

# Salt geology and hydrocarbon plays in the northeastern Gulf of Mexico

Abu Chowdhury,\* TGS, Houston, describes the Crimson Tide depth migrated survey project initiated to provide a better understanding of salt tectonics and the associated accumulation of hydrocarbons in the northeastern Gulf of Mexico.

The source rock 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).

Basin analysis associated with a depth survey which overlaps the southern extent of the Crimson Tide survey shows that the Tertiary section may also act as a hydrocarbon source rock.

The potential and proven reservoir rocks include the Upper Jurassic to Lower Cretaceous Norphlet, Smackover, Haynesville, Cotton Valley, Hosston, and James Limestone/Sligo as well as Tertiary sands. These units comprise several depositional environments including continental, coastal, shallow and deep marine sands, nearshore, marine shelf, ramp carbonates, and reef facies.

### Data

The Phase 46 and Phase 49 TGS seismic surveys were combined and pre-stack depth migrated data to form the Crimson Tide PSDM survey (Figure 1). The survey data were used to better understand the salt and associated geology in the deepwater and carbonate shelf areas. A regional 2D interpretation project integrated approximately 1100 wells, including 300 wells with biostratigraphic data, to provide a

basis for the understanding of salt tectonics, regional geology, and hydrocarbon plays in this area.

The Phase 46 and Phase 49 data sets are described in the accompanying table:

Project	Size	Acquisition Direction	Cable Length	Data Length	Fold
P-46 2D	15,827 mi (2 mi x 2 mi)	Northwest-southeast	8 km	14 s	106
P-49 2D	7644 mi (2 mi x 2 mi)	Northwest-southeast	7.2-7.8 km	12.3 s	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 pre-stack time migration (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

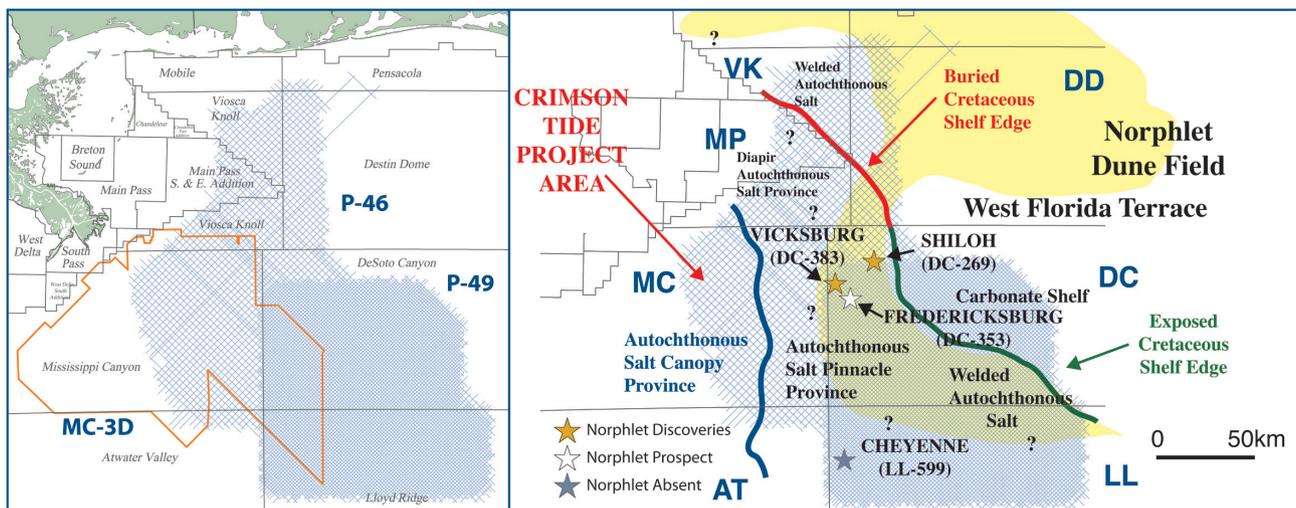


Figure 1 Map of study area seismic surveys and regional geology.

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4. Salt-flood velocity model created by overlaying the top of salt interpretation on the sediment velocity model and flooding the volume with salt velocity below the top of salt
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 from the lower Pliocene down to the Mid-Jurassic were mapped. The sequence boundaries were picked based on the integrated interpretation of biostratigraphic data, well log stacking patterns, and seismic reflection patterns.

## Regional geology

The western part of the survey area is characterized by allochthonous salt in the eastern Mississippi Canyon deepwater 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 3.0 km, and the ratio of salt to sediment is approximately 30:70. Some salt bodies in Mississippi Canyon in the Thunder Horse area appear to be rooted and show thickness 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 towards the carbonate shelf margin and platform to the east. The salt bodies in the east are mostly autochthonous or deep-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 structures.

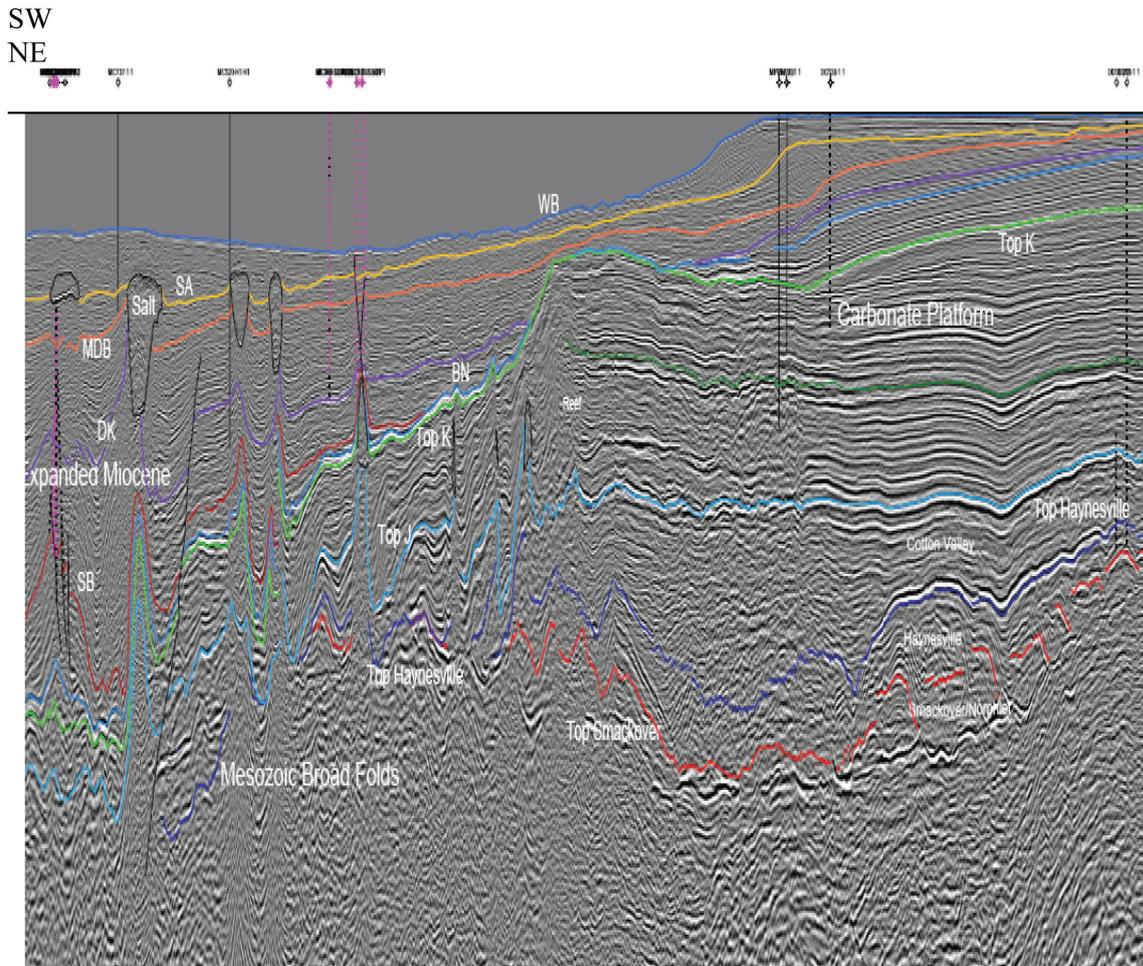


Figure 2 Pre-stack depth migrated seismic section showing the regional geology and wells - Destin Dome to Mississippi Canyon (right to left).

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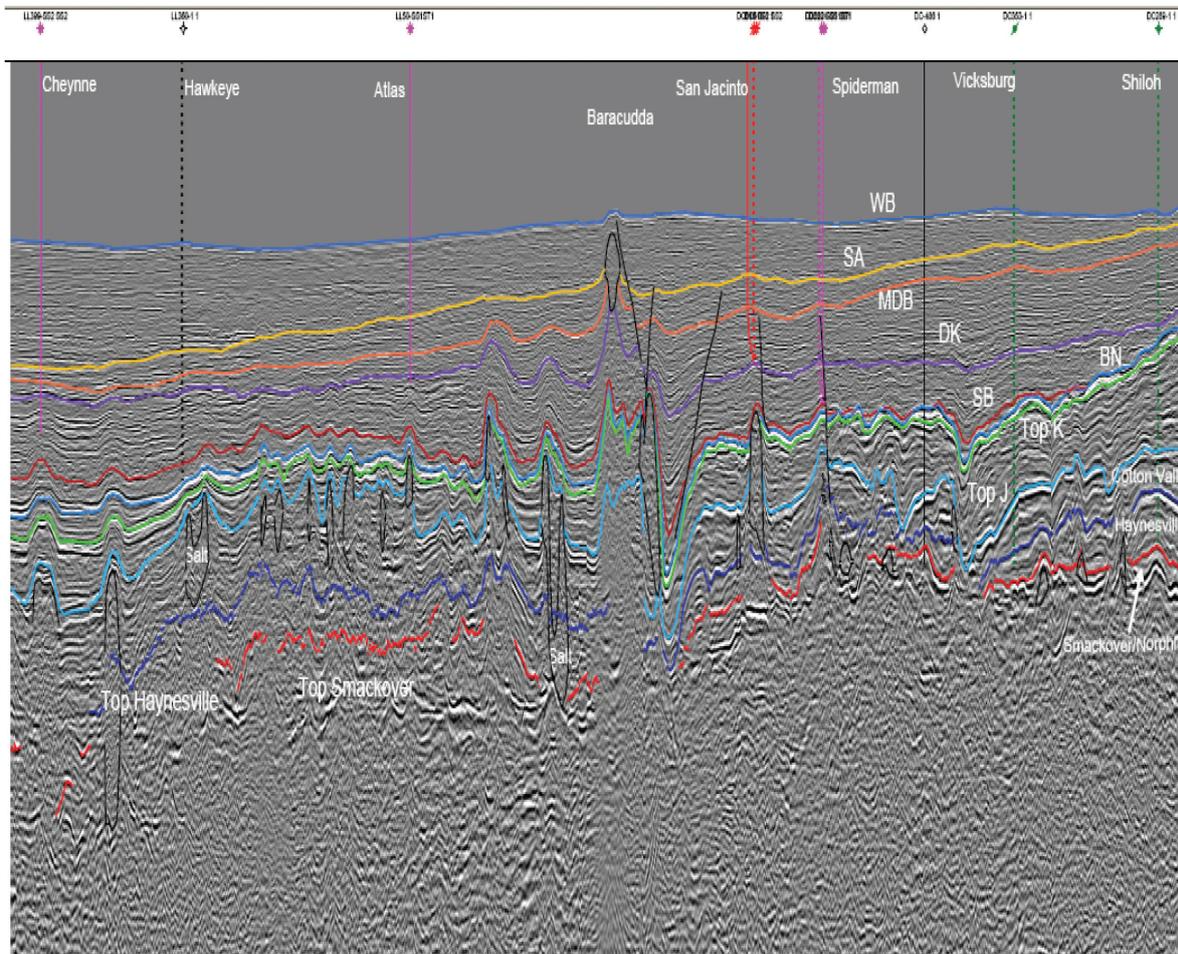


Figure 3 Pre-stack depth migrated seismic section showing the regional geology and hydrocarbon prospects – DeSoto Canyon to Lloyd Ridge (right to left).

These geologic boundaries as shown on seismic sections (Figures 2, 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 deeper water units 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 (Figures 2, 3, 4). To the northwest in the Mississippi Canyon area, significant amounts of hydrocarbons have been found in the expanded Miocene sections. The common plays are associated with turtle structures created by deflation and collapsing of strata as salt withdrew (Figure 4). Other trapping structures are associated with folds with three- to four-way dips, salt flanks, salt overhangs, salt mini-

basins and fault closures. Imaging of salt, faults, and the associated geology provided by pre-stack depth migration enable proper evaluation of the prospects and identification of potential hydrocarbon prospects.

Mesozoic Jurassic-Cretaceous rocks are expanded to the east and attain significant thicknesses on the carbonate platform. Figure 4 shows the Shell Vicksburg discovery well drilled down to 25,400 ft, testing 300 ft of hydrocarbon in the Jurassic folded sections in the DeSoto Canyon area, located east of Mississippi Canyon. The Shell Shilo prospect shown on the seismic has a correlative Jurassic folded structure.

The hydrocarbon plays further east have not been explored. The potential plays are associated with the Mesozoic broad folded structures related to the autochthonous salt rollers in the carbonate shelf and platform areas. Significant hydrocarbon plays associated with reefs and back reefs are possible in this area (Figure 2).

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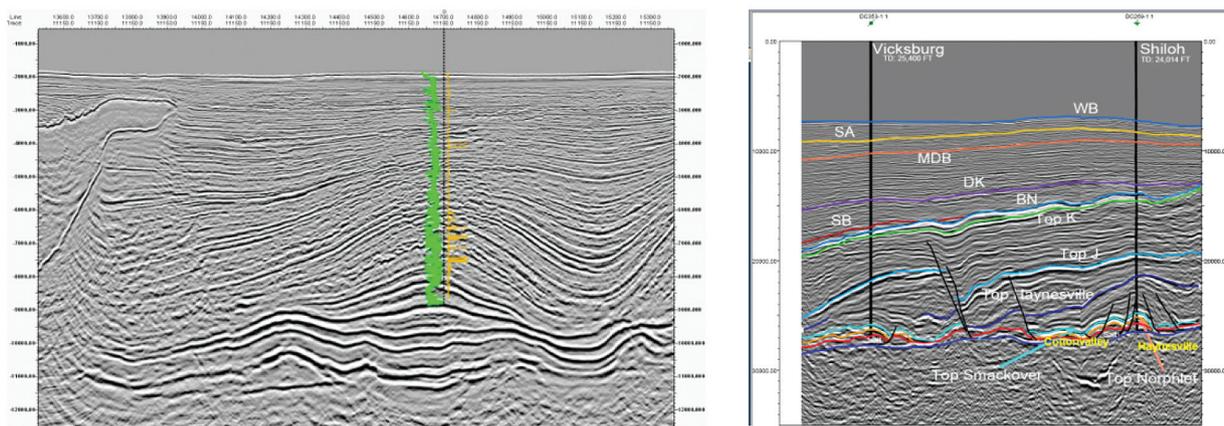


Figure 4 Thunder Horse in Mississippi Canyon (left) and Vicksburg and Shiloh Prospects in DeSoto Canyon.

### Conclusions

In the northeastern Gulf of Mexico, pre-stack depth migrated data offer opportunities for identifying new plays: the Wilcox Paleocene-Eocene play in Mississippi Canyon and Jurassic/Cretaceous Norphlet/SmackOver and Cotton Valley plays in the Destin dome and DeSoto Canyon areas.

### Acknowledgements

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### References

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