DOI:10.1190/segam2017-17744515.1

Horizon-based semblance picking tomography – A case study for velocity model building for Yucatan Platform depth imaging

Xinyi Sun, Guy Hilburn, Yang He and Vijay Singh, TGS*

Summary

We describe a special tomography workflow that has been implemented in our Yucatan Platform depth imaging 2D project in the Mexican GOM (MGOM). The workflow is designed for a very rugose water bottom like the Yucatan Platform and Escarpment area with very shallow water and very low S/N seismic data quality. It yields a geologically-conformed carbonate platform velocity model as well as a 3D structurally-consistent image quality. The workflow includes an initial model built in 3D, enhanced curvature-picking from a horizon-based semblance scan and a 3D consistent model update with tomography inversion.

Introduction

The Yucatan platform in MGOM is part of our regional seismic survey area (Figure 1), which extends from the Yucatan peninsula through the Campeche Escarpment to the abyssal seafloor. The Yucatan belongs to the Maya Block of the Central American region and is comprised of continental crystalline basement rocks overlain by carbonate-dominant Mesozoic and Cenozoic sediments. The highly karsted middle Cretaceous causes seismic reflected energy to be scattered and noisy. The upper Tertiary carbonates produce a very shallow section with restricted seismic reflection angles.

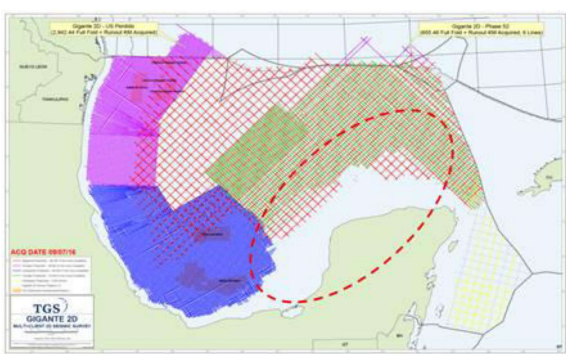

Figure 1: Seismic survey with Yucatan area circled.

Unlike the nonplatform deep water area where seismic data quality for normal semblance picking on migrated CDP gathers can easily produce reliable picking curvature for tomography inversion (Figure 2). The Escarpment area with its rugose water bottom creates strong off-plane reflection events. This requires the initial model to be 3D consistent in the tomography update. However, the Platform area with very shallow water and a very low S/N reflection energy allows too small a range of angle coverage and low coherency to support a sensible curvature-based tomography inversion. Therefore an enhanced tomography workflow, with horizon-based semblance picking, is developed to address these issues and is first successfully implemented in the Yucatan platform area of seismic depth imaging.

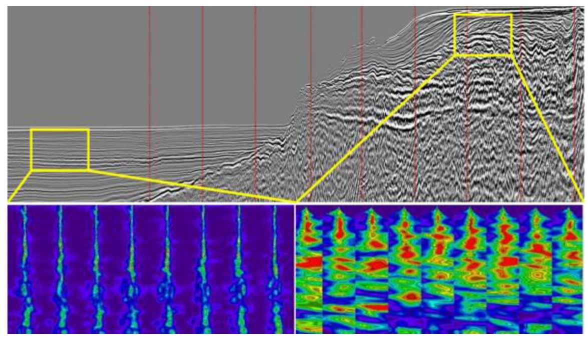

Figure 2: CDP semblance and image (above) from deep water good to platform bad data quality (below).

Methodology

The horizon-based semblance picking tomography workflow includes 3 key components:

- Initial model built with 3D water bottom to minimize off-plane issue in reflection energy content for migration model definition;
- Coherent curvature picking of migration gather semblance scan along horizons with a reliable horizon autopicking scheme;
- 3D consistent tomography inversion.

The requirement of an initial model built in 3D is ensure that inline and crossline models begin with a consistent water bottom. This may not be guaranteed if the water bottom is picked from early arrivals of each line's water flood migration. Stamping with a 3D consistent water layer for the initial PSDM model at this rugose water bottom area is the first step necessary for tomography to be successful in the sediment model update (Figure 3).

CDP-based curvature picking from scanned semblance on depth migration gathers is common practice for TTI-tomography (Yang et al., 2011) but this scheme can fail if the gather quality is too low to pick coherent events (Figure 2). Instead of picking curvature within a CDP gather, the horizon-based semblance selects events across all CDP gathers of the entire line and provides curvature picks only along coherent events. The first step in semblance-picking is horizon autopicking. To improve the image for horizon-based picking, we use an iterative image-guided, image-smoothing approach to create an enhanced image, modified from structurally consistent smoothing tools presented by Hale (2009). Horizons are picked from the enhanced image (Figure 4) to guide semblance picking and also to condition supergather formation for improved picking quality. Horizon-based semblance coherency is further enhanced by smoothing picked curvature values along horizons such that tomographic updates yield layer-conformed geological models.

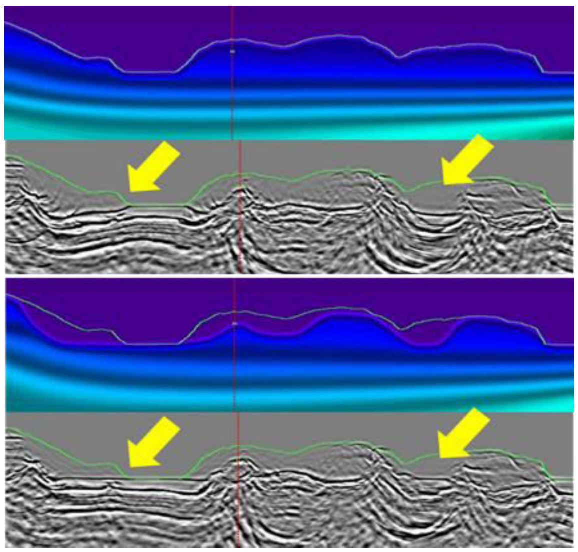

Figure 3: 2D model (above) vs. 3D model (below) image comparison due to water-bottom.

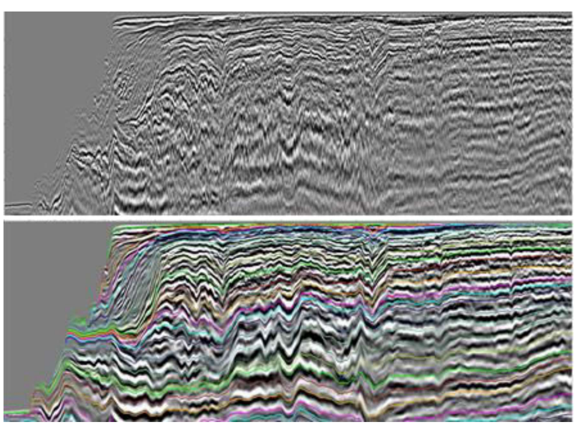

Figure 4: Raw image (above) vs. enhanced image for horizon picking (below).

Tomographic inversion from horizon-based semblance-picking provides a structure-constrained and 3D consistent migration model. The joint TTI-tomography inversion with image-guided regularization (Hilburn et al., 2014) and structure-conformed curvature picking from all lines produces an updated 3D model such that both image and model mis-tie are greatly reduced (Figure 5).

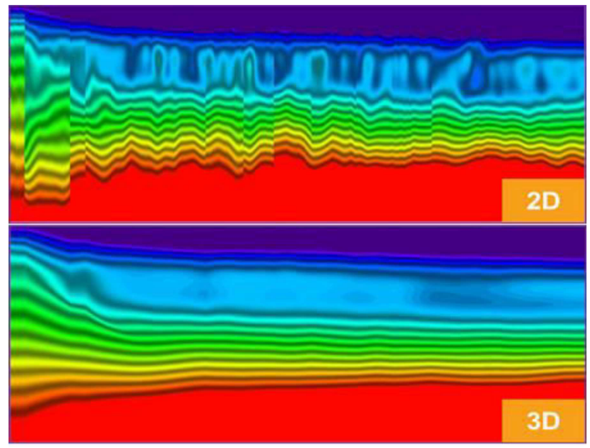

Figure 5: 2/3D model along arbitrary trajectory.

Data Examples

The circled area in Figure 1 indicates the area we address with our special workflow for this depth imaging project. Figure 2 shows a portion of a line's image from deep water, good quality data, to the Yucatan platform of unrecognized signals. This effect is also demonstrated by corresponding semblance scanned from CDP gathers. The expanded semblance shows difficulty in the platform area for a sensible model update as compared with deep water, a good data-quality area.

Figure 3 demonstrates how 2D and 3D water bottoms impact the initial model build. Migration with the water-layer stamped with a 3D water bottom produces a correct migration image below the water-bottom reflection while a 2D water bottom yields incorrect structure. The depths from our 3D multibeam water-bottom survey are incorporated in the 3D water bottom model build.

Figure 4 shows the raw and enhanced image comparison that is used for horizon-picking, overlaid with picking horizons. The reliable horizons picked from this robust image enhancement approach will be used to scan for semblance and pick curvature for tomography inversion. These horizons are also useful in tomography inversion regularization and model smoothing to produce a layer-conformed geological model for migration.

Figure 5 is a comparison of our model-building approach between 2D and 3D along an arbitrary trajectory through many 2D lines. The 3D model from the workflow is a by-product of this 2D survey and will be used for a final image redepth of all lines for a consistent geologic interpretation (Whiteside et al., 2013).

Figures 6 and 7 show model and migration image comparisons between 2D models, built with CDP-based semblance picking tomography, and 3D models, built with horizon-based semblance picking tomography. The migration image quality and geological structure are significantly improved with the new workflow. The migration model also benefits from the new flow due to the 3D initial model and horizon-guided model updates.

Conclusions

We successfully develop and implement a special model-building workflow in our Yucatan platform area of a 2D depth imaging project with horizon-based semblance picking tomography. It addresses the 2D and 3D issue in depth imaging in a similar area with a rugose water bottom, very shallow reflections and highly scattered noise. The final depth imaging and migration model from horizon-based semblance picking tomography produces the best geologically-conformed velocity and structure-conformed image quality.

Acknowledgments

The authors would like to thank TGS for the permission to present this work, the Imaging department and its staff for processing and our R&D department for tool development and support on this project. We also thank James Keay for providing geological background of this area and special thanks to Connie VanSchuyver for editing and reviewing the manuscript.

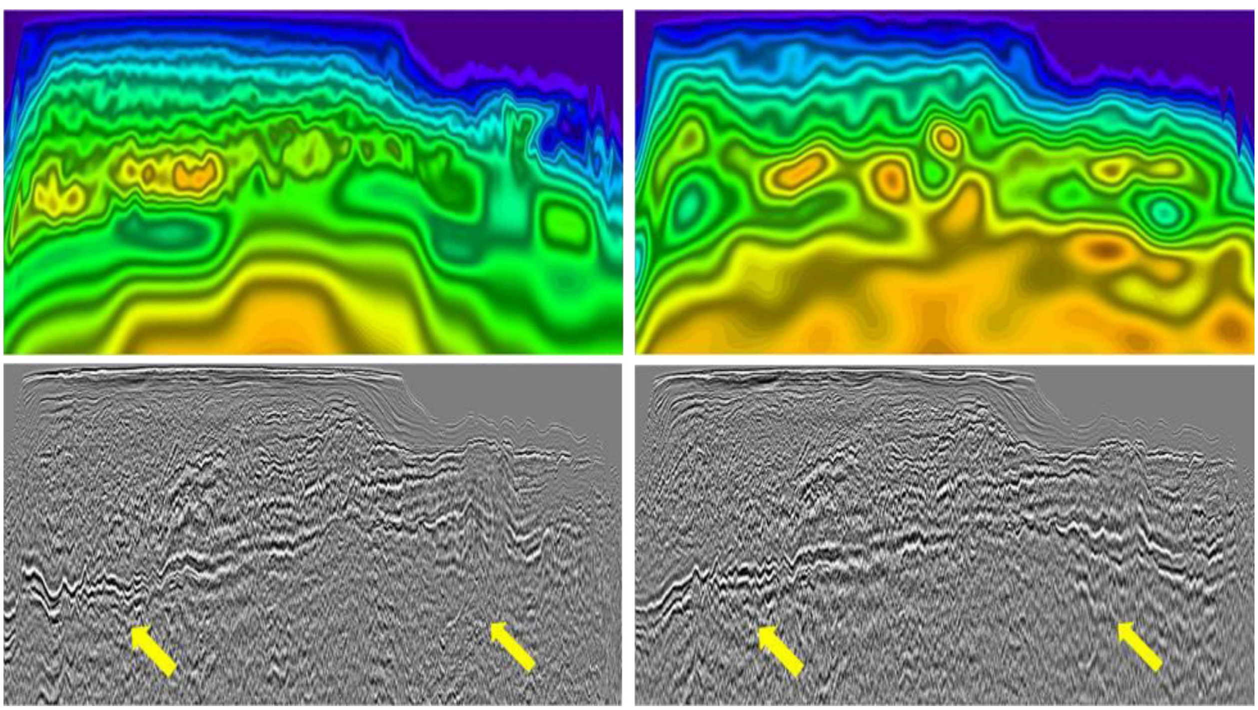

Figure 6: Model and image comparison with CDP-based (above) vs. horizon-based (below) semblance picking tomography (L245).

EDITED REFERENCES

Note: This reference list is a copyedited version of the reference list submitted by the author. Reference lists for the 2017 SEG Technical Program Expanded Abstracts have been copyedited so that references provided with the online metadata for each paper will achieve a high degree of linking to cited sources that appear on the Web.

REFERENCES

Advocate, D. M., and K. C. Hood, 1993, An empirical time-depth model for calculating water depth, northwest Gulf of Mexico: Geo-Marine Letters, **13**, 207–211, http://dx.doi.org/10.1007/BF01207749.

Hale, D., 2009, Structure-oriented smoothing and semblance: CWP Report 635, Colorado School of Mines, 261–270.

He, Y., and J. Cai, 2011, Anisotropic tomography for TTI and VTI media: 81st Annual International Meeting, SEG, Expanded Abstracts, 3923–3927, http://dx.doi.org/10.1190/1.3628025.

Hilburn, G., Y. He, Z. Yan, and F. Sherrill, 2014, High-resolution tomographic inversion with image-guided preconditioning and offset-dependent picking: 84th Annual International Meeting, SEG, Expanded Abstracts, 4768–4772, http://dx.doi.org/10.1190/segam2014-1219.1.

Whiteside, W., B. Wang, H. Bondeson, and Z. Li, 2013, 3D imaging from 2D seismic data, an enhanced methodology: 83rd Annual International Meeting, SEG, Expanded Abstracts, 3618–3622, http://dx.doi.org/10.1190/segam2013-1148.1.