Eagle Ford Shale Prospecting with 3-D Seismic Data Within a Tectonic and Depositional System Framework*

Galen Treadgold[1], Steve Sinclair[2], David F. Nicklin[2], and Bruce Campbell[1]

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[1]Global Geophysical Services, Houston, TX (galen.treadgold@weinmangeoscience.com)
[2]Matador Resources, Dallas, TX

Abstract

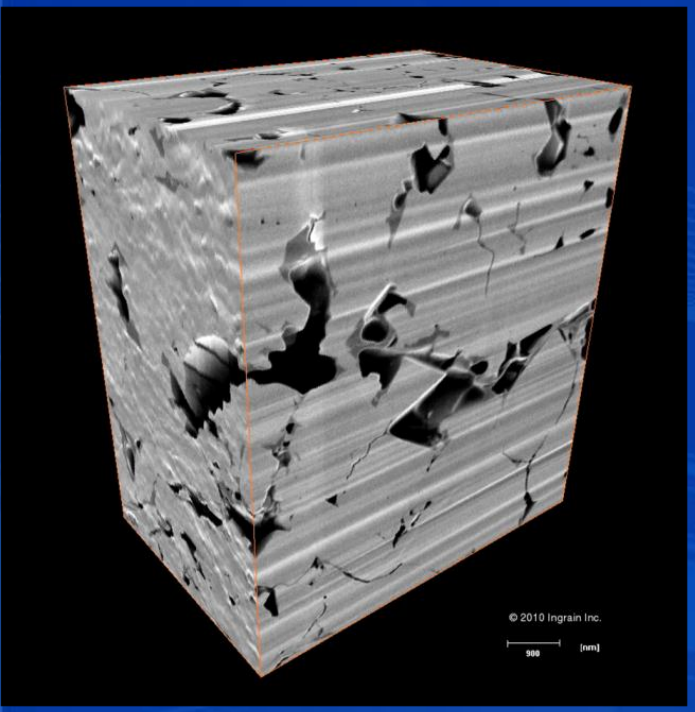
The Eagle Ford Shale in South Texas is one of the more exciting shale plays in the United States at the current time. Recently published reports of well tests describe gas well rates exceeding 17 mmcf/d and oil well rates in excess of 1500 bopd and unconfirmed rates of 2000 bopd. Acreage lease rates continue to climb as more positive results come from drilling within the trend. A key issue for the exploration companies is finding where to focus acreage acquisition and optimize drilling plans for optimal gas and oil recovery. Our paper will first consider the geologic context of the Eagle Ford and then look at geophysical techniques, in particular comparing and contrasting the value of 3D processing seismic attributes in building a successful exploration plan.

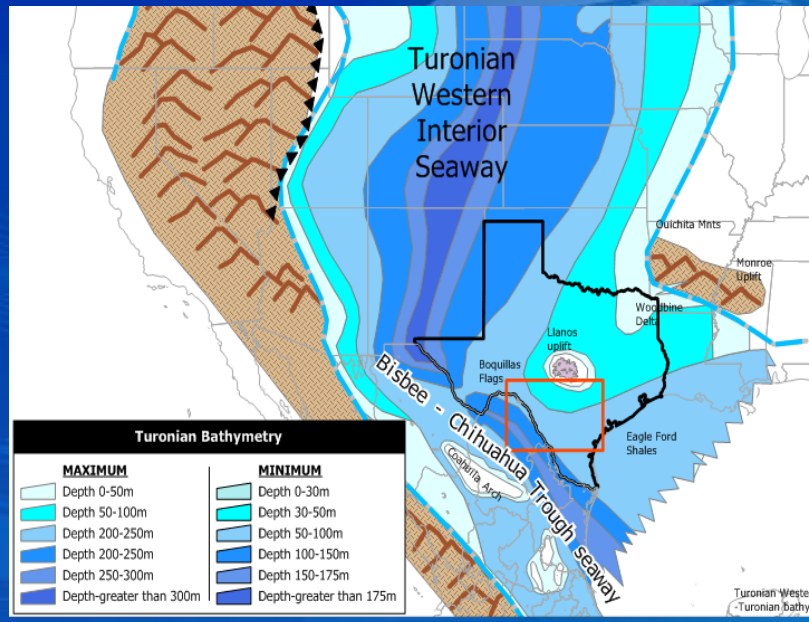
Conventional subsurface data, such as wireline logs, cores and cuttings, are limited in availability to many companies currently exploring the play. Interpretation of these data is often ambiguous at best. As a result, thorough understanding of the regional aspects of the play remains elusive to many companies. It is our belief that modern seismic data and interpretation techniques can add significantly to the database and greatly enhance regional understanding of the play for many companies. Newly acquired 3D datasets provide a continuous characterization of the subsurface, which highlights drilling hazards (faults), and also offers the potential for identifying better reservoir quality intervals (higher TOC shale sections with greater porosity and fractures). Extracting rock properties from the seismic should be the goal of any processing and interpretation effort. Linking the results of well tests to the attributes derived from the seismic will provide operators with a far more reliable predictive capability in any shale play.

Ultimately, the pursuit of Eagle Ford acreage and the designing of an Eagle Ford drilling campaign is best accomplished through a comprehensive understanding of the geologic framework coupled with a focused interpretation of the seismic. This shale is one of the more exciting domestic shale plays, and presents ample opportunities to make and lose money. The smart operator will utilize all the tools available to study the target section while recognizing the limitations of the technology.

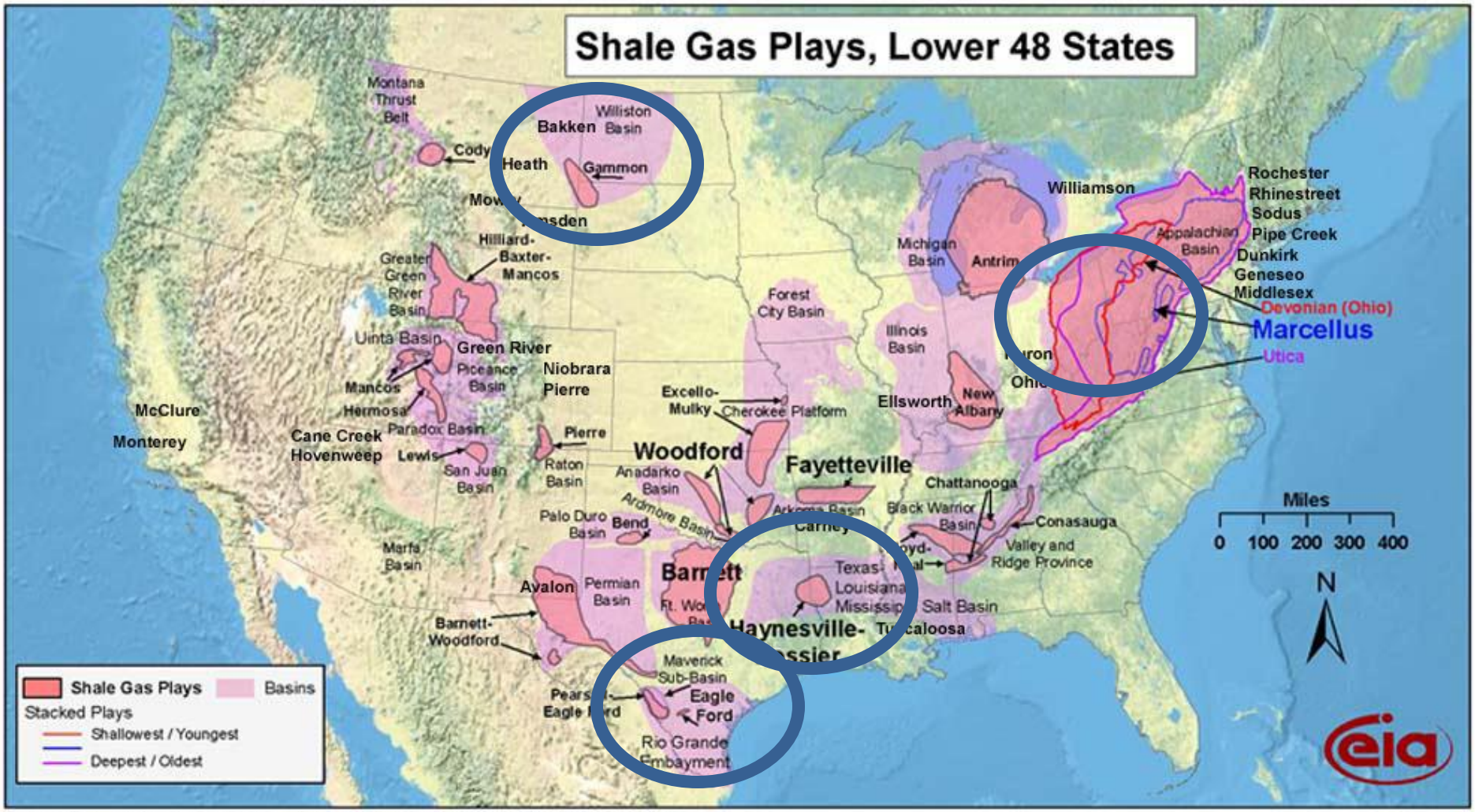
Eagle Ford Shale Exploration – Regional Geology meets Geophysical Technology

Galen Treadgold and Steve Sinclair





US Shale Plays



Source: Energy Information Administration based on data from various published studies.
Updated: March 10, 2010

Unconventional Reservoirs – Key Geophysical Technology

- Background Geology
- Seismic Acquisition
- Anisotropic Processing
- Elastic and Acoustic Inversion
- Surface Attributes
- Frac Monitoring (Microseismic)

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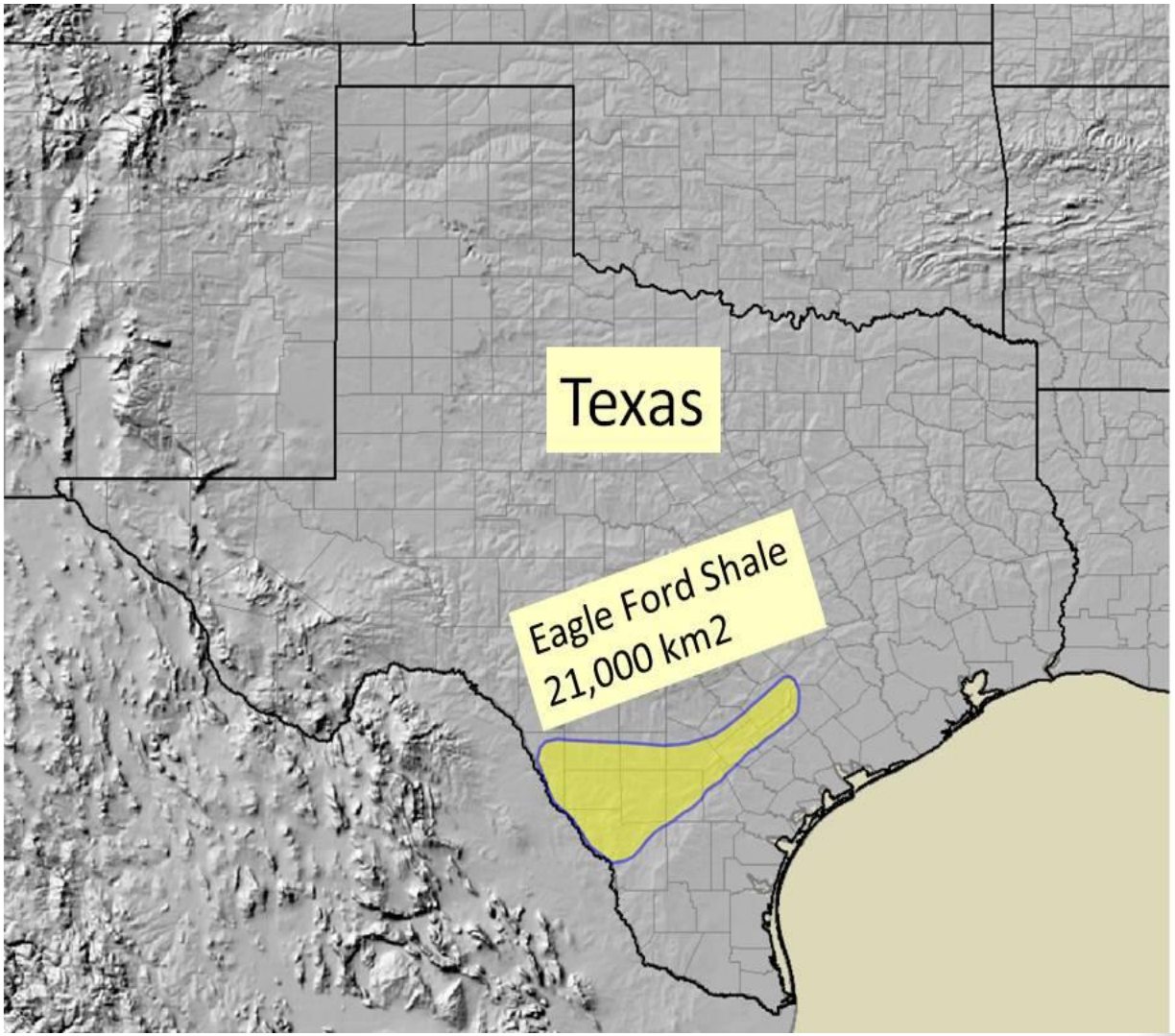
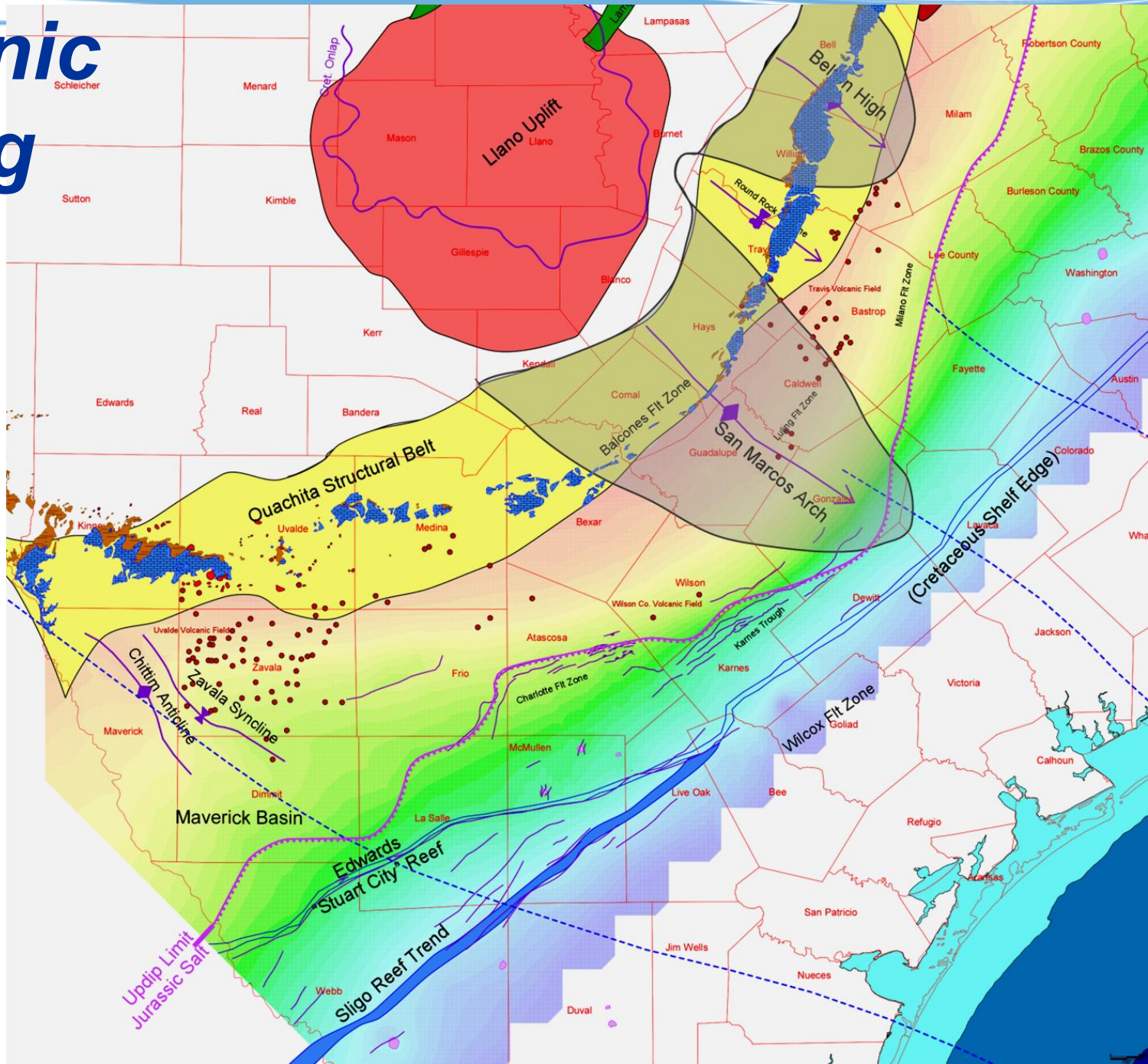
South Texas Eagle Ford



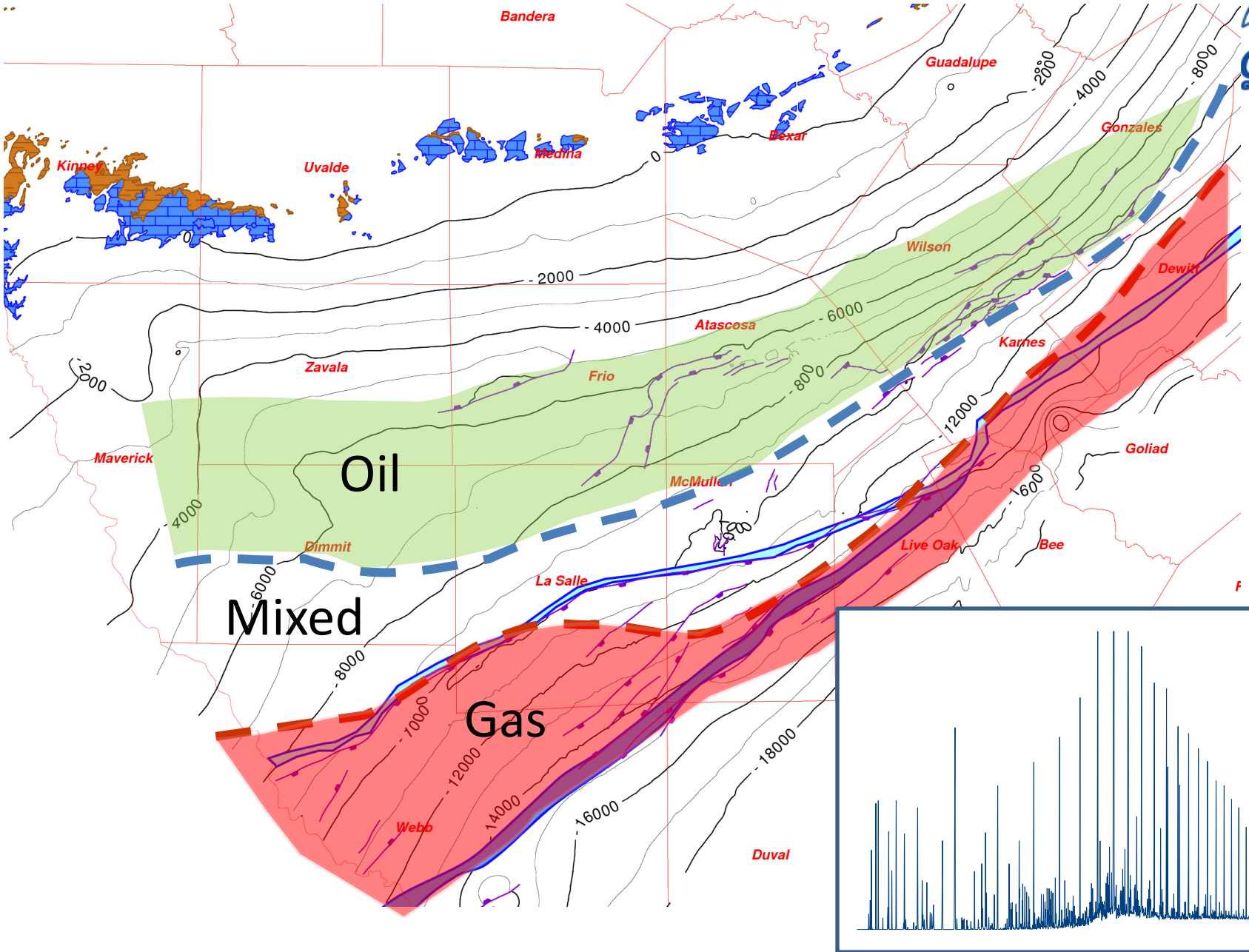
What makes the Eagle Ford work ?

- High TOC rock ≥ 4%
- Porosities in excess of 12%
- Effective porosity feet (PHIH) greater than 9
- Enhanced permeability via micro or macro fractures
- Thermal maturity

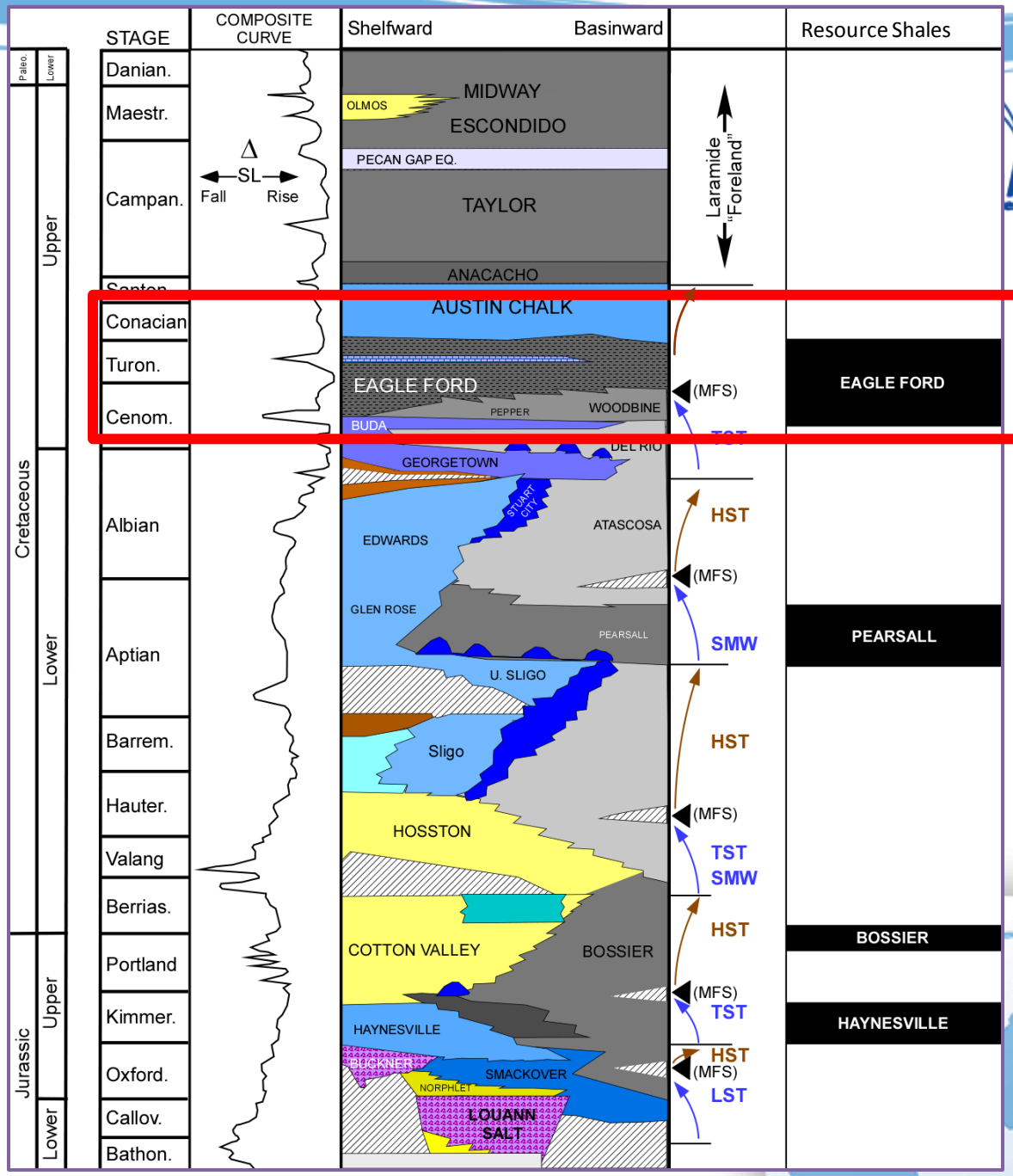
Tectonic setting



Petroleum Fairways

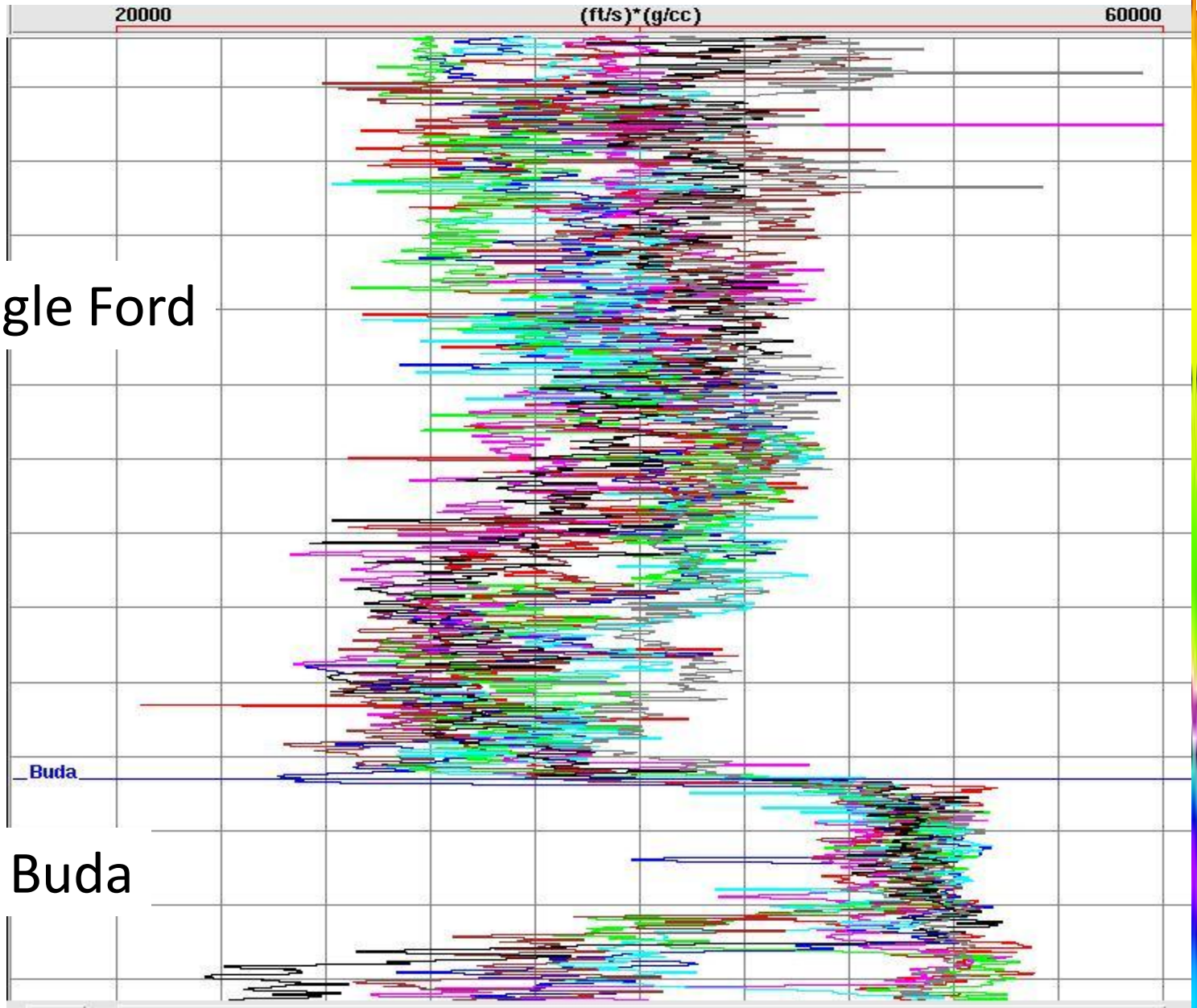


Stratigraphy



ldhammer et. al. 1991

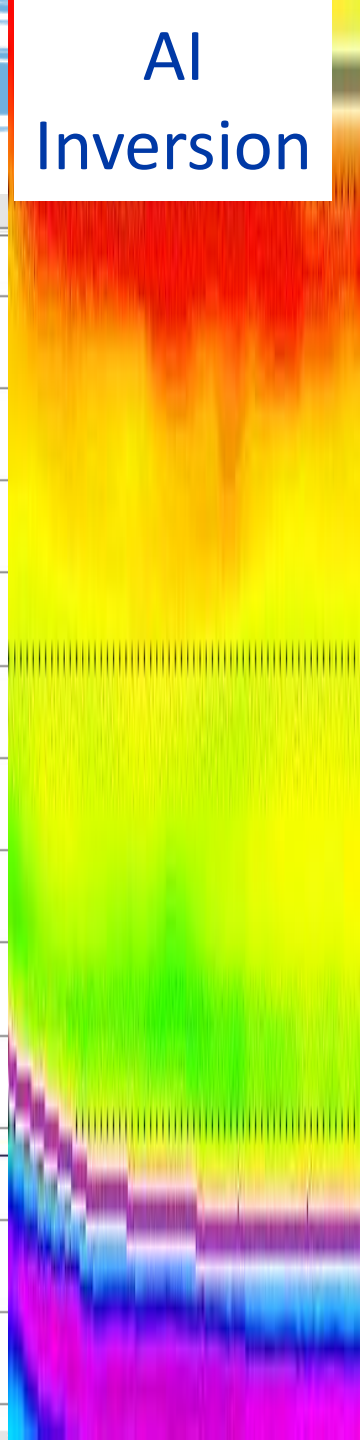
Impedance – 8 wells



Eagle Ford

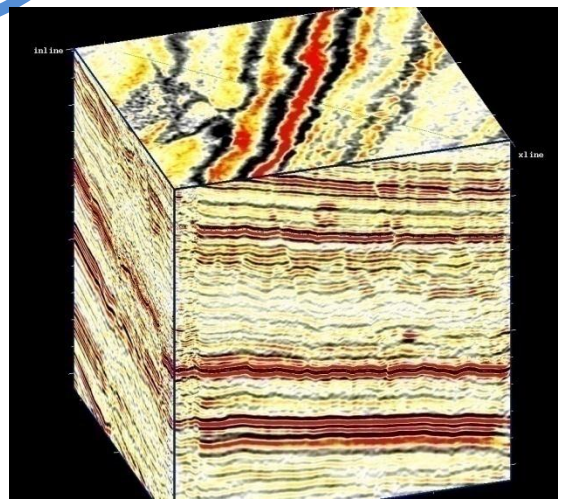
Buda

AI Inversion



Shale Prospecting…..what we're after

Vp
Vs
Density



- Brittle/Ductile Quality
  - LMR - MuR
- Lithology (rock type, clay content…)
- TOC
- Fluid Content
- Porosity
- Pore Pressure, Effective Stress
- Stress Field Orientation
- Fracture Density
- Bulk Modulus
- Poisson's Ratio
- Acoustic Impedance
- Elastic Impedance

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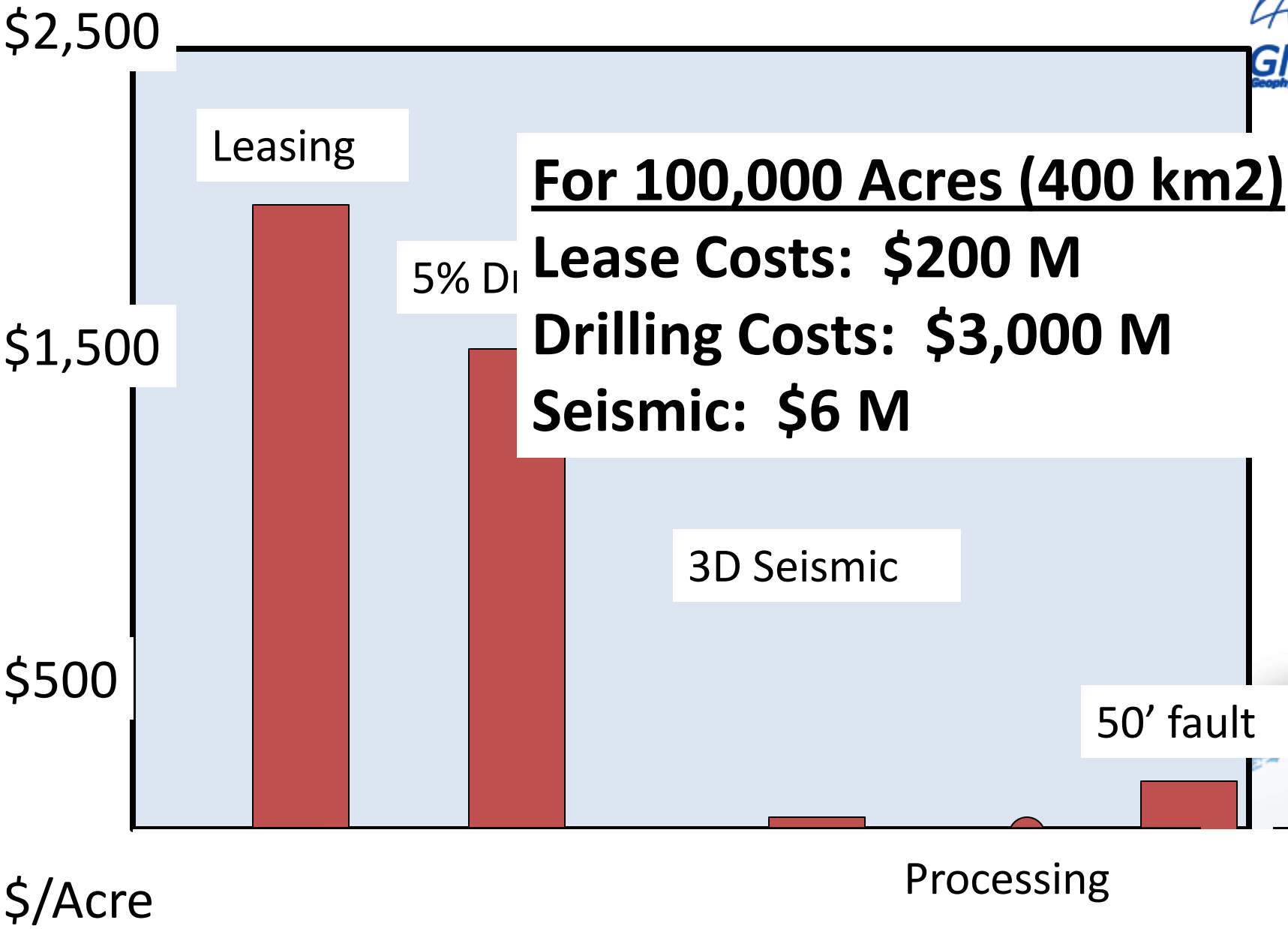
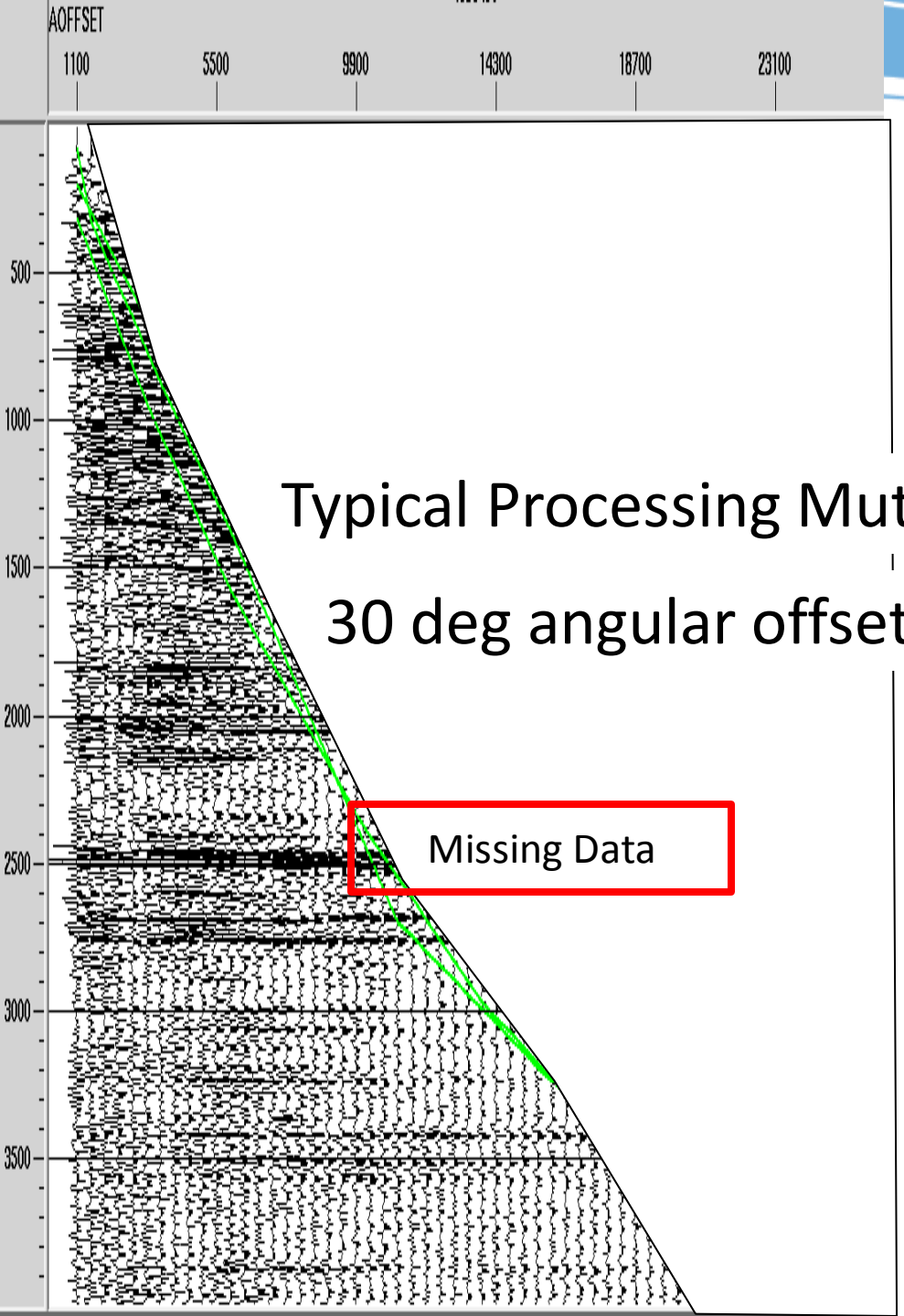
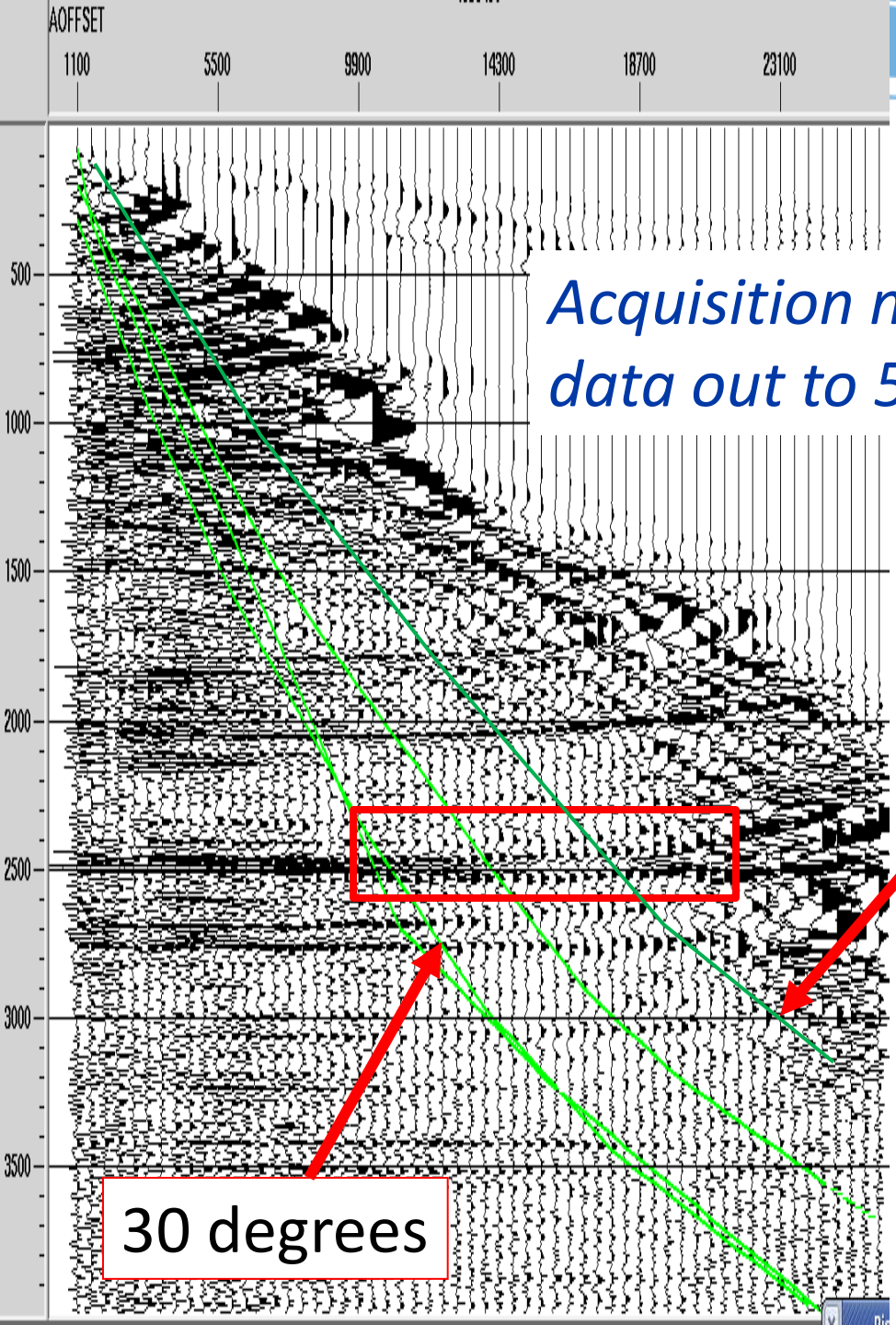
Cost Perspective – Eagle Ford



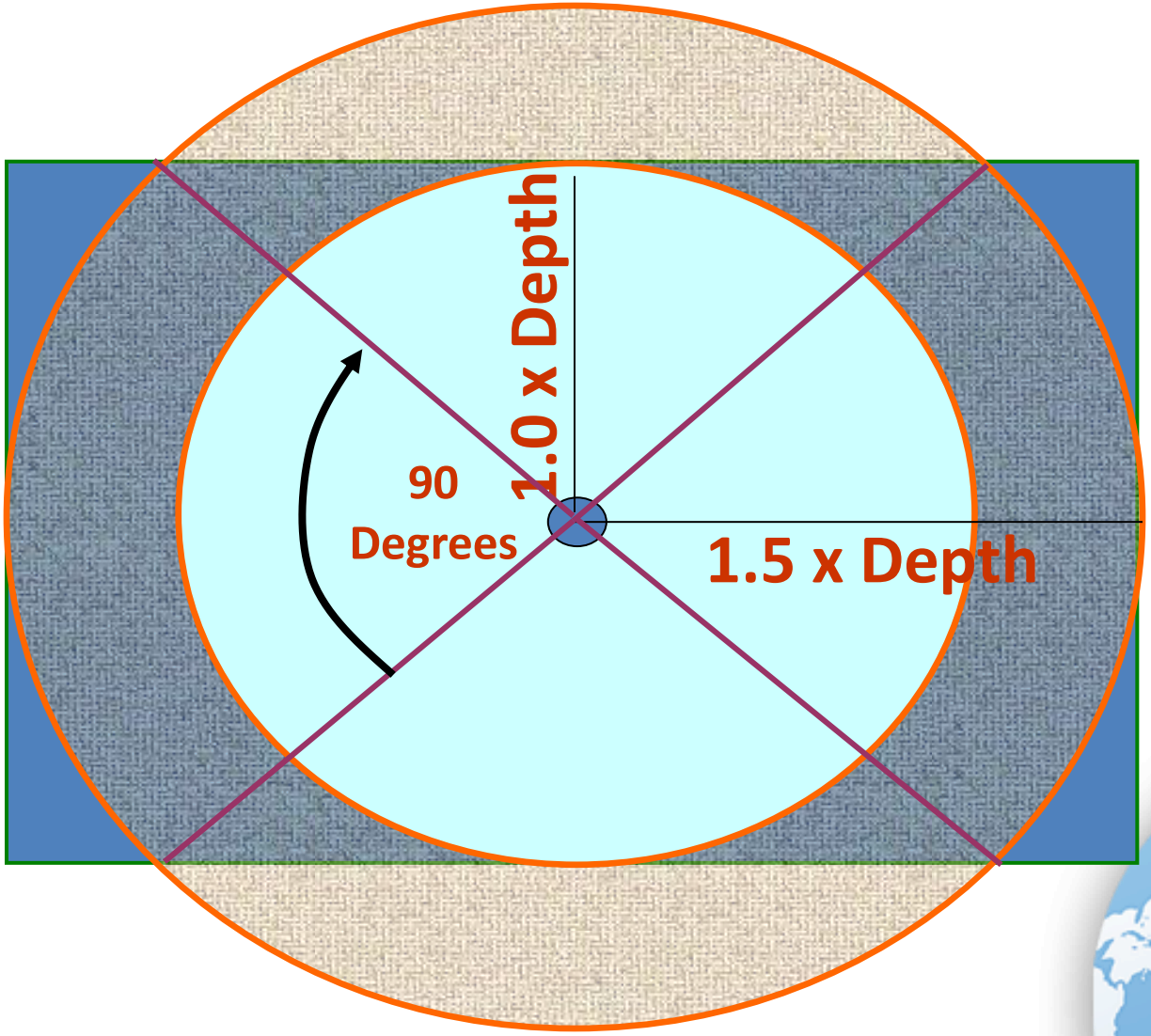


Pre-Stack Seismic Data

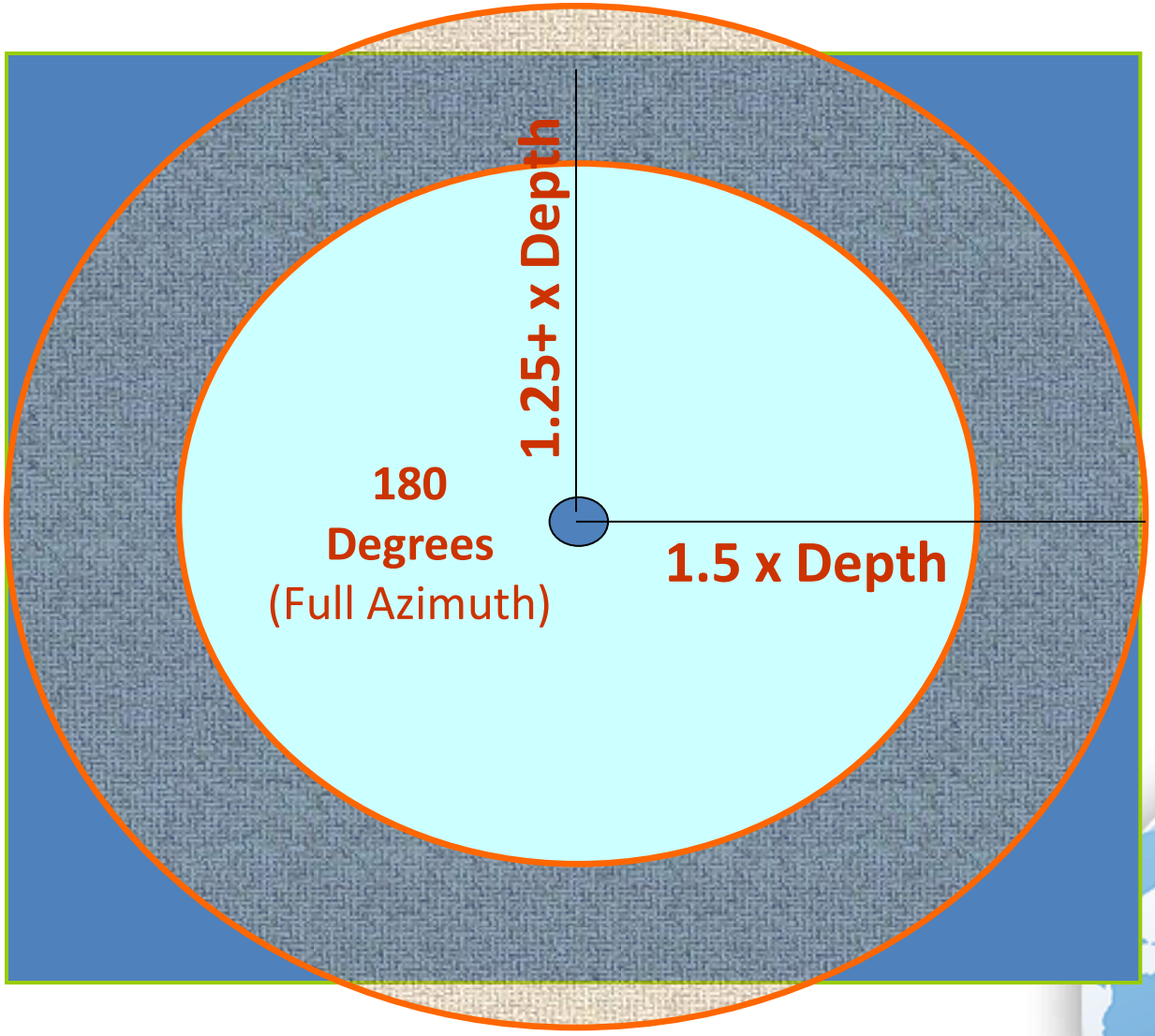


Acquisition needs to provide data out to 50 degrees or more.

Traditional Acquisition



Full Azimuth Shooting



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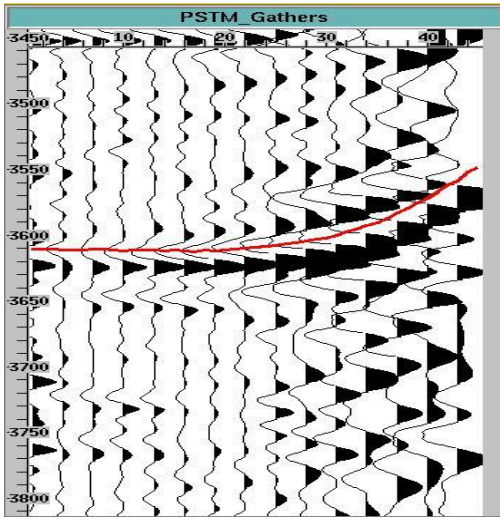
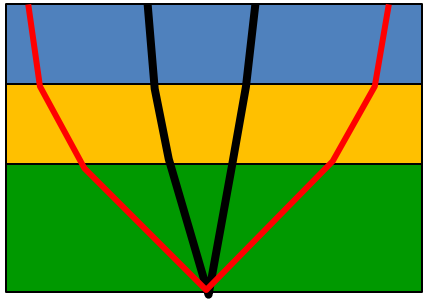
Anisotropic Processing

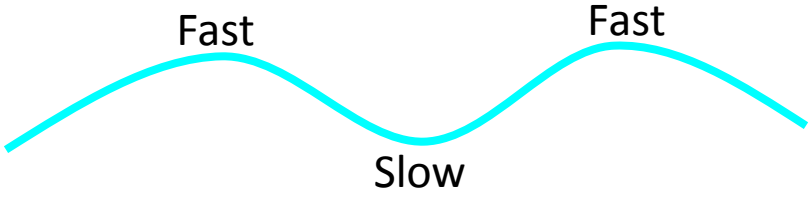
VTI
Layer Anisotropy

Offset

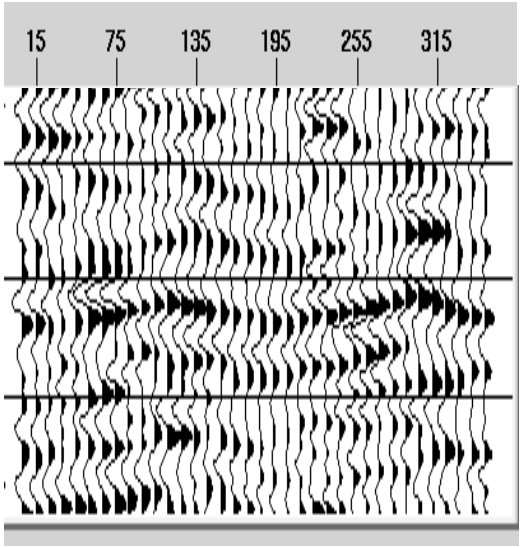


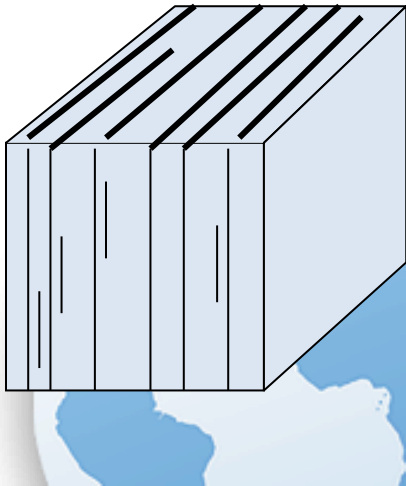


HTI
Azimuthal Anisotropy



Azimuth

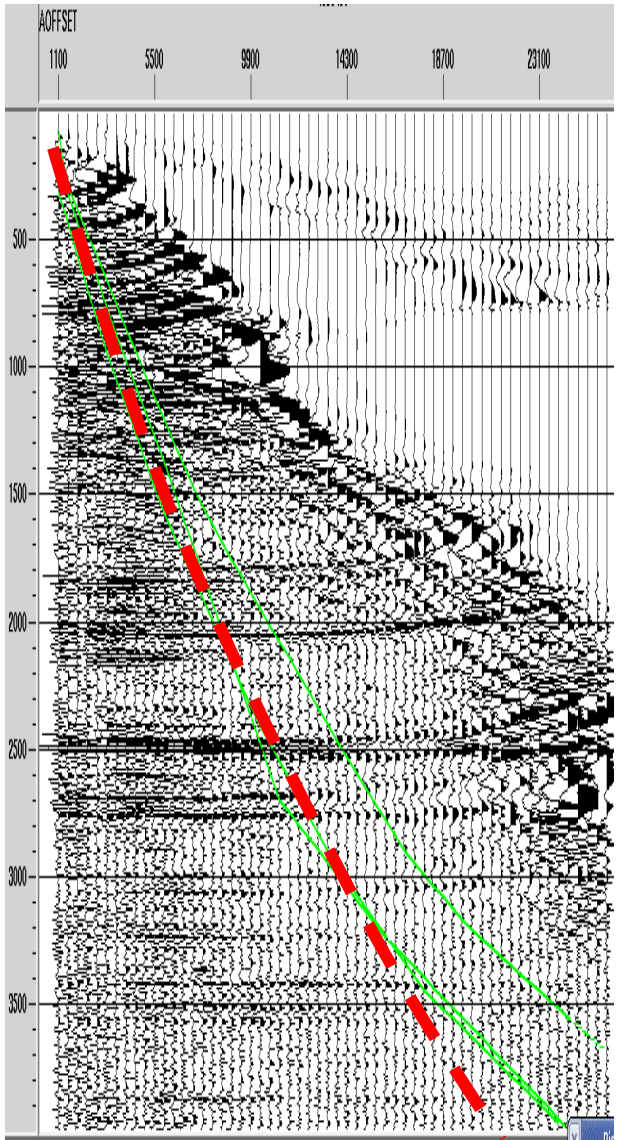




Need Full Azimuth, Far Offset Data

Near Offset

Far Offset



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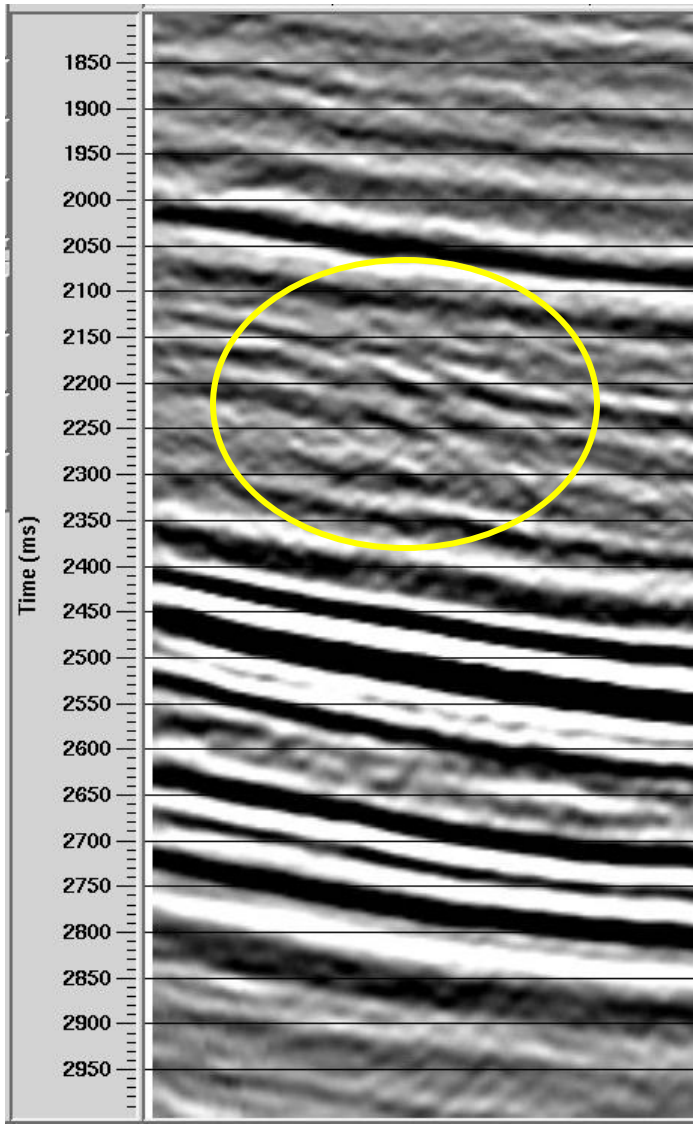
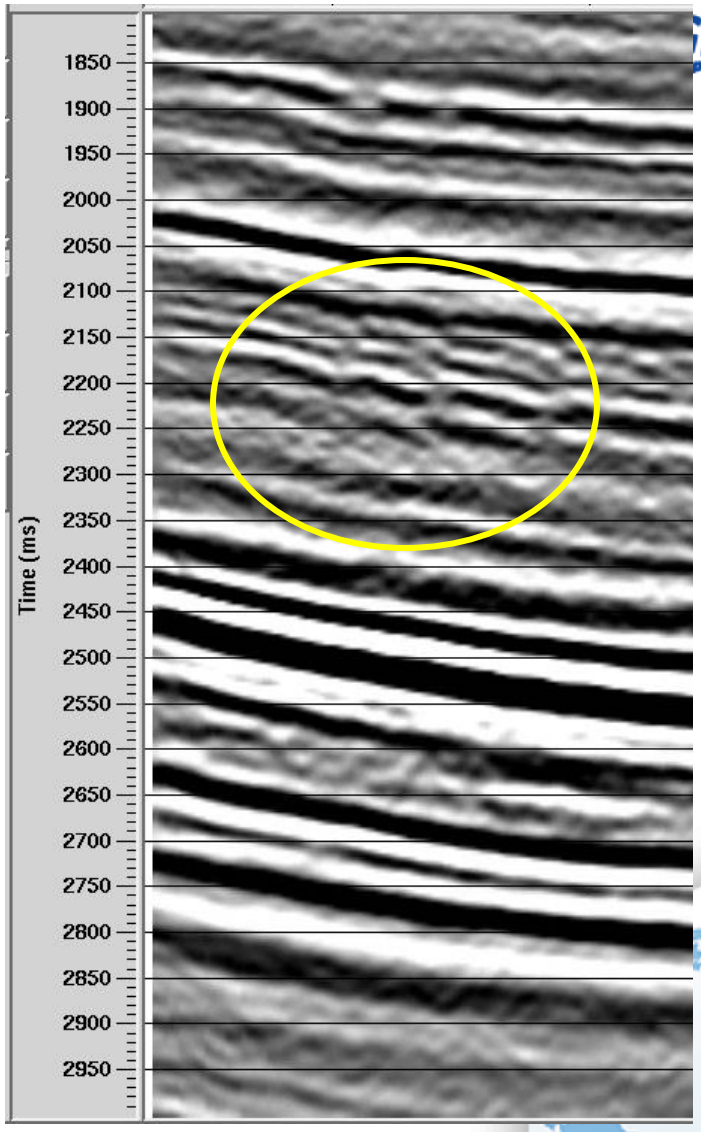
- Stress Field Orientation
- Fracture Density
- Bulk Modulus
- Poisson's Ratio
- Acoustic Impedance
- Elastic Impedance

Far Stack Impact – Proper Migration

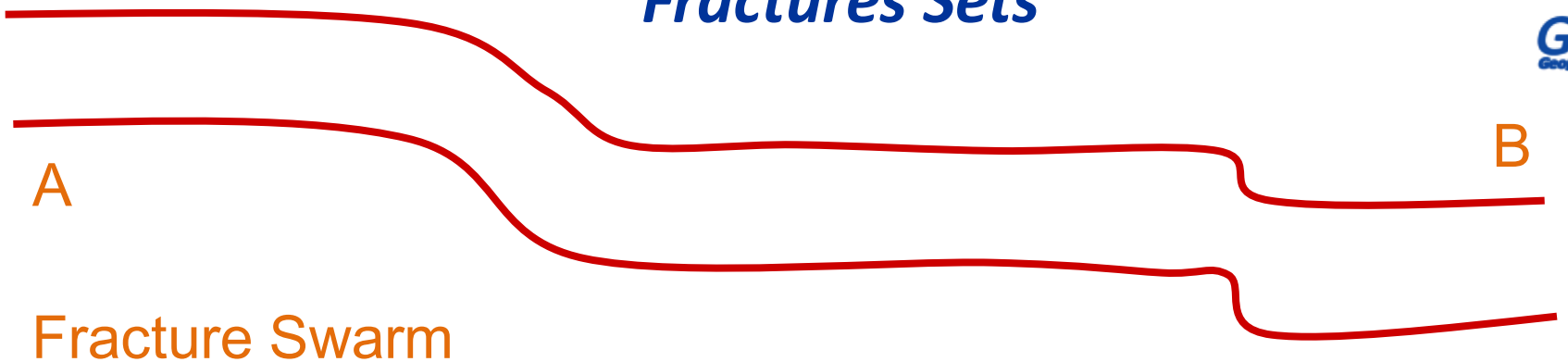


Isotropic

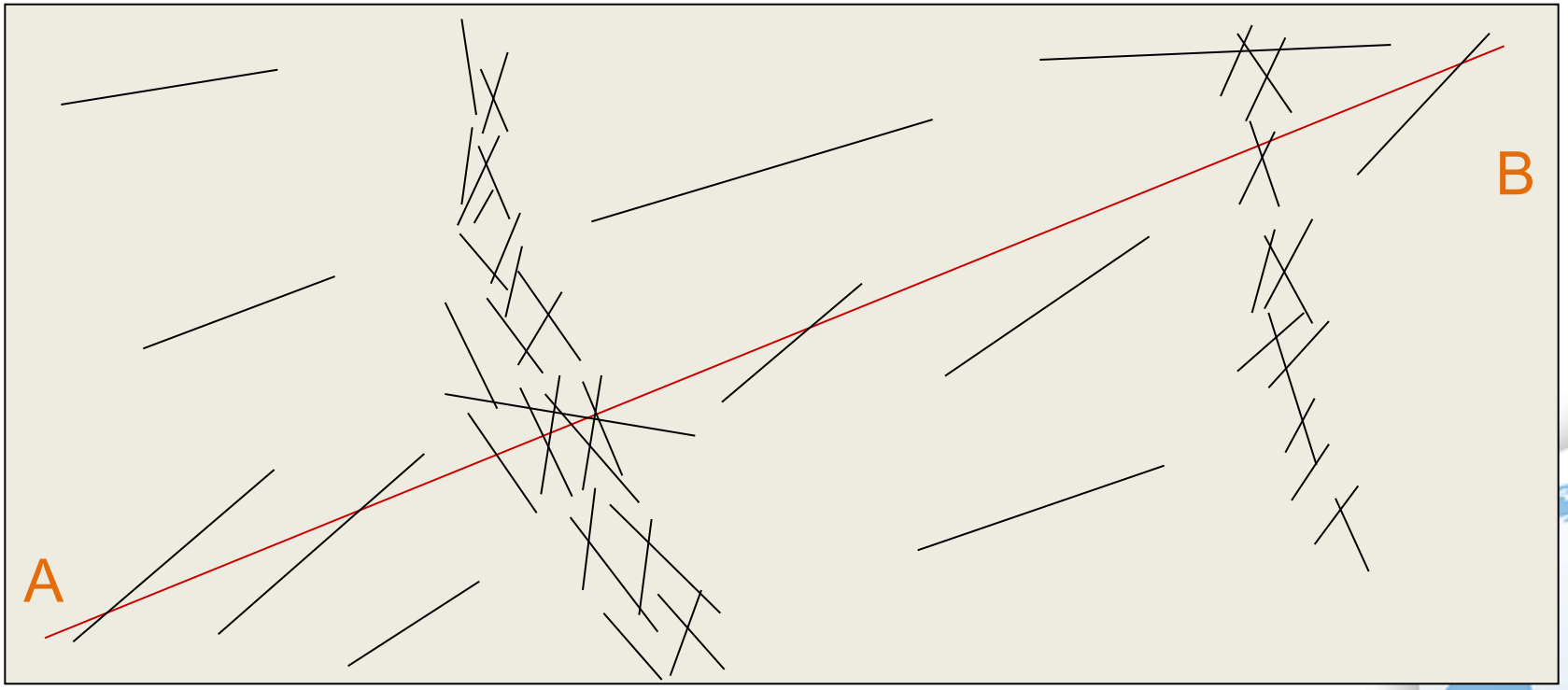


Anisotropic

Conceptual Cross Section & Map View of Fractures Sets



Fracture Swarm

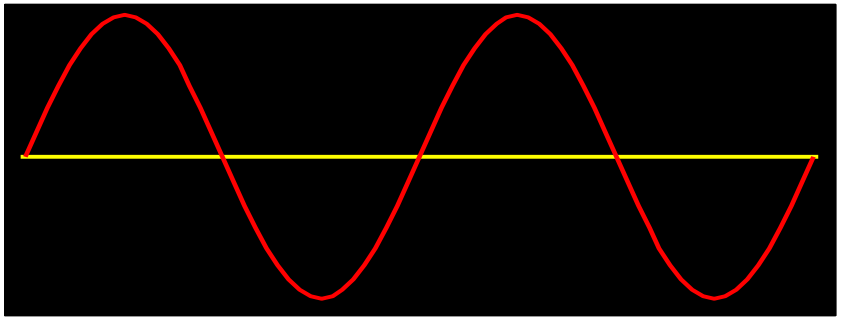


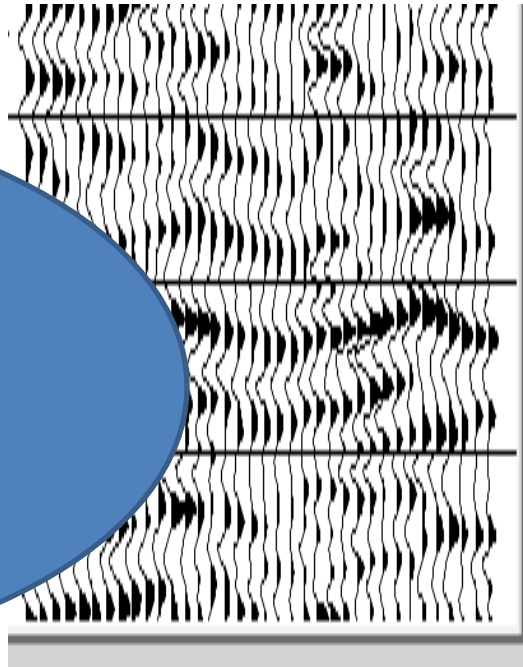
Fracture/Stress Prediction From 3D Seismic

Super Gathers

VOT's

Azimuthal Imaging





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Inversion Products

Vp

Density

Vs

AI

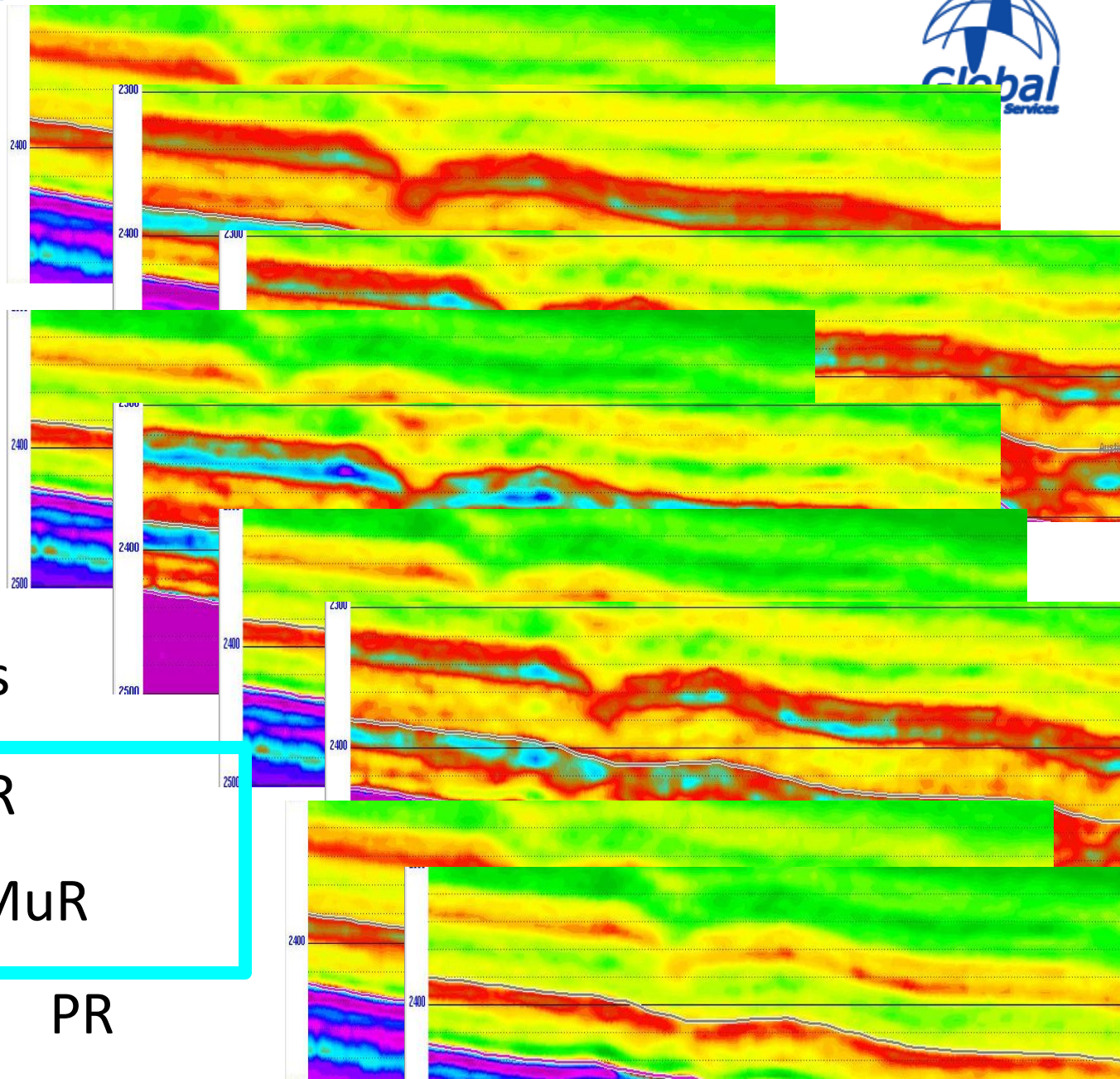
SI

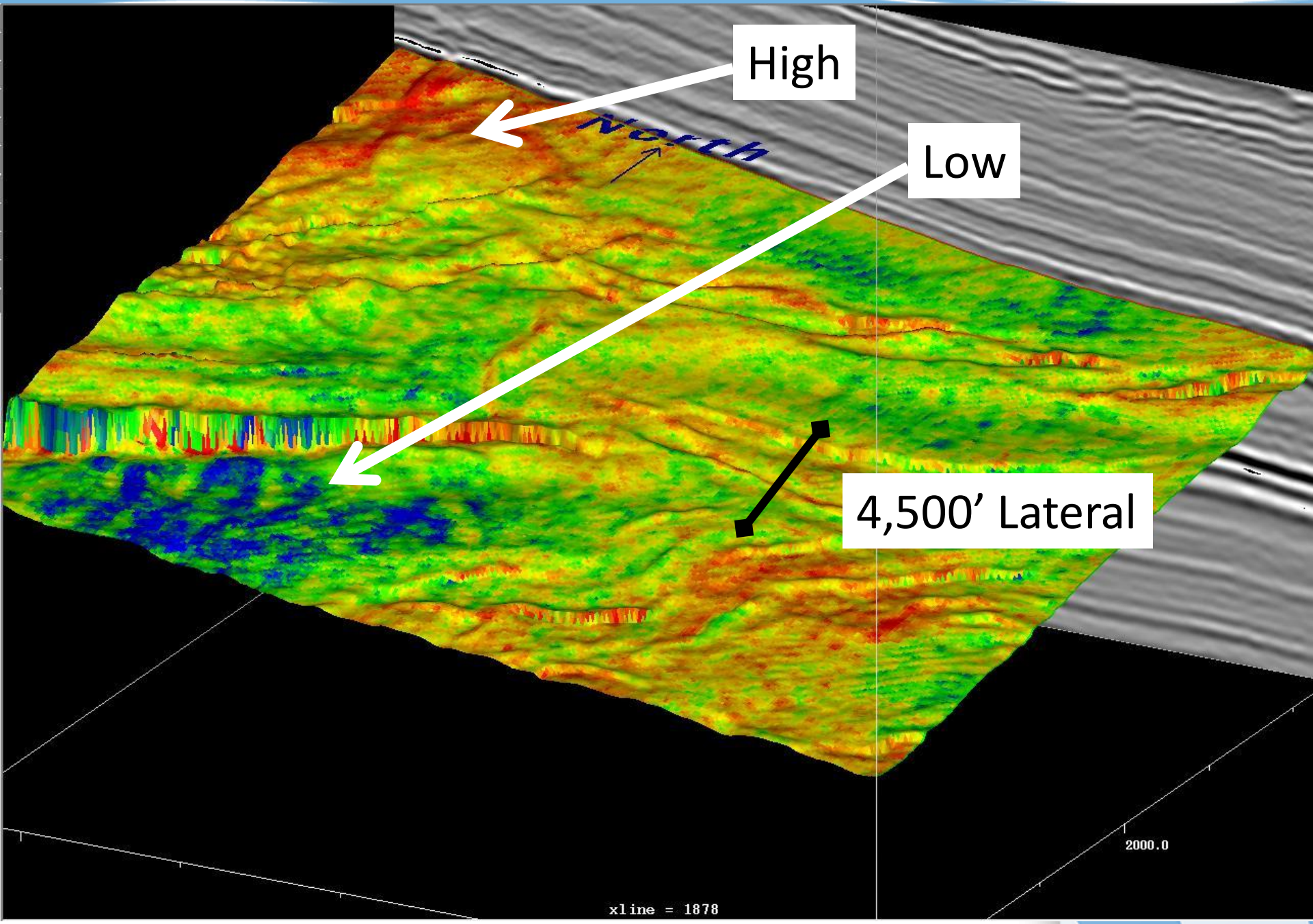
Vp/Vs

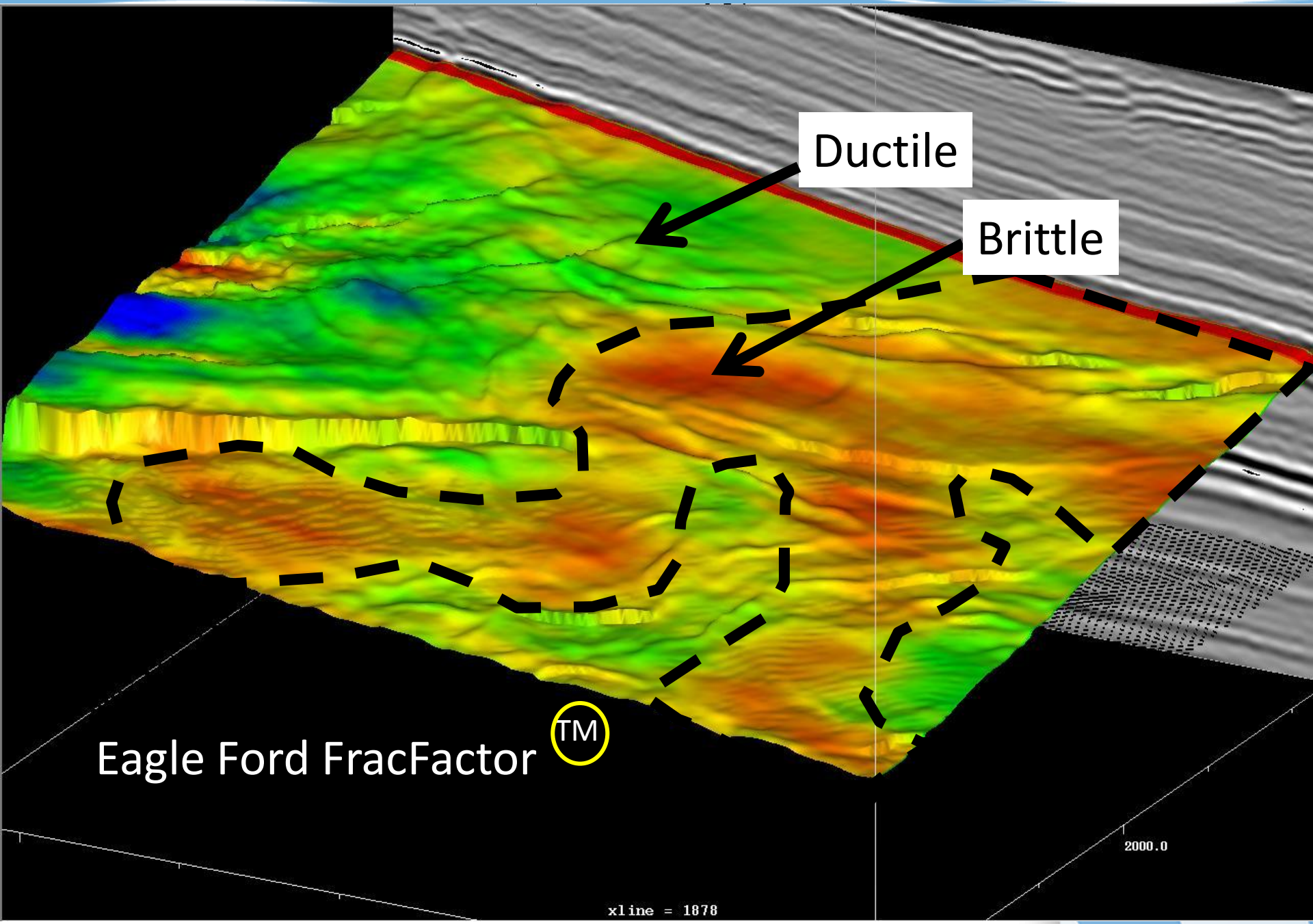
LMR

MuR

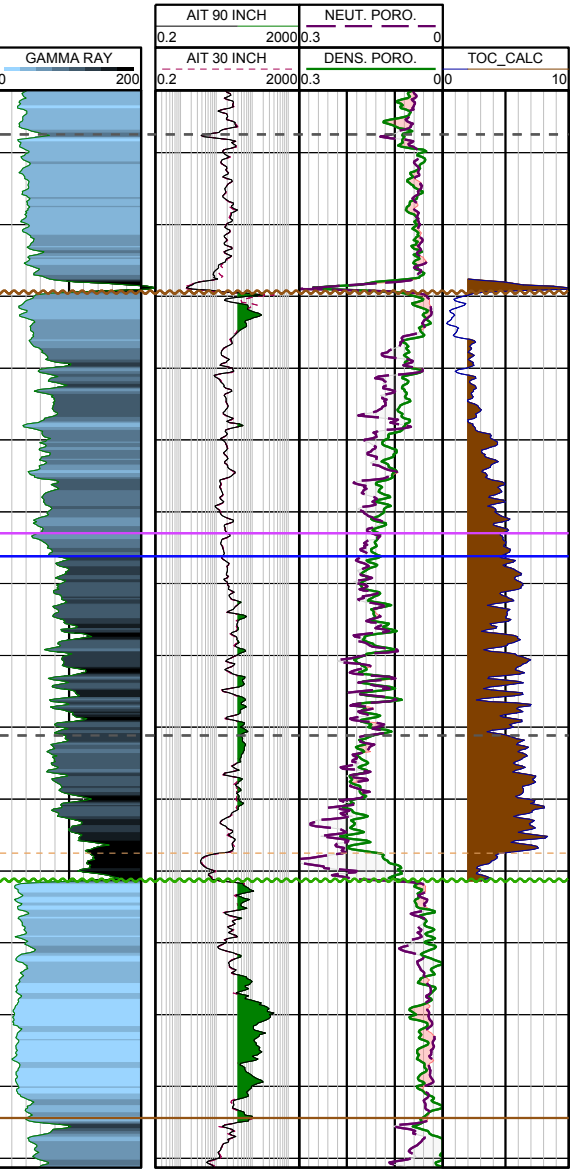
PR

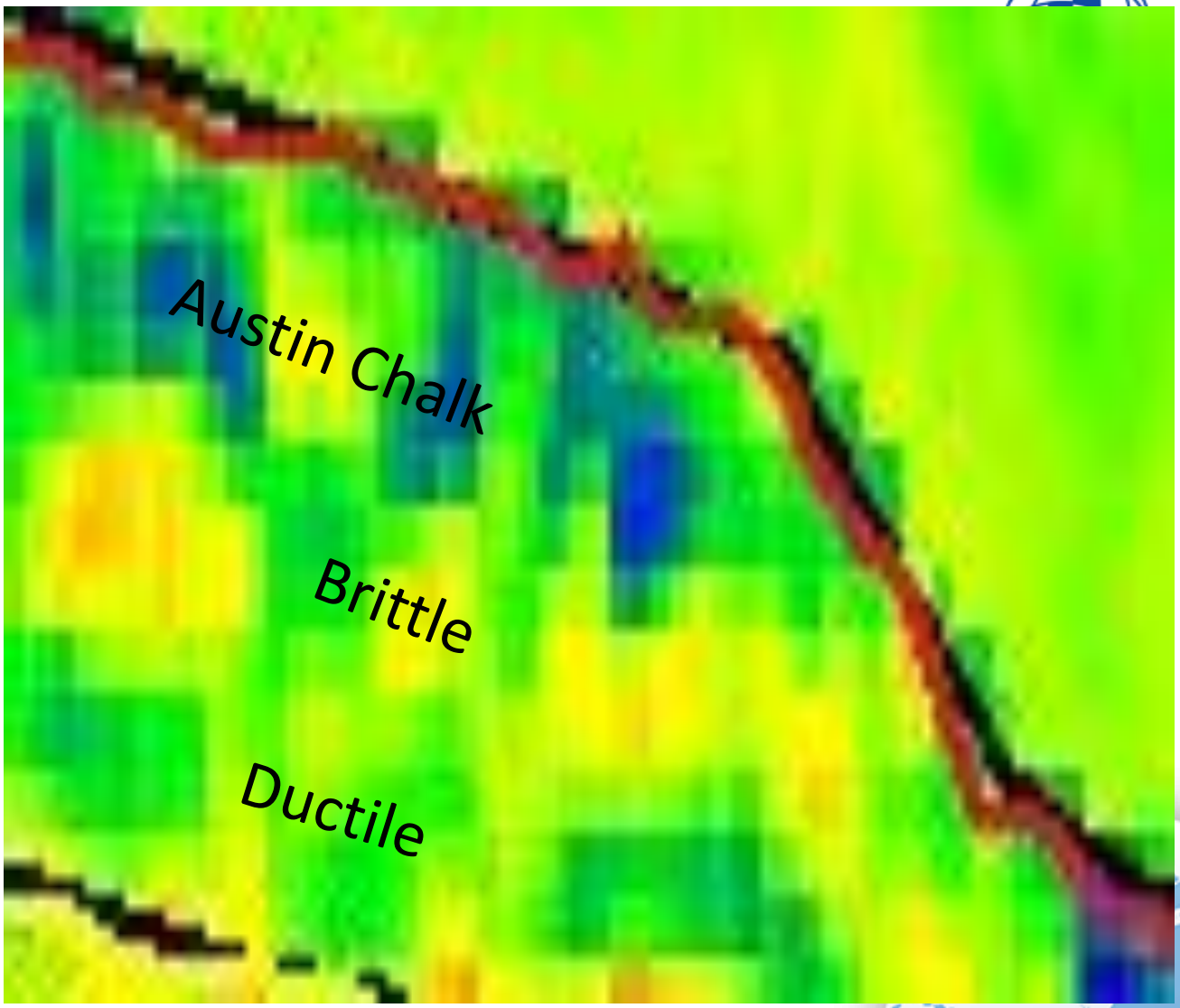



High
North
Low
4,500’ Lateral
2000.0
xline = 1878


Ductile
Brittle
Eagle Ford FracFactor TM
2000.0
xline = 1878

Limited Calibration





75

100

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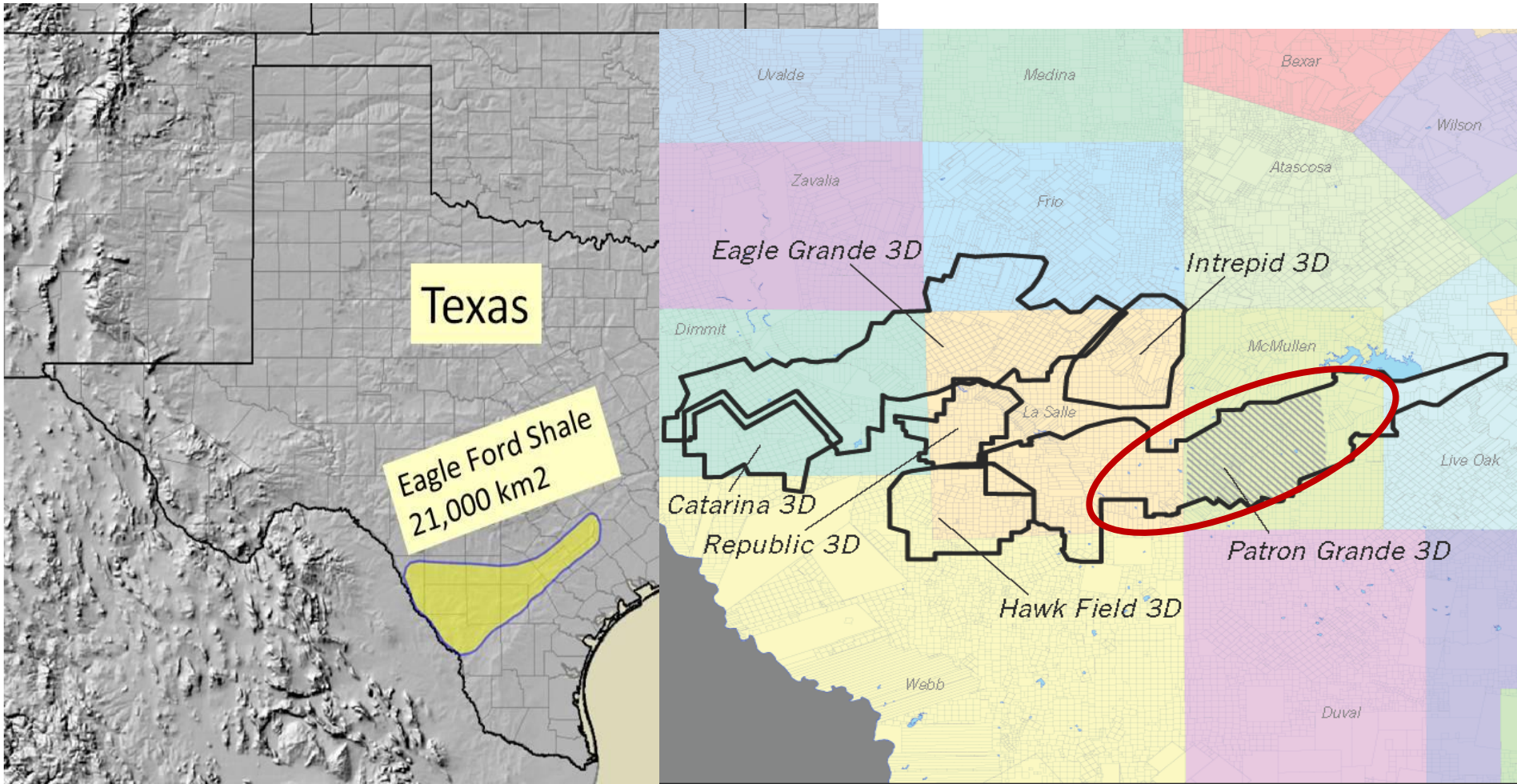
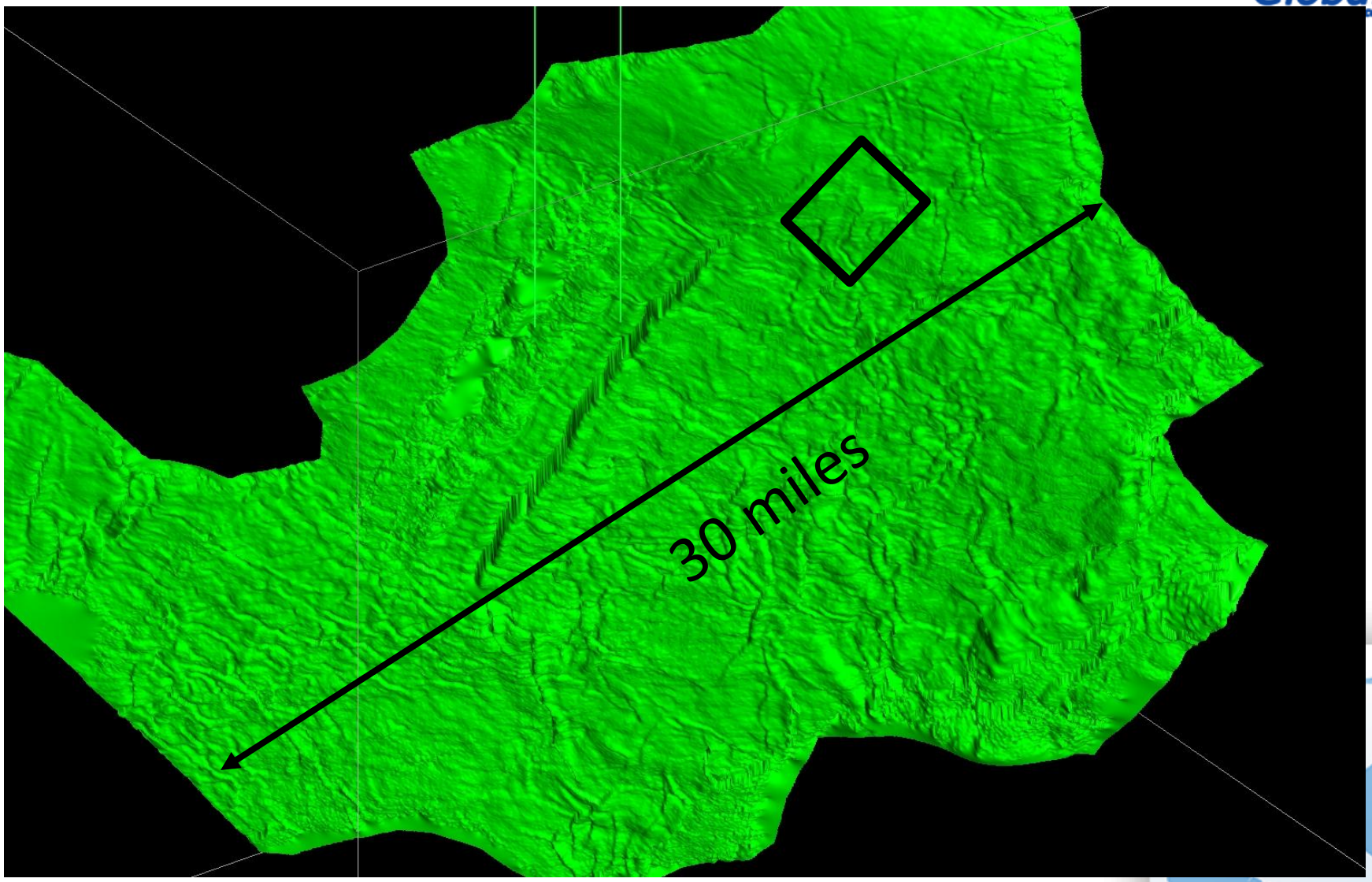
- Surface Attributes and Interpretation
- Frac Monitoring (Microseismic)

Current Eagle Ford Efforts

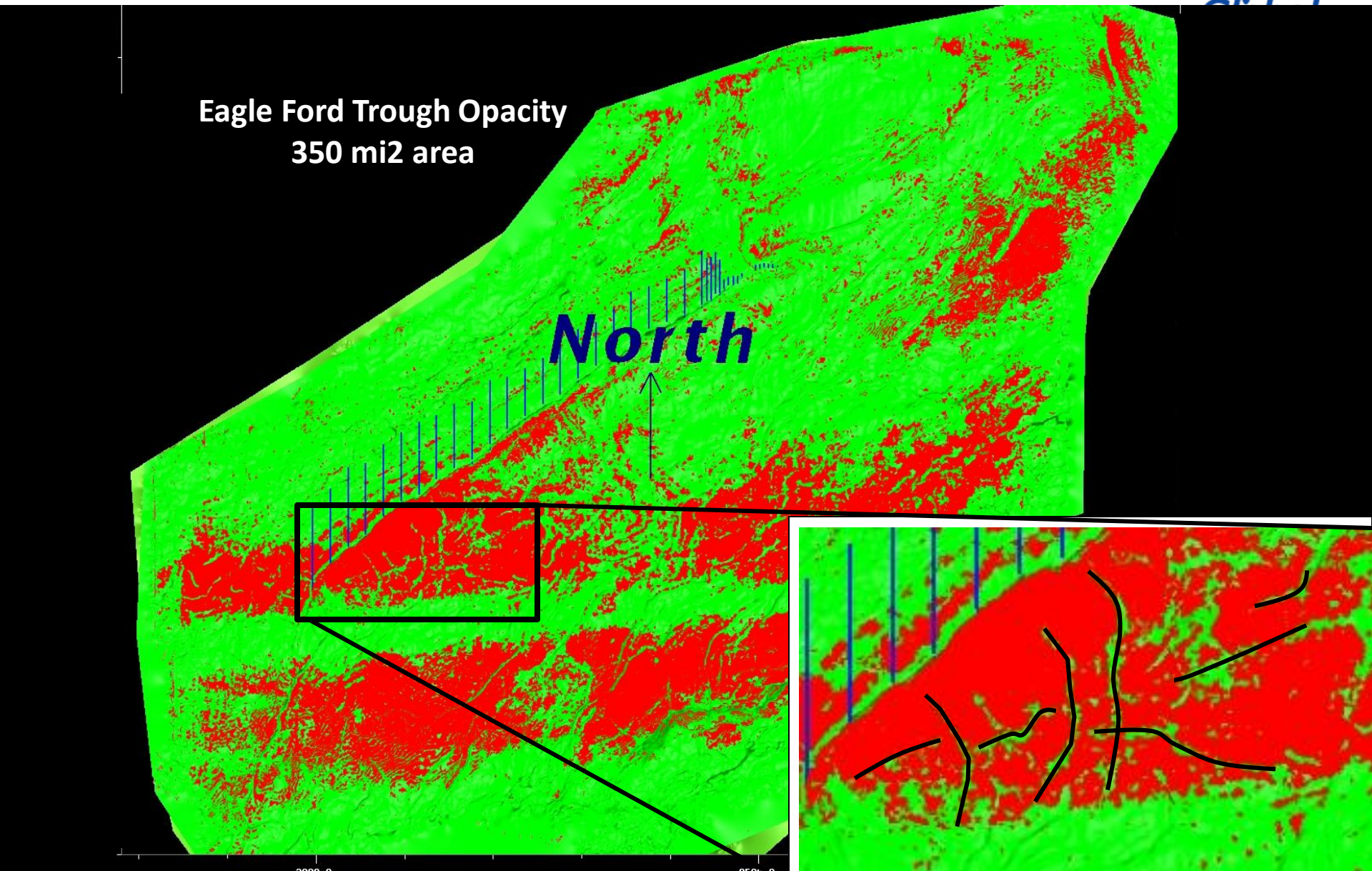
Nearly 5,000 km2 – P and some Shear



Base Eagle Ford – 440 mi2



Uniform Shale???



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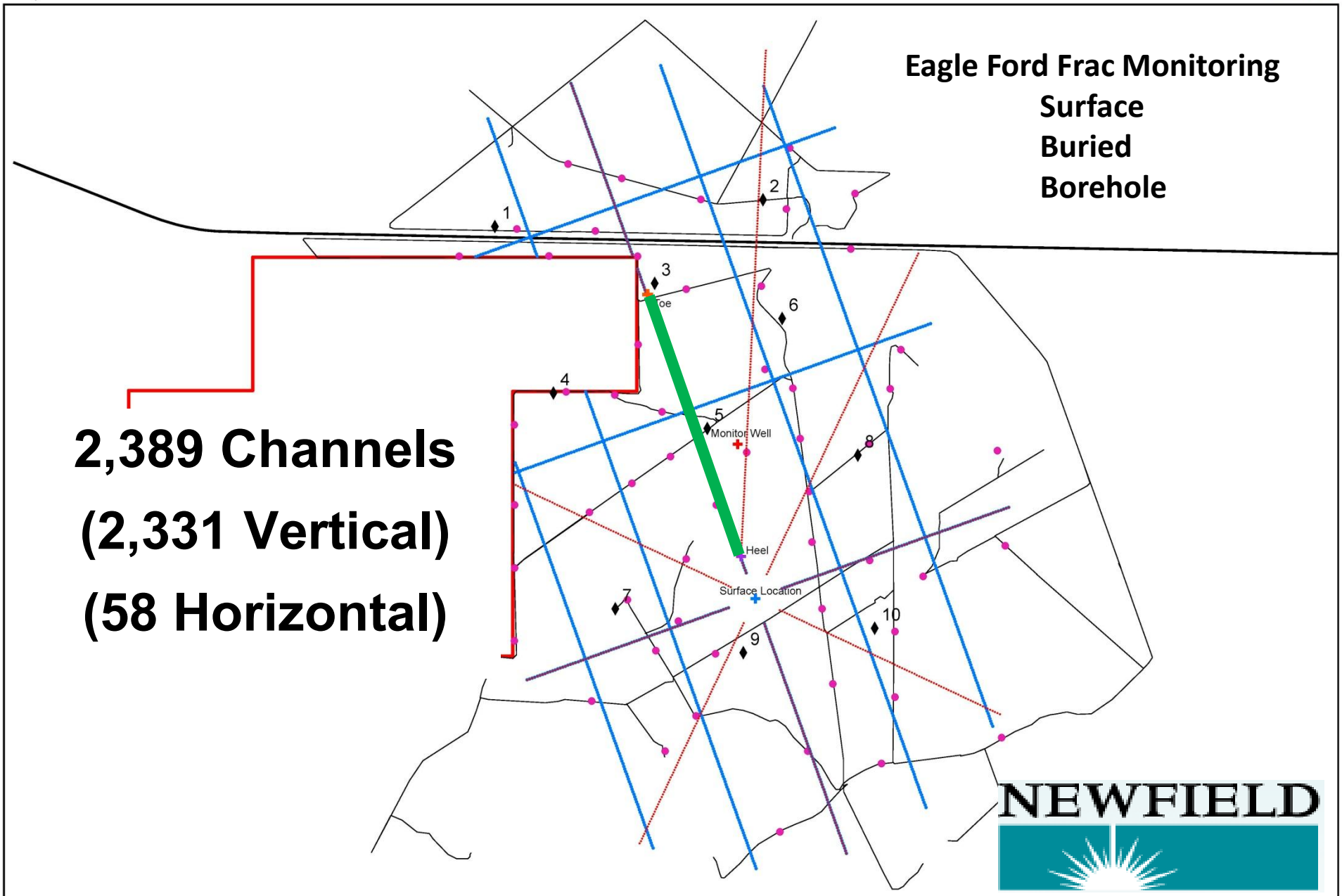
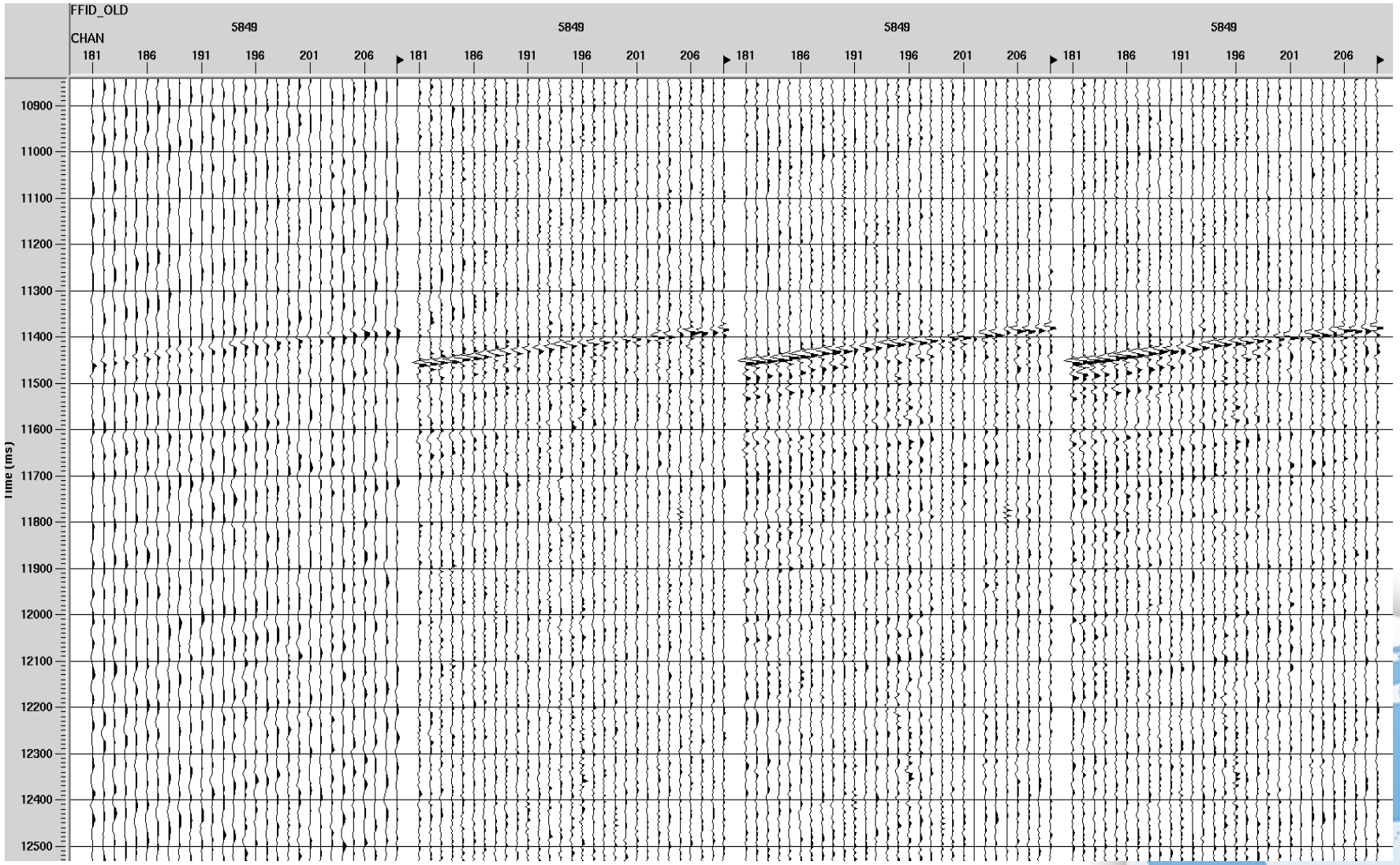
Field Operations –
3C Sonde Grid Installation

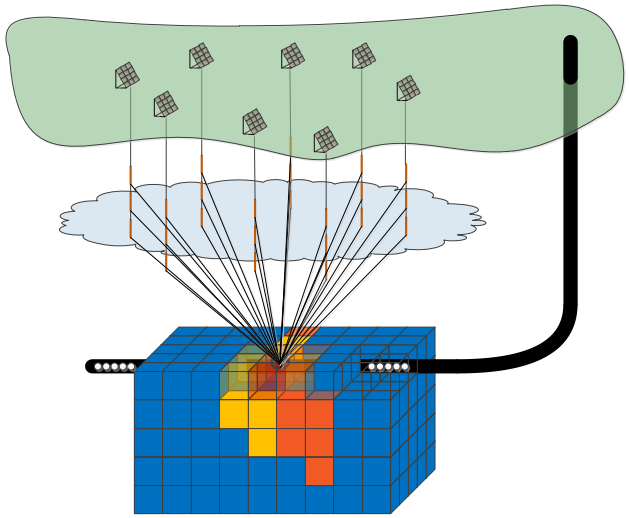

Eagle Ford Frac Monitoring
Surface
Buried
Borehole
2,389 Channels
(2,331 Vertical)
(58 Horizontal)
1
2
3
Toe
4
5
Monitor Well
6
7
8
9
10
Heel
Surface Location
NEWFIELD

Data Analysis –
Understanding signal and noise issues

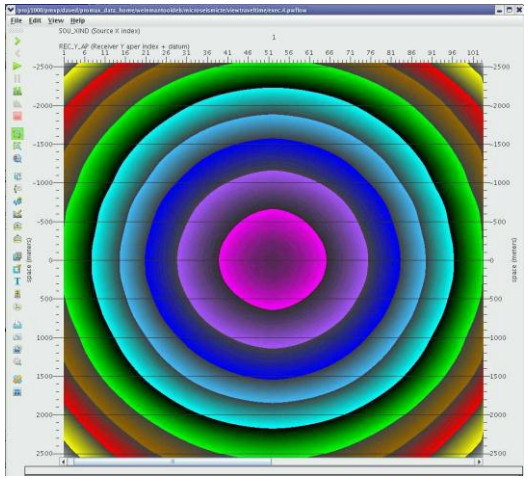


Seismic Emission Tomography

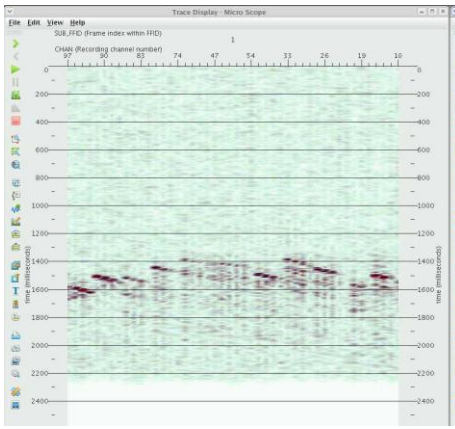
Kirchhoff migration to image microseisms



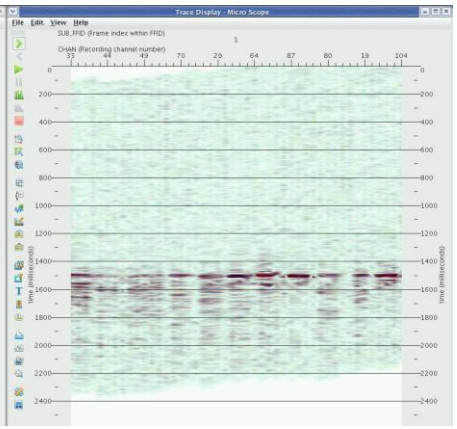
Ray Tracing



Travel Times



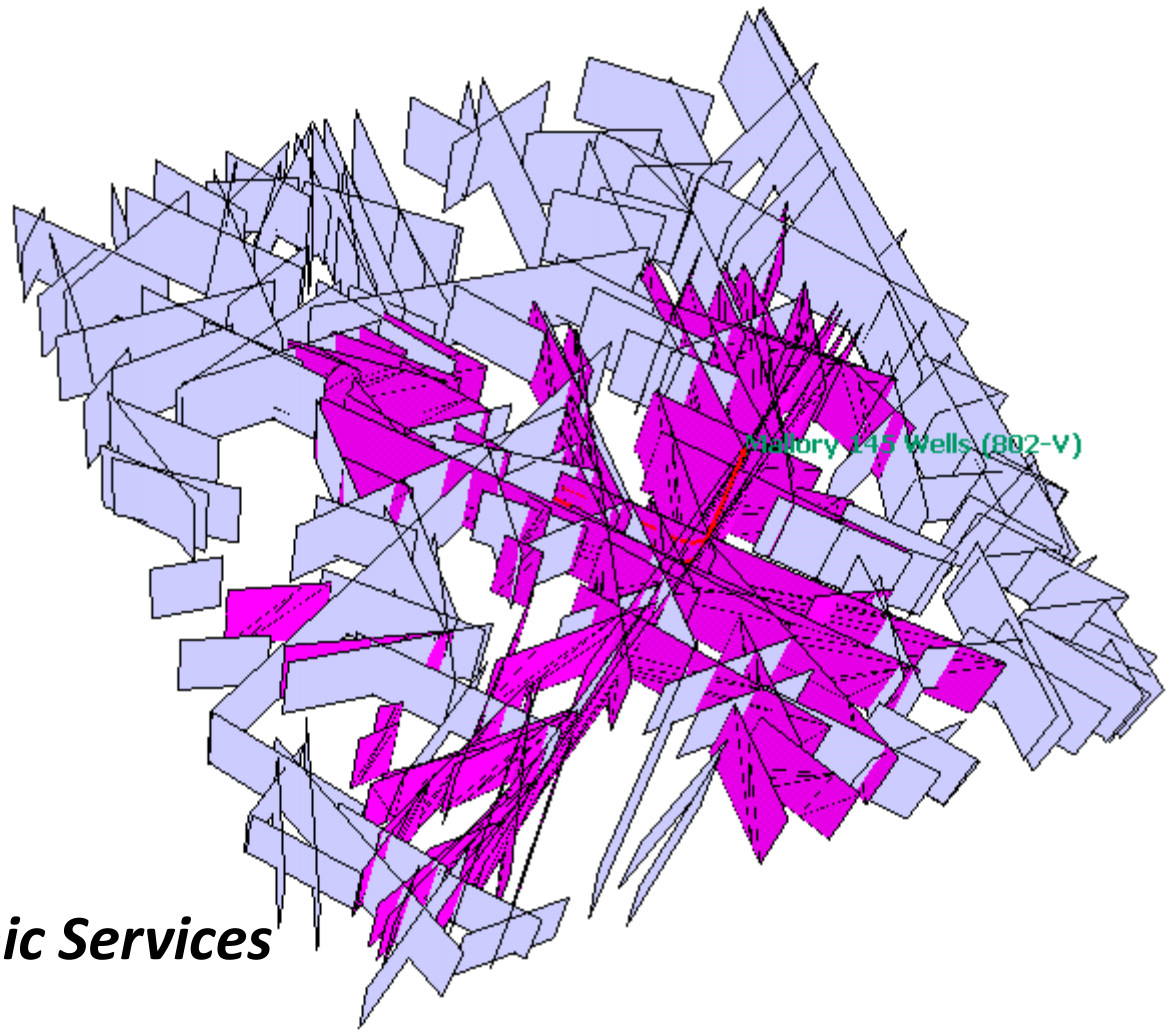
Before Moveout



After Travel Time Moveout

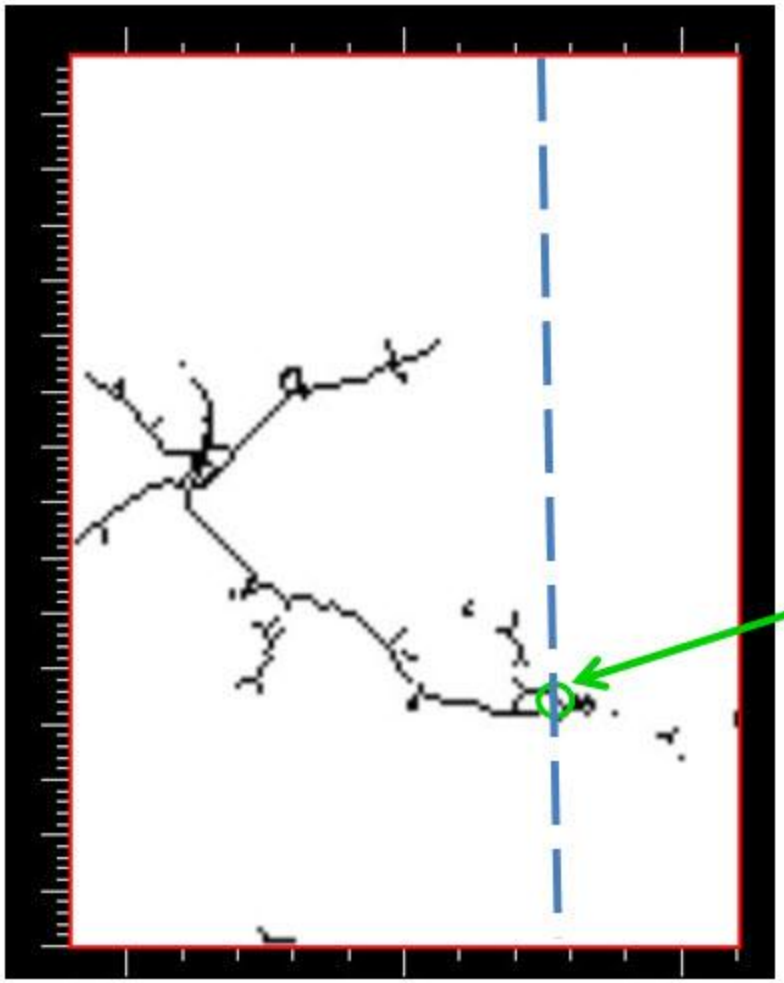
Semblance Processing

- Stacking
- Clamping
- Skeletonizing



Global Microseismic Services

Fracture Skeleton
6 Minutes From Stage 12



Location of Perfs for Stage 12

Surface Monitoring highlights Eagle Ford fracture network (conformed by borehole results)

Semblance Window 1000ms, 100

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Wish to thank

Key Matador Resources Staff

David Nicklin

Bo Henk

Anne L. McColloch

Key Global Staff

Bruce Campbell

Jerry Henderson

Mary Davis

Bill McLain

Peter Geiser