RESERVOIR CHARACTERIZATION OF THE ALDRICH, ALDRICH NE AND KEILMAN NORTH FIELDS, NESS COUNTY, KANSAS FOR POTENTIAL EXPLORATION OF SUB-MISSISSIPPIAN FORMATIONS

by

JARRED A. LEIS

B.S., Kansas State University, 2010

A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Department of Geology
College of Arts and Sciences

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2013

Approved by:

Major Professor
Dr. Matthew Totten

Abstract

Petroleum producing areas within the mid-continent region discovered in the first half of the 1900's often ignored the potential of deeper horizons once hydrocarbons were discovered in shallower zones. In Ness County, Kansas the deepest horizon typically explored are Mississippian-aged rocks. One of the largest fields in Ness County is the Aldrich Field, first discovered in 1929. The Mississippian in this field contains an active water-drive, which was produced by an "open-hole" completion method. This precluded drilling deeper horizons. Although modern drilling and completion techniques allow drilling through and isolating water-drive reservoirs like the Mississippian, very few deep exploratory wells have been drilled in Ness County. Wells that penetrate sub-Mississippian horizons are typically drilled as disposal wells, along the flanks of the main structure.

This study evaluates the potential of several sub-Mississippian formations to be hydrocarbon reservoirs. Drill cuttings from five wells that penetrate these formations were analyzed using a combination of petrographic microscope, Scanning Electron Microscope (SEM), and chemical methods. Reservoir quality porosity was observed in several sub-Mississippian zones. The presence of hydrocarbon staining was observed in the Viola samples of three wells, and the Arbuckle in one well. Staining was confirmed by EDS spectra under the SEM.

The results of this study suggest a good potential of zones deeper than normally drilled to contain hydrocarbons in rocks with reservoir quality porosity. These zones were not drill stem tested in the Aldrich field, and structural advantage to these wells might be expected by drilling the apex of the trapping anticline to further evaluate the deeper horizons.

Table of Contents

List of Figures

List of Tables

Acknowledgements

There are many people and groups that I would like to thank for helping me complete my master's and thesis. First of all I would like to thank my advisor Dr. Matthew Totten for taking me on as a graduate student and pitching the idea for this thesis to me. He has passed on many skills of a petroleum geologist to me that I think will always be valuable to me. I would also like to thank my committee members, Dr. Sam Chaudhuri and Dr. Allen Archer.

I would also like to thank all the other graduate students that have been here with me over the past two years. They have all been very helpful in lending a hand whenever needed as well as providing some much needed relief from studying and research. I would like wish all of you all the best of luck in the world in whatever you decide to do with your careers.

Some organizations that I would like to thank are the Kansas Geological Survey and Kansas Geological Foundation for supplying me with very helpful data including: well logs, wellbore cuttings, and numerous reports and papers that made my job a lot easier. Also I would like to thank Paul and Deana Strunk for providing scholarship money for all the GTA's including me, without their help it would have made graduate school a lot harder for me. I also would like to thank Mewbourne Oil Company and Chesapeake Energy for providing me with internships my two summers as an undergrad, the knowledge I gained from those two summers is unbelievable.

Chapter 1 - Introduction

Ness County has long been known as a prolific producer of oil in the State of Kansas. Most of this oil is produced from Mississippian and Pennsylvanian aged formations. The exploration for deeper, older, sub-Mississippian oil production has been very limited within the county. Wells that have been drilled into the sub-Mississippian formations are almost exclusively drilled as saltwater disposal wells. This is prevalent in the study area, which includes the Aldrich, Aldrich NE, and Keilman North fields of Ness County. These fields occur along a large subsurface anticline that trends from northeast to southwest. This anticline influences all the production in this area, and the most productive wells are situated on or near the hinge line of the anticline. The question addressed within this study is whether the sub-Mississippian formations could be productive in these fields. The formations known to occur below the Mississippian include the Viola Limestone, Simpson Sandstone, and Arbuckle formations. Theses have been penetrated in eight wells, none of which produce oil or gas. All were drilled as saltwater disposal wells along the flanks of the anticline. Although these fields haven't been explored for sub-Mississippian formations they have been very prolific oil producers from Mississippian and Pennsylvanian formations as displayed in Table 1.

Field Name	**Field Total Production (up to2011)**
Aldrich	9,144,450bbls
Aldrich NE	4,867,982bbls
Keilman North	431,856bbls
	TOTAL PRODUCTION OF AREA: 14,444,288bbls

Table 1: Total production for the fields in the study area
(Kansas Geological Survey, 2012)

Historic Well Completions and Techniques

One of the main reasons that the deeper horizons have not been explored is because of lack of drilling and completion technology available when the wells were originally drilled. The Aldrich field was discovered during a period when the majority of wells were completed using a "barefoot completion" technique. This technique involves drilling until the total depth is very close to the top of the desired producing horizon before setting production casing. (http://www.spe.org/glossary/wiki/doku.php/terms:barefoot_completion)

Once the casing has been set the operator will then deepen the well until the top of the producing formation is barely penetrated. This method was thought to reduce the amount of reservoir water the well would produce. Available cementing technology was not adequate to isolate reservoirs with a significant water drive, as found in the Mississippian formations in the study area. Current cementing technology allows drilling through highly porous, water drive formations such as the Mississippian, allowing deeper horizons to be evaluated.

Geologic Setting

The Aldrich anticlinal trend is located in western Ness County Kansas situated in Townships 17S and 18S, and Ranges 24W, 25W, and 26W. Geologically the Aldrich trend is located in the eastern part of the Hugoton Embayment; the specific location in relation to the state of Kansas is shown in Figure 1. Figure 1 also shows the major anticlines of Kansas. Figure 3 shows the location of the study area in relation to Ness County.

The Hugoton Embayment is part of the Anadarko Basin, which covers large parts of western Oklahoma and western Kansas, as well as the northeast part of the Texas Panhandle (Merriam, 1963). The Hugoton Embayment is the shelf-like extension of the Anadarko, and occupies one third of Kansas (28,600 square miles). The eastern edge of the Hugoton

Embayment is marked by the Central Kansas Uplift and Cambrian Arch. To the west the basin ends with the Las Animas Arch in eastern Colorado. As the Embayment extends southward the sediments thicken as they get further into the Anadarko Basin. The Hugoton Embayment is the deepest basin in Kansas with a sedimentary package that, in places, is 9,500 feet thick before pre-Cambrian basement rock is encountered (Merriam, 1963).

Previous Work on Deep Horizons in Ness County

This study is not the first that has investigated the potential of deep horizon plays in Ness County, Carr et al. (1997)studied the deeper Mississippian rocks in the Schaben field, located in eastern Ness County (Figure 2). The Schaben Field is comparable to the Aldrich because it is an old field, first discovered in 1963, with production realized in the very top horizons of the Mississippian. The availability of modern petrophyscial logs from a newer well, Carr et al. (1997) concluded that the lower Mississippian was a viable target for future exploration. Further study (Montgomery et al., 2000) suggested numerous potential lower Mississippian infill wells. These wells were subsequently drilled and production of the Schaben Field was increased by 200 barrels of oil per day. The new productive lower Mississippian wells had initial production rates between 12-108 barrels of oil per day. This information provides evidence that there is the possibility of lower Mississippian and possibly older formations to be productive in Ness County.

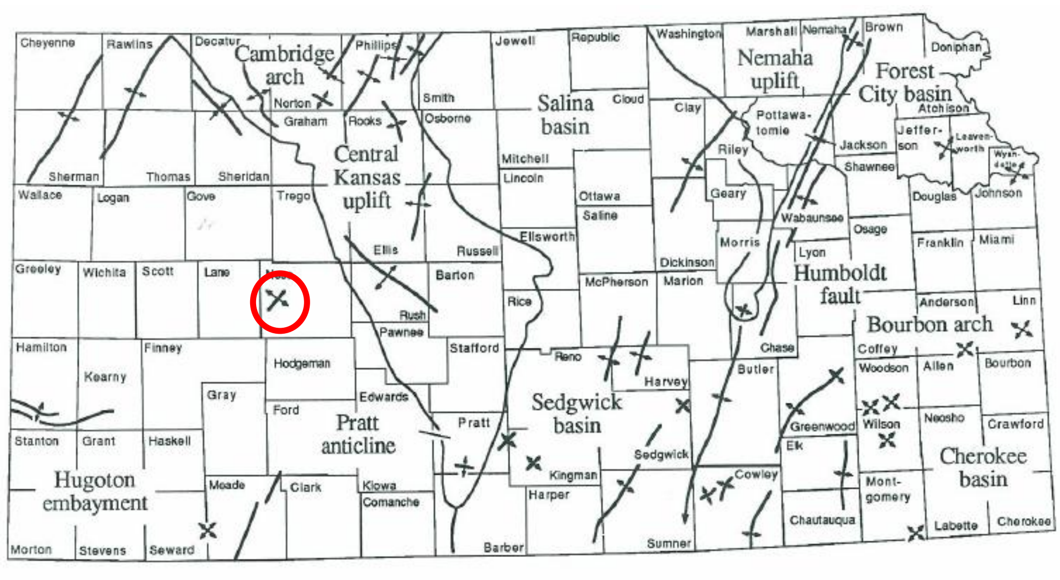


Figure 1: Major Anticlines in Kansas as shown by the bold black lines, also shown in the figure are the boundaries of the Hugoton Embayment in Kansas (Merriam, 1963)

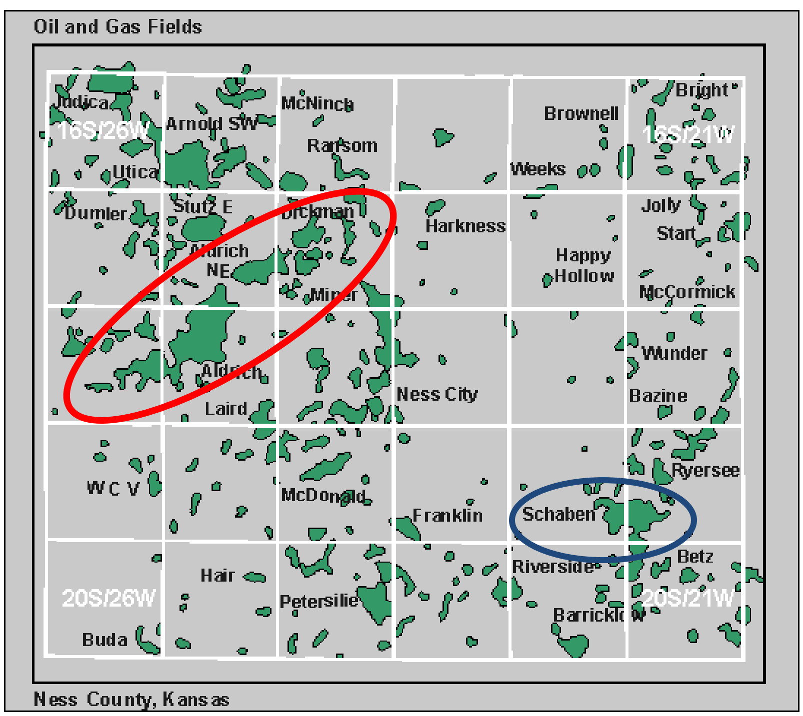


Figure 2: Study area in relation to Ness County (Red Circle) and where the Schaben Field lays (Blue Circle) (Kansas Geological Society, 2012)

Stratigraphy of the Aldrich Trend

The stratigraphy for the fields along the Aldrich anticline is very similar to the stratigraphy of other oil-bearing basins in western Kansas. For these fields to date hydrocarbon production is achieved only in Pennsylvanian (Lansing-Kansas City, Marmaton-including the Fort Scott limestone, and Cherokee Formations) and Mississippian aged formations. Although rarely penetrated, the Viola, Simpson, and Arbuckle formations are present in the study area (Figure 9). Most of the lithologies within this area are carbonates or shales, with rare sandstones present. These are found within the Cherokee group, and the Simpson (Zeller, 1968)

Lansing-Kansas City Group

The youngest producing formation within the study is the Lansing-Kansas City (LKC). The LKC is composed of mostly limestone, with shales separating the different limestone layers. The LKC represents the beginning of the Missourian Stage of Pennsylvanian age. The Lansing is composed of one shale and two limestone members, while the Kansas City is a much thicker package and is composed of 27 members of shale and limestone that have been found throughout Kansas (Zeller, 1968).These are often denoted in the subsurface by alphabetic nomenclature of each layer (Watney, 1980) Hydrocarbon production in this study area is found only in the Aldrich field. There is no known production from the Lansing in the Aldrich NE or Keilman North fields. Figure 3 represents the stratigraphic column for the Lansing Group, and Figure 4 represents the Kansas-City Group stratigraphic column. Receding and seceding seas represent the depositional environment for the LKC. (Zeller, 1968).

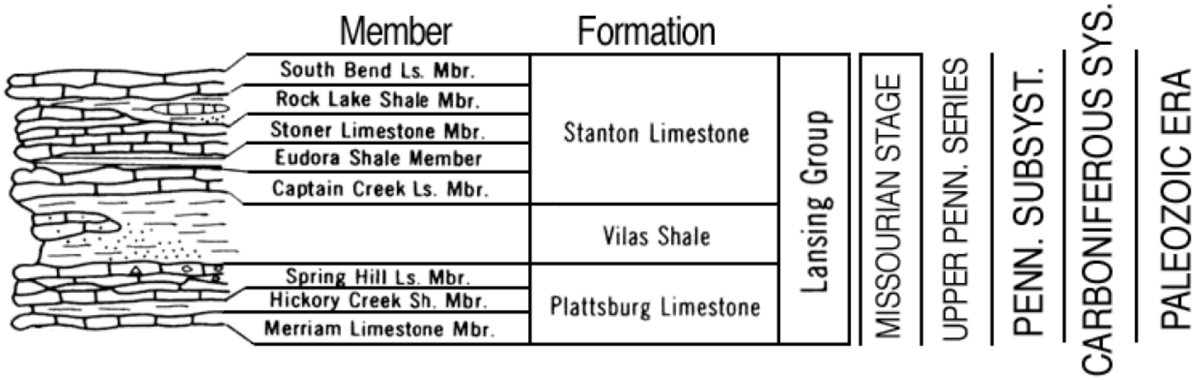


Figure 3: Lansing Group stratigraphic Column (Zeller, 1968)

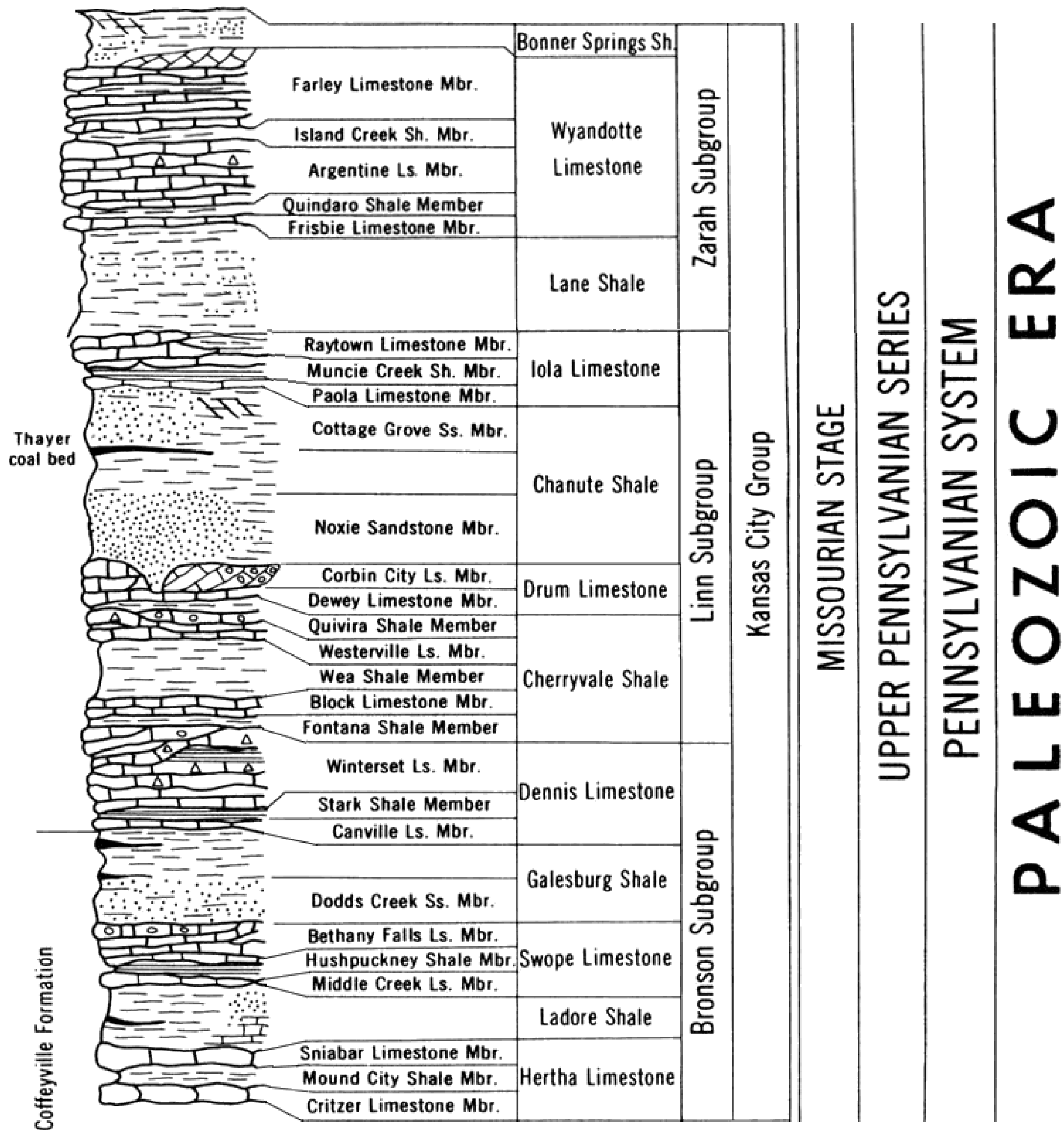


Figure 4: Kansas City Group Stratigraphic Column (Zeller, 1968)

Marmaton Group

The Marmaton Group is commonly split into two sub-groups the Marmaton and Fort Scott Limestone (Merriam, 1963). The Marmaton sub-group is composed of four limestones and four shales that separate them. This stratigraphy also represents receding and advancing seas as the depositional environment. In the study area the Marmaton sub-group has proven productive in both the Aldrich NE and Keilman North fields. The other sub-group of the Marmaton is the Ft. Scott Limestone. The Ft. Scott is comprised of two limestones and one shale that separates them. The Ft. Scott can range anywhere from 13 to 145 ft thick depending where you are in Kansas; in this study area the Ft. Scott is between 20 and 25 feet thick. The Ft. Scott has been proven productive in only the Aldrich field of this study area (Zeller, 1968). Figure 5 shows the stratigraphic column for the entire Marmaton group.

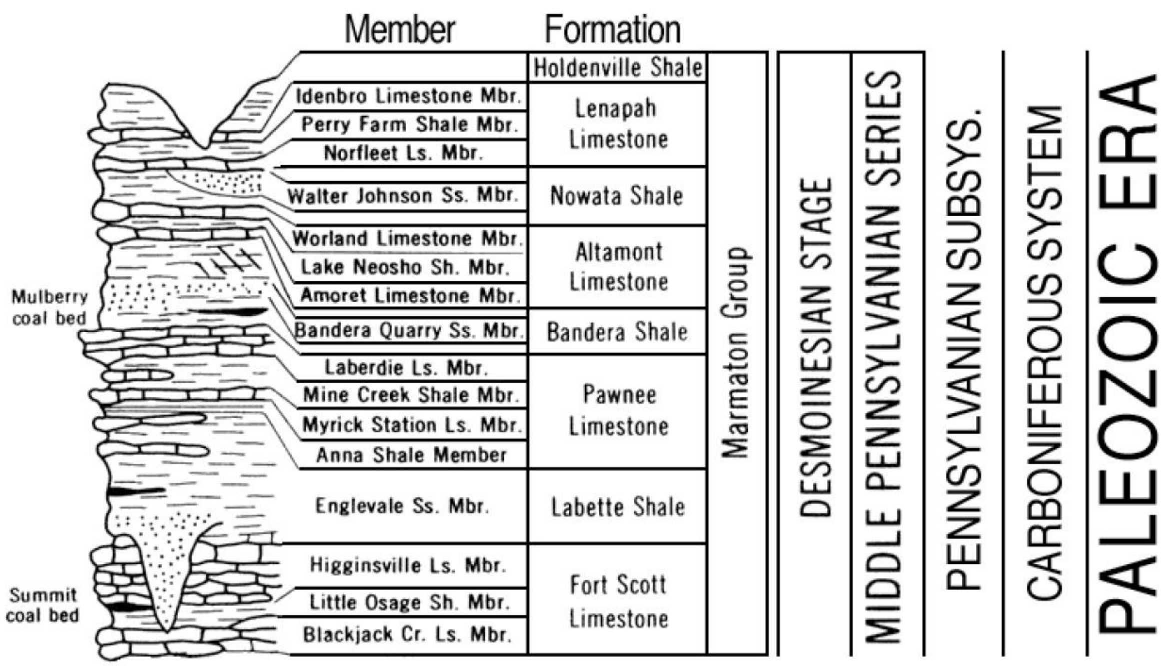


Figure 5: Marmaton Group Stratigraphic Column (Zeller, 1968)

Cherokee Group

Unlike the other Pennsylvanian formations described the Cherokee is almost limestone free; the Cherokee Group is comprised of almost all sandstone and shale (Figure 6). The Cherokee also contains coal deposits throughout that are very useful for stratigraphic identification on petrophysical logs (Merriam, 1963). The Cherokee represents the beginning of Pennsylvanian aged deposition in Ness County on top of the unconformity of the Mississippian section. In the study area the Cherokee has been productive in the Keilman North and Aldrich NE fields.

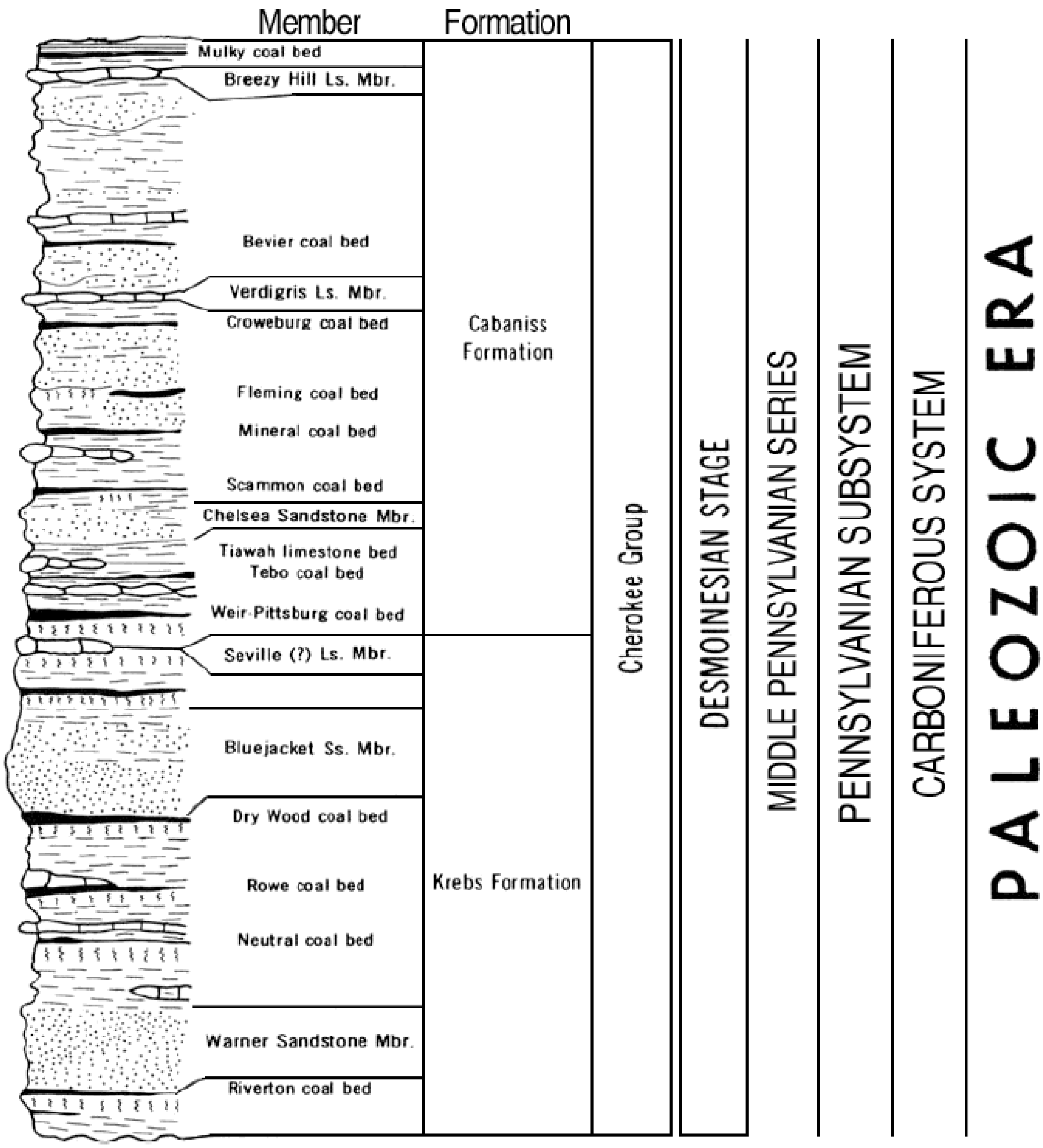


Figure 6: Cherokee Group Stratigraphic Column (Zeller, 1968)

Mississippian Group

The Mississippian group is a very thick sequence comprised mainly of limestone and dolomite. The Mississippian is commonly split into three different stages: Chesteran Stage, Warsaw Stage, and Kinderhookian Stage (Zeller, 1968). The Chesteran is the uppermost unit of the Mississippian and is comprised of limestone and shale. The Warsaw is the middle stratigraphic unit of the Mississippian and is comprised of limestone, dolomite, and chert. The lowest unit in the Mississippian is the Kinderhookian, it is composed mainly of all dolomite, chert, and shale (Merriam, 1963; Zeller, 1968). The Mississippian section is the most prolific oil producer in the study area, as well as Ness County (Kansas Geologic Survey, 2012). The first unit of Mississippian that is encountered is the St. Louis unit in the study area, due to the thinning of the Mississippian towards the Central Kansas Uplift. Figure 7 shows the stratigraphic units of the upper Mississippian units and Figure 8 shows the stratigraphic column of the lower Mississippian Units. Most oil production in the study area is encountered in the top horizons of the Mississippian. Lower Mississippian zones are potential sub-Mississippian horizons for future exploration of the Aldrich trend, in the study area there are 8 wells that have penetrated into the lower Mississippian horizons.

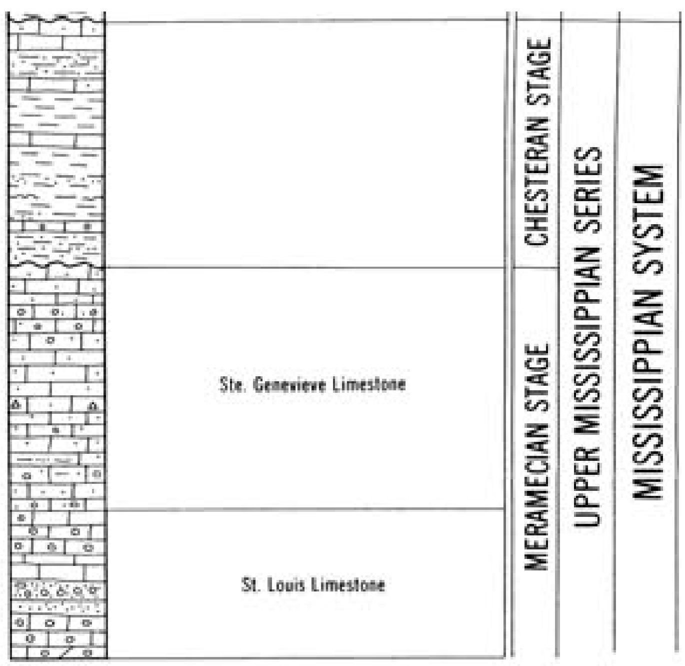


Figure 7: Upper Mississippian stratigraphic column (Zeller, 1968)

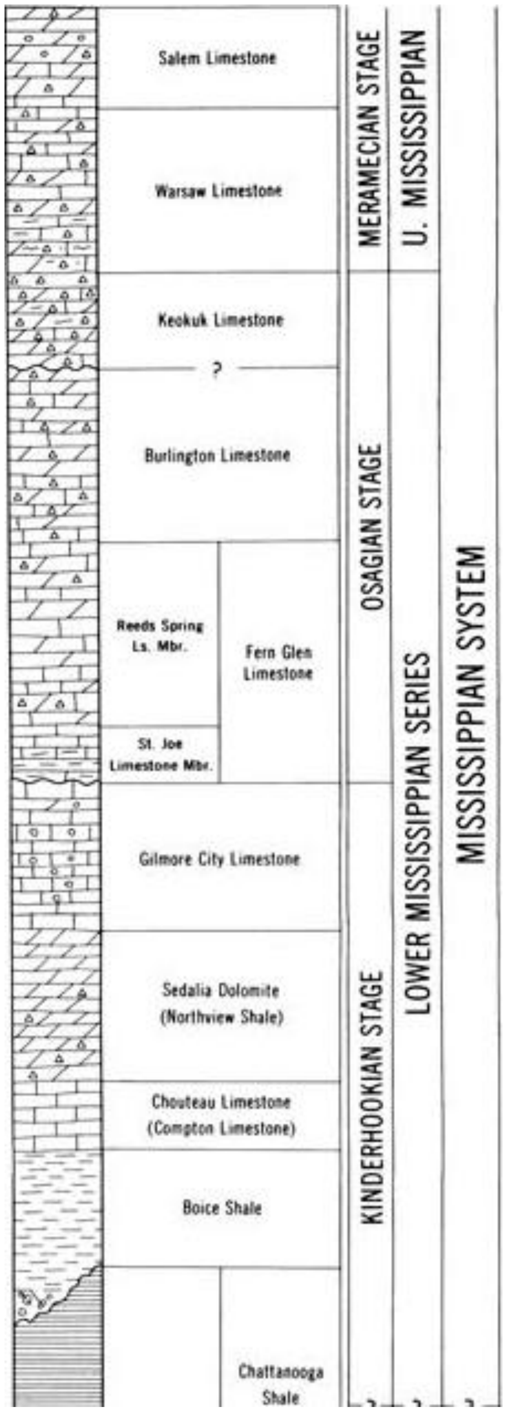


Figure 8: Lower Mississippian stratigraphic column (Zeller, 1968)

Sub-Mississippian Formations

Viola Group: The Viola group (Ordovician) is made up mainly of dolomite which contains many vuggs which contribute to good porosity and permeability and therefore makes an excellent reservoir rock for hydrocarbons (Merriam,1963; Zeller, 1968). There is very little well data in this area for the Viola because there are only eight wells in the area that have penetrated below the Mississippian. Out of the eight wells that penetrate below the Mississippian we were able to get drilling cuttings from the Kansas Geological Survey for five of these wells. Electric logs were also acquired for five of the sub-Mississippian wells. Figure 9 shows the stratigraphy for all the Sub-Mississippian units in the area including the Viola. The nearest oil production in the Viola is in eastern Pawnee County, approximately 60 miles from the study area (Figure A-1) (Newell, et. Al, 1987)

Simpson group: The Simpson group (Ordovician aged) is commonly split into two members, the Platteville formation and the St. Petersburg Sandstone (Figure 9). The Platteville formation is comprised of shale, limestone, dolomite and sandstone. The Lower St. Petersburg member is comprised of almost all sandstone and shale. The St. Petersburg sands are usually composed of entirely all large quartz grains that are loosely cemented, which make excellent reservoir rock (Zeller, 1968). Like all sub-Mississippian formations in this area there is very limited data for the Simpson group. Pawnee County is also the nearest know Simpson production (Figure A-2) to the study area (Newell et. al, 1987)

Arbuckle Group: The Arbuckle is early Ordovician to late Cambrian age and represents the last formation before the Reagan Sandstone and the Granite Wash and crystalline basement (Figure 9). The Arbuckle is comprised almost entirely of dolomite with some streaks of sandstone present (Zeller, 1968). The Arbuckle is a very prominent hydrocarbon producer to the east of this study area in the Central Kansas Uplift where the Mississippian has been completely eroded. Just like the other two sub-Mississippian formations in this study area our well data is limited. The nearest known Arbuckle production (Newell et. al, 1987) to the study area is in Rush, Pawnee, and Trego Counties (Figure A-3).

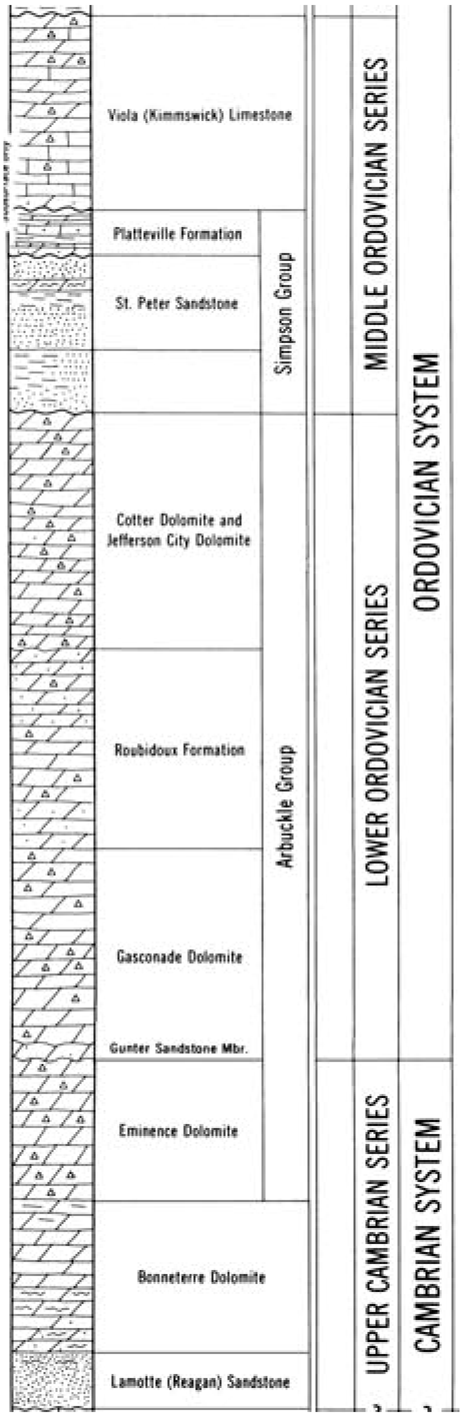


Figure 9: Sub-Mississippian formations stratigraphic column (Zeller, 1968)

Project Objectives

This study investigates the potential that any of the sub-Mississippian formations to be productive hydrocarbon producers. The Aldrich Trend is an ideal area to test this objective because of the established anticlinal structure. Wells drilled along the flanks of the anticline have established the presence of formations known to be highly productive in other areas of western Kansas. This study investigates the potential for deeper horizons to mirror the structural advantage found in the Mississippian-aged reservoirs, the likelihood of these horizons to be permeable reservoirs, and whether any evidence exists that hydrocarbons might be trapped within the reservoirs.

This is important to the energy production to the state of Kansas because elsewhere in the state there exists massive amounts of oil produced out of sub-Mississippian formations. Figure A-4 shows the oil production by interval for the year of 1992 and shows that the Arbuckle produced 15% of the oil in Kansas that year. Figure A-4 also shows that Upper and Middle Ordovician (Viola and Simpson) produced four percent of the oil in Kansas that year. This is important for this study because there is already proven Mississippian production but there is the possibility that there could be sub-Mississippian oil remaining virtually unexplored. Because of this possibility this study will assess to the best possible knowledge whether or not sub-Mississippian exploration would be feasible in this area.

Chapter 2 - Methods

The potential of the sub-Mississippian formations as petroleum reservoirs requires the evaluation of four components of the petroleum system. These four components include adequate structure as a trapping mechanism, the presence of seals between each potential reservoir, sufficient porosity and permeability, and evidence of hydrocarbons within these reservoirs. The following methods were employed to assess each of these four components.

Structure Maps

Structure maps for the Lansing-Kansas City, Ft. Scott Limestone, and Mississippi Lime were made from well data gathered from the Kansas Geological Survey. These structure maps were analyzed to assess the possibility of concentric folding between these three formations. Cross-sections composed from petrophyscial were also analyzed to identify concentric folding between the Pennsylvanian formations and the Mississippian.

To compose the structure maps a database was compiled of well data from different sources. The first database made was an excel spreadsheet, that contained all of the well data from the project area. For this project 387 wells were included in the database. The tops from the Kansas Geological Society's website as well as location data were entered in the database. In addition to the data that was acquired from the Kansas Geological Society we acquired well logs for the wells that penetrated sub-Mississippian wells from the Kansas Geological Society Library.

Kansas State University was granted a license to use Petra software from the software company IHS. Petra is an oil and gas mapping software that allows the user to make subsurface maps and cross sections using digital well data. After the database of well data was compiled the data was then imported into Petra. Once the data was uploaded a base-map was created. A land grid file that was compatible with Petra was obtained from Whitestar, a Denver, CO based company. After the land grid file was uploaded well locations were spotted onto the land grid (Figure, 10). Formation tops were posted which allowed the structure maps on specific formation tops (Figure, 11).

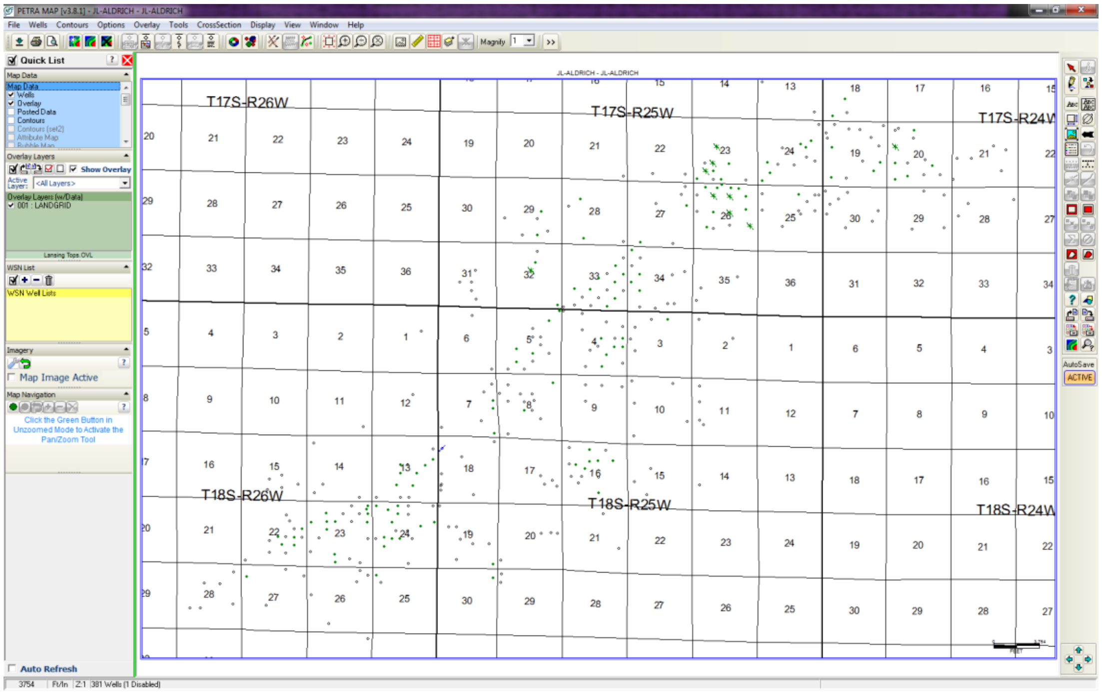


Figure 10: Screen shot of Petra with the well locations on the base map

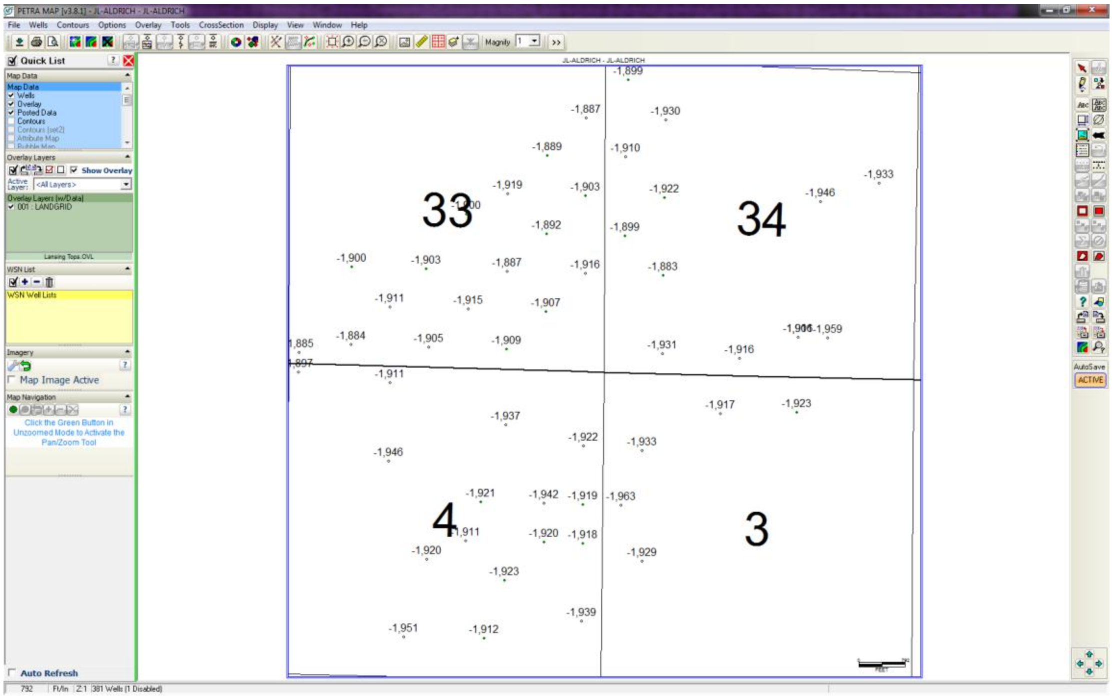


Figure 11: Screen from Petra with formation tops for the Mississippi posted above the well symbol for a portion of the area

Cross Sections

Cross sections of petrophysical logs across the Aldrich anticline were made to help identify concentric folding across these formations: Heebner Shale, Lansing Limestone, Fort Scott Limestone, Cherokee Shale, and Mississippian formations. Sub-Mississippian formations were also included for the cross section that is composed of all sub-Mississippian wells in the area.

The cross sections, like the structure maps, were composed using Petra software. Petrophysical logs were obtained from the Kansas Geological Society library and loaded into Petra software. Formation picks were then made based on the characteristics of the logs. The formation picks were correlated along three lines that cross the Aldrich anticline, the lines cross the north, south and middle areas of the structure. Also a cross-section was made that includes all the wells that penetrated below the Mississippian to assess if concentric folding occurs in the sub-Mississippian formations.

Well Cuttings Analyses

Well cuttings were available from the Kansas Geological Survey for five wells that penetrated the sub-Mississippian horizons (Table, 2). Well cuttings were examined under a binocular microscope and noted for good reservoir properties (porosity and permeability) as well as identifying any shale units that would make a good sealing layer for any of the sub-Mississippian formations. Any kind of oil stain or any other evidence that oil had been, or passed through, the samples was noted. One good indicator of oil passing through a formation is the presence of pyrite in sample so any presence of pyrite in the samples was noted (Seewald, 2003). Figure 12 shows an example from one of the sub-Mississippian well's cutting description that we configured.

Well Name	**Sec-Twn-Rge**	**API#**	**Deepest Formation Reached**
Reed #1	27-17S-25W	15-135-00522	Viola
Everett #1	7-18S-25W	15-135-00588	Arbuckle
John C. Shearer #2	23-17S-25W	15-135-19054-0001	Arbuckle
Stiawalt #3	20-17S-24W	15-135-21501	Arbuckle
Ilene Norton #2	32-17S-25W	15-135-25175	Arbuckle

Table 2: Five sub-Mississippian wells for cutting analysis

Reed "A" #1
15-135-00522

Formation	Depth	Rock Description	Samples Taken
MISSISSIPPI	4500-4505	Dol: tan-gry., pyrite., gd vug pors	
	4505-4510	Dol: tan-gry., pyrite., gd vug pors	
	4510-4515	Dol: tan-gry., gd vug pors	
	4515-4520	Dol: tan-gry., gd vug pors	
	4520-4525	Dol: tan-gry., gd vug pors	
	4525-4530	Dol: tan-gry., pyrite., gd vug pors	
	4530-4535		
	4535-4540	Dol: tan-gry., pyrite., gd vug pors/ Sh: gry-blk	
	4540-4545	Sh: AA/ Dol: AA	
	4545-4550	Dol: tan-gry., xln pors/ Sh: AA	
	4550-4555	Dol: tan-gry., sctrd vug pors	
	4555-4560	Dol: wht-tan., sctrd vug pors	
	4560-4565	Dol: wht-tan., sctrd vug pors/ Cht: wht., xln	Yes
	4565-4570	Dol: AA/ Cht: AA	
	4570-4575	Cht: wht., xln/ Sh: blk	
	4575-4580	Cht: AA/ Dol: tan-brn., sctrd pors	Yes
	4580-4585	Sh: gry-blk/ Cht: wht. Xln	

Figure 12: An example of well cuttings descriptions

Scanning Electron Microscope Cutting Analysis

The most prospective samples from the sub-Mississippian wells were further analyzed in a Scanning Electron Microscope within the Biology department at Kansas State University. These cuttings were chosen to get a close up look at the porosity and permeability of the samples, which came from the upper parts of the Viola and Arbuckle. The SEM in the Biology department had EDS (Energy-dispersive X-ray spectroscopy) capabilities that allowed the chemical analyses to be performed.The EDS capability of the SEM was also used to geochemically analyze some of the potential oil stains that were noticed under the binocular microscope. In particular, the samples were analyzed to determine the presence of any carbon that would give evidence that the possible oil stains were a form of hydrocarbon. The machine conditions that were used by this particular SEM were 2.50kV x 100 and 3.00kV x 100.

The samples that were selected for SEM analysis were mounted on a disc with adhesive before placement in the SEM. Four samples were mounted to each disc then placed in the SEM where a vacuum was applied to the SEM chamber to allow the analysis to begin. No coatings were applied to the samples before placing them into the SEM.

Chapter 3 - Structure Maps & Cross-Sections

Structure maps were prepared from the formation tops data that were obtained from the Kansas Geological Foundation and the Kansas Geologic Survey. The three formations mapped were the: Lansing-Kansas City, Ft. Scott Limestone, and the Mississippian Limestone. These were constructed to see if there is any structural variation between these Mississippian and Pennsylvanian formations.

Lansing-Kansas City Structure

The Lansing-Kansas City structure for this area is an anticlinal feature as shown in Figure 13 that is trending northeast to southeast. The productive wells for the field (wells with a green dot symbol on the base map) occur where the Lansing-Kansas City is structurally high. Because there is very little Lansing-Kansas City production in this area it is hard to predict from the structure map whether Lansing-Kansas City production is influenced solely by structure or also by other characteristics.

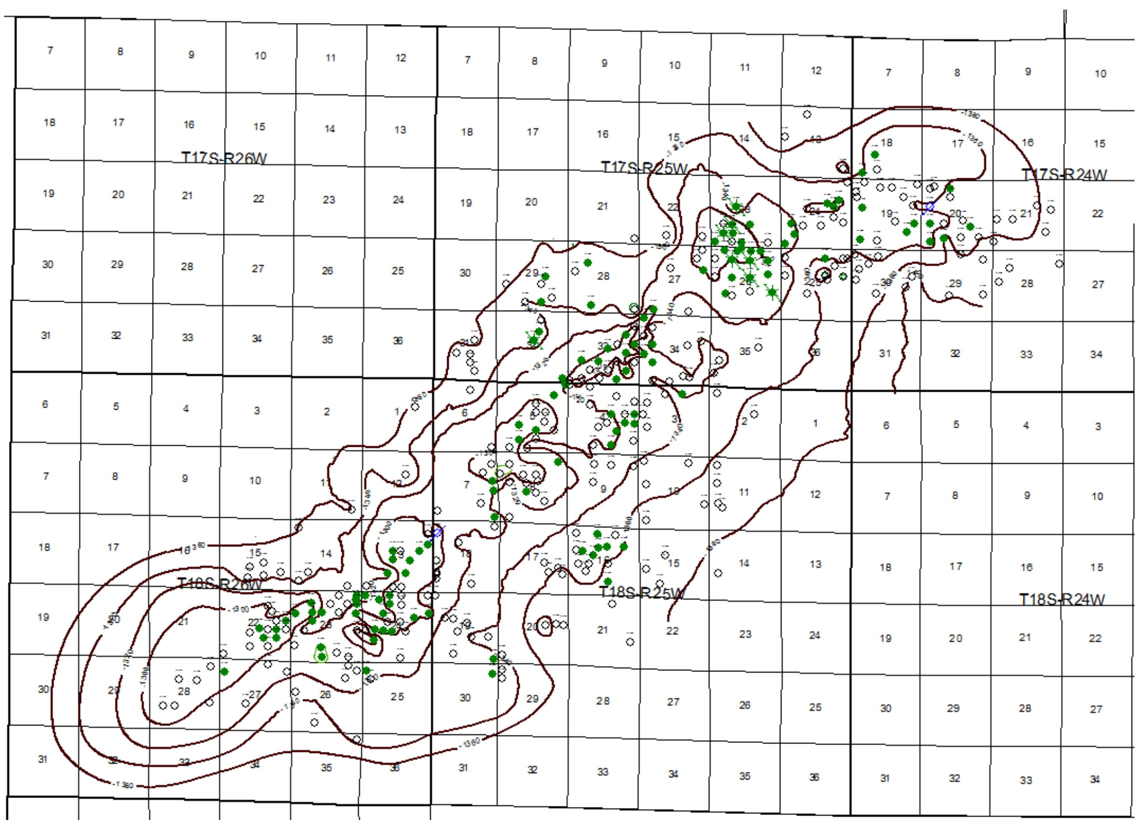


Figure 13: Lansing-Kansas City structure

Ft. Scott Structure

The structure map of the Ft. Scott also shows an anticlinal feature (Figure 14). Like the Lansing-Kansas City there, is very little production data for the Ft. Scott in this area so it isn't apparent if Ft. Scott production is structurally controlled or if it is controlled by some other factor. Figure 14 illustrates that the productive wells for the field are typically incorporated with positive structure in the Ft. Scott.

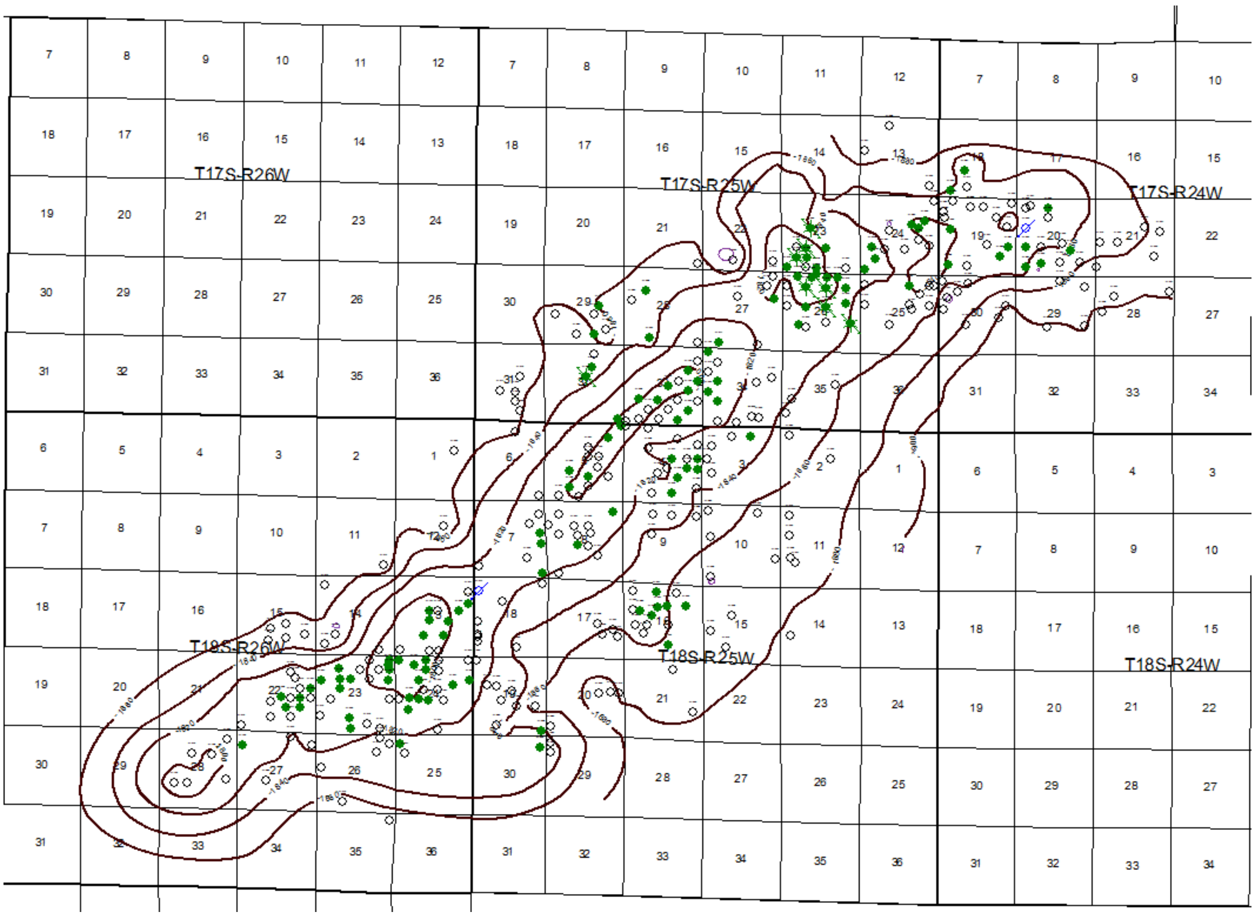


Figure 14: Structure map of the top of the Ft. Scott Limestone

Mississippian Structure

The Mississippian structure confirms the anticlinal feature as shown in Figure 15. This structure map shows that the Mississippian structure is very influential in the oil production for this area because almost all production in this area comes from the Mississippian

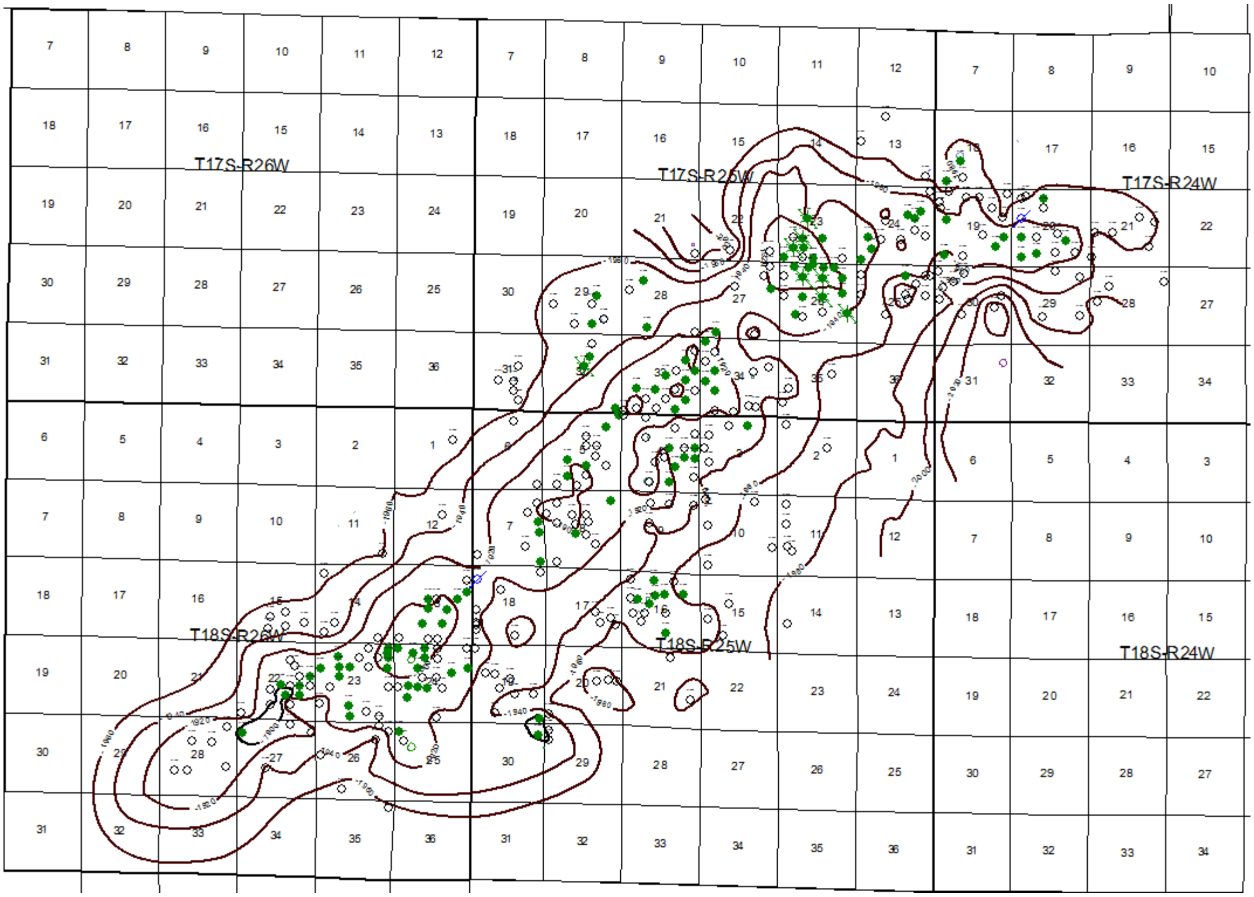


Figure 15: Mississippian structure, with the green dots representing productive oil wells that are influenced by the Mississippian structure

Comparison of Structure Maps

To accurately assess the concentric nature of the anticlinal structure comparisons between the structure of the three formations mapped an isopach map from the top of the Lansing to the top of the Mississippian was made. This map shows that there is not over thirty feet of difference across the study area in the thickness of this interval (Figure 16). This map shows that the formations are folding with each other.

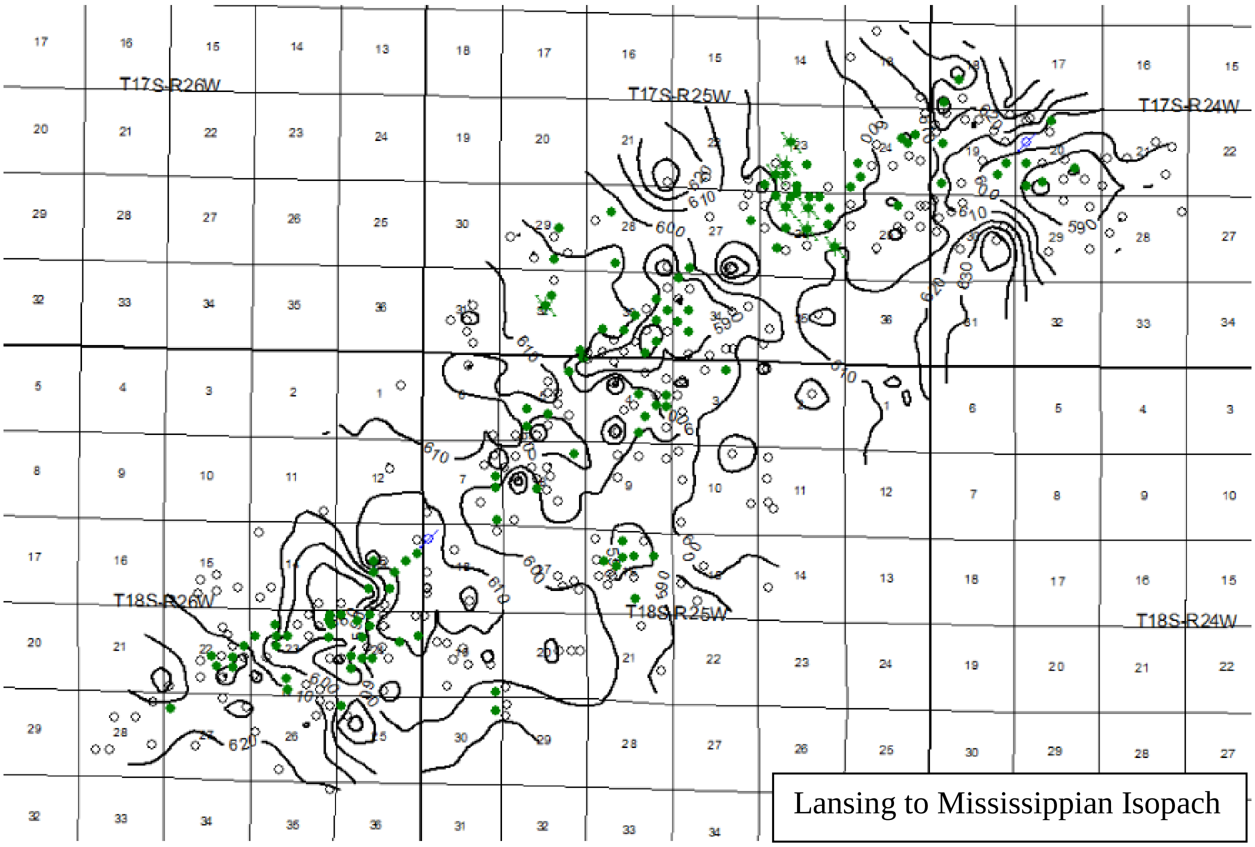


Figure 16: Lansing to Mississippian isopach map, very little difference in thicknesses across the study

Cross-Section Analysis

Cross-sections across the anticlinal feature were constructed from petro-physical logs. These were composed to show any concentric folding as well as to show the anticlinal feature from one side of the structure to the other. Three cross-sections were composed across the study area in different parts of the structure (Figure 17) and one cross-section that goes through all of the Sub-Mississippian wells (Figure 21). Figure 18 shows cross-section (A-A') going through the southern end of the structure and shows the best example of concentric folding and overall anticlinal structure. Figure 19 shows cross-section B-B', that goes across the middle part of the structure, and cross-section C-C' (Figure 20) shows the northern end of the structure.

To prepare these cross-sections the well-logs for each well were analyzed and five different formation tops were picked for the wells that didn't penetrate below the Mississippi, 7 formation tops were picked for the Sub-Mississippian wells. The following formations were picked for the shallow wells: Heebner Shale, Lansing-Kansas City, Ft. Scott Limestone, Cherokee Shale, and the Mississippian. The sub-Mississippian wells included the same picks as the shallow wells with the addition of a Viola and Arbuckle pick.

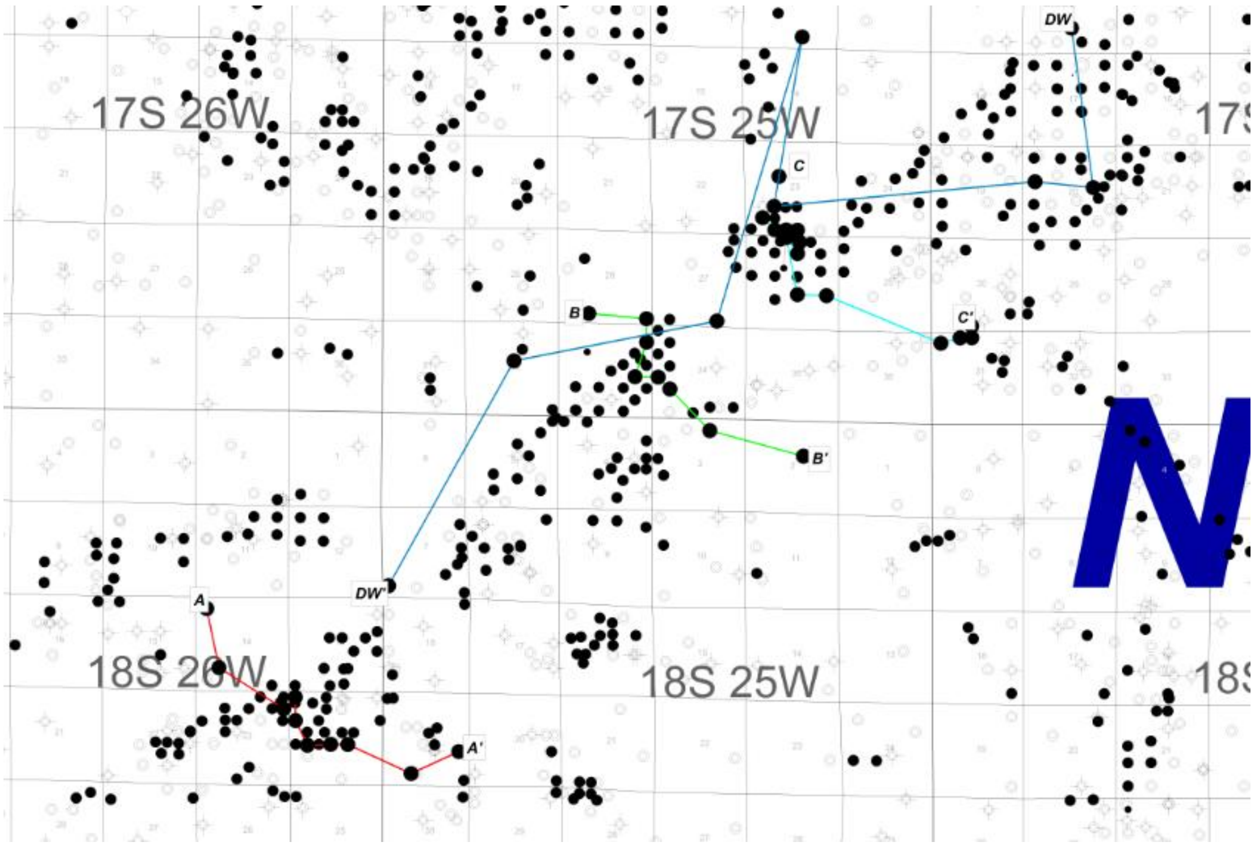


Figure 17: Showing where all the cross-sections are located in the study area

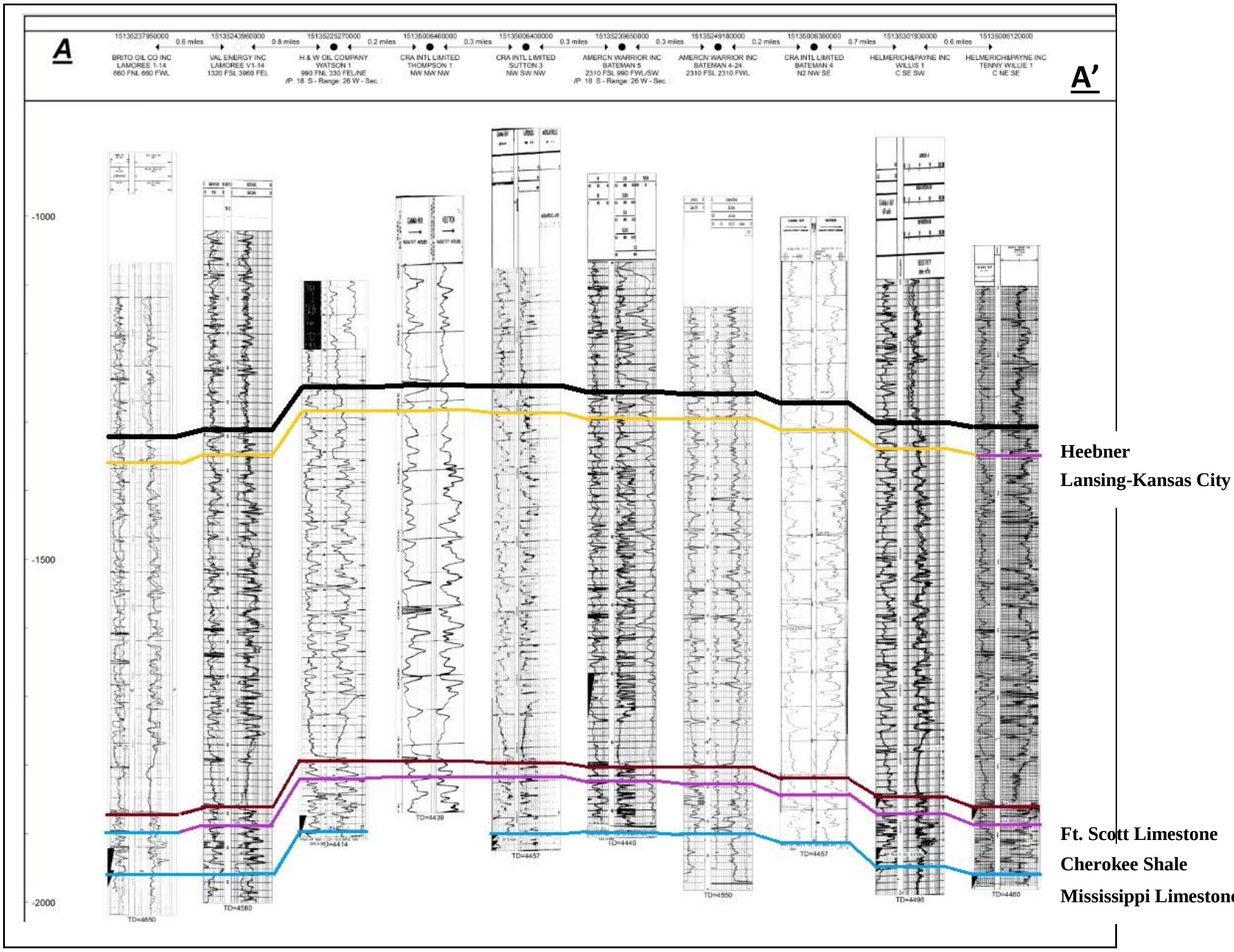


Figure 18: Cross-section A-A’ that goes across the southern end of the structure

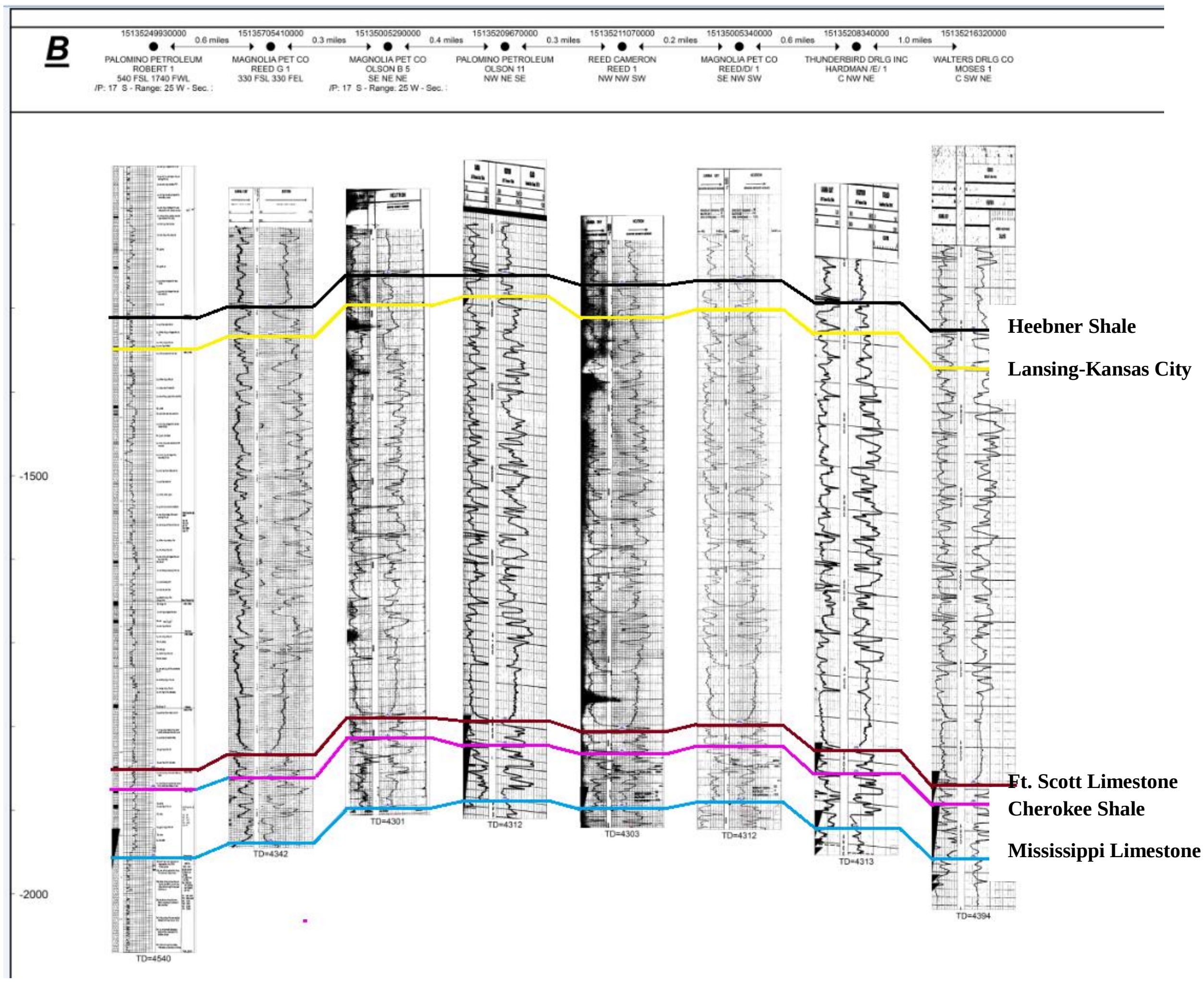


Figure 19: Cross-section B-B', that crosses the middle section of the structure

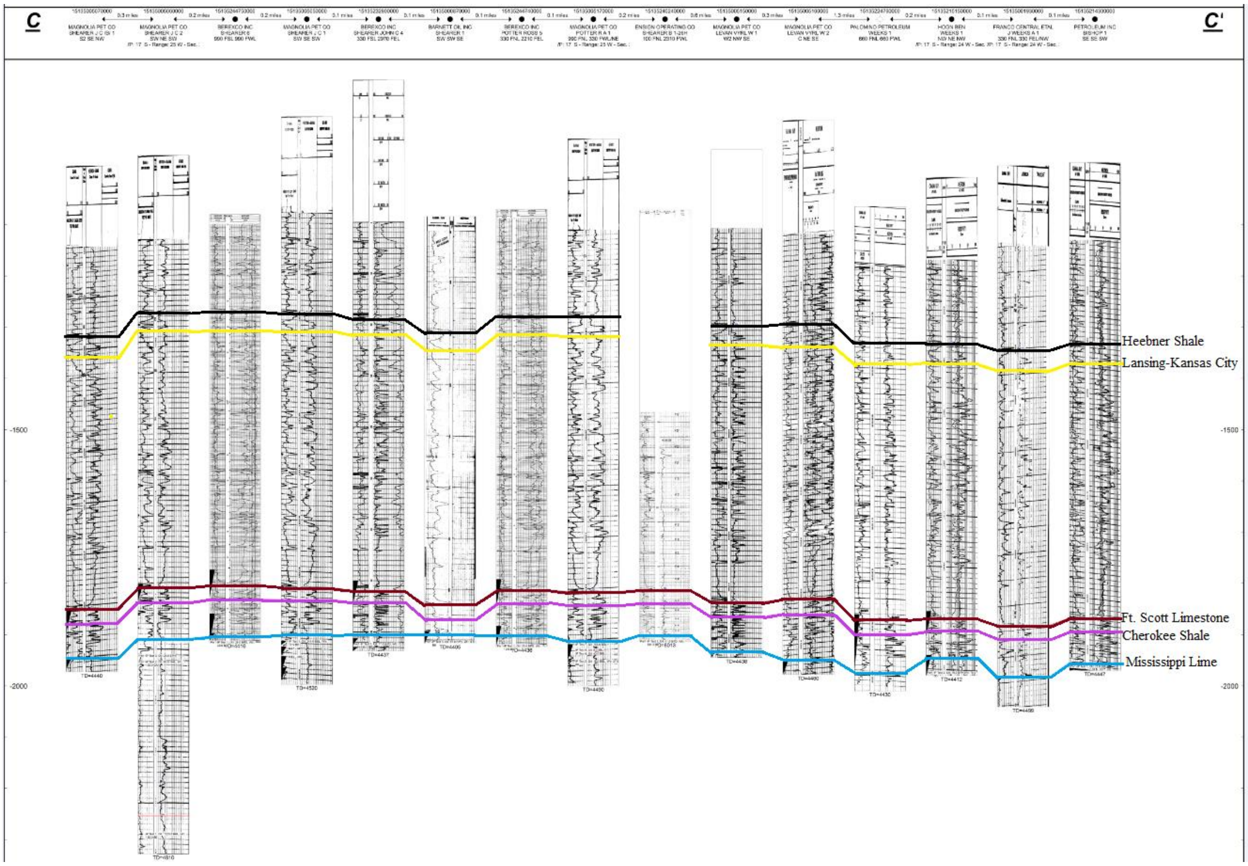


Figure 20: Cross-section C-C' that crosses the northern end of the structure

As well as the cross sections that were made to show the structural components of the shallower formations a cross-section of the sub-Mississippian wells was constructed to assess what the structural control looked like for the Sub-Mississippian formations (Figure 21). There is one well (John C. Shearer #2) that runs on the top of the structure that was a very productive well in the Mississippi (1200BOPD) but in the samples acquired from the KGS the top 40 feet of Arbuckle samples were missing (Figure 21). There are two other wells through the cross-sections and structure maps that are slightly on structure (Figure 22), compared to the other 3 wells that are situated on the flanks of the anticline.

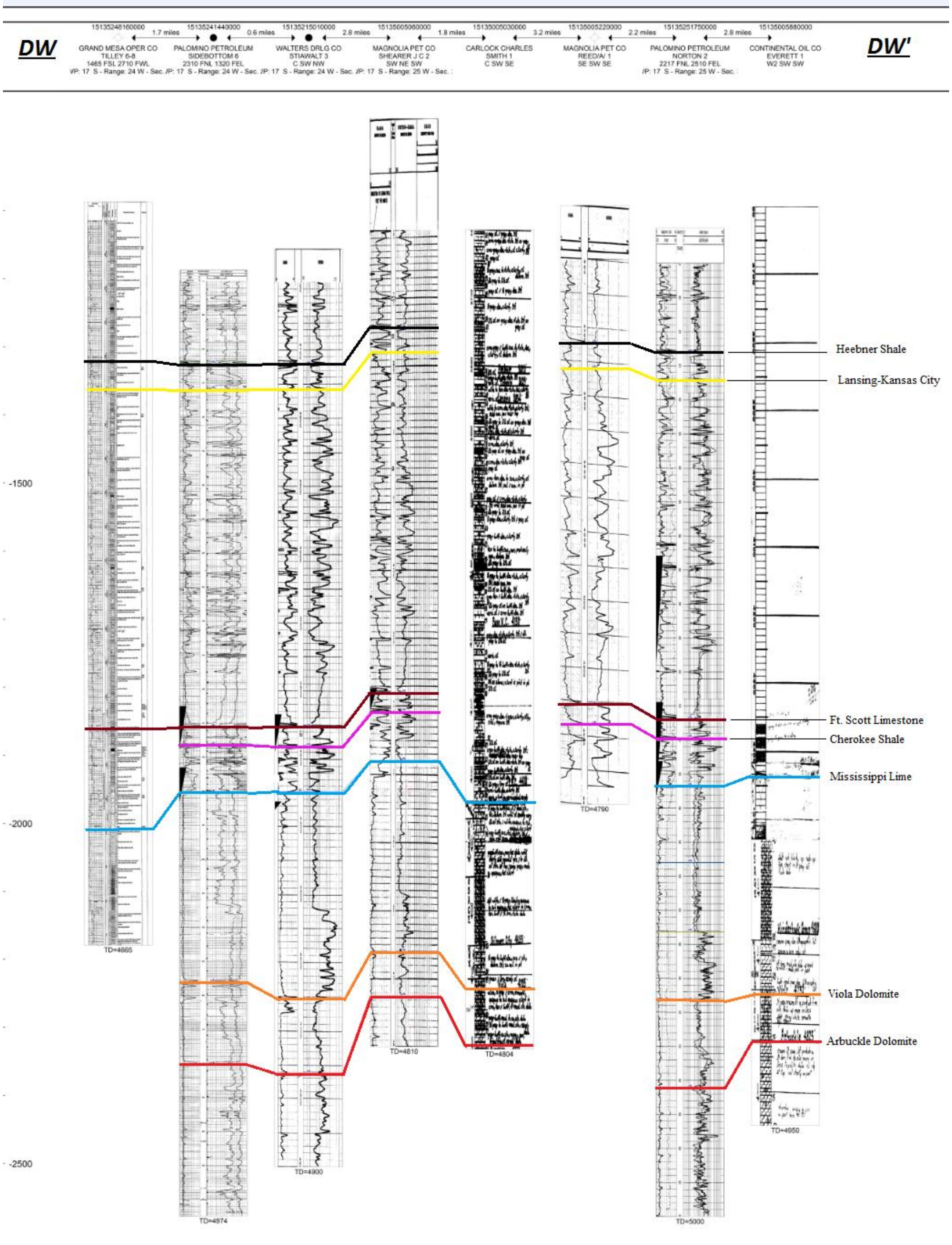


Figure 21: Deep well cross-section (DW-DW'), all five of our sub-Mississippian wells are included on the cross-section as well as showing that the John C. Shearer #2 runs 10-20 feet higher on structure than the other Sub-Mississippian wells

Sub-Mississippian Structure Analysis:

With the structure maps that were constructed, the next step was to analyze where the sub-Mississippian wells were located in relation to the anticlinal structure (Figure 22). Looking at Figure 22 the only sub-Mississippian well that is in the study area that is situated on a good structural high in the Mississippian is the John C. Shearer #2. The Stiawalt #3 is also situated in relatively good structure in the Mississippian, which if concentric folding continues in the deeper horizons, the John C. Shearer #2 and the Stiawalt #3 should have the best potential of containing any traces of oil from deeper horizons present in the cuttings analysis.

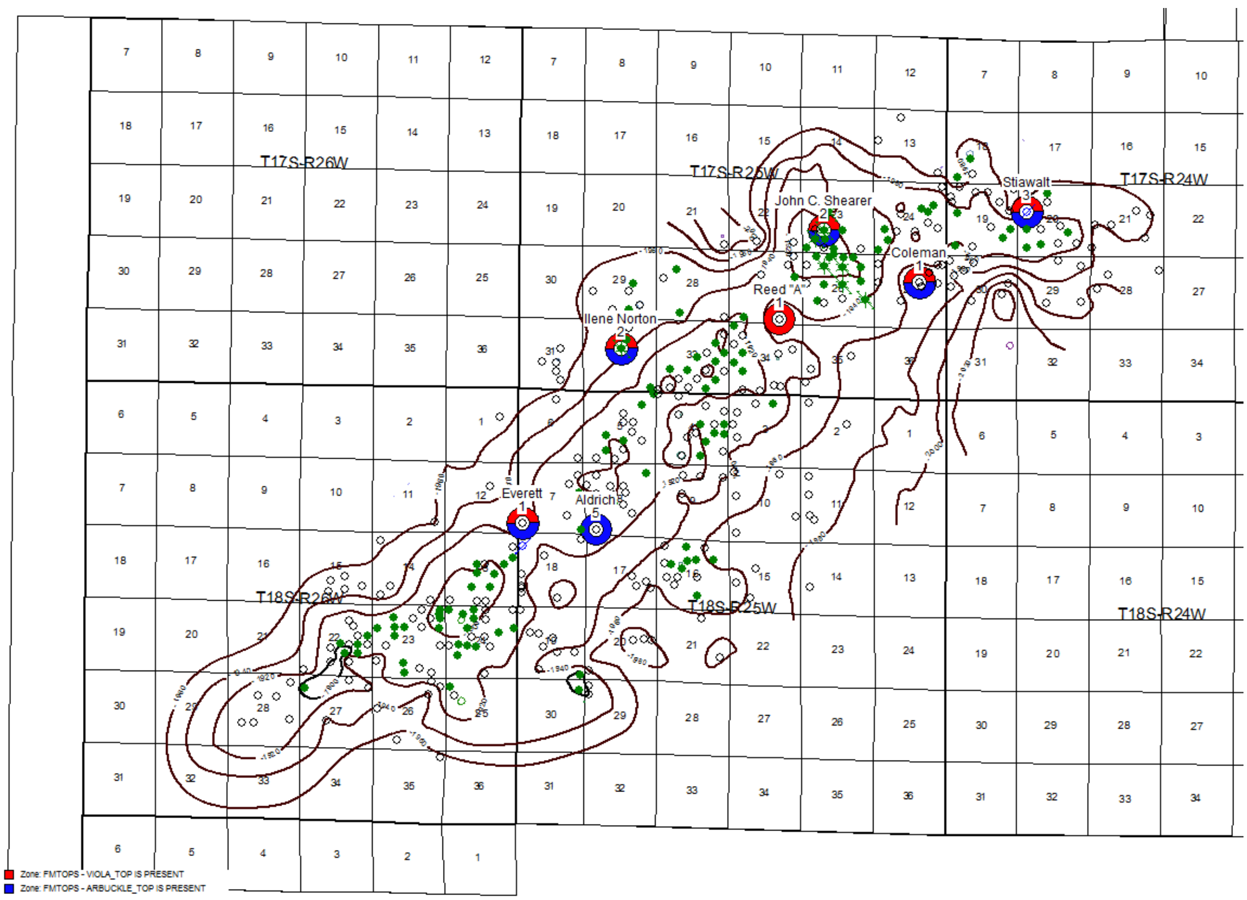


Figure 22: Sub-Mississippian wells in relation to our Mississippian structure contours, the blue on the color wheel represent wells that have Arbuckle present and the red represents wells that have Viola present the Reed "A" #1 was only drilled to the Viola. The John C. Shearer #2 and Stiawalt #3 are the only Sub-Mississippian wells that are on the structural high

Chapter 4 - Cuttings Analyses Results

Binocular Microscope Cuttings Analyses

The following figures are the results that were obtained from the analyses of the sub-Mississippian cuttings using a binocular microscope. The purpose of these analyses was to assess the sub-Mississippian cuttings for porosity and permeability characteristics of the cuttings as well as any oil satins or pyrite present. In the following charts the formation is identified as well as the depth the samples were viewed from, a sample description and a column to indicate whether samples were held from that interval for further analyses

Reed "A" #1
15-135-00522

Formation	Depth	Rock Description	Samples Taken
MISSISSIPPI	4500-4505	Dol: tan-gry., pyrite., gd vug pors	
	4505-4510	Dol: tan-gry., pyrite., gd vug pors	
	4510-4515	Dol: tan-gry., gd vug pors	
	4515-4520	Dol: tan-gry., gd vug pors	
	4520-4525	Dol: tan-gry., gd vug pors	
	4525-4530	Dol: tan-gry., pyrite., gd vug pors	
	4530-4535		
	4535-4540	Dol: tan-gry., pyrite., gd vug pors/ Sh: gry-blk	
	4540-4545	Sh: AA/ Dol: AA	
	4545-4550	Dol: tan-gry., xln pors/ Sh: AA	
	4550-4555	Dol: tan-gry., sctrd vug pors	
	4555-4560	Dol: wht-tan., sctrd vug pors	
	4560-4565	Dol: wht-tan., sctrd vug pors/ Cht: wht., xln	Yes
	4565-4570	Dol: AA/ Cht: AA	
	4570-4575	Cht: wht., xln/ Sh: blk	
	4575-4580	Cht: AA/ Dol: tan-brn., sctrd pors	Yes
	4580-4585	Sh: gry-blk/ Cht: wht. Xln	
	4585-4590	Cht: AA/ Sh: AA	
	4590-4595	Sh: AA/ Dol: wht-tan., poor xln pors	
	4595-4600	dol: wht-tan., vug pors/ Sst: lithic., red., sub ang	
	4600-4605	Dol: wht-tan., vug pors/ Sh: gry-blk	
	4605-4610	Sh: gry-blk/ Dol: AA	
	4610-4615	Dol: wht-tan., poor xln pors	
	4615-4620	Cht: wht., xln., ang	
	4620-4625	Cht: AA/ Dol: tan-gry., vug pors	Yes
	4625-4630	Dol: tan-gry., vug pors	
	4630-4635	Sh: gry-blk/ Dol: AA	Yes
	4635-4640	Dol: tan-brn., gd vug pors	Possible
	4640-4645	Cht: wht., xln	
	4645-4650	Cht: AA/ Dol: wht-tan., sctrd xln pors	
	4650-4655	Cht: AA/ Dol: AA	
	4655-4660	Cht: AA	
	4660-4665	Cht: AA/ dol: wht-tan., poor xln pors	
	4665-4670	Dol:wht-tan., poor xln pors/ Cht: AA	
	4670-4675	Dol: wht-tan., sctrd vug pors	
	4675-4680	Dol: wht-tan., sctrd vug pors	Possible
	4680-4685	Dol: wht-tan., sctrd vug pors	
	4685-4690	Dol: wht-tan., sctrd vug pors	
	4690-4695	Dol: wht-tan., sctrd vug pors	
	4695-4700	Dol: wht-tan., sctrd vug pors	
	4700-4705	Dol: tan., xln., poor vug pors	
	4705-4710	Dol: tan., xln., poor vug pors	
	4710-4715	Dol: tan., xln., poor vug pors	
	4715-4720	Dol: tan., xln., poor vug pors	
	4720-4725	Dol: tan., xln., fair vug pors	
	4725-4730	Dol: tan., xln., gd vug pors	

Reed "A" #1			
15-135-00522			
	4730-4735	Dol: tan., xln., gd vug pors	Possible
	4735-4740	Dol: tan., xln., gd vug pors	
	4740-4745	Dol: gry., xln., gd vug pors	
	4745-4750	Dol: gry., xln., gd vug pors	
	4750-4755	Dol: gry., xln., gd vug pors	
	4755-4760	Dol: tan-gry., fair vug pors	
	4760-4765	Dol: AA/ Sh: blk	
	4765-4770	Dol: AA	
	4770-4775	Sh: Blk/ Dol: tan-gry., gd vug pors	
VIOLA	4775-4780	Dol: tan-gry., gd vug pors	Yes
	4780-4785	Dol: tan-gry., xln., sctrd vug pors	Possible
	4785-4790	Dol: tan-gry., xln., xln+vug pors	Possible
	4790-4792	Dol: tan-gry., xln., fair pors	

Figure 23: Well cutting descriptions for the Reed "A" #1

Reed "A" #1

For the Reed "A" #1 well, located in Section 27 Township 17S Range 25W, certain depths looked prospective for reservoir properties. The lower Mississippian formations for this well showed good porosity from depths: 4620-4625, 4670-4700, 4725-4755. The interval 4620-4625 was described as white chert and tan/gray dolomite with vuggy porosity. For the depth 4670-4700 the samples were identified as dolomite that was a white/tan color and had scattered vuggy porosity throughout this section (Figure 23). For the depth 4725-4755 the samples were identified as grey crystalline dolomite that had good vuggy porosity throughout (Figure 23). The next unit that stood out in this well from the Lower Mississippi was the shale unit from the depth of 4760-4765 (Figure 23). This Shale was identified as black shale that could possibly act as a sealing layer for the Viola, located in the next 5ft sample below (Figure 23). The Viola group for this well had prospective samples in the depths of 4775-4780 and 4780-4790. The samples from 4775-4780 were described as tan/gray dolomite with good vuggy porosity throughout. The samples from 4780-4790 are crystalline dolomite tan/gray in color with scattered vuggy and crystalline porosity (Figure 23).

Everett #1
15-135-00588

Formation	Depth	Rock Description	Samples Taken
Cherokee	4432-4434	Sh: gry-blk	
	4434cir	Sh: gry-blk	
Mississippi	4434-4439	Dol: gry., vry poor pors., no stain	
	4439-4444	Dol: gry., fair-gd vug pors., no stain	
	4444-4449	Dol: gry., gd vug pors., no stain	
	4449-4454	Dol: gry., vry gd pors., no stain	
	4454-4459	Dol: gry., fair vug pors	
	4459-4464	Dol: gry., fair vug pors	
	4464-4469	Dol: gry., xln., poor pors	
	4469-4474	dol: gry., gd vug pors	
	GAP		
	4481-4486	Dol: tan., gd vug pors	
	4486-4491	Dol: tan., big vugs., vry gd pors	
	4491-4496	Dol: tan., gd vug pors	
	4496-4501	Dol: tan., vry gd vug pors	
	GAP		
	4504-4510	dol: wht-tan., gd vug pors	
	4510-4515	Dol: wht-tan., fair vug pors	
	4515-4520	Dol: tan-gry., good vug pors	Possible
	4520-4525	Dol: tan-gry., good vug pors	Possible
	4525-4530	Dol: tan-gry., good vug pors	Possible
	4530-4535	Dol: tan-gry., good vug pors	Possible
	4535-4540	Dol: tan-gry., good vug pors	
	4540-4545	Dol: tan-gry., fair vug pors	
	4545-4550	Dol: tan-gry., fair vug pors	
	4550-4555	Dol: tan-gry., good vug pors	
	4555-4560	Dol: tan-gry., good vug pors	
	4560-4565	Dol: tan-gry., fair vug pors	
	4565-4570	Dol: tan-gry., fair vug pors	
	4570-4575	Dol: AA/ Cht: wht., xln	
	4575-4580	Dol: wht-tan., good vug pors/ Sh: Gry-blk	
	4580-4585	Dol: AA/ Sh: AA	
	4585-4590	Sh: AA/ Dol: gry-tan., gd vug pors	
	4590-4595	Sh: AA/ Dol: gry-tan., gd vug pors	
	4595-4600	Dol: gry-tan., gd vug pors	
	4600-4605	Dol: gry-tan., gd vug pors	
	4605-4610	Dol: tan-gry., gd vug pors/ Sh: gry-blk	
	4610-4615	Sh: gry-blk/ Cht: wht., xln., ang	
	4615-4620	Cht: AA	
	4620-4625	Cht: AA	
	4625-4630	Sh: gry-blk	
	4630-4635	Sh: gry-blk/ Qtz: lrg rd grains	
	4635-4640	Sh: AA/ Qtz: AA	
	4640-4645	Qtz: Lrg sub-ang grains/ Sst: Lith., gry-brn	
	4645-4650	Cht: wht., xln., ang.,/ Dol: gry-tan., sctrd vug pors	
VIOLA	4650-4655	Dol: gry-tan., sctrd vug pors	Yes

Everett #1
15-135-00588

	4655-4660	Sh: gry-blk/ Cht: wht., xln., ang	Yes
	4660-4665	Dol: wht-gry., gd vug pors	Yes
	4665-4670	Dol: AA/ Cht: wht., xln	Yes
	4670-4675	Dol: AA/ Cht: AA/ Congl	
	4675-4680	Dol: AA., poss oil stain/ Cht: AA	
	4680-4685	Dol: AA	
	4685-4690	Cht: wht., xln., ang	
	4690-4695	Dol: tan-brn., vug pors	Yes
	4695-4700	Dol: gry-brn., poor xln pors	
	4700-4705	Dol: tan-brn., xln pors	
	4705-4710	Dol: AA	
	4710-4715	Dol: tan-gry., xln & vug pors	
	4715-4716	Dol: tan-gry., vug pors., no stain	Yes
	GAP		
	4721-4725	Dol: tan., xln pors	
	4725-4730	Dol: tan., xln pors	
	4730-4735	Dol: tan., xln pors	
	4735-4740	MISSING	
	4740-4745	Dol: tan-gry, vug pors	Yes
	4745-4750	Dol: tan-gry, vug pors	
	4750-4752	Dol: tan-gry., gd vug pors	Yes
	4752-4760	Dol: tan-gry., gd vug pors	
	4760-4765	Cht: wht., ang., xln/ Dol: AA	
	4765-4770	Cht: AA/ Sh: gry-blk	
	4770-4775	Dol: tan-gry., fair xln pors/ Cht: AA	
	4775-4780	Dol: AA/ Cht: AA	
	4780-4785	Dol: tan-gry., fair sctrd xln pors	
	4785-4790	Dol: tan-gry., fair sctrd xln pors	
	4790-4795	Dol: tan-gry., fair sctrd xln pors	
	4795-4800	Dol: tan-gry., poor xln pors	
	4800-4805	Dol: tan-gry., poor xln pors	
	4805-4810	Dol: tan-gry., poor xln pors	
	4810-4815	Dol: AA/ Cht: wht., ang., xln	
	4815-4820	Dol: AA/ Sh: gry-blk	
	4820-4825	Sh: gry-blk	
ARBUCKLE	4825-4830	Dol: tan-gry., sctrd gd pors	
	4825-4830	Dol: tan-gry., sctrd gd pors	
	4830-4835	Dol: tan-gry., sctrd vug pors	Yes
	4835-4840	Dol: tan-gry., poor pors	Yes
	4840-4845	Dol: tan-gry., vug pors	
	4845-4850	Dol: tan-gry., xln., poor pors	
	4850-4855	Dol: tan-gry., xln., poor pors	
	4855-4860	Dol: tan-gry., xln., poor pors	
	4860-4865	Dol: tan-gry., xln., poor pors	
	4865-4870	Dol: tan-gry., xln., poor pors	
	4870-4875	Dol: tan-gry., fait xln pors	
	4875-4880	Dol: tan-gry., sctrd pors	

Everett #1
15-135-00588

4880-4885	Dol: tan-gry., sctrd pors
4885-4890	Dol: tan-gry., sctrd pors
4890-4895	Dol: tan-gry., sctrd pors
4895-4900	Dol: tan-gry., sctrd vug pors
4900-4905	Dol: tan-gry., sctrd vug pors
4905-4910	Dol: tan-gry., sctrd vug pors
4910-4915	Dol: tan-gry., sctrd vug pors
4915-4920	Dol: tan-gry., sctrd vug pors
4920-4925	Dol: tan-gry., sctrd vug pors
4925-4930	Dol: tan-gry., poor pors
4930-4935	Dol: tan-gry., gd xln pors
4935-4940	Dol: tan-gry., gd xln pors
4940-4950	Dol: tan-gry., poor xln pors

Figure 24: Well cutting descriptions for the Everett#1

Everett #1

The Everett #1 well, in Section 7 Township 18S Range 25W, has good reservoir qualities in the Lower Mississippian from the depths: 4515-4540 and 4550-4560. From the depths 4625-4635 a possible sealing shale unit was found for the Viola (Figure 24). From 4515-4540 the samples were described as tan/gray dolomite that had good vuggy porosity throughout (Figure 24). From 4550-4560 the samples were also described as tan/gray dolomite that had good porosity throughout (Figure 24). The shale that is present in the Lower Mississippi was found to be present from 4625-4640 and was described as a gray to black shale that could possibly have sealing qualities. For the Sub-Mississippian formations in the Everett #1 there were good reservoir properties found from the depths 4650-4655, 4660-4670, 4825-4830, and 4830-4835. The sample from 4650-4655 (VIOLA) was described as a gray/tan dolomite with scattered vuggy porosity. Samples from 4660-4670 (VIOLA) were described as a white/gray dolomite with good vuggy porosity throughout (Figure 24), there is also an SEM picture of a sample taken between 4665-4670 (Figure 28). One sample from this section (4660-4670) was also chemically analyzed in the SEM. The sample section 4825-4830 represents the top sample taken from the Arbuckle and is described as a tan/gray dolomite with good scattered crystalline porosity. Samples from 4830-4835 were also described as a tan/gray dolomite but with scattered vuggy porosity. The rest of the Arbuckle beyond 4835 did not show as good of porosity as the other samples. There was one shale unit from 4820-4825 that separated the Viola and Arbuckle that could possibly be a sealing layer; it was described as black shale (Figure 24).

John C. Shearer #2
15-135-19054-0001

Formation	Depth	Rock Description	Samples Taken
Mississippi	4375-4380	Dol: tan-gry., no pors	
	4380-4385	Dol: wht-brn., no pors	
	4385-4390	Dol: tan-brn., no pors	
	4390-4395	Dol: tan-brn., some sctrd pors	
	4395-4398	Dol: tan-gry., fair vug pors	
	4398-4405	Dol: tan-gry., good sctrd pors	
	4405-4410	Dol: Tan-gry., gd pors	
	4410-4415	Dol: tan-brn., gd pors	
	4415-4420	Dol: tan-brn., vry gd pors	
	4420-4425	Dol: tan-gry., gd pors	
	4425-4430	Dol: wht-tan., vry gd pors	
	4430-4435	Dol: wht-tan., vry gd pors	
	4435-4440	Dol: wht-tan., fair-gd pors	
	4440-4445	Dol: tan-brn., fair pors	
	4445-4450	Dol: gry brn., fair pors	
	4450-4455	Dol: tan-brn., fair pors	
	4455-4460	Dol: tan-brn., some sctrd pors	
	4460-4465	Dol: tan-brn., some sctrd pors	
	4465-4470	Dol: tan-gry., fair pors	
	4470-4475	Dol: tan-brn., fair pors	
	4475-4480	Dol: tan-brn	
	4480-4485	Dol: tan-gry., vry sctrd pors	
	4485-4490	Dol: tan-gry., no pors/ Cht: wht., xln	
	4490-4495	Dol: tan-gry., no pors/ Cht: wht., xln	
	4495-4500	Dol: wht-gry., no pors/ Cht: wht., xln	
	4500-4505	Dol: wht-gry., no pors/ Cht: wht., xln	
	4505-4510	Dol: wht-brn., sctrd vug pors	
	4510-4515	Dol: wht-brn., sctrd pors	
	4515-4520	Dol: wht-brn., sctrd vug pors/ Cht: wht., xln	
	4520-4525	Dol: wht-brn., sctrd vug pors/ Cht: wht., xln	
	4525-4530	Dol: wht-brn., vug pors	
	4530-4535	Dol: wht-brn., no pors	
	4535-4540	Dol: wht-brn/ Cht: wht	
	4540-4545	Dol: wht-brn/ Cht: wht	
	4545-4550	Dol: wht-brn/ Cht: wht/ Possible Breccia	Yes
	4550-4555	Dol: wht-brn/ Cht: wht	
	4555-4560	Cht: wht., angular/ Dol: wht-brn	
	4560-4565	Dol: tan-brn., poor sctrd pors/ Cht: wht	Yes
	4565-4570	Dol: wht-brn/ Cht: wht	
	4570-4575	Dol: wht-brn., no pors	
	4575-4580	Sh: gry-blk	
	4580-4585	Dol: tan-brn., vug pors/ Sh: AA	
	4585-4590	Dol: gry-brn/ Cht: wht	
	4590-4595	Dol: gry-brn., vug pors/ Cht: wht	
	4595-4600	Dol: gry-brn., vug pors/ Cht: wht	
	4600-4605	Dol: wht-gry., xln	

John C. Shearer #2
15-135-19054-0001

	4605-4610	Dol: wht., xln., no pors	
	4610-4615	Dol: wht-gry., no pors	Yes
	4615-4620	Dol: wht-gry., no pors	
	4620-4625	Sh: gry/ Dol: wht-gry., xln	
	4625-4630	Sh: gry/ Dol: wht-gry., xln	
	4630-4635	Dol: wht-gry/ Sh: gry	
	4635-4640	Dol: wht., lrg xl's., sctrd pors	
	4640-4645	Dol: wht., no pors	
	4645-4650	Dol: wht., fair pors	
	4650-4655	Dol: wht-gry., vug pors	Yes
Viola	4655-4660	Dol: wht-gry., sctrd vug pors	Yes
	4660-4665	Dol: wht-gry., good vug pors	Yes
	4665-4670	Dol: wht-gry., large vug pors	Yes
	4670-4675	Dol: wht-gry., poor pors	
	4675-4680	Dol: wht-gry., fair pors	Yes
	GAP		
Arbuckle	4755-4760	Dol: wht-tan., sctrd vug pors	
	4760-4765	Dol: wht-tan., good pors	Yes
	4765-4770	Dol: wht-tan., good pors	Yes
	4770-4775	Dol: wht-tan., xln angular., vry gd poors	Yes
	4775-4780	Dol: wht-tan., xln angular., vry gd poors	
	4780-4785	Dol: wht-tan., xln angular., vry gd poors	
	4785-4790	Dol: wht-tan., vry gd pors	
	4790-4795	Dol: wht-tan., vry gd pors	
	4795-4800	Dol: wht-tan., fair pors	
	4800-4805	Dol: wht-tan., fair pors	
	4805-4810	Dol: wht-tan., fair pors	

Figure 25: Well cutting descriptions for the John C. Shearer #1, notice that there is a gap in the samples from 4680-4755 (which excludes the top 40ft of the Arbuckle)

John C. Shearer #2

For the John C. Shearer #2 well, located in section 23 Township 17S Range 25W, the Lower Mississippian units didn't have as much positive reservoir quality as the other Sub-Mississippian wells in the study area. There was however a shale unit in the Lower Mississippian that could possibly be a sealing unit for the underlying Viola formation, the samples from 4620-4630 (Lower Mississippian) contained mainly gray/black shale (Figure 25). In the Viola formation samples had good reservoir characteristics present in the depth ranges of 4655-4660 and 4660-4670. The samples from 4655-4660 were described as white/gray dolomite with scattered vuggy porosity. The samples from 4660-4670 were described as white/gray dolomite with good, large vuggy porosity throughout the samples (Figure 25). Arbuckle samples were analyzed and these depths had good reservoir properties: 4755-4760, 4760-4770, and 4770-4795. Samples from 4755-4760 were described as white/tan dolomite with scattered vuggy porosity. Samples from 4760-4770 were found to be a white/tan crystalline dolomite with good porosity throughout. And the deepest samples analyzed from this well with good reservoir properties were from 4770-4795, and were described as a white/tan crystalline dolomite with very good porosity (Figure 26). There was no shale unit found between the Viola and the Arbuckle on this well using this method but if there was a shale present there it's likely not shown in the samples because the sample box for this well is missing any samples from 4680-4755. According to the Kansas Geological Survey's database the Arbuckle top for this well is 4726 and the first Arbuckle sample present is at 4755, therefore the top 29 feet of Arbuckle samples from this well are missing.

Stiawalt #3
15-135-21501

Formation	**Depth**	**Rock Description**	**Samples Taken**
Mississippi	4375	Dol: brn-tan., gd pors., poss oil stain	
	4375-4380	Dol: tan., poor vug pors., no stain	
	4380-4390	dol: tan-gry., fair vug pors., poss poor stain	
	4390-4400	Dol: tan-gry., poor vug pors., no stain	
	4400-4410	Dol: tan-gry., poor vug pors., no stain	
	4410-4420	Dol: tan-gry., fair vug pors	
	4420-4430	Dol: tan-gry., fair-gd pors., poss poor stain	
	4430-4440	Dol: tan-gry., poor vug pors., no stain	
	4440-4450	Dol: tan-gry., sctrd qtz., poor vug pors.	
	4450-4460	Cht: wht., xln., ang./ sctrd Dol	
	4460-4470	Cht: wht., xln., ang./ sctrd Dol	
	4470-4480	Cht: wht., xln., ang./ sctrd Dol	
	4480-4490	Cht: AA/ Dol: tan-gry., poor vug pors.	
	4490-4500	Cht: AA/ Dol: tan-gry., poor vug pors.	
	4500-4510	Cht: AA/ Dol: tan-gry., no pors	
	4510-4520	Cht: AA/ Dol: tan-gry., no pors	
	4520-4530	Cht: AA/ Dol: brn., no pors	
	4530-4540	Dol: tan-wht/ Cht: wht., xln	
	4540-4550	Dol: tan-wht/ Cht: wht., xln	
	4550-4560	Dol: tan-wht/ Cht: wht., xln	
	4560-4570	Dol: tan-wht/ Cht: wht., xln	
	4570-4580	Dol: tan-wht/ Cht: wht., xln	
	4580-4590	Dol: tan-wht/ Cht: wht., xln	
	4590-4600	Dol: tan-wht., fuscilinids/ Cht: AA	
	4600-4610	Dol: tan-wht., no pors	
	4610-4620	Dol: tan-wht., no pors	
	4620-4630	Dol: tan-wht., no pors	
	4630-4640	Dol: wht-gry., vry poor pors.	
	4640-4650	Dol: wht-gry., Sh: gry-blk	
VIOLA	4650-4660	Dol: wht-gry., Sh: gry-blk	
	4660-4670	Dol: tan-gry., sctrd vug pors	
	4670-4680	Dol: tan-gry., sctrd vug pors	
	4680-4690	Dol: tan-gry., sctrd vug pors/ Cht: wht., xln	
	4690-4700	Dol: tan-gry., no pors/ Cht: wht., xln	
	4700-4710	Dol: tan-gry., no pors	
	4710-4720	Dol: tan-gry., no pors	
	4720-4730	Dol: tan-gry., no pors/ Cht: wht., xln	
	4730-4740	Dol: tan-gry., no pors/ Cht: wht., xln	
	4740-4750	Dol: tan-gry., no pors/ Cht: wht., xln	
	4750-4760	Dol: tan-gry., no pors/ Cht: wht., xln	
Arbuckle	4760-4770	Dol: gry-brn., vug pors	Yes
	4770-4780	Dol: gry-brn., poor vug pors	
	4780-4790	Dol: gry-brn., vug pors	Yes
	4790-4800	Dol: gry-brn., poor sctrd pors	
	4800-4810	Dol: gry-brn., no pors/ Cht: wht., xln	
	4810-4820	Dol: gry-brn., poor vug pors	Yes

Stiawalt #3
15-135-21501

	4820-4830	Dol: gry-brn., no pors	
	4830-4840	Dol: gry-brn., no pors	
	4840-4850	Dol: tan-brn., some sctrd pors	
	4850-4860	Dol: tan-brn., no pors	
	4860-4870	Dol: tan-brn., no pors	
	4870-4880	Dol: tan-brn., gd vug pors	Yes
	4880-4890	Dol: tan-brn., gd vug pors	
	4890-4900	Dol: tan-brn., gd vug pors	

Figure 26: Well cutting descriptions for the Stiawalt #3

Stiawalt #3

The Stiawalt #3, located in Section 20, Township 17S and Range 24W, like the John C. Shearer #2 the Lower Mississippian cuttings did not have as good of reservoir characteristics as the Everett #1 and the Reed "A" #1. We did however find like all the other wells that there is a shale unit that separates the Lower Mississippian form the Viola. From the depths of 4640-4660 there is gray/black shale present separating the two units and creating a possible sealing layer for the Viola below. The Viola in this well had good reservoir properties present from the depths 4660-4680 (Figure 26). From 4660-4680 the cuttings were described as tan/gray dolomite with scattered vuggy porosity through the samples (Figure 26). The viola that was deeper than 4680 began to lose the good porosity seen in the upper part. The depths that we found good reservoir in the Arbuckle cuttings were: 4760-4770 and 4780-4790. The cuttings from 4760-4770 were found to be a gray/brown dolomite with vuggy porosity throughout the samples (Figure 26). The cuttings from 4780-4790 were also a gray/brown dolomite with vuggy porosity throughout (Figure 26). This well is the second best structurally situated Sub-Mississippian well in the study area (Figure 22).

Ilene Norton #2
15-135-25175

Formation	Depth	Rock Description	Samples Taken
Cherokee	4350-4360	Sh: gry-blk	
Mississippi	4360-4370	Dol: wht-gry., no pors/ Sh: gry-blk	
	4370-4380	Dol: tan-brn., sctrd poor pors	
	4380-4390	Dol: tan-gry., no pors., no stain	
	4390-4400	Dol: tan-gry., gd vug pors., no stain	
	4400-4410	Dol: tan-gry., gd vug pors., no stain	
	4410-4420	Dol: tan-gry., gd vug pors., possible stains	
	4420-4430	Dol: tan-gry., vry gd vug pors., no stain	Yes
	4430-4440	Dol: tan-gry., vry gd vug pors., possible stains	
	4440-4450	Dol: tan-gry., vry gd vug pors., odd scndry mins	Yes
	4450-4460	Dol: tan-gry., vry gd vug pors., no stain	
	4460-4470	Dol: tan-gry., gd vug pors., no stain	
	4470-4480	Dol: tan-gry., fair vug pors	
	4480-4490	Dol: wht-tan., sctrd fair pors	
	4490-4500	Dol: wht-tan., gd vug pors	
	4500-4510	Dol: wht-tan., gd vug pors	
	4510-4520	Dol: wht-tan., gd vug pors	
	4520-4530	Dol: AA/ Cht: wht., ang	
	4530-4540	Dol: tan-gry., poor pors/ Cht: AA	
	4540-4550	Dol: tan-gry., poor pors/ Cht: AA	
	4550-4560	Dol: gry-brn., fair pors/ Cht: AA	
	4560-4570	Dol: AA/ Cht: AA	
	4570-4580	Dol: tan-gry., fair vug pors/ Cht: AA	
	4580-4590	Cht: wht., ang/ Sh: gry-blk	
	4590-4600	Sh: gry-blk/ Cht: AA	
	4600-4610	Sh: AA/ Cht: AA	
	4610-4620	Sh: AA/ Cht: AA	
	4620-4630	Cht: wht., ang/ Sh: gry-blk	
	4630-4640	Dol: wht-tan., sctrd fair pors	
	4640-4650	Dol: wht-tan., fair-gd xln pors	Yes
	4650-4660	Sh: gry-blk/ Dol: wht-tan., fair xln pors	
	4660-4670	Sh: AA/ Dol: tan., gd vug pors (VIOLA)	Yes
Viola	4670-4680	Dol: tan., gd vug pors	
	4680-4690	Dol: tan-gry., xln., poor xln pors	
	4690-4700	Dol: tan-gry., xln., poor xln pors	
	4700-4710	Dol: AA / Sh: gry-blk	
	4710-4720	Dol: wht., xln	
	4720-4730	Dol: tan-gry., xln	
	4730-4740	Dol: tan-gry., xln	
	4740-4750	Dol: tan-gry., xln	
	4750-4760	Dol: tan-gry., sctrd gd vug pors	Yes
	4760-4770	Dol: tan-gry., gd vug pors	Yes
	4770-4780	Dol: tan-gry., gd vug pors	Yes
	4780-4790	Dol: tan-gry., xln., sctrd xln pors	
	GAP	Possible Simpson Sand Missing	
Arbuckle	4810-4820	Dol: gry-brn., no pors., no stain	

Ilene Norton #2
15-135-25175

4820-4830	Dol: gry-brn., sctrd pors	
4830-4840	Dol: gry-brn., sctrd pors	Yes
4840-4850	Dol: gry-brn., vug pors	Yes
4850-4860	dol: tan-brn., poor vug pors	
4860-4870	Dol: tan-brn., sctrd vug pors	Yes
4870-4880	Dol: tan-brn., no pors	
4880-4890	Dol: tan-brn., no pors	
4890-4900	Dol: tan-brn., no pors	
4900-4910	Dol: tan-brn., no pors	
4910-4920	Dol: tan-brn., no pors/ Cht: wht., ang	
4920-4930	Dol: tan-brn., no prs	Yes
4930-4940	Dol: wht-gry., gd vug pors	
4940-4950	Dol: wht-gry., gd vug pors	
4950-4960	Dol: tan-brn., fair vug pors	
4960-4970	Dol: tan-brn., fair vug pors	
4970-4980	Dol: tan-brn., fair vug pors	
4980-4990	MISSING	
5000 cir 30min	Dol: tan-brn.,sctd vug pors	
5000 cir 1hr	Dol:tan-brn., gd vug pors	

Figure 27: Well cutting descriptions for the Ilene Norton #2

Ilene Norton #2

Samples from the Ilene Norton, located in Section 32 Township 17S Range 25W, have good reservoir characteristics like all the other Sub-Mississippian wells in the study. In the Lower Mississippian units of this well there are good reservoir characteristics found at the depth interval of 4490-4520. From 4490-4520, the cuttings are described as white/tan dolomite with good vuggy porosity throughout the interval (Figure 27). Also like the other Sub-Mississippian wells in the Lower Mississippian there is a Shale unit present separating the Mississippi from the Viola. From the depth of 4650-4670 there is gray/black shale present that could possibly create a sealing layer between the two formations (Figure 27). The Viola in this well had good reservoir properties form 4670-4680, which was described as tan dolomite with good vuggy porosity present throughout all the cuttings (Figure 27). The rest of the Viola had poor porosity qualities. The Arbuckle had two depth intervals that had good reservoir properties and they were: 4820-4840, 4840-4850, and 4930-4950. The cuttings from 4820-4840 were described as gray/brown dolomite with scattered porosity. Cuttings from the interval 4840-4850 were analyzed as gray/brown dolomite with vuggy porosity present throughout the entire interval. And the deepest interval that showed reservoir potential for the Arbuckle in this well was from 4930-4950; which was described as white/gray dolomite with good vuggy porosity throughout the entire interval (Figure 27). SEM chemical analysis was performed on this well for the Viola interval of 4660-4670 (Figure 31) and on the Arbuckle interval 4830-4840 (Figure 32).

Scanning Electron Microscope Analysis Results

Samples that had possible oil staining present in the binocular microscope analyses were selected for Scanning Electron Microscope Analysis. Below are the photomicrographs and EDS analyses that were a result of the SEM work.

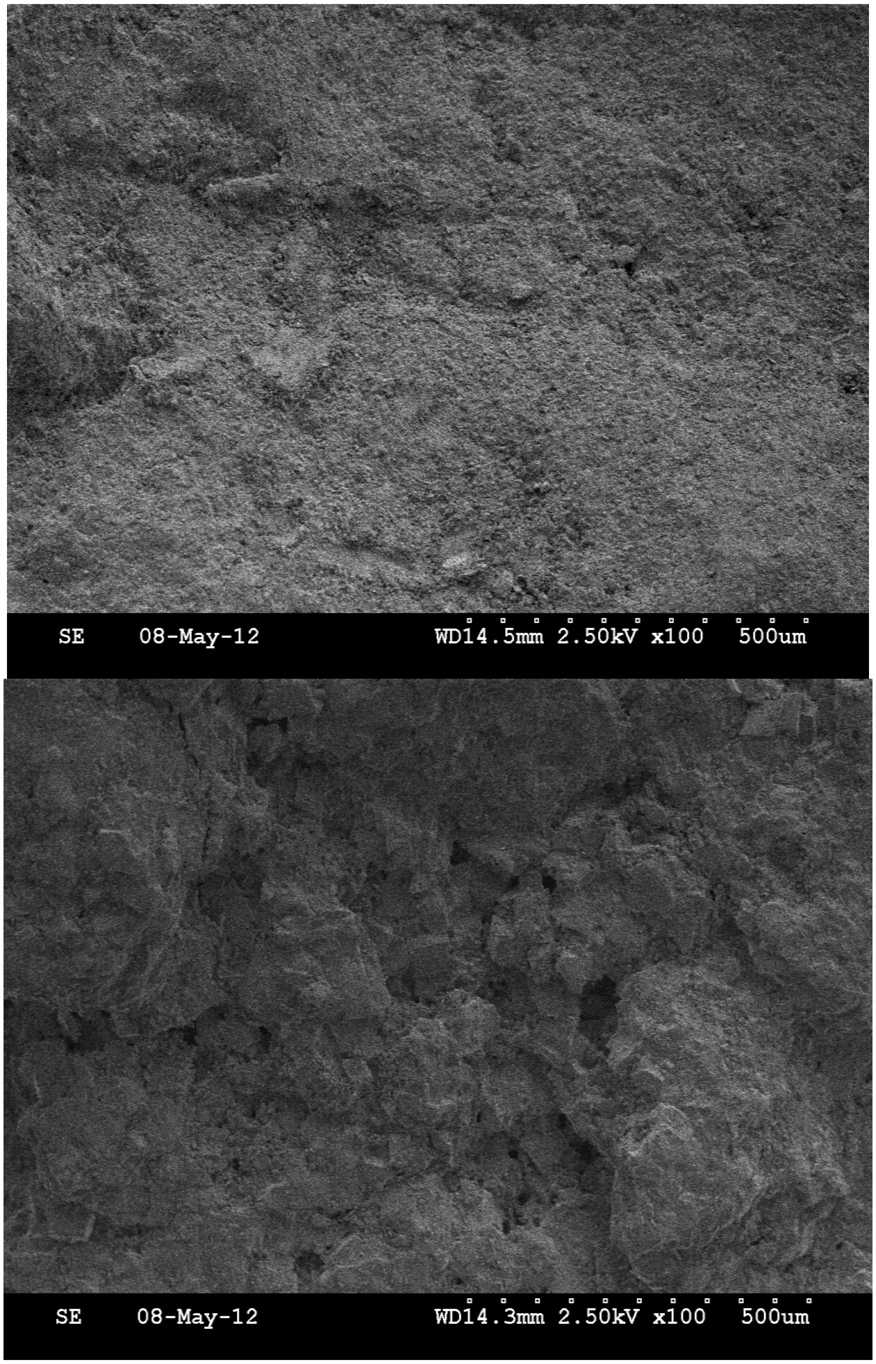
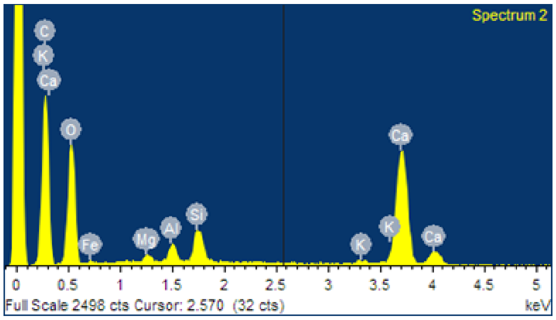


Figure 28: SEM photomicrographs for the Everett #1, the top picture is from the Viola (4665-4670) and the bottom picture is from the Arbuckle (4835-4840). Notice the difference in porosity between these two samples

Clark - Leis 050812



Element	Weight%	Atomic%
C K	40.87	51.53
O K	44.96	42.57
Mg K	0.51	0.32
Al K	0.91	0.51
Si K	1.79	0.97
K K	0.24	0.09
Ca K	10.31	3.90
Fe K	0.39	0.11
Totals	100.00	

Spectrum processing :

No peaks omitted

Processing option : All elements analyzed (Normalised)

Number of iterations = 5

Standard :

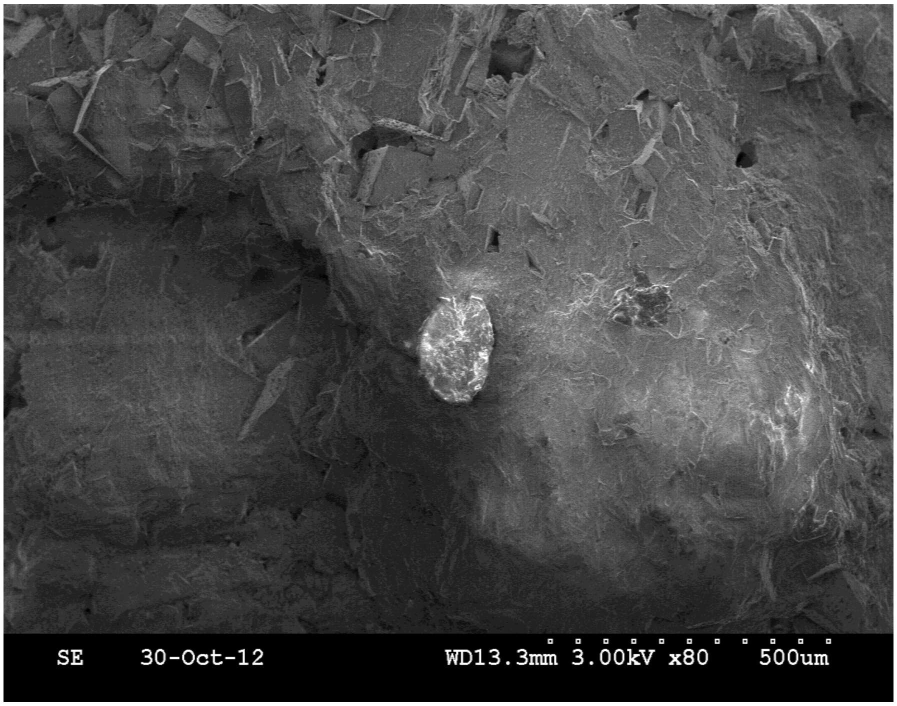
C CaCO3 1-Jun-1999 12:00 AM

O SiO2 1-Jun-1999 12:00 AM

Mg MgO 1-Jun-1999 12:00 AM

Al Al2O3 1-Jun-1999 12:00 AM

Figure 29: The EDS chemical results from the SEM for the Viola (4665-4670) in the Everett#1. Abundant Carbon present.



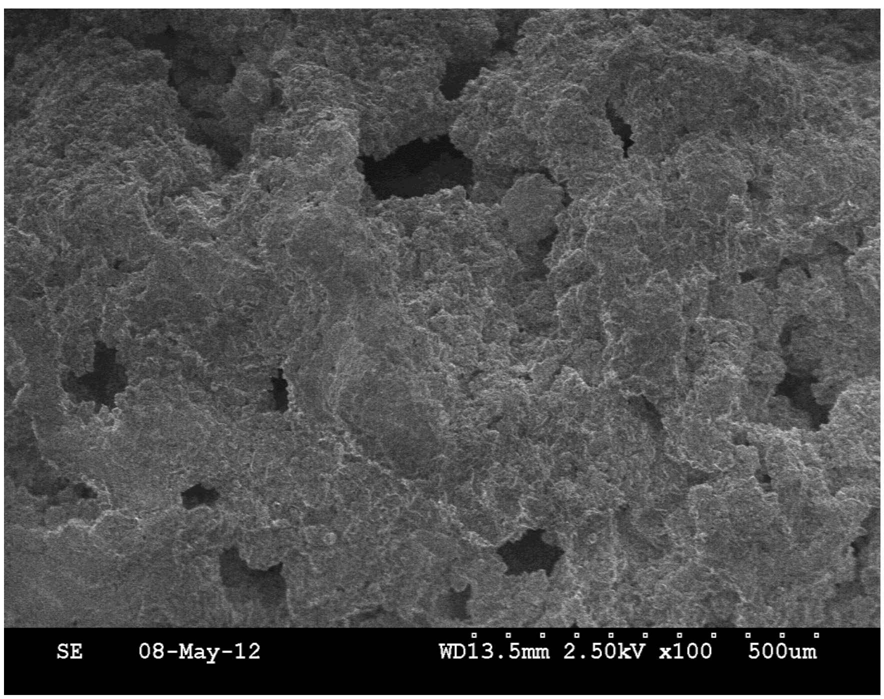


Figure 30: SEM photomicrographs from the Ilene Norton #2, the Top picture is the Viola Sample (4660-4670) and the bottom picture is the Arbuckle sample (4830-4840), very good porosity characteristics in each sample.

Totten - Leis 103012 10/30/2012 3:14:47 PM

Spectrum processing :

Peak possibly omitted : 2.640 keV

Processing option : All elements analyzed (Normalised)

Number of iterations = 5

Standard :

C CaCO3 1-Jun-1999 12:00 AM

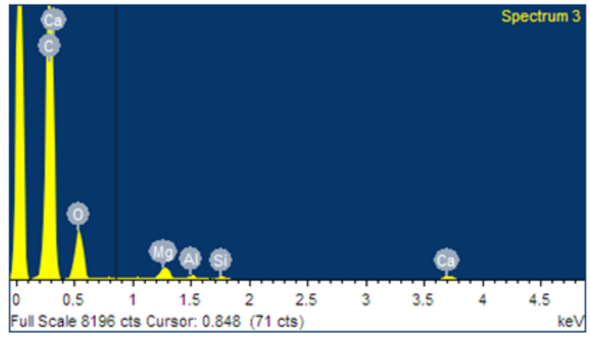
O SiO2 1-Jun-1999 12:00 AM

Mg MgO 1-Jun-1999 12:00 AM

Al Al2O3 1-Jun-1999 12:00 AM

Si SiO2 1-Jun-1999 12:00 AM

Ca Wollastonite 1-Jun-1999 12:00 AM



Element	Weight%	Atomic%
C K	67.06	73.57
O K	30.95	25.49
Mg K	1.08	0.58
Al K	0.24	0.12
Si K	0.16	0.07
Ca K	0.51	0.17
Totals	100.00	

Comment:

Norton No 2 Viola 4660 to 4670 2nd Spot

INCA

Figure 31: Chemical analysis from the Ilene Norton #2 Viola (4660-4670), this analysis yielded a good carbon percentage (73.57%)

Totten - Leis 103012

10/30/2012 3:26:42 PM

Spectrum processing :

Peak possibly omitted : 6.360 keV

Processing option : All elements analyzed (Normalised)

Number of iterations = 5

Standard :

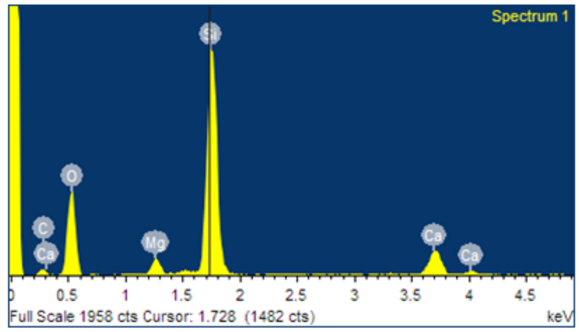
C CaCO3 1-Jun-1999 12:00 AM

O SiO2 1-Jun-1999 12:00 AM

Mg MgO 1-Jun-1999 12:00 AM

Si SiO2 1-Jun-1999 12:00 AM

Ca Wollastonite 1-Jun-1999 12:00 AM



Element	Weight%	Atomic%
C K	11.24	17.21
O K	51.59	59.29
Mg K	2.33	1.76
Si K	29.37	19.23
Ca K	5.47	2.51
Totals	100.00	

Comment:

Norton No 2 Arbuckle 4830 to 4840

Figure 32: EDS Chemical analysis from the Ilene Norton #2 Arbuckle section of 4830-4840, very little carbon present

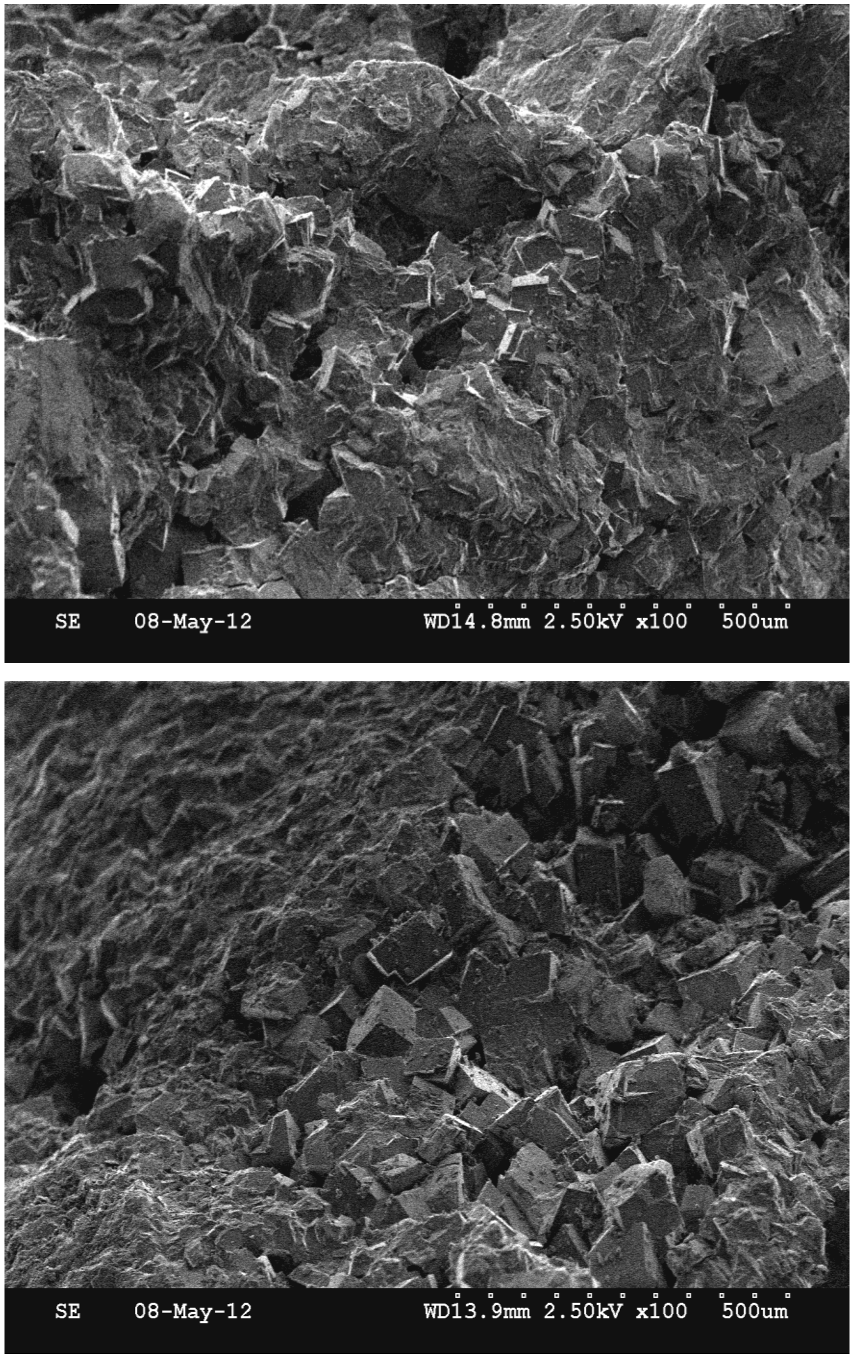


Figure 33: SEM photomicrographs pictures from the Reed "A" #1, the top sample comes from the Lower Mississippian (4620-4625) and the top picture is from the Viola (4775-4780), this well was not drilled deeper than the viola

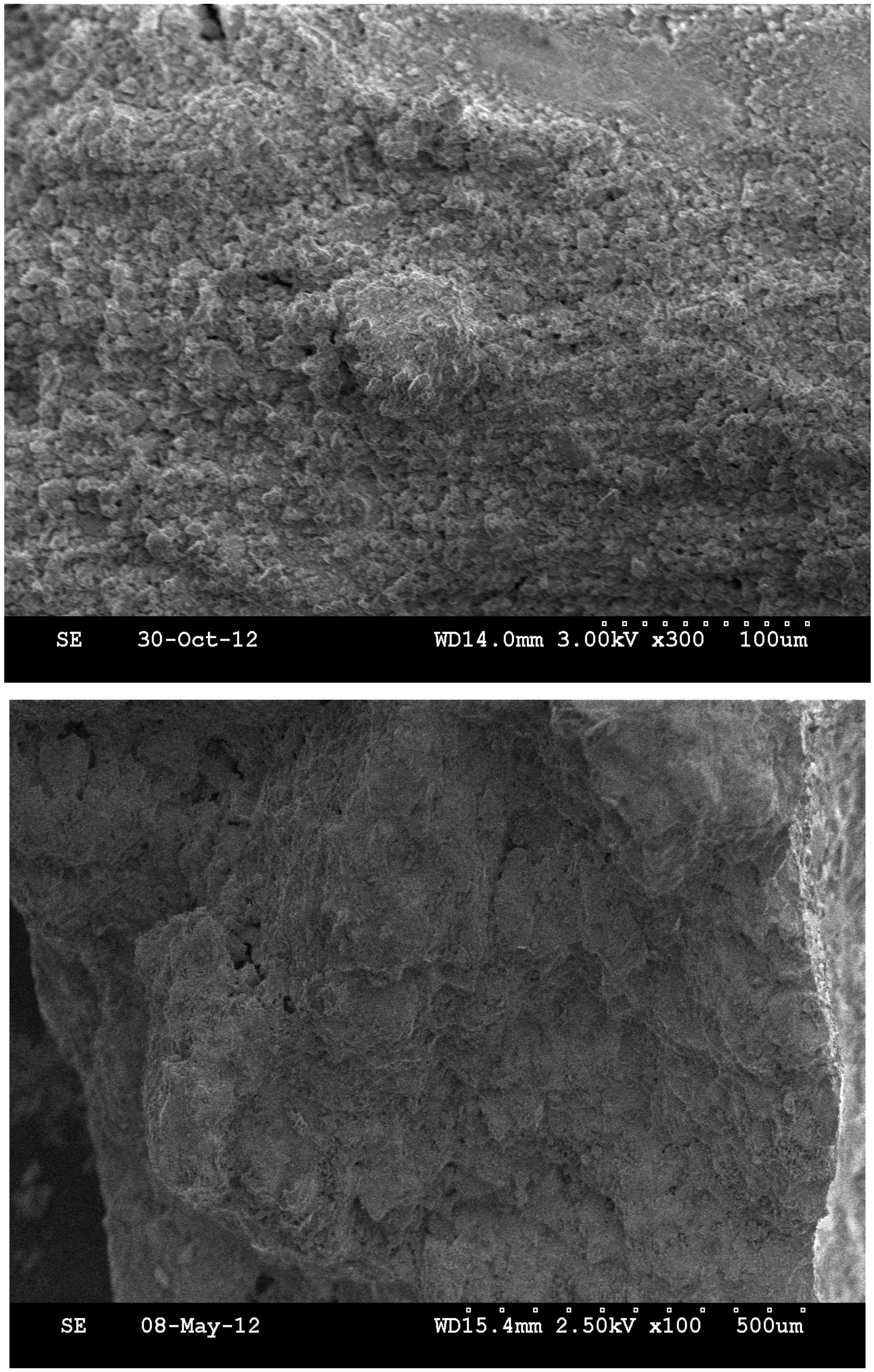


Figure 34: SEM photomicrographs pictures from the John C. Shearer #2, the top picture is of the Viola (4655-4660) and the bottom picture is from the Arbuckle (4760-4765)

Totten - Leis 103012

10/30/2012 3:55:14 PM

Spectrum processing :

No peaks omitted

Processing option : All elements analyzed (Normalised)

Number of iterations = 4

Standard :

C CaCO3 1-Jun-1999 12:00 AM

O SiO2 1-Jun-1999 12:00 AM

Mg MgO 1-Jun-1999 12:00 AM

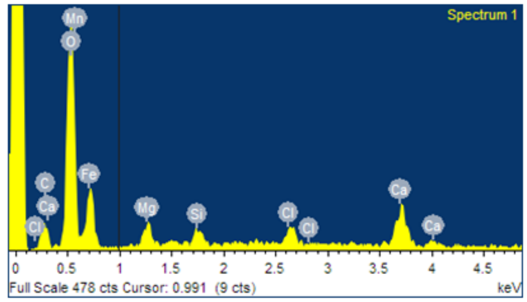
Si SiO2 1-Jun-1999 12:00 AM

Cl KCl 1-Jun-1999 12:00 AM

Ca Wollastonite 1-Jun-1999 12:00 AM

Mn Mn 1-Jun-1999 12:00 AM

Fe Fe 1-Jun-1999 12:00 AM



Element	Weight%	Atomic%
C K	9.30	18.64
O K	37.04	55.75
Mg K	2.15	2.13
Si K	1.06	0.91
Cl K	1.22	0.83
Ca K	2.98	1.79
Mn K	0.64	0.28
Fe K	45.61	19.67
Totals	100.00	

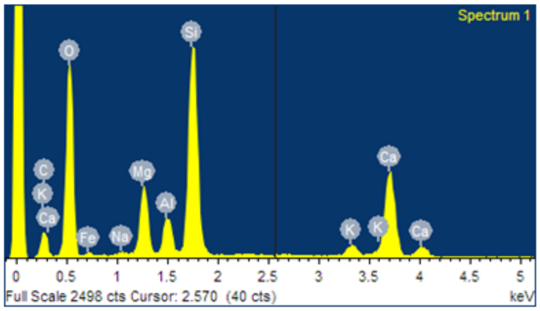
Comment:

John Shearer No 1 Viola 4655 to 4660

Figure 35: EDS Chemical analysis from the John C. Shearer #2 Viola (4655-4660), No significant Carbon present

Clark - Leis 050812

5/8/2012 2:08:16 PM



Spectrum processing :

No peaks omitted

Processing option : All elements analyzed (Normalised)

Number of iterations = 5

Standard :

C CaCO3 1-Jun-1999 12:00 AM

O SiO2 1-Jun-1999 12:00 AM

Na Albite 1-Jun-1999 12:00 AM

Mg MgO 1-Jun-1999 12:00 AM

Al Al2O3 1-Jun-1999 12:00 AM

Si SiO2 1-Jun-1999 12:00 AM

K MAD-10 Feldspar 1-Jun-1999 12:00 AM

Ca Wollastonite 1-Jun-1999 12:00 AM

Element	Weight%	Atomic%
C K	14.59	21.55
O K	54.23	60.16
Na K	0.26	0.20
Mg K	4.98	3.63
Al K	2.41	1.58
Si K	13.40	8.47
K K	0.97	0.44
Ca K	8.44	3.74
Fe K	0.71	0.23
Totals	100.00	

INCA

Figure 36: EDS Chemical analysis from the John C. Shearer #2 Arbuckle sample (4760-4765), this well sits in the best structural location however the top 40ft of Arbuckle samples are missing for this well. The Carbon percentages for this well are the lowest of the other chemical analyses

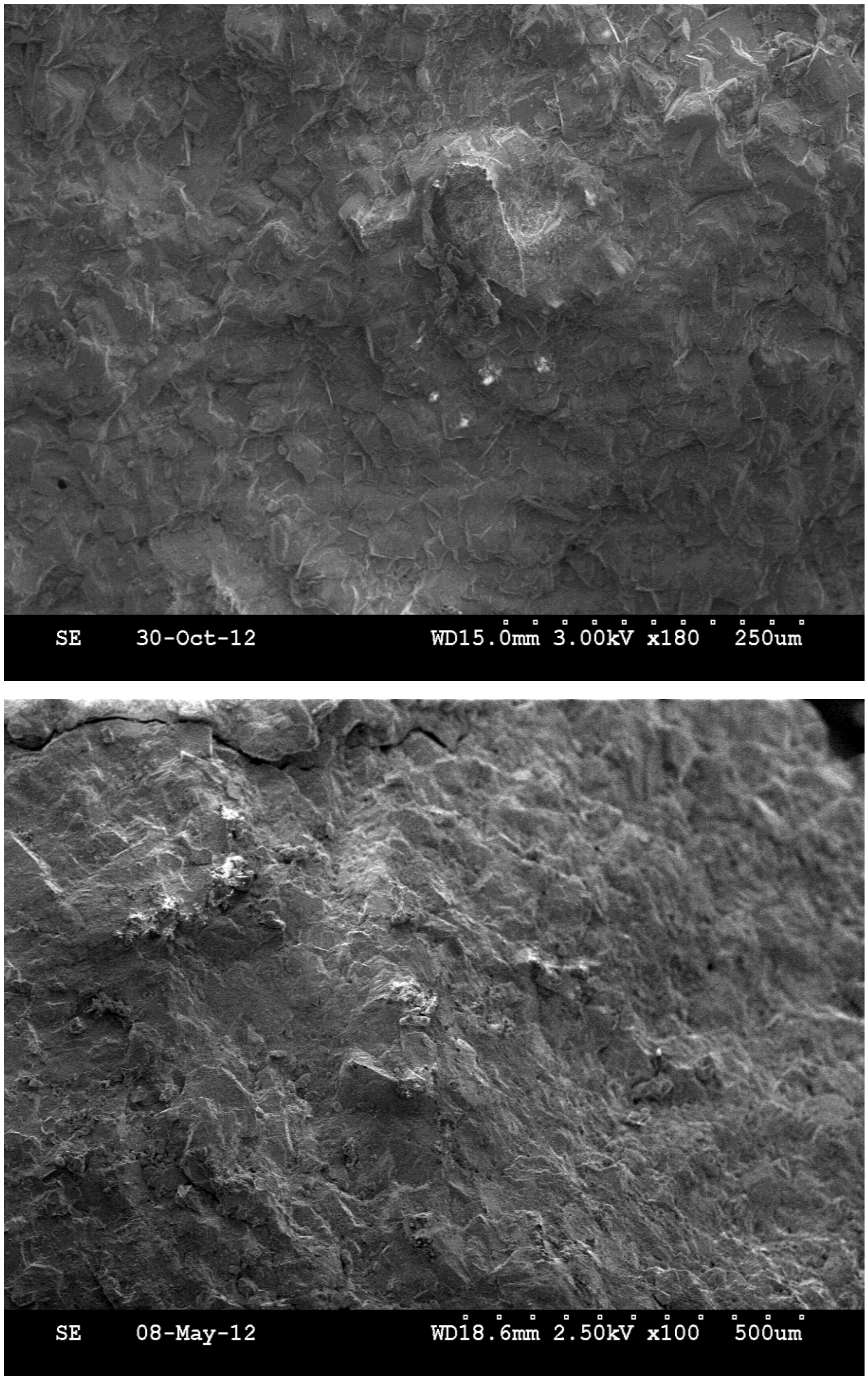


Figure 37: SEM photomicrographs pictures for the Stiawalt #3, the top picture is from the Viola (4680-4690) and the bottom picture is from the Arbuckle (4780-4790)

Totten - Leis 103012

10/30/2012 2:51:52 PM

Spectrum processing :

No peaks omitted

Processing option : All elements analyzed (Normalised)

Number of iterations = 5

Standard :

C CaCO3 1-Jun-1999 12:00 AM

O SiO2 1-Jun-1999 12:00 AM

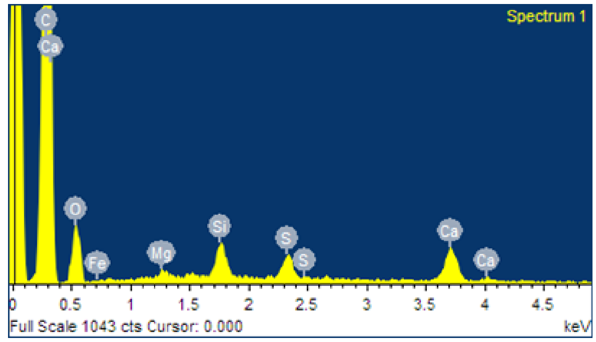
Mg MgO 1-Jun-1999 12:00 AM

Si SiO2 1-Jun-1999 12:00 AM

S FeS2 1-Jun-1999 12:00 AM

Ca Wollastonite 1-Jun-1999 12:00 AM

Fe Fe 1-Jun-1999 12:00 AM



Element	Weight%	Atomic%
C K	77.50	83.82
O K	17.85	14.49
Mg K	0.24	0.13
Si K	0.99	0.46
S K	0.83	0.33
Ca K	1.75	0.57
Fe K	0.84	0.20
Totals	100.00	

Comment:

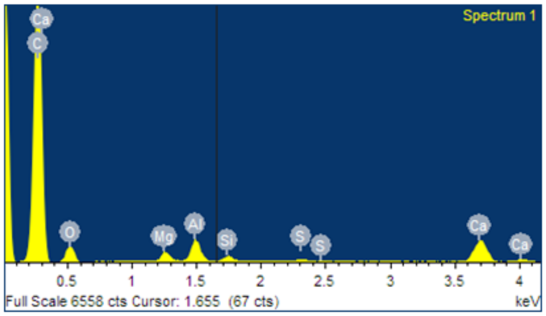
Stiwalt No 3 (4680 - 4690 ft)

INCA

Figure 38: EDS Chemical analysis from the Stiawalt #3 Viola, very high abundance of Carbon present

Clark - Leis 050812

5/8/2012 1:55:31 PM



Element	Weight%	Atomic%
C K	77.25	84.35
O K	15.55	12.75
Mg K	0.88	0.47
Al K	1.85	0.90
Si K	0.45	0.21
S K	0.22	0.09
Ca K	3.56	1.17
Fe K	0.23	0.05
Totals	100.00	

Spectrum processing :

No peaks omitted

Processing option : All elements analyzed (Normalised)

Number of iterations = 5

Standard :

C CaCO3 1-Jun-1999 12:00 AM

O SiO2 1-Jun-1999 12:00 AM

Mg MgO 1-Jun-1999 12:00 AM

Al Al2O3 1-Jun-1999 12:00 AM

Si SiO2 1-Jun-1999 12:00 AM

S FeS2 1-Jun-1999 12:00 AM

Ca Wollastonite 1-Jun-1999 12:00 AM

Fe Fe 1-Jun-1999 12:00 AM

INCA

Figure 39: EDS Chemical analysis from the Stiawalt #3 Arbuckle sample (4780-4790). This sample resulted in the best Carbon percentage of the chemical analyses performed (84.35% Carbon)

Chapter 5 - Discussion

Lower Mississippian Potential

The Lower Mississippian does not show all of the four characteristics to accumulate hydrocarbons, and is the weakest candidate of the sub-Mississippian formations analyzed for future exploration. Of the four components necessary for a hydrocarbon accumulation: an apparent structure, an overlying sealing unit, porous rock, and presence of hydrocarbons; the lower Mississippian satisfies only one. Each component is further discussed below

Structure: Structure for the lower Mississippian is uncertain in this study, there are no cross section picks made in the deep wells cross-section or a structure map to prove apparent structure in the lower Mississippian. In order for the lower Mississippian to be analyzed for structural attributes, certain zones in the lower Mississippian need to be identified and correlated in each well that penetrated that zone. These zones need to be identified and correlated in order for formation tops to be applied to allow cross section picks to be made and possible structure mapping in the lower Mississippian.

Reservoir Rocks: Reservoir rock is the one component of a hydrocarbon accumulation that the lower Mississippian displays. All wells in the study showed good reservoir properties in the lower Mississippian in multiple horizons (Figures: 23-27). One SEM photomicrograph was taken from the lower Mississippian (4620-4625) in the Reed "A" #1, which shows a dolomite with large vuggy pores (Figure 33). The photomicrograph agrees with the sample description for the sample given under the binocular microscope of a tan/grey dolomite with vuggy porosity (Figure 23). No other lower Mississippian samples were examined under the SEM.

Seal: There is no apparent shale unit to act as a seal in the lower Mississippian observed in the binocular microscope analysis.

Presence of Hydrocarbon: No evidence that hydrocarbons had been, or had washed through the lower Mississippian was observed.

Viola Potential

The Viola satisfies all four of the petroleum system requirements for hydrocarbon accumulation, and is the strongest candidate for further exploration. A positive structure is apparent, with porous reservoir rock overlain by a thick shale that should make a good seal. In addition, oil-staining is apparent in several of the key wells. Each component is further discussed below

Structure: The Viola shows evidence of concentric folding present in sub-Mississippian wells shown in the deep well cross section in figure 21. Figure 21 shows that the Viola folds with the Mississippian and the other formations. Because of limited well control a structure map on the Viola was not prepared. Therefore the sub-Mississippian wells are highlighted on the Mississippian structure map in figure 22. Figure 22 shows that the majority of sub-Mississippian wells in the study are not situated in areas of high Mississippian structure. Two wells are however situated in high Mississippian structure, the John C. Shearer #2, and the Stiawalt #3.

Reservoir Rocks: Cutting analyses for the Viola also yielded many promising characteristics from the binocular microscope and the SEM. The binocular microscope descriptions showed that the Viola has good porous rock at the top of the formation as well as deeper into it (Figures: 23-27). The SEM photomicrographs help solidify the binocular microscope description by giving a very detailed look at petrographic and reservoir properties of the intervals analyzed.

The Stiawalt #3 Viola (4680-4690) SEM photomicrograph shows a crystalline dolomite with scattered vugs making porosity in the sample (Figure 40). The photomicrograph observations match the description given under the binocular microscope of a tan/gray dolomite with scattered vuggy porosity (Figure 26). The Ilene Norton #2 Viola (4660-4670) SEM photomicrograph shows a crystalline dolomite with vuggy porosity (Figure 41). The photomicrograph observations match the description given under the binocular microscope of a tan dolomite with good vuggy porosity (Figure 27). The Everett #1 Viola (4665-4670) SEM photomicrograph shows a dolomite with some scattered porosity (Figure 42). The photomicrograph observations relate well to the binocular microscope description of a tan/grey dolomite with good vuggy porosity, although in the photomicrograph (Figure 42) porosity wasn’t as clearly noted as in the binocular microscope description (Figure 24). The John C. Shearer #2

Viola (4655-4660) SEM photomicrograph shows a dolomite with small vuggs making up the porosity (Figure 34), which agrees with the binocular microscope description of a dolomite with vuggy porosity (Figure 25). The Reed “A” #1Viola (4775-4780) SEM photomicrograph shows a crystalline dolomite with good vuggy porosity (Figure 33), which matches the binocular microscope description of a tan/grey dolomite with vuggy porosity (Figure 23).

Seal: In all the sub-Mississippian wells cutting analyses there was a shale unit overlying the top of the Viola. This could act as a possible seal for the underlying Viola (Figures: 23 -27).

Presence of Hydrocarbons: The Viola yielded the best overall results from the SEM. Three out of the five wells that were analyzed in the SEM produced high Carbon percentages from Viola intervals when EDS analyses was performed on them. The Stiawalt #3 (4680-4690) yielded the highest carbon percentage (83.82%) of any Viola sample Figure 38); the spot that the EDS was shot is highlighted below in Figure 40. The Ilene Norton #2 Viola (4660-4670) yielded the second highest Carbon percentage (73.57%) out of the Viola samples analyzed (Figure 31). The spot that the EDS analysis was performed on in the Ilene Norton #2 is highlighted below in figure 41. The Everett #1 also yielded good percentages of carbon (51.53%) in the EDS analysis from the interval of 4665-4670 (Figure 29). The spot that the EDS analysis was performed on for this interval was seen as a curious dark spot in one of the pores, highlighted below in Figure 42.

Neither the John C. Shearer #2 (4655-4660) nor the Reed “A” #1 (4775-4780) yielded any significant amounts of carbon present (Figure 35). The John C. Shearer #2 Viola did appear to have an oil stain present in the SEM photomicrograph, but after EDS chemical analysis the spot resulted in a very low (18.64%) Carbon percentage (Figure 35). The Reed “A” #1 Viola (4775-4780) did not show any evidence of oil staining in either microscope analysis therefore no EDS chemical analysis was taken from the sample.

Figure 40: The spot that EDS chemical analysis was taken from, Stiawalt #3 (4680-4690)

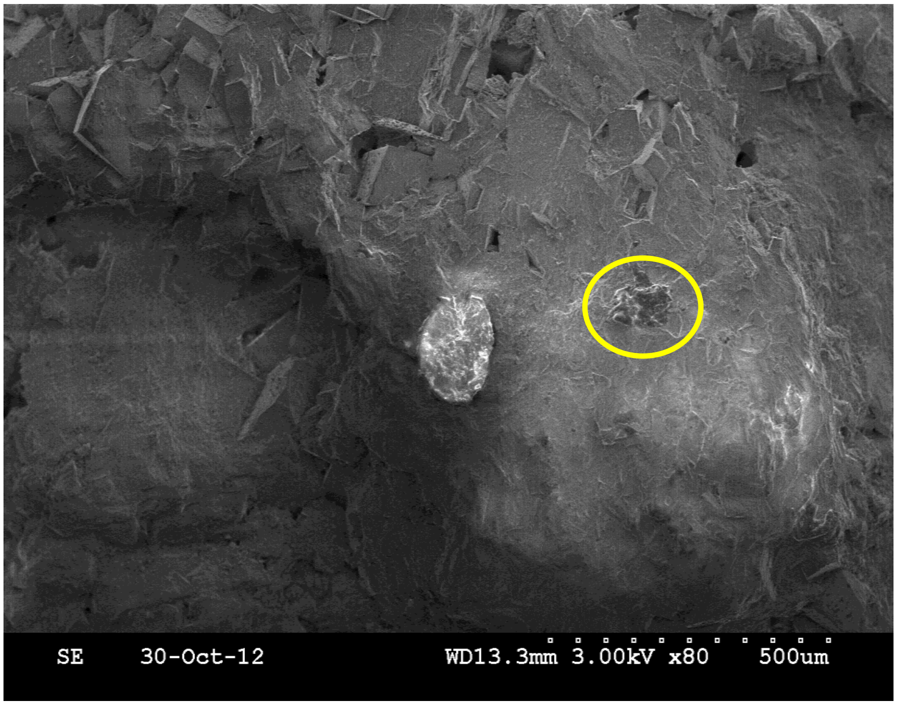


Figure 41: Spot that EDS chemical analysis was taken from, Ilene Norton #2 (4660-4670)

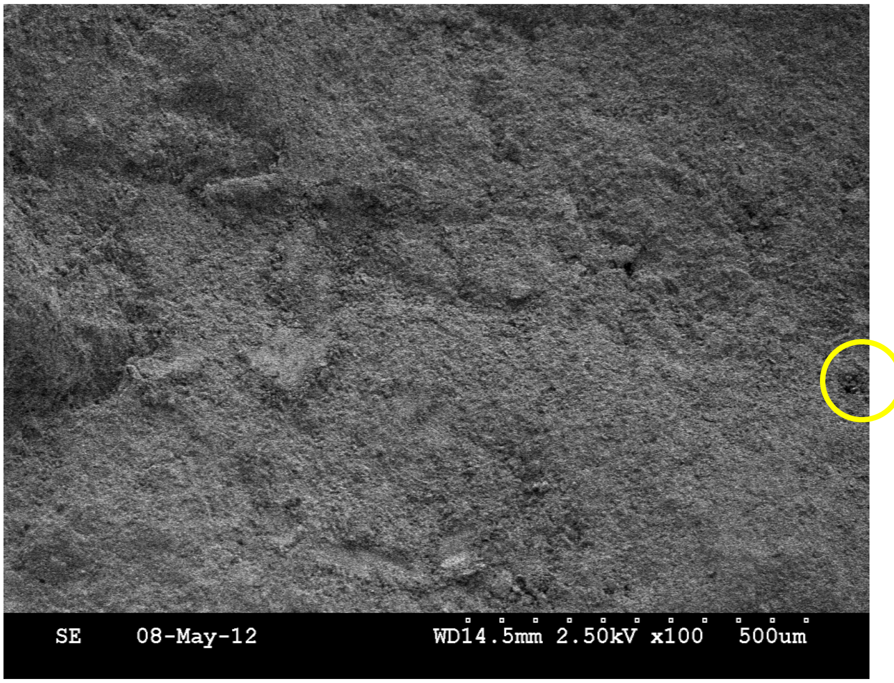


Figure 42: Spot that EDS chemical analysis was taken from, Everett #1 (4665-4670)

Arbuckle Potential

The Arbuckle satisfies all four of the petroleum system requirements necessary for hydrocarbon accumulation, and is the second strongest candidate for further exploration. A positive structure is apparent, with porous rock overlain by a shale that should make a good seal. In addition, oil-staining is apparent in one key well. Each component is further discussed below.

Structure: The Arbuckle shows evidence of concentric folding present in the sub-Mississippian wells shown in the deep wells cross section in Figure 21. Figure 21 shows that the Arbuckle folds with the Mississippian and the other formations. Because of limited well control a structure map on the Arbuckle was not prepared. Therefore the sub-Mississippian wells are highlighted on the Mississippian structure map in Figure 22. Figure 22 shows that the majority of sub-Mississippian wells in the study are not situated in areas of high Mississippian structure. Two wells are however situated in high Mississippian structure, the John C. Shearer #2 and the Stiawalt #3.

Reservoir Rocks: The Cutting analyses, like the other two sub-Mississippian formations, yielded promising reservoir characteristics from the binocular microscope and SEM. The binocular microscope descriptions, for the five sub-Mississippian wells analyzed, showed that the Arbuckle also has abundant porous zones within it (Figures: 23-27). The binocular microscope descriptions are compared to the SEM photomicrographs, taken from selected intervals, below.

The Stiawalt #3 Arbuckle (4780-4790) SEM photomicrograph shows a dolomite with small scattered vugs making porosity (Figure 37). This matches the binocular microscope description for this interval of a grey/brown dolomite with vuggy porosity (Figure 26). The Ilene Norton #2 Arbuckle (4830-4840) SEM photomicrograph shows a dolomite with good vuggy porosity (Figure 30). The photomicrograph observation agrees with the binocular microscope description of a grey/tan dolomite with scattered porosity (Figure 27). The Everett #1 Arbuckle (4835-4840) SEM photomicrograph shows a dolomite with vuggy porosity (Figure 28). This matches the binocular microscope description of a tan/grey dolomite with good porosity (Figure 24). The John C. Shearer #2 Arbuckle (4760-4765) SEM photomicrograph shows a dolomite with scattered vuggy porosity (Figure 34). This agrees with the binocular microscope description of a white/tan dolomite with good porosity (Figure 25).

Seal: In the sub-Mississippian well cuttings analyzed the unit overlying the Arbuckle varies or is not present in the sample boxes. The Everett #1 interval of 4820-4825 is described in the binocular microscope analysis as all shale, which overlies the top of the Arbuckle (Figure 24). The Stiawalt #3 shows no shale unit overlying the Arbuckle in the Binocular microscope analysis (Figure 26). And in both the John C. shearer #2 and the Ilene Norton #2 the samples for the interval directly above the Arbuckle are missing from the sample boxes (Figures 25 and 27).

Presence of Hydrocarbons: The Arbuckle did not yield as promising of results from the EDS analyses as the Viola. Unlike the Viola that had three out of the five wells tested result in high Carbon percentages, the Arbuckle had one sample out of four analyzed with the EDS yield a high Carbon percentage. The Stiawalt #3 Arbuckle (4780-4790) was the one well that yielded a high Carbon percentage in the Arbuckle. The EDS chemical analysis from the spot highlighted below in figure 43 yielded the highest Carbon percentage of 84.35% the highest of any EDS analysis done in the study (Figure 39).

No other wells that penetrated the Arbuckle (John C. Shearer #2, Ilene Norton #2, Everett #1) yielded high Carbon percentages. The John C. Shearer #2 is the best structurally situated well in the study and did not yield high Carbon percentages in the Arbuckle, which is likely due to the top 30 feet of samples from the Arbuckle missing in the sample box.

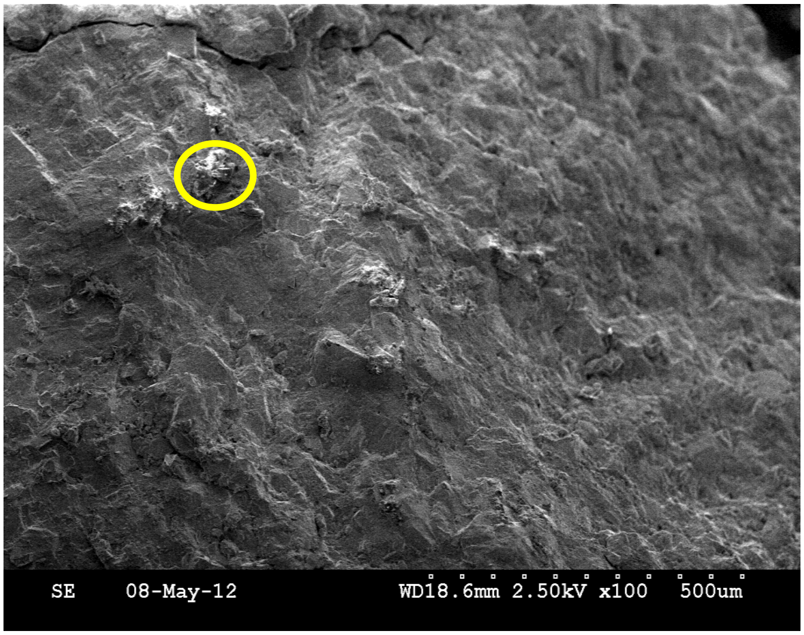


Figure 43: The spot that EDS chemical analysis was performed on, Stiawalt #3 (4780-4790)

Chapter 6 - Conclusions

The goal is to give insight into the further development of the Aldrich trend using the methods presented. Based upon structure maps of the younger formations (Mississippian and younger) using the well data from the 387 wells it appears that the anticlinal structure trapping existing hydrocarbons represents concentric folding. This folding also appears to continue into the older formations, supporting the existence of potential structural traps in sub-Mississippian formations.. The anticlinal feature present is also very well illustrated in the three cross-sections crossing the different areas of the Aldrich field. With these cross-sections it is easy to see that not only the three formations that structure maps were made for (Lansing-Kansas City, Ft. Scott Limestone, and Mississippian Limestone), but the other formations picked from the electric logs are forming a concentric fold. The cross-section that covers the Sub-Mississippian wells shows that not only do the Mississippian and Pennsylvanian formations appear to fold with each other but the Sub-Mississippian wells also appear to be structural higher in wells that are structurally high in the younger formations. With this data shown there are likely structural highs in the Viola and Arbuckle formations where there are structural highs in the younger formations.

From looking at the cuttings that were obtained from the Kansas Geological Survey for the sub-Mississippian wells that had cuttings available, many areas below the Mississippian formations had good reservoir properties. In each well analyzed using the binocular microscope we seen at least one, if not more, areas in both the Viola and Arbuckle that have very good reservoir properties. Also in these wells there appeared to be a sealing unit present separating the top of the Viola from the bottom of the Mississippi. There were also shales that could act as sealing units separating the Arbuckle from the Viola.

Lastly with the use of the Scanning Electron Microscope I was able to get a closer look of the porosity and any other distinguishing features of the Sub-Mississippian well cuttings. I was also able to get chemical data from different features of the cuttings and was able to conclude that there are likely oil stains present on four different samples. The wells that had the high amounts of carbon present in the chemical analyses that led me to believe they were oil stains included the: Everett #1 Viola, Ilene Norton #2 Viola, and the Stiawalt #3 (which yielded good carbon percentages in both the Arbuckle and the Viola). It should be noted that the carbon percentages are well above that expected from carbonate, using the oxygen numbers as the limit for CO3.

With the results of these methods I found that the wells that were closest to structural highs in the Mississippian and Pennsylvanian had the best Carbon percentages present in the Sub-Mississippian cuttings. The Stiawalt #3, second structurally highest well, yielded the two best carbon percentages found in both the Viola and Arbuckle. As a whole the Viola yielded the best carbon percentages over the Arbuckle; the Viola had three different samples that were Carbon rich and the Arbuckle had only one. This leads me to believe that the Viola would be a better target for Sub-Mississippian oil production in the Aldrich Trend than the Arbuckle.

Even though this is an old field, discovered in 1929, and has produced millions of barrels of oil I think that there is potential for there to be even more new discoveries made here in the sub-Mississippian formations. New sub-Mississippian wells need to be drilled in areas that are on structural highs in the Mississippian and Pennsylvanian. With the results obtained from the Stiawalt #3 oil stains were seen in the samples but no drill stem testing or other drilling tests were performed to see how much oil was present in the porous sections of the Viola and Arbuckle. 3-D seismic acquisitions would also help access the structural attributes of the sub-Mississippian formations, to pick the best possible drilling locations for Sub-Mississippian exploration.

References

Bhattacharya, Saibal, Paul Gerlach, Tim Carr, Willard Guy, Scott Beatty, and Evan Franseen. "PC-Based Reservoir Characterization and Simulation of Schaben Field, Ness County, Kansas." *Oklahoma Geological Survey Circular*. 101. (2000): 171-182. Print.

Carpenter, Gail. "Geological Notes, Ness County, KS." *Bulletin of the American Association of Petroleum Geologists*. 29.5 (1945): 564-570. Print.

Carr, T.R., W.R. Guy, E.K. Franseen, and S. Bhattacharya. "The Schaben Field (Mississippian), Ness County, Kansas." *American Association of Petroleum Geologists, Annual Meeting Abstracts.* (1996): p. A23-A24

Carr, Timothy R., G. Paul Willhite, Dana Atkins-Heljeson, Scott Beaty, Saibal Bhattacharya, Even Franseen, Paul Gerlach, Willard Guy, John Hopkins, W. Lynn Watney, Rodney Reynolds, Shapour Vossoughi, and G. Paul Willhite. "Improved Oil Recovery in Mississippian Carbonate Reservoirs of Kansas." *Class 2, USODE Annual Report DOE/BC/14987-10.* (1997)

Link, Peter. *Basic Petroleum Geology*. Tulsa: OCGI Publications, 1982. 130. Print.

Lousiana State University, *User's Guide and Documentation Manual for BOAST 3 Version 1.5.* U.S. Department of Energy, Contract DE-AC22-91BC14831

Merriam, D.F., "The Geologic History of Kansas" *Bulletin 162. Lawrence, KS: University of Kansas Publications.* (1963): 117-149

Montgomery, S.L., E.K. Franseen, S Bhattacharya, P.M. Gerlacha, and W.L. Guy. "Scahben Field, Kansas: Improving performance in a Mississippian Shallow-Shelf Carbonate." *AAPG Bulletin*. 84. (2000): 1069-1086. Print.

Morgan, J.V., "Correlation of radioactive logs of the Lansing and Kansas City Groups in Central Kansas." *Journal of Petroleum Technology*. 4. 13 (1952): 111-118

Newell, D.K., Watney L.W., Cheng W.L., Brownrigg R.L., "Stratigraphic and Spatial Distribution of Oil and Gas Production in Kansas." *Kansas Geological Survey, Subsurface Geology Series 9*. (1987)

Seewald, Jeffery S., "Organic-Inorganic Interactions in Petroleum-Producing Sedimentary Basins." *Nature*. 426. November (2003): 331. Print.

SPE International. N.p., 26 Aug. 2011. Web. <(http://www.spe.org/glossary/wiki/doku.php/terms:barefoot_completion>.

Surdam, R.C., L.J. Crossey., "Organic-Inorganic Reactions During Progressive Burial: Key to Porosity and Permeability Enhancement and Preservation." *Phil. Trans. R. Soc. Lend.* (1985): 135-156

Surdam R.C., Z.S. Jiao., D.B. MacGowen., “Redox Reactions Involving Hydrocarbons and Mineral Oxidants: A Mechanism for Significant Porosity Enhancement in Sandstones.” *AAPG Bulletin.* 77. (1993) 1509-1518

Watney, L.W., “Cyclic Sedimentation of the Lansing-Kansas City Groups in Northwestern Kansas and Southwestern Nebraska: A Guide to Petroleum Exploration.” *Kansas Geological Survey Bulletin*. 220. (1980)

Zeller, D., “Stratigraphic Succession in Kansas.” Bulletin 189. Lawrence, KS: University of Kansas Publications, (1968): 1-8

Appendix

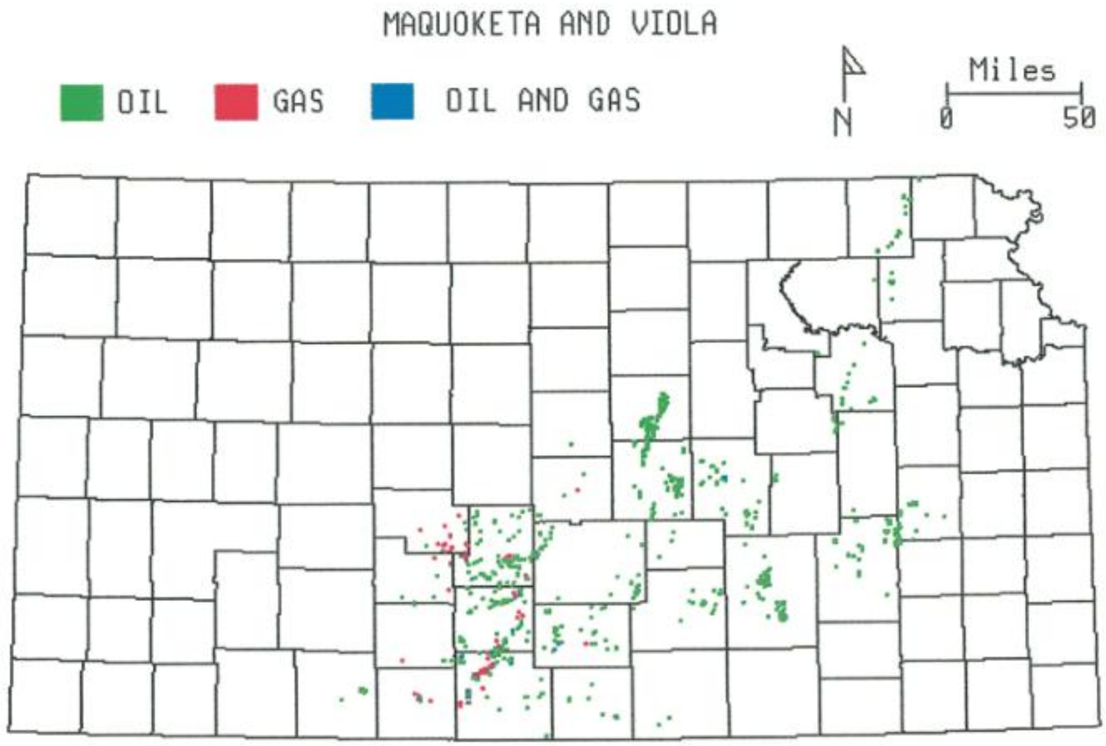


Figure A-1: Known Viola production in Kansas (KGS, 1987)

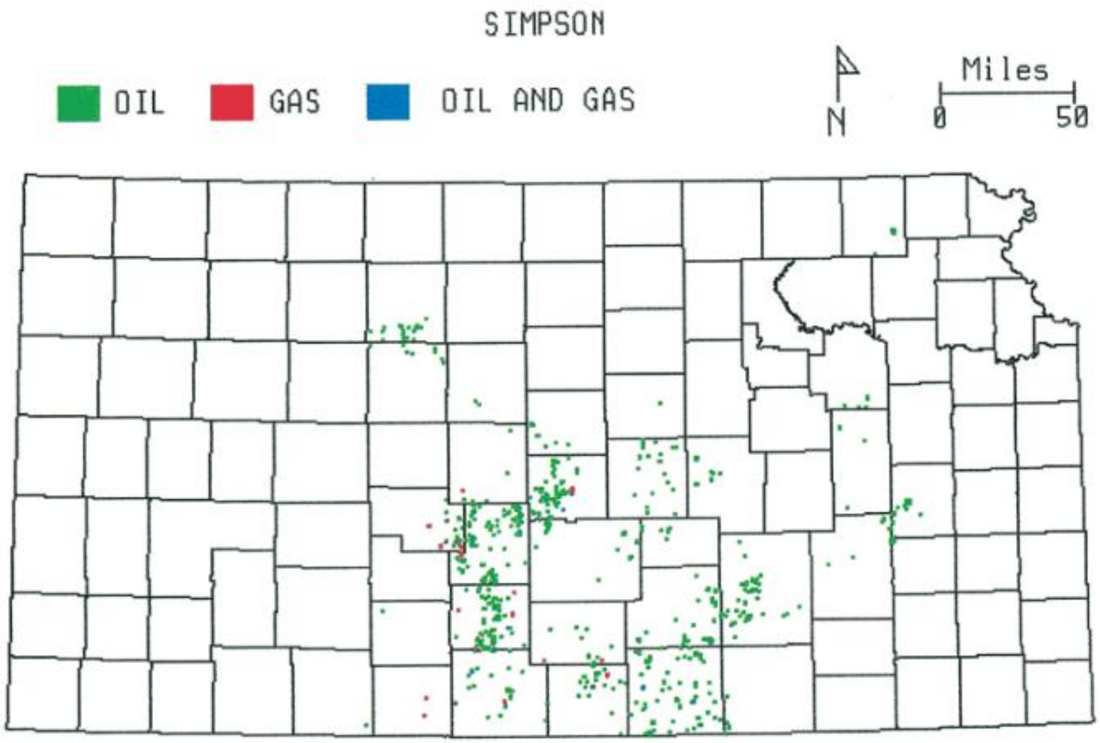


Figure A-2: Known Simpson production in Kansas (KGS, 1987)

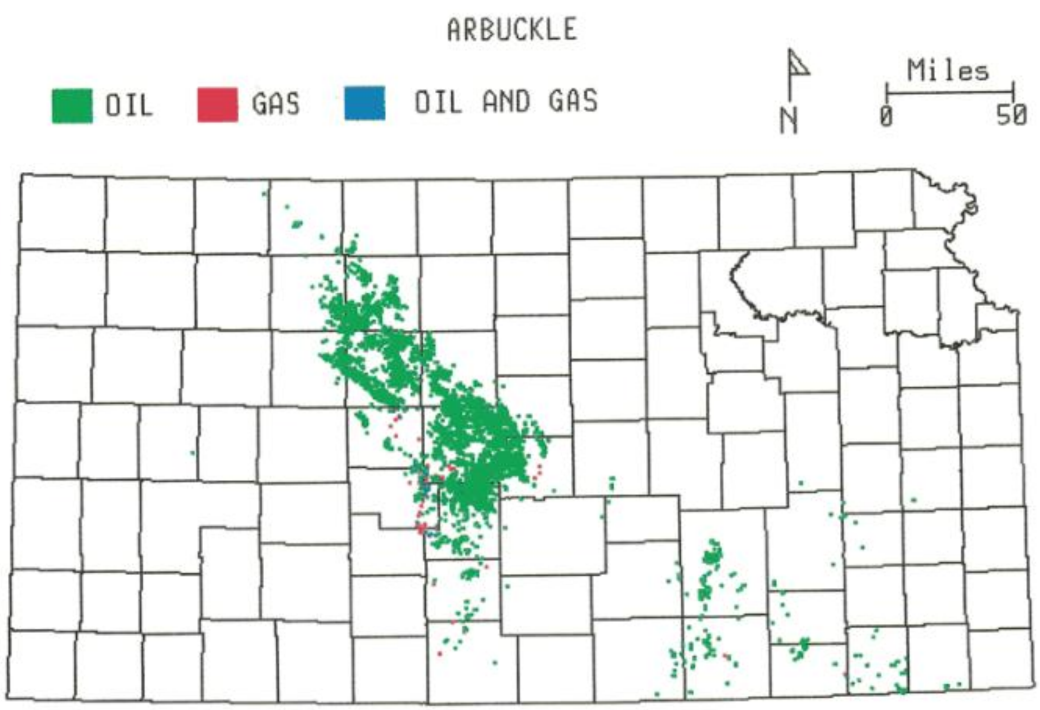


Figure A-3: Known Arbuckle production in Kansas (KGS, 1987)

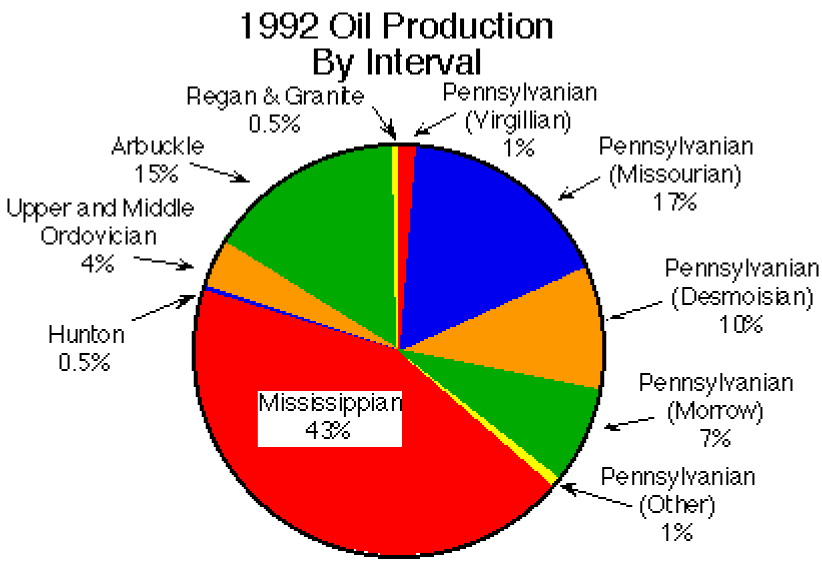


Figure A-4: Kansas oil production by interval in 1992 (KGS, 1992)