SPIRO SS
SPRINGER DETACHMENT
?
1000'
2000'
CROSS SECTION D-D'
Plate VI
MARLINE COLLINS
OSU SCHOOL OF GEOLOGY
DRY WELL
PRODUCTIVE WELL
SPIRO SS
RED OAK SS
HARTSHONE FM
MC ALESTER FM
SAVANNAH FM
ATOKA FM
FAULTS
BOTTOM OF WELL
UPLIFTED DIRECTION
1 MILE
O
1 MILE
THE LINE INDICATES THE RELATIVE POSITIONS OF EACH WELL EAST OR WEST OF THE X- SECTION. UP IS WEST.
Pin Line


S
N
1
2
3
5
6
7
8
9
10
11
12
13
14
15
16
17
E
E'
SEA LEVEL
SEA LEVEL
1000
2000
3000
4000
5000
6000
7000
8000
9000
10,000
11,000
12,000
13,000
14,000
TI VALLEY FAULT
CHOCTAW FAULT
NORTH CHOCTAW FAULT
RED OAK SS
SPIRO SS
CHOCTAW DETACHMENT
SPRINGER DETACHMENT
1000'
2000'
CROSS SECTION E-E'
Plate VII
MARLINE COLLINS
OSU SCHOOL OF GEOLOGY
DRY WELL
PRODUCTIVE WELL
SPIRO SS
RED OAK SS
HARTSHONE FM
MC ALESTER FM
SAVANNAH FM
ATOKA FM
FAULTS
BOTTOM OF WELL
UPLIFTED DIRECTION
1 MILE
O
1 MILE
THE LINE INDICATES THE RELATIVE POSITIONS OF EACH WELL EAST OR WEST OF THE X- SECTION. UP IS WEST.
Pin Line


Red Oak
WELL SYMBOLS
Location Only
Gas Well
Dry Hole
Service Well
Junked Gas Well
Temporarily Abandoned
Suspended Gas Well
Abandoned Oil Well
Abandoned GAS Well
0
2,000
4,000
6,000
FEET
September 24, 2005
6N 18E
5N 18E
5N 1
4N 18E
4N 19



Red Oak
WELL SYMBOLS
Location Only
Gas Well
Dry Hole
Service Well
Junked Gas Well
Temporarily Abandoned
Abandoned Oil Well
Abandoned GAS Well
0
2,000
4,000
6,000
FEET
September 24, 2005
5N 19
8E


6N 18E
6N 19E
5N 18E
5N 19E
4N 18E
4N 19E
3N 18E
3N 19E


A
B
C
D
E
18E
6N/19E
8E
5N/19E
4N/19E
A' B
C'
D'
E'
PLATE XI

VITA

Marline Collins

Candidate for the Degree of

Master of Science

Thesis: STRUCTURAL GEOMETRY OF LATE PALEOZOIC THRUSTING, WILBURTON AND DAMON QUADRANGLES, ARKOMA BASIN, SOUTHEAST OKLAHOMA

Major Field: Geology

Biographical:

Born in France

Education: Coastal Georgia Community College, Brunswick, Ga., Armstrong Atlantic State University, Savannah, Ga. Received Bachelor of Science Degree in Geology from Oklahoma State University, OK. in 2001.

Phi Kappa Phi National Honor Society
Golden Key National Honor Society
Sigma Gamma Epsilon Earth Science National Honor Society

Professional Experience:

Teaching Assistant: Department of Geology, Oklahoma State University, OK.
Teaching Assistant OSU Geology Field Camp, Canon City, Co.
Internship with Continental Resources Exploration Co., Enid, OK.
Full time position with Continental Resources Exploration Co., Enid, OK.

Professional Membership:

AAPG, GSA, SEPM