**Exploitation and Optimization of Reservoir Performance in Hunton
Formation, Oklahoma**

QUARTERLY TECHNICAL PROGRESS REPORT

Submitted by

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Abstract

West Carney Field produces from Hunton Formation. All the wells produce oil, water and gas. The main objective of this study is to understand the unique behavior observed in the field. We would also like to extend the analysis to other similar fields.

This report specifically addresses two issues relevant to our understanding of the West Carney reservoir. In the first part, we discuss our efforts to develop the geological model which can help us understand how the depositional environment affects the producing behavior. In the previous Budget Period, we described fourteen cores. In this report, we present preliminary analysis of several additional cores and conodont work. Based on the additional data collected, it is clear that the earlier geological model is simplified and needs to be updated. The complexity in geological environment can explain some of the unusual behavior observed in the field production.

The second issue deals with how to develop a model for gauging a potential success of a de-watering project. We have a developed hypothesis regarding what makes it successful, however, we need to test it against the available data. We have started collecting data from other fields producing from Hunton formation so that we can test this hypothesis. In this report, we provide the details of our effort to collect additional information.

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Experimental

No experimental work is conducted during this quarterly period.

Results and Discussion

One of the unique aspects of West Carney Hunton Formation (WCHF) is its geological complexity. Although the field appears hydrodynamically continuous, geologically, it is highly heterogeneous. We would like to reconcile our dynamic and petrophysical observations with the geological model in this Budget Period. We have started describing new cores towards that effort. The preliminary analysis indicates that the geological depositional model is significantly more complex than envisioned earlier. Some of this complexity may help us explain the unusual production characteristics observed in the field.

Another unique aspect about this reservoir is that large amount of water needs to be produced before we can produce significant quantities of oil and gas. We have hypothesized the elements of success of such reservoir. We, however, need to prove this hypothesis by testing it against large amount of data available from the field (WCHF) as well as other fields producing from the Hunton formation. We have started collecting data from other fields, and will soon begin to analyze the data.

Objectives

The main objectives of the proposed study are as follows:

- To understand and evaluate an unusual primary oil production mechanism which results in decreasing (retrograde) oil cut (ROC) behavior as reservoir pressure declines.
- 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 evaluate various secondary recovery techniques for oil reservoirs producing from fractured formations.
- To enhance the productivity of producing wells by using new completion techniques.

These objectives are important for optimizing field performance from West Carney Field located in Lincoln County, Oklahoma. 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.

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.

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.

West Carney Field is at the end 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 CO₂, methane and flue gas as possible injection fluids.

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 have completed the Budget Period I and have fulfilled many of the objectives. We have developed a viable model to explain the reservoir mechanism and have been able to develop a correlation between core and log data so that we can extend our analysis to other, yet unexploited, regions. In Budget Period II, we will continue to drill several additional, geologically targeted wells. Depending on the depositional system, these wells can be either vertical or horizontal wells. We will closely examine the secondary recovery techniques to improve the ultimate recovery from this field. In the mean time, we will continue to refine our geological and petrophysical model so that we can extend our approach to other adjacent fields. In the 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 beginning of Budget Periods II and III.

Summary of Technical Progress

The summary of progress is divided into three sections. The first section discusses the field activities. The second section discusses the Geological progress and third section provides engineering progress.

Field Activities

The field activities continued during this period. The field is being developed rapidly; Marjo Operating Company drilled three additional horizontal wells during this period. In addition to drilling new wells, the production from the existing wells is being carefully monitored.

Geological Analysis

James Derby

In Budget Period I we described 14 cores and outlined an “Island model” of a field created by a high standing “island” of the Cochrane Limestone, surrounded by a younger dolomite reservoir unit, the Clarita Formation. (Figure 1) Distal to the field we postulated a carbonate mudstone facies based on well-log and preliminary core data. This simple picture is complicated by recognition of two phases to the Cochrane. The older unit, the Lower Cochrane is present throughout the field and appears to be present in the western, thicker part of the limestone facies at positions stratigraphically (and paleotopographically) higher than the younger Upper Cochrane and Clarita formations. The Upper Cochrane, overlain by Clarita dolomite, was identified in only two wells in the eastern part of the field. Clarita was positively identified in dolomite facies in one well west of the western thick Lower Cochrane wells. These stratigraphic units are positively identified by paleontologic age determination, specifically by conodonts.

We now have 28 cores, 26 in the field and 2 from outside the field, that provide critical regional stratigraphic information. A major part of our effort to date, since the beginning of work in BP11, is compiling the data on all 28 wells, transporting the cores to the site for description, and taking of samples for analysis and thin sections. The data management is summarized on the attached well summary tables. (Table 1 & Table 2)

Table 1

WELL DATA: All wells cored and Analyzed by StimLab

DOE/TU West Carney Hunton Project

TABLE OF WELLS CORED: Thickness, Core/Log adjustment, Data

X = top or base of Hunton not cored;; (footage) = top or base of core; *italicized depth* is "core depth" of fm top or base picked on logs

	Hunton Top		Core/log	Hunton Base		Thickness	Status & Data, * = Completed							Lithology		
	Core	Log	adj.	Core	Log		Wk	TS	PC	SEM	Cono	UH	Wett			
1	5705 - Mary Marie 1-11	4961	4944	17	5003.5		42.5 cored	C	33	C	4	14*	10	4	Ls/ 2'dol	
2	5712 - Wilkerson 1-3	4953.4	4937.5	15.8	4999.8	4984	46.4 cored	C	17*	C	1			8	1	Ls/ 2'dol
3	5733 - Toles 1-10	4964	X	na	5003.7	X	39.7 cored	C	8*	C						Ls/ 2'dol
4	5818 - Henry 1-3	X (4966)	4958	7.5	X (4996.6)		30.6+ cored	C		C						Ls/5' dol/lis
5	5838 - Danny 2-34	X (4930)	4918	10.8	4984.3		54.3+ cored	C		C				4	1	Ls
6	5874 - Joe Givens 1-15	5017.8	5010	9	5044		26.2 cored	C		C						Ls/ 0.1' dol
7	5887 - Williams 1-3	4943.5	4934	9.5	4983.7	4974	40.2 cored	C		C				8		Ls/ 5' dol
8	5899 - McBride South 1-10	X (4962)	4947	13.3	4996.2	4983	34.3 cored 36 log	C	1*	C		1*		4		Ls/dol/lis
9	5913 - Boone 1-4	X (5037)	5028	6.5	5066.5	5060	29.5+ cored 32 log	C	6*	C		6*		4	1	Ls/ dol Ls/ 4' dol
10	5934 - Carter 1-14	X (4940)	4927	13.3	4995.8	4983	56.1 cored 56 log	C	16	C		18*		4	2	1'dol/ Ls/ 2'dol
11	5943 - Anna 1	4967.1	4947	20.1	5004.7	4985	37.6 cored	C	10	C						Dol
12	5992 Carney Townsite 2-5	X (4906)	4907	0	X (4966); 4978.3L	4978	60 cored; 71 log	C	8*	C		10*/16		4		Dol/Ls
13	6011 - Bailey 2-6	X(4876)	4875	-2.8	X(4934)	4964	58 cored; 89 log	C	20	C		12*/35				14' Dol/Ls
14	6029 - Kathryn 2-14	X(4994)	4990	2.5	5030.5	5028	36.5 core 38 log									Ls/Dol/Ls/Dol
15	Geneva 2-32						9 ft cored		1							Ls(Cri pkstn)
16	6051-Carter Ranch 2-15	5006	5000	6	5035.1	5030	29.1 cored	C	5	C						
17	6061-Carney Ext SWDW # 1	5042.7	5038.0	4.7	X(5131); =5156 L	5151	88.7 core 113 log		15					10		Ls
18	6088-Cal 1-11	X(5034)	5025	1.8	5135.8	5134	101.8core 108.5 log							21		no Pent br facies? wkstn Karst/12' mdstn/6' burr mdstn
19	6100-Mark Houser 1-11	X(4961)	4940		X(5077.6)	5066	116.6core 126 log									need log
20	6112-JB 1-13	4971.9	4966	5.9	X(5058.8)	5120	86.9 core 154 log									
21	6131-Saunders 1-13	4917.3	4911	6.3	X(4940.5) 5059.32	5053	23.2 core 142 log									
22	6143-Points 1-13	4989.5	4978	11.5	X(5107)	5096	117.5 core 118 log									Ls
23	6150-Mercer 1-28	X(4527)	4526	0?	X(4583)	4606	56 cored 80 log							17		
24	6209-Griffen 1-14	X (5082)	5077	5	X(5142); 5191.5	5186.5	60 cored 109.5 log							14		Ls/dol/limy dol
25	6247-Morrow 1-27	X(4905)	4886	0.5	4956.5	4956	53 cored 69 log									
26	6281-Chandler SWDW #1-33	X(4810)	4797.5	3.3	X(4869.8)	4865	59.8 core 68 log							14		
27	6302-Stevenson 1-14	X(5143)	5103	2	X(5167.6)	5186	24.6 core 85 log									
28	6563-W Carney Ext SWDW # 2	X(5140)	5135	6	X(5232) 5275L	5271	92 cored 135.5 log									

Wk = Work status (Core description), PC = Porosity Codes, Core description, Pore codes: C = Completed; IP = In Process.
 TS = Thin Sections, # made, * described ; SEM = Scanning Electron Microscopy, Cono = Conodont micropaleontology, # of samples, * completed
 UH = Core Plug samples at Univ. Houston; Wett = Wettability Analysis,
 Hg Inj = Mercury injection porosimetry
 Numbers in front of Well Name is StimLab well Identification Number

Table 2

[illegible]

Wk = Work status (Core description), C = Completed; IP = In Process; PC = Parasity Codes

TS = Thin Sections, # made, * described; SEM = Scanning Electron Microscopy, Cono = Conodont micropaleontology, # of samples, * completed

UH = Core Plug samples at Univ. Houston; Wett = Wettability Analysis.

Hg Inj = Mercury injection porosimetry

Numbers in front of Well Name is StimLab well Identification Number

* Mercer not logged, but 75' offset (MFC Petroleum #1-28 Cruse) was logged (N.D. Sonolateral og - same thickness - 601) -Sandeep to digitize. Import digitized log data for Cruse 1-28 into Mercer 1-28

Conodont studies have been completed on two additional wells, as shown in the figure “Wells with Conodont Studies”, (Figure 2). This shows that the two wells outside the field, the Mercer to the north and Chandler SWDW to the southeast both have Clarita, Upper Cochrane, and Lower Cochrane present. This new data, and stratigraphic details from these cores, shows that the original simple model was generally correct, but far more complex than initially envisioned.

Figure 2

Critical to understanding the stratigraphy of West Carney Hunton Field (WCHF) is recognition that the lithostratigraphic units are sequences formed during 5 cycles of sea level change from lowstand to highstand during the late Ordovician and earliest Silurian. (See Figure 3). The bathymetric changes produced a complex of depositional and diagenetic facies that directly affects the development of reservoir facies in the Hunton Group.

Silurian stratigraphical nomenclature with graptolite and conodont zonations (reviewed in Holland and Bassett, 1989) correlated with a master sea-level curve (modified from Johnson and McKerrow, 1991). Water depth is calibrated with respect to benthic assemblage zones. The absolute time scale is from McKerrow et al. (1985). Highstands are numbered 1–8.

Figure 3

Preliminary core descriptions of the Mercer and the Chandler SWDW cores, as well as for the Cal, Morrow, and Saunders wells are included in [Appendix A](#). Description of 14 cores and conodont analyses of 8 wells was included in the Final Report of Budget Period I. Details of the preliminary conodont analyses for 2 additional wells, the Mercer and Chandler SWDW, are given in the individual Conodont Sample tables. (Table 3 & Table 4) The Mercer, Chandler, and basal Cal contain shaly lime mudstone and siliciclastic shale sequences that are not present in the WCHF central portion.

Table 3

CONODONT SAMPLES- Marjo Mercer 1-28, 28-17N-2E

[On log-plots, enter the top or "to" depth]

Depth FROM	TO	Spl #	Gp/Fm	LITHOLOGY	Grams	# Cono	Age	Series	"Zone"	Strat Position	TS
			Hunton								
				Dol, Vuggy, foss							
4527.4	4528	1	Clarita	grnstn				Wenlock	5	78	x
4528.4	4529	2		aa, . v oily						77	x
4531.2	4532	3	Clarita	aa				Wenlock	5	74	x
				aa,v. vuggy, moldic;							
4537.3	4538	4	Prices Falls	gilsonite pore fill				Up Lland	5a	68	x
				Shaly crinoidal							
4543.1	4543.8	14		wkstn						62.2	
4545.2	4546	5	Prices Falls	Ls, foss burr wkstn				Lland	5a	60	x
4550.1	4550.8	6		AA-tite, burr mdstn						55.2	
4553.2	4553.9	15		AA-tite						52.1	x
4558.3	4559	7	Up Cochran	AA				Lland	4	47	x
				Burr muddy ls, sl.							
4564.1	4564.7	8		foss wkstn						41.3	x
				LS, wkstn 0.5' below							
4566.4	4567	9	Up Cochran	base of dK shale				Lland	4	39	x
				bottom of shale,							
				muddy foss							
4570	4570.5	10		mdstn/wkstn						35.5	x
				Foss mdstn/wkstn							
4570.5	4571	11	Lower Cochrane	clean				Lland	3	35	x
4574.6	4575	16		Foss mdstn/wkstn						31	
				Ls, w burrowed							
				mudrock streaks,							
4575.4	4576	17		shaly at base						30	
				Dense ls, mdstn							
4577.2	4577.9	12		clean						28.1	x
4582	4582.7	13	? Lo Cochrane	aa				Lland	3?	23.3	x

Strat Position is footage above or below (-) the Hunton/Sylvan contact at 4606 ft, by gamma-ray & CBL log..

Note : Lithology is limestone, unless mentioned otherwise

TS = Thin Section of this sample

"Zone" = "Zones" 1-6 of of simplified conodont zoanation adopted for this study

Table 4

CONODONT SAMPLES- CHANDLER SWDW

[On log-plots, enter the top or "To" depth]

Depth		Spl #	Gp/Fm	LITHOLOGY	Grams	# Cono	Age	Series	"Zone"	Strat Position	TS
FROM	TO										
			Hunton				Silurian				
4810	4810.6	Ch-1		Dol						67.7	
4816.4	4817	Ch-2		Dol						61.3	
4822.5	4823	Ch-3	Clarita	Dol				Wenlock	5	55.3	x
				Dol, Vuggy,							
4824.9	4825.7	Ch-4		Diag Terrane						52.6	
			Clarita,	Dol, Vuggy,							
4833	4833.6	Ch-5	Misener leak	Diag Terr				Wenlock high	5	44.7	
4835	4835.6	Ch-6	?up Coch	Dol, Diag Terr				Llandov	4?	42.7	x
				Dol, Burrowed,							
4838.7	4839.4	Ch-7	Up Cochrane	Diag Terr				Llandov	4	38.9	x
4840	4840.7	Ch-8	Up Cochrane	Foss Wkstn				Llandov	4	37.6	
4843	4843.7	Ch-9	Up Cochrane	Shaly, f grnstrn				Llandov	4	34.6	x
4847.2	4847.8	Ch-10	?	Shaly ls				Llandov		30.5	
4853.5	4854.4	Ch-11	Low? Coch	Burr, Mdstn				Llandov	3?	23.9	
4862	4862.7	Ch-12	Low? Coch	Burr, Mdstn				Llandov	3?	15.6	x
4866.4	4867	Ch-13	Low Coch	Burr, Mdstn				Llandov	3	11.3	x
				Burr, Mdstn,							
4868.9	4869.7	Ch-14	Low Coch	Shaly lam				Llandov	3	8.6	x

Note: All samples, #1-14, were shipped to Barrick on 6/4/03; Barrick provided prelim results 6/22

Strat Position is footage above or below (-) the Hunton/Sylvan contact at 4878.3, core depth; log base is 4865, 13.3 ' correction.

Note : Lithology is limestone, unless mentioned otherwise

TS = Thin Section of this sample

"Zone" = "Zones" 1-5 of of simplified conodont zoanation adopted for this study

Our preliminary interpretation during Budget Period I was that the shaly intervals represented the Prices Falls Member of the Clarita Formation (See Figure 1). This is simply not true in the Chandler and only partly true in the Mercer. In the Chandler, the Clarita & Prices Falls interval are entirely in a dolomite grainstone facies with much dissolution (moldic) porosity. The dolomite extends downward into the Upper Chandler for at least 5 feet, what I interpret to be "Diagenetic Terrane" facies. Limy shale and nodular shaly limestones extend downward into units identified as Upper Cochrane and Lower Cochrane. In the Mercer, six feet of Clarita dolomite is underlain by 12 feet of porous, gilsonitic and oil stained, dolomite grainstone and 10 feet of shaly lime mudstone, both containing a Prices Falls conodont fauna. The underlying Upper Cochrane (10.6 feet) and Lower Cochrane (16 feet cored) contain interbedded light-colored nodular shaly lime mudstones , light green limy shales, and dark-gray, apparently

organic rich shales. My preliminary hypothesis is that these interbedded sequences are off-bank condensed sequences representing both highstand (dark, laminated, organic-rich shales) and lowstand (light-colored, burrowed, local “birdseye” calcite) depositional environments. In terms of the facies zones described by Stanley (2001), these would be Zones 1 and 5. (Figure 4) However, the spatial distribution of the facies in the WCHF area suggests that a modified platform model, as opposed to a ramp model, may be more applicable to WCHF (See Figure 5). In this model, the light-colored muddy carbonates are deposited in the quiet shoal waters of the shelf lagoon, while the thick shell banks of the central part of WCHF (final report BP1) are deposited in somewhat deeper water. The dark-colored shales and shaly limestones are deposited in deep water, during sea level rise, either off bank, or prior to bank/platform development.

Idealized standard facies model of the Hunton Group, based on a carbonate-ramp model of deposition. Illustrated are the main facies zones, their diagnostic depositional textures, and the bathymetric positions the major units of the Hunton would have hypothetically formed under this depositional scheme. *N.W.B.* and *S.W.B.* represent normal wave base and storm wave base, respectively. Only rocks formed under facies zones 2 through 5 occur in the outcrop belt around the Arbuckle Mountains. No vertical or horizontal scale is implied.

Figure 4

A. Carbonate Platform

B. Carbonate Ramp

Comparison of shelf profiles of differing regional carbonate buildups. *A*—Typical carbonate-platform style with a near-horizontal top and an abrupt shelf margin with steep paleoslopes where high-energy sediment is deposited. *B*—Carbonate-ramp style that builds up from positive areas and down gentle regional paleoslopes that have no obvious break between shelf and basin. Note that in ramp buildups, the high-energy zone occurs relatively close to shore, and the facies patterns tend to be wide and irregular in comparison with a carbonate platform. No vertical or horizontal scale is implied. Diagram modified from Wilson (1975, fig. 11-2).

Figure 5

The Cal has not yet been analyzed, however its position relative to the West Carney SWDW #1 suggests that the core is in the Lower Cochrane interval. The shaly nodular limestone facies is probably a deeper-water facies, analogous to facies zone 5 of Stanley, 2001, (see Figure 4)

deposited during the initial flooding event and prior to establishment of the Lower Cochrane grain –supported carbonate bank that grew to over 100 feet in thickness less than 1 mile away.

Clearly the depositional model, and therefore the diagenetic model, for WCHF is being continuously modified as new data is obtained.

Engineering Analysis

Manas Gupta and Mohan Kelkar

We have fairly good understanding of how and why oil and gas are produced from West Carney Hunton Field. We believe that the successful ingredients for producing oil and gas from watered out reservoir include:

- Heterogeneous reservoir characteristics. More heterogeneous the reservoir, more likely that oil and gas will be trapped after water influx
- Low porosity. Lower the porosity, higher is the probability of trapped hydrocarbon saturation
- Moderate and/or limited aquifer. The aquifer strength has to be limited to be able to reduce the pressure in the reservoir
- Oil wet characteristics. More oil wet the reservoir prior to water invasion, more is the amount of trapped hydrocarbons.

This model is based on intuitive understanding as well as field observations. We need to provide statistical and physical basis for this model. In addition to applying certain statistical tests to the log and core data collected in WCHF, the analysis needs to be extended to other yet unexploited areas, where several additional wells can be drilled which can be either vertical or horizontal wells.

To further extend our analysis, Log and DST data has been collected which includes wells drilled in the Lincoln County, Seminole County, Pottawatomie and Hughes County. Log data for 290 wells have been collected which includes 11 Townships.

LOG DATA

Township	No. of Wells
12 N 6 E	25
13 N 5 E	26
13 N 6 E	27
10 N 5 E	20
11 N 6 E	34
11 N 7 E	20
10 N 6 E	48
12 N 5 E	24
10 N 7 E	22
9 N 7 E	32
9 N 11E	9

Log data collected includes the Neutron and Density Porosity Logs, Deep, Medium and Shallow Resistivity Logs and SP Logs. Along with the log data, DST Data for 340 wells has also been collected for wells drilled in these 11 Townships.

In the next quarter, the Log Data will be digitized, so that Statistical Analysis can be done to determine if our proposed model fits the data, and if needed, what additional data are necessary.

Technology Transfer

Rahul Joshi took first place in the Masters division in the SPE Student Paper Contest, Mid-Continent Division, at the University of Missouri – Rolla on April 5, 2003 with his paper titled “Exploitation and Optimization of Reservoir Performance in Hunton Formation, Oklahoma.”

Two workshops titled “Dewatering of the Hunton Reservoir in West Carney Field – Mystery Solved?” were conducted in April 2003. Presentations were made by Mohan Kelkar, Joe Podpechan, Brian Keefer, Sandeep Ramakrishna, Rahul Joshi, and Jeff Frederick. Participants received a bound copy and DVD copy of the presentations. Fifty-three people attended at the DoubleTree Hotel in Tulsa, OK on April 16th; and twenty-three people attended at the Metro Technology Center in Oklahoma City, OK on April 21st. Feedback has been positive and word-of-mouth has generated post-workshop requests for more information on the project.

Sandeep Ramakrishna, Brian Keefer, and Mohan Kelkar submitted a paper titled “Correlating Static Data to Dynamic Characteristics: Hunton Reservoir,” for publication by the University of Kansas in May 2003.

The project web site is being converted to new software due to technology issues between The University of Tulsa’s servers and the current web design software. With this conversion, cascading style sheet (CSS) technology is being applied to provide a uniform appearance and allow for quick formatting changes in the future. The new site will go live in July 2003 and will become the point of contact for all future technology transfer.

Conclusions

Based on the work done in this report, the following conclusions can be drawn:

- Based on the descriptions of new cores in the field, the earlier geological model needs to be revised. We are currently in the process of describing the new cores as well as conduct additional conodont studies to finalize the revised model.
- We believe that the main ingredients of a successful de-watering project include heterogeneity of the reservoir, low porosity, wettability of the rock, and the strength of aquifer. We need to validate our hypothesis by applying to the WCHF as well as surrounding fields in Hunton formation.

References

1. Johnson, M.E., 1996, Stable Cratonic Sequences and a Standard for Silurian Eustasy: Geological Society of America, Special Paper 306, p. 203-211.
2. Stanley, T.M., 2001, Stratigraphy and Facies Relationships of the Hunton Group, Northern Arbuckle Mountains and Lawrence Uplift, Oklahoma: Oklahoma Geological Survey Guidebook 33, 73 p.

Appendix A

Table 5: Mercer 1-28 Preliminary Stratigraphic Description

Quick Review Of Slabbed Cores

UNIT	FROM	TO	THK	DESCRIPTION
Top of Core = 4527				
Woodford Shale (not cored)				
Misener Sandstone (not cored)				
Hunton Group (55 ft. cored)				
Clarita Fm (6.7 ft.)				
	4527	4533.7	6.7	Dol, pale brown, med fossilif. grnstr-pkstr, much moldic porosity.
Clarita-Prices Falls Member (21.6 ft)				
	4533.7	4545.8	12.1	Dol, dark gry to black, abund. gilsonite & oil stain, fossilif., moldic porosity, burrowed. disturbed bedding, possibly diagenetic terrane. abund. small crinoids
	4546.8	4555.3	8.5	Ls, shaly, pale brown burrow-mottled shaly lime mdstr, sparse fossilif., rare crinoids & brachioids. Pyrite nodules at base.
Upper Cochrane (10.6 ft.)				
	4555.3	4561.2	5.9	Ls, shaly, pale brown-gray burrow-mottled shaly lime mdstr. Sharp upper contact, abund small crinoids at top.
	4561.2	4565.9	4.7	Shale, limy & Ls, shaly. Abrupt top & bottom contacts. Two intervals of abund. fossil fragments, dom. crinoids.
Lower Cochrane (16.1 ft.)				
	4565.9	4569.3	3.4	Ls, buff to light gray, burrowed mdstr, "birdseye" crystals common. Grades to shale below.
	4569.3	4570.6	1.3	Sh, dk grn-gry, limy, thinly laminated, part nodular.
	4570.6	4576.6	6	Ls, shaly, lt gry-greenish gray, nodular mdstr with thin shaly partings and 0.5' of shale at base.
	4576.6	4582	5.4	Ls, pale brown, burrow mottled mdstr & v.f. fossilif. wkstr; sparse shaly partings.
Base of Core = 4582				

Table 6: Chandler SWDW Preliminary Stratigraphic Description

Quick Review Of Slabbed Cores

UNIT	FROM	TO	THK	DESCRIPTION
Hunton (entire core, 59.75 ft. cored)				
Clarita FM. (24.9 ft.)				
G	4810	4834.9	24.9	Dol, md dk gy, abund vuggy moldic porosity, some Karst fractures with fill, 2ndry tight zones NOTE: is this sabkha crusts? Small cavities with lam fill; TS at 4822.5 dol- TS 4834.8 - 4835 poss TS at 4833 - sel Cono s.l. poss TS at 4825 photo karst fill at 4817
Upper Cochrane FM. (15.3 ft.)				
F	4834.9	4839.9	5	Dol, burrowed, prob "diagenetic terrane", sparse isolated vugs; altered burrowed wkstn + mdstn, laminated at top
E	4839.9	4842.4	2.5	Ls, dolomitic, fine foss wkstn to foss mdstn, burrowed, partly dolomitized, sparse large crinoid
D	4842.4	4850.2	7.8	Shale, limy to Shaly Ls med grn-gy, vuggy, with lime mdstn lenses, burrow fill. Large white chert nodule TS 4843 - 43.3 grnstn TS 4843.6 - .7 with blk center Grades at top-top 2' has thin lime grnstn bed
C	4850.2	4853.5	3.3	Ls, lt gy burrowed mdstn with shaly laminae, black chert nodule, sparse large crinoid; TS 4862.0 burrowed mdstn
Lower Cochrane FM. (16.85 ft.)				
B	4853.5	4859.5	6.5	Shale, med grn gy, with lime mdstn nodules, grades up in top ft to burrowed cherty mdstn
A	4859.4	4869.75	10.35	Limestone, nodular burrowed mudstone, with shaly laminae and beds up to 1 cm thick. With 7 large black chert nodules; shaly at top 0.5' and basal 2 ft. TS 4867.4 chert nodule

Note: Formation assignments based on conodont analysis as of 6-22-03 and are subject to modifications as more data is obtained.

Table 7: Marjo Morrow 1-27 Preliminary Stratigraphic Description

Quick Review Of Slabbed Cores

UNIT	FROM	TO	THK	DESCRIPTION
				Note 1: Unit D looks like dolomitized upper part of Chandler SWDW - with tight streaks alternating with grmstn Note 2: Core log correction very close to Core depth = Log depth, by visual inspection
Hunton (51.5 ft cored)				
D	4905	4951.2	46.2	Ls, fine foss grmstn + pkstn; loc mdstn; thin intervals of Pent. Brach, small brachs at 4947 - 46, 4922 - 24, 4908 Porosity is moldic (?) or micro vug., appears uniformly oil stained
C	4951.2	4956.4	5.2	Dol, variegated, shaly in part, loc. Fossilif. with small brachs, burrowed - Diagenetic Terrane? No obv. Karst, mostly tight. Pyrite nodules, Dol nodules - photos
Keel FM?			0.1	
B	4956.4	4956.5	0.1	Oolitic chert, ovate nodule, 0.1 ft thick, white, blk to white Oolites TS
Sylvan Shale				
A	4956.5	4959	2.5	Dolomite, argillaceous; dolomitic siltstone

Table 8: Marjo Saunders Preliminary Stratigraphic Description

Quick Review Of Slabbed Cores

UNIT	FROM	TO	THK	DESCRIPTION
Woodford/Misener				
	4915	4915.3	2.3	Shale blk, with 3" basal ss, f. gr, dgy, pebbly at 4915.1 - .3 irreg corroded surface at contact
Hunton (25.2 ft. cored)				
	4915.3	4940.5	25.2	Ls, v.c. pent brach coquina; brachs up to 3" long, vuggy, drusy calcite fills in brach cavities, woodford shale in cavity fill, @ 4920 - 20.5. mostly tightly cemented with scattered large vugs. Vugs are open, with drusy calcite linings.

Table 9: Marjo Cal 1-113 Preliminary Stratigraphic Description

Quick Review Of Slabbed Cores

UNIT	FROM	TO	THK	DESCRIPTION
Hunton Group (101.8 ft. cored)				
J	5034	5051	17	Ls; sparse pentamerid brach pkstn;
I	5051	5111	60	Ls, fine crinoid-brach wkstn with intrbdd mdstn, loc. Intensely fractured.
H	5111	5115.5	4.5	Ls, mdstn, with fractures and soln cavity fill, with cave flowstone
G	5115.1	5115.6	0.5	Ls, cavern fill Parabreccia? With vertical open fracture filled with Karst mud. (get TS of this)
F	5115.6	5129.7	14.1	<u>Ls</u> , pale-br <u>mdstn</u> , sparsely fossilif. rare crinoids; fractured, Karst fill in dissol.cavites, Crackle breccia, both V & H
E	5129.7	5133.9	4.2	Ls, Shaly, nodular, pale yellow-brn mdstn, with abund dark gry shale layers; prob burrowed mottled strongly pyritic 32 - 33.7; large white chert 33.7 - 33.9;
D	5133.9	5135.4	1.5	Ls, mdstn, pale yellow brn, burrowed mottled, sparse shaly laminae
C	5135.4	5135.8	0.4	Ls, pale yellow brn - (buff); mdstn, burrowed corrosion contacts top and bottom
Sylvan Shale (9.8 ft. cored)				
B	5135.8	5138	2.2	Dol, mdstn argill; pale grn - gry at top, grades down to med grn gry with incr argill pyrite in top 0.2; blk chert nodule in top 0.2 with thin shale layers
A	5138	5145.6 TD	7.6	Shale, med grn gry, Dolomitic, burrowed grades in part, mod - strongly fissile, up to Dolomite

Note: The entire Hunton is very tightly cemented with no significant matrix porosity. Permeability is entirely due to solution-enlarged fractures. The lower 20 ft. of the Hunton appears to be a deeper water facies than seen in most field wells. This facies appears to be BA 4 & 5 (below storm wave base), as opposed to BS 3 & 2 for most Carney limestone wells.