OVERVIEW OF 3D SEISMIC BASED SILURO-DEVONIAN EXPLORATION EFFORTS IN CHAVES COUNTY, NEW MEXICO

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ABSTRACT

Nearly 50 wells have been drilled in Chaves County, New Mexico searching for Siluro-Devonian reservoirs based on 3D seismic information. The success rate for this play has improved dramatically from a pre-3D success rate of less than 10% to almost 50%. Although the 3D program has doubled the number of producing wells, it appears that the 3D wells are going to recover less oil than was recovered from the pre-3D wells. High finding costs attributable to risk factors that have not yet been eliminated by the use of 3D seismic technology have recently brought this exploration play to a virtual standstill. However, the potential remains high for significant future reserve additions from the Siluro-Devonian formation in Chaves County. Future reserves will be found by using the lessons of the 1990's to develop sound exploration techniques that will include the continued use of 3D seismic technology.

INTRODUCTION & HISTORY

An estimated 50 wells targeting the Siluro-Devonian formation in Chaves County, New Mexico have been drilled in period between 1990 and 2002 (does not include Fusselman and Montoya tests). Most of these wells were drilled on the basis of 3D seismic information. Drilling depths range from under 7,000' in the northwest to over 13,000' in the southeastern part of the county.

Prior to the early 1990's approximately 260 Devonian tests had been drilled in Chaves County, all of which were drilled without the benefit of 3D seismic data. The pre-3D drilling resulted in only 21 producing well (10 new field oil discoveries and 11 development wells). The resulting combined wildcat and development success rate was only 8% (wildcat = 3% & development = 24%).

While the pre-3D success rate was poor, the production from the resulting fields was notable. The 10 Siluro-Devonian fields discovered prior to the use of 3D seismic had recovered approximately 4.5 million barrels of oil from 21 wells through the end of 1990 (215MBO average per well).

During the early 1990's the advent of more affordable 3D seismic data resulted in a renewed interest in the Chaves County Siluro-Devonian play. Affordable 3D offered a potential solution to identifying and imaging these relatively small structural traps and to limiting the number of development wells needed to drain the productive features.

Figure 2 shows the location of the estimated 225 square miles of 3D seismic data that has been acquired in Chaves County (33 surveys). The average survey size was just under 7 square miles with actual survey size ranging from under 4 square miles to just over 20 square miles. Data acquisition and processing costs ranged between $20,000-$25,000 per square mile.

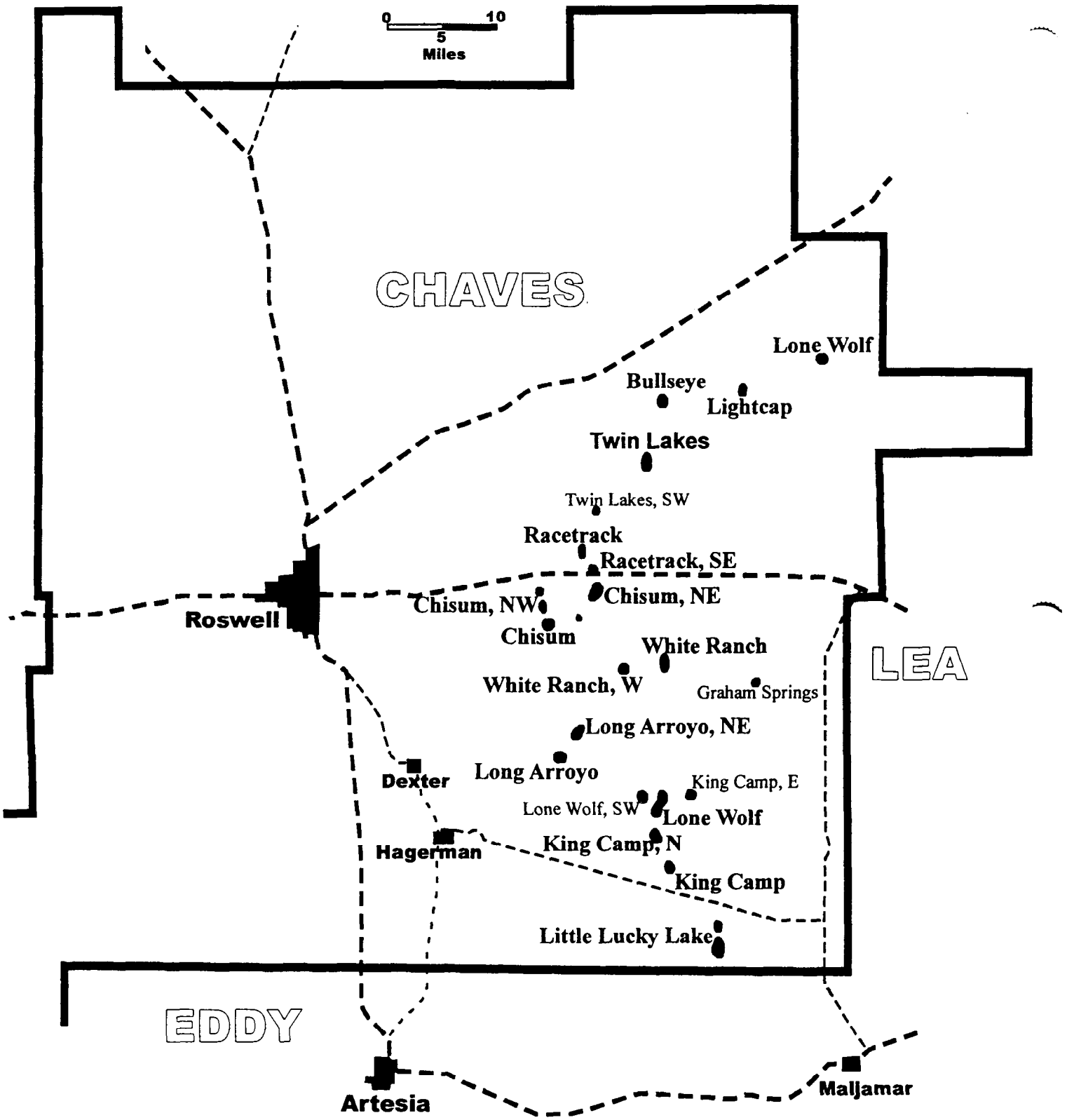

Figure 1. Regional Map of Chaves County, New Mexico Showing Siluro-Devonian Oil Fields

RESULTS

At least 47 Siluro-Devonian tests (31 wildcats and 16 development wells) were drilled based on the previously mentioned 3D seismic data (see Table 1 & Figure 3). Of the 47 wells documented, 22 were completed as Siluro-Devonian oil wells, 3 were completed in zones other than the Siluro-Devonian and 22 were plugged and abandoned.

Out of the 31 wildcats drilled, 10 were new field Siluro-Devonian discoveries, 3 were new field discoveries in formations other than the Siluro-Devonian and 18 were dry holes. This equates to a Siluro-Devonian wildcat success rate of 30%.

Of the 16 development wells drilled, 12 were completed as Siluro-Devonian oil wells and 4 were plugged and abandoned, resulting in an impressive 75% development success rate.

While the combined wildcat and development success rate of 47% is a dramatic improvement over the 8% pre-3D seismic success rate, it should be qualified in that 7 of the 22 wells completed as Siluro-Devonian oil wells will not produce at least 50,000 barrels of oil and are not considered to be a commercial success. This brings the commercial well count down to 15 and the combined success rate down to 32%.

It appears that reserves from the 3D wells are going to average less than the 215MBO per well average recovery from pre-3D wells. To date, approximately 2.4 million barrels of oil have been recovered from the 22 wells drilled on 3D. It is estimated that the 15 commercial wells will produce an additional 600,000 barrels of oil over their economic life resulting in estimated recovery from the 22 3D wells of 3.0 million barrels for an average of 143MBO per well (only about 2/3 of the recovery from pre-3D wells). This figure is somewhat skewed in that over 2.8 million barrels will be recovered from the 15 commercial wells (~185 MBO average for the 15 commercial wells)

It is important to note the accuracy with which the 3D identified the structures. The 3D seismic data correctly predicted structure 75% of the time. Seismic pitfalls, such as velocity problems, have not had a significant impact in this play.

However, in a play where structure was once considered as the only risk, there are other risks to be considered such as fault seals, reservoir quality and migration pathways.

In at least 7 of the 25 wells that were not productive in the Siluro-Devonian the structure was accurately predicted and reservoir quality rock was encountered but the structure were water bearing, the apparent result of younger faulting breaching the reservoir causing migration of oil out of the structure.

In 3 of the dry holes the structure was accurately predicted but poor quality reservoir rock was the culprit.

In 2 of the dry holes the structure was accurately predicted but the wells were drilled too low on the feature to be productive

Faulting below the Mississippian unconformity was identified as the culprit in 2 of the dry holes.

In 1 of the dry holes the structure was accurately predicted, the feature had reservoir quality rock and the feature did not appear to have been influenced by younger faulting, yet the feature was not a hydrocarbon bearing feature. This particular feature appeared to have been blocked from basinal hydrocarbon migration by a productive fault trend feature immediately downdip and basinward from the barren feature.

Most of the remaining dry holes were the result of incorrect interpretation of the seismic data and/or poor seismic data.

3D Success Rate (Devonian Only)
Chaves County, New Mexico (1/1/02)

OPERATOR	WELL NAME	LOCATION sec-twshp-rnge	STATUS	SEISMIC SUCCESS	CAUSE
Elk Oil Co.	S. Lone Wolf #1	29-13s-29e	Oil	Yes	
Elk Oil Co.	S. Lone Wolf #2	29-13s-29e	Marginal	Partial	Low Relief
Elk Oil Co.	MA Fed #1	28-8s-31e	P & A	Yes	Breached
Hanagan Pet.	Charlie St. #1	7-12s-28e	Oil	Yes	
Hanagan Pet.	Gray Wolf #1	33-10s-27e	Marginal	Yes	Small Structure
Hanagan Pet.	Lobo #1	33-13s-29e	Oil	Yes	
Hanagan Pet.	Leapin Lizard #1	4-14s-29e	P & A	No	Pre-Miss Fault
Hanson Op.	Ladson	33-10s-27e	P & A	No	Interpretation
Klabzuba Oil	White 1-A	12-10s-27e	P & A	Yes	?
Klabzuba Oil	White #3	13-10s-27e	Oil	Yes	
Klabzuba Oil	Kaywal	14-12s-28e	P & A	Yes	Low Relief
Manzano Oil Co.	McClellan #1	26-13s-29e	Marginal	Yes	Small Structure
Manzano Oil Co.	Vest #1		Other-Oil	Yes	Reservoir
Marbob Energy	Havasu #1	13-13s-27e	P & A	Yes	Breached
Marbob Energy	CF #7	13-11s-27e	Oil	Yes	
Marbob Energy	CF #10	12-11s-27e	Oil	Yes	
Marbob Energy	CF #11	12-11s-27e	Marginal	Yes	Reservoir
Marbob Energy	Marathon #1	33-13s-29e	P & A	No	Interpretation
Marbob Energy	Quatro #1	9-11s-29e	P & A	No	Interpretation
Marbob Energy	True Grit #1	3-11s-28e	Oil	Yes	
Marbob Energy	Ramos #1	33-12s-28e	Oil	Yes	
Marbob Energy	Ramos #2	33-12s-28e	Oil	Yes	
Marbob Energy	Rooster Cogburn	9-11s-28e	Oil	Yes	
Marbob Energy	McClintock	30-9s-28e	Marginal	Yes	Small Structure
Marbob Energy	3D Exploration	11-12s-29e	P & A	No	Interpretation
Marbob Energy	Lambert #1	7-13s-31e	P & A	No	Interpretation
Marbob Energy	Katie Elder	36-11s-27e	Other-Oil	Yes	Breached
Marbob Energy	Duke #1	16-11s-28e	P & A	Yes	Too Low
Marbob Energy	Apache Springs	34-10s-30e	Other-Gas	Yes	Breached
Marbob Energy	Rio Bravo #1	30-10s-28e	Oil	Yes	
Marbob Energy	Hellfighter #1	30-10s-28e	P & A	Yes	Too Low
Matador Pet.	Kinahan	20-15s-30e	Marginal	Yes	?
Matador Pet.	LLL #1	32-15s-30e	Oil	Yes	
McClellan Oil	Branex #1	6-11s-31e	P & A	No	Interpretation
McClellan Oil	Stevens #1	28-13s-29e	Oil	Yes	
Primero Operating	Hiway #1	36-10s-27e	P & A	Yes	Migration
Primero Operating	Moriah #1	18-10s-29e	P & A	Yes	Breached
Rachel	Terra #1	8-13s-29e	P & A	No	Interpretation
Samedan	Culp Ranch #1	11-12s-30e	P & A	No	Interpretation
Strata	Faisan #1	26-12s-31e	P & A	Yes	Breached
S & J Oper.	LE Ranch #1	29-11s-28e	Marginal	Yes	?
Texas Ind. Prod.	LLL #1	29-15s-30e	P & A	No	Pre-Miss Fault
Thornton Oper.	Northern Lites	7-8s-29e	Oil	Yes	
Thornton Oper.	Seagull	6-13s-29e	P & A	No	Interpretation
Thornton Oper.	McClellan #1	26-13s-29e	Oil	Yes	
Yates	Butkus	9-13s-31e	P & A	No	Data
Yates	Unforgiven	11-12s-27e	P & A	Yes	Breached

Table 1. 3D Success Rate for Siluro-Devonian Wells in Chaves Co., NM

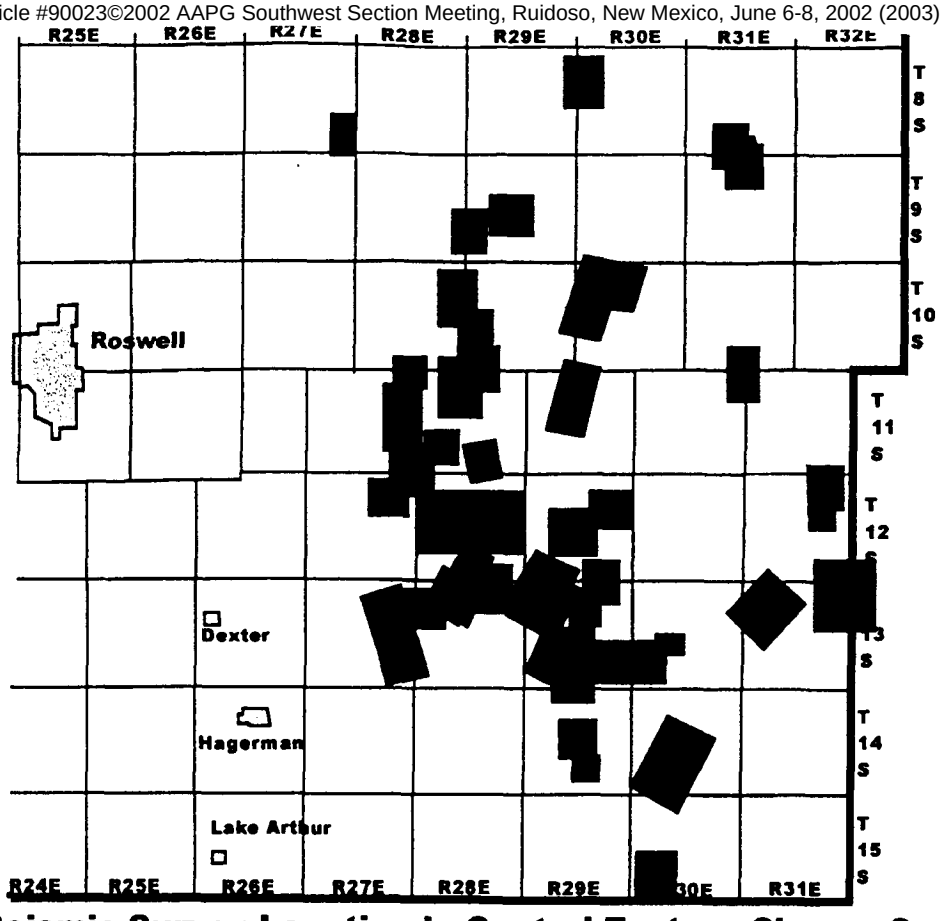

Figure 2. 3D Seismic Survey Location in Central-Eastern Chaves County, NM

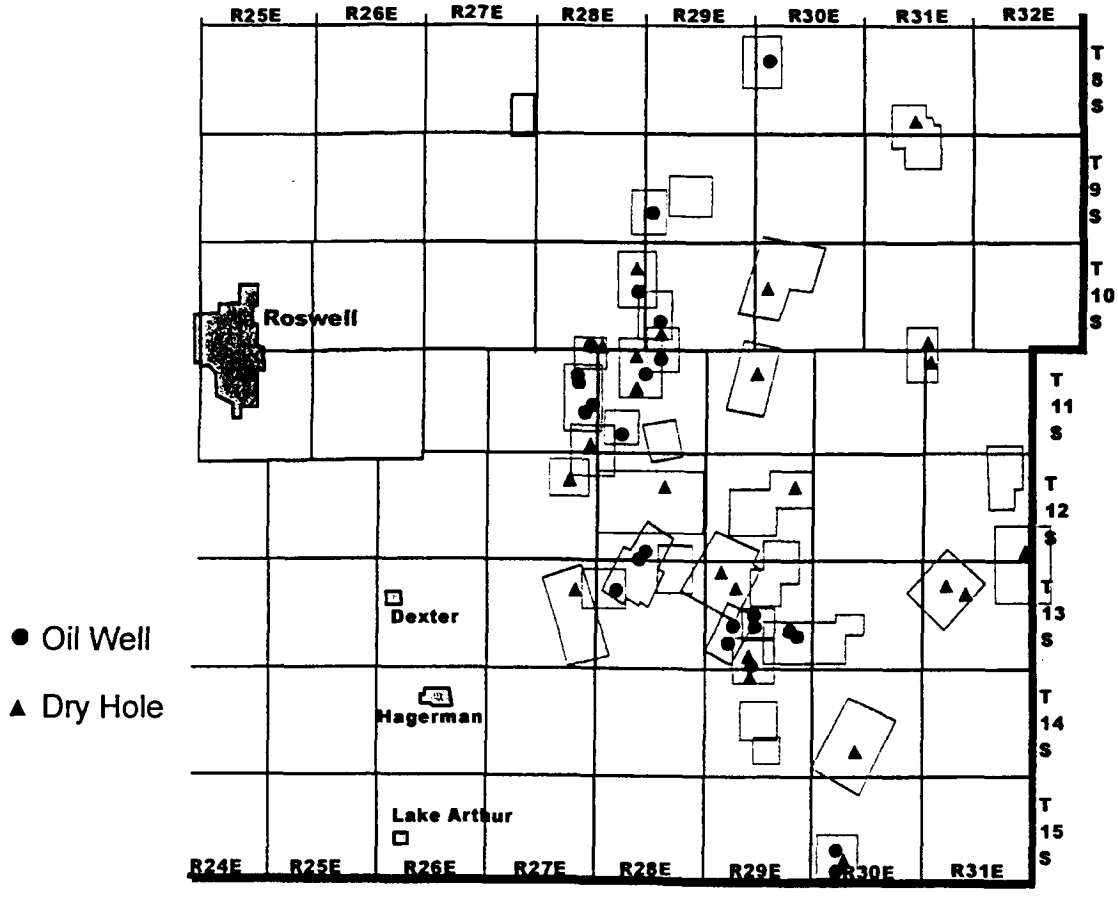

Figure 3. Location of Wells drilled Based on 3D Seismic Information

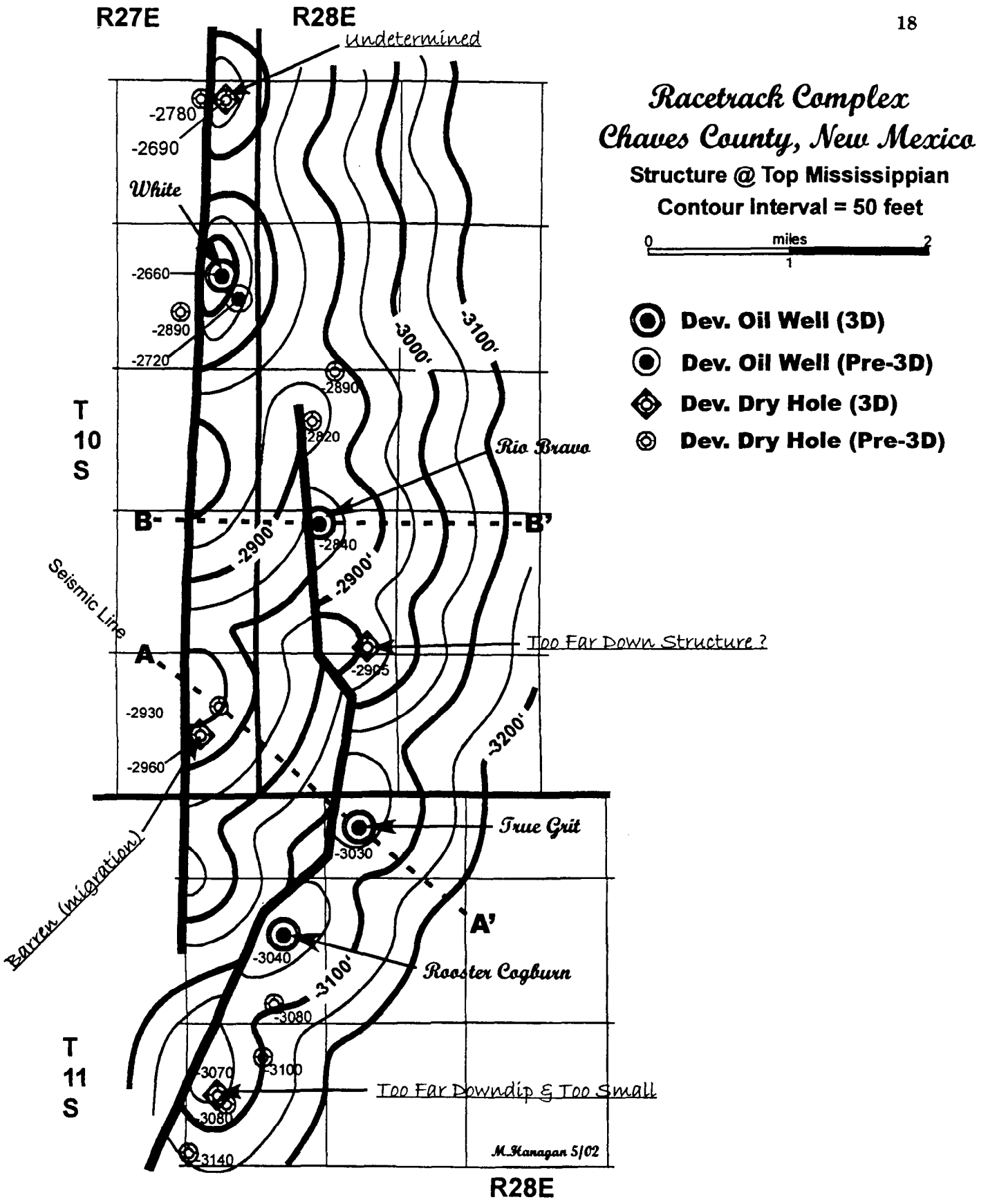

Figure 4. Structural Contour Map on the Top of the Mississippian Unconformity

In the 7 Siluro-Devonian producers that look like they will be non-economic, low relief structures and small reservoir size are the most common causes of the low production.

Using estimated seismic costs of $5,000,000 (225 square miles x $22,500) and a rough estimate of leasehold, drilling and completion costs of $23,000,000 (all 47 wells included), the total cost of finding and developing (including all dry holes) the approximately three million barrels of oil attributable to the 3D program was around $28,000,000. The resulting combined finding and development cost of the entire program is estimated to be $9.33 per barrel.

CHISUM, EAST-RACETRACK FIELD DISCUSSION

The Chisum, Northeast, the Racetrack and Racetrack, Southeast oil fields ("Racetrack Complex") are all located along the same fault trend in the central portion of Chaves County. The Racetrack Complex offers a good case study for the 3D play Siluro-Devonian play in that the complex contains examples of 3D successes as well as offers examples of the pitfalls that have resulted in dry holes. Within the complex there are breached structures, tight structures, structures that have been blocked from hydrocarbon migration and structural closures that are located too far downdip on features to be productive.

Approximately 25 square miles of 3D seismic data has been acquired over this area and 9 wells were drilled based on interpretation of the data. Drilling resulted in 4 producers and 4 dry holes. Production through April 2002 from the 4 wells was 430 MBO and estimated recoverable reserves should be around 770 MBO (average 193 MBO per well).

Figure 4 is a structural contour map drawn on the top of the Mississippian unconformity. The most obvious feature is the high-angle reverse fault that bounds the west side of the complex. Throw on the fault is 100'-200' (down to the west side) and initial movement on the fault was late Mississippian to early Pennsylvanian time with continued flexure into Wolfcampian time. The fault "scissored" with the eastern limb moving northward and in front of the western limb. The timing of the scissor faulting is not clear, although it is probably younger than late Pennsylvanian time. This is probably the best example of "scissor" faulting in Chaves County. The faulting apparently resulted in the portion of the western limb that is in the "shadow" of the eastern limb being blocked from hydrocarbon migration as evidenced by the barren structures along the southern end of the western limb. The presence of oil-bearing structures in the structurally lower eastern limb also seems to support hydrocarbon migration from the basin as opposed to up the fault planes.

Figures 5 and 6 are seismic lines across the complex that demonstrates many of the attributes that are common throughout the play. Productive features are always fault bounded (usually by down to the west faults) with varying amount of roll into the fault. Thinning in the interval from the lower Pennsylvanian clastics (Atoka) to the Siluro-Devonian is evident and supports the timing of the primary movement as late Mississippian to Early Pennsylvanian. Additional thinning is common in the Abo to lower Pennsylvanian section although it is normally relatively minor when compared to the thinning of the deeper beds. As seen in Figures 5 and 6, the Siluro-Devonian seismic

event is often very difficult to pick. Mapping on the Mississippian unconformity seismic event has proven to be reliable with only a few exceptions.

Productive features found in the Racetrack Complex are low relief features having only 25' to 125' of closure. Area under closure for these structures ranges from less than 40 acres to more than 300 acres; however, the productive area of these reservoirs is much less than the area under closure. Throughout the play, the productive area is normally only 25% to 35% of the area under closure. Why the structures are only 1/3 filled is uncertain. Thin oil columns (10'-50') sitting on top of a very strong water drive combine to limit the economically recoverable reserves from fields across the play.

The following is a very brief summary of the productive features found within the Racetrack Complex:

The White structure (section13-T10S-R27E) covers around 300 acres of closure with 100' of relief (50'+ oil column). Production from the 2 wells on the feature has been 235 MBO (April, 2002) and recoverable reserves are estimated to be 325 MBO.

The True Grit structure (section 3-T11S-R28E) has approximately 160 acres under closure with 60' of relief (20' oil column). The one well feature has recovered 125 MBO and recoverable reserves are estimated to be 180 MBO.

The Rio Bravo structure (section 30-T10S-R28E) has approximately 120 acres under closure with 70' of relief (25' oil column). The Rio Bravo #1 has flowed 115 MBO (still flowing) and recoverable oil is estimated to be 175 MBO.

The Rooster Cogburn structure has 140 acres under closure with only 30' of relief (10' oil column). The one well feature has recovered 70 MBO with recoverable oil estimated to be only 90 MBO.

EXPLORATION FINDINGS & RECOMMENDATIONS

The following is a brief discussion of things to look for and things to avoid when exploring for Siluro-Devonian reservoirs in Chaves County, New Mexico. These observations and recommendations are far from "all encompassing" and are intended to be an aid for future exploration. There will certainly be exceptions to almost every point mentioned so "buyer beware".

1. Look along prominent fault trends and when possible, look along established productive fault trends. Every productive feature that I have seen in Chaves County is fault bound (usually on west side) and most are located on fault systems with established production along the fault trend. There are several prominent fault systems in the eastern part of the county that, to date, have yielded little to no Siluro-Devonian oil. In addition, very little oil has been found in structures located along minor splays off of more prominent systems.
2. Mapping on of the Mississippian seismic event is recommended. However, as you move south and east into the deeper parts of the play where there is a thicker

Woodford shale section it is practical to map on the Woodford event. Beware if the Woodford structure differs significantly from the Mississippian structure.

3. Lower Pennsylvanian (Atoka) to Mississippian isochron mapping has proven to be very effective, however it is not always easy to tie into a reliable and continuous lower Pennsylvanian seismic event. Abo to Mississippian isochron maps should be looked at on every prospect. If no thinning is evident from the Abo to the top of the Mississippian there probably is not a prospect.
4. Avoid small structures. With these reservoirs only being 1/3 filled, small structures are usually uneconomic. Structures having less than 80 acres under closure generally have a productive area of less than 25 acres and recoverable oil of less than 30 MBO.
5. While these reservoirs are usually associated with low relief structures, it is probably wise to avoid structures having less than 50' of relief.
6. Use caution when dealing with structures where the faulting cuts into the San Andres section. This becomes more common as you move into the northern and western parts of the county; these faults seem to be more common on the east side of the structure. There are productive fields associated with this type of structure but there are numerous structures that appear to have been breached by this type of faulting. At a minimum, when dealing with structures affected by younger faulting, make sure that there is good roll into the fault(s). Roll into the fault is not necessary when dealing with structures unaltered by younger faulting.
7. Where there is strong evidence of a scissor fault, avoid drilling in the "shadow" of the basinward limb of the fault. While the jury is out as to if these features are sourced up the fault plane or by migration from the basin (or both), the Racetrack example provides evidence that a structure in the "shadow" can be barren.
8. Use 3D technology to explore for these reservoirs and don't wait to acquire your 3D data for development. One or two properly placed wells will drain the vast majority of these features.
9. Try to use existing 2D seismic and/or other relatively cheap exploration methods to establish a good reason for shooting a 3D survey. While there have not been many large 3D surveys shoot in Chaves County, it is interesting to note that the two largest surveys shoot to date have resulted in no production.
10. Go to Church because you're gonna need all the help you can get.

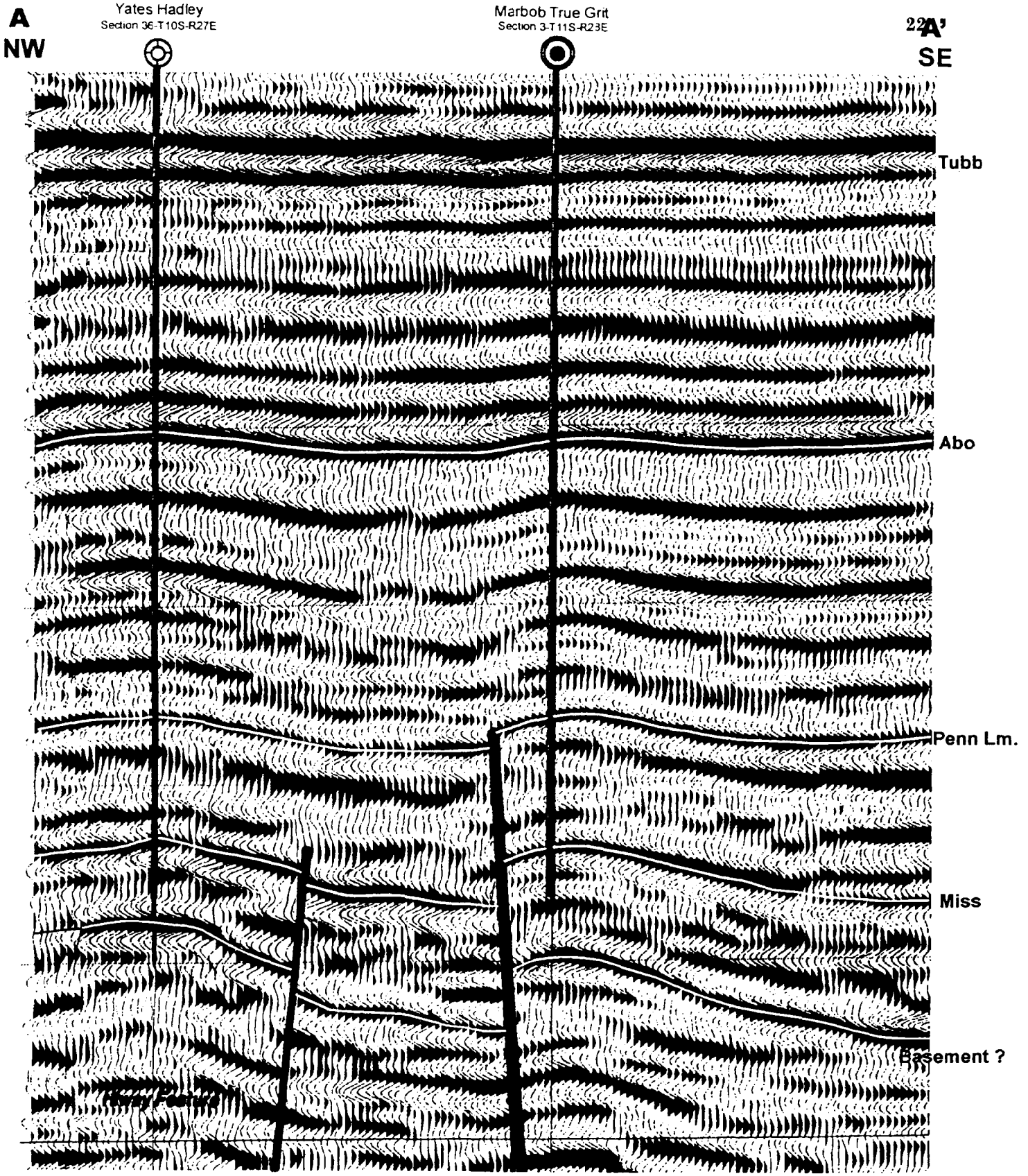

Figure 5. Northwest to Southeast Seismic Line (A-A') Across Racetrack Complex

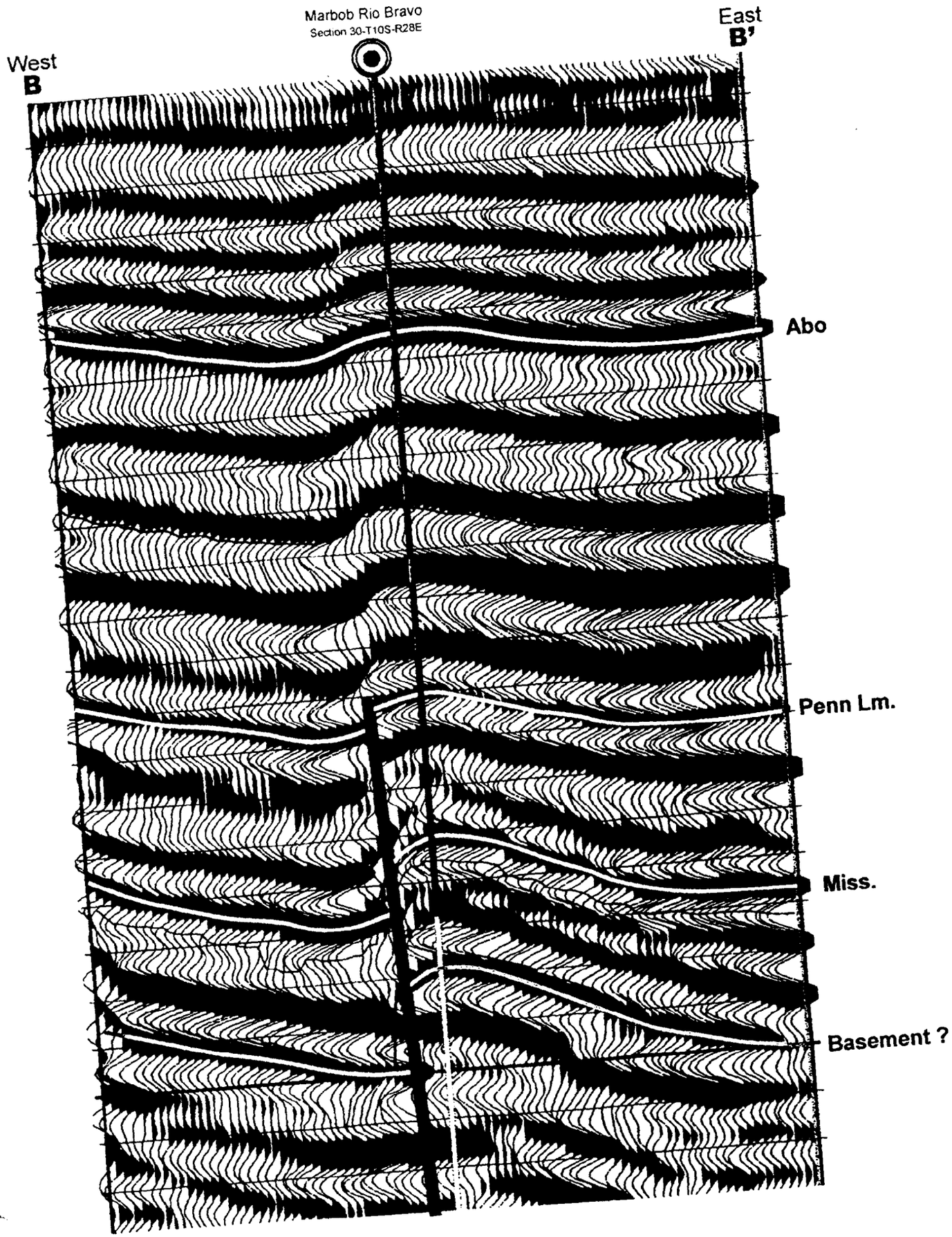

Figure 6. West to East Seismic Line (B-B') Across Racetrack Complex

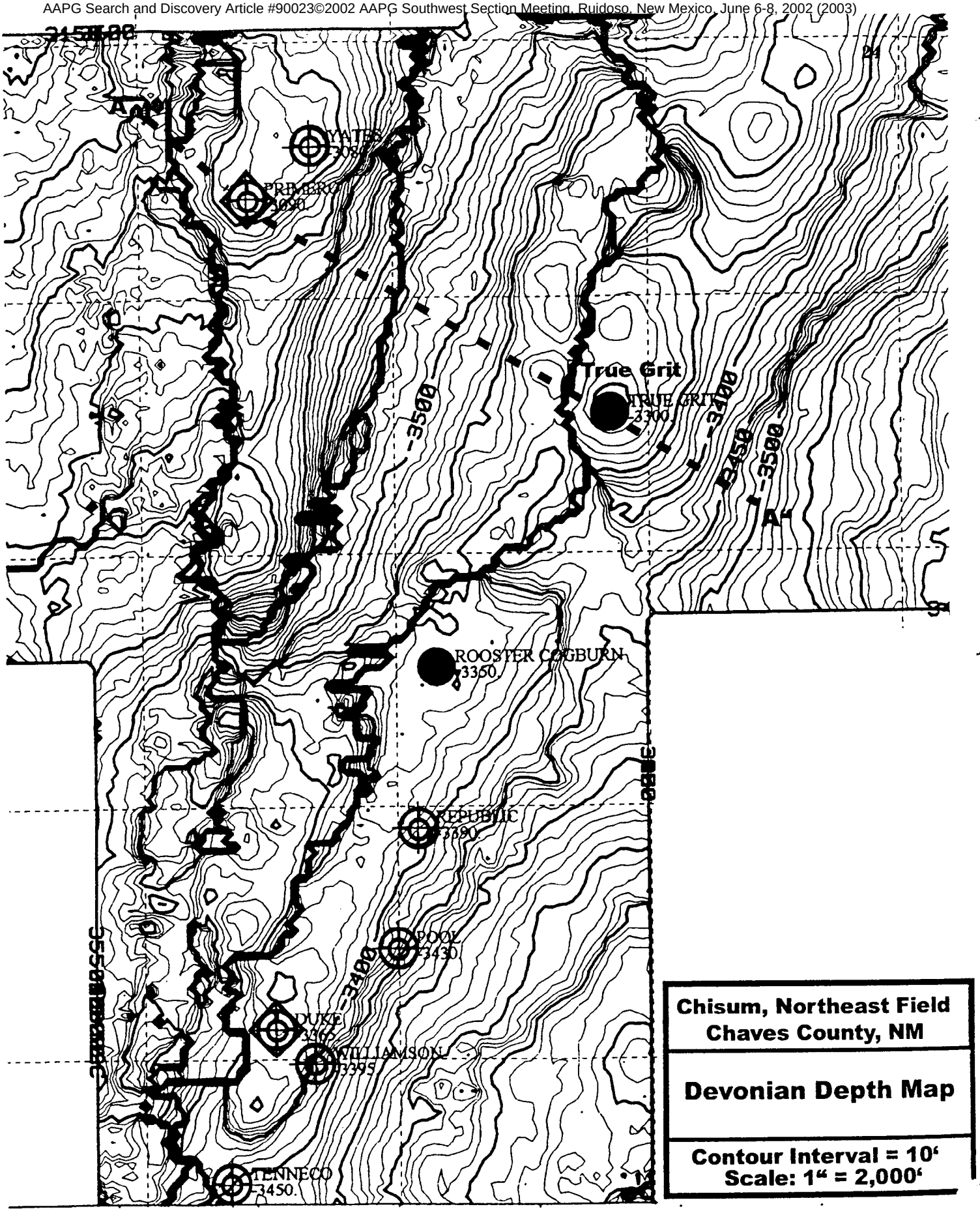

Figure 7. Structure Map on top of Devonian at Chisum, Northeast Field