Seismic Multiattribute Analysis for Shale Gas/Oil within the Austin Chalk and Eagle Ford Shale in a Submarine Volcanic Terrain, Maverick Basin, South Texas*

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Abstract

We conducted seismic multiattribute analysis by combining seismic data with wireline logs to determine hydrocarbon sweet spots and predict resistivity distribution (using the deep induction log) within the Austin Chalk and Eagle Ford Shale in South Texas. Our investigations show that hydrocarbon sweet spots are characterized by high resistivity, high total organic carbon (TOC), high acoustic impedance (i.e., high brittleness), and low bulk volume water, suggesting that a combination of these log properties is required to identify sweet spots. Although the lower Austin Chalk and upper and lower Eagle Ford Shale intervals constitute hydrocarbon-sweet-spot zones, resistivity values and TOC concentrations are not evenly distributed; thus, the rock intervals are not productive everywhere. Most productive zones within the lower Austin Chalk are associated with Eagle Ford Shale vertical-subvertical en echelon faults, suggesting hydrocarbon migration from the Eagle Ford Shale. Although the quality factor (Q) was not one of the primary attributes for predicting resistivity, it nevertheless can serve as a good reconnaissance tool for predicting resistivity, brittleness, and bulk volume water-saturated zones. In addition, local hydrocarbon accumulations within the Austin Chalk may be related to Austin TOC-rich zones or to migration from the Eagle Ford Shale through fractures. Some wells have high water production be-cause the water-bearing middle Austin Chalk on the downthrown side of Eagle Ford Shale regional faults constitutes a large section of the horizontal well, as evidenced by the Q attribute. Furthermore, the lower Austin Chalk and upper Eagle Ford Shale together appear to constitute a continuous (unconventional) hydrocarbon play.

Reference Cited

Condon, S.M., and T.S. Dyman, 2003, “2003 Geologic Assessment of Undiscovered Conventional Oil and Gas Resources in the Upper Cretaceous Navarro and Taylor Groups, Western Gulf Province, Texas” In Petroleum Systems and Geologic Assessment of Undiscovered Oil and Gas, Navarro and Taylor Groups, Western Gulf Province, Texas, US: Geological Survey Digital Data Series 69–H, Web accessed May 9, 2014, http://pubs.usgs.gov/dds/dds-069/dds-069-h/REPORTS/69_H_CH_2.pdf.

Seismic multiattribute analysis for shale gas/oil within the Austin Chalk and Eagle Ford Shale in a submarine volcanic terrain, Maverick Basin, South Texas

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Highlights

- Acoustic impedance and volcanic mounds
- Resistivity Prediction within the Austin Chalk and Eagle Ford Shale
- Instantaneous quality factor (Q) attribute, faults, water saturation, and hydrocarbon production

Overview

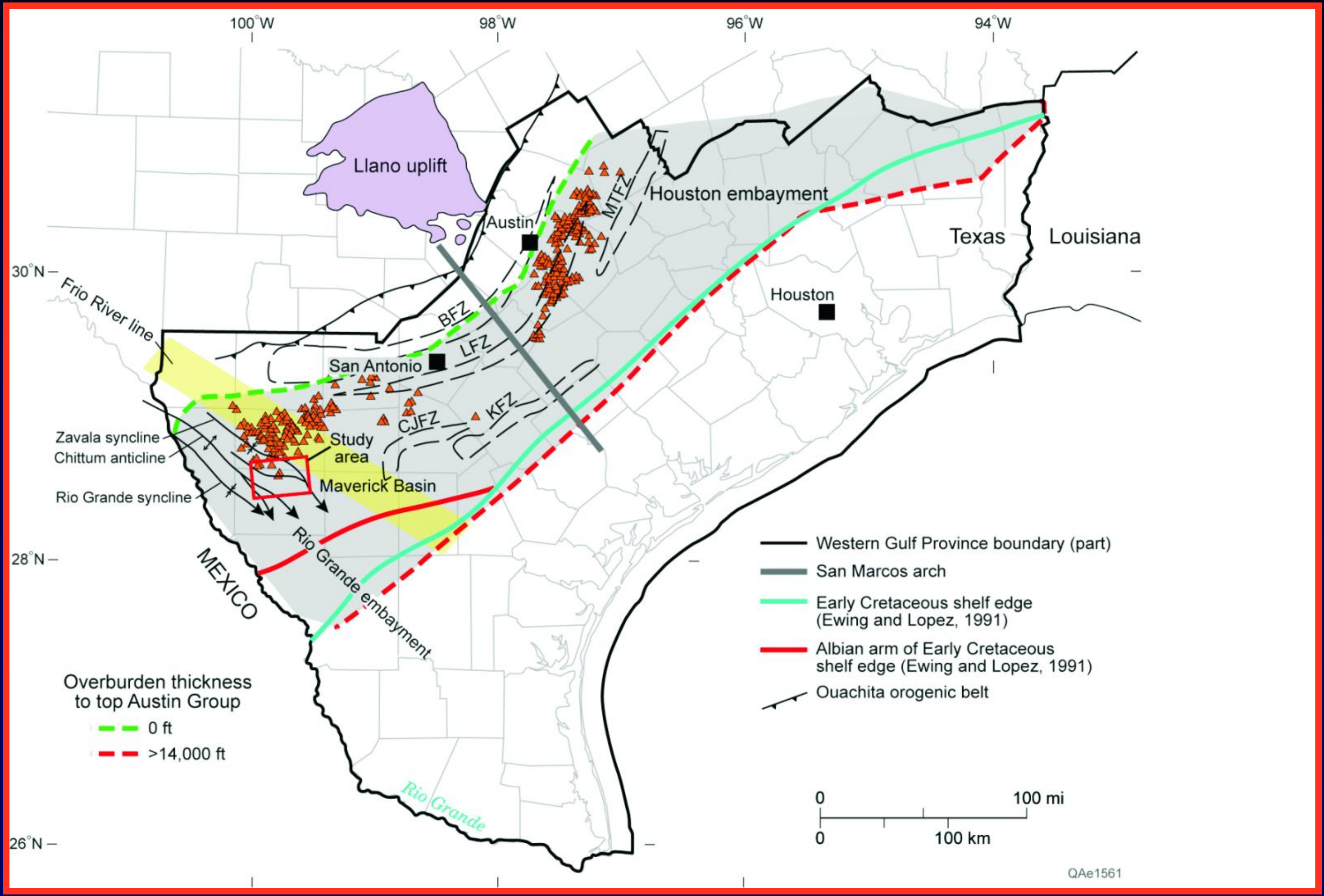
- Location and Geologic setting
- Stratigraphy
- Database
- Structure—Horizon maps and volcanic mounds
- Rock property prediction—Workflow
- Results
- Conclusions

Objectives

- Perform seismic inversion study and obtain porosity, TOC, and resistivity volumes within the Austin Chalk and the Eagle Ford Shale that could be used to augment hydrocarbon exploration efforts.

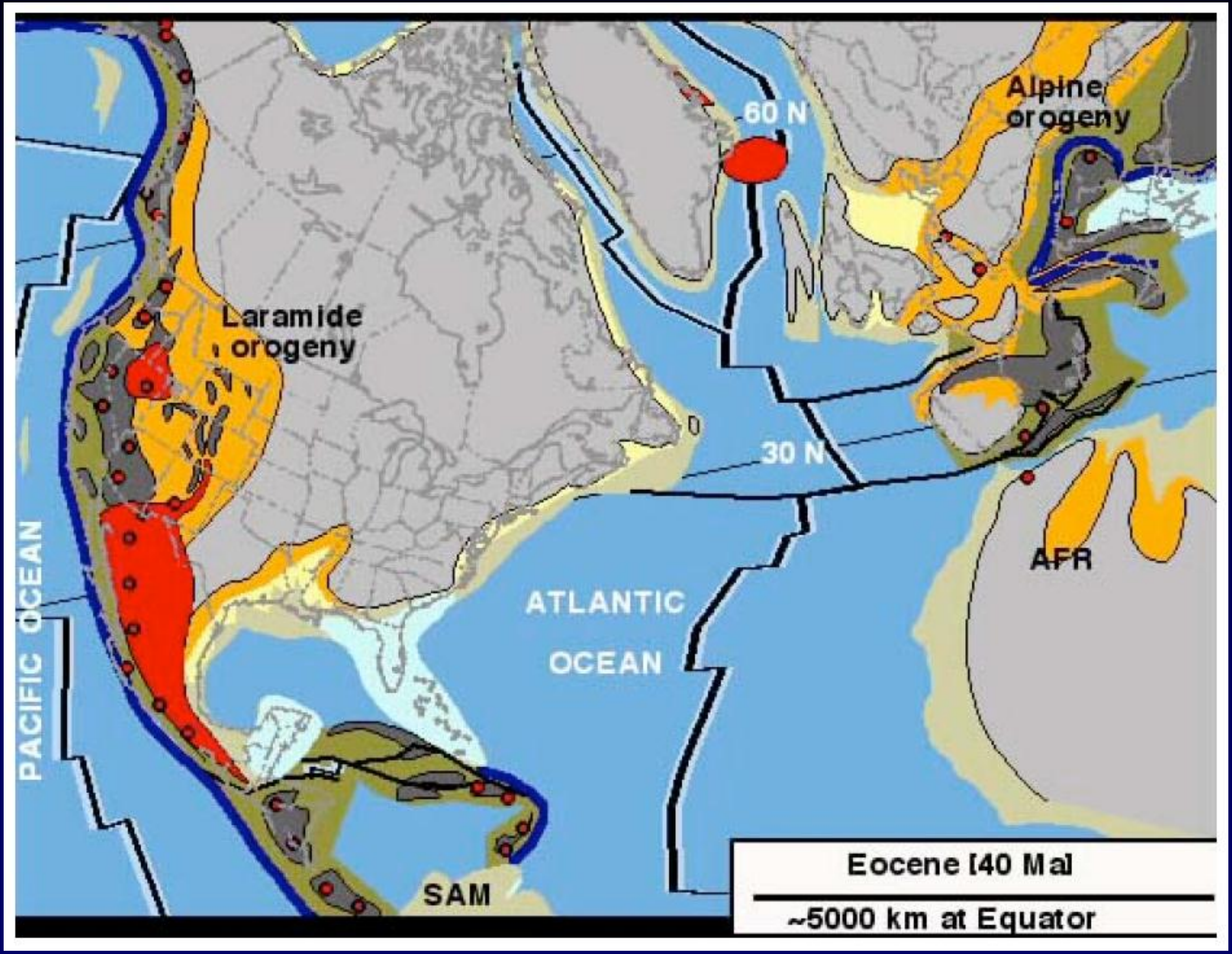
- Obtain pertinent seismic attributes that could be used to characterize the Austin Chalk and Eagle Ford Shale and identify sweet spots.

Location and Geologic Setting



(Modified after Condon and Dyman, 2003
US Geological Survey Assesment Team)

Laramide Orogeny—Areal Extent



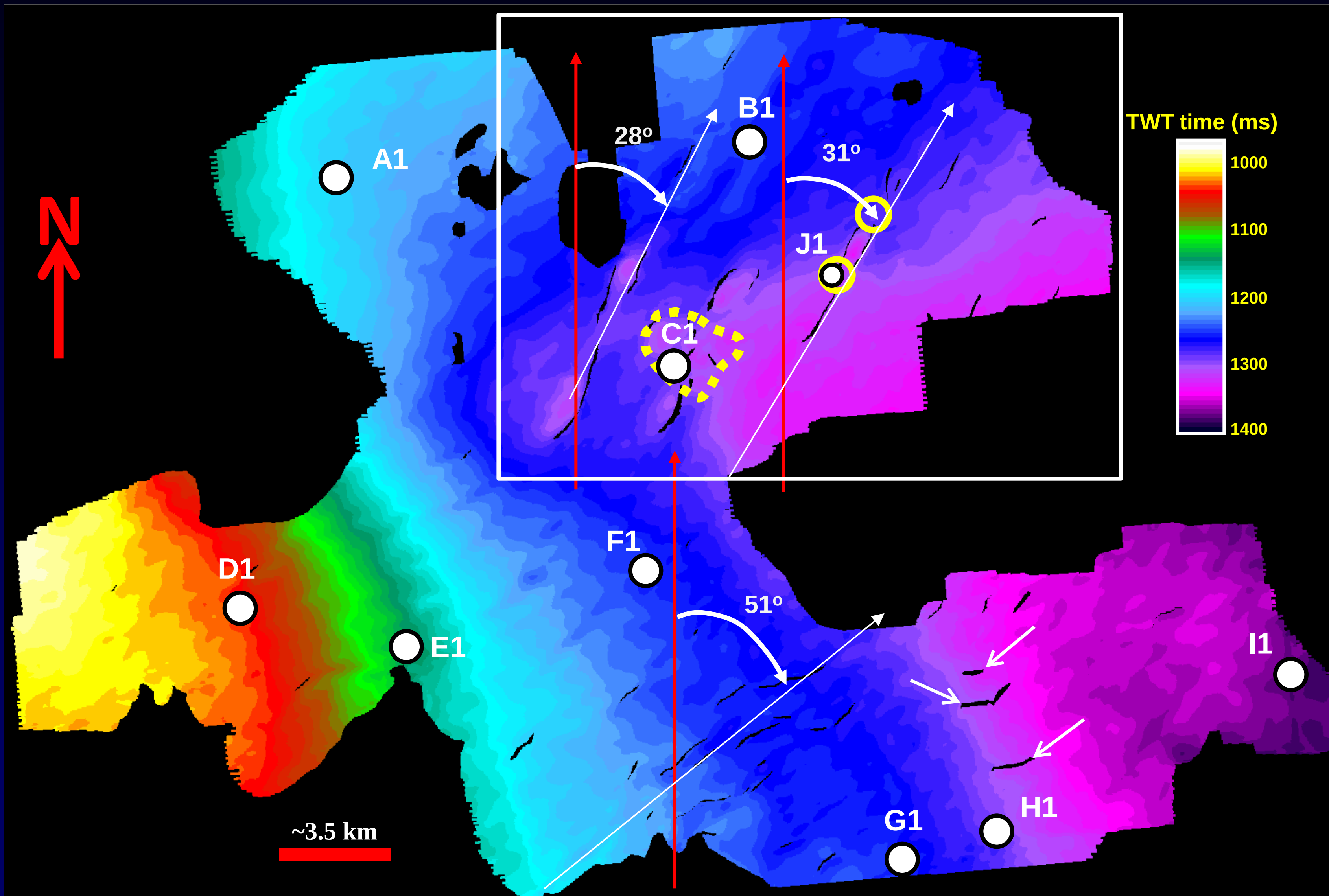
University of Colorado, Boulder, 2008

Stratigraphy

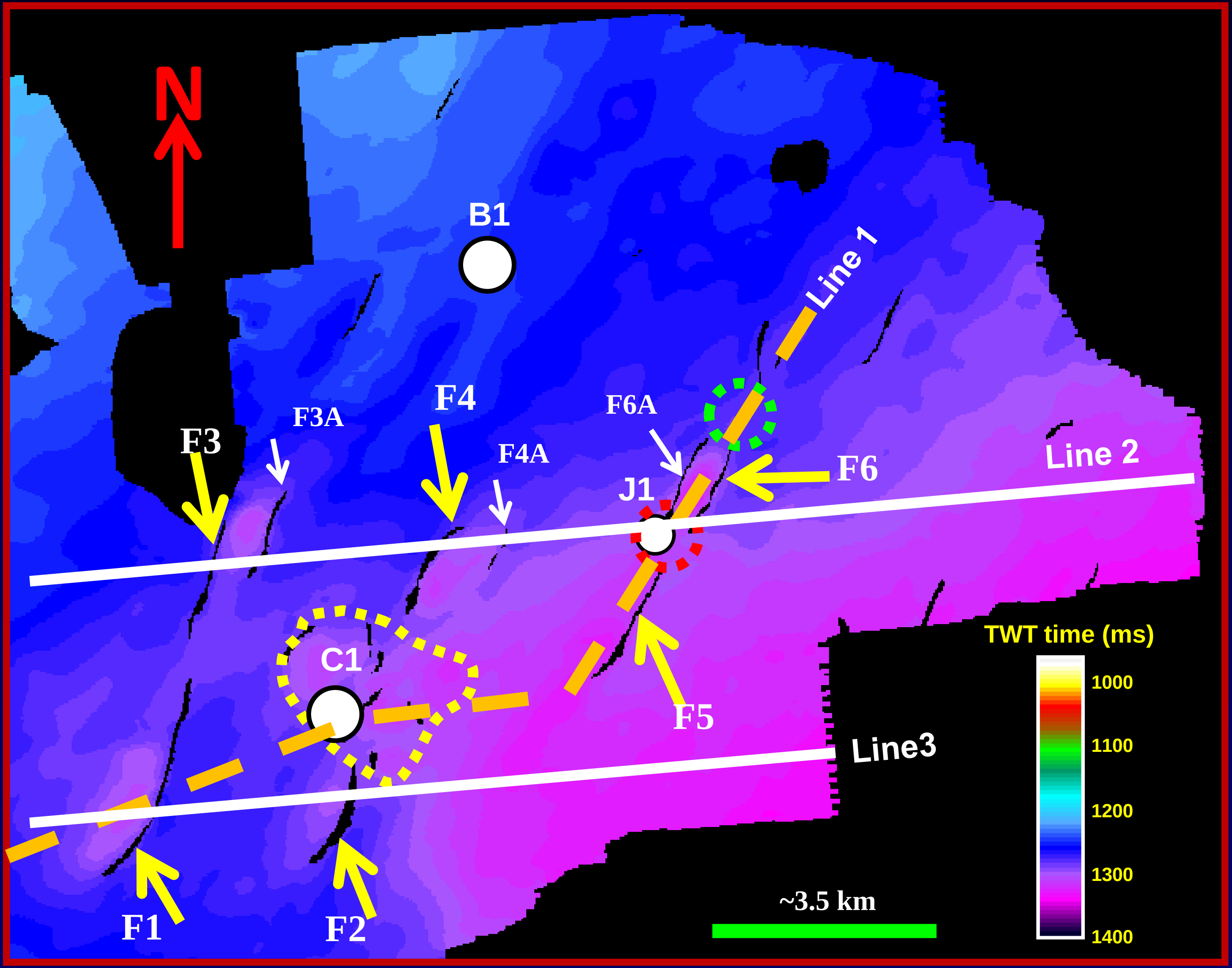
Database

- 3D survey covers an area of about 437 square miles (~1132 square km)
- Stacking bin size is ~33 m by 33 m and sampling rate during acquisition was 2 ms
- 9 vertical wells with required log suites

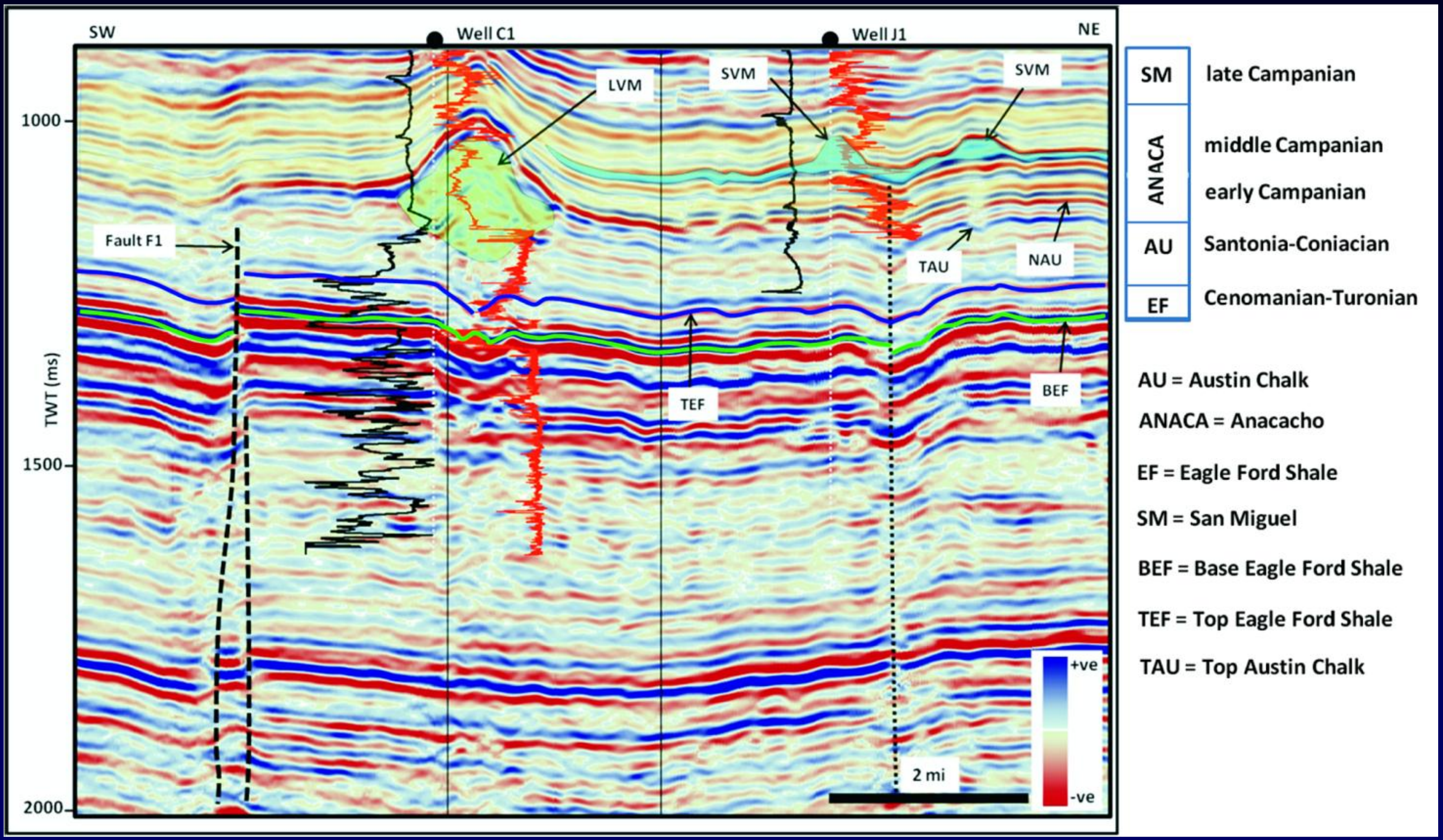
Base Eagle Ford Horizon Time Maps



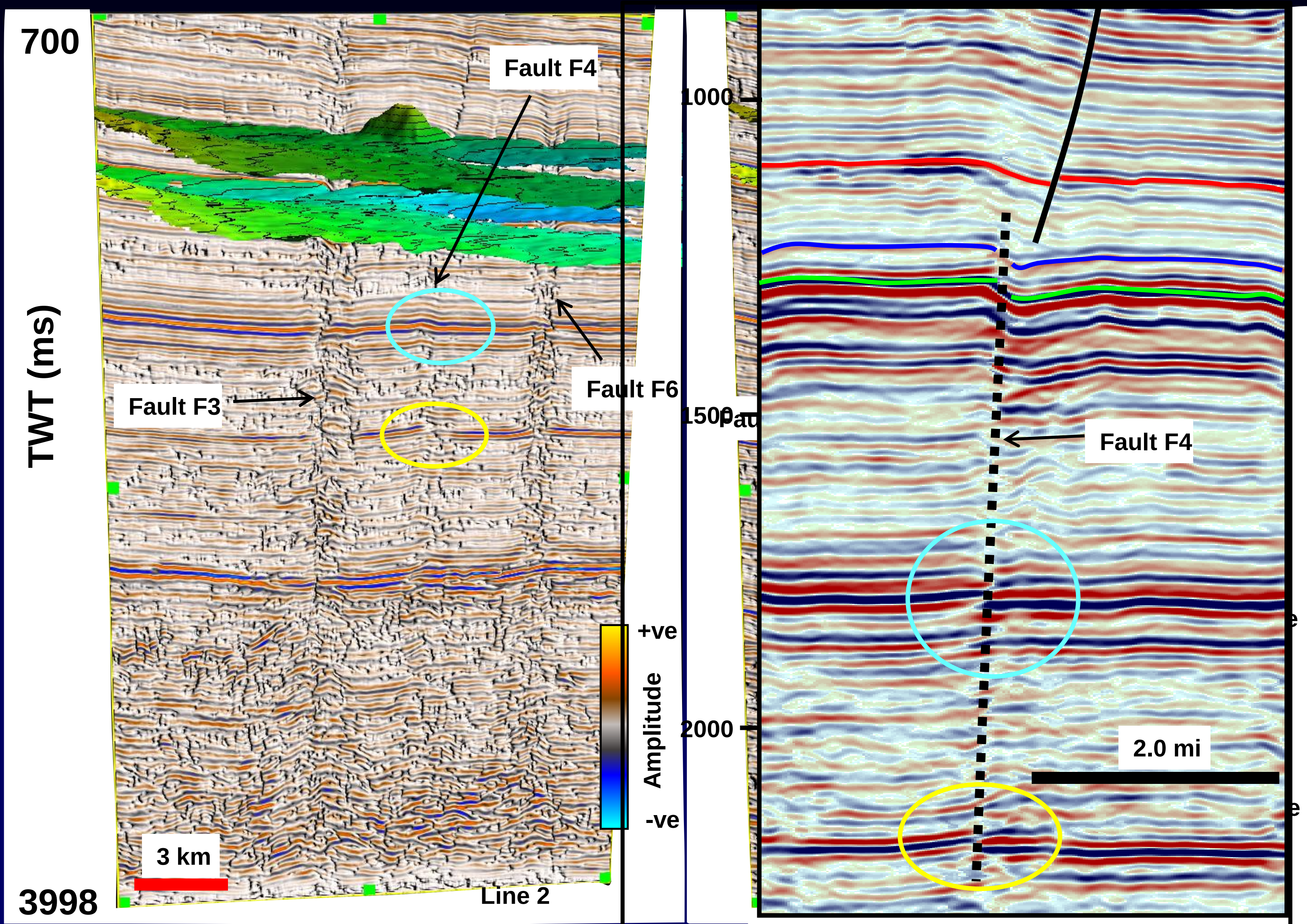
Seismic Transects Through Identified Volcanic Mounds



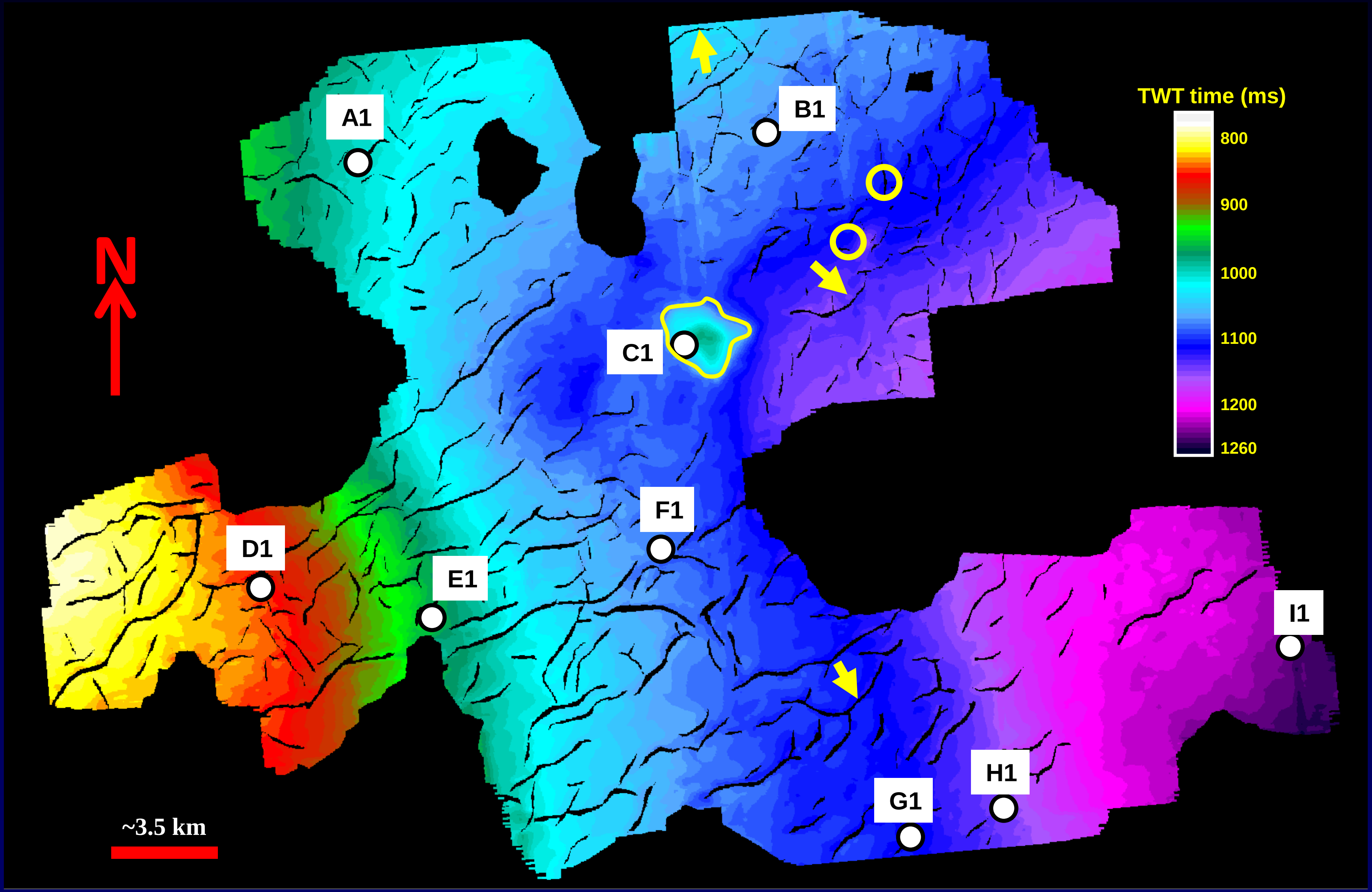
Volcanic Mounds—Line 1



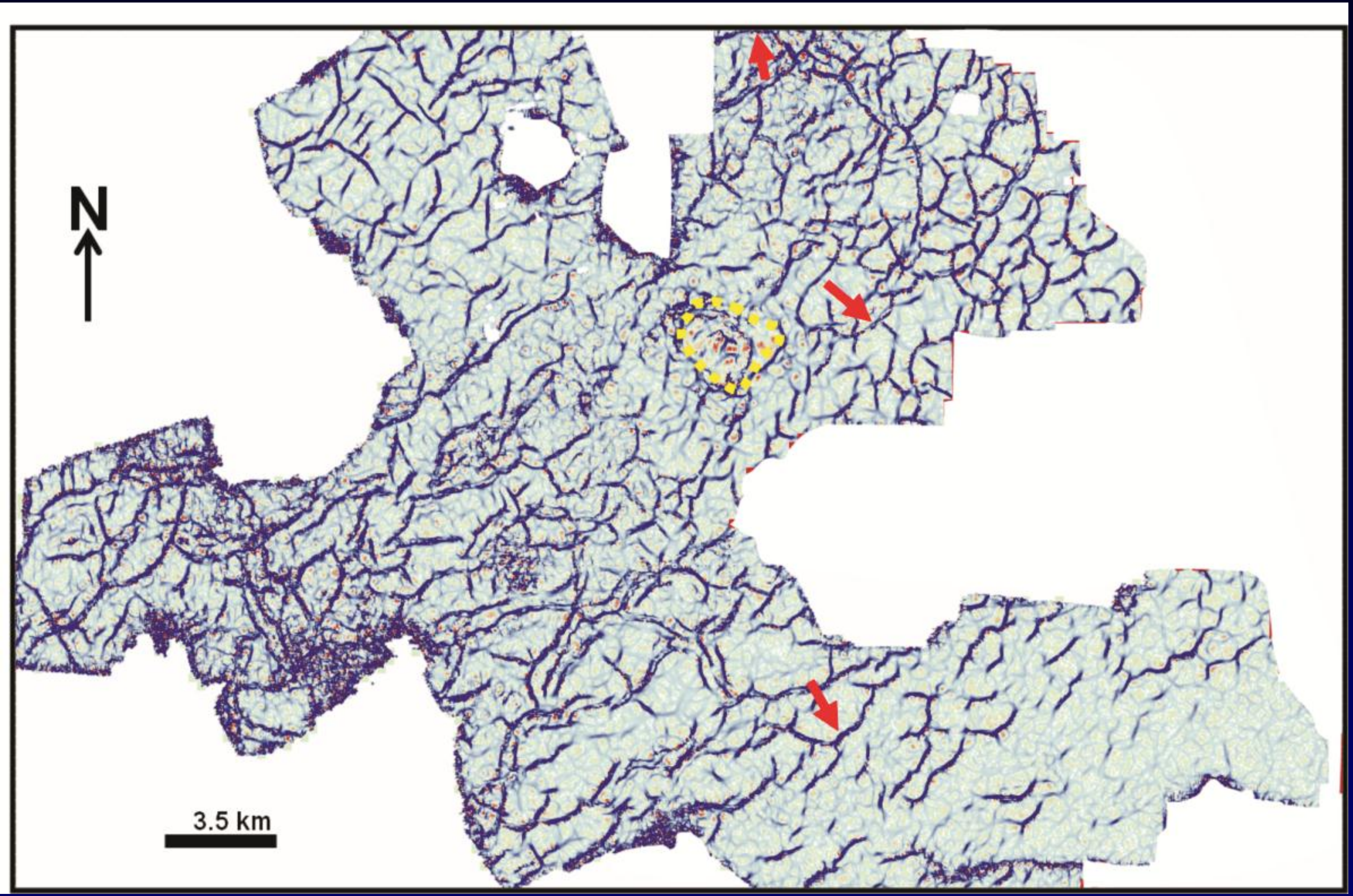
Volcanic Mounds—Lines 2 & 3



Time Map at Top Austin Chalk

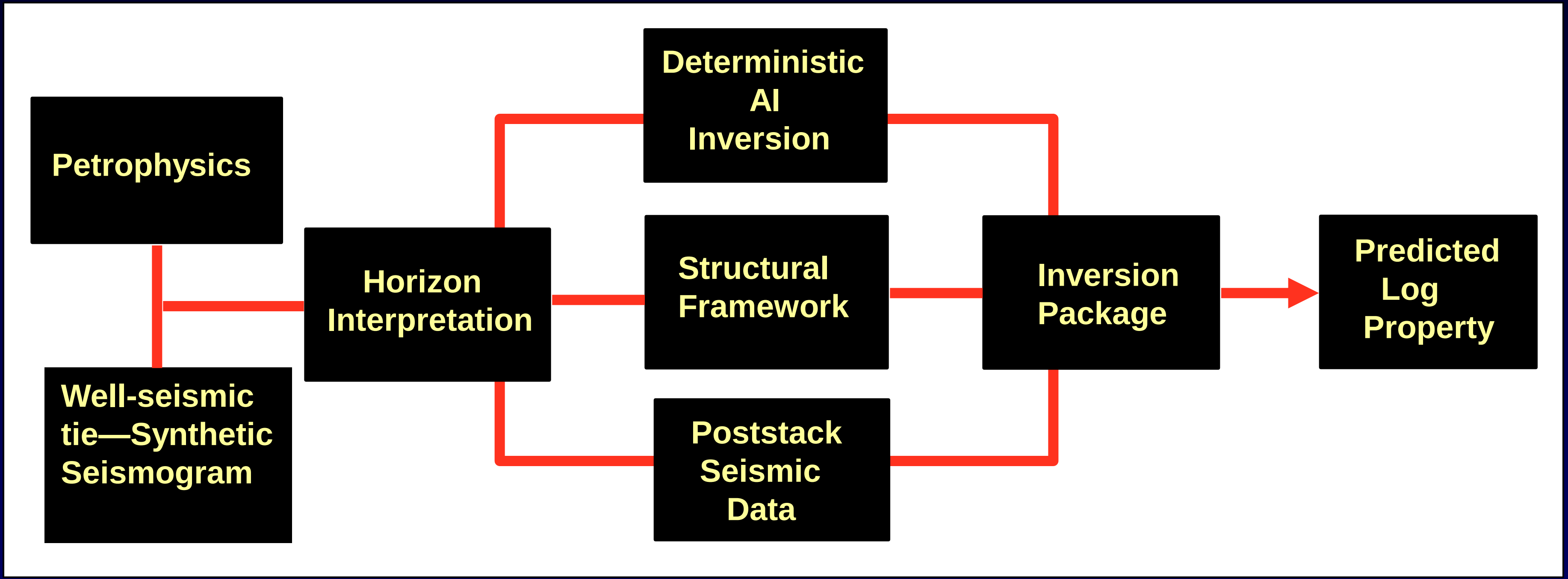


Extracted Curvature Attribute at Top Austin Chalk

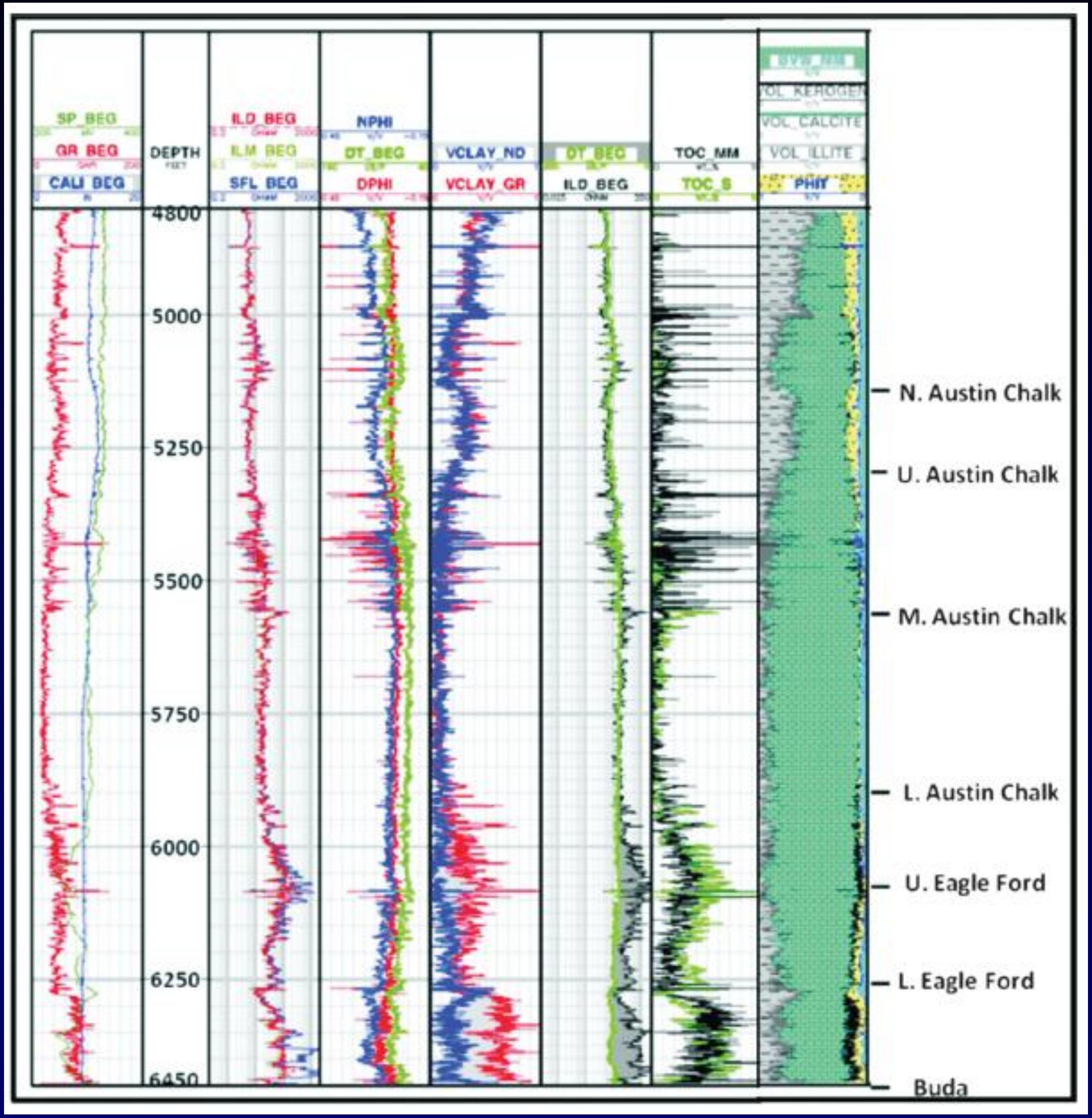


Seismic Attribute Prediction of Rock Physical Properties

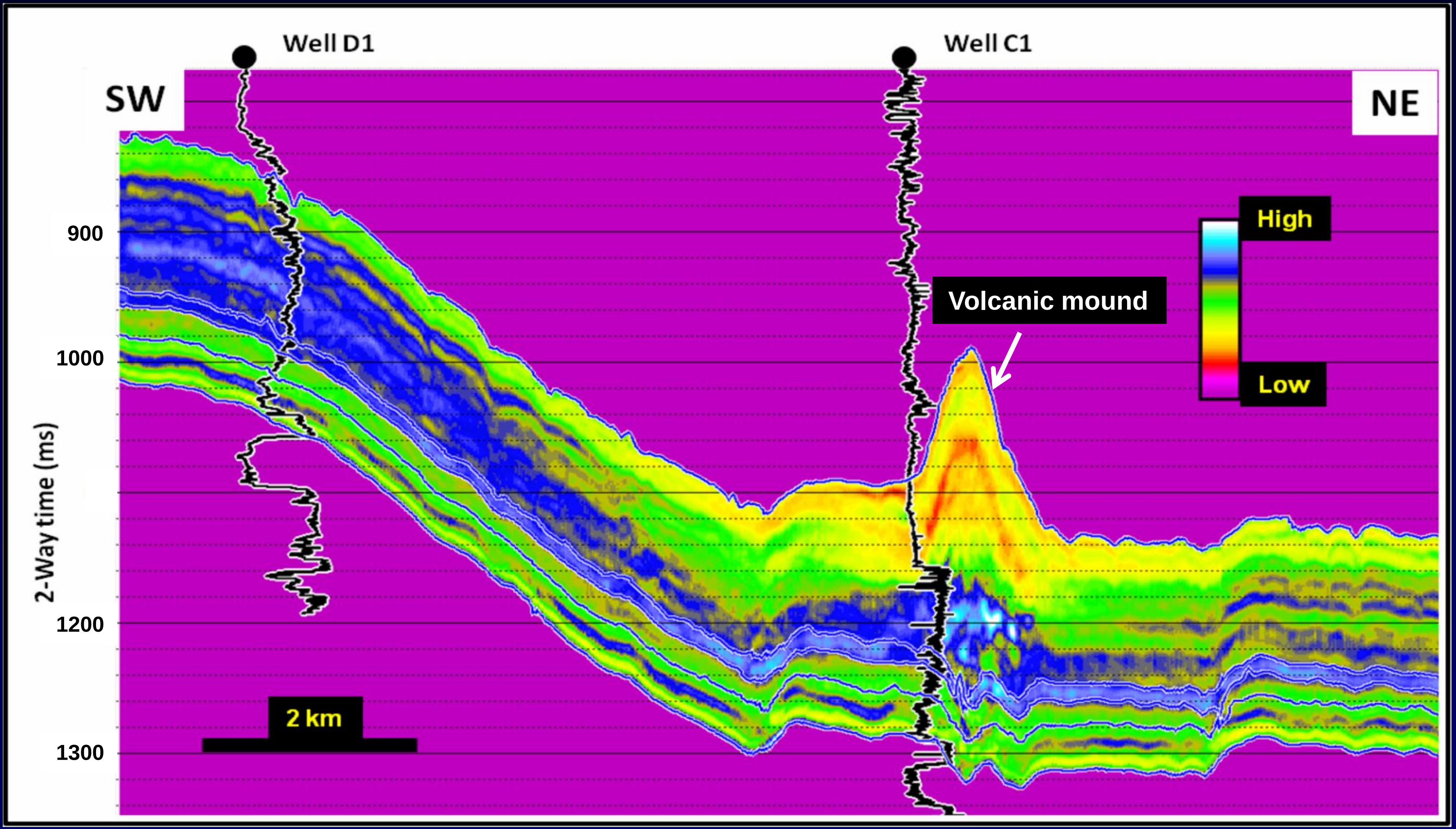
Rock Property Prediction: Workflow—An Integrated Approach



Petrophysical Results



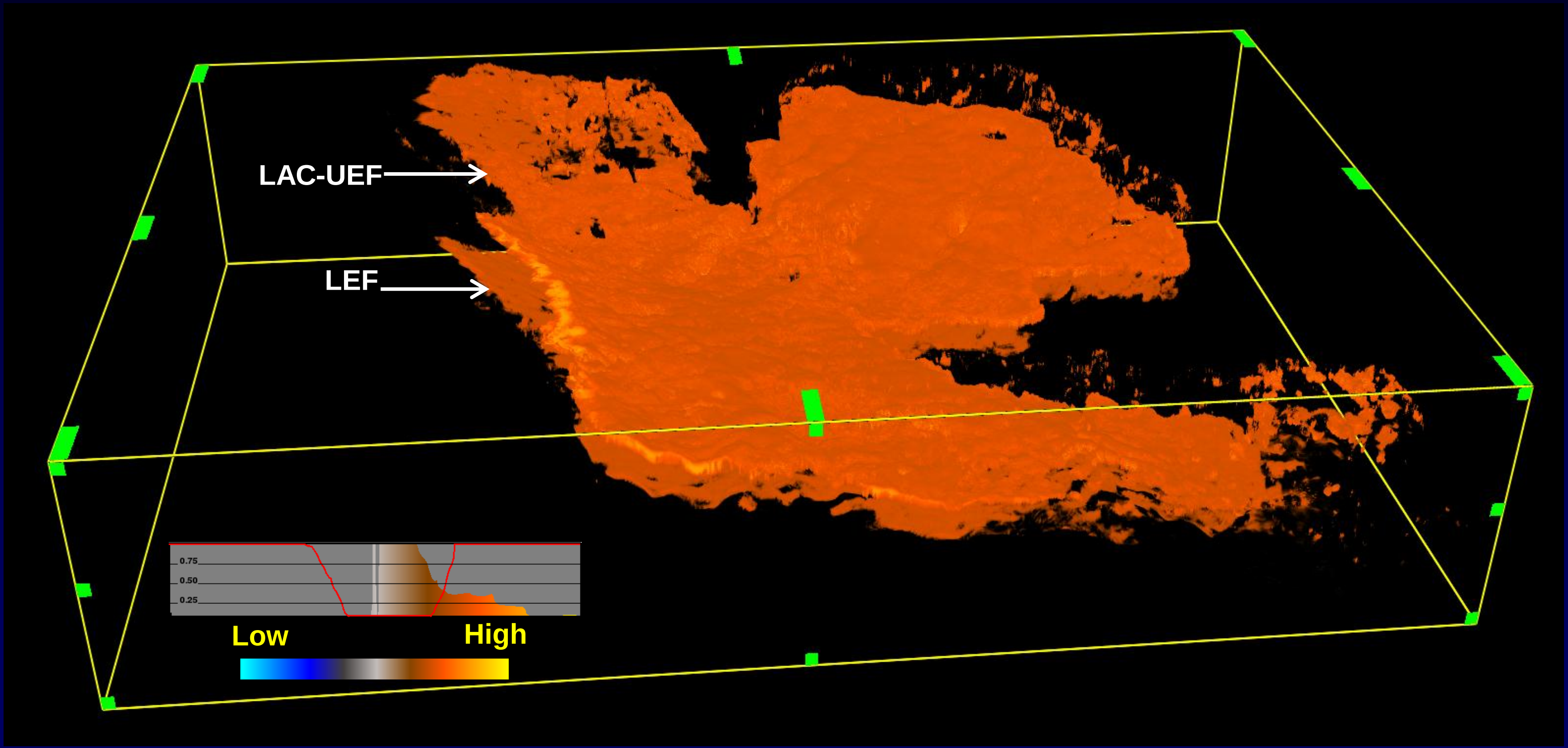
Results—Acoustic Impedance Inversion



Resistivity Prediction—Selected Attributes

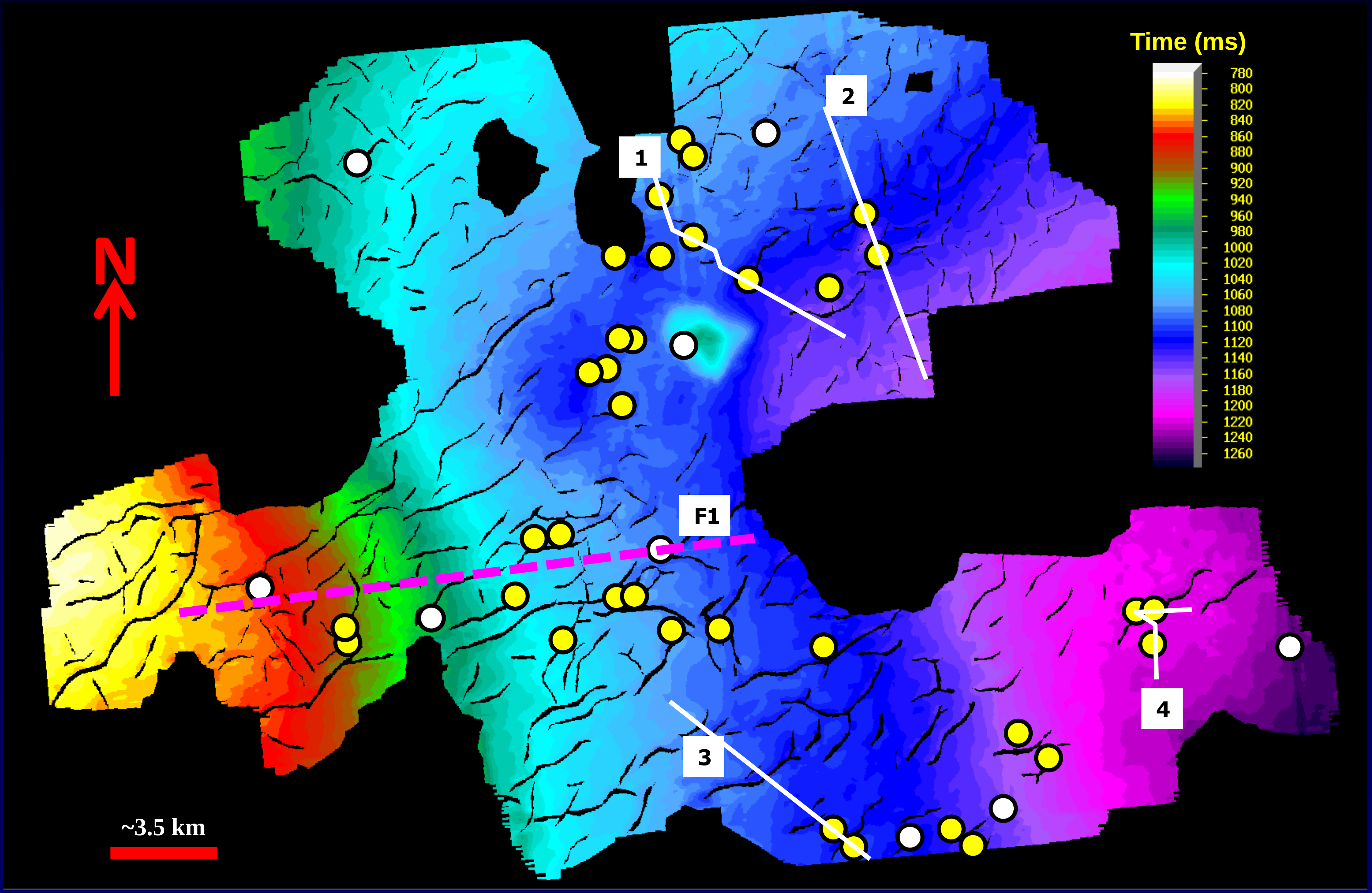
Physical-property-related	Frequency-related
TOC (1)	Filter 5/10–15/20 Hz (2)
(Impedance)^2 (4)	Average frequency (3)
(P-wave velocity)^ 2 (5)	
Sqrt (V_{clay}) (6)	

3D Display of Predicted Resistivity

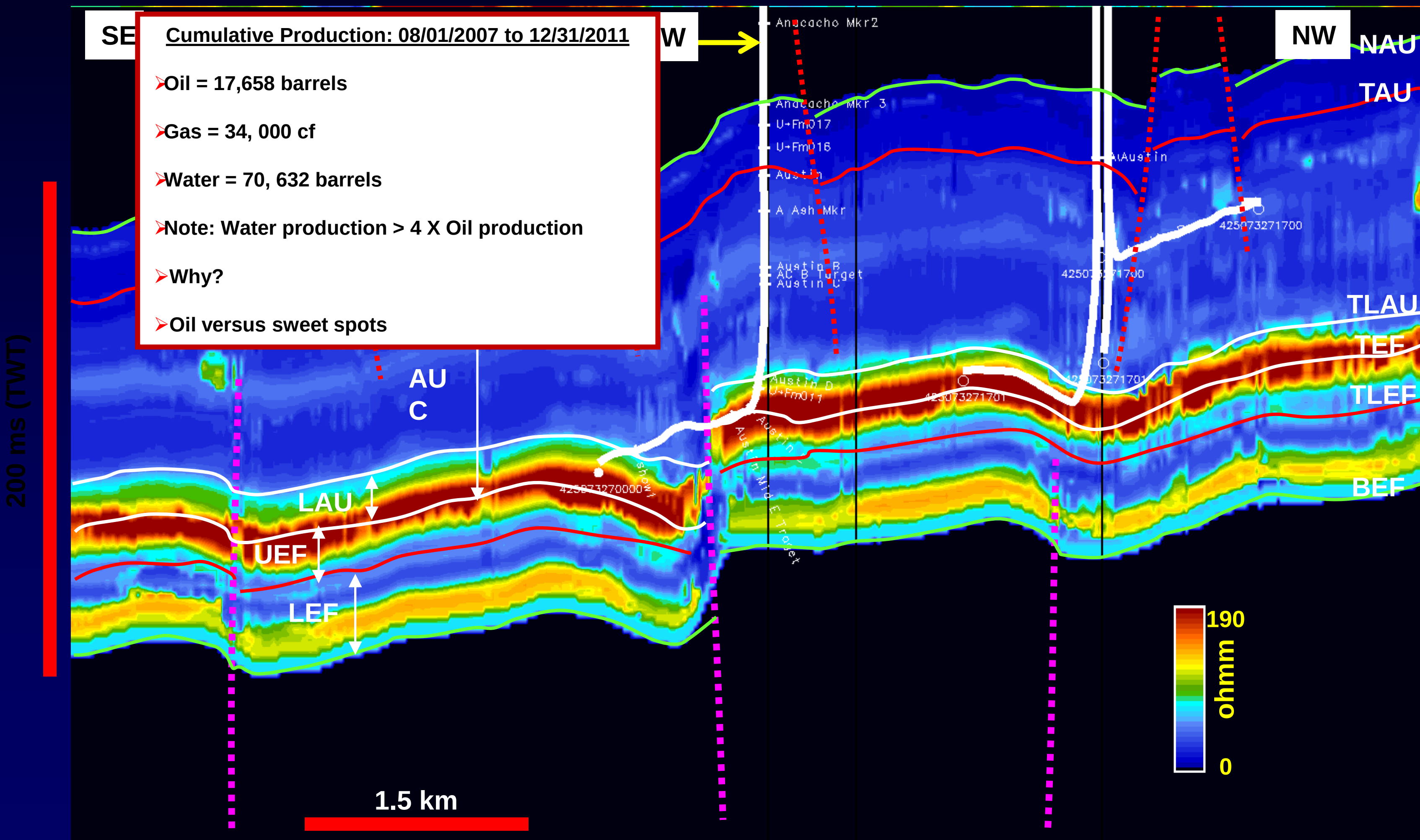


Horizontal Well Drilling Results

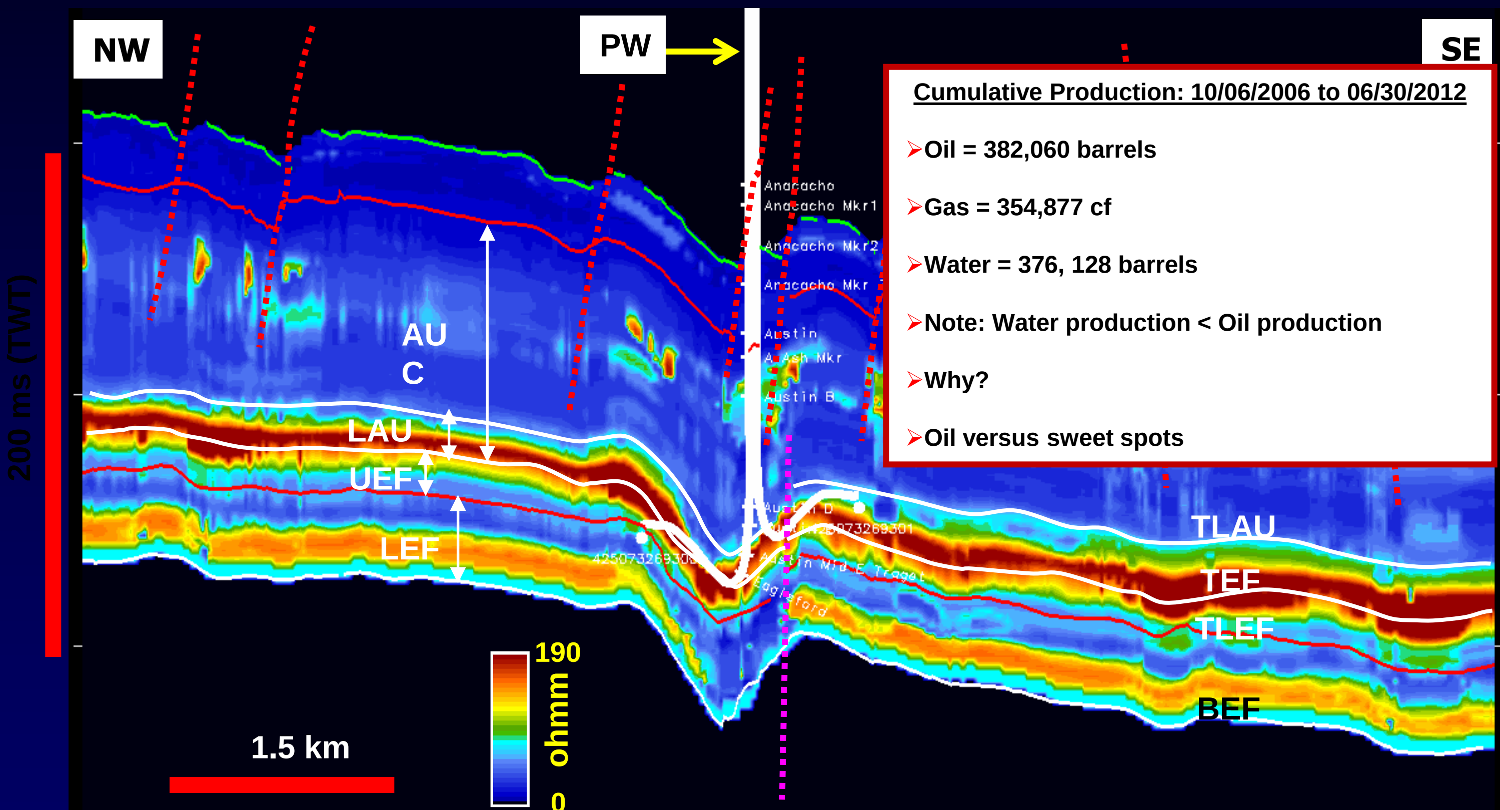
Results—Seismic Attribute Prediction of Rock Properties



Fractures & Faults versus Water & Oil Production—Trajectory 1



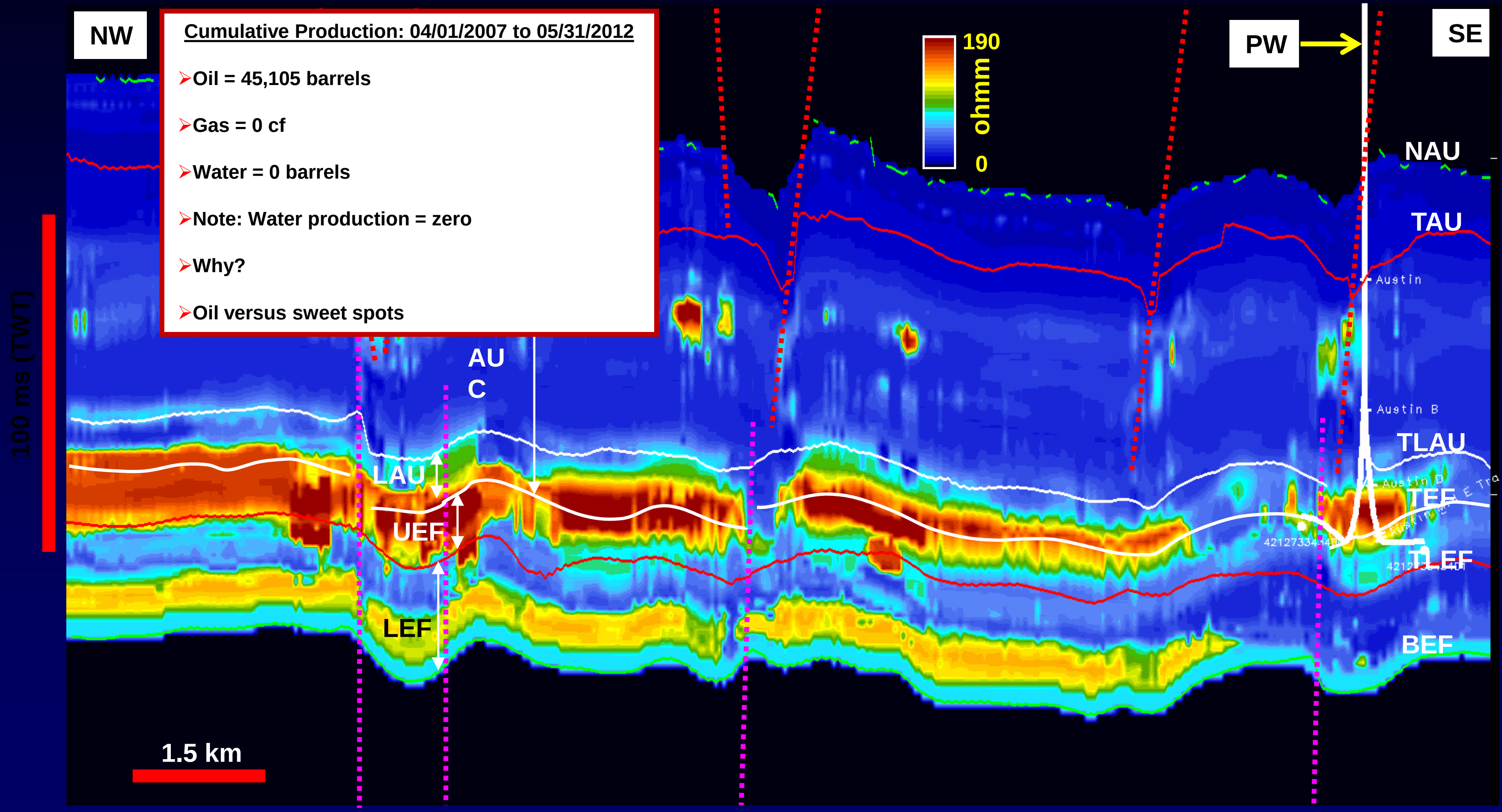
Fractures & Faults versus Water & Oil Production—Trajectory 2



Cumulative Production: 10/06/2006 to 06/30/2012

- **Oil = 382,060 barrels**
- **Gas = 354,877 cf**
- **Water = 376, 128 barrels**
- **Note: Water production < Oil production**
- **Why?**
- **Oil versus sweet spots**

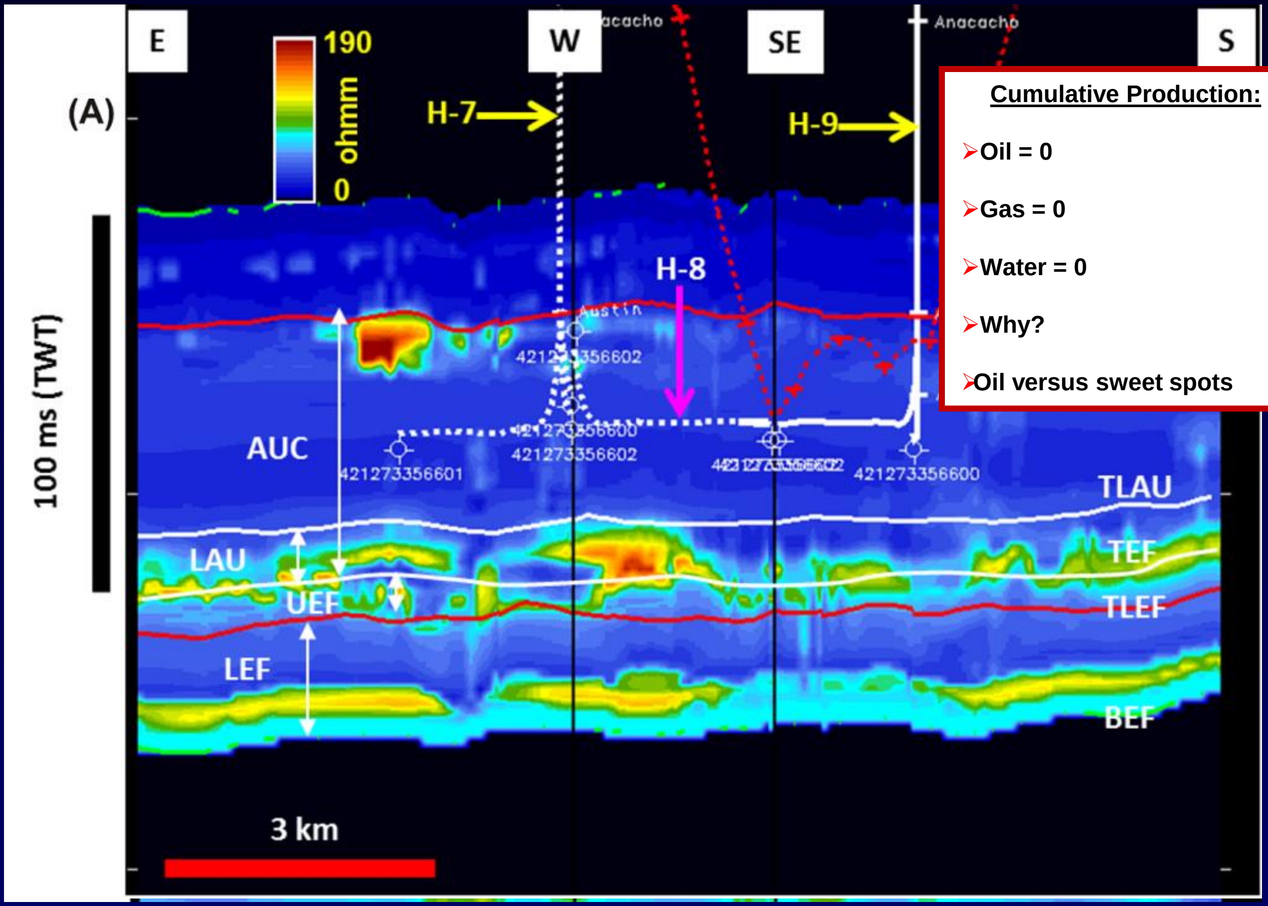
Fractures & Faults versus Water & Oil Production—Trajectory 3



Cumulative Production: 04/01/2007 to 05/31/2012

- Oil = 45,105 barrels
- Gas = 0 cf
- Water = 0 barrels
- Note: Water production = zero
- Why?
- Oil versus sweet spots

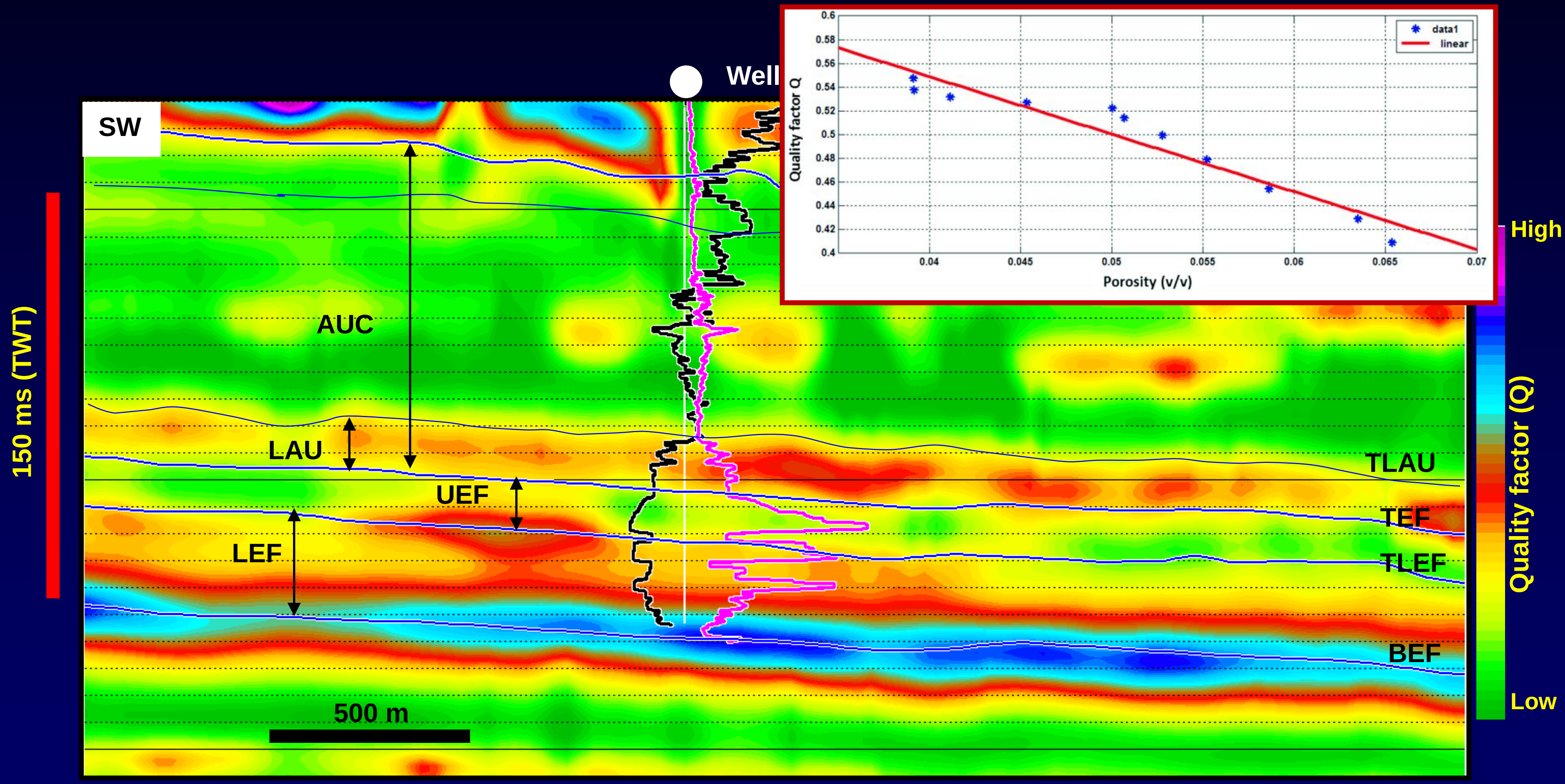
Fractures & Faults versus Water & Oil Production—Trajectory 4



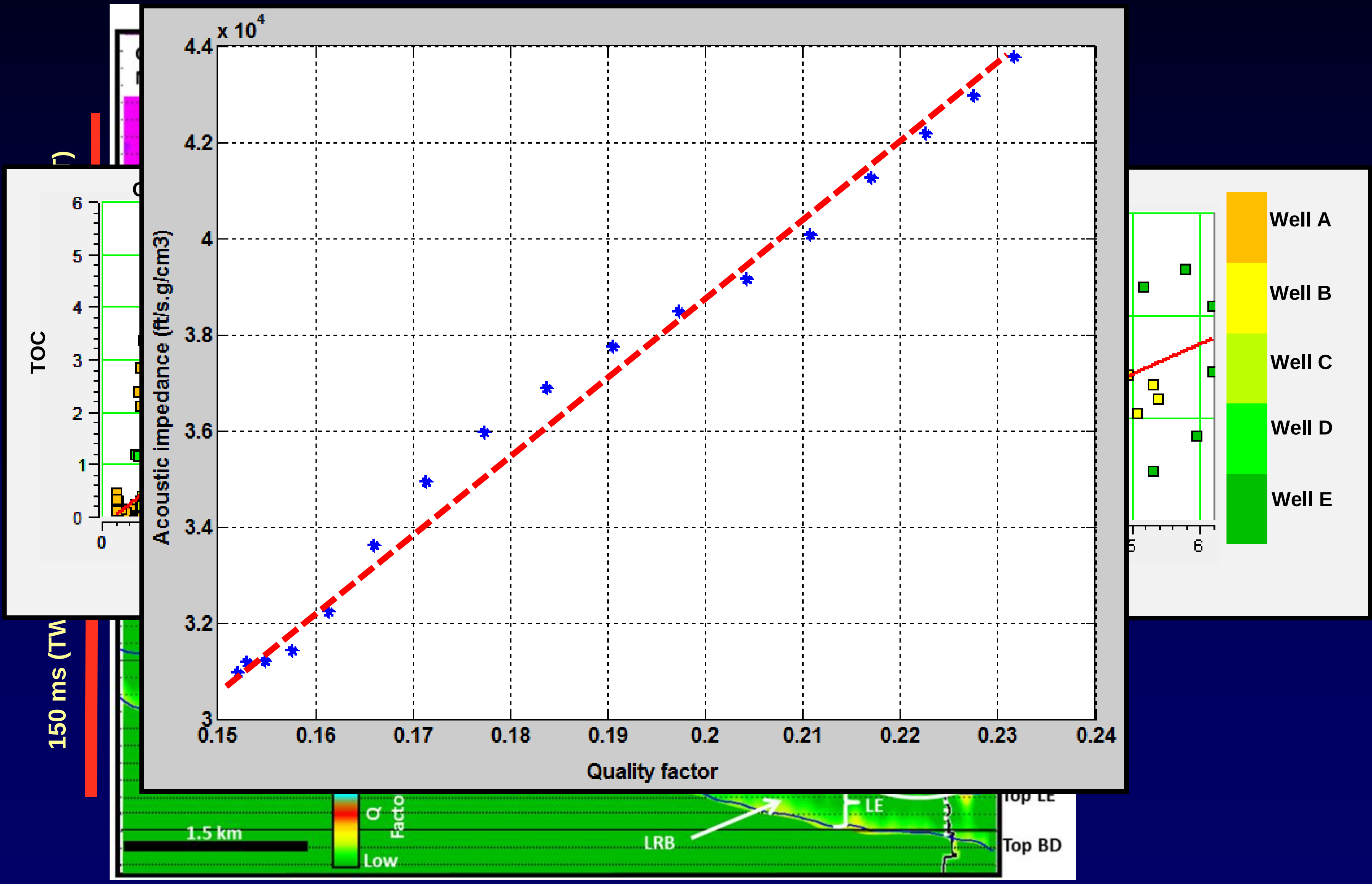
Cumulative Production:

- Oil = 0
- Gas = 0
- Water = 0
- Why?
- Oil versus sweet spots

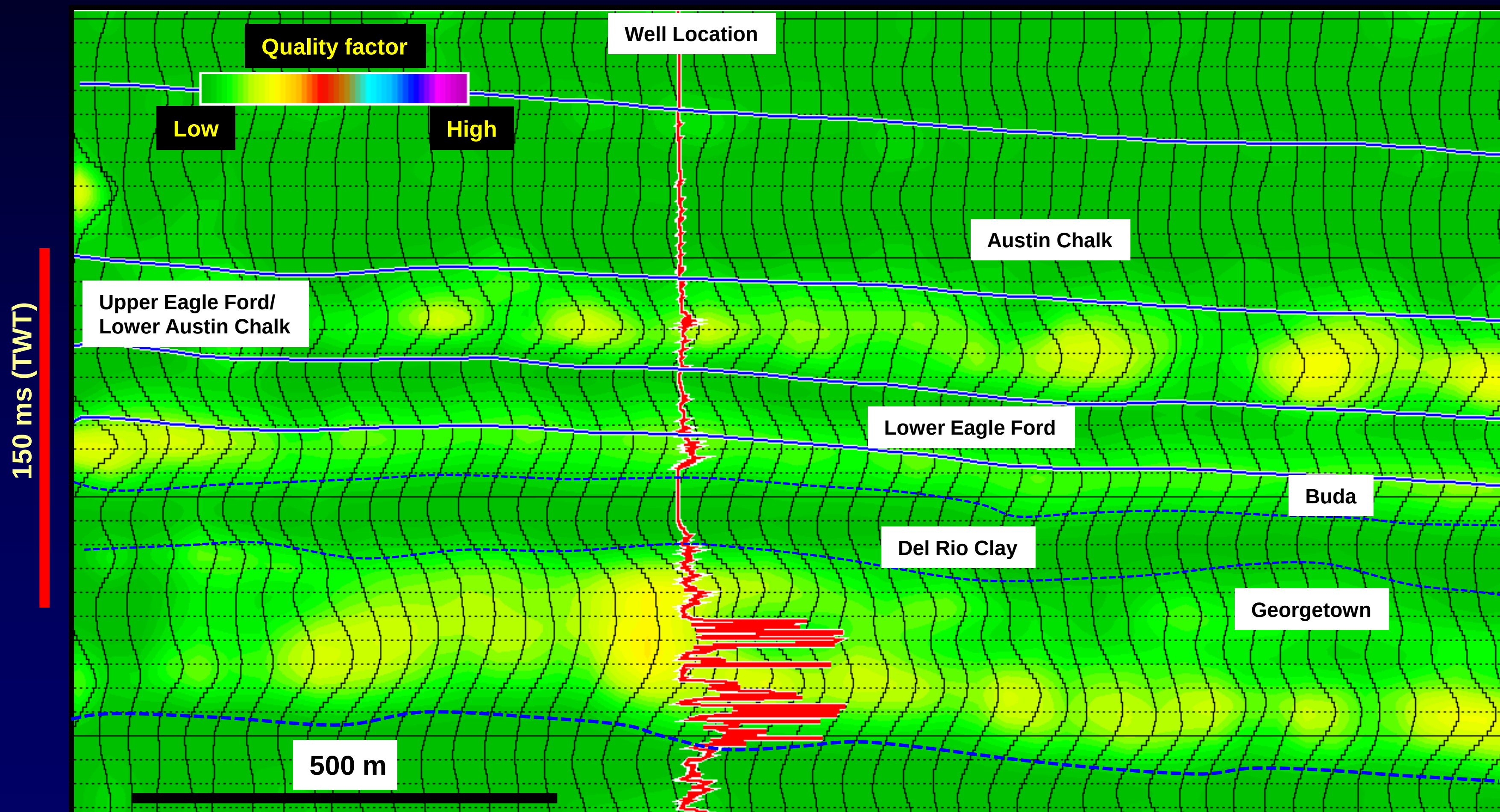
Correlation Between Quality Factor (Q), Water saturation, resistivity, and porosity



Correlation between Q, Resistivity, TOC, and Acoustic Impedance



Correlation between Resistivity and Quality Factor (Q)



Conclusions

- Sweet spots within the Eagle Ford Shale and Austin Chalk are characterized by high resistivity, high TOC, high acoustic impedance (i.e., high Q, high brittleness), and low bulk volume water, suggesting that a combination of these properties is required to identify sweet spots

- Wells that have high water production do so because, they were completed in the marly, water-bearing middle Austin section that sits on the downthrown side of the regional faults

- From inversion results, the lower Austin Chalk and upper Eagle Ford Shale together constitute a continuous (unconventional) hydrocarbon play

- The Eagle Ford Shale is a unique shale in which TOC increases with increasing bed resistance—i.e., increasing Q. Therefore, Q can serve as a good reconnaissance tool for predicting resistivity, brittle zones, sweet spots, and water saturated zones

- Finally, Q can be used to identify other brittle formations below the Eagle Ford Shale such as Georgetown. In fact, Q could serve as an ideal tool for mechanical stratigraphy

Acknowledgments

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