Eagleford Shale Exploration Models: Depositional Controls on Reservoir Properties

Kevin Corbett

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Abstract

Exploration in the Eagleford Shale follows on recognition that a large percentage of the hydrocarbons generated never migrated. The Eagleford has long been seen as a major petroleum source, principally for the Austin Chalk, but also for oil in the underlying Buda, and in shallower Cretaceous and Tertiary horizons. Previous work has focused primarily on source rock character and documenting source potential. Important now is understanding the Eagleford in a reservoir context and documenting depositional, diagenetic, and structural controls on hydrocarbon saturation, permeability, lateral and vertical variability to optimize leasing, horizontal bore location, and completion techniques.

Lower Cretaceous basin geometry exerted a primary control on Eagleford Shale deposition, creating local depocenters where primary organic content is higher, controlling downslope current transport, thereby producing areas of ponded density-current deposits, bypassed margins, and focusing the location of more distal turbidite fans. In addition, Eagleford depocenter geometry exerted fundamental control on later migration through fault reactivation, which established pathways and barriers to up-dip migration.

This study focuses on an area extending from LaSalle County in the southwest through Atascosa, Wilson, and Gonzales to Fayette County on the northeast and down-dip through Webb, McMullen, Live Oak, Karnes, and Dewitt counties. Two fundamental plays are found in this region, separated by the Stuart City Edwards reef trend. Up-dip of the reef margin, the Eagleford is normally pressured, primarily an oil reservoir, characterized by significant lateral variability in organic-rich shale abundance and reservoir quality related to reef margin controlled depocenters. Down-dip of the reef margin the Eagleford is modestly to strongly over-pressured, primarily a gas reservoir, and characterized by lateral reservoir variability and primary permeability controlled by the location of distal turbidite deposition. Reactivation of faults underlying the Stuart City trend produced barriers to up-dip migration and areas of focused gas accumulation. Corridors between reactivated faults focused oil migration and produced significant variability in oil saturation within the up-dip play. Mapping basic rock properties on well logs has allowed high-grading of Eagleford reservoir properties and suggests the potential to define seismically optimal well locations.
References


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PRESENTATION OVERVIEW

✓ General Eagleford Characteristics
✓ Play Activity
  ➢ Geographic extent of drilling - Reported production tests/rates
✓ Regional Geologic Setting - S. Texas & Karnes Trough
✓ Study Area – Wilson, Karnes, Gonzales & Dewitt Cos.
  ➢ Structural controls on deposition
  ➢ Stratigraphic variation with structure
✓ Summary & Conclusions
EAGLEFORD SHALE PLAY

✓ Source Rock for Austin Chalk & Buda Lime production
✓ Structural & Strat Controls on Eagleford Source Quality, Migration/Trapping, Reservoir Quality
✓ Person – Dubose Edwards Shelf Edge Divides Oil & Gas Plays
   ➢ Down-Dip Gas Play – expanded ‘un-deformed” Austin-Eagleford
   ➢ Up-Dip Oil Play – many similarities to Bakken
✓ Karnes Trough - local depo-center of thick, organic-rich Eagleford Shale
   ➢ Sediment trap for shelf-derived Eagleford “middle” siltstone
   ➢ Fault-controlled graben system with expected higher natural fracture intensity
UPPER CRETACEOUS STRATIGRAPHY

Lower Eagleford Onlaps Underlying Buda Ls

Upper Eagleford Max Flood Shale

Austin Chalk Thickens Basinward & Grabowski Identifies a Lower Distal Member
EAGLEFORD DRILLING ACTIVITY

- 65 Wells – 6/05 through 5/09
  - 11 Edwards Down-Dip Trend
  - 32 Greater Grimes Field
  - 22 Karnes Trough Up & Down
- 34 Oil Play – 31 Gas Play
- 170 – 345 BOPD IP Grimes Oil
- 3.8 – 8.3 MMCF/D Edwards
- 6.5 – 12.1 MMCFE/D Karnes Tr.

Strat Section S. Texas
Lwr Austin TOC Avg 3.7%
Eagleford TOC Avg 3.7%

From: Grabowski, 1995
PETROHAWK S. TEXAS ACTIVITY

Eagleford Shale Drilling Results

LaSalle County, Texas

- Brown Trust 1H
  - IP = 8.1 MMCF/D = 201 BO/D

- Storey 1H
  - IP = 4.3 MMCF/D = 380 BO/D

- Dora Martin 1850 1H
  - IP = 8.8 MMCF/D = 50 BO/D

- Dora Martin 1716 1H
  - IP = 9.7 MMCF/D

- Dora Martin 1H
  - IP = 8.3 MMCF/D

- Henderson - Cenizo 874
  - IP = 9.1 MMCF/D

- Henderson - Cenizo 877
  - IP = 13.2 MMCF/D

McMullen County, Texas

- Donnell Minerals 366 1H
  - IP = 4.5 MMCF/D = 225 BO/D

- Donnell Minerals 1H
  - IP = 3.6 MMCF/D = 395 BO/D

- STS-Palmert 944 1H
  - IP = 9.1 MMCF/D

Increasing condensate yield

Edwards Reef Trend

Waiting on frac

2009 Expected locations

WRANGLER RESOURCES, LLC
PETROHAWK EAGLEFORD CORE

Haynesville and Eagleford: The Geologic Signature of "Core" Rock

Haynesville Shale: HK EGP #63H  
Eagleford Shale: HK DORA MARTIN #1H

WRANGLER RESOURCES, LLC
Top Eagleford picked on SP & Resistivity

High GR doesn’t correlate with SP & ILD

Lower Austin of Grabowski SP-GR “Gap”

Oil Saturation in core correlates with >40 ohm

“Middle” silt has drill break & gas shows
AUSTIN-EAGLEFORD FRACS VS DEPTH

Figure 4. Fracture distributions in oriented cores from the Bell-Sample No. 1 and Robinson-Troell No. 1 wells: (a) Bell-Sample all fractures, (b) Bell-Sample oil-filled fractures, (c) Robinson-Troell all fractures, (d) Robinson-Troell oil-filled fractures.

From: Corbett, Van Alstine & Edman, 1997.
Austin Chalk compacted early – lost substantially all matrix porosity & permeability
  Barrier to fluid migration
Eagleford Shale enters oil maturity at 6000’ burial – peak oil 8000’-9000’
  Excess fluid pressure with maturity
  Natural “hydrofracturing” at Austin-Eagleford contact
Faults and others barriers to migration bank oil down-dip

WRANGLER RESOURCES, LLC
## AUSTIN RE-WORK INCREMENTAL PRODUCTION

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<th>API</th>
<th>Well Name</th>
<th>Number</th>
<th>Petra ID</th>
<th>Prod Inc.</th>
<th>Rework Date</th>
<th>Rework Type</th>
<th>Lease Prod. Data</th>
<th>Notes</th>
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<td>33,085</td>
<td>Nov-89</td>
<td>Re-enter Frac</td>
<td>No</td>
<td>Frac 6770' - 6970' 11,000 Bbls Fresh Wtr, 160 Bbls 10% HCL</td>
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**Avg Incremental Prod. Increase:** 24,201

| Horizontal Re-Drill, Sidetrack or Extension | | | | | | | | |
| 421773189700 | Culpepper A | 1H | 6629 | 120,067 | Jan-98 | Horiz Redrill | No | This well was lengthened after 170 MBO and added huge incremental - avg lateral 835’ redrill added 1562’ |
| 421773178300 | Jewett | 1 | 6632 | 61,683 | Aug-97 | Horiz Redrill | No | 3178’ lateral redrill of original high-angle well that penetrated to Buda |
| 422553126100 | George | 1 | 6607 | 45,522 | May-97 | Horiz Redrill | No | Re-drilled vertical to horiz |
| 421773030700 | Speckhammer | 2 | 6227 | 186,907 | Jun-96 | Horiz Re-Drill | Yes | 81-84 Prod. No. 1 Well |
| 421773078500 | Bing | 1 | 6265 | 32,000 | Jan-91 | Horiz Ext. | No | Extended horizontal leg from 10,349 to 11,420 |
| 421773158000 | Perkins Oil Unit | | | | | | | |
| 421773091000 | Billings B-1 | 1 | 6590 | 10,222 | Aug-92 | Horiz Sidetrack | No | Plugged original hole and kicked-off new ~3000’ horizontal 1 month prod only at time of report ~1000 lateral no final survey filed |

**Avg Incremental Prod. Increase:** 58,629

### Production History Indicates Re-Work - No Record on RRC Website Well Potential Files

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<tr>
<th>API</th>
<th>Well Name</th>
<th>Number</th>
<th>Petra ID</th>
<th>Prod Inc.</th>
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<th>Rework Type</th>
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**Avg Incremental Prod. Increase:** 10,946

**Average Incremental Reserves All Re-Works:** 29,973
EAGLEFORD OILS FIRST SHOT FIELD

Family 1A Oil
- Less Mature, Formed Where Found

Family 1B Oil
- Maturity Exceeds Present Day DOB, Migrated

Figure 3. Map showing the location of oil samples in the First Shot Field (dashed outline), county lines, and major faults in and adjacent to the field. From: Corbett, Van Alstine & Edman, 1987.
EAGLEFORD PLAY DISTRIBUTION

Wilson
Karne
Gonzales
DeWitt
Eagleford Oil Play
Eagleford Gas Play
SUMMARY

- Person-Dubose Edwards shelf edge breaks the Eagleford Play into an up-dip oil play and a down-dip gas play
  - Controls migration with faults as barriers
  - Created the Karnes Trough depocenter – thicker section, restricted circulation, trapped “middle” siltstone

- Austin-Eagleford contact is gradational and thus a continuous system for reservoir purposes

- >40 Ohm deep resistivity correlates well with oil saturated core & shows

- Trapping by up-dip pinchout & fault barriers