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EXPLOITATION AND OPTIMIZATION OF RESERVOIR PERFORMANCE IN HUNTON FORMATION, OKLAHOMA

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By:
Mohan Kelkar

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Executive Summary

This report presents the work done so far on Hunton Formation in West Carney Field in Lincoln County, Oklahoma. West Carney Field produces oil and gas from the Hunton Formation. The field was developed starting in 1995. Some of the unique characteristics of the field include decreasing water oil ratio over time, decreasing gas-oil ratio at the beginning of production, inability to calculate oil reserves in the field based on log data, and sustained oil rates over long periods of time.

To understand the unique characteristics of the field, an integrated evaluation was undertaken. Production data from the field were meticulously collected, and eighteen wells were cored and logged to better understand the petrophysical and engineering characteristics. Based on the work done in the first year, some of the preliminary conclusions can be listed as follows:

- Based on PVT analysis, the reservoir most likely produces from an oil rim with a gas cap on top of it.
- The reservoir appears slightly neutral to oil wet in characteristic.
- The production behavior of the reservoir can be explained by simplified model consisting of three stratified layers containing gas, oil and water respectively. Many of the characteristics are reproduced in both analytical and numerical models.
- Production performance from many of the Hunton wells exhibits similar declining characteristics. This should enable us to develop type curves for the field wide application.
- Out of the eighteen wells cored, ten wells have been geological described. Geologically, the reservoir appears very complex. So far, eleven facies have been identified in the reservoir. Close examination of porosity types has resulted in twelve different porosity types.

Future work in the project would include:

- Development of better PVT characteristics for the field.
- Build multi-well numerical models to reproduce the performance of the reservoir.
- To relate geology to petrophysical characteristics to understand reservoir continuity.
- To develop rock type-log correlation to extend the geological analysis to logged (non-cored) wells.
- To develop standard type curves for evaluating individual well performance.

On the technology transfer front, we will continue to update our web site, and send our first newsletter shortly.

Acknowledgement

The research effort described in this report was supported by the U.S. Department of Energy under Contract No. DE-FC26-00NT15125. Additional support is provided by Marjo Operating Company, Inc., the University of Houston, Joe Podpechan and James R. Derby and Associates, Inc. The computer facilities were provided by The University of Tulsa.

We would like to thank Brian Keefer from Marjo Operating Company, Inc. for his valuable contribution and insight to our work. Our special thanks also go to Rhonda Lindsey and Dan Ferguson from the Department of Energy for their enthusiasm and valuable suggestions.

April 2001

Mohan Kelkar

1. Introduction

The West Carney Field is located in Lincoln County, Oklahoma. The location of the field is shown in **Figure 1**. The field, which was discovered in 1980, produces from Hunton Formation in a shallow-shelf carbonate reservoir. The early development in the field was sporadic. Many of the initial wells were abandoned due to high water production and constraints in surface facilities for disposing excess produced water. The field development began in earnest in 1995 by Altex Resources. They had recognized that production from this field was only possible if large volumes of water can be disposed. Being able to dispose large amounts of water, Altex aggressively drilled several producers. With few exceptions, all these wells exhibited similar characteristics. The initial production indicated trace amount of oil and gas with mostly water as dominant phase. As the reservoir was depleted, the oil cut eventually improved, making the overall production feasible. The decreasing oil cut (ROC) behavior has not been well understood. However, the field has been subjected to intense drilling activity because of prior success of Altex Resources.

Currently, three operators dominate this area. Out of the three, we are working closely with Marjo Operating Company. The acreage of Marjo Operating Company is shown in **Figure 2** below. For this report, therefore, we will concentrate on this area.

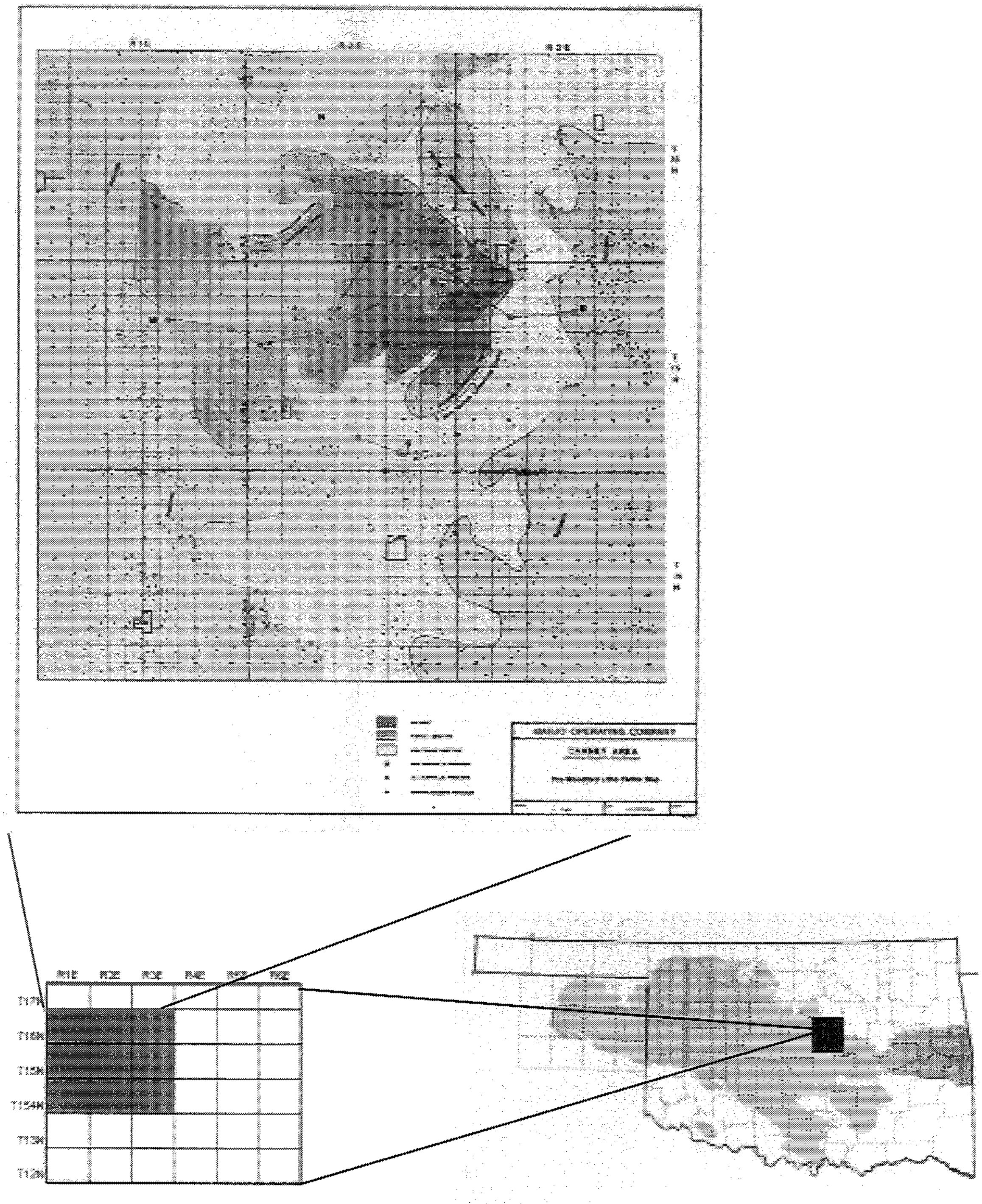

Figure 1: Location of the West Carney Field

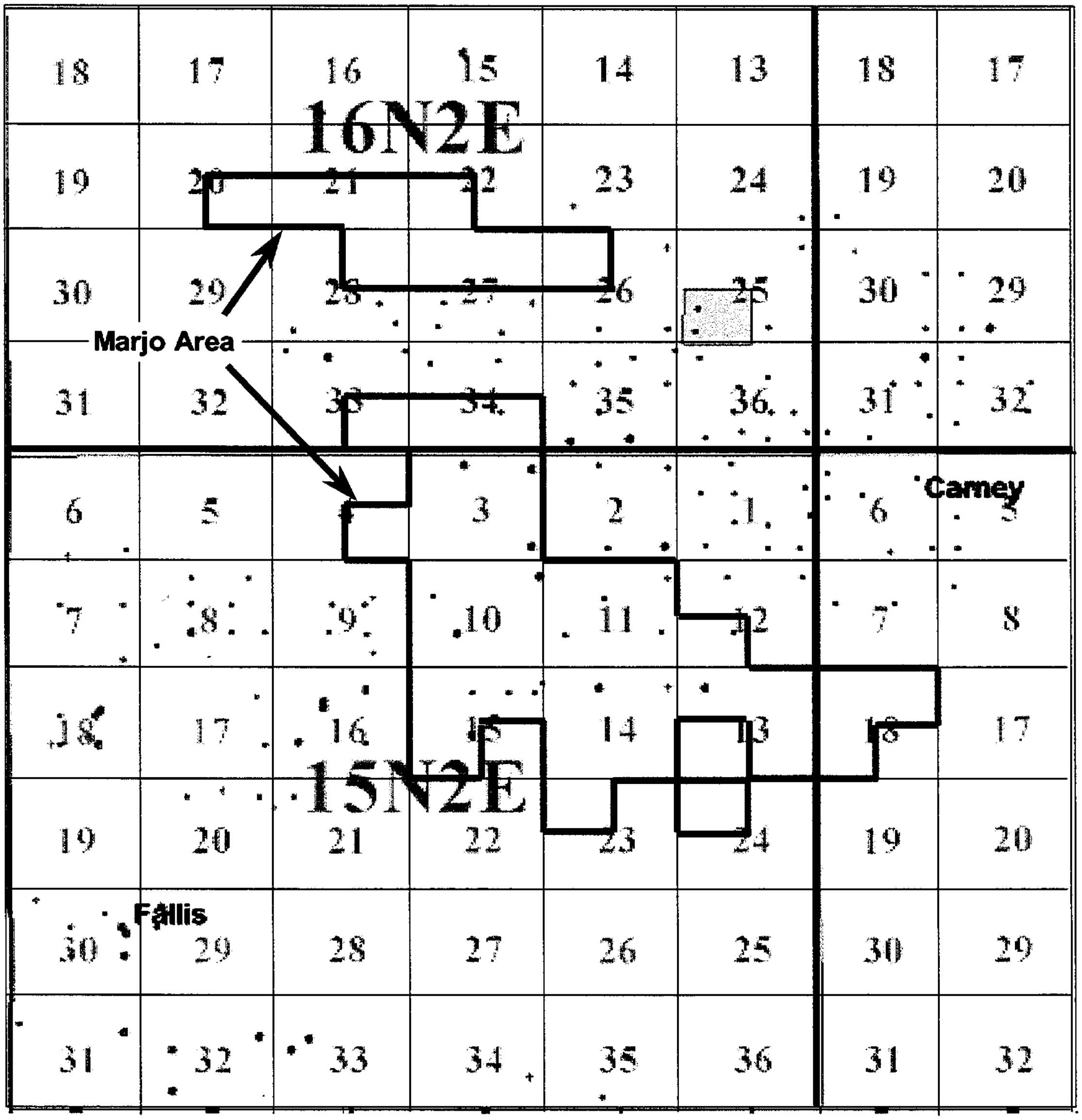

Figure 2: Marjo Operating Company acreage

In this work, we will investigate the primary production mechanism by conducting several core flood experiments. After collecting cores from representative wells, we will study the wettability of the rock and simulate the depletion behavior by mimicking such behavior under controlled lab conditions.

The excess water production also requires careful attention to optimize the performance of the reservoir. The excess water requires expensive surface handling facilities, increased lifting costs, additional disposal expense and reduction in well productivity due to increased hydrostatic head. To improve the water handling, we will examine implementation of a downhole separator. If installed successfully, much of the water can be disposed of in the Arbuckle Formation, which is below the Hunton Formation. This will reduce the produced water cut as well as the size of the surface facilities. Instead of using conventional water knock out; we intend to use liquid-liquid compact separators (LLCS). This will reduce installation and operating costs of surface water separation.

Another difficulty in producing from the Hunton Formation is the inability to correctly predict the well locations. At present, the locations of wells have been determined in a haphazard manner without significant geological consideration. To develop the entire field, it is imperative that the depositional model be clearly understood and quantified. This can be done by collecting core samples, running modern imaging logs and describing the geological facies in some detail. This will allow us to quantify the geological model, enabling a geostatistical description of lithofacies. By quantifying uncertainties in the model, the future well locations can be optimized. In addition, we would also like to correlate the facies data with the log data so that the core analysis can be extended to non-cored wells.

West Carney Field is at the beginning of an exploitation phase. All the wells are under primary production. However, the pressure in the reservoir is decreasing and eventually some additional mechanism will have to be used to recover the remaining resources. For proper exploitation of the reservoir, it is best that we examine alternate methods of secondary recovery. One possible method we are going to investigate is huff-n-puff of gas injection. We will investigate both CO_2 and flue gas as possible injection fluids.

Economic feasibility of producing oil from this field also depends on the initial oil in place. The prior experience in this field indicates that the initial oil saturation is difficult to determine based on conventional well logs. To remedy this problem, we need to understand where the oil is coming from. We also need to develop better production data analyses techniques to evaluate the performance of the wells. In addition, a single well tracer test also could be useful. It has the ability to investigate a much bigger volume than the log data and will be able to determine the initial oil saturation more accurately.

The overall project goal would be to validate our hypothesis and to determine the best method to exploit reservoirs exhibiting ROC behavior. To that end, we will collect and analyze core samples, and run a single well tracer test during the Budget Period I. We will continue to drill vertical wells during this period. Once we understand the mechanism and are able to quantify the geological model, in Budget Period II we will drill several additional wells. Depending on the feasibility, we will equip some of the vertical wells with a downhole separator, as well as a surface compact separator. This will allow us to compare the new technology with the existing one. In Budget Period III, we will monitor the field performance and revise and refine our models to further optimize the performance.

To ensure that the technology developed in this project is communicated to a wide cross-section of interested individuals, we will undertake an aggressive technology transfer program. This will include publishing and presenting papers at various technical meetings, publishing a semi-annual newsletter and conducting technical workshops for small operators and independents at the end of Budget Periods II and III.

2. Objectives

The main objectives of the proposed study can be summarized as follows:

- To understand and evaluate an unusual primary oil production mechanism which results in decreasing (retrograde) oil cut (ROC) behavior as the reservoir pressure declines.
- To develop better, produced water, disposal techniques so as to minimize lifting costs, surface separation costs and water disposal costs.
- To improve calculations of initial oil in place so as to determine the economic feasibility of completing and producing a well.
- To optimize the location of new wells based on understanding of geological and petrophysical properties heterogeneities.
- To develop correlation between rock types and log curves so that the evaluation can be extended to other areas where limited core data are available
- To develop decline type curves for evaluating performance of existing and new wells
- To evaluate various secondary recovery techniques for oil reservoirs producing from fractured formations.
- To enhance the productivity of producing wells by using new completion techniques.

3. Technical Progress

The summary of progress is divided into four sections. The first section discusses the field activities. The second section discusses the engineering progress. The third section discusses the geological work done so far. The last section presents the technology transfer activities.

3.1 Field Activities

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The field activities continued at hurried pace during the first year of the project. The operator (Marjo Operating Company) has drilled more wells than required by the Department of Energy. **Table 1** below lists the wells drilled in the field. The wells in bold represent the wells drilled after the project was initiated. The table also shows the wells that have been cored. A total of twenty-nine wells have been drilled – two of them are disposal wells. With the exception of one well – which is horizontal – all the other wells are drilled as vertical wells. In the original proposal, we had intended to core six wells, and extend the core analysis to other logged wells. Subsequently, based on the encouraging results, the operator has decided to core most of the newly drilled wells. To date, we have data from eighteen cored wells. Because of the extensive nature of cored wells, we did not see the need to collect any formation micro-scanner logs. Instead, we ran a standard suite of logs (neutron, density, gamma ray, micro, resistivity) in each of the drilled wells.

Table 1: List of wells drilled by Marjo Operating Company

Well Name	Location Section	Twp/Blk	Rng/Survey	Disposition/Position	Drilling Data	Drilling Completed	Well Completed
Ables 1-34	C SE SW Sec. 34	16N	2E	Gas Producer		4/3/00	4/10/00
Alan Ross 1-11	11	15N	2E	Oil Producer		7/14/99	
Anna #1-15	SE NW NE Sec. 15	15N	2E	Oil Producer	Core (Hunton) 4967-5010.	9/13/00	9/29/00
Bailey #1-6	SW Sec. 6	15N	3E	Oil Producer			
Bailey #2-6	SE NE SW Sec. 6	15N	3E	Oil Producer	Core from 4876-4936.	12/6/00	
Bailey 1-6	SW/4 Sec 6	15N	3E	Oil Producer		11/23/97	
Boone #1-4	C SW SE Sec. 4	15N	2E	Oil Producer	Core Hunton	8/7/00	8/21/00
Carney Townsite #2-5	NW NW NW Sec. 5	15N	3E	Oil Producer	Cored Hunton from 4906-4966.	11/6/00	11/27/00
Carney Townsite 1-5	5	15N	3E	Oil Producer		3/2/00	
Carter #1-14	C NE SE Sec. 14	15N	2E	Oil Producer		9/1/00	
Carter Ranch #2-15	NW NW SE Sec. 15	15N	2E	Oil Producer	Core Hunton 5006-5041.	1/27/01	2/7/01
Christy 1-15	15	15N	2E	Oil Producer			2/26/00
Danny 1-34	SE/4 Sec 34	16N	2E	Oil Producer		3/23/00	3/28/00
Danny 2-34	C SE SE Sec. 34	16N	2E	Oil Producer	Cored Hunton lm from 4930-4989.	5/8/00	
Denney #1-31	31	16N	3E	Oil Producer	Hunton was not cored.	8/16/00	8/24/00
Franny 1-11	11	15N	2E	Oil Producer		7/24/99	
Garrett 1-11	11	15N	2E	Oil Producer		12/8/99	
Geneva #1-32	32	16N	3E	Oil Producer		12/22/99	
Geneva #2-32	C NE SW Sec. 32	16N	3E	Oil Producer	Cored from 4889 to 4898.	1/12/01	2/1/01
Gerry #3-6	Sec. 6	15N	3E	Oil Producer			
Gerry 2-6	SW NW NW Sec 6	15N	3E	Oil Producer	Pipe got stuckdifferentially in hunton	10/17/98	10/28/98
Green #1-26	SW NW Sec 26	16N	2E	Oil Producer	uphole. Lost 50 bbls mud in top of	5/8/99	
Henry #1-3	NW/4 Sec 3	15N	2E	Oil Producer		4/15/00	
Joe Givens #1-15	15	15N	2E	Oil Producer	HCl. Formation broke @ 1500#.	6/24/00	
Katheryn #1-14	14	15N	2E	Oil Producer	circulation @ 5198', Lost circulation	10/27/99	
Kathryn #2-14	NW NW NW Sec. 14	15N	2E	Oil Producer	Cored Hunton (4994-5037).	12/20/00	1/15/01
Lewis #1-14	14	15N	2E	Oil Producer	7 7/8" pilot hole to 660' and reamed	10/7/99	
Mary Marie #1-11	11	15N	2E	Oil Producer		1/6/00	
Mary Marie #2-11	11	15N	3E	Oil Producer		4/26/00	5/2/00
McBride North #1-10	10	15N	2E	Oil Producer		3/13/00	
McBride South #1-10	SE/4 Sec. 10	15N	2E	Oil Producer		7/25/00	8/3/00
Parkview #1-3	C SE SE Sec. 3	15N	2E	Oil Producer		1/31/00	2/14/00
Patsy #1	SE Sec. 6	15N	3E	Oil Producer			
Patsy #2				Oil Producer			
Patsy #3	SE Sec. 6	15N	3E	Oil Producer			
Pearl #1-12	12	15N	2E	Oil Producer		8/3/99	
Pearl SWDW #1	15	15N	2E	Disposal	out	9/21/99	
Ranch SWDW #1	SW SW NE Sec 3	15N	2E	Disposal	6851'. Unstick bit and use 5 7/8"	6/10/00	
Schwake #1-10	10	15N	2E	Oil Producer		11/27/99	
Toles #1-10	10	15N	2E	Oil Producer		2/11/00	
Townsend #1-13	13	15N	2E	Oil Producer		11/6/99	
W. Carney Ext. SWDW	5	15N	3E	Disposal		2/28/01	3/12/01
White #1-27	C W/2 SE NE Sec 27	16N	2E	Oil Producer		6/25/99	
Wilkerson #1-3	N/2 S/2 NE NE Sec 3	15N	2E	Oil Producer		1/20/00	
Wilkerson #2-3	3	15N	2E	Oil Producer	14 jts 10 3/4 surface pipe and cmt	10/20/00	10/31/00
Williams #1-3	SW Sec. 3	15N	2E	Oil Producer		7/12/00	
Wilson # 1-6	SW NE NE Sec 6	15N	3E	Oil Producer			

3.2 *Engineering Analysis*

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This section is divided into several sub-sections. In the first sub-section, we will discuss some of the preliminary observations from the field. In the second sub-section, we will present some of the results from PVT analysis of the reservoir sample fluid. In the third sub-section, we will discuss the results from the core studies. In the fourth sub-section, we will present an analytical model, which was developed to reproduce the field performance. In the fifth sub-section, we will discuss the results from numerical studies to help us understand the field behavior. In the last sub-section, we will present the results of production data analysis.

3.2.1 Field Observations

To establish primary mechanism by which oil is being produced from the West Carney field, we first need to identify the unique production characteristics observed in the field. Specifically, Hunton Formation exhibits four anomalous characteristics:

- Water oil ratio over time decreases – For most wells, when the well is completed, it would produce large quantities of water with limited quantities of oil. Over time, the water production would decrease, and oil production will slightly increase resulting in lowering of water oil ratio.

- Gas oil ratio over time decreases, and then increases – For many wells, at the initial stages of production, the gas oil ratio is very high. As the production continues, the gas oil ratio will decrease over time. During the later stages of well production, the gas oil ratio will increase again.

- Gas oil ratio shows an increase for most wells when the wells are shut-in – When the well is shut in for workover, and is opened back, the gas oil ratio will temporarily increase, and will slowly decrease over time. This is consistent with previous observations.

- In some wells, when the well is shut-in, instead of observing pressure buildup, pressure drawdown is observed – normally, when the well is shut-in, it exhibits an increase in pressure over time, which can be used to determine reservoir properties. For some wells in the Hunton Formation, if the well is shut-in, the pressure will decrease over 24 hour period indicating some type of back flow in the reservoir.

- No correlation exists between fluorescence and oil production – the wells that indicate high fluorescence may not be very productive wells. On the other hand, the wells, which indicate poor fluorescence, can be good productive wells. This indicates lack of correlation between log data and productivity of a well. This also poses difficulty in predicting reserves based on the log data.

3.2.2 PVT Analysis

To understand the fluid characteristics in the field, we collected a sample fluid from Schwake Well (No. 1-10) located in SW quarter of Sec. 10–15N-2E. The API gravity of oil is 43 indicating a light oil and the gas gravity is 0.84 indicating very rich gas. Knowing the existing gas oil ratio and the individual composition of the liquid and gas streams, a well stream composition was created, and was tested under constant composition expansion (CCE). The mixture exhibited a dew point of 7,000 psia – an unrealistic number – which is not very useful. See **Figure 3** below which indicates that the behavior is similar to a standard condensate reservoir with percentage of liquid volume slowly increasing and then decreasing till it reaches zero value at about 7,000 psia.

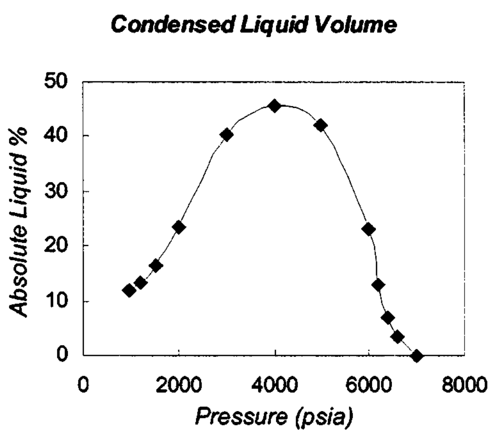

Figure 3: Condensed liquid volume in CCE experiment

That is, the mixture indicated that it is in two-phase region, but was originally a condensate fluid. Since we did not have the fluid sample at the original reservoir pressure, it is difficult to guess what the physical state of the fluid was at initial conditions. It is, however, also true that the initial reservoir pressure is less than 2,100 psia. Therefore, the dew point pressure of 7,000 psia has very limited meaning. Although it is hard to conclusively predict what type of initial condition existed in the reservoir, the fluid analysis indicates that the most likely physical state is a gas cap with oil rim below the gas cap. Obviously, we also need to account for the presence of water in the reservoir. The current model is based on this assumption.

3.2.3 Core Studies

The main goal of the core studies is to understand the primary mechanism by which the oil is produced. As part of the understanding, we conducted several wettability tests, as well as measured relative permeabilities in selected cores.

Consider a scenario. If an oil-saturated, fractured reservoir is flooded with brine, then brine flushes out the oil from all the fractures first. The level of brine imbibition into the matrix depends on the level of water wettability of the matrix. If the matrix is water-wet, then large amounts of brine is imbibed and the oil saturation falls to the residual oil saturation, typically of the order of 30% to 40%. If the matrix is oil-wet, brine is not imbibed into the matrix spontaneously and the oil saturation stays high. Application of high brine pressure does not produce more oil because this oil is trapped in disconnected matrix blocks. If the matrix is mixed-wet, the amount of water imbibition can be correlated directly to the Amott water index, and the oil saturation will be intermediate between the last two cases. Let us presume that this reservoir is oil-wet or mixed-wet and was invaded by brine before the discovery of the reservoir. At the discovery, the fractures will be filled with brine and the matrix blocks with oil primarily. When the wells are drilled and pressure falls at the wellbore, the fractures would produce brine first. The oil in the matrix blocks would expand until the bubble point is reached after which solution gas would come out of the oil. This expansion would increase the hydrocarbon (oil & gas) cut and decrease the water cut with time. The amount of oil production during the primary production would depend on both the solution gas ratio and the initial oil saturation, which in turn depends on the wettability of the matrix. Thus, the two variables that need to be ascertained to validate this scenario are wettability and initial oil saturation. The objective of the first phase of this project is to determine wettability and water-oil relative permeability of core samples to help decipher the primary depletion mechanism of the reservoir.

3.2.3.1 Methodology

The relative permeability was determined by the unsteady state method in the native state. The wettability was determined by the Amott method. Core plugs, as received, were scanned by a CT scanner to detect vugs and fractures. Dead reservoir crude oil was injected into each core with some backpressure to remove all gas. The oil pore volume was determined by a tracer test. For relative permeability, cores were then waterflooded at room temperature and pressure. Pressure drop and effluent oil cut were monitored. JBN analysis was used to extract the imbibition relative permeability. The water pore volume was then determined from a second tracer test. An oil flood was then conducted to determine the drainage relative permeability.

For wettability, a core plug was placed in an imbibition cell filled with brine after the determination of initial oil pore volume. The amount of oil expelled from the core was monitored as a function of time. After brine imbibition ceased, brine was injected into the core and the production of oil was monitored. The brine pore volume was then determined by a tracer method. The plug was then placed in an imbibition cell filled with reservoir dead oil. The amount of spontaneous oil imbibition was monitored. After the cessation of oil imbibition, the core was flooded with reservoir dead oil and water production was monitored. The amounts of spontaneous and forced imbibitions are used in calculating Amott wettability.

After the wettability and relative permeability tests, the cores were weighed and then extracted in a Dean-Stark extractor. This extraction gave the brine volume. The core was then vacuum dried. The difference between the dry weight and the saturated weight gave the fluid weight. The oil volume was calculated from the difference between the total fluid volume and the brine volume. Porosity and air permeability of the dry core were measured.

3.2.3.2 Results

The cores analyzed are listed in **Table 2**. They are all limestone except for Core 7, which is a dolomite. A composite core was prepared by juxtaposing together Cores 1 and 2 and the relative permeability of the composite was determined. Core 3 was used for relative permeability where as it's adjacent core (Core 4) was used for Amott wettability determination. It was observed that the spontaneous imbibition is small in these cores. In Core 5, spontaneous imbibition is first measured and then relative permeability is measured during the forced imbibition test. Thus both Amott wettability and relative permeability are measured on the same core. Cores 6 and 7 were found to be fractured. Thus relative permeability and wettability tests could not be run on these two samples.

Table 2: List of cores studied

Core	Well	Depth
1	Mary Marie	4967.7
2	Mary Marie	4967.7
3	Mary Marie	4968.6
4	Mary Marie	4968.7
5	Wilkerson	4974.9
6	Danny	4972
7	Boone	5065.5

The CT scan images of Cores 3 and 4 are shown in **Figures 4-7**. Figure 4 shows the cross-sections at 2, 4 and 6 cm from one edge of Core 3. Figure 5 shows the longitunal sections through the same core. The darker regions in the image are lower density regions and correspond to vugs. Many vugs are apparent in these scans. There were no visible fractures in these scans. Figures 6 and 7 show the cross-sectional and longitudinal CT sections of Core 4. Again, a few vugs were visible, but no fractures. The major (visible) fractures in such formations are vertical and have a low probability of intersecting cores. We observed visible fractures in Cores 6 and 7.

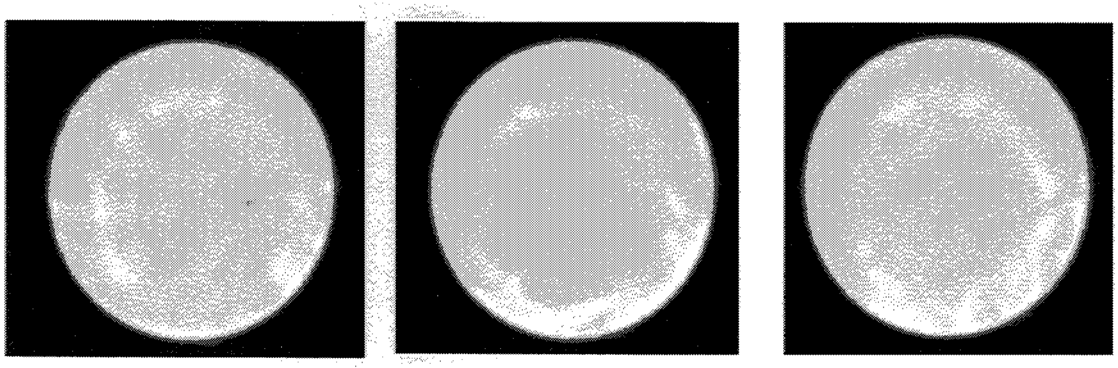

Figure 4: Cross-sectional CT scans at 2, 4, and 6 cm from one side of core 3

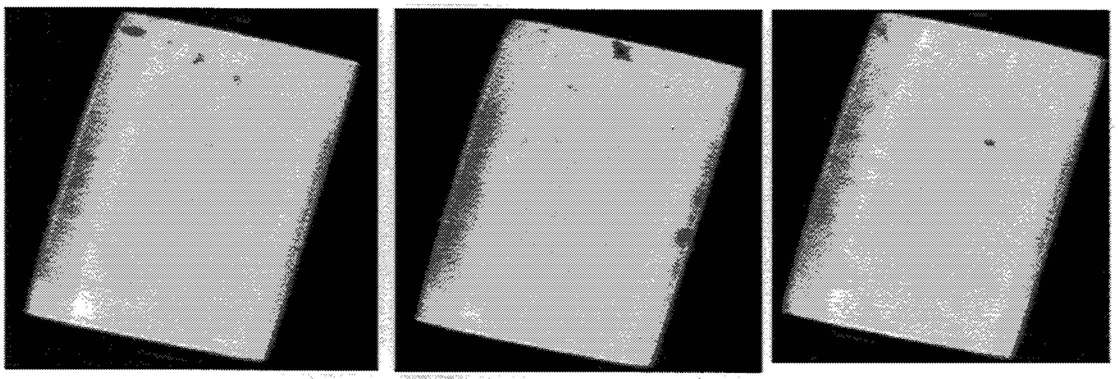

Figure 5: Longitudinal CT scans of core 3

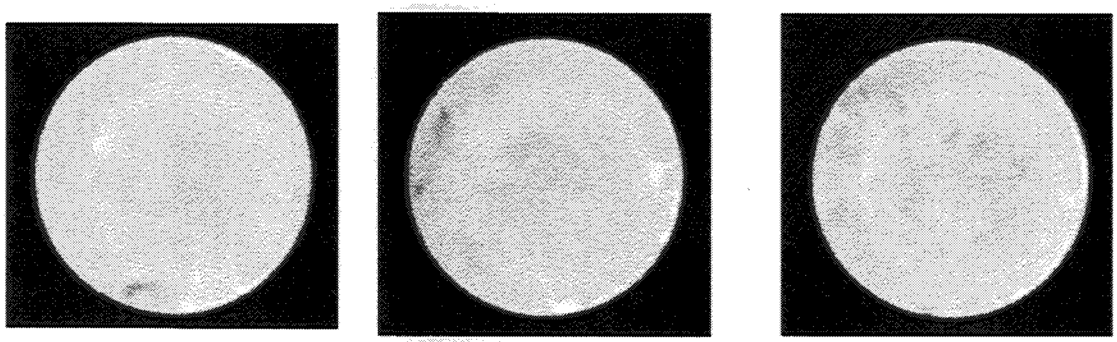

Figure 6: Cross-sectional CT scans at 2, 4, and 6 cm from one side of core 4

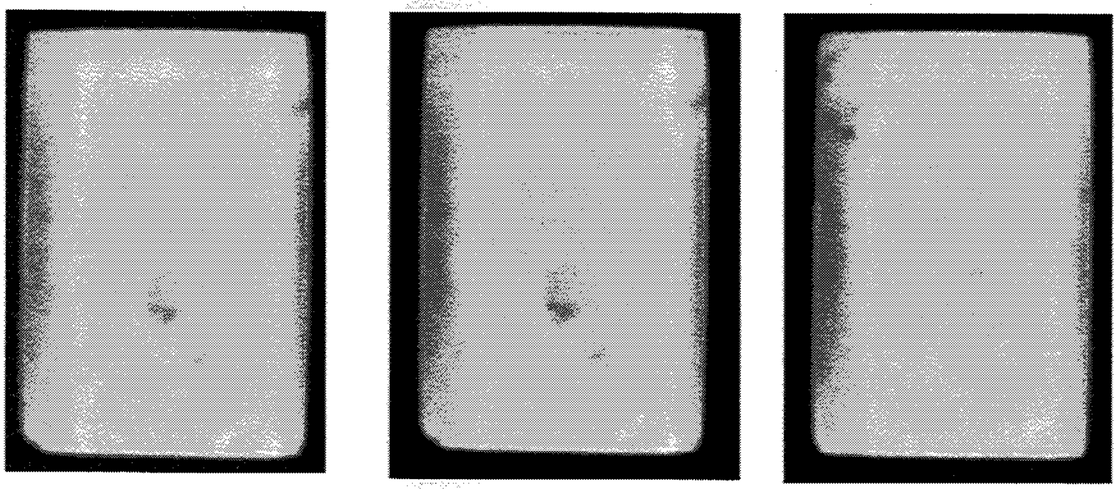

Figure 7: Longitudinal CT scans of core 4

Imbibition relative permeabilities have been measured in cores (1&2), 3 and 5. **Figures 8-9** show these relative permeabilities. It can be observed that the brine relative permeability at residual oil saturation is consistently above 0.2, typical of mixed/oil-wet reservoirs. This end-point relative permeability is below 0.1 for water-wet reservoirs. The brine-oil crossover relative permeability is above 0.1, another indication of mixed/oil-wettability. The initial brine saturation is low, from 2% to 25%. The relative permeability curves tend to move to the right with the initial brine saturation. Oil occupancy in microporosity can explain such behavior.

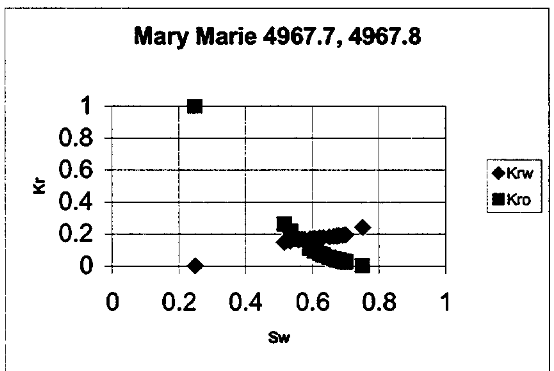

Figure 8: Imbibition relative permeability of core 1 and 2 composite

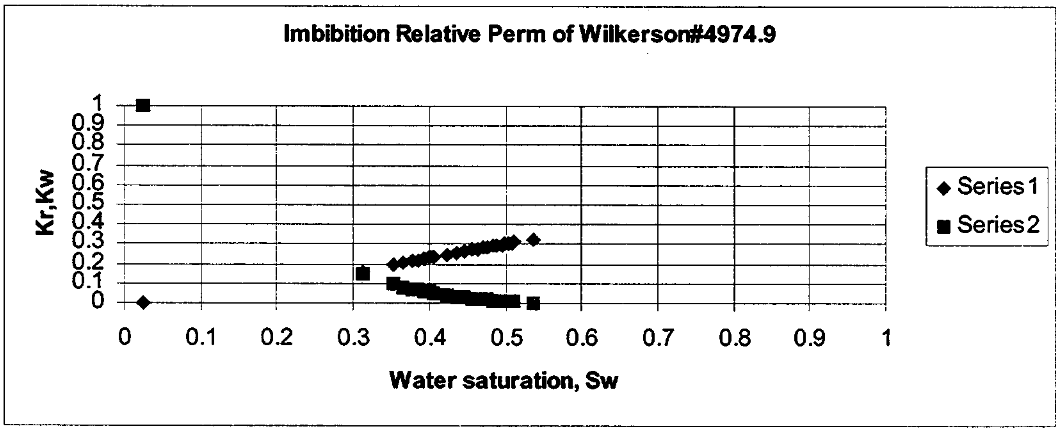

Figure 9: Imbibition relative permeability of core 3

The drainage relative permeability of Core 3 is shown in **Figure 10**. The residual brine saturation is much higher than the initial brine saturation. This behavior was seen consistently in all cores.

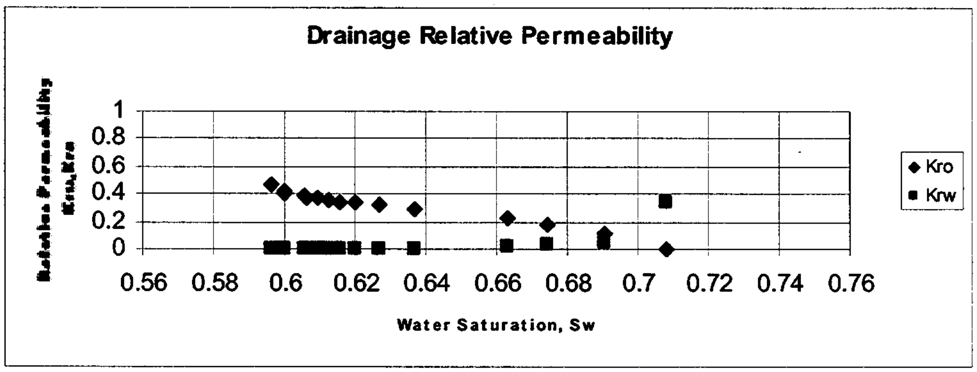

Figure 10: Drainage relative permeability of Mary Marie 4968.6

The Amott index of wettability was measured for Core 4. The brine index is 0.11 and the oil index is 0.15, resulting in an Amott wettability index of –0.04. The Amott index is being measured for Core 5. The brine index is 0. This wettability index indicates a mixed-wet or neutral wet formation.

The preliminary conclusions based on the core analysis are:

- CT Scans show that most cores used were not fractured though they contained a few vugs. Two of the cores had visible fractures.
- The Amott wettability index close to zero lends weight to our hypothesis that the rock material is neutral or mixed wet.
- End point imbibition relative permeability close to 0.2 for brine further supports the observation that the rock matrix is neutral/mixed wet.
- Large hysteresis was observed between imbibition and drainage, especially in residual brine saturation.
- Imbibition relative permeability data of all the cores studied were similar except for a shift for initial oil saturation.

In the next year, we will conduct more relative permeability / wettability studies and investigate the potential for improved oil recovery.

3.2.4 Analytical Model

Based on the field observations, we first decided to build a simple analytical model. Although the reservoir produces significant amount of gas, we assumed that the reservoir model consists of two layers having inter-layer crossflow. The upper layer is the oil layer having zero horizontal permeability and the bottom layer is initially filled with water. The bottom layer has high horizontal permeability so that it would produce first, resulting in lowering of pressure. As the well is drilled, the layer pressure in the water zone is depleted and the oil migrates into the bottom layer and gets produced along with the water.

3.2.4.1 Assumptions

1. ρ_o and ρ_w are constant.

2. Water and oil formation volume factors are equal.

3. Viscosities of two-phases are assumed to be the same.

4. Both the oil and water layers are homogeneous. The oil layer's horizontal permeability is zero.

5. The relative permeabilities are linear functions of saturations,

$$k_{rw} = 1 - k_{ro}$$

or,

$$k_w = kk_{rw} = k(1 - k_{ro})$$
$$k_o = kk_{ro}$$

where k is the absolute permeability.

The detailed derivation of the final expression is provided in Appendix A. However, in dimensionless form, the solution for the oil layer can be written as,

$$\bar{p}_D = \frac{\cos\sqrt{s}z_D}{s\cos\sqrt{s}}$$

where the solution is written in Laplace space, which can be inverted into real space. The dimensionless terms are defined as,

$$z_D = \frac{z}{h}$$
$$t_D = \frac{kt}{\phi\mu c_t A}$$
$$p_D(z_D, t_D) = \frac{P_i - P(z,t)}{P_i - P_2(r,t)}$$

As can be seen from this derivation, the pressure in oil layer depends on the pressure in the bottom layer – which is a water layer. The solution for water layer can be written as,

$$\bar{p}_D = \frac{K_1(\sqrt{u}r_{eD})I_0(\sqrt{u}r_D) + I_1(\sqrt{u}r_{eD})K_0(\sqrt{u}r_D)}{s[K_1(\sqrt{u}r_{eD})I_0(\sqrt{u}) + I_1(\sqrt{u}r_{eD})K_0(\sqrt{u})}$$

This solution is also in Laplace space, which needs to be inverted into real domain.

3.2.5 Numerical Model

Although analytical model is useful to understand the general behavior of fluids, it involves several approximations. It does not account for gas phase, which is being produced, and it does not account for the relative permeability values of different phases. The numerical model is designed based on the production characteristics of the field. The model consists of three layers having an independent gas layer not in communication with the other two layers, which are oil, and water layers. The water layer has very high permeability due to the fractures. This is consistent with PVT properties observation that the reservoir consists of oil rim underneath a gas cap. The typical characteristics we want to reproduce from numerical experiment are.

1. Decreasing gas-oil ratio.
2. Increase in gas-oil ratio after the well was shut-in.
3. Association of oil production with that of water production.
4. Decreasing water-oil ratio.

3.2.5.1 Single-Well Model

To start with, we began with a model to reproduce a single-well performance. We used 160 acre spacing typical of the reservoir. We made the following assumptions.

1. High values of horizontal and vertical permeability for water layer were used to accommodate for the fractures.
2. The horizontal permeability of oil layer is zero.

3. Vertical permeability of gas layer is zero as it is assumed to be independent of the other two layers.

Figure 11 below shows the schematic of the single-well model.

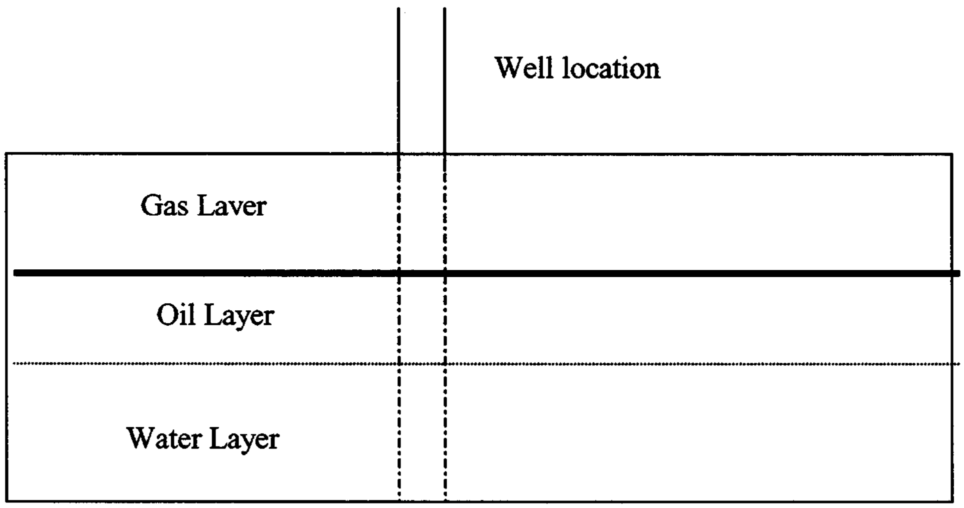

Figure 11: Single-well model

In this model, the uppermost zone is the gas layer, the middle zone is the oil layer and bottom zone is high permeability water layer. In the oil layer, horizontal permeability is negligible and thus the oil flows into the water layer and gets produced along with the water. This results in the initial increase of oil production rate as exhibited by the wells. We have considered the gas layer to have no cross-flow with the other two layers in order to capture the typical behavior of the increase in gas-oil ratio after the shut-in.

Using this model we tried to match the production behavior of the Schwake Well. The Schwake Well was considered as the base because of the availability of continuous bottom hole pressure data, which is used in normalizing the production data. The rock properties used to generate these results are consistent with the core and log data. To incorporate for the fractures in the water layer we used relatively high values of permeability.

Figure 12 shows the production behavior of the Schwake Well and the results from the numerical model.

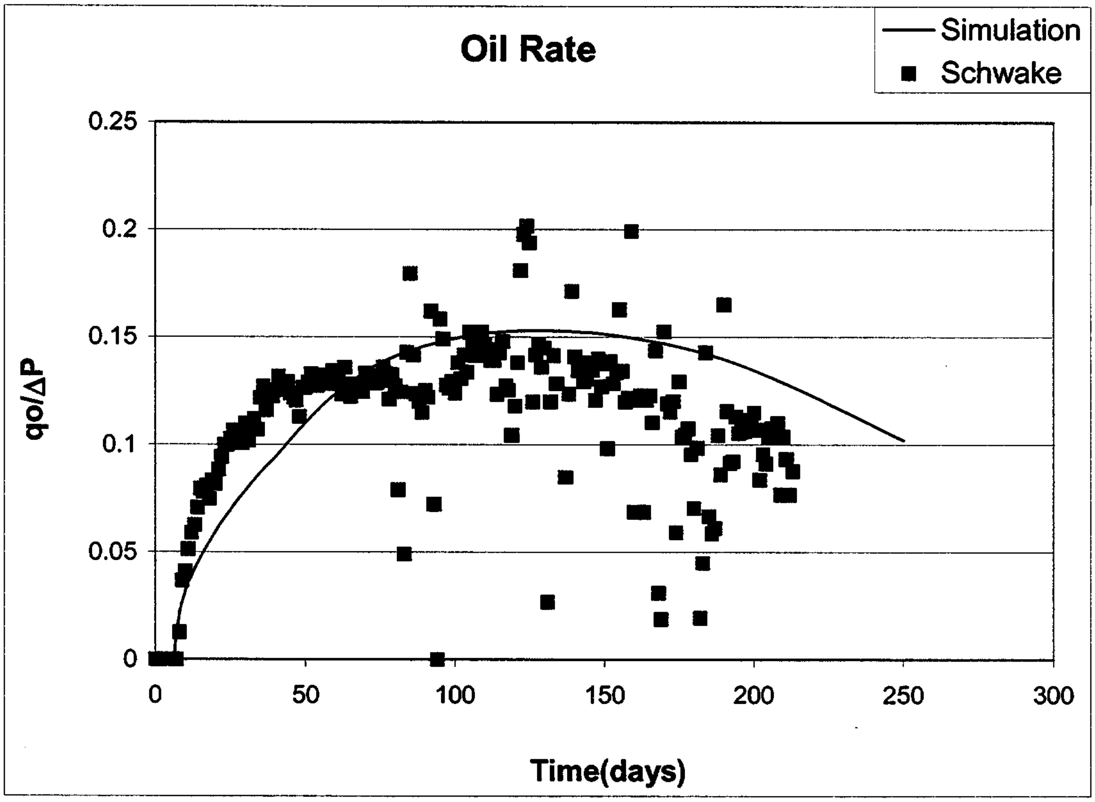

Figure 12: Match between actual and simulated oil rates

The above plot shows the normalized oil rate with respect to time and it can be seen that the results of the numerical model matches well with that of the actual data from Schwake Well. There is no initial oil production from a well. As the water layer pressure is depleted, the oil moves into the water zone and starts producing. The numerical model could capture the initial increase in oil rate and after reaching a maximum at about 55 days it starts declining. The reason for this being the oil coming from the water layer and thus takes time to reach the maximum production rate.

Figure 13 below shows the performance of gas rate as a function of time. Again the match is reasonable and exhibits a typical behavior observed from a well. Gas rate decreases at the beginning, and slowly starts increasing. Notice that the initial rapid increase in the gas rate could not be captured in the model. We still do not understand the reason for this quick increase.

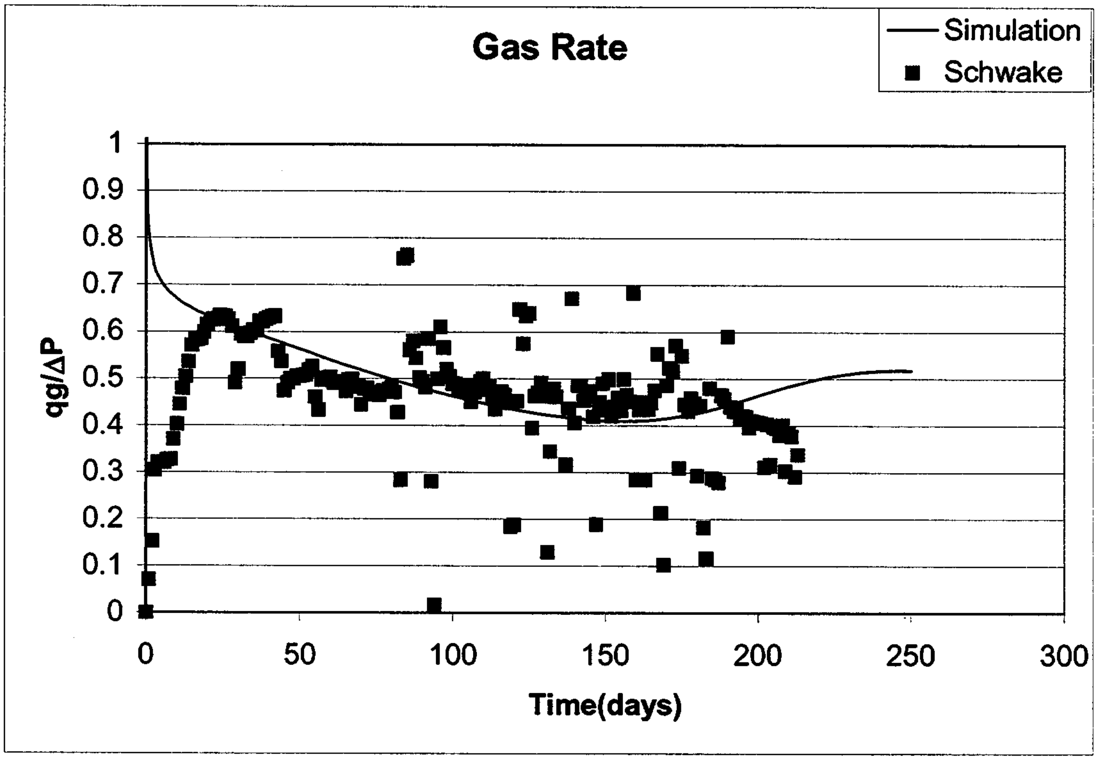

Figure 13: Match between observed and simulated gas rates

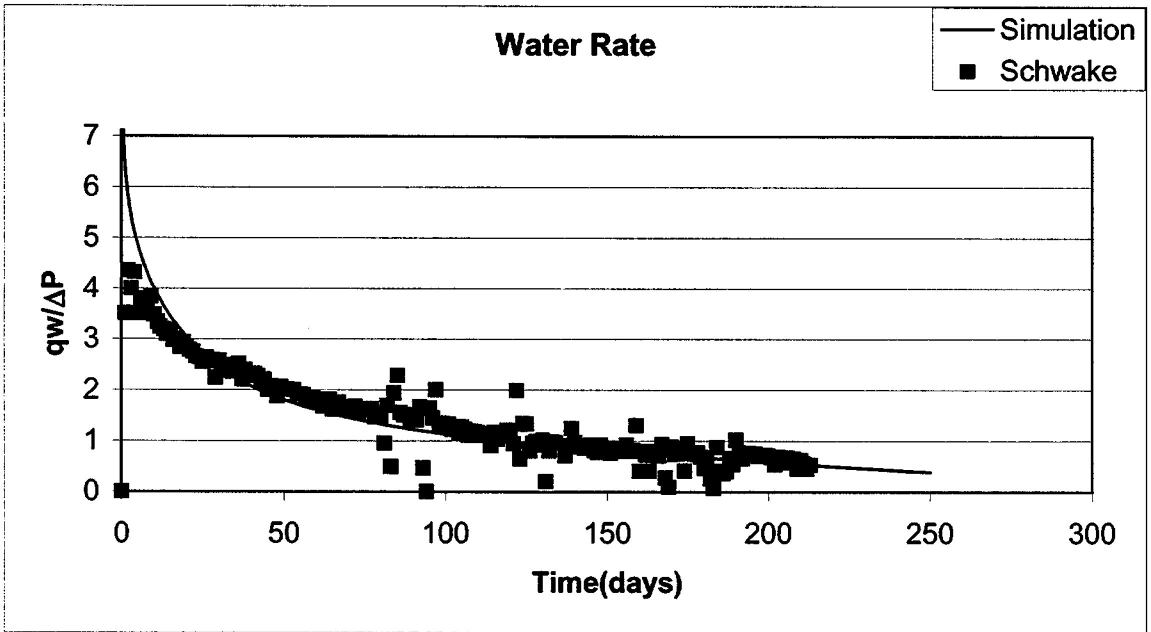

Figure 14: Match between observed and simulated water rates

It can be seen from **Figure 14** the model could regenerate the water production profile of the Schwake Well.

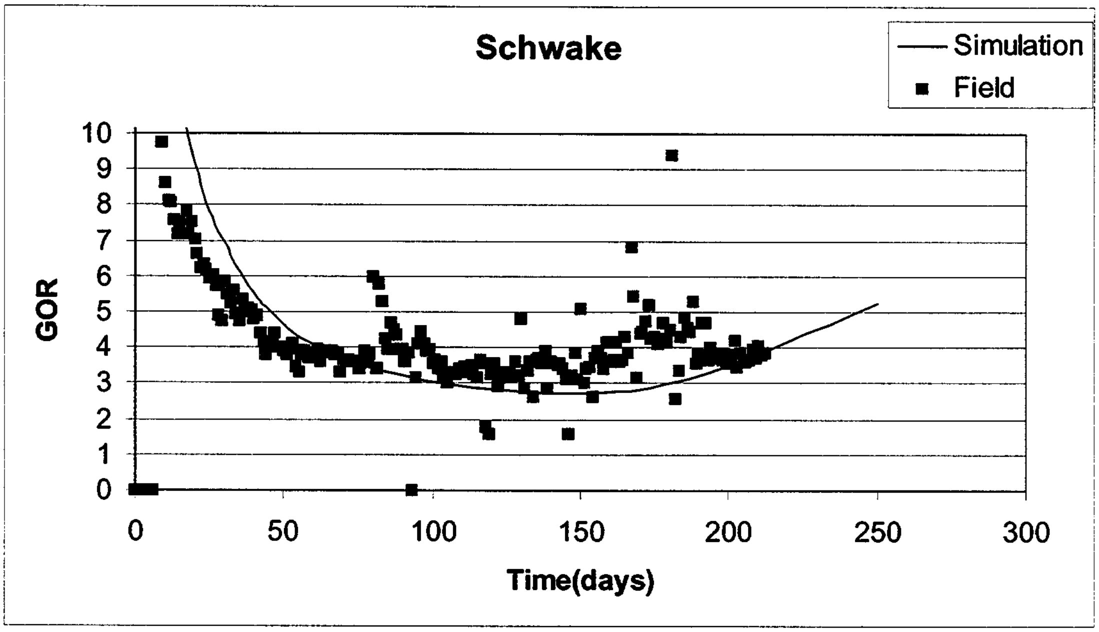

Figure 15: Match between observed and simulated GOR's

Figure 15 above shows the gas-oil ratio. The discrepancy in GOR between the actual field data and the model at early times is due to the difference in the gas rates. As explained earlier the model could not match the initial increase of gas rate as observed in the field.

3.2.5.2 Multiple Well Model

One of the difficulties in this reservoir is that all the wells do not exhibit the same behavior in early stages of production. Wells like Schwake exhibit performance, which indicates a slow increase in oil rate over time, whereas, some other wells in the field, the decline in the oil rates is more conventional. To explain this discrepancy, we built a multi-layer model. To explain this characteristic we considered the field to have continuous water zones, but non-continuous oil and gas zones. The well was placed in this part of the field and the adjacent well was produced for sometime so that the oil flows into the water layer because of the pressure difference. This could be equated to a single layer model exhibiting the same behavior as observed in the field. **Figure**

16 shows a schematic of multi-well, multi-layer model. The impermeable zone surrounding the well #2 is a 40-acre area. There is no oil and gas associated with well #2.

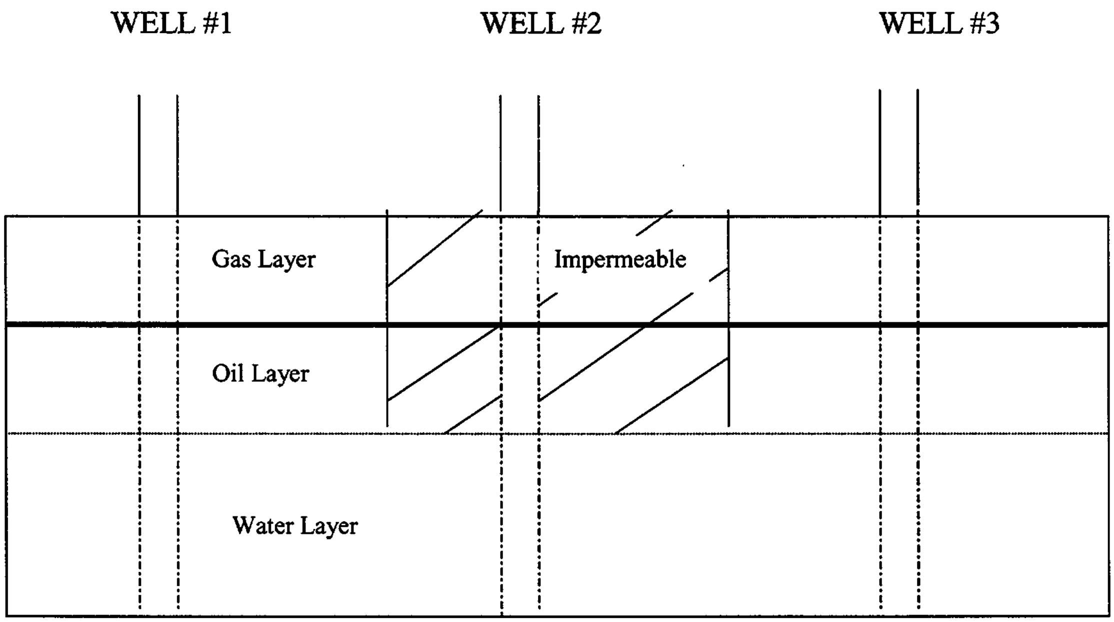

Figure 16: Schematic of multi-well model

The above diagram explains the multi-well model having three wells. The well #1 starts producing at a time when the virgin pressure exists in the field and thus this well shows the behavior similar to the Schwake Well. Due to the production from well #1 the pressure in the water layer gets depleted resulting in the migration of oil into it. This also affects the region where well #2 and well #3 are located as the water layer is continuous and has high permeability. Thus, when well #2 and well #3 start producing they show the typical declining behavior of oil and gas production. **Figure 17** below shows the oil rate behavior for wells #2 and #3 after well #1 has produced for a long time.

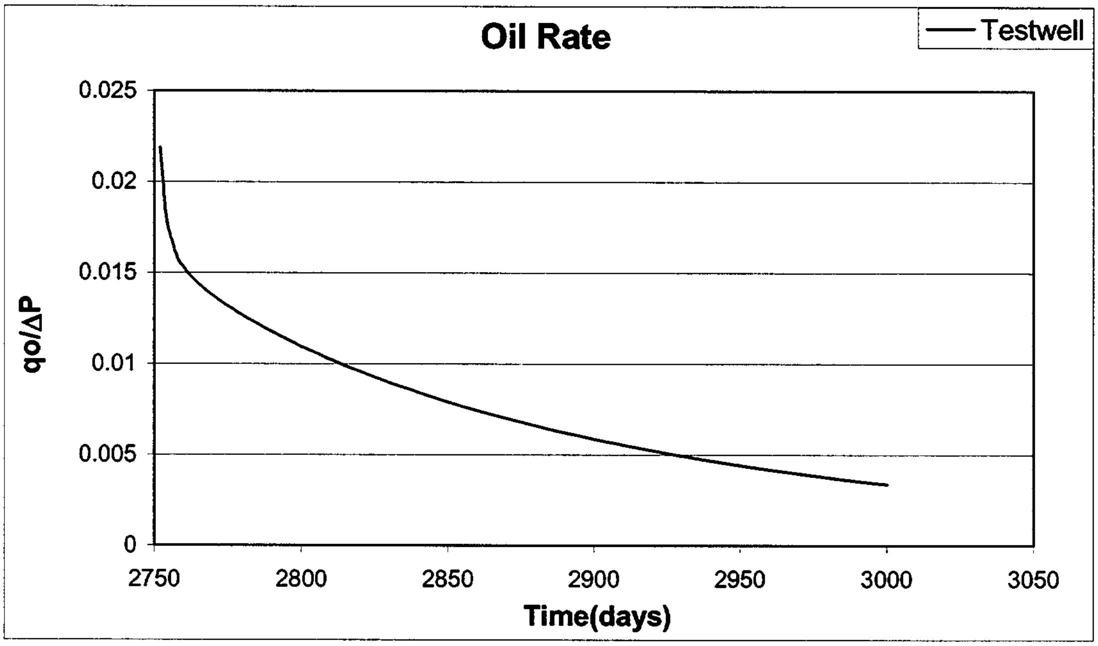

Figure 17: Oil Rate vs. time for Well 3

This plot shows the oil rate for the well #3 and it can be seen that it shows the typical declining behavior. Both **Figures 18** and **19** show similar behavior for gas and water rates as well.

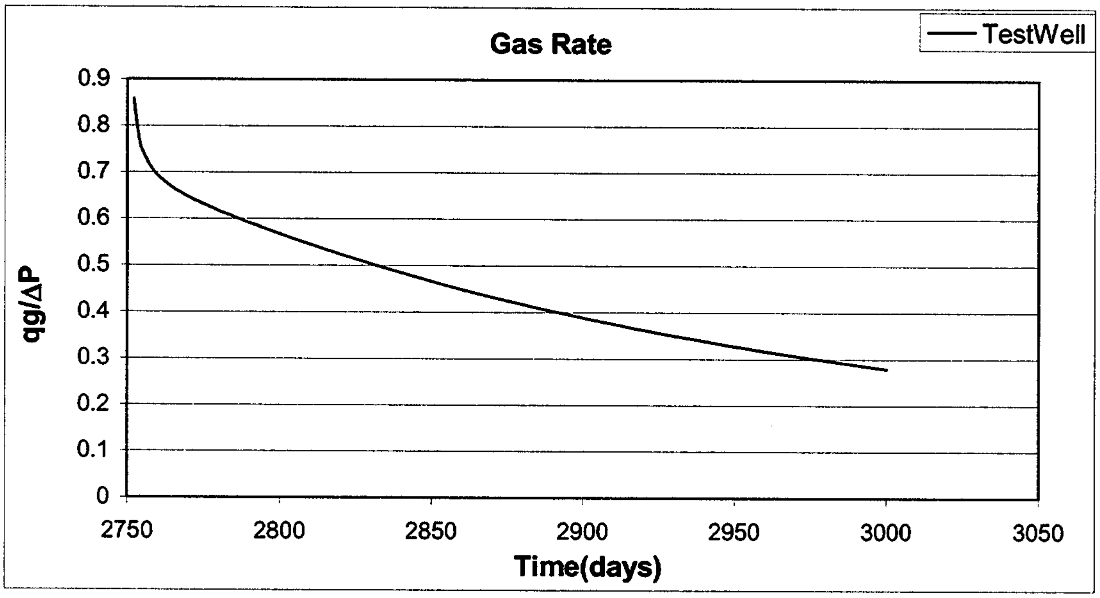

Figure 18: Gas rate as a function of time for Well 3

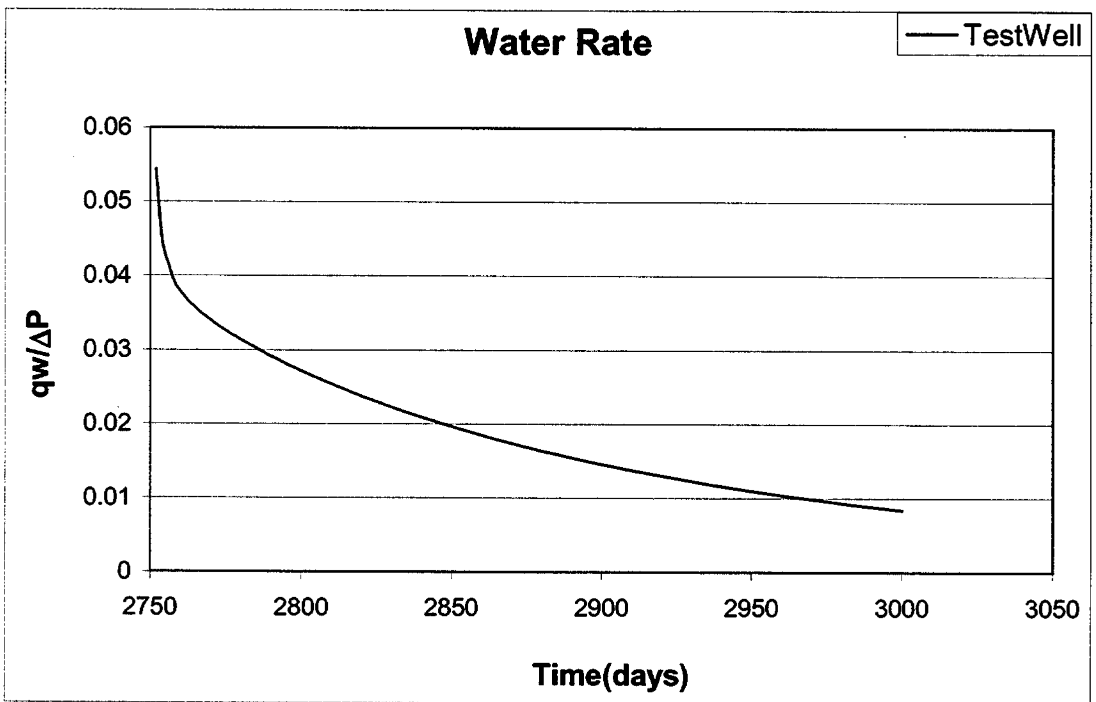

Figure 19: Water rate as a function of time

It is evident from the above results that we are able to qualitatively produce the results from the numerical model. In the future work, we need to build more geologically realistic model based on geological input, and also incorporate some of the relative permeability results which are collected as part of the study.

3.2.6 Production Data Analysis

Part of the engineering analysis involves evaluating production performance of existing wells so that any common characteristics, if present, can be captured. If certain production characteristics are repeated in most of the wells, then these characteristics can be used to predict the performance of other wells producing from the same or similar fields.

With this view in mind, production rates were plotted on a log-log plot as a function of time. To account for variations in bottom hole pressures, we normalized the rates with pressure drop in the reservoir as a function of time. For some wells, we had the well flowing measurements available as a function of time. For other wells, we had to estimate those values based on the limited data.

Figure 20 shows the plot of oil rate vs. time on log-log plot for many wells in the field. The log-log plots are shifted such that the coordinate axes remain parallel to each other. Each different symbol represents a different well. Although there is a considerable variation in the rates, by lateral shifting, the production from these different wells overlays on top of each other. This indicates that certain production characteristics are common to all these wells. It is worth noting that some wells show an increase in oil production rates at the beginning. This is a unique feature in this field, and as explained in the previous section, is a result of how the oil is produced at the beginning. For wells, which are drilled in the later stages, the oil production declines much more normally over the time period of observation. It is also worth noticing that we are able to see that the production captured covers both the transient as well as pseudo-steady state decline. This should help us in determining many of the reservoir parameters and to be able to predict the reserves, as well as future performance of the individual wells.

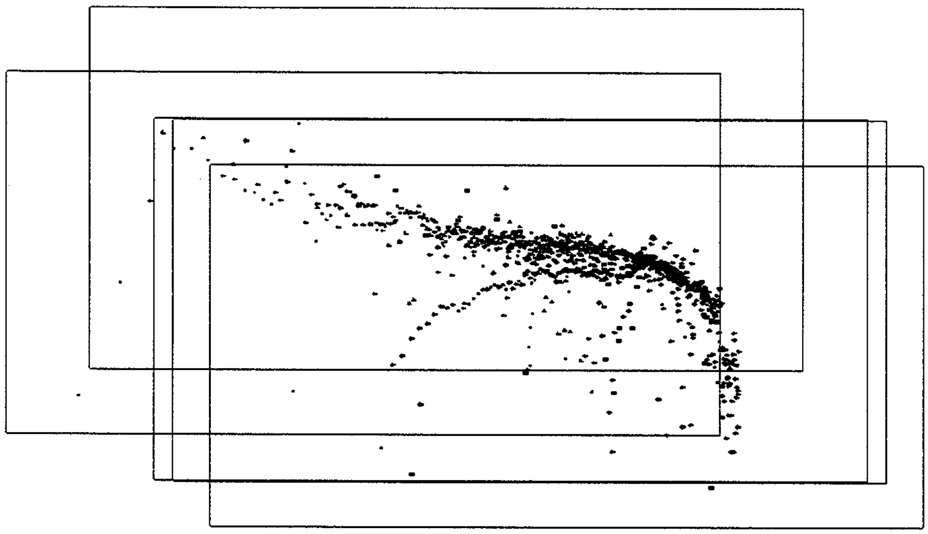

Figure 20: Oil rate vs. time on log-log plot

Figure 21 shows the behavior of gas production as a function of time, and **Figure 22** shows the behavior of water production as a function of time. Similar to oil rates, both gas and water rates also show characteristic decline for all the wells presented in this plot. One important difference worth noting is that for gas rates, some wells exhibit similar behavior to oil where the rate increases at the beginning, and then slowly decreases. However, for water rate, the decline is much more conventional. This behavior is consistent with the observations made in the previous two sections regarding the type of reservoir from which oil and gas is being produced.

Future work will involve developing appropriate type curves suitable for the entire reservoir based on the production characteristics of representative wells. In addition, we will also develop a regression algorithm, which can calculate the reservoir parameters based on the production data evaluation. We will further test the type curves as well as our algorithm for wells producing from other fields in similar formations.

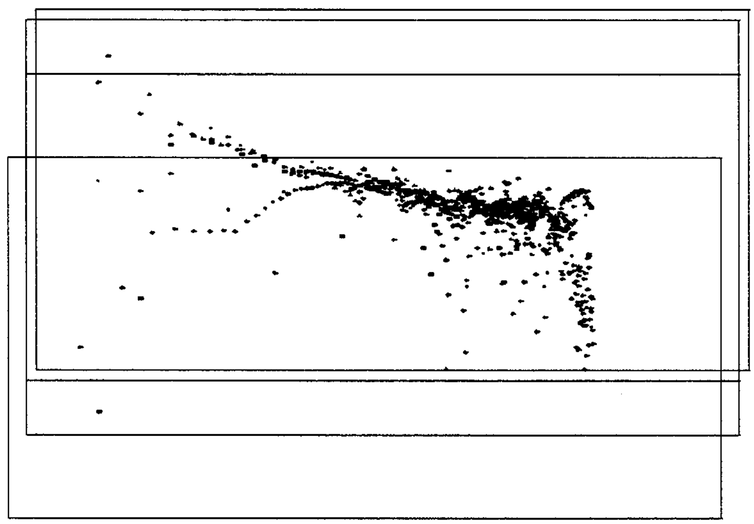

Figure 21: Log-log plot of normalized gas production vs. time

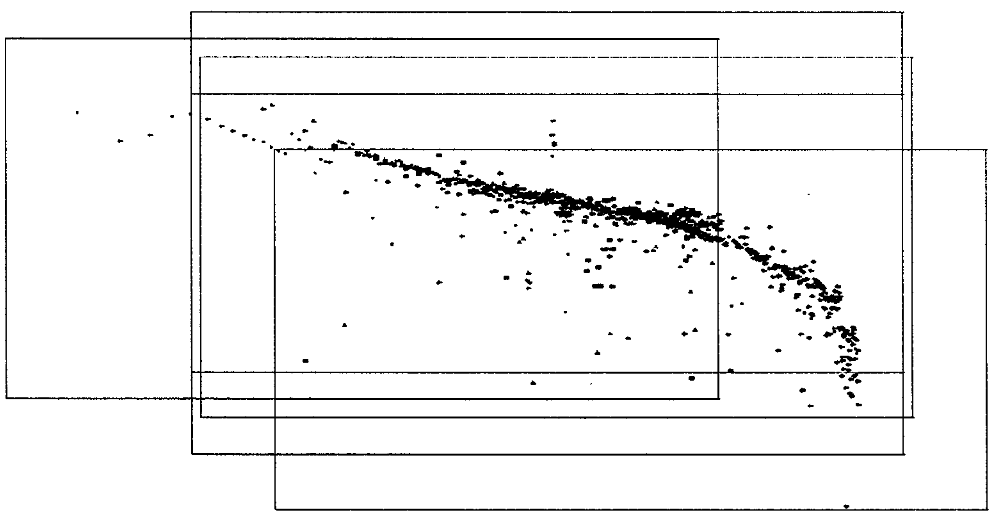

Figure 22: Log-log plot of normalized water rate vs. time

3.2.7 Miscellaneous Engineering Aspects

In our original proposal, we had indicated that the water disposal problem is one of the important considerations, and we would like to evaluate downhole separators (DHOWS) to dispose off the water in lower formations. Subsequent to submittal of the proposal, we re-evaluated the application of DHOWS for a typical well in the West Carney Field. Since the submittal, we had drilled several wells and had collected additional data from many wells. When economic evaluation was run on a typical well, we observed the following results as listed in **Table 3** below. As can be seen from the table below, the NPV without DHOWS is higher than with DHOWS. Because of higher operating costs, the cumulative production is also higher without DHOWS than with DHOWS. Considering the risk and uncertainty involved in installing the DHOWS, it appears that it is not feasible to test it at this time. We are in communication with the manufacturer and have relayed this information to them. If more efficient DHOWS comes in the market, which makes the economics look better, we would be willing to re-visit this issue.

Table 3: Cost comparison

	Case 1: Without DHOWS	Case 2: With DHOWS	Case 1-Case 2
NPV (M$)	$ 568.278	$ 558.814	$ 9.464
Np (Mbbls)	81.478	78.998	2.480
Gp (MMscf)	244.434	236.993	7.441

In addition to DHOWS, we are also going to test a compact water oil separator to improve the efficiency of field separation. Currently, such a separator is being tested on The University of Tulsa campus under lab conditions. When it is ready to be tested in the field, we would install it to compare its efficiency with more conventional separators.

3.3 Geological Analysis

James R. Derby, James R. Derby & Associates
Sandeep Ramakrishna, The University of Tulsa

The West Carney Field is located on the west side of Carney, Lincoln County, Oklahoma. Numerous authors have described the Hunton Group of central Oklahoma. All agree that the Hunton is a Shallow-Shelf Carbonate Reservoir. Johnson[1] in a review of Anadarko Basin strata (Carney Field is on the North Shelf of the basin) states:

"Middle Ordovician through earliest Mississippian sediments throughout the Oklahoma basin consist of fossiliferous shallow-water carbonates interbedded with...clastic sediments..." The sequence includes...."carbonates of the Hunton Group....".

More recently, Hunton has been reviewed in the context of sequence stratigraphy. Scott[2] states:

"During the Silurian and Early Devonian, an east-west carbonate platform bordered a basin in southern Oklahoma. These carbonate units have long been mapped as the Hunton Group, which contains important hydrocarbon reserves in the Mid-Continent."

In the same publication, Fritz and Medlock[3] state:

"The Hunton Group, also of the Tippecanoe sequence, ranges in age from uppermost Ordovician to Lower Devonian. The Hunton was deposited on a shallow carbonate ramp and is composed primarily of shallow-water mudstones and wackestones, grainstones are also common. Marlstones are developed in the distal part of the ramp."

The most complete and authoritative work is that of Amsden[4] in which he describes the lithology and facies of the Hunton from Township 10E to the western border of Oklahoma from outcrop studies and 125 well cores. His maps show in detail the distribution and facies of each of the Hunton formations throughout the area (see **Figure 23**). From Amsden's descriptions it is clear that the Hunton Group strata in the Carney and Coyle Fields was deposited in a Shallow-Shelf environment.

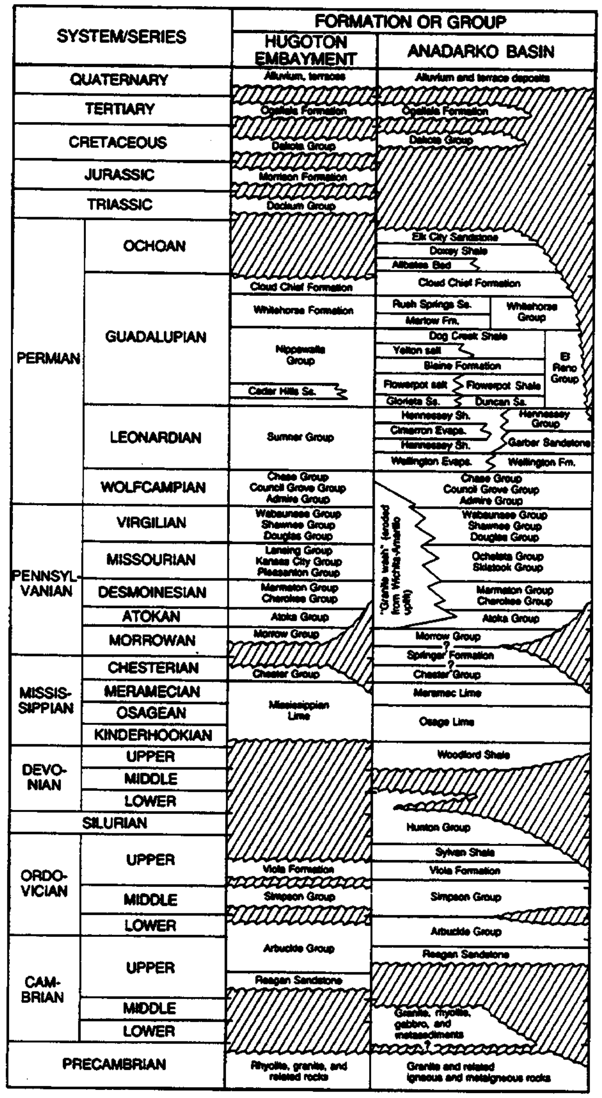

Figure 23: Stratigraphic column for the Anadarko basin and Hugoton embayment.[5-6] Height of formation/group boxes is not related to thickness of unit.

The Carney Area is northeast, and paleogeographically, more shoreward from the outcrop exposures of the Hunton Group in the Arbuckle Mountains of south central Oklahoma. Amsden[4] describes the Arbuckle Mountain outcrops of the Hunton units found in the Carney area as follows:

"...an upper Henryhouse Formation..., which is a fossiliferous marlstone, and a lower Chimneyhill Subgroup...., composed mainly of organo-detrital limestones, commonly with oolite of the Keel Formation at the base...However to the north and northwest the Henryhouse marlstones grade into *Kirkidium*-bearing limestones and the entire Silurian section is dolomitized, so the relationships between the Chimneyhill and the overlying *Kirkidium* biofacies is obscured."

Note that the Hunton Group ranges in age from Late Ordovician to Early Devonian. Note also that the strata equivalent to the Henryhouse Formation in central Oklahoma are referred to the *Kirkidium* Biofacies, a term that Amsden uses as if it were a formation name.

In contrast to the fossiliferous marlstones (*fossiliferous mudstones and wackestones of the Dunham classification-writer)* of the Henryhouse Formation, the *Kirkidium* Biofacies is "a grain-supported, organo-detrital limestone, mostly with micrite cement but including some spar."[4] It is commonly oolitic, and locally develops a fair amount of primary porosity. Amsden[4] comments that the "mudstone lithology (of the Henryhouse Formation), would seem an unlikely texture for primary porosity"...and that of the 58 fields Kunsman[7] reported as producing from the Henryhouse Formation, "...many of these certainly represent strata that are herein referred to the *Kirkidium* Biofacies." The *Kirkidium* Biofacies fauna includes the name-giver large brachiopod, crinoids, solitary and colonial corals including *Halysites*, stromatopoids, trilobites, bryozoa, and ostracodes; clearly a Shallow-Shelf fauna.

Amsden[4] states "Chimneyhill sedimentation was initiated by oolitic deposition that appears to represent a shallow-water, reasonably high-energy deposit....The Keel oolite was followed by deposition of the Cochrane and Clarita, which represent sheets of organic debris spread out on the sea floor cemented with micrite or spar....both the Cochrane and Clarita appear to have been deposited in relatively quiet water, possibly the outer neritic zone....Benthic (fossil) forms such as crinoids, trilobites, and ostracodes are abundant, along with brachiopods and mollusks, corals are uncommon."

The Hunton Group is a composite of seven formations, each separated by an unconformity, as shown in **Figure 24.**[3] The effect of these unconformities is to produce repeated zones of paleokarst, and a complex system of truncation of the units, as shown in Figure 24. The Carney Area lies in an area where the top is deeply truncated, it is possible that the "Henryhouse" Formation is totally removed in the Carney Area. The Hunton in the Carney Area is generally considered to be Chimneyhill Subgroup, but the precise identity and age of the stratigraphic units in the field are yet to be determined. The possibility exists that units as young as the Frisco are present in the field, as elsewhere the Frisco is known to overlie all older units of the Hunton Group.

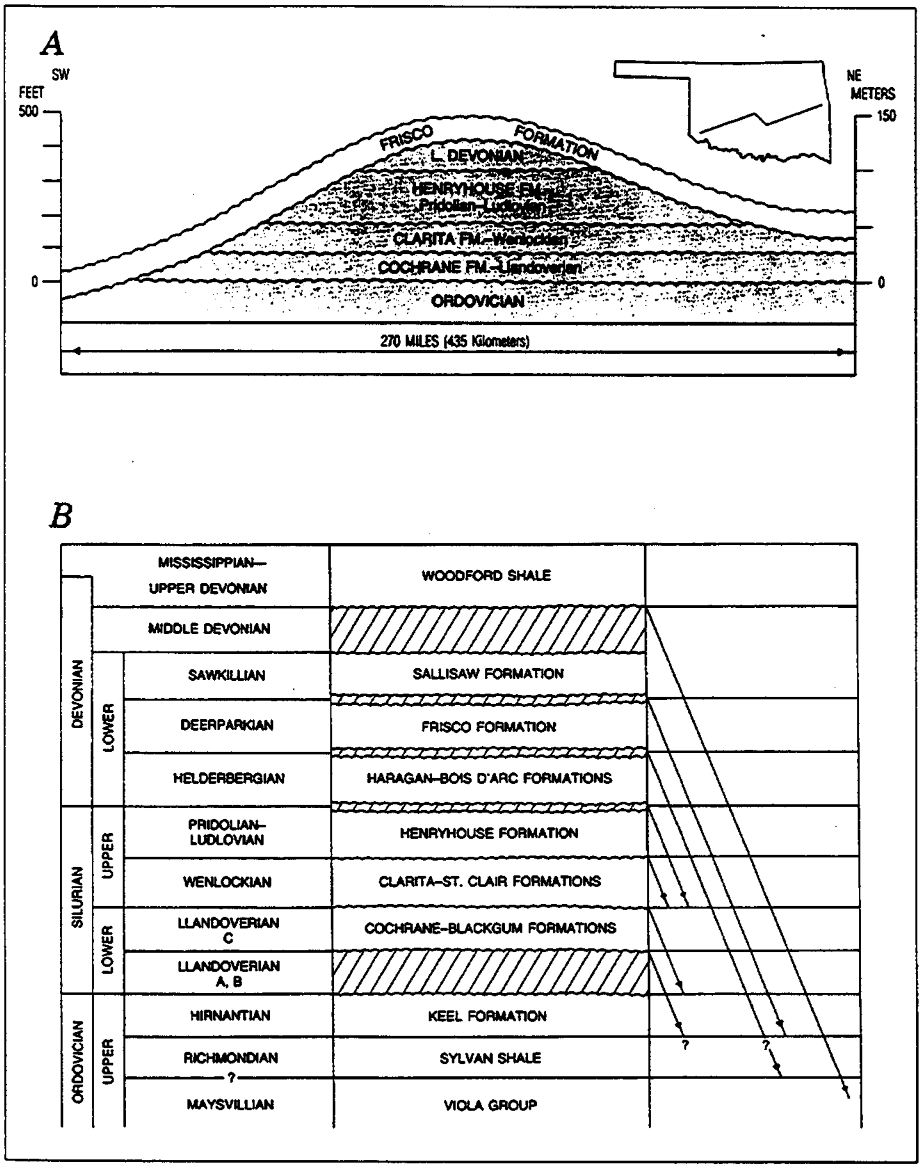

Figure 24: Diagrammatic representations based on brachiopod and conodont data within the Hunton Group: (a) stratigraphic section showing the uncomfortable relationship between the Frisco Formation and the underlying Devonian and Silurian strata, and (b) chart showing the stratigraphic division recognized in Oklahoma and adjacent areas with arrow indicating the known point of maximum truncation.

In addition to the above discussion, the reader is also referred to a recent very useful review of the Hunton Formation by Rottman, et al.[8] As this is a work in progress; this is not intended to be a finished product. The Data on which these preliminary conclusions are based are all included in Appendix B.

3.3.1 Stratigraphy

At the onset of this study, it was uncertain which formation or formations of the Hunton Group were present in West Carney Hunton Field (WCHF). It was generally assumed that the Chimneyhill Subgroup was present, but many contended that it is the Clarita Formation that is present. The logs in WCHF (see Appendix B) clearly show that the Hunton Limestone is a single unit, uninterrupted by shale or major lithologic changes. The is no evidence in both logs and cores, of the Prices Falls Member (a shaly unit) of the Clarita. At this time, it is clear that at least the basal 56 feet of the Hunton in WCHF is Cochrane Formation. The Keel does not appear to be present; nor is there any evidence of younger Hunton formations.

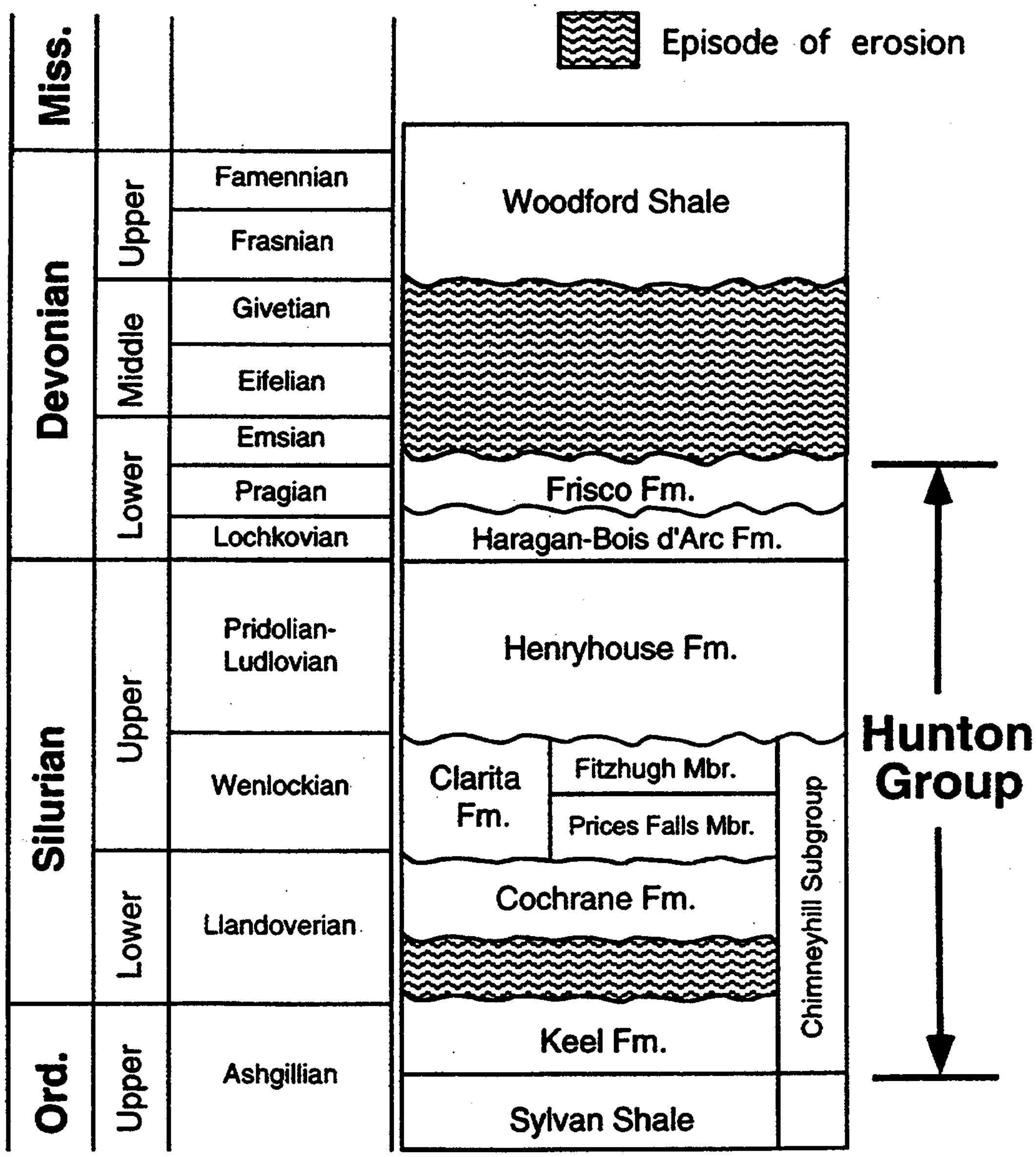

Figure 25: Stratigraphy of the Hunton and associated formations.[8]

Paleontological studies by Dr. James E. Barrick of Texas Tech University (see Appendix B) has determined that the Hunton Group in the West Carney Hunton Field, as studied to date, is entirely Earliest Silurian (middle to late Aeronian stage, Middle Llandovery) in age, and therefore entirely falls within the interval considered to be the Cochrane Formation. This is the earliest of the wholly Silurian Formations of the Hunton Group.

The Conodont evidence suggests that the Cochrane in WCHF is Middle Llandovery, not Late Llandovery in age.

No evidence has developed for the presence of the Keel Fm (latest Ordovician to earliest Silurian) or of any of the overlying formations of the Hunton Group. Although the Cochrane has been extensively karsted in the WCHF, we have no evidence of significantly younger, such as Devonian Woodford; faunas being carried down into the Cochrane during karst cave dissolution and infill. This suggests that the principal karsting events are early, intra-Hunton.

3.3.3.1 Physical Stratigraphy

The rock sequence contained in the 10 cores analyzed to date appears to represent one depositional cycle or sequence in the Early Silurian. Facies are largely grain-supported fossilferous grainstones and packstones, with minor wackestones. Very little carbonate mudstones are present. The Environment of Deposition appears to be mostly open marine shelf, in water depths of less than 60 meters. One well, the Carney Townsite, may include shoal water to shoreline facies.

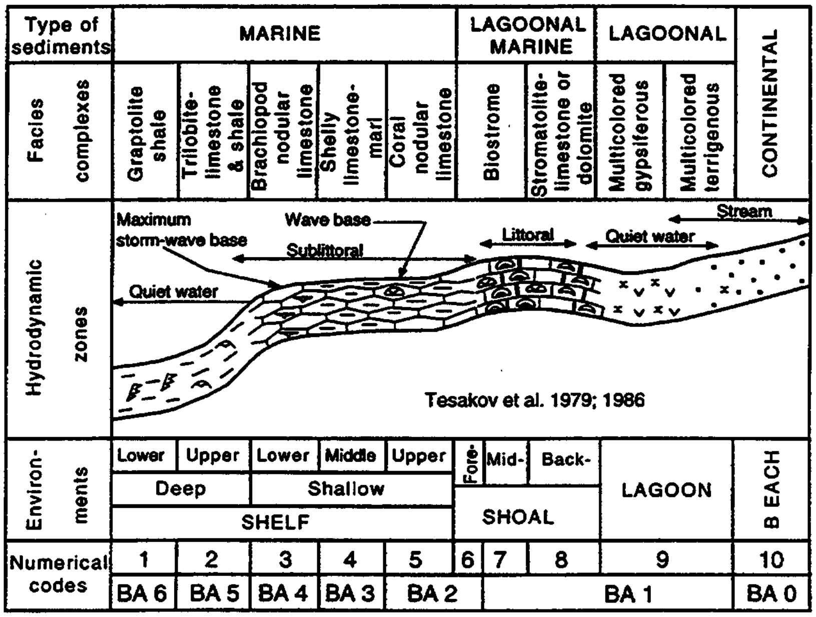

Figure 26: Facies model for Early Silurian Shores and Shelves of North America and Siberia. B.A. 0 – 6 indicate Benthic Assemblage zones.[9]

BATHYMETRY OF EARLY SILURIAN MARINE COMMUNITIES								
Welsh Basin ZIEGLER (1965)		Williston Basin JOHNSON & LESCINSKY (1986)		Michigan Basin JOHNSON & CAMPBELL (1980)		East Iowa Basin JOHNSON (1980)		depth (m)
0	Rocky shore	0	Red beds & frosted sands					0 ±
1	Lingulid	1	Stromatolite	1	Stromatolite			0–10
2	Eocoeliid	2	Coral–Stromatoporid	2	Coral–Stromatoporid	2	Coral–Stromatoporid	10–30
3	Pentamerid	large size variation in Cyclocrinitid algae		3	Pentamerid	3	Pentamerid	30–60
4	Stricklandiid	small	lower photic zone limits			4	Stricklandiid	60–90
5	Clorindid	BEADLE & JOHNSON (1986)						90–120
6	Graptolite	Sedimentary Environments						120–?
← clastics →		← platform carbonates →						

Figure 27: Depth ranges of Silurian Benthac assemblages.[11]

In the 10 cores described to date and from photos and core analyses of 4 others, eleven distinct facies are identified within the Hunton; the distribution of these facies is highly variable from well to well. The list of facies codes, below, lists 14 Facies, 3 of which (1, 13, 14) do not occur in the Hunton (see Appendix B).

3.3.1.2 Facies Types

All facies can be recognized in limestone, partially dolomitized limestone, and dolomite, so long as the allochems are recognizable. Facies #2 is the descriptor for completely recrystallized (or totally crystalline of primary origin) rock in which no pre-cursor sediment is recognizable. The specific rock type is described in the pore code, which distinguishes between limestone, partially dolomitized limestone, and dolomite.

1. Argillaceous Dolomite (Greenish-gray, resembles Sylvan Fm)
2. Crystalline Dolomite (No fossils or allochems identifiable)
3. Small Brachiopod Grainstone/Packstone/Wackestone
4. Fine Crinoid Grainstone/Packstone/Wackestone
5. Coarse Crinoid Grainstone/Packstone
6. Mixed Crinoid-Brachiopod Grainstone/Packstone/Wackestone
7. Big Pentamerid Brachiopod Coquina
8. Coral & Diverse Fauna
9. Coral & Crinoid Grainstone-Wackestone
10. Sparse Fossil Wackestone
11. Mudstone, carbonate
12. Fine- Medium Grainstone
13. Shale (Woodford, Sylvan)
14. Fine Sandstone (Misener SS)

Figures 28-34 presents a series of whole and slabbed core photographs illustrating the various facies types. The reader is referred to the core descriptions and tables of pore code and facies code descriptions in Appendix B for a foot-by-foot description of each core.

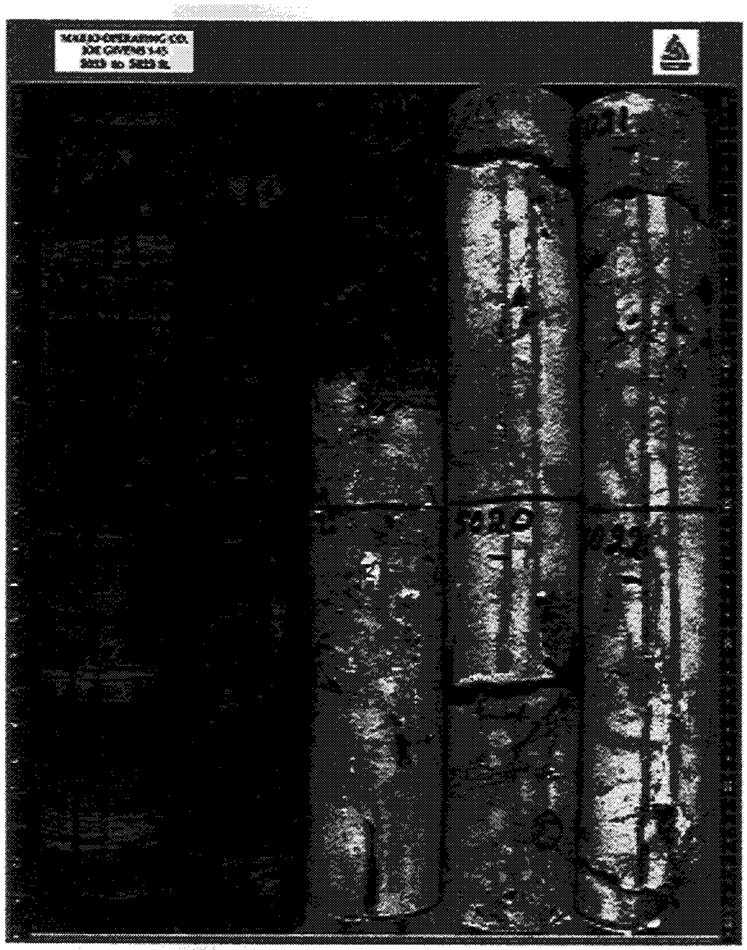

Figure 28: Joe Givens 1-15 whole core photo 5013 to 5023 illustrating facies 6, 13, 14; also irregular karsted surface of the Hunton beneath the Misener SS, and open vertical solution-enhanced fractures.

Figure 29: Joe Givens 1-15 slabbed core photo 5013 to 5023, same interval as #1, illustrating facies 6, 13, 14; also irregular karsted surface of the Hunton beneath the Misener SS, and open vertical solution-enhanced fractures, partly filled with karst sediment, in part fine sandstone.

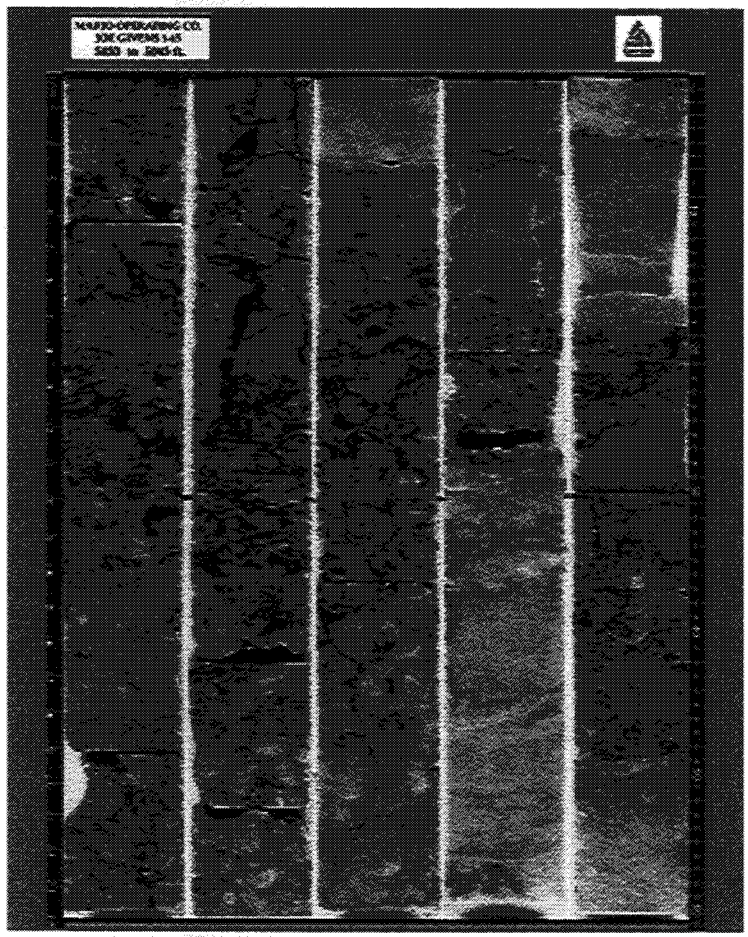

Figure 30: Joe Givens 1-15 slabbed core photo 5033-5043; illustrating facies 3, 4, 6; also showing karst sediment in open cavities and fissures within 7 feet of the base of the Hunton.

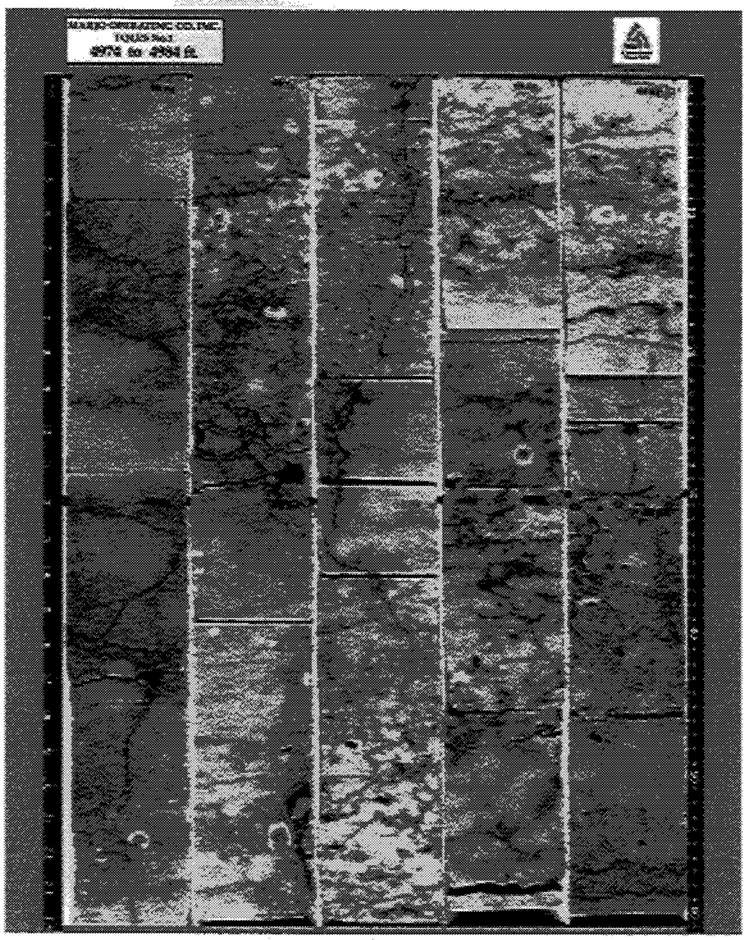

Figure 31: Toles 1-10 slabbed core photo 4974-4985, illustrating facies 4,5,6,7, and abundant factures, with minor karst infill.

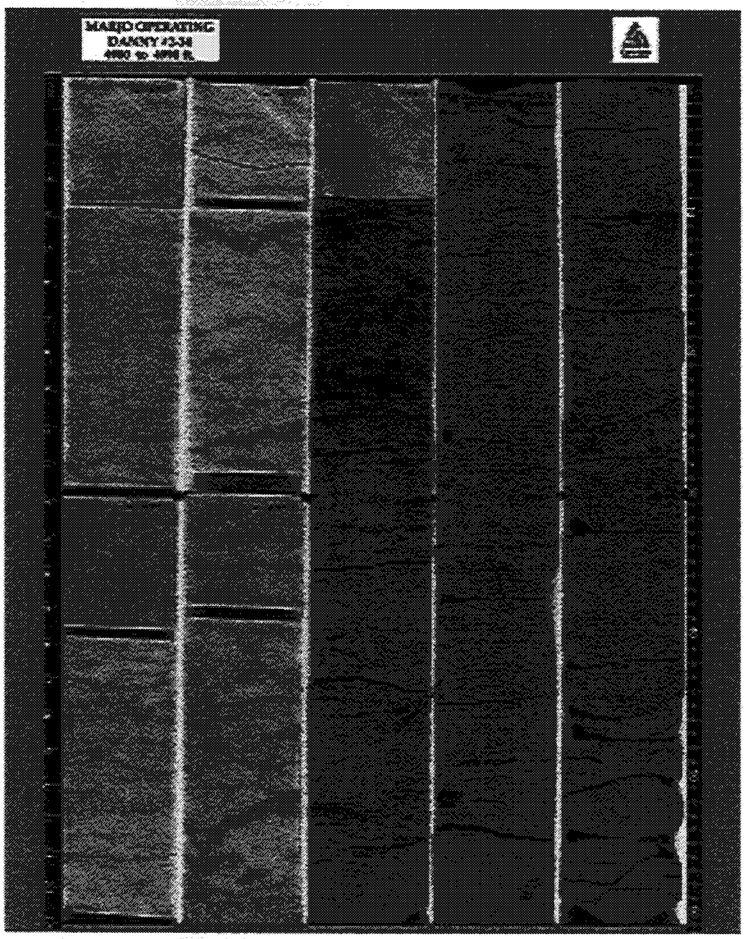

Figure 32: Danny 2-34 slabbed core photo 4980-4990; illustrating facies 5, 1, 13 and the contact with the Sylvan Shale.

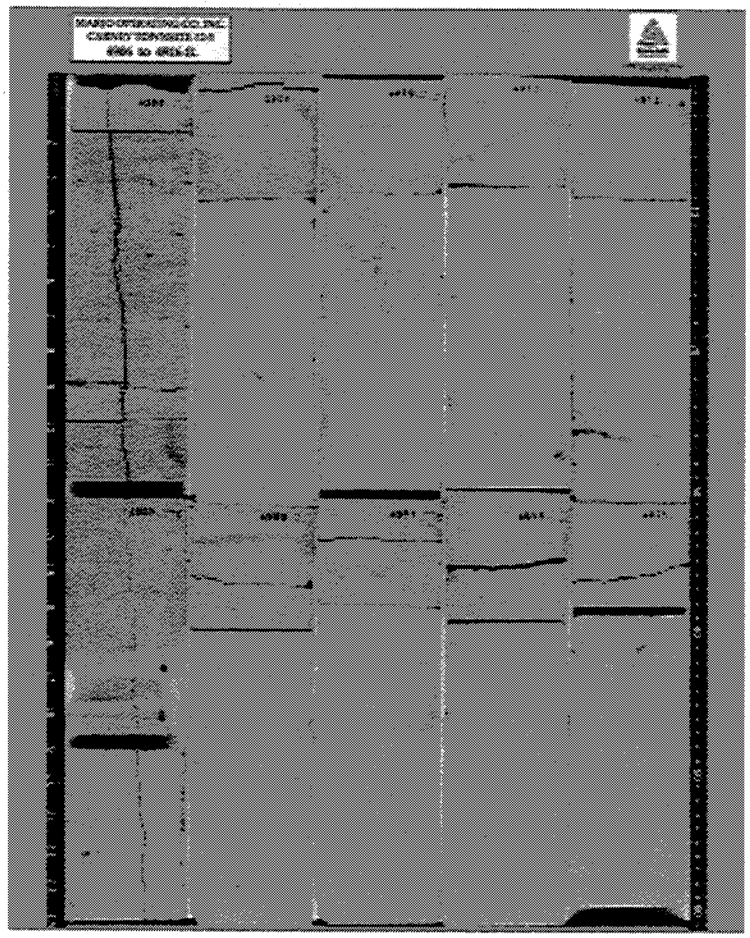

Figure 33: Carney Townsite 2-5 slabbed core photo 4906-4916, illustrating facies 2, 4, 6.

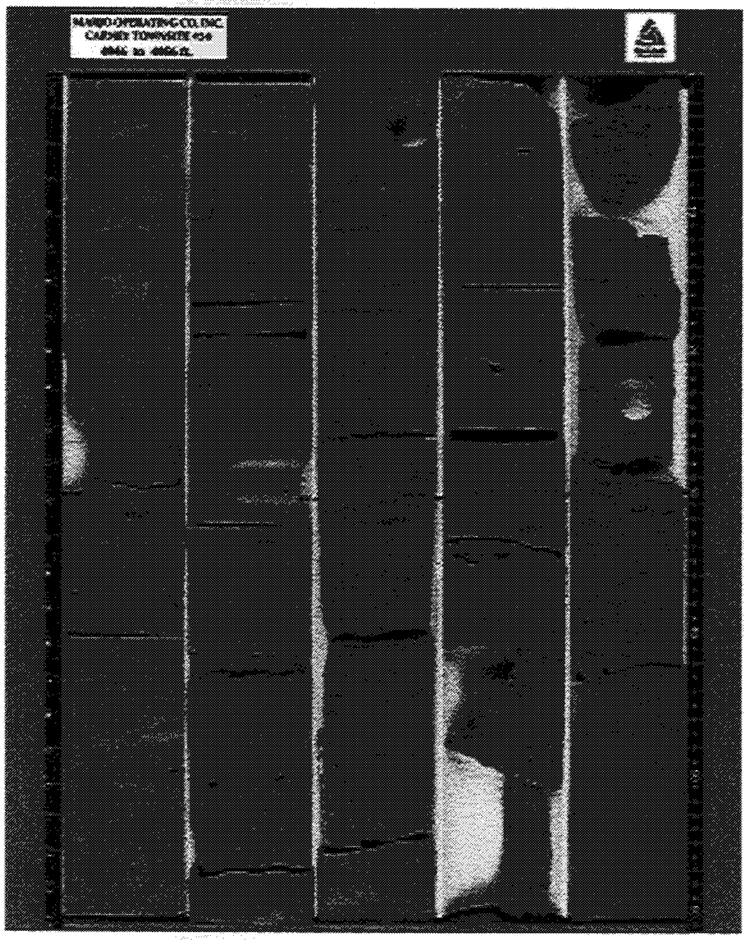

Figure 34: Carney Townsite 2-5, slabbed core photo 4946-4956, illustrating facies 4, 10, 11, 12, and karst sediment infill in small cavities or micro-caverns.

3.3.2 Stratigraphic Correlation

The evidence from both log and core data is that across the area of thin Hunton WCHF in western Lincoln County (less than 90 feet thick), there is no clear sequence of bedded strata. Unlike most Mid-Continent Paleozoic stratigraphic units, which are cyclic and divisible into thin, laterally extensive sub-units, the Cochrane in WCHF is not, at this time, readily divisible into subunits. The following describes a common sequence in the Hunton, but no sequence holds true for all wells

Typical Sequence From Top to Bottom (usually limestone, except as noted):

- Mixed Crinoid and Big Brachiopod grainstones and packstones
- Big Pentamerid Brachiopod coquina, coarse grainstone
- Mixed Crinoid-Brachiopod fine grainstone, or Crinoid Grainstone/Packstone, interbedded coarse and fine.
- Small Brachiopod grainstone (possibly *Stricklandia),* or Mixed Brachiopods and Crinoids
- Basal 1-4 ft: Dolomite, commonly dolomitized brach-crinoid facies

The generalized sequence shown above is inconsistent from well to well. Five wells, Danny, Henry, Mary Marie, McBride, and Wilkerson more or less conform to the above sequence. The Toles is similar, but more varied. In some wells, the Big Pentamerid Brachiopod Coquina (Facies 7) is almost the entire thickness of the Cochrane; e.g., the Henry, Mary Marie, McBride South, and Williams (undescribed). These wells would correspond to Depth Zone B.A. 3.[9]

In other wells, the Big Brachiopod facies is nearly to totally absent, e.g., the Boone, Carter, Carney Townsite, Joe Givens and Bailey (undescribed). The Carter, Boone, and Joe Givens are dominated by crinoidal facies, and the Boone especially seems to lack the Big Brachiopod component. These wells possibly represent an even shallower facies, B.A. 2. The Carney Townsite core contains a few feet of mottled, disturbed bedding dolomite, which possibly represents Sabkha conditions, therefore probably B.A. 1. The geographic distribution of the facies is not clear at this time; we intend to create facies slice maps to illustrate facies distribution.

As stated above, results of conodont studies on the Mary Marie, Boone, and Carter, all suggest that the Hunton in the WCHF is entirely Cochrane Fm (Earliest Silurian, basal Hunton). However, the stratigraphically highest sample analyzed to date is only 56 feet above the base of the Hunton (Carter Well) and the Hunton is 89 feet thick in the Bailey #2-6, so another 33 feet remain to be analyzed in the eastern part of the field. The new wells drilled in Logan County, the Carney Extension and the Cal, encountered more than 120 feet of Hunton. We will sample and analyze these as soon as available. Lists of samples analyzed for conodonts and results are listed in Appendix B.

The conodont faunas suggest an open marine, shelf setting, as expected from the megafossil assemblages present. Based on the work of Markes Johnson[9] the big Pentamerid Brachiopod coquina suggests a depth of 30-60 meters and a position on the ocean-facing side of the littoral to sublittoral transition, in biostromal deposits.

Karst is universally present in all cored wells, but is highly variable between wells. The core descriptions include a separate section describing the effects of karst, separate from the stratigraphic sequences. Effects of karst ranges from open fissures extending through the entire Hunton and thick collapse breccias, to minor fracture breccia and vuggy porosity. The abundance of collapse breccias suggests that Hunton thickness in WCHF may be significantly affected by karst. We plan to prepare isopach maps of overlying units to see if the karst dissolution and collapse is reflected in younger sediments.

Karst sediment ranges from medium sand to clay, and fills open fissures, caverns, vugs, inter-particle space in collapse breccias, and intra-fossil cavities. Karst sediments may occlude porosity and reduce permeability, at least as recognized by core analysis. For example, the Joe Givens #1-15 is heavily karsted, with sand-filled fissures extending to the base of the Hunton; however it shows very poor porosity on both well logs and core analysis. (Some of the karst passages are obviously not filled, as the Joe Givens has a high fluid flow and is one of the better producers.)

The development of karst and its effects on potential reservoirs is well-illustrated in a paper by Loucks.[10] The features illustrated are present abundantly in WCHF cores and are listed in the karst features part of each well core description. The reader is urged to read Louck's paper in its entirety, especially the portion on the areal extent of karst. At this time we have not yet attempted to create an appropriate model for WCHF, as is clearly needed to simulate fluid flow through karst channels.

Engineering data and drilling experience clearly show open karst channels interconnect the wells. The Marjo Geneva 2-32 (NE-SW-32-16N-3E) well was being drilled in January 2001 when it lost circulation while coring, and pumped in Lost Circulation Material (LCM). A nearby operator was swab-testing the Altex Covey Heirs 3-32 (SE-NW-32-16N-3E) 1,320 feet away, almost immediately recovered the LCM in their swab test. Formation pressure data has also verified the free interconnection between some wells.

3.3.3 Porosity Types

Porosity development in the Cochrane Fm of the Hunton Group in WCHF is a combination of original sediment type, early and late diagnesis. Most of the sediment is so severely altered by early to middle diagenesis, that original sediment type no longer is a factor. For example, much of the section is coarse grainstone, but most coarse grainstones are so strongly affected by early dissolution that the grainstone fabric is totally collapsed into a tight matrix of coarse, inter-sutured grains, with virtually no fine matrix or secondary spar. Other grainstones are more conventionally filled with porosity-occluding spar or syntaxial overgrowths (especially on Pelmatozoan). "Crinoid" grains are similarly devoid of effective porosity. In many packstones, effective porosity is developed only as result of dissolution of fine carbonate mud matrix.

A classification of porosity types for this study is given below, and in Appendix B. This is simply an *ad hoc* listing of porosity types encountered so far and does not preclude other types in the future. In Appendix B, each sample analyzed by StimLab is assigned a porosity code, providing a foot-by-foot description of the reservoir. Many of these porosity code assignments may be modified in the future by more detailed information resulting from thin section or acetate peel analysis of selected intervals. Porosity types are shown below.

Limestones (grain density 2.71 to <2.73)

1. Interconnected Vuggy porosity

   Vug or MO with IG, SF or other connection, TV general, Vug general. Not vugs with tight matrix.

2. Coarse Matrix porosity

   Inter-particle (IP), IG or IX of coarse-grained rock, > .25 mm particle size. Many include dissolution porosity that is inter-particle micro vugs (dissolution of spar or matrix).

3. Fine Matrix porosity

   Inter-particle (IP), IG or IX of medium to fine-grained rocks, < .25 mm particle size. Includes fine non touching vugs and non touching fine Moldic (MO) porosity along with intra-particle porosity

4. Fracture

   FR or SF without significant matrix or vugs.

   For this study, includes solution-enhanced fractures with sand in-fill.

Dolomite (> 50% dolomite; grain density 2.79 or higher)

5. Vuggy (vug) or Moldic (MO) in coarse crystalline (IX) matrix (> .25 mm)

6. Coarse crystalline with Inter-crystalline porosity (IX) (> .25 mm)

7. Medium to fine crystalline (IX) (.25 mm to .02 mm)

8. Fracture FR or SF without significant matrix porosity

Partly Dolomitized Limestone (10 – 50 % dolomite; gr density 2.73-2.78)

9. Interconnected Vuggy porosity

Vug or MO with IG, SF or other connection, TV general, Vug general. Not vugs with tight matrix.

10. Coarse Matrix porosity

    Inter-particle (IP), IG or IX of coarse-grained rock, > .25 mm particle size. May include dissolution porosity that is inter-particle micro vugs (dissolution of spar or matrix).

11. Fine Matrix porosity

    Inter-particle (IP), IG or IX of medium to fine-grained rocks, < .25 mm particle size. Includes fine non touching vugs and non touching fine Moldic (MO) porosity along with intra-particle porosity

12. Fracture

    FR or SF without significant matrix or interconnected vuggy porosity.

    For this study, includes solution-enhanced fractures with sand in-fill.

Because of the complex porosity structure, we checked the core porosity vs. log porosity to make sure that we are obtaining reasonable representation of porosity values using log data. As an example, **Figure 35** shows a plot of running average of core porosity vs. average log porosity (average of density and neutron porosity)

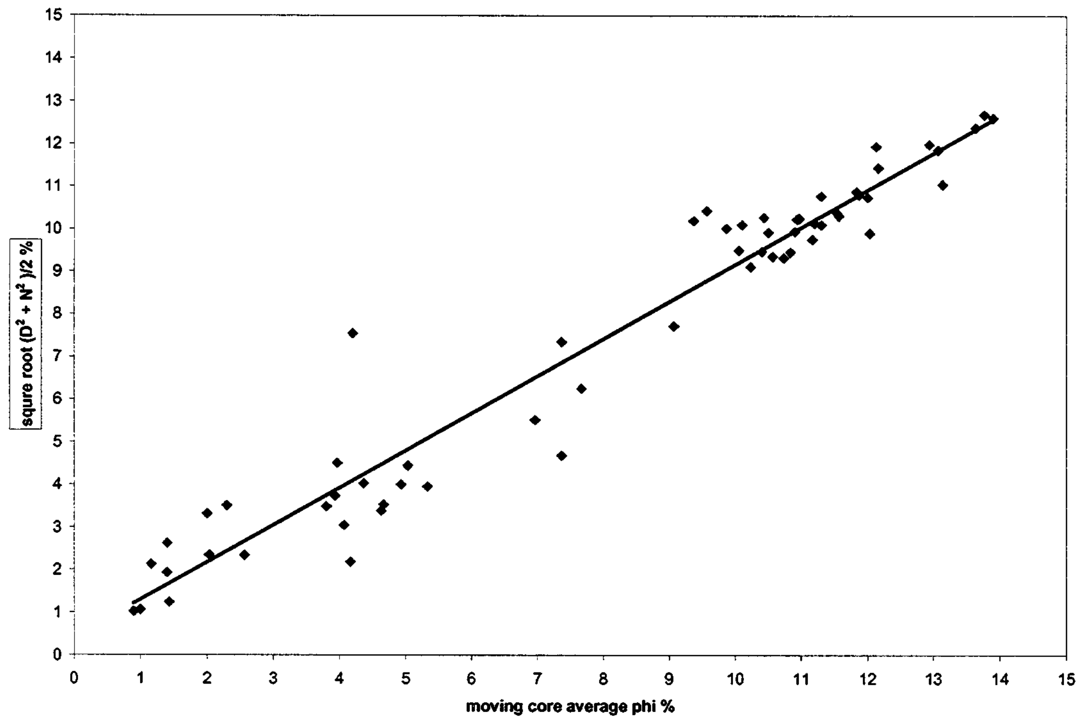

Figure 35: Core porosity vs. average log porosity

For the wells described so far, we compared the moving average porosity data with density porosity, neutron porosity and a square root average of neutron and density porosities. The results are shown below in Table 4. This table shows that for majority of wells, average of the two porosities correlates the best with core data. There is only one well where density log provides a superior correlation. However, a closer examination of that well reveals that for that well (Givens), the correlation coefficient for all the three methods is low. It is easy to see that the average method works well even for the wells where one of the other methods is found to be superior in terms of correlation coefficient. In essence, the average method provides a good correlation irrespective of dominant rock type environment.

Table 4: Comparison between log and core data

Well Name	Density Log	Neutron Log	$((D^2+N^2)/2)^{0.5}$	The Best Correaltion	Dominant Rock Type
Boone 1-4	0.1016	0.7393	0.8066	average	Dolomitic limestone
Carney Townsite 2-5	0.8196	0.9437	0.9452	average	Dolomitic Limestone
Carter 1-14	0.4771	0.6682	0.8862	average	Limestone
Danny 2-34	0.7259	0.5043	0.7791	average	Limestone
Henry 1-3	0.3592	0.6495	0.668	average	Limestone
Joe Givens 1-15	0.3017	0.1343	0.283	Density	Limestone
Mary Marie 1-11	0.7291	0.806	0.7803	Neutron	Limestone
McBride South 1-10	0.0753	0.6543	0.6192	Neutron	Limestone
Wilkerson	0.5775	0.8466	0.8271	Neutron	Limestone

3.4 Technology Transfer

Virginia Bentley and Mohan Kelkar, The University of Tulsa

As part of the technology transfer phase of the project, a web page has been developed (http://www.tucrs.utulsa.edu). The web page serves two purposes, one being the transfer of information to the general public, and secondly to serve as a working project web site accessible only to team members.

Figure 36 shows the initial page displayed each time the web site is retrieved. The general public has access to Hunton project team members, publications generated from the project and a search feature. This page also provides links to the Department of Energy's National Petroleum Technology Office and to the University of Houston.

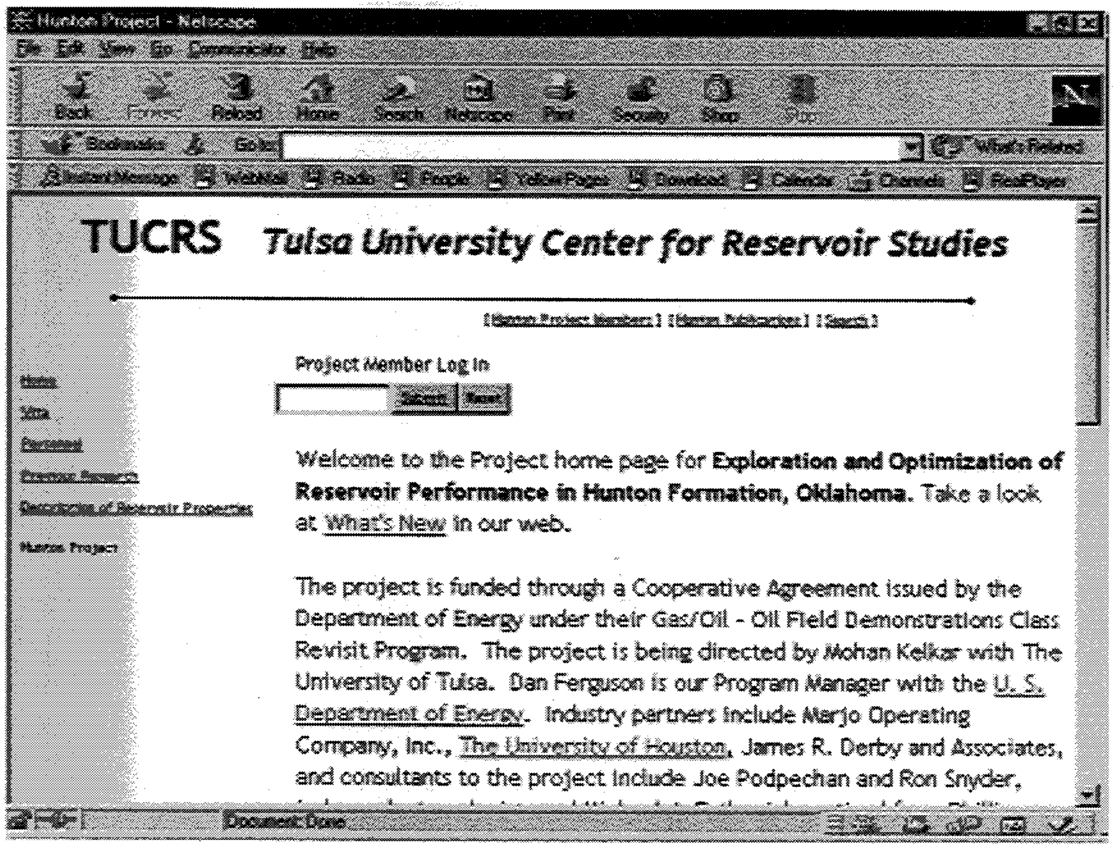

Figure 36: Home page of Hunton web site

Figure 37 displays the Hunton project team member's page. This page includes information on the team members involved in the project, as well as links to their email addresses should they like to request further information on the project.

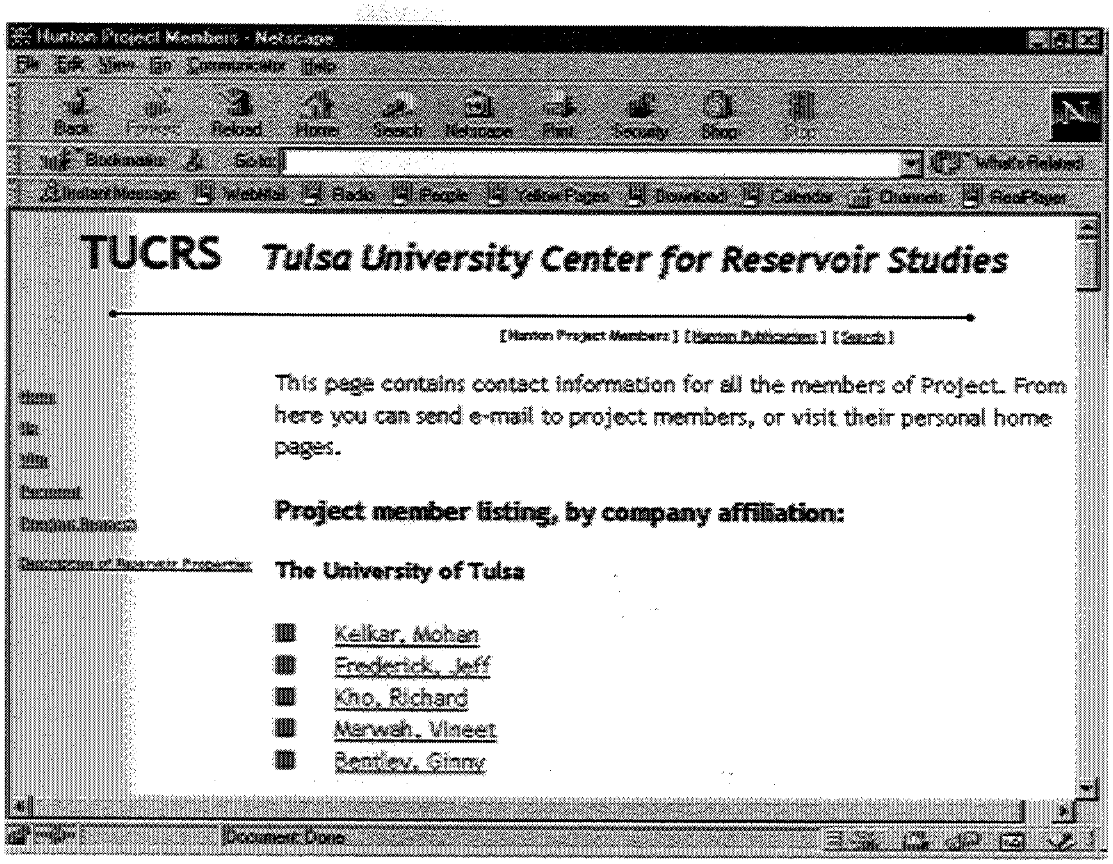

Figure 37 – Hunton project team member's page

Figure 38 displays the publications page. From this page the general public can access technical status reports on the project, presentations and publications, and newsletters.

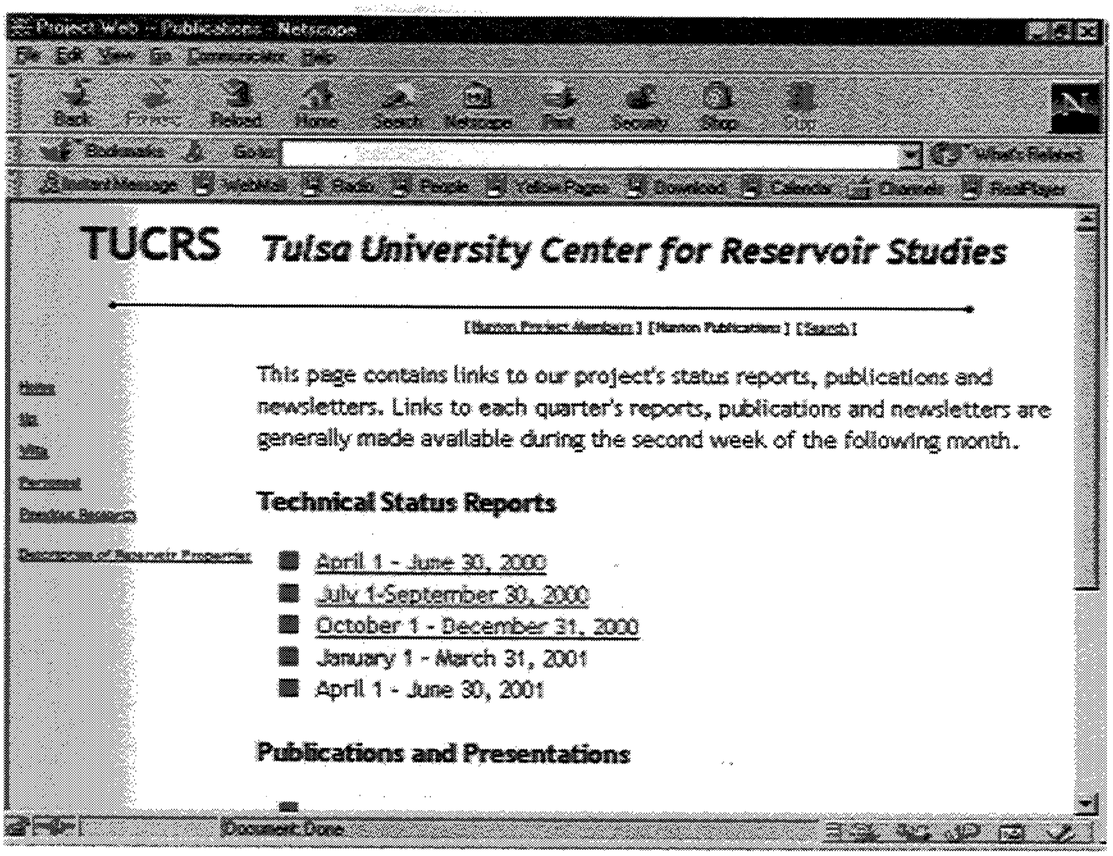

Figure 38: Hunton publications page

Figure 39 shows the search page. The general public can search the web site using a specific word or a combination of words. A brief explanation of the query language is available, along with examples.

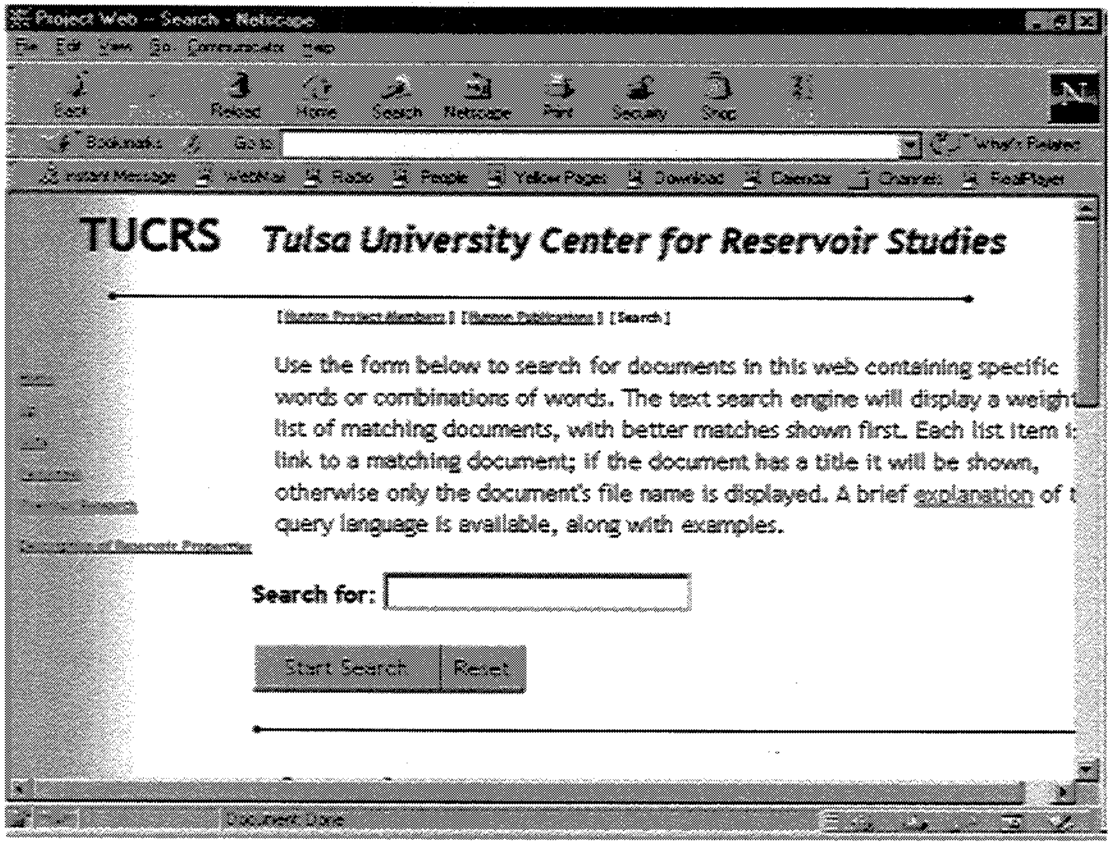

Figure 39: Search page

After entering a password on the home page, project team members have access to a myriad of information. **Figure 40** shows the initial page displayed after log in.

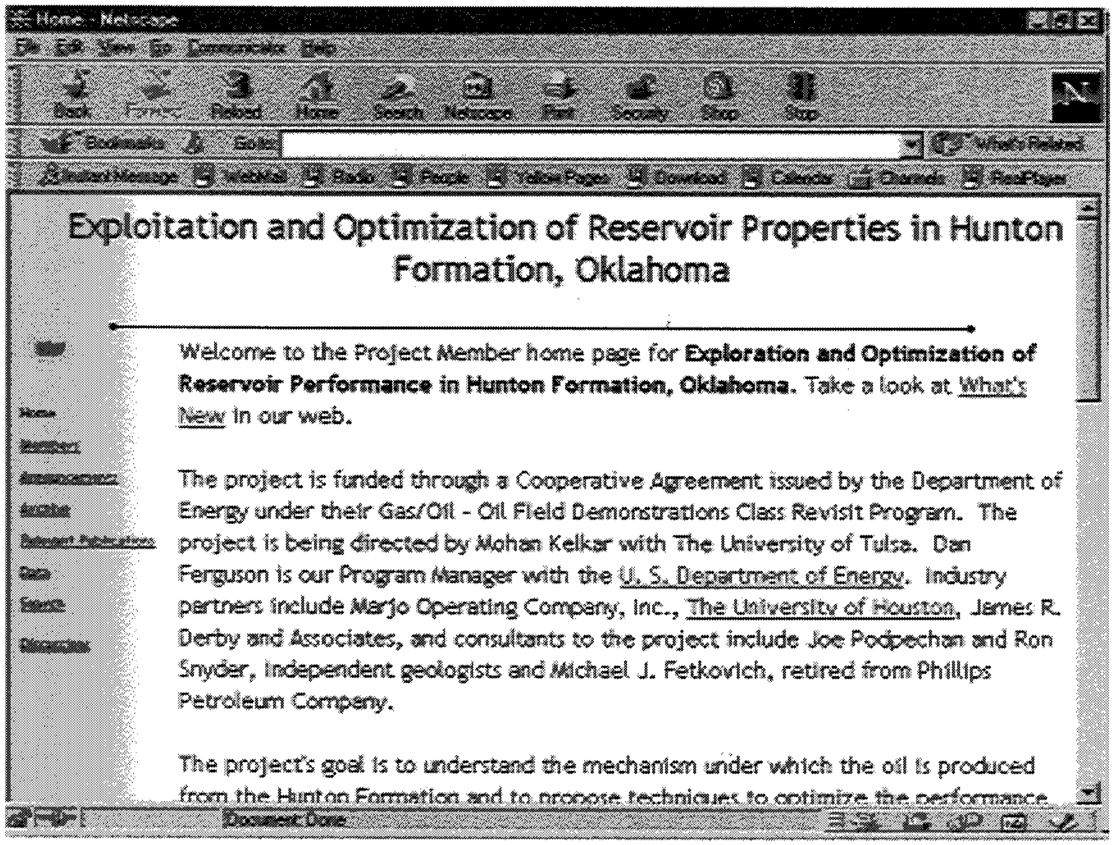

Figure 40: Project member's home page

Figure 41 shows the announcements page. This page lists scheduled project events such as upcoming project meetings and key milestones as well as our focused goals for the current and next quarter.

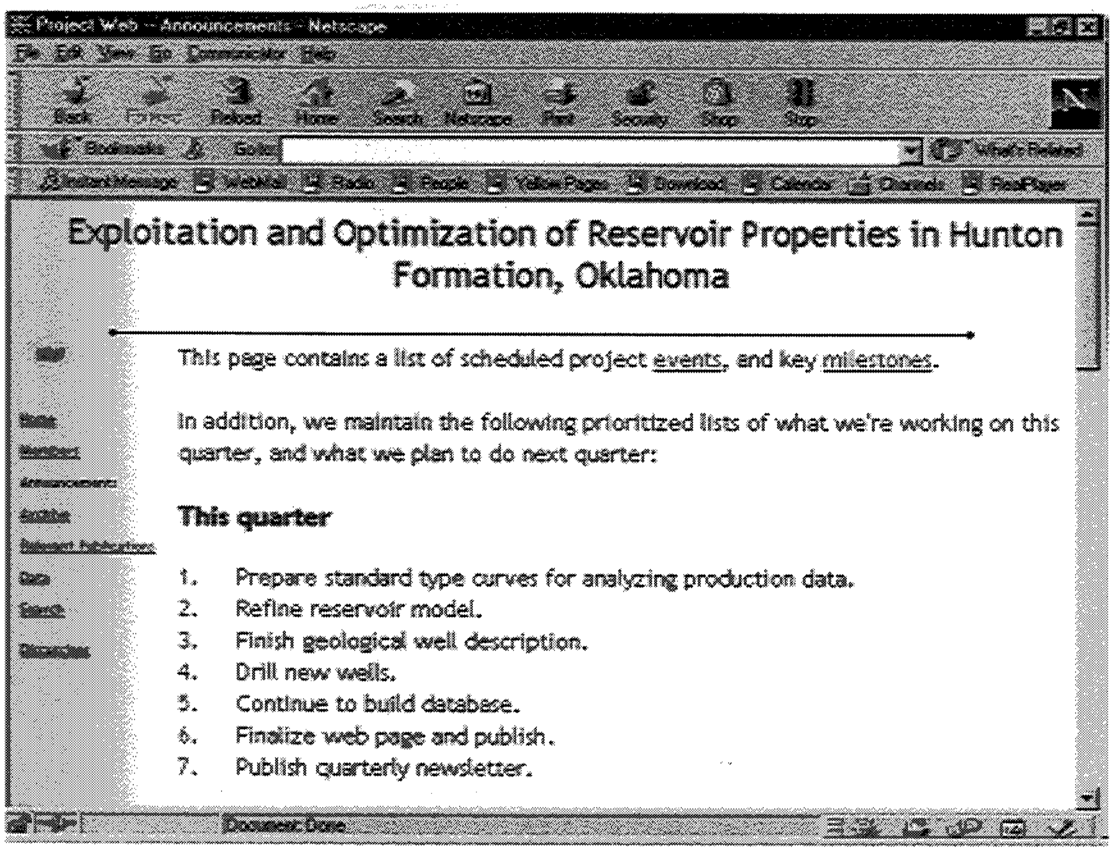

Figure 41: Announcements page

Figure 42 shows the archive page. From this page, project team members have access to internal documents authored by project members, project meeting minutes, technical status reports and database programs.

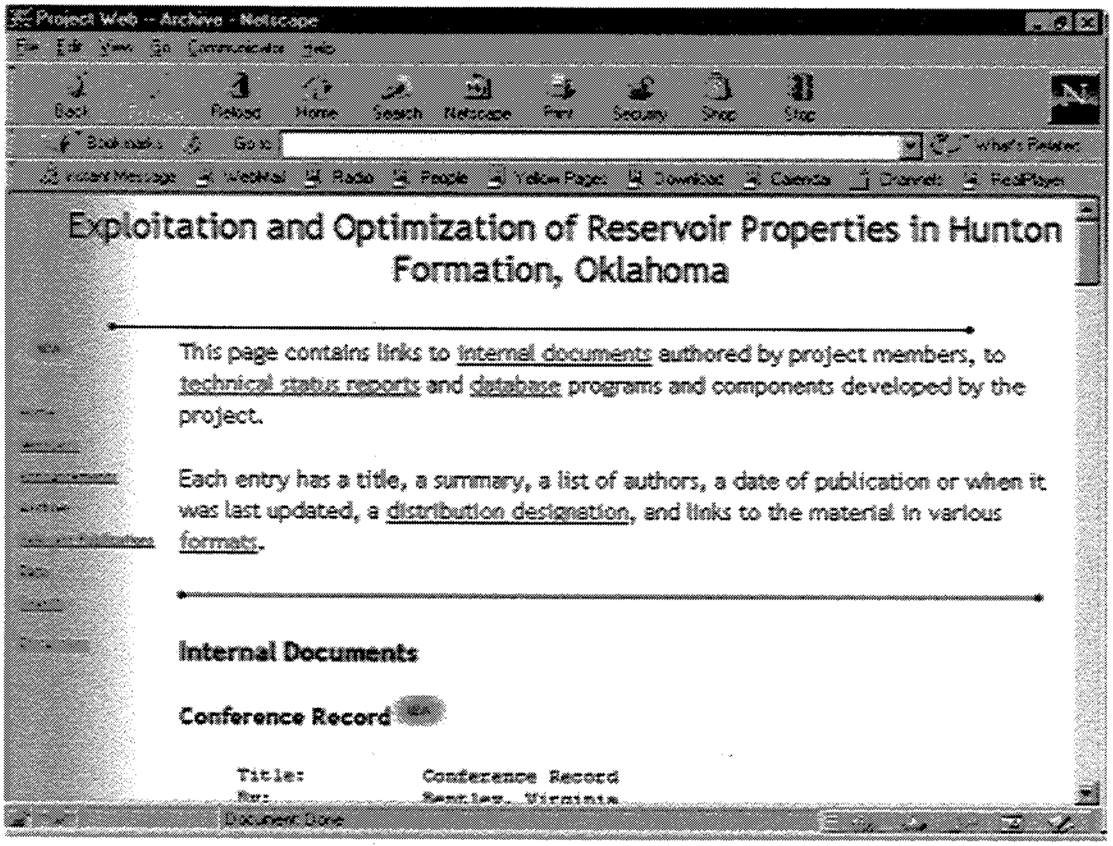

Figure 42: Archive page

Figure 43 shows the relevant publications page. This page contains links to published documents related to the project, but that are authored by non-team members. Team members can submit an article relevant to the project to be posted.

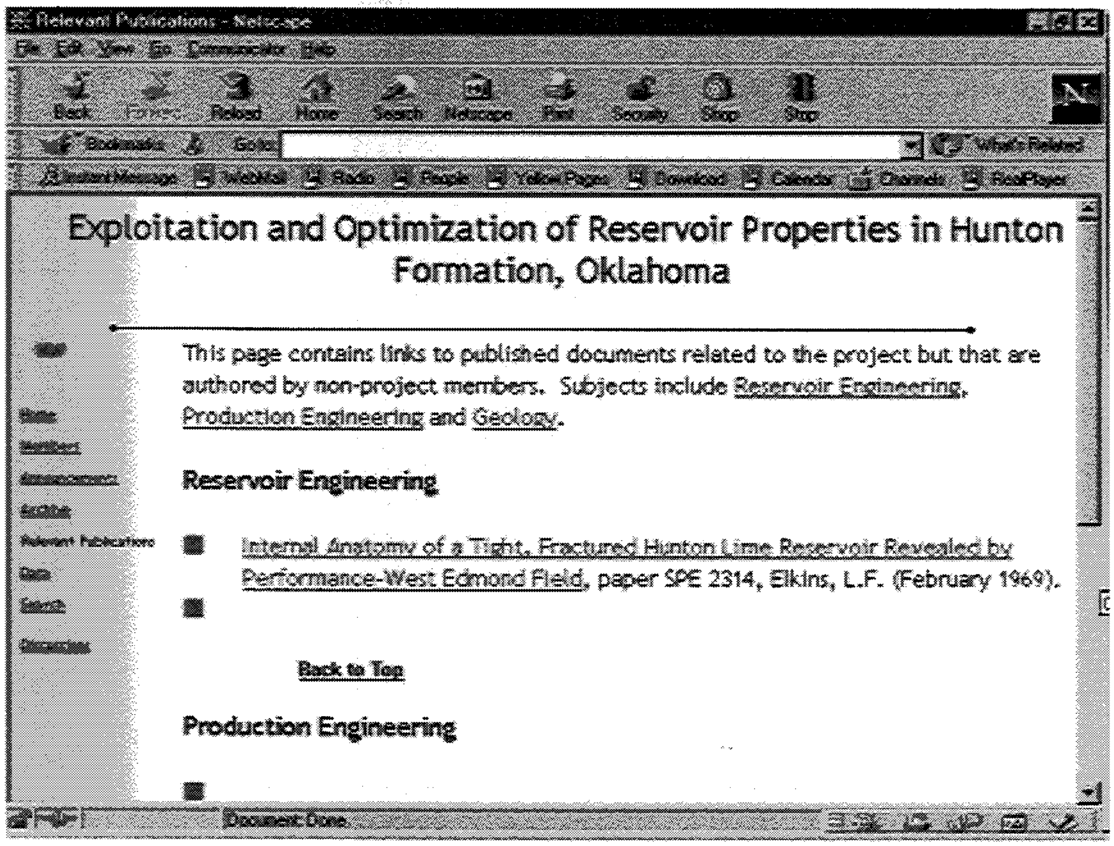

Figure 43: Relevant publications page

Figure 44 shows the data page. While this page is still under construction, it will be the heart of the project. Features of this page include a plat map and options for various database searches. Future features will include an interactive plat map with specific well locations linked to individual wells.

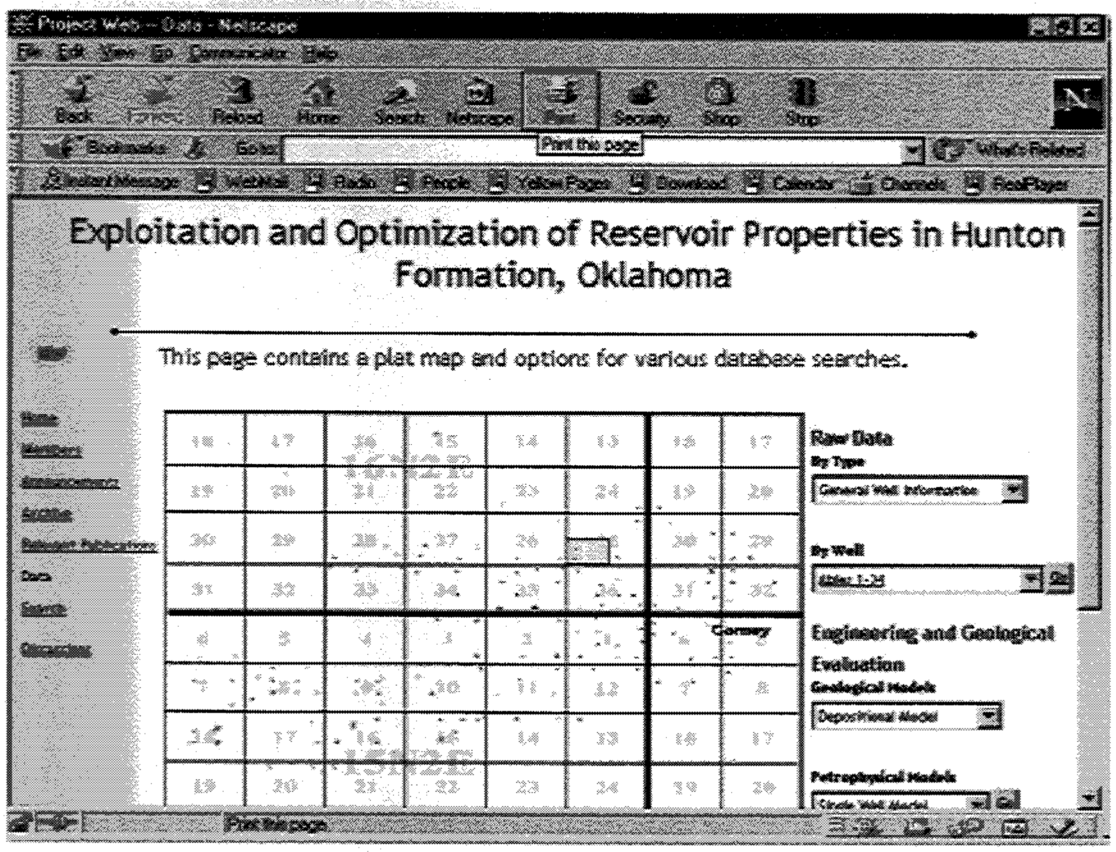

Figure 44: Data page

In addition to the search page referred to earlier, a discussion page (see **Figure 45**) is included. On this page a knowledge base is included and should prove helpful to project team members to record common questions and answers regarding the project.

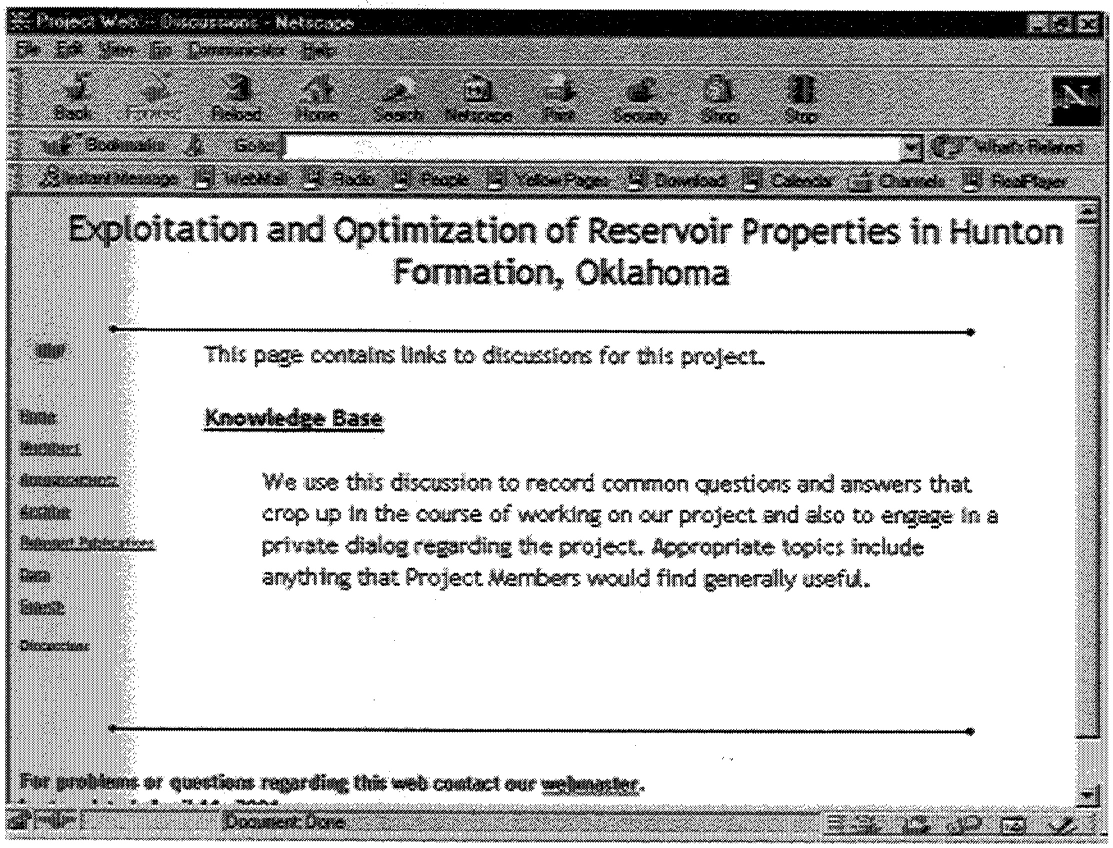

Figure 45: Discussion page

As can be seen, the private web pages clearly demonstrate an interactive web site designed to enhance communication and aid in the dissemination of information to project team members.

In addition to the web site, we intend to publish a newsletter with one month. This newsletter will be mailed to various operators and interested parties, as well as posted on the web page. Because of the fact that the project was just initiated, we do not have any publications to date. However, we intend to start publishing very soon.

4. References

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Appendix A

Derivation of Analytical Model Solution

Assumptions

1. ρ_o and ρ_w are constant.

2. Water and Oil formation volume factors are equal.

3. Viscosities of two phases are assumed to be the same.

4. Both layers are homogeneous with horizontal permeability zero for the oil layer

5. The relative permeabilities are linear functions of saturations.

$$k_{rw} = 1 - k_{ro}$$

Or,

$$k_w = kk_{rw} = k(1 - k_{ro})$$
$$k_o = kk_{ro}$$

where k is the absolute permeability.

Top Layer (Oil Layer)

In this layer the flow is only in the z-direction.

Using mass balance, we get,

$$(\rho v)_z - [(\rho v)_z + \frac{\partial}{\partial z}(\rho v)_z.\Delta z] = \frac{\partial}{\partial t}(\Delta z \phi \rho)$$
$$-\frac{\partial}{\partial z}(\rho v) = \frac{\partial}{\partial t}(\phi \rho)$$
$$Also, v = -\frac{k}{\mu}\nabla p$$
$$\frac{\partial}{\partial z}(\frac{k}{\mu}\rho \nabla p) = \frac{\partial}{\partial t}(\phi \rho)$$

Eliminating ρ, we obtain,

$$\frac{\partial}{\partial z}\left(\frac{k}{\mu}\frac{\partial p}{\partial z}\right)+C\left[\frac{k}{\mu}\left(\frac{\partial p}{\partial z}\right)^2\right]=\phi C\frac{\partial p}{\partial t}$$

The second term on LHS is negligible and thus eliminating it we obtain

$$\frac{\partial}{\partial z}\left(\frac{k}{\mu}\frac{\partial p}{\partial z}\right) =\phi C\frac{\partial p}{\partial t}$$

Thus,

$$\frac{\partial^2 p}{\partial z^2}=\frac{1}{\eta}\frac{\partial p}{\partial t}$$

where, $\eta=\frac{k}{\phi c\mu}$

Dimensionless Variables,

$$z_D=\frac{z}{h}$$
$$t_D=\frac{kt}{\phi\mu c_t A}$$
$$p_D(z_D,t_D)=\frac{P_i-P(z,t)}{P_i-P_2(r,t)}$$

Therefore,

$$\frac{\partial^2 p_D}{\partial z^2{}_D}=\frac{\partial p_D}{\partial t_D}$$

Taking Laplace Transformation, we get,

$$\frac{\partial^2 \bar{p}_D}{\partial z^2{}_D}=s\bar{p}_D$$

Boundary Conditions,

$$\frac{\partial p}{\partial z}(@z=0)=0$$
$$p(h,t)=P_2$$

P_2 = Pressure of layer two.

Initial Condition,

$$p(z,0) = P_i$$

Using the boundary and initial conditions we obtain,

$$\bar{p}_D = e^{-\sqrt{s}zD}\left(\frac{e^{\sqrt{s}}}{s + e^{2\sqrt{s}}s} + \frac{e^{\sqrt{s}+2\sqrt{s}zD}}{s + e^{2\sqrt{s}}s}\right)$$

Thus the pressure of the top layer depends on the pressure of the bottom layer.

Bottom Layer (Water Layer)

Due to the cross-flow between the two layers the oil migrates into this layer and gets produced along with water.

Mass Balance equations for oil and water phases are,

Oil $\rightarrow \frac{1}{r}\frac{\partial}{\partial r}\left(\frac{k_o \rho_o r}{\mu_o B_o}\frac{\partial p}{\partial r}\right) + \frac{k_z \rho_o}{\mu_o B_o}[P_1 - p(r)] = \phi \frac{\partial}{\partial t}\left(\rho_o \frac{S_o}{B_o}\right)$

Water $\rightarrow \frac{1}{r}\frac{\partial}{\partial r}\left(\frac{\rho_w r}{B_w}\frac{\partial p}{\partial r}\right) = \phi \frac{\partial}{\partial t}\left(\rho_w \frac{S_w}{B_w}\right)$

Denoting $\alpha_o = \frac{k_o}{\mu_o B_o} and \alpha_w = \frac{k_w}{\mu_w B_w}$

We can also write,

$$S_w = 1 - S_o$$

$$\frac{\partial S_w}{\partial t} = -\frac{\partial S_o}{\partial t} = -B_o \frac{\partial}{\partial t}\left(\frac{S_o}{B_o}\right) - \frac{S_o}{B_o}\frac{\partial B_o}{\partial p}\frac{\partial p}{\partial t}$$

Thus Water equation can be written as,

$$\frac{1}{r}\frac{\partial}{\partial r}(\alpha_w r\frac{\partial p}{\partial r}) = \phi(-\frac{B_o}{B_w}\frac{\partial}{\partial t}(\frac{S_o}{B_o}) - \frac{S_o}{B_o B_w}\frac{\partial B_o}{\partial p}\frac{\partial p}{\partial t} - \frac{S_w}{B_w^2}\frac{\partial B_w}{\partial p}\frac{\partial p}{\partial t})$$

Defining total compressibility to be,

$$c_t = -\frac{S_o}{B_o}\frac{\partial B_o}{\partial p} - \frac{S_w}{B_w}\frac{\partial B_w}{\partial p}$$

Using total compressibility the equation becomes,

$$\frac{1}{r}\frac{\partial}{\partial r}(\alpha_w r\frac{\partial p}{\partial r}) = \frac{\phi}{B_w}(-B_o\frac{\partial}{\partial t}(\frac{S_o}{B_o}) + c_t\frac{\partial p}{\partial t})$$

$$\frac{1}{r}\frac{\partial}{\partial r}(\alpha_w r\frac{\partial p}{\partial r}) + \frac{b}{r}\frac{\partial}{\partial r}(\alpha_o r\frac{\partial p}{\partial r}) + \frac{bk_z}{\mu_o B_o}(P_1 - p(r)) = \frac{\phi c_t}{B_w}\frac{\partial p}{\partial t}$$

where, $b = \frac{B_o}{B_w}$

Defining dimensionless variables,

$$r_D = \frac{r}{r_w}$$

$$t_D = \frac{kt}{\phi\mu c_t r_w^2}$$

$$p_D = \frac{P_1 - p(r)}{P_1 - p_{wf}}$$

In dimensionless form equation becomes,

$$\frac{1}{r_D}\frac{\partial}{\partial r_D}(r_D\frac{\partial p_D}{\partial r_D}) - \frac{k_z}{k}r_w^2 p_D = \frac{\partial p_D}{\partial t_D}$$

In Laplace space equation takes the form,

$$\frac{1}{r_D}\frac{\partial}{\partial r_D}(r_D\frac{\partial \overline{p}_D}{\partial r_D}) - (\frac{k_z}{k}r_w^2 + s)\overline{p}_D = 0$$

Let $u = \frac{k_z}{k} r_w^2 + s$

Thus equation takes the form,

$$\frac{1}{r_D}\frac{\partial}{\partial r_D}(r_D \frac{\partial \bar{p}_D}{\partial r_D}) - u\bar{p}_D = 0$$

General solution of above equation is,

$$\bar{p}_D = AK_0(\sqrt{u}r_D) + BI_0(\sqrt{u}r_D)$$

Boundary conditions are,

$$\frac{\partial p}{\partial r}(@r = r_e) = 0$$
$$p(r_w, t) = p_{wf}$$

Using the above boundary conditions, we obtain $\bar{p}_D$,

$$\bar{p}_D = \frac{K_1(\sqrt{u}r_{eD})I_0(\sqrt{u}r_D) + I_1(\sqrt{u}r_{eD})K_0(\sqrt{u}r_D)}{s[K_1(\sqrt{u}r_{eD})I_0(\sqrt{u}) + I_1(\sqrt{u}r_{eD})K_0(\sqrt{u})}$$

Appendix B

Geological Analysis

TABLE OF WELLS CORED

	Hunton Top			Hunton Base			Status and Data							
Well Name	Core	Log	Core/Log Adjustment	Core	Log	Thickness	Wk	TS	PC	SEM	Cono	UH	Wett	Lithology
Anna 1	4967.1	4947.0	20.1	5004.7	4985.0	37.6								Dol
Bailey 2-6	X(4876)	4875.0	2?	X(4934)	4964.0	58 cored; *89 log*								14' Dol/Ls
Boone 1-4	X (5037)	5028.0	6.5	5066.5	5060.0	29.5+	C	6*	C		6*	4	1	Ls/ dol Ls/ 4' dol
Carney Townsite 2-5	X (4906)	4907.0	1.3	X (4966); *4979.3L;*	4978.0	60 cored; *73.3 log*	C	8*	C		10	4		Dol/Ls
Carter 1-14	X (4940)	4927.0	13.3	4995.8	4982.5	56.1	C	16	C		18*	4	2	1'dol/ Ls/ 2'dol
Danny 2-34	X (4930)	4918.0	10.8	4984.3		54.3+	C		C			4	1	Ls
Henry 1-3	X (4966)	4958.0	7.5	X (4996.6)		30.6+	C		C					Ls/5' dol/ls
Joe Givens 1-15	5017.8	5010.0	9.0	5044.0		26.2	C		C					Ls/ 0.1' dol
Kathyrn	X(4994)	4990.0	2.5	5030.5	5028.0	36.5 core *38 log*								Ls/Dol/Ls/Dol
Mary Marie 1-11	4961.0	4944.0	15.2	5003.5		42.5	C	33	C	4	14*	10	4	Ls/ 2'dol
McBride South 1-10	X (4962)	4947.0	13.3	4996.2	4983.0	34.3	C	1*	C		1*	4		Ls/dol/ls
Toles 1	4964.0	X	na	5003.7	X	39.7	C	8*	C					Ls/ 2'dol
Wilkerson 1-3	4953.4	4937.5	15.8	4999.8	4984.0	46.4	C	17*	C	1		8	1	Ls/ 2'dol
Williams 1-3	4943.5	4934.0	9.5	4983.7	4974.0	40.2						8		Ls/ 5' dol

X = top or base of Hunton not cored; or well not logged; (footage) = top or base of core
Wk = Work status (Core description), PC = Porosity Codes. Core description, Pore codes: C = Completed; IP = In Process.
TS = Thin Sections, * described ; SEM = Scanning Electron Microscopy, Cono = Conodont micropaleontology, * completed
UH = Core Plug samples at Univ. Houston; Wett = Wettability Analysis,

Core Description

Pore-type terminology and abbreviations used in this paper compared to abbreviations used in Lucia (1983) and Choquette and Pray (1970)

	Abbreviations	
Term	Lucia (1983)	Choquette and Pray (1970)
Interparticle	IP	BP
Intergrain	IG	-
Intercrystal	IX	BC
Vug	VUG	VUG
Separate vug	SV	-
Moldic	MO	MO
Intra33particle	W/P	WP
Intragrain	WG	-
Intracrystal	WX	-
Intrafossil	WF	-
Intragrain Microporosity	μG	-
Shelter	SH	SH
Touching Vug	TV	-
Fracture	FR	FR
Solution-Enlarged Fracture	SF	CH*
Cavernous	CV	CV
Breccia	BR	BR
Fenestral	FE	FE

*Channel

Explanation

Fabric Terminology is the Rock-Fabric classification of Dunham, 1962: Grainstone and Packstone for grain-supported rocks, grainstones having no mud; and Wackestones (>10% grains) and Mudstones for mudsupported rocks. Lucia's, 1995 important distinction between Grain dominated and Mud dominated Packstones has not been encountered yet, as all packstones seen are grain dominated.

Pore Types Column uses the pore classification of Lucia 1995 (left), with the occasional use of PP for pinpoint porosity (discrete fine pores of uncertain origin, usually microvugs, may be dissolved mud or partial molds).

Av Pore % Average porosity through the interval from core analysis adjusted by rock and thin-section data.

% TV Touching vug porosity (see Lucïa's explanation below). TV% is included in the AvPore% number. Interconnected moldic pores is also TV porosity.

Chalky As used by Archie, 1952, for dull or earthy appearing rock, composed of fine crystals, not tightly interlocking, usually soft or friable.

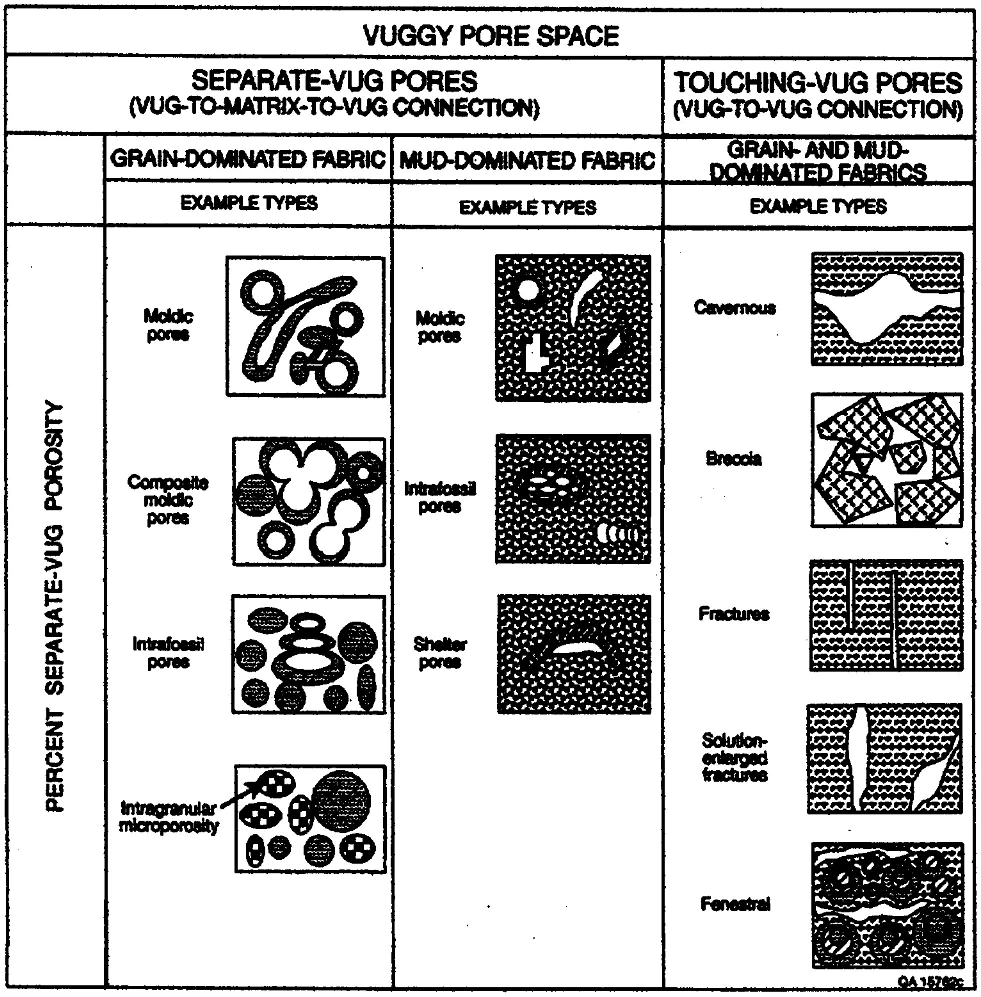


Figure 46: Geological and petrophysical classification of vuggy pore space based on vug interconnection. The volume of separate vug pore space is important for characterizing the petrophysical properties.

CORE DESCRIPTION
MARJO BOONE 1-4, SEC. 4, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	Depth To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
Woodford Shale		Shale		nil	nil				not cored
Misener Sandstone		SS		nil	nil				not cored
5037.0	**Hunton Limestone (29.5)**								**TOP OF CORE**
5037.0	5042.8	Ls	pkstn	SF,IG,IP	3	2	N	6	c to med cri-brac pkstn, pinkish gy (5YR 8/1), tightly cemented with closely spaced SF, especially in top two feet, slight karst breccia, karst cavities filled with silt sized carbonates, sparse large brac and cri
5042.8	5045.8	Ls	pkstn	MO,IG	2	1	N	9	c cri coral pkstn, pinkish gy, tightly cemented with moldic porosity in favositid corals.
5045.9	5047.9	Ls	grnstn	IG, IXLN	8	-	N	9	c coral cri grnstn, yellow gy to v pale orange (10YR 8/2), with sparse large MO vugs in favositid and rugose corals, partially dolomitized, good IG porosity
5047.9	5051.7	Ls	grnstn	IG,IXLN	8	1	sli	5	partly dolomitized, c cri grnstn, v pale orange, sli oil stain, with large karst cavities filled with fine carbonate silt upto 0.2 ft wide x 0.3 high. Sli SF, sli chalky, grades to unit below

CORE DESCRIPTION
MARJO BOONE 1-4, SEC. 4, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth									
From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
5051.7	5056.2	Ls	grnstn	IG,MO,IXLN	7	1	Y	4	partly dolomitized, f cri grnstn with sparse large cri grains, v pale orange with oil stains, sparse corals with MO porosity, lower 2 ft with thin current bedding, very sparse large brac. Cleanly washed intra sparite
5056.2	5059.7	Ls	grnstn	IG,sli MO	6	-	N	6	partly dolomitized, c cri brac coral grnstn, v pale orange to pinkish gy, with v large pent brac (5056 to 5057), increasingly tightly cemented towards base
5059.7	5062.2	Ls	grnstn	IG	2	-	N	5	c cri grnstn, not dolomitic, pinkish gy to moderately orange pink 10 R 7/4 , sparse brac, sparse vertical frac completely filled with carbonate silt (karst ?), sli vertical frac, crystalline
5062.2	5066.5	Dol	XLN	IXLN,MO,SF	9	3	N	6	Dol, recrystallized, cri brac coral grnstn, pinkish gy to gysh orange, with large MO porosity around bracs and corals, partly connected by solution enhanced frac, basal 0.1 ft is laminated dolomite with felted texture, possible replacement of anhydrite
TOP SYLVAN ?									
5066.5	5067.9	Dol	mdstn	-	-	-	-	11	contact at the top, marked by 3 mm of pyrite. Burrow mottled, indistinct bedding, increasing fissile downward.

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO BOONE 1-4, SEC. 4, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

KARST

Depth		Description
5037.0	5041.4	Fracture Breccia, small dissolution cavities with clay and silt infill
5041.4	5044.5	Intact Host Rock
5044.5	5044.7	Clay filled fissure
5044.7	5048.2	Intact Host Rock
5048.2	5053.6	Dissolution cavities, discontinous, upto 0.2 ft wide X 0.3 ft high, no apparent fractures, filled with laminated carbonate silt
5053.6	5055.0	Intact Host Rock
5055.0	5055.6	fissure , near vertical, 3 to 10 mm wide filled with carbonate silt
5055.6	5060.5	Intact Host rock
5060.5	5060.7	Vertical fissures , 4 mm wide, filled with carbonate silt.
5060.7	5067.9	Intact Host Rock

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO BOONE 1-4, SEC. 4, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

STYLOLITES

Depth		Description[1]
5038.0	5038.5	irr
5040.7		ha
5042.0	5055.0	moderately spaced hummocky, some irreg-a
5057.5	5066.5	widely spaced hummocky

[1]ha = high amplitude, la = low amplitude, irr= irregular, dis = significant dissolution, ps = parallel sets, irreg-a = irregular anastomosing sets

FRACTURES

Depth		Description[2]
5037.0	5038.0	SF, partly clacite filled , 2-8 mm wide, V & I
5038.0	5041.0	HFc, with SF @ 5039.9 to 41.2
5044.8	5045.8	HFc
5055.0	5055.7	sediment filled SF
5059.0	5061.1	HFc, V

[2]Fr = open hairline fractures, HFc = healed fractures, calcite-filled, SF = solution enlarged fractures, width given in mm; V = vertical, I = inclined, H = horizontal

CORE DESCRIPTION
MARJO CARNEY TOWNSITE 2-5, SEC. 5, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	Depth To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
Woodford Shale		Shale		nil	nil				not cored
Misener Sandstone		SS		nil	nil				not cored
4906.0	**Hunton Limestone (60 ft)**								
4906.0	4907.0	Dol	XLN	IX,SF	9	2	N	2	Dol, limy, f xln , v pale orange 10 YR 8/2, equant subhedral crystalls, faint foss allochems, vertical frac
4907.0	4910.0	Ls	XLN pkstn	IX, SF	11	3	N	4	Ls, strongly dolomitic gysh orange 10YR 7/3, fine to med foss pkstn with minor wkstn, vague thin bedding, allochems largely fine cri grains, sparse large cri & small brac, sli MO & SV porosity, prominent vertical SF 4907 to 4908.3 with associated large vugs
4910.0	4912.0	Dol	XLN	IX,SF	12	1	N	4	Dol, limy, gysh orange, dolomitized f cri pkstn & wkstn, SF 4910 to 4910.6 & associated minor vuggy porosity. Thin horizontal zones of dense rexln matrix possibly are rexln stylolite zones
4912.0	4916.0	Ls	grnstn	IX, SV	10.5	-	N	5	Ls, strongly dolomitized, gyish orange, med cri brac grnstn? With numerous coarse cri grains & sparse small brac

CORE DESCRIPTION
MARJO CARNEY TOWNSITE 2-5, SEC. 5, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth									
From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4916	4927	Dol	XLN pkstn	IX,SF	13	2	N	4	Dol limy gysh orange, dolomitized f cri pkstn with thin intervals of moderately abundant small brac fragments, irregularly thin bedded, apparently grainsize sorted, numerous sub horizontal tightly cemented layers or possibly rexln stylolites. Scattered foss moulds & SV. @ 4921.9 is karst cavity .04 ft X 0.2 ft wide filled with laminated carbonate silt. Vertical SF 4919.4 to 4919.7 & 4925.5 to 4927. Thin collapse breccia @ 4926.7 to 4926.9
4927	4940.3	Ls	pkstn/grnstn	IG,SF,MO	10	3	N	4	Ls, strongly doltzd, gysh orange, f to c cri pkstn, grnstn with 3 ft of mixed cri brac pkstn 4931 to 4934. Large vugs associated with SF & minor mosaic breccia scattered through the interval. Also contains thin intervals of karst solution cavities filled with carbonate silt. v c cri debri @ 4930 to 4930.4. Numerous subhorizontal tight cemented zones, possibly recrystallised stylolites or possibly mdstn layers
4940.3	4941	Dol	pkstn	SF,Vug,IX	6.9	5	N	4	Dol, limy, gysg orange to lt gy, f cri pkstn with tight cemented zones a/a, SF with large xln vuggy porosity and 3 karst cavities filled with carbonate silt

CORE DESCRIPTION
MARJO CARNEY TOWNSITE 2-5, SEC. 5, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4941	4943.7	Ls	pkstn/wkstn	IG, Mo	4	1	N	4	Ls, lt gy to pinkish gy 5 YR 8/1, f to med cri pkstn/wkstn thin inetrvals of MO and sli SF porosity in wkstn layers, numerous calcite filled frac & silt filled karst fissures
4943.7	4944.6	Dol	mdstn	IX, Sf	6	2	N	11	Dol, limy pinkish gy mottled med gy, f mdstn , probably sabkha mdstn

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO CARNEY TOWNSITE 2-5, SEC. NW NW NW 5, T15N, R3E
LINCOLN COUNTY, OKLAHOMA

KARST

Depth		Description
4921.9		0.4X0.2 ft wide filled with laminated carbonate silt
4926.7	4926.9	Thin collapsed breccia and connected to vertical solution fracture with karst silt fill
4928.2	4928.4	karst micr caverns with silt fill 0.5 ft high X 0.1 ft wide
4929.3	4929.9	Narrow vertical zone of mosaic breccia, max 0.2 ft wide, v good associated vuggy porosity
4933.5		Micro cavern .07 ft high X .25 ft wide filled with carbonate silt
4940.3	4940.6	3 karst cavities filled with carbonate silt connected to vugs and SF
4942.1	4943.6	silt filled karst fissures
4944.4	4944.9	Irregular karst micro-caverns carbonate silt filled
4946.3	4946.6	Irregular karst micro-caverns carbonate silt filled
4956.4	4956.9	a/a
4960.6	4961.3	a/a
4962.6	4962.7	a/a

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO CARNEY TOWNSITE 2-5, SEC. NW NW NW 5, T15N, R3E
LINCOLN COUNTY, OKLAHOMA

STYLOLITES

Depth		Description[1]
4906.7		smooth stylolite
4947.6		parallel
4953.6		ha
4954.4		parallel la
4956.6		smooth
4957.1		la
4957.2		ha
4958.5		ha
4958.7		la
4960.2		smooth
4960.6		ha
4961.5		smooth
4962.1	4962.4	parallel smooth
4963.6	4963.8	parallel la
4964.4	4964.5	irreg-a
4965.5	4965.6	irreg-a

[1]ha = high amplitude, la = low amplitude, irr= irregular, dis = significant dissolution, ps = parallel sets, irreg-a = irregular anastomosing sets,

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO CARNEY TOWNSITE 2-5, SEC. NW NW NW 5, T15N, R3E
LINCOLN COUNTY, OKLAHOMA

FRACTURES

Depth		Description[2]
4906.0	4908.3	SF V 1 mm
4910.0	4910.6	V , parallel SF 0.2 to 0.5 mm
4915.2	4915.4	SF V 0.1 mm
4919.4	4919.7	SF V 0.5 mm
4925.5	4927.0	SF V 0.5 to 4 mm wide with associated minor collapse breccia
4929.2	4929.9	irregular vertical SF upto 5 mm wide and associated narrow mosaic breccia
4933.3	4933.6	a/a upto 4 mm wide
4940.3	4941.0	discontinous SF 0.5 mm to 6mm wide associated with large vugs
4941.1	4941.6	HFc V
4941.6	4941.8	SF vertical 0.5mm
4942.0	4943.3	HFc V, very minor SF < 0.2 mm
4943.3	4943.9	SF 0.5 mm
4944.6	4947.0	discontinous very tight SF < 0.1 mm
4947.0	4948.7	vertical SF 0.1 mm , whole core shows intersecting vertical fractures across entire core, partial XLN fill in frac
4949.0	4951.2	SF V 0.1 mm
4951.2	4955.0	SF V 1 mm
4957.1	4966.0	well developed vertical SF associated with (+/- 1 mm) widely spaced small vugs

[2]Fr = open hairline fractures, HFc = healed fractures, calcite-filled;
SF = solution enlarged fractures, width given in mm; V = vertical,
I = inclined, H = horizontal

CORE DESCRIPTION
MARJO CARTER 1-14, SEC.14, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
Woodford Shale		Shale		nil	nil				not cored
Misener Sandstone		SS		nil	nil				not cored
4940.0 **Hunton Limestone (55.8)**									
4940.0	4941.3	Dol	XLN	IX,Vug	7	2	N	6	Dol, lt olive gy 5Y6/1, f xln with slight dissolution vugs, appears burrow mottled, abundant stylolites, silt filled fractures
4941.3	4942.0	Ls	grnstn	IG	5	-	N	6	Ls, yellowish gy 5 Y 8/1, med cri brac grnstn, sparse large brac, collapsed (leached) grnstn fabric
4942.0	4950.2	Ls	grnstn/ pkstr	TV,IG	9	2	sli	7	Ls, yellowish gy, c brac grnstn/pkstn, large pent brac coquina with partially collapsed (dissolved) fine grnstn fabric and abundant vuggy porosity, vugs commonly dissolution of inter brac matrix
4950.2	4952.2	Ls	grnstn	IG, FR	3	1	N	6	Ls, pinkish gy, 5Y8/1, c brac cri grnstn, porosity occluded by syntaxial overgrowth, slight frac
4952.2	4955.3	Ls	grnstn	IG,SV	5	-	N	6	Ls, sli dolomitic, yellowish gy, med to c cri brac grnstn with sparse large vugs

CORE DESCRIPTION
MARJO CARTER 1-14, SEC.14, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth									
From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4955.3	4958.4	Ls	grnstn	IG,SF	2	1	N	5	Ls, pinkish gy, c cri grnstn with v sparse brac, vertical frac mostly calcite filled, locally mottled med gy, karst stained?
4958.4	4960.0	Ls	grnstn	IG	3	-	N	5	Ls, sli dolomitic, pinkish gy, c cri grnstn with sparse med brac fragments, tightly cemented
4960.0	4962.1	Ls	grnstn	IG,SV	2	-	N	5	Ls, pinkish gy, c cri grnstn with scattered large vugs
4962.1	4976.6	Ls	grnstn	IG,TV	3	1	N	6	Ls, pinkish gy v c brac cri grnstn, partly heavily leached and vuggy
4976.6	4979.7	Ls	grnstn	IG,SF	2	1	N	5	Ls, lt gyish orange pink 5YR 8/2, c cri grnstn with sparse solution frac and minor small vugs. 4978.7 mto 4979.3 karst mosaic breccia with sediment filled cavity 0.1X 0.1 ft laminated carbonate silt. Mostly tightly cemented
4979.7	4983.0	Ls	grnstn	IG,TV	2	1	N	3	Ls, pinkish gy c brac grnstn, small to med bracs and sparse v large cri in dense grnstn matrix, sparse vugs

CORE DESCRIPTION
MARJO CARTER 1-14, SEC.14, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth									
From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4983.0	4987.2	Ls	grnstn	IG,TV	6	1	N	6	Ls, sli dolomitic, pinkish gy to med lt gy, c to med brac cri grnstn, vuggy with some baroque dolomite vug fill, one large coral @ 4985.4
4987.2	4988.8	Ls	grnstn	IG,Vug	5	-	N	6	Ls, pinkish gy, c brac cri grnstn , sparse separate vugs
4988.8	4994.1	Ls	grnstn	IG	7	1	Y	6	Ls, dolomitic in parts, pinkish gy to v lt gy, f cri grnstn & f cri brac grnstn, dolomitic below 4991, good IG porosity, karst dissolution 4989.7 to 4990 with carbonate silt infill
4994.1	4995.8	Dol	grnstn	IG,IX,TV	10	5	N	12	Dol, med ltgy to lt brnish gy, med to f crystalline dolomictic grnstn, locally dolomitic mdstn with two zones of well developed interconnected vuggy posority @ 4994.9 & 4995.3, includes zones that resemble sabkha dolomite as well as basal 0.3 ft appears to a coarse clastic grnstn below 4991, good IG porosity

CORE DESCRIPTION
MARJO CARTER 1-14, SEC.14, T15N-2E
LINCOLN COUNTY, OKLAHOMA

Depth From	Depth To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
Sylvan Shale (4.1 ft cored)									**Unconformity** (Irregular surface, about 1 cm relief, short sediment-filled fractures)
4995.8	4999.9	Dol	IX	-	4	-	N	1	Dol, argillaceous lt grnsh gy, pyritic, burrow mottled, upper contact is irregular but sharp and contains short vertical fracture filled with material from overlying Hunton, an unconformity.

Note : slabbed only to 4997.2

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO CARTER 1-14, SEC. 14, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

KARST

Depth		Description
4940.0	4941.0	minor karst silt in small SF
4941.0	4956.0	Intact Host Rock
4956.0	4958.5	sli dissolution & cavity filled with dark karst silt
4958.5	4978.5	Intact Host Rock
4978.5	4979.3	karst mosaic breccia with sediment filled cavity 0.1 ft X 0.1 ft, laminated carbonate silt
4979.3	4989.7	Intact Host Rock
4989.7	4990.0	dissolution cavities filled with carbonate silt
4990.0	4999.0	Intact Host rock

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO CARTER 1-14, SEC. 14, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

STYLOLITES

Depth		Description[1]
4940.0	4941.0	irreg-a, darkly stained
4941.3		single hummocky, possibly bitumen
4942.4		peak la
4947.4		ha
4950.3		la
4953.2		la
4956.0		la
4957.0		la
4957.8		la
4958.4		ha
4959.4		irr
4960.5		irr
4965.6		la
4973.4	4973.8	parallel set irr
4975.4		la
4976.6	4976.7	irreg-a
4978.2	4978.4	parallel sets
4982.4		la
4983.0	4983.6	sparse hummocky

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO CARTER 1-14, SEC. 14, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

STYLOLITES (Continued)

Depth		Description[1]
4988.7	4989.3	irreg-a
4990.3	4990.9	parallel sets
4993.3		irr
4993.4		ha

[1]ha = high amplitude, la = low amplitude, irr= irregular, dis = significant dissolution, ps = parallel sets, irreg-a = irregular anastomosing sets,

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO CARTER 1-14, SEC. 14, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

FRACTURES

Depth		Description[2]
4940.0	4940.3	Fracture, silt filled
4951.7	4952.4	HFc & SF discontinous V
4953.0	4953.2	HFc , V & H
4956.0	4956.8	SF,I
4962.8	4963.2	HFc,
4965.0	4965.8	HFc V & I
4966.5	4967.5	HFc V
4968.0	4968.5	HFc V
4971.4	4976.0	HFc, branching V
4977.6	4978.2	HFc
4978.7	4979.8	SF & HFc V, I, H
4983.6	4983.9	HFc V
4986.4	4986.7	HFc V
4994.5	4994.9	HFc I , intersecting

[2]Fr = open hairline fractures, HFc = healed fractures, calcite-filled; SF = solution enlarged fractures, width given in mm; V = vertical, I = inclined, H = horizontal

CORE DESCRIPTION
MARJO DANNY 2-34, SEC. 34, T16N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
Woodford Shale		Shale		nil	nil				not cored
Misener Sandstoı		SS		nil	nil				not cored
4930.0	**HUNTON LIMESTONE (54.3 feet cored, top not cored)**								
4930.0	4954.5	Ls	pkstn/wkstn	SF,MO-TV, IG	4	3	N	7	LS, c pkstn w thin intervals of f wkstn, abundant large pent brac in pkstn, pinkish gy to lt gy, strongly karsted with sand infill, terra rossa @ 4931.2 & 4944.4
4954.5	4961.4	Ls	wkstn	SF	3	3	sli	10,7	LS, f wkstn w sparse pent brac, lt gy, one interval of abundant brachs from 4958.3 to 4959.4
4961.4	4965.6	Ls	pkstn/wkstn	SF,SLI MO	6	5	Y	10	LS, f pkstn / c wkstn w v abundant large pent brach (brachs do not create a grn supported matrix)
4965.6	4971.0	Ls	wkstn	SF,STY, MV	6	5	Y	3	LS, sparse brac wkstn, pinkish gy to lt gy, dense mud matrix w sparse large pent brac, sty & vertical fractures

CORE DESCRIPTION
MARJO DANNY 2-34, SEC. 34, T16N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4971.0	4973.3	Ls	f grnstn	IG,SV, MO,STY	9	1	Y	5	LS, f foss grnstn w scattered large brac incl *Virginia?* , v pale orange (buff), fining upward to overlying wkstn
4973.3	4977.0	Ls	grnstn	IG,SV,SF,MV	7	1	sli	5	LS, v c cri grnstn, pinkish gy, clean biosparite
4977.0	4984.3	Ls	grnstn	IG,SV, MO,MV	4	0	sli	5	LS, c to med cri grnstn, pinkish gy to lt gy, mostly clean biosparite, sparse large vugs, basal contact sharp, abundant cri, sparse corals
SYLVAN SHALE (5.7 ft cored)									
4984.3	4985.8	Dol	mdstn	IX	4	0	N	1	DOL, silt size, grnish gy, burrowed, pyritic
4985.8	4990.0	Shale	sh	-	-	-	-	13	SHALE, grnsh gy,large pyrite nodules, thin lenses of lt gy silt
4990.0	**BASE OF CORE**								

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO DANNY 2-34, SEC. 34, T16N, R2E
LINCOLN COUNTY, OKLAHOMA

KARST

Depth		***Generalized* Description**
4930.0	4975.7	Mixed Mosaic and Fracture Breccia with some Intact Host Rock, both fine-sand and clay filled, with open fissures.
4975.7	Base	Intact Host Rock

Depth		***Detailed* Description**
4930.0	4931.2	Intact Host rock
4931.2	4932.6	Mosaic breccia with open fissures (0.04ft)
4932.6	4934.4	Intact Host rock
4934.4	4937.0	Mosaic breccia with open fissures (0.02ft)
4937.0	4939.4	Intact Host Rock
4939.4	4954.5	Mosaic Breccia, All of the above have fine sand and clay infill sediments, partly with geopetal laminae. 4945.3 to 4948.2 open solution fractures (0.02ft). 4951.3 to 4954.4 sediment filled fissures (0.03 to 0.15 ft)
4954.5	4957.5	Intact Host rock
4957.5	4957.6	Sand filled cavern, fine sand grading upto laminated fine silt
4957.6	4965.1	Fractured breccia with open solution fractures 1 to 2 mm and sediment filled fissures (0.02ft)
4965.1	4965.9	Mosaic breccia, very fine sand fill
4965.9	4975.7	Fractured breccia with sparse Mosaic breccia sediment fill and long vertical fissures, fine sand and clay filled (0.02ft)
4975.7	TD	Intact Host rock

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO DANNY 2-34, SEC. 34, T16N, R2E
LINCOLN COUNTY, OKLAHOMA

STYLOLITES

Depth		Description[1]
4935.0	4935.5	sparse irr
4941.0	4942.0	irr
4954.5	4957.5	sparse irr
4959.7	4960.4	ha close
4964.4	4964.7	ha
4967.2		la open
4968.3	4968.6	ha
4970.4	4970.6	ha
4974.3	4974.8	hummocky close
4975.4	4976.3	la sparse
4976.3	4978.4	hummocky close
4978.4	4984.3	irr ps

[1]ha = high amplitude, la = low amplitude, irr= irregular, dis = significant dissolution, ps = parallel sets, irreg-a = irregular anastomosing sets,

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO DANNY 2-34, SEC. 34, T16N, R2E
LINCOLN COUNTY, OKLAHOMA

FRACTURES

Depth		Description[2]
4930.0	4932.7	SF, V 0.5 - 4mm
4933.7	4937.0	Sf, V 0.5 - 2mm
4937.0	4939.3	HFc, V,H
4939.3	4941.0	SF, V, I 0.5 - 1mm
4941.0	4943.0	HFc, V
4943.0	4943.6	SF, V 0.5
4943.6	4945.3	FR
4945.3	4948.2	SF, V 0.5- 4mm
4948.2	4949.8	FR, HFc, V
4949.8	4954.5	SF, V 0.5 mm (sand filled , HFc)
4954.5	4957.5	sparse HFc
4957.5	4961.3	SF, V, 0.5 - 1 mm
4962.0	4971.1	SF, V, I, 0.5 - 2mm
4971.0	4974.2	SF, V, I 1-4mm, totally filled with carbonate silt
4974.2	4977.5	short (<2") FR, SF , V 0.5 mm
4977.5	4990.0	No Fractures

[2]Fr = open hairline fractures, HFc = healed fractures, calcite-filled;
SF = solution enlarged fractures, width given in mm; V = vertical,
I = inclined, H = horizontal

CORE DESCRIPTION
MARJO HENRY 1-3, SEC. 3, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth									
From	**To**	**Lith**	**Fabric**	**Pore Types**	**Av Pore %**	**% TV**	**Chalky**	**Facies**	**Description**
Woodford Shale		Shale		nil	nil				not cored
Misener Sandstone		SS		nil	nil				not cored
4966.0	**Hunton Limestone (30.6)**								**TOP OF CORE**
4966.0	4973.0	Ls	grnstn	TV,SF	4	3	N	7	Ls, pinkish gy 5YR 8/1, mottled to dk gy, c pent brac coquina with fine grnstn matrix. Heavily altered by karsting with mosaic and collapsed breccia, solution cavities filled with dk gy fine sand, gyish orange silt. Abundant vugs and frac and thin intervals of tightly cemented intact Ls
4973.0	4981.5	Ls	grnstn	TV,SF	3	3	N	7	Ls, a/a with scattered white chert replacing large brac and Ls clasts
4981.5	4986.2	Ls	grnstn	TV,SF	2	2	N	7	Ls, a/a no chert
4986.2	4990.7	Ls	grnstn	IG,FR	1	-	N	7	Ls, pinkish gy 5 YR 8/1, c pent brac grnstn with fine grnstn matrix, mostly intact rock with minor karst dissolution (4988.5 to 4990) with dk sand infill
4990.7	4993.0	Ls	grnstn	IG,TV	5.5	2	N	7	Ls, lt olive gy 5Y 7/1, c pent brac grnstn with fine grnstn matrix, good secondary IG porosity and minor vuggy porosity

CORE DESCRIPTION
MARJO HENRY 1-3, SEC.3, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4993.0	4995.1	Dol	grnstn	IX,TV	7	2	N	7	Dol, buff, lt gyish orange 10YR 7/3, c brac grnstn, dolomitized with scattered vugs, largely dissolved brac cavity fill
4995.1	4996.6	Dol	grnstn	IX, SF	8.5	1	N	12	Dol, buff above, lt olive gy below 4996.1, fine grnstn, dolomitized to med crystalline matrix, abrupt color contact @ 4996.1 at irregular stylolite, contains sparse small brac
4996.6									**BASE OF CORE**

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO HENRY 1-3, SEC. 3, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

KARST

Depth		Description
4966.0	4986.0	Chaotic Breccia carbonate clasts with short intervals resembling mosaic breccia, interclast matrix is dominantly fine grained dk gy silisiclastic sand and minor gyish orange carbonate silt
4986.0	Bottom	Intact Host Rock, with karst dissolution cavities (4988.5 to 4990.1) filled with dk gy calcitic silt

FRACTURES

Depth		Description[2]
4966.0	4968.4	SF V,I,H
4969.0	4970.4	SF V,I,H
4970.9	4973.9	SF , 0.5 mm to 1 mm V
4976.7	4990.0	Healed frac with calcite infill V,I,H. @ 4986 to 4986.7 SF 1mm
4995.0	4995.7	SF V 1mm

[2]Fr = open hairline fractures, HFc = healed fractures, calcite-filled;
SF = solution enlarged fractures, width given in mm; V = vertical,
I = inclined, H = horizontal

CORE DESCRIPTION
MARJO JOE GIVENS 1-15, SEC.15, T15N, R20E
LINCOLN COUNTY, OKLAHOMA

Depth From	Depth To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
Woodford Shale			**(1.6ft cored)**						
5013.0	5014.6	Shale		nil	nil			13	Shale, dk gy N3, fissile, carbonaceous, pyritic
Misener Sandstone			**(3.2 ft thick)**						
5014.6	5017.2	Sh, SS		nil	nil			13	Shale, aa, with thin beds and laminae of f.gr. Ss, loc. Pyritic
5017.2	5017.8	SS						14	SS, med-dk gy, vfg-fg, sli calc, with thin sh laminae. Basal 1.5 cm (0.05') laminated SS, broken by collapse into underlying karst cavern.
Hunton Limestone			**(26.2 ft. thick)**						**TOP OF CORE**
5018.8	5023.1	Ls	Grnstn,Pkstr	TV, SF, IG	5	3	N	6	Limestone, pinkish gray 5YR8/1 with patchy dk gray f. ss infill. Grainstone of large pentamerid brachiopods, interbedded with dense brach-crinoid packstone(?). Partly dissolved by micro karst to chaotic breccia. Misener sand infill in open vertical fractures, vugs, and interclast voids.Intergrain porosity in fg ss infill. Coarse calcite crystals in vugs. common vertical fracturing, partly healed. Scattered favositid corals.

CORE DESCRIPTION
MARJO JOE GIVENS 1-15, SEC.15, T15N, R20E
LINCOLN COUNTY, OKLAHOMA

Depth From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
5032.4	5038.6	Ls	Grnstn, Pkstn	TV, SF, IG	4	2	N	6	Ls, aa, crinoid -brach grainstone, largely dissolved by karsting to chaotic breccia of individual crinoids and brachs, infilled by vfg-fg sand, oil stained.
5038.6	5043.9	Ls	Grnstn, Pkstn	SF, IG	2	1	N	4, 6, 3	Ls, pinkish-gy, coarse brach grainstone (*Stricklandia?* , orthids?) with interbeds of dense fine brach pkstn(?). Thin karst chaotic breccias with sand infill, gradational contacts.
5043.9	5044.0	Dol	Xln	IX	4	0	N	2	Dolomite, calcitic, varigated brownish gray, crinkly laminae, indefinite contacts above and below.
Sylvan Shale			**(3.2 ft cored)**						
5044.0	5046.0	Dol	Mdstn		nil	0		1	Dolomite mudstone, argillaceous, greenish gray,5GY6/1, abund pyrite throughout, terra rosa near top.
5046.0	5047.2	Sh						13	Shale, greenish gray, dolomitic, blocky, pyritic, burrow mottled.
5047.2									**BASE OF CORE**

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO JOE GIVENS 1-10, SEC. 15, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

KARST

Depth		***General* Description**
5017.8	5042.6	Mostly dissolution mosaic breccia, with thin intervals of chaotic breccia with Misener fine sand infill, few open vugs between karst clasts. Thin intervals of intact host rock between breccias. Vertical fissures up to 0.2 ft wide filled with sand.
5042.6	5043.9	Mostly intact host rock

Depth		***Detailed* Description**
5017.8	5018.3	Chaotic breccia, fine sand infill, part open vugs.
5018.3	5018.8	Intact Host rock
5018.8	5025.5	Large vugs and vertical fissures, 0.1-0.2 ft wide, sandfilled.
5020.4	5021.8	Chaotic breccia, fine sand infill, part open vugs.
5025.5	5026.4	Intact Host Rock
5026.4	5027.0	Mosaic Breccia, sand filled
5027.0	5030.3	Mostly Intact Host rock, sli fracture breccia
5030.3	5036.9	Mosaic Breccia, fine sand filled, fissures 0.01 to 0.07 ft wide.
5036.9	5037.2	Intact Host rock, mostly
5037.2	5038.6	Mosaic breccia, fine sand filled, fissures 0.1-0.3 ft wide.
5038.6	5039.5	Intact host rock with vertical sediment-filled solution-enlarged fractures, 3mm wide.
5039.5	5039.9	Mosaic Breccia, sand filled
5039.9	5041.6	Intact host rock
5041.6	5042.6	Mosaic breccia, fossiliferous, vuggy, sand infill
5042.6	5044.0	Intact host rock
5044.0		Base of Hunton

CORE DESCRIPTION
MARJO MARY MARIE 1-11, SEC. 11, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	Depth To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
Woodford Shale									
4960.0	4960.7	Shale		nil	nil			13	Shale, dk gy N3, fissile, carbonaceous, pyritic
Misener Sandstone									
4960.7	4961.0	SS		nil	nil			14	SS, med. Gy, vfg, calc, large brachiopods & fragments (Disconformity: erosional surface)
Hunton Limestone									
4961.0	4965.5	Ls	Pkstn, Grnstn	IG	<2	0		6	Ls, pinkish gy (5YR8/1)-lt brn gy (5yr6/1), brachiopod-crinoid pkstn & grnstn. Karst: dissol breccias tightly cemented, Misener SS cavern fill in top 4 ft. Tight.
4965.5	4971.6	Ls	Pkstn	PP,MO,TV	7	3		7	Ls, v pale orange 10YR8/2, c. brach pkstn. PP porosity probably dissolution of mud matrix. Abund. Lg pentamerid brachs. Coral at 4970.5
4971.6	4973.6	Ls	Pkstn	IG	<2	0		7	Ls, aa, pinkish gy, tightly cemented
4973.6	4975.3	Ls	Pkstn	TV:SF, MO	4	4		7	Ls, aa., large solution enhanced fractures, partly connecting moldic pores.
4975.3	4983.6	Ls	Pkstn	PP, SV	<2	0		7	Ls, aa, tightly cemented, locally pin-point (IG?) porosity. Thin beds of large brachs with moldic separate vugs (SV). Strongly karsted (partly dissolved) and infilled with geopedal mud; sli terra rosa.

CORE DESCRIPTION
MARJO MARY MARIE 1-11, SEC. 11, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	Depth To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4983.6	4988.4	Ls	Pkstn	PP, M0, SF	5	2		7	Ls, aa to v.pale orange 10YR6/2, fine to coarse brach pkstn. Much PinPoint (probably intergranular) porosity, minor moldic and solution-enhanced fractures.
4988.4	4994.2	Ls	Grnst	SV, MO	1	0		7	Ls, aa, large pentamerid brachs in v. fgr collapsed grainstone matrix. Many vertical fractures completely cemented. Separate moldic vugs.
4994.2	5001.6	Ls	Grnst	IX, SV	<1	0		6	Ls, pinkish gy, vfg mixed crinoidal and brachiopod grainstone, leached collapsed grains uniformly tightly cemented. <1% porosity except in basal foot which has 2% pinpoint separate vug (?moldic) porosity. Very rare large brachiopods. Basal 0.12 ft. is greenish gray 5GY6/1 fine packstone with sharp basal contact on a dissolution surface. Probably a sequence boundary.

CORE DESCRIPTION
MARJO MARY MARIE 1-11, SEC. 11, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	Depth To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
5001.6	5003.5	Ls, dolo	Pkstn, Grnstn	IX, IG	5	0		6	Ls, v pale orange, part dolomitized. Mostly crinoidal/ brachiopod packstone and grainstone, in part dolomitized to uniform fine crystalline mosaic. Small pentamerid brachiopods in a fine to medium grained matrix, locally with abundant mud. All porosity is secondary, as dissolved mud matrix, dissolved crystals & fossil grains. Slight healed vertical fractures. Basal 0.2 ft is vfg grainstone with no brachiopods.Sharp basal contact on erosional surface. (Disconformity: erosional surface)
5003.5	**Sylvan Shale**								
5003.5	5006.0	Dol	Mdstn	IX	-			1	Dol, argillaceous, greenish-gray, burrow-mottled, pyritic. Top 1 ft closely fractured, abund pyrite throughout, terra rosa near top. Gradational into shale below by apparent decreasing dolomite content.
5006.0	50016.0	Shale			nil	0		13	Shale, greenish gray,5GY6/1, pyritic. Slightly dolomitic or silty, partly burrowed.

CORE DESCRIPTION
MARJO MCBRIDE SOUTH 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	Depth To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
Woodford Shale		Shale		nil	nil				not cored
Misener Sandstone		SS		nil	nil				not cored
Hunton Limestone		**(34.3)**							
									Note : From the top 4962 to 4972 we have 3 cycles. Tight Ls at the top grading downward into vuggy karsted porous Ls grading downward to dolomite and the base of dolomite is abrupt contact on the underlying Ls and all contacts appear inclined about 30 degree from horizontal
4962.0	4965.0	Ls	grnstn	TV,SF	6	3	N	7	Ls, lt brownish gy 5YR7/1 with med gy partings, c pent brac grnstn with fine carbonate grnstn matrix. The bottom 0.8 ft becomes dolomitic down to an abrupt contact at a stylolite
4965.0	4966.8	Ls	pkstn	Vugs, SF	3	1	N	7	Ls, pinkish gy to lt gy, c pent brac grnstn with fine grnstn carbonate matrix, partly very tightly cemented, lower part vuggy
4966.8	4968.0	Dol	grnstn	Vugs IX	4	1	N	7	Dol, lt olive gy 5Y6/1, c pent brac grnstn with fine matrix largely dolomitized, abundant karst silt and fine qtz sand infill, mostly carbonate

CORE DESCRIPTION
MARJO MCBRIDE SOUTH 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth									
From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4968.0	4970.1	Ls	grnstn	IG , Vugs	2	1	N	7	Ls, lt pinkish gy to ly gy, c pent brac grnstn with fine grn carbonate matrix, tightly cemented at top with increasing karst dissolution and fine quartz sand infill to the base. 30 degree incline sharp contact with dolomiteat 4970.1
4970.1	4971.9	Dol	grnstn	IX,Vug	7	3	N	7	Dol, lt olive gy, c pent brac grnstn with med crystalline dolomitic matrix grading downward into partially dolomitized Ls a/a.
4971.9	4983.1	Ls	grnstn	IG, Vug	2	1	N	7	Ls, lt pinkish gy to med gy (in karsted sediments), c pent brac grnstn with fine grn carbonate matrix, mostly v tightly cemented with zones of karst dissolution, vuggy porosity and karst solution frac filled with med gy quartz sand
4983.1	4990.3	Ls	pkstn/wkstn	IG,Vug	2	1	N	6	Ls, lt pinkish gy to med gy (in karsted sediments), c pent brac pkstn with moderate to abundant cri material, mostly v tightly with zones of karst dissolution, vuggy porosity and karst solution frac filled with med gy fine quartz sand. Thin interbeds of sparsely foss wkstn, tightly cemented. Uppermost contact is sharp, inclined at 30 degree in next 0.5 feet

CORE DESCRIPTION
MARJO MCBRIDE SOUTH 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth									
From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4990.3	4994.3	Ls	grnstn	IG,FR	3	2	N	3	Ls, lt pinkish gy , v fine brac grnstn, tightly cemented with widely scattered large brac, includes thin section zones of karst mosaic breccia with minor med gy infill, leached IG porosity associatedwith karst zones
4994.3	4996.3	Ls	grnstn	IG,FR	4	1	N	6	Ls, lt brnish gy 5 YR7/1, v c large brac cri grnstn with v c grn matrix, partially dissolved by karst, but all vugs and cavities are filled with dk gy carbonate silt and very fine qtz sand, v sharp contact with Sylvan below, includes cri grns up to 1 inch long
TOP SYLVAN		**(1.7 ft)**							
4996.3	4998.0	Dol	mdstn	IG	5	-	N	1	Dol, grnsh gy 5 GY 6/1, argillaceous with wispy laminae and burrow mottles suggesting moderately disturbed bedding, scattered irregular pyritic zones

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO McBRIDE SOUTH 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

KARST

Depth		Description
4962.0	4971.6	Mosaic Breccia, very slight clast movement, fine carbonate silt and fine quartz sand infill with 2 one foot intervals
4971.6	4972.8	Intact Host rock
4972.8	4973.3	Mosaic Breccia a/a
4973.3	4979.1	Intact Host rock
4979.1	4980.9	Intact Host rock with vertical karst fissure upto .15 ft wide filled with v fine qtz sand
4980.9	4983.1	Intact Host Rock with karst dissolution, qtz sand infill
4983.1	4990.3	Intact Host Rock with minor dissolution and silt and fine qtz sand infill
4990.3	4994.1	Intact Host Rock
4994.1	4994.8	Fracture Breccia and karst dissolution with fine quartz sand infill

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO McBRIDE SOUTH 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

STYLOLITES

Depth		Description[1]
4962.0	4964.3	irreg-a
4964.9		la peaked with major dissolution
4965.0	4966.0	scattered irr
4968.0	4968.8	irreg-a
4969.1		ha with major dissolution
4971.8	4971.9	ha sets with major dissolution
4972.8	4973.1	fitted irr
4973.5	4973.8	ha
4981.3	4981.9	inclined hummocky
4983.1	4983.7	inclined hummocky
4986.3	4986.7	irr
4990.3	4990.9	irr
4992.1		ha
4992.5		irr
4992.8		la
4993.3	4993.8	irr
4994.5	4994.8	stylo brecciated

[1]ha = high amplitude, la = low amplitude, irr= irregular, dis = significant dissolution, ps = parallel sets, irreg-a = irregular anastomosing sets,

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO McBRIDE SOUTH 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

FRACTURES

Depth		Description[2]
4962	4965.2	SF V 0.5 mm
4966	4967.3	SF 0.1 mm
4971.3	4972.6	FR
4976.3	4976.8	HFc I
4979	4981.7	SF sediment filled
4983.3	4983.7	HFc I
4985	4985.9	HFc I
4987.7	4988.1	HFc V & I
4990	4991.8	FR V
4992.8	4993.2	FR V
4995	4995.4	FR I
4996.4	4996.8	FR V

[2]Fr = open hairline fractures, HFc = healed fractures, calcite-filled;
SF = solution enlarged fractures, width given in mm; V = vertical,
I = inclined, H = horizontal

CORE DESCRIPTION
MARJO TOLES 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	Depth To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
Woodford Shale		Shale		nil	nil				not cored
Misener Sandstone		SS		nil	nil				not cored
4964.0	**Hunton Limestone (39.7 feet cored)**								
4964.0	4973.8	Ls	Pkstn, Grnstn	IP,BR,SF	3.0	2.0	N	6,7	patches & stringers of dark gray matrix, coarse crinoid-brachiopod packstone and grainstone. Leached skeletal grains gives compacted fabric, partly dissolved by micro karst. Misener sand infill in open semi-horizontal vugs & sparse solution-enlarged fractures. Vugs largely leached mudstone matrix & brach shelter infill. Coarse calcite crystals in vugs.Karst collapse breccia mostly clast supported (cave floor); thin intervals of high (5-10%) vuggy porosity . Abundant large
4973.8	4983.0	Ls	Grnstn	SV, Fr, SF	4.0	2.0	Y	4,5	Ls, aa to white, med gr crinoid grainstone, mostly recrystallized. Abund small separate vugs. Vert & inclined fractures(cave roof?) with slight movement, solution-enlarged fractures with Woodford clay infill. Sparse v.lg crinoids (to 1.5"), sparse thin layers of brachiopods.

CORE DESCRIPTION
MARJO TOLES 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4983.0	4984.5	Ls	Grnstn	SV,Mo, SF	6.0	3.0	Y	6.0	Ls, aa to lt brn gy, dk gy along fractures, stylolites, and in vugs; coarse brach-crinioid grainstone, compacted, leached, large moldic brach vugs. Dissol breccia at top. Zones of abundant microvugs, apparently interconnected molds.
4984.5	4987.1	Ls	Grnstn	IX, V, Fr	5.0	1.0	Y	4.0	Ls,aa, fine crinoid grainstone, strongly recrystallized, num microvugs & sparse large vugs. 1 lg sed-filled vug.
4987.1	4991.0	Ls	Grnstn	V, Imo, Fr	10.0	4.0	Y	7,9	v.coarse crinoid-brach grainstone, large coral (Favosites?) in basal 0.5 ft. Strongly leached, abund large vugs, mostly clay-sediment infilled, inside brachs & corals, abund moldic microvugs. Partly recrystallized to coarse spar. Top contact probably a dissolution (cave roof) contact.
4991.0	4996.6	Ls	Grnstn	SF, SV, Mo	3.0	1.0	P	5,8	(sparrite), partly compacted with fitted grains. Rare brachs, corals, bryozoan & stromatoporoid fragments. Tightly cemented, strongly recrystallized IP, SFs with dk-gy Woodford ? fill.
4996.6	4998.3	Ls	Pkstn	SF, Vug	2.0	0.0	N	5,6	with thin grainstones; foss allochems <3mm.

CORE DESCRIPTION
MARJO TOLES 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	Depth To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4998.3	5001.8	Ls	Grnstn	SF, IX, Vug	3.0	2.0	N	5,6	Ls, pk-gy, c crinoid-brach grainstone, part recrystall., fractured, vuggy, both partly clay-filled. Sharp upper boundary at corrosion surface, poss seq boundary
5001.8	5003.7	Dol	Grnstn/Xlln	IX, Mo, Fr	4.0	1.0	N	5.0	((5GY 6/1), c. grainstone with large brachs to fine grainstone to med xln dol. Moldic pores around large brachs.
5003.7	**Sylvan Shale (0.6 ft cored)**								
5003.7	5004.4	Dol	Mdstn	IX	3.0	0.0	N	1.0	(5GY6/1),mudstone, argillaceous, pyritic, burrow mottled.
5004.4	**Base of Core**								

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO TOLES 1, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

KARST

Depth		Description
4960.0	4961.2	Dissolution mosaic breccia, slight Woodford sediment infill
4961.2	4968.1	Intact Host rock
4968.1	4969.3	Clast-supported breccia, rounded clasts in upper 0.3 ft, clasts .5-1 cm, interclast TV porosity
4969.3	4970.6	Intact Host rock
4970.6	4972.8	Clast-supported breccia, Clasts partly whole brachiopods. Post-breccia laminated internal sediments. Inter-clast solution-enlarged fractures
4972.8	4973.4	Intact Host rock
4973.4	4974.5	Solution-enlarged fractures, Woodford clay filled
4974.5	4979.7	Fracture breccia, minor movement
4979.7	4983.0	Intact Host rock
4983.0	4983.5	Mosaic Breccia, clay filled
4983.5	4987.0	Intact Host rock, mostly
4986.2	4986.3	Cavern, .05' x .25', laminated grainstone fill
4986.4	4987.1	Fracture breccia
4987.1		Cave roof, dissolution cavity below
4987.1	4987.8	Clast supported breccia, slight clay fill
4987.8	4988.9	Intact grainstone, leached
4988.9	4990.8	Clast supported breccia, much clay fill, large vugs
4990.8	5001.7	Fracture breccia, sparse fractures, sli clay infill in SF

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO TOLES 1, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

STYLOLITES

Depth		Description[1]
4964.0	4967.5	irreg-a, abundant
4969.3		ha
4971.8		ha
4973.4		la, dis
4982.4		ha, dis, much dissol.porosity above and below
4983.9	4984.0	ps
4988.9		ha
4993.0		irr
4993.5		irr
5000.4		irr, dis
5001.7		ha, dis, v hi ampl, much dissol, >0.2' lost

[1]ha = high amplitude, la = low amplitude, irr= irregular, dis = significant dissolution, ps = parallel sets, irreg-a = irregular anastomosing sets,

CORE DESCRIPTION
KARST, STYLOLITE AND FRACTURE FEATURES
MARJO TOLES 1, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

FRACTURES

Depth		Description[2]
4965.4	4966.2	HFc, V
4969.2	4972.2	HFc, V
4972.2	4972.8	SF, 1 mm
4973.4	4974.5	SF, 2-7 mm, clay-filled
4974.5	4979.7	SF, 1-2 mm, 95% clay-filled
4977.1	49977.7	HFc
4981.1	4981.9	SF, I, 0.5 mm
4982.8	4983.5	SF, V, 1-2 mm, 90% clay-filled
4984.6	4984.9	Fr, VIH, irregular, sli clay-fill
4986.4	4987.1	Fr, VIH, irregular, sli clay-fill
4990.2	4990.8	SF, VIH, 1-2 mm, part clay-filled
4990.8	4992.2	SF, VIH, < 1mm, sli clay-fill
4993.0	4993.5	SF, V, 1 mm
4994.2	4996.5	SF, V & H, 1-2 mm, part blk clay-filled
4996.5	4998.5	HFc
4998.5	5001.0	SF, V, 1-2 mm, part clay-filled

[2]Fr = open hairline fractures, HFc = healed fractures, calcite-filled; SF = solution enlarged fractures, width given in mm; V = vertical, I = inclined, H = horizontal

CORE DESCRIPTION
MARJO WILKERSON 1-3, SEC. 3, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	Depth To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
Woodford Shale (2.43 ft cored)									
4950	4952.43	Shale		nil	nil			13	Shale, dk gy N3, fissile, carbonaceous, pyritic
Misener Sandstone (0.99 ft)									
4952.43	4952.42	SS		nil	nil			14	SS, med-dk Gy, vfg-fg, calc, abund large brachiopods & fragments, sharp upper contact. ---Disconformity: erosional surface---
Hunton Limestone (46.38 ft)									
4953.42	4958	Ls	Pkstn, Grnstn	IG,BR,SF	6	3	Y	7	Limestone, pinkish gray 5YR8/1 with patchy dark gray matrix, brachiopod packstone and grainstone. Leached skeletal grains gives collapsed fabric, partly dissolved by micro karst. Misener sand infill in open vertical fractures and vugs. Vugs largely leached mudstone matrix. coarse calcite crystals in vugs. collapse breccia 4954.5-56. Abundant large strophomenid brachiopods. common vertical fracturing.
4958	4960	Ls	Pkstn	PP, SV, MO	3	0	Y	7	Ls, aa, little sand infill, mostly tightly cemented, isolated moldic vugs
4960	4962.6	Ls	Pkstn	SF, MO	5	2	Y	7	Ls, aa, brach packstone. Short vertical fractures, open, solution-enlarged. Many vugs surrounding brachiopod shells, moldic on outer (primary) shell
4962.6	4965.3	Ls	Pkstn	SF,MO	3.5	1	P	7	Ls, aa, brach packstone. Mostly tight matrix. Solution enlarged and moldic (SF,MO) porosity sparse. Coral at 66.7'. Coarse crystalline calcite layer (0.1') @ 65.1, ? cavern fill.

CORE DESCRIPTION
MARJO WILKERSON 1-3, SEC. 3, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth									
From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4965.3	4967	Ls	Pkstn, Grnstn	SF, MO	4.5	3	P	7	Ls, aa, brach packstone and grainstone, decreasing mud matrix. Touching vugs common, vertical open fractures crystal-lined. Thin zone of 8% TV porosity at 4966-66.4'.
4967	4973.5	Ls	Grnstn	SV:MO	1.5	0	N	7	Ls, aa, brach grainstone, large Pentamerids less abundant. Mostly tightly cemented with sparse separate moldic vugs. Recrystallized to dense spar at 4971.5-71.7, ?cavern fill.
4973.5	4975.8	Ls	Pkstn	IG,MO,SF	10	2	Y	7	Ls, v pale orange 10YR8/2, leached vuggy brach packstone. Good secondary intergranular porosity due to dissol of mud matrix, good moldic vugs, mod. fractures
4975.8	4978.7	Ls	Pkstn	MO	1.5	0	N	6	Ls, pinkish gy, crinoidal & brach packstone, tighly cemented. Rare moldic vugs. Large crinoid at 4978.5
4978.7	4981.7	Ls	Grnstn	IX?, MO	1	0	N	6	Ls, aa, mixed crinoidal & brach fine grainstone, tightly cemented. Sparse large brachs & large crinoids,

CORE DESCRIPTION
MARJO WILKERSON 1-3, SEC. 3, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4981.7	4992.7	Ls	Grnstn	IG, MO	2	0	N	6.5.4	Ls, grayish orange pink 5YR7/2, crinoidal grainstone ("pink encrinite" of workers), fine to vfg, with sparse large crinoids & sparse thin layers of small brachiopods. Trace of ooids. Leached, collapsed grainstone , about 5% mud matrix. Porosity largely intergranular, due to leaching of mud matrix, with 1% microporosity in mud. Thin layers of moldic porosity up to 3%. Bottom 1' has 4% porosity, moldic & fine fractures. [4985.2-86.2 is brachiopod ppkstn, vuggy; appears out of place. Probably Misplaced Core!]
4992.7	4994.9	Ls	Grnstn	IG	1.8	0	N	5	Ls , aa, tightly cemented, terra rosa; stylolitc base; ?depositional boundary
4994.9	4997.9	Ls	Grnstn	IG, MO	8	0	P	6	Ls, aa, brach/crinoid grnstn, coarse grained. Rare corals, abund. large Pentamerid brachs (diff. Species from above). Sparse mud matrix, leached to fine Separate Vugs in intergranular space. Basal 0.3' is dark muddy grainstone , stylolitic. Possible Sequence boundary.

CORE DESCRIPTION
MARJO WILKERSON 1-3, SEC. 3, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth From	To	Lith	Fabric	Pore Types	Av Pore %	% TV	Chalky	Facies	Description
4997.9	4999.8	Dol	Grnstn	IX, MO	10	1	P	3	Dolomite and dolomitic limestone, lt olive gy 5Y6/1, dolomitized brach/crinoid grainstone. Excellent intercrystalline porosity, and moldic porosity on primary (outer) layer of large pentamerid brachs. Abrupt contact at base. Basal 0.2' is fine-grained grainstone, possibly oolitic (Need TS). Possibly Keel Oolite unit reported by Amsden in the Kirkpatrick 1 Blevins in 7-17N-4W, Logan Co, OGS Bull. 129. ---Disconformity: erosional surface---
4999.8	**Sylvan Shale (4.4 ft cored)**								
4999.8	5004.2	Dol	Mdstn	IX		0		1	Dol,argillaceous mudstone, greenish gray,5GY6/1, top is erosional surface, abund pyrite throughout, terra rosa near top

Coding of Porosity and Facies Types

Porosity Types

<u>Code #</u>

Limestones (grain density 2.71 to <2.73)

13. Interconnected Vuggy porosity

    Vug or MO with IG, SF or other connection, TV general, Vug general. Not vugs with tight matrix.

14. Coarse Matrix porosity

    Inter-particle (IP), IG or IX of coarse-grained rock, > .25 mm particle size. Many include dissolution porosity that is inter-particle micro vugs (dissolution of spar or matrix).

15. Fine Matrix porosity

    Inter-particle (IP), IG or IX of medium to fine-grained rocks, < .25 mm particle size. Includes fine non touching vugs and non touching fine Moldic (MO) porosity along with intra-particle porosity

16. Fracture

    FR or SF without significant matrix or vugs. For this study, includes solution-enhanced fractures with sand in-fill.

Dolomite (> 50% dolomite; grain density 2.79 or higher)

17. Vuggy (vug) or Moldic (MO) in coarse crystalline (IX) matrix (> .25 mm)

18. Coarse crystalline with Inter-crystalline porosity (IX) (> .25 mm)

19. Medium to fine crystalline (IX) (.25 mm to .02 mm)

20. Fracture FR or SF without significant matrix porosity

Partly Dolomitized Limestone (10 – 50 % dolomite; gr density 2.73-2.78)

21. Interconnected Vuggy porosity

    Vug or MO with IG, SF or other connection, TV general, Vug general. Not vugs with tight matrix.

22. Coarse Matrix porosity

    Inter-particle (IP), IG or IX of coarse-grained rock, > .25 mm particle size. May include dissolution porosity that is inter-particle micro vugs (dissolution of spar or matrix).

23. Fine Matrix porosity

    Inter-particle (IP), IG or IX of medium to fine-grained rocks, < .25 mm particle size. Includes fine non touching vugs and non touching fine Moldic (MO) porosity along with intra-particle porosity

24. Fracture

    FR or SF without significant matrix or interconnected vuggy porosity. For this study, includes solution-enhanced fractures with sand in-fill.

Facies Types

<u>Code #</u>

25. Argillaceous Dolomite (Greenish-gray, resembles Sylvan Fm)
26. Crystalline Dolomite
27. Small Brachiopod Grainstone/Packstone/Wackestone
28. Fine Crinoid Grainstone/Packstone/Wackestone
29. Coarse Crinoid Grainstone/Packstone
30. Mixed Crinoid-Brachiopod Grainstone/Packstone/Wackestone
31. Big Pentamerid Brachiopod Coquina

32. Coral & Diverse Fauna
33. Coral & Crinoid Grainstone-Wackestone
34. Sparse Fossil Wackestone
35. Mudstone
36. Fine- Medium Grainstone
37. Shale
38. Fine Sandstone

POROSITY AND FACIES CODES
MARJO BOONE 1-4, SEC. 4, T15N, R2E
LINCOLN COUNTY, OKLHAOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments
1	5037.1	to	38.0	5037.6	3.1	2.72	4	6	29.4	Hunton Fm
2	5038.3	to	39.0	5038.7	3.7	2.71	4	6	28.2	
3	5039.1	to	39.9	5039.5	4.7	2.71	2	6	27.4	
4	5040.1	to	40.9	5040.5	3.1	2.71	2	6	26.4	
5	5041.0	to	41.4	5041.2	2.2	2.71	2	6	25.5	
6	5042.0	to	42.9	5042.5	1.6	2.71	3	6	24.5	
7	5043.0	to	43.9	5043.5	2.8	2.71	3	9	23.5	
8	5044.0	to	44.6	5044.3	2.3	2.71	3	9	22.5	
9	5045.0	to	45.8	5045.4	0.7	2.71	2	9	21.5	
10	5046.1	to	47.0	5046.6	7.4	2.74	10	9	20.4	
11	5047.0	to	47.9	5047.5	7.9	2.76	10	9	19.5	
12	5048.0	to	48.6	5048.3	9.9	2.76	10	5	18.5	Karst cavity fill
13	5049.3	to	50.0	5049.7	10.4	2.75	10	5	17.2	
14	5050.0	to	50.6	5050.3	6.9	2.73	10	5	16.5	
15	5051.0	to	51.8	5051.4	6.8	2.73	10	5	15.5	
16	5052.0	to	52.8	5052.4	5.5	2.73	10	4	14.5	
17	5053.2	to	54.0	5053.6	6.3	2.76	10	4	13.3	
18	5054.0	to	54.8	5054.4	5.9	2.76	10	4	12.5	
19	5055.0	to	55.5	5055.3	9.2	2.74	10	4	11.5	bedded grnstn, current bedding
20	5056.0	to	56.8	5056.4	10.6	2.72	2	6	10.5	
21	5057.0	to	57.6	5057.3	9.0	2.75	10	6	9.5	
22	5058.5	to	59.0	5058.8	5.1	2.78	10	6	8.0	
23	5059.0	to	59.7	5059.4	4.4	2.78	10	4	7.5	
24	5060.3	to	61.0	5060.7	1.5	2.70	2	5	6.2	
25	5061.0	to	61.8	5061.4	1.1	2.71	2	5	5.5	
26	5062.2	to	63.0	5062.6	5.6	2.73	10	4	4.3	

POROSITY AND FACIES CODES
MARJO BOONE 1-4, SEC. 4, T15N, R2E
LINCOLN COUNTY, OKLHAOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments
27	5063.0	to	63.9	5063.5	7.8	**2.79**	5	6	3.5	
28	5064.0	to	64.3	5064.2	9.3	**2.80**	5	6	2.5	
29	5065.7	to	66.0	5065.9	13.1	**2.88**	5	6	0.8	
30	5066.0	to	66.4	5066.2	8.1	**2.85**	5	4	0.5	
31	5067.1	to	67.3	5067.2	4.3	**2.96**	5	1	-0.6	Sylvan Shale, argill. Dol
	5067.9		Base of core					1	-1.4	

Strat Position is footage above or below (-) the Hunton/Sylvan contact at 5006.5, core depth

POROSITY AND FACIES CODES
MARJO CARNEY TOWNSITE 2-5, SEC. 5, T15N, R3E
LINCOLN COUNTY, OKLHAOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments and Thin Section*
1	4906.1	to	6.9	4906.5	9.1	2.80	7	2	71.9	*limy Dol, equant f xln, no allochems
2	4907.5	to	8.0	4907.8	11.0	2.78	10	4	70.5	
3	4908.3	to	9.0	4908.7	11.2	2.75	10	4	69.7	
4	4909.3	to	10.0	4909.7	11.7	2.78	10	4	68.7	
5	4910.3	to	11.0	4910.7	12.6	2.81	7	4	67.7	
6	4911.3	to	12.0	4911.7	11.7	2.80	7	4	66.7	
7	4912.3	to	13.0	4912.7	10.3	2.76	10	6	65.7	
8	4913.3	to	14.0	4913.7	10.5	2.77	10	6	64.7	
9	4914.3	to	15.0	4914.7	9.9	2.76	10	6	63.7	
10	4915.3	to	16.0	4915.7	10.8	2.78	10	6	62.7	
11	4916.3	to	17.0	4916.7	11.5	2.79	7	6	61.7	*Dolomitized med cri wkstn, dissol. porosity, limy Dol
12	4917.5	to	18.0	4917.8	12.4	2.80	7	4	60.5	
13	4918.3	to	19.0	4918.7	11.7	2.78	11	4	59.7	
14	4919.0	to	19.7	4919.4	12.4	2.82	7	4	59.0	
15	4920.3	to	21.0	4920.7	12.3	2.80	7	6	57.7	
16	4921.0	to	21.7	4921.4	14.1	2.81	7	6	57.0	
17	4922.0	to	22.6	4922.3	12.8	2.83	7	6	56.0	
18	4923.0	to	23.6	4923.3	14.0	2.80	7	4	55.0	
19	4924.3	to	25.0	4924.7	14.5	2.81	7	4	53.7	*Dolomitized med cri pkstn, limy Dol
20	4925.1	to	25.7	4925.4	13.2	2.82	7	4	52.9	
21	4926.0	to	26.8	4926.4	11.7	2.82	7	4	52.0	
22	4927.1	to	27.8	4927.5	11.2	2.76	9	4	50.9	
23	4928.3	to	29.0	4928.7	10.7	2.74	10	5	49.7	
24	4929.3	to	30.0	4929.7	11.0	2.76	9	5	48.7	
25	4930.3	to	31.0	4930.7	8.6	2.73	9	5	47.7	
26	4931.3	to	32.0	4931.7	9.1	2.73	10	6	46.7	*sli dol LS, med cri brac pkstn
27	4932.2	to	32.9	4932.6	10.4	**2.73**	9	6	45.8	
28	4933.3	to	34.0	4933.7	10.1	**2.76**	9	6	44.7	
29	4934.3	to	35.0	4934.7	11.0	**2.78**	10	4	43.7	
30	4935.0	to	35.7	4935.4	11.6	**2.76**	10	4	43.0	
31	4936.3	to	37.0	4936.7	10.9	**2.77**	10	4	41.7	
32	4937.0	to	37.6	4937.3	11.4	2.78	9	4	41.0	

POROSITY AND FACIES CODES
MARJO CARNEY TOWNSITE 2-5, SEC. 5, T15N, R3E
LINCOLN COUNTY, OKLHAOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments and Thin Section*
33	4938.3	to	39.0	4938.7	10.5	2.79	10	4	39.7	
34	4939.4	to	40.0	4939.7	9.8	2.80	10	4	38.6	
35	4940.2	to	40.9	4940.6	6.9	2.79	5	4	37.8	
36	4941.4	to	42.0	4941.7	4.2	2.77	1	4	36.6	
37	4942.4	to	43.0	4942.7	4.0	2.70	2	4	35.6	
38	4943.0	to	43.3	4943.2	3.6	2.71	2	4	35.0	
39	4944.0	to	44.3	4944.2	6.4	2.81	7	11	34.0	
40	4945.3	to	46.0	4945.7	2.5	2.71	3	4	32.7	
41	4946.0	to	46.7	4946.4	3.0	2.74	4	12	32.0	*4946.4-.6 dolomite Ls, rexlzd grnstn, Fr
42	4947.3	to	48.0	4947.7	7.1	2.80	11	10	30.7	*4946.8-.9 limy dol, rexlzd pkstn/wkstn, SV
43	4948.0	to	48.6	4948.3	12.0	2.84	8	10	30.0	
44	4949.0	to	49.3	4949.2	3.9	2.76	11	4	29.0	
45*	4950.1	to	51.0	4950.6	6.2	2.84	7	10	27.9	
46*	4951.1	to	52.0	4951.6	2.1	2.76	11	11	26.9	
47	4952.5	to	52.8	4952.7	5.6	2.78	9	4	25.5	
48*	4953.1	to	54.0	4953.6	5.4	2.77	9	4	24.9	
49*	4954.9	to	55.0	4955.0	5.0	2.81	7	11	23.1	
50*	4955.1	to	56.3	4955.7	4.4	2.81	7	4	22.9	
51*	4956.0	to	57.0	4956.5	2.0	2.77	11	11	22.0	
52*	4957.5	to	58.0	4957.8	1.3	2.71	3	4	20.5	
53*	4958.1	to	59.0	4958.6	0.9	2.71	3	10	19.9	
54*	4959.1	to	60.0	4959.6	1.3	2.71	3	3	18.9	
55*	4960.1	to	61.0	4960.6	2.0	2.72	3	3	17.9	*LS, med-f collapsed grnstn, fine brachs
56	4961.3	to	62.0	4961.7	2.7	2.71	3	9	16.7	
57	4962.0	to	62.5	4962.3	2.2	2.71	3	6	16.0	
58	4963.5	to	64.0	4963.8	1.2	2.71	3	5	14.5	
59	4964.0	to	64.7	4964.4	0.9	2.72	3	6	14.0	*med-c cri brach-ostr grnstn, karst dissol
60*	4965.1	to	66.0	4965.6	0.9	2.71	3	6	12.9	
	4966.0		Base of Core						12.0	

Strat Position is footage above or below (-) the Hunton/Sylvan contact at 4978 feet, core depth. Core depth appears to equal log depth.

POROSITY AND FACIES CODES
MARJO CARTER 1-14, SEC. 14, T15N, R3E
LINCOLN COUNTY, OKLHAOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments & Thin Sections*
1	4940.2	to	40.9	4940.6	6.7	2.85	7	6	55.6	Hunton Fm; * fine xln Dol, IX + dissolved IX
2	4941.4	to	42.0	4941.7	5.6	2.71	2	6	54.4	** a) med grnstn, collapsed ~ .5 mm, 0 porosity. B) c grnstn
3	4942.3	to	43.0	4942.7	9.3	2.71	1	7	53.5	
4	4943.1	to	43.7	4943.4	11.0	2.70	1	7	52.7	
5	4944.4	to	45.0	4944.7	6.7	2.71	1	7	51.4	
6	4945.0	to	45.6	4945.3	9.1	2.70	1	7	50.8	* c brac pkstn, matrix dissolved, IG porosity
7	4946.0	to	46.4	4946.2	10.3	2.70	1	7	49.8	
8	4947.3	to	48.0	4947.7	7.3	2.71	1	7	48.5	
9	4948.3	to	49.0	4948.7	9.1	2.70	1	7	47.5	
10	4949.5	to	50.0	4949.8	6.1	2.70	2	7	46.3	
11	4950.4	to	51.0	4950.7	3.8	2.71	2	6	45.4	* c brac cri grnstn, syntax overgrowth
12	4951.0	to	51.6	4951.3	2.9	2.71	2	6	44.8	
13	4952.3	to	53.0	4952.7	6.6	2.74	10	6	43.5	
14	4953.0	to	53.6	4953.3	2.3	2.72	2	6	42.8	
15	4954.0	to	54.6	4954.3	4.8	2.73	10	5	41.8	
16	4955.3	to	56.0	4955.7	2.5	2.72	2	5	40.5	* c cri grnstn, syntax overgrowth, IG porosity, karst silt
17	4956.0	to	56.6	4956.3	2.3	2.71	4	6	39.8	
18	4957.0	to	57.6	4957.3	1.6	2.72	2	5	38.8	
19	4958.0	to	58.7	4958.4	1.0	2.72	2	5	37.8	
20	4959.3	to	60.0	4959.7	3.8	2.75	10	5	36.5	
21	4960.4	to	61.0	4960.7	2.6	2.71	2	5	35.4	
22	4961.3	to	62.0	4961.7	2.1	2.70	2	5	34.5	* c cri grnstn, syntax overgrowth, tight

POROSITY AND FACIES CODES
MARJO CARTER 1-14, SEC. 14, T15N, R3E
LINCOLN COUNTY, OKLHAOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments & Thin Sections*
23	4962.0	to	62.6	4962.3	4.3	2.71	1	6	33.8	* c cri brac grnstn, leached , vuggy
24	4963.3	to	64.0	4963.7	2.6	2.71	2	6	32.5	
25	4964.0	to	64.6	4964.3	2.1	2.71	2	6	31.8	
26	4965.3	to	66.0	4965.7	1.6	2.72	2	6	30.5	
27	4966.0	to	66.6	4966.3	2.4	**2.71**	2	6	29.8	
28	4967.3	to	68.0	4967.7	1.7	**2.71**	2	6	28.5	
29	4968.8	to	69.0	4968.9	2.9	**2.72**	1	6	27.0	
30	4969.0	to	69.6	4969.3	4.9	**2.72**	1	6	26.8	
31	4970.5	to	71.0	4970.8	2.6	**2.72**	2	6	25.3	
32	4971.0	to	71.6	4971.3	1.5	2.71	2	6	24.8	
33	4972.4	to	73.0	4972.7	1.9	2.71	2	6	23.4	
34	4973.3	to	74.0	4973.7	1.0	2.71	2	6	22.5	
35	4974.6	to	74.6	4974.6	1.5	2.71	4	6	21.2	
36	4975.0	to	75.7	4975.4	1.3	2.71	2	6	20.8	* c cri brac grnstn, tight, syntax overgrowth
37	4976.0	to	76.6	4976.3	1.4	2.71	2	6	19.8	
38	4977.3	to	78.0	4977.7	1.2	2.70	2	5	18.5	* (4976.8) c cri grnstn, tight, syntax overgrowth
39	4978.0	to	78.6	4978.3	1.7	2.70	2	5	17.8	
40	4979.6	to	80.0	4979.8	0.9	2.71	2	5	16.2	
41	4980.1	to	80.7	4980.4	0.9	2.71	2	6	15.7	
42	4981.3	to	82.0	4981.7	2.2	2.73	10	3	14.5	
43	4982.0	to	82.7	4982.4	2.6	2.71	2	3	13.8	
44	4983.0	to	83.5	4983.3	5.7	2.75	10	3	12.8	
45	4984.0	to	84.6	4984.3	5.4	2.76	10	6	11.8	*2x2 slide, Doltzd c m cri brac grnstn, sli baroque Dol
46	4985.0	to	85.6	4985.3	6.1	2.75	9	6	10.8	
47	4986.0	to	86.6	4986.3	6.0	2.75	10	6	9.8	

POROSITY AND FACIES CODES
MARJO CARTER 1-14, SEC. 14, T15N, R3E
LINCOLN COUNTY, OKLHAOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments & Thin Sections*
48	4987.4	to	87.9	4987.7	5.4	2.70	1	6	8.4	
49	4988.0	to	88.6	4988.3	4.2	2.71	2	6	7.8	
50	4989.0	to	89.6	4989.3	4.6	2.71	3	4	6.8	
51	4990.0	to	90.6	4990.3	6.0	2.72	3	4	5.8	
52	4991.3	to	92.0	4991.7	10.3	2.73	11	6	4.5	* f cri brac grnstn, good IG porosity
53	4992.0	to	92.6	4992.3	11.4	2.73	11	6	3.8	
54	4993.0	to	93.7	4993.4	5.2	2.73	11	6	2.8	
55	4994.0	to	94.4	4994.2	1.1	2.80	11/7	6/12	1.8	* Ls, f cri brac grnstn / f Dol grnstn, IG, IX porosity (4994.1)
56	4995.0	to	95.5	4995.3	11.6	2.89	7	12	0.8	* med-f xln Dol grnstn, good IX porosity, f xln baroqued Dol
57	4996.3	to	97.0	4996.7	4.6	2.94	7	1	-0.5	Sylvan Shale, * v f argill dol mdstn
	4999.9	Base of Core						1	-4.1	

Strat Position is footage above or below the Hunton/Sylvan contact at 4995.8, core depth.

POROSITY AND FACIES CODES
MARJO DANNY 2-34, SEC. 34, T16N, R2E
LINCOLN COUNTY, OKLHAOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments
1	4930.2	to	30.9	4930.6	4.1	2.73	9	7	54.1	Hunton Fm
2	4931.2	to	31.5	4931.4	2.4	2.72	4	7	53.1	large 0.1 feet SF, open
3	4932.0	to	32.6	4932.3	1.5	2.72	4	7	52.3	Large SF, open
4	4933.3	to	34.0	4933.7	1.8	2.71	4	7	51.0	
5	4934.0	to	34.2	4934.1	1.7	2.72	4	7	50.3	
6	4935.0	to	35.2	4935.1	1.7	2.71	3	7	49.3	
7	4936.0	to	36.2	4936.1	3.3	2.72	1	7	48.3	
8	4937.0	to	37.6	4937.3	2.7	2.72	1	7	47.3	
9	4938.0	to	38.6	4938.3	1.1	2.71	1	7	46.3	
10	4939.3	to	40.0	4939.7	6.1	2.73	9	7	45.0	
11	4940.2	to	41.0	4940.6	5.2	2.73	9	7	44.1	
12	4941.2	to	42.0	4941.6	1.4	2.71	4	7	43.1	
13	4942.5	to	43.0	4942.8	2.0	2.72	1	7	41.8	
14	4943.0	to	43.5	4943.3	2.9	2.73	12	7	41.3	
15	4944.3	to	45.0	4944.7	2.6	2.73	12	7	40.0	Terra Rossa + much sand and silt karst infill
16	4945.3	to	46.0	4945.7	5.8	2.73	9	7	39.0	
17	4946.2	to	46.9	4946.6	4.7	2.73	9	7	38.1	big open SF + vugs
18	4947.0	to	47.4	4947.2	3.8	2.72	1	7	37.3	
19	4948.0	to	48.4	4948.2	2.9	2.72	1	7	36.3	

POROSITY AND FACIES CODES
MARJO DANNY 2-34, SEC. 34, T16N, R2E
LINCOLN COUNTY, OKLHAOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments
20	4949.3	to	50.0	4949.7	1.6	2.72	4	7	35.0	
21	4950.0	to	50.7	4950.4	1.6	2.71	4	7	34.3	SF filled with sand !
22	4951.3	to	52.0	4951.7	5.4	2.71	1	7	33.0	Big vugs, vertical sand filled fissures (SF)
23	4952.3	to	53.0	4952.7	4.1	2.72	1	7	32.0	
24	4953.3	to	53.7	4953.5	2.8	2.72	1	7	31.0	
25	4954.0	to	54.7	4954.4	2.8	2.72	1	7	30.3	second generation karst infill
26	4955.3	to	56.0	4955.7	1.0	2.72	3	10	29.0	
27	4956.0	to	56.6	4956.3	0.9	**2.72**	3	10	28.3	
28	4957.0	to	57.6	4957.3	1.1	**2.72**	3	10	27.3	
29	4958.3	to	59.0	4958.7	3.0	**2.71**	1	7	26.0	Brac, corals
30	4959.0	to	59.7	4959.4	3.5	**2.72**	1	7	25.3	
31	4960.6	to	61.0	4960.8	3.2	**2.73**	12	10	23.7	
32	4961.3	to	62.0	4961.65	4.1	2.71	1	7	23.0	long SF, big scattered vugs, sand filled fractures
33	4962.1	to	62.7	4962.4	7	2.71	4	7	22.2	
34	4963.3	to	64.0	4963.65	8.3	2.71	4	7	21	
35	4964.3	to	65.0	4964.65	2.5	2.71	4	7	20	
36	4965.1	to	65.8	4965.45	2.6	2.72	4	7	19.2	
37	4966.4	to	67.0	4966.7	2.9	2.72	4	10	17.9	
38	4967.0	to	67.7	4967.35	3	2.71	4	10	17.3	

POROSITY AND FACIES CODES
MARJO DANNY 2-34, SEC. 34, T16N, R2E
LINCOLN COUNTY, OKLHAOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments
39	4968.0	to	68.6	4968.3	5.5	2.72	4	10	16.3	
40	4969.1	to	69.9	4969.5	5.8	2.71	4	10	15.2	
41	4970.3	to	71.0	4970.65	5.1	2.71	4	10	14	
42	4971.0	to	71.4	4971.2	7.2	2.71	3	3	13.3	
43	4972.3	to	73.0	4972.65	11.3	2.71	3	3	12	
44	4973.0	to	73.7	4973.35	8.3	2.7	2	5	11.3	
45	4974.2	to	74.9	4974.55	2.6	2.71	2	5	10.1	
46	4975.3	to	76.0	4975.65	8.3	2.71	2	5	9	
47	4976.3	to	77.0	4976.65	6.5	2.72	2	5	8	
48	4977.0	to	77.4	4977.2	4.6	2.71	2	5	7.3	
49	4978.3	to	79.0	4978.65	4.5	2.71	2	5	6	
50	4979.0	to	79.7	4979.35	3.2	2.71	2	5	5.3	
51	4980.3	to	81.0	4980.65	3.6	2.7	2	5	4	
52	4981.3	to	82.0	4981.65	3.1	2.7	2	5	3	
53	4982.3	to	83.0	4982.65	1.5	2.71	2	5	2	
54	4983.3	to	84.0	4983.65	2.3	2.71	2	5	1	
	4984.3							1	0	Top of Sylvan
55	4984.4	to	84.8	4984.6	4	2.91	7	1	-0.1	Sylvan, argill. Dol
	4985.8		4990.0					13	-1.5	Sh
	4990.0		Base of core						-5.7	

(-) the Hunton/Sylvan contact at 4984.3 ft., core depth.

POROSITY AND FACIES CODES
MARJO HENRY 1-3, NW/4, SEC. 3, T15N, R2E
LINCON COUNTY, OKLAHOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments
1	4966.0	to	4967.0	4966.5	3.0	2.71	1	7	38.5	
2	4967.0	to	4968.0	4967.5	2.6	2.72	4	7	37.5	
3	4968.0	to	4969.0	4968.5	3.3	2.71	1	7	36.5	
4	4969.0	to	4970.0	4969.5	11.0	2.72	4	7	35.5	
5	4970.0	to	4971.0	4970.5	3.9	2.72	1	7	34.5	
6	4971.0	to	4972.0	4971.5	2.8	2.72	4	7	33.5	
7	4972.0	to	4973.0	4972.5	3.4	2.71	4	7	32.5	
8	4973.0	to	4974.0	4973.5	3.2	2.71	4	7	31.5	
9	4974.0	to	4975.0	4974.5	2.2	2.72	1	7	30.5	
10	4975.0	to	4976.0	4975.5	3.6	2.71	1	7	29.5	
11	4976.0	to	4977.0	4976.5	5.9	2.72	1	7	28.5	
12	4977.0	to	4978.0	4977.5	3.2	2.72	1	7	27.5	
13	4978.0	to	4979.0	4978.5	1.8	2.72	3	7	26.5	
14	4979.0	to	4980.0	4979.5	2.8	2.72	1	7	25.5	
15	4980.0	to	4981.0	4980.5	3.6	2.72	1	7	24.5	
16	4981.0	to	4982.0	4981.5	2.8	2.71	1	7	23.5	
17	4982.0	to	4983.0	4982.5	3.5	2.72	1	7	22.5	
18	4983.0	to	4984.0	4983.5	1.2	2.71	4	7	21.5	
19	4984.0	to	4985.0	4984.5	0.9	2.72	3	7	20.5	
20	4985.0	to	4986.0	4985.5	1.4	2.71	3	7	19.5	
21	4986.0	to	4987.0	4986.5	0.7	2.72	4	7	18.5	
22	4987.0	to	4988.0	4987.5	1.1	2.71	3	7	17.5	
23	4988.0	to	4989.0	4988.5	1.3	2.72	3	7	16.5	
24	4989.0	to	4990.0	4989.5	1.0	2.72	3	7	15.5	
25	4990.0	to	4991.0	4990.5	3.1	2.72	3	7	14.5	leached f grnstn matrix, c brach coquina
26	4991.0	to	4992.0	4991.5	6.5	2.72	3	7	13.5	aa
27	4992.0	to	4993.0	4992.5	6.2	**2.73**	1	7	12.5	
28	4993.0	to	4994.0	4993.5	7.8	**2.77**	9	7	11.5	dolomitic lst, good IX + vugs
29	4994.0	to	4995.0	4994.5	6.4	**2.83**	10	7	10.5	
30	4995.0	to	4996.0	4995.5	10.2	**2.80**	6	12	9.5	fine gr grnstn, doltzd
31	4996.0	to	4996.6	4996.3	7.3	**2.84**	6	12	8.5	
	4996.6		Base of core						7.9	

Base of Hunton, contact with Sylvan, is at 4997 log depth, which = **5004.5 Core Depth**

Strat Position is footage above or below (-) the Hunton/Sylvan contact at 5004.5 ft., core depth.

POROSITY AND FACIES CODES
MARJO JOE GIVENS 1-15, SEC. 15, T15N, R2E
LINCON COUNTY, OKLAHOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments
	5013.0							13		Woodford Sh
	5014.6							13		Misener, sandy shale
	5017.2						3	14		Misener SS (14 = fine sandstone)
	5017.8						1	6	26.2	Top of Hunton, vuggy
1	5018.0	to	19.0	5018.5	5.7	2.71	1	6	26.0	
2	5019.0	to	20.0	5019.5	2.5	2.72	1	6	25.0	
3*	5020.0	to	21.0	5020.5	1.6	2.72	4	6	24.0	
4	5021.0	to	22.0	5021.5	2.8	2.70	4	6	23.0	
5	5022.0	to	23.0	5022.5	1.9	2.70	4	6	22.0	
6	5023.0	to	24.0	5023.5	1.7	2.72	4	6	21.0	
7	5024.0	to	25.0	5024.5	1.1	2.71	4	6	20.0	
8	5025.0	to	26.0	5025.5	1.2	2.70	4	6	19.0	
9	5026.0	to	27.0	5026.5	1.0	2.70	4	6	18.0	
10*	5027.0	to	28.0	5027.5	1.4	2.71	4	6	17.0	
11	5028.0	to	29.0	5028.5	0.8	2.71	4	8	16.0	
12	5029.0	to	30.0	5029.5	0.6	2.71	4	6	15.0	
13	5030.0	to	31.0	5030.5	1.9	2.71	4	6	14.0	
14	5031.0	to	32.0	5031.5	1.6	2.70	4	6	13.0	
15	5032.0	to	33.0	5032.5	1.7	2.71	4	6	12.0	
16	5033.0	to	34.0	5033.5	2.9	2.70	4	6	11.0	
17	5034.0	to	35.0	5034.5	2.2	2.71	4	6	10.0	
18	5035.0	to	36.0	5035.5	2.9	2.70	4	6	9.0	
19	5036.0	to	37.0	5036.5	3.7	2.71	4	6	8.0	
20	5037.0	to	38.0	5037.5	2.2	2.71	4	6	7.0	
21	5038.0	to	39.0	5038.5	1.9	2.70	4	6	6.0	
22	5039.0	to	40.0	5039.5	1.4	**2.71**	4	6	5.0	
23	5040.0	to	41.0	5040.5	0.8	**2.71**	3	4	4.0	
24	5041.0	to	42.0	5041.5	1.3	**2.70**	3	4	3.0	
25	5042.0	to	43.0	5042.5	1.3	**2.71**	2	6	2.0	
26*	5043.0	to	44.0	5043.5	2.2	**2.72**	2	3	1.0	
	5044.0		46				7	1	0.0	Sylvan Fm.: Argill. Dol
	5046.0		47.2					13	-2	Shale
	5047.2		Base of core						-3.2	

* Indicates plug analysis.

Strat Position is footage above or below (-) the Hunton/Sylvan contact at 5044 ft., core depth.

POROSITY AND FACIES CODES
MARJO MARY MARIE 2-11, SEC 11, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Thin Section
	4960.0		4960.7					13		Woodford Shale: Black shale, carbonaceous
	4960.7		4961.0					14		Misener Sandstone: vf ss
	4961.0								42.5	Top of Hunton Group: Cochrane Fm
1	4961.5	to	61.8	4961.7	1.7	2.71	2	6	42.0	
2	4962.0	to	62.7	4962.4	1.0	2.70	2	6	41.5	
3	4963.1	to	63.9	4963.5	0.8	2.71	2	6	40.4	
4	4964.3	to	64.9	4964.6	1.0	2.70	2	6	39.2	
5	4965.2	to	65.6	4965.4	1.6	2.70	2	6	38.3	bottom 0.1 ft. is facies 7, Pent. Brach coquina
6	4965.7	to	66.0	4965.9	6.1	2.71	2	7	37.8	
7	4966.0	to	66.3	4966.2	6.2	2.70	2	7	37.5	
8	4966.6	to	67.0	4966.8	4.5	2.71	2	7	36.9	
9	4967.0	to	67.4	4967.2	7.3	2.69	2	7	36.5	
10	4968.2	to	69.0	4968.6	8.1	2.69	1	7	35.3	
11	4969.0	to	69.3	4969.2	7.3	2.70	2	7	34.5	
12	4970.0	to	70.4	4970.2	5.8	2.69	1	7	33.5	
13	4971.2	to	71.9	4971.6	2.8	2.70	1	7	32.3	
14	4972.2	to	73.0	4972.6	1.9	2.71	2	7	31.3	
15	4973.0	to	73.4	4973.2	1.2	2.70	2	7	30.5	
16	4973.6	to	74.0	4973.8	4.6	2.72	1	7	29.9	
17	4974.3	to	75.0	4974.7	2.9	2.72	4	7	29.2	
18	4975.3	to	75.6	4975.5	0.9	2.70	3	7	28.2	
19	4976.3	to	77.0	4976.7	0.8	2.71	3	7	27.2	
20	4977.0	to	77.7	4977.4	0.9	2.71	3	7	26.5	
21	4978.2	to	79.0	4978.6	0.8	2.72	3	7	25.3	
22	4979.2	to	79.7	4979.5	1.7	2.71	4	7	24.3	
23	4980.0	to	80.6	4980.3	1.0	2.71	3	7	23.5	

POROSITY AND FACIES CODES
MARJO MARY MARIE 2-11, SEC 11, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Thin Section
24	4981.0	to	81.7	4981.4	2.0	**2.71**	3	7	22.5	
25	4982.2	to	83.0	4982.6	1.1	**2.71**	3	7	21.3	
26	4983.0	to	83.7	4983.4	2.2	**2.72**	3	7	20.5	
27	4984.4	to	84.8	4984.6	5.7	**2.70**	1	7	19.1	
28	4985.3	to	85.8	4985.6	3.2	**2.71**	1	7	18.2	
29	4986.0	to	86.5	4986.3	5.0	2.70	3	7	17.5	
30	4987.4	to	87.8	4987.6	4.5	2.71	1	7	16.1	
31	4988.3	to	88.8	4988.6	2.3	2.71	3	7	15.2	
32	4989.1	to	89.8	4989.5	0.6	2.70	3	7	14.4	
33	4990.5	to	91.0	4990.8	0.5	2.70	3	7	13.0	
34	4991.2	to	92.0	4991.6	0.8	2.69	3	7	12.3	
35	4992.2	to	93.0	4992.6	0.8	2.71	3	7	11.3	
36	4993.3	to	94.0	4993.7	1.3	2.70	3	7	10.2	
37	4994.3	to	95.0	4994.7	1.2	2.71	3	6	9.2	
38	4995.2	to	95.6	4995.4	0.7	2.70	3	6	8.3	
39	4996.2	to	97.0	4996.6	0.7	2.71	3	6	7.3	
40	4997.2	to	98.0	4997.6	1.1	2.71	3	6	6.3	
41	4998.2	to	98.5	4998.4	0.8	2.70	3	6	5.3	
42	4999.0	to	99.7	4999.4	0.8	2.71	3	6	4.5	
43	5000.2	to	0.8	4950.5	0.9	2.72	3	6	3.3	
Plug 1	5001.2			4950.6	2.6	2.70	2	6	2.3	
Plug 2	5001.8			4950.9	6.0	2.68	2	6	1.7	
44	5002.0	to	2.6	4952.3	5.3	2.71	2	6	1.5	
45+	5003.4	to	3.4	4954.3	0.6	2.71	2	6	0.1	
	5003.5	to	5006.0				7	1	0.0	Sylvan Shale: argill. Dolomite, greenish gray
	5006.0		5016.0					13	-2.5	greenish-gy shale
	5016.0		Base of Core						-12.5	

Strat Position is footage above or below (-) the Hunton/Sylvan contact at 5003.5 ft., core depth.

POROSITY AND FACIES CODES
MARJO McBRIDE SOUTH 1-10, SE/4 SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments & Thin Sections*
1	4962.6	to	63.0	4962.80	6.5	2.74	9	7	33.7	Hunton Fm
2	4963.3	to	64.0	4963.65	6.5	2.76	9	7	33.0	
3	4964.0	to	64.7	4964.35	4.7	2.78	9	7	32.3	
4	4965.3	to	66.0	4965.65	1.5	2.72	2	7	31.0	
5	4966.4	to	67.0	4966.70	4.4	2.73	9	7	29.9	
6	4967.0	to	67.7	4967.35	4.4	**2.80**	7	7	29.3	
7	4968.0	to	68.7	4968.35	1.6	2.72	3	7	28.3	
8	4969.0	to	69.7	4969.35	2.6	2.72	3	7	27.3	
9	4970.2	to	71.0	4970.60	7.8	**2.83**	5	7	26.1	
10	4971.3	to	71.9	4971.60	2.3	2.75	11	7	25.0	
11	4972.7	to	73.0	4972.85	1.5	2.71	3	7	23.6	
12	4973.0	to	73.8	4973.40	1.6	2.72	3	7	23.3	
13	4974.0	to	74.7	4974.35	1.5	2.72	3	7	22.3	
14	4975.3	to	76.0	4975.65	2.9	2.71	1	7	21.0	
15	4976.0	to	76.7	4976.35	1.0	2.72	3	7	20.3	
16	4977.0	to	77.6	4977.30	2.0	2.71	1	7	19.3	
17	4978.0	to	78.6	4978.30	2.6	2.71	3	7	18.3	
18	4979.3	to	79.9	4979.60	1.8	2.72	3	7	17.0	*Dense c. brach pkstn, rxlzd; karst sand infill in vugs
19	4980.0	to	80.6	4980.30	1.5	2.71	4	7	16.3	
20	4981.3	to	82.0	4981.65	1.2	2.72	3	7	15.0	
21	4982.6	to	83.0	4982.80	1.9	2.72	1	7	13.7	
22	4983.6	to	84.0	4983.80	0.6	2.71	3	6	12.7	
23	4984.0	to	84.7	4984.35	2.4	2.72	1	6	12.3	
24	4985.0	to	85.4	4985.20	2.8	2.72	1	6	11.3	
25	4986.0	to	86.6	4986.30	0.9	2.72	3	6	10.3	
26	4987.0	to	87.7	4987.35	1.6	2.71	3	6	9.3	
27	4988.0	to	88.7	4988.35	3.4	2.72	1	6	8.3	
28	4989.4	to	90.0	4989.70	2.4	2.72	3	6	6.9	
29	4990.3	to	91.0	4990.65	1.4	2.73	12	3	6.0	
30	4991.0	to	91.5	4991.25	1.6	2.71	4	3	5.3	
31	4992.0	to	92.7	4992.35	4.2	2.72	3	3	4.3	
32	4993.6	to	94.0	4993.80	4.1	2.72	3	6	2.7	
33	4994.3	to	95.0	4994.65	4.3	2.72	3	6	2.0	
34	4995.0	to	95.6	4995.30	4.8	2.72	3	6	1.3	
35	4996.3	to	96.7	4996.50	6.2	**2.91**	7	1	0.0	Sylvan Shale
36	4997.4	to	97.7	4997.55	5.4	**2.86**	7	1	-1.1	
	4998.0		Base of core						-1.7	

Strat Position is footage above or below (-) the Hunton/Sylvan contact at 4996.3 ft., core depth.

POROSITY AND FACIES CODES
MARJO TOLES 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments
	4964.0								39.70	Top of Core: Hunton Fm
1	4964.4	to	65.0	4964.7	3.1	2.71	1	7	39.30	* 4964.2 c brac pkstn, vugs are matrix dissolved -SV
2	4965.0	to	65.6	4965.3	2.1	2.71	1	6	38.70	
3	4966.0	to	66.6	4966.3	1.8	2.71	1	7	37.70	* 4967.8 c brac pkstn, TV with frac
4	4967.0	to	67.8	4967.4	2.3	2.71	1	7	36.70	
5	4968.0	to	68.8	4968.4	4.4	2.71	1	6	35.70	
6	4969.2	to	69.8	4969.5	1.8	2.71	3	6	34.50	
7	4970.3	to	71.0	4970.7	2.4	2.72	1	7	33.40	
8	4971.5	to	72.0	4971.8	2.6	2.71	1	7	32.20	* 4971.4 c collapsed grnstn
9	4972.3	to	73.0	4972.7	3.5	2.71	4	6	31.40	
10	4973.3	to	74.0	4973.7	2.5	2.71	4	6	30.40	
11	4974.3	to	75.0	4974.7	3.3	2.70	4	6	29.40	
12**	4975.5	to	76.0	4975.8	4.5	2.71	4	5	28.20	
13**	4976.3	to	76.9	4976.6	3.5	2.71	4	5	27.40	
14	4977.3	to	78.0	4977.7	3.1	2.70	3	4	26.40	
15	4978.1	to	78.8	4978.5	3.7	2.70	4	5	25.60	
16	4979.2	to	80.0	4979.6	2.7	2.70	3	4	24.50	
17	4980.0	to	80.7	4980.4	1.6	2.70	3	4	23.70	
18	4981.0	to	81.5	4981.3	2.2	2.70	3	4	22.70	
19	4982.0	to	82.8	4982.4	2.1	2.70	3	4	21.70	
20	4983.0	to	83.4	4983.2	5.0	2.71	2	7	20.70	
21**	4984.0	to	84.8	4984.4	4.2	2.70	2	5	19.70	
22**	4985.5	to	86.0	4985.8	5.2	2.70	3	4	18.20	
23**	4986.0	to	86.5	4986.3	3.4	2.70	3	4	17.70	
24**	4987.0	to	87.7	4987.4	6.1	2.71	2	7	16.70	
25**	4988.0	to	88.8	4988.4	4.9	2.71	2	7	15.70	
26**	4989.2	to	90.0	4989.6	7.0	**2.70**	2	7	14.50	

POROSITY AND FACIES CODES
MARJO TOLES 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments
27	4990.3	to	91.0	4990.7	6.7	**2.71**	4	9	13.40	Big favositid coral
28	4991.3	to	91.9	4991.6	2.0	**2.70**	4	9	12.40	* 4991.1 brach-coral-crinoid grnstn
29	4992.0	to	92.4	4992.2	2.0	**2.72**	4	5	11.70	frac with karst infill
30	4993.0	to	93.3	4993.2	1.8	**2.71**	4	5	10.70	
31	4994.6	to	95.0	4994.8	2.9	2.71	4	5	9.10	
32	4995.3	to	95.8	4995.6	2.5	2.71	1	5	8.40	* 4995.9 cri-bryo-brach-coral-strom grnstn , vugs
33+	4996.1	to	*	4996.1	2.3	2.70	2	5	7.60	
34	4997.0	to	97.5	4997.3	1.0	2.71	4	4	6.70	* 4996.9 - 97 crinoid-brach grnstn, tight
35	4998.5	to	99.0	4998.8	1.6	2.70	4	5	5.20	
36	4999.3	to	100.0	4999.7	2.2	2.71	1	5	4.40	
37	5000.0	to	0.5		2.6	2.71	4	5	3.70	
38	5001.0	to	1.8		2.1	2.71	2	5	2.70	Ls c cri
39	5002.2	to	2.8		5.9	2.86	5	4	1.50	Dol, f cri grnstn with sparse big brachs
40	5003.0	to	3.4		3.8	2.87	5	5	0.70	* 5003.7 Dolomite, calcite intercrystallne fill
	5003.7							1	0.00	Sylvan Shale
41	5004.1	to	4.4		3.0	2.79	11	1	-0.40	"Sh" , Dol, argill mdstn
	5004.4	Base of Core							-0.70	

Strat Position is footage above or below (-) the Hunton/Sylvan contact at 5003.7 ft., core depth.

POROSITY AND FACIES CODES
MARJO WILKERSON 1-3, SEC. N/2 S/2 NE NE 35, T15N, R2E
LINCOLN COUNTY, OKLHAOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments and Thin Section*
	4950.0									
	4950.0		4952.4					13		Woodford Shale
	4952.4		4953.4					14		Misener SS
1	4952.7	to	53.3	4953.00	2.1	2.6	ss	14		: * ss + sh, ca cement
	4953.4								46.4	Top of Hunton Fm
2	4953.6	to	54.0	4953.80	5.8	2.7	2	7	46.2	
3	4954.5	to	55.0	4954.75	5.9	2.7	1	7	45.3	* Ls, BB Coquina brac pkstn. Qtz sand fill in vugs
4	4955.0	to	55.7	4955.35	5.9	2.7	1	7	44.8	
5	4956.5	to	57.0	4956.75	6.7	2.7	1	7	43.3	
6+	4957.3	to	57.3	4957.30	5.5	2.7	1	7	42.5	
7	4958.6	to	59.0	4958.80	3.2	2.7	1	7	41.2	* c brac pkstn
8	4959.0	to	59.4	4959.20	3.1	2.7	1	7	40.8	
9	4960.0	to	60.5	4960.25	4.4	2.7	1	7	39.8	* c brac - coral pkstn
10	4961.1	to	61.7	4961.40	5.4	2.7	1	7	38.7	
11	4962.0	to	62.4	4962.20	3.8	2.7	1	7	37.8	
12	4963.1	to	63.8	4963.45	2.6	2.7	2	7	36.7	
13	4964.2	to	64.6	4964.40	3.9	2.7	2	7	35.6	* c brac pkstn
14	4965.4	to	66.0	4965.70	4.3	2.7	1	7	34.4	
15	4966.5	to	66.9	4966.70	3.5	2.7	2	7	33.3	* c brac grnstn
16	4967.1	to	67.9	4967.50	1.8	2.7	2	7	32.7	
17	4968.0	to	68.5	4968.25	1.0	2.7	2	7	31.8	* c brac grnstn
18	4969.1	to	69.7	4969.40	2.2	2.7	2	7	30.7	
19	4970.1	to	70.7	4970.40	1.3	2.7	1	7	29.7	* c brac grnstn
20	4971.1	to	71.7	4971.40	0.9	2.7	2	7	28.7	
21	4972.1	to	72.8	4972.45	1.1	2.7	2	7	27.7	
22	4973.4	to	74.0	4973.70	5.0	2.7	2	7	26.4	
23	4974.0	to	74.5	4974.25	9.7	2.7	1	7	25.8	* c brac pkstn
24	4975.0	to	75.2	4975.10	10.4	2.7	1	7	24.8	
25	4976.1	to	76.8	4976.45	1.3	2.7	2	7	23.7	

POROSITY AND FACIES CODES
MARJO WILKERSON 1-3, SEC. N/2 S/2 NE NE 35, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Core #	From		To	Mid-Depth Core Depth	Phi Core Phi	Grain Density	Pore Code	Facies Code	Strat Position	Comments and Thin Section*
26	4977.1	to	77.8	4977.45	1.7	2.7	2	7	22.7	
27	4978.0	to	78.6	4978.30	1.4	2.7	2	6	21.8	
28	4979.0	to	79.5	4979.25	1.1	2.7	3	6	20.8	* v f cri-brac grnstn
29	4980.1	to	80.7	4980.40	1.2	2.7	3	6	19.7	
30	4981.1	to	81.6	4981.35	1.4	2.7	3	6	18.7	
31	4982.3	to	82.9	4982.60	3.1	2.7	3	6	17.5	
32	4983.3	to	83.9	4983.60	3.4	2.7	2	4	16.5	* med cri grnstn, collapsed
33	4984.1	to	84.8	4984.45	2.5	2.7	2	4	15.7	
34	4985.3	to	86.0	4985.65	2.2	2.7	2	7	14.5	
35	4986.3	to	86.9	4986.60	1.5	2.7	2	5	13.5	* v c brac grnstn
36	4987.1	to	87.8	4987.45	1.2	2.7	2	5	12.7	
37	4988.0	to	88.5	4988.25	1.0	2.7	2	4	11.8	* med cri grnstn
38	4989.1	to	89.8	4989.45	2.3	2.7	2	4	10.7	
39	4990.3	to	90.9	4990.60	1.8	2.7	2	5	9.5	
40	4991.1	to	91.8	4991.45	4.0	2.7	2	5	8.7	* med cri grnstn
41	4992.1	to	92.7	4992.40	3.2	2.7	2	5	7.7	
42	4993.5	to	94.0	4993.75	1.9	2.7	2	5	6.3	
43	4994.4	to	95.0	4994.70	1.6	2.7	2	5	5.4	
44	4995.4	to	96.0	4995.70	6.6	2.7	2	6	4.4	
45	4996.0	to	96.4	4996.20	8.4	2.7	2	6	3.8	4996.1 c brac-cri grnstn
46	4997.1	to	97.7	4997.40	6.1	2.7	2	6	2.7	
47	4998.1	to	98.7	4998.40	7.9	2.8	11	3	1.7	Ls,Dol
48	4998.7	to	99.4	4999.05	11.2	**2.8**	6	3	1.1	Dol
	4999.6	to	4999.8				7	12	0.2	Dol grnstn
	4999.8		5004.2					1	0	Sylvan Sh: argill dol mdstn, greenish-gray
	5004.2		**Base of Core**					1	-4.4	

Strat Position is footage above or below (-) the Hunton/Sylvan contact at 4999.8 ft., core depth.

DATA TABLES FOR CORE PLOTS

LIMESTONES

(Grain Density 2.71 to < 2.73)

INTERCONNCETED VUGGY POROSITY

Vug or MO with IG, SF or other connection TV general, Vug general. Not vugs with tight matrix

COARSE MATRIX POROSITY

Inter-particle (IP), IG or IX of medium to coarse grained rock, >.25 mm particle size. Many include dissolution porosity that is inter-particle micro vugs (dissolution of spar or matrix)

FINE MATRIX POROSITY

Inter-particle (IP), IG or IX of fine grained rocks, <.25 mm particle size. Includes fine non touching vugs and non touching fine moldic (MO) porosity along with intra-particle porosity

FRACTURE

FR or SF without significant matrix or vugs. For this study, includes solution enhanced fractures with sand in-fill.

DOLOMITES

(> 50% dolomite; Grain Density 2.79 or higher)

VUGGY(VUG) OR MOLDIC (MO) POROSITY

In coarse crystalline (IX) matrix (>.25mm)

COARSE CRYSTALLINE POROSITY

With Inter-crystalline porosity (IX) (>.25mm)

MEDIUM TO FINE CRYSTALLINE POROSITY

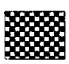
(IX) (.25mm to .02 mm)

FRACTURE

FR or SF without significant matrix or vugs. For this study, includes solution enhanced fractures with sand in-fill.

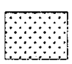
PARTLY DOLOMITIZED LIMESTONE

(10 - 50% DOLOMITE, Grain Density 2.73 - 2.78)



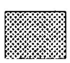
INTERCONNCETED VUGGY POROSITY

Vug or MO with IG, SF or other connection TV general, Vug general. Not vugs with tight matrix



COARSE MATRIX POROSITY

Inter-particle (IP), IG or IX of medium to coarse grained rock, >.25 mm particle size. Many include dissolution porosity that is inter-particle micro vugs (dissolution of spar or matrix)



FINE MATRIX POROSITY

Inter-particle (IP), IG or IX of fine grained rocks, <.25 mm particle size. Includes fine non touching vugs and non touching fine moldic (MO) porosity along with intra-particle porosity

FRACTURE

FR or SF without significant matrix or vugs. For this study, includes solution enhanced fractures with sand in-fill.

TABLE SHOWING FACIES CODES

ARGILLACEOUS DOLOMITE

CRYSTALLINE DOLOMITE

SMALL BRACHIOPOD GRAINSTONE/PACKSTONE/WACKESTONE

FINE CRINOID GRAINSTONE/PACKSTONE/WACKESTONE

COARSE CRINOID GRAINSTONE/PACKSTONE

MIXED CRINOID -BRACHIOPOD GRAINSTONE/PACKSTONE/WACKESTONE

BIG PENTAMERID BRACHHIOPOD COQUINA

CORAL AND DIVERSE FAUNA

CORAL AND CRINOID GRAINSTONE / WACKESTONE

SPARSE FOSSIL WACKESTONE

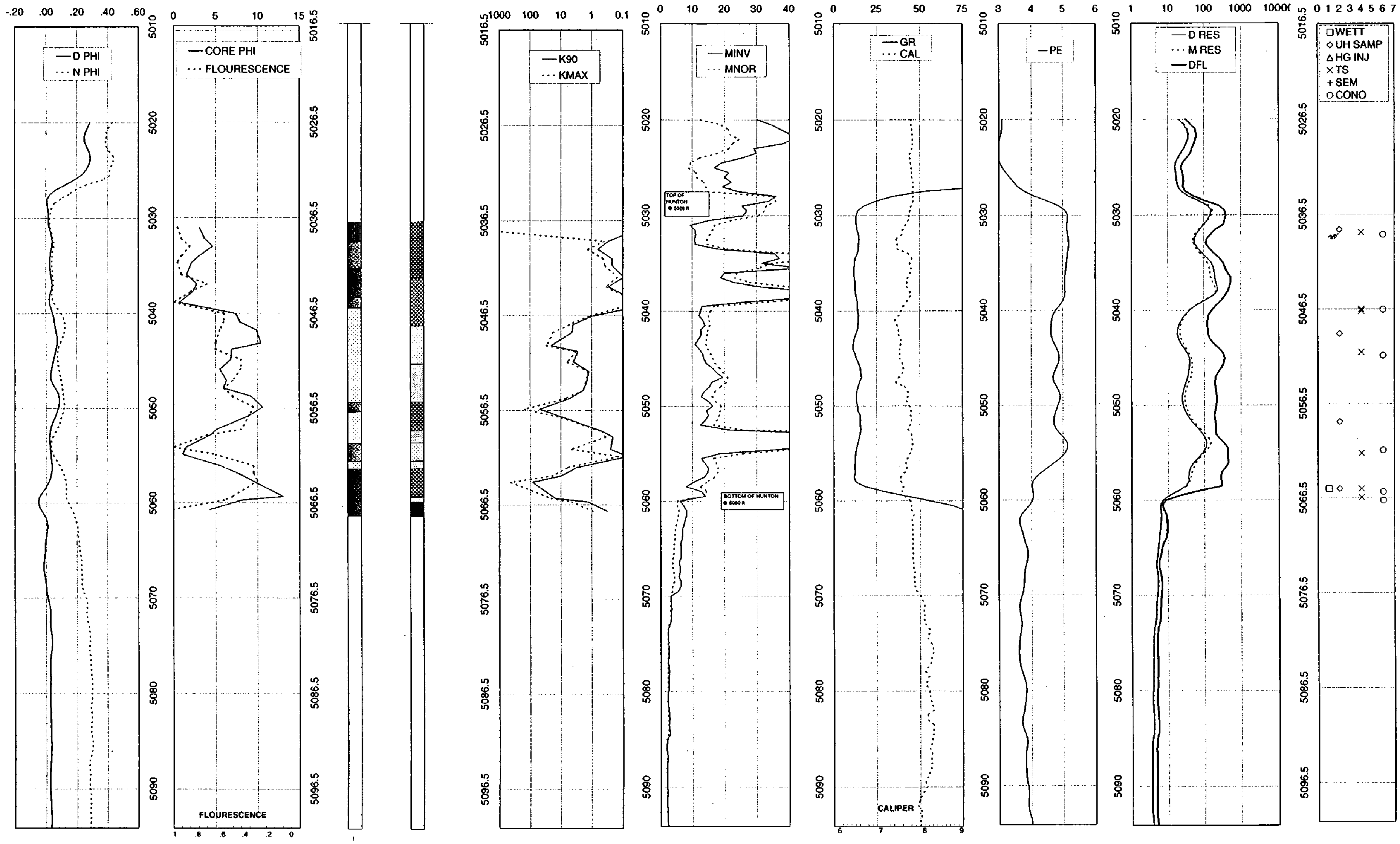
MUDSTONE

FINE - MEDIUM GRAINSTONE

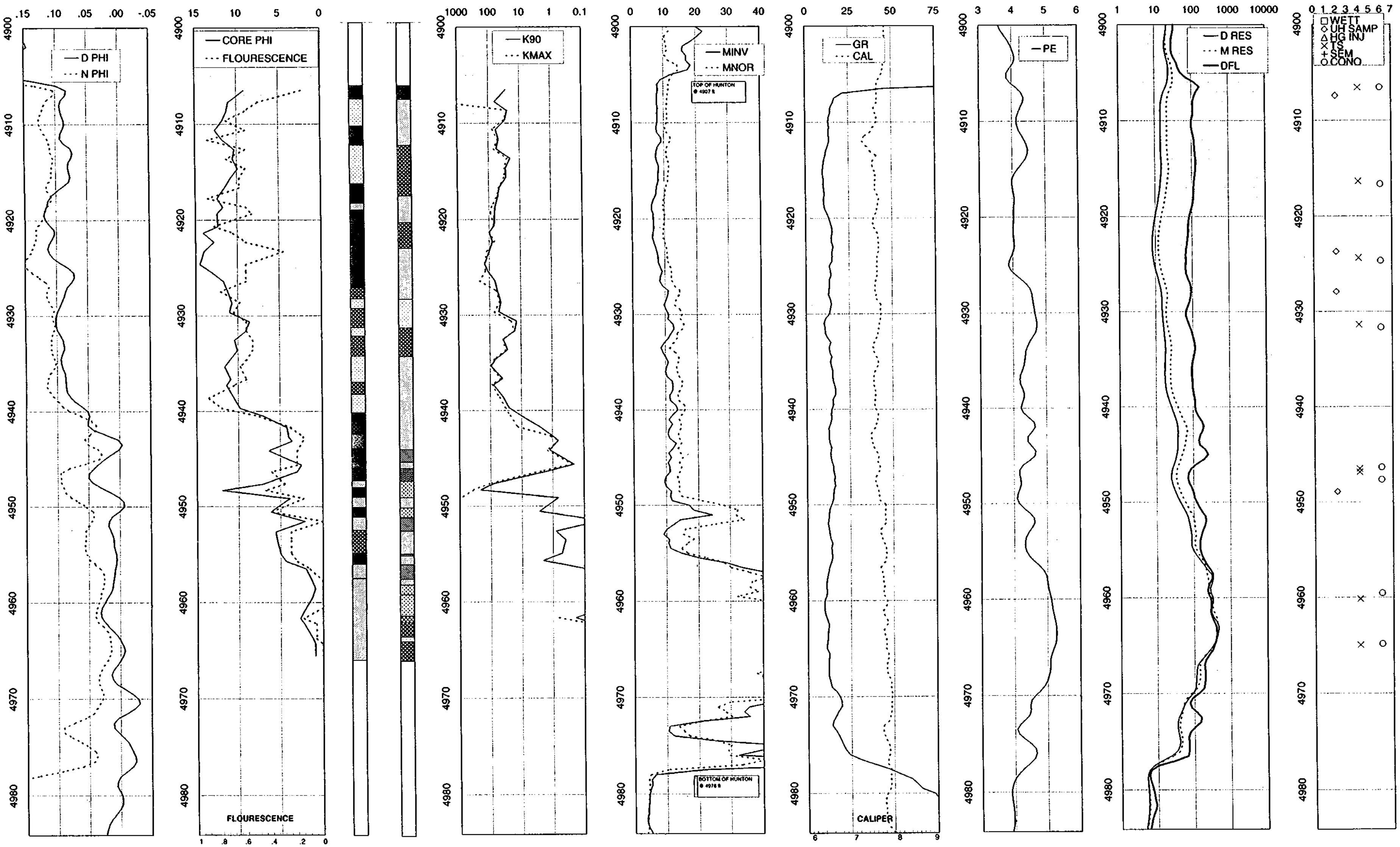
SHALE

FINE SANDSTONE

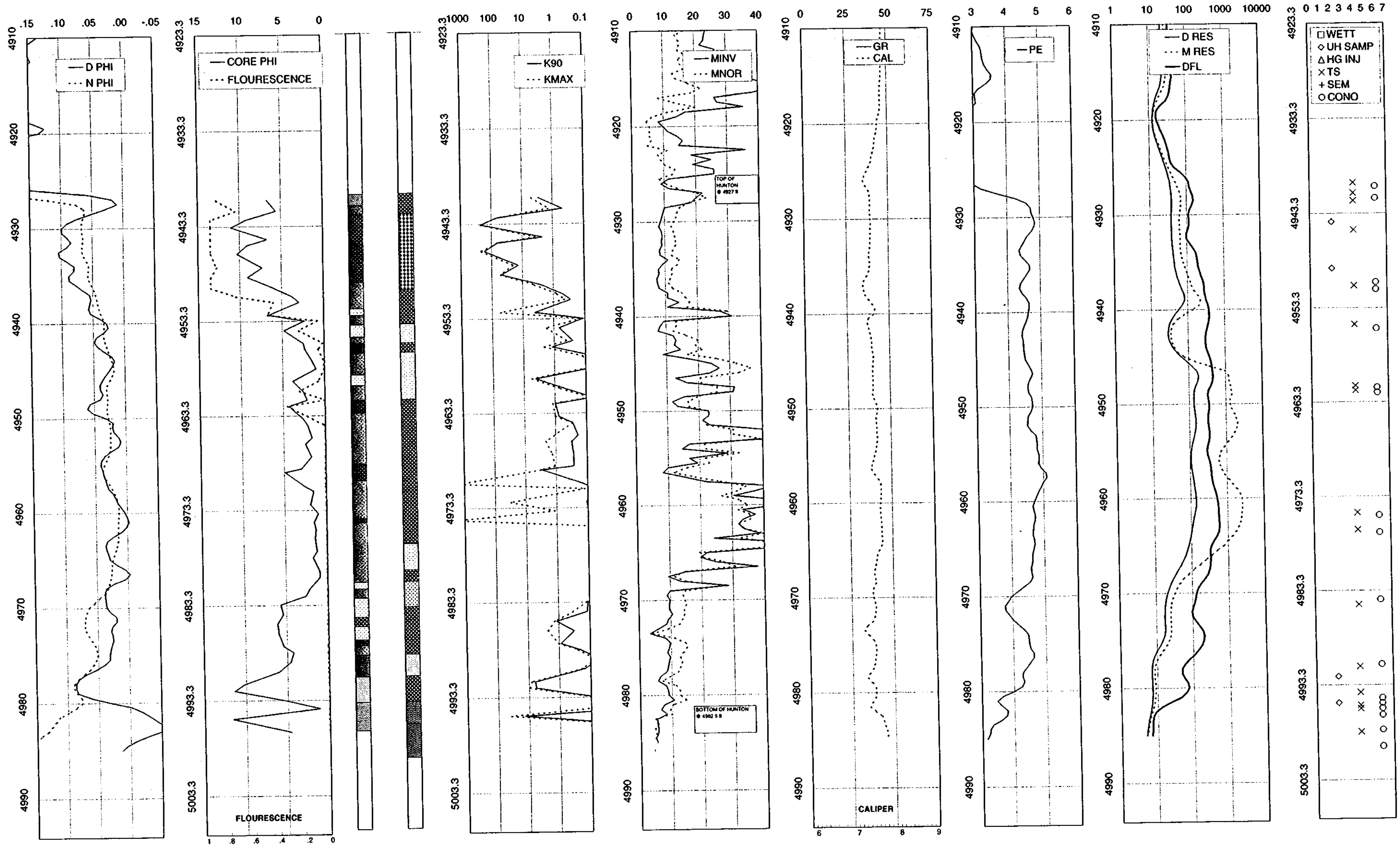
MARJO BOONE 1-4



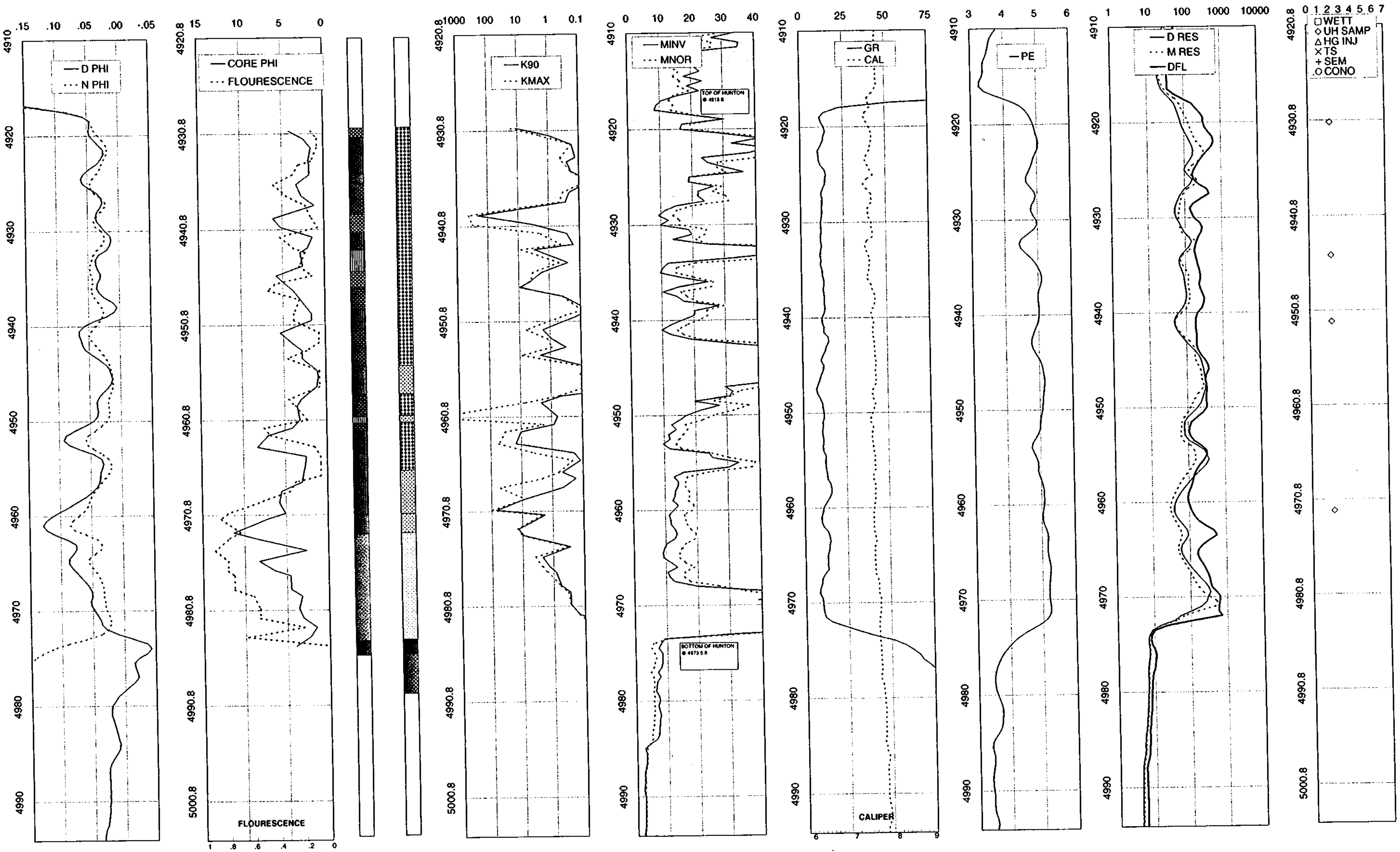
MARJO CARNEY TOWNSITE 2-5



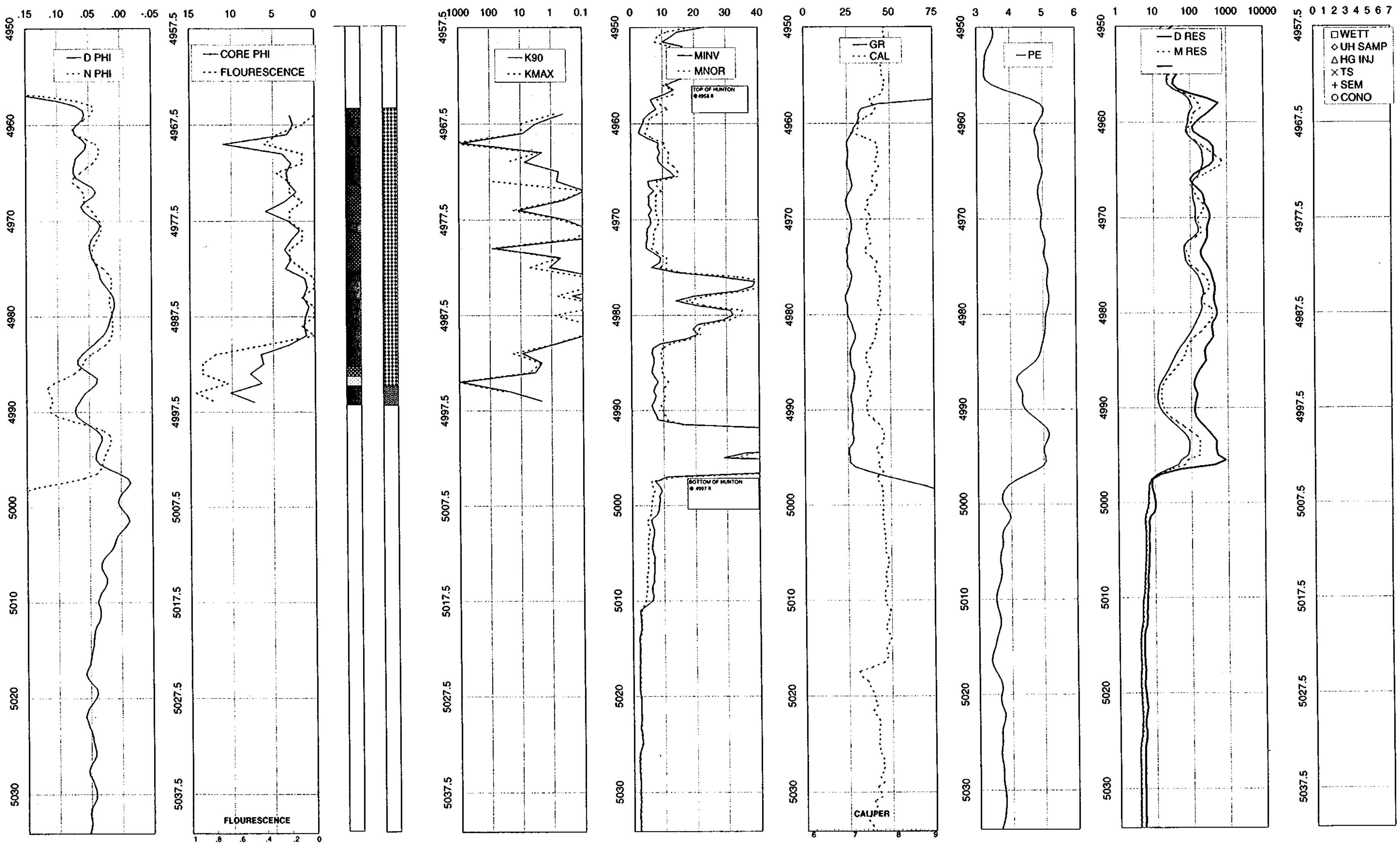
MARJO CARTER 1-14



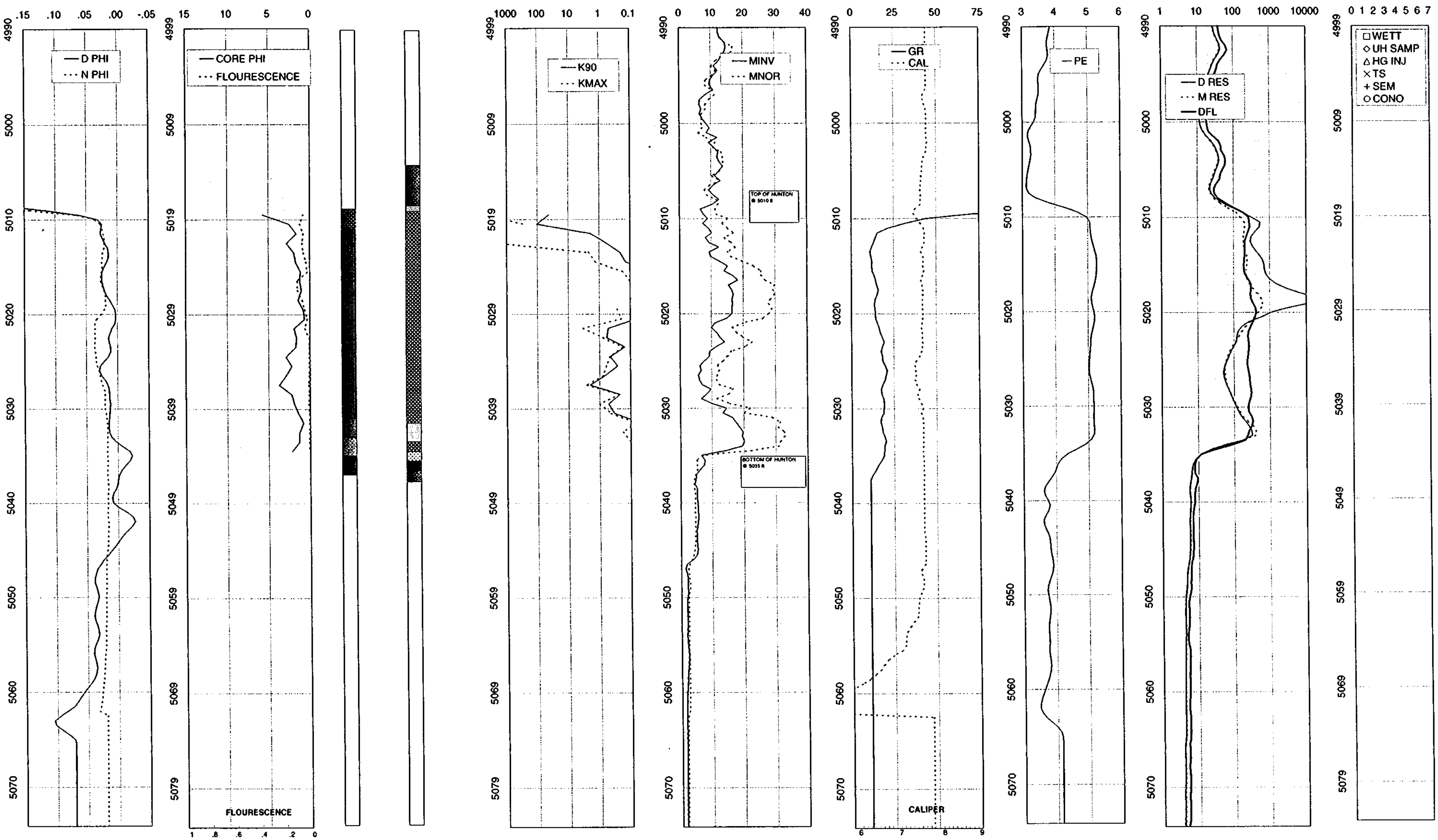
MARJO DANNY 2-34



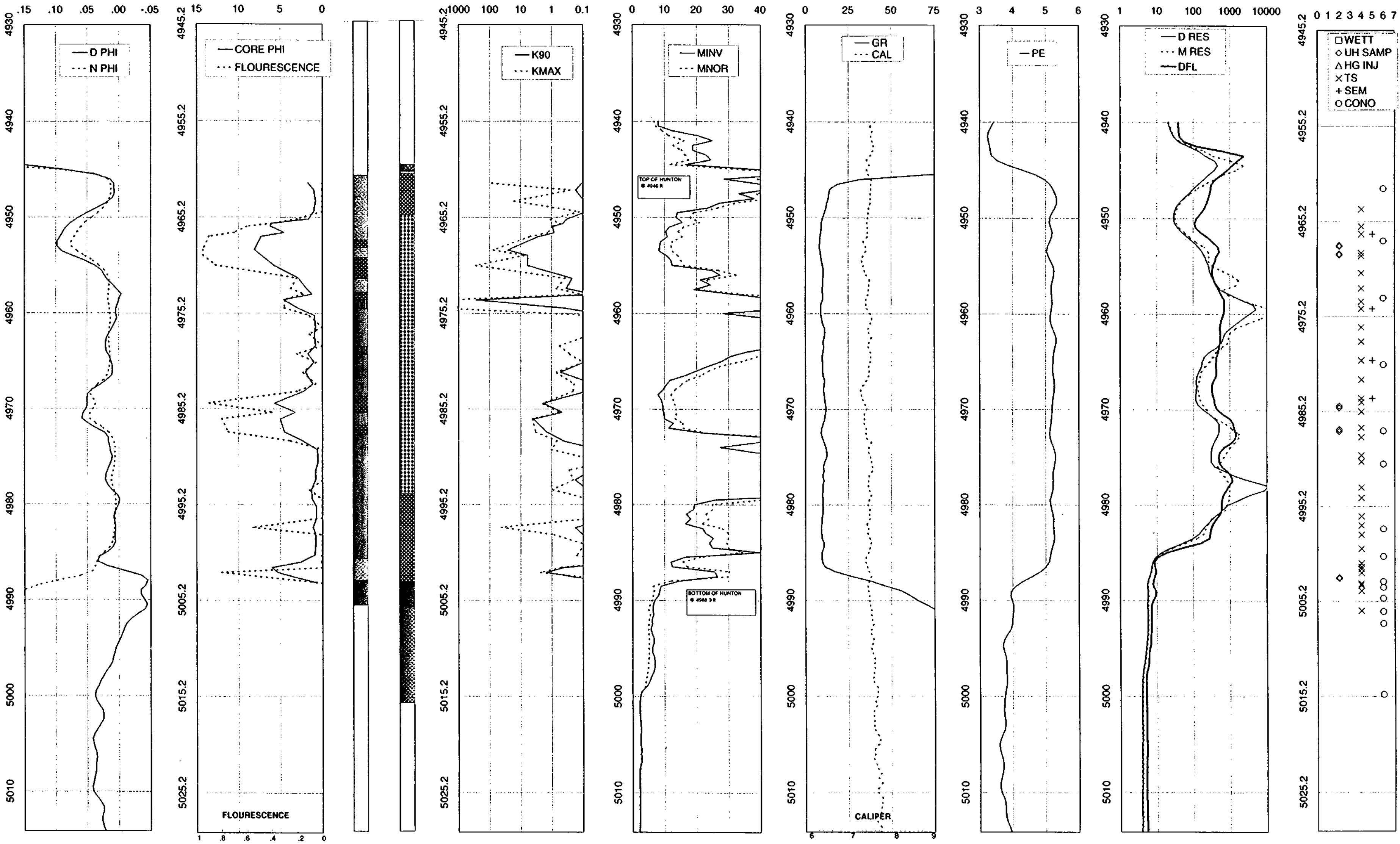
MARJO HENRY 1-3



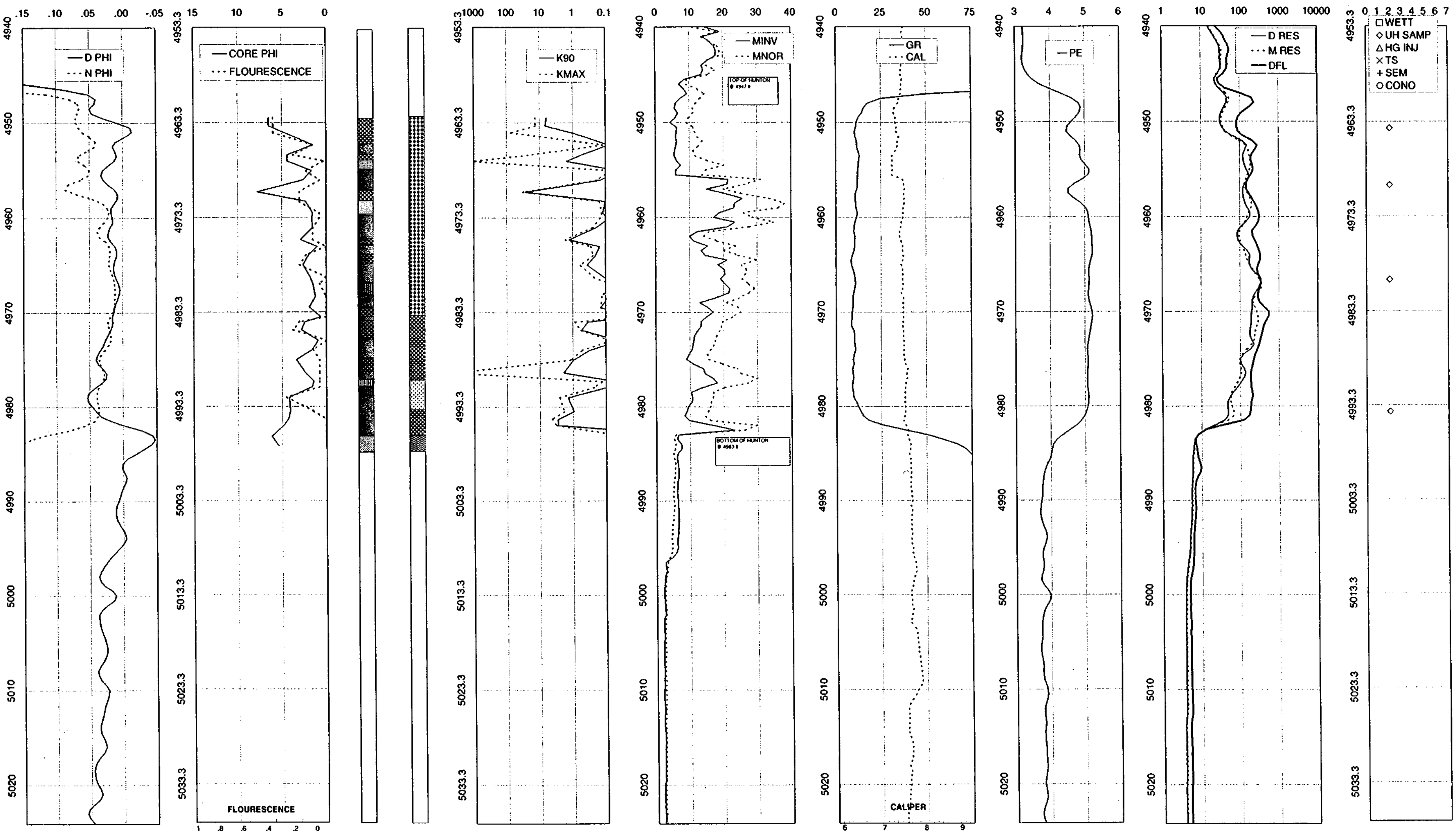
Marjo Joe Givens 1-15



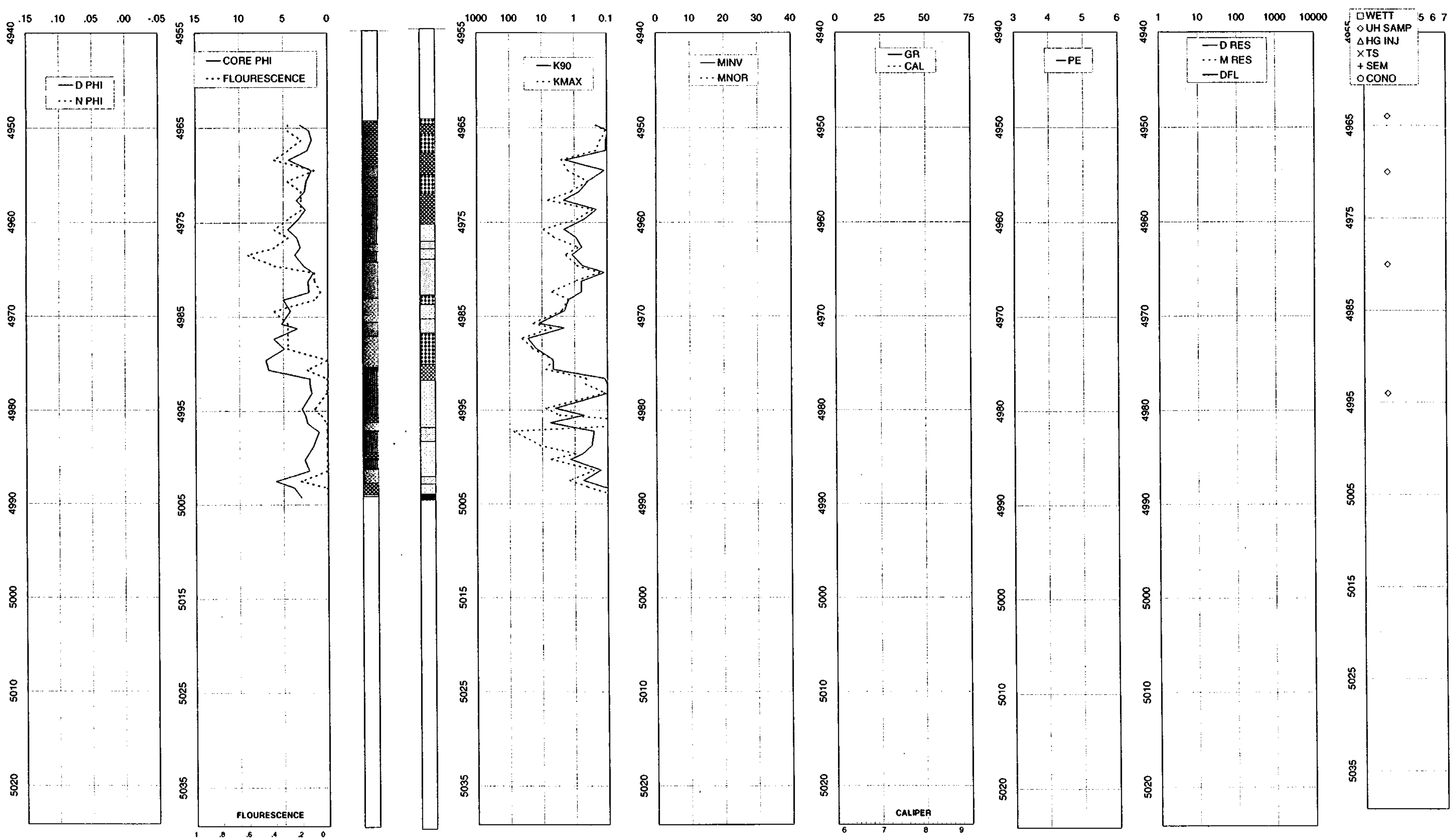
MARJO MARY MARIE 1-11



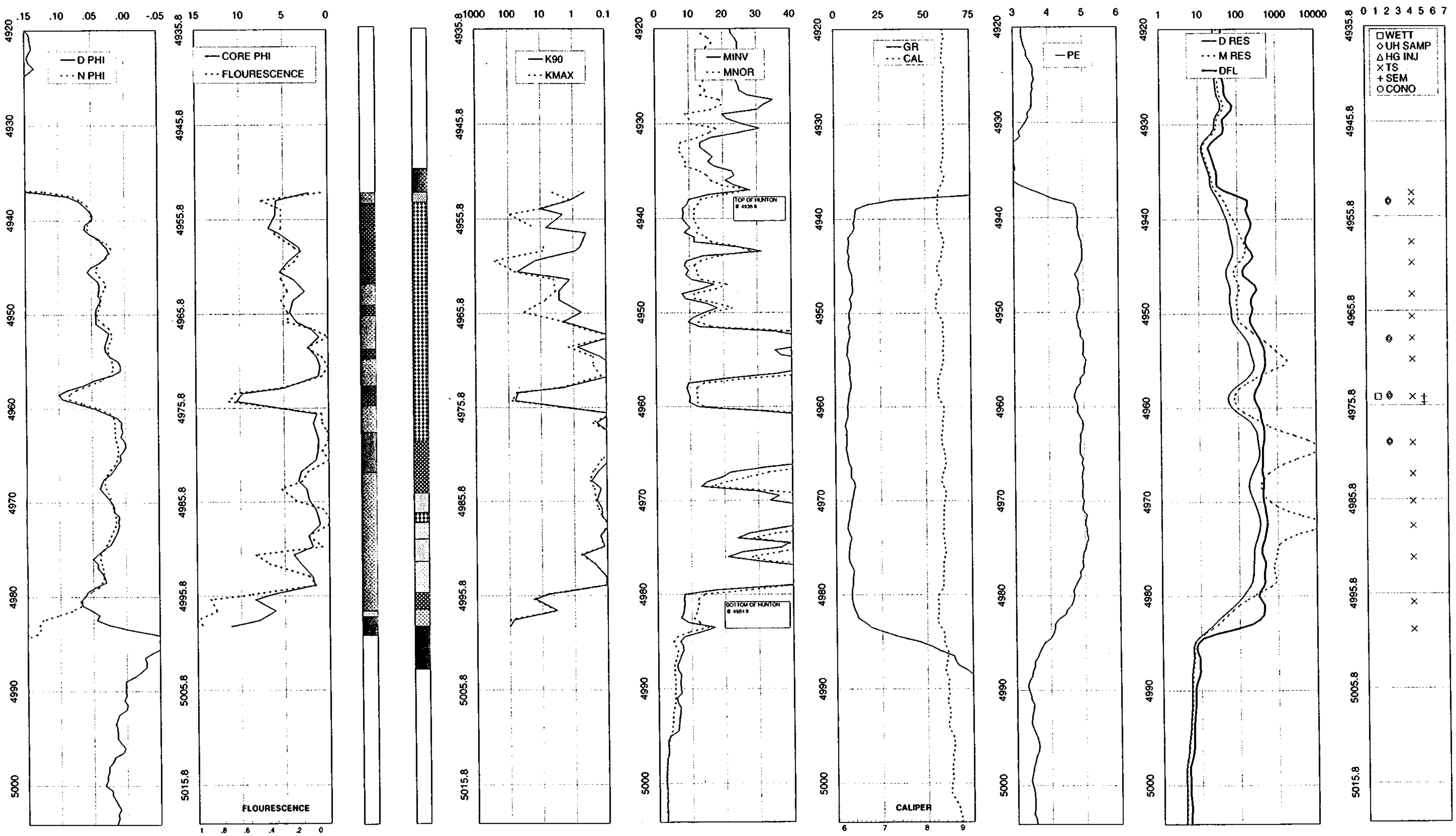
MARJO MCBRIDE SOUTH 1-10



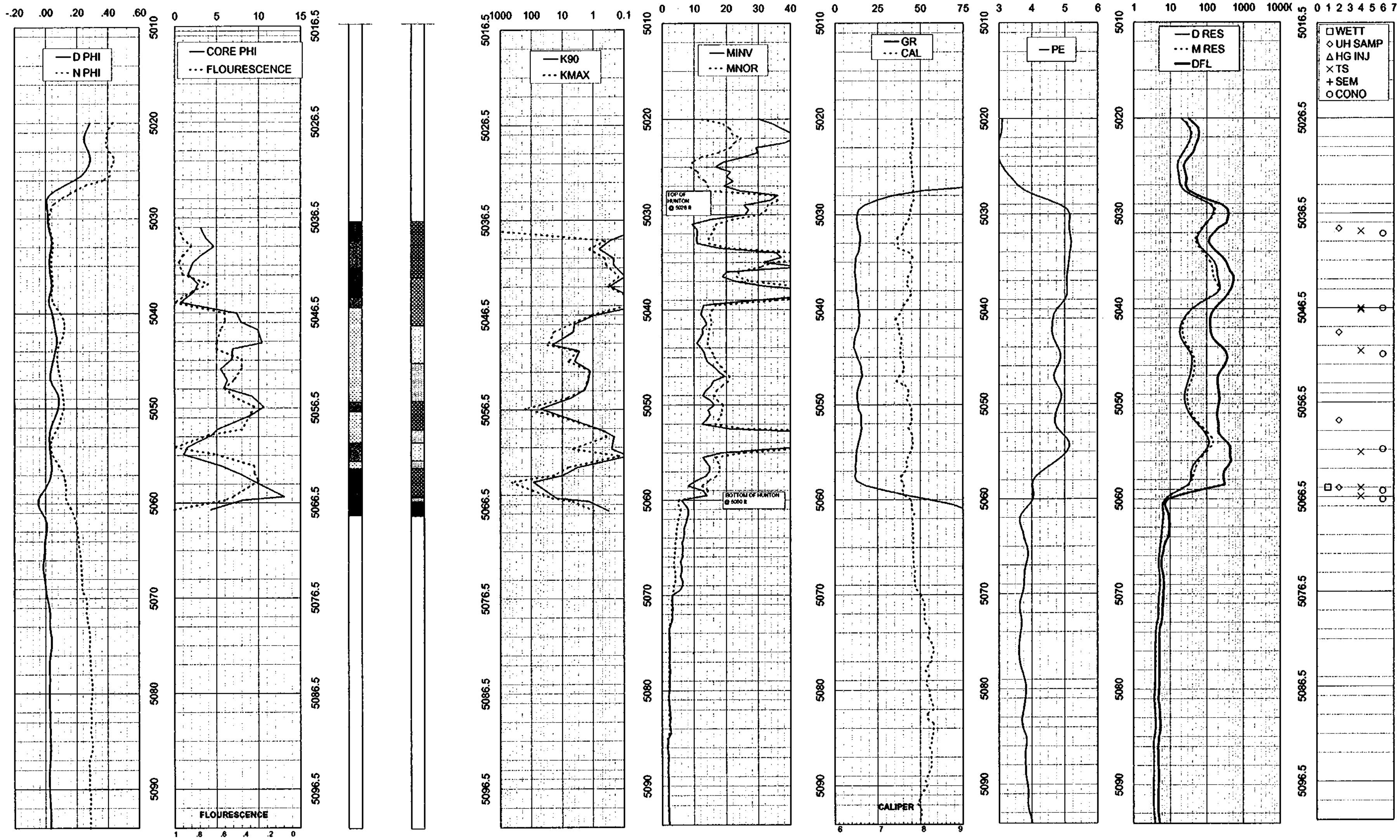
MARJO TOLES 1-10



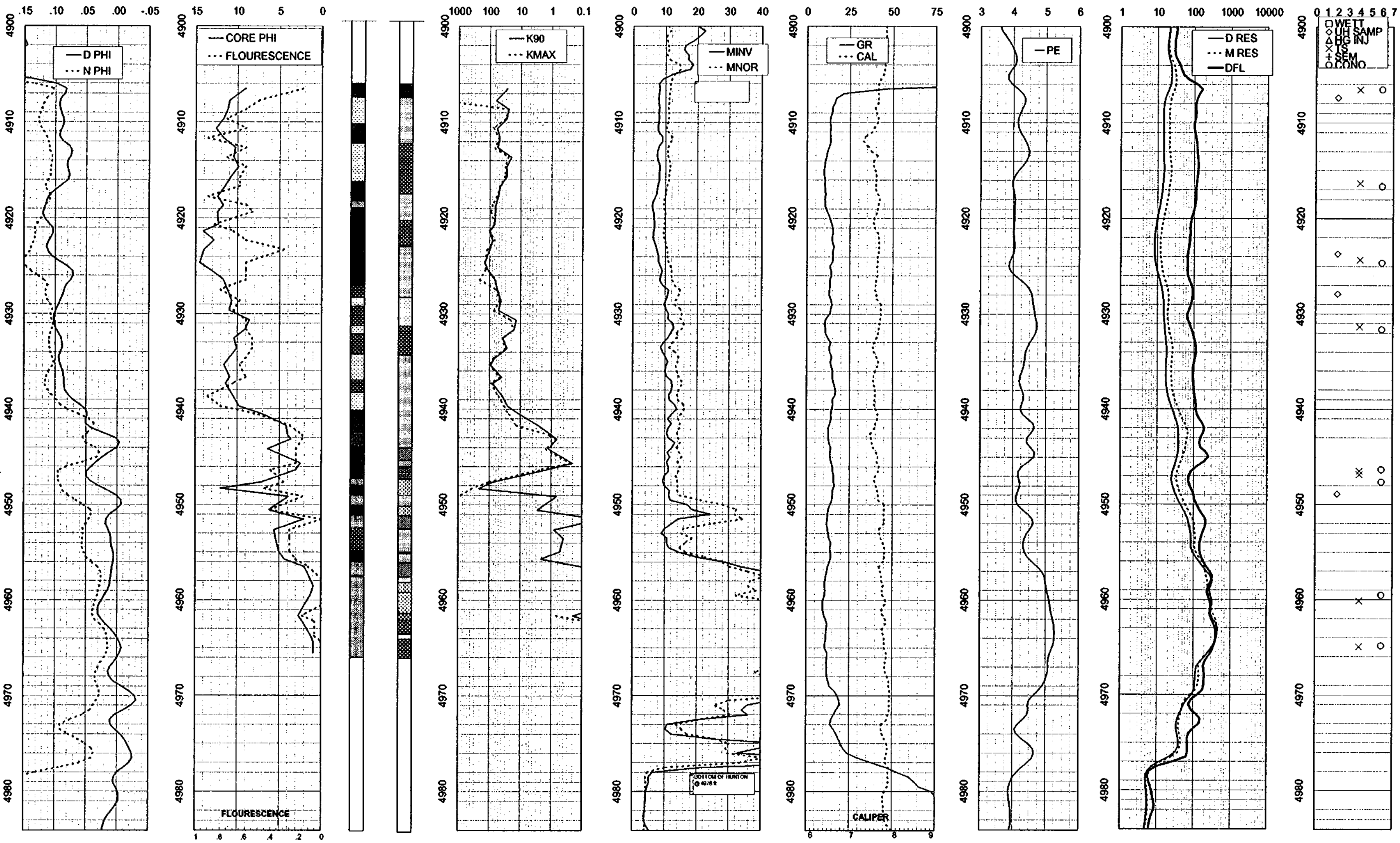
MARJO WILKERSON 1-3



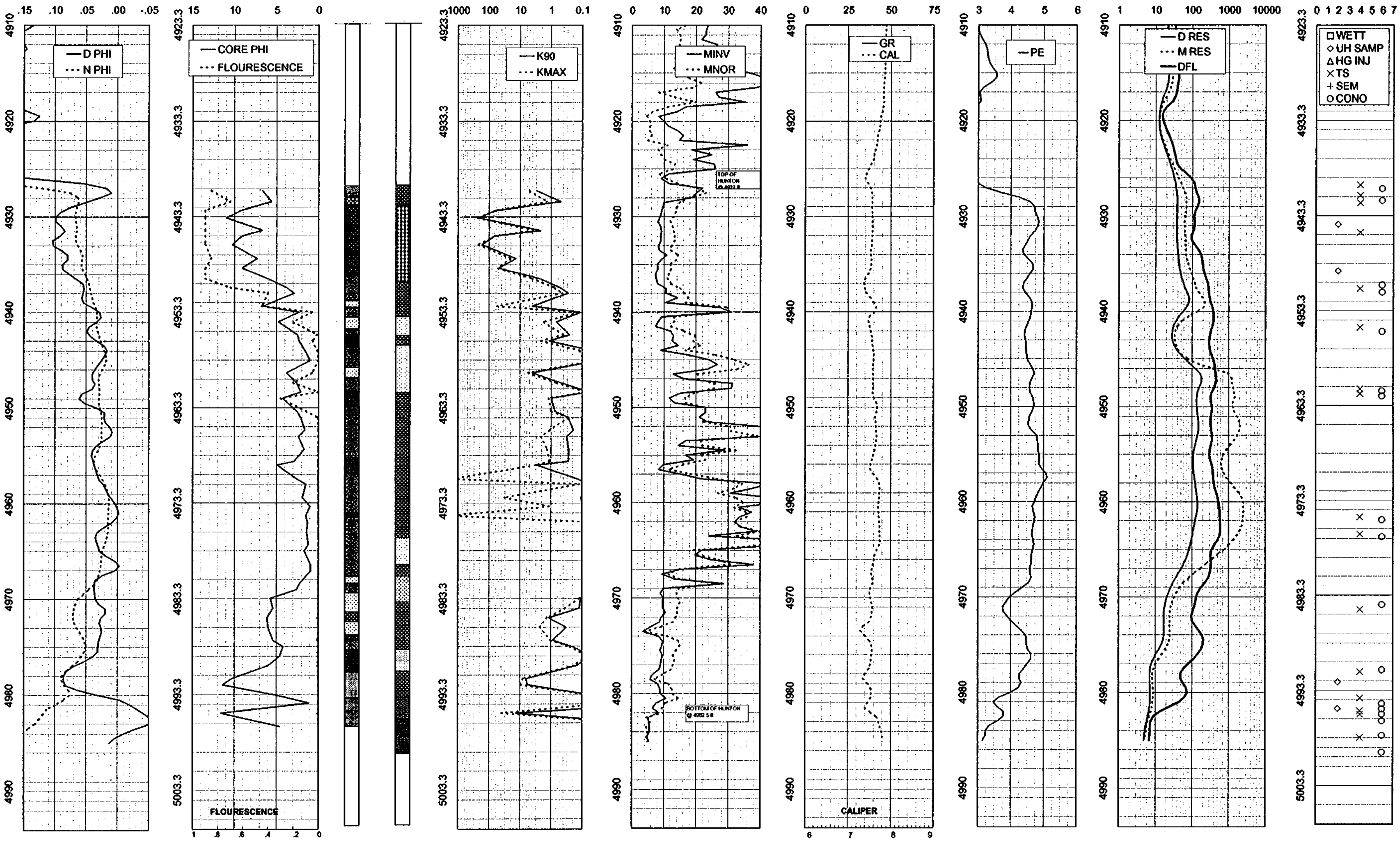
MARIO BOONE 1-4, SEC. 4, T15N, R2E
LINCOLN COUNTY, OKLAHOMA



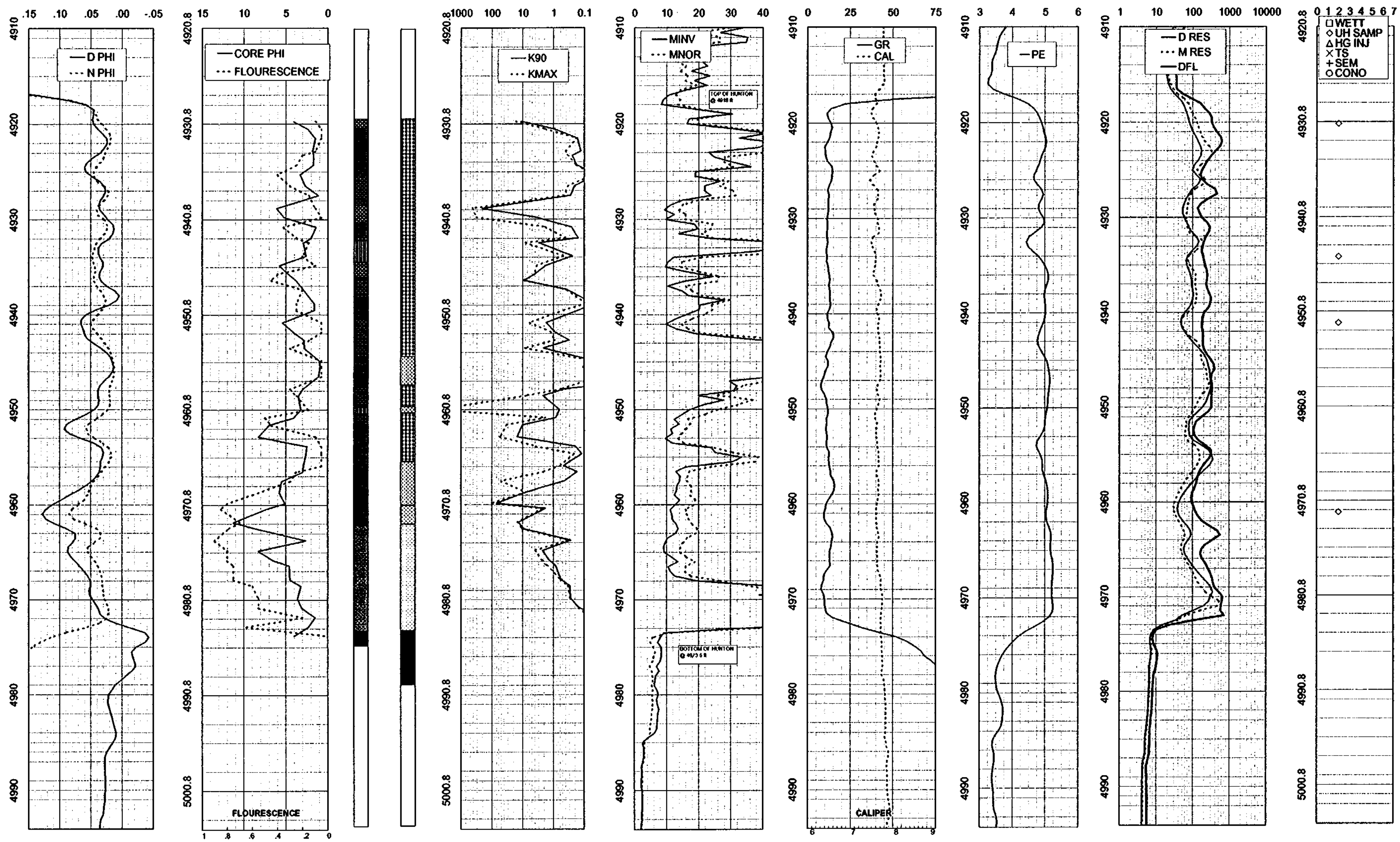
MARJO CARNEY TOWNSITE 2-5, SEC. 5, T15N, R2E
LINCOLN COUNTY, OKLAHOMA



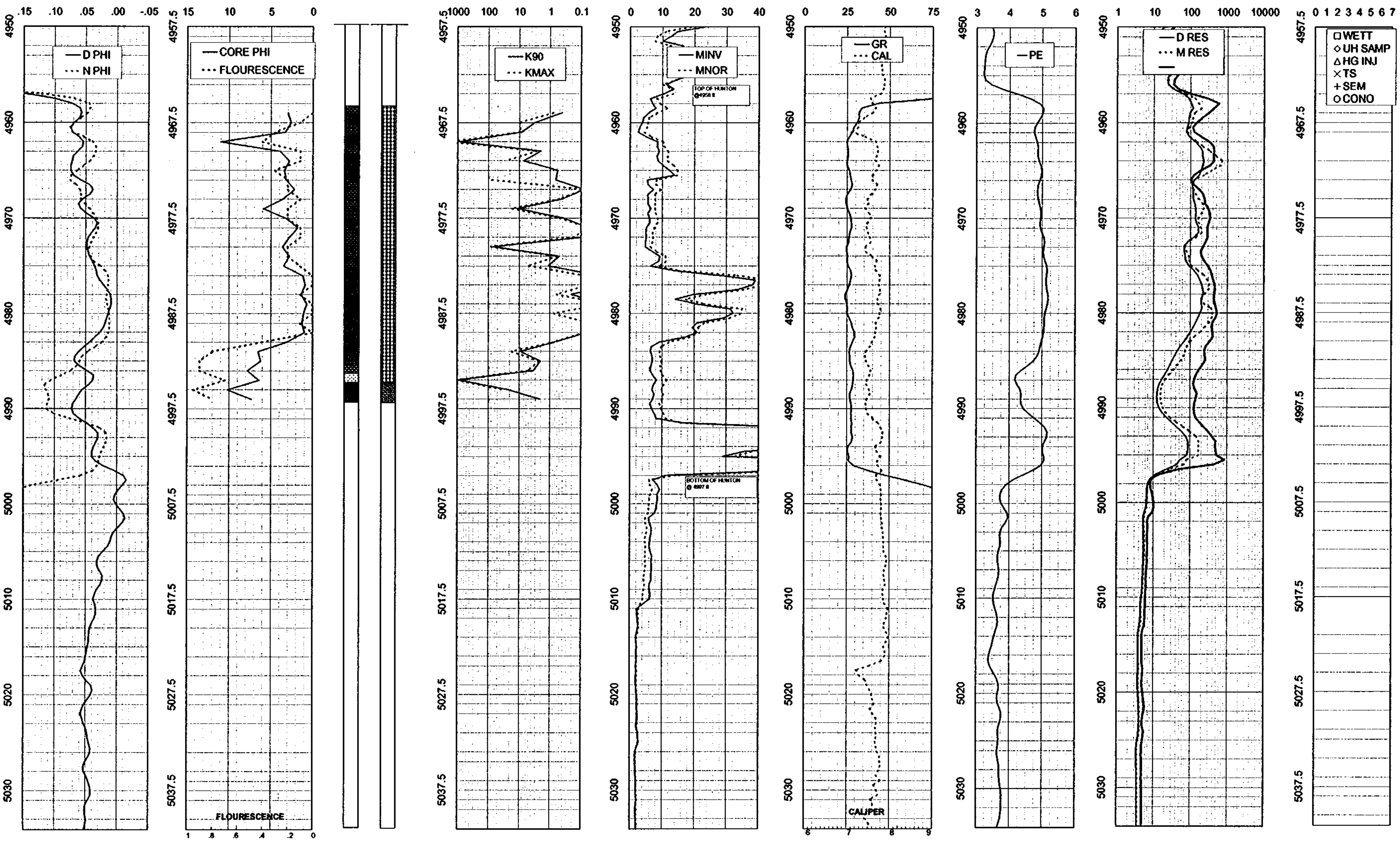
MARJO CARTER 1-14, SEC. 14, T15N, R2E
LINCOLN COUNTY, OKLAHOMA



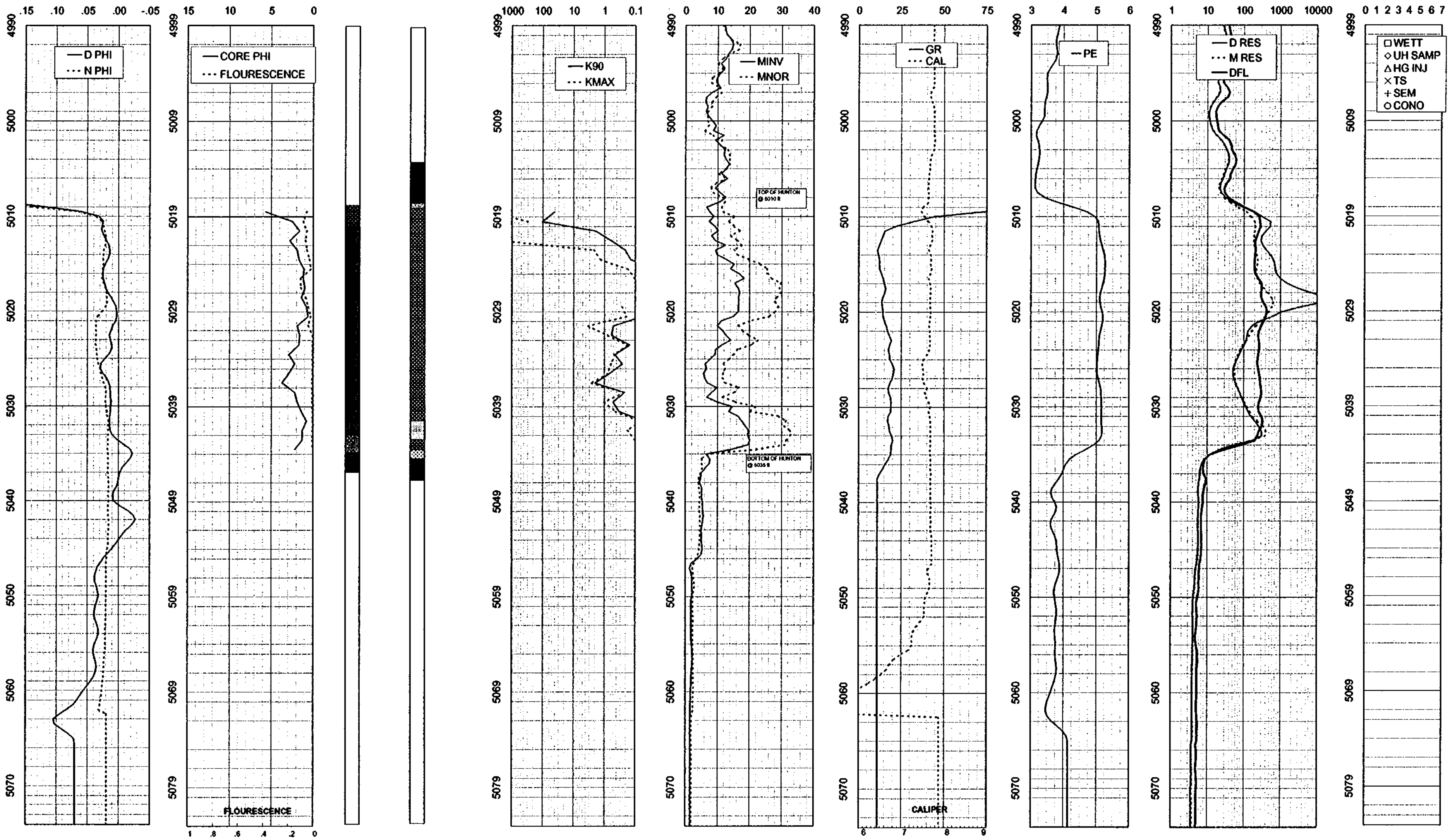
MARJO DANNY 2-34, SEC. 34, T16N, R2E
LINCOLN COUNTY, OKLAHOMA



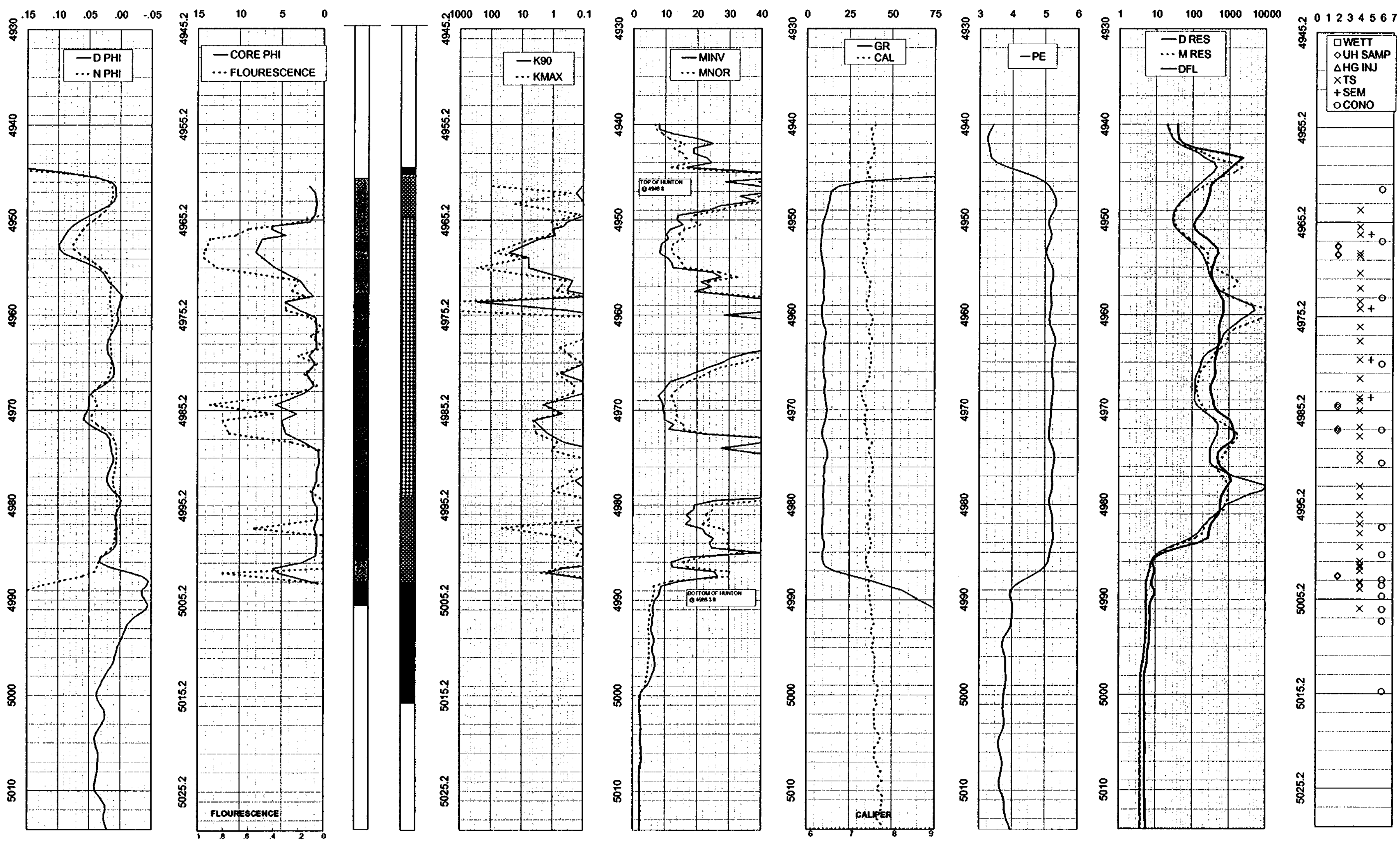
MARJO HENRY 1-3, SEC. 3, T15N, R2E
LINCOLN COUNTY, OKLAHOMA



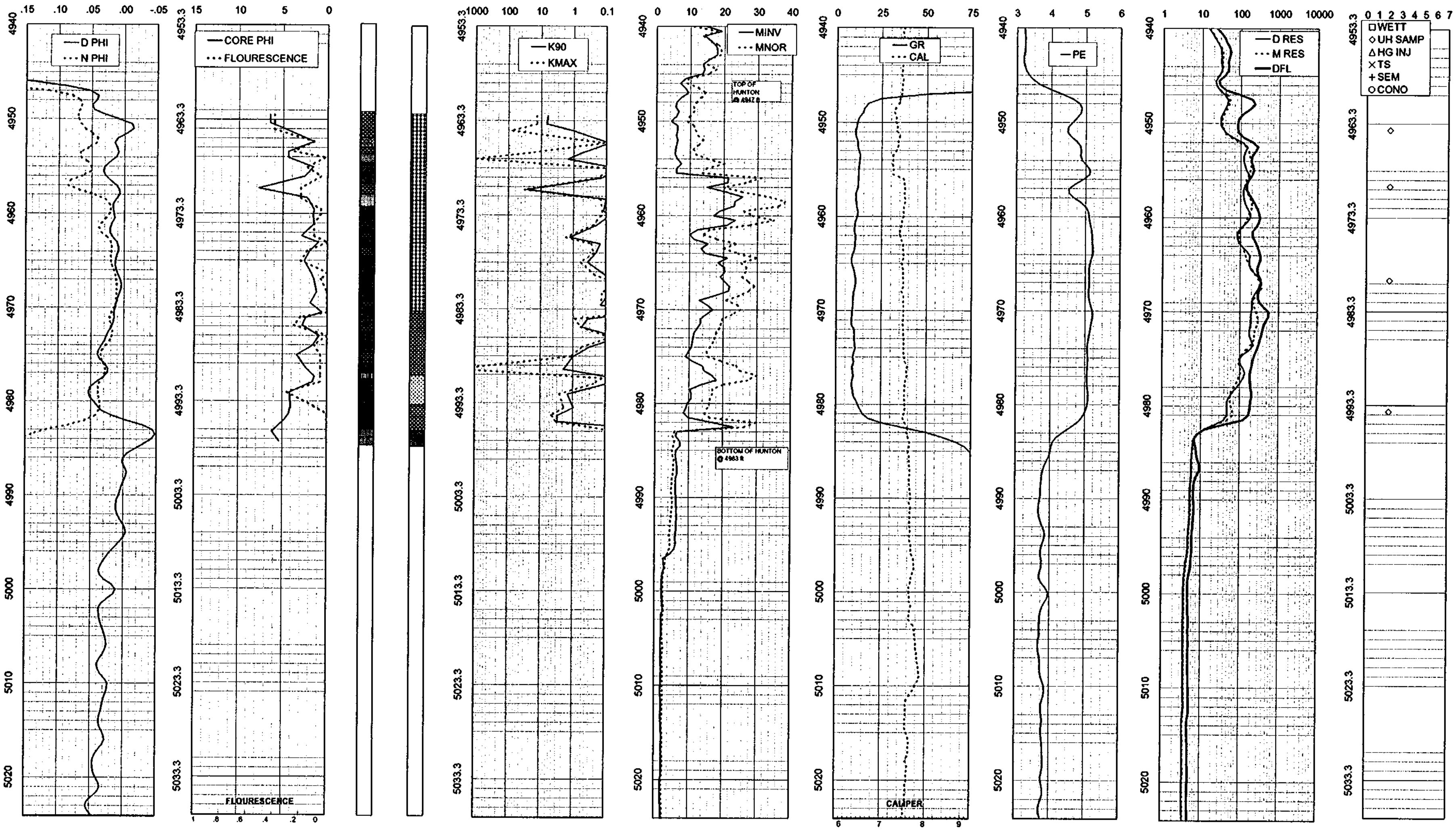
Marjo Joe Givens 1-15, SEC. 15, T15N, R20E
LINCOLN COUNTY, OKLAHOMA



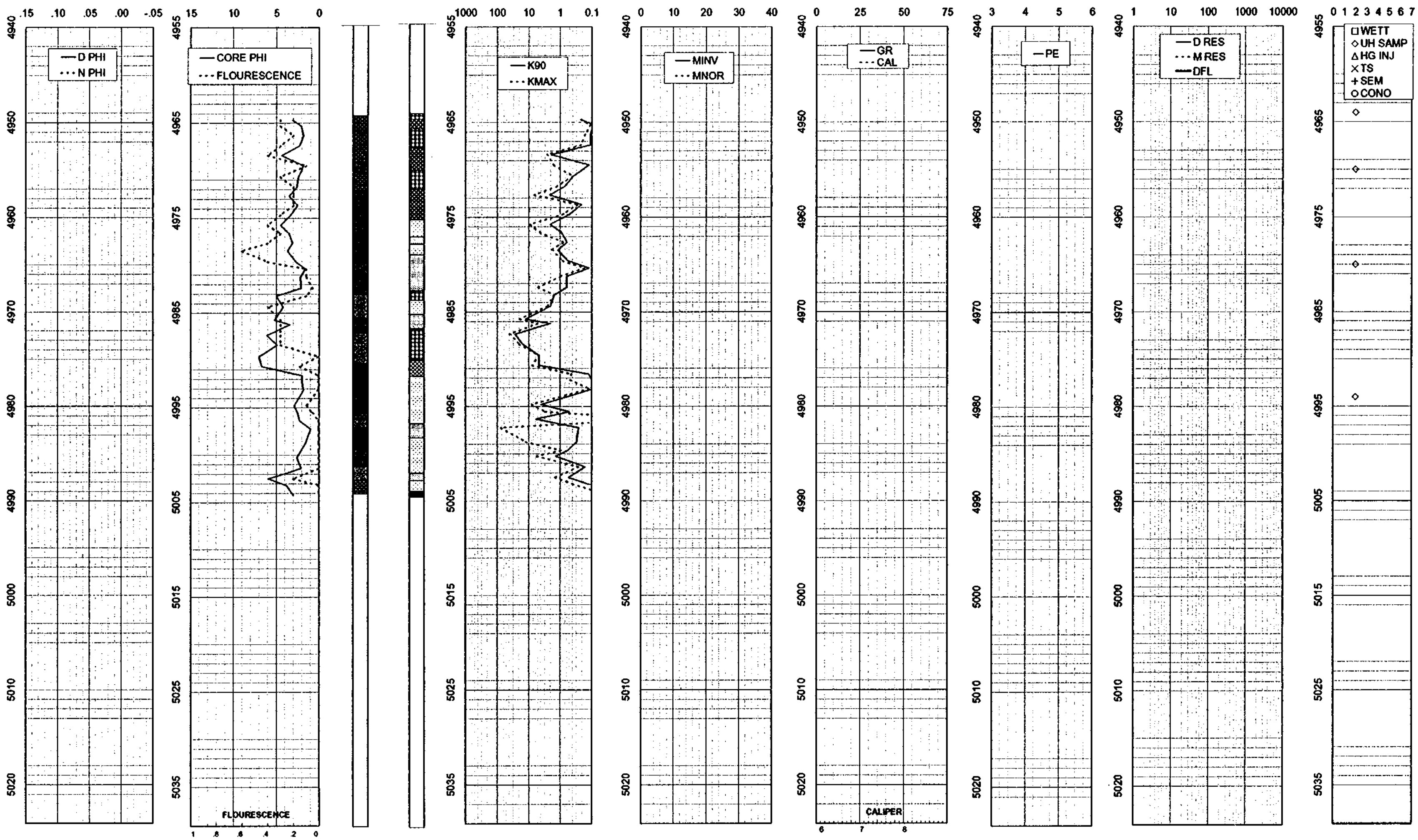
MARJO MARY MARIE 1-11, SEC.11, T15N, R2E
LINCOLN COUNTY, OKLAHOMA



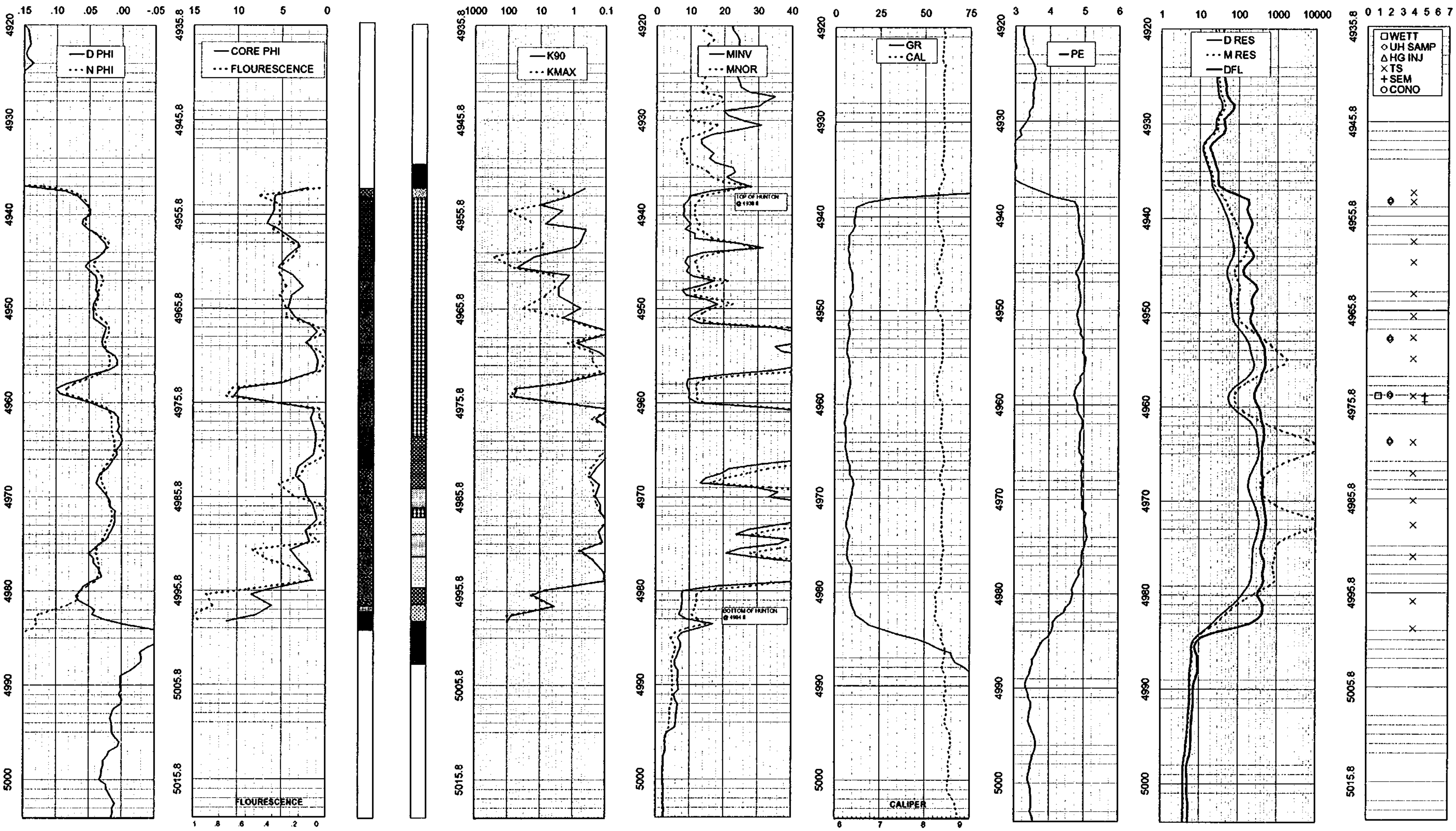
MARJO MCBRIDE SOUTH 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA



MARJO TOLES 1-10, SEC 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA



MARJO WILKERSON 1-3, SEC. 3, T15N, R2E
LINCOLN COUNTY, OKLAHOMA



Preliminary Report on Conodont Faunas of the Hunton Group
West Carney Hunton Field
Lincoln County, Oklahoma

James E. Barrick, Ph.D., Texas Tech University

Samples were selected by James R. Derby. In the comments below, clarifying comments are added by Derby, but enclosed in brackets.

Evaluation of Conodont Faunas

Age of Hunton Samples: Middle to Late Aeronian (Middle Llandovery), Early Silurian

The samples from the Hunton carbonates are dominated by taxa that have been used rarely for precise age determinations. The combination of species present in the three wells is typical of a Early Silurian Llandovery age. Similar species associations occur in Llandovery carbonates elsewhere in Oklahoma: the Cochrane Formation of central and southern Oklahoma and the Blackgum and Tenkiller formations of eastern Oklahoma.

The most indicative species recovered is *Distomodus staurognathoides*, which can be recognized in spite of the broken Pa elements from these samples. This species was obtained from the base of the Hunton section in the Carter core (4994.5-4994.9') and about 20 feet above the base in the Boone core (5046.1-5047'). *Distomodus staurognathoides* appears in the middle Aeronian (middle Llandovery) and ranges through the late Aeronian and Telychian (late Llandovery). However, species common and typical of Telychian conodont faunas are absent (*Pterospathodus* and related forms). The species of *Oulodus* that is present here resembles *O. panuarensis*, which is late Rhuddinian to Aeronian in age. The distinctive species in the cores of *Walliserodus* is very similar to *W. blackstonensis,* which was described from Aeronian beds in Arctic Canada. Based on this information, the Hunton section sampled in the Carter, Boone, and Mary Marie cores is probably middle to late Aeronian in age.

Conodont faunas from the Cochrane, Blackgum, and Tenkiller formations are also difficult to date directly because the conodont faunas are dominated by coniforms. A more diverse conodont fauna obtained from the Cason Limestone of northern Arkansas contains many of the same coniform species in addition to more diagnostic taxa. The oldest Cason samples bear *Distomodus tridens,* which occurs in upper Rhuddinian beds in Australia, and the highest beds have yielded *D. staurognathoides,* of middle Aeronian and younger age. Thus, there is good evidence from conodonts that a carbonate section of latest Rhuddinian to Aeronian age stretches from northern Arkansas into northern Oklahoma and across Oklahoma into the Anadarko Basin. Amsden (1966 and other papers) had earlier described the brachiopod *Triplesia alata* from the Cochrane, Blackgum, and Cason formations, which occurs in the Blackgum with a species, *Stricklandia protriplesiana*, which he interpreted to be indicative of an Llandovery C1-2 age, or late Aeronian.

The Hunton interval sampled in these three cores clearly belong to at least the upper part of the late-Rhuddinian-Aeronian carbonate package of the southern mid-continent region.

Sylvan Samples: Late Ordovician

Conodont faunas of the Sylvan Shale in Oklahoma have not been described in detail, so detailed comparison is not possible at this time. The conodonts recovered from most Sylvan samples represent Late Ordovician taxa. The one possible exception is the sample from 5066.5-5067' in the Boone core; these coniforms cannot be distinguished from Early Silurian species, although are may well be Ordovician in age.

Paleoecological and Paleoenvironmental Evidence

The conodont fauna from the cores {WCHF cores} differ in general faunal aspects from conodont faunas from the Cochrane, Blackgum, Tenkiller, and Cason formations {on the outcrop}. Conodont faunas from most Aeronian carbonates in the southern mid-continent region are strongly dominated (up to 90%) by elements of the coniform species *Panderodus unicostatus* and *Walliserodus curvatus*. This faunal association comprises the conodont biofacies that characterizes the fully open marine part of the broad shallow-water Llandovery carbonate platform. The shelly faunal assemblage of these carbonates is best assigned to Benthic Assemblage (B.A. 4), a middle to outer carbonate shelf position.

In contrast, the faunas from the cores {WCHF cores} are characterized by an abundance of *Oulodus* elements, uncommon *Panderodus unicostatus,* and a distinctly different species of *Walliserodus* {from the *Walliserodus* species, *curvatus*, found in the outcrop}. In the Llandovery, similar *Oulodus*-dominated conodont biofacies are commonly associated with the more heterogeneous carbonate facies of the shallower water B. A. 3 (carbonate build-ups, etc.). Because the Hunton section in at least one core, the Mary Marie, grades upward into pentamerid {Big brachiopod Coquina} beds, a definitive indicator of B. A. 3, a shallower-water position on the shelf is likely for this area and may be responsible for the distinct conodont fauna of the cored intervals.

Faunal Lists, By Well

Marjo Mary Marie #1-11, Sec. 14, T15N-R2E, Lincoln County, Oklahoma

Sample Fauna

Hunton

MM - 1: 4961.5-4962.0' 400 g processed

Panderodus unicostatus - 1

indet. ramiforms - 6

(residue full of quartz grains, many with overgrowths - unlike lower samples)

MM-2: 4967.0-4967.50' 500 g

indet. ramiform frags - 2

MM-3: 4973.0-4973.5' 500 g

Panderodus unicostatus - 2

indet. Sa-type element - 1

MM-4: 4980.0-4980.5' 600 g

Ozarkodina sp. indet. 1 - Pa; 2 ramiforms

Oulodus sp. indet. - 3 ramiforms

Pseudooneotodus sp. - 1

MM-5: 4987.0-4987.5' 500 g

BARREN

MM-6: 4990.5-4991.0' 650 g

Walliserodus sp. - 1

Dapsilodus sp. - 1

Pseudooneotodus sp. -1

Oulodus sp. 1 - 18 ramiforms; 10+ frags.

Ozarkodina? so. - 5 ramiforms

Distomodus? sp. - 1 ramiform

MM-7: 4997.2-4998.0 750 g

Walliserodus sp. - 2

Dapsilodus sp. - 2

Panderodus unicostatus - 11

P. aff. *recurvatus* - 1

Distomodus sp. - 3 ramiforms

Oulodus sp. 1 - 12 ramiforms; 14+ frags.

Ozarkodina? sp. - 16 ramiforms

Aspelundia? sp. - 1 ramiforms

MM-8: 5000.2-5000.8' 550 g

Walliserodus sp. - 1

Panderodus unicostatus - 14

Pseudooneotodus sp. - 1

Oulodus sp. 1 - 11 P? elements; 47 ramiforms; ten's of frags.

MM-9: 5003.0-5003.5' 150 g

Dapsilodus sp. - 4

Panderodus unicostatus - 2

Oulodus sp. 1 - 9 ramiforms

Ozarkodina sp. - 2 P; 1 ramiform

Sylvan

5003.5-5004.6' 650 g

Late Ordovician species

5004.6-5005.2' 750 g

Late Ordovician species

5006.0-5006.6' 850 g

Late Ordovician species

MM-10: 5007.3-5008.0' 800 g

Late Ordovician species

MM-11: 5014.0-5016.0' 650 g

Late Ordovician

<u>Marjo Boone #1-4, Sec. 4, T15N-R2E, Lincoln County, Oklahoma</u>

Hunton

5038.3-5039' 700 g

Panderodus unicostatus – 10 coniforms

Pseudooneotodus sp. – 1 coniform

Oulodus sp. 1 (robust) – 13 ramiforms

Oulodus sp. 2 (delicate) – 7 ramiforms

5046.1-5047' 650 g

Walliserodus sp. – 3 coniforms

Panderodus unicostatus – 3 coniforms

Pseudooneotodus sp. – 1 coniform

Oulodus sp. 1 (robust) – 58 ramiforms

Oulodus sp. 2 (delicate) – 2 ramiforms

Distomodus staurognathoides? – Pa –1; ramiforms - 12

5051-5051.8' 700 g

Panderodus unicostatus – 4 coniforms

Oulodus sp. 1 (robust) – 1 ramiform

5061-5061.9' 700 g

Walliserodus sp. – 107 coniforms

Panderodus unicostatus – 27 coniforms

P. aff. *P. recurvatus* – 2 coniforms

Pseudooneotodus sp. – 3 coniforms

Oulodus sp. 1 (robust) – 48 ramiforms

Oulodus sp. 2 (delicate) – 6 ramiforms

5065.7-5066' 350 g (80 g undissolved)

Walliserodus sp. – 27 coniforms

Panderodus unicostatus – 2 coniforms

P. aff. *P. recurvatus* – 2 coniforms

Ramiform fragments - 2

Sylvan

5066.5-5067' 350 g (120g undissolved)

Walliserodus sp. – 14 coniforms

Panderodus sp. – 1 coniform

Marjo Carter #1-14, Sec. 14, T15N-R2E, Lincoln County, Oklahoma

Hunton

4940-4940.9'   1100 g

Oulodus sp. 1 (robust) – 14 ramiforms

Oulodus sp. 2 (delicate)? - 1 ramiform

Panderodus unicostatus – 1 coniform

Walliserodus sp. – 7 coniforms

4941.4-4942'   600 g

Oulodus sp. 1 (robust) – 11 ramiforms

Oulodus sp. 2 (delicate)? - 2 ramiforms

Distomodus sp. – 1 ramiform

Panderodus unicostatus – 1 coniform

4950.4-4951'   350 g

Oulodus sp. 1 (robust)? – 1 ramiform

Panderodus sp. – 2 coniforms

Walliserodus sp. – 1 coniform

4951-4951.7'   500 g

Oulodus sp. 1 (robust) – 6 ramiforms

Panderodus unicostatus – 3 coniforms

4955-4956'   1400 g

Oulodus sp. 1 (robust) – 8 ramiforms

Oulodus sp. 2 (delicate)? - 5 ramiforms

Panderodus unicostatus – 2 coniforms

Dapsilodus sp. – 2 coniforms

4961.5-4962' 700 g

Oulodus sp. 1 (robust) – 19 ramiforms

Oulodus sp. 2 (delicate)? - 8 ramiforms

Distomodus sp. indet. Pa – 1; 4 ramiforms

Panderodus unicostatus – 4 coniforms

Dapsilodus sp. – 4 coniforms

4962-4962.6' 500 g

Oulodus sp. 1 (robust)? – 1 ramiform

Distomodus sp. – 1 ramiform

Oulodus sp. 2 (delicate)? - 1

4975-4975.7' 500 g

Panderodus unicostatus – 3 coniforms

Decoriconus sp. – 2 coniforms

Dapsilodus sp. – 3 coniforms

4976.8-4977.5' 500 g

Oulodus sp. 1 (robust) – 2 ramiforms

Distomodus sp. – 1 ramiform

4984.0-84.6' 950 g

Panderodus unicostatus – 2 coniforms

4990.9-4991.4' 500 g

Panderodus unicostatus – 4 coniforms

4994.5-4994.9' 550 g

Large fauna > 200 elements, including

Distomodus staurognathoides – 2 Pa elements, broken

Abundant *Panderodus*. aff. *P. recurvatus*

Oulodus sp. 1 (robust)

Common *Panderodus unicostatus*

Walliserodus sp.

4995.6-4896.0' (upper white carbonate) 250 g

Panderodus unicostatus – 3 coniforms

Walliserodus sp. – 1 coniform

Oulodus sp. 1 (robust) – 3 (+ fragments)

Sylvan

4995.6-4896.0' (Basal green unit) 250 g

Panderodus unicostatus – 1 coniform (leaked?)

Oulodus sp. 1 (robust) – 1 ramiform (leaked?)

Ordovician coniform – 1

4996.3- 4997.0' 700 g

Late Ordovician conodonts

4997.6-4998.5' 400 g

Late Ordovician conodonts

4999.6-5000.0' 400 g

Late Ordovician conodonts

{EARLIER NOTES BY Dr. Barrick upon analysis of single wells: Marjo Mary Marie Faunas. Comments dated 12/12/2000}

Summary of Faunas

1. Faunas from the interval above 4991' are undiagnostic, but probably Silurian in age.

2. From interval 5003.5' to 4491', the lack of Ordovician-style elements and presence of the coniform genera *Dapsilodus* and *Walliserodus* restricts this to the Silurian (no younger than late Ludlow).

A few elements appear to be pieces of *Distomodus*, a Llandovery genus – but they are not well preserved.

Oulodus sp. A, the most abundant species here, resembles early Llandovery species like *O. kentuckyensis* and would suggest a Rhuddinian – early Aeronian age.

If the one element labeled as *Aspelundia* in sample MM-7 is *Apelundia*, then a early Llandovery age is confirmed.

This interval is probably Cochrane equivalent, although it lacks the characteristic faunal composition of the Cochrane seen elsewhere in the Arbuckle Mountains outcrop region or elsewhere in the Oklahoma subsurface.

{Marjo Carter 1-14 Fauna: After studying the upper 2/3rds of the Carter Fauna; dated 2/23/2001}

As I prepared this summary, I noticed that the faunas of these two cores really are rather different in faunal composition.

The Boone well has the most typical Cochrane-type fauna in terms of species present and relative abundance. However, unlike regular Cochrane faunas, the samples contain the robust *Oulodus* species that so completely dominates the Mary Marie samples. Note that the robust *Oulodus* replaces *Walliserodus* as one goes up the core. Also note that the basal sample, from the "Sylvan" lacks the typical Ordovician species – the *Walliserodus* that occurs here is identical with those in the overlying samples.

The Carter well contains representatives of *Dapsilodus* and *Decoriconus*, which are uncommon in the Cochrane. These coniforms usually suggest a somewhat deeper water/more offshore shelf setting. Note that they occur in the lower core samples. Also, *Walliserodus* is present in the Carter samples near the top of the core.

Both cores are Llandoverian (Early Silurian) in age. In addition to the coniform taxa, *Distomodus* is present. If the Pa element in Boone 5046.1-5047' is *D. staurognathoides* (juvenile Pa), then this sample must be mid-Aeronian or younger.

THIN SECTION SAMPLES
MARJO CARNEY TOWNSITE 1-14, SEC. 14, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth							
From	To	Std	2x2	SEM	CS	Lithology	Detailed Lithology
4906.2	4906.9	x				Dol, lt gy f xln	open vert fract, with xln lining 4906-4908.4
4916.3	4916.4	x				Dol, limy f xln	micro vug + 1 lining 1"x11/2" vug
4924.3	4924.4	x				Dol, limy, v lt gy	many microvugs
4931.3	4931.4	x				Ls, sli dol v lt gy	chalky, pp, foss, f foss wkstn-pkstn with spares lg cri
4946.4	4946.6	x				Ls, lt gy, dense hard	silt tan cavity fill
4946.8	4946.9		x			Ls, lt gy, dense hard	mdstn/wkstn, sli pp
4960.1	4960.2	x				Ls, lt tan gy	v dense and tight 1% porosity
4964.9	4965	x				Ls, f foss, wkstn/pkstn	

THIN SECTION SAMPLES
MARJO CARTER 1-14, SEC. 14, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth							
From	**To**	**Std**	**2x2**	**SEM**	**CS**	**LITHOLOGY**	**Detailed Lithology**
4940.0	4940.1	x				dol grstn	
4941.1	4941.2	x					
4941.9	4942.0	x				c foss grstn	smooth tril, ost, frags lg brac
4945.0	4945.1	x				vuggy br grstn	
4950.9	4951.0	x				c br-cri grstn	c.br, tril,cri
4955.0	4955.1	x				c br-cri grstn	big brac-pent
4961.5	4961.6	x				f foss pkstn	few lg cri - cri sparite, no other foss
4962.0	4962.1	x				c foss grstn	sparite, lg brac-pent
4975.0	4975.1	x				br-cri grstn	leached vuggy, v big pent brac, tril, lg cri
4976.8	4976.9	x				br-cri grstn	sm v big pent brac, v lg cri,lg ost or tril
4984.6	4985.0		x			m-c brac grstn	
4991.3	4991.4	x				f foss wkstn	pp porosity chalky
4994.0	4994.2	x				dol grstn	f xln, vuggy&tight, loc washouts
4995.4	4995.5	x				coralline lst	altered to c dol, moldic
4995.7	4995.9	x				**contact ?**	f xln gy dol & grn gy argill dol
4998.2	4998.3	x				grn gy argill dol	

THIN SECTION SAMPLES
MARJO MARY MARIE 1-11, SEC. 11, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth							
From	**To**	**Std**	**2x2**	**SEM**	**CS**	**Lithology**	**Details**
4963.9			x		x		
4965.7			x		x		
4966.5			x	x	x		
4968.5			x		x		
4968.8			x		x		
4970.6			x		x		
4972.2			x		x		
4973.6			x		x		
4974.3	4974.4		x	x	x		
4976.3			x		x		
4977.8			x		x		oil stained vugs
4979.8			x	x	x		
4981.8			x		x		
4983.8			x	x	x		
4984.2			x		x		
4985.2			x		x		
4986.9			x		x		
4987.9			x		x		
4989.9			x		x		
4990.5			x		x		
4993.2			x		x		
4998.2			x		x		stain

THIN SECTION SAMPLES
MARJO MARY MARIE 1-11, SEC. 11, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth							
From	**To**	**Std**	**2x2**	**SEM**	**CS**	**Lithology**	**Details**
4999.6	4999.7		x		x		diameter sample
5001.2		x	x		x		vertical fractures
5001.6			x		x		across contact
5001.8		x	x		x		fractures
5002.2			x		x		fractures
5003.3	5003.4		x		x		across stylolite
5003.5	5003.6	x				Contact; lt gy dol/grn gy argill dol	
5004.1	5004.2	x				grn gy argill dol	
5006.2	5006.3	x				grn gy argill dol	

CS = Cover Slip

THIN SECTION SAMPLES
MARJO MCBRIDE SOUTH 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth							
From	To	Std	2x2	SEM	CS	Lithology	Detailed Lithology
4979.6	4979.8	x				Dol Ls with sed filled frac	dense foss pkstn/wkstn strongly recrystallised c xln brac pkstn, big brac facies, ? Misener infill

THIN SECTION SAMPLES
MARJO TOLES 1-10, SEC. 10, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth							
From	**To**	**Std**	**2x2**	**SEM**	**CS**	**Lithology**	**Detailed Lithology**
4964.2						Ls	Pkstn
4967.8						Ls	Pkstn
4971.4						Ls	Grnstn
4979.2						Ls	Grnstn
4991.1						Ls	Grnstn
4995.9			x			Ls	Grnstn
4996.6						Ls	Grnstn
4997.0						Ls	Grnstn
5003.7						Dol	Crystalline

THIN SECTION SAMPLES
MARJO WILKERSON 1-3, SEC. 3, T15N, R2E
LINCOLN COUNTY, OKLAHOMA

Depth							
From	To	Std	2x2	SEM	CS	Lithology	Detailed Lithology
4953.3			x				
4953.3			x				
4954.3			x				
4958.5			x				
4960.7			x				
4964.0	4964.1		x				
4966.4			x				
4968.7			x				
4970.9	4971.0		x				
4974.9			x				
4975.5			x	x			
4979.8			x				
4983.1			x				
4986.0			x				
4986.0			x				
4988.6			x				
4990.9	4992.0		x				
4996.7			x		***		
4999.6			x				

*** Note : Sample is polished