Structural Styles of Eocene Jackson and Oligocene Vicksburg Formations within the Rio Grande and Houston Embayments near the San Marcos Arch, Refugio and Calhoun Counties, South Texas Gulf Coast

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ABSTRACT

This paper presents structural styles associated with Eocene Jackson and Oligocene Vicksburg formations in the vicinity of the San Marcos Arch within the Rio Grande and Houston embayments of the South Texas Gulf Coast. Previous studies that focused on the Rio Grande Embayment documented structural styles that include coast-perpendicular faults, diapiric shale, and subbasins.

Present work involves mapping the structural styles in the Houston Embayment and comparing the deformation pattern in both basins using 3D seismic data from four different surveys. Two of the seismic surveys (surveys #1 and #2) are located in Refugio County in the Rio Grande Embayment. The other two are located in the Houston Embayment—one (survey #3) within Calhoun County, and the other (survey #4) straddling Calhoun and Jackson counties and Matagorda Bay. Methods of investigation consist of seismic interpretation, 3D visualization, and seismic-attribute extraction.

Our investigation shows that although the studied areas within the Rio Grande and Houston embayments are separated by ~40–55 km (~25–34 mi), and although both basins have been affected by extensional tectonic forces, deformational patterns of strata on either side of the San Marcos Arch are different. In the Rio Grande Embayment, in addition to coast-parallel synthetic and antithetic faults, structural styles also include a northwest-southeast-trending curvilinear anticline, and prominent coast-orthogonal faults and shale ridges. However, in the Houston Embayment, the dominant structural style consists of coast-parallel synthetic growth faults and shale diapirs.

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Structural Styles of Eocene-Jackson and Oligocene-Vicksburg Formations within the Rio Grande and Houston Embayments near the San Marcos Arch, in Refugio and Calhoun Counties, South Texas Gulf Coast

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Objective

- Previous work by Ogiesoba and Hernandez (2015) showed that in addition to the synthetic and antithetic growth faults, the dominant structural features in the Rio Grande in the vicinity of the San Marcos Arch are coast-orthogonal shale ridges, sub-basins, and coast-orthogonal faults.

- Our current work builds on Ogiesoba and Hernandez (2015) work by extending the previous interpretation into the Victoria County and the Houston Embayment in the vicinity of the San Marcos Arch.

- Our objective is to determine the similarity between the deformational pattern in the Vicksburg Formation within the Rio Grande and the Houston Embayments in the vicinity of the San Marcos Arch.

Overview

- Review of previous work in the area
- Present work: Location of study area and database
- Interpretation method
- Results
- Summary and Conclusions

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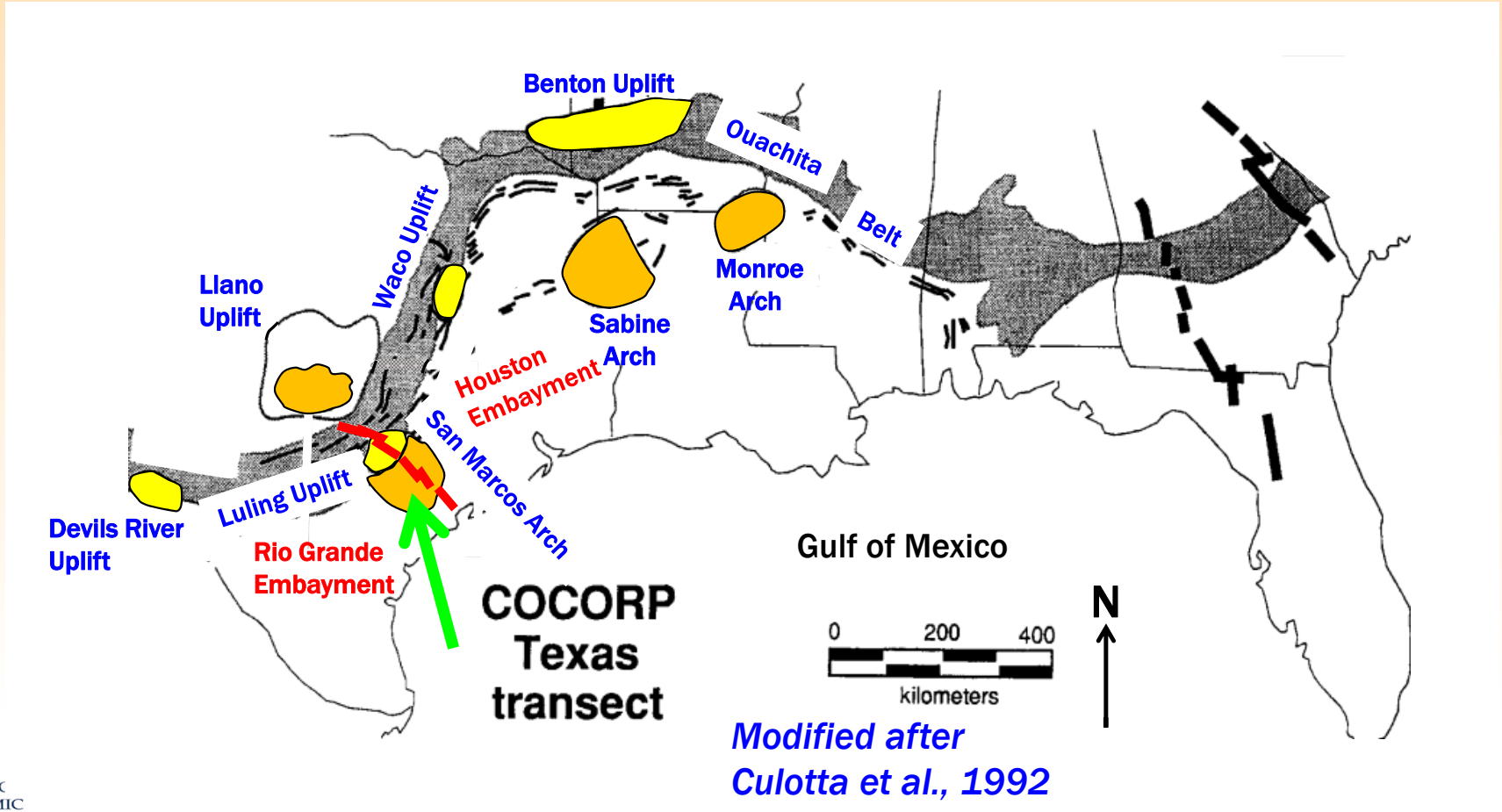
Previous Work: San Marcos Arch, Rio Grande, and Houston Embayments

- 1. Culotta et al. (1992), published results of the COCORP (Consortium for Continental Reflection Profiling) San Marcos Arch survey—a single 2D seismic line, composed of 3 segments and covering a distance of 250 kilometers from Port Lavaca on the central Texas coast to the southeastern side of the Llano Uplift.

- 2. Coleman and Galloway (1990), discussed oil and gas fields within the Vicksburg Formation in the Rio Grande and Houston Embayments and in the vicinity of the San Marcos Arch.

- 3. Ogiesoba and Hernandez (2015), discussed coast-orthogonal shale ridges and sub-basins in the Rio Grande Embayment in the vicinity of the San Marcos Arch axis.

Previous work: Culotta et al., 1992–COCORP San Marcos Arch Survey



Modified after Culotta et al., 1992

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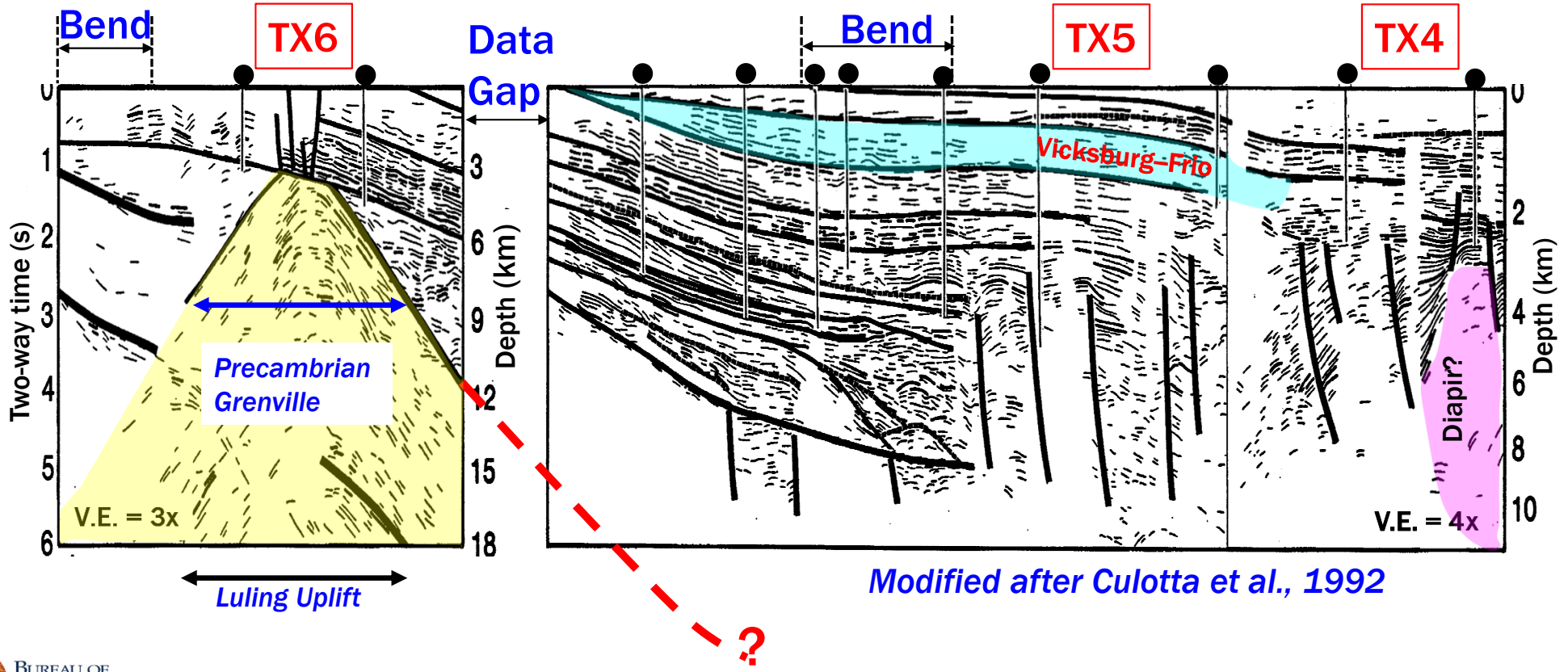
Previous work: Culotta et al., 1992--COCORP Line TX6



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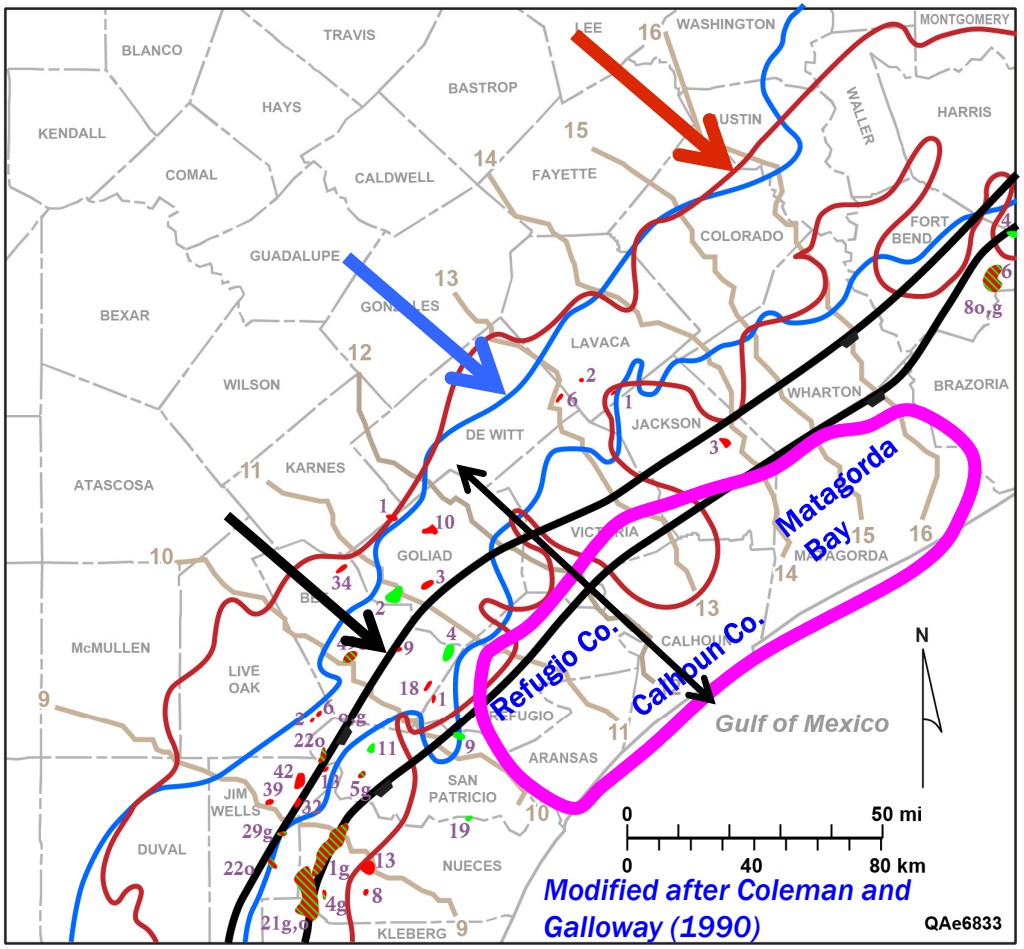
Previous work: Coleman and Galloway (1990)



Gas field
Oil field
Oil and gas field
Upper Vicksburg production
Lower Vicksburg production
Seismic line
42 Field location number
g > 1,000,000 MCFG cumulative production
o > 1,000,000 MCFG cumulative production

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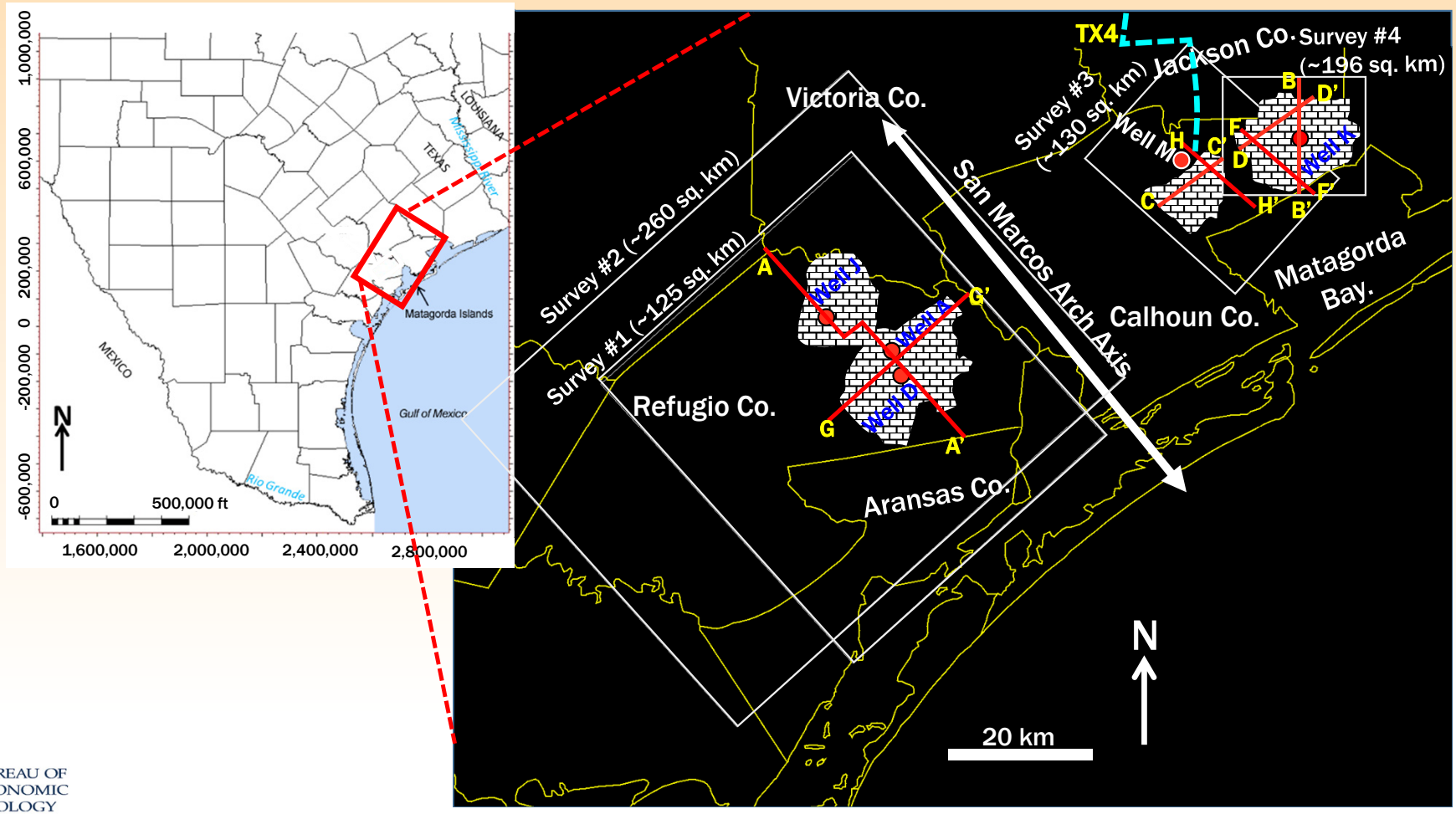
Present Work: Study Area and Database



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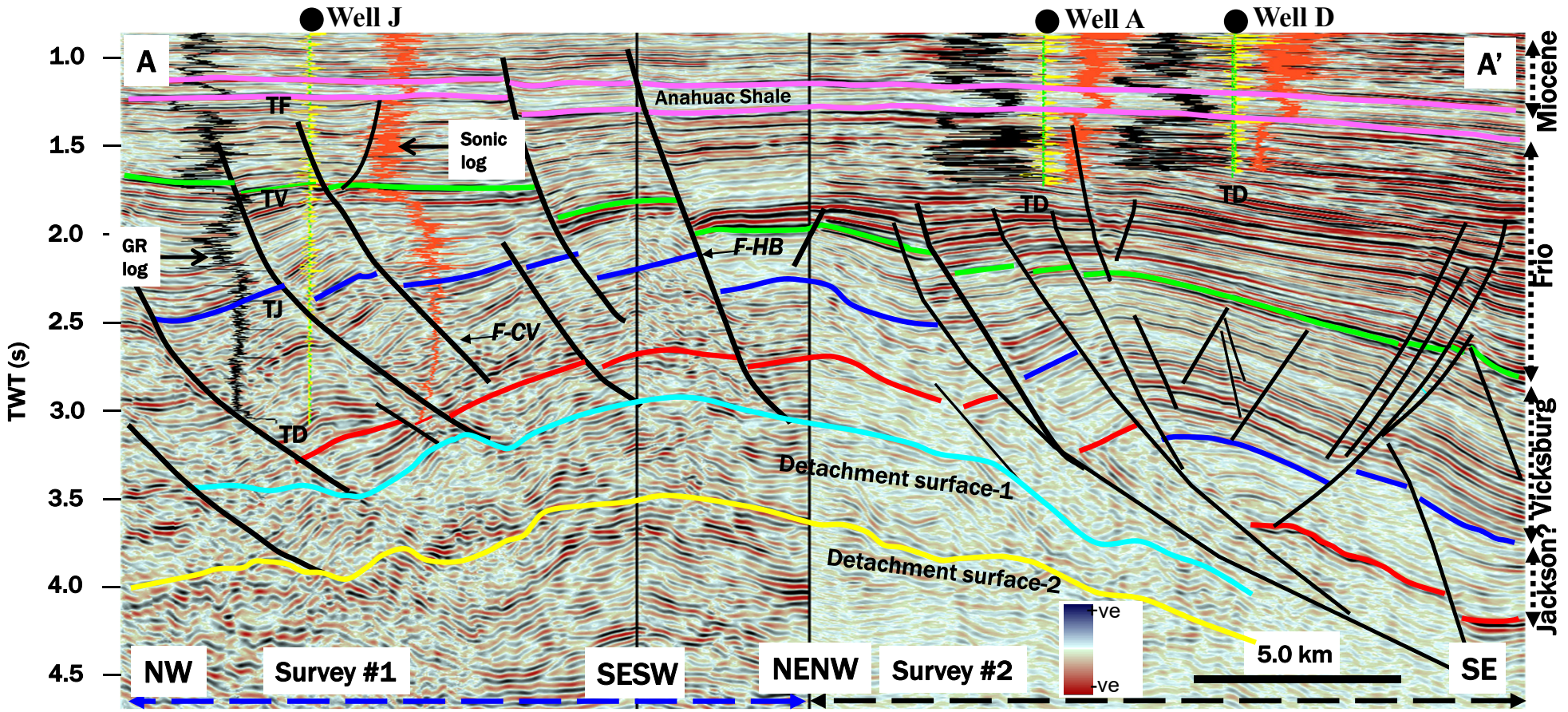
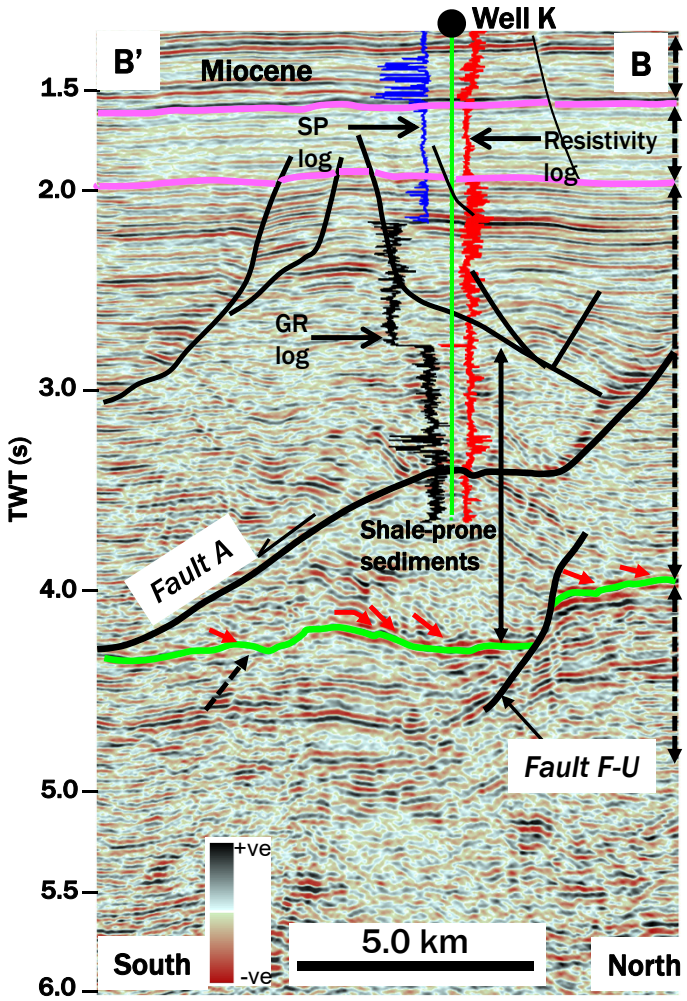
Present Work: Interpretation Method

- Perform well-to-seismic tie and identify key stratigraphic horizons
- Track horizons using auto-dip mode where data quality is good; and point-to-point mode where data quality is fair to poor
- In surveys #3 and #4 where drilled wells did not penetrate the Vicksburg Formation, top Vicksburg is recognized by identifying the first major unconformity surface below Frio Formation onto which lower Frio strata downlap—by employing seismic stratigraphic principles
- Use 3D visualization tool to display mapped horizons in 3D and observe shale ridges and valleys

Seismic Interpretation Results



Seismic Interpretation Results



Well K Total Depth (TD):

~14,780 feet (~4,500 m)

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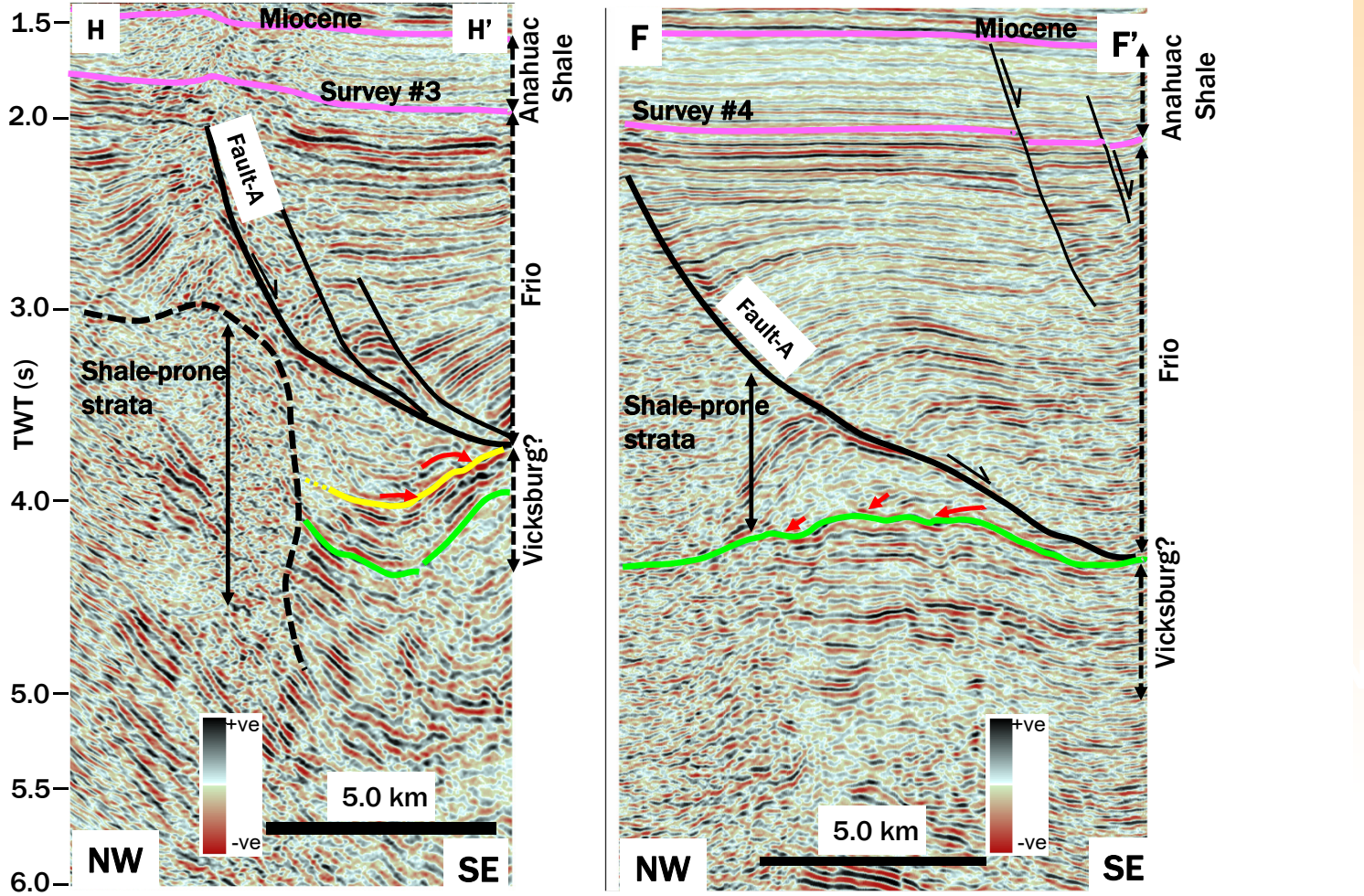
Seismic Interpretation Results



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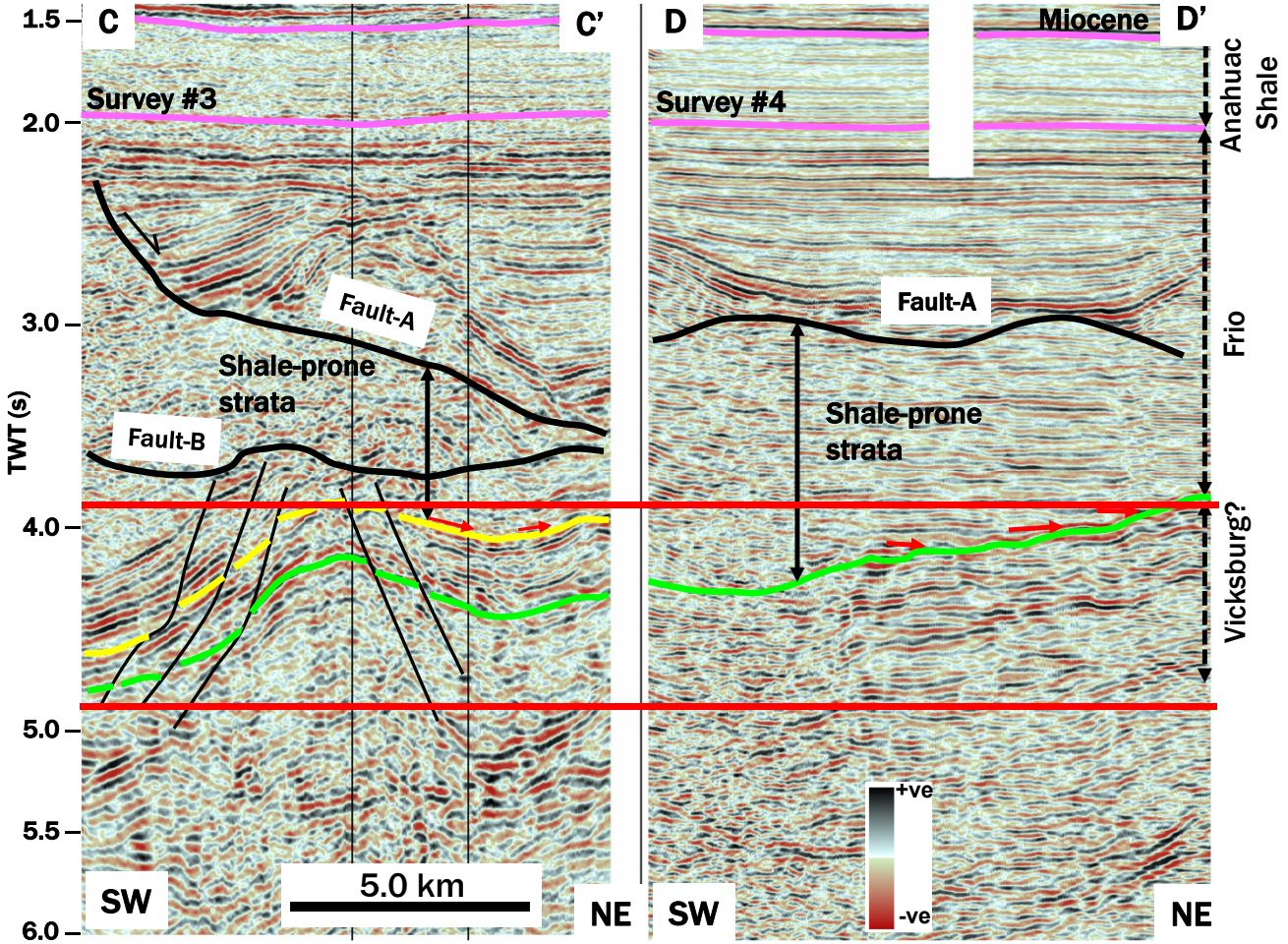
Seismic Interpretation Results



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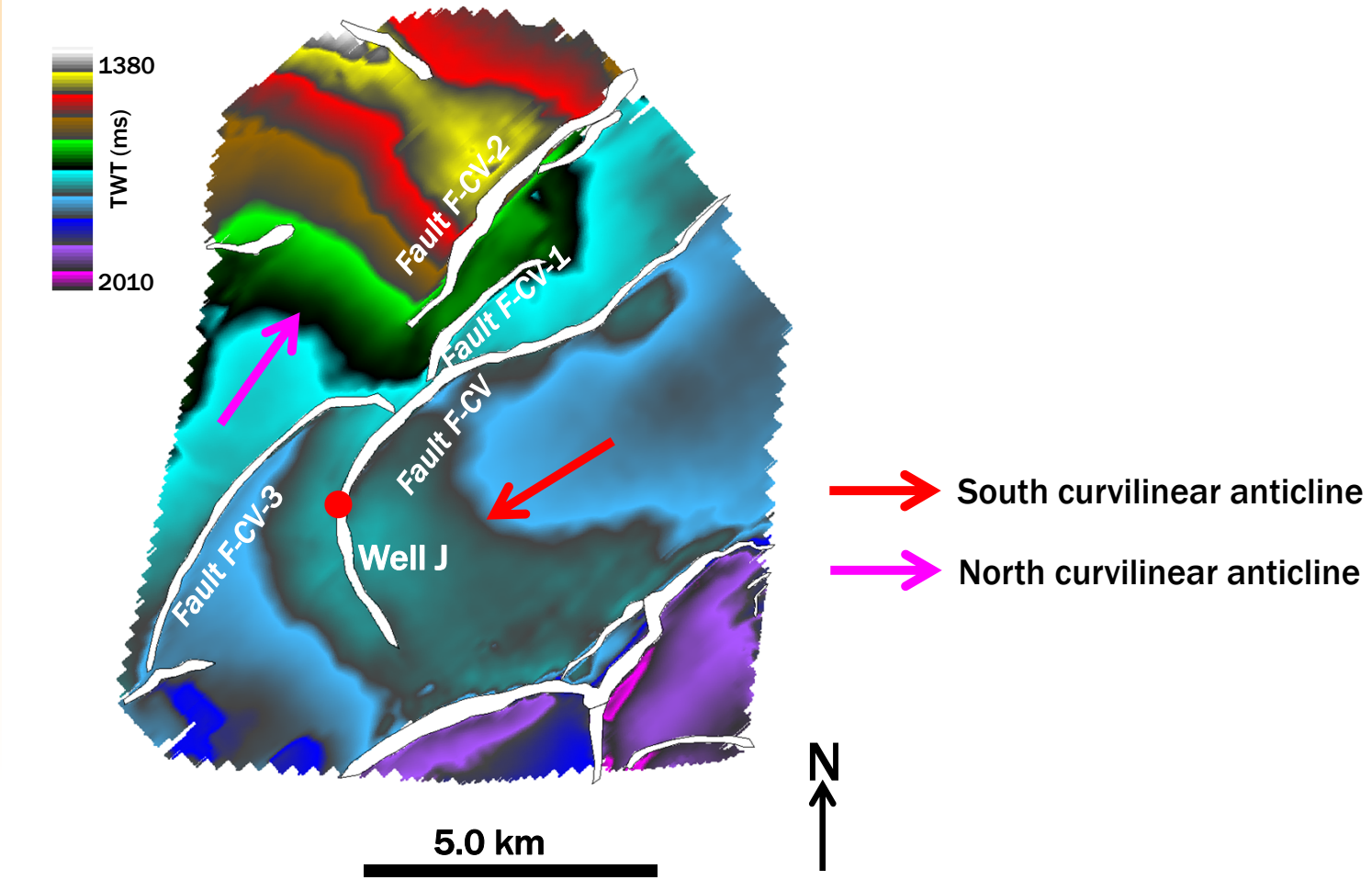
Results: Map at Top Vicksburg in survey #1



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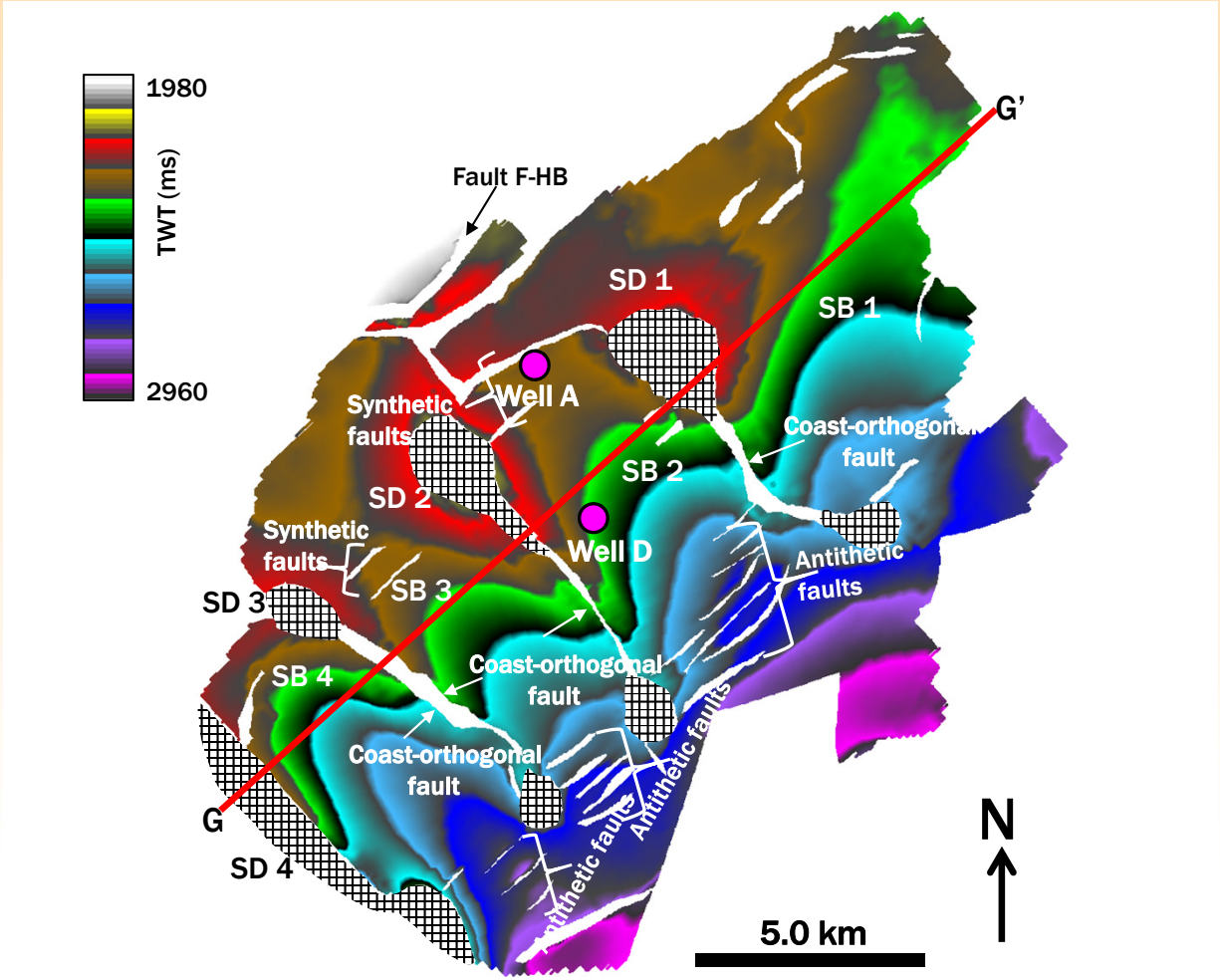
Results: Map at Top Vicksburg in survey #2



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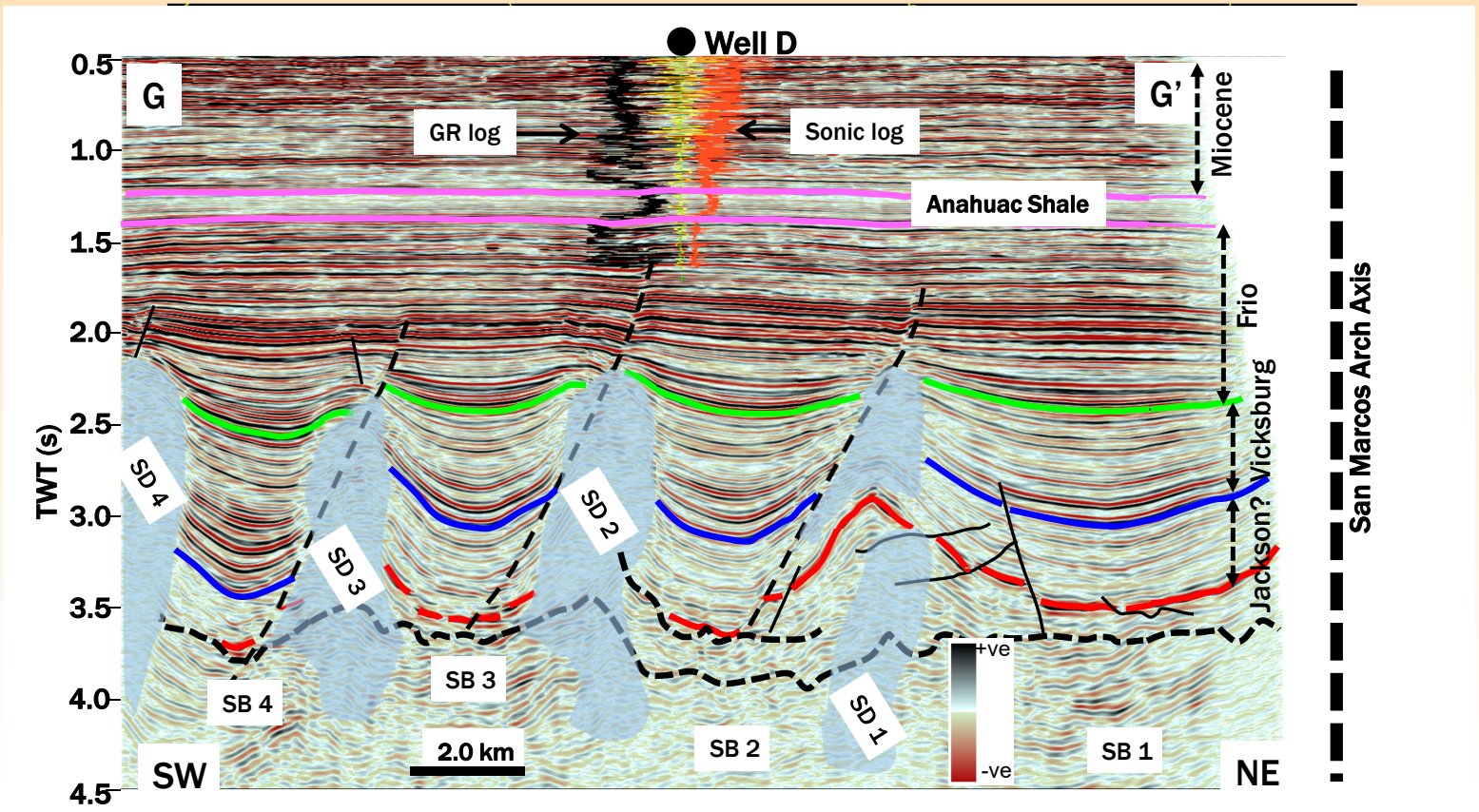
Seismic Interpretation Results: Cross Section Line G—G’



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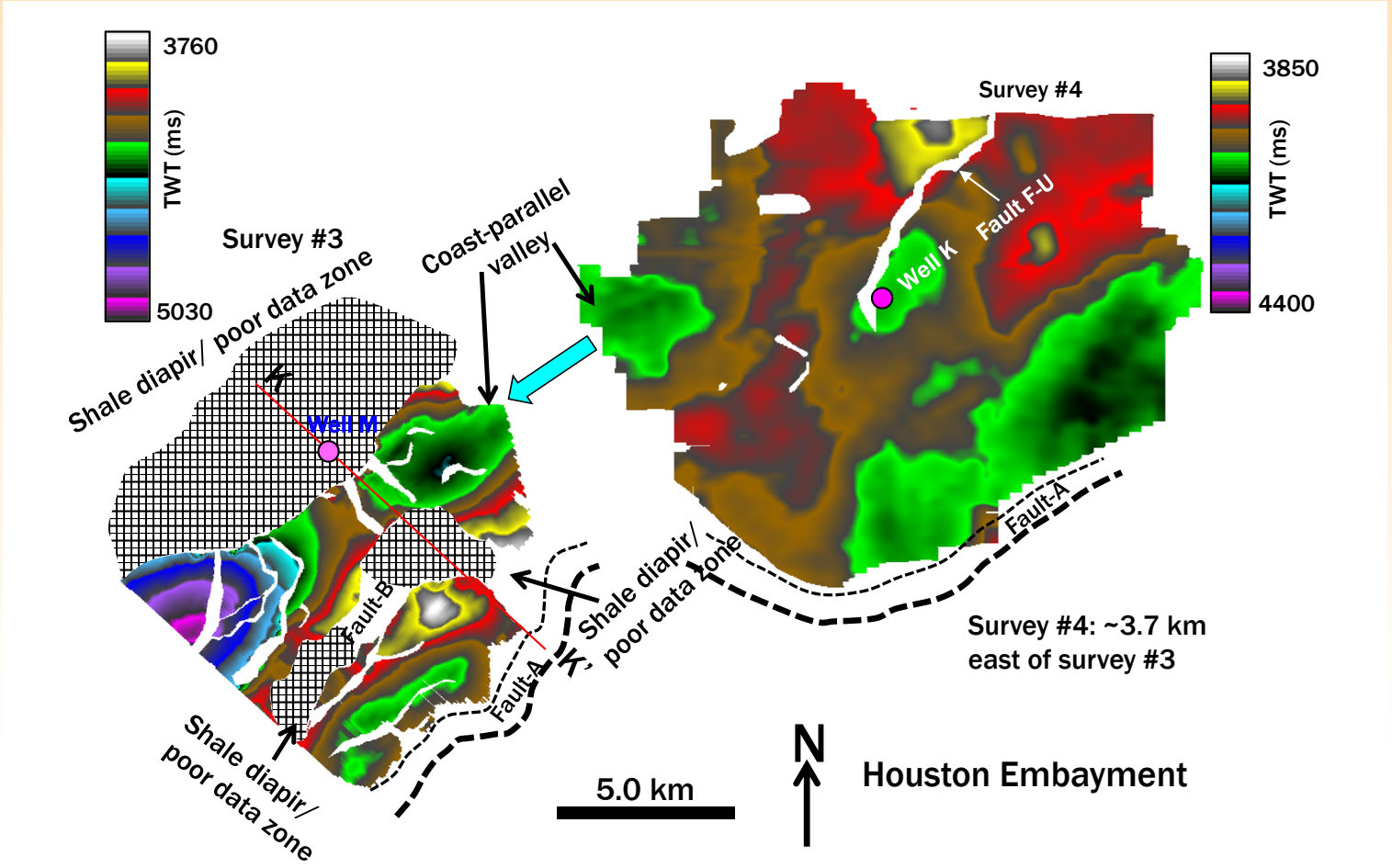
Results: Map at Top Vicksburg in surveys #3 and #4



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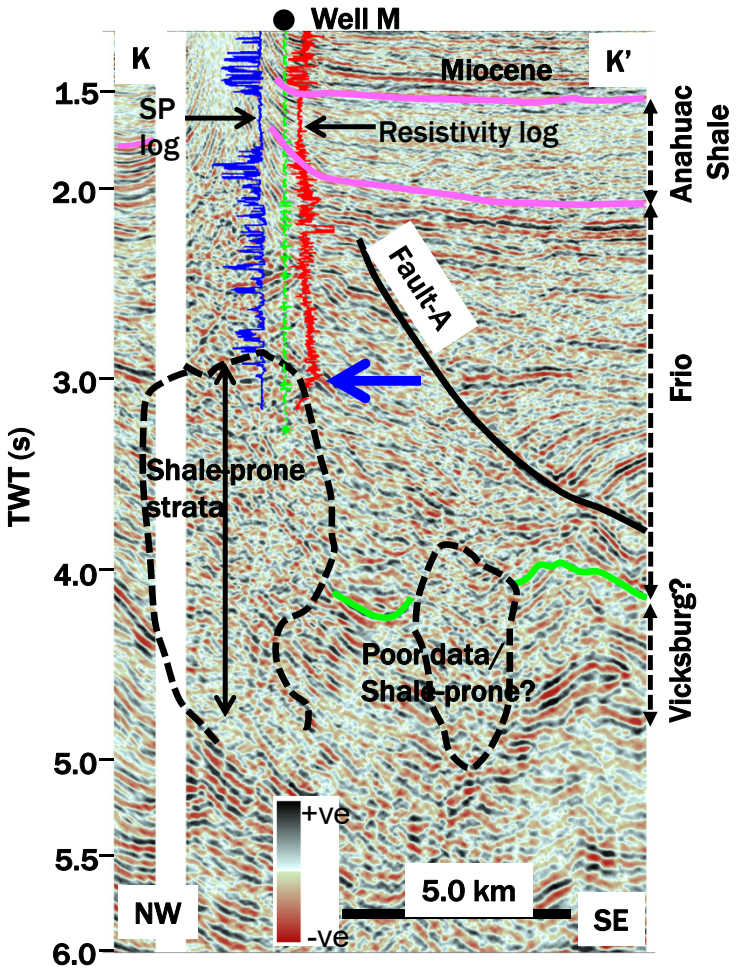
Seismic Interpretation Results: Cross Section Line K—K’



Well Total Depth (TD) ~13,300 feet (~4,050 m)

From Blue Arrow to TD, Shale zone is ~750 feet (~230 m)

Resistivity dropped rapidly to ~ 0 (OHMM)

Conductivity increased to maximum ~ 2000 (MMHO)

Suggesting overpressured shale

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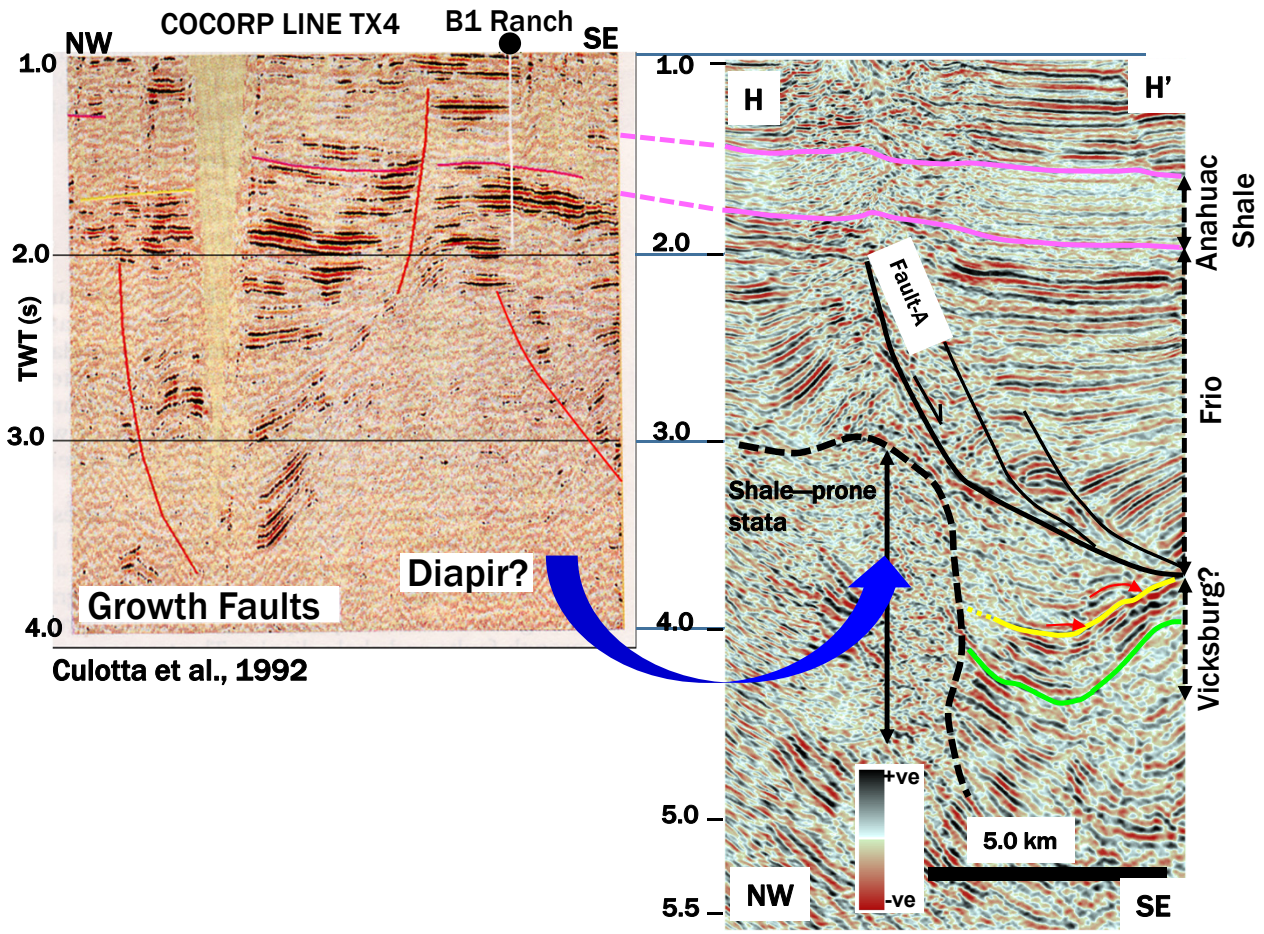
Results: Comparison of COCORP TX4 and Seismic Line H–H’



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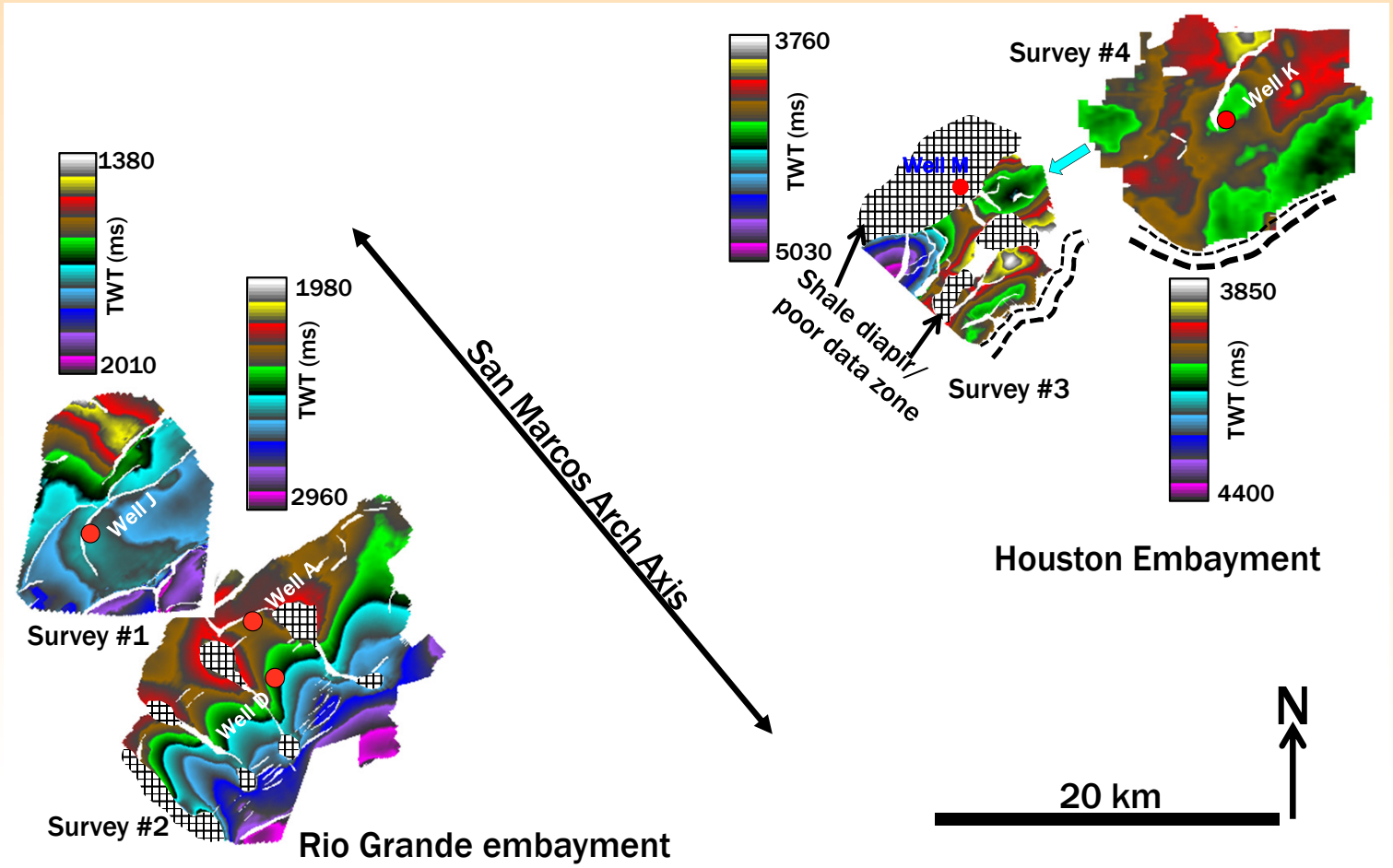
Results: Map at Top Vicksburg in surveys #1 through #4



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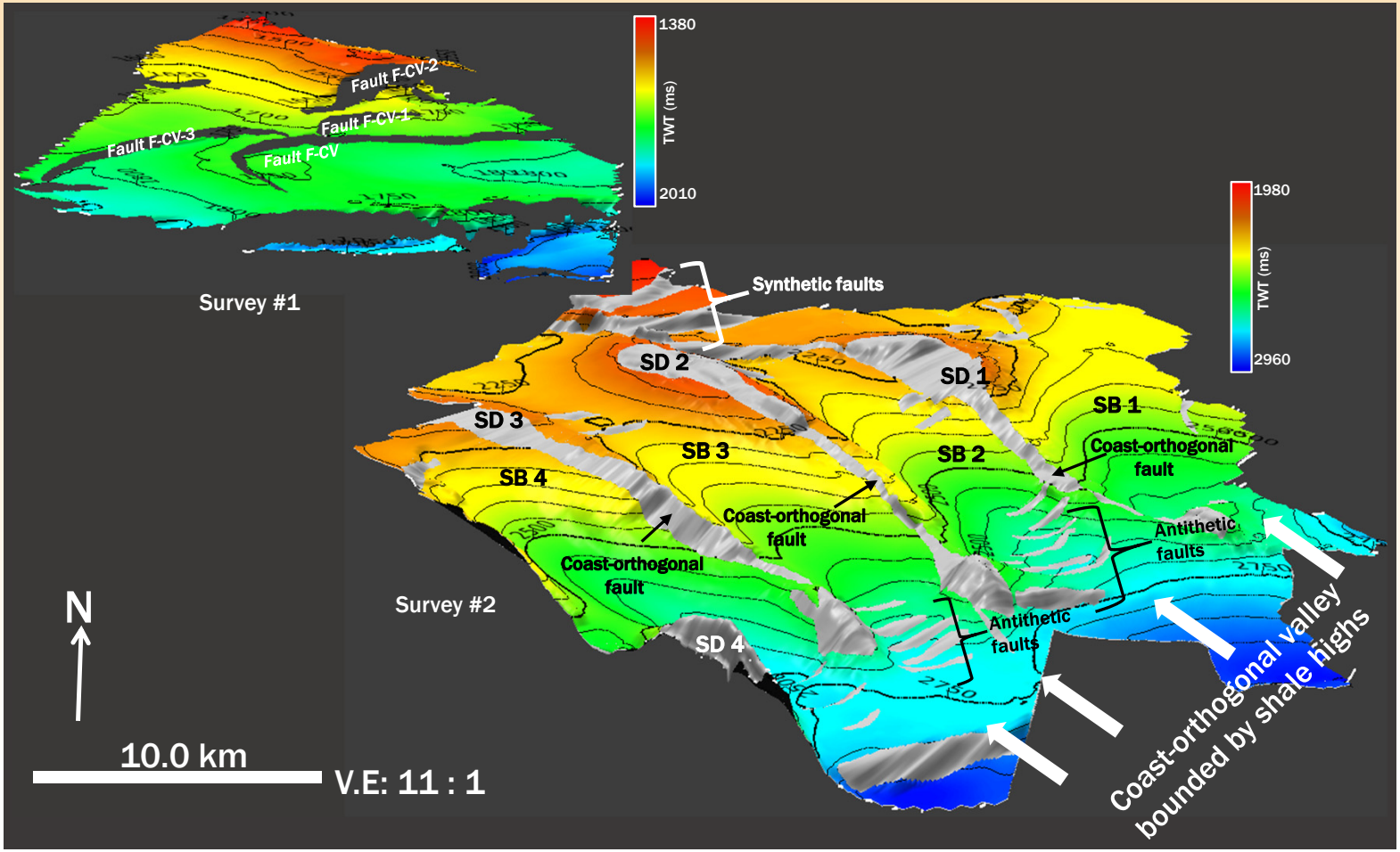
3D Display of Map at Top Vicksburg in Surveys 1 & 2



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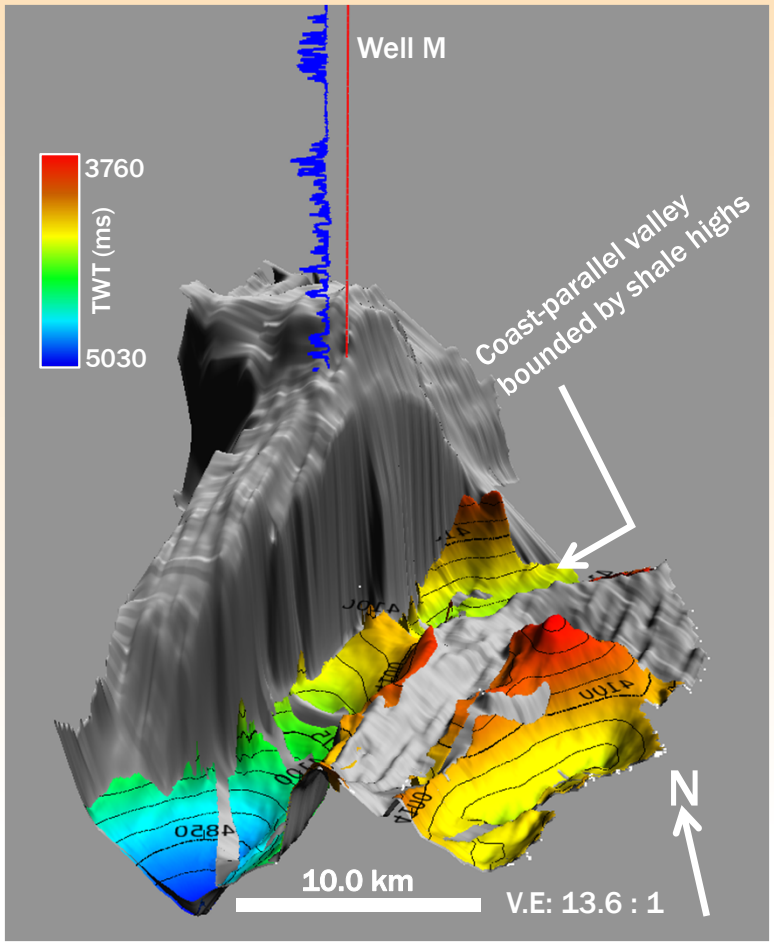
3D Display of Map at Top Vicksburg in Survey 3



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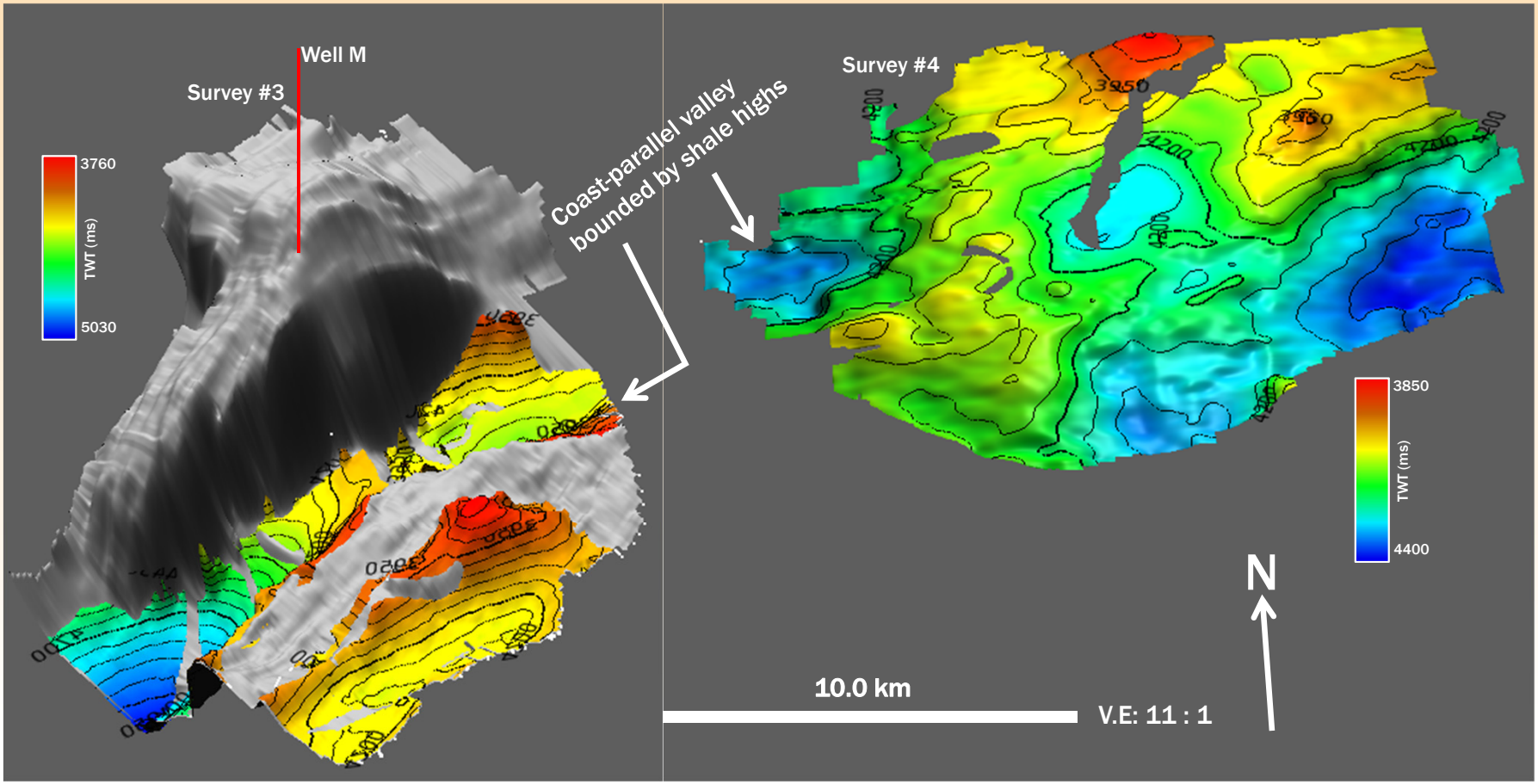
3D Display of Map at Top Vicksburg in Surveys 3 & 4



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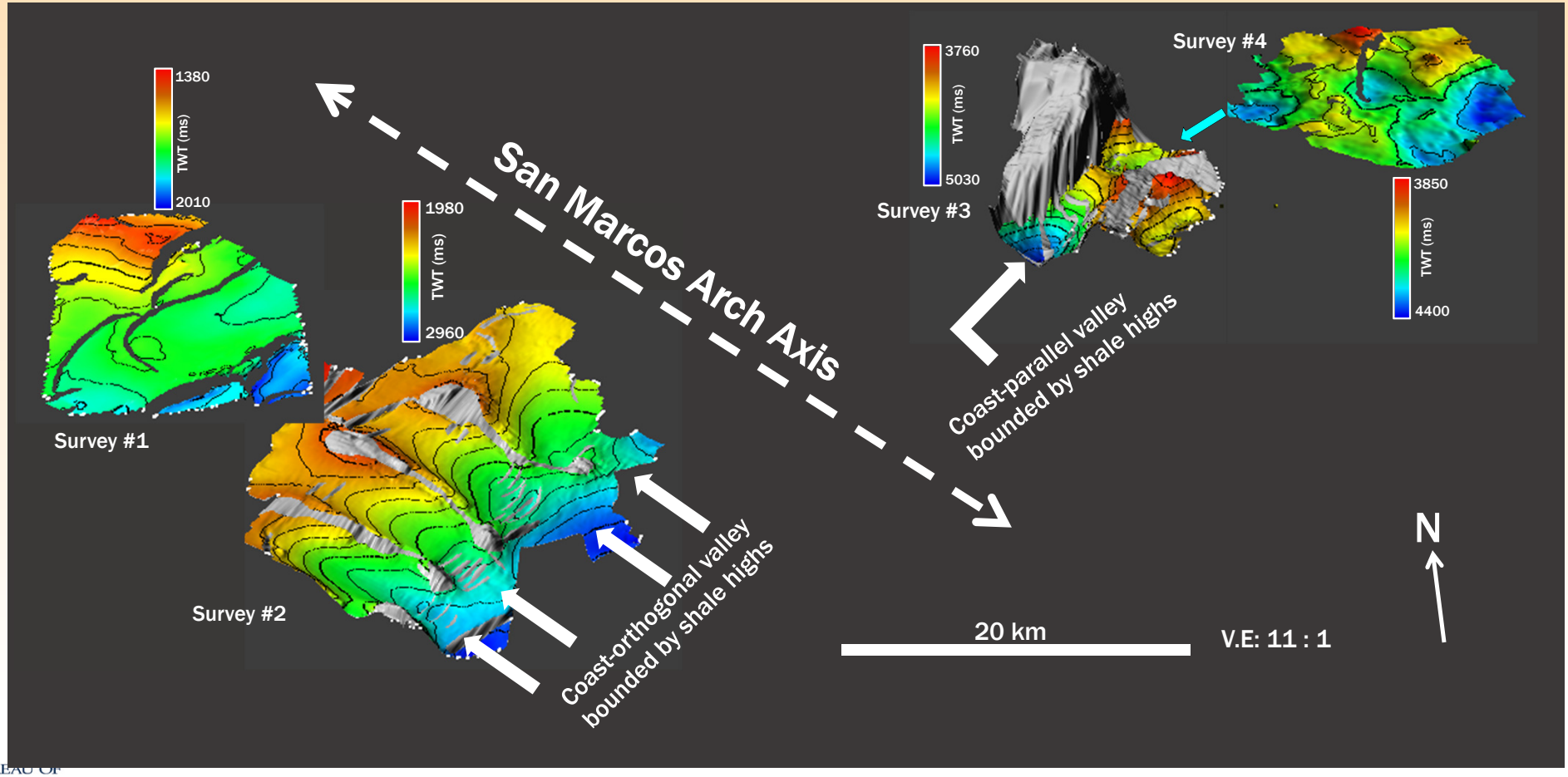
3D Display of Map at Top Vicksburg in Surveys 1 thru 4



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Summary & Conclusions

- In the Rio Grande, in addition to the synthetic and antithetic faults, the dominant structural style includes prominent alternating coast-orthogonal shale ridges, sub-basins, and coast-orthogonal faults.

- In contrast, in the Houston Embayment, the dominant structural styles are synthetic faults and coast-parallel sub-basins and coast-parallel shale ridges. Antithetic faults are few to none.

- In the Houston Embayment, top Vicksburg is deeper (4,600—5,850 m), and appears to be more deformed than it is in the Rio Grande Embayment, where it occurs at about 1,550—3,380 m. The severity of deformation increases with nearness to the axis of the San Marcos arch.

- Finally, although the prevailing mechanisms of deformation in both basins were extensional tectonics, strata deformational pattern in each basin are different.

Acknowledgments

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- Neumin Exploration
- Brigham Exploration (now part of Statoil)