STRUCTURAL GEOMETRY OF THE LATE PALEOZOIC THRUSTING IN THE HARTSHORNE, HIGGINS, ADAMSON AND GOWEN QUADRANGLES, SOUTHEASTERN OKLAHOMA

By

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CHAPTER I

INTRODUCTION

Located in the southeastern corner of Oklahoma and western Arkansas is one of the best developed foreland basins. The Arkoma Basin was formed during the Pennsylvanian Ouachita Orogeny. The basin developed as a result of the collision between the Llanoria plate and the southern edge of the North American plate. The Arkoma Basin is bounded by the Ozark uplift to the north and the Ouachita Mountains to the south (Fig. 1).

The Ouachita Mountains are divided into three sections. These sections are the anticline and syncline dominated Central Belt, the Broken Bow Uplift and the fold and thrust dominated region known as the Frontal Belt (Fig. 2). The Frontal Belt is bordered by the Winding Stair thrust fault to the south and the Choctaw thrust fault to the north. The Choctaw Fault is the leading edge thrust to a system of imbricate thrust faults within the Frontal Belt and it acts as one of the limbs to a well developed triangle zone within the Arkoma Basin. The north dipping Carbon backthrust acts as the other limb of the triangle zone (Cemen et al., 2001).

The study area is located between the Arkoma Basin and the Ouachita Mountains and includes parts of Townships 4 and 5 North and Ranges 16 to 18 East and lies within the Adamson, Gowen, Hartshorne and Higgins quadrangles. Previous studies applied in the vicinity of the study area concentrated on evaluation and understanding the structural features located in the subsurface (Akhtar 2005, Sagnak 1996, Kaldirim 2004, Hadaway 2004, and Collins 2006).

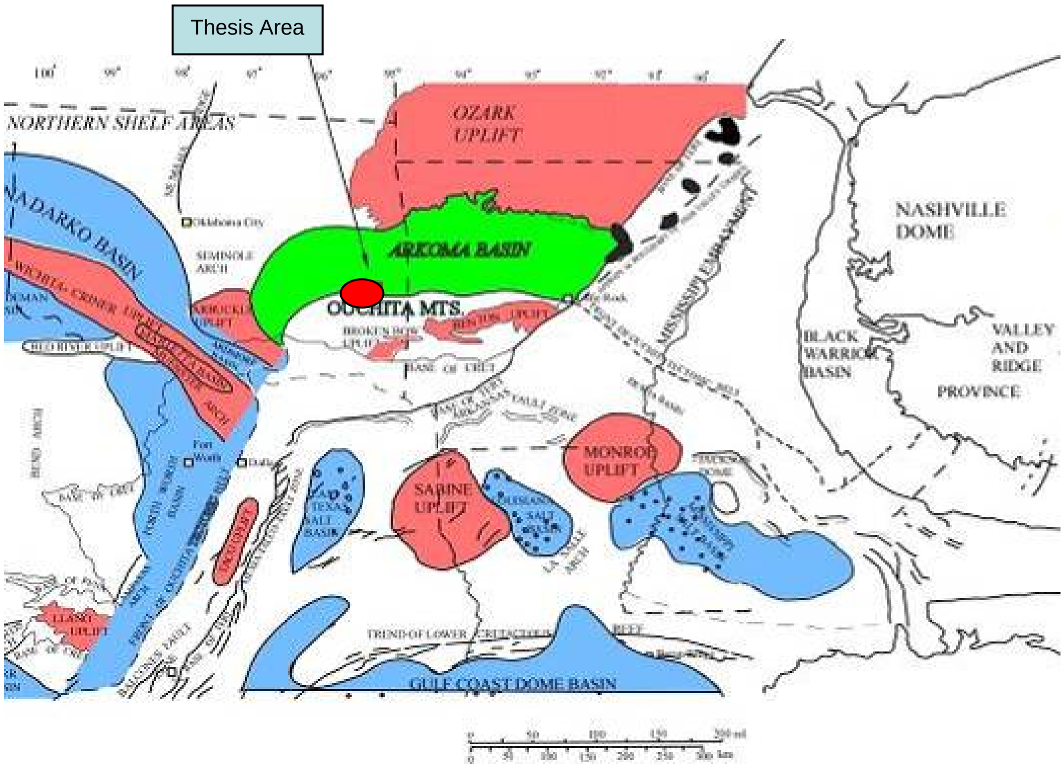


Fig. 1: Geologic provinces in parts of Oklahoma and Arkansas with the general location of thesis area. (Johnson, 1988, Modified from Cemen, 2003 and Collins, 2006)

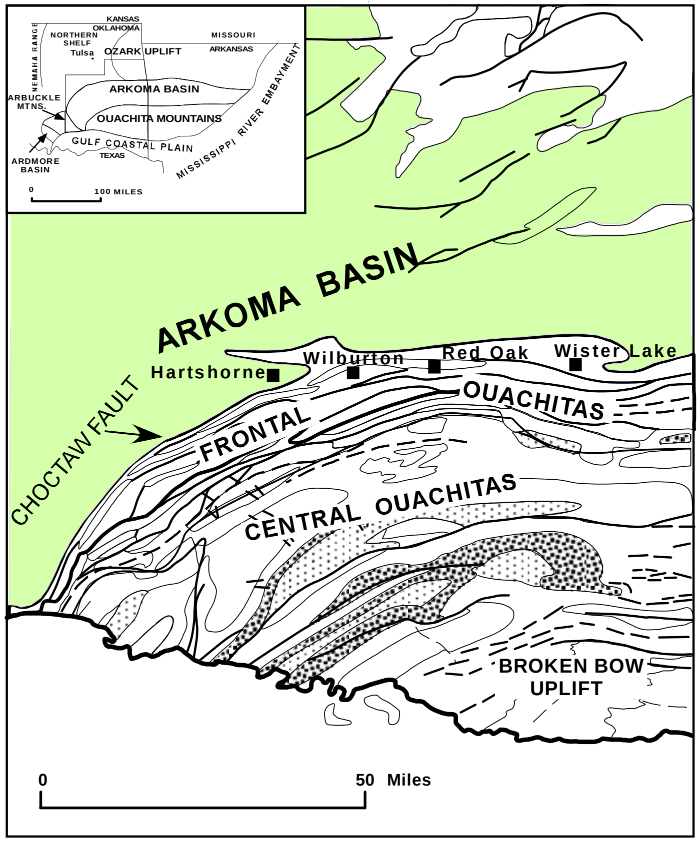


Fig. 2: Geological provinces in the Ouachita Mountains and the Arkoma Basin. (Cemen et al., 2001).

Statement of Purpose

Since the mid-1990's many previous M.S. thesis projects examined the subsurface structural geology of an area that extended from Wister Lake to the Hartshorne Gas Field (Akthar 1995, Sagnak 1996, Ronck 1996, Evans 1997, Mehdi 1998, McPhail 2001, Kaldirim 2004, Hadaway 2004, Collins 2006). These projects relied on the use of well log data, scout cards completion information and 2-D seismic lines. As a result, cross sections were constructed to describe the structural geometry of the subsurface. These cross sections proposed that the triangle zone consisted of the southward dipping

Choctaw fault that acted as the southern limb of the triangle zone and the northward dipping Carbon backthrust being the northern limb, with the Lower Atokan Detachment (L.A.D.) being the triangle zones base. Bellow the L.A.D. was a duplex system that thrusted the Spiro Sandstone into stacked thrust sheets. This duplex system had varying numbers of sharply dipping horses with no deformation within them. Above the L.A.D. was an area of little deformation where the middle Atokan units are relatively undisturbed.

The main purpose of this thesis is to provide a better understanding of the subsurface structural geometry of the Wilburton Gas Field area using well log data and 3-D seismic data provided by Devon Energy Corporation. This study also addressed the sequence stratigraphy of the Lower Atokan Spiro reservoir in the area using wireline logs of the wells drilled for gas production.

Methods of Investigation

To define the subsurface structural geometries seven cross sections were constructed. In addition, structural contour maps of the Spiro thrust sheets and isopach maps of each of the thrust sheets were constructed using the Geoplus Petra Software. Restoration of the cross sections and shortening calculations were done using the key bed method. The Spiro Sandstone was chosen as the key bed because of its sheet like depositional pattern and its wide distribution across the area.

Depositional and sequence stratigraphic modeling for this study was primarily based upon three datasets that include: 1) an extensive collection of wireline well logs 2) isopach maps 3) published studies on the Spiro and other Atokan units.

The primary curves from well logs used in the interpretations were gamma ray curve because of their high resolution and sensitivity to intercalated sandstone and shale units. Log motifs of specific intervals were compared with published studies on the geological interpretation of well logs (Rider, 1986). Gamma ray motifs were analyzed for upward coarsening or fining patterns, serration, blocky versus curvy character and API values.

Isopach maps published in Gross et al., (1995) were used to identify thickness patterns of sedimentary packages. These maps were compared with published studies of barrier islands, such as Rampino and Sanders (1981) and Galloway and Hobday (1996). Published studies on the Spiro Sandstone (Hess, 1995; Lumsden et al., 1971) were used to test the interpretations made from the aforementioned datasets.

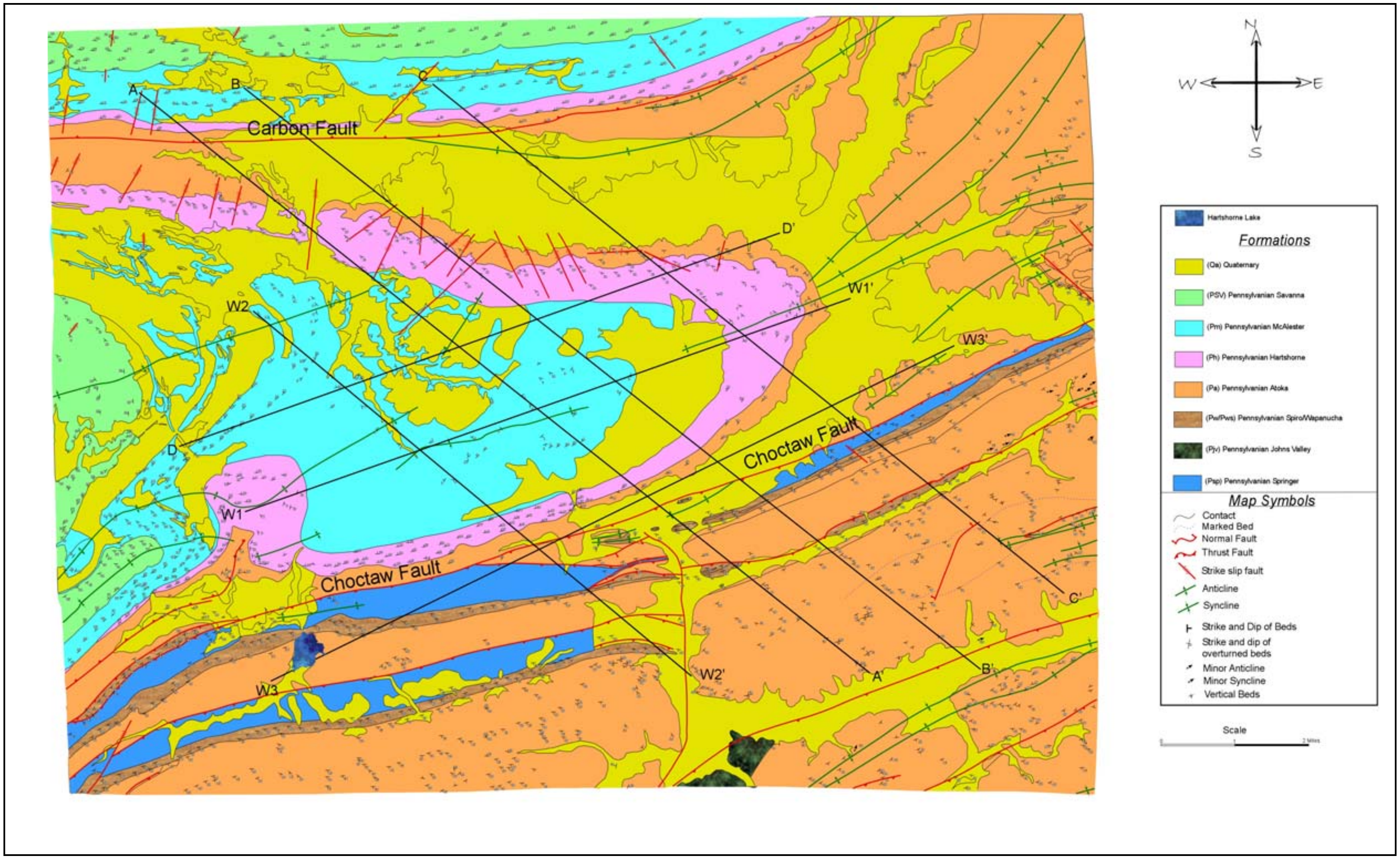


Fig. 3 (Plate 1): Simplified geological map of the study area with the location of cross section lines (Modified from Suneson & Ferguson, 1989. Hemish, 1991. Suneson, 1995.

To develop the cross sections and the maps needed for this study, the following tools and methods were used:

1) Topographic maps of the Adamson, Gowen, Hartshorne and Higgins quadrangles obtained from the United States Geological Survey (Suneson and Hemish, 1989).

2) Geologic maps of the Adamson, Gowen, Hartshorne and Higgins quadrangles were obtained from the Oklahoma Geological Survey. These maps were used to describe the surface geology of the area and help develop a simplified surface geologic map using the Canvas drafting software (Fig. 3) (Plate 1).

3) 3D seismic lines were provided by Devon Energy Corporation. These seismic lines were used to describe the subsurface structure of the study area in more detail.

4) 3D seismic was used to provide a detailed account of the thrust sheet geometry and exact location. This was possible by matching the well location and depth with the 3D seismic image that was provided by Devon Energy Corporation.

5) Raster images of well logs and well data donated by Devon Energy Corporation. These raster images and well data were downloaded into the Geoplus Petra software and used to establish the location of each well, the type of well (gas, oil, water), the total depth of each well, deviation data and top of the Spiro sandstone.

6) Paper copies of certain wells were obtained from the Oklahoma City Geological Society Log Library. These were used to identify certain stratigraphic units.

7) "Scout tickets" were obtained from the Oklahoma City Geological Society log library to assist in the location of the positions of the Spiro, Brazil and Red Oak sandstones.

8) To establish the location of certain deviated wells on the cross sections, Boak's Method of minimum curvature was used (Boak's, 1992).

9) The Spiro sandstone isopach map and Spiro thrust sheet maps were created with the Geoplus Petra software program.

Boak's Minimum Curvature Method

During the construction of cross sections wells were encountered that are deviated. To accommodate for the deviation, the Boak's method was used (Fig. 4). The Boaks Method states that the deviated portion of the well is assumed to be a single arc. To determine the vertical depth from the measured depth for the arc (Φ) the following variables are needed (Boak, 1992). (1) The inclination angle in degrees from vertical (α), (2) compass bearing in degrees from north (β) and (3) the survey point number (i) knowing that the Survey point number at the surface is equal to 0 (Hadaway, 2004).

When these variables have been obtained we can calculate Φ by applying the following equation

$$\Phi = \cos^{-1} [(\cos \alpha_{i-1})(\cos \alpha_i) + (\sin \alpha_i)(\sin \alpha_{i-1})(\cos(\beta_i-(\beta_{i-1}))]$$

The assumed kickoff angle in our study was 20°, while the angle when approaching the end of the well was closer to 40°. When these angles are obtained we can find Φ by using the equation S= r Φ were the length of the arc is (S) and the radius is (r). The radius (r) is found using the scale of our well and our 20° and 40° angles along our circular arc.

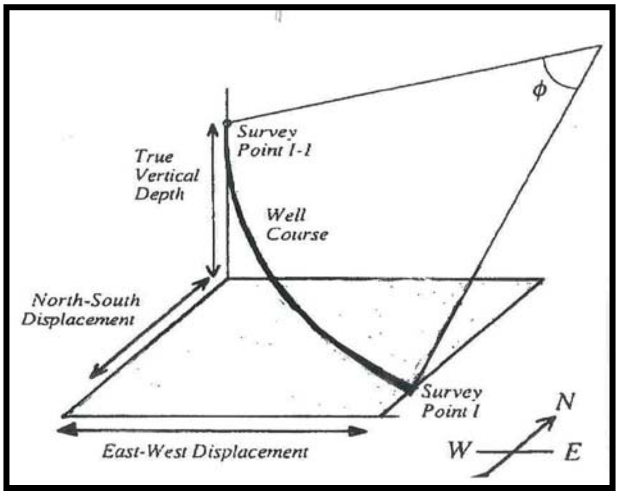


Fig. 4: Boak's Minimum Curvature method (Boak, 1992)

Construction of the Cross section:

In order to develop the seven cross sections and the maps required for this study, a systematic, stepwise approach was used. This approach is separated into two phases.

Phase 1: The preliminary construction of the structural map and cross sections

Tops of the Spiro Sandstone in the footwall of the Choctaw fault were picked from paper copies and raster images of wireline logs were provided by Devon Energy Corporation. This information was inputted into the Geoplus Petra software along with well locations, the township and ranges, section numbers and the outline of the area of 3-D seismic that was donated by Devon Energy Corporation. Petra was used to grid the picked Spiro sandstone tops and constructed a simple structural contour map of the footwall of Choctaw Fault. When the map is closely examined, the areas affected by faulting are detailed by locating the areas where structural contours density increase. This information allowed us to choose the appropriate locations for the construction of the seven cross sections. Information regarding the wells, well depths and the Spiro tops were all transferred onto hand drafted cross sections. The vertical scale that was chosen allowed a 2:1 vertical exaggeration to better illustrate the features of the subsurface.

Phase 2: Using the 3D Seismic to find the approximate location of each thrust sheet, backthrust and hidden Spiro units

3D Seismic data provided by Devon Energy Corporation was used to locate individual thrust sheets and the associated Spiro sandstone units located in the footwall of the Choctaw fault zone. 3D seismic was not used to describe the features located in the hanging wall of the Choctaw fault because the Choctaw fault and all faults on its hanging wall generated excessive noise that affected the quality of the seismic data. Most structural features located in the hanging wall of Choctaw were interpreted using well log data, scout cards and surface structural data provided from Devon Energy, Oklahoma City Log Library and surface geology maps. The final stage of the cross section construction involved using the 3D seismic as a tool to approximate the location of all thrusts, backthrusts and hidden Spiro units that were not recognized using well logs.

Tectonics of the Ouachita Orogeny

Branan (1968) is the first recognized publication to use the name Arkoma Basin for the basinal rocks in southeastern Oklahoma and Arkansas. Although there are several models explaining the tectonics of the Arkoma Basin (Roeder 1973, Keller & Cebull 1973, Buchannan & Johnson 1986), Housknecht and Kecena (1983) is usually recognized as the model that explains most of the observed features. The following is a brief summary of the tectonics of the Ouachita Orogeny based on Housknecht and Kecena (1983).

During the rifting stage (Fig. 5-A) (Fig. 6-A), the southern edge of the North American plate became dominated by passive margin sedimentation. This type of sedimentation would continue until the late Devonian. At that time, the southern part of the North American craton developed a classic shelf-slope-rise geometry, this would continue until the early to middle Paleozoic (Houseknecht & Kacena, 1983). Sediments deposited on the shelf itself consisted of carbonates with little amounts of mud and sand indicative of a shallow marine environment known as the Arbuckle facies. Darker shales with less sandstones and carbonates are located farther south, away from the shelf. These are indicative of a deep marine environment known as the Ouachita facies (Fig. 7-B) (Houseknecht & Kacena, 1983).

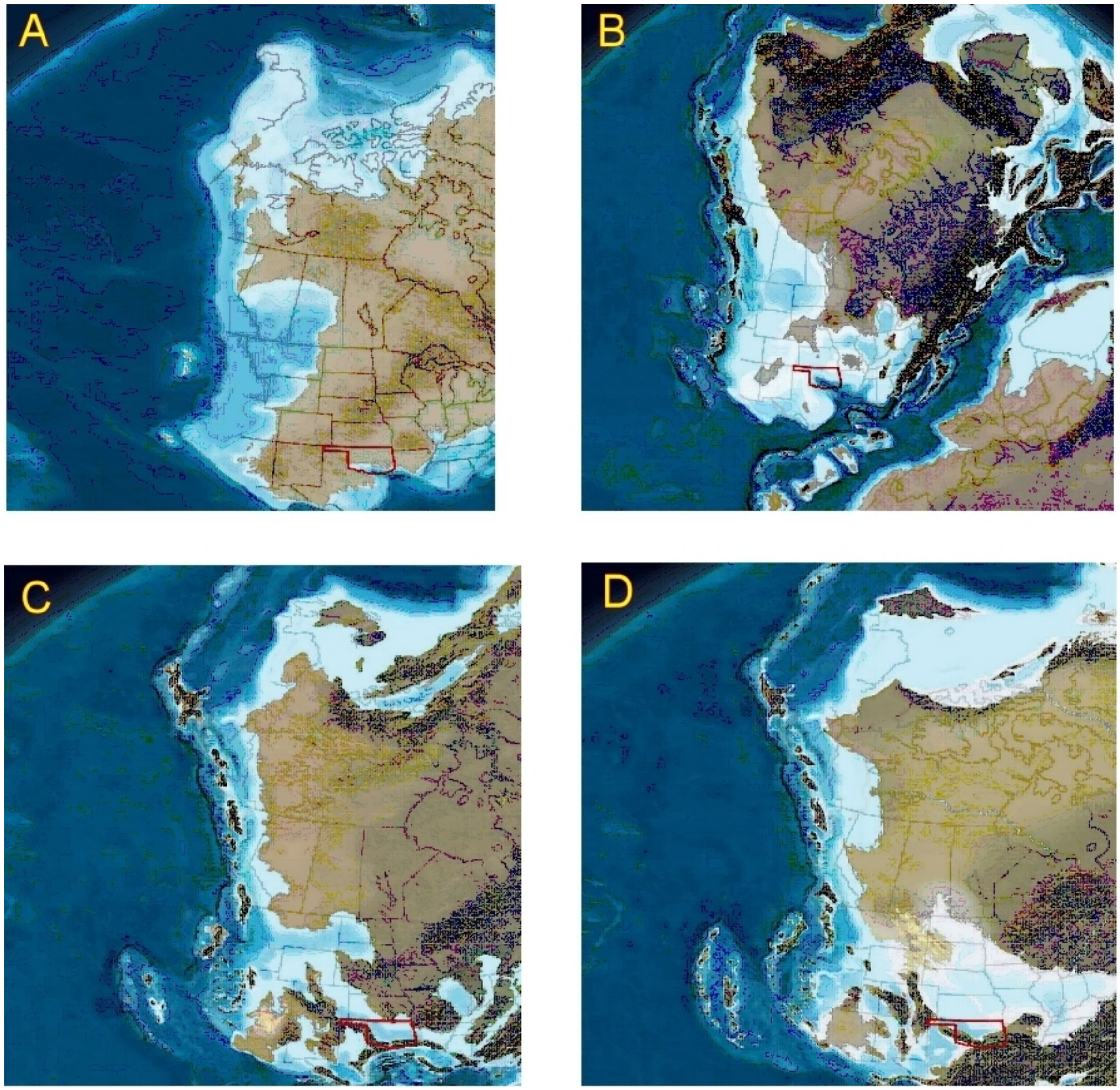


Fig. 5: Illustration of the paleogeography of Oklahoma during A) Cambrian (510 mya). B) Mississippian (345 mya). C) Pennsylvanian (315 mya). D) Pennsylvanian (300mya) (Blakey, 2005).

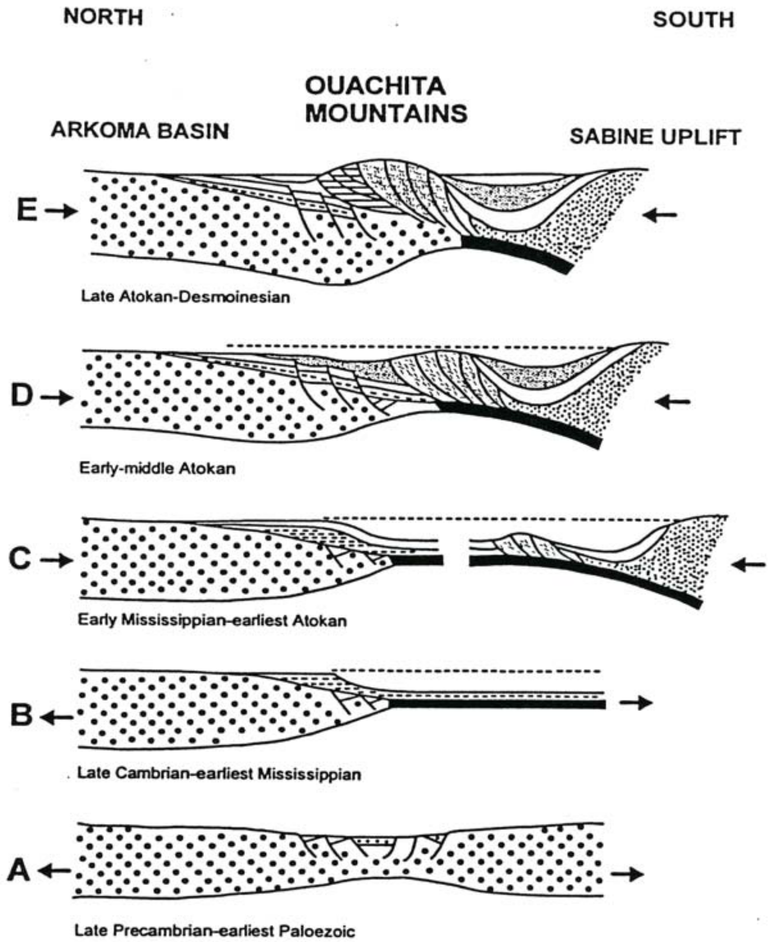


Fig. 6: Tectonic evolution of the Ouachita Mountains and the Arkoma Basin. A: rifting stage. B: Passive Margin. C: Start of the contraction and crustal loading. D: Normal Faulting. E: Final stages of thrusting. (Houseknecht & Kacena, 1983).

By the middle Devonian to early Mississippian time, the southern edge of the North American oceanic plate started to subduct under the Llanoria plate to the south. It is unknown exactly when the subduction occurred, but there is evidence of wide spread metamorphism during the Devonian that could be attributed to the subduction. In addition there is volcanic debris and volcaniclastic sandstones in the Stanley formation that would support the subduction model (Fig. 5-B)(Fig. 6-C) (Houseknecht & Kacena, 1983).

In the late Mississippian to early Atokan (Fig. 5-C), the subduction of the oceanic plate continued, but the shelf units that were deposited before were undisturbed except for some detrital material that was being added from the north. During this period deposition of limestones, sandstones and shale continued in a shallow marine to non marine environment. This is indicative of the Atokan facies that includes the Spiro sandstone unit. With increased vertical load and flexural bending being applied due to the northward subduction, the result was an array of normal faults just south of the North American Plate (Houseknecht & Kacena, 1983). The subsidence caused by the normal faulting as well as the simultaneous deposition of sediments resulted in the abrupt increase in sediment thickness during the early to middle Atokan (Fig. 7) (Houseknecht & Kacena, 1983).

By the late Atokan most of the major structural deformation had stopped. Thin skinned thrust developed as the subduction complex continued to collide with the North American plate. As a result of the collision the Ouachita Mountains were uplifted. Deposition during this time consisted of shallow marine, fluvial and deltaic sediments. Tectonic activity was relatively little sine the Desmoinesian except for some minor thrust faulting and folding (Fig. 6-E) (Houseknecht & Kacena, 1983).

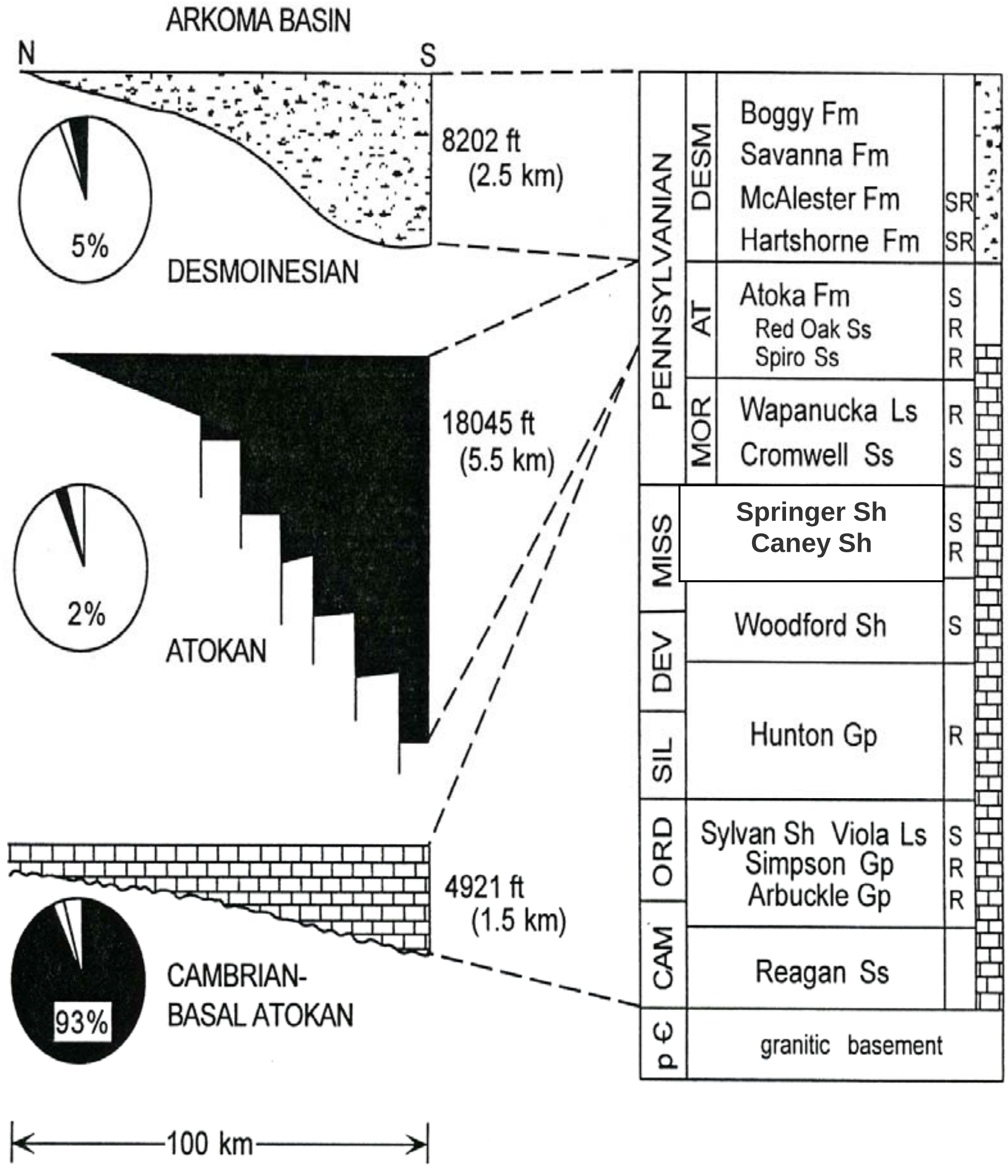


Fig. 7: Pie chart explaining the depositional history and the coinciding Stratigraphic frame work of the Arkoma Basin in southeastern Oklahoma (Houseknecht & McGilvery, 1990)

CHAPTER II

STRATIGRAPHY OF THE ARKOMA BASIN

Pre Pennsylvanian Rock Units

The Arkoma Basin contains strata ranging from the Cambrian to the Pennsylvanian (Fig. 8). These deposits form a nonconformity with the underlying crystalline Proterozoic basement. The oldest sedimentary unit in the basin is the Upper Cambrian Timbered Hills Group. This group includes the Reagan Sandstone and the Honey Creek Limestone. These grade into the Cambrian-Lower Ordovician Arbuckle Group which includes the Fort Sill Limestone, the Royer Dolomite, and the Signal Mountain Limestone. These are overlain conformably by the upper Ordovician rock units of the Arbuckle Group. These include the Butterfly Dolomite, the McKenzie Hill Formation, the Cool Creek Formation, the Kindblade Formation, and the West Spring Creek Formation. These formations represent a shallow marine deposition, and contain shallow marine faunal assemblages that include trilobites, brachiopods, mollusks, and sponges.

The Middle and Late Ordovician strata consists of the Simpson Group, Viola

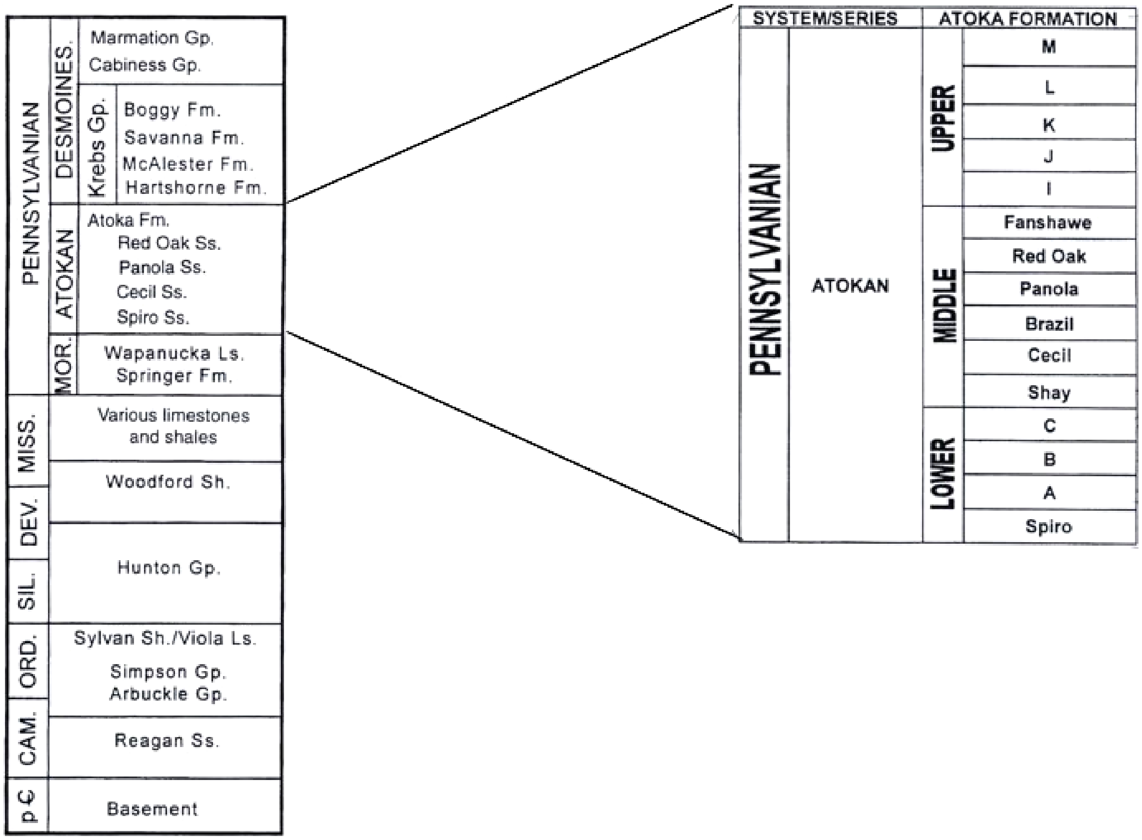


Fig. 8: Stratigraphy of the Arkoma Basin (reproduced from Cemen et al., (2001).

Group, and the Sylvan Shale. The Simpson Group illustrates a change in the depositional environment. This group contains skeletal calcarenites, skeletal carbonates, mudstones, sandstones, and shales. The overlying Viola Group contains limestones and nodular chert-rich mudstones. There is a facies change from Viola Group into the Sylvan Shale which contains graptolites and chitinozoans and indicates deeper water conditions.

The Silurian and early Devonian Periods contain the Hunton Group. The Hunton Group contains carbonates composed of skeletal mudstones and skeletal calcarenites. A regional unconformity separates the Hunton carbonates from the overlying upper Devonian Woodford Shale. The Woodford is an organic fissile shale with beds of vitreous and siliceous chert (Ham, 1978). This unconformity is interpreted as a sequence boundary and suggests a relative-drop in sea-level in the Arkoma Basin.

The Mississippian is represented by the Caney Shale, which is a dark organic shale that contains phosphate nodules. The Springer Shale is an informal unit equivalent to the Caney Shale of the upper Mississippi/lower Pennsylvanian. The Springer differs from the Caney by the appearance of siderite or clay-ironstone beds (Ham, 1978). A more detailed interpretation of the Pre-Pennsylvanian rocks is available by Johnson (1988), Ham (1978).

Pennsylvanian Rock Units

The Pennsylvanian rock units (Fig. 8) are significant to this study because they are penetrated by wells that are used to construct the cross sections. The Pennsylvanian is represented by the Morrowan, Atokan, and Desmoinesian series.

The Morrowan rocks of the Arkoma Basin are the Cromwell Sandstone, the Union Valley Limestone, and the Wapanucka Limestone. They are approximately 300 feet thick in the north and 1000 feet thick in the south of the basin (Johnson, 1988). The Wapanucka Formation of the upper Morrowan series consists of various shoal limestones, spiculites, shales and sandstones (Grayson, Jr., 1979). Overlying the Wapanucka Formation is the sub-Spiro shale. Wapanucka Limestone is exposed on the southern side of the Choctaw Fault. This can be seen at Limestone ridge (Sutherland, 1988) and the study area.

Atokan strata lie conformably on top of Morrowan strata and are were divided into three units (Lower, Middle and Upper Atokan). This division was based on depositional histoy of the basin in response to structural events of that period (Sutherland, 1988). The Atokan strata can range in thickness from hundreds of feet in the northern part of the Arkoma Basin to 10,000ft (Sutherland, 1988).

The Spiro Formation is considered the base of the Early Atokan within the Arkoma Basin. The Spiro crops out to the south of the Choctaw Fault within the study area. Further description of the Spiro will be provided in Chapter III.

After the deposition of the lower Atokan units, the Arkoma Basin transitioned from a stable shelf to a tectonic foredeep (Houseknecht and McGilvery, 1990). The Middle Atokan is composed of the Shay, Cecil, Brazil, Panola, Red Oak and Fanshawe sandstones that formed the from sediment deposited within thick units of shale (Fig. 8) (Cemen et al., 2001). The units are fine grained, lithic to sublithic arenites, which accumulated most of their detritus material from the eastern portion of the Ouachita Oroginic belt (Houseknecht and McGilvery, 1990).

The Krebs group of the lower Desmoinesian 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.

CHAPTER III

SEDIMENTOLOGY OF THE ATOKAN FORMATION

The Atokan Formation is composed mostly of deep marine shale deposits. It contains several sands. The Spiro sandstone is the lowermost sand unit of the Atoka Formation. Mahaffie (1994) defined sheet sands as most closely "resembling fan lobe deposits and are characterized in outcrop by their laterally-continuous, tabular external geometries". The Atoka Formation contains the Spiro sandstone unit. This unit has been interpreted as a sheet sand (Lumsden et al., 1971). The Spiro is an important reservoir sand unit. It is used in structural reconstructions because of its well recognized e-log and seismic signature. The Spiro is also the most productive gas reservoir in the Atokan Basin.

Sedimentology of the Spiro Sandstone

The Spiro Sandstone is a very fine-medium grained arenite (Lumsden et al., 1971) (Hess & Cleaves, 1995). It is moderately to well-sorted and is primarily composed of quartz clasts (>95%) (Houseknecht and McGilvery, 1990). It is also a sheet sand and is laterally extensive, making it a useful marker bed for structural reconstruction. The thickness of the Spiro Sandstone ranges between 100 feet in the deeper parts of the basin in the south to zero where it pinches out in the north. Although no detailed biostratigraphic analysis of the Spiro microfauna has been done, based on underlying shales the unit is dated as Morrowan in age (Mc Caleb, 1963). Fossils within the Spiro include crinoids, bryozoans, brachiopods and other shelf fauna (Lumsden et al., 1971).

Lumsden et al (1971) divided the Spiro into eight lithofacies based on data from cores, drill cuttings, and outcrop. His lithofacies scheme is described below;

1. Shale Facies

"The shale facies has silt stringers and was distant from sources of sediment supply, it was deposited in offshore parts of the shelf" (Lumsden et al., 1971).

2. Poteau Facies

"These are very fine grained and tightly cemented sands. Indications of shallow water deposition include bioturbation and interbedded sandstones and muds characteristic of lagoonal deposition" (Lumsden et al., 1971).

3. South Red Oak Facies

"Sandstones in this facies are similar in grain size to the Poteau Facies but differ in porosity, lighter color, thickness, and presence of cross bedding" (Lumsden et al., 1971).

4. Kinta Facies

"This facies was formed by the reworking of the Foster Sands by a transgression. It consists of a light-gray, uniformly thick, even-bedded sand" (Lumsden et al., 1971).

5. North Red Oak Facies

"This facies is a southern extension of the Kinta Facies and also has characteristics of the South Red Oak and Wilburton Facies. Fossil fragments are abundant, and this is interpreted as a complex of beach, bar, tidal flat, tidal channel, and lagoonal environments" (Lumsden et al., 1971).

6. West Kinta Facies

"This is a thin interval showing a decrease in grain size and an increase in calcite cement" (Lumsden et al., 1971).

7. Wilburton Facies

"Sand in this Wilburton Facies is light colored, fine grained and very fossiliferous" (Lumsden et al., 1971).

8. Limestone Facies

"Clastic quartz decreases and calcareous grains increase as the Spiro forms a gradational contact with the underlying Wapanucka Limestone" (Lumsden et al., 1971).

Sequence Stratigraphy of the Spiro Sandstone

Two sequence stratigraphic models were studied to understand the depositional history of the Spiro Sandstone. According to Lumsden et al (1971) the Spiro was deposited during a transgression, Hess (1995) agrees with this interpretation and further describes the depositional history of the Spiro Sandstone as part of the reworking of the older Foster sands that had been either deposited directly over the Sub-Spiro shale, or it was deposited over the Wapanucka limestone as part of the filling of the incised valleys created during the Low Stand and subsequent shelf exposure.

The model proposed here is based upon 1) Well log signatures 2) Fossil fauna and 3) Architecture of the Spiro Sandstone. 164 well logs (See Appendix A for Well names and locations) were examined for log motifs that would best characterize the Spiro Sandstone. The typical Gamma Ray motif (Fig. 9) is slightly serrated, blocky, with a sharp base and upward fining profile. The serration is interpreted as clay rich horizons within the sandstone, the blocky profile is characteristic of high net:gross sheet sands, the sharp base suggests an erosional contact with the underlying strata, and the upward fining suggests retrogradation. These characteristics (fining upwards of a shallow-marine sand) suggest a transgression where parasequences would be back-stepping (Van Wagoner et al, 1990). The sharp erosional base is interpreted as a flooding surface.

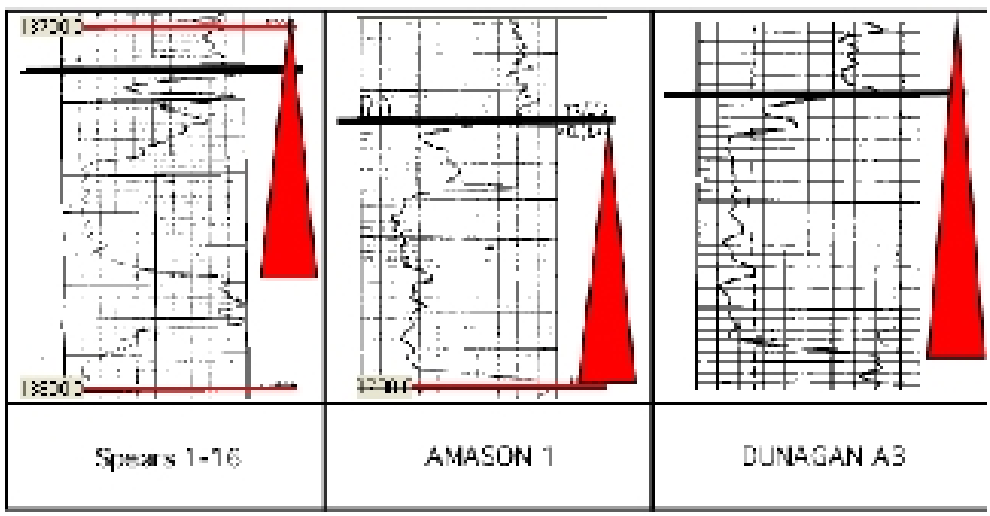


Fig. 9: Gamma Ray profiles of the Spiro Sandstone from the Wilburton Gas Field showing upwards fining.

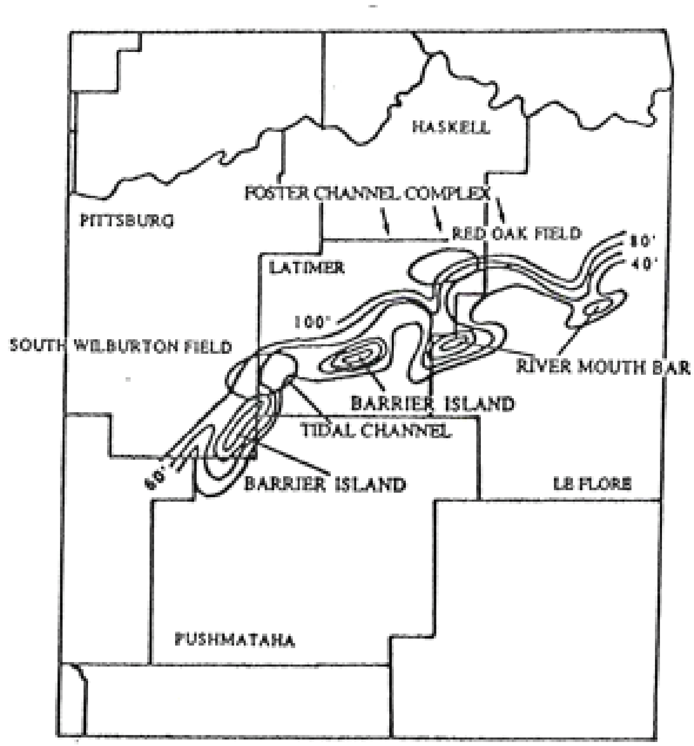


Fig. 10: Isopach map of the Spiro Sandstone in the study area (Reproduced from Gross et al., 1995).

The Spiro is exceptionally fossiliferous and contains a shelf assemblage that includes crinoids, bryozoans, and brachiopods. Transgressive systems tracts are known for their faunal abundance. Lowstand deposition is centered in the deeper parts of the basin, and the shelf is exposed. Due to these conditions shelf faunas are rare and impoverished, producing a scanty fossil record. These observations also support the deposition of the Spiro Sandstone during a transgression.

The strongest evidence for the Spiro Sandstone being part of a Transgressive Systems Tract comes from the architecture of the Spiro Deposits. Isopach maps of the Spiro Sandstone by Gross et al. (1995) shows a trend of barrier islands (Fig. 10). The laterally extensive sheet like geometry of the Spiro Sandstone is attributed to the reworking of older Foster Sands during a transgression. The Spiro Sandstone incises the older Sub-Spiro Shale and the Wapanucka Limestone. This erosional contact is interpreted as a ravinement surface created during a transgression. The proposed Transgressive system tract model (Fig. 11) is similar to the model by Hess (1995).

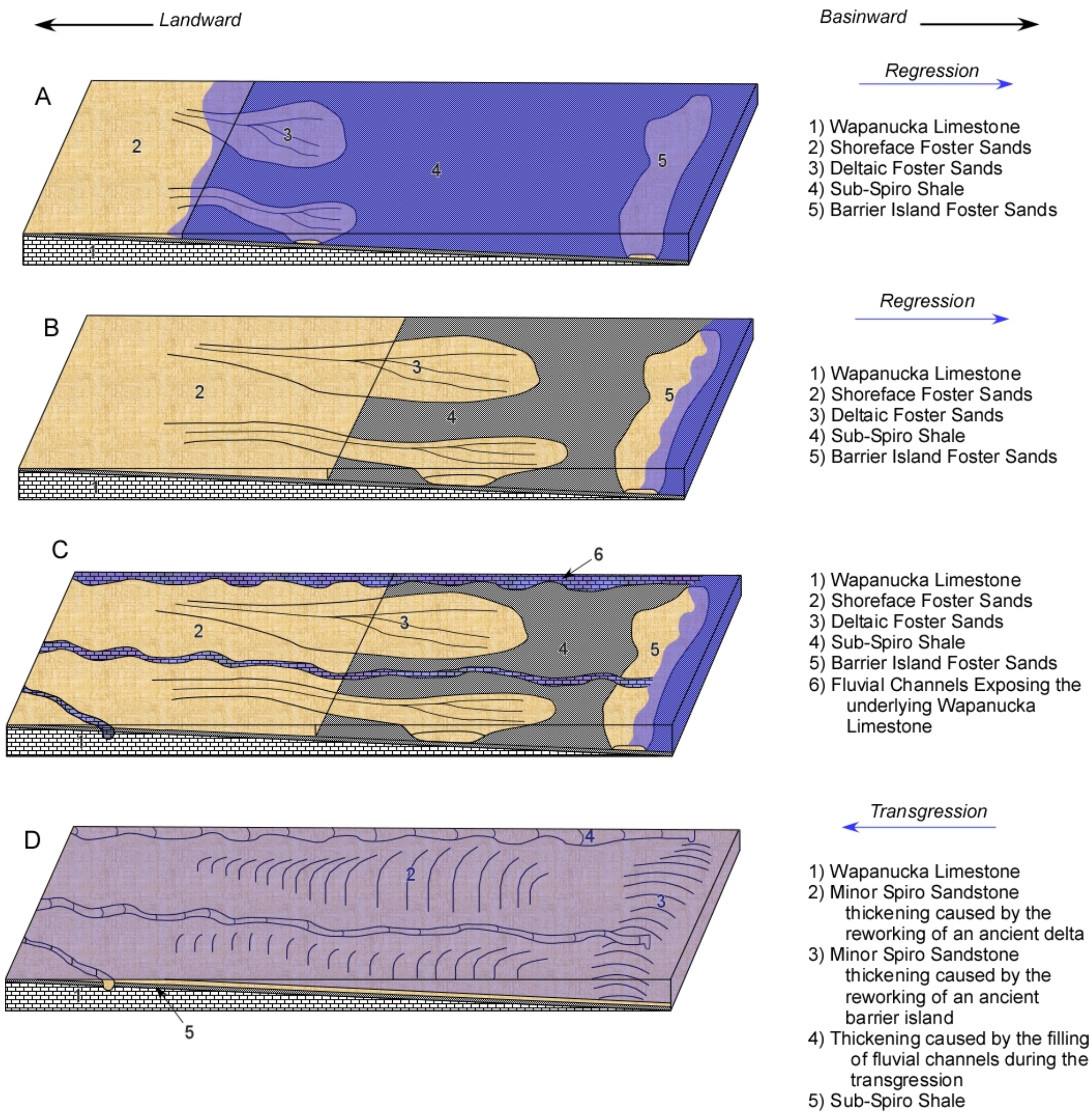


Fig. 11: Sequence stratigraphic model of the Spiro Sandstone deposition

CHAPTER IV

GENERAL GEOMETRY OF THRUST SYSTEMS

The study area is intensely deformed by several large thrusts. Before these thrusts are discussed in detail, this section introduces the reader to some important components of thrust systems. A thrust system contains many thrust faults closely spaced from each other and are connected at depth to a common detachment surface (Boyer and Elliot, 1982) (Marshak and Woodward, 1986). As a result of the increasing stresses being applied in a fold and thrust belt, the subsurface will most commonly develop imbricate fans, backthrusts, duplex structures, triangle zones and lateral ramps (Boyer and Elliot, 1982). The following is a short description of these features.

Imbricate Fans

When increasing stress affects a certain area, the resulting stresses allow for faults to be created. These imbricate thrust faults are created deep within the basin at a common detachment surface and move upsection to shallower depths (Fig. 12). There are two types of imbricate fan thrust faults. 1) Leading Imbricate Fault System: The first type of thrust faults have most of the displacement in the leading thrust which would leave the footwall with the most displacement (Fig. 12-A); and 2) Trailing Imbricate Fans of thrust faults have most displacement at the trailing thrust, leaving the bulk of the displacement in the hanging wall of the leading edge thrust fault (Fig. 12-B).

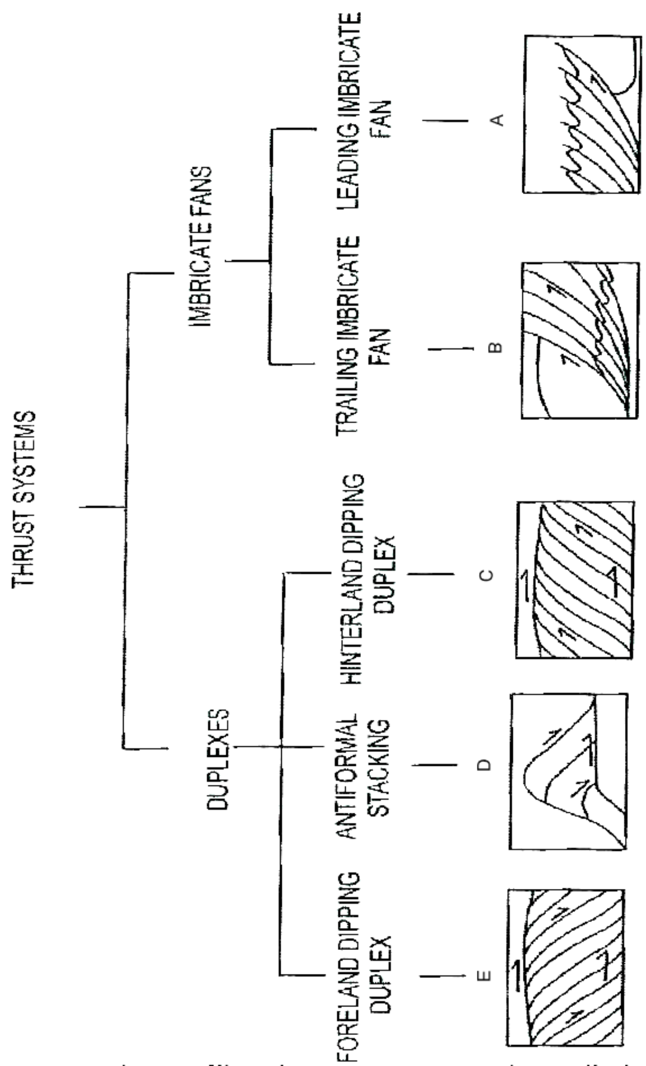


Fig. 12: Possible thrust Geometries that might be present in a thrust system (Modified from Boyer and Elliot, 1982)

Backthrusts

Backthrusting is a phenomenon where a fault forms in a direction that opposes the regional movement of the major thrusts (Butler, 1987). These structural features can develop at the leading-edge of the thrust sheet when a barrier becomes an obstacle for the thrust sheet to move forward and therefore creating a release for the extra energy in the form of a backthrust (Butler, 1987). Backthrusts are a major factor in the creation of triangle zones in many thrust belts around the world (Fig. 13) (Butler, 1987). Backthrusts may also be created if the propagation rate exceeds the displacement rate (Bulter, 1987).

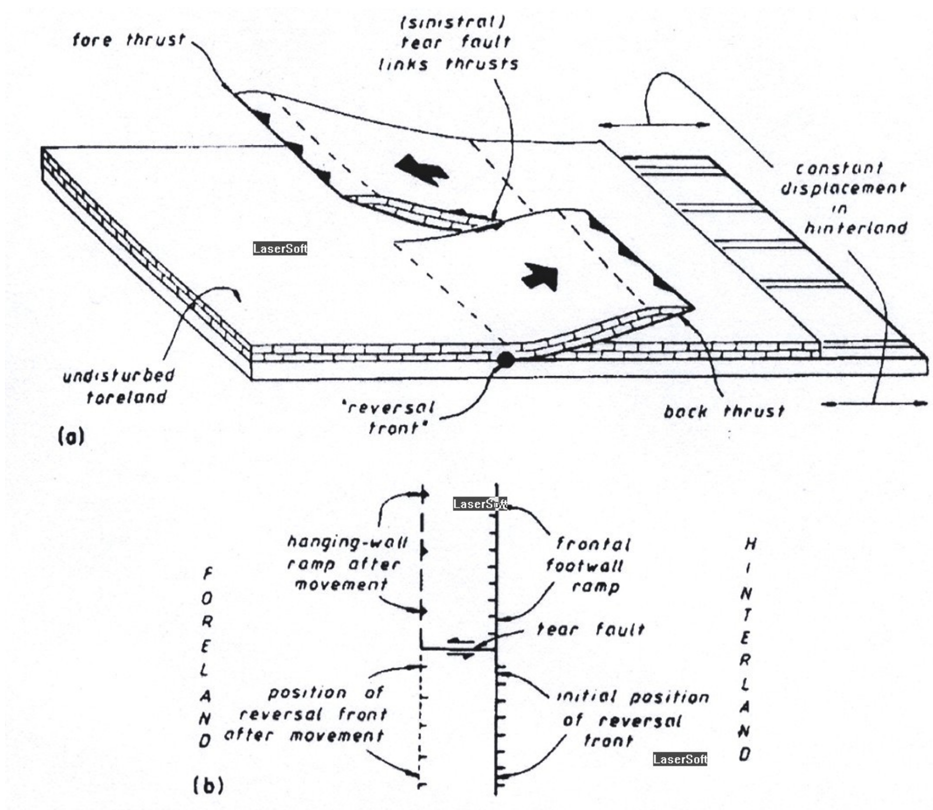


Fig. 13: A) A 3D representation of the relationship between forethrusts and backthrusts. B) A plan view of the relationship between forethrusts and backthrusts (Butler, 1987)

Webel (1987) proposed three types of backthrusting in the Rocky Mountain fold-thrust belt. Type I of these backthrusts can be seen in all tepee structures and triangle zones. These are low angle thrusts faults that are located ahead of the leading thrust fault and dipping in the opposite angle (Fig. 14-A)(Webel, 1987).

Type II backthrusts are relatively high angle thrusts and are created behind the trace of the major thrust faults (Fig. 14-B). They illustrate pop up structures that are created when a snakehead fold passes over a subsurface ramp. Type III backthrusts are strongly associated with basement arches, angle of ramping and listric normal faulting (Webel, 1987). Backthrusts of this nature are low angled gravity induced backthrusts that are activated when a listric normal fault is created. The normal fault was induced because of the high angle ramp that was created as a result of a basement arch. The resulting high angle ramp allowed for an incipient backthrust to glide down the ramp to create a shallow backthrust (Fig. 14-C).

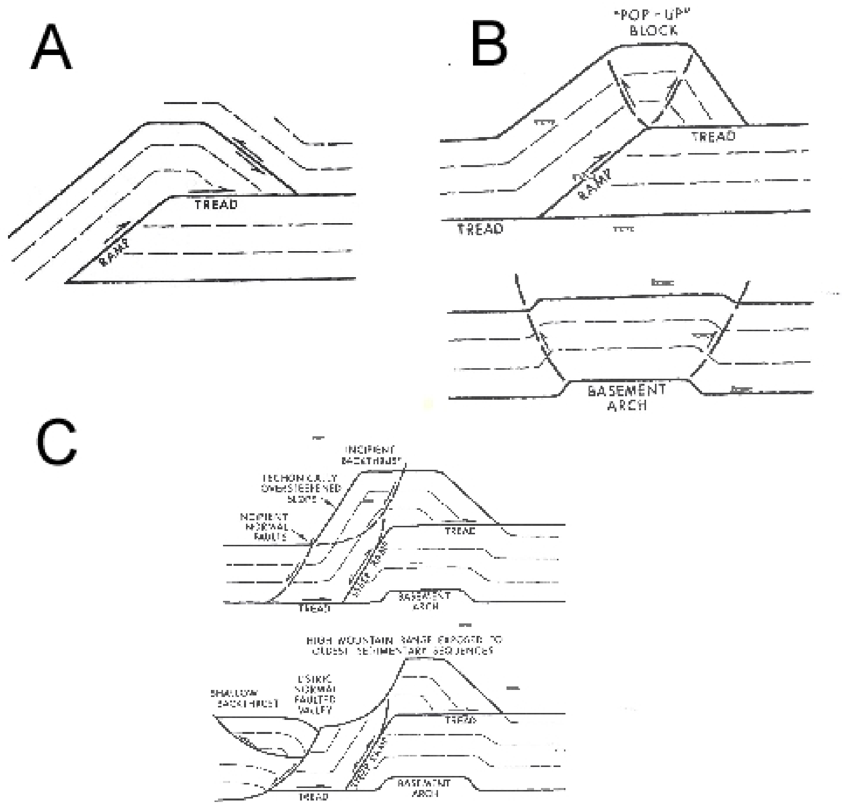


Fig. 14: A) Illustration of the Type I Backthrusts associated with Tepee structures and Triangle Zones. B) Illustration of Type II backthrusts. C) Illustration of a Type III Backthrust showing a gravity induced slide resulting from a basement arch increasing the steepness of the ramp angle. (Webel, 1987)

Duplex Structures

Duplex structures are imbricate fans that are created from a common basal detachment and cut up section to meet at a higher detachment. The bottom basal detachment in a duplex structure is called a floor thrust while the upper basal detachment is labeled the roof thrust. As the imbricate fans cut up section from the floor thrust to the roof thrust a feature with thrusts bounding it from all direction will develop. This structure is called a horse. Duplexes are a combination of horses that have formed due to the compression or thrusting in an area (McClay, 1992)(Fig. 15).

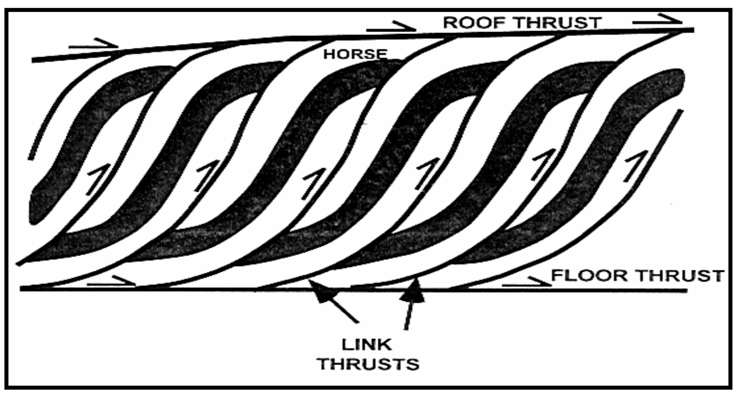


Fig. 15: Terminology associated with Duplex's (McClay, 1992)

Figure 12 shows three different duplex structures of Boyer and Elliot (1982);

1) Hinterland Dipping Duplex (Fig. 12-C): The fault slip is less than the deformed fault length (McClay, 1992). The horses in the duplex dip in the direction of the hinterland.

2) Foreland Dipping Duplex (Fig. 12-E): The fault slip is larger than the deformed fault length (McClay, 1992). The horses dip towards the foreland rather than the hinterland.

3) Antiformal Stack: The fault slip is equal to that of the deformed fault length (McClay, 1992). Each horse is thrusted up onto the other giving way to stacked formation (Fig. 12-D).

Triangle Zones

The term Triangle zones was first used by Peter Gordy in an internal report to describe the structural characteristics of the eastern margin of the Canadian Cardillera (Jones, 1996). They are usually the result of two opposite dipping thrust faults, associated with a basal detachments surface thus creating a triangle shape. The geometry of the triangle zone can be attributed to the continuation of the fold and thrust belt convergence and deformation. Butler (1987) stated that when convergence gets close to the foreland then deformation in the direction of the stress starts to decrease but the stresses continue to build. This built up stress then gives way to inherent thrusts and backthrusts (Butler, 1987).

Couzens and Wiltschko (1994) classified triangle zones into three types (Fig. 16):

1. Type I: The triangle zone is characterized by two opposite dipping thrusts that are symmetrical to each other and are floored by a single detachment surface.
2. Type II: The triangle zone is characterized by two opposing thrust systems that are asymmetrical to each other and are floored by a single detachment surface.

3. Type III: The triangle zone is characterized by two opposing thrust systems that are asymmetrical to each other and are floored by two detachment surfaces.

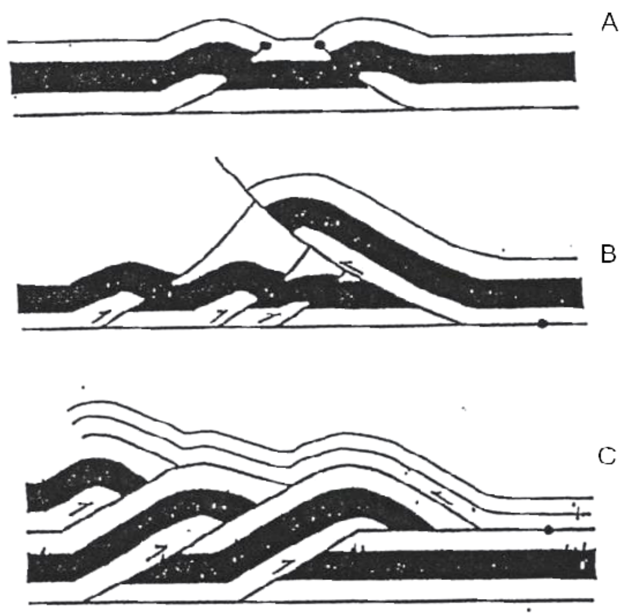


Fig. 16: Triangle zone geometry (Couzens and Wiltschko, 1998)

Lateral Ramps

Lateral ramps were first introduced to describe a tectonic ramp that is parallel to the direction of thrusting (Boyer and Elliot, 1982) (Fig. 17). But lateral ramps have been observed to disrupt stratigraphic levels along strike and decollment changes (Pohn, 2000).

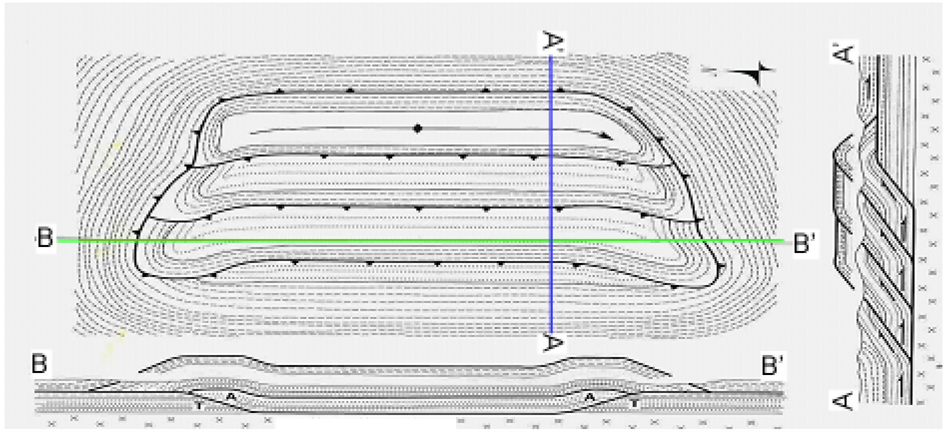


Fig. 17: Illustration of surface geological map and two cross sections. A-A' is showing the duplex structure and direction of thrusting. B-B' is showing two lateral ramps (Boyer & Elliott, 1982).

The association of lateral ramps with thrust faulting is accomplished due to the fact that thrust faults can either die out to the flanks of the thrusting (Fig. 18-A), or the thrust sheet can distribute the stress from one fault to another via a lateral ramp (Fig. 18-B) (Pohn, 2000). Four types of lateral ramps are proposed by Pohn (2000). The geometry of the first lateral ramp can be considered the simplest. This is where parallel sided ramps are connected to a horizontal decollement (Fig. 19-A), the second being parallel sided ramps connected to a dipping decollement surface (Fig. 19-B), the third is a horizontal decollement surface with converging ramps (Fig. 19-C), finally the convergent sided ramps with the dipping decollement surface (Fig. 19-D) (Pohn, 2000).

Lateral ramps are features that do not often outcrop to the surface but they can be observed using seismic reflection. These seismic reflection lines can illustrate that cross strike faults in the subsurface can form the foundations or deflecting buttress of lateral ramps (Pohn, 2000). Surface expressions of certain geological features can supply clues as to the location of lateral ramping in the area. These surface features are:

1. The distinct change in folds magnitude or the sudden termination of a fold (Pohn, 2000).
2. A sudden change in the magnitude of a fault (Pohn, 2000).
3. Basin interruption due to cross strike border faults (Pohn, 2000).

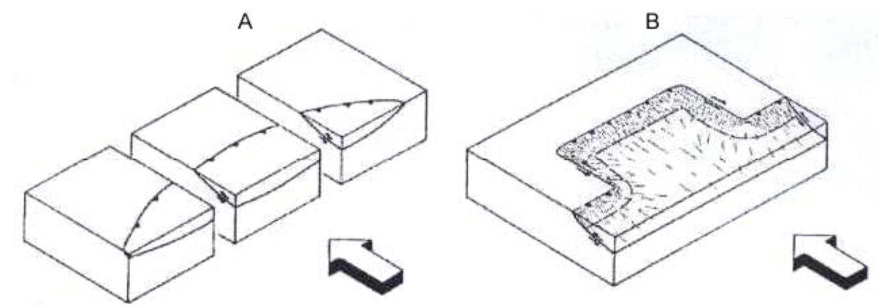


Fig. 18: 3D view of the formation of Lateral ramps, A) Showing the fault dying out to the flanks of thrusting. B) The lateral progression from one fault to another via a lateral ramp (Pohn, 2000).

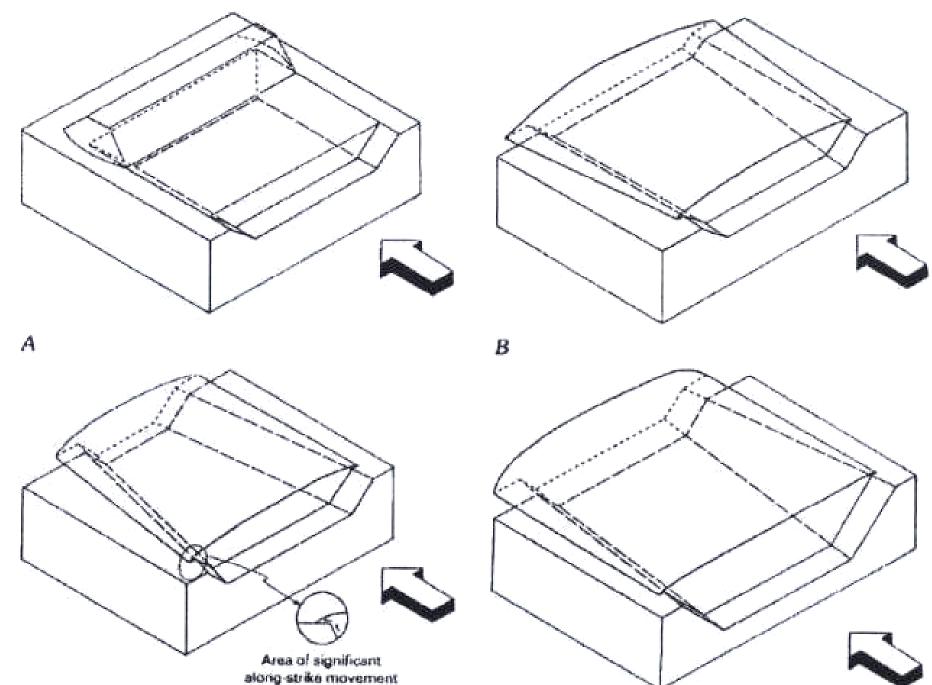


Fig. 19: Lateral ramp geometries. Arrows show direction of movement. A) Parallel side ramps connected to a horizontal decollement. B) Parallel sided ramps to a dipping decollement. C) Converging lateral ramps on a horizontal decollement. D) Convergent sided lateral ramps on dipping decollement (Pohn, 2000).

CHAPTER V

STRUCTURAL GEOLOGY OF THE FRONTAL OUACHITAS-ARKOMA BASIN TRANZITION ZONE

Although many workers studied the geology of the Ouachita Mountains and the Arkoma Basin, first subsurface structural interpretations of the transition zone were only published in the 80's. Arbenz (1984) proposed the presence of a decollement deep below the surface. He mapped a south-dipping imbricate fault system that was accompanied by a backthrust that established a triangle zone (Fig. 20).

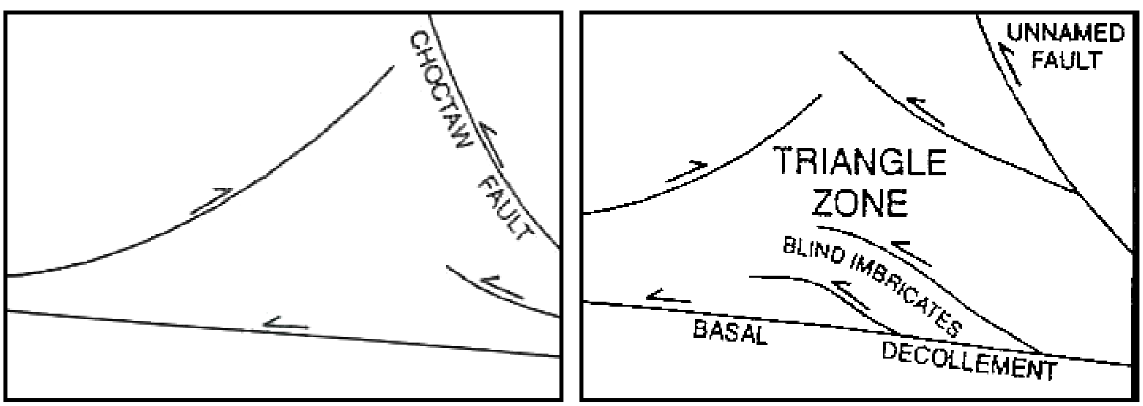


Fig. 20: Illistration of the subsurface in the transition zone. (Arbenz, 1984)(Arbenz, 1989)

Many controversial interpretation of the transition zone were proposed in the late 1980's and early 1990's. Hardie (1988) was the first to describe the geometrical relationship between the Blanco thrust fault to the north and the Choctaw thrust fault to the south in the vicinity of Hartshorne, Oklahoma (Fig. 21-A).

Milliken (1988) suggested the presence of a “bi-vergent” imbricate thrust system that was floored by a detachment surface at depth (Fig. 21-B). The presence of this deep detachment surface was agreed upon by Camp and Ratcliff (1989), they also identified the presence of a thick triangle zone with a deep detachment.

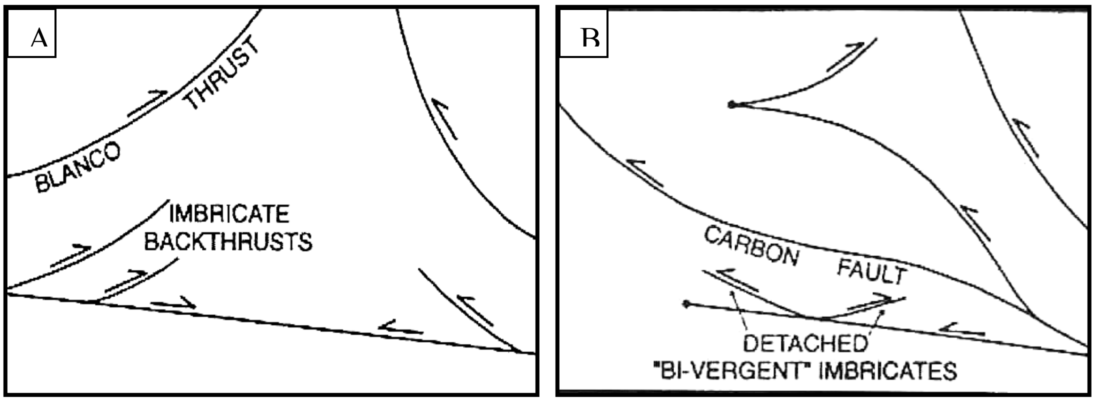


Fig. 21: A) Illustration of the subsurface as presented by Hardie (1988), B) Illustration of the subsurface as presented by Milliken (1988), Camp & Ratcliff (1989).

Reeves and others (1990) interpreted a thin triangle zone floored by two north-directed duplex structures (Sunneson, 1995). He suggested that there was a decollement surface that separated the duplex structures and that the deep decollement is in Lower Atokan Strata (Fig. 22-A).

Perry and Suneson (1990) interpreted a seismic section that showed not one but two triangle zones. One of these triangle zones was located above the shallow detachment surface. The other triangle zone was located between the shallow detachment surface and the deep detachment surface was accompanied by imbricate thrusts (Fig. 22 B).

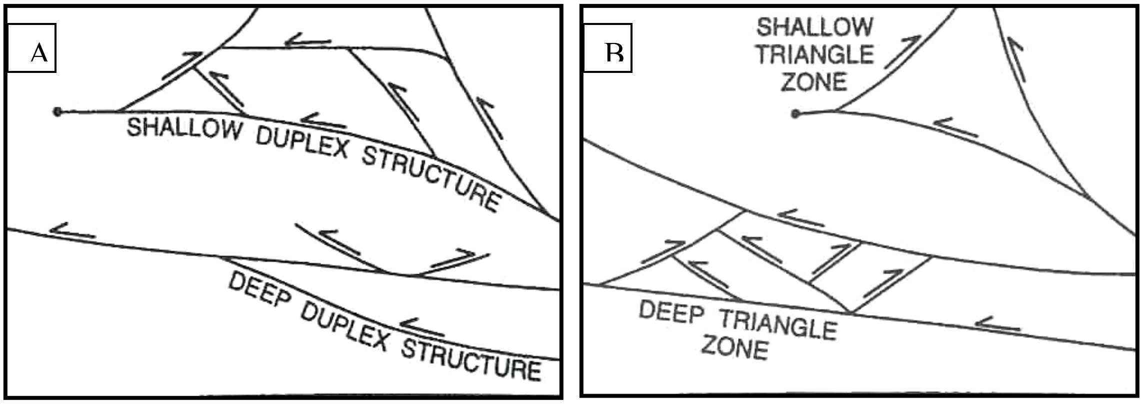


Fig. 22: A) Illustration of the subsurface as presented by Reeves and others (1990), B) Illustration of the subsurface as presented by Perry and Suneson (1990)

Wilkerson and Wellman (1993) proposed the presence of a thin triangle zone in the Hartshorne area. The floor of the triangle zone is the roof thrust of the duplex structure that they named the Gale Buckeye thrust system (Fig. 23). They also discovered tear faulting and a series of blind imbricate thrusts located near the base of the duplex structure.

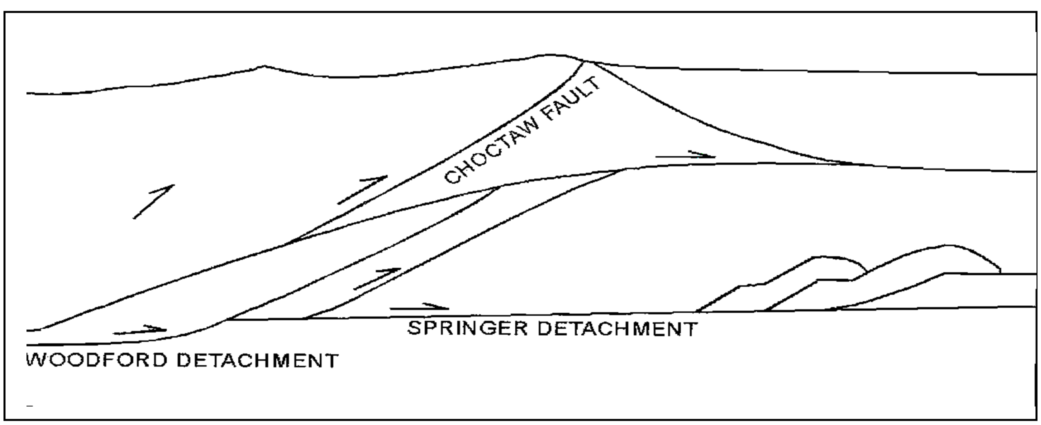


Fig. 23: Illustration of the subsurface as presented by Wilkerson and Wellman (1993)

In the early 1990's, gas exploration in the western part of the Arkoma Basin became very important. The Wilburton Gas Field was the center of the exploration activity. With a grant from the Oklahoma Center for Advancement in Science and

Technology (OCAST), Dr. Ibrahim Cemen of Oklahoma State University, School of Geology and his student started a subsurface structural study of the Wilburton Gas Field and surrounding areas. The purpose of this study was to examine the structural geometry of the transition zone between the frontal Ouachitas and the Arkoma Basin.

Cemen, Sagnak and Akthar (2001) summarized the structural geology work in the Wilburton Gas Field and proposed a well developed triangle zone in the Wilburton Gas Field area. This triangle zone has the Choctaw Fault as its southern flank, while the backthrust fault known as the Carbon fault is the northern flank of the triangle zone. A detachment surface called the Lower Atokan Detachment (L.A.D.) is the base of the triangle Zone. The LAD is the roof thrust for a deeper duplex structure and the Springer detachment is the floor thrust. This duplex structure has a number of hinterland dipping horses (Fig. 24).

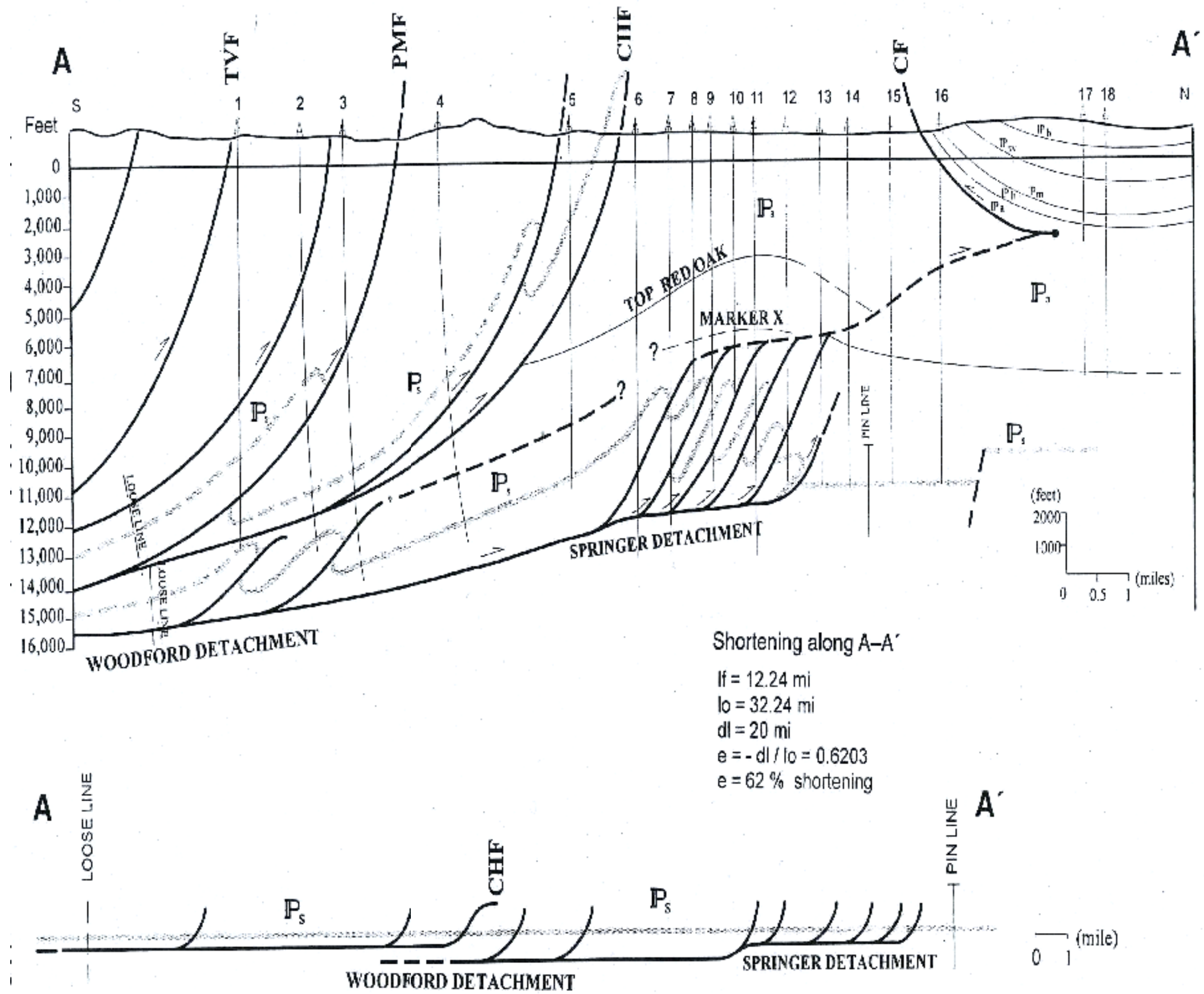


Fig. 24: Illustration of the subsurface and the amount of shortening as done by Cemen et al., 2001

CHAPTER VI

STRUCTURAL GEOLOGY OF THE STUDY AREA

The study area is dominated by structural features that are consistent with the contraction that the Transition zone experienced during the Pennsylvanian. To understand the structural geology of the study area, seven cross sections were constructed (Fig. 3). Four of these cross sections are oriented parallel to the tectonics transport direction. These four cross sections were constructed to illustrate the position of the triangle zone and duplex structure within the study area. Within the triangle zone, the Carbon Fault is the northern most backthrust. This backthrust is only present on cross sections A-A’ (Fig. 27), B-B’ (Fig. 28) and C-C’ (Fig. 29). Cross section W2-W2’ (Fig. 32) does not extend far enough north to cross it. The major structural feature in the area is the Choctaw Fault. This fault separates the highly deformed, tightly folded and faulted Frontal Ouachitas from the mildly deformed, broadly folded Arkoma Basin. The three remaining cross sections were constructed perpendicular to the tectonic transport direction. This was directed at detecting the amount of lateral movement that may have been present in the footwall of the Choctaw Fault.

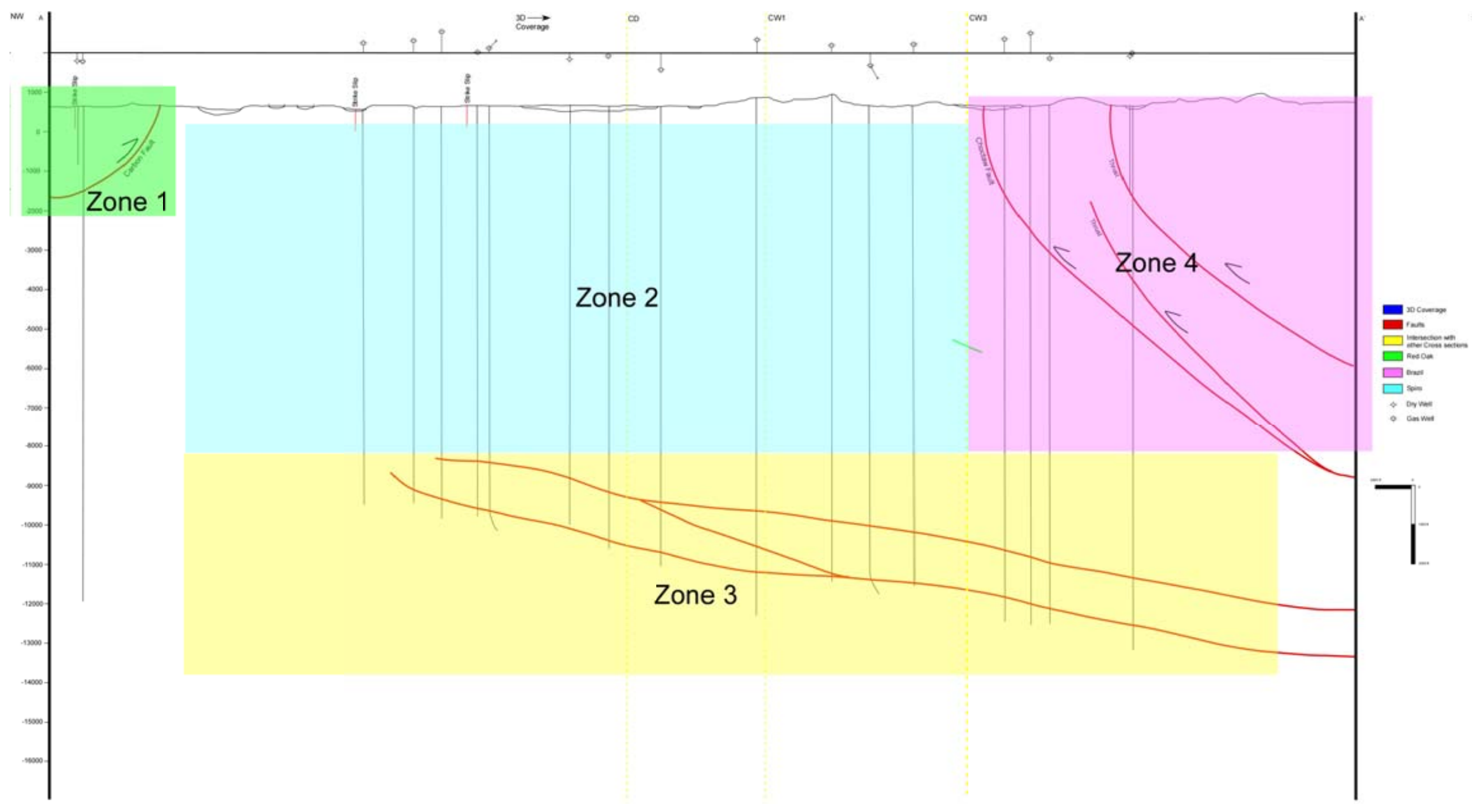


Fig. 25: Simplified Look at Cross section A-A` illustrating the various zones within the Cross section

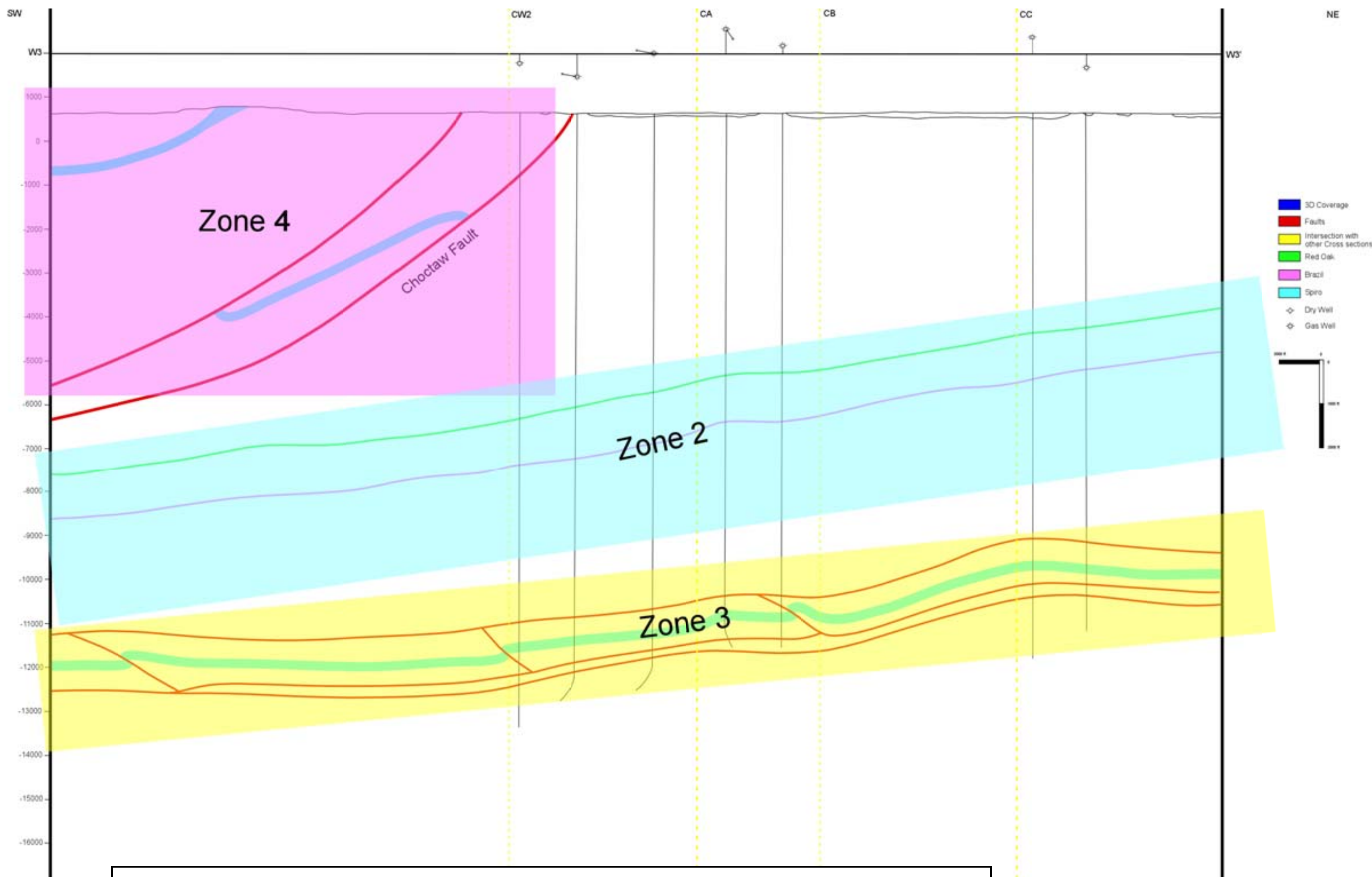


Fig. 26: Simplified view of Cross section W3-W3` illustrating the various Zones within a cross section oriented roughly East-West.

The four NW-SE cross sections that were oriented perpendicular to the strike of Choctaw are divided into four zones (Fig. 25). These zones are chosen based on the structural features that are present. They are also transferred to the three NE-SW cross sections that are oriented roughly parallel to the Choctaw fault. The NE-SW cross sections could display zones 2 and 3 while zone 4 only appears on the southern most cross section W3-W3' (Fig. 26).

Zone 1:

This area encompasses the Carbon Fault and all features that lie north of it. As previously mentioned Zone 1 is only displayed in cross sections A-A' (Fig. 27), B-B` (Fig. 28) and C-C' (Fig. 29), since the remaining cross sections did not extend far enough to the north. The 3D seismic does not extend far enough to the north to display the Carbon fault as well. All information obtained for this area is from previous studies and surface structural geology maps (Suneson et al., 1996).

The Carbon fault dips at about 50^{o} at the surface. The angle decreases at depth and the fault becomes almost horizontal at around -1700 ft. The Pennsylvanian McAlester, Atoka and Hartshorne are exposed at the surface of the hanging wall of the Carbon Fault (Fig. 3).

Zone 2:

This zone is located south of the Carbon fault which is interpreted as a backthrust (Cemen et al., 2001). Geological maps by Suneson et al., (1996) contain small strike-slip faults to the south of the surface trace of the Carbon fault. These types of structures do not seem to have any affect on Zone 3 that lies deeper within the footwall of Choctaw.

The surface formations that are located in this area are mostly Pennsylvanian McAlester, Hartshorne, Atoka and Savannah, with a layer of Quaternary covering them in certain areas (Fig. 3).

Within the footwall of Choctaw at around - 4000ft we come across the Red Oak Formation and the Brazil Formation at a depth of -5000ft. Abnormal fractures within these formations were critical in the discovery of a feature that can be described as a shallow thrust. This shallow thrust was not present in former cross sections that were studied (Hadaway, 2005) (Collins, 2006) and it was not seen on the well log data. This shallow thrust-That was named the Middle Atokan Thrust (M.A.T.) - was only visible through the use of 3D seismic where the thrust seem to be originating as a splay from the Choctaw fault and is present at - 9500ft. The M.A.T. increases in dip angle as it cuts up section into shallower depths. The M.A.T. appears to be younger in age in comparison to the Choctaw Fault, as there is no visible Spiro unit within the thrust wedge between the Choctaw Fault and the M.A.T. This shallow thrust is well observed in cross sections W2-W2’ (Fig. 32) but it becomes less apparent in the eastern most cross section C-C` (Fig. 29). Various numbers of out of sequence thrusts splay from the M.A.T. and displace the Brazil and Red Oak layers. These backthrusts dip in the foreland direction at angle of about 65^{o}.

Zone 3:

The footwall of the Choctaw fault contains a well developed duplex structure. The roof thrust of the duplex structure is the Lower Atokan Detachment (L.A.D.). The L.A.D. serves as the base of the triangle zone that is located in the transition zone (Cemen et al., 2001). The floor thrust of the duplex structure is known as the Springer detachment (Cemen et al., 2001). The Springer detachment drops in elevation the further south you move and becomes the Woodford detachment (Cemen et al., 2001). The cause for the rise and fall of the detachment surfaces is the normal faulting in the pre- Pennsylvanian units.

The Springer detachment rises from a depth of about -13000ft and continues to rise to about -9000ft in the northern part of the study area. At the northern end of the duplex, the Springer detachment rises and gently folds the Spiro units. The duplex structure contains five to seven horses. The 3D seismic data indicates that the thrust faults in the duplex structure had a decreased angle of dip when compared to the cross sections constructed by Mehdi (1998), Hadaway (2005) and Collins (2006).

The duplexes contained many small backthrusts within the horses themselves. At first, it was thought that these backthrusts were actually tear faults or even a major flower structure that had developed from deep within the pre-Pennsylvanian layers and extended to affect the Red Oak and Brazil formations. But these findings could not be confirmed when combined with the 3D seismic data.

The backthrusts appear to be younger than the south dipping thrusts that developed the horses. The north dipping backthrusts were causes minor displacements when compared to the displacement of the actual horses. These backthrusts might have caused the Spiro sandstone unit to increase in thickness. This increase in thickness can be seen in cross sections W1-W1' (Fig. 31), where the Spiro thickness in this unit is at 561ft when compared to the average amounts of Spiro thickness of about 250ft-300ft.

The lateral ramps that are present are more likely caused by the movement of the thrust sheet atop of each other and the shifting from one thrust sheet to another similar to the geometry proposed by Boyer and Elliot (1982) (Fig. 25). This can be seen on cross sections D-D’ (Fig. 30), W1-W1’ (Fig. 31) and Cross section W3-W3’ (Fig. 33)

At the northern end of the duplex is a horst structure that drops the level of the Spiro unit below -10,500ft. This system of normal faults is located relatively north of the study area, outside the range of the 3D seismic data. A combination of cross sections developed prior to this study (Collins, 2006) (Hadaway, 2005), and well log data, assisted in the location of these normal faults.

The overall trend of the duplex is consistent with the findings of Collins (2006) where the Spiro formation and the duplexes are at shallower depths to the east of the study area while the farther west the duplex structure becomes deeper.

Zone 4:

The northern edge of this zone is also the northern border that separates the Frontal Belt of the Ouachita Mountains from the Arkoma Basin. This border is known as the hinterland dipping Choctaw thrust fault. The Choctaw fault cuts through the study area and trends west-southwest to east-northeast. It is the leading edge thrust in a break forward style imbricate thrust system that encompasses many faults on its hanging wall (Cemen et al., 2001). At the surface, the Choctaw fault has a relatively high dip angle of about 70^{o} and as the fault moves deeper within the basin the dip angle becomes shallower. The dip angle is almost horizontal at depths of about -8500ft where the Choctaw fault acts as a detachment surface to a system of imbricate faults that include the Pine Mountain Fault, Ti Valley Fault (Cemen et al., 2001).

The surface geology south of the Choctaw fault shows many assemblages of thrust faults, anticline and syncline pairs and some strike slip faults. The strike slip faults seem to not be deep enough to affect zone 3 and the duplex structure. Surface geological maps (Fig. 3) indicate that the Pennsylvanian Atoka formation, Johns Valley, Springer and Spiro/Wapanucka package crop out at the south of the trace of the Choctaw Fault.

Although all the cross sections running roughly east-west did not penetrate Zone 4, cross section W3-W3' (Fig. 33) did intersect the Choctaw Fault. Because of the acute angle of intersection, the Choctaw fault and Spiro units within the hanging wall of Choctaw had a large surface expression. This relative increase was adjusted for in the subsurface.

Unfortunately because of the number of thrusts located within the hanging wall of Choctaw and the close proximity of these faults to each other, the ability to use the 3D seismic was lost as the Choctaw fault created too much of a noise factor to be able to make an accurate seismic interpretation. Therefore, all data gathered on the hanging wall of the cross sections was created using well log information and scout cards.

Cross sections restoration and calculation of shortening

To calculate the amount of shortening that had been experienced in the study area, three factors needed to be determined. *The First Factor* was the method of calculation. Because of the concentric nature of the folds due to the amount of incompetent shale units within the basin (Cemen et al., 2001), the method of restoration that was used is the key bed method. The formation that was chosen as the key bed for the calculations was the Spiro sandstone unit because it is a sheet like sandstone that extends well within the basin.

The Second Factor to finding the amount of shortening is the sections being calculated. Three areas were chosen to calculate the amount of shortening, they are:

1) The overall duplex structure
2) The minor backthrusts that are located within the duplex structure to calculate the impact these backthrusts had on the overall compression within the duplex.
3) The overall study area that encompasses the duplex structure and the Choctaw imbricate fault structure.

The Third Factor to calculating the shortening was the positioning of the pin line and loose lines. The pin line for was placed north of the duplex structure to symbolize the end of the deformation. To calculate the shortening applied to the overall duplex structure, the loose line was placed further south just beyond the start of the first duplex. This was similarly the case for the calculations for the minor backthrusts within the duplex structure. To calculate the overall shortening, the loose line was placed at the southern edge of the hanging wall where there is no piercing point for the Spiro Sandstone units.

The Fourth Factor is the calculation of shortening. To complete the calculation of shortening applied in an area two variables are needed. 1) Is the final length of the Spiro unit after the deformation had occurred (L_f). 2) The original length of Spiro sandstone unit before deformation (L_o). This can be achieved by measuring the Spiro units individually. By subtracting the final length of the deformed Spiro (L_f) from the original length of the Spiro before deformation (L_o) the result will be the shortening distance. The percent of shortening was calculated using the following equation

$\frac{Lf - Lo}{Lo} X\, 100$ (Table 1).

Shortening applied to the overall duplex structure					
	L_f (ft)	L_o (ft)	L_f (ft)-L_o (ft)	L_f (ft)-L_o (ft)/L_o (ft)	Percentage
Cross section A-A'	45921.6	55843.1	-9921.5	-0.178	17.77
Cross section B-B'	45372.5	55764.7	-10392.2	-0.186	18.64
Cross section C-C'	39764.7	50745.1	-10980.4	-0.216	21.64
Cross section W2-W2'	39137.3	46352.9	-7215.6	-0.156	15.57
Shortening applied due to the backthrusts within the duplex structure					
Cross section A-A'	45921.6	50588.2	-4666.63	-0.092	9.22
Cross section B-B'	45372.6	47764.7	-2392.16	-0.050	5.01
Cross section C-C'	39764.7	41803.9	-2039.21	-0.049	4.88
Cross section W2-W2'	39137.3	41803.9	-2666.67	-0.064	6.38
Shortening applied to the overall structure within the study area					
Cross section A-A'	45921.6	97411.8	-51490.19	-0.529	52.86
Cross section B-B'	45372.6	107215.7	-61843.15	-0.577	57.68
Cross section C-C'	39764.7	87843.1	-48078.43	-0.547	54.73
Cross section W2-W2'	39137.3	90039.2	-50901.97	-0.565	56.53

Table 1: Excel spread sheet indicating the shortening calculations done on three areas within the study area.

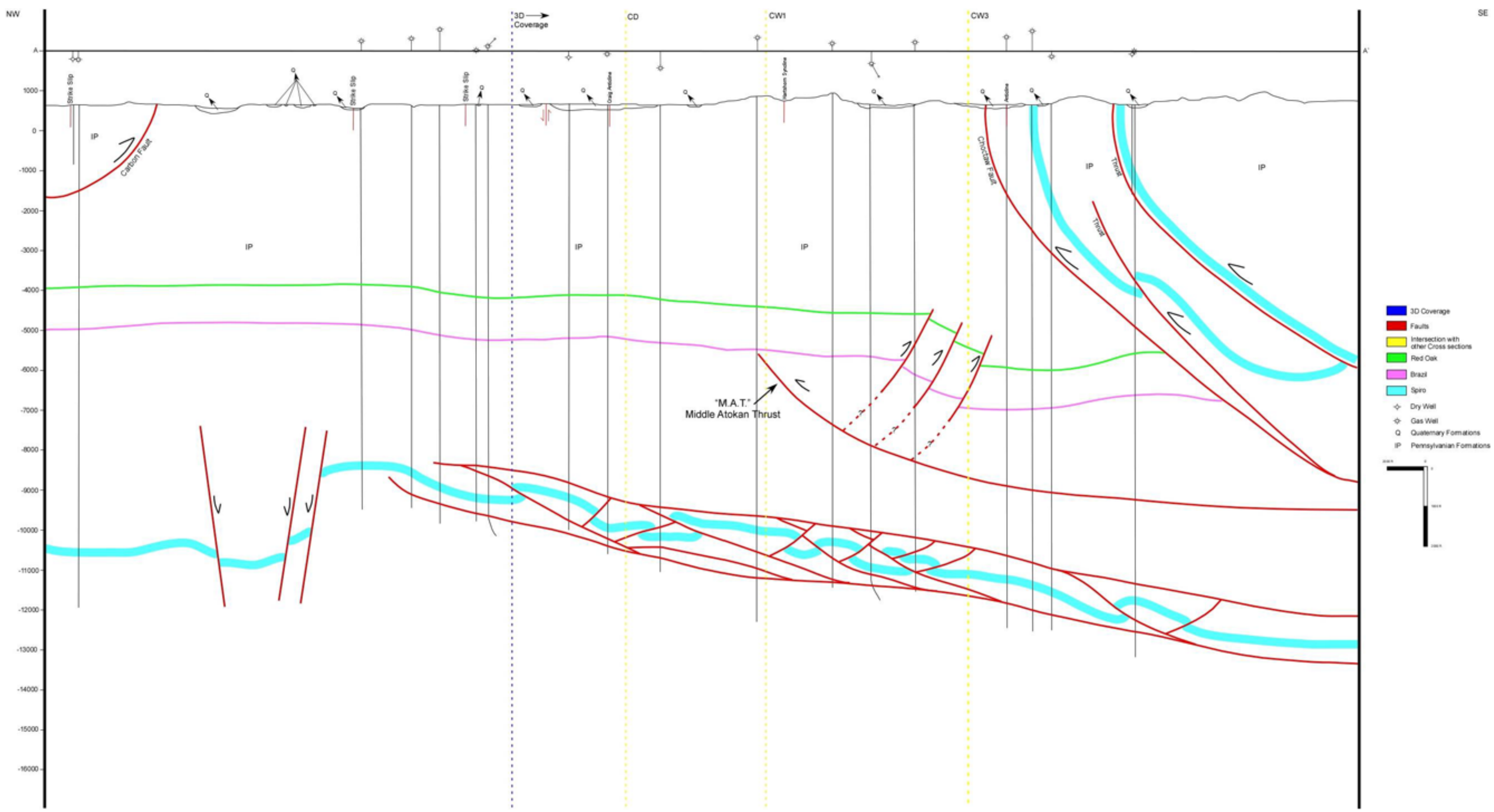


Fig. 27 (Plate 2): Cross section A-A`

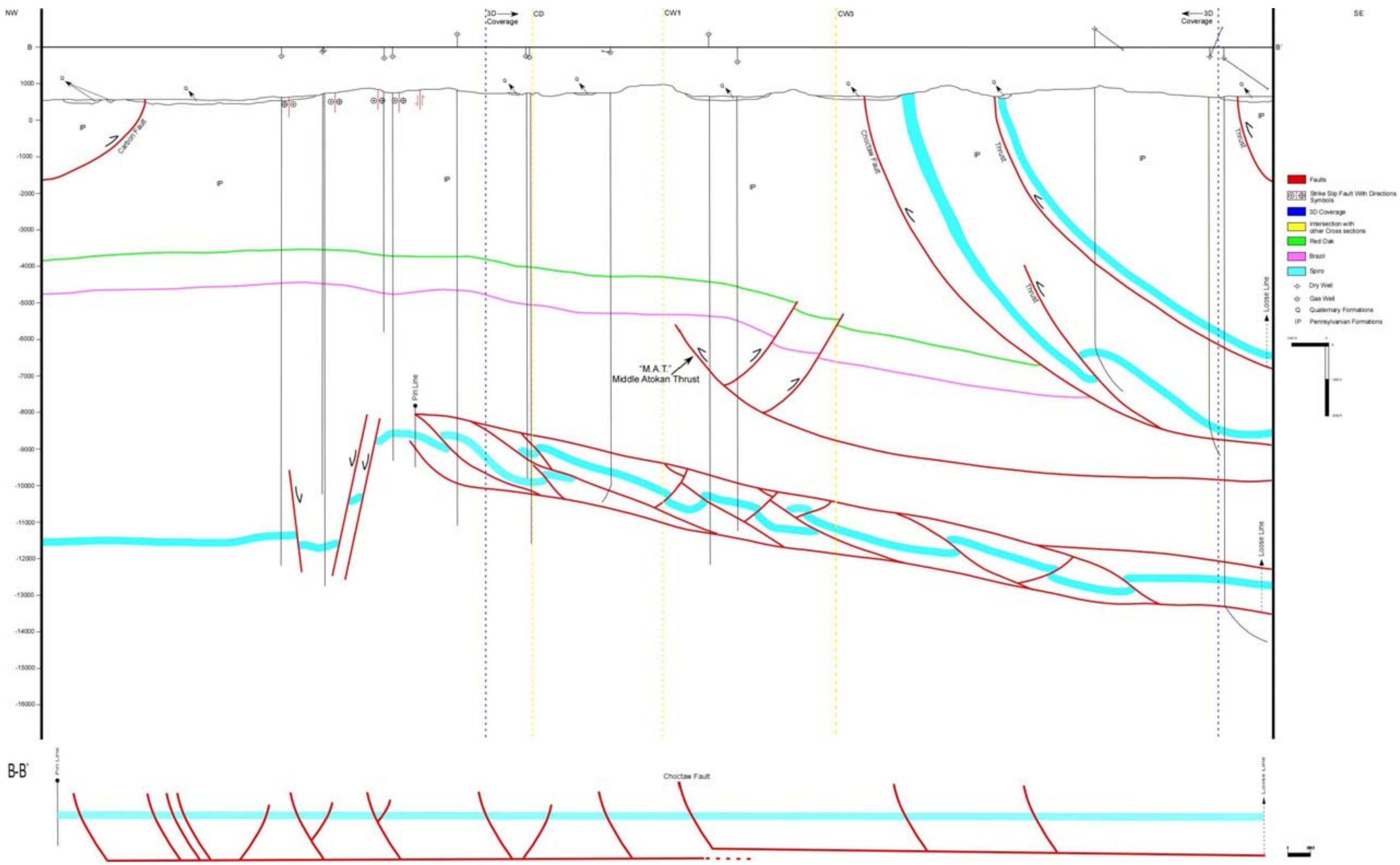


Fig. 28 (Plate 3): Cross section B-B`

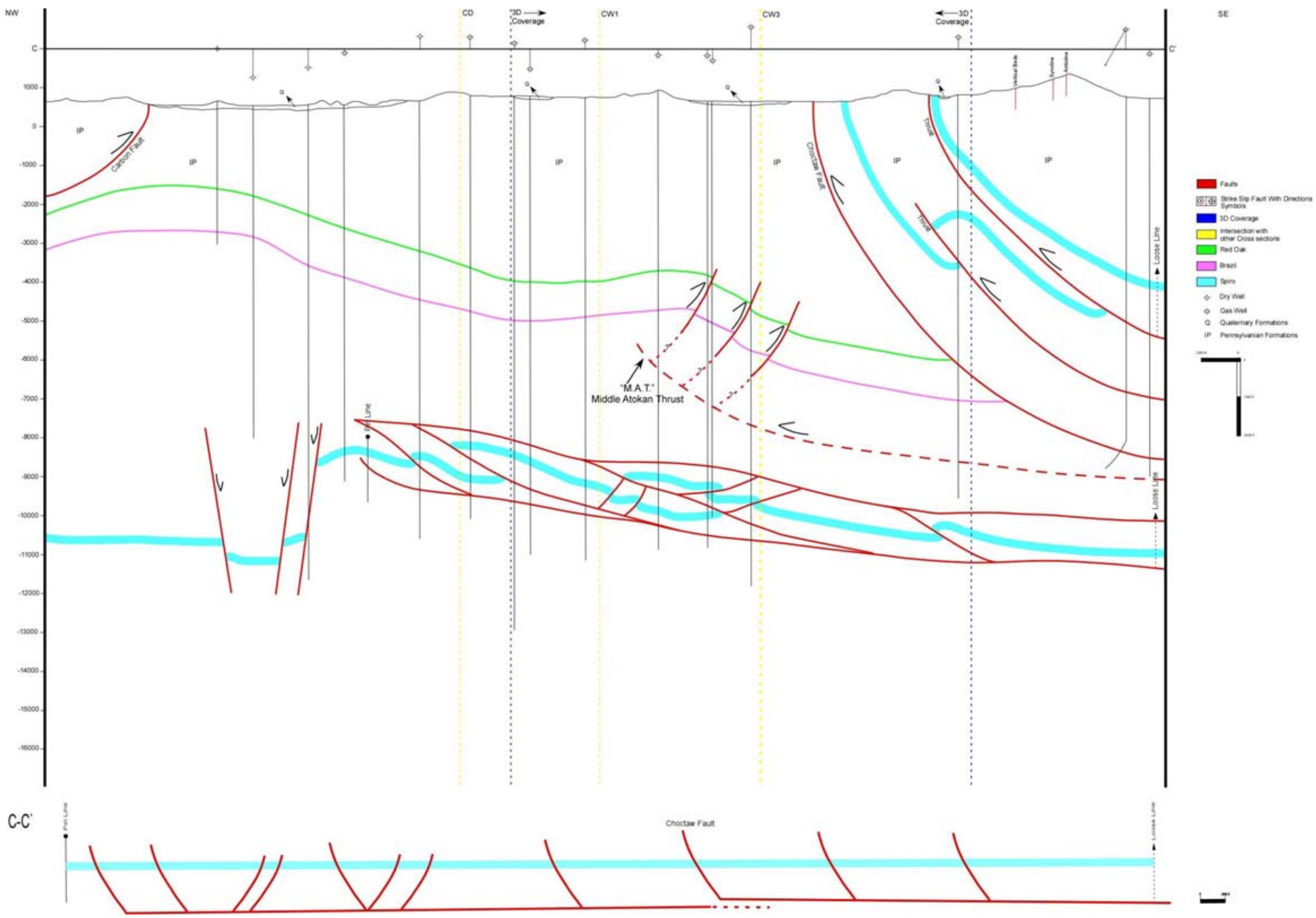


Fig. 29 (Plate 4): Cross section C-C`

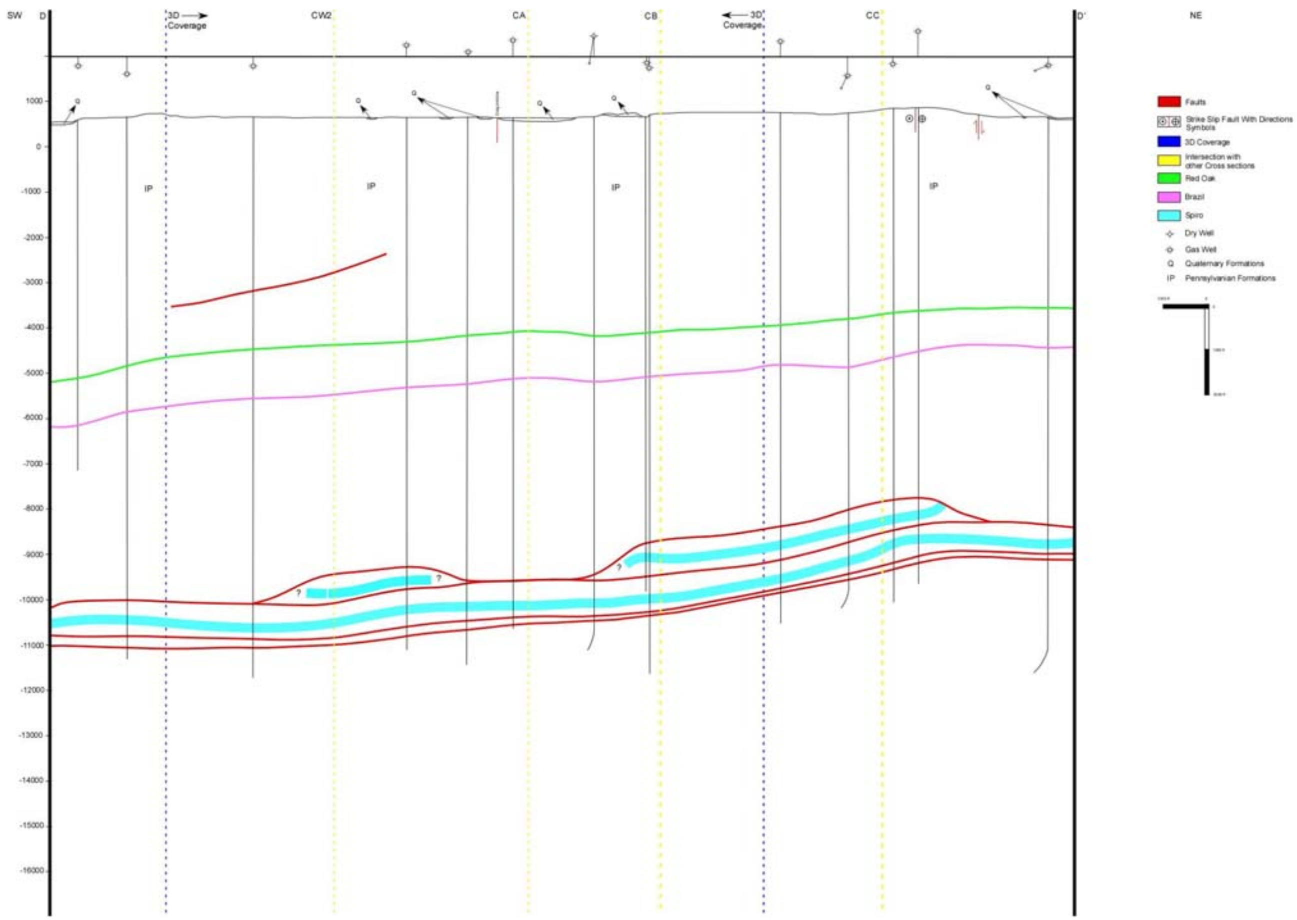


Fig. 30 (Plate 5): Cross section D-D`

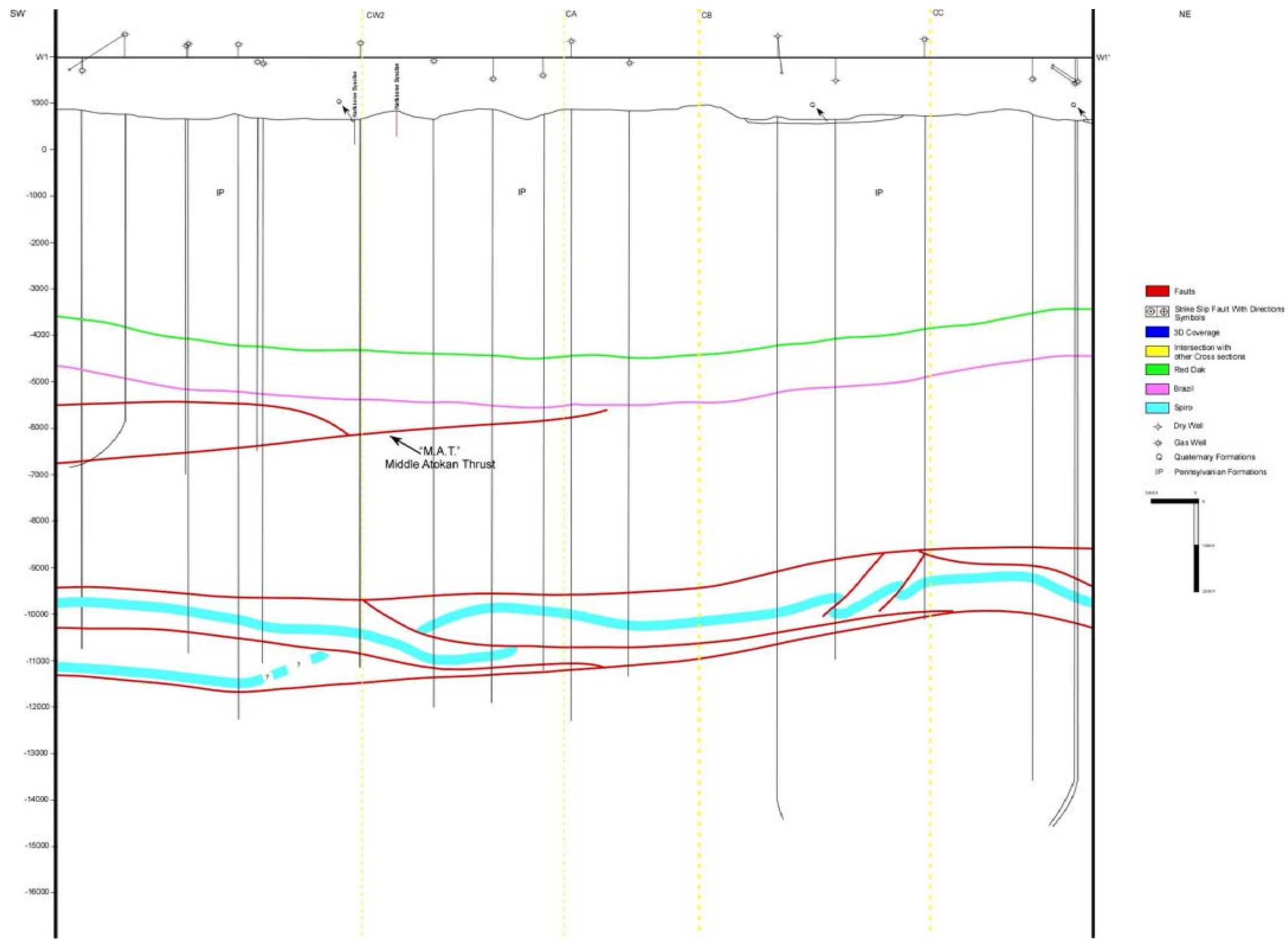


Fig. 31 (Plate 6): Cross section W1-W1`

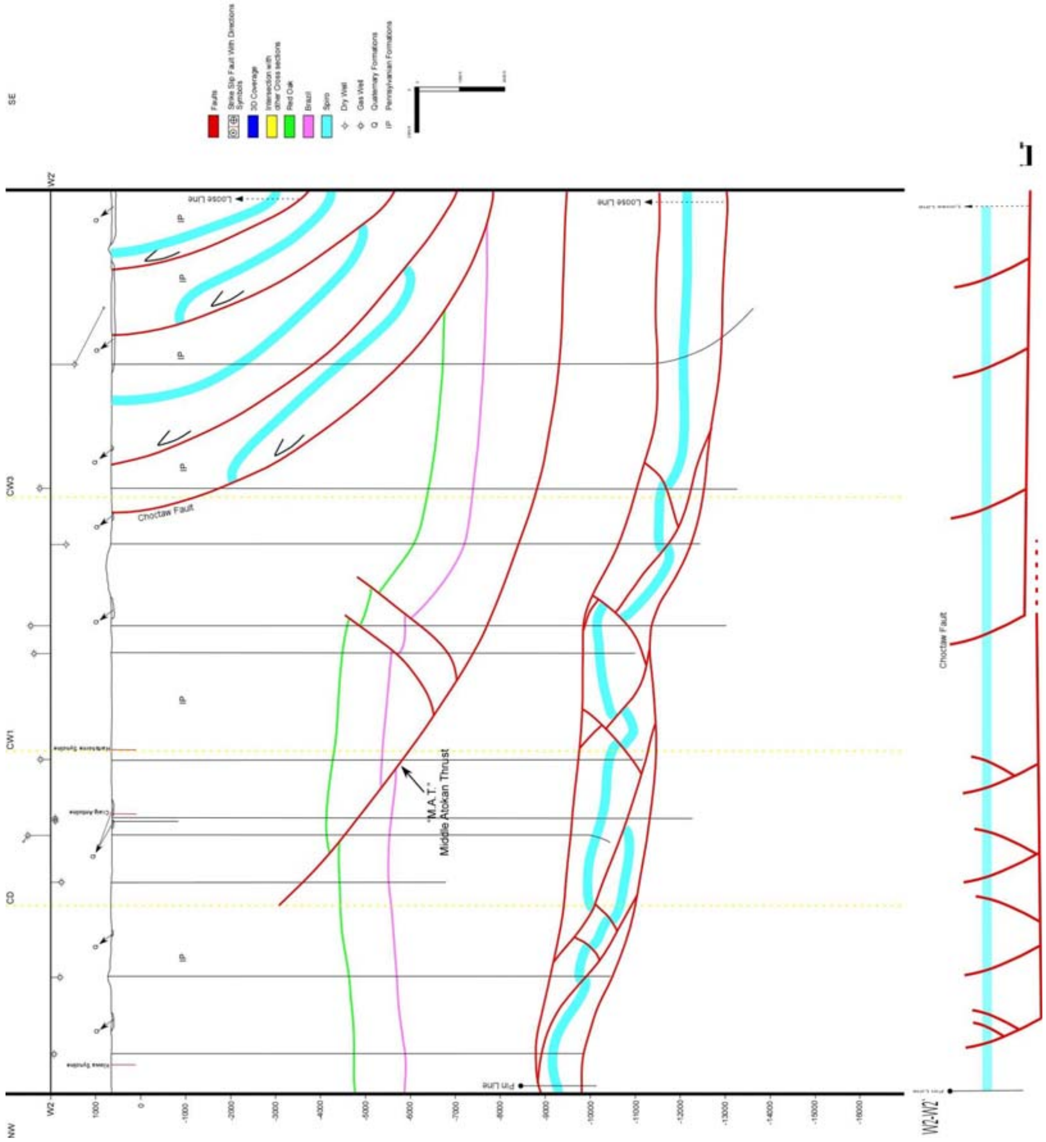


Fig. 32 (Plate 7): Cross section W2-W2`

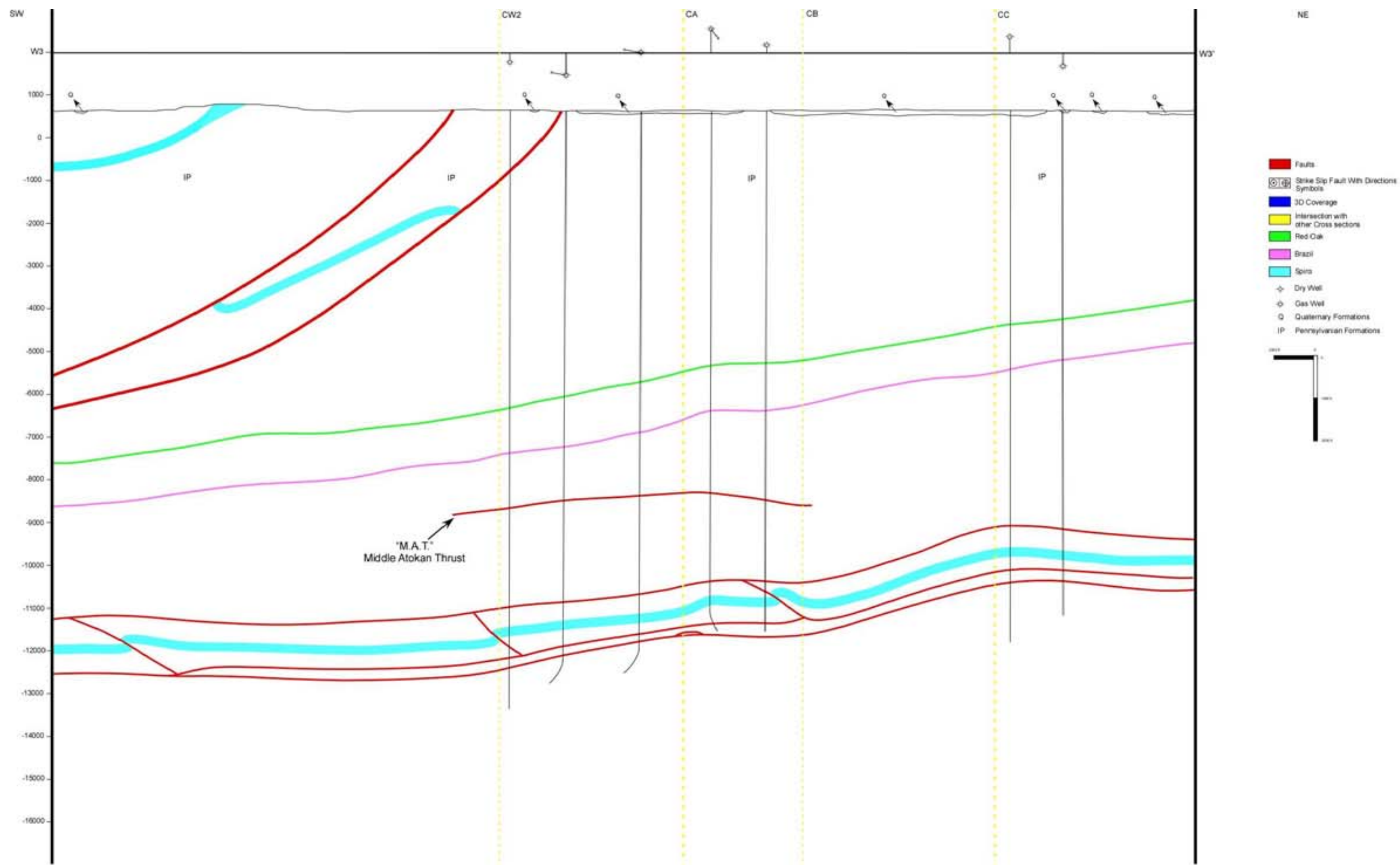


Fig. 33 (Plate 8): Cross section W3-W3`

CHAPTER VII

CONCLUSIONS

South of the Carbon fault is the footwall of the Choctaw fault. The shallow part of the footwall is dominated by the Brazil and Red Oak layers. These layers were essential in locating a shallow splay from the Choctaw fault. This shallow splay was named the Middle Atokan Thrust (M.A.T.) and appeared to have various numbers of out of sequence thrusts. Due to the lack of the Spiro sandstone units within the M.A.T. the thrust was deemed younger in age. This shallow thrust system was well observed on the western 3D seismic lines while it seemed to lose strength on the eastern side of the survey.

Deeper in the footwall of Choctaw, is Zone 3 and the location of a well developed duplex thrust system. These duplexes are hinterland dipping with a dip angle of $\approx 20^{o}$-25^{o}. The roof thrust of the duplex system is the Lower Atokan Detachment (L.A.D.) and the sole thrust is the Springer Detachment. The duplex system becomes shallower as to the north and exhibits some indications of backthrusting within the duplex itself.

Shortening calculations were examined for three specific areas in the study area. The shortening calculation found for the backthrusts that were located within the duplex structure varied from 4% to 10%. The shortening calculation for the duplex structure was found to be between 15% and 21%. The overall shortening that was calculated for the study area was between 52% and 58%.

REFERENCES

Akthar, Saleem, 1995, The Geometry of Thrust Systems in the Wilburton Gas Field and Surrounding, Latimer County, Oklahoma, M.S. thesis, Oklahoma State University, Stillwater, Ok, p.1-97.

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.

Blakey, R.C., 2005, Paleogeography and Geologic Evolution of North America, http://www4.nau.edu/geology/.

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., 1982, Thrust Systems, American Association of Petroleum Geologists Bulletin, v 66, p. 1196-1230.

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.

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

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.

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., 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.

Collins, M., 2006, Geometry of Late Paleozoic Thrusting, Wilburton and Damon Quadrangles, Arkoma Basin, Southeastern Oklahoma, M.S. thesis, Oklahoma State University, Stillwater, Ok, p. 1-103.

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..

Evans, J., 1997, Structural Geometry of Thrust Faulting in the Baker Mountain and Panola Quadrangles, Southeastern Oklahoma, M.S. Thesis, Oklahoma State University, Stillwater, Ok, p. 1-103.

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

Grayson, R.C. Jr., 1979, Stop Descriptions, 5th day, Oklahoma Geological Survey Guidebook 19, Ozark and Ouachita Shelf to Basin Transition, Oklahoma-Arkansas, p. 67-75.

Gross, J.S., Thompson, S.A., Claxton, B.L., and Carr, M.B., 1995, Reservoir Distribution and Exploration potential of the Spiro Sandstone in the Choctaw Trend, Arkoma Basin, Oklahoma and Arkansas, AAPG Bulletin, v. 79, issue 2, p. 159-185.

Hadaway, S., 2004, Structural Geometry of Thrust Faulting in the Hartshorne Southwest Quadrangle, Arkoma Basin, southeast Oklahoma, M.S. Thesis, Oklahoma State University, Stillwater, Ok, p. 1-68.

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, p. 101-111.

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 environment of the Lower Atokan Spiro Sandstone in the Wilburton, Red Oak, and Kinta Fields, Arkoma Basin, Oklahoma, M.S. Thesis, Oklahoma State University, p. 159.

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, v. 1, October 1983- Tectonic and Sedimentary Evolution of the Arkoma Foreland Basin.

Jones, P. B., 1996, Triangle Zone Geometry, Terminology and Kinematics, Bulletin of Canadian Petroleum Geology, V. 44, N. 2, p. 139-152.

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, p. 1-5.

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.

Mahaffie, M.J., 1994, Reservoir classification for turbidite intervals at the Mars discovery, Mississippi Canyon 807, Gulf of Mexico, in P. Weimer, A.H Bouma, and B.F. Perkins eds., Submarine fans and turbidite systems: GCS-SEPM Foundation 15th Annual Research Conference, p. 233-244.

Marshak S., and Mitra, G., 1998, Basic Methods of Structural Geology. Prentice Hall, Englewood Cliffs, NJ, p. 303-332.

McCaleb, J. A. 1963, The goniatite fauna from the Pennsylvanian Winslow Formation of northwest Arkansas, Journal of Paleontology, v. 37, p. 867-888.

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, Stillwater, Ok.

Mehdi, S., 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, Stillwater, Ok, p. 1-107.

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

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, p. 1-63.

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.

Rider, M.H. 1996. Geological Interpretation of Well-Logs. Halsted Press. p. 1-288.

Ronck, J., 1997, Structural geology of thrust faulting in the Wister Lake Area of the frontal Ouachita Mountains, Arkoma Basin, Southeastern Oklahoma, M.S. Thesis, Oklahoma State University, Stillwater, Ok, p. 1-111.

Sagnak, Ata, 1996, Geometry of Late Paleozoic Thrusting between Wilburton-Hartshorne Area, Arkoma Basin, southeast Oklahoma, M.S. Thesis, Oklahoma State University, Stillwater, Ok, p. 1-131.

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.

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

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.

Van Wagoner, J.C., Mitchum, R.M., Campion.K.M., and Rahmanian, V.D., 1990, Siliciclastic Sequence Stratigraphy in Well Logs, Cores, and Outcrops. AAPG Methods in Exploration Series, No.7, p. 1-60.

Webel, S., 1987, Significance of Backthrusting in the Rocky Mountain Thrust Belt, The Thrust Belt Revisited; 38th Annual Field Conference Guidebook, Wyoming Geological Association, p 37-53.

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.

APPENDIX

UWI (APINum)	Well Name	Township	Range	Section	Normally Faulted Spiro Tops (ft)	Normally Faulted Spiro Bot (ft)
35077205720000	BLUE MOUNTAIN	4N	17E	22		
35077206090000	WALLACE	4N	17E	15		
35077203220000	W P LERBLANCE	5N	17E	36		
35077203380000	JESSIE BENNETT	5N	18E	30		
35077204690000	HUNTER TUCKER	5N	18E	31		
35077205450000	DELLA HOLT	5N	17E	35		
35077205430000	STATE	5N	18E	28		
35077205310000	DOBBS STATE UNIT MA	5N	18E	29		
35077214630000	MABRY 12	4N	17E	12		
35077214470000	SPARKS	4N	17E	1		
35077205080001	STATE C UNIT	5N	18E	28		
35077212870000	MC CASLIN	4N	17E	2		
35077212760000	MC CASLIN	4N	17E	2		
35077212580000	SMITH	5N	18E	20		
35077212380000	LAYDEN	4N	17E	3		
35077212160000	PARKER ALFORD	5N	17E	27		
35077210000000	HENLEY	5N	17E	25		
35077209960000	KITCHELL	4N	17E	14		
35077209930000	SIVIL	5N	17E	22		
35077209800000	DARBY	5N	17E	23		
35077209490000	STATE C	5N	18E	28		
35077209350000	WHITNEY	5N	17E	34		
35077209210000	BENNETT STATE	5N	18E	19		
35077208700000	JESSIE BENNETT	5N	18E	30		
35077208580000	ANDREW KURILKO	5N	17E	35		
35077208090000	HENLEY	5N	17E	25		
35077208070000	CAUDRON	5N	17E	26		
35077208000000	CAUDRON	5N	17E	26		
35077207860000	FABBRO	5N	17E	24		
35077207810000	SMITH	5N	18E	20		
35077206920000	LEBLANCE	5N	17E	36		
35077205850000	CAUDRON	5N	17E	26		
35077205650000	DARBY	5N	17E	23		
35077205280000	FABBRO	5N	17E	24		
35077205270000	MABRY	4N	18E	7		
35077205250000	BENNETT	5N	18E	30		
35077205050000	SMITH	5N	18E	20		
35077205040000	BENNETT STATE	5N	18E	19		
35077201050000	KENNEDY	5N	18E	32		
35077204810000	BENNETT STATE	5N	18E	19		
35077209540000	D OBBS STATE	5N	18E	29		
35077200800000	MC CASLIN	4N	17E	2		
35077210530000	SIVIL	5N	17E	22		
35077210960000	BENNETT STATE	5N	18E	19		
35077203090000	WHITNEY	5N	17E	34		
35077204510000	MABRY TRUST	4N	17E	12		
35077200790000	PATTISON	4N	17E	1		
35077210700000	CAUDRON	5N	17E	23		
35077600300000	M C WATTS	5N	18E	33		
35077301470000	MABRY	4N	18E	9		
35077300110000	J L HENLEY	5N	17E	25		

UWI (API Num)	Well Name	Township	Range	Section	Normally Faulted Spiro Tops (ft)	Normally Faulted Spiro Bot (ft)
35077300040000	MOSE C WATTS	4N	18E	3		
35077300000000	DARBY SUBDIVISION	5N	17E	23		
35077210410000	DARBY	5N	17E	23		
35077210260000	CAUDRON	5N	17E	26		
35077210100000	PARKER ALFRED	5N	17E	27		
35077204180000	ALFRED PARKER	5N	17E	27		
35077204130000	DARBY SUBDIVI	5N	17E	23		
35077204020000	FABBRO	5N	17E	24		
35077204010000	MC CASLIN	4N	17E	2		
35077204260000	HUNTER TUCKER	5N	18E	31		
35077203900000	SPARKS	4N	17E	3		
35077203520000	SAMS	5N	17E	22		
35077203410000	CAUDRON	5N	17E	26		
35077203360000	SMITH	5N	18E	20		
35077203130000	ANDREW KURILKO	5N	17E	35		
35077202930000	MABRY TRUST	4N	18E	5		
35077202840000	KENNEDY	5N	18E	32		
35077202810000	WHITNEY	5N	17E	34		
35077202190000	P S O	4N	17E	10		
35077202540000	KENT HEIRS	5N	17E	14		
35077202460000	SILVER BULLET	4N	17E	11		
35077201750000	RASPOTNIK	5N	17E	10	12174	
35077201740000	VAUGHN	5N	17E	12	12349	12497
35077201590000	KENT	5N	17E	15		
35077201410000	HUNTER TUCKER	5N	18E	31		
35077200960000	ANDREW KURILKO	5N	17E	35		
35077200710000	WHITNEY	5N	17E	34		
35077205440000	MABRY 9001 JV-P	4N	18E	11		
35077205890000	WORKMAN JVP-9001	4N	18E	22		
35077214300000	MABRY RANCH	4N	18E	10		
35077205740000	NEWELL	4N	18E	23		
35077205760000	SPEARS	4N	18E	21		
35077204870000	SHARP	5N	17E	2	11511	11736
35121216560000	WALLACE	4N	17E	21		
35121208200000	MOSS	5N	16E	13		
35121214020000	USA	5N	17E	28		
35121214060000	CHARLES CASTEEL	5N	17E	32		
35121214150000	P D BOWMAN	5N	17E	29		
35121214440000	WAYNE WALLACE	4N	17E	21		
35121216140000	BOWMAN	5N	17E	21		
35121216730000	HARE	5N	17E	33		
35121216620000	PAULINE BOWMAN	5N	17E	20		
35121214570000	BELUSKO	4N	17E	6		
35121214870000	BOWMAN	5N	17E	20		
35121216570000	PD BOWMAN	5N	17E	29		
35121212080000	WRIGHT	4N	17E	18		
35121212780000	EDITH RICHARDS	5N	17E	30		
35121210930000	POTICHNY	5N	17E	33		
35121213230000	HARTSHORNE	4N	17E	6		
35121218070000	USA	5N	17E	28		
35121213520000	ALEXANDER	4N	17E	9		

UWI (API Num)	Well Name	Township	Range	Section	Normally Faulted Spiro Tops (ft)	Normally Faulted Spiro Bot (ft)
35121213440000	ROCK ISLAND IMPROVE	4N	17E	8		
35121213380000	PETTIT	5N	17E	31		
35121213310000	WEBBER	5N	17E	18		
35121213210000	ROCK ISLAND	4N	17E	5		
35121213190000	POTICHNEY	5N	17E	33		
35121213120000	WOODS PROSPECT	5N	16E	36		
35121201110000	POTICHNY	5N	17E	33		
35121201330000	STINE	4N	17E	4		
35121218870001	CASTEEL CHARLES `A`	5N	17E	32		
35121218510000	P D BOWMAN	5N	17E	29		
35121218500000	U S A	5N	17E	28		
35121218420000	BOWMAN	5N	17E	21		
35121218350000	EDITH RICHARDS	5N	17E	30		
35121219090000	ANDERSON K	5N	17E	19		
35121205370000	SWEET	4N	17E	9		
35121203190000	BOWMAN	5N	17E	17	12330	12549
35121205950000	DURAN	5N	17E	18	11960	
35121206800000	BERNARDI JONES	5N	16E	10	11100	
35121208900000	COOK	5N	16E	14	11759	11957
35121213340000	LEWIS	4N	16E	12		
35121213490000	NEEDHAM	4N	16E	11		
35121207300000	SMALLWOOD	4N	16E	3		
35121204950000	MCBEE	5N	16E	23		
35121217630000	PEDEN	5N	16E	24		
35121214820000	AIMERITO	5N	16E	34		
35121212070000	SMALLWOOD	4N	16E	10		
35121211920000	GEORGE PEDEN	5N	16E	24		
35121212980000	HAILEYVILLE TOWNSITE	5N	16E	35		
35121212200000	TEX	4N	16E	14		
35121213080000	MILLER	5N	16E	26		
35121201370000	WOODS PROSPECT	5N	16E	36		
35121200920000	GEORGE PEDEN	5N	16E	24		
35121218440000	MASS UNIT	5N	16E	25		
35121228110000	SIRMANS LOIS	4N	16E	12		
35121202060000	MARCANGELI	5N	16E	34		
35121201580000	U S A	5N	16E	27		
35121201680000	W WALLACE	4N	17E	17		
35121206250000	US GOVERNMENT	5N	16E	27		
35121201770000	U S A	5N	16E	35		
35121201980000	NEEDHAM	4N	16E	11		
35121202370000	MADDEN	4N	16E	2		
35121202290000	FRANTZ NEEDHAM	4N	16E	14		
35121202200000	LEWIS	4N	16E	12		
35121202190000	SLAUGHTER	4N	16E	1		
35121201450000	R E KING	5N	16E	26		
35121201550000	HARTSHORNE	4N	17E	6		
35121200310000	PAULINE BOWMAN	5N	17E	20		
35121221060000	KING	5N	16E	26		
35121221230000	MCBEE	5N	16E	23		
35121213390000	ANDERSON	5N	17E	19		
35121214230000	W C CAMP	4N	16E	4		

UWI (APINum)	*Well Name*	*Township*	*Range*	*Section*	*Normally Faulted Spiro Tops (ft)*	*Normally Faulted Spiro Bot (ft)*
35121210120000	MASS	5N	16E	25		
35121232160000	KENDRICK	4N	16E	13		
35121232330000	FINK	5N	16E	36		
35121230540000	AIMERITO	5N	16E	27		
35121229220000	LEWIS JAMES	4N	16E	12		
35121228510000	CAMP	5N	16E	34		
35121230870000	KING	5N	16E	26		
35121220030000	WOODS	5N	16E	36		
35121217880000	ANDERSON	5N	17E	19		
35121219200000	USA	5N	16E	35		
35121219820000	NEEDHAM	4N	16E	11		

UWI (API Num)	Well Name	Township	Range	Section	Spiro Thrust Sheet A Tops (ft)	Spiro Thrust Sheet A Bot (ft)
35077205720000	BLUE MOUNTAIN	4N	17E	22		
35077206090000	WALLACE	4N	17E	15		
35077203220000	W P LERBLANCE	5N	17E	36		
35077203380000	JESSIE BENNETT	5N	18E	30		
35077204690000	HUNTER TUCKER	5N	18E	31		
35077205450000	DELLA HOLT	5N	17E	35		
35077205430000	STATE	5N	18E	28		
35077205310000	DOBBS STATE UNIT MA	5N	18E	29		
35077214630000	MABRY 12	4N	17E	12		
35077214470000	SPARKS	4N	17E	1		
35077205080001	STATE C UNIT	5N	18E	28		
35077212870000	MC CASLIN	4N	17E	2		
35077212760000	MC CASLIN	4N	17E	2		
35077212580000	SMITH	5N	18E	20		
35077212380000	LAYDEN	4N	17E	3		
35077212160000	PARKER ALFORD	5N	17E	27		
35077210000000	HENLEY	5N	17E	25		
35077209960000	KITCHELL	4N	17E	14		
35077209930000	SIVIL	5N	17E	22	9266	9547
35077209800000	DARBY	5N	17E	23		
35077209490000	STATE C	5N	18E	28		
35077209350000	WHITNEY	5N	17E	34		
35077209210000	BENNETT STATE	5N	18E	19		
35077208700000	JESSIE BENNETT	5N	18E	30		
35077208580000	ANDREW KURILKO	5N	17E	35		
35077208090000	HENLEY	5N	17E	25		
35077208070000	CAUDRON	5N	17E	26		
35077208000000	CAUDRON	5N	17E	26		
35077207860000	FABBRO	5N	17E	24		
35077207810000	SMITH	5N	18E	20		
35077206920000	LEBLANCE	5N	17E	36		
35077205850000	CAUDRON	5N	17E	26		
35077205650000	DARBY	5N	17E	23		
35077205280000	FABBRO	5N	17E	24		
35077205270000	MABRY	4N	18E	7		
35077205250000	BENNETT	5N	18E	30		
35077205050000	SMITH	5N	18E	20		
35077205040000	BENNETT STATE	5N	18E	19		
35077201050000	KENNEDY	5N	18E	32		
35077204810000	BENNETT STATE	5N	18E	19		
35077209540000	DOBBS STATE	5N	18E	29		
35077200800000	MC CASLIN	4N	17E	2		
35077210530000	SIVIL	5N	17E	22		
35077210960000	BENNETT STATE	5N	18E	19		
35077203090000	WHITNEY	5N	17E	34		
35077204510000	MABRY TRUST	4N	17E	12		
35077200790000	PATTISON	4N	17E	1		
35077210700000	CAUDRON	5N	17E	23		
35077600300000	M C WATTS	5N	18E	33		
35077301470000	MABRY	4N	18E	9		
35077300110000	J L HENLEY	5N	17E	25		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet A Tops (ft)	Spiro Thrust Sheet A Bot (ft)
35077300040000	MOSE C WATTS	4N	18E	3		
35077300000000	DARBY SUBDIVISION	5N	17E	23		
35077210410000	DARBY	5N	17E	23		
35077210260000	CAUDRON	5N	17E	26		
35077210100000	PARKER ALFRED	5N	17E	27		
35077204180000	ALFRED PARKER	5N	17E	27		
35077204130000	DARBY SUBDIVI	5N	17E	23		
35077204020000	FABBRO	5N	17E	24		
35077204010000	MC CASLIN	4N	17E	2		
35077204260000	HUNTER TUCKER	5N	18E	31		
35077203900000	SPARKS	4N	17E	3		
35077203520000	SAMS	5N	17E	22		
35077203410000	CAUDRON	5N	17E	26		
35077203360000	SMITH	5N	18E	20		
35077203130000	ANDREW KURILKO	5N	17E	35		
35077202930000	MABRY TRUST	4N	18E	5		
35077202840000	KENNEDY	5N	18E	32		
35077202810000	WHITNEY	5N	17E	34		
35077202190000	P S O	4N	17E	10		
35077202540000	KENT HEIRS	5N	17E	14	9000	
35077202460000	SILVER BULLET	4N	17E	11		
35077201750000	RASPOTNIK	5N	17E	10		
35077201740000	VAUGHN	5N	17E	12		
35077201590000	KENT	5N	17E	15	8921	
35077201410000	HUNTER TUCKER	5N	18E	31		
35077200960000	ANDREW KURILKO	5N	17E	35		
35077200710000	WHITNEY	5N	17E	34		
35077205440000	MABRY 9001 JV-P	4N	18E	11		
35077205890000	WORKMAN JVP-9001	4N	18E	22		
35077214300000	MABRY RANCH	4N	18E	10		
35077205740000	NEWELL	4N	18E	23		
35077205760000	SPEARS	4N	18E	21		
35077204870000	SHARP	5N	17E	2		
35121216560000	WALLACE	4N	17E	21		
35121208200000	MOSS	5N	16E	13	8930	9136
35121214020000	USA	5N	17E	28		
35121214060000	CHARLES CASTEEL	5N	17E	32		
35121214150000	P D BOWMAN	5N	17E	29		
35121214440000	WAYNE WALLACE	4N	17E	21		
35121216140000	BOWMAN	5N	17E	21		
35121216730000	HARE	5N	17E	33		
35121216620000	PAULINE BOWMAN	5N	17E	20	9833	10056
35121214570000	BELUSKO	4N	17E	6		
35121214870000	BOWMAN	5N	17E	20	9490	9753
35121216570000	PD BOWMAN	5N	17E	29		
35121212080000	WRIGHT	4N	17E	18		
35121212780000	EDITH RICHARDS	5N	17E	30	9931	10149
35121210930000	POTICHNY	5N	17E	33		
35121213230000	HARTSHORNE	4N	17E	6		
35121218070000	U S A	5N	17E	28		
35121213520000	ALEXANDER	4N	17E	9		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet A Tops (ft)	Spiro Thrust Sheet A Bot (ft)
35121213440000	ROCK ISLAND IMPROVE	4N	17E	8		
35121213380000	PETTIT	5N	17E	31		
35121213310000	WEBBER	5N	17E	18	9469	
35121213210000	ROCK ISLAND	4N	17E	5		
35121213190000	POTICHNEY	5N	17E	33		
35121213120000	WOODS PROSPECT	5N	16E	36		
35121201110000	POTICHNY	5N	17E	33		
35121201330000	STINE	4N	17E	4		
35121218870001	CASTEEL CHARLES `A`	5N	17E	32		
35121218510000	P D BOWMAN	5N	17E	29		
35121218500000	U S A	5N	17E	28		
35121218420000	BOWMAN	5N	17E	21		
35121218350000	EDITH RICHARDS	5N	17E	30		
35121219090000	ANDERSON K	5N	17E	19	9140	
35121205370000	SWEET	4N	17E	9		
35121203190000	BOWMAN	5N	17E	17		
35121205950000	DURAN	5N	17E	18		
35121206800000	BERNARDI JONES	5N	16E	10		
35121208900000	COOK	5N	16E	14		
35121213340000	LEWIS	4N	16E	12		
35121213490000	NEEDHAM	4N	16E	11		
35121207300000	SMALLWOOD	4N	16E	3		
35121204950000	MCBEE	5N	16E	23	8999	
35121217630000	PEDEN	5N	16E	24	8999	9183
35121214820000	AIMERITO	5N	16E	34		
35121212070000	SMALLWOOD	4N	16E	10		
35121211920000	GEORGE PEDEN	5N	16E	24	9082	9284
35121212980000	HAILEYVILLE TOWNSITE	5N	16E	35		
35121212200000	TEX	4N	16E	14		
35121213080000	MILLER	5N	16E	26	9507	
35121201370000	WOODS PROSPECT	5N	16E	36		
35121200920000	GEORGE PEDEN	5N	16E	24	9240	
35121218440000	MASS UNIT	5N	16E	25	10464	10656
35121228110000	SIRMANS LOIS	4N	16E	12		
35121202060000	MARCANGELI	5N	16E	34		
35121201580000	U S A	5N	16E	27	9612	
35121201680000	W WALLACE	4N	17E	17		
35121206250000	US GOVERNMENT	5N	16E	27	9410	9615
35121201770000	U S A	5N	16E	35		
35121201980000	NEEDHAM	4N	16E	11		
35121202370000	MADDEN	4N	16E	2		
35121202290000	FRANTZ NEEDHAM	4N	16E	14		
35121202200000	LEWIS	4N	16E	12		
35121202190000	SLAUGHTER	4N	16E	1		
35121201450000	R E KING	5N	16E	26	9330	
35121201550000	HARTSHORNE	4N	17E	6		
35121200310000	PAULINE BOWMAN	5N	17E	20	9264	
35121221060000	KING	5N	16E	26	9278	
35121221230000	MCBEE	5N	16E	23	9568	9759
35121213390000	ANDERSON	5N	17E	19	9550	
35121214230000	W C CAMP	4N	16E	4		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet A Tops (ft)	Spiro Thrust Sheet A Bot (ft)
35121210120000	MASS	5N	16E	25	9734	
35121232160000	KENDRICK	4N	16E	13		
35121232330000	FINK	5N	16E	36		
35121230540000	AIMERITO	5N	16E	27		
35121229220000	LEWIS JAMES	4N	16E	12		
35121228510000	CAMP	5N	16E	34		
35121230870000	KING	5N	16E	26	9966	10197
35121220030000	WOODS	5N	16E	36		
35121217880000	ANDERSON	5N	17E	19		
35121219200000	USA	5N	16E	35		
35121219820000	NEEDHAM	4N	16E	11		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet B Tops (ft)	Spiro Thrust Sheet B Bot (ft)
35077205720000	BLUE MOUNTAIN	4N	17E	22		
35077206090000	WALLACE	4N	17E	15		
35077203220000	W P LERBLANCE	5N	17E	36		
35077203380000	JESSIE BENNETT	5N	18E	30		
35077204690000	HUNTER TUCKER	5N	18E	31		
35077205450000	DELLA HOLT	5N	17E	35		
35077205430000	STATE	5N	18E	28		
35077205310000	DOBBS STATE UNIT MA	5N	18E	29		
35077214630000	MABRY 12	4N	17E	12		
35077214470000	SPARKS	4N	17E	1		
35077205080001	STATE C UNIT	5N	18E	28		
35077212870000	MC CASLIN	4N	17E	2		
35077212760000	MC CASLIN	4N	17E	2		
35077212580000	SMITH	5N	18E	20		
35077212380000	LAYDEN	4N	17E	3		
35077212160000	PARKER ALFORD	5N	17E	27		
35077210000000	HENLEY	5N	17E	25		
35077209960000	KITCHELL	4N	17E	14		
35077209930000	STVIL	5N	17E	22		
35077209800000	DARBY	5N	17E	23		
35077209490000	STATE C	5N	18E	28		
35077209350000	WHITNEY	5N	17E	34		
35077209210000	BENNETT STATE	5N	18E	19		
35077208700000	JESSIE BENNETT	5N	18E	30		
35077208580000	ANDREW KURILKO	5N	17E	35		
35077208090000	HENLEY	5N	17E	25		
35077208070000	CAUDRON	5N	17E	26		
35077208000000	CAUDRON	5N	17E	26		
35077207860000	FABBRO	5N	17E	24		
35077207810000	SMITH	5N	18E	20		
35077206920000	LEBLANCE	5N	17E	36		
35077205850000	CAUDRON	5N	17E	26		
35077205650000	DARBY	5N	17E	23	9478	9766
35077205280000	FABBRO	5N	17E	24	11568	11812
35077205270000	MABRY	4N	18E	7		
35077205250000	BENNETT	5N	18E	30		
35077205050000	SMITH	5N	18E	20		
35077205040000	BENNETT STATE	5N	18E	19	11322	11515
35077201050000	KENNEDY	5N	18E	32		
35077204810000	BENNETT STATE	5N	18E	19	10727	10980
35077209540000	DOBBS STATE	5N	18E	29		
35077200800000	MC CASLIN	4N	17E	2		
35077210530000	STVIL	5N	17E	22		
35077210960000	BENNETT STATE	5N	18E	19		
35077203090000	WHITNEY	5N	17E	34		
35077204510000	MABRY TRUST	4N	17E	12		
35077200790000	PATTISON	4N	17E	1		
35077210700000	CAUDRON	5N	17E	23	9751	9985
35077600300000	M C WATTS	5N	18E	33		
35077301470000	MABRY	4N	18E	9		
35077300110000	J L HENLEY	5N	17E	25		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet B Tops (ft)	Spiro Thrust Sheet B Bot (ft)
35077300040000	MOSE C WATTS	4N	18E	3		
35077300000000	DARBY SUBDIVISION	5N	17E	23	9930	
35077210410000	DARBY	5N	17E	23	9782	10088
35077210260000	CAUDRON	5N	17E	26		
35077210100000	PARKER ALFRED	5N	17E	27		
35077204180000	ALFRED PARKER	5N	17E	27	10216	10442
35077204130000	DARBY SUBDIVI	5N	17E	23	9047	9301
35077204020000	FABBRO	5N	17E	24	9399	
35077204010000	MC CASLIN	4N	17E	2		
35077204260000	HUNTER TUCKER	5N	18E	31		
35077203900000	SPARKS	4N	17E	3		
35077203520000	SAMS	5N	17E	22		
35077203410000	CAUDRON	5N	17E	26		
35077203360000	SMITH	5N	18E	20		
35077203130000	ANDREW KURILKO	5N	17E	35		
35077202930000	MABRY TRUST	4N	18E	5		
35077202840000	KENNEDY	5N	18E	32		
35077202810000	WHITNEY	5N	17E	34		
35077202190000	P S O	4N	17E	10		
35077202540000	KENT HEIRS	5N	17E	14		
35077202460000	SILVER BULLET	4N	17E	11		
35077201750000	RASPOTNIK	5N	17E	10		
35077201740000	VAUGHN	5N	17E	12		
35077201590000	KENT	5N	17E	15		
35077201410000	HUNTER TUCKER	5N	18E	31		
35077200960000	ANDREW KURILKO	5N	17E	35		
35077200710000	WHITNEY	5N	17E	34		
35077205440000	MABRY 9001 JV-P	4N	18E	11		
35077205890000	WORKMAN JVP-9001	4N	18E	22		
35077214300000	MABRY RANCH	4N	18E	10		
35077205740000	NEWELL	4N	18E	23		
35077205760000	SPEARS	4N	18E	21		
35077204870000	SHARP	5N	17E	2		
35121216560000	WALLACE	4N	17E	21		
35121208200000	MOSS	5N	16E	13		
35121214020000	USA	5N	17E	28		
35121214060000	CHARLES CASTEEL	5N	17E	32		
35121214150000	P D BOWMAN	5N	17E	29	10723	11023
35121214440000	WAYNE WALLACE	4N	17E	21		
35121216140000	BOWMAN	5N	17E	21	9409	9661
35121216730000	HARE	5N	17E	33		
35121216620000	PAULINE BOWMAN	5N	17E	20		
35121214570000	BELUSKO	4N	17E	6	12127	
35121214870000	BOWMAN	5N	17E	20	9069	9282
35121216570000	PD BOWMAN	5N	17E	29	9804	
35121212080000	WRIGHT	4N	17E	18		
35121212780000	EDITH RICHARDS	5N	17E	30	9564	9777
35121210930000	POTICHNY	5N	17E	33		
35121213230000	HARTSHORNE	4N	17E	6		
35121218070000	U S A	5N	17E	28	10601	10842
35121213520000	ALEXANDER	4N	17E	9		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet B Tops (ft)	Spiro Thrust Sheet B Bot (ft)
35121213440000	ROCK ISLAND IMPROVE	4N	17E	8		
35121213380000	PETTIT	5N	17E	31	11702	11921
35121213310000	WEBBER	5N	17E	18		
35121213210000	ROCK ISLAND	4N	17E	5		
35121213190000	POTICHNEY	5N	17E	33		
35121213120000	WOODS PROSPECT	5N	16E	36		
35121201110000	POTICHNY	5N	17E	33		
35121201330000	STINE	4N	17E	4		
35121218870001	CASTEEL CHARLES `A`	5N	17E	32		
35121218510000	P D BOWMAN	5N	17E	29	10143	10401
35121218500000	U S A	5N	17E	28	10677	10908
35121218420000	BOWMAN	5N	17E	21	10882	11118
35121218350000	EDITH RICHARDS	5N	17E	30	9779	10021
35121219090000	ANDERSON K	5N	17E	19		
35121205370000	SWEET	4N	17E	9		
35121203190000	BOWMAN	5N	17E	17		
35121205950000	DURAN	5N	17E	18		
35121206800000	BERNARDI JONES	5N	16E	10		
35121208900000	COOK	5N	16E	14		
35121213340000	LEWIS	4N	16E	12		
35121213490000	NEEDHAM	4N	16E	11		
35121207300000	SMALLWOOD	4N	16E	3		
35121204950000	MCBEE	5N	16E	23		
35121217630000	PEDEN	5N	16E	24		
35121214820000	AIMERITO	5N	16E	34	10389	
35121212070000	SMALLWOOD	4N	16E	10		
35121211920000	GEORGE PEDEN	5N	16E	24		
35121212980000	HAILEYVILLE TOWNSITE	5N	16E	35	11040	
35121212200000	TEX	4N	16E	14		
35121213080000	MILLER	5N	16E	26		
35121201370000	WOODS PROSPECT	5N	16E	36	11240	
35121200920000	GEORGE PEDEN	5N	16E	24		
35121218440000	MASS UNIT	5N	16E	25	10136	10330
35121228110000	SIRMANS LOIS	4N	16E	12		
35121202060000	MARCANGELI	5N	16E	34	10664	
35121201580000	U S A	5N	16E	27		
35121201680000	W WALLACE	4N	17E	17		
35121206250000	US GOVERNMENT	5N	16E	27		
35121201770000	U S A	5N	16E	35	10332	10638
35121201980000	NEEDHAM	4N	16E	11		
35121202370000	MADDEN	4N	16E	2		
35121202290000	FRANTZ NEEDHAM	4N	16E	14		
35121202200000	LEWIS	4N	16E	12		
35121202190000	SLAUGHTER	4N	16E	1		
35121201450000	R E KING	5N	16E	26		
35121201550000	HARTSHORNE	4N	17E	6		
35121200310000	PAULINE BOWMAN	5N	17E	20		
35121221060000	KING	5N	16E	26		
35121221230000	MCBEE	5N	16E	23		
35121213390000	ANDERSON	5N	17E	19		
35121214230000	W C CAMP	4N	16E	4		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet B Tops (ft)	Spiro Thrust Sheet B Bot (ft)
35121210120000	MASS	5N	16E	25		
35121232160000	KENDRICK	4N	16E	13		
35121232330000	FINK	5N	16E	36	10367	10590
35121230540000	AIMERITO	5N	16E	27	10445	10660
35121229220000	LEWIS JAMES	4N	16E	12		
35121228510000	CAMP	5N	16E	34	10526	10754
35121230870000	KING	5N	16E	26		
35121220030000	WOODS	5N	16E	36	11607	11830
35121217880000	ANDERSON	5N	17E	19	9830	
35121219200000	USA	5N	16E	35	10939	11149
35121219820000	NEEDHAM	4N	16E	11		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet C Tops (ft)	Spiro Thrust Sheet C Bot (ft)
35077205720000	BLUE MOUNTAIN	4N	17E	22		
35077206090000	WALLACE	4N	17E	15		
35077203220000	W P LERBLANCE	3N	17E	36		
35077203380000	JESSIE BENNETT	3N	18E	30		
35077204690000	HUNTER TUCKER	3N	18E	31		
35077205450000	DELIA HOLT	3N	17E	35		
35077205430000	STATE	3N	18E	28		
35077205310000	DOBBS STATE UNIT MA	3N	18E	29		
35077214630000	MABRY 12	4N	17E	12		
35077214470000	SPARKS	4N	17E	1		
35077205080001	STATE C UNIT	3N	18E	28		
35077212870000	MC CASLIN	4N	17E	2		
35077212760000	MC CASLIN	4N	17E	2		
35077212580000	SMITH	3N	18E	20		
35077212380000	LAYDEN	4N	17E	3		
35077212160000	PARKER ALFORD	3N	17E	27		
35077210000000	HENLEY	3N	17E	25		
35077209960000	KITCHELL	4N	17E	14		
35077209930000	SIVIL	3N	17E	22		
35077209800000	DARBY	3N	17E	23		
35077209490000	STATE C	3N	18E	28		
35077209350000	WHITNEY	3N	17E	34		
35077209210000	BENNETT STATE	3N	18E	19		
35077208700000	JESSIE BENNETT	3N	18E	30		
35077208580000	ANDREW KURILKO	3N	17E	35		
35077208090000	HENLEY	3N	17E	25		
35077208070000	CAUDRON	3N	17E	26		
35077208000000	CAUDRON	3N	17E	26		
35077207860000	FABBRO	3N	17E	24		
35077207810000	SMITH	3N	18E	20		
35077206920000	LEBLANCE	3N	17E	36		
35077205850000	CAUDRON	3N	17E	26		
35077205650000	DARBY	3N	17E	23		
35077205280000	FABBRO	3N	17E	24		
35077205270000	MABRY	4N	18E	7		
35077205250000	BENNETT	3N	18E	30		
35077205050000	SMITH	3N	18E	20		
35077205040000	BENNETT STATE	3N	18E	19		
35077201050000	KENNEDY	3N	18E	32		
35077204810000	BENNETT STATE	3N	18E	19		
35077209540000	DOBBS STATE	3N	18E	29		
35077200800000	MC CASLIN	4N	17E	2		
35077210530000	SIVIL	3N	17E	22		
35077210960000	BENNETT STATE	3N	18E	19		
35077203090000	WHITNEY	3N	17E	34		
35077204510000	MABRY TRUST	4N	17E	12		
35077200790000	PATTISON	4N	17E	1		
35077210700000	CAUDRON	3N	17E	23		
35077600300000	M C WATTS	3N	18E	33		
35077301470000	MABRY	4N	18E	9		
35077300110000	J L HENLEY	3N	17E	25		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet C Tops (ft)	Spiro Thrust Sheet C Bot (ft)
35077300040000	MOSE C WATTS	4N	18E	3		
35077300000000	DARBY SUBDIVISION	5N	17E	23		
35077210410000	DARBY	5N	17E	23		
35077210260000	CAUDRON	5N	17E	26		
35077210100000	PARKER ALFRED	5N	17E	27		
35077204180000	ALFRED PARKER	5N	17E	27		
35077204130000	DARBY SUBDIVI	5N	17E	23		
35077204020000	FABBRO	5N	17E	24		
35077204010000	MC CASLIN	4N	17E	2		
35077204260000	HUNTER TUCKER	5N	18E	31		
35077203900000	SPARKS	4N	17E	3		
35077203520000	SAMS	5N	17E	22		
35077203410000	CAUDRON	5N	17E	26		
35077203360000	SMITH	5N	18E	20		
35077203130000	ANDREW KURILKO	5N	17E	35		
35077202930000	MABRY TRUST	4N	18E	5		
35077202840000	KENNEDY	5N	18E	32		
35077202810000	WHITNEY	5N	17E	34		
35077202190000	P S O	4N	17E	10		
35077202540000	KENT HEIRS	5N	17E	14		
35077202460000	SILVER BULLET	4N	17E	11		
35077201750000	RASPOTNIK	5N	17E	10		
35077201740000	VAUGHN	5N	17E	12		
35077201590000	KENT	5N	17E	15		
35077201410000	HUNTER TUCKER	5N	18E	31		
35077200960000	ANDREW KURILKO	5N	17E	35		
35077200710000	WHITNEY	5N	17E	34		
35077205440000	MABRY 9001 JV-P	4N	18E	11		
35077205890000	WORKMAN JVP-9001	4N	18E	22		
35077214300000	MABRY RANCH	4N	18E	10		
35077205740000	NEWELL	4N	18E	23		
35077205760000	SPEARS	4N	18E	21		
35077204870000	SHARP	5N	17E	2		
35121216560000	WALLACE	4N	17E	21		
35121208200000	MOSS	5N	16E	13		
35121214020000	USA	5N	17E	28		
35121214060000	CHARLES CASTEEL	5N	17E	32	10996	
35121214150000	P D BOWMAN	5N	17E	29		
35121214440000	WAYNE WALLACE	4N	17E	21		
35121216140000	BOWMAN	5N	17E	21		
35121216730000	HARE	5N	17E	33		
35121216620000	PAULINE BOWMAN	5N	17E	20		
35121214570000	BELUSKO	4N	17E	6	10717	10952
35121214870000	BOWMAN	5N	17E	20		
35121216570000	PD BOWMAN	5N	17E	29		
35121212080000	WRIGHT	4N	17E	18	12569	
35121212780000	EDITH RICHARDS	5N	17E	30		
35121210930000	POTICHNY	5N	17E	33	10590	10838
35121213230000	HARTSHORNE	4N	17E	6	10542	10782
35121218070000	USA	5N	17E	28		
35121213520000	ALEXANDER	4N	17E	9		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet C Tops (ft)	Spiro Thrust Sheet C Bot (ft)
35121213440000	ROCK ISLAND IMPROVE	4N	17E	8		
35121213380000	PETTIT	5N	17E	31	10309	10606
35121213310000	WEBBER	5N	17E	18		
35121213210000	ROCK ISLAND	4N	17E	5	11263	
35121213190000	POTICHNEY	5N	17E	33	11610	11902
35121213120000	WOODS PROSPECT	5N	16E	36	10474	10791
35121201110000	POTICHNY	5N	17E	33		
35121201330000	STINE	4N	17E	4		
35121218870001	CASTEEL CHARLES `A`	5N	17E	32		
35121218510000	P D BOWMAN	5N	17E	29		
35121218500000	U S A	5N	17E	28		
35121218420000	BOWMAN	5N	17E	21		
35121218350000	EDITH RICHARDS	5N	17E	30		
35121219090000	ANDERSON K	5N	17E	19		
35121205370000	SWEET	4N	17E	9		
35121203190000	BOWMAN	5N	17E	17		
35121205950000	DURAN	5N	17E	18		
35121206800000	BERNARDI JONES	5N	16E	10		
35121208900000	COOK	5N	16E	14		
35121213340000	LEWIS	4N	16E	12	11138	11379
35121213490000	NEEDHAM	4N	16E	11	10640	10878
35121207300000	SMALLWOOD	4N	16E	3	11451	
35121204950000	MCBEE	5N	16E	23		
35121217630000	PEDEN	5N	16E	24		
35121214820000	AIMERITO	5N	16E	34		
35121212070000	SMALLWOOD	4N	16E	10	10772	11029
35121211920000	GEORGE PEDEN	5N	16E	24		
35121212980000	HAILEYVILLE TOWNSITE	5N	16E	35		
35121212200000	TEX	4N	16E	14	11828	12121
35121213080000	MILLER	5N	16E	26		
35121201370000	WOODS PROSPECT	5N	16E	36		
35121200920000	GEORGE PEDEN	5N	16E	24		
35121218440000	MASS UNIT	5N	16E	25		
35121228110000	SIRMANS LOIS	4N	16E	12	11629	11898
35121202060000	MARCANGELI	5N	16E	34		
35121201580000	U S A	5N	16E	27		
35121201680000	W WALLACE	4N	17E	17		
35121206250000	US GOVERNMENT	5N	16E	27		
35121201770000	U S A	5N	16E	35		
35121201980000	NEEDHAM	4N	16E	11	11109	
35121202370000	MADDEN	4N	16E	2	10440	
35121202290000	FRANTZ NEEDHAM	4N	16E	14	11686	
35121202200000	LEWIS	4N	16E	12	11373	
35121202190000	SLAUGHTER	4N	16E	1	10641	
35121201450000	R E KING	5N	16E	26		
35121201550000	HARTSHORNE	4N	17E	6	10880	
35121200310000	PAULINE BOWMAN	5N	17E	20		
35121221060000	KING	5N	16E	26		
35121221230000	MCBEE	5N	16E	23		
35121213390000	ANDERSON	5N	17E	19		
35121214230000	W C CAMP	4N	16E	4	11092	11301

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet C Tops (ft)	Spiro Thrust Sheet C Bot (ft)
35121210120000	MASS	5N	16E	25		
35121232160000	KENDRICK	4N	16E	13	11953	
35121232330000	FINK	5N	16E	36		
35121230540000	AIMERITO	5N	16E	27		
35121229220000	LEWIS JAMES	4N	16E	12	11341	11596
35121228510000	CAMP	5N	16E	34		
35121230870000	KING	5N	16E	26		
35121220030000	WOODS	5N	16E	36		
35121217880000	ANDERSON	5N	17E	19		
35121219200000	USA	5N	16E	35		
35121219820000	NEEDHAM	4N	16E	11	10774	11035

UWI (APINum)	*Well Name*	*Township*	*Range*	*Section*	*Spiro Thrust Sheet D Tops (ft)*	*Spiro Thrust Sheet D Bot (ft)*
35077205720000	BLUE MOUNTAIN	4N	17E	22		
35077206090000	WALLACE	4N	17E	15		
35077203220000	W P LERBLANCE	5N	17E	36	11054	11300
35077203380000	JESSIE BENNETT	5N	18E	30	9779	10033
35077204690000	HUNTER TUCKER	5N	18E	31	10607	
35077205450000	DELLA HOLT	5N	17E	35	10752	11021
35077205430000	STATE	5N	18E	28		
35077205310000	DOBBS STATE UNIT MA	5N	18E	29	9770	10020
35077214630000	MABRY 12	4N	17E	12		
35077214470000	SPARKS	4N	17E	1		
35077205080001	STATE C UNIT	5N	18E	28		
35077212870000	MCCASLIN	4N	17E	2		
35077212760000	MCCASLIN	4N	17E	2		
35077212580000	SMITH	5N	18E	20	9141	9386
35077212380000	LAYDEN	4N	17E	3	12257	
35077212160000	PARKER ALFORD	5N	17E	27	10270	
35077210000000	HENLEY	5N	17E	25	10284	10555
35077209960000	KITCHELL	4N	17E	14		
35077209930000	SIVIL	5N	17E	22		
35077209800000	DARBY	5N	17E	23	9278	
35077209490000	STATE C	5N	18E	28		
35077209350000	WHITNEY	5N	17E	34	11101	11372
35077209210000	BENNETT STATE	5N	18E	19	8727	9175
35077208700000	JESSIE BENNETT	5N	18E	30	9996	10295
35077208580000	ANDREW KURILKO	5N	17E	35	10494	10762
35077208090000	HENLEY	5N	17E	25	10804	
35077208070000	CAUDRON	5N	17E	26	8998	9262
35077208000000	CAUDRON	5N	17E	26	10635	
35077207860000	FABBRO	5N	17E	24	8998	
35077207810000	SMITH	5N	18E	20	10471	10658
35077206920000	LEBLANCE	5N	17E	36		
35077205850000	CAUDRON	5N	17E	26	9300	9541
35077205650000	DARBY	5N	17E	23	9066	9380
35077205280000	FABBRO	5N	17E	24	9714	9952
35077205270000	MABRY	4N	18E	7		
35077205250000	BENNETT	5N	18E	30	11388	11651
35077205050000	SMITH	5N	18E	20	10579	10777
35077205040000	BENNETT STATE	5N	18E	19	9260	9532
35077201050000	KENNEDY	5N	18E	32		
35077204810000	BENNETT STATE	5N	18E	19	8481	8734
35077209540000	DOBBS STATE	5N	18E	29		
35077200800000	MCCASLIN	4N	17E	2		
35077210530000	SIVIL	5N	17E	22	9827	10102
35077210960000	BENNETT STATE	5N	18E	19	9441	9674
35077203090000	WHITNEY	5N	17E	34	10700	10960
35077204510000	MABRY TRUST	4N	17E	12		
35077200790000	PATTISON	4N	17E	1		
35077210700000	CAUDRON	5N	17E	23	9008	9245
35077600300000	M C WATTS	5N	18E	33		
35077301470000	MABRY	4N	18E	9		
35077300110000	J L HENLEY	5N	17E	25	10011	

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust SheetD Tops (ft)	Spiro Thrust Sheet D Bot (ft)
35077300040000	MOSE C WATTS	4N	18E	3		
35077300000000	DARBY SUBDIVISION	5N	17E	23		
35077210410000	DARBY	5N	17E	23	9131	9460
35077210260000	CAUDRON	5N	17E	26	10280	10841
35077210100000	PARKER ALFRED	5N	17E	27	8997	
35077204180000	ALFRED PARKER	5N	17E	27	9202	9442
35077204130000	DARBY SUBDIVI	5N	17E	23		
35077204020000	FABBRO	5N	17E	24		
35077204010000	MC CASLIN	4N	17E	2	11287	
35077204260000	HUNTER TUCKER	5N	18E	31		
35077203900000	SPARKS	4N	17E	3	11616	
35077203520000	SAMS	5N	17E	22	9520	9744
35077203410000	CAUDRON	5N	17E	26	9159	9443
35077203360000	SMITH	5N	18E	20		
35077203130000	ANDREW KURILKO	5N	17E	35	10978	11222
35077202930000	MABRY TRUST	4N	18E	5		
35077202840000	KENNEDY	5N	18E	32		
35077202810000	WHITNEY	5N	17E	34	11453	11706
35077202190000	P S O	4N	17E	10		
35077202540000	KENT HEIRS	5N	17E	14		
35077202460000	SILVER BULLET	4N	17E	11		
35077201750000	RASPOTNIK	5N	17E	10		
35077201740000	VAUGHN	5N	17E	12		
35077201590000	KENT	5N	17E	15		
35077201410000	HUNTER TUCKER	5N	18E	31		
35077200960000	ANDREW KURILKO	5N	17E	35	11052	
35077200710000	WHITNEY	5N	17E	34	11137	
35077205440000	MABRY 9001 JV-P	4N	18E	11		
35077205890000	WORKMAN JVP-9001	4N	18E	22		
35077214300000	MABRY RANCH	4N	18E	10		
35077205740000	NEWELL	4N	18E	23		
35077205760000	SPEARS	4N	18E	21		
35077204870000	SHARP	5N	17E	2		
35121216560000	WALLACE	4N	17E	21		
35121208200000	MOSS	5N	16E	13		
35121214020000	USA	5N	17E	28	10961	11219
35121214060000	CHARLES CASTEEL	5N	17E	32		
35121214150000	P D BOWMAN	5N	17E	29		
35121214440000	WAYNE WALLACE	4N	17E	21		
35121216140000	BOWMAN	5N	17E	21		
35121216730000	HARE	5N	17E	33	10797	11055
35121216620000	PAULINE BOWMAN	5N	17E	20		
35121214570000	BELUSKO	4N	17E	6		
35121214870000	BOWMAN	5N	17E	20		
35121216570000	PD BOWMAN	5N	17E	29		
35121212080000	WRIGHT	4N	17E	18		
35121212780000	EDITH RICHARDS	5N	17E	30		
35121210930000	POTICHNY	5N	17E	33		
35121213230000	HARTSHORNE	4N	17E	6		
35121218070000	U S A	5N	17E	28	9790	10105
35121213520000	ALEXANDER	4N	17E	9		

UWI (API Num)	Well Name	Township	Range	Section	Spiro Thrust Sheet D Tops (ft)	Spiro Thrust Sheet D Bot (ft)
35121213440000	ROCK ISLAND IMPROVE	4N	17E	8		
35121213380000	PETTIT	5N	17E	31		
35121213310000	WEBBER	5N	17E	18		
35121213210000	ROCK ISLAND	4N	17E	5		
35121213190000	POTICHNEY	5N	17E	33	10663	10920
35121213120000	WOODS PROSPECT	5N	16E	36		
35121201110000	POTICHNY	5N	17E	33	11045	
35121201330000	STINE	4N	17E	4	10892	
35121218870001	CASTEEL CHARLES `A`	5N	17E	32	11600	
35121218510000	P D BOWMAN	5N	17E	29		
35121218500000	U S A	5N	17E	28		
35121218420000	BOWMAN	5N	17E	21		
35121218350000	EDITH RICHARDS	5N	17E	30		
35121219090000	ANDERSON K	5N	17E	19		
35121205370000	SWEET	4N	17E	9		
35121203190000	BOWMAN	5N	17E	17		
35121205950000	DURAN	5N	17E	18		
35121206800000	BERNARDI JONES	5N	16E	10		
35121208900000	COOK	5N	16E	14		
35121213340000	LEWIS	4N	16E	12		
35121213490000	NEEDHAM	4N	16E	11		
35121207300000	SMALLWOOD	4N	16E	3		
35121204950000	MCBEE	5N	16E	23		
35121217630000	PEDEN	5N	16E	24		
35121214820000	AIMERITO	5N	16E	34		
35121212070000	SMALLWOOD	4N	16E	10		
35121211920000	GEORGE PEDEN	5N	16E	24		
35121212980000	HAILEYVILLE TOWNSITE	5N	16E	35		
35121212200000	TEX	4N	16E	14		
35121213080000	MILLER	5N	16E	26		
35121201370000	WOODS PROSPECT	5N	16E	36		
35121200920000	GEORGE PEDEN	5N	16E	24		
35121218440000	MASS UNIT	5N	16E	25		
35121228110000	SIRMANS LOIS	4N	16E	12		
35121202060000	MARCANGELI	5N	16E	34		
35121201580000	U S A	5N	16E	27		
35121201680000	W WALLACE	4N	17E	17		
35121206250000	US GOVERNMENT	5N	16E	27		
35121201770000	U S A	5N	16E	35		
35121201980000	NEEDHAM	4N	16E	11		
35121202370000	MADDEN	4N	16E	2		
35121202290000	FRANTZ NEEDHAM	4N	16E	14		
35121202200000	LEWIS	4N	16E	12		
35121202190000	SLAUGHTER	4N	16E	1		
35121201450000	R E KING	5N	16E	26		
35121201550000	HARTSHORNE	4N	17E	6		
35121200310000	PAULINE BOWMAN	5N	17E	20		
35121221060000	KING	5N	16E	26		
35121221230000	MCBEE	5N	16E	23		
35121213390000	ANDERSON	5N	17E	19		
35121214230000	W C CAMP	4N	16E	4		

UWI (API Num)	*Well Name*	*Township*	*Range*	*Section*	*Spiro Thrust Sheet D Tops (ft)*	*Spiro Thrust Sheet D Bot (ft)*
35121210120000	MASS	5N	16E	25		
35121232160000	KENDRICK	4N	16E	13		
35121232330000	FINK	5N	16E	36		
35121230540000	AIMERITO	5N	16E	27		
35121229220000	LEWIS JAMES	4N	16E	12		
35121228510000	CAMP	5N	16E	34		
35121230870000	KING	5N	16E	26		
35121220030000	WOODS	5N	16E	36		
35121217880000	ANDERSON	5N	17E	19		
35121219200000	USA	5N	16E	35		
35121219820000	NEEDHAM	4N	16E	11		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet E Tops (ft)	Spiro Thrust Sheet E Bot (ft)
35077205720000	BLUE MOUNTAIN	4N	17E	22		
35077206090000	WALLACE	4N	17E	15		
35077203220000	W P LERBLANCE	3N	17E	36	10276	10567
35077203380000	JESSIE BENNETT	3N	18E	30		
35077204690000	HUNTER TUCKER	3N	18E	31	9812	10070
35077205450000	DELLA HOLT	3N	17E	35		
35077205430000	STATE	3N	18E	28	10357	10616
35077205310000	DOBBS STATE UNIT MA	3N	18E	29	8774	9067
35077214630000	MABRY 12	4N	17E	12		
35077214470000	SPARKS	4N	17E	1		
35077205080001	STATE C UNIT	3N	18E	28	9794	10074
35077212870000	MC CASLIN	4N	17E	2		
35077212760000	MC CASLIN	4N	17E	2		
35077212580000	SMITH	3N	18E	20	8088	8317
35077212380000	LAYDEN	4N	17E	3		
35077212160000	PARKER ALFORD	3N	17E	27		
35077210000000	HENLEY	3N	17E	25		
35077209960000	KITCHELL	4N	17E	14		
35077209930000	SIVIL	3N	17E	22		
35077209800000	DARBY	3N	17E	23		
35077209490000	STATE C	3N	18E	28	9083	9342
35077209350000	WHITNEY	3N	17E	34		
35077209210000	BENNETT STATE	3N	18E	19		
35077208700000	JESSIE BENNETT	3N	18E	30	9139	9392
35077208580000	ANDREW KURILKO	3N	17E	35		
35077208090000	HENLEY	3N	17E	25	9796	10075
35077208070000	CAUDRON	3N	17E	26		
35077208000000	CAUDRON	3N	17E	26		
35077207860000	FABBRO	3N	17E	24		
35077207810000	SMITH	3N	18E	20	8794	9044
35077206920000	LEBLANCE	3N	17E	36	11201	11479
35077205850000	CAUDRON	3N	17E	26		
35077205650000	DARBY	3N	17E	23		
35077205280000	FABBRO	3N	17E	24		
35077205270000	MABRY	4N	18E	7		
35077205250000	BENNETT	3N	18E	30	9858	10156
35077205050000	SMITH	3N	18E	20	9101	9343
35077205040000	BENNETT STATE	3N	18E	19		
35077201050000	KENNEDY	3N	18E	32		
35077204810000	BENNETT STATE	3N	18E	19		
35077209540000	D OBBS STATE	3N	18E	29	8925	9159
35077200800000	MC CASLIN	4N	17E	2		
35077210530000	SIVIL	3N	17E	22		
35077210960000	BENNETT STATE	3N	18E	19		
35077203090000	WHITNEY	3N	17E	34		
35077204510000	MABRY TRUST	4N	17E	12		
35077200790000	PATTISON	4N	17E	1		
35077210700000	CAUDRON	3N	17E	23		
35077600300000	M C WATTS	3N	18E	33		
35077301470000	MABRY	4N	18E	9		
35077300110000	J L HENLEY	3N	17E	25		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet E Tops (ft)	Spiro Thrust Sheet E Bot (ft)
35077300040000	MOSE C WATTS	4N	18E	3		
35077300000000	DARBY SUBDIVISION	5N	17E	23		
35077210410000	DARBY	5N	17E	23		
35077210260000	CAUDRON	5N	17E	26		
35077210100000	PARKER ALFRED	5N	17E	27		
35077204180000	ALFRED PARKER	5N	17E	27		
35077204130000	DARBY SUBDIVI	5N	17E	23		
35077204020000	FABBRO	5N	17E	24		
35077204010000	MC CASLIN	4N	17E	2		
35077204260000	HUNTER TUCKER	5N	18E	31	10191	10440
35077203900000	SPARKS	4N	17E	3		
35077203520000	SAMS	5N	17E	22		
35077203410000	CAUDRON	5N	17E	26		
35077203360000	SMITH	5N	18E	20	9076	9318
35077203130000	ANDREW KURILKO	5N	17E	35		
35077202930000	MABRY TRUST	4N	18E	5		
35077202840000	KENNEDY	5N	18E	32		
35077202810000	WHITNEY	5N	17E	34		
35077202190000	P S O	4N	17E	10		
35077202540000	KENT HEIRS	5N	17E	14		
35077202460000	SILVER BULLET	4N	17E	11		
35077201750000	RASPOTNIK	5N	17E	10		
35077201740000	VAUGHN	5N	17E	12		
35077201590000	KENT	5N	17E	15		
35077201410000	HUNTER TUCKER	5N	18E	31	10085	
35077200960000	ANDREW KURILKO	5N	17E	35		
35077200710000	WHITNEY	5N	17E	34		
35077205440000	MABRY 9001 JV-P	4N	18E	11		
35077205890000	WORKMAN JVP-9001	4N	18E	22		
35077214300000	MABRY RANCH	4N	18E	10		
35077205740000	NEWELL	4N	18E	23		
35077205760000	SPEARS	4N	18E	21		
35077204870000	SHARP	5N	17E	2		
35121216560000	WALLACE	4N	17E	21		
35121208200000	MOSS	5N	16E	13		
35121214020000	USA	5N	17E	28		
35121214060000	CHARLES CASTEEL	5N	17E	32		
35121214150000	P D BOWMAN	5N	17E	29		
35121214440000	WAYNE WALLACE	4N	17E	21		
35121216140000	BOWMAN	5N	17E	21		
35121216730000	HARE	5N	17E	33		
35121216620000	PAULINE BOWMAN	5N	17E	20		
35121214570000	BELUSKO	4N	17E	6		
35121214870000	BOWMAN	5N	17E	20		
35121216570000	PD BOWMAN	5N	17E	29		
35121212080000	WRIGHT	4N	17E	18		
35121212780000	EDITH RICHARDS	5N	17E	30		
35121210930000	POTTCHNY	5N	17E	33		
35121213230000	HARTSHORNE	4N	17E	6		
35121218070000	U S A	5N	17E	28		
35121213520000	ALEXANDER	4N	17E	9		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet E Tops (ft)	Spiro Thrust Sheet E Bot (ft)
35121213440000	ROCK ISLAND IMPROVE	4N	17E	8		
35121213380000	PETTIT	5N	17E	31		
35121213310000	WEBBER	5N	17E	18		
35121213210000	ROCK ISLAND	4N	17E	5		
35121213190000	POTICHNEY	5N	17E	33		
35121213120000	WOODS PROSPECT	5N	16E	36		
35121201110000	POTICHNY	5N	17E	33		
35121201330000	STINE	4N	17E	4		
35121218870001	CASTEEL CHARLES `A`	5N	17E	32		
35121218510000	P D BOWMAN	5N	17E	29		
35121218500000	U S A	5N	17E	28		
35121218420000	BOWMAN	5N	17E	21		
35121218350000	EDITH RICHARDS	5N	17E	30		
35121219090000	ANDERSON K	5N	17E	19		
35121205370000	SWEET	4N	17E	9		
35121203190000	BOWMAN	5N	17E	17		
35121205950000	DURAN	5N	17E	18		
35121206800000	BERNARDI JONES	5N	16E	10		
35121208900000	COOK	5N	16E	14		
35121213340000	LEWIS	4N	16E	12		
35121213490000	NEEDHAM	4N	16E	11		
35121207300000	SMALLWOOD	4N	16E	3		
35121204950000	MCBEE	5N	16E	23		
35121217630000	PEDEN	5N	16E	24		
35121214820000	AIMERITO	5N	16E	34		
35121212070000	SMALLWOOD	4N	16E	10		
35121211920000	GEORGE PEDEN	5N	16E	24		
35121212980000	HAILEYVILLE TOWNSITE	5N	16E	35		
35121212200000	TEX	4N	16E	14		
35121213080000	MILLER	5N	16E	26		
35121201370000	WOODS PROSPECT	5N	16E	36		
35121200920000	GEORGE PEDEN	5N	16E	24		
35121218440000	MASS UNIT	5N	16E	25		
35121228110000	SIRMANS LOIS	4N	16E	12		
35121202060000	MARCANGELI	5N	16E	34		
35121201580000	U S A	5N	16E	27		
35121201680000	W WALLACE	4N	17E	17		
35121206250000	US GOVERNMENT	5N	16E	27		
35121201770000	U S A	5N	16E	35		
35121201980000	NEEDHAM	4N	16E	11		
35121202370000	MADDEN	4N	16E	2		
35121202290000	FRANTZ NEEDHAM	4N	16E	14		
35121202200000	LEWIS	4N	16E	12		
35121202190000	SLAUGHTER	4N	16E	1		
35121201450000	R E KING	5N	16E	26		
35121201550000	HARTSHORNE	4N	17E	6		
35121200310000	PAULINE BOWMAN	5N	17E	20		
35121221060000	KING	5N	16E	26		
35121221230000	MCBEE	5N	16E	23		
35121213390000	ANDERSON	5N	17E	19		
35121214230000	W C CAMP	4N	16E	4		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet E Tops (ft)	Spiro Thrust Sheet E Bot (ft)
35121210120000	MASS	5N	16E	25		
35121232160000	KENDRICK	4N	16E	13		
35121232330000	FINK	5N	16E	36		
35121230540000	AIMERITO	5N	16E	27		
35121229220000	LEWIS JAMES	4N	16E	12		
35121228510000	CAMP	5N	16E	34		
35121230870000	KING	5N	16E	26		
35121220030000	WOODS	5N	16E	36		
35121217880000	ANDERSON	5N	17E	19		
35121219200000	USA	5N	16E	35		
35121219820000	NEEDHAM	4N	16E	11		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet F Tops (ft)	Spiro Thrust Sheet F Bot (ft)
35077205720000	BLUE MOUNTAIN	4N	17E	22	13640	13970
35077206090000	WALLACE	4N	17E	15	13989	14387
35077203220000	W P LEBLANCE	5N	17E	36		
35077203380000	JESSIE BENNETT	5N	18E	30		
35077204690000	HUNTER TUCKER	5N	18E	31		
35077205450000	DELIA HOLT	5N	17E	35		
35077205430000	STATE	5N	18E	28	12569	12790
35077205310000	DOBBS STATE UNIT MA	5N	18E	29	11430	11630
35077214630000	MABRY 12	4N	17E	12	12055	12390
35077214470000	SPARKS	4N	17E	1	11960	
35077205080001	STATE C UNIT	5N	18E	28		
35077212870000	MCCASLIN	4N	17E	2	11853	12130
35077212760000	MCCASLIN	4N	17E	2	11375	
35077212580000	SMITH	5N	18E	20		
35077212380000	LAYDEN	4N	17E	3	11812	12085
35077212160000	PARKER ALFORD	5N	17E	27		
35077210000000	HENLEY	5N	17E	25		
35077209960000	KITCHELL	4N	17E	14	13210	
35077209930000	SIVIL	5N	17E	22		
35077209800000	DARBY	5N	17E	23		
35077209490000	STATE C	5N	18E	28	11547	11761
35077209350000	WHITNEY	5N	17E	34		
35077209210000	BENNETT STATE	5N	18E	19		
35077208700000	JESSIE BENNETT	5N	18E	30		
35077208580000	ANDREW KURILKO	5N	17E	35		
35077208090000	HENLEY	5N	17E	25		
35077208070000	CAUDRON	5N	17E	26		
35077208000000	CAUDRON	5N	17E	26		
35077207860000	FABBRO	5N	17E	24		
35077207810000	SMITH	5N	18E	20		
35077206920000	LEBLANCE	5N	17E	36		
35077205850000	CAUDRON	5N	17E	26		
35077205650000	DARBY	5N	17E	23		
35077205280000	FABBRO	5N	17E	24		
35077205270000	MABRY	4N	18E	7		
35077205250000	BENNETT	5N	18E	30		
35077205050000	SMITH	5N	18E	20		
35077205040000	BENNETT STATE	5N	18E	19		
35077201050000	KENNEDY	5N	18E	32	10892	
35077204810000	BENNETT STATE	5N	18E	19		
35077209540000	DOBBS STATE	5N	18E	29	11538	11749
35077200800000	MCCASLIN	4N	17E	2	11360	
35077210530000	SIVIL	5N	17E	22		
35077210960000	BENNETT STATE	5N	18E	19		
35077203090000	WHITNEY	5N	17E	34		
35077204510000	MABRY TRUST	4N	17E	12		
35077200790000	PATTISON	4N	17E	1	11372	
35077210700000	CAUDRON	5N	17E	23		
35077600300000	M C WATTS	5N	18E	33		
35077301470000	MABRY	4N	18E	9		
35077300110000	J L HENLEY	5N	17E	25		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet F Tops (ft)	Spiro Thrust Sheet F Bot (ft)
35077300040000	MOSE C WATTS	4N	18E	3		
35077300000000	DARBY SUBDIVISION	5N	17E	23		
35077210410000	DARBY	5N	17E	23		
35077210260000	CAUDRON	5N	17E	26		
35077210100000	PARKER ALFRED	5N	17E	27		
35077204180000	ALFRED PARKER	5N	17E	27		
35077204130000	DARBY SUBDIVI	5N	17E	23		
35077204020000	FABBRO	5N	17E	24		
35077204010000	MC CASLIN	4N	17E	2		
35077204260000	HUNTER TUCKER	5N	18E	31		
35077203900000	SPARKS	4N	17E	3		
35077203520000	SAMS	5N	17E	22		
35077203410000	CAUDRON	5N	17E	26		
35077203360000	SMITH	5N	18E	20		
35077203130000	ANDREW KURILKO	5N	17E	35		
35077202930000	MABRY TRUST	4N	18E	5		
35077202840000	KENNEDY	5N	18E	32	10917	
35077202810000	WHITNEY	5N	17E	34		
35077202190000	P S O	4N	17E	10	12140	
35077202540000	KENT HEIRS	5N	17E	14		
35077202460000	SILVER BULLET	4N	17E	11	12325	12610
35077201750000	RASPOTNIK	5N	17E	10		
35077201740000	VAUGHN	5N	17E	12		
35077201590000	KENT	5N	17E	15		
35077201410000	HUNTER TUCKER	5N	18E	31		
35077200960000	ANDREW KURILKO	5N	17E	35		
35077200710000	WHITNEY	5N	17E	34		
35077205440000	MABRY 9001 JV-P	4N	18E	11		
35077205890000	WORKMAN JVP-9001	4N	18E	22		
35077214300000	MABRY RANCH	4N	18E	10		
35077205740000	NEWELL	4N	18E	23		
35077205760000	SPEARS	4N	18E	21		
35077204870000	SHARP	5N	17E	2		
35121216560000	WALLACE	4N	17E	21	13389	13722
35121208200000	MOSS	5N	16E	13		
35121214020000	USA	5N	17E	28		
35121214060000	CHARLES CASTEEL	5N	17E	32		
35121214150000	P D BOWMAN	5N	17E	29		
35121214440000	WAYNE WALLACE	4N	17E	21	13248	13578
35121216140000	BOWMAN	5N	17E	21		
35121216730000	HARE	5N	17E	33		
35121216620000	PAULINE BOWMAN	5N	17E	20		
35121214570000	BELUSKO	4N	17E	6		
35121214870000	BOWMAN	5N	17E	20		
35121216570000	PD BOWMAN	5N	17E	29		
35121212080000	WRIGHT	4N	17E	18		
35121212780000	EDITH RICHARDS	5N	17E	30		
35121210930000	POTICHNY	5N	17E	33		
35121213230000	HARTSHORNE	4N	17E	6		
35121218070000	USA	5N	17E	28		
35121213520000	ALEXANDER	4N	17E	9	12206	

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet F Tops (ft)	Spiro Thrust Sheet F Bot (ft)
35121213440000	ROCK ISLAND IMPROVE	4N	17E	8	12025	
35121213380000	PETTIT	5N	17E	31		
35121213310000	WEBBER	5N	17E	18		
35121213210000	ROCK ISLAND	4N	17E	5		
35121213190000	POTICHNEY	5N	17E	33		
35121213120000	WOODS PROSPECT	5N	16E	36		
35121201110000	POTICHNY	5N	17E	33		
35121201330000	STINE	4N	17E	4		
35121218870001	CASTEEL CHARLES `A`	5N	17E	32		
35121218510000	P D BOWMAN	5N	17E	29		
35121218500000	U S A	5N	17E	28		
35121218420000	BOWMAN	5N	17E	21		
35121218350000	EDITH RICHARDS	5N	17E	30		
35121219090000	ANDERSON K	5N	17E	19		
35121205370000	SWEET	4N	17E	9	12495	
35121203190000	BOWMAN	5N	17E	17		
35121205950000	DURAN	5N	17E	18		
35121206800000	BERNARDI JONES	5N	16E	10		
35121208900000	COOK	5N	16E	14		
35121213340000	LEWIS	4N	16E	12		
35121213490000	NEEDHAM	4N	16E	11		
35121207300000	SMALLWOOD	4N	16E	3		
35121204950000	MCBEE	5N	16E	23		
35121217630000	PEDEN	5N	16E	24		
35121214820000	AIMERITO	5N	16E	34		
35121212070000	SMALLWOOD	4N	16E	10		
35121211920000	GEORGE PEDEN	5N	16E	24		
35121212980000	HAILEYVILLE TOWNSITE	5N	16E	35		
35121212200000	TEX	4N	16E	14		
35121213080000	MILLER	5N	16E	26		
35121201370000	WOODS PROSPECT	5N	16E	36		
35121200920000	GEORGE PEDEN	5N	16E	24		
35121218440000	MASS UNIT	5N	16E	25		
35121228110000	SIRMANS LOIS	4N	16E	12		
35121202060000	MARCANGELI	5N	16E	34		
35121201580000	U S A	5N	16E	27		
35121201680000	W WALLACE	4N	17E	17	12750	13042
35121206250000	US GOVERNMENT	5N	16E	27		
35121201770000	U S A	5N	16E	35		
35121201980000	NEEDHAM	4N	16E	11		
35121202370000	MADDEN	4N	16E	2		
35121202290000	FRANTZ NEEDHAM	4N	16E	14		
35121202200000	LEWIS	4N	16E	12		
35121202190000	SLAUGHTER	4N	16E	1		
35121201450000	R E KING	5N	16E	26		
35121201550000	HARTSHORNE	4N	17E	6		
35121200310000	PAULINE BOWMAN	5N	17E	20		
35121221060000	KING	5N	16E	26		
35121221230000	MCBEE	5N	16E	23		
35121213390000	ANDERSON	5N	17E	19		
35121214230000	W C CAMP	4N	16E	4		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet F Tops (ft)	Spiro Thrust Sheet F Bot (ft)
35121210120000	MASS	5N	16E	25		
35121232160000	KENDRICK	4N	16E	13		
35121232330000	FINK	5N	16E	36		
35121230540000	AIMERITO	5N	16E	27		
35121229220000	LEWIS JAMES	4N	16E	12		
35121228510000	CAMP	5N	16E	34		
35121230870000	KING	5N	16E	26		
35121220030000	WOODS	5N	16E	36		
35121217880000	ANDERSON	5N	17E	19		
35121219200000	USA	5N	16E	35		
35121219820000	NEEDHAM	4N	16E	11		

UWI (API Num)	Well Name	Township	Range	Section	Spiro Thrust Sheet G Tops (ft)	Spiro Thrust Sheet G Bot. (ft)
35077205720000	BLUE MOUNTAIN	4N	17E	22		
35077206090000	WALLACE	4N	17E	15		
35077203220000	W P LEBLANCE	5N	17E	36		
35077203380000	JESSIE BENNETT	5N	18E	30		
35077204690000	HUNTER TUCKER	5N	18E	31		
35077205450000	DELLA HOLT	5N	17E	35		
35077205430000	STATE	5N	18E	28		
35077205310000	DOBBS STATE UNIT MA	5N	18E	29		
35077214630000	MABRY 12	4N	17E	12		
35077214470000	SPARKS	4N	17E	1		
35077205080001	STATE C UNIT	5N	18E	28		
35077212870000	MC CASLIN	4N	17E	2		
35077212760000	MC CASLIN	4N	17E	2		
35077212580000	SMITH	5N	18E	20		
35077212380000	LAYDEN	4N	17E	3		
35077212160000	PARKER ALFORD	5N	17E	27		
35077210000000	HENLEY	5N	17E	25		
35077209960000	KITCHELL	4N	17E	14		
35077209930000	SIVIL	5N	17E	22		
35077209800000	DARBY	5N	17E	23		
35077209490000	STATE C	5N	18E	28		
35077209350000	WHITNEY	5N	17E	34		
35077209210000	BENNETT STATE	5N	18E	19		
35077208700000	JESSIE BENNETT	5N	18E	30		
35077208580000	ANDREW KURILKO	5N	17E	35		
35077208090000	HENLEY	5N	17E	25		
35077208070000	CAUDRON	5N	17E	26		
35077208000000	CAUDRON	5N	17E	26		
35077207860000	FABBRO	5N	17E	24		
35077207810000	SMITH	5N	18E	20		
35077206920000	LEBLANCE	5N	17E	36		
35077205850000	CAUDRON	5N	17E	26		
35077205650000	DARBY	5N	17E	23		
35077205280000	FABBRO	5N	17E	24		
35077205270000	MABRY	4N	18E	7	13490	13755
35077205250000	BENNETT	5N	18E	30		
35077205050000	SMITH	5N	18E	20		
35077205040000	BENNETT STATE	5N	18E	19		
35077201050000	KENNEDY	5N	18E	32		
35077204810000	BENNETT STATE	5N	18E	19		
35077209540000	DOBBS STATE	5N	18E	29		
35077200800000	MC CASLIN	4N	17E	2		
35077210530000	SIVIL	5N	17E	22		
35077210960000	BENNETT STATE	5N	18E	19		
35077203090000	WHITNEY	5N	17E	34		
35077204510000	MABRY TRUST	4N	17E	12	12405	12775
35077200790000	PATTISON	4N	17E	1		
35077210700000	CAUDRON	5N	17E	23		
35077600300000	M C WATTS	5N	18E	33	11363	
35077301470000	MABRY	4N	18E	9	13100	
35077300110000	J L HENLEY	5N	17E	25		

UWI (API Num)	*Well Name*	*Township*	*Range*	*Section*	*Spiro Thrust Sheet G Tops (ft)*	*Spiro Thrust Sheet G Bot (ft)*
35077300040000	MOSE C WATTS	4N	18E	3	11322	11482
35077300000000	DARBY SUBDIVISION	5N	17E	23		
35077210410000	DARBY	5N	17E	23		
35077210260000	CAUDRON	5N	17E	26		
35077210100000	PARKER ALFRED	5N	17E	27		
35077204180000	ALFRED PARKER	5N	17E	27		
35077204130000	DARBY SUBDIVI	5N	17E	23		
35077204020000	FABBRO	5N	17E	24		
35077204010000	MC CASLIN	4N	17E	2		
35077204260000	HUNTER TUCKER	5N	18E	31		
35077203900000	SPARKS	4N	17E	3		
35077203520000	SAMS	5N	17E	22		
35077203410000	CAUDRON	5N	17E	26		
35077203360000	SMITH	5N	18E	20		
35077203130000	ANDREW KURILKO	5N	17E	35		
35077202930000	MABRY TRUST	4N	18E	5	12085	
35077202840000	KENNEDY	5N	18E	32		
35077202810000	WHITNEY	5N	17E	34		
35077202190000	P S O	4N	17E	10		
35077202540000	KENT HEIRS	5N	17E	14		
35077202460000	SILVER BULLET	4N	17E	11		
35077201750000	RASPOTNIK	5N	17E	10		
35077201740000	VAUGHN	5N	17E	12		
35077201590000	KENT	5N	17E	15		
35077201410000	HUNTER TUCKER	5N	18E	31		
35077200960000	ANDREW KURILKO	5N	17E	35		
35077200710000	WHITNEY	5N	17E	34		
35077205440000	MABRY 9001 JV-P	4N	18E	11	13120	13341
35077205890000	WORKMAN JVP-9001	4N	18E	22	14250	14616
35077214300000	MABRY RANCH	4N	18E	10	13260	
35077205740000	NEWELL	4N	18E	23	14883	
35077205760000	SPEARS	4N	18E	21	13713	14006
35077204870000	SHARP	5N	17E	2		
35121216560000	WALLACE	4N	17E	21		
35121208200000	MOSS	5N	16E	13		
35121214020000	USA	5N	17E	28		
35121214060000	CHARLES CASTEEL	5N	17E	32		
35121214150000	P D BOWMAN	5N	17E	29		
35121214440000	WAYNE WALLACE	4N	17E	21		
35121216140000	BOWMAN	5N	17E	21		
35121216730000	HARE	5N	17E	33		
35121216620000	PAULINE BOWMAN	5N	17E	20		
35121214570000	BELUSKO	4N	17E	6		
35121214870000	BOWMAN	5N	17E	20		
35121216570000	PD BOWMAN	5N	17E	29		
35121212080000	WRIGHT	4N	17E	18		
35121212780000	EDITH RICHARDS	5N	17E	30		
35121210930000	POTICHNY	5N	17E	33		
35121213230000	HARTSHORNE	4N	17E	6		
35121218070000	US A	5N	17E	28		
35121213520000	ALEXANDER	4N	17E	9		

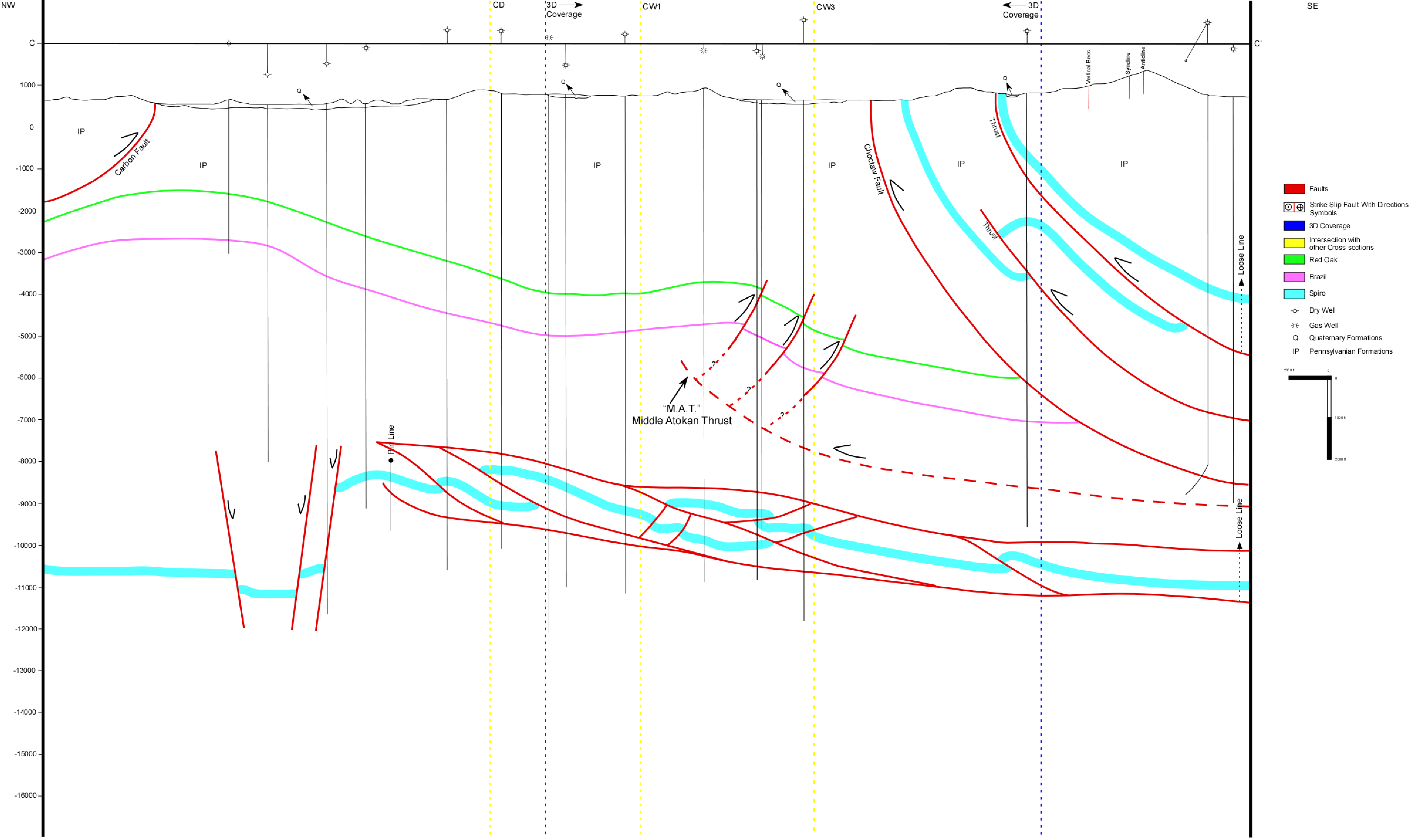
UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet G Tops (ft)	Spiro Thrust Sheet G Bot. (ft)
35121213440000	ROCK ISLAND IMPROVE	4N	17E	8		
35121213380000	PETTIT	5N	17E	31		
35121213310000	WEBBER	5N	17E	18		
35121213210000	ROCK ISLAND	4N	17E	5		
35121213190000	POTICHNEY	5N	17E	33		
35121213120000	WOODS PROSPECT	5N	16E	36		
35121201110000	POTICHNY	5N	17E	33		
35121201330000	STINE	4N	17E	4		
35121218870001	CASTEEL CHARLES `A`	5N	17E	32		
35121218510000	P D BOWMAN	5N	17E	29		
35121218500000	USA	5N	17E	28		
35121218420000	BOWMAN	5N	17E	21		
35121218350000	EDITH RICHARDS	5N	17E	30		
35121219090000	ANDERSON K	5N	17E	19		
35121205370000	SWEET	4N	17E	9		
35121203190000	BOWMAN	5N	17E	17		
35121205950000	DURAN	5N	17E	18		
35121206800000	BERNARDI JONES	5N	16E	10		
35121208900000	COOK	5N	16E	14		
35121213340000	LEWIS	4N	16E	12		
35121213490000	NEEDHAM	4N	16E	11		
35121207300000	SMALLWOOD	4N	16E	3		
35121204950000	MCBEE	5N	16E	23		
35121217630000	PEDEN	5N	16E	24		
35121214820000	AIMERITO	5N	16E	34		
35121212070000	SMALLWOOD	4N	16E	10		
35121211920000	GEORGE PEDEN	5N	16E	24		
35121212980000	HAILEYVILLE TOWNSITE	5N	16E	35		
35121212200000	TEX	4N	16E	14		
35121213080000	MILLER	5N	16E	26		
35121201370000	WOODS PROSPECT	5N	16E	36		
35121200920000	GEORGE PEDEN	5N	16E	24		
35121218440000	MASS UNIT	5N	16E	25		
35121228110000	SIRMANS LOIS	4N	16E	12		
35121202060000	MARCANGELI	5N	16E	34		
35121201580000	USA	5N	16E	27		
35121201680000	W WALLACE	4N	17E	17		
35121206250000	US GOVERNMENT	5N	16E	27		
35121201770000	USA	5N	16E	35		
35121201980000	NEEDHAM	4N	16E	11		
35121202370000	MADDEN	4N	16E	2		
35121202290000	FRANTZ NEEDHAM	4N	16E	14		
35121202200000	LEWIS	4N	16E	12		
35121202190000	SLAUGHTER	4N	16E	1		
35121201450000	R E KING	5N	16E	26		
35121201550000	HARTSHORNE	4N	17E	6		
35121200310000	PAULINE BOWMAN	5N	17E	20		
35121221060000	KING	5N	16E	26		
35121221230000	MCBEE	5N	16E	23		
35121213390000	ANDERSON	5N	17E	19		
35121214230000	W C CAMP	4N	16E	4		

UWI (APINum)	Well Name	Township	Range	Section	Spiro Thrust Sheet G Tops (ft)	Spiro Thrust Sheet G Bot (ft)
35121210120000	MASS	5N	16E	25		
35121232160000	KENDRICK	4N	16E	13		
35121232330000	FINK	5N	16E	36		
35121230540000	AIMERITO	5N	16E	27		
35121229220000	LEWIS JAMES	4N	16E	12		
35121228510000	CAMP	5N	16E	34		
35121230870000	KING	5N	16E	26		
35121220030000	WOODS	5N	16E	36		
35121217880000	ANDERSON	5N	17E	19		
35121219200000	USA	5N	16E	35		
35121219820000	NEEDHAM	4N	16E	11		

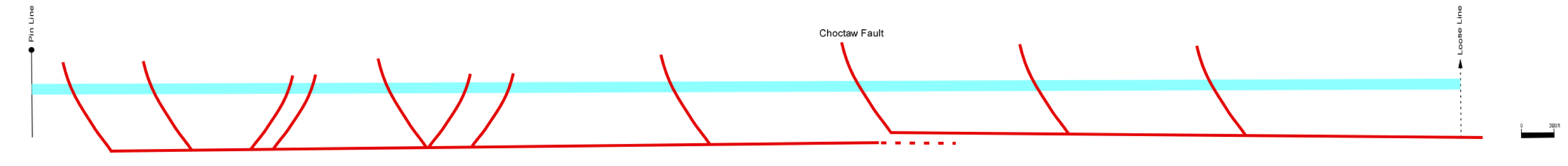
N
W
E
S
A
B
C
Carbon Fault
D'
W1'
W2
W3'
D
W1
Choctaw Fault
Choctaw Fault
C'
W2'
A'
B'
W3
Hartshorne Lake
Formations
(Qa) Quaternary
(PSV) Pennsylvanian Savanna
(Pm) Pennsylvanian McAlester
(Ph) Pennsylvanian Hartshorne
(Pa) Pennsylvanian Atoka
(Pw/Pws) Pennsylvanian Spiro/Wapanucha
(Pjv) Pennsylvanian Johns Valley
(Psp) Pennsylvanian Springer
Map Symbols
Contact
Marked Bed
Normal Fault
Thrust Fault
Strike slip fault
Anticline
Syncline
Strike and Dip of Beds
Strike and dip of overturned beds
Minor Anticline
Minor Syncline
Vertical Beds
Scale
0
1
2 Miles

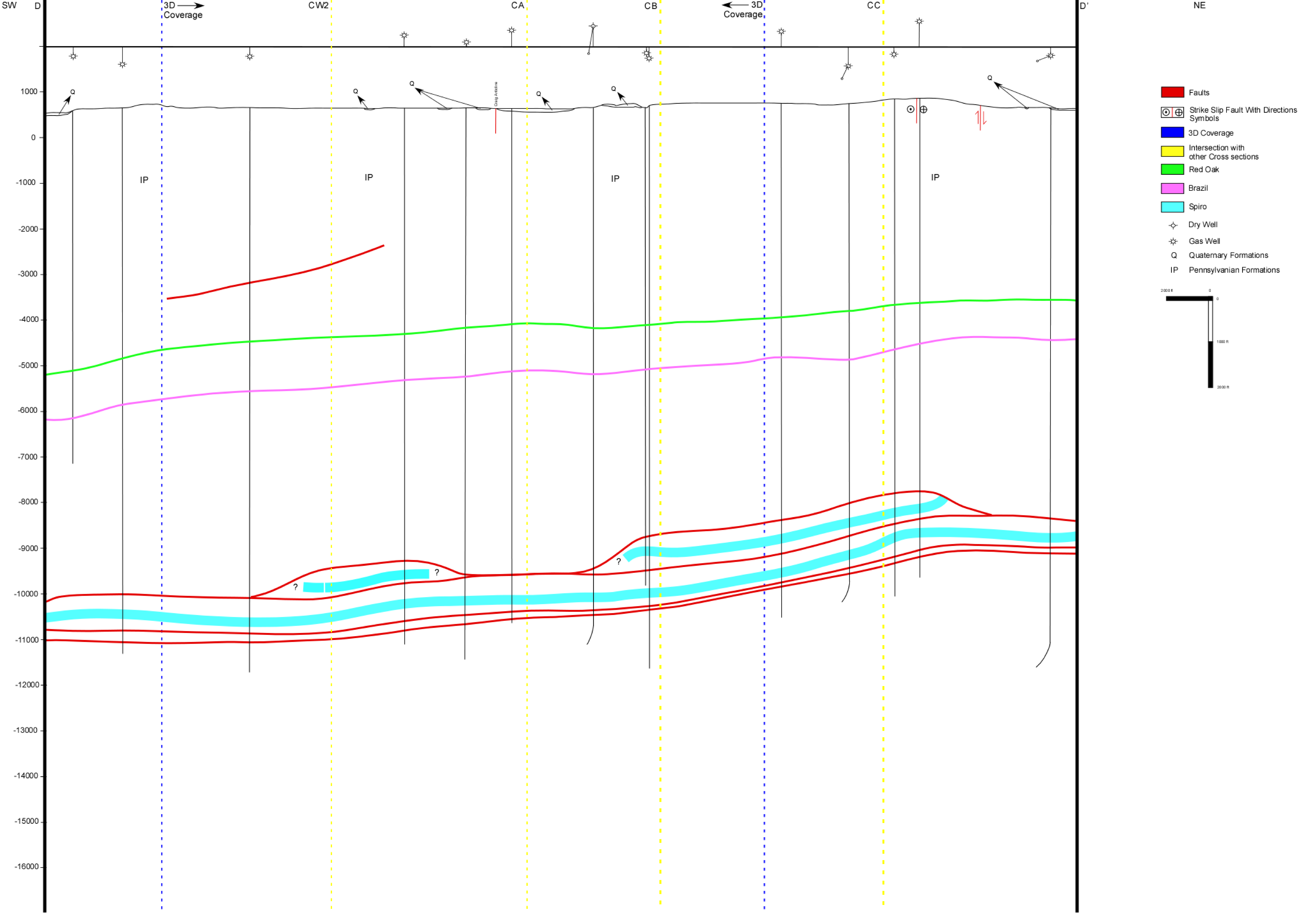

NW
SE
A
A`
3D Coverage
CD
CW1
CW3
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
-13000
-14000
-15000
-16000
IP
Carbon Fault
Strike Slip
Craig Anticline
Hartshorn Syncline
Anticline
Choctaw Fault
Thrust
"M.A.T."
Middle Atokan Thrust
Pin Line
Loose Line
Faults
Strike Slip Fault With Directions Symbols
3D Coverage
Intersection with other Cross sections
Red Oak
Brazil
Spiro
Dry Well
Gas Well
Q Quaternary Formations
IP Pennsylvanian Formations
A-A`
Pin Line
Choctaw Fault
Loose Line

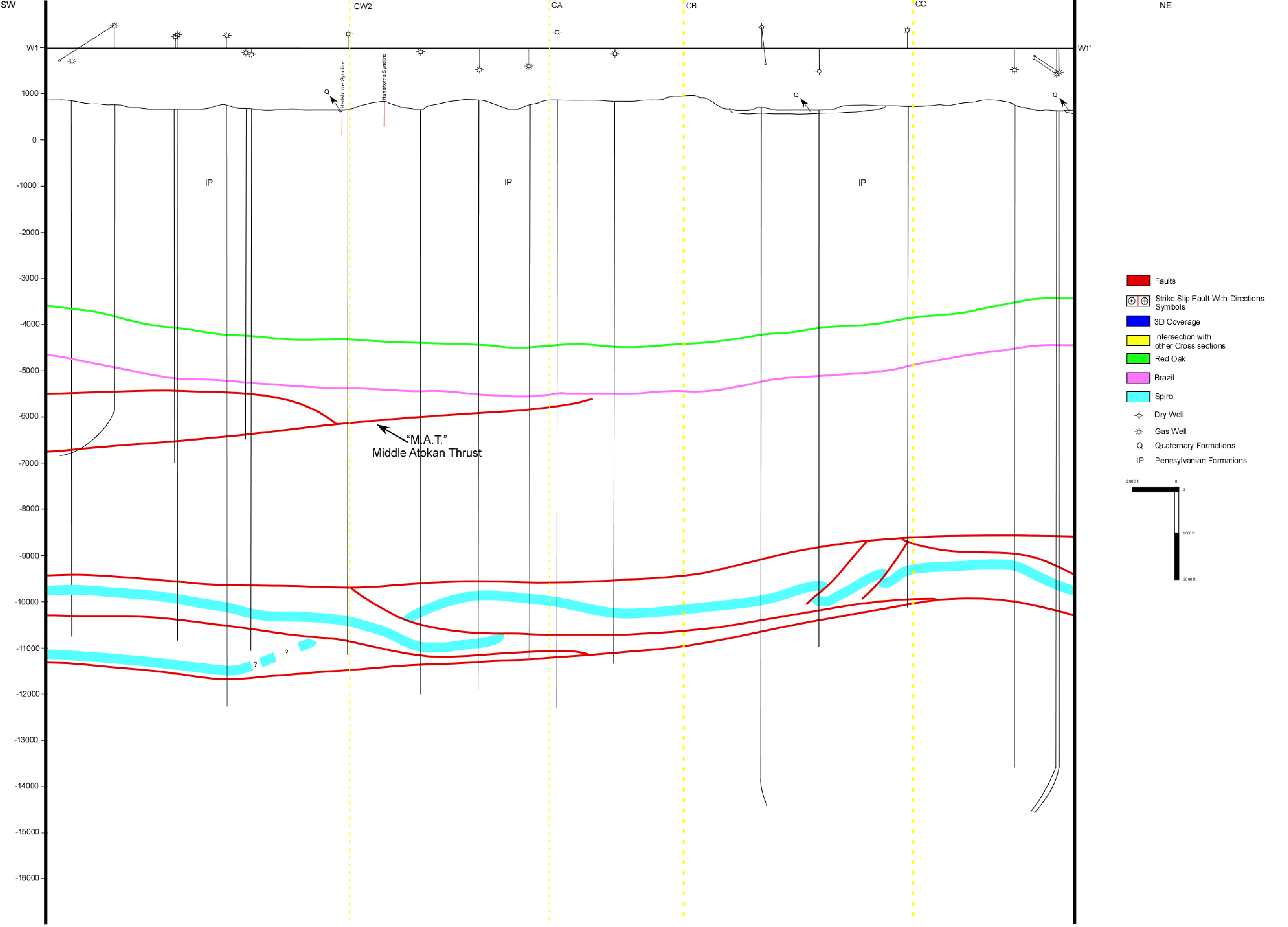
NW
SE
B
B'
3D Coverage
3D Coverage
CD
CW1
CW3
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
-13000
-14000
-15000
-16000
IP
Carbon Fault
Choctaw Fault
Thrust
Thrust
Thrust
"M.A.T."
Middle Atokan Thrust
Pin Line
Loose Line
Loose Line
Faults
Strike Slip Fault With Directions Symbols
3D Coverage
Intersection with other Cross sections
Red Oak
Brazil
Spiro
Dry Well
Gas Well
Quaternary Formations
Pennsylvanian Formations
B-B`
Pin Line
Choctaw Fault
Loose Line

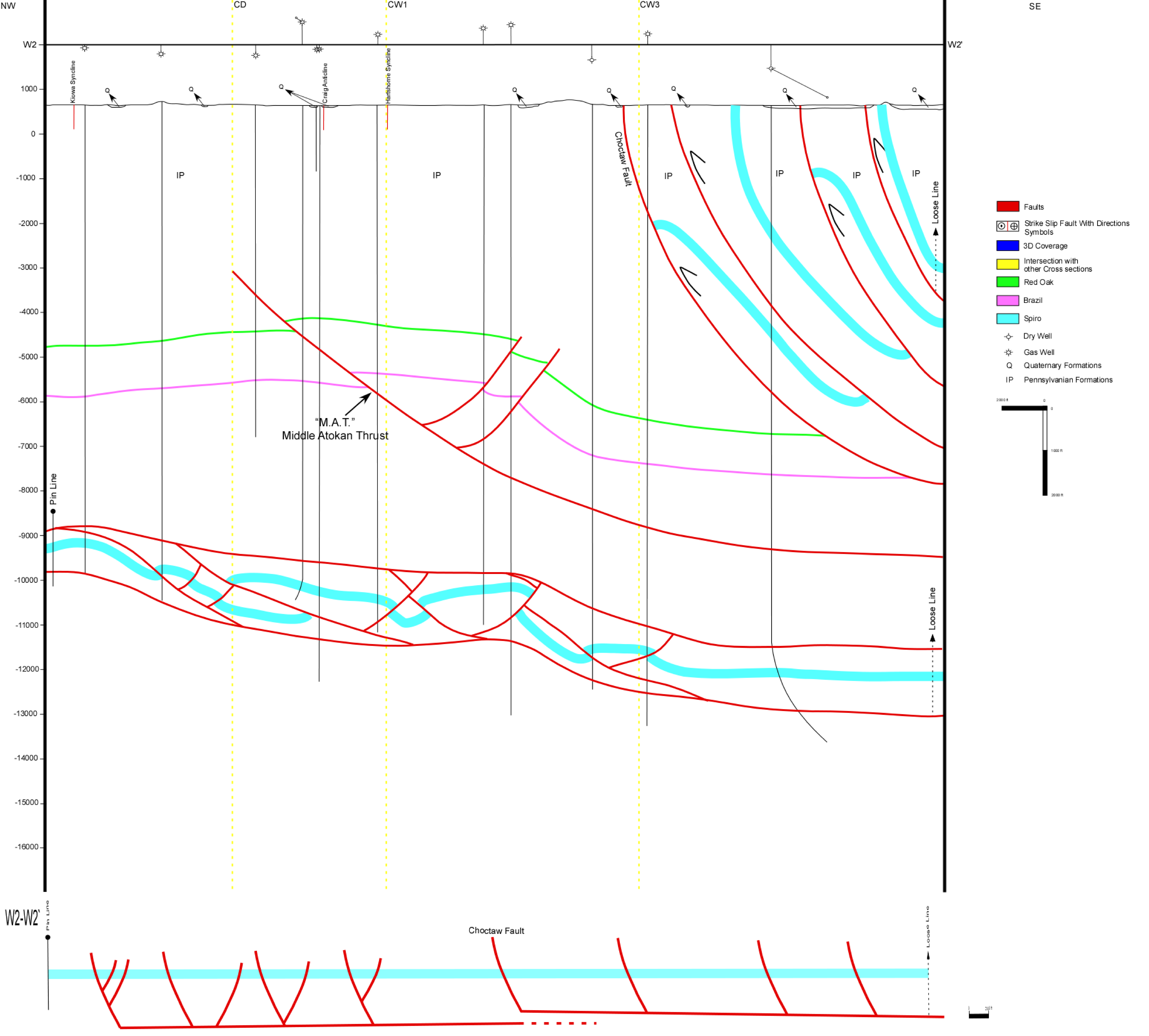

NW
SE
C
C'
CD
3D Coverage
CW1
CW3
3D Coverage
Vertical Beds
Syncline
Anticline
IP
Carbon Fault
Choctaw Fault
Thrust
Thrust
"M.A.T."
Middle Atokan Thrust
Pin Line
Loose Line
Loose Line
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
-13000
-14000
-15000
-16000
Faults
Strike Slip Fault With Directions Symbols
3D Coverage
Intersection with other Cross sections
Red Oak
Brazil
Spiro
Dry Well
Gas Well
Quaternary Formations
Pennsylvanian Formations

C-C`

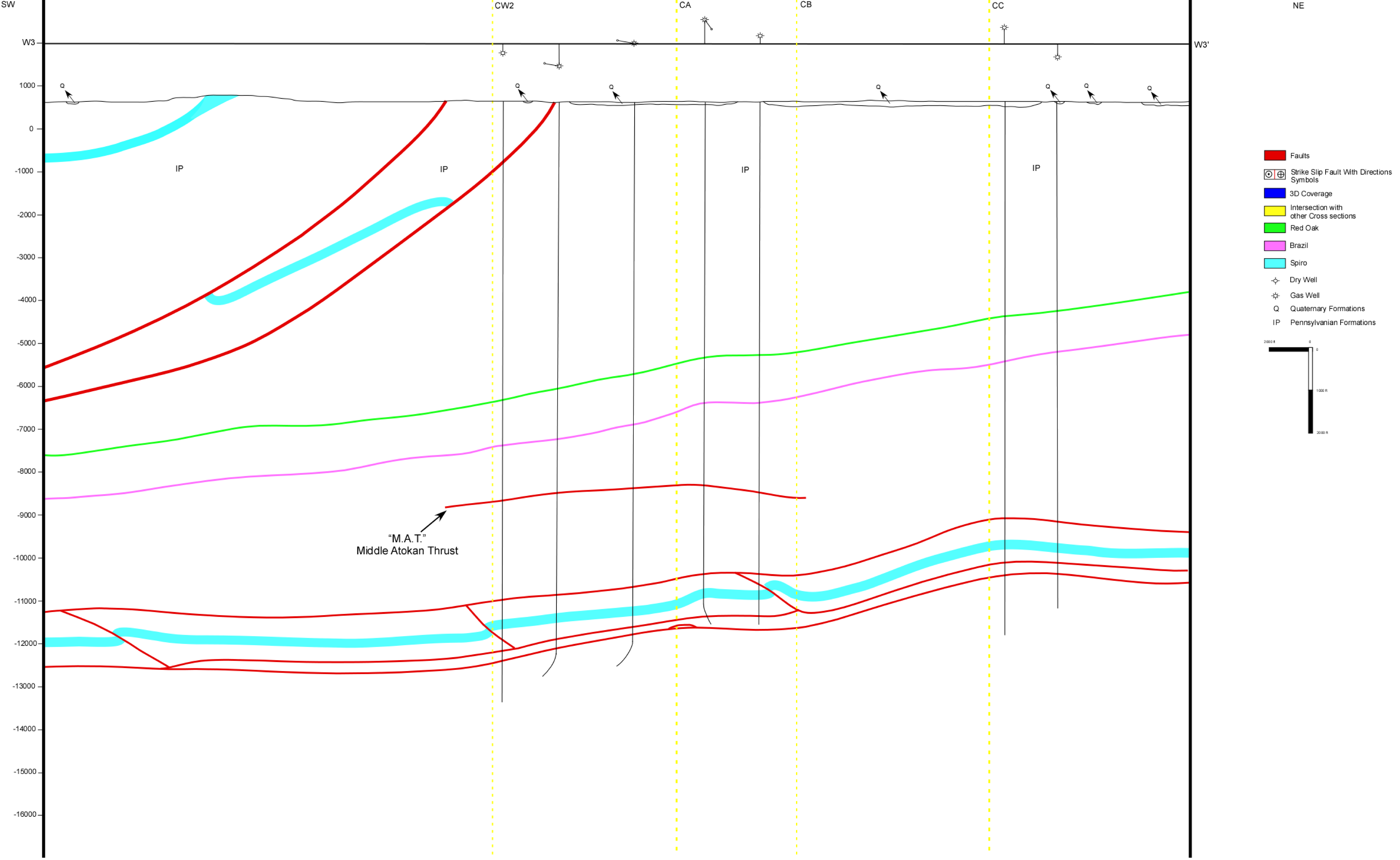

Pin Line
Choctaw Fault
Loose Line


SW
D
3D Coverage
CW2
CA
CB
3D Coverage
CC
D'
NE
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
-13000
-14000
-15000
-16000
IP
IP
IP
IP
?
?
?
Faults
Strike Slip Fault With Directions Symbols
3D Coverage
Intersection with other Cross sections
Red Oak
Brazil
Spiro
Dry Well
Gas Well
Q Quaternary Formations
IP Pennsylvanian Formations


SW
NE
CW2
CA
CB
CC
W1
W1'
Hartshorne Syncline
Hartshorne Syncline
Q
IP
IP
IP
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
-13000
-14000
-15000
-16000
"M.A.T."
Middle Atokan Thrust
?
?
Faults
Strike Slip Fault With Directions Symbols
3D Coverage
Intersection with other Cross sections
Red Oak
Brazil
Spiro
Dry Well
Gas Well
Q Quaternary Formations
IP Pennsylvanian Formations



NW
SE
CD
CW1
CW3
W2
W2'
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
-13000
-14000
-15000
-16000
Kiowa Syncline
Craig Anticline
Hartshorne Syncline
IP
Choctaw Fault
"M.A.T."
Middle Atokan Thrust
Pin Line
Loose Line
Faults
Strike Slip Fault With Directions Symbols
3D Coverage
Intersection with other Cross sections
Red Oak
Brazil
Spiro
Dry Well
Gas Well
Q Quaternary Formations
IP Pennsylvanian Formations
W2-W2'
Choctaw Fault


SW
CW2
CA
CB
CC
NE
W3
W3'
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
-13000
-14000
-15000
-16000
IP
IP
IP
IP
"M.A.T."
Middle Atokan Thrust
Faults
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3D Coverage
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Brazil
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Dry Well
Gas Well
Q Quaternary Formations
IP Pennsylvanian Formations

VITA

AbdulWahab Mohammed Sadeqi

Candidate for the Degree of

Master of Science

Thesis: STRUCTURAL GEOMETRY OF THE LATE PALEOZOIC THRUSTING IN THE HARTSHORNE, HIGGINS, ADAMSON AND GOWEN QUADRANGLES, SOUTHEASTERN OKLAHOMA

Major Field: Geology

Biographical:

Personal Data: Born in Royal Oak, Michigan on June 18^{th} 1979, the son of Dr. Mohammed I. Sadeqi and Dr. Salwa H. Darwish

Education: Received a Bachelor of Arts in Geology from the University of Colorado at Boulder in December of 2003. Completed the requirements for a Masters of Science degree in Geology from Oklahoma State University at Stillwater in May of 2007.

Experience:

- Teaching Assistant: Boone Pickens School of Geology, Oklahoma State University.
- Geotechnician: Encana Oil Company, Denver, Colorado.
- Student Services Contract: United State Geological Survey, Boulder Colorado.
- Physical Science Technician: United State Geological Survey, Boulder Colorado.

Professional Memberships: American Association for Petroleum Geologist

Name: AbdulWahab Mohammed Sadeqi Date of Degree: May, 2007

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: STRUCTURAL GEOMETRY OF THE LATE PALEOZOIC THRUSTING IN THE HARTSHORNE, HIGGINS, ADAMSON AND GOWEN QUADRANGLES, SOUTHEASTERN OKLAHOMA

Pages in Study: 101 Candidate for the Degree of Master of Science

Major Field: Geology

Scope and Method of Study:

The purpose of this thesis is to delineate the subsurface structural geometry of the Wilburton Gas Field area, using well log data and 3D seismic data.
7 cross sections were constructed in the study area. Raster images of well logs were imported into PETRA software to assist in the mapping process.

Findings and Conclusions:

The presence of the Wilburton triangle zone is confirmed. The duplex structure in the footwall of Choctaw contains hinterland dipping break-forward thrusts which form horses in the duplex. These thrusts dip ~25^{o} southward. The horses are apparently cut by foreland dipping backthrusts. Shortening calculation for the backthrusts within the duplex is ~10%. It is ~21% for the duplex structure and ~58% for the study area. Middle Atokan units were displaced by a splay from the Choctaw fault named the Middle Atokan Thrust (M.A.T.).

ADVISER’S APPROVAL: Dr. Ibrahim Cemen