Eagleford Shale Exploration Models: Depositional Controls on Reservoir Properties*

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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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Corbett, K.P., D.R. Van Alstine, and J.D. Edman, 1997, Stratigraphic controls on fracture distribution in the Austin Chalk: AAPG Hedberg Research Conference, Reservoir Scale Deformation - Characterization and Prediction, June 22-28, 1997, Bryce, Utah (also Applied Paleomagnetics,Inc. --http://www.appliedpaleomagnetics.com/Articles/Pdf/1997Corbett.pdf) (accessed May 27, 2010).

Grabowski, G. J., Jr., 1995, Organic-rich chalks and calcareous mudstones of the Upper Cretaceous Austin Chalk and Eagleford Formation, south-central Texas, U.S.A., *in* B. Katz, ed., Petroleum source rocks: New York, Springer-Verlag, p. 209–234.

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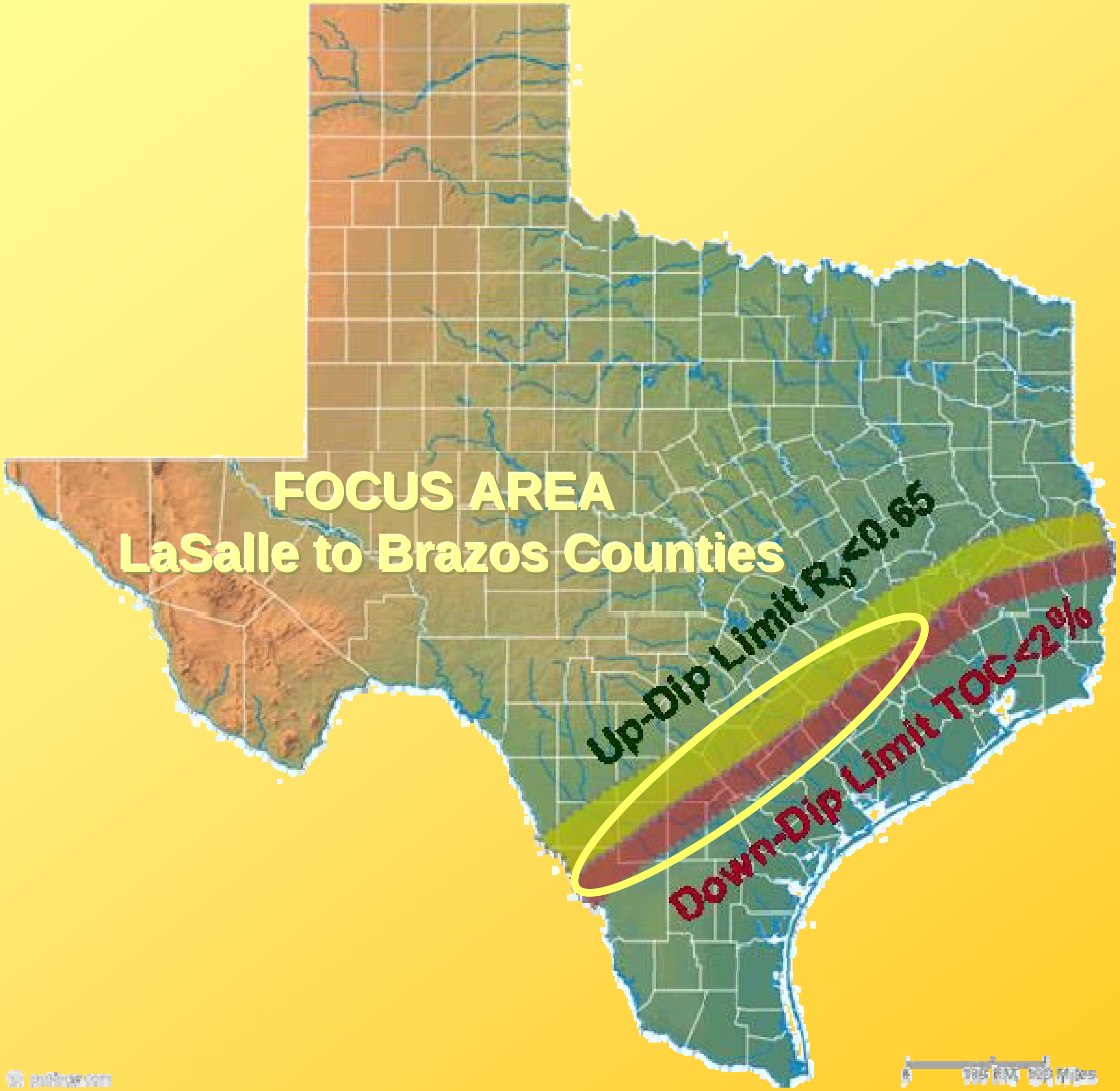
PRESENTATION OVERVIEW

- ✓ **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**

REFERENCE MAP EAGLEFORD



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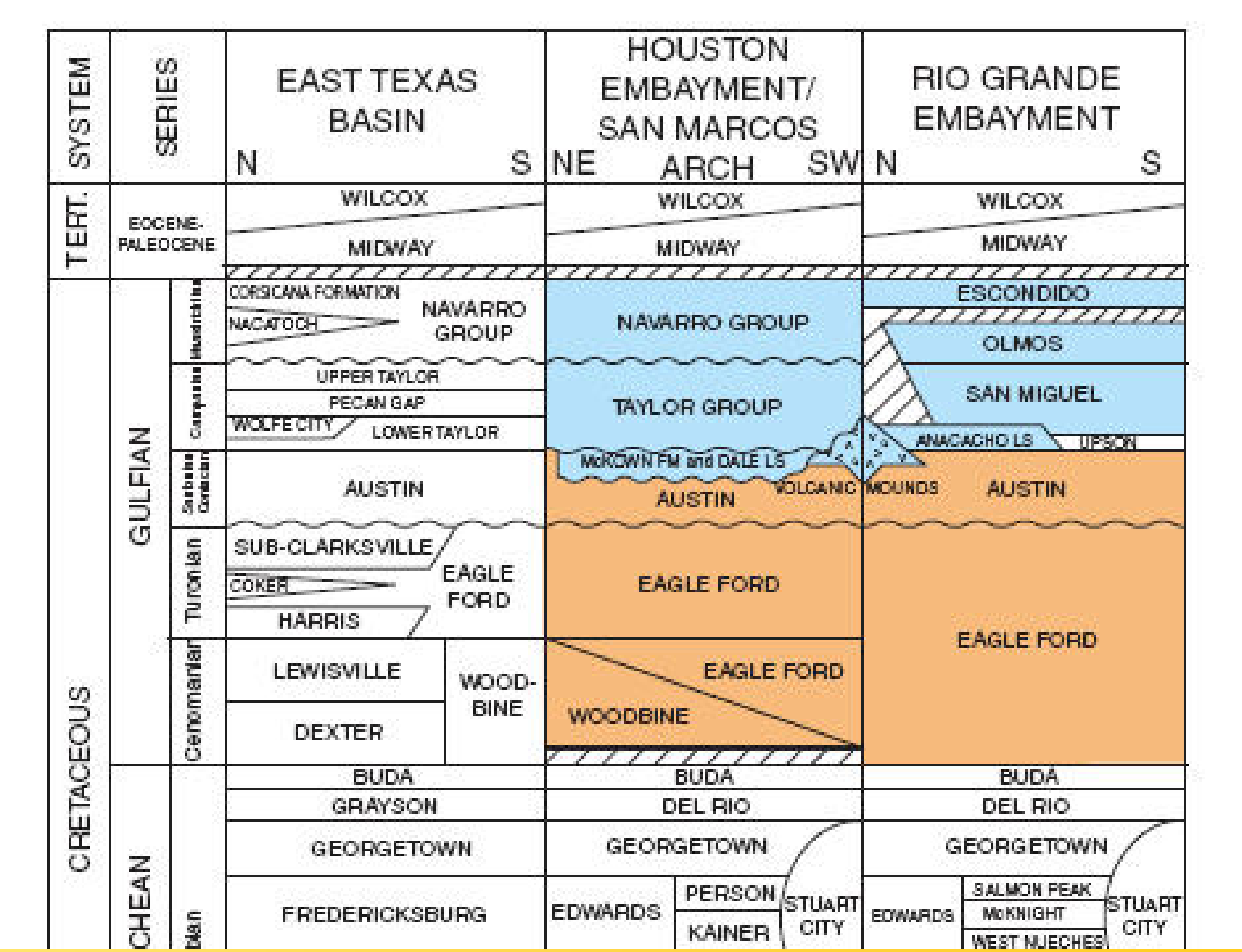
UPPER CRETACEOUS STRATIGRAPHY



From: Condon & Dyman, 2006: USGS DDS-69-H

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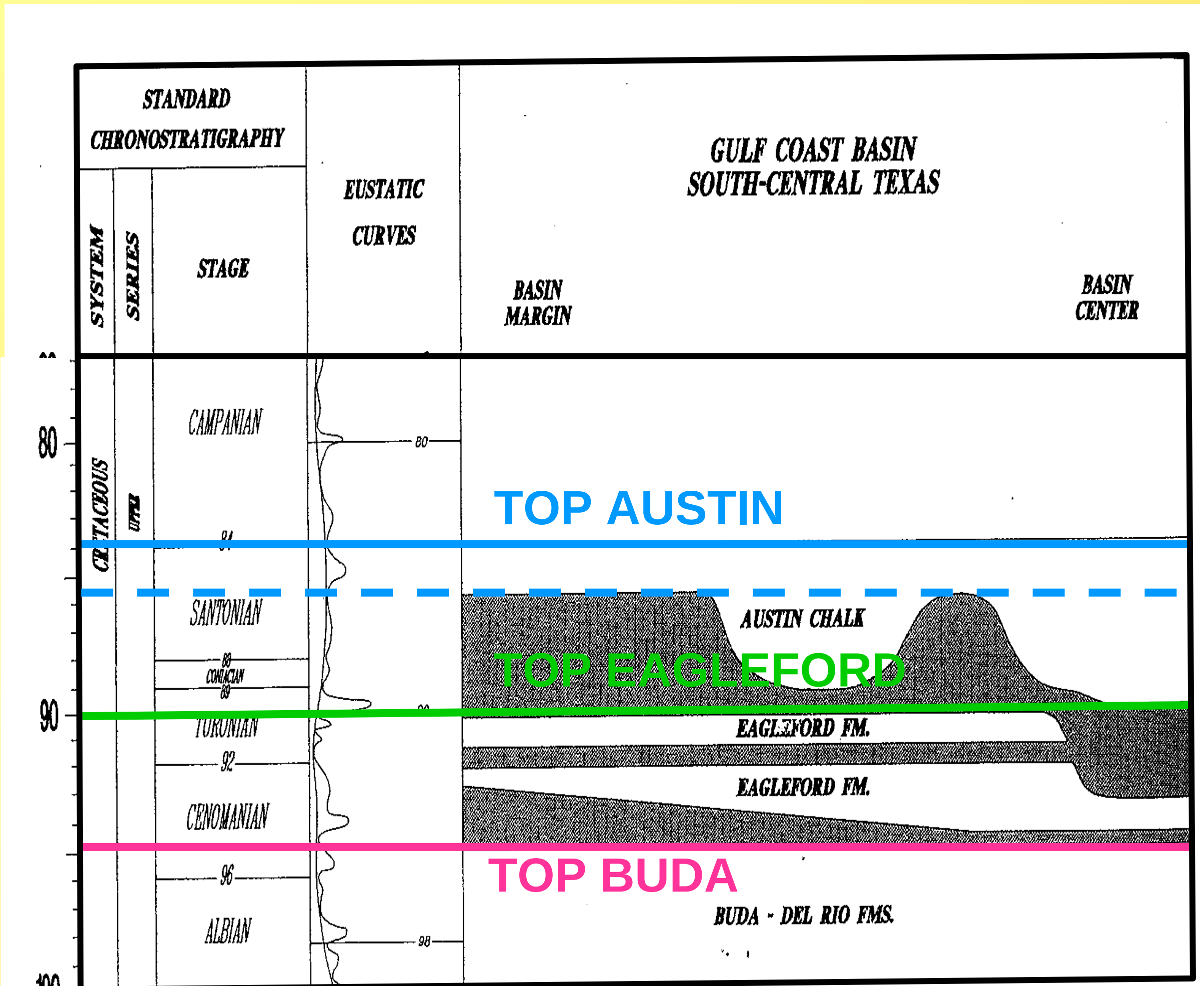
CHRONOSTRATIGRAPHY UPPER CRETACEOUS

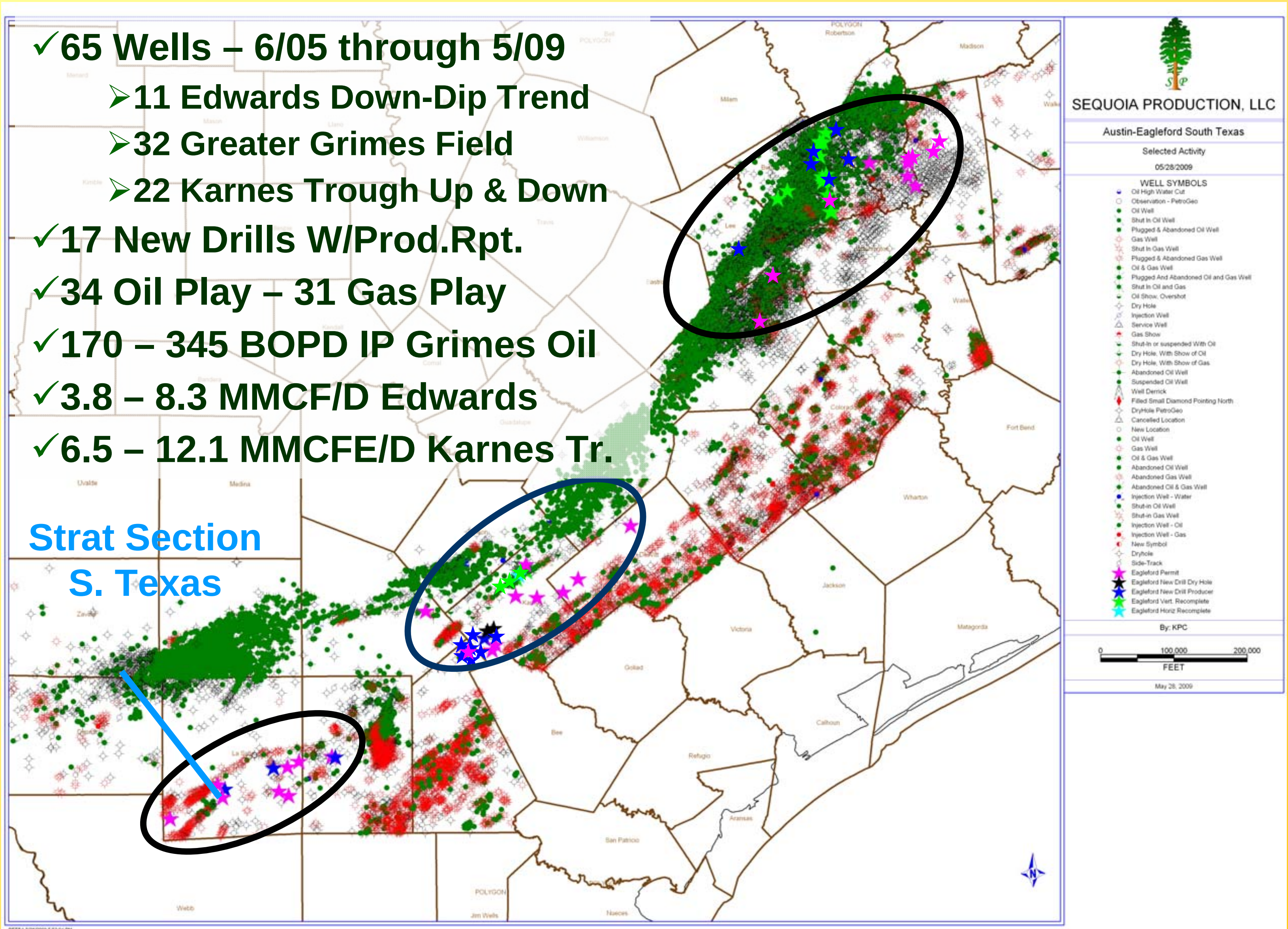


From: Grabowski, 1995

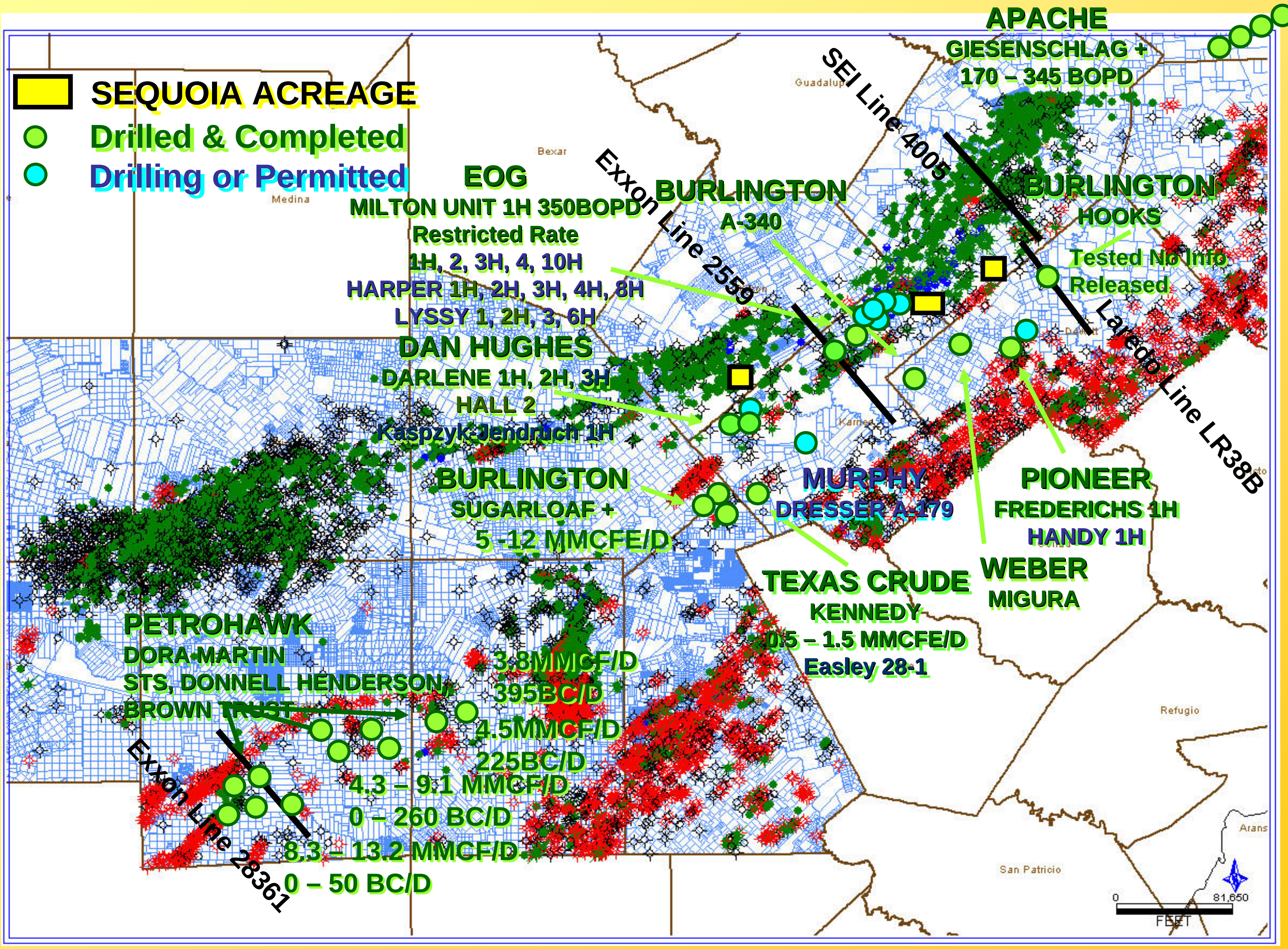
- ✓Lower Eagleford Onlaps Underlying Buda Ls
- ✓Upper Eagleford Max Flood Shale
- ✓Austin Chalk Thickens Basinward & Grabowski Identifies a Lower Distal Member

EAGLEFORD DRILLING ACTIVITY

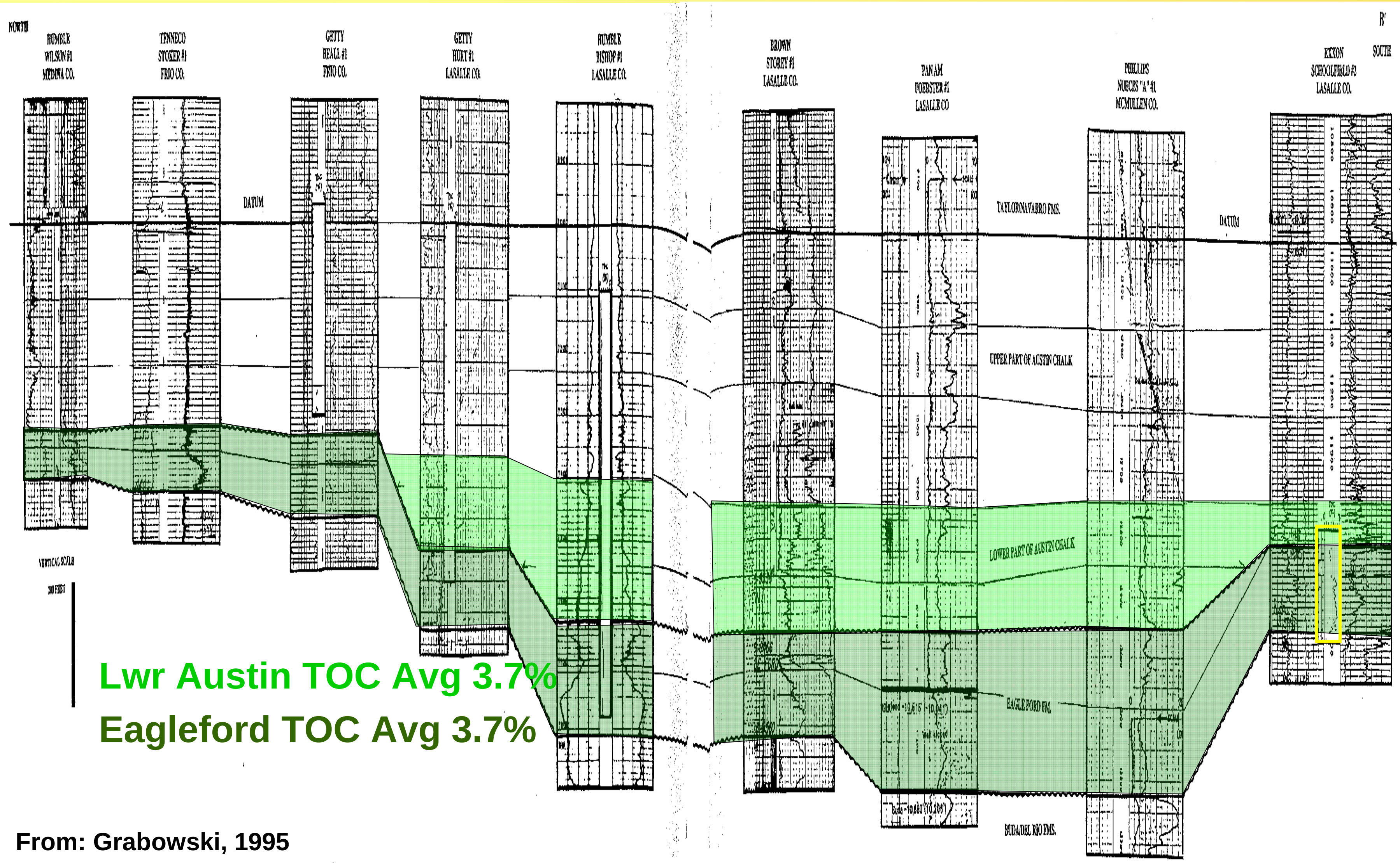
- ✓65 Wells – 6/05 through 5/09
  - ➢11 Edwards Down-Dip Trend
  - ➢32 Greater Grimes Field
  - ➢22 Karnes Trough Up & Down
- ✓17 New Drills W/Prod.Rpt.
- ✓34 Oil Play – 31 Gas Play
- ✓170 – 345 BOPD IP Grimes Oil
- ✓3.8 – 8.3 MMCF/D Edwards
- ✓6.5 – 12.1 MMCFE/D Karnes Tr.



EAGLEFORD DRILLING ACTIVITY



SOUTH TEXAS STRAT SECTION

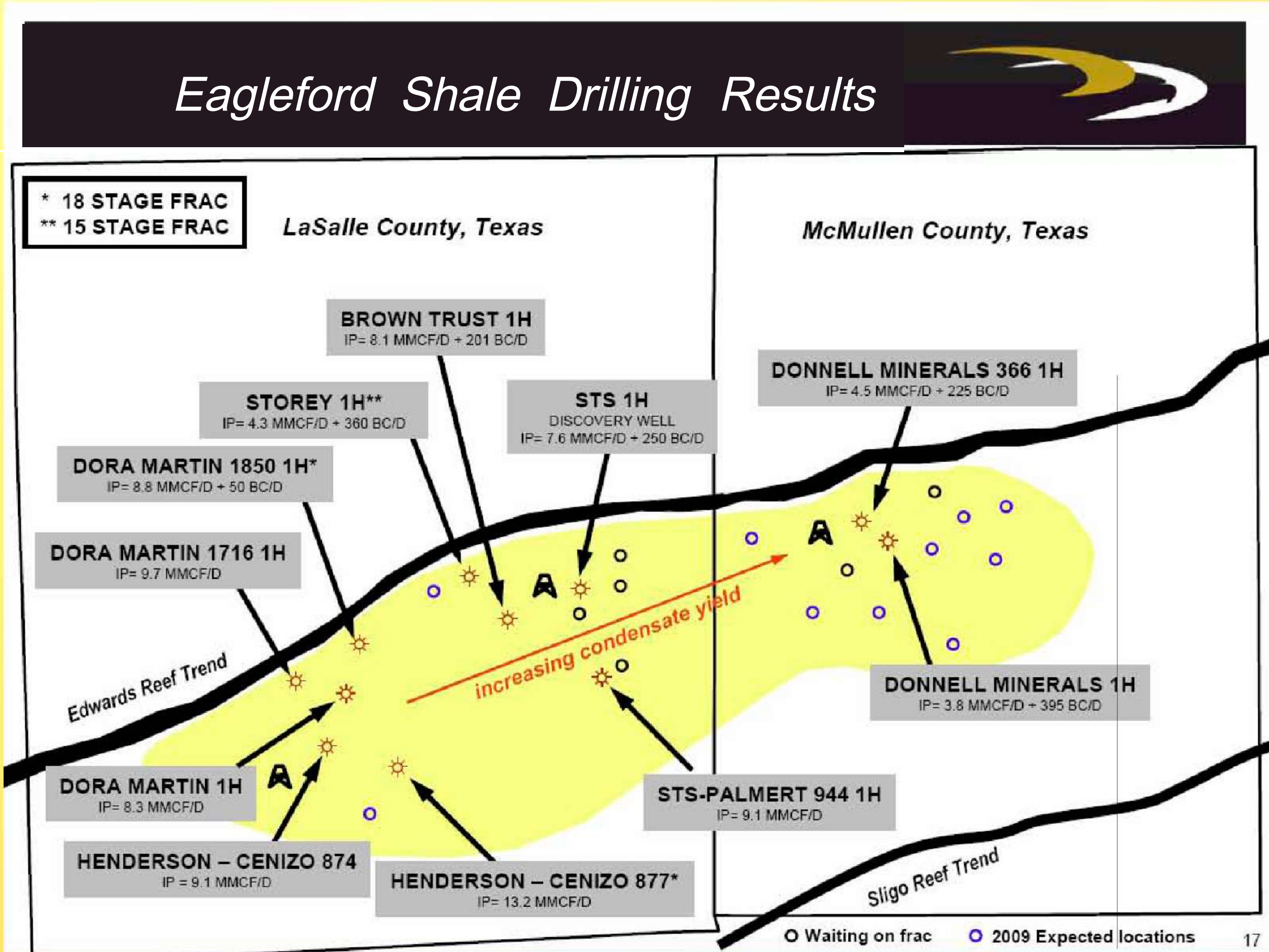


Lwr Austin TOC Avg 3.7%

Eagleford TOC Avg 3.7%

From: Grabowski, 1995

PETROHAWK S. TEXAS ACTIVITY



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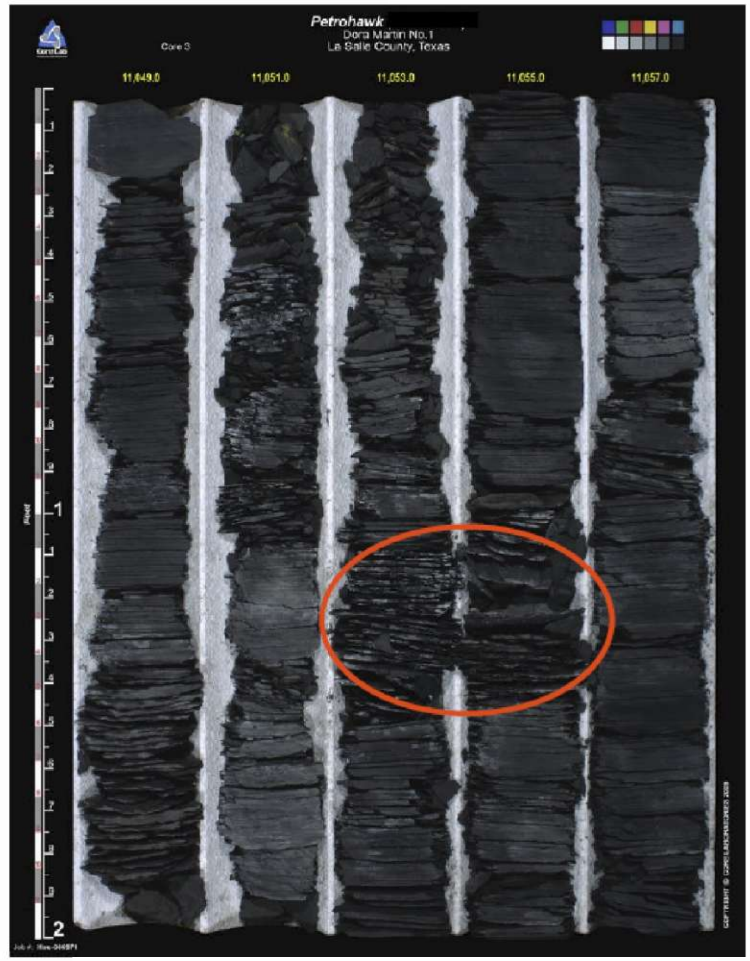
PETROHAWK EAGLEFORD CORE

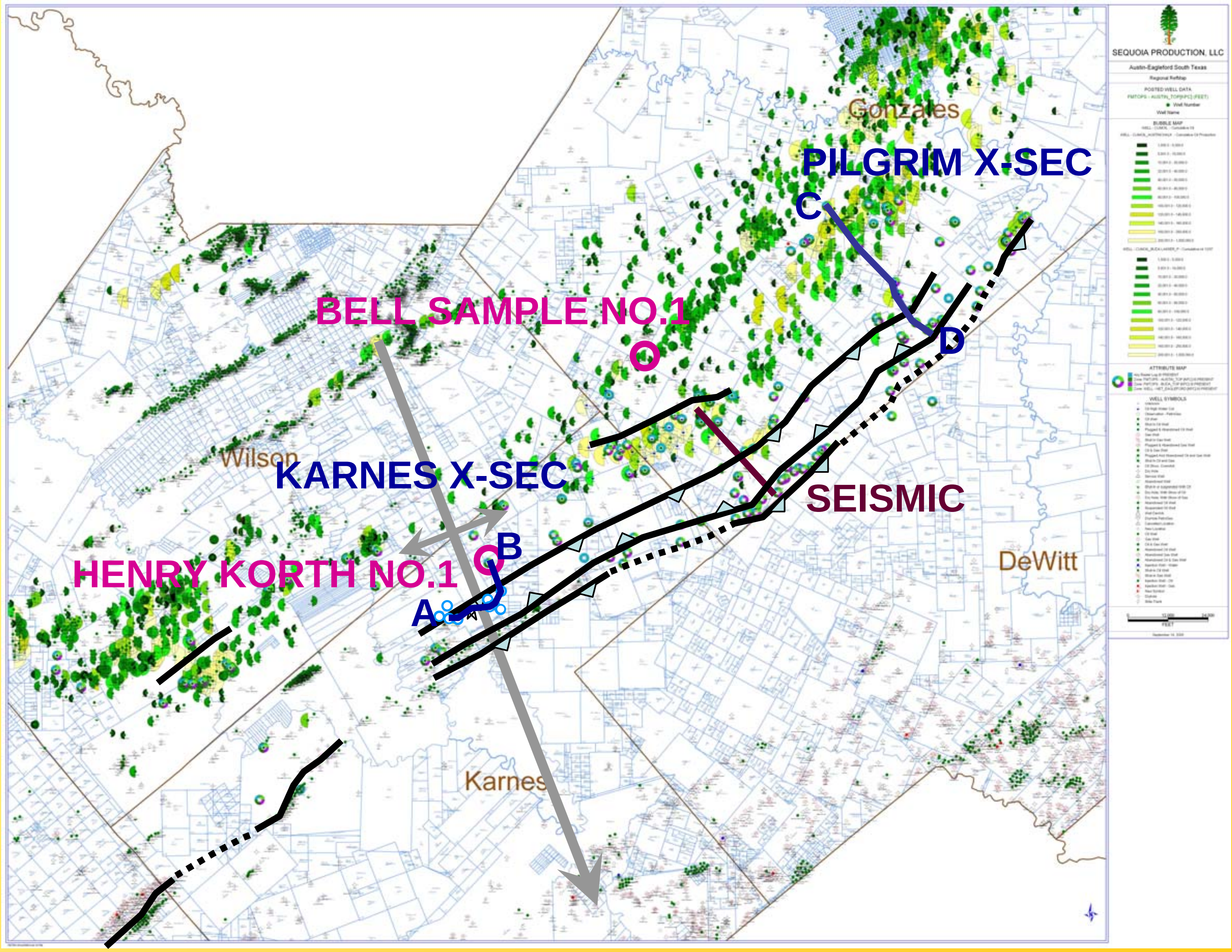
Haynesville and Eagleford: The Geologic Signature of "Core" Rock

Haynesville Shale: HK EGP #63H



Eagleford Shale: HK DORA MARTIN #1H

KARNES TROUGH AREA



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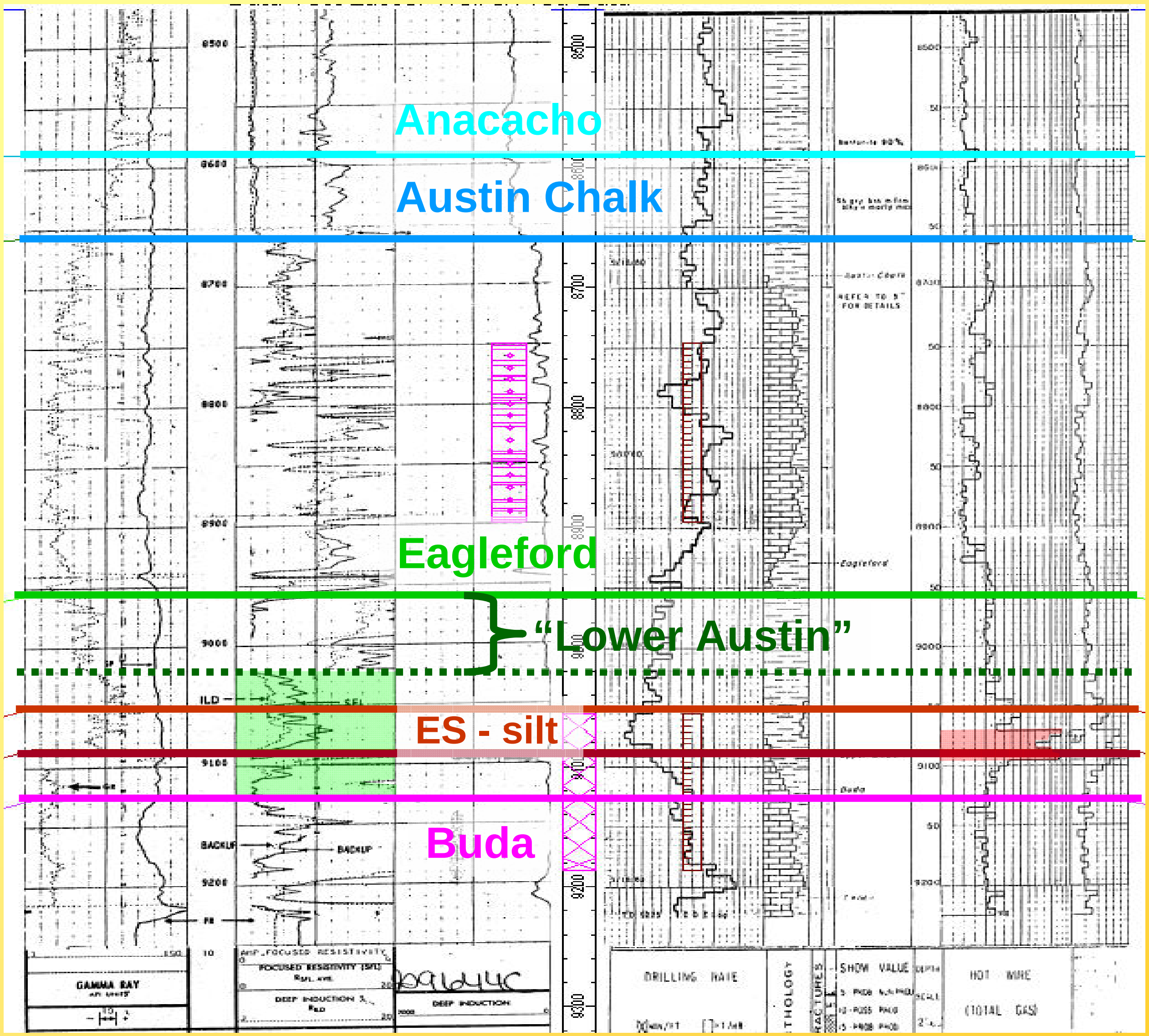
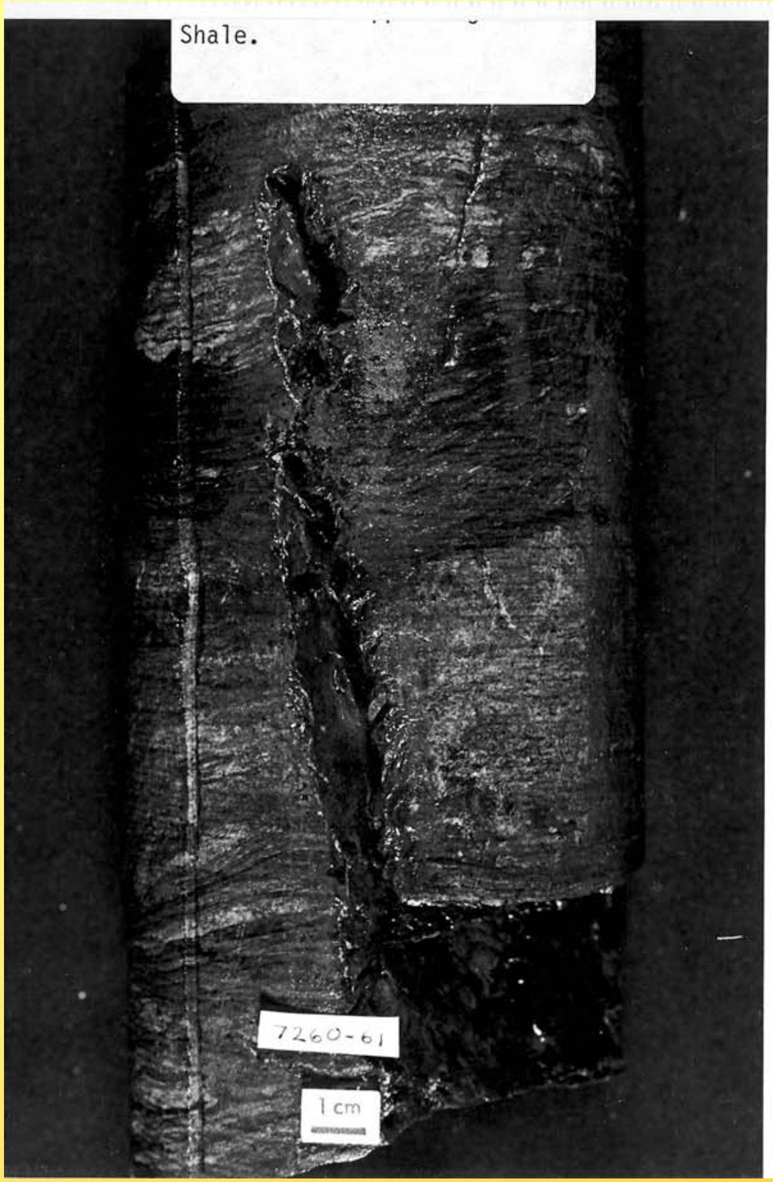
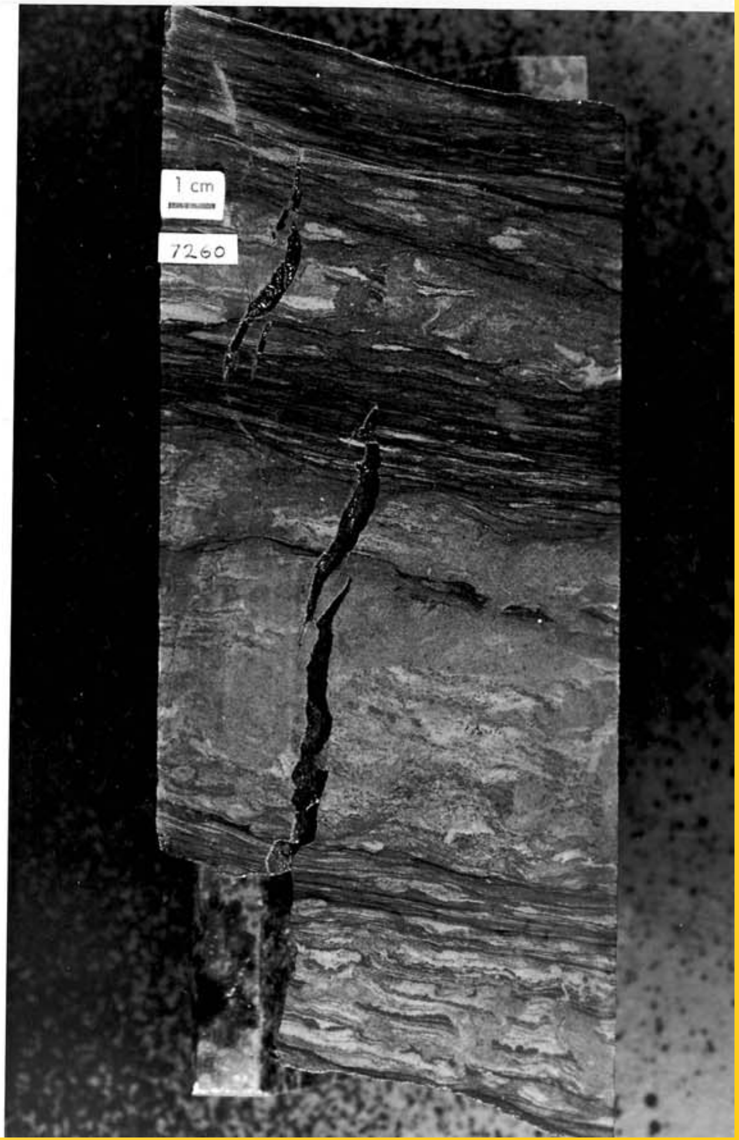
EAGLEFORD TYPE LOG
HENRY KORTH NO.1



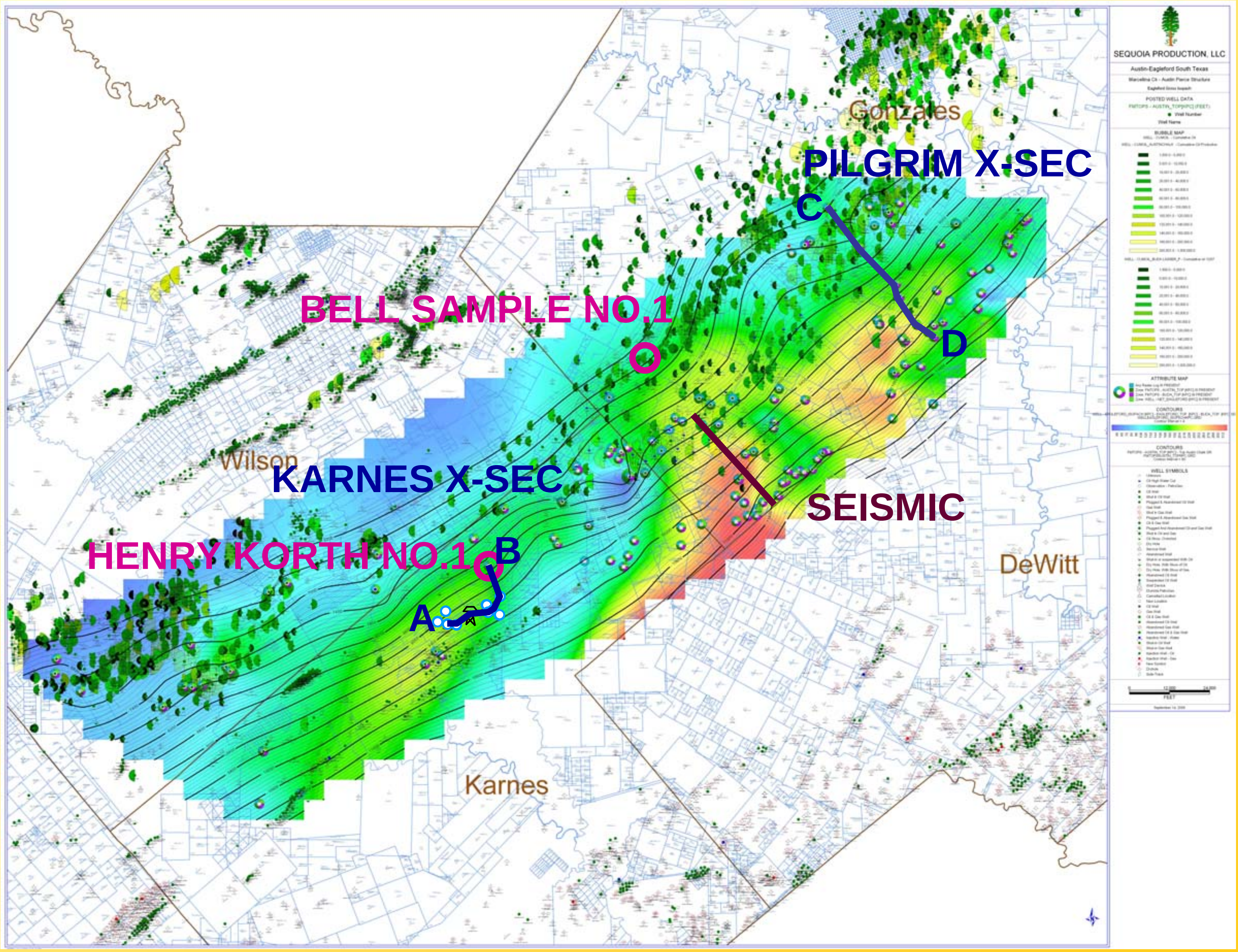
- ✓Top Eagleford picked on SP & Resistivity
- ✓High GR doesn't correlate with SP & ILD
- ✓Lower Austin of Grabowski SP-GR "Gap"
- ✓Oil Saturation in core correlates with >40 ohm
- ✓"Middle" silt has drill break & gas shows

EAGLEFORD CORE BELL SAMPLE NO.1

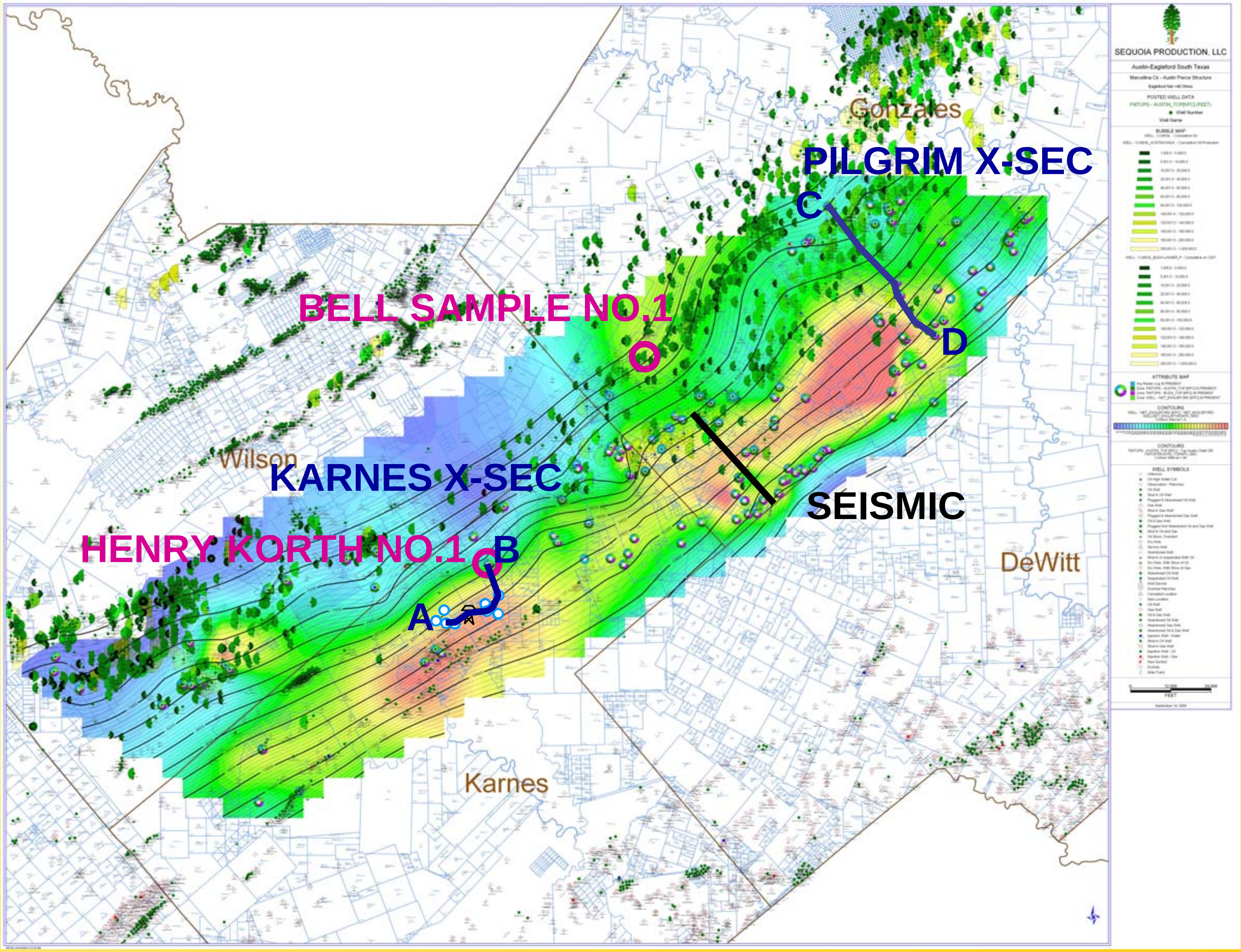




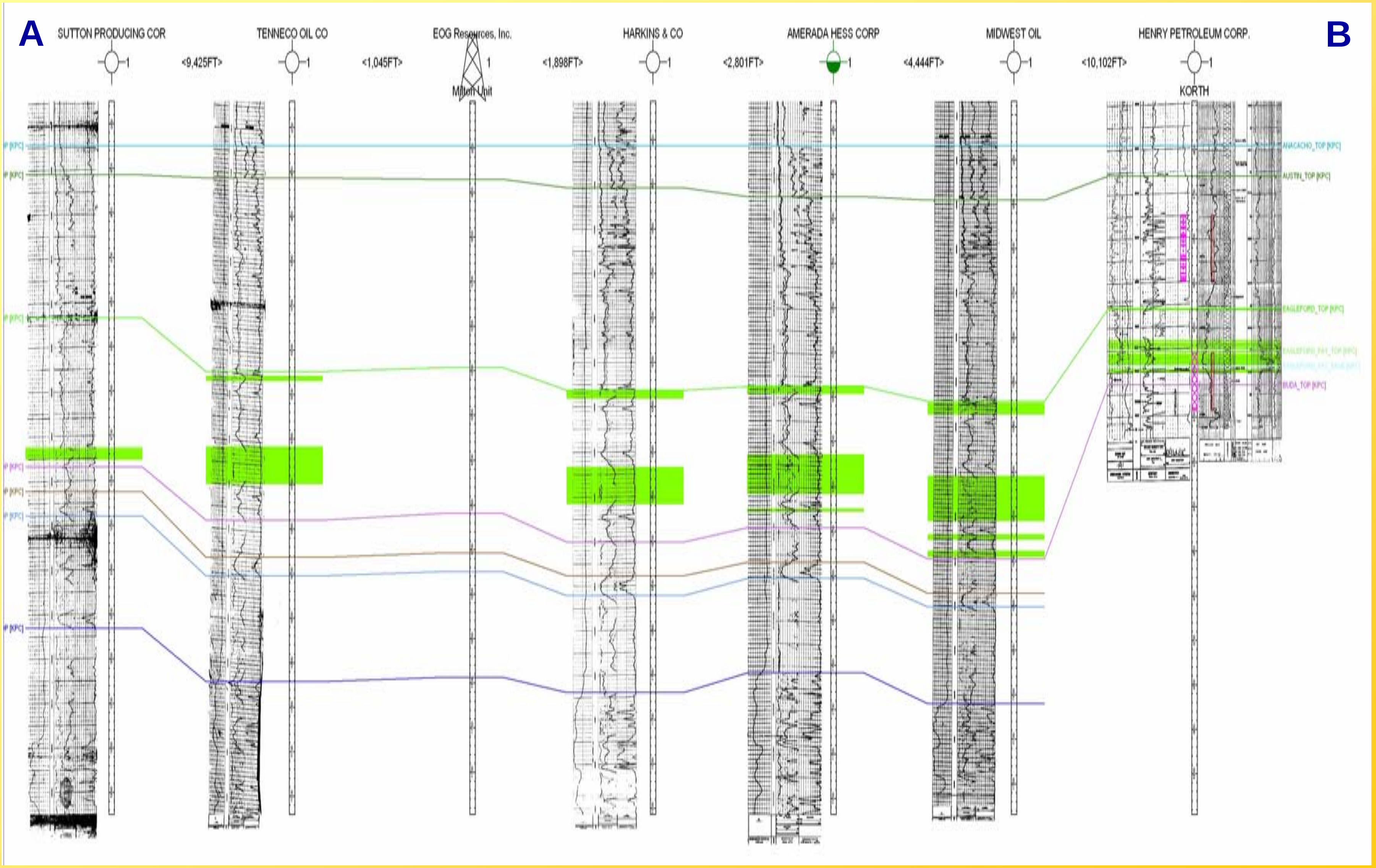
EAGLEFORD GROSS ISOPACH



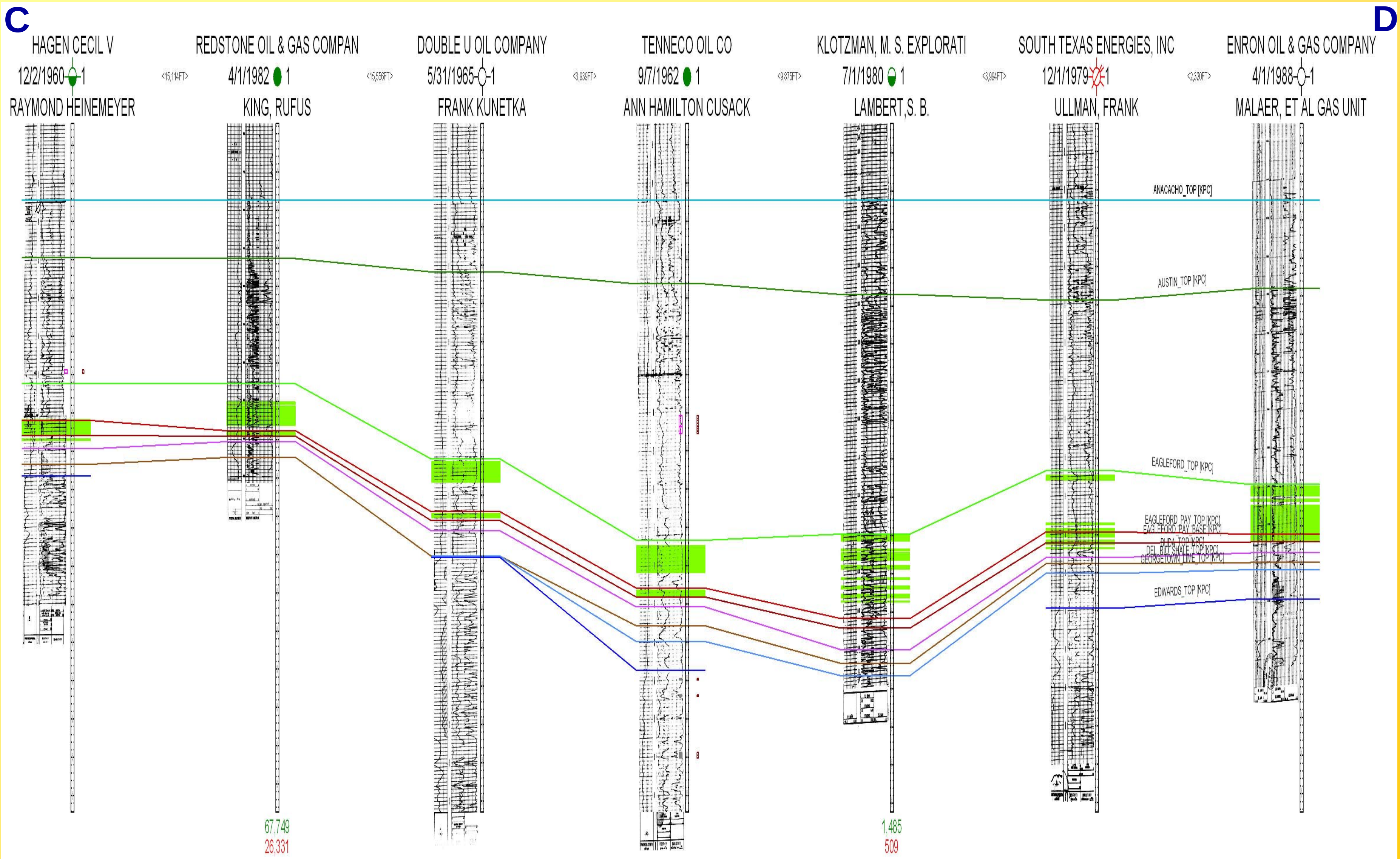
EAGLEFORD NET ISOPACH



STRAT-SECTION KARNES TROUGH



STRAT-SECTION PILGRIM AREA



AUSTIN-EAGLEFORD FRACS VS DEPTH

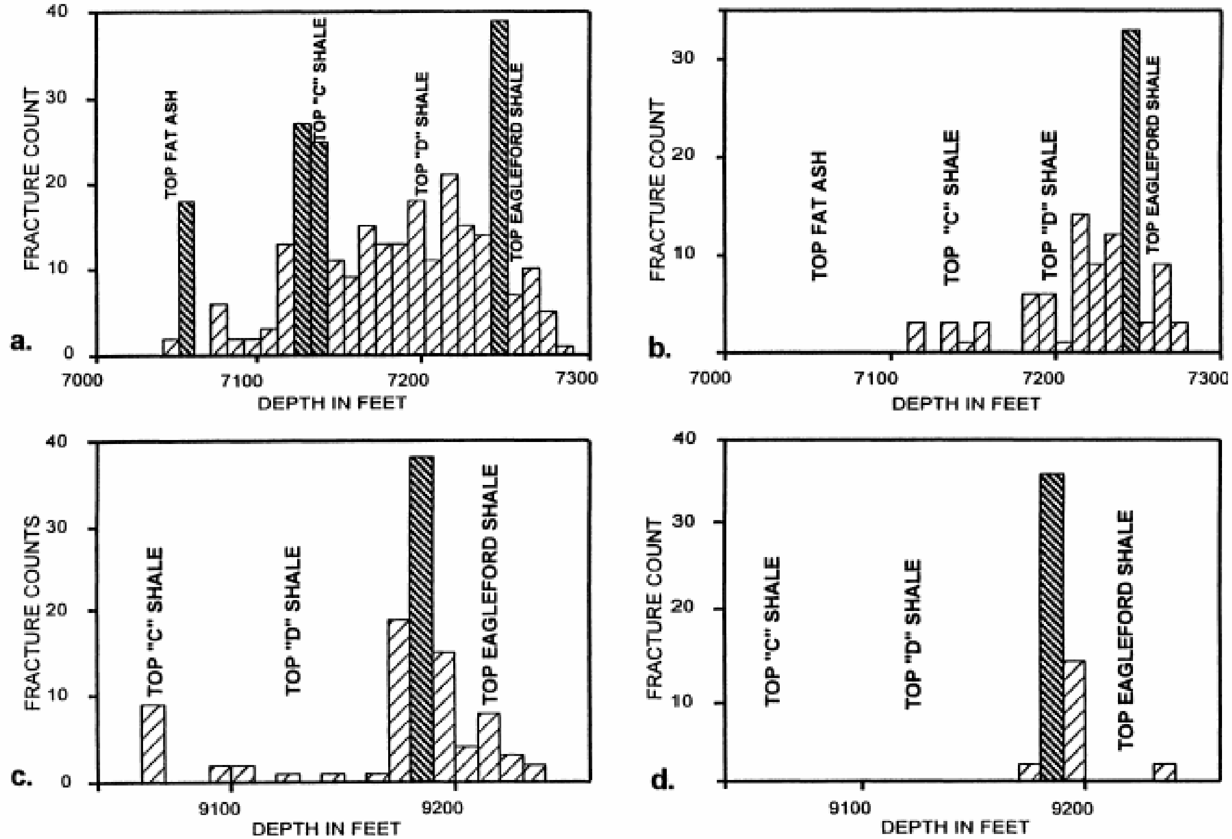
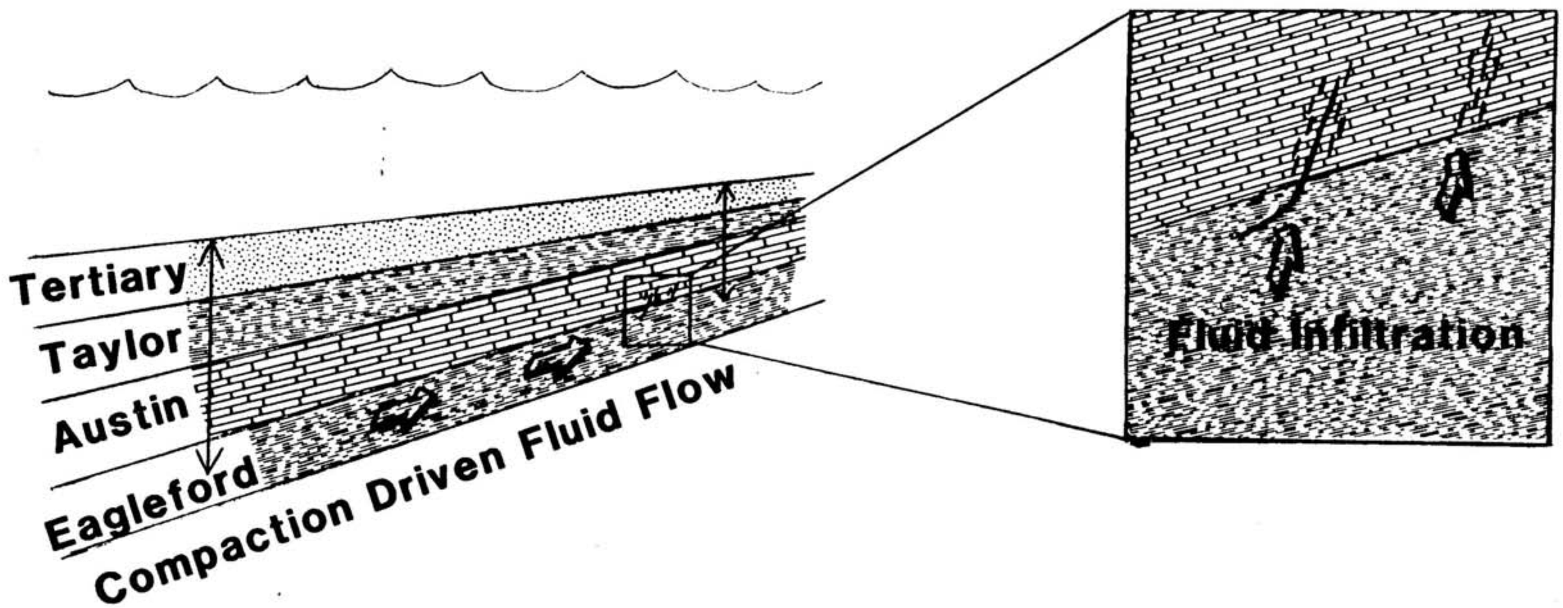


Figure 4. Fracture distributions in oriented cores from the Bell-Sample No. 1 and Robinson-Troell No. 1 wells: (a) Bell-Sample all fractures, (b) Bell-Sample oil-filled fractures, (c) Robinson-Troell all fractures, (d) Robinson-Troell oil-filled fractures.

From: Corbett, Van Alstine & Edman, 1997.

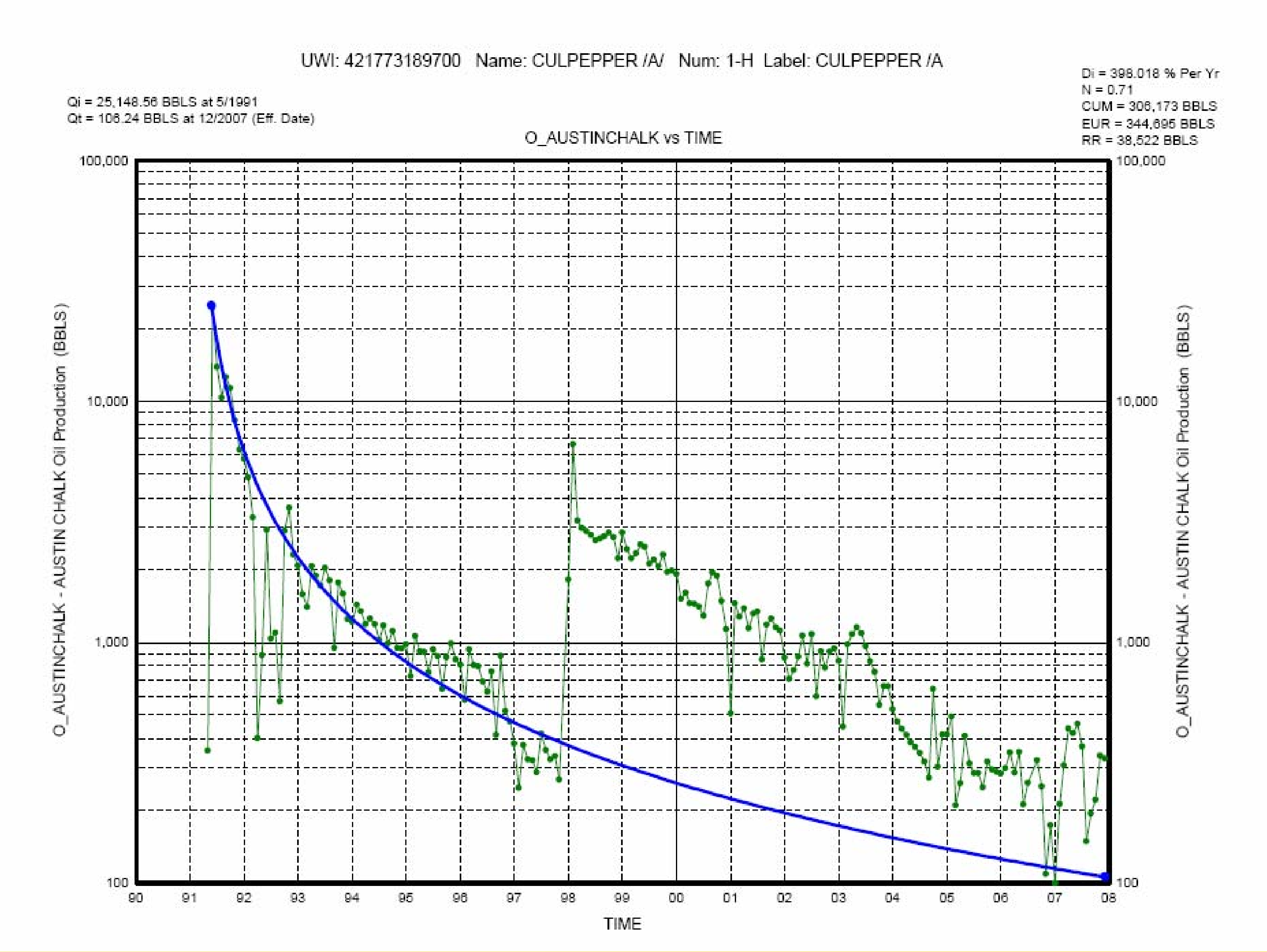
AUSTIN-EAGLEFORD
MATURATION-MIGRATION-TRAPPING



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

CULPEPPER A-H1 RATE-TIME



AUSTIN RE-WORK INCREMENTAL PRODUCTION

API	Well Name	Number	Petra ID	Prod Inc.	Rework Date	Rework Type	Lease Prod. Data	Notes
Vertical ReFracs								
421773044000	Kasper	1	6255	15,012	May-93	Perf & Frac	No	8165' - 8515' 10,000 Gals Acid & 300 Ball Sealers
421773079200	Tinsley A	1	6260	18,525	Mar-89	Frac	No	6714' - 6966' 11,800 Bbls FreshWtr-160Bbls 10% Acid
421773016800	Chandler	1	6401	39,065	Nov-89	Re-enter Frac	No	Frac 6770' - 6970' 11,000 Bbls Fres Wtr, 160 Bbls 10% HCL
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 170MBO and added huge incremental - orig lateral 835' redrill added 1652'
421773178900	Jewett	1	6632	61,683	Aug-97	Horiz. Redrill	No	3178' lateral redrill of original high-angle well that penetrated to Buda
422553128100	George	1	6687	55,522	May-97	Horiz. Redrill	No	Re-drilled vertical to horiz
421773090700	Spieckerman	2	6227	136,907	Jun-96	Horiz. Re-Drill	Yes	81-84 Prod. No.1 Well
421773075000	Ehrig	1	6263	32,000	Jan-91	Horiz Ext.	No	Extended horizontal leg from 10,349 to 11,420
421773193000	Perkins Oil Unit	1	6375	1,000	Dec-07	Horiz. Redrill	No	Plugged original hole and kicked-off new ~3000' horizontal 1 month prod only at time of report
421773089100	Billings B-1	1	6599	10,222	Aug-92	Horiz Sidetrack	No	~1000 lateral no final survey filed
Avg Incremental Prod. Increase				**59,629**				
Production History Indicates Re-Work - No Record on RRC Website Well Potential Files								
421773083800	Ruddock	1	6356	12,694	Sep-91	??	No	
421773188300	Troell et al	1	6455	8,339	Dec-99	??	No	
421773099900	Patterson Mary B	1	6488	4,439	May-98	??	No	
421773203200	Preston	1H	6493	14,124	Sep-99	??	No	
421773131000	McCoy	1	6553	9,527	Mar-86	??	No	
421773092400	Culpepper A	1	6561	8,273	Nov-88	??	No	
421773186200	Culpepper	2	6587	6,195	Jan-90	??	No	
421773089100	Billings B	1	6599	9,439	Jun-88	??	No	
421773180000	Chippewa Ward Billings	1	6615	9,339	Jul-94	??	No	
421773194000	Smith E E Jr Est	5-H	6634	27,089	Dec-97	??	Yes	
Avg Incremental Prod. Increase				**10,946**				
Average Incremental Reserves All Re-Works				**29,973**				

EAGLEFORD OILS FIRST SHOT FIELD

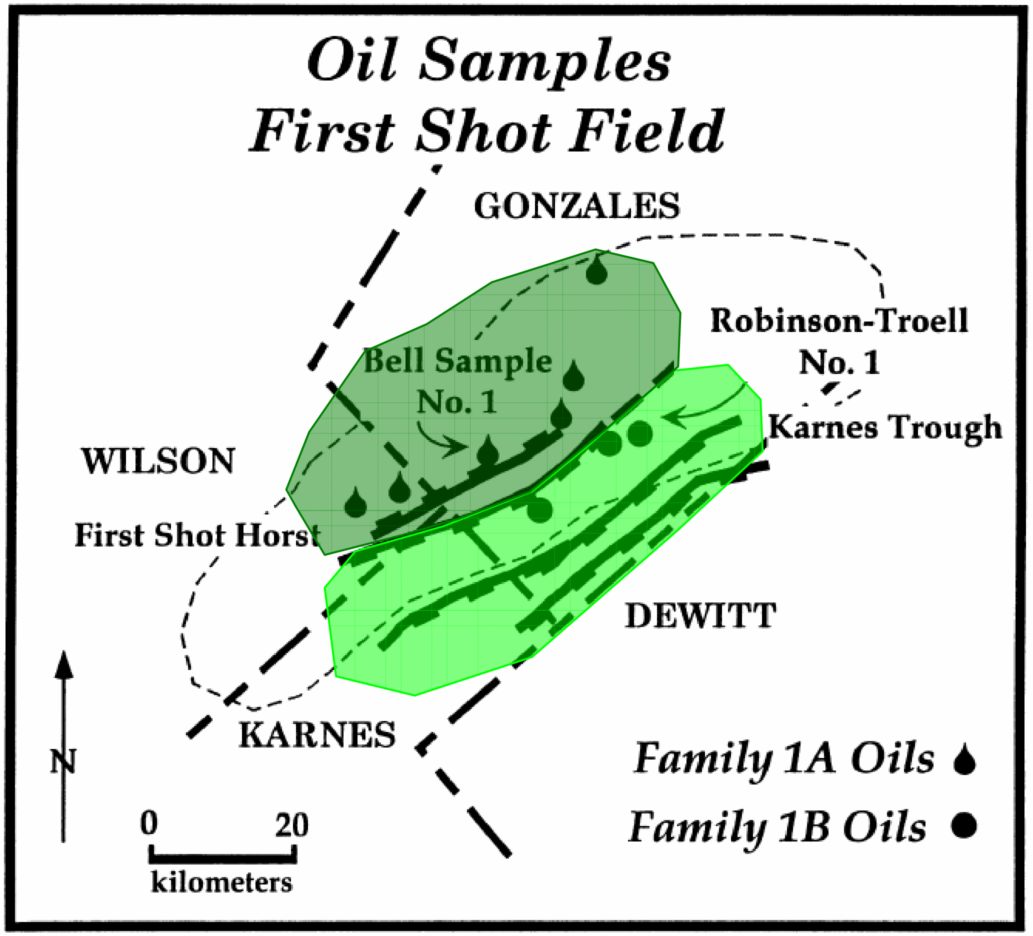


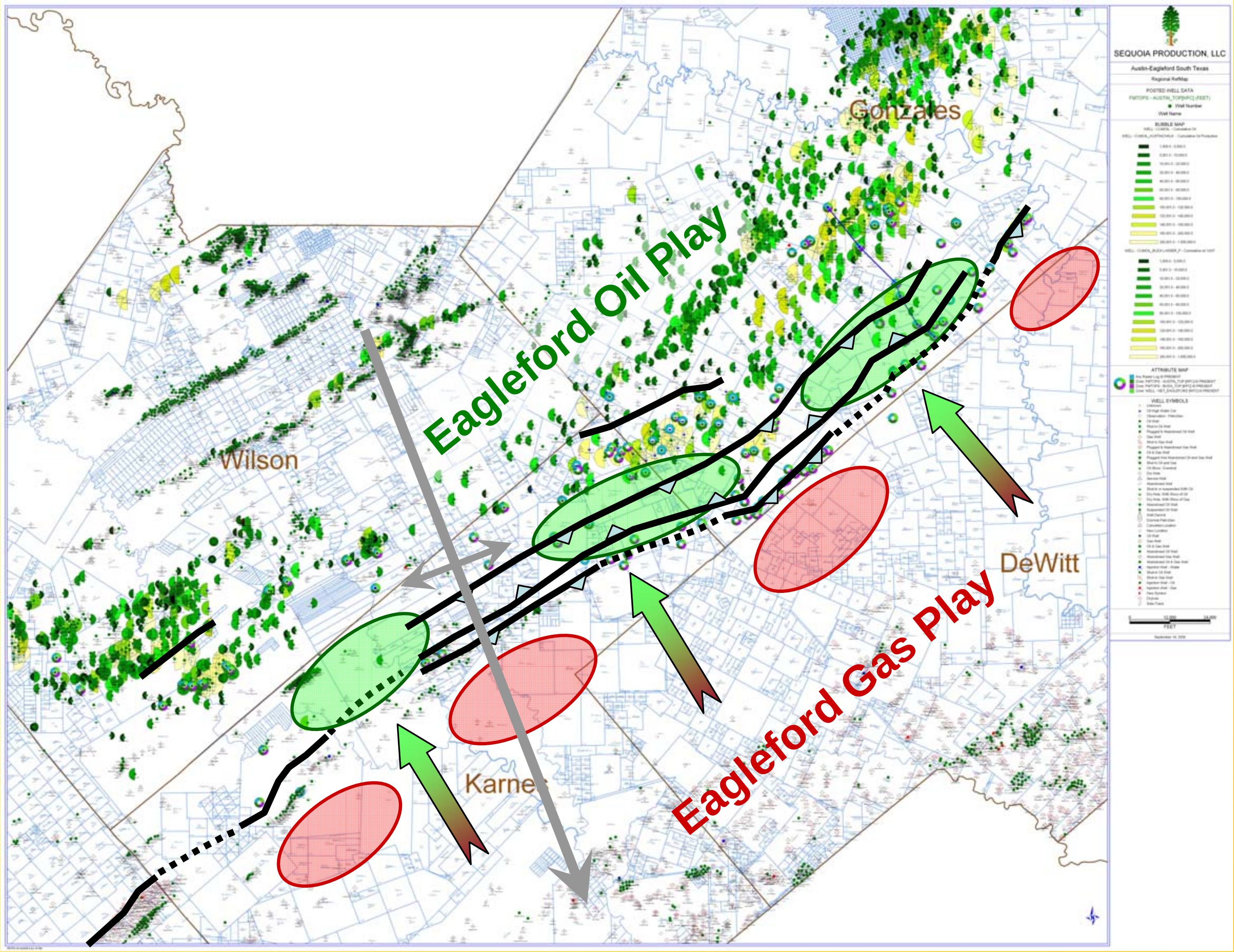
Figure 3. Map showing the location of oil samples in the First Shot Field (dashed outline), county lines, and major faults in and adjacent to the field.

From: Corbett, Van Alstine & Edman, 1987.

✓***Family 1A Oil***
– Less Mature,
Formed Where Found

✓***Family 1B Oil***
– Maturity Exceeds
Present Day DOB, Migrated

EAGLEFORD PLAY DISTRIBUTION



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