[PS]Salt Geology and Hydrocarbon Plays in the Northeastern Gulf of Mexico*

Abu Chowdhury[1]

Search and Discovery Article #10215 (2009)
Posted November 10, 2009

*Adapted from poster presentation at AAPG Convention, Denver, Colorado, June 7-10, 2009. Please refer to closely related article by Abu Chowdhury and Laura Borton, 2007, Salt Geology and New Plays in Deep-Water Gulf of Mexico: Search and Discovery article #10132

[1]TGS-NOPEC Geophysical Company, Houston, TX (mailto:achowdhury@tgsnopec.com)

Abstract

In the Northeastern Gulf of Mexico offshore, two pre-stack depth migration projects were undertaken recently to better image the salt geology and new plays. The Phase 46 survey area covers the eastern Mississippi canyon, Main Pass and Viosca Knoll, and the western Destin Dome, Desoto Canyon and northern Lloyd Ridge. P-49 survey is an infill of P-46 in the Desoto Canyon and Lloyd Ridge. The surveys together comprise approximately 24,000 line miles of 2D seismic data. The surveys were pre-stack depth migrated and are currently being used for a deep-water interpretation project integrating approximately 1100 wells, including 300 biostratigrahic wells. The pre-stack depth migrated data identify major geologic sequence boundaries, associated depositional units, salt features and various hydrocarbon plays. The autochthonous Mid-Jurassic Louann (mother) salt, Upper Jurassic sediments and the overlying Tertiary sequences are well manifested in the data sets. In the Mississippi Canyon area to the west, the expanded Miocene play is characterized by broad rollover structures created by the loading of sediments, deflation and subsequent withdrawal of the mother salt. The Tertiary sections thin to the east as the basement ramps up towards the Florida Platform, at the expense of Cretaceous and Jurassic Rocks that constitute the potential plays associated with salt rollers and diapirs. The good imaging of the sedimentary section and folded structure helps delineate the Tertiary and Mesozoic plays in the survey area.

The pre-stack depth migrated data offers opportunities for conducting detailed exploration including finding new plays below the proven Miocene section in the Mississippi Canyon area. A new Wilcox play, the Wilcox Paleocene-Eocene play west of Mississippi Canyon is yet to be tested in the Mississippi Canyon. To the east, the Mesozoic Jurassic-Cretaceous plays have been tested by some wells. Further east, the shelf edge and carbonate platform areas offer opportunities for these plays as well as the carbonate and reef plays as an extension of the onshore plays, e.g. Jurassic/Cretaceous Norphlet, Smackover and Cotton Valley plays.

Introduction

Salt and sediment interactions play a major role in producing reservoir rocks and traps for hydrocarbon accumulation in the Gulf of Mexico (GOM). Advanced seismic technology, specifically pre-stack depth migration, and deep-water wells drilled recently have provided better understanding of salt geology and new plays for hydrocarbon accumulations.

The geology in the survey area (Figure 1) varies from the deepwater Miocene expanded sections tested by many wells in the eastern Mississsippi Canyon area to Mesozoic plays to the east as tested by only a few wells drilled. The southeastern part of the survey area in the eastern Gulf of Mexico remains to be tested.

The source rocks for the hydrocarbons in the Upper Jurassic, Cretaceous and Tertiary reservoirs in the eastern Gulf of Mexico is postulated to be Upper Jurassic Smackover lime mudstone (Mancini et al., 2008). The reservoir rocks are Upper Jurassic to Lower Cretaceous Norphlet, Smackover, Haynesville, Cotton Valley, Hosston, and James Limestone/Sligo. These are continental, coastal, shallow and deep marine sands, and nearshore, marine shelf, ramp carbonates and reef facies.

Data

Two seismic pre-stack depth migrated data sets (Figure 1) were used to better understand the salt and associated geology in the deepwater and the carbonate shelf areas. Phase 46 and phase 49, the regional 2D projects, integrated approximately 1100 wells, including 300 biostratigraphic wells, in the interpretation of salt, regional geology and hydrocarbon plays.

The data sets are described below:

Project	Size	Acquisition Direction	Cable Length	Data Length	Fold
P-46 2D	15,827 miles (2 miles x 2 miles)	Northwest-Southeast	8 km	14 seconds	106
P- 49 2D	7,644 miles (2 miles x 2 miles)	Northwest-Southeast	7.2-7.8 km	12.3 seconds	104

Methodology - Salt Interpretation and Pre-stack Depth Migration

The top and base of salt were mapped during the pre-stack depth migration process, which is outlined below:

1. Sediment velocity model created by converting PSTM velocities to depth and removing salt velocities.
2. Pre-processed gathers migrated with sediment velocity model.
3. Top of salt interpreted based on its seismic signature of high amplitude, low frequency reflections, and diagnostic reflection geometries.
4. Salt-flood velocity model created by overlaying the top of salt interpretation on the sediment velocity model and flooding the volume below the top of salt with salt velocity.
5. Pre-processed gathers migrated with salt-flood velocity model.
6. Base of salt interpreted.
7. Final velocity model created by overlaying the top and base of salt interpretations on the sediment velocity model and filling the body with salt velocity.
8. Final migration.
9. Post-processing.

To aid in picking top and base of salt, water bottom and top of salt multiples were calculated and mapped to discriminate primary salt reflections from multiple reflections. In addition, depth gathers were analyzed for flatness as a quality control.

Eight sequence boundaries, including the salt from the lower Pliocene down to the Mid- Jurassic, were also mapped to decipher the geology. The sequence boundaries were picked based on the integrated interpretation of biostratigrahic data, well log stacking patterns, and seismic reflection patterns.

Regional Geology

The survey area is characterized by allocthonous salt in the west in the eastern Mississippi Canyon deep water area (Figure 1). The allochthonous salt ranges from diapiric bodies to regional Roho salt structures to thin welds.

Many of these salt features are associated with a regional decollement surface. The thickness of the majority of these salt structures varies from 0.2 km to 3 kms, and the ratio of salt to sediment is approximately 30:70. Some salt bodies in Mississippi Canyon in Thunder Horse area (Figure 4) appear to be rooted and show thicknesses up to 8 km. Salt sediment interaction during the Miocene created folded and turtle structures where significant hydrocarbons have been trapped. The eastern part of the survey area ramps up toward the carbonate shelf margin and platform to the east. The salt bodies in the east are mostly autochthonous rooted diapirs and rollers. The salt-sediment ratio in the east is approximately 20:80. The salt bodies in the east are responsible for creating broad folded structures. The folded reservoir rocks are composed of Upper Jurassic and Cretaceous rocks underlain by low relief Louann Salt autochthons.

These geologic boundaries as shown on seismic sections (Figure 2, Figure 3) are abbreviated after their paleontological or formation associations. They represent geologic sections starting from Lower Pliocene (SA) down to Jurassic (JU). The seismic shows the carbonate platform, shelf edge and the deeper water geology from northeast to southwest. The salt varies from mostly autochthonous rollers and diapirs to allochthonous diapirs and canopies from northeast to southwest.

Hydrocarbon Plays

The geology presents a variety of hydrocarbon plays within the survey area (Figure 2, Figure 3, Figure 4). To the northwest in the Mississippi Canyon area significant amounts of hydrocarbon have been found in the expanded Miocene sections. The common plays are associated with turtle structures created by deflation and collapsing of sedimentary beds as salt withdrew (Figure 4). Other trapping structures are associated with folds with 3 to 4 way dips, salt flanks, and salt overhangs, salt mini basins and faults. Imaging of salt, faults and the associated geology offered by pre-stack depth migration enables proper evaluation of the prospects.

Mesozoic Jurassic-Cretaceous rocks are expanded to the east and attain significant thicknesses onto the carbonate platform. Figure 4 shows the recent Shell Vicksburg discovery well drilled to 25,000 ft, testing 300 ft of hydrocarbon in the upper Mesozoic folded sections of the Desoto Canyon area, east of Mississippi Canyon. The Shell Shiloh prospect shown on the seismic also shows the correlative upper Mesozoic folded structure.

The hydrocarbon plays further east have not been explored well. The potential plays are associated with the Mesozoic broad folded structures associated with autocthonous salt rollers in the carbonate shelf and platform areas. Significant hydrocarbon plays associated with reefs and back reefs are also expected (Figure 2).

Conclusions

In the Northeastern Gulf of Mexico, the pre-stack depth migrated data offers opportunities for identifying new plays: Wilcox Paleocene-Eocence play in the Mississippi Canyon, and Jurassic/Cretaceous Norphlet/SmackOver and Cotton Valley plays in the Destin Dome and Desoto Canyon areas.

Acknowledgements

The author thanks TGSNOPEC for allowing presentation of this paper. I am grateful to Ray Martin and Jack Baker, senior consultants and Charlotte le Roy for their help in the interpretation of the project.

Reference

E. Mancini, E.A. Mancini, J. Obid, M. Badali, K. Liu, and W.C. Parcell, 2008, Sequence-stratigraphic analysis of Jurassic and Cretaceous strata and petroleum exploration in the central and eastern Gulf coastal plain, United States, AAPG Bulletin, v. 92(12), p. 1655 - 1686.

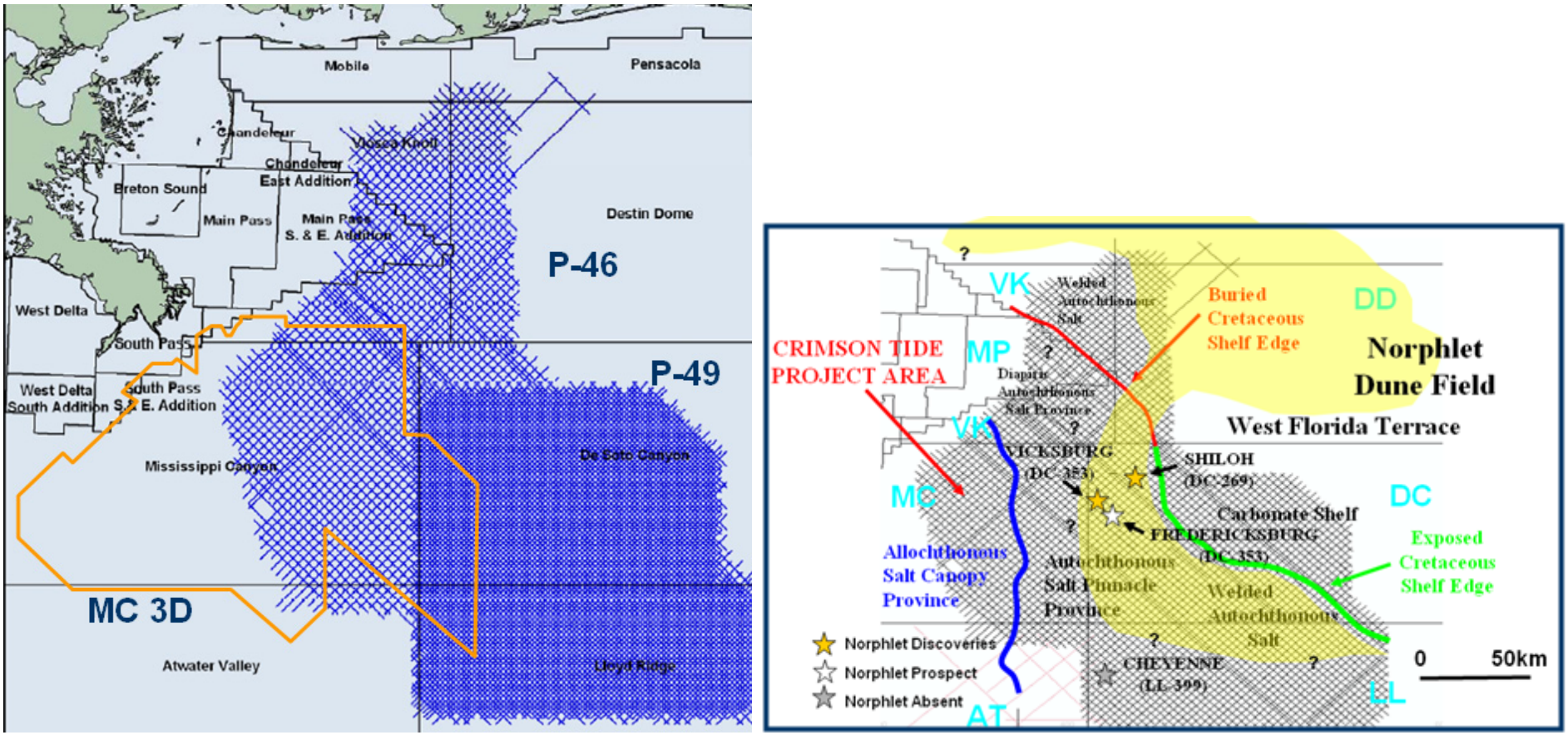

Figure 1. Map of study area seismic surveys and regional geology.

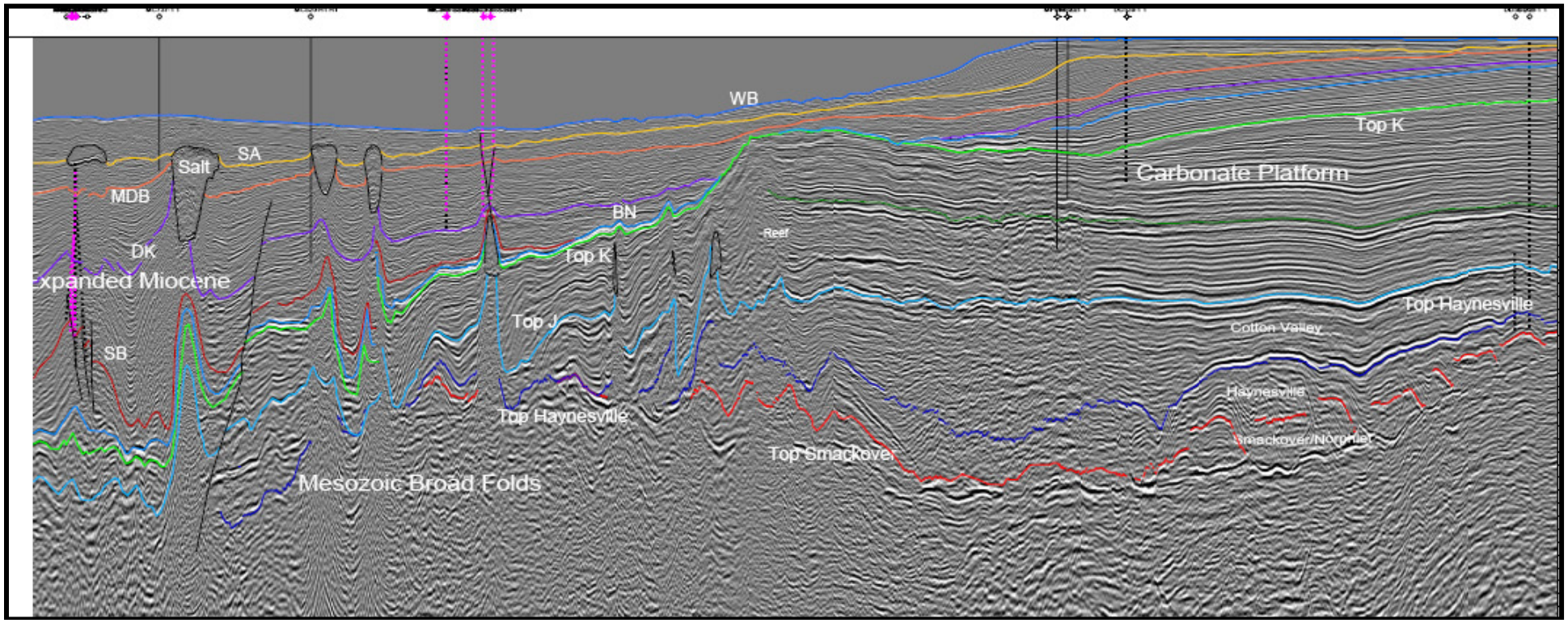

Figure 2. Pre-stack depth migrated seismic section showing the regional geology and wells. Destin Dome to Mississippi Canyon (right to left).

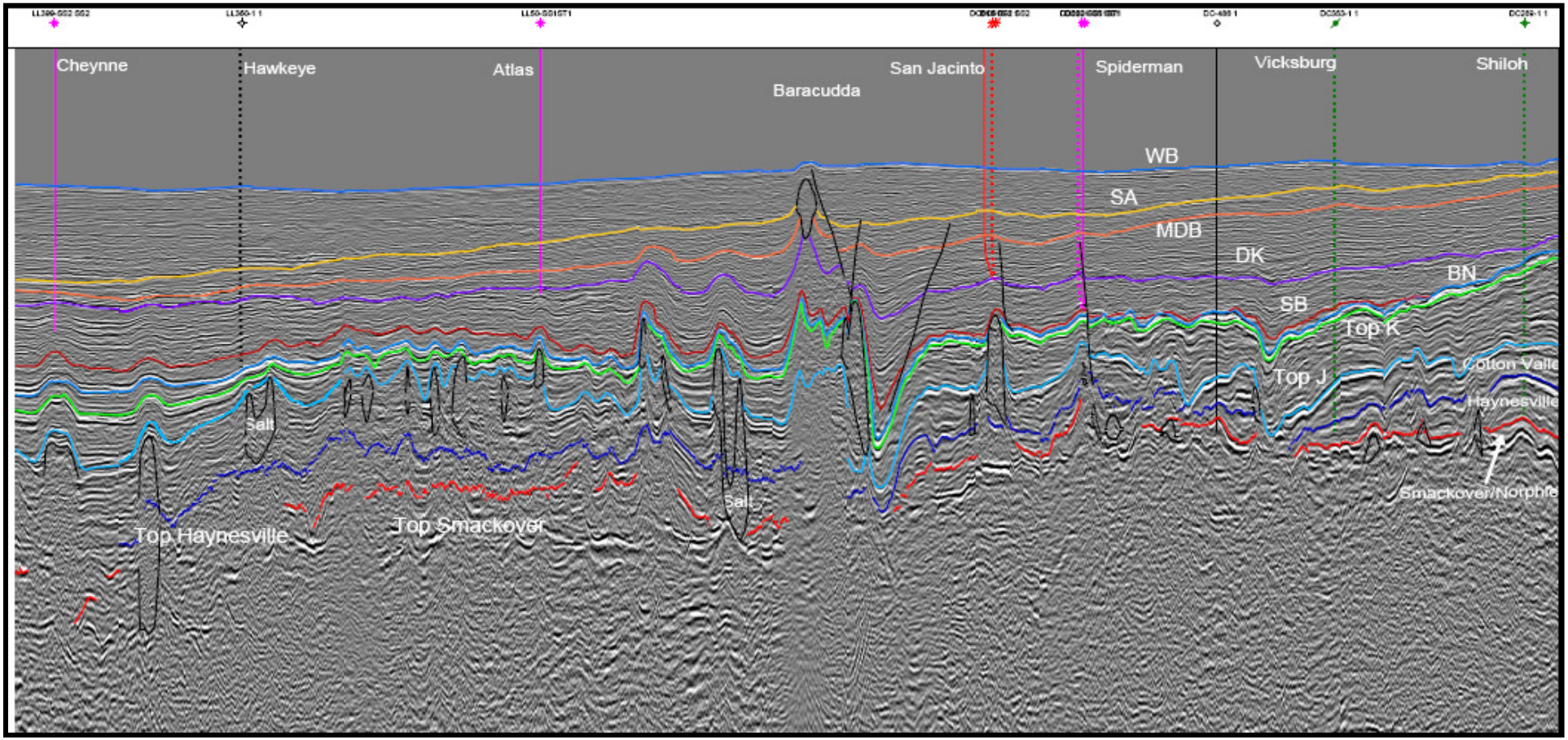

Figure 3. Pre-stack depth migrated seismic section showing the regional geology and hydrocarbon prospects. Desoto Canyon to Lloyd Ridge (right to left).

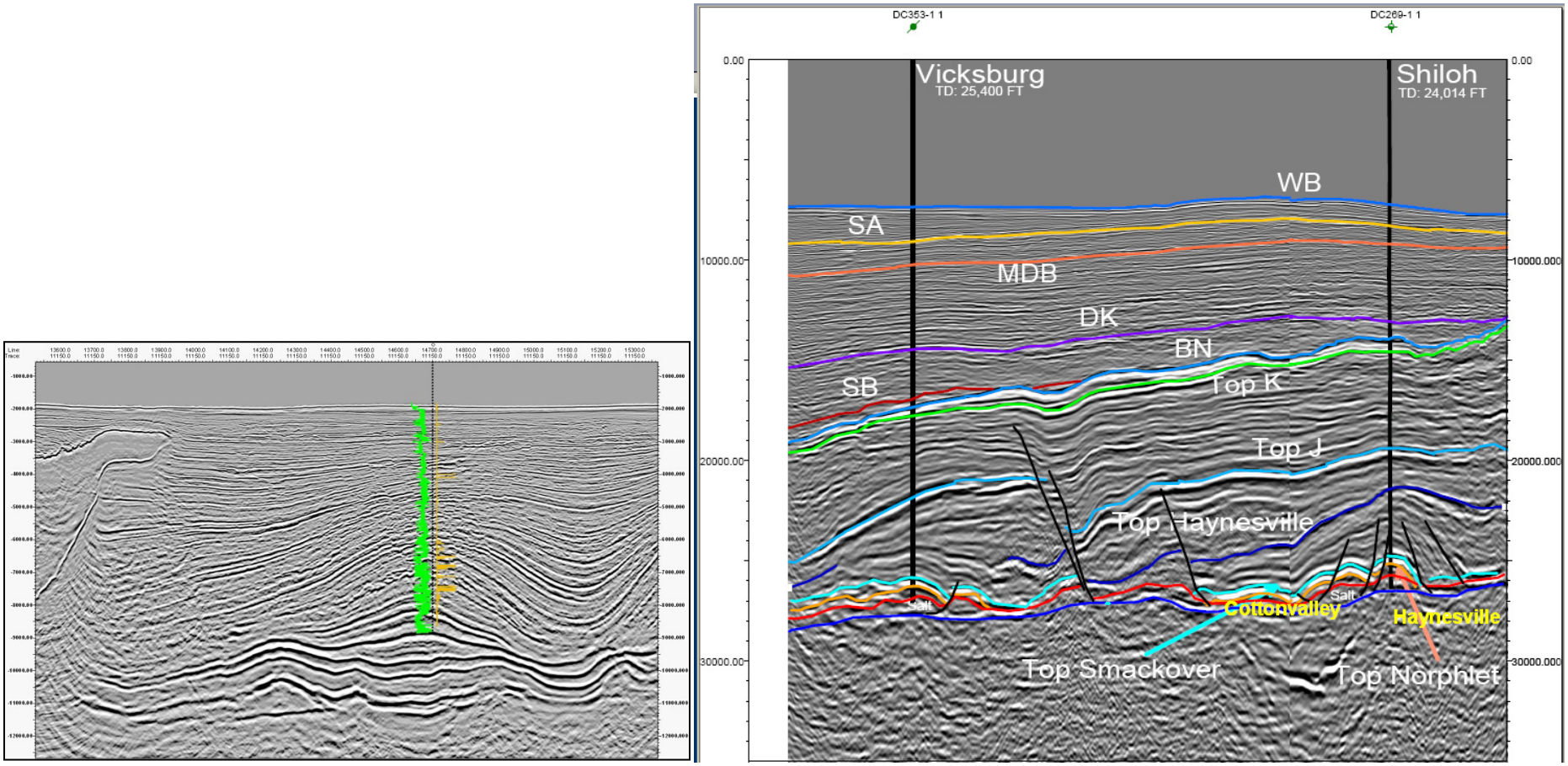

Figure 4. Thunder Horse in Mississippi Canyon, and Vicksburg and Shiloh Prospects in Desoto Canyon.