

# Sabinas Basin Lower Cretaceous to Jurassic Production— Comparison to South Texas Equivalents

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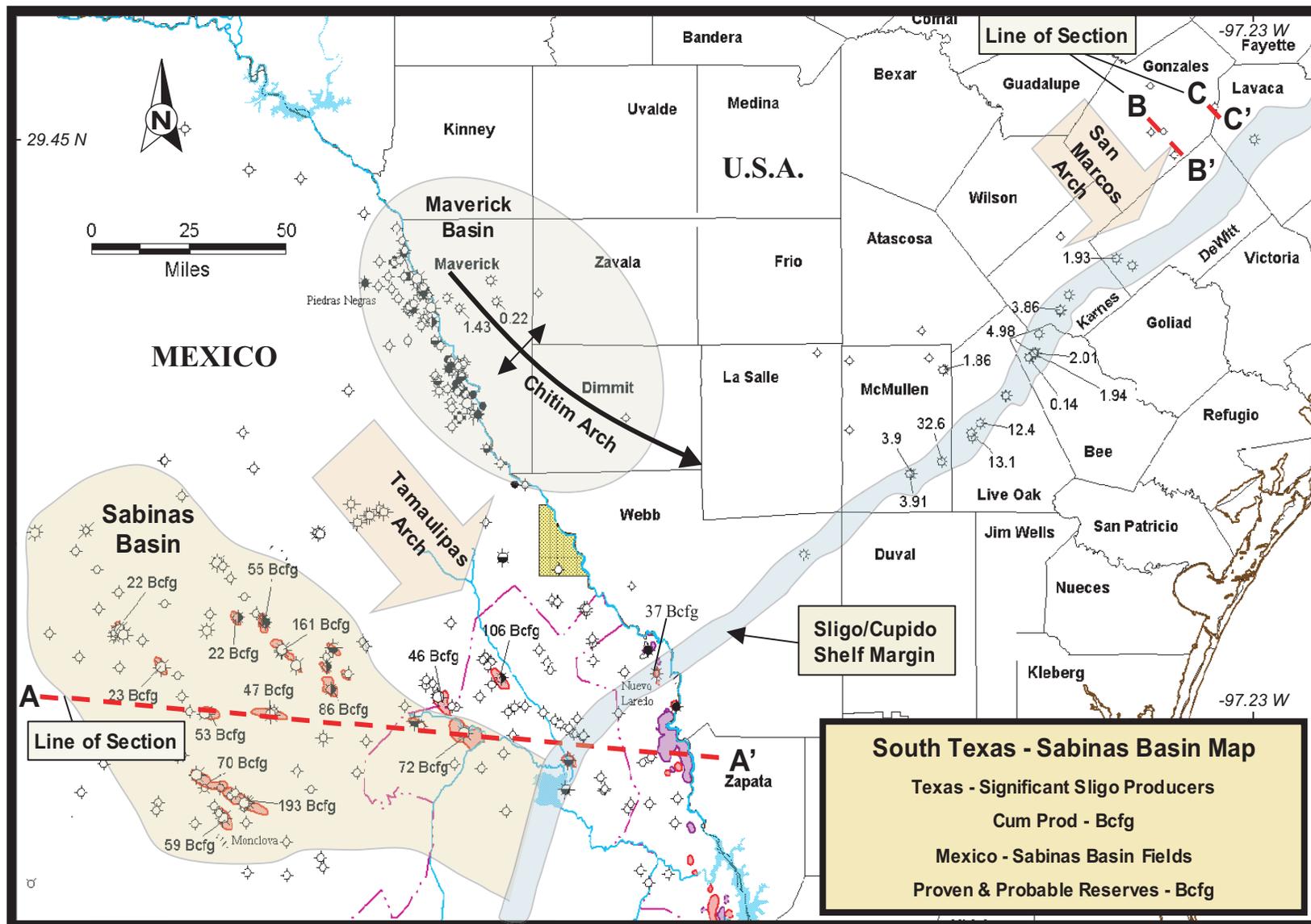
## Abstract

This paper will attempt to draw some analogies to structural and stratigraphic similarities and differences between the productive Lower Cretaceous/Jurassic strata of the Sabinas Basin in Mexico with that of the San Marcos Arch area of South Texas where a wildcat drilled in 1969 logged interesting gas shows in a lower Hosston dolomite. The possibilities for production in the South Texas strata will be postulated based on these analogies. Jurassic to Lower Cretaceous stratigraphy has been correlated from the San Marcos Platform to the northern Burgos and Sabinas Basins of northern Mexico. The correlations and analogs between the two are important for exploration in South Texas. Lower Cretaceous to Jurassic strata of the Sabinas Basin include three important plays that produce from fractured formations; La Virgen, La Casita, and La Gloria have produced a combined 375 Bcfg with two important new discoveries described.

Both Texas and Mexican data have been utilised, including well logs illustrating mutual stratigraphic relationships. A comparison of the productive structures of the Sabinas Basin to well logs and the seismic definition of a Jurassic wildcat drilled on the southeastern flank of the San Marcos Arch, suggests that similar productive trends for the South Texas area may be possible. The Hosston dolomite overlies the Cotton Valley shale, a proven source rock that is postulated to be within the gas generation window. Large down-to-the basin growth faults in the area created rollover anticlines, potential gas targets in fractured upper Sligo to Cotton Valley strata.

## Introduction

The map in [Figure 1](#) illustrates the study area from the San Marcos Platform of South Texas to the Sabinas Basin of northeastern Mexico, and [Figure 2](#) illustrates the stratigraphic correlation of the formations in both basins. [Figure 1](#) depicts that production from the Lower Cretaceous Sligo Formation in South Texas is predominantly from wells within the reef trend with the exception of four producers in Maverick County and one producer in McMullen County located on the edge of a salt dome (IHS Energy, 2004). In contrast, with the exception of the Anahuac and Totonaca fields located within the Lower Cretaceous Cupido shelf margin, the productive fields in the Sabinas Basin are located on the platform behind the margin. The papers published by González-García, 1984; Eguiluz de A., 1996, 1997, 1999 and Ziga-Rodríguez et al., 2003, give an excellent overview of the Sabinas Basin while the South Texas area has been covered by several prominent researchers (Tucker, 1965; Bebout and Loucks, 1977; Bebout et al., 1981; Budd and Loucks, 1981). Although referred to in many publications, the San Marcos Platform has not been studied in great detail, likewise several interesting deep wildcats have been drilled in the area. Based on our analysis of the two areas, there are three important factors concerning the productive Lower Cretaceous/Jurassic formations of the Sabinas Basin that are analogous to what is seen in the description of the Mobil #1 Dixon et al wildcat drilled in 1969 on the San Marcos Platform with implications for potential production in South Texas and include: rock properties, productive structures, and hydrocarbon generation and migration history.



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Epoch		Age	Sabinas Basin Formations	South Texas Formations	Lithology	Petroleum System and Plays	Cumulative Bcfg by Play		
<b>Mesozoic</b>	<b>Cretaceous</b>	<b>Upper</b>	Maestrichtian	Escondido			Escondido		
				Olmos			Olmos		
			Campanian	San Miguel			San Miguel		
				Upson Clay					
		Santonian							
		Coniacian		Austin			Austin Chalk		
		Turonian		Eagle Ford			Eagle Ford-Austin		
		Cenomanian	Buda-Del Rio	El Burro/ Stuart City Reef			Stuart City Reef / Glen Rose		
			Glenn Rose	Stuart City Reef			Georgetown		
		Albian	Klamachi		Edwards	Stuart City Reef			
	Tamaulipas Superior			Glen Rose					
	Aptian	Garasian	La Pena		Pearsall Shale		La Peña - La Peña		
		Bedoulian							
	<b>Lower</b>	Barremian	La Virgen	Cupido			Cupido reef	215	
					Sligo		La Virgen		
		Huaterivian	La Mula					Padilla	
			Padilla						
		Valanginian	B. Viejo	Taraises					
Berriasian			Menchaca	Hosston			Menchaca - Barril Viejo		
Tithonian		La Casita		Cotton Valley Sand	Konwies Lime	La Casita - La Virgen(!)	107		
				Bossier Shale		La Casita			
Kimmeridgian				Cotton Valley Lime					
Oxfordian		La Gloria - Olvido		Buckner					
Callovian		Minas Viejas		Norphlet		La Gloria - Olvido	53		
				Louann Salt					
Bathonian		Lechos Rojos		Werner anhydrite					
Upper Triassic		Nazas		Eagle Mills (red beds)					

Figure 2. Stratigraphic chart, South Texas to Sabinas Basin, Mexico.

## Sabinas Basin

Pemex established gas production in the Sabinas Basin (Figure 3) in 1975 when it completed the Buena Suerte 2A discovery. To date, Pemex has drilled 259 wells, 142 exploratory and 117 development wells, discovering 21 fields including 2 recent gas discoveries (Pirineo 1 and Forastero 1). Wildcat success rate according to Pemex is about 25% (Eguiluz de A., 1999). Pemex is currently only producing gas from four fields, seven are shut-in, and ten are undeveloped, some due to lack of pipeline infrastructure. Pemex has estimated a total resource potential of about 1.5 Tcfg of which approximately 375 Bcfg has been produced through 1 January 2004. Current dry gas production in the basin comes from La Virgen, La Casita, and La Gloria plays in the Monclova, Buena Suerte, Lampazos, and Merced fields located in a platform depositional setting behind the Cupido/Sligo reef margin.

More than 20,000 ft of Late Jurassic and Early Cretaceous rocks in the Sabinas Basin underwent compressive structural deformation during the Laramide orogeny from latest Cretaceous to Early Tertiary time forming a variety of structural traps, the most important of which are long and narrow, northwest-southeast trending, plunging anticlines bounded by thrust and/or reverse faults. The main fields are confined to the Sabinas Basin depocenter where gas generation potential was the greatest and structures are more dramatic; however, the Garza, Lampazos, and Zuloaga fields produce on the Salado/Tamaulipas Arch on small broad anticlinal traps and have a total resource potential of about 150 Bcfg. A simplified cross-section across the basin (Figure 4) illustrates the complexity of the basin architecture.

### Petroleum System

La Casita and La Virgen are the only proven petroleum system in the Sabinas Basin (González-García, 1984; Eguiluz de A., 1999; Ziga-Rodríguez et al., 2003). They comprise one Late Jurassic (Tithonian) source rock (La Casita Formation), and three groups of reservoirs, the Lower Cretaceous (Barremian) La Virgen Formation, the Upper Jurassic (Tithonian) La Casita Formation, and the Upper Jurassic (Oxfordian) La Gloria Formation. Figure 5 is a type log in the Sabinas Basin, illustrating formation tops to the La Casita Formation.

Fractured dolomites and limestones of La Virgen Formation are the most significant reservoirs. La Virgen Formation is divided into five informal units whose combined thickness can reach up to 4,900 ft. The lowermost Unit I, the main reservoir in the Monclova-Buena Suerte field (Eguiluz de A., 1999), is 820 ft to 1,476 ft thick, and produces gas from highly fractured, low primary porosity, 4%-5%, packstone-grainstones and dolomites. Unit I is sealed by up to 1,312 ft of limestone-anhydrite of Unit II with varying percentages of anhydrite. La Casita produces gas from quartz arenites of the middle member of the La Casita Formation. Quartz arenites have an average intergranular porosity of 5% but can exceed 9%, and an estimated gross thickness that varies from 164 ft to 656 ft. La Gloria produces gas from fractured, medium to coarse-grained, quartz arenites that are 100 ft to 164 ft thick, with porosities varying between 3 to 10% (7% average).

The main source for La Casita Formation consists of more than 4,900 ft of shale and sandstone and is composed of black, carbonaceous shales and shaly limestones in the upper and lower members. Shales have a total organic content varying from <.5% to 4% (averaging 2.5%) of Type II and Type III kerogens (González-García and Holguin-Quiñonez, 1992b; Holguin-Quiñonez et al., 1994). Source rocks of the La Casita Formation range from immature to overmature, depending on depth of burial. Basin modeling suggests that source rocks of the La Casita may have entered the oil window sometime in the Late Cretaceous, possibly in the Campanian, and began generating gas in the Early Paleocene, with a possible dry gas generation peak in the Late Paleocene (Figure 6). The timing of gas generation, at the end of the formation of Laramide compressional structures favored upward gas migration into Jurassic and Cretaceous reservoirs within anticlinal structures, and downward migration into the underlying La Gloria Formation (Eguiluz de A., 1999).

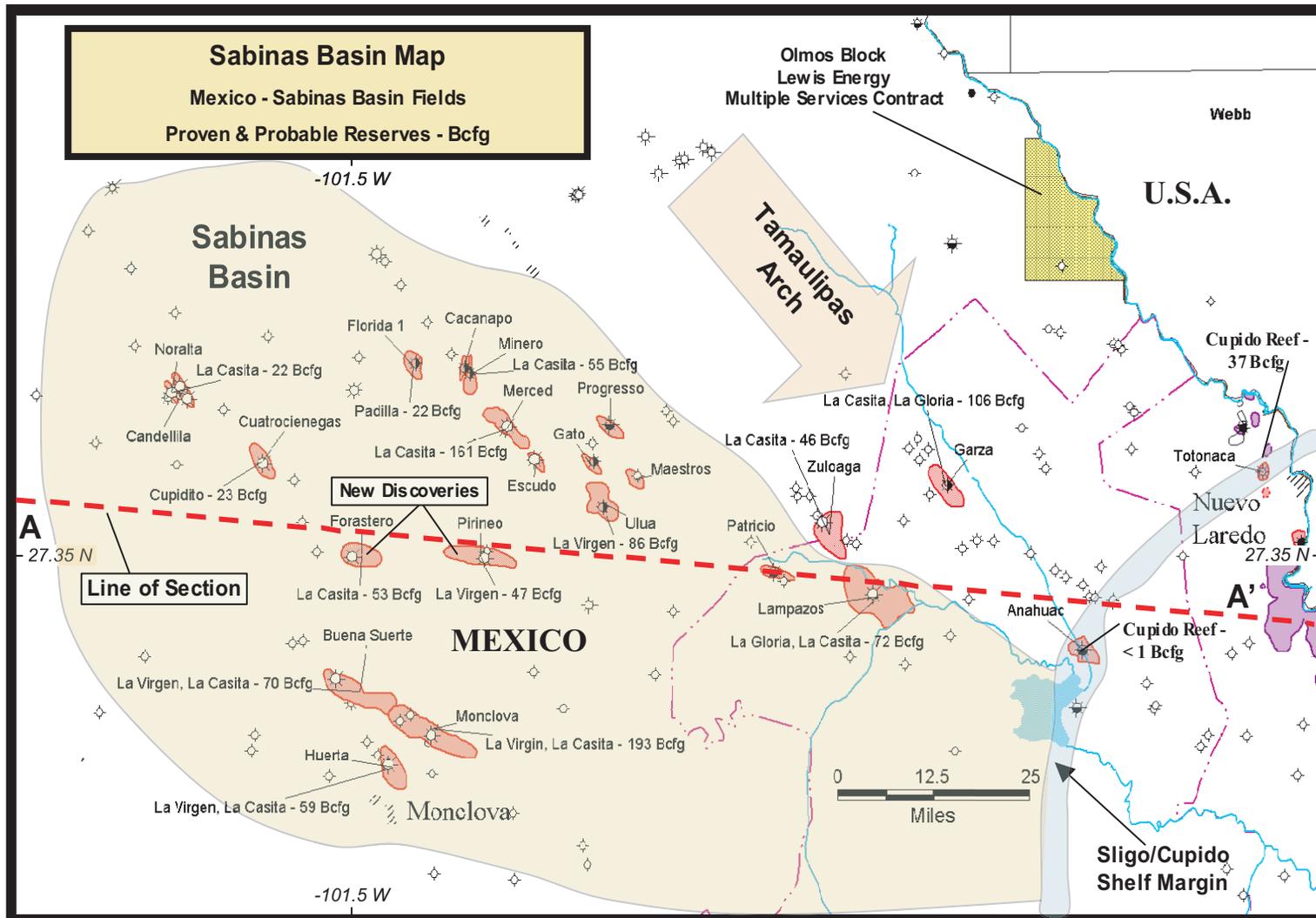
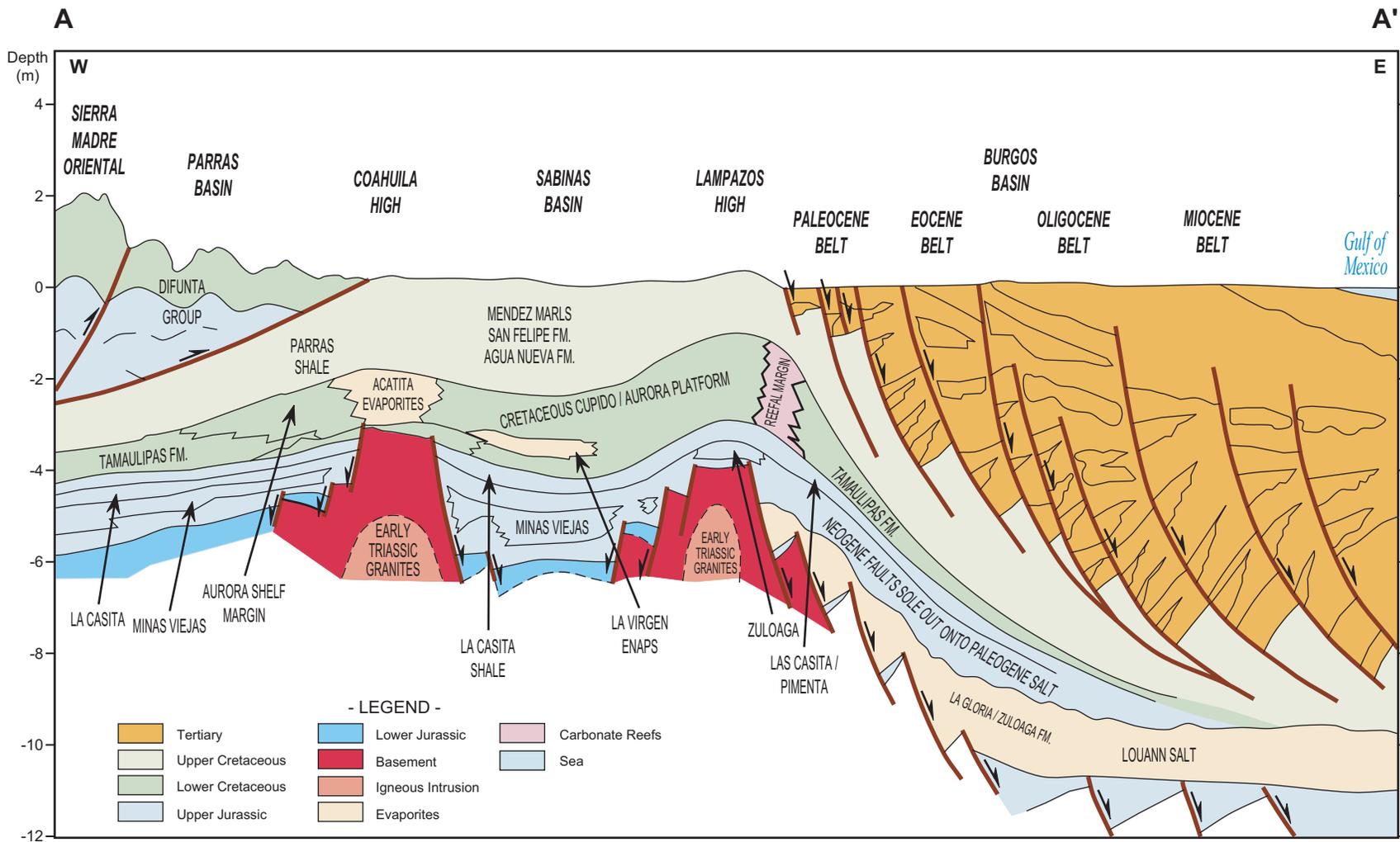


Figure 3. Sabinas Basin map, Mexico.



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**Figure 4. Cross-section A-A' Sabinas Basin, Mexico.**

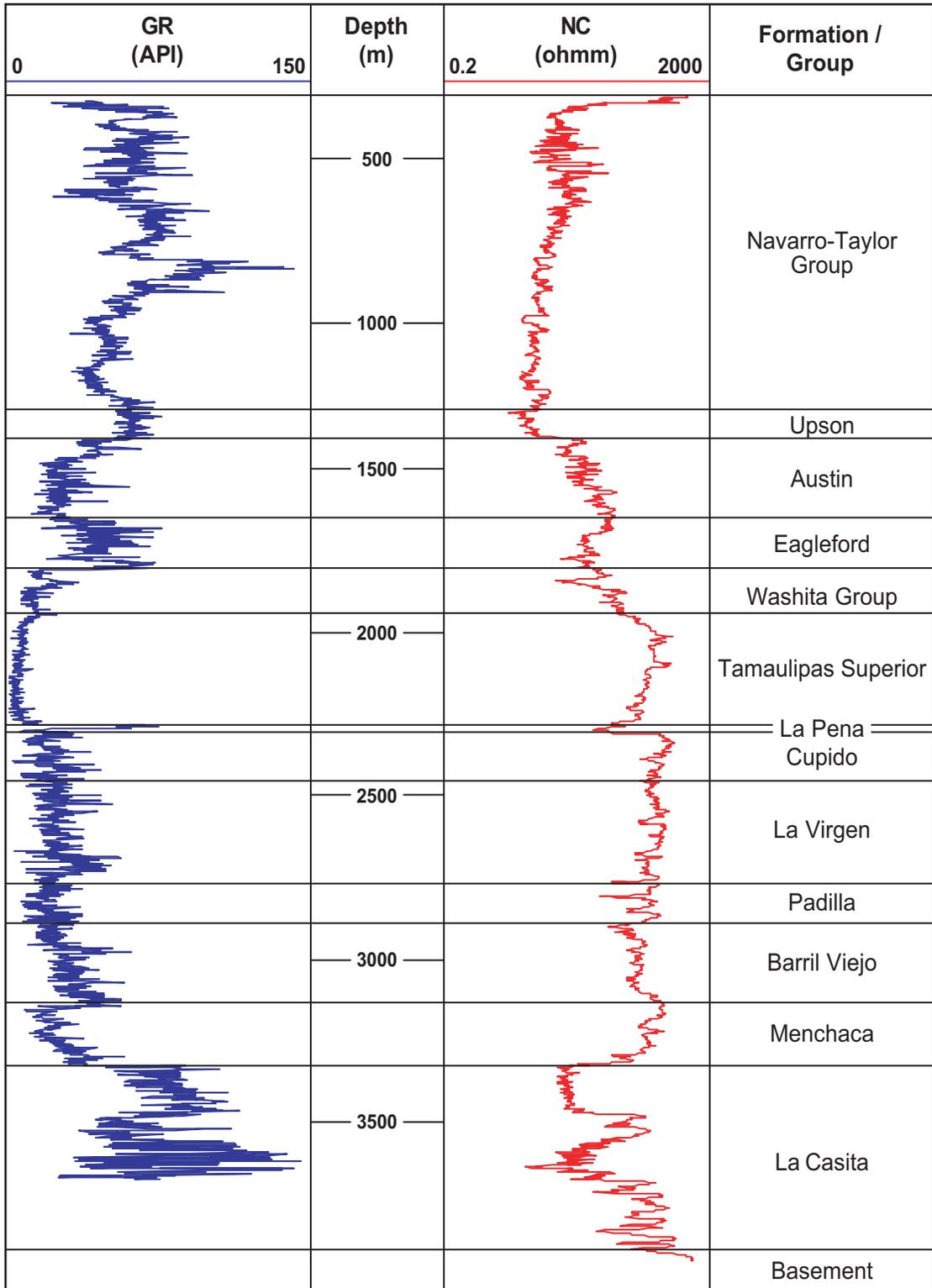
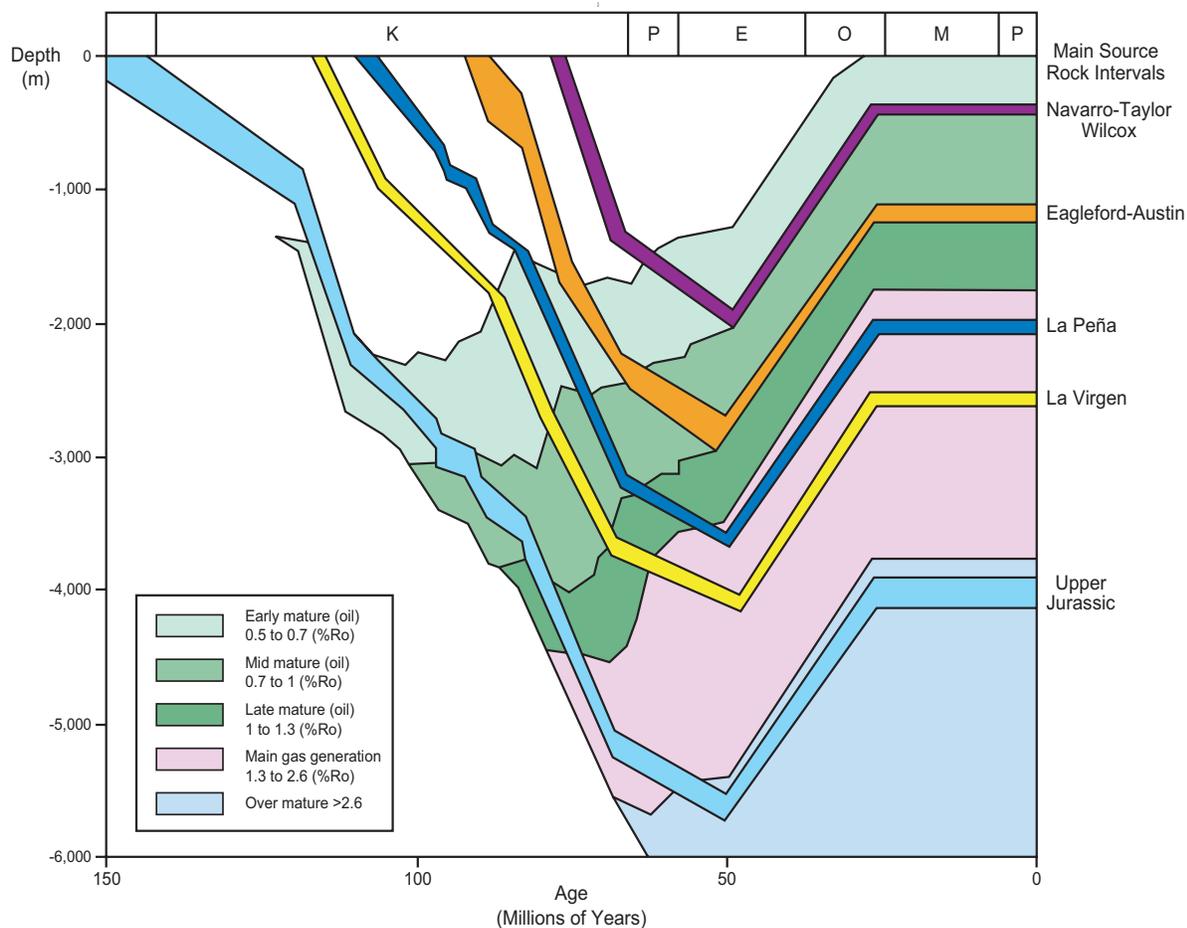


Figure 5. Type log, Sabinas Basin, Mexico.



**Figure 6. Gas generation evolution, Sabinas Basin, Mexico.**

## Recent Discoveries

Pemex completed the Pirineo 1 wildcat as a gas discovery in the Sabinas Basin during September 2003 after spudding the well on 1 May. Pemex tested the well from 6,366 ft to 7,642 ft through a 26/64" choke for 12.5 MMcfg/d with an FTP of 3,158 psia. The gas stream has H<sub>2</sub>S and some CO<sub>2</sub>. Pemex reached a TD of 7,642 ft on the Pirineo 1 wildcat during August 2003 when lost circulation and gas shows were encountered in the Barremian La Virgen Formation. The Pirineo structure is a tightly folded anticline bounded by a reverse fault located on the southwestern side of the structure. The lithology of the productive interval consists of tight carbonates classified as partially dolomitized wackestones and packstones with some miliolids and pelotoids. The carbonates are fractured with matrix porosity in the 4-9% range. The Pirineo 1 discovery was drilled on the crest of the structure where maximum fracturing was mapped from structural curvature analysis. Pemex drilled the well underbalanced in order to minimize formation damage of the low porosity target horizons. Pemex indicated that year-end 2003 proven reserves for the discovery are estimated at 15 Bcfg and proven and probable reserves are estimated at 47.4 Bcfg. Pemex plans to develop the field with up to 10 wells and possibly some horizontals.

Pemex completed the Forastero 1 wildcat as a significant gas discovery in the Sabinas Basin during February 2004 after spudding the well on 25 June 2003. Pemex perforated the La Casita from 13,707 ft to 15,045 ft and tested 15.4 MMcfg/d and 5 bc/d through a 24/64" choke with a stabilized FTP of approximately 5,700 psia. The Forastero 1 is located on a thrust bounded, northwest to southeast oriented anticline. Pemex estimated year-end 2003 proven and probable reserves for the discovery of 53 Bcfg and plans to develop the field with up to eight wells.

## Summary

The key points of the Sabinas Basin productive trend include: a) a number of different horizons from the Lower Cretaceous Cupido to the Upper Jurassic La Gloria formations are productive from tight, naturally fractured limestones, dolomites, and sandstones, and b) the hydrocarbon migration history was coincident with the structural deformation of the basin that allowed hydrocarbons to migrate into the fractured reservoirs, and c) Pemex has encountered many drilling and evaluation difficulties with wells drilled in the basin.

## South Texas Cretaceous/Jurassic Trend

The map in Figure 7 illustrates the trend of the Karnes-Dubose trough around the San Marcos platform and the large down thrown anticlinal structures associated with this feature in the Lower Cretaceous/Jurassic section that are of main interest to this study. During the 1960s, several companies began searching in earnest along the San Marcos platform for Jurassic Smackover production believing the positive structural feature must be a large regional fetch area. The Superior Oil Company, partnered with Mobil, in the drilling of two deep Smackover wildcats on the San Marcos Arch, the Mobil #1 Dixon-Munson-Textfel Unit, plugged on 20 September 1969, and the Superior #1 D. C. McManus, plugged and abandoned on 5 September 1974 with gas shows in the upper Sligo Formation. The latter well is shown on the dip cross-section in Figure 8. The key well for this study is the Mobil #1 Dixon et al wildcat located on the southeastern area of the San Marcos Platform in southeastern Gonzales County.

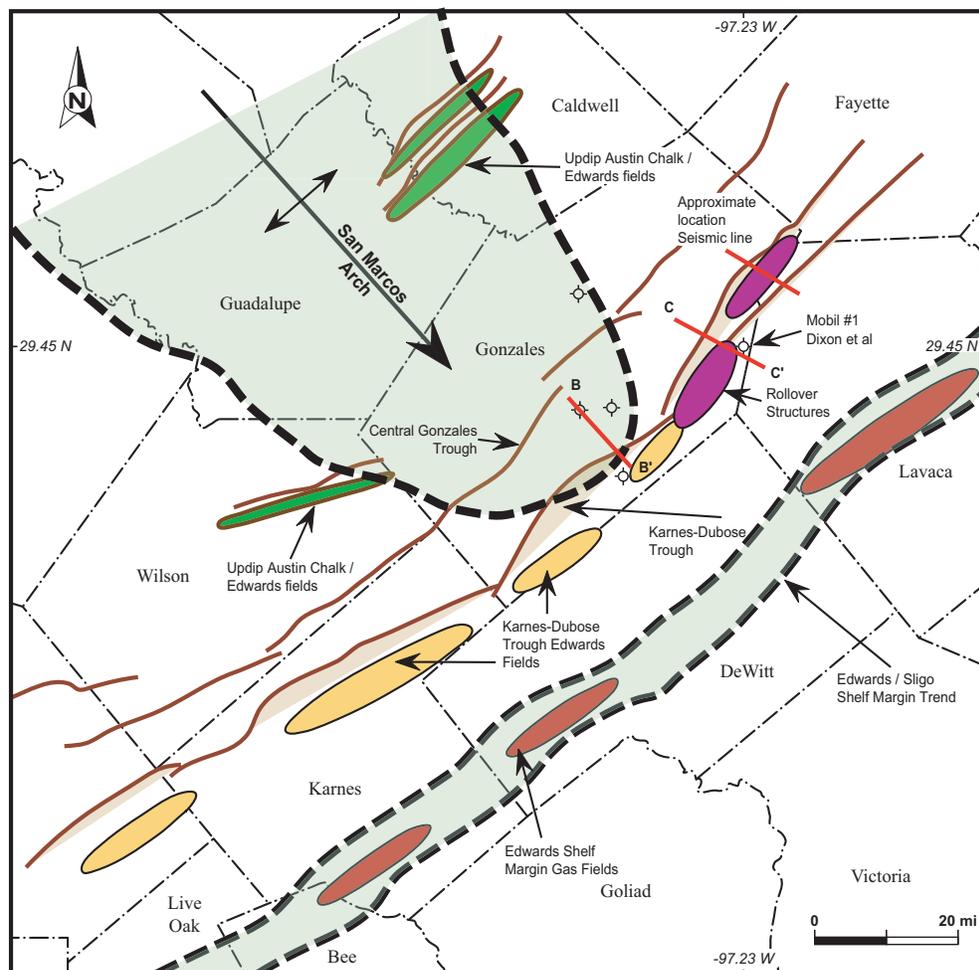


Figure 7. San Marcos platform map, South Texas.

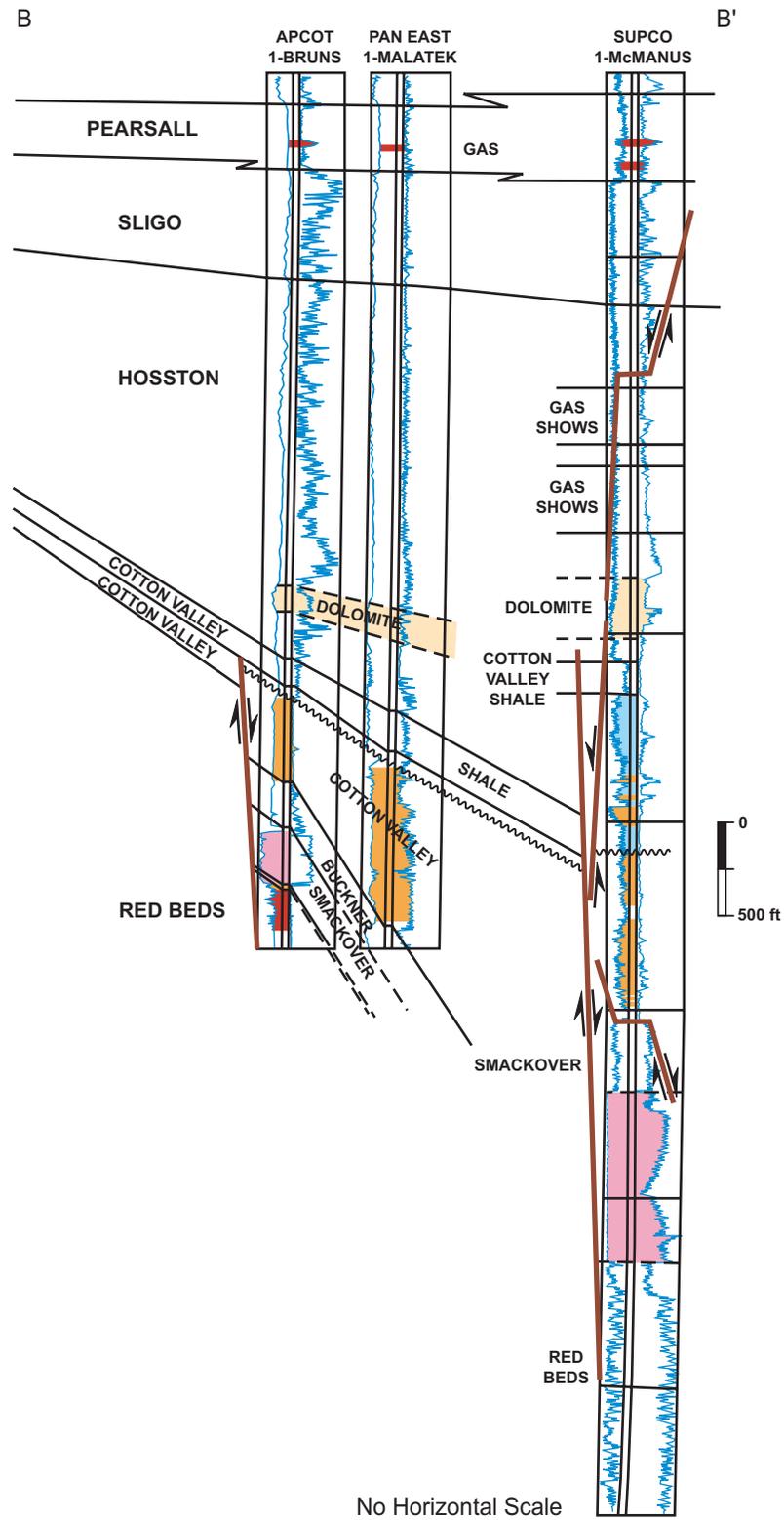


Figure 8. Dip cross section B-B' San Marcos platform, South Texas.

The Mobil #1 Dixon et al wildcat was drilled to a TD of 21, 285', approximately 285' into the Smackover Formation, when drill-pipe was stuck and it was decided to plug the well during September 1969 after spudding the well in March 1969. The dolomite section of the lower Hosston Formation from 17,350 ft to about 17,425 ft mudlogged gas shows (Figure 9) while drilling. The Lower Hosston dolomite was never tested. Within the first 500 ft of the Cotton Valley Group, several interesting, tight sandstones were drilled and gas shows also recorded. Comparing this to the Sabinas Basin productive fields, it became apparent that there were some interesting analogies if the proper structural setting could be found in South Texas.

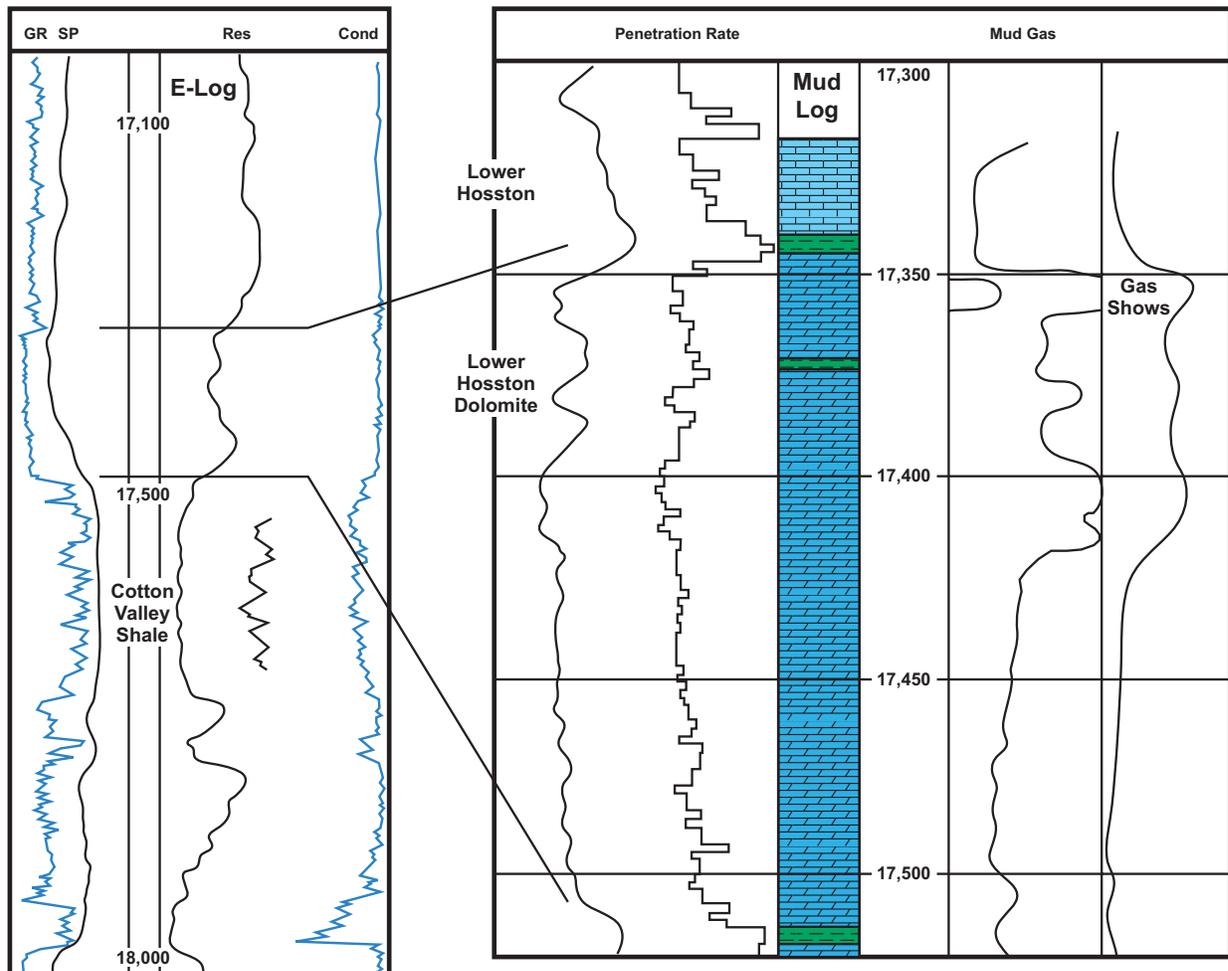


Figure 9. Mudlog and E-log, Mobil #1 Dixon et al., San Marcos platform, South Texas.

### General Structure of the San Marcos Arch

The Karnes-Dubose trough gently wraps in an arcuate fashion around the San Marcos arch and is believed to represent an important paleo-topographic feature that influenced deposition of the lowermost Jurassic formations including the Louann Salt. The throw of the down thrown fault block associated with the Karnes-Dubose trough is estimated to be on the order of 1,000 ft and has been active since at least the Albian. The structural setting of the Mobil #1 Dixon et al on the down thrown side of the Karnes-Dubose trough is illustrated in Figures 10 and 11. Warren Exploration gave the author the seismic line and cross-section seen in Figures 8 and 10, after leaving the oil industry in the mid 1990s.

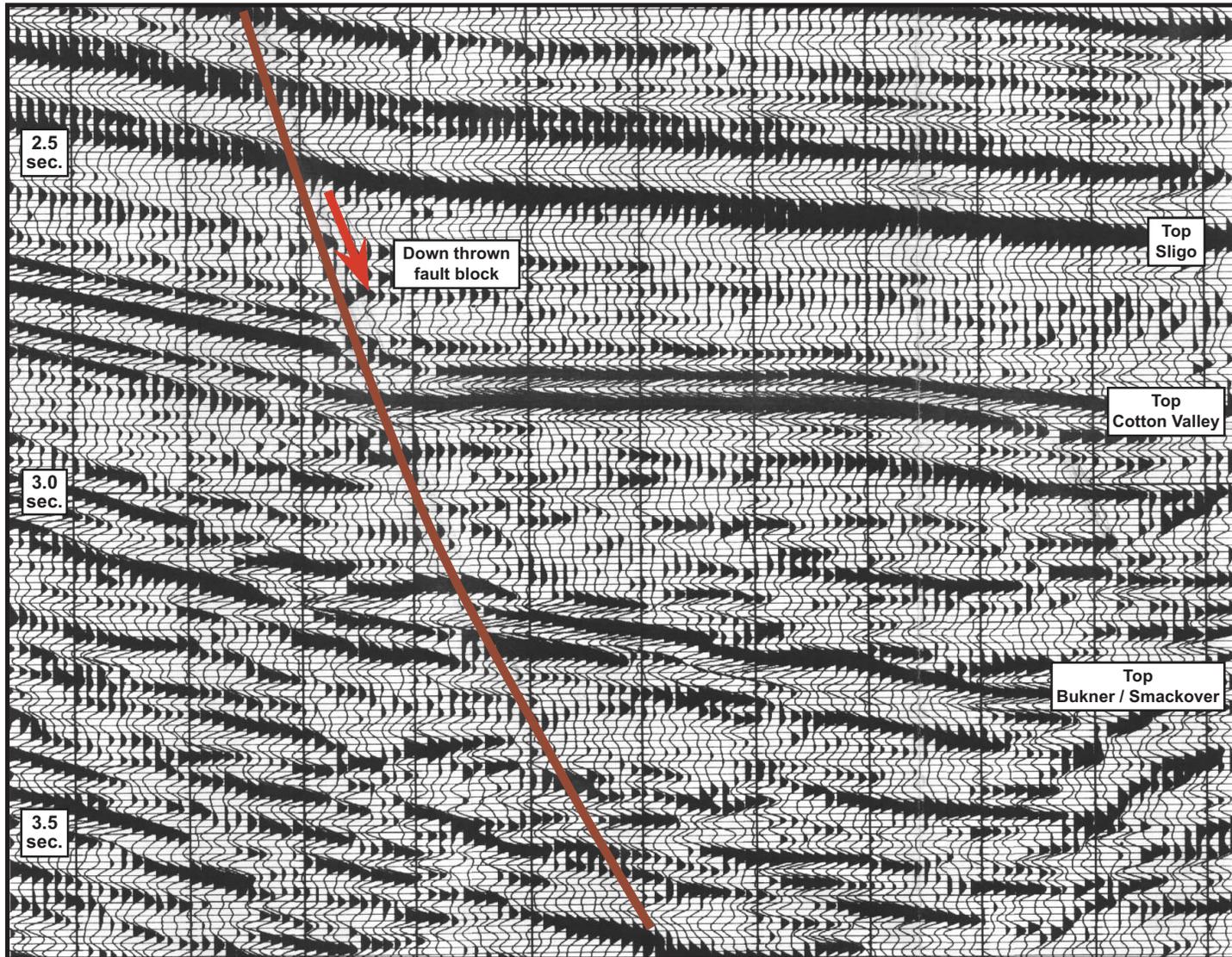


Figure 10. Seismic line, Karnes-Dubose trough, San Marcos platform, South Texas.

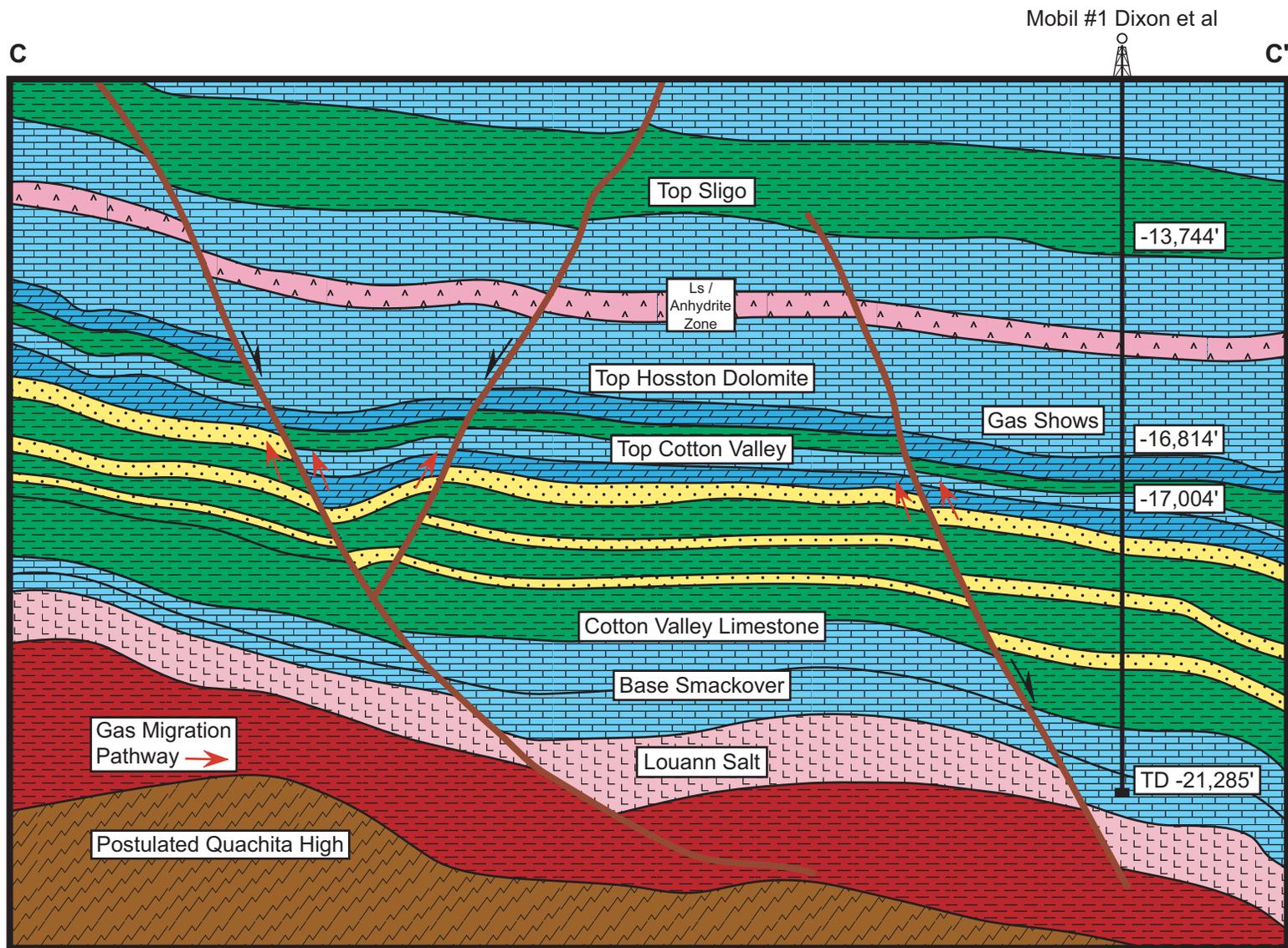


Figure 11. Schematic cross-section C-C', Karnes-Dubose trough, San Marcos platform, South Texas.

The seismic line (Figure 10) is located 10 miles north-east of the Mobil #1 Dixon et al wildcat and some amplitude anomalies can be seen in the Lower Cretaceous/Jurassic formations which may be an indication of fracturing. The well was drilled downdip and off the optimum closure of the rollover anticline by about two miles. The main point is that the rollover structure seen in this line, some with horst and grabens, is very similar all along the Karnes-Dubose trough trend. The Karnes-Dubose trough existed since at least Early Cretaceous Edwards Formation deposition and may have formed as the result of a slope break in Jurassic sediments; although, the nature of the Jurassic and underlying Quachita strat are poorly understood. Faulting was continuous from the Late Albian through possibly the Eocene in the trough as a result of continued sediment loading. A key concept concerning Edwards production, at the shelf edge and along the Karnes-Dubose fault trend, is that the faults have acted as conduits for hydrocarbon migration and fluids that have enhanced porosity along the fault zones (Fritz et al., 2000).

## Petroleum System

From the general mudlog sample descriptions of the Mobil #1 Dixon et al well (Table 1) and the analogy with the Sabinas Basin, it is possible to infer that the petroleum system in South Texas comprises one Late Jurassic (Kimmeridgian/Tithonian) source rock (Cotton Valley Group–Bossier Shale—approximately 2,500 feet thick), and three potential reservoirs, the Lower Cretaceous (Berriasian to Bedoulian) Sligo/Hosston formations, the Upper Jurassic (Tithonian) Cotton Valley Group sandstones (Schuler Formation of East Texas), and the Upper Jurassic (Oxfordian) Smackover Formation. It should be noted that the Sligo/Hosston formations contain a number of black, carbonaceous shale interbeds that may also have generated hydrocarbons. Also the #1 Dixon et al logs indicate that there are at least 200 ft of Cotton Valley shales immediately below the Lower Hosston dolomite.

**Table 1. Mobil #1 Dixon et al., Sligo Fm. to Smackover Fm., summary cuttings description.**

Group	Formation	Member	Depth	Mobil #1 Dixon et al. - General Cuttings Description
	Sligo	Upper	14,250'	dark grey to brown hard, dense limestone with dark, black carbonaceous shale interbeds
	Sligo	Anhydritic	16,780'	dark grey to brown, hard, dense limestone with dark, black carbonaceous shale interbeds and anhydrite
	Sligo	Lower	16,860'	dark grey to brown, hard, dense limestone with pyrite and some anhydrite, pelleted limestone, abundant calcite
	Hosston	Lower	17,350'	white, light grey to brown, dense to sucrosic dolomite, gas shows
Cotton Valley	Knowles/Schuler	Upper shale	17,510'	grey and black, calcareous shale with some dolomite and limestone interbeds, hot gamma ray
Cotton Valley	Knowles/Schuler	Dolomitic limestone	17,710'	dense, grey brown, dolomitic limestone and sandy limestone
Cotton Valley	Knowles/Schuler	Sandy unit	17,930'	fine to medium grained, clear white quartz sand with interbeds of brown, dense limestone, dark brown, black dolomite and black, silty, micaceous, calcareous shale with abundant pyrite
Cotton Valley	Bossier	Shale	18,800'	dark grey and black, calcareous, micaceous, silty shale with interbeds of quartz conglomerate and very fine, calcareous tight sand
Cotton Valley	Gilmer/CV Lime		20,250'	grey, white, tight, microcrystalline limestone grading to sandy limestone and dolomite with some quartz sand
	Buckner		20,690'	clear and milky quartz conglomerate with traces of anhydrite and some red and green sandstone interbedded with red shale
	Smackover		21,000' TD 21,285'	clear and milky quartz conglomerate grading into interbedded anhydrite and cream, pink, cryptocrystalline limestone with occasional interbeds of oolites

It is estimated that the shales of the Cotton Valley Group, buried to about 10,000 ft, generated the oil and gas that filled the Albian Edwards traps that formed on the up thrown side of the Karnes-Dubose trough after migrating up the fault planes. The Cotton Valley Group located within the Karnes-Dubose trough region is postulated to have a hydrocarbon generation history very similar to the Sabinas Basin (Figure 6), reaching the gas generation window in the Early Paleocene after being buried to about 14,000 ft, with a possible dry gas generation peak in the Late Paleocene.

## South Texas–Mexico Analogies

The above descriptions concerning the Lower Cretaceous and Jurassic formations of South Texas and Mexico lead to the conclusion that the rocks in this broad geographical area formed under similar paleo-environmental conditions. What is different about the Sabinas Basin is the deformation related to the Laramide orogeny. In attempting to draw an analogy between the productive structures in the Sabinas Basin and South Texas, the nearest possibilities are related to the formation of rollover anticlinal structures on the down thrown side of the Karnes-Dubose trough trend. Similar conditions could exist along the trough that would have allowed hydrocarbons to migrate up the large faults and into overlying potential reservoirs enhanced by the faulting and folding associated with the trough. Since these structures formed fairly early in the Late Cretaceous, and hydrocarbons have been migrating up the fault plane for at least 60 million years, it is postulated that there could be significant fields developed along the Karnes-Dubose fault trend.

## Conclusions

The main conclusions that can be drawn from this comparative study of the Sabinas and the South Texas basins are:

1. The lithologies and hydrocarbon generation and migration history of both basins are similar.
2. In both areas, the key is to look for naturally fractured reservoirs and faulting which allowed hydrocarbon migration and the movement of porosity enhancing fluids.
3. The La Casita equivalent Cotton Valley Group is estimated to have generated a large amount of hydrocarbons.
4. The subtle nature of the fractured reservoirs may have resulted in some productive zones having been bypassed in previously drilled wells and the majority of wells never targeted these specific potential reservoir parameters.

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