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

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Search and Discovery Article #10361 (2011)
Posted October 11, 2011

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Houston, Texas, USA, April 10-13, 2011

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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)
Unconventional Reservoirs – Key Geophysical Technology

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South Texas Eagle Ford
What makes the Eagle Ford work?

- High TOC rock $\geq 4\%$
- Porosities in excess of 12\%
- Effective porosity feet (PHIH) greater than 9
- Enhanced permeability via micro or macro fractures
- Thermal maturity
Tectonic setting
**Stratigraphy**

<table>
<thead>
<tr>
<th>STRATUM</th>
<th>COMPOSITE CURVE</th>
<th>SHELFWARD</th>
<th>BASINWARD</th>
<th>RESOURCE SHALES</th>
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Modified from Goldhammer et al. 1991

Resource Shales

- EAGLE FORD
- PEARSSALL
- BOSSIER
- HAYNESVILLE

TST

(MFS)

(LST)
Impedance – 8 wells

Eagle Ford

Buda
Shale Prospecting.....what we’re after

- 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

Vp
Vs
Density
Unconventional Reservoirs – Key Geophysical Technology

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- Frac Monitoring (Microseismic)
Cost Perspective – Eagle Ford

For 100,000 Acres (400 km²)

- Lease Costs: $200 M
- Drilling Costs: $3,000 M
- Seismic: $6 M

$/Acre

Leasing

5% Drilling

3D Seismic

50’ fault

Processing
Typical Processing Mute
30 deg angular offset

Missing Data
Acquisition needs to provide data out to 50 degrees or more.
Traditional Acquisition

1.0 x Depth

1.5 x Depth

90 Degrees
Full Azimuth Shooting

180 Degrees (Full Azimuth)

1.5 x Depth

1.25+ x Depth
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Anisotropic Processing

VTI
Layer Anisotropy

HTI
Azimuthal Anisotropy
Need Full Azimuth, Far Offset Data

- Brittle/Ductile Quality
  - LMR - MuR
- Lithology (rock type, clay content...)
- TOC
- Fluid Content
- Porosity
- Pore Pressure, Effective Stress
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- 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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Eagle Ford Impedance

Low

High

4,500’ Lateral

North
Eagle Ford FracFactor™
Limited Calibration

Austin Chalk
Brittle
Ductile
Unconventional Reservoirs – Key Geophysical Technology

- Background Geology
- Seismic Acquisition
- Anisotropic Processing
- Elastic and Acoustic Inversion
- 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???

Eagle Ford Trough Opacity
350 mi2 area
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Field Operations –
3C Sonde Grid Installation
RESEARCH PROGRAM | Grid InSight
Compilation

Eagle Ford Frac Monitoring
Surface
Buried
Borehole

2,389 Channels
(2,331 Vertical)
(58 Horizontal)
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
Surface Monitoring highlights Eagle Ford fracture network (conformed by borehole results)

Fracture Skeleton
6 Minutes From Stage 12

Location of Perfs for Stage 12

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