CONVENTIONAL AND UNCONVENTIONAL RESOURCE EVALUATION IN THE SOUTHEAST NEW MEXICO: OLD AND NEW PLAYS

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ABSTRACT

The work described in this paper was performed in conjunction with a contract from the U.S, Bureau of Land Management, Pecos District to estimate oil and gas development in southeastern New Mexico for the next 20 years. This district covers the bulk of the Permian Basin in New Mexico, and contains numerous oil and gas reservoirs. Producing oil and gas fields of the region were divided into 27 plays, based upon similarities such as depositional environment, lithology, tectonic history, and trapping mechanisms. The approach relied heavily on the work of Broadhead (2004) but expanded into reservoirs not covered in that study. Plays were analysed based on key factors such as geology, development histories, pool-wide production histories and trends, and the impacts of market demand, price, regulatory change, and impacts of changing technologies. Conventional resource potential of the Ellenburger play and unconventional resource potential of the Woodford Shale play are presented as samples of this work.

INTRODUCTION

The objective of this work is to estimate a reasonable development of production in southeast New Mexico for the next 20 years, with emphasis on federal lands managed by the U.S. Bureau of Land Management (BLM). In 1924, the Flynn, Welch, Yates State No. 3 well opened the first commercial oilfield in Southeast New Mexico (Lang 1935). The Jal and Hobbs fields in Lea County were discovered in 1927 and 1928, respectively, and the Permian Basin of southeastern New Mexico has continuously produced since then.

The Reasonable Foreseeable Development Scenario (RFDS) is a planning tool used by Bureau of Land Management to provide a reasonable estimate of what oil and gas exploration and development activities might be proposed, should a decision be made to lease the area. Under this scenario, the RFDS projects what activities might be conducted by a mineral lessee under current and reasonably foreseeable regulatory conditions and industry interest. The RFDS is a 20-year forward-looking estimation of oil and gas exploration and development that is exclusive of other concerns that might compete for use of land in a multiple-use scenario. As such, it is information about one resource, with a projection of that resource as developed in a reasonable foreseeable manner. (Brister et al., 2005)

In this paper we present more detail about the methods, and then will use two plays as examples of the work. A Conventional resource potential of the Ellenburger play and unconventional resource potential of the Woodford Shale play are presented as samples of this work. Many of the data are from published literature; however, new insights were derived by integrating these data.

METHODOLOGY

A decision was made to create a framework for the effort by grouping known reservoirs in the study area into plays based on work of Broadhead (2004) and Dutton et al., (2004). These studies only covered major oil plays and did not include gas plays, thus we expanded on these studies by including both known gas plays and potential future oil and gas plays not discussed in their work. Additionally all play data are being organized as an integrated Geographic Information System (GIS) database. Plays are defined based upon similarities such as depositional environment, lithology, tectonic history, and trapping mechanism. Figure 1 provides an outline of important reservoir elements in the study area, Figures 2 and 3 show the plays in a stratigraphic framework for the area. For each identified existing and potential future play, we considered key factors such as reservoir geology, development history, pool-wide production history and drilling trends. Statistical data were compared with outside factors such as oil and gas prices, technology and regulatory changes to determine what influence these factors have had and might exert in the future.

A similar basic set of data was collected for each play. Information includes basic statistics on geology, history, production, pertinent regulations, locations and technologies. Data was collected for all the plays and the important pools. Following data collection, we analyzed various reservoir parameters to create a variety of statistics on reservoir production and technological development. The final step of each play analysis was to create a prediction of the future potential of each play.

DATA COLLECTION

One of the most time consuming processes for this project was gathering historical production data for each of the pools. Production data for the years 1935-1970 were only available as paper data in Annual Reports of the New Mexico Oil and Gas Engineering Committee. It was first necessary to digitize data for production and well count by pool. This information was then merged with production data from IHS's PI/Dwights® database for years 1971 to the present. This merging datasets was a non-trivial task due to changes in pool names and data reporting formats, along with the necessary quality control required in any digitization project. Historical production data of the individual pools were showcased in the form of lifetime production curves. All current pools in southeast New Mexico are listed in our database. Where possible, other data was compiled, including pool creation and expansion dates, acre spacing and spacing changes, number of wells by year, annual cumulative production, and lifetime cumulative production. Regulatory information on spacing and pool development was obtained from the New Mexico Oil Conservation Division (OCD).

Another key task was the assimilation of geological data regarding each play and the significant pools within the play. Most geological information was gathered from books from the Roswell Geological Society, New Mexico Bureau of Geology and Mineral Resources, Rocky Mountains Atlas and the Texas Oil and Gas Atlas. Finally, we collected information about technology including data on completions, recompletions, changes in production methods, and pertinent regulatory changes that have taken place throughout the life of a given play. Most of this data was collected from scout cards, digitized well files that are available online, and various publications of the Roswell Geological Society.

DATA ANALYSIS

All the aforementioned data was consolidated into spreadsheets, and important statistical data such as production, well counts, locations, dates, and types of completion were put into a GIS to examine the evolution of various plays over time. The influence of the market on reservoir development was examined using well counts and permits filed versus time and commodity price. Injection data was also used to see if there were major waterflood projects that impacted the production of the plays. The well permits, including their design, location, spacing, operation, and abandonment, as well as environmental activities and discharges, including water management and disposal, underground injection, wildlife impacts, surface disturbance, and safety, were also taken in consideration for this analysis.

TECHNOLOGY TRENDS

One important aspect of predicting future development is examining the new trends in technology that may impact given reservoir types and a number of such changes were considered for each play. Technological trends include changes in fracing technology such as Petro-fracking® that uses a petroleum product as a base instead of water, slick-water fracing, changes in fluid type and amount, increased use of 3-D seismic surveys, horizontal drilling, downhole commingling, multi-zone completions, multiple well pads, and changes in rules that allow for down-spacing of particular fields to tap undrained areas in existing pools.

PLAY ANALYSIS EXAMPLES

In the next section, two plays that were analyzed using the above methods are described: First, a conventional oil play in a carbonate rock, and second an unconventional oil and gas play in shale.

CONVENTIONAL PLAY – ELLENBURGER CARBONATE RESERVOIR

The Ellenburger play provides an example of a mature play. In New Mexico the play consists of seven major pools Located on the Central Basin Platform

Geology

In New Mexico, the Ordovician-aged Ellenburger Formation is comprised of dolostones that were deposited on a restricted inner platform. Although dolomitized, some reservoirs have shown remnants of an intratidal to supratidal facies succession (Broadhead, 2004). The Ellenburger was later subjected to extensive subaerial diagenesis due to changes in relative sea level. Resulting porosity types include intercrystalline matrix, vugs, karst dissolution pores, and fractures. The source for the petroleum system is problematic. It is believed that the source rocks are the shales within the Middle-Late Ordovician Simpson Group. However, where the Simpson is absent, Ellenburger oil appears to be sourced from the Woodford Shale or younger strata (Pennsylvanian or Permian). (Loucks, R. 2008)

Reservoir Characteristics

The traps consist mainly of structural plays that are anticlinal structures, and typically faulted. The seal rocks are the Simpson shales in the Central Basin Platform area. The gross thickness ranges from 20 to 410 ft with an average of 189 ft. Reservoir porosities are often less than 5% for the dolostone matrix, with significant enhancement in solution collapse areas due to karst-related vugs and fractres. Permeability ranges from a few to few hundred millidarcys, and can also be enhanced in some areas due to karsting. Reservoir rocks for these fields are karsted and fractured dolostone that contain oil with an average API gravity of 45 and a sulfur content of 0.2 wt. %.

Historical Field Development

Table 1 provides a timeline for the development of the Ellenburger play in New Mexico and significant initial reservoir data for each field. The Dublin field was first discovered in 1944 but was non productive and abandoned. Brunson was discovered in1945 and was the first significant field. Subsequent development continued along margins of the Central Basin Platform (CBP) with the most recent discovery in 1967. Few of the later fields provided substantial production.

Production History

Table 2 and 3 summarize the total oil & gas production history of Ellenburger through August of 2010. Figure 5 shows production history for the Ellenburger play in New Mexico in comparison with resource prices and well count. Currently only few Ellenburger wells are producing and most of the wells that were drilled to the Ellenburger were recompleted to overlying productive formations like the Simpson.

Predicted Future Potential

The future potential for further oil and gas development in the Ellenburger is low as most of the pools have been thoroughly explored. In addition, the Ellenburger is a deep and thus relatively expensive development target. Some potential may exist for use of the deep reservoirs as saltwater disposal (SWD) wells and in coming years many of the inactive wells may be recompleted and used as injection wells. Currently there are three active SWD wells in southeast New Mexico. Technologies mostly likely to impact further Ellenburger development would be the possibility of multiple completions (along with Simpson group), and for disposal of produced water. Existing wells also have geothermal potential (Petty, S., and Livesay, B., 2007). Table 4 summarizes Ellenburger potential.

UNCONVENTIONAL PLAY – WOODFORD SHALE RESERVOIR

Stratigraphy

Southeastern New Mexico has a wide variety of potential unconventional reservoir rocks, including black shales, black cherts, sandstones, siltstones, and lighter-colored shales (Comer, 1991). Black shale is widespread and is represented by the late Devonian Woodford, a (Ellison, 1950; Meyer and Barrick, 2000; Broadhead, 2010) (Figs. 1 and 2). In the Permian Basin, the Woodford overlays Silurian and Lower Devonian carbonate strata of the Wristen Group and is overlain by Lower Mississippian limestone. Both the Wristen and Thirtyone carbonates have been a good source for oil and gas in New Mexico.

Woodford Source Rock Characteristics

The Woodford Shale in the Delaware Basin and Central basin ranges in thickness from zero to 300 feet and is found at depths of 7,000 to 18,000 feet (Broadhead 2010). Other reservoirs within the deep Delaware Basin produce primarily gas from depths of more than 17,000 ft and oil with associated gas from reservoirs shallower than 13,000 ft in the Northwest Shelf and Central Basin Platform. Broadhead (2010) states that Woodford shales are black organic-rich shales that are generally a hydrocarbon source facies. Present day Total Organic Carbon (TOC) ranges from 1.7 to 4.9 wt % in comparison to original pre-maturation TOC ranging from 1.8 to 6.8%. Both the original and present TOCs are greatest in southern Lea County and decrease to the north and west in southeast New Mexico. The kerogen fraction is dominated by amorphous and herbaceous type shales. Woody and inertinitic types are prevalent to the north, closer to the Woodford pinch out. Thermal maturity is greatest in southwestern Lea and southeastern Eddy counties with a thermogenic gas and condensate window and thermal maturity is lower to the north and west with an Oil Window.

Historical Field Development

There is no gas production from the Woodford to date, and the Gladiola Woodford Pool is the only productive Woodford oil reservoir in southeast New Mexico. This pool is located in the northern Lea County where the Woodford is in the oil maturation window. Most Gladiola production was oil with associated gas, and was of short duration, lasting only from 2004-2006. Total Gladiola Woodford production was 9322 bbls of oil, 3062 mcf of gas and 435625 bbls of water.

Estimated Resource Potential

An attempt was made to quantify the volumes of Woodford Shale oil and gas in-place using Comer's (2005) hydrogen mass balance method. This work is presented in detail elsewhere in this publication. For this study only on the results are discussed. Figure 6 identifies three regions of Woodford potential: Region I (oil and thermogenic gas window), Region II (thermogenic gas only) and Region III (oil with associated gas). For each region oil and gas volumes have been estimated using methods described in Comer (2005) and Bammidi, V.S. et.al (2011). The estimated volumes were 36 billion barrels of original oil in-place and 44.5 trillion cubic feet of original gas in-place (New Mexico) in comparison to 119 billion barrels of original oil in-place and 230 trillion cubic feet of gas in-place in the Woodford for the entire Permian Basin (Texas and New Mexico).

Predicted Future Potential

Unconventional oil and gas from the Woodford Shale has significant promise in southeastern New Mexico (Table 5). Dual completions of deeper wells that go through the Woodford to produce from reservoirs like the Thrirtyone Deepwater Chert, Wristen carbonate buildups, and the Fusselman should be considered for recompletions of older wells. Through the use of improved fracturing methods, horizontal drilling (for shallower potential reservoirs) and advanced log and seismic technologies, the resource potential can be converted to proven reserves.

CONCLUSIONS

Oil and gas reservoirs of southeastern New Mexico have been analyzed using a play-based framework, in support of the RFDS for the Pecos Field Office of the BLM. This study defined 27 plays for analysis, and two sample plays have been presented in this paper. The Ellenburger Formation, a conventional carbonate reservoir, has little future potential with the possible exception of use as a saltwater disposal zone in existing wells, or as a geothermal resource and the Woodford Shale which has future potential for unconventional oil and gas development in New Mexico. Each of the 27 resource plays has been converted to geo-referenced databases and will be available online at completion of the project.

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Table 1

Ellenburger Initial Reservoir Data (Source: Roswell Geological Society Symposium Books)

Pool Name	**Discovery Year**	**Initial Pressure**	**Trap Type**	**Drive Mechanism**	**API Gravity**
Dublin Abandoned	1944	-	-	-	-
Brunson	1945	3040 psi@4300ft	Truncated Anticline	Solution gas and partial water drive	40.2
Fowler	1949	4060 psi @9600 ft	Closed anticline	Gas drive	45
Teague	1950	3040 psi @6497 ft –	Anticline	Depletion Drive	45
Dollarhide	1951	3496 psi @7122 ft	Anticline	Volumetric drive	41.8
Justis	1957	3319 psi @8100 ft	Anticline	Gas & Water Drive	42
Stateline	1965	Field Shut-in Pressure 5016 psi	-	Solution gas drive	42.8

Table 2

Major Oil Producing Pools of Ellenburger

Pool Names	**Total Cum Oil (Aug 2010) bbls**	**% of total Oil production**	**Cum %**
BRUNSON;ELLENBURGER	27,226,825	39.71	39.71
FOWLER;ELLENBURGER	16,849,764	24.58	64.29
JUSTIS;ELLENBURGER	8,173,934	11.92	76.21
STATELINE;ELLENBURGER	4,126,279	6.02	82.23
Ellenburger Total Liquid Production	**68560207 bbls**		

Table 3
Major Gas Producing Pools of Ellenburger

Pool Names	**Total Cum Gas (Aug 2010) MCF**	**% of total gas production**	**Cum %**
BRUNSON;ELLENBURGER	94,699,060	41.67	41.67
MONUMENT;ELLENBURGER	38,921,454	17.13	58.80
LANGLEY;ELLENBURGER	25,278,216	11.12	69.93
CUSTER;ELLENBURGER	21,807,913	9.60	79.52
FOWLER;ELLENBURGER	16,747,285	7.37	86.89
Ellenburger Total Gas Production	**227,239,344 MCF**		

Table 4
Impact of Technologies on Ellenburger and Woodford Shale

S.No.	**Technology**	**Ellenburger Carbonate**	**Woodford Shale**
1.	Fracturing	Not useful	Yes -very useful
2.	3D Seismic/ Micro Seismic	Yes	Yes-very useful
3.	Horizontal Drilling	Not useful	Useful in some regions
4.	Advanced Completions	Yes – Uphole potential	Yes - very useful
5.	Downhole Commingling	Yes	Not useful
6.	Improved Recovery Target	Not useful	Not useful
7.	Produced Water Disposal	Yes	Not useful
8.	Geothermal Wells	Yes	Not useful
9.	CO_2 Sequestration	No	Not useful
10.	Clean Fuel	No	Yes

Table 5
Comparison of Volumes of Original In-Place Oil and Gas (Bammidi,V.S., et al. 2011) to Comer's (2005) Assessment

Woodford Shale in Permian Basin	**Original In-Place Product Volume (Bammidi, V.S.,** et al.**, 2011) New Mexico**		**Original In-Place Product Volume (Comer, 2005) New Mexico & Texas**	
	Oil (Billion bbls)	**Gas (Trillion** ft^3**)**	**Oil (Billion bbls)**	**Gas (Trillion** ft^3**)**
Region I	1.68	0.019	35	.11
Region II	0	44.49	0	220
Region III	34.38	0.00051	84	9.0
Total	**36.06**	**44.6**	**119**	**229.11**

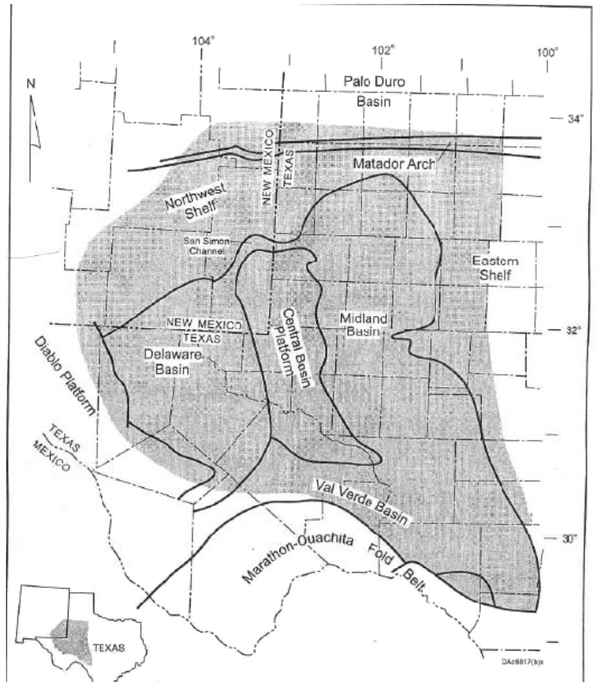

Figure 1 - Play Boundaries and Basins Permian Basin in west Texas and southeastern New Mexico (from Dutton et al., 2003, as modified from Hills, 1984 and Frenzel et al., 1988).

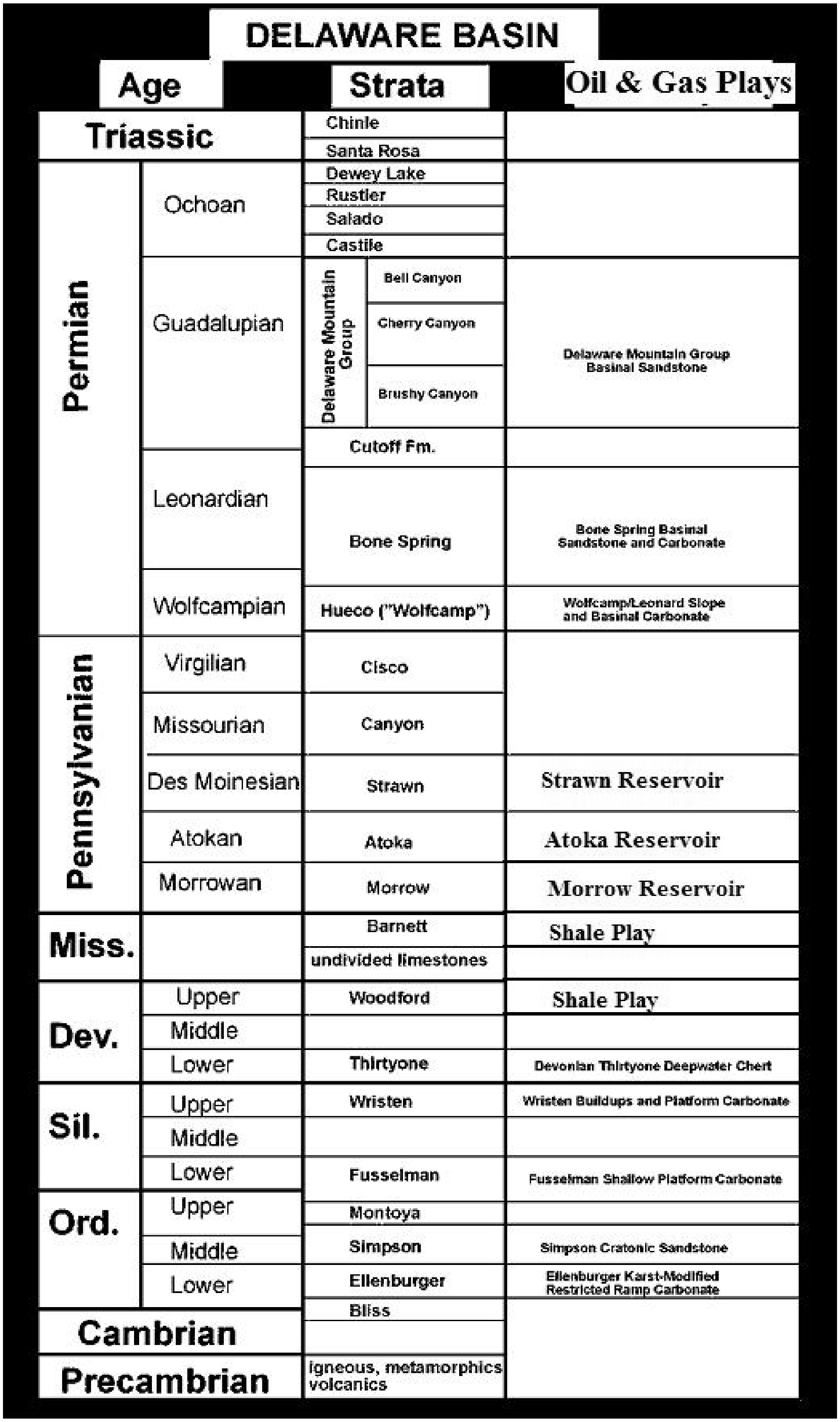

Figure 2- Stratigraphic Unit – Delaware Basin (Modified from Broadhead, 2004)

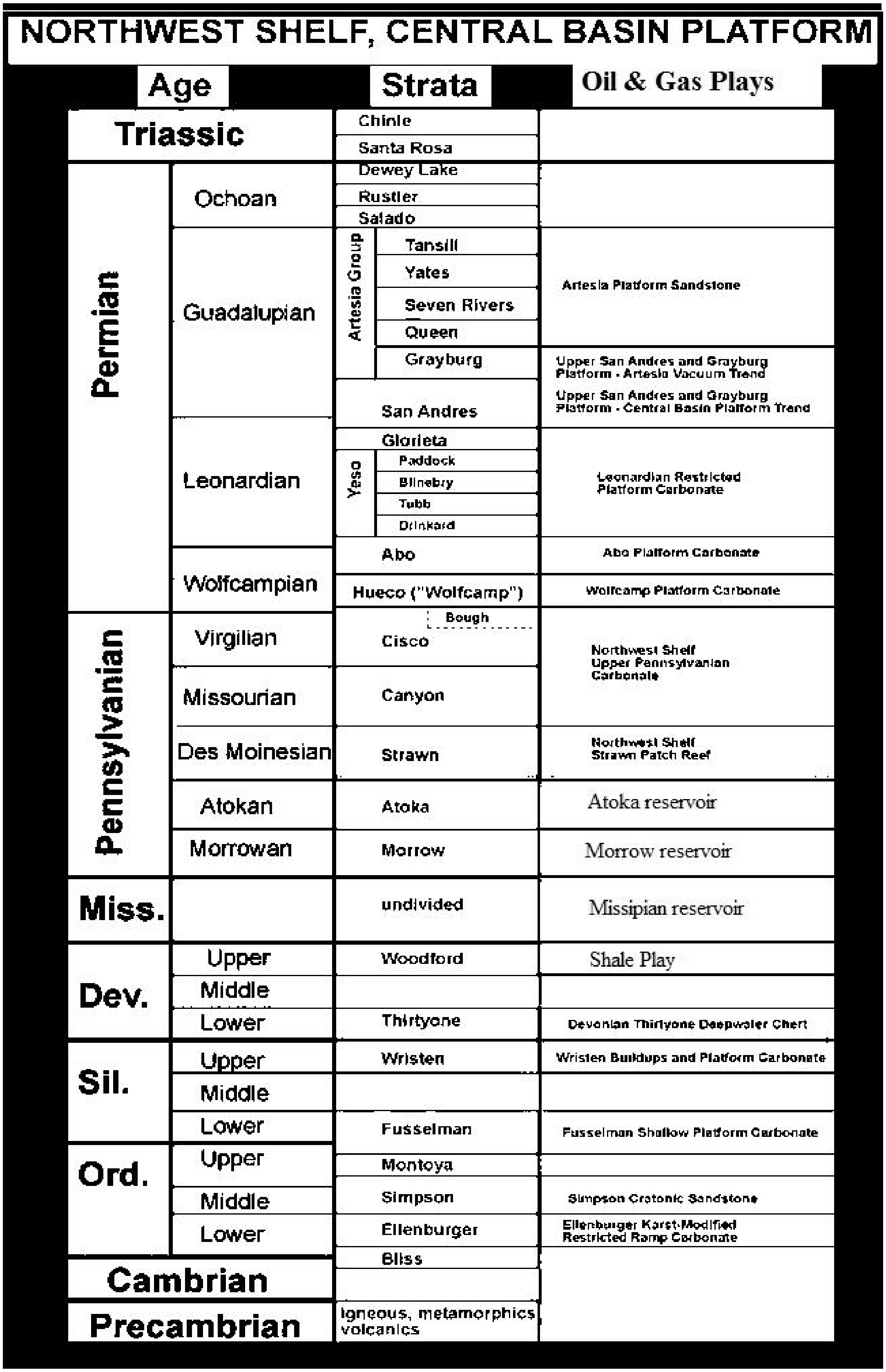

Figure 3 - Stratigraphic Chart – NorthWest Shelf and Central Basin Platform (modified from Broadhead, 2004).

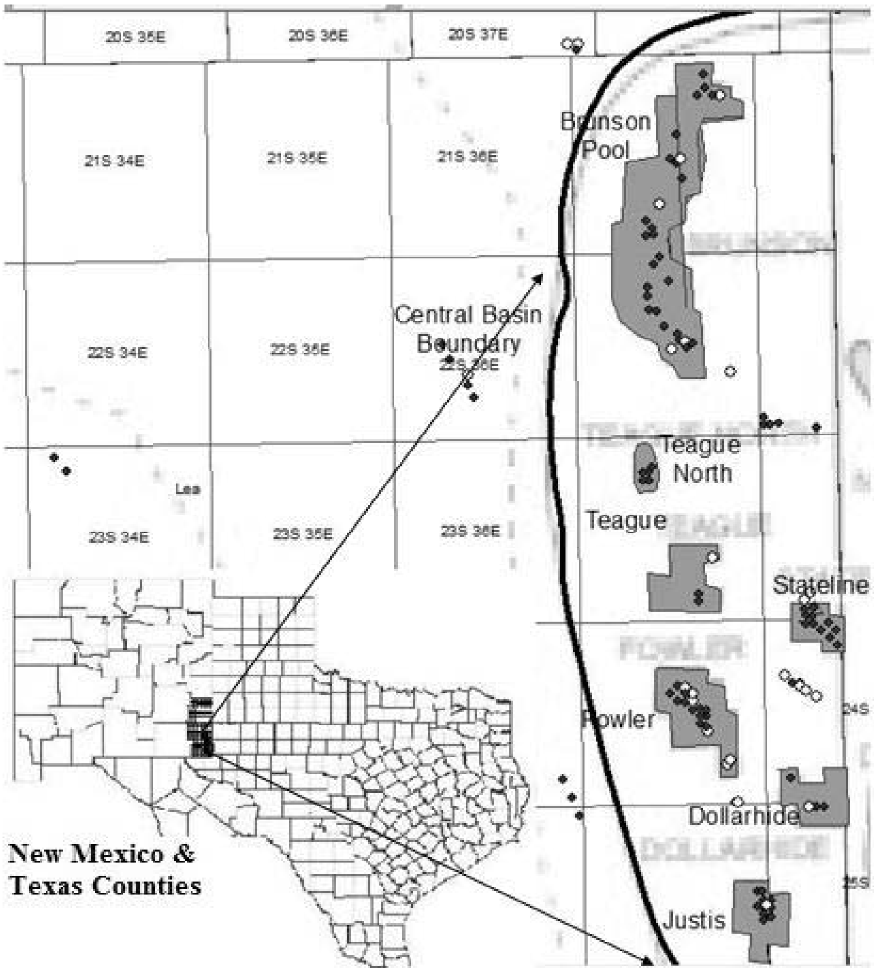

Figure 4 – Ellenburger well density in southeastern New Mexico, Grey colored shapes are pool boundaries. Black dots are inactive wells and white dots are active wells. It can be seen that most wells are inactive.

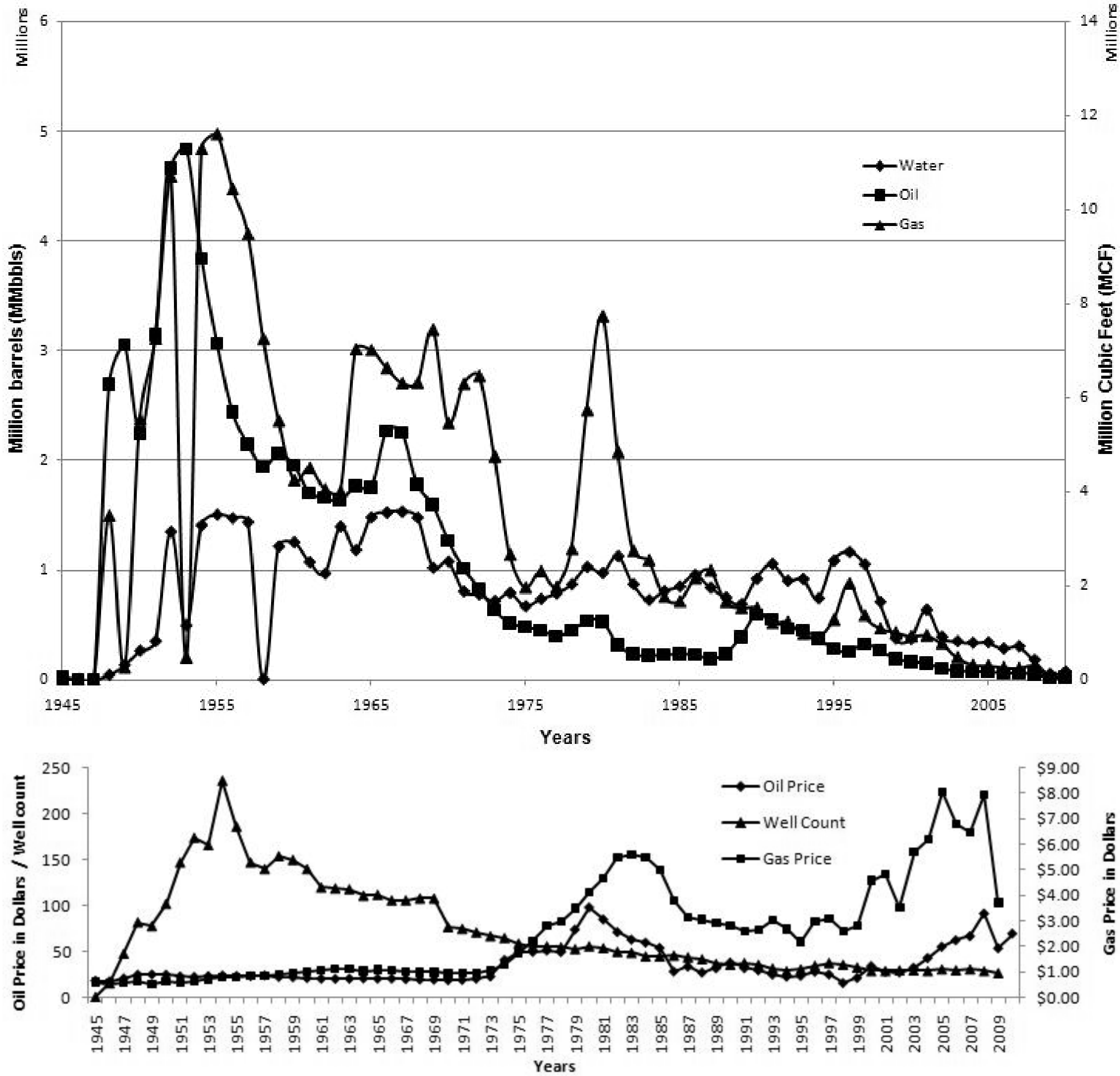

Figure 5 - Production History of Ellenburger in Southeast New Mexico, upper plate, and inflation adjusted oil and gas prices, lower plate.

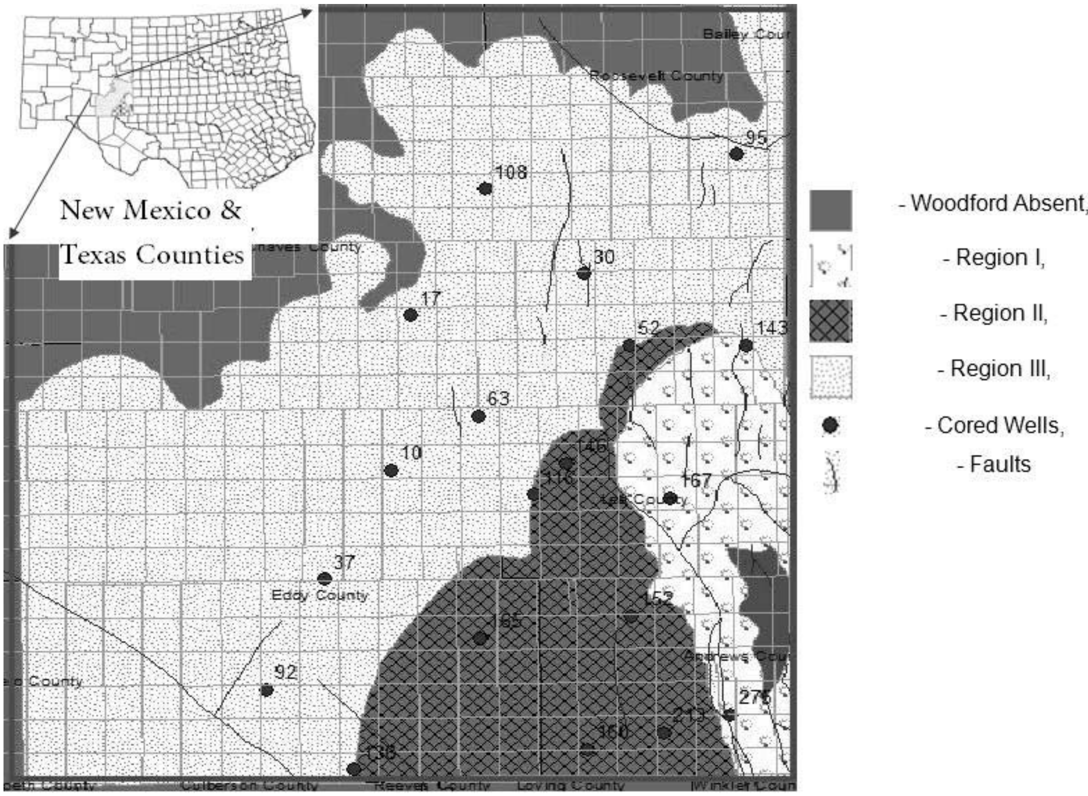

Figure 6 – Woodford Shale play in Southeast New Mexico