Eagle Ford Development Case Study Utilizing 3D Seismic in Structurally Complex Area, Atascosa County, Texas*

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Abstract

Development of the Eagle Ford oil accumulation in South Texas may generally be divided into two gradational trends, black oil and volatile oil. The black oil trend is characterized by: shallower depth, thinner Eagle Ford interval, lower gravity oil (<35 deg) lower GOR (<1000 to 1), and generally poorer economic returns than the volatile oil trend. Many areas of Eagle Ford development are also structurally simple with only regional basinal dip. However, Abraxas Petroleum Corporation is developing an area in the black oil trend that is structurally complex due to graben faulting and resultant folding. Because of the faulting during Eagle Ford deposition, the Eagle Ford interval expands from about 100 ft. thick outside the graben to about 180 ft. within the graben. The expanded interval provides opportunity, but economic development in this part of the trend requires extreme attention to detail and high coordination between geology, geophysics, drilling and completion.

Interpretation of the 3D seismic data set over the field area requires drastic geologic assumptions in order to accurately convert to depth. Velocity values based on the drilling and geosteering of nine widely spaced horizontal wells indicates that velocity is faster near the downthrown side of growth faults. Improved interpretation of the 3D seismic data has resulted in improved geosteering of the horizontal wells.

Stratigraphically, the Eagle Ford was divided into 13 para-sequences in an attempt to determine if certain intervals had different characteristics during hydraulic fracture treatments and resulting productivity. Hydraulic fracture gradient plots indicate that areas near faults have subnormal gradients, but position within the Eagle Ford does not exhibit a consistent trend. However, well performance relative to Eagle Ford completion interval does indicate a correlation.

Selected References

Bohacs, Kevin M., Jeffry D. Ottmann, Remus Lazar, Mirela Dumitrescu, Robert Klimentides, Juergen S. Schieber, Rafaela Montelli, and Chengjie Liu, 2011, Deciphering genetic controls on the occurrence, distribution, and character of fine-grained rocks (mudstone/shale); an
integrated sequence-stratigraphic analysis of the Cenomanian-Turonian of North America: Geological Society of America, Abstracts with Programs, v. 43/5, 656 p.


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Late Cenomanian Paleogeography

Legend
- Eagle Ford Wells
- Margins
  - Distal
  - Medial
  - Proximal
  - Coastal Plain


GRASS FARM #1H
Eagle Ford Regional Sequence Stratigraphy

Eagle Ford Hydrocarbon Phases

- Black Oil
- Volatile Oil
- Wet Gas
- Dry Gas
Eagle Ford cores throughout the study area contain a range of facies which are dominated by foraminifera packstones with scour surfaces, planar to ripple lamination, rip-up clasts, and moderate bioturbation in the proximal depositional environments and massive to faintly laminated, biogenic marls (predominantly composed of coccoliths and forams) with thin and sparse limestone interbeds in distal settings.
Eagle Ford Depositional Model

Core Lab Eagle Ford Consortia
Modified from Handford and Loucks (1993)
Grass Farm #1H

Eagle Ford Shale (198 feet)

<table>
<thead>
<tr>
<th>Core Depth (ft)</th>
<th>Log Depth (ft)</th>
<th>Cored</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,525.0</td>
<td>7,735.4</td>
<td>7,537.0</td>
</tr>
</tbody>
</table>

Target Interval 7670-7690’ (log)
7658-7678’ (core)

Kamp Ranch Zone

Buda Lms
Jourdanton Fault Interpretation
Syndepositional Graben Thickening
Jourdanton Fault Interpretation

Seismic Line #1

Seismic Line #2
North Fault Block
- HBP
- 43+ potential locations

South Fault Block
- 1st well completed, 12/2014
- 48+ potential locations
Seismic Line 1

Blue Eyes 1H well path

Seismic data displayed in this presentation is owned and controlled by Seitel Data, Ltd.
Blue Eyes 1H, Post-Drill X-Section
Seismic Line 2

Cat Eye 1H well path
Cat Eyes 1H, Post-Drill X-Section
Eagle Eyes 1H, Post–Drill X-Section
Post-Drill Ave. Velocity Map (Buda)
Structurally, Buda Limestone dips abruptly down near downthrown side of faults ("reverse drag").

Faults were active at Eagle Ford through Austin Chalk deposition, causing greater thickness of higher velocity sediments near downthrown side of faults.
Defining the Target Interval
Example from Grass Farm 1H

Eagle Ford Shale (198 feet)

<table>
<thead>
<tr>
<th>Core Depth (ft)</th>
<th>Log Depth (ft)</th>
<th>Cored</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,525.0</td>
<td>7,735.4</td>
<td>7,537.0</td>
</tr>
<tr>
<td>7,747.4</td>
<td>7,747.4</td>
<td>210.4</td>
</tr>
</tbody>
</table>

Target Interval 7670-7690’ (log)
7658-7678’ (core)

Kamp Ranch Zone

Buda Lms
### Grass Farm 1H- Basic Log

<table>
<thead>
<tr>
<th>Depth (FT)</th>
<th>RM</th>
<th>RHOB</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.2</td>
<td>1.95</td>
</tr>
<tr>
<td>200</td>
<td>0.2</td>
<td>1.95</td>
</tr>
<tr>
<td>20</td>
<td>1.95</td>
<td>2.95</td>
</tr>
</tbody>
</table>

**Core Lab Eagle Ford Consortia**
Summary of Mineralogy By Depth

MINERALOGY by XRD
(Grass Farm #1H Well)

Depth, feet

Volume Percent

Qtz  Ksp  Plg  Cal  Dol  Pyr  Mar  I/S  I/M  Chl  Kao  Ker

Core Lab Eagle Ford Consortia
Sample Summary: 7534.0 ft  
Foraminifera Packstone

φ = 4.4%  \quad k_e = 1.24E-08 \text{ mD}
Sw = 38.0%  \quad S_g = 43.8%
So = 18.2%  \quad GD = 2.69 \text{ g/cc}
TOC = 1.28%  \quad Ro = \text{N/A}

Quartz  
Plagioclase  
Dolomite & Fe-Dolomite  
Marcasite  
Kaolinite  
Chlorite  
K-Feldspar  
Calcite  
Pyrite  
Illite & Mica  
Illite/Smectite  
Kerogen

Core Lab Eagle Ford Consortia
Sample Summary: 7654.5 ft
Foraminifera Marl

ϕ = 11.1%  \quad k_e = 6.54 \times 10^{-8} \text{ mD}
Sw = 23.2%  \quad Sg = 13.1%
So = 63.7%  \quad GD = 2.58 \text{ g/cc}
TOC = 4.38%  \quad Ro = \text{N/A}
Sample Summary: 7677.5 ft
Skeletal-Foraminifera Marl

$\phi = 7.1\%$  $k_e = 7.65 \times 10^{-9} \text{ mD}$

$S_w = 27.6\%$  $S_g = 8.7\%$

$S_o = 63.8\%$  $G_D = 2.64 \text{ g/cc}$

$T_OC = 2.72\%$  $R_O = N/A$

Core Lab Eagle Ford Consortia
Sample Summary: 7693.5 ft
Organic Marl

\[ \phi = 1.9\% \quad k_e = 3.58 \times 10^{-9}\ \text{mD} \]
\[ Sw = 48.9\% \quad S_g = 23.1\% \]
\[ So = 28.0\% \quad GD = 2.55\ \text{g/cc} \]
\[ TOC = 4.08\% \quad Ro = 0.70\%* \]

*Calculated by Jacob’s formula
Jourdanton X-Section Eagle Ford
Blue Eyes 1H, Post-Drill X-Section
Cat Eyes 1H, Post-Drill X-Section
Eagle Eyes 1H, Post-Drill X-Section
Snake Eyes 1H, Post-Drill X-Section
Ribeye 2H, Post-Drill Cross-Section
Zone 2 Pink

\[ R^2 = 0.8567 \]

- **EUR/Stage**
  - Y-axis
- **% of Stages in Zone**
  - X-axis

- **Series 1**
  - Green diamonds
- **Linear (Series 1)**
  - Black line

The chart shows the relationship between EUR/Stage and the percentage of stages in Zone 2 Pink, with a goodness of fit of 0.8567.
Frac Gradient and Well Results

- Frac gradient not zone dependent (0.9-1.05 psi/ft)
- Frac gradient is lower near faults (<0.85 psi/ft)
- Completion zone does not have strong correlation to well results, yet.
- Wells with sidetracks after Buda strike underperform