Emergence of the Lower Tertiary Wilcox Trend in the Deepwater Gulf of Mexico*

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Abstract

Described here is the background of the three-year wildcat drilling program in the Lower Tertiary Wilcox trend in the deepwater US Gulf of Mexico (GoM). Discussed following the introduction and background covering the key BAHA, Trident and Great White discoveries in the west, are the important Cascade discovery to the east in Walker Ridge Block; and ongoing activity, and challenges to be addressed to ensure economic feasibility of the potentially prolific Wilcox trend.

Introduction

The Wilcox stratigraphic section has long been recognized as an important petroleum resource in Southeast Texas to Southwestern Louisiana, producing primarily gas from fluvial, deltaic and shallow marine sandstone reservoirs since the 1930s. The total estimated ultimate recovery for the onshore Wilcox is 24 Tcf gas or 4 BBoe. Not until the drilling of the BAHA 2 well in March 2001, was the linked depositional system of the Wilcox from shelf fluvial deltaics to basin deepwater turbidites, a distance greater than 250 mi (403 km), tested by the drill bit.

Although this wildcat, drilled in 7,790 ft (2,375 m) of water in the Alaminos Canyon area of the Northwest GoM was noncommercial, it established a working petroleum system in the Perdido Fold Belt (PFB) (Figure 1). The soon-to-follow nearby discoveries, Trident in July 2001 and Great White in June 2002, proved the significant hydrocarbon potential of the PFB by documenting oil accumulations in a variety of turbidite deposits from sheet sands to amalgamated and leveed channel systems.

Shortly after the PFB Great White discovery in 2002, the Cascade discovery was announced, located approximately 275 mi (444 km) east in the Walker Ridge protraction area of the Central GoM (Figure 1). This wildcat was drilled to a depth of 27,929 ft (8515 m) in 8140-ft (2482-m) water. Not only did this significant well extend the Wilcox play to the east, it established the existence of turbidite sands greater than 350 mi (107 km) down dip from the source deltaics and confirmed the Wilcox as a world class depositional and potential petroleum system.

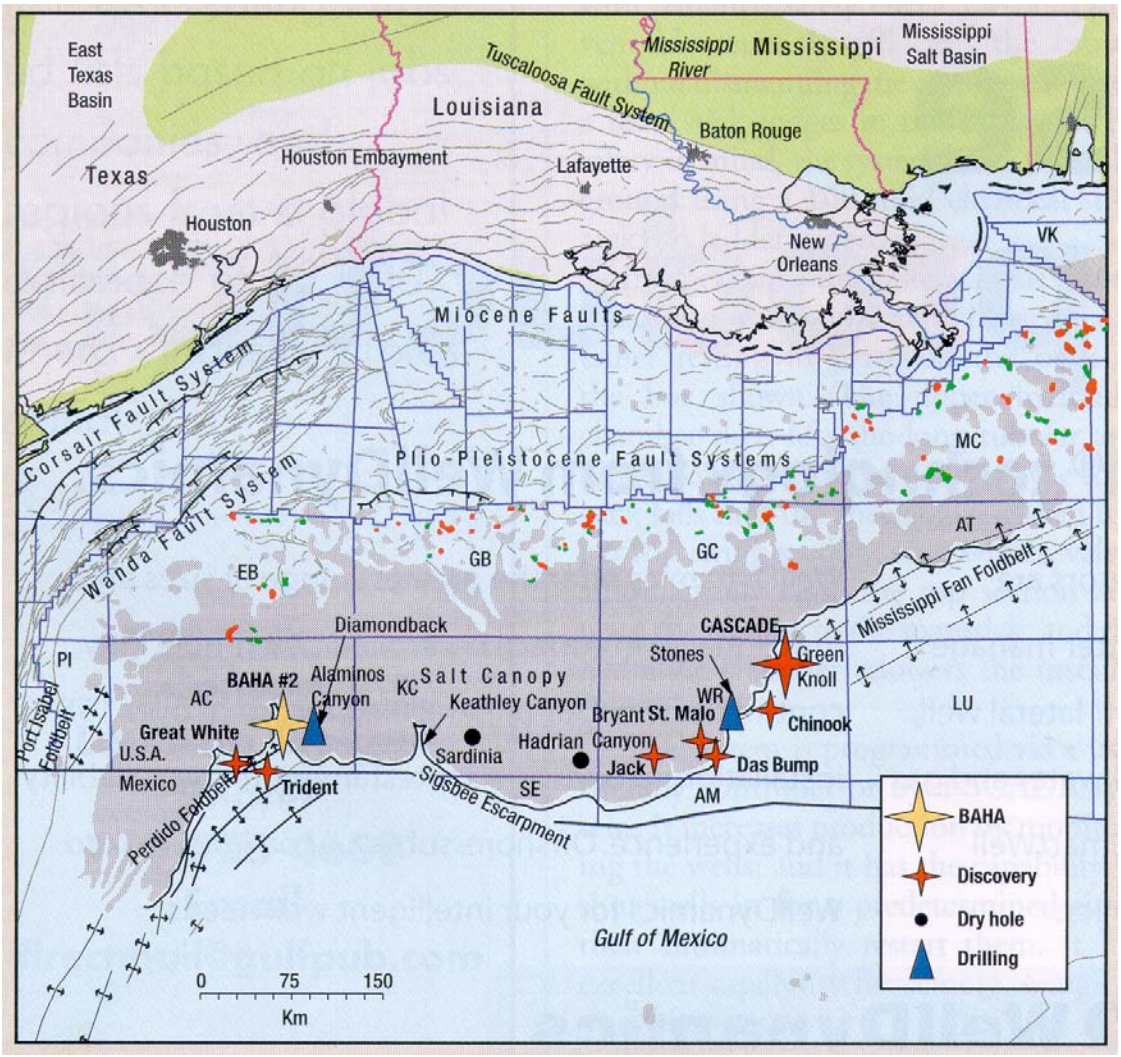

Figure 1. Location and GoM salient feature map. (Wood Mackenzie, *US GoM Deepwater Upstream Report 1999.)*

The Chinook, June 2003, and St. Malo, October 2003, discoveries followed. These extended the Lower Tertiary Trend across several structural provinces from the PFB in Alaminos Canyon through Keathley Canyon to Walker Ridge. Trend water depths range from 5000 ft to 10,000 ft (1524 m to 3049 m) and objective depths from 10,000 ft to 30,000 ft (3049 m to 9146 m) subsea.

More than 12 Bbbl of oil in place have been discovered to date. Potential recoverable reserves per discovery range from 30 to 400 MMboe, with a 69% success rate, i.e., 9/13. Trend-potential ranges from 3 to 15 Bbbl of recoverable oil. All discoveries have a common basinal setting, distal Louann salt basin rim, and are salt-cored anticlinal closures with tectonic styles ranging from thrusted symmetrical box-folds of the PFB in Alaminos Canyon (Figure 2A), to salt pillow structures of Walker Ridge (Figure 2B), and possibly continuing to asymmetrical thrusts of the Mississippi Fan Fold Belt in Green Canyon and Atwater Valley protraction areas (Figure 2C).

Key technical challenges for trend commerciality are: 1) reservoir quality and flow capability; 2) drilling and completion technology; and 3) development of infrastructure. Continued discoveries in the trend and successful flow tests planned in early 2006 could very well transform the Lower Tertiary Wilcox into a world-class petroleum system in the deepwater GoM.

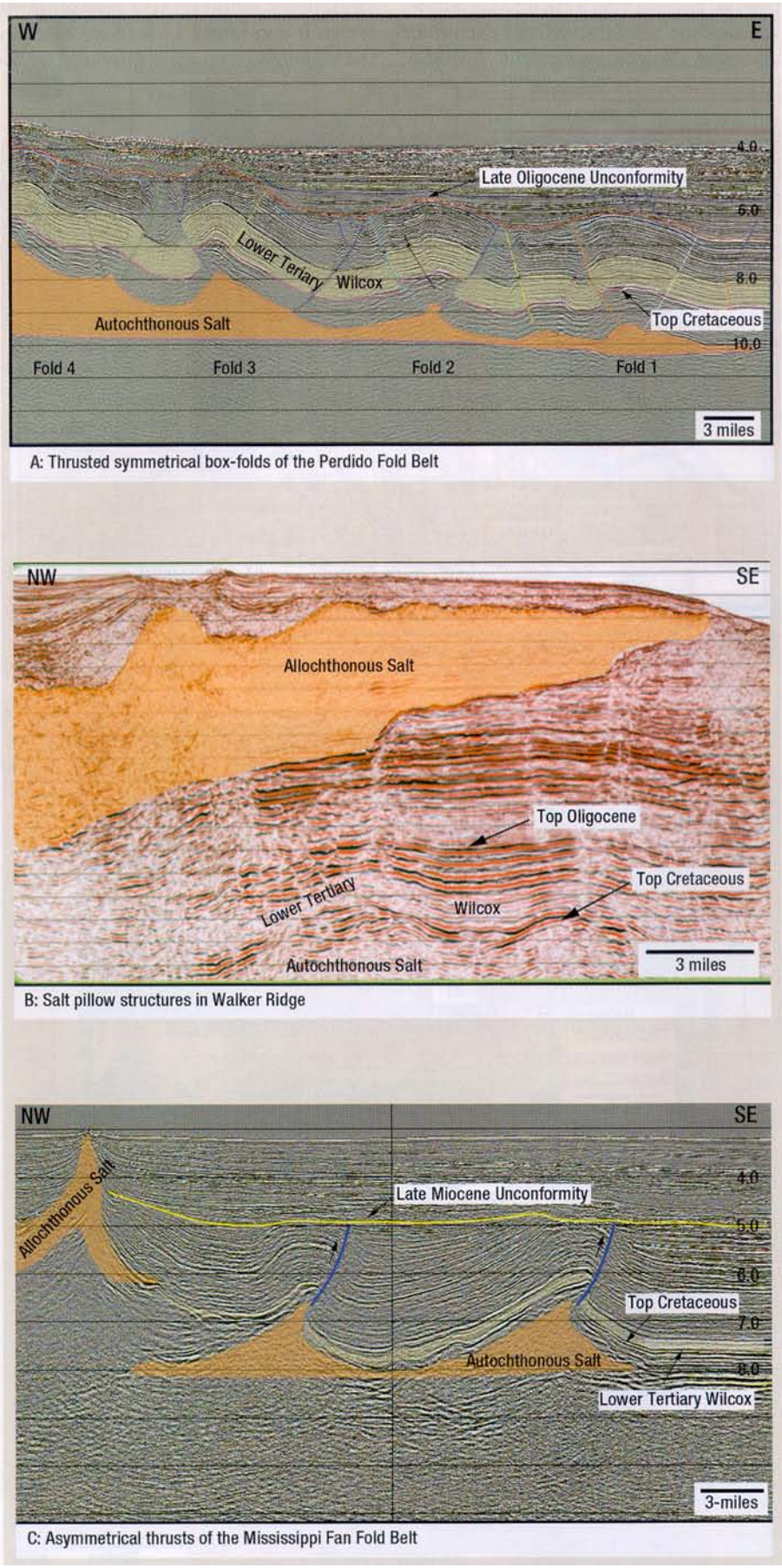

Figure 2. Tectonic styles. A: Perdido Fold Belt in Alaminos Canyon area; B: Walker Ridge area; C: Mississippi Fan Fold Belt in Atwater Valley area.

Testing the Concept

In 1996, ten years after initial acreage leasing in the PFB, the industry consortium of Shell, Texaco, Amoco and Mobil combined resources to drill the "largest remaining undrilled structure in North America" named BAHA (Figure 3). The BAHA 1 (Alaminos Canyon Block 600) was designed to test fractured Mesozoic carbonates with a proposed total depth of 22,000 ft (6707 m) in 7612 ft (2321 m) of water.

This was the initial test of the promising exploration trend encompassing several large salt-cored anticlines created by a series of thrusted box folds trending southwest to northeast that traverse the boundary between Mexican and US territorial waters (Figure 3). However, the well was abandoned due to mechanical problems at 11,208 ft (3417 m) resulting from a narrow drilling margin encountered while drilling the Eocene section. Although the well did not achieve its objective, it did prove a working petroleum system, and was able to qualify and hold the lease by logging 15 ft (5 m) of oil pay in an upper Eocene sand.

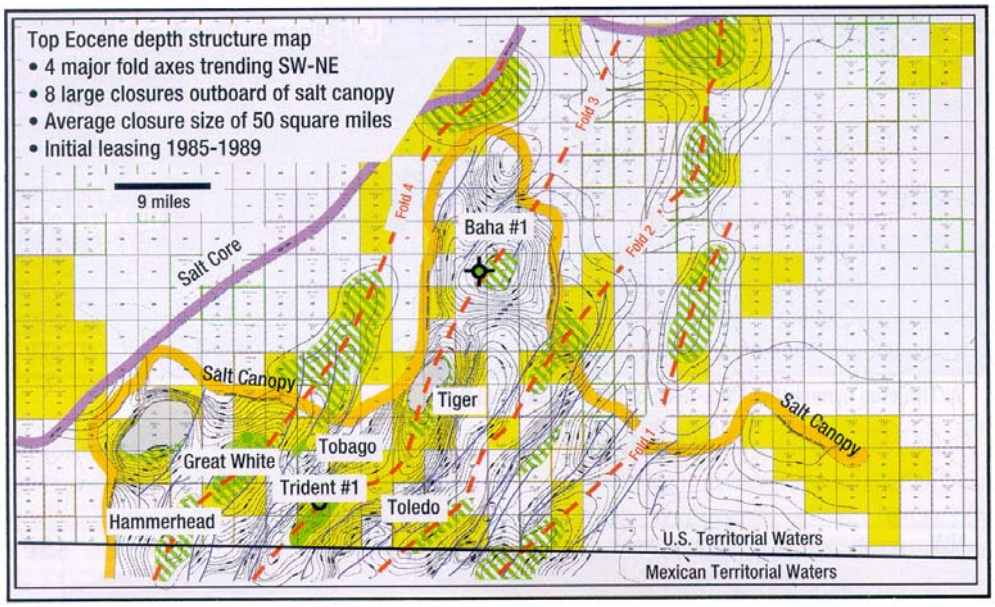

Figure 3. Perdido Fold Belt and BAHA wildcat test.

Five years later in 2001, BAHA 2 was drilled on Alaminos Canyon Block 557 in 7790 ft (2375 m) water to 19,164 ft (5843 m) (Figure 4). The primary target was fractured shallow-to-deepwater Mesozoic carbonates, with a secondary target (but considered much higher risk) of deepwater turbidites in the Lower Tertiary Oligocene to Paleocene (Frio to Wilcox). The well did test the Mesozoic carbonates, but found them to be non-porous, non-fractured chalks and micritic limestone. And the well did encounter extensive Wilcox equivalent turbidite sands over a 4500-ft (1372-m) gross interval. It also found 12 ft (4 m) of oil in the Upper Wilcox, again proving a working petroleum system (Figure 5).

The results of this well had two profound impacts on the petroleum industry: 1) the massive sand-rich turbidite section of the Wilcox was very encouraging for future exploration potential; and 2) the final cost to drill was $112 million. If this cost could not be reduced considerably, this new and exciting trend would be "dead in the water."

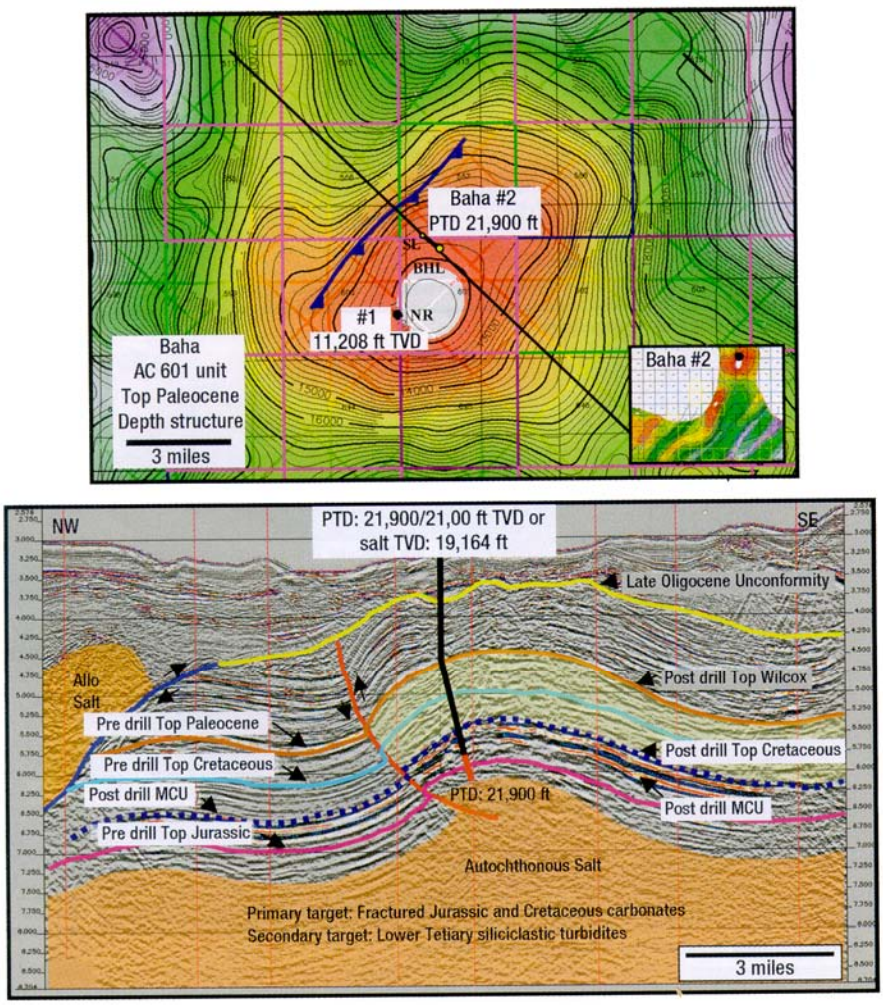

Figure 4. BAHA 2 map and seismic.

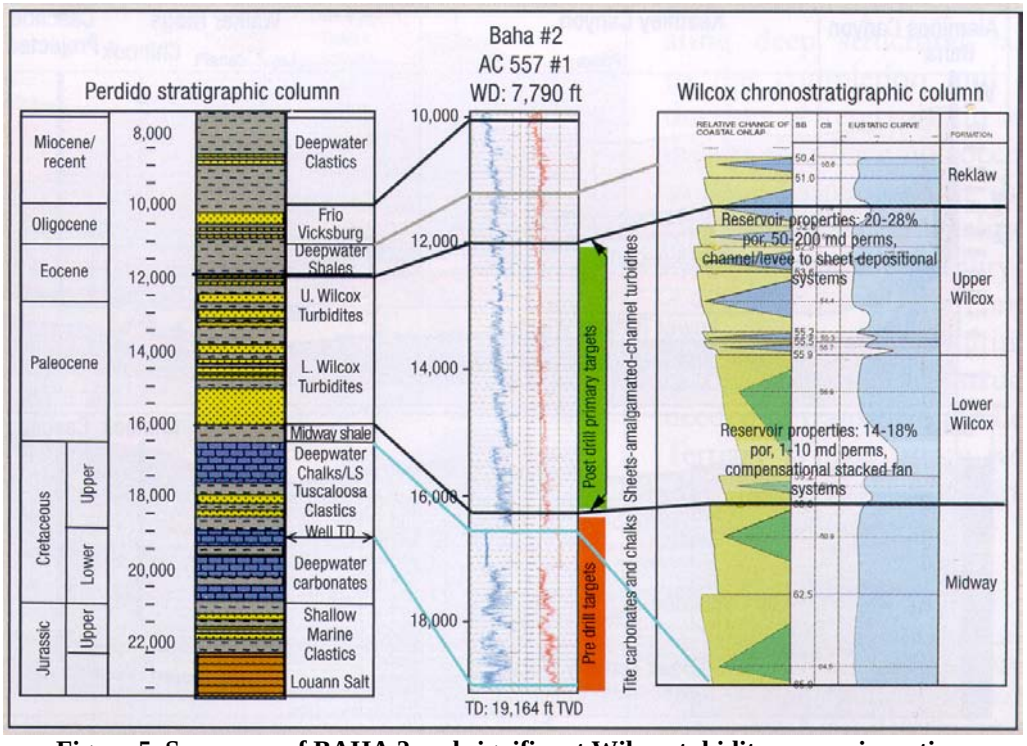

Figure 5. Summary of BAHA 2 and significant Wilcox tubidite reservoir section.

Perdido Fold Belt Evaluation

One month after completion of BAHA 2, Unocal spudded the Trident 1, 30 mi (48 km) south on another anticlinal closure along the same fold axis as BAHA in Alaminos Canyon Block 903 (Figure 3). This set a world record for water depth, 9687 ft (2953 m), and drilled to a total depth of 20,500 ft (6250 m). This discovery introduced a 300+ ft (92 m) gross hydrocarbon oil column in the Wilcox section that was very correlative to the BAHA amalgamated sheets and channel turbidites, implying a very extensive deepwater fan system. Equally as important, the well was drilled for a total cost of $34 million (70% less than the BAHA well). And the players in the trend were then convinced that wells could be drilled in a timely and cost-efficient manner, enhancing the trend's economical potential.

A number of wildcats followed. In June 2002, Shell announced the Great White discovery which was followed by three Wilcox tests in 2004. ChevronTexaco drilled Toledo, a new world record water depth (10,011 ft/ 3052 m) in January, which was reported non-commercial, and the Tiger discovery in March. Unocal's Tobago discovery followed in May 2004 (Figure 6).

After drilling of the BAHA, Trident and Great White prospects, integration of the subsurface data (wireline logs and tests, and core data) and seismic data (reprocessed 3D pre-stack time and depth migration) provided a much more complex depositional model in the upper Wilcox section. Initially, many depositional models predicted widespread, laterally extensive sheet sands. However, delineation drilling and high-quality seismic data has shown that the Upper Wilcox depositional system is a mud-rich, channel levee to amalgamated channels in a toe of slope-to-basin floor setting (Figure 7). Whereas, the Lower Wilcox section is characterized by sheet- to amalgamated-sheet sands and is interpreted to be a regionally extensive basin floor fan system.

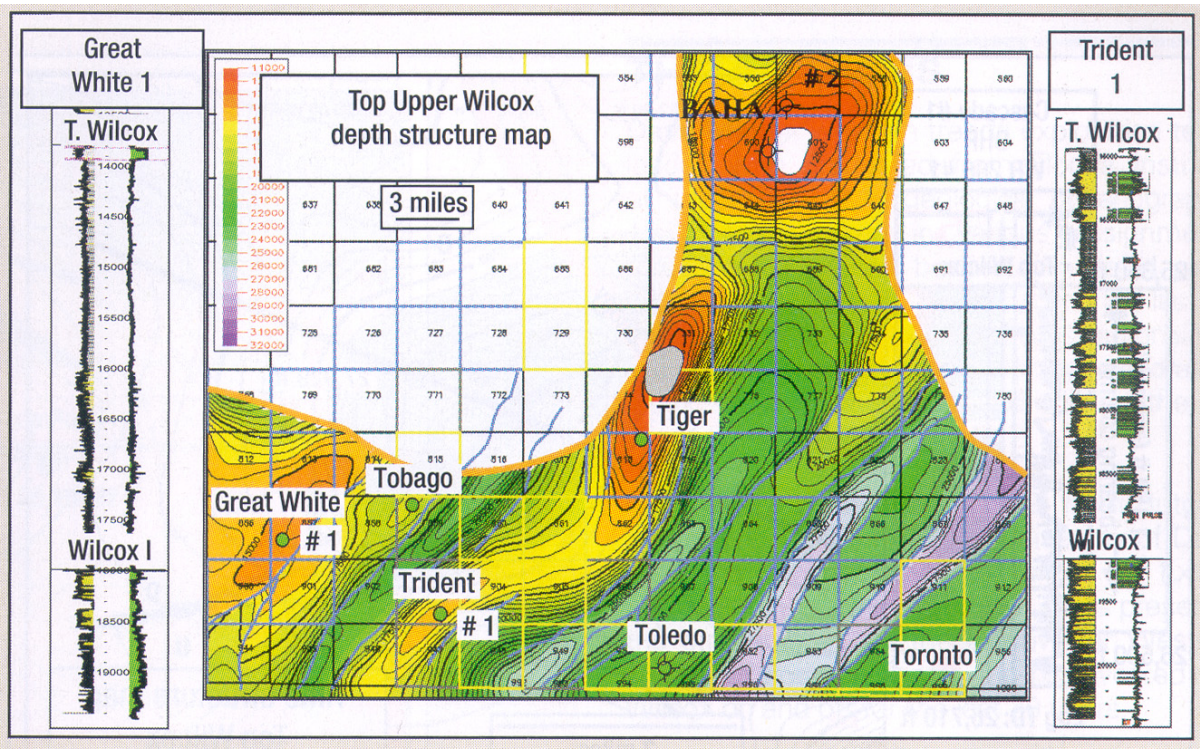

Figure 6. Summary of Perdido Fold Belt (PFB) Wilcox wildcat drilling through May 2004.

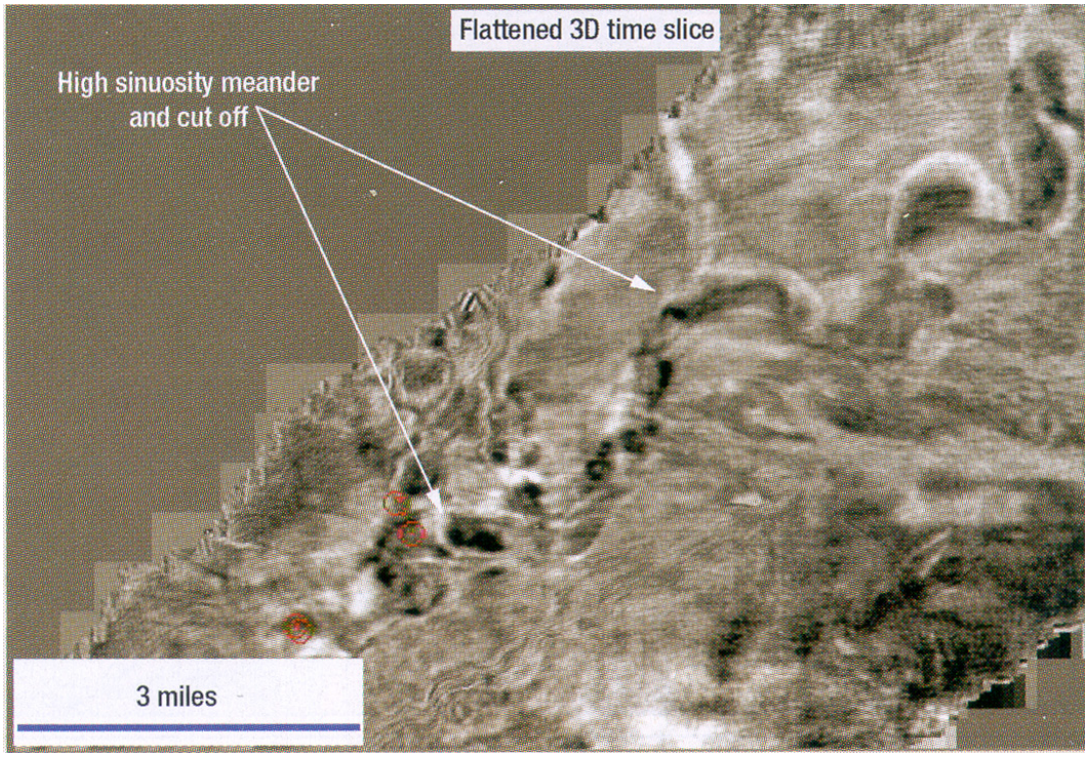

Figure 7. Channel levee system over the Trident structure in the PFB.

Cascade and Walker Ridge

Just as the third wildcat in the PFB (Great White) was starting to drill in early 2002, a very significant wildcat was also beginning operations almost 275 mi (444 km) to the east on Walker Ridge Block 206 in the Central GoM. BHP Billiton was drilling the Cascade prospect in 8140 ft (2482 m) of water to a depth of 27,929 ft (8514 m) to test the same Eocene to Paleocene Wilcox section as seen in the PFB (Figure 8). The well found a 1150-ft (350-m) gross hydrocarbon column on the northeast flank of a salt-cored anticline (Figure 9). Although the gross interval of the Wilcox is approximately 40% thinner in Walker ridge than the PFB, it has about 50% more sand. This trend-extending well was the beginning of a very active exploration program that is continuing today. However, it did not come without some earlier disappointments.

In the fall of 2000, BHP began operations on the Chinook prospect in Walker Ridge Block 425 in 8835 ft (2694 m) of water, and Unocal was drilling the Dana Point prospect in 7036 ft (2145 m) of water. Both wildcats were chasing lower Miocene sands that were the reservoirs of the prolific Mississippi Fan Fold Belt discoveries, Atlantis and Mad Dog (1998), located about 50 mi (80 km) north in Green Canyon. After encountering a sand-poor Miocene section, both wells were plugged and abandoned as dry holes. The untested Wilcox section was approximately 500 ft (152 m) below the drill bit.

After the success at Cascade, BHP went back to Chinook in June 2003 and drilled the Chinook Deep wildcat on Walker Ridge Block 469. After drilling to 27,652 ft (8430 m) and evaluating the Wilcox, BHP had a discovery. Unocal followed with a second deeper test on the Dana Point structure called St. Malo 1, which drilled to 29,066 ft (8862 m) and was another discovery in the Wilcox section (Figure 10). The St. Malo wildcat was very significant in that it was the first sub-salt test in the trend, drilling through approximately 10,000 ft (3049 m) of the Sigsbee Salt Canopy.

ChevronTexaco made another sub-salt discovery on its Jack prospect in Walker ridge Block 759 in May 2004. BP followed with another possible sub-salt discovery on Das Bump in May 2004, which is interpreted to have a common oil/ water contact with St. Malo.

To date, five Wilcox structures have been tested in Walker ridge, and all have been discoveries.

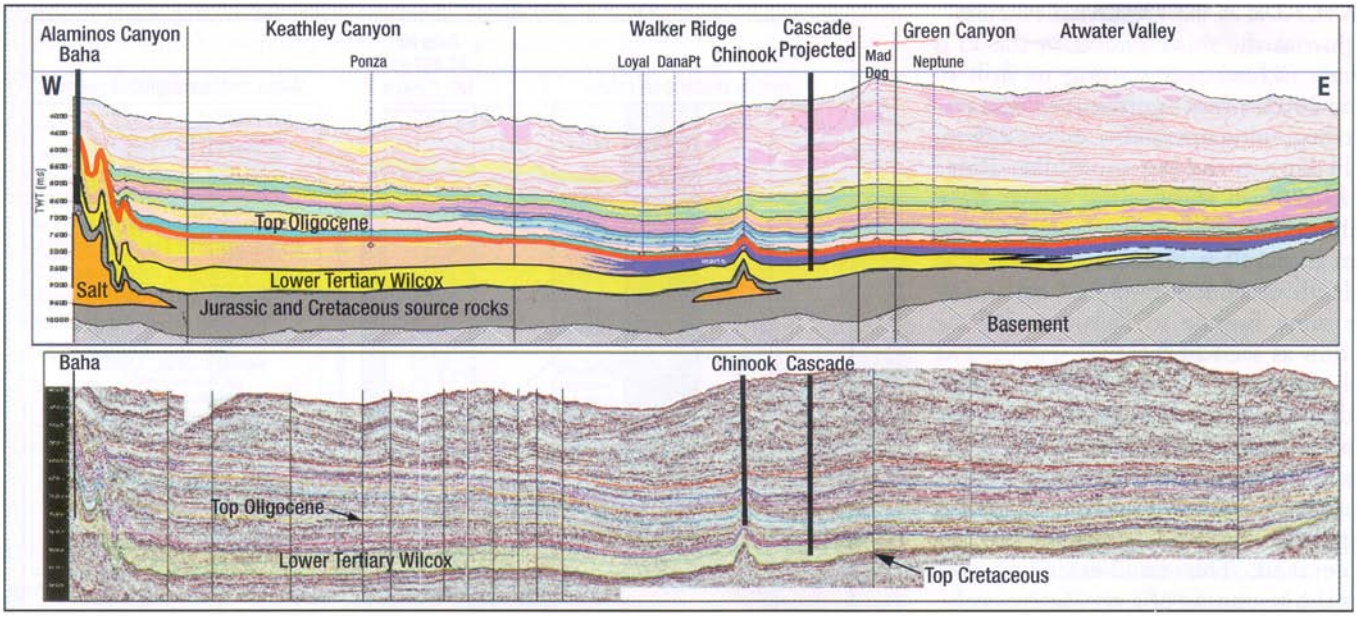

Figure 8. Regional transect (X-section and seismic), PFB in Alaminos Canyon to Cascade to Atwater Valley.

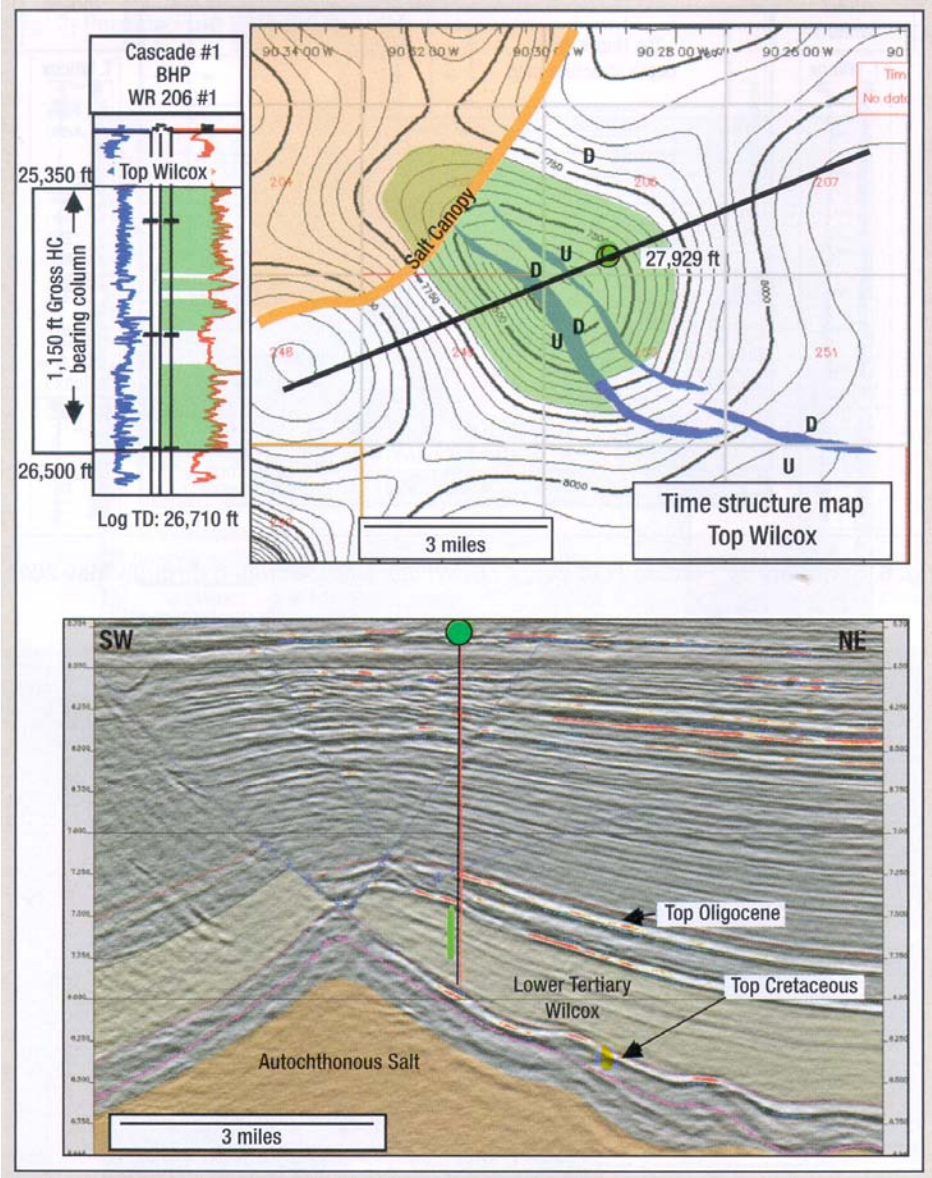

Figure 9. The Cascade discovery.

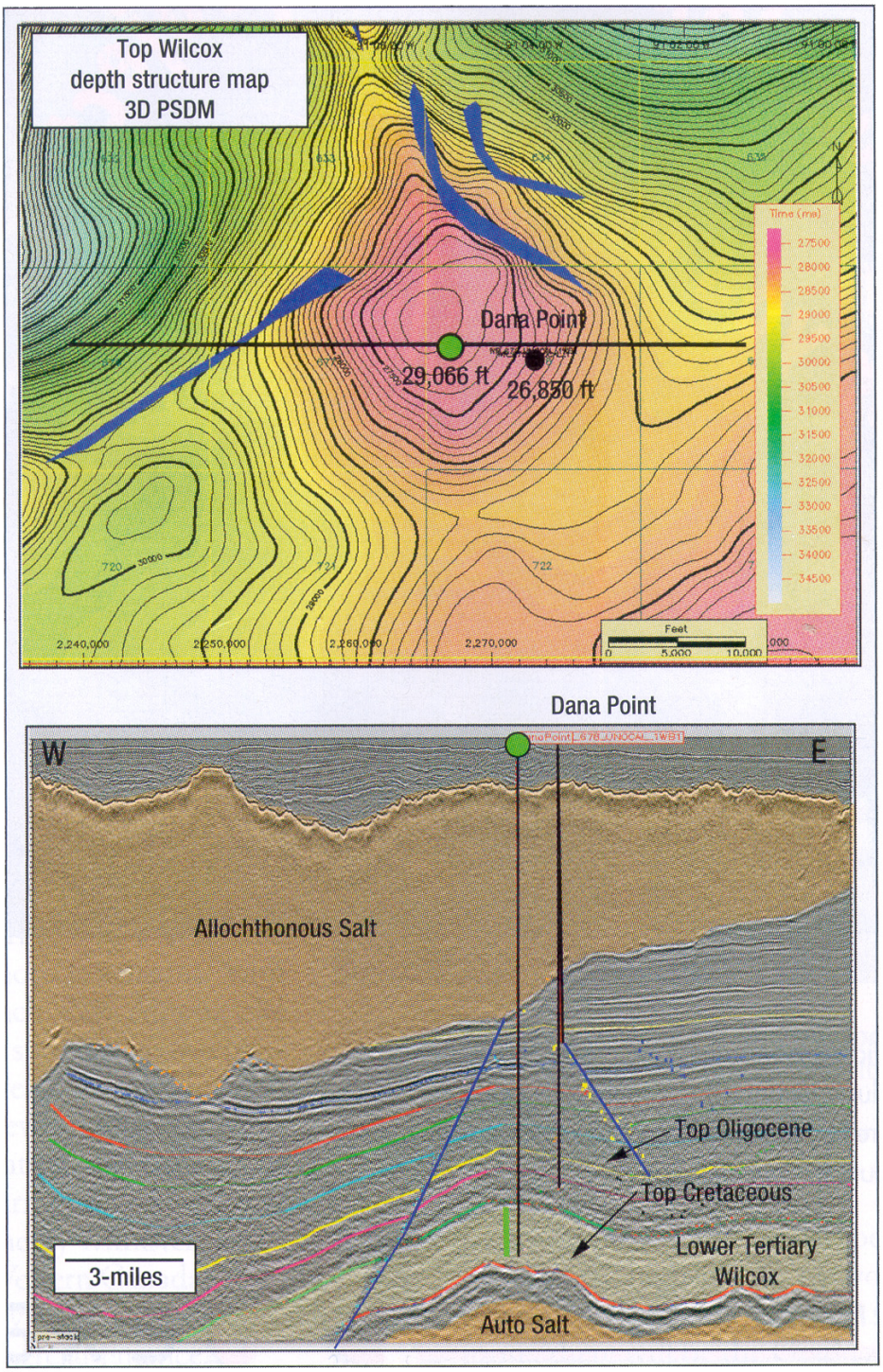

Figure 10. The St. Malo discovery.

Current Activity and Trend Summary

In September 2004, Unocal drilled a dry hole on the Sardinia prospect in Keathley Canyon Block 681 (Figure 1). This was the first Wilcox test in the Keathley Canyon area designed to evaluate the petroleum system between the PFB to the west and Walker ridge to the east. The wildcat was located about 90 mi (44 km) west of the Walker Ridge Jack discovery and 100 mi (160 km) east of the PFB Great White discovery. In January 2005, the ExxonMobil Hadrian well (Keathley Canyon Block 919) was also plugged and abandoned and is considered a dry hole (Figure 1).

There are two wildcats drilling in the trend that were likely completed by the end of April 2005. The Diamondback prospect is the first sub-salt wildcat in the PFB and is operated by BP (Figure 1). This well is evaluating a large anticlinal closure along the first and most distal fold axis of the PFB. BP also operates the Stones prospect that is drilling in Walker Ridge on an anticline located between the Chinook and St. Malo discoveries (Figure 1). It appears that this well could be another success as the operator was logging after cutting a conventional core.

To date, 13 prospects/ wildcats have been drilled in the Wilcox trend with nine discoveries, for a 69% success rate. Over 12 Bbbl oil in place have been discovered in the early stages of this emerging trend. There is considerable upside potential of up to 15 Bbbl recoverable oil reserves for this deepwater turbidite depositional system that covers over 34,000 mi^2 (54,740 km^2) in the Northwest GoM deepwater basin (Figure 11). However, most of the remaining play will be in the sub-salt environment, testing structures below the mobilized Louann salt canopies that range from 7000-ft to 20,000-ft (2134-m to 6098-m) thick, in water depths from 5000 ft to 10,000 ft (1524 m to 3049 m), and drill depths from 10,000 ft to 30,000 ft (3049 m to 9146 m) subsea.

Several inherent technical challenges need to be addressed to ensure economic feasibility of the Lower Tertiary Wilcox trend. These range from the cost-effective drilling of complex salt canopies and evaluating deep structural targets to the completion and production of reservoirs in water depths that have not occurred to date. Understanding the oil chemistry, reservoir quality and associated flow capability will determine the drilling/ completion technology, and ultimately the creation of infrastructure needed to transform the Lower Tertiary Wilcox into a world-class petroleum system in the deepwater GoM.

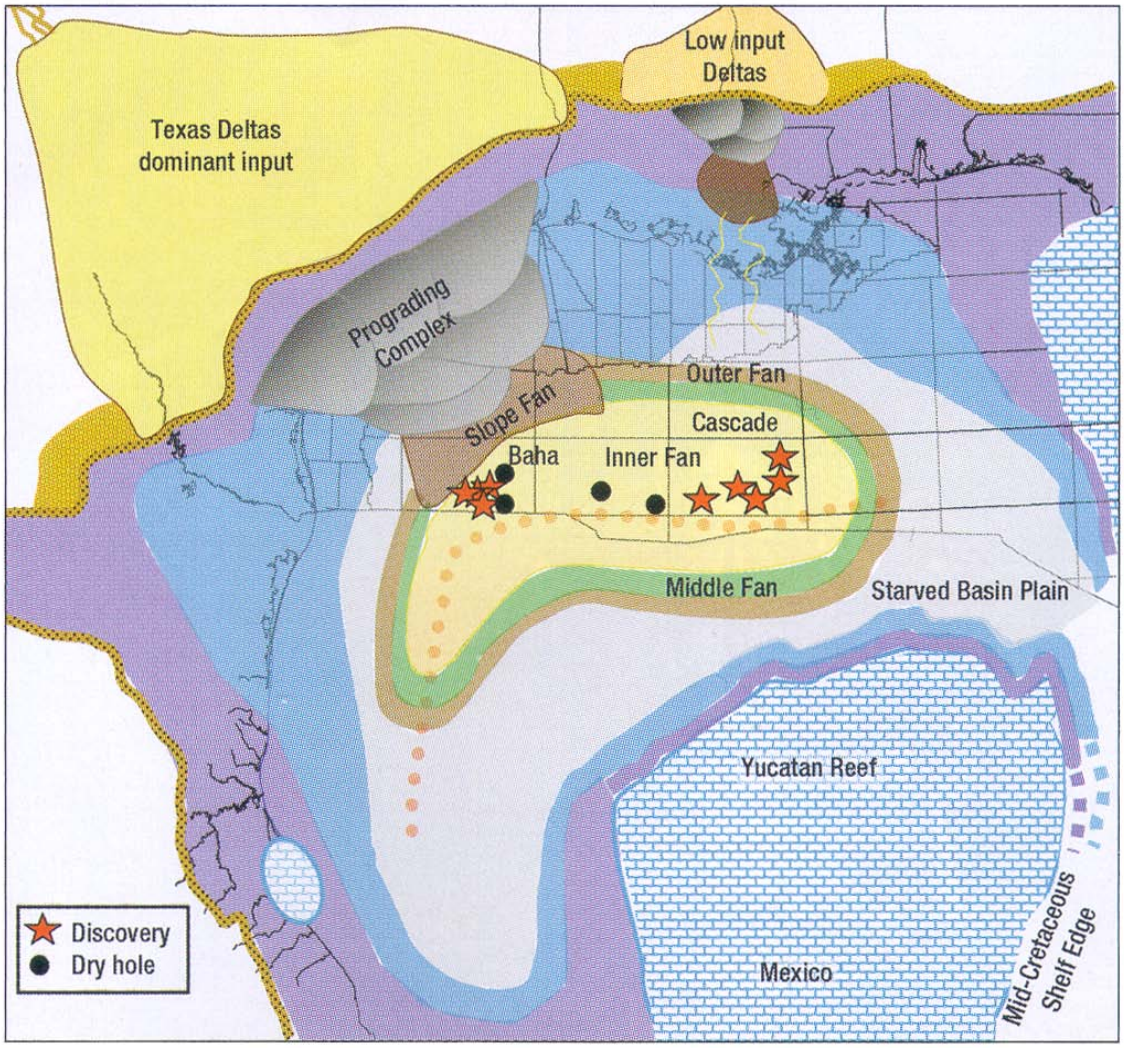

Figure 11. Schematic Wilcox depositional model with key trend wells.

Acknowledgment

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David Rains (drap@chevron.com**)** joined ChevronTexaco in August of 2001, where he was assigned to the GOM Deepwater Business Unit on the Western Trends Exploration Team. He received an MS in geology in 2001 from Texas A&M University and earned a BS in geology from Baylor University in 1998. As an exploration geologist, he has worked on the ground floor of the emerging Lower Tertiary Trend. He is currently subsurface coordinator for the Jack and St. Malo discoveries.

Bob Meltz graduated from Northern Illinois University with an MS in geology in 1982. In his 23 years' industry experience with Texaco and ChevronTexaco, he has worked in all the major northern GoM onshore and offshore trends, including ultra-deepwater exploration, and he is presently a development geologist at Typhoon field in the Green Canyon area.

Tom Hall has a BS in civil engineering (1977) and an MS in geology (1979), both from West Virginia University. He has worked for Chevron/ Texaco for 24 years and is presently a geologist assigned to the Deepwater Regional Team. He has been actively involved in deepwater Wilcox exploration for the past nine years.