Progress Report

December 2012

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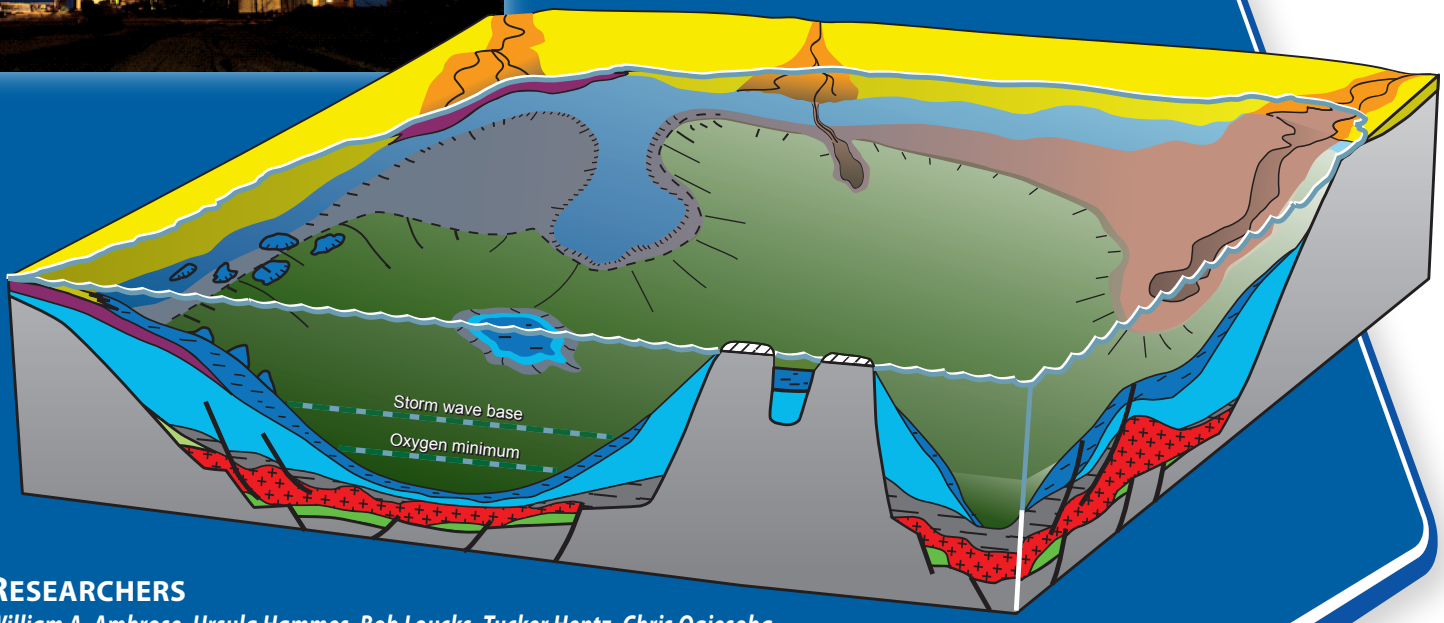

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PROJECT STARR

STATE OF TEXAS ADVANCED OIL AND GAS RESOURCE RECOVERY

STATE OF TEXAS ADVANCED RESOURCE RECOVERY PROGRAM (STARR)

PROGRESS REPORT, DECEMBER 2012

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EXECUTIVE SUMMARY

The State of Texas Advanced Resource Recovery program (STARR) has been successful in its major objective to increase royalty income to the Permanent School Fund and severance taxes to the General Fund through technology and research projects that promote the drilling of profitable oil and gas wells in the State of Texas.

The Bureau of Economic Geology (BEG) currently receives funds from the State to conduct research that assists oil and gas operators in adding new or increasing existing production throughout the state of Texas. STARR is required to be revenue neutral—that is, revenue associated with STARR projects must equal or exceed the amount appropriated to the program by the Legislature. This progress report summarizes and documents in detail the accomplishments of Project STARR over the last 2 years (September 2010 through August 2012).

To date, the STARR program has completed studies or is currently working on 46 fields **(Fig. 1)**. Credit to the STARR program for the 2010–2012 biennium, in accordance with methodology approved by the State of Texas Comptroller's office, is $153,260,171. Relative to total income of $9.0 million over the current biennium, STARR is revenue positive by a factor of 17.

Table 1. Summary of royalty and severance tax revenue from September 1, 2010, through July 31, 2012. Credit to the STARR program is in accordance with methodology approved by the State of Texas Comptroller's office.

REGIONAL STUDIES	Oil (bbl)	Oil Well Head Value ($)	Oil Royalty ($)	Oil Severance Tax ($)	Gas (Mcf)	Gas Well Head Value ($)	Gas Royalty ($)	Gas Severance Tax ($)	25% Oil Severance	25% Gas Severance	Total Oil Severance Tax Revenue	Total Gas Severance Tax Revenue	Total Revenue
CLEVELAND/MARMATON/ATOKA	5,296,768.00	489,139,192.12		22,011,263.65	31,966,079.00	132,569,173.31		9,942,688.00	5,502,815.91	2,485,672.00	5,502,815.91	2,485,672.00	
HAYNESVILLE	9,073.00	768,597.81		34,586.90	135,519,875.00	577,380,277.73		43,303,520.83	8,646.73	10,825,880.21	8,646.73	10,825,880.21	
EAGLE FORD	65,654,486.00	7,019,506,430.47		315,877,789.37	560,386,334.00	1,747,112,716.02		131,033,453.70	78,969,447.34	32,758,363.43	78,969,447.34	32,758,363.43	
FIELD STUDIES/OPERATOR													
Sugar Creek/BBX Operating	214,728.00	21,492,062.99		967,142.83	3,469,592.00	9,417,997.83		706,349.84			967,142.83	706,349.84	
Dismukes/CML Exploration	129,547.00	13,218,122.69		594,815.52	22,815.00	58,291.37		4,371.85			594,815.52	4,371.85	
K-R-S/Cobra Oil and Gas	29,070.00	2,990,766.76		134,584.50	639,519.00	1,587,131.27		119,034.85			134,584.50	119,034.85	
Granite Wash/Devon	59,190.00	5,837,947.03		262,707.62	2,023,753.00	4,474,967.12		335,622.53			262,707.62	335,622.53	
Bend Conglomerate/Devon	12.00	1,157.45		52.09	30,186.00	104,632.51		7,847.44			52.09	7,847.44	
Lavaca Bay/Neumin Production Company	17,262.00	1,688,450.48	337,690.10	75,980.27	216,990.00	773,201.59	154,640.32	57,990.12			75,980.27	57,990.12	
La Sara/Risco La Sara	5,997.00	548,777.82		24,695.00	1,882.00	4,695.68		352.18			24,695.00	352.18	
Spraberry/Chesapeake, Pioneer, Conoco-Phillips	4,175,272.00	395,476,779.10		17,796,455.06	5,729,575.00	20,856,149.39		1,564,211.20			17,796,455.06	1,564,211.20	
Refugio/TC Oil	12.00	1,157.45		52.09	30,186.00	104,632.51		7,847.44			52.09	7,847.44	
Totals:	75,591,417	$7,950,669,442	$337,690	**$357,780,125**	740,036,786	$2,494,443,866	$154,640	**$187,083,290**	$84,480,910	$46,069,916	$104,337,395	$48,873,543	
	Oil Grand Total	Oil Well Head Value Grand Total	Oil Royalty Grand Total	Oil Severance Tax Grand Total	Gas Grand Total	Gas Well Head Value Grand Total	Gas Royalty Grand Total	Gas Severance Tax Grand Total	25% Oil Severance Tax ($)	25% Gas Severance Tax ($)	Total Oil Severance Tax Revenue	Total Gas Severance Tax Revenue	
			10% of Royalty				10% of Royalty						
			$33,769				$15,464				**$104,337,395**	**$48,873,543**	**$153,260,171**

- Royalties occur only when production is on State (GLO) leases; 10% of royalties is the agreed STARR credit when incremental production occurs on a State lease.
- Severance taxes: 4.6% for oil; 7.5% for gas.
- Well-head values based on monthly oil and gas prices reported by EIA.
- 25% of severance tax is the agreed STARR credit for regional studies.
- Please refer to Table 3 for STARR revenue-neutrality methodology.

INTRODUCTION

A variety of oil and gas companies request reservoir characterization and exploration assistance from STARR (see supporting letters, **Appendix A**). The Bureau of Economic Geology (BEG), The University of Texas at Austin, with STARR funding from the State of Texas, provides technical support. Opportunities for increased production and associated reserves have been identified, and these opportunities have been or are being drilled by cooperating companies. Recent projects are described in the present report. STARR's revenue-neutrality calculations are typically conducted for the trailing 2-year period at the time of reporting. For this report, calculations cover the period from September 1, 2010, through July 31, 2012. STARR personnel provide assistance and advice to numerous operators on optimal development strategies, appropriate well log suites, styles of reservoir heterogeneity and their effects on oil and gas recovery, and evaluation of exploration targets, as well as regional geology and unconventional resources.

STARR has a technology-transfer approach that includes workshops, presentations, publications, website content, and digital data sets. As part of STARR's public outreach, 3-D visualizations of STARR field studies that display reservoir architecture have been constructed for presentation to oil and gas companies, as well as to middle and high school students, to raise interest and awareness of oil and gas exploration in Texas. Through technology transfer we envision that many remaining State Lands oil and gas reserves will be explored and developed in future decades to sustain the Texas Permanent School Fund. As a result of this State funding, STARR personnel have received several awards **(Appendix B)**, and the program has provided the public with numerous publications, workshops, and lectures **(Appendices C and D).** Since the last biennium report, STARR personnel have produced 25 professional papers, approximately 50 abstracts, 53 presentations, 6 reports, and 11 workshops and chapters in guidebooks **(Appendices C and D).**

During the 2010–2012 biennium, STARR personnel gave a variety of presentations to industry partners, including T-C Oil Company, BASA Resources, MPG Petroleum, CML Exploration, Vision Resources, BBX Operating, Stalker Energy, Cobra Oil and Gas, Pioneer Resources, Risco La Sara Operations, Arête Resources, Tracker Resources, Chesapeake Energy, AEATX, Newfield, and Valence Operating**.**

To date, STARR has generated 46 field studies **(Fig. 1 and Table 2);** approximately 50 Texas operators have been, or are currently, involved in Project STARR **(Table 2)**. STARR studies have been used to recommend more than 300 infill wells, step-out wells, and recompletions over the project's 20-year duration **(Tyler et al., 1998; Hardage et al., 2000; Loucks et al., 2002a, 2004, 2006; Hammes et al., 2008; Ambrose et al. 2010b.** Eighteen new field studies were added during the 2010–2012 biennium**.**

STARR is currently conducting five regional studies, including unconventional reservoirs in (1) the Eagle Ford Shale in South Texas, (2) the Pearsall Formation in the Maverick Basin and adjacent areas of South Texas, (3) the Haynesville Shale in the East Texas Basin, (4) tight-gas sandstone reservoirs in the Cleveland Formation and Marmaton Group in the western Anadarko Basin in the Texas Panhandle, and (5) conventional reservoirs in the Frio Formation on the south-central Texas Gulf Coast **(Fig. 2).** Two of these regional studies (Pearsall and Frio Formations) are ongoing, and final results and credit matrix numbers will be included in the 2012–2014 STARR biennium report.

Highlights of the present biennium (September 2010–August 2012):

- STARR is revenue positive by a net factor of about 17 and has helped generate approximately $544.8 million for the State of Texas. Credit to the STARR program for the 2010–2012 biennium, in accordance with methodology approved by the State of Texas Comptroller's office, is $153,260,171. The high positive revenue factor is chiefly due to several thousand successful wells drilled in the highly productive Eagle Ford unconventional oil and shale-gas play in southwest Texas and the unconventional Spraberry-Wolfcamp play in the Permian Basin, as well as other active plays such as the Cleveland-Marmaton play in the Texas Panhandle.

- Eighteen new reservoir characterization projects (field studies) and six regional studies contributed to the successful completion of a variety of new wells and improved waterflood strategies. A partial list of examples includes Lavaca Bay field (Frio Formation), Dimmit County and adjacent areas (Eagle Ford Shale and Austin Chalk), Alabama Ferry field (Glen Rose Formation), Midland County and adjacent counties (Spraberry Formation and Wolfcamp Series), Haynesville Gas Shale field in east Texas, and Eliasville and Breckinridge fields (Caddo Limestone, North Texas).

- A regional study of the Cleveland Formation and Marmaton Group in a 3,000-mi^2 area in the Anadarko Basin in the Texas Panhandle helped us gain new insights into exploration fairways. Results were published in Bureau of Economic Geology Report of Investigations No. 275 (98 pages) in September 2011.

- A regional study of the Eagle Ford Shale that focused on the Maverick Basin and adjacent areas provided a comprehensive stratigraphic framework for evaluating geologic controls on Eagle Ford production trends in the most productive part of the Eagle Ford Trend in Texas. Results were published in the 2010 *Gulf Coast Association of Geological Societies Transactions*.

- STARR's field study of the Spraberry Formation and Wolfcamp Series in the Permian Basin provided a detailed and comprehensive framework for continued successful drilling of tight-oil reservoirs in one of the most productive unconventional trends in Texas. The field project has been expanded to a regional study, and results will be released in an upcoming Bureau of Economic Geology Report of Investigations at the beginning of calendar year 2013.

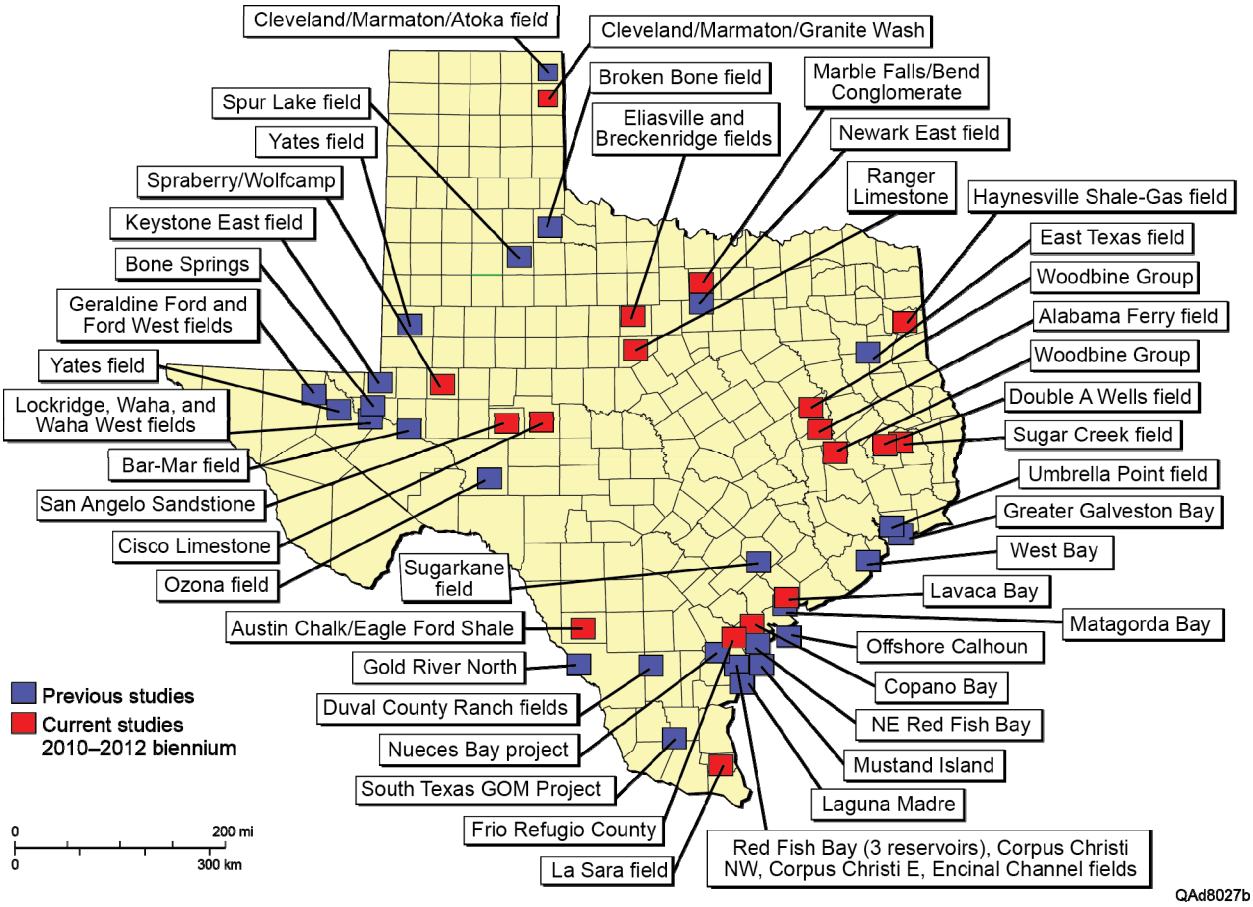


Figure 1. STARR field studies completed prior to the 2010–2012 biennium (blue squares) and new field studies in the 2010–2012 biennium (red squares). Eighteen new field studies were added in the 2010–2012 biennium.

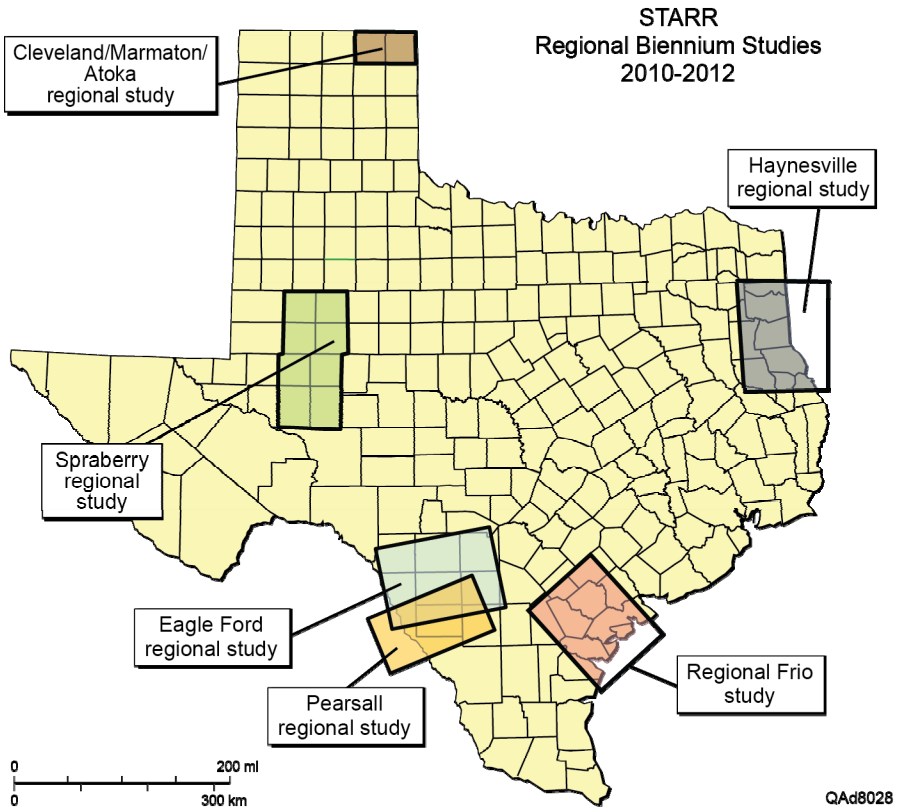


Figure 2. STARR regional studies for the 2010–2012 biennium.

Table 2. STARR field studies, 1995 to present.

Field	Operator	Period of Project STARR Interaction
Keystone East field	Bass Enterprises, Hallwood Energy, Pioneer Natural Resources, Vista Resources	1995–1999
Geraldine Ford and Ford West fields: (primary funding by U.S. Department of Energy)	Conoco, Incorporated	1995–1997
Lockridge, Waha, and Waha West fields: (primary funding by U.S. Department of Energy and Gas Research Institute)	Shell Oil and Mobil Oil (now ExxonMobil)	1996–1998
Bar Mar field	Hanson Corporation	1997–1998
Ozona field	Union Pacific Resources (now Anadarko), Cross Timbers Oil Co.	1996–1998 1998–1999
Duval County Ranch field	Killam Oil	1998–1999
Umbrella Point field	Panaco, Incorporated	1995–1999
Red Fish Bay field (shallow Frio)	Pi Energy	1996–1997

Corpus Christi East field (Frio)	**Sabco Oil and Gas, Royal Exploration**	**1998–2000**
Corpus Christi NW field (Frio)	**Sabco Oil and Gas , Royal Exploration**	**1998–2000**
Encinal Channel field (Frio)	**Sabco Oil and Gas, Royal Exploration**	**1999–2000**
Mustang Island 889 field (Frio)	**Sabco Oil and Gas**	**2000–2001**
Red Fish Bay field (Middle Frio)	**IBC Petroleum, Cinco**	**2001–2008**
Red Fish Bay field (Deep Frio)	**Boss Exploration, Cinco**	**2003–2008**
Mustang Island Offshore (Frio)	**Cabot Oil and Gas**	**2003**
Northeast Red Fish Bay Project (Frio)	**Cabot Oil and Gas**	**2003**
Laguna Madre (Frio)	**Novus**	**2004–2005**
Yates field EOR (Permian)	**Kinder Morgan**	**2004–2006**
Galveston-Bay Shelf area study (Frio)	**Santos USA Corp**	**2004–2006**
Carancahua and Matagorda Bay Projects (Frio, Miocene)	**Brigham Exploration Company**	**2004–2008**
West Bay area study (Alligator Point field; Frio, Miocene)	**Gulf Energy Exploration**	**2005–2007**
LaSalle, Calhoun offshore (Frio)	**Gulf Energy Exploration**	**2005–2007**
Gold River North field (Olmos)	**Huber**	**2006**
Gold River North field (Olmos)	**St. Mary's Land and Exploration**	**2007–2009**
East Texas field (Woodbine)	**Various Operators**	**2006–2008**
North Newark field (Barnett)	**Various operators**	**2007–2009**
Spur Lake and Broken Bone fields	**Gunn Oil Co.**	**2007–2009**
Mustang Island (Frio)	**Sabco Operating Co.**	**2006–2008**
Copano Bay	**MPG Petroleum**	**2007–2009**
East Texas field (Moncrief lease)	**Danmark Energy**	**2007–2009**
Sugarkane field	**Texas Crude**	**2006–2008**
Cleveland/Marmaton/Atoka field	**Jones Energy, Ltd.**	**2008–2010**
Lavaca Bay field	**Neumin Production Company**	**2008–2010**
Alabama Ferry field	**Antioch Energy LLC**	**2009–2011**
Haynesville	**Petrohawk, Common Resources, BP**	**2009–2011**
Spraberry/Wolfcamp (Midland County)	**Pioneer Resources**	**2010–2012**
Lavaca Bay field (Frio)	**Neumin Production Co.**	**2010–2012**
Eliasville/Breckinridge fields (Caddo Limestone)	**BASA Resources**	**2011–2013**
Dismukes field (Dimmit County: Austin Chalk/Eagle Ford hale	**CML Exploration**	**2011-2013**
Sugar Creek field (Austin Chalk/Woodbine)	**BBX Operating**	**2011–2013**
Double A Wells field (Woodbine)	**Vision Resources**	**2011–2013**
K-R-S field (Marble Falls Limestone)	**Cobra Oil and Gas, Stalker Energy**	**2011–2013**
Bend Conglomerate (Wise County)	**Devon Energy**	**2011–2013**
La Sara field (Frio)	**Risco La Sara Operations**	**2011–2013**
Ranger Limestone (Eastland County)	**Stalker Energy**	**2011–2013**
Austin Chalk (Dimmit County)	**Newfield Exploration Company**	**2011–2013**
Frio Formation (Refugio County)	**T-C Oil Company**	**2012–2014**
Cleveland/Marmaton/Granite Wash (Hemphill County)	**Devon Resources, Arête Resources**	**2012–2014**
Woodbine Group (Leon County)	**Risco La Sara Operations, Chesapeake Energy**	**2012–2014**
Woodbine Group (Walker County)	**Chesapeake Energy**	**2012–2014**
Cisco Limestone (Tom Green County)	**AEATX**	**2012–2014**
Pearsall Formation (McMullen, Dimmit Counties)	**Valence Operating Company**	**2012–2014**
San Angelo Sandstone (Irion County)	**Renda Energy**	**2012–2014**
Atoka/Cherokee Group (Ochiltree, Lipscomb, Hemphill Counties)	**Arête Resources**	**2012–2014**

Mississippian Lime (Shackelford, Stephens, Throckmorton, Young Counties	**Tracker Resources**	**2012–2014**
Glorieta Group (Ward County)	**Whiting Resources**	**2012–2014**
Woodbine/ Eagle Ford (Polk County)	**BP**	**2012–2014**

STARR REVENUE-NEUTRALITY METRICS

An important goal of the STARR program is to demonstrate revenue neutrality to the State of Texas Comptroller's Office each reporting biennium to be considered for funding in the next biennium. Starr's revenue neutrality is calculated for 2 years. For the 2010–2012 biennium we calculated our revenue neutrality from September 1, 2010, through July 31, 2012. This 2-year interval was chosen because our progress report is typically being submitted before the end of the current legislative biennium. Both royalties to the Permanent School Fund and State severance tax are accounted for in revenue-neutrality calculations (**Table 3)**. This metrics table was developed in conjunction with the State of Texas Comptroller's Office in 2004 and slightly modified following discussion with the Comptroller's Office in 2006. Five major types of projects are noted in **Table 3**.

Table 3. Project STARR revenue-neutrality metrics.

	Type of STARR recommendation	Expiration period following recommendation (Initial/incremental production must begin before recommendation expires)	Time period for credit following initial production	Royalty Credit (royalties to PSF)*	Severance tax credit
1.	Drilling new infill or step-out well in established field	4 years	2 years	100%	100%
2.	Drilling new infill or step-out well in established field with multiple reservoir intervals	4 years	2 years following completion of each additional reservoir interval	100%	100%
3.	Recompletion—missed pay well in established field	4 years	2 years	100%	100%
4.	Enhanced oil recovery (EOR) field project	4 years	2 years following date selected by STARR within a 5-year period from initial operator action	100% of incremental production	100% of incremental production
5.	Exploration well	4 years	2 years	100%	100%
	5.a. Subsequent development wells following discovery of new field	2 years following initial production from exploration well	2 years	100%	100%
	5.b. Copycat wells following discovery of new field	2 years following initial production from exploration well	2 years	25%	25%
6.	Wells drilled on basis of influence of regional trend studies	4 years starting 6 months after releasing study	2 years	25%	25%

* Project STARR receives revenue-neutrality credit only for the fraction of royalty that goes into the General Revenue Fund of the State of Texas. State Land royalties initially go into the Permanent School Fund, and a percentage of that fund is transferred to the General Revenue Fund each year. Project STARR receives credit for the amount that is provided to the General Revenue Fund each year.

Field Studies

STARR field studies include step-out wells, well deepening, recompletions, targeted infill drilling, injection-profile modification, waterflood optimization, and drilling of untested deeper targets under producing fields. STARR added 18 new field studies in the 2010–2012 biennium (**Fig. 1**). These fields are widely distributed in Texas and include sandstone reservoirs on the Gulf Coast and in East Texas Basin, west-central Texas, and the Texas Panhandle. Carbonate

reservoirs include the Marble Falls Formation, Ranger Limestone, and Caddo Formation in north Texas, the Casco Limestone in west-central Texas, and the Glen Rose Formation in the East Texas Basin. Unconventional reservoirs in southwest Texas (Eagle Ford Formation) and the Permian Basin (Spraberry and Wolfcamp) round out the remainder of the field studies.

Regional Studies

STARR regional studies are based on analysis of the sequence-stratigraphic architecture of sedimentary basins and using this framework for delineating and evaluating geologic controls on oil and gas production. We use sequence-stratigraphic principles that have been developed by major oil companies over the past 20 years. We also apply methods developed by STARR for Gulf of Mexico stratigraphy **(Brown and others, 2004, 2005; Hammes and others, 2007)**. These studies emphasize trends in new exploration fairways. Deep to ultradeep reservoirs, such as those in the higher risk, deep-shelf gas play (offshore Tertiary-age sandstone reservoirs between the depths of 15,000 and 35,000 ft) are an example of where new studies are needed to encourage exploration drilling. The regional study of the south Texas Frio Formation (**Fig. 2**) is an example of a STARR study that is delineating the geometry and extent of potentially productive sandstones within growth-fault-bounded subbasins, beyond the current limits of existing well control.

STARR conducted a regional study of tight (low-permeability) oil- and gas-reservoirs in the Pennsylvanian Cleveland Formation and Marmaton Group in the Texas Panhandle. The study demonstrates the need to develop a robust sequence-stratigraphic and depositional-facies framework for a more complete understanding of the controls on reservoir quality and continuity in these low-permeability formations and to help define and extend play fairways into new areas (**Ambrose, 2011**).

Unconventional Resources

Unconventional hydrocarbon resources, such as shale gas, shale oil, tar sands, tight-gas sandstones, cherts, carbonates, and low-pressure gas, are and will continue to be important hydrocarbon resources for the future of Texas. Oil and gas produced from shale constitute some of the most active exploration plays in Texas, with prospects ranging from far west Texas to the Fort Worth Basin and east Texas. These plays, including the Eagle Ford and Haynesville, are affecting large areas of State Lands in Texas. STARR is conducting several studies on shale oil and gas to promote this resource, for it should have a great impact on production of hydrocarbons from State Lands. In the upcoming biennium, STARR will be investigating other shale plays, including the Pearsall play in southwest Texas, as well as expanding its field study of the Wolfberry play at the regional scale in the Permian Basin in west Texas.

PROJECTS IN THE 2010–2012 BIENNIUM

Field Studies

Spraberry/Wolfcamp (Wolfberry) Field Study

The Permian (Leonardian) Spraberry and Dean sandstones have produced oil throughout the Midland Basin since the late 1940's. Known as the Spraberry Trend, productive areas extend across 18 counties and contain more than 10 billion barrels (Bbbl) of oil (**Fig. 3**). More recently, operators have been including deeper formations in their Spraberry Trend completions: first, the Wolfcamp (Lower Permian) that underlies the Dean and sometimes deeper zones in the Pennsylvanian. This expanded productive interval is called the Wolfberry play. Multiple hydraulic-fracture stimulation stages open up these low-permeability formations to production over a 4,000-ft (1,220-m) vertical interval between 6,000 and 10,000 ft (1,830 and 2,630 m) below land surface. Since the late 1990's, more than 8,700 Wolfberry oil wells have been completed and have produced 216 million barrels (MMbbl) of oil and 544 billion cubic ft (Bcf) of gas. Initial well production averages 30 to 125 barrels (bbl) of oil per day, and ultimate per-well recovery is estimated at 100,000 to 140,000 bbl of oil equivalent. Key accomplishments in this study include publication and presentation of regional stratigraphy and lithofacies distribution, quantification of reservoir and source rock attributes, and production statistics.

The Wolfberry play is a resource play characterized by heterogeneous lithologies, low-permeability values, and reservoirs and source rocks in close proximity. The paleogeographic setting was a deep ocean basin surrounded by shallow carbonate platforms. Basin-floor stratigraphy comprises alternating layers of calcareous and siliciclastic lithofacies having widespread continuity. In siliciclastic intervals, such as the Spraberry and Dean, turbidite sandstones and laminated siltstones are interbedded with organic-rich mudrocks (**Fig. 4**). In calcareous intervals, such as the lower Leonard and the Wolfcamp, carbonate debris flows are interbedded with carbonate turbidites and organic-rich calcareous mudrocks. Although coarser-grained turbidites and debris flows are the obvious reservoirs, finer-grained calcareous facies are also productive after fracture stimulation.

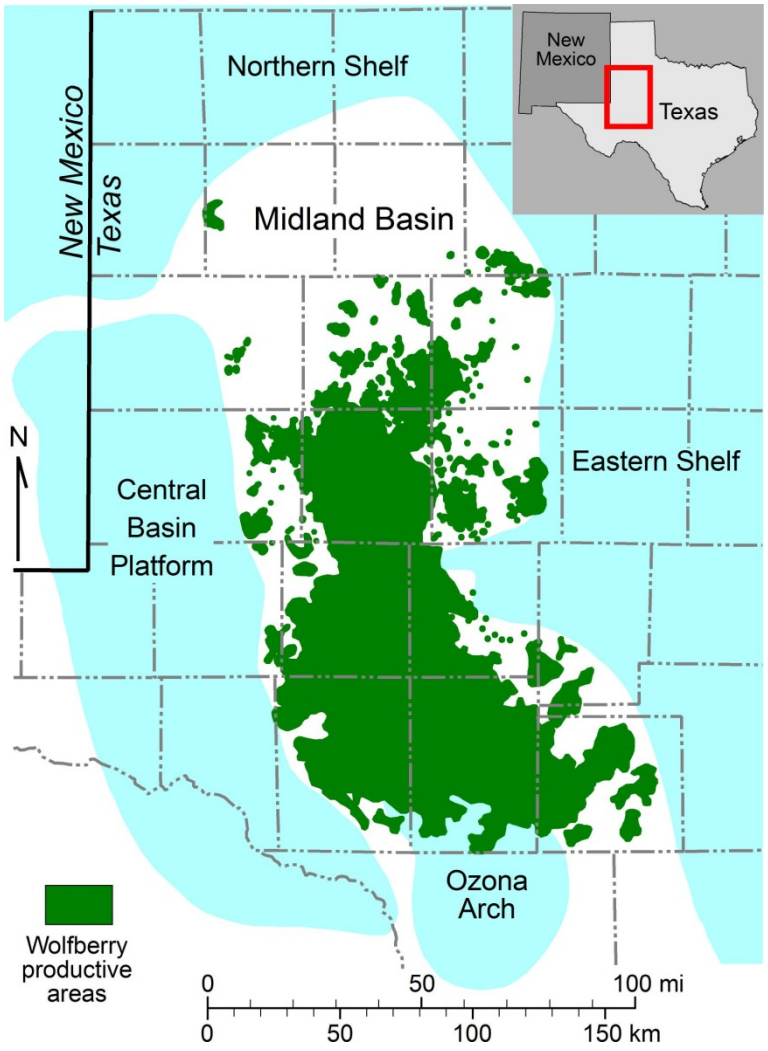


Figure 3. Map of the Midland Basin in west Texas showing Wolfberry productive areas in green (as of late 2010). The Wolfberry play is located within a Permian deep-water ocean basin. Surrounding shallow-water carbonate platforms shown in blue.

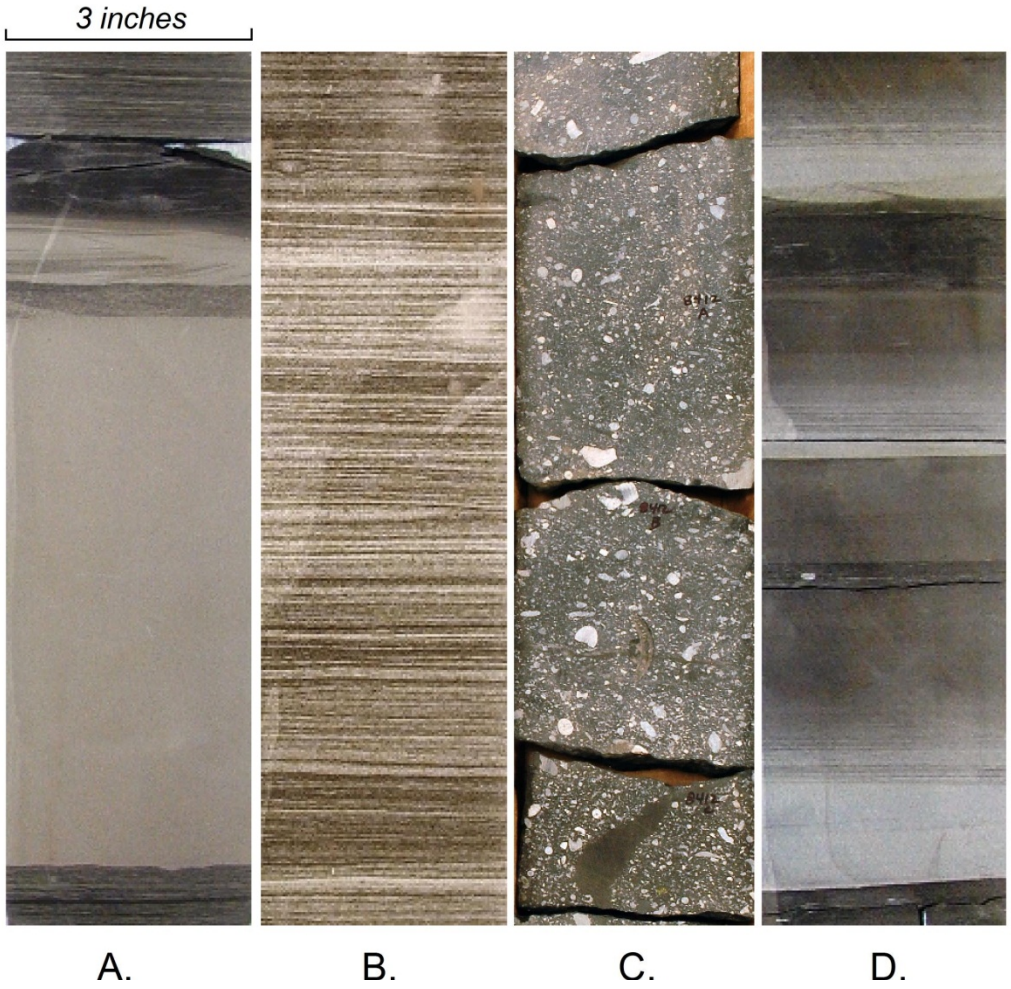


Figure 4. Photographs of Wolfberry lithofacies observed in core. (A) Complete turbidite sandstone enclosed in laminated siltstone, Dean. (B) Laminated siltstone, Spraberry. (C) Muddy debris flow with carbonate lithoclasts and bioclasts, Wolfcamp. (D) Thin carbonate turbidites interbedded with organic-rich mudrock, Wolfcamp. Slabbed cores 3 inches wide.

Lavaca Bay Reservoir Field Study

Exploration in the Frio Formation on the Texas Gulf Coast continues to be active in deep (commonly ≥12,000-ft [≥3,660-m]), lower Frio sandstone gas reservoirs in growth-fault-bounded subbasins (**Brown and others, 2004, 2005; Hammes and others, 2007**), such as those that occur in Lavaca Bay, **(Fig. 1).** The objective of the Lavaca Bay study, in partnership with Neumin Production Company, was to describe and identify stratigraphic and structural controls on potential gas reservoir compartments (**Ambrose and others, 2010a**). Lavaca Bay field has produced more than 125 Bcf, and individual well production in lower Frio slope-fan and

lowstand prograding-wedge deposits is as much as 9.8 Bcf. Lower Frio slope-fan deposits, principal targets for development wells in the field, are composed typically of narrow (<0.6 mi [<1 km]), sinuous belts of more than 40 ft (>12 m) of gross sandstone (**Fig. 5**). The overall geometry of the sandy framework facies is similar to that described by **Galloway and Hobday (1996)** for slope and base-of-slope depositional systems, with a point-sourced, elongate, and sinuous channel-feeder system. Sandstone geometry in this lowstand interval is consistent with unconfined or bypass systems described by **Prather (2003).** Reservoirs of this type are typically one seismic wavelet thick that have shoestring plan geometries. Reservoir discovery and development in these lowstand slope systems are challenging, owing to thin, narrow, channel-fill sandstones and a high degree of interbedded sandstone and shale beds **(Kendrick, 2000).**

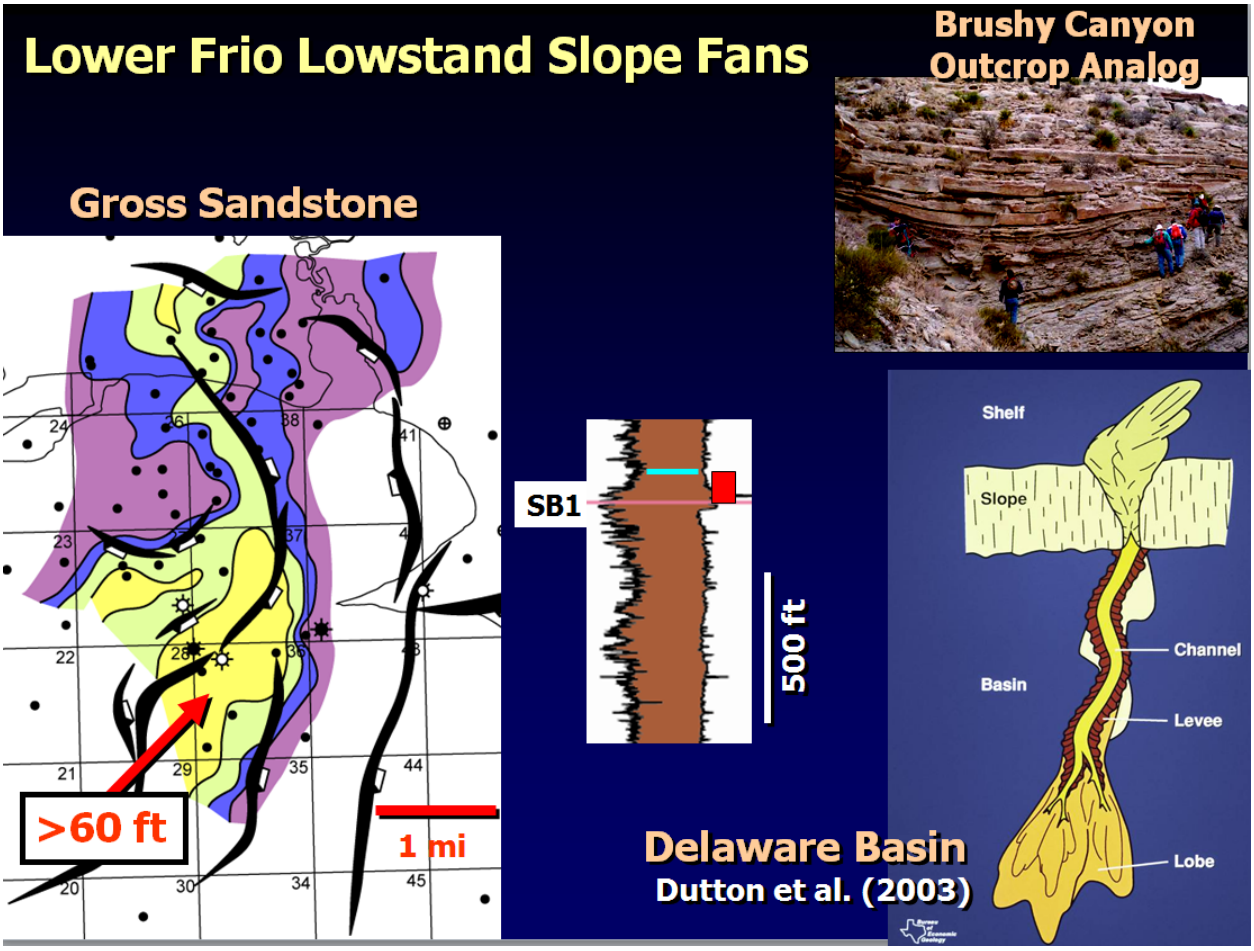


Figure 5. Lower Frio lowstand slope-fan systems in Lavaca Bay field, including typical gross-sandstone geometry, log response, and outcrop and subsurface analogs (**Ambrose and others, 2010a; Dutton and others, 2003**).

Middle Frio lowstand prograding-wedge deposits, also important reservoir targets in the field, collectively exhibit a clinoform geometry (**Fig. 6**). The basal progradational cycle in this clinoform package contains proximal-slope-channel deposits with sinuous and narrow

(commonly <0.6-mi [<1.0-km]) depositional axes with locally more than 100 ft (>30.5 m) of gross sandstone (**Fig. 6**). Reservoir continuity in this interval is a function of narrow slope-channel sandstone bodies, a high degree of fault segmentation with channel-fill sandstones confined to fault-bounded structural corridors, and the presence of laterally stacked channel bodies within meanderbends similar to those described by **Labourdette and Bez (2010).**

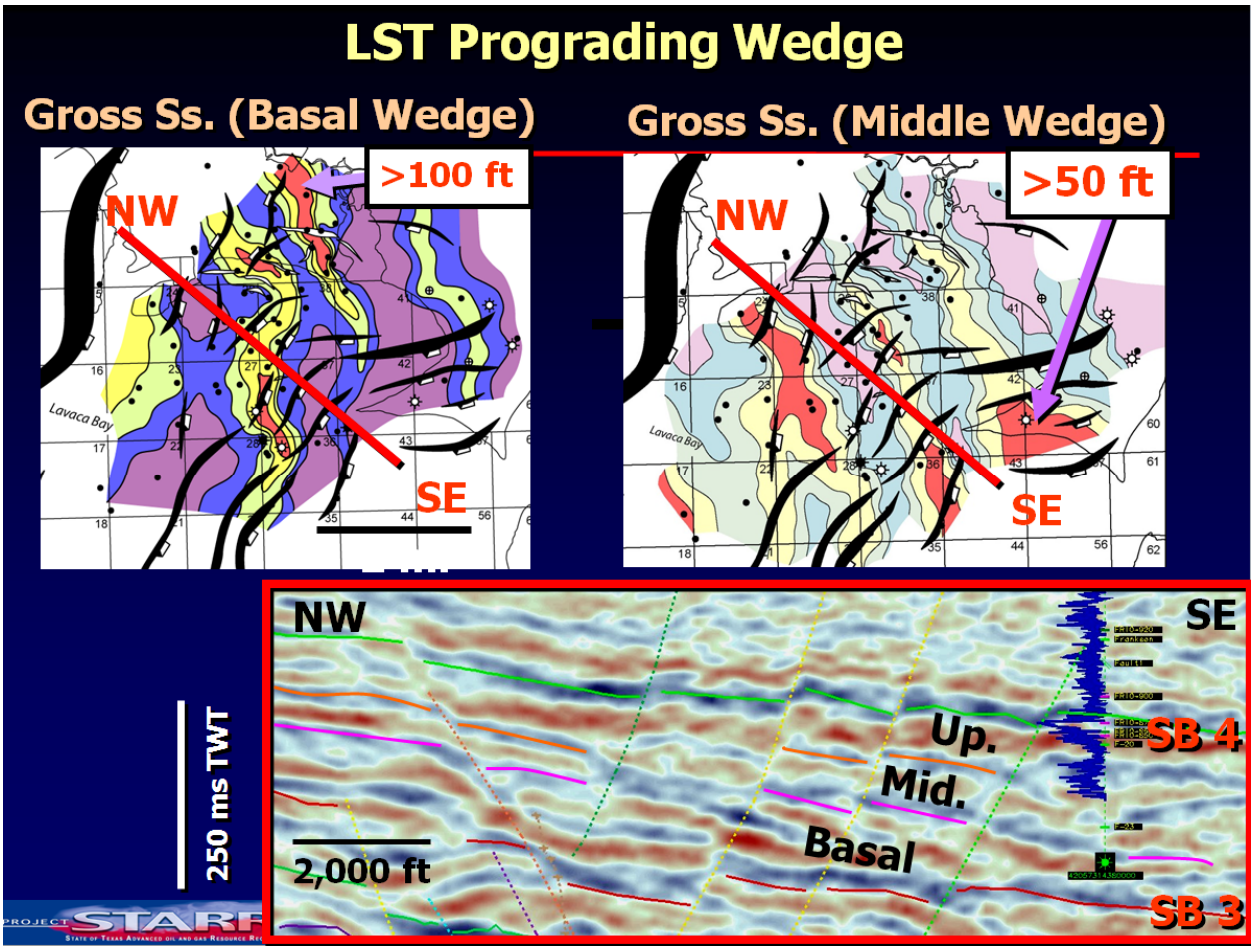


Figure 6. Middle Frio lowstand prograding-wedge systems that form combination structural and stratigraphic traps in Lavaca Bay field**.** Modified from **Ambrose and others (2010a).**

Neumin Production Company in 2012 successfully drilled and produced new conventional gas targets in Lavaca Bay field, incorporating STARR seismic and log interpretations. Initial results in one new well in State waters in the bay indicate additional gas reserves at volumes consistent with previous individual wells, with expected ultimate production of more than 9 Bcf.

Boonsville (Bend Conglomerate) Field Study

The two current primary producing stratigraphic zones in the northern Fort Worth Basin are the Mississippian Barnett Shale and the younger Pennsylvanian (lower Atokan Stage) lower Atoka Group (Bend Conglomerate). Natural gas production from the Barnett Shale of Newark East field that began around 1998 has established it as one of the currently most active and prolific natural gas plays in the United States (**Montgomery and others, 2005; Pollastro and others, 2007**). In contrast, the shallower, siliciclastic, lower Atoka play is mature and has been steadily producing primarily natural gas from multiple fields since the early 1950's. Boonsville field, the focus of this STARR study, encompasses approximately 2,300 mi^2 (~6,000 km^2) in Wise County and parts of adjacent counties (**Fig. 7**) and is by far the largest of the lower Atoka fields in the play, as gauged by total gas and oil production, areal extent, and number of producing wells. Lower Atoka reservoirs in all fields have collectively produced more than 3.2 trillion cubic ft (Tcf) of natural gas and more than 36.3 MMbbl of oil from more than 5,700 total wells (**IHS Energy, Inc., 2011**). Although Boonsville field and the smaller lower Atoka fields are in advanced stages of production, operators continue to explore the interval for infield prospects. However, no published data exist regarding the play-scale distribution of individual reservoir units of the lower Atoka succession to help guide drilling. To address this issue, we conducted a study of the chronostratigraphic framework of the interval in all of Wise County and easternmost Jack County (~960 mi^2 [~2,500 km^2]) of the northern Fort Worth Basin to describe and interpret cores and construct high-resolution maps of gross sandstone trends (**Figs. 8 and 9**). These core descriptions and maps were integrated with maps of hydrocarbon production (**Fig. 10**) to provide an exploration framework for oil and gas operators. Results of the study were published in a 2012 issue of the *AAPG Bulletin* (**Hentz and others, 2012**).

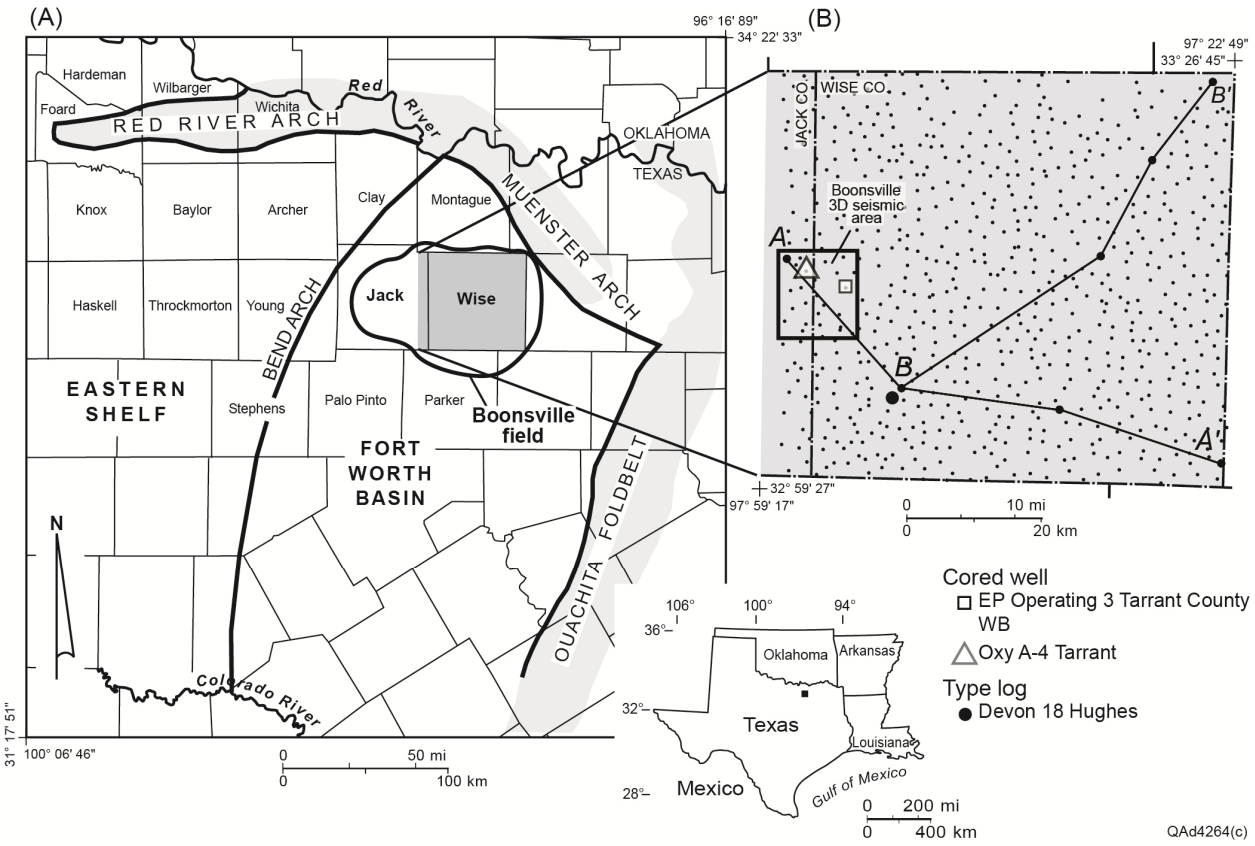


Figure 7. Location of Boonsville field study area**.** From **Hentz and others (2012).**

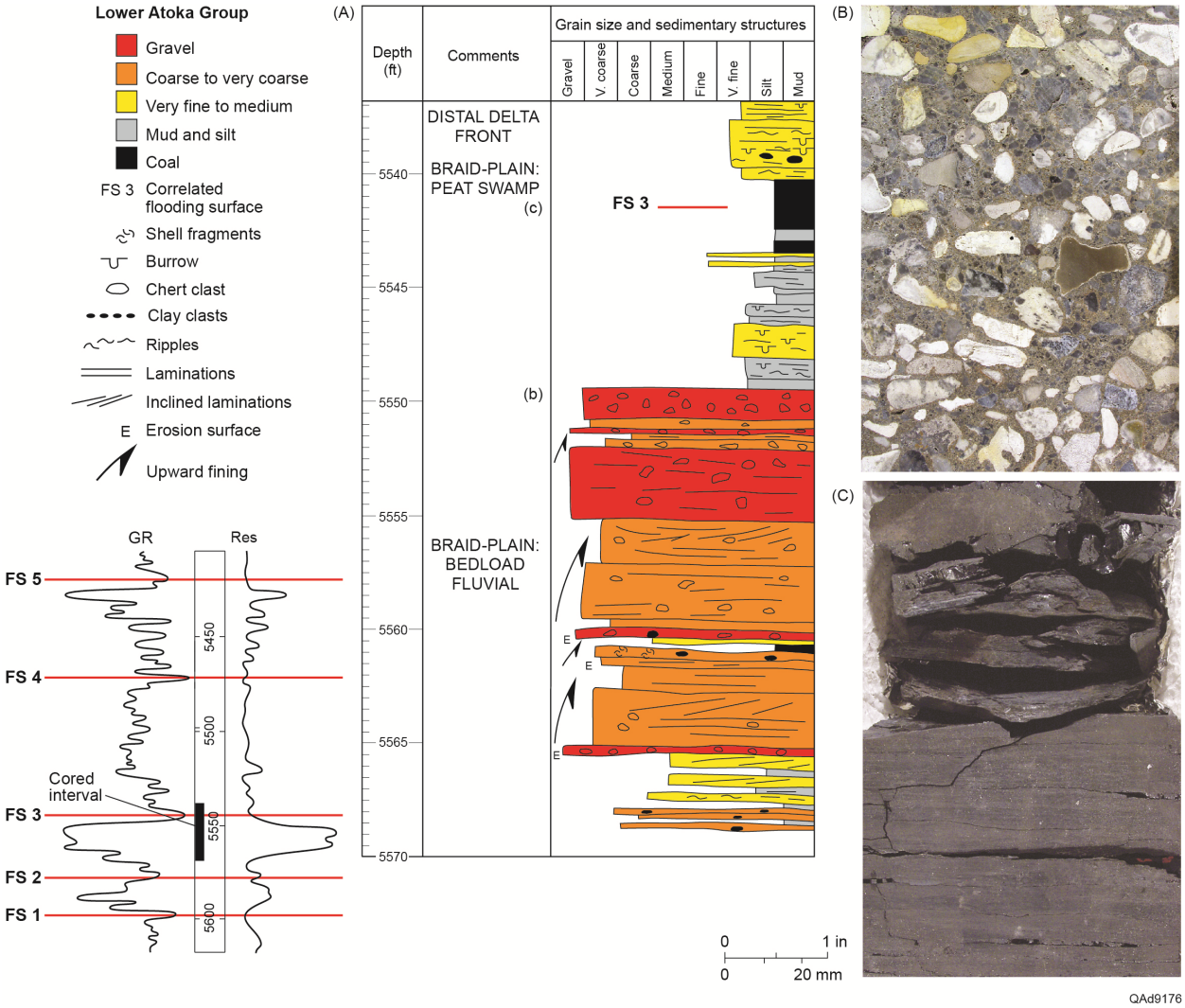


Figure 8. Core description and photographs of braided-stream fluvial deposits in lower Atoka Bend Conglomerate. Gross-sandstone thickness map of stratigraphic interval in which core occurs shown in **Figure 9.** From **Hentz and others (2012).**

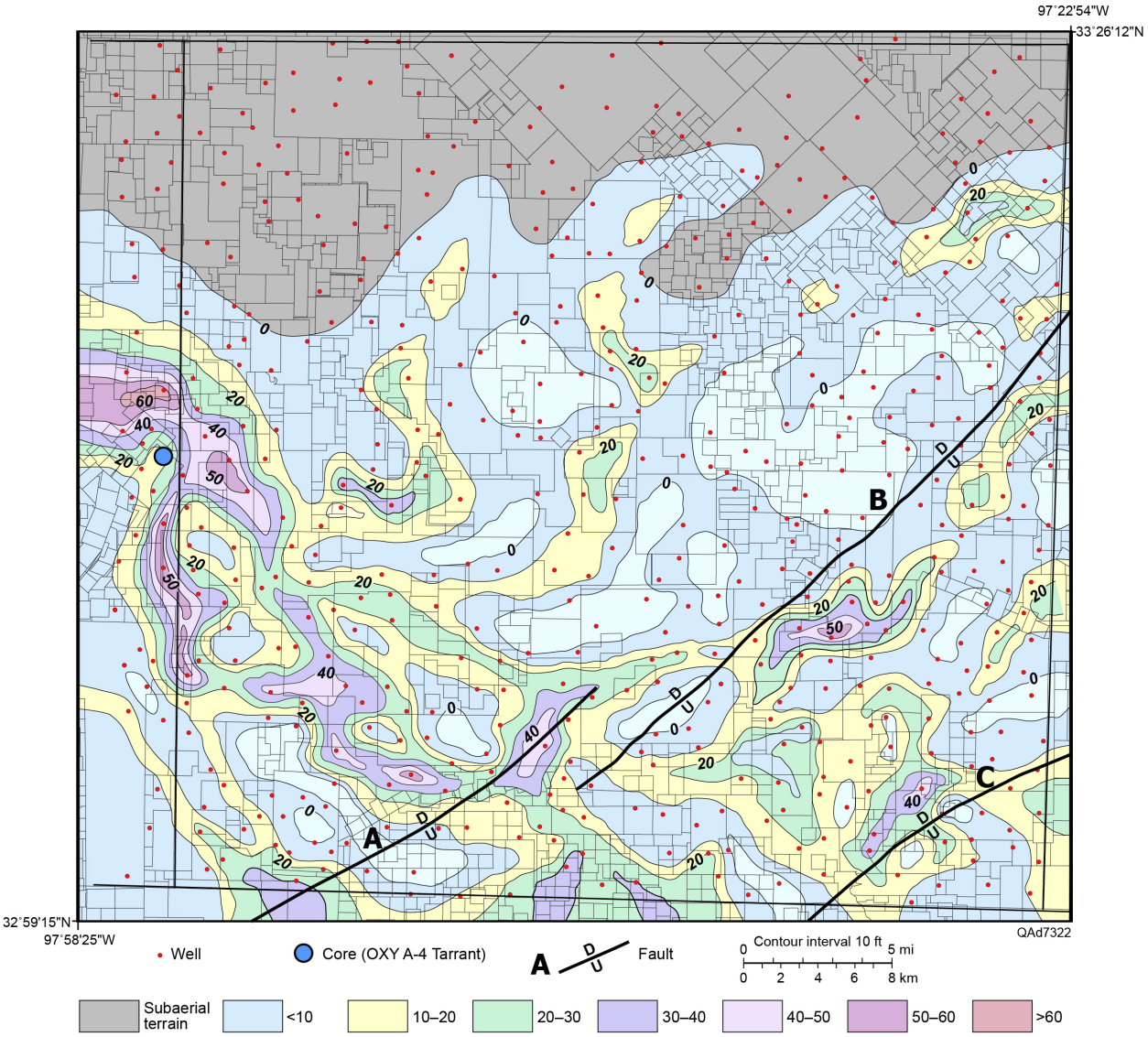


Figure 9. Gross-sandstone-thickness map of braided-stream fluvial deposits in Bend Conglomerate interval. Core description shown in **Figure 8.** From **Hentz and others (2012).**

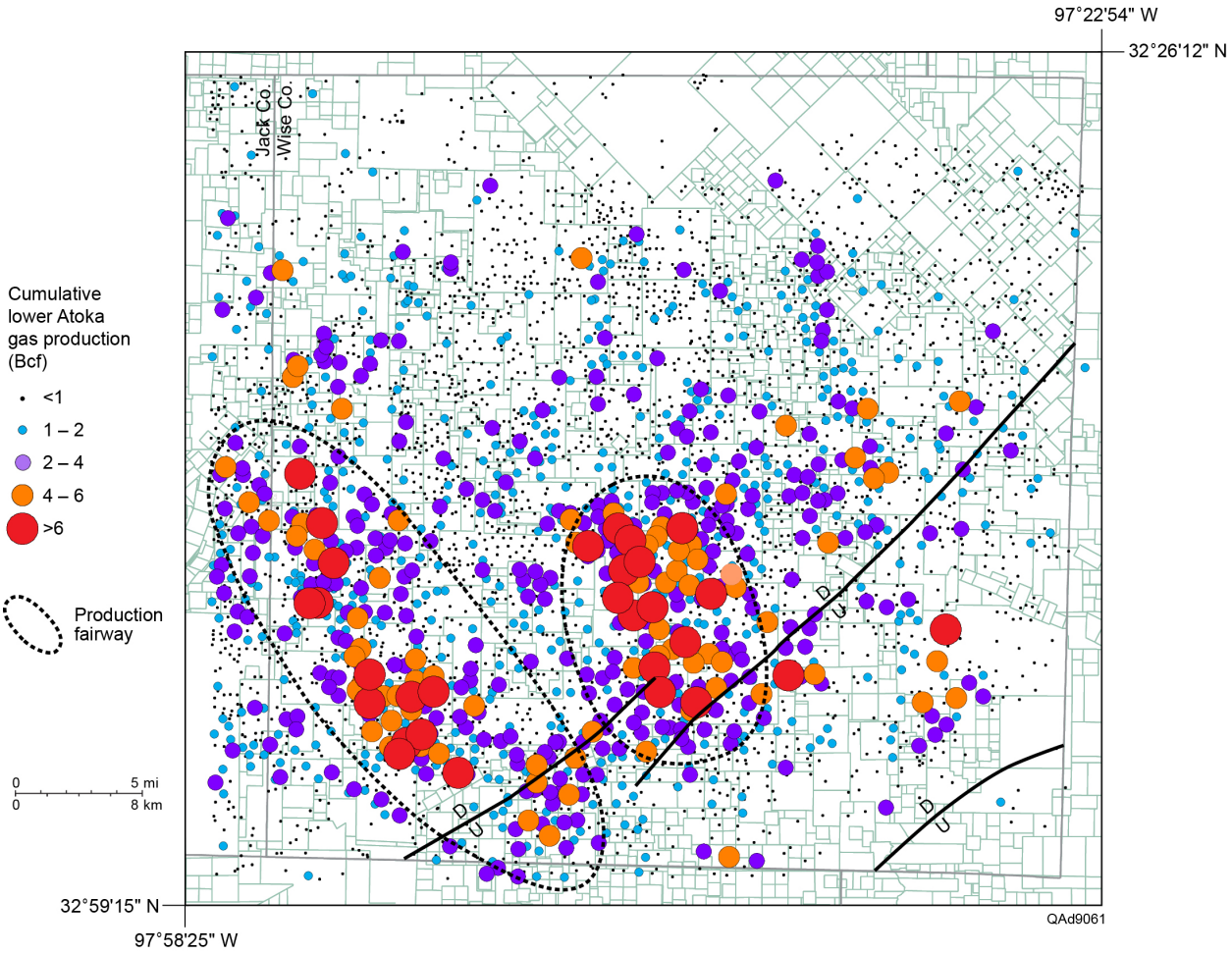


Figure 10. Cumulative lower Atoka gas production per well in Boonsville study area, with two northwest-trending production fairways that correspond to similarly aligned braided-stream gross-sandstone-thickness trends. From **Hentz and others (2012).**

Regional Studies

Regional Cleveland and Marmaton Gas Study

The Cleveland Formation has produced more than 1.1 Tcf of gas and 37.3 MMbbl from low-permeability (tight) sandstones since 1956 in a play area that comprises Ochiltree and Lipscomb Counties, Texas, and adjacent Ellis County, Oklahoma. Cleveland sandstones are part of a productive trend of tidally modified, shallow-marine sandstones in the Anadarko Basin that encompasses the Texas Panhandle and western Oklahoma**.** Sandstones in the Cleveland Formation and Marmaton Group commonly require hydraulic fracturing and/or horizontal drilling to maximize permeability pathways and enhance productivity. Important issues that

affect the success of these horizontal wells include sandstone-body thickness, lateral continuity and geometry, and degree of interbedded siltstones that increase matrix content, thereby reducing overall porosity and reservoir quality. Primary production in the Cleveland Formation is from thick fluvial and estuarine sandstones within a valley-fill system (**Fig. 11**).

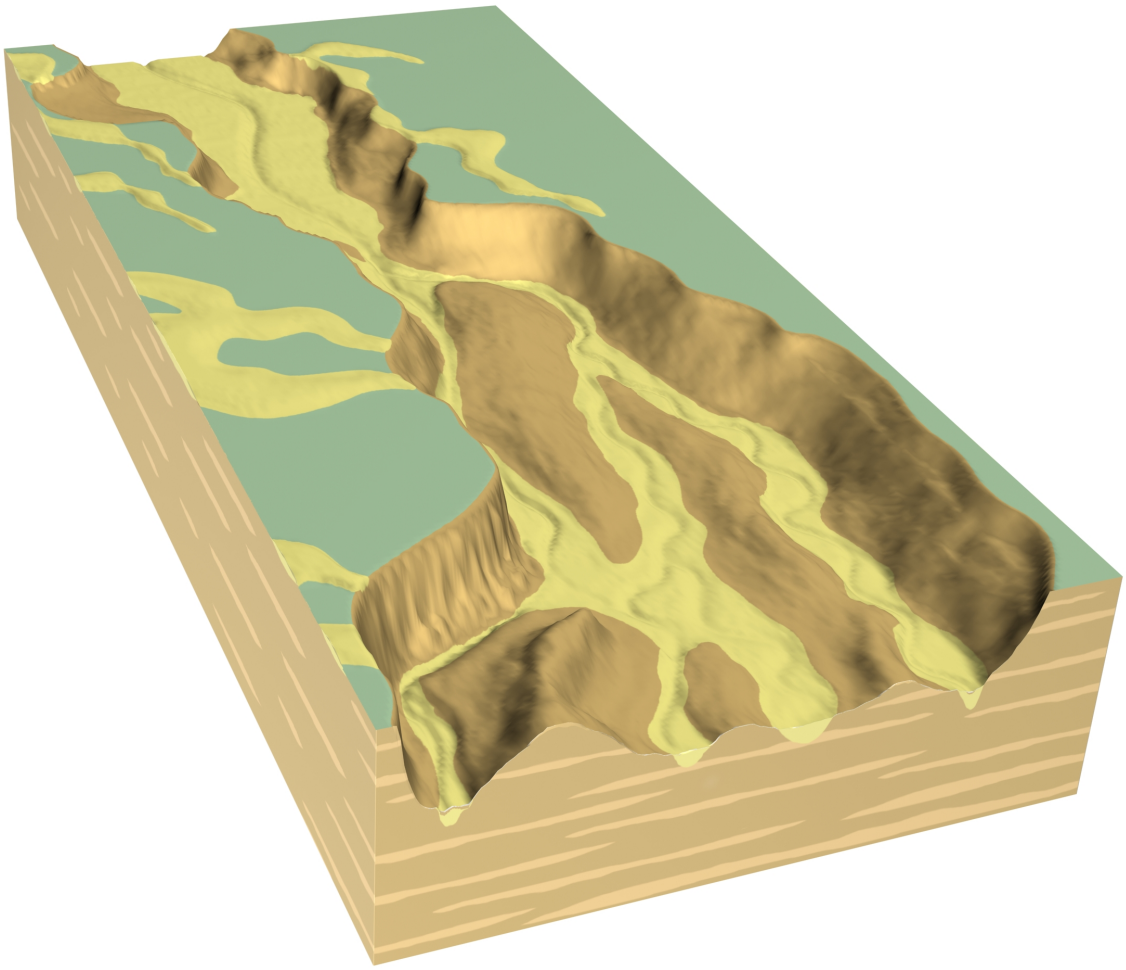


Figure 11. Incised-valley-fill depositional model of Cleveland Formation in Texas Panhandle and western Oklahoma. Thick valley-fill sandstones contain one of the major oil plays in the Cleveland Formation (see "IVF Oil HZ 1 Trend" in **Figure 12)**. From **Ambrose and others (2011)**.

The Cleveland-Marmaton STARR project, initially conducted with Jones Energy, Ltd., used a data set consisting of 1,127 wells and 5 conventional cores, with approximately 250 ft (~75 m) of section from the Cleveland Formation, as well as production data from both the Cleveland Formation and Marmaton Group from more than 900 wells (**Fig. 12**). The study also includes a play analysis of the Marmaton Group, which shares a similar depositional origin with the Cleveland Formation. The study demonstrates the need to develop a robust sequence-stratigraphic and depositional-facies framework for a complete understanding of the controls on reservoir quality and continuity in these low-permeability formations. Results from this study were published in BEG Report of Investigations No. 275 (98 pages), released in September 2011.

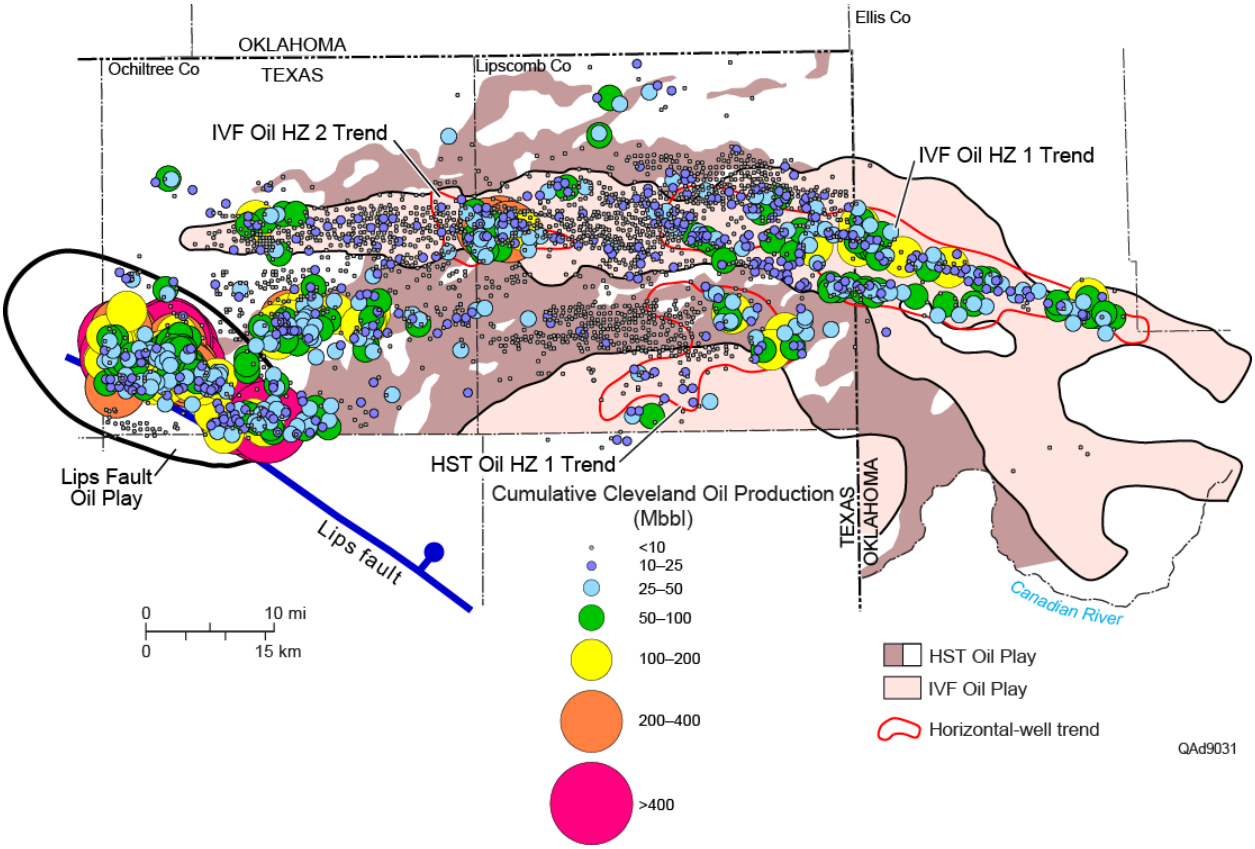


Figure 12. Cleveland oil plays and trends of predominantly horizontal wells superimposed on bubble map of cumulative Cleveland oil production of thousands of barrels (Mbbl) per well in northwest part of Anadarko Basin. Most oil production in the Cleveland Formation in this area coincides with an east-trending paleovalley in Ochiltree and north-central Lipscomb Counties, Texas, that extends eastward intro Ellis County, Oklahoma. Other productive areas include the northeast margin of the Lips Fault, as well as older, highstand shelf deposits in southern Ochiltree and Lipscomb Counties. Valley-fill depositional model shown in **Figure 11.** From **Ambrose and others (2011)**.

South Texas Regional Frio Study

The Oligocene Frio Formation is a leading oil- and gas-bearing stratigraphic unit on the South Texas Gulf Coast. More than 70 Tcf of gas and 8 Bbbl of oil have been produced from mainly upper Frio sandstones and, more recently, from deeper, lower Frio sandstones. Additional reserves occur in these deeper, downdip plays, requiring an understanding of the regional sequence stratigraphy. Our study focuses on a four-county area on the South Texas Gulf Coast (**Fig. 13**).

The STARR regional Frio study has identified and mapped six major third-order sequences in the Frio Formation **(Fig. 14)**. Each sequence consists of basin-floor and slope-fan deposits and lowstand prograding wedges of shelf-edge to slope origin. Sandstones in shallow-marine deposits within these prograding wedges vary in terms of reservoir quality, ranging from burrowed sections of interbedded lower, fine-grained sandstone and mudstone, to clean, well-sorted sandstone of beach origin **(Fig. 15).**

Growth faults, associated with thick sediment accumulation, were active primarily during lowstand episodes. Shifting of the depocenters in time, in conjunction with growth-fault activity, resulted in partitioning of reservoir sandstones between the slope and basin and the shelf. Because genetically similar but progressively younger lowstand depositional systems successively filled each subbasin from northwest to southeast, this sequence-based approach has demonstrated that Frio reservoirs are less continuous than previously thought, resulting in a great potential for additional reservoir compartments representing exploration targets. Recent results from the study were presented at the 2012 GCAGS Convention (**Olariu and others, 2012).**

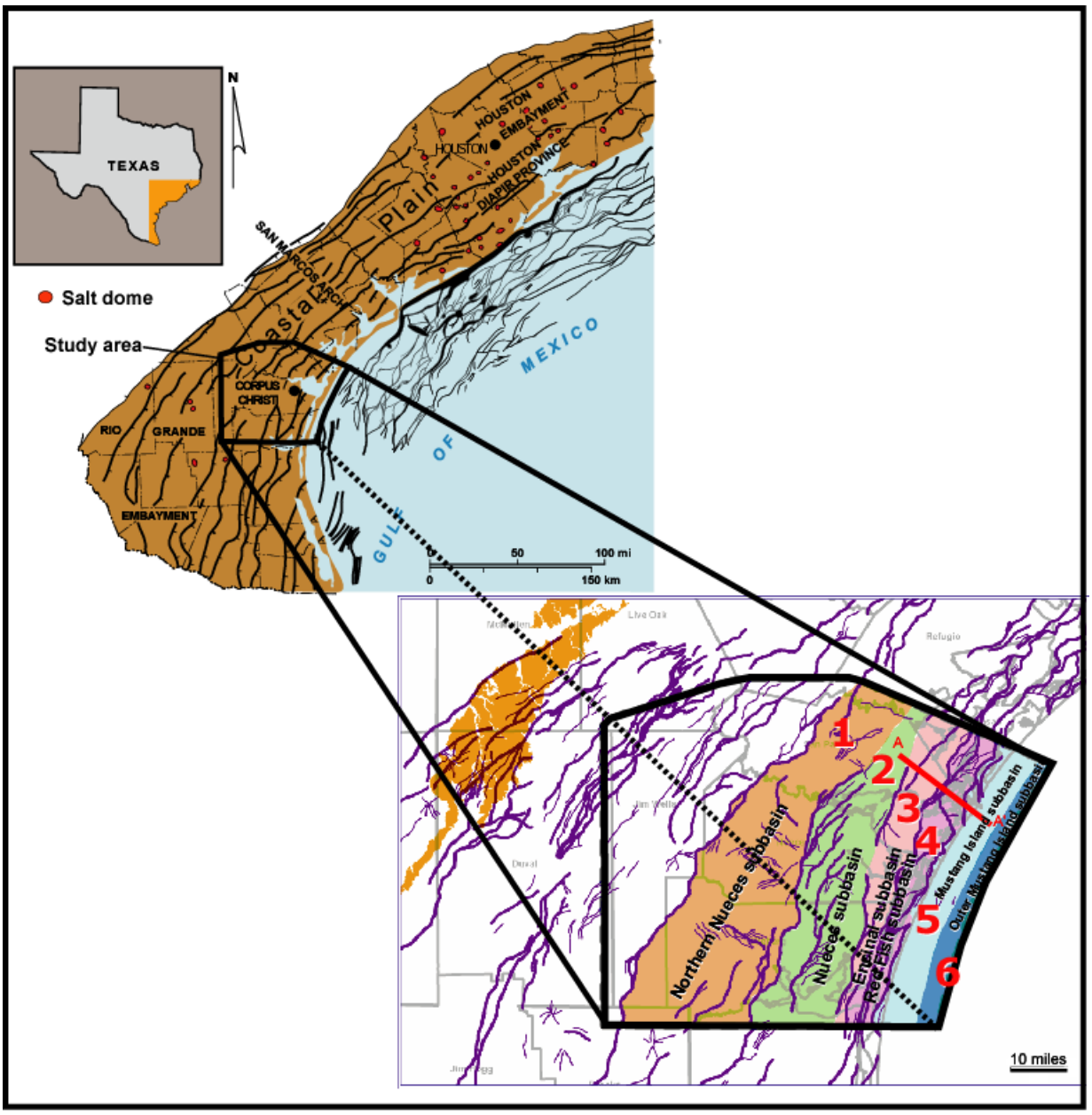


Figure 13. Location map of lower Texas regional Frio study area. Inset shows six Frio subbasins and cross section A-A′, shown in **Figure 14.**

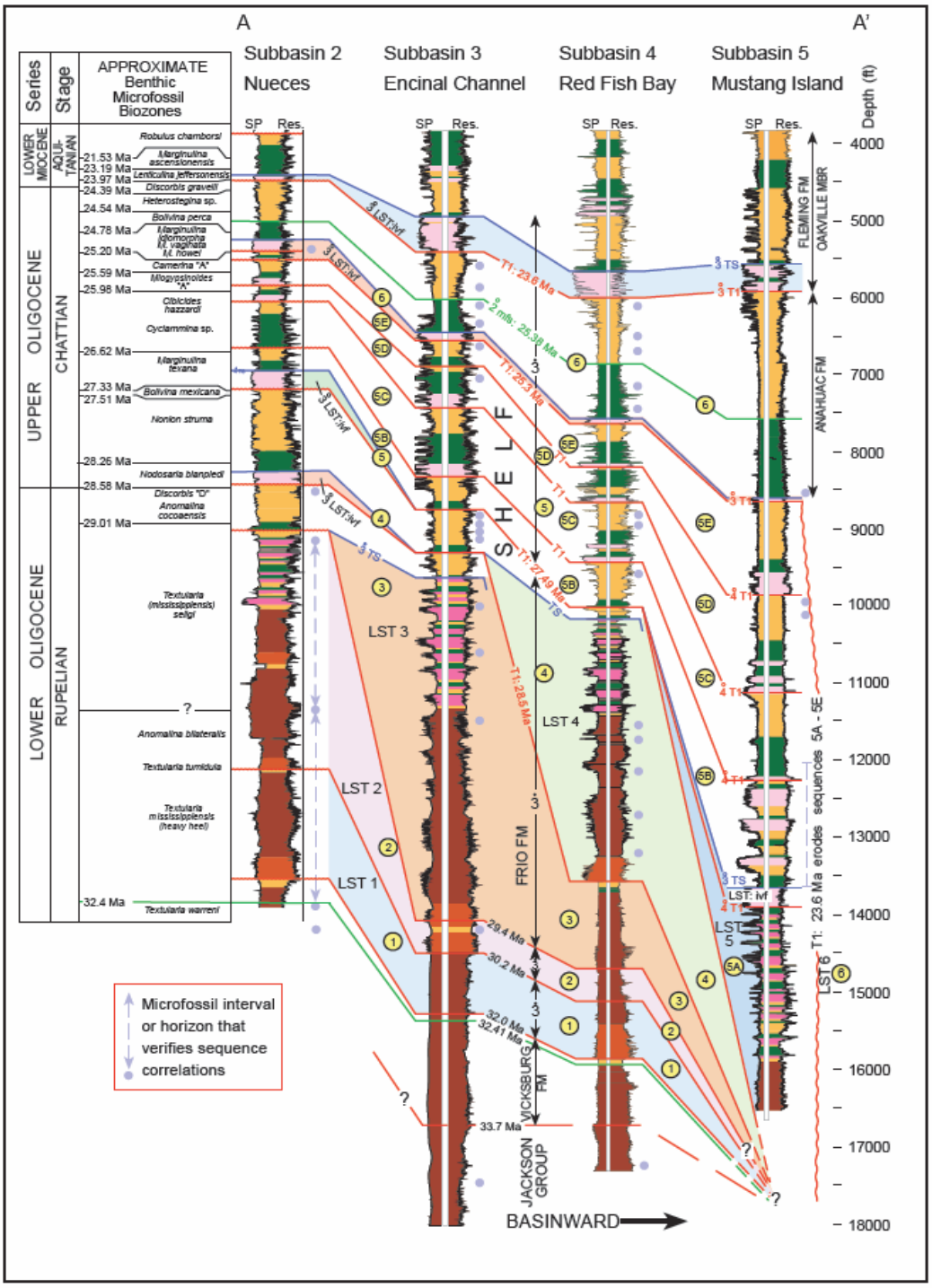
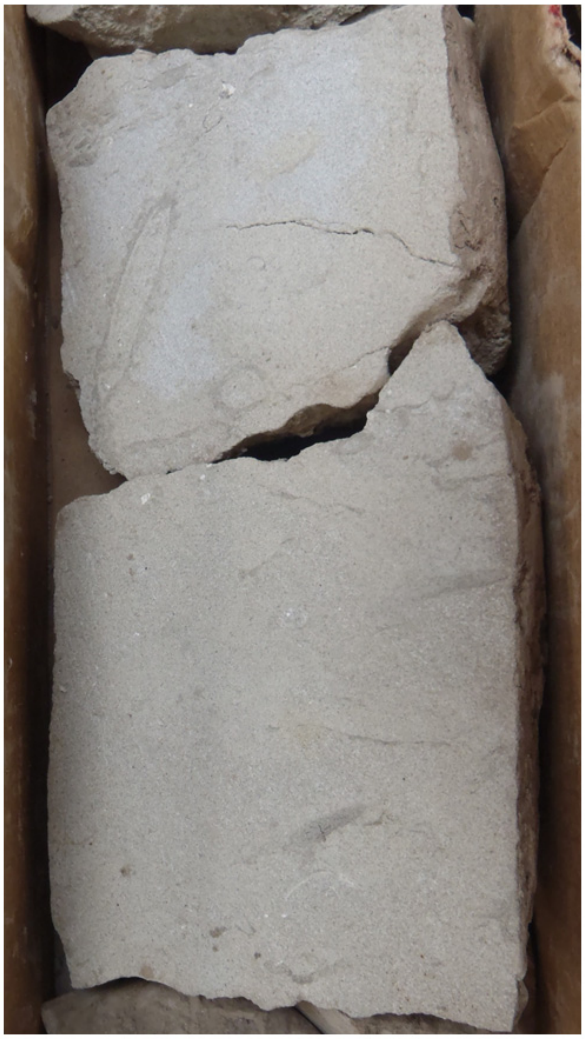


Figure 14. Cross section A-A′ of Frio subbasins 2 through 5 (showing progressively younger strata from NW to SE. Line of section shown in **Figure 13.** From **Brown and others (2004)**.

(a)



(b)

Figure 15. Photographs of shallow-marine deposits from lowstand prograding-wedge systems in Frio Formation in area of Redfish Bay near Corpus Christi, Texas. (a). Burrowed, very fine grained sandstone. (b). Fine-grained, well-sorted beach sandstone. Cores approximately 2.5 inches across. Modified from **Olariu and others (2012).**

Unconventional Resources

Eagle Ford Shale

The Eagle Ford Shale, along with the Wolfberry in the Permian Basin, is the leading shale play in Texas (**Fig. 16**), producing both oil and gas. Containing a significant carbonate content (up to 70 percent in southwest Texas), the Eagle Ford Shale is brittle and amenable to hydraulic fracturing. It is also the primary source rock for the Austin Chalk and the giant East Texas field in the East Texas Basin (**Ambrose and others, 2009**).

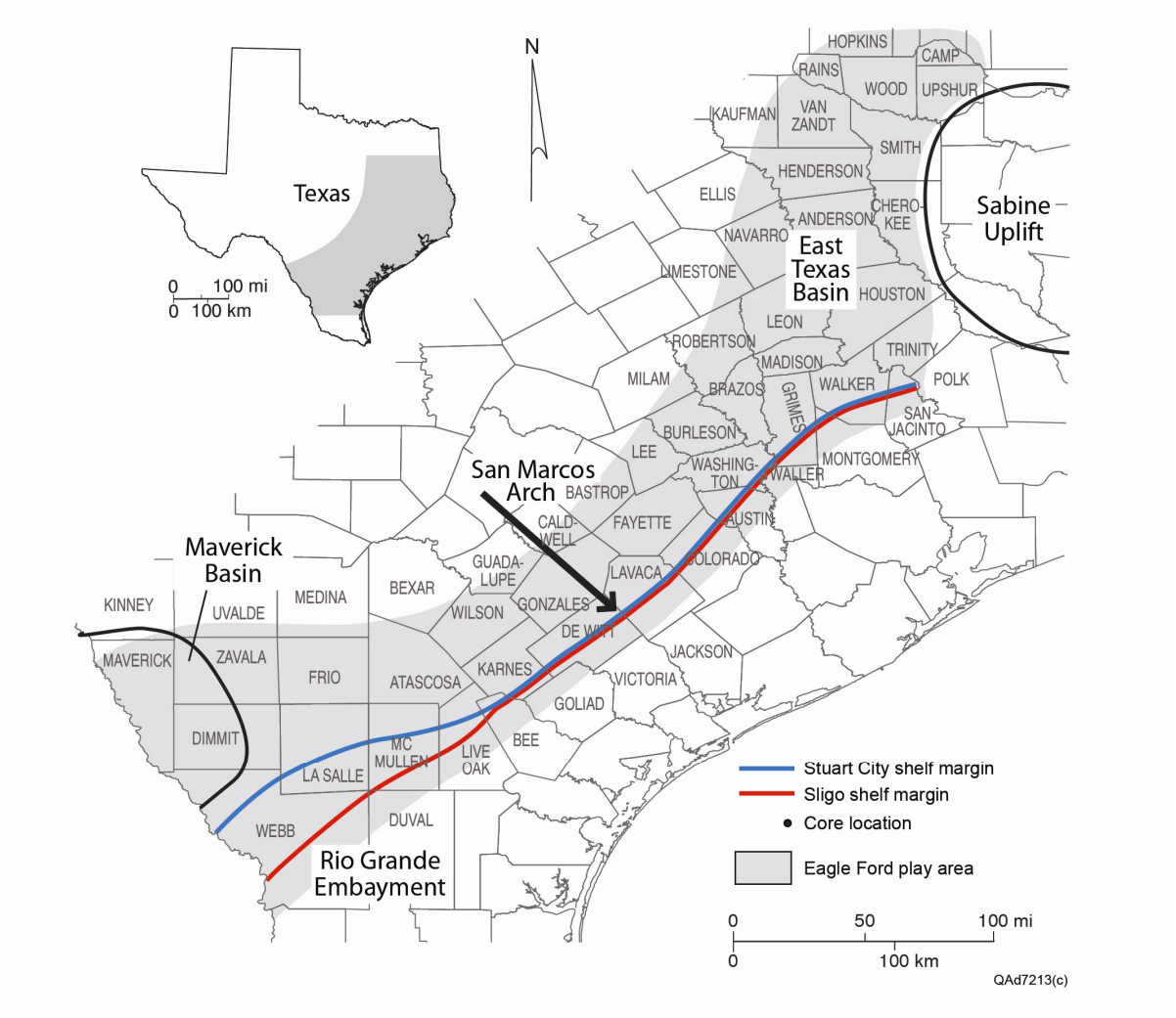


Figure 16. Regional extent of Eagle Ford play in Texas. **From Hentz and Ruppel (2010).**

Petrohawk drilled some of the early wells in the play in 2008 in Hawkville field, La Salle County, with the discovery well producing 7.6 million cubic feet of gas per day (MMcf/d) from 10 frac stages **(Railroad Commission of Texas, 2012a).** There were 368 producing oil leases in 2011, a significant increase from only 72 producing oil leases in 2010. Cumulative oil

production, mainly from Dimmit and northwestern Webb Counties, from January through May 2012 was approximately 38.7 MMbbl, almost equaling cumulative production in 2011 (~40.8 MMbbl) **(Figs. 17 and 18) (Railroad Commission of Texas, 2012b).** Recent reports indicate that liquid hydrocarbon production (oil plus hydrocarbon liquids) from the Eagle Ford Shale is approaching 1 MMbbl/d. The Eagle Ford Trend also produces gas (**Fig. 19**), but at minor levels compared with levels of oil and condensate (**Fig. 20**). The Railroad Commission of Texas reports that gas-well gas production was 2011 at 290 Bcf and 121 Bcf from January through May 2012.

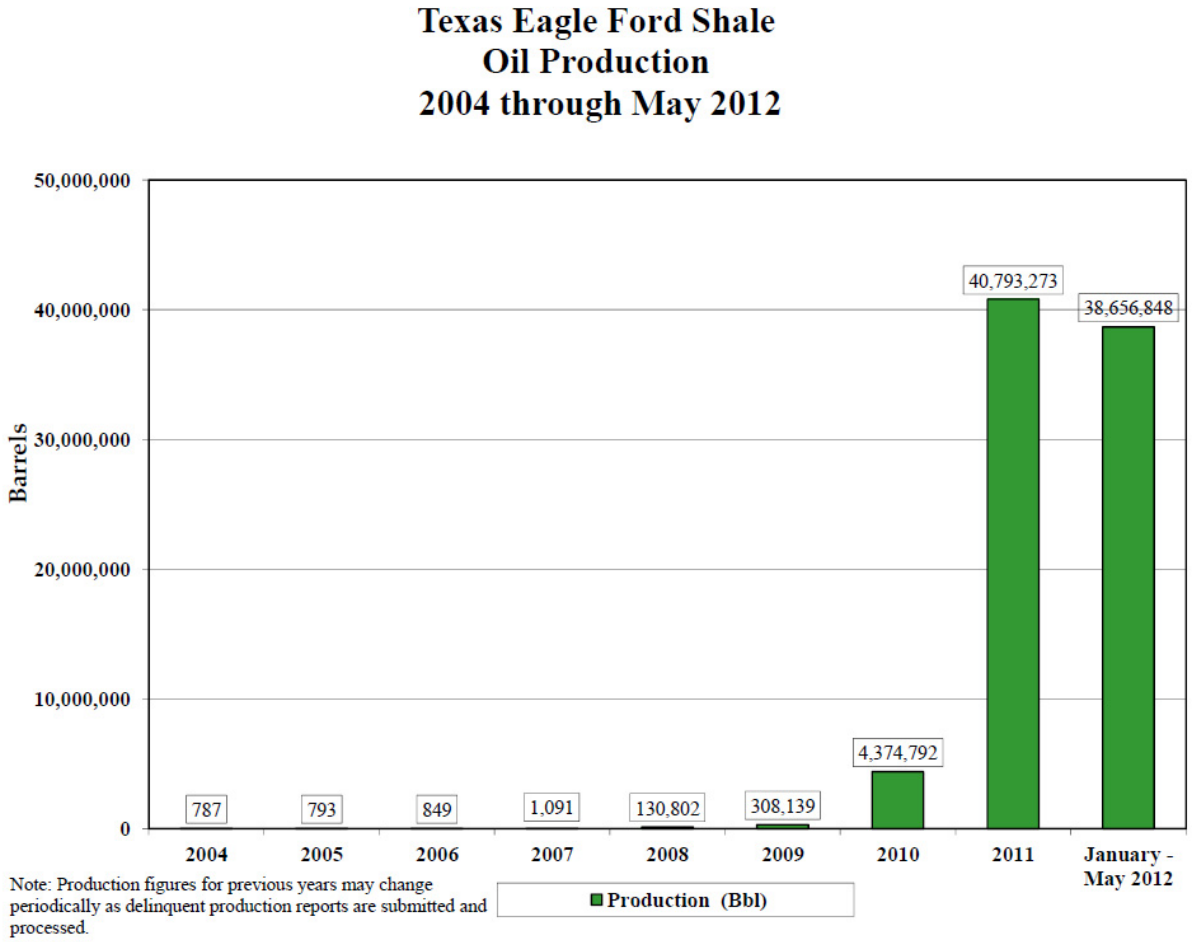


Figure 17. Recent Eagle Ford oil production in Texas. **From Railroad Commission of Texas (2012b).**

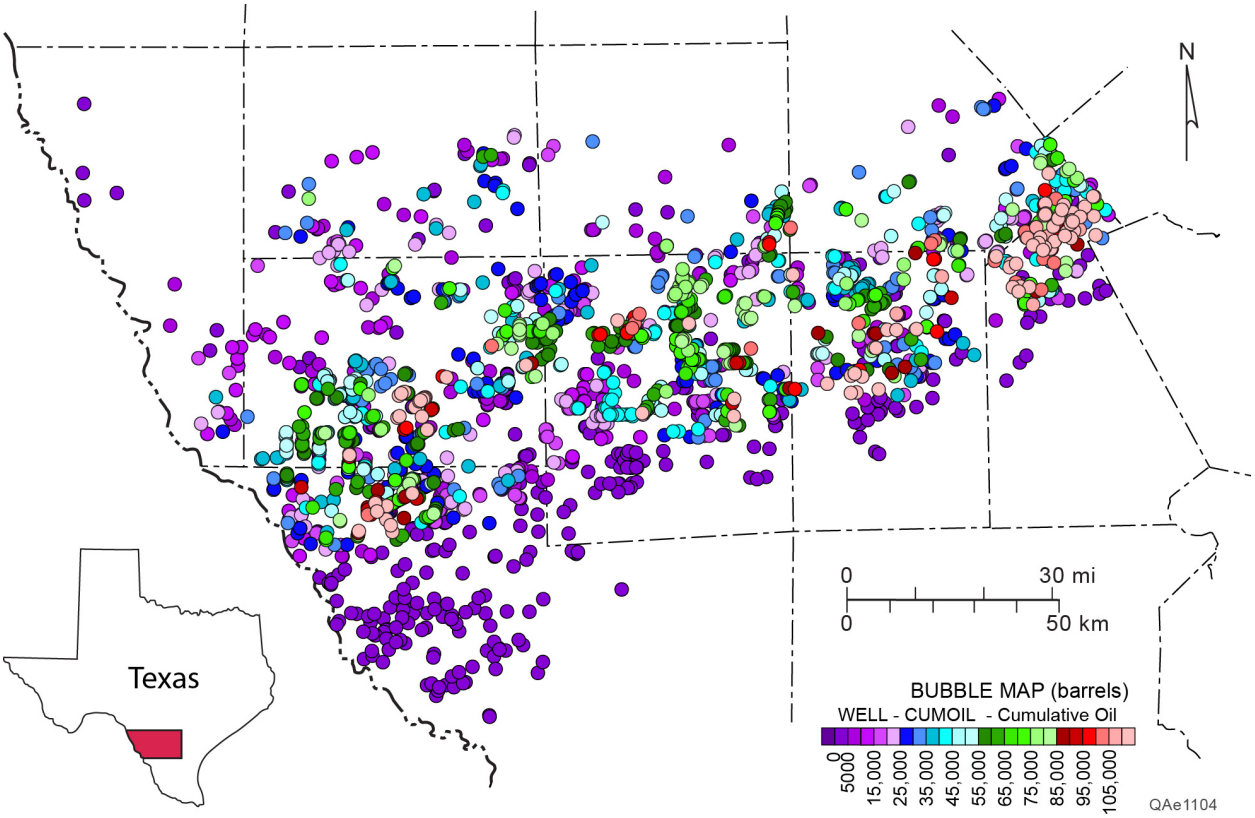


Figure 18. Distribution of oil production in Eagle Ford Shale in southwest Texas.

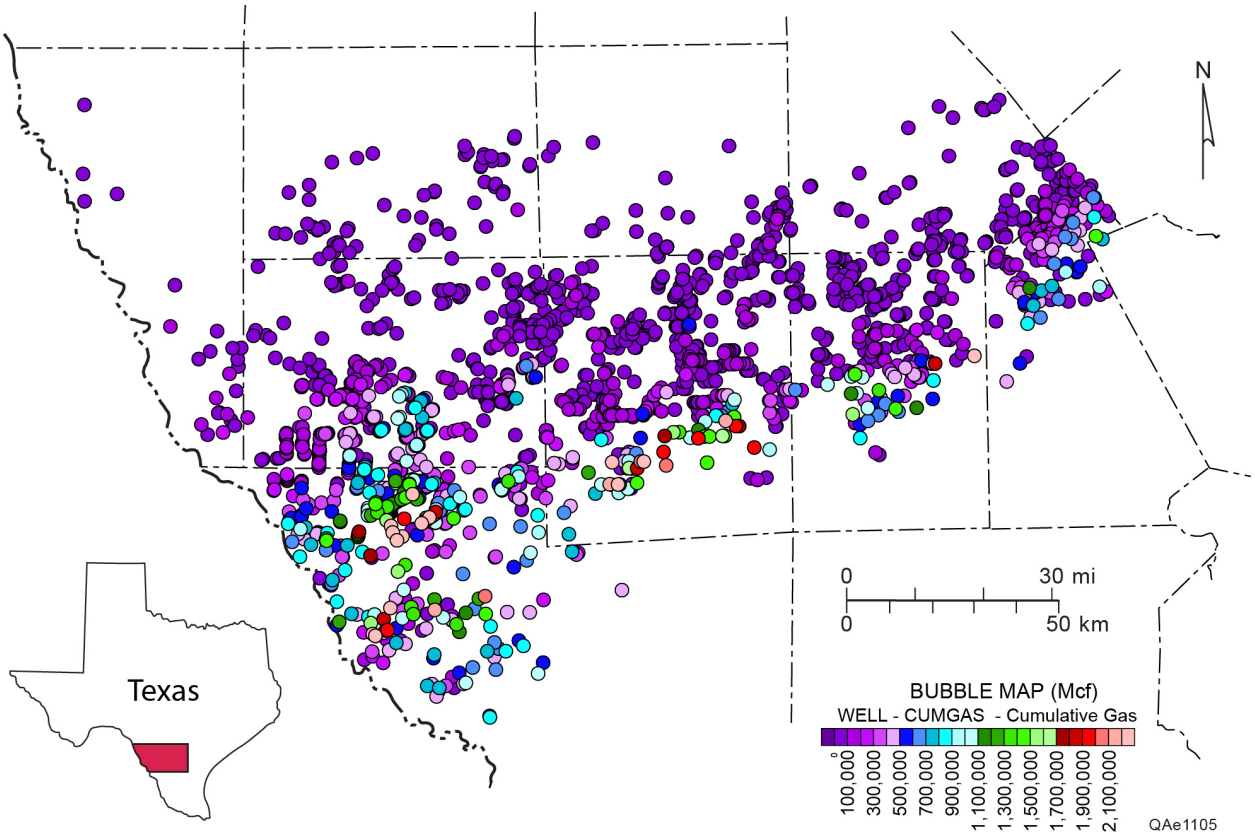


Figure 19. Distribution of gas production in Eagle Ford Shale in southwest Texas.

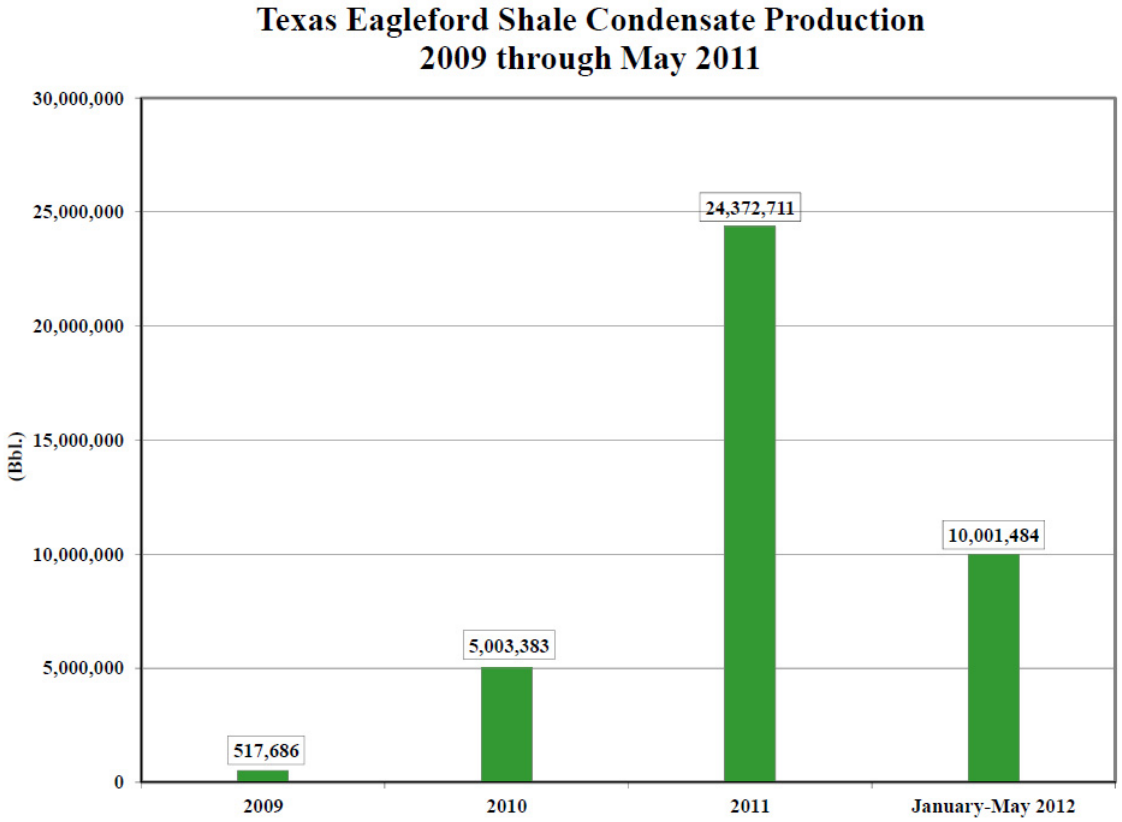


Figure 20. Recent Eagle Ford condensate production in Texas. **From Railroad Commission of Texas (2012c).**

The main objective of this STARR project was to provide a regional lithostratigraphic framework of the Eagle Ford Shale and adjacent units such as the Austin Chalk. This framework is an aid for explorationists, defining potential producing areas in the Eagle Ford Shale that are based on observations of its depth, thickness, and general lithologic character in the subsurface. The lower Eagle Ford interval, composed predominantly of dark-gray and relatively more-organic-rich mudrock, has a higher production potential than the less-organic-rich upper Eagle Ford interval. The upper Eagle Ford interval is characterized by overall lower gamma-ray values and consists of interbedded dark- and light-gray calcareous mudrock. The lower Eagle Ford interval extends continuously from the Maverick Basin/Rio Grande Embayment, across the San Marcos Arch, and to the northeast flank of the arch (**Fig. 21**). The cored lower Eagle Ford Shale from the Getty J. T. Wilson No. 1 well in northern La Salle County has an average TOC value of 2.8 weight percent, with a maximum of 6.8 weight percent **(Dawson, 2000**). Given the

consistently higher gamma-ray values, core analyses, and TOC analyses from outcrop samples, the lower Eagle Ford zone is most likely richer in organic content than the upper unit.

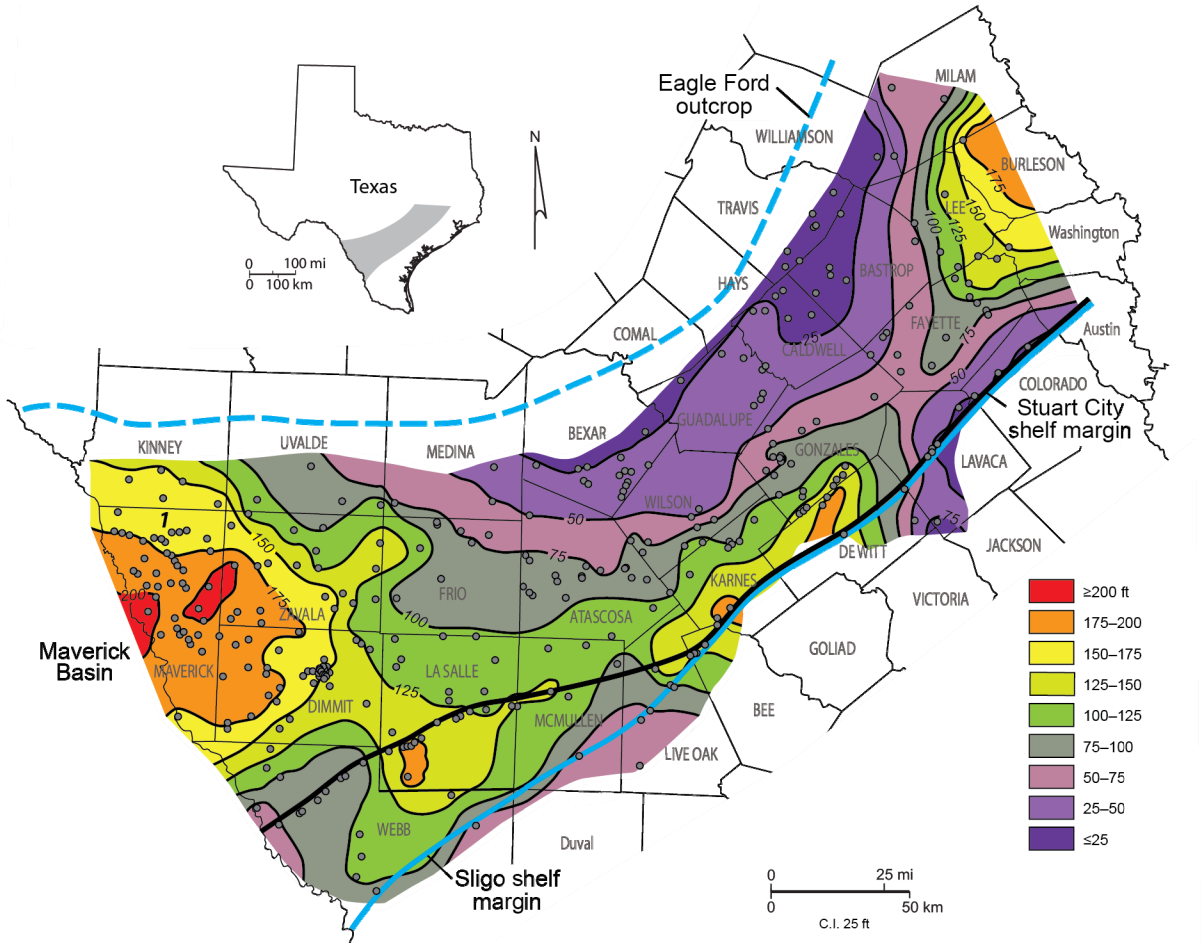


Figure 21. Net-thickness (isopach) of the lower Eagle Ford Shale in the southwest and central Texas Gulf Coast. Modified from **Hentz and Ruppel (2010).**

Haynesville Shale

The Upper Jurassic Haynesville shale-gas play in east Texas and west Louisiana has estimated recoverable reserves in the hundreds of trillions of cubic feet and high initial production rates, with each well expected to produce an average of 6.5 Bcf. The Haynesville Shale was deposited during a second-order transgression in which carbonates formed on the shelf and preexisting highs and organic-rich shales formed in the basin (**Hammes and Carr, 2009; Hammes and others, 2011; Hammes and Frébourg, 2012**) **(Figs. 22 and 23).** Lithology and facies in the Haynesville vary considerably **(Fig. 24).** They include siliceous mudstones that contain as much as 80 percent detrital quartz, clays, and skeletal carbonaceous mudstones that contain as much as 50 percent carbonates with an average total organic content (TOC) of up to 4 percent. TOC

content is partly diluted by increased clastic influx from the north, where silica-dominated lithologies are most abundant, and carbonate platforms in the west and south, where carbonate-dominated lithologies are more abundant. Considering variation in lithologies is important for fracture stimulation, production, and petrophysical interpretations because these parameters are affected by varying clay, pyrite, and organic content, potentially skewing porosity, TOC, and resistivity calculations into higher values.

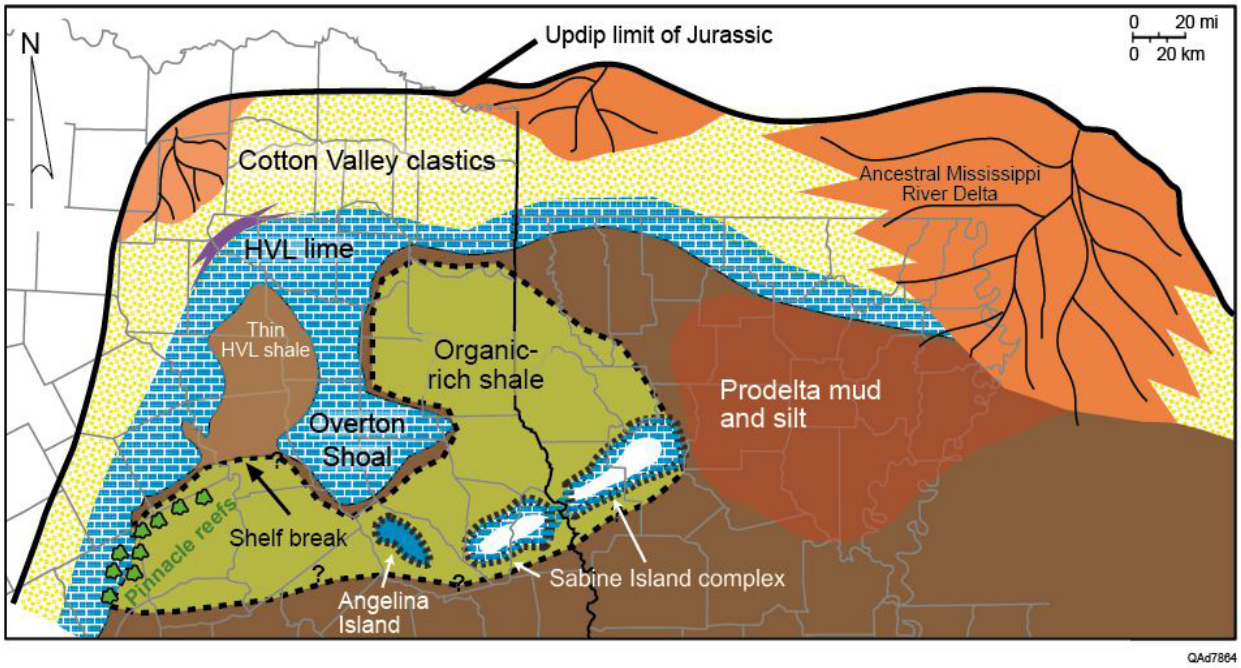


Figure 22. Haynesville paleogeography. High TOC values and productivity are associated with organic-rich shale facies in east Texas and west Louisiana. **From Hammes and others (2011).**

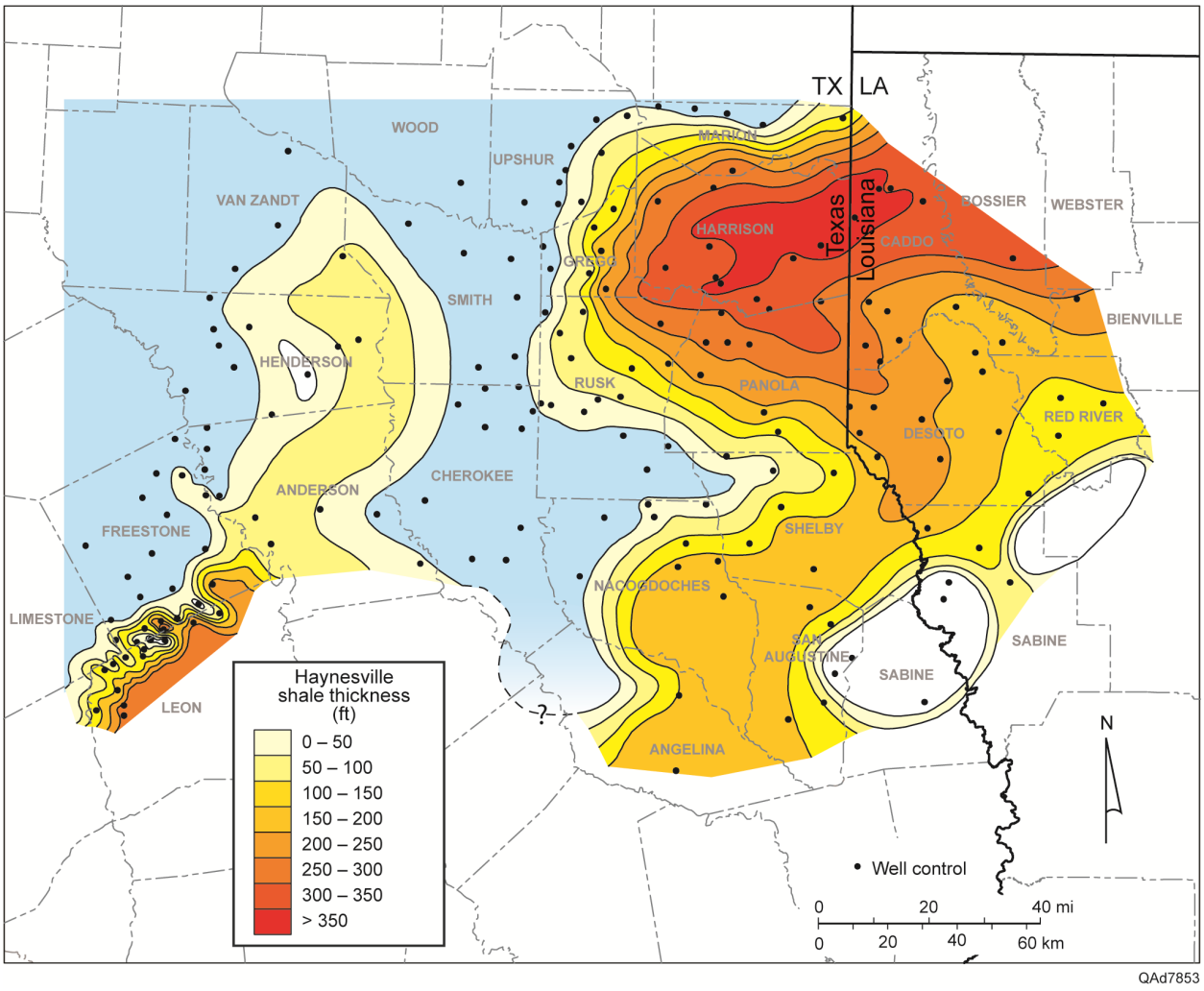


Figure 23. Thickness of the Haynesville Shale facies in east Texas and west Louisiana. **From Hammes and others (2011).**

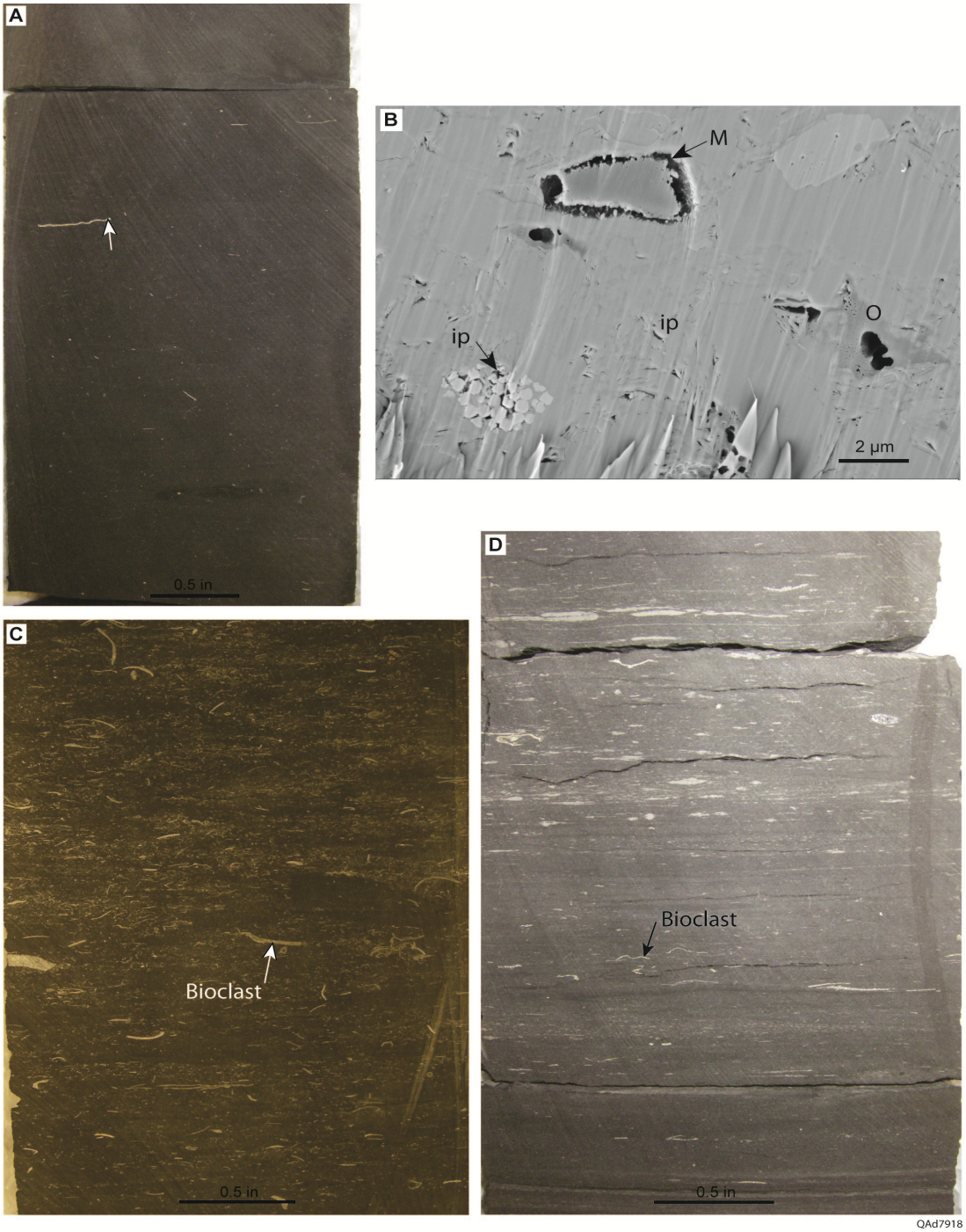


Figure 24. Haynesville core photographs, showing variations in rock type and nanopores in organics and interparticle pores. (A) Unlaminated siliceous mudstone, (B) SEM photomicrograph, (C) bioturbated calcareous mudstone, and (D) laminated calcareous mudstone. From **Hammes and Carr (2009).**

NEW PROGRAM ELEMENTS ADDED IN CURRENT BIENNIUM

Eight new program elements (in addition to the oil and gas program) were added to STARR in the biennium. which began September 1, 2011. Each of the eight initiatives targets research that impacts key economic opportunities or challenges in Texas. A summary of these programs and progress for the first 16 months of the biennium is presented here.

- Water Economics – This research targets water quantity and quality for improved decision-making. The long-term plan is to develop a framework to track water use and economic activity throughout the value chain. Initial work involved a critical examination of power-plant water usage, in collaboration with the Texas Water Development Board and technologists in the power plant sector (NRG, Luminant). We are working toward obtaining additional funding from power companies to leverage the State's investment. We are also assessing ways to predict drought severity and potential impacts to agriculture and municipal users by including an assessment of soil-moisture storage through mapping and satellite measurements. Results are being geared to on-the-ground decision-making by water managers, thus optimizing the water resources available to stakeholders.
- Water/Energy Nexus – This program element includes studies of water quantity and quality that relate to energy exploration (oil, coal) and conversion (refining, cooling, etc.) in Texas and that assess how possible water limitations could impact energy systems, including new energy resources that have become economic via hydraulic fracturing. We have utilized STARR funds as a match for a U.S. Department of Energy grant proposal on water usage. We plan to hire a hydrostratigrapher to pursue parts of this research.
- Energy Economics – This program examines costs and revenues of energy and carbon in Texas. It predicts future value added under varying price, cost, regulatory, and other market assumptions, from sources such as severance taxes, sales taxes, state tariffs, etc. on pipelines, export terminals, gas treatment plants, refinery expansions, clean coal projects, etc. In the current biennium, three new hires were made, and two key software packages (AURORAxmp for electric power modeling and REMI Policy Insight) were purchased and installed. We use these modeling packages to run our own independent scenarios, against which companies and agencies can compare their own assumptions on value added. A public workshop is planned in 2013 to convey results of this modeling.
- Environmental Economics – This program assesses economic impacts from natural resource reallocation or limitations stemming from possible listing of endangered species and identification of invasive species in Texas. In the current biennium, the team examined the potential impacts of listing fresh-water mussel species in numerous Texas rivers. We collaborated with specialists at Texas A&M University and will continue to do so in 2013.
- Geothermal – This program investigates potential in Texas for electric power generation from steam or hot water produced from subsurface reservoirs. Geothermal energy would

provide base-load additions to the Texas power grid, rather than fluctuating additions that accrue from wind- and solar-power generation. We collaborate extensively with researchers in the well-known geothermal research program at Southern Methodist University, and we leverage the STARR investment extensively with funds from the U.S. Department of Energy (DOE). Texas benefits from having subsurface temperature data available for the one-million-plus oil and gas wells in the state. From these wells, we have mapped temperature and heat-flow anomalies in several areas of the state, enabling the private sector to target these areas for possible commercial development. Recent improvements in heat-exchange technologies mean that moderately hot reservoirs that previously were subeconomic may now be candidates for commercial power generation. We are actively working with several companies interested in such ventures, including Sologen Geothermal at the Pleasant Bayou site in the Galveston Bay area.

- Hazards Mapping and Response – This program assesses potential for geological hazards (such as sinkholes, landslides, and flooding) associated with geological instability. Findings will be compiled into an atlas that can be used by government agencies, industry, and other stakeholders. In the current biennium, a world-class airborne lidar (light detection and ranging) system was obtained with federal funding approved by the General Land Office. This system provides extremely rapid and accurate terrain mapping, water-depth mapping up to several meters in depth, and vegetation classification and mapping. Planning is under way to establish a rapid response team with extensive imaging and mapping capabilities. Planned studies for the Guadalupe Delta and Copano Bay (two areas vulnerable to hurricane impacts under conditions of rising sea level) will enable us to gain a better understanding of, and map physical changes from, past storm events. We have applied for federal funds and have used STARR funds as a cost share in our proposal. Armed with the knowledge from this study, including future lidar imagery, we can more accurately predict future storm impacts. Some STARR funds were also used to support a postdoctoral fellow conducting research on the Wink Sink collapse features in west Texas, where possible future collapses are a concern.
- Coastal/Wetlands Ecosystems of Texas – This program conducts wetland trend assessments in coastal areas of Texas and assesses ecosystem services and their role in mitigation of damages from storm events. A temporary hire was made to launch this research, and a proposal was made for additional funds from federal sources. We purchased a spectro-radiometer that enables us to ground-truth our airborne lidar interpretations, particularly with respect to mapping of vegetation types in the vast coastal belt. An extensive written report on coastal wetland status and trends, to appear as a Bureau of Economic Geology Report of Investigations, is in preparation and is scheduled to be published in 2013.
- Mapping and Mineral Resources – This program involves mapping of the surface geological formations of Texas and assessment of the presence of industrial rocks and minerals used by Texas industries and society. End products are publications, hard-copy

maps, and Geographic Information System (GIS) data sets that can be usefully combined with other map coverage. These activities enable development of an economic minerals program in Texas that would promote collaboration with private industry partners, as is currently done in oil and gas. The STARR funds extend and enhance funds received from the U.S. Geological Survey's STATEMAP program, from which we were awarded $123,000 in 2012, an increase of 80 percent over 2011. The increase was made possible by the cost share committed from STARR funds in our STATEMAP proposal. With new STARR and STATEMAP funds, we have expanded our general mapping program, which produces detailed geological maps of areas undergoing rapid economic development (such as the I-35 corridor). Funds have enabled the hiring of a minerals geologist who will conduct research on future frac-sand resources and on nonenergy mineral resources. This is the first time in several decades that Texas has had a professional dedicated to this value-added research.

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APPENDIX A

2010–2012 Letters of Cooperation

The following are letters from partner companies with whom the STARR program has collaborated over the last several years. The letters support the strong interaction between STARR and industry.

Neumin Production Company
Point Comfort, TX

Dr. William Ambrose
Project Director
STARR Project
Bureau of Economic Geology
Jackson School of Earth Sciences
The University of Texas at Austin
P. O. Box X, UT Station
Austin, Texas 78713

October 30, 2012

Dear Dr. Ambrose:

I would like to acknowledge the contributions made to our oil and gas exploration programs in the Lavaca Bay Field by research carried out and published by the State of Texas Advanced Resource Recovery project (STARR) at the Texas Bureau of Economic Geology. The published research by the Bureau has contributed to our discovery of Gas/Condensate in State Tract 39, Calhoun County, Texas. We hope that the STARR program will continue to receive funding from the State of Texas. We and other independent companies do not have the benefit of major geologic research programs and therefore, results of the Bureau's research on various methods of exploration has been very helpful in our efforts to discover new reserves in Texas.

The Bureau's studies, publications and presentations have provided an education and insight to many recent advances in petroleum exploration that has been successfully applied to our areas of interest. The recently drilled 3905 well is an example and an additional well will be drilled in the near future. This demonstrates the STARR program's ability to turn academic studies into economic success.

Respectfully,

R. Dean Johnstone
Geoscientist
Neumin Production

PIONEER
NATURAL RESOURCES

Pioneer Natural Resources USA, Inc.
5205 N. O' Connor Blvd., Suite 200
Irving, Texas 75039-3746
Tel: (972) 444-9001 Fax: (972) 969-3587

William Ambrose
Director STARR Project
Bureau of Economic Geology
Jackson School of Earth Sciences
The University of Texas at Austin
University Station, Box X
Austin, Texas 78713

Dear Mr. Ambrose:

I am a geologist with Pioneer Natural Resources USA, Inc., located in Irving, Texas. From 2009 to 2011, Pioneer collaborated with the Bureau of Economic Geology (BEG) on core-based research as part of the State of Texas Advanced Resource Recovery project (STARR). I would like to acknowledge the contributions made to Pioneer's own research program in the Spraberry and Wolfberry plays by this STARR partnership.

BEG's Core Research Center, with its collection of legacy well samples, is a valuable asset for petroleum reservoir characterization studies in Texas. For this partnership, geologists and engineers from Pioneer and BEG got together to study cores and take samples for laboratory testing. The results of this collaboration helped Pioneer to achieve a better understanding of Spraberry/Wolfberry geology and to reduce geologic uncertainty in their development program.

Sincerely,

Kit Clemons
Geologist
Pioneer Natural Resources
Irving, TX 75039
972-969-5744

Dr. William Ambrose
Project Director
STARR Project
Bureau of Economic Geology
Jackson School of Earth Sciences
The University of Texas at Austin
P.O. Box X, UT Station
Austin, Texas 78713

October 30, 2012

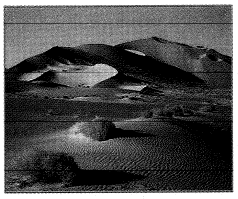
Dear Dr. Ambrose:

I would like to acknowledge the contributions made to our drilling program in the Austin Chalk as a result of the research performed by the STARR Project on the Austin Chalk and Eagle Ford using our donated 3D seismic data in Dimmit and Zavala County, Texas. The various inversion volumes created by your group show that it is possible to identify untapped economic reserves in the Austin Chalk away from existing well control. The positive results from our recent horizontal drilling in the Austin Chalk generally confirm that the seismic inversion is an effective tool in identifying the best areas for drilling the fractured Austin Chalk. We plan to continue applying the methods outlined in your research to new 3D seismic surveys to identify new drilling locations in the future.

As you know, small independent companies like CML, rather than the majors, do the vast majority of the onshore drilling in Texas. Unlike major oil companies, smaller companies do not have the resources to conduct extensive research projects to help become more efficient oil finders. The STARR program fills that void for CML and other companies like ours and we hope that the STARR program will continue to be funded by the State of Texas.

Sincerely,

Philip Buch
Exploration Manager
CML Exploration, LLC



Vision Gas Resources, L.L.C.

520 Post Oak Blvd.
Suite 200
Houston, Texas 77027

Tel: (713) 861-7187
Fax: (713) 861-7201

October 30, 2012

Dr. William Ambrose
Project Director
STARR Project
Bureau of Economic Geology
Jackson School of Earth Sciences
The University of Texas at Austin
P. O. Box X, UT Station
Austin, Texas 78713

Dear Mr. Ambrose:

I would like to acknowledge the contributions made to our oil and gas exploration program at Vision Gas LLC in the Woodbine Sandstone in Polk and Tyler counties, Texas by research carried out and presented at the GCAGS Meeting in Austin this month by the State of Texas Advanced Resource Recovery project (STARR) at the Texas Bureau of Economic Geology. The core descriptions and interpretations you provided in the Double A Wells Field were especially useful to us in our ongoing exploration and production activities.

We hope that the STARR program will continue to receive funding from the State of Texas. We and other independent companies do not have the benefit of major geologic research programs and therefore, results of the Bureau's research on various methods of exploration has been very helpful in our efforts to discover new reserves in Texas.

Respectfully,

Art

Arthur E. Berman
Geosciences Manager
Vision Gas Resources, LLC

STALKER ENERGY, L.P.

Mr. William Ambrose
Project Director
STARR Project
Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin
P. O. Box X, UT Station
Austin, Texas 78713-8924

November 15, 2012

Dear Mr. Ambrose:

I would like to acknowledge the contributions made to our oil and gas exploration programs in the Bend Arch - Fort Worth Basin by research carried out and published by the State of Texas Advanced Resource Recovery project (STARR) at the Bureau of Economic Geology. The research conducted by the Bureau has contributed significantly to our exploration efforts in several counties in the Bend Arch petroleum province. We hope that the STARR program will continue to receive funding from the State of Texas. Stalker Energy L.P. (Stalker), as well as many other smaller independent companies do not have the benefit of major geologic research programs and therefore, results of the Bureau's scientific research has been very helpful in our efforts to pursue and discover new reserves in Texas. This type of specific scientific assistance would otherwise be unavailable to small E&P companies which contribute significantly to the overall hydrocarbon production in the State of Texas.

The Bureau's studies, publications and presentations have provided an education and insight to many recent advances in petroleum exploration and development. These concepts and techniques are currently being applied in our areas of interest. This demonstrates the STARR program's ability to turn academic studies into economic success. Stalker is grateful for the STARR program and hopes it will continue to receive funding from the State of Texas.

Respectfully,

A. Dax McDavid
Geologist
Stalker Energy L.P.

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Austin Texas, 78703

BASA Resources Inc.
14875 Landmark, Suite 400
Dallas, Texas 75254
214-559-4200

Dr. William Ambrose
Project Director
STARR Project
Bureau of Economic Geology
Jackson School of Earth Sciences
The University of Texas at Austin
P. O. Box X, UT Station
Austin, Texas 78713

November 7, 2012

Dear Dr. Ambrose:

I would like to acknowledge the contributions made to our oil and gas exploration programs in the Eliasville Field by research carried out and published by the State of Texas Advanced Resource Recovery project (STARR) at the Texas Bureau of Economic Geology. The core and seismic research by the Bureau has contributed to our understanding of oil in Stephens County, Texas. We hope that the STARR program will continue to receive funding from the State of Texas. We and other independent companies do not have the benefit of major geologic research programs and therefore, results of the Bureau's research on various methods of exploitation and exploration has been very helpful in our efforts to discover additional reserves in Texas.

The Bureau's studies, publications and presentations have provided an education and insight to many recent advances in petroleum exploration that has been successfully applied to our areas of interest. The STARR program continues to help companies like BASA Resources turn academic studies into economic success.

Respectfully,

Jim Barton
Vice President of Geosciences
BASA Resources, Inc.

APPENDIX B

Project STARR Awards

STARR Program, Outstanding Research Award, Jackson School of Geosciences, The University of Texas at Austin, December 2010.

Grover E. Murray Award for Third-Place Paper published in GCAGS Transactions, Loucks, R. G., et al., titled: Preliminary Classification of Matrix Pores in Mudrocks, 2010.

Third Place, Gordon I. Atwater Best Poster Award, Hentz, T. F., and Ruppel, S. C.., titled: Regional Lithostratigraphy of the Eagle Ford Shale, 2010.

A. I. Levorsen Award for Best Paper presented at Gulf Coast Section, GCSSEPM/GCAGS Annual Meeting, Loucks, R. G., et al., titled: Preliminary Classification of Matrix Pores in Mudrocks, 2010.

Bureau of Economic Geology Publication Award for the following publication: Ambrose, W. A., ed., 2011, Sequence stratigraphy, depositional systems, and hydrocarbon play analysis of the Pennsylvanian Cleveland Formation and Marmaton Group, Anadarko Basin, North Texas and western Oklahoma: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 275, 98 p.

AAPG President's Certificate for Excellence in Presentation (Oral Presentations,): Loucks, R. G., Ruppel, S. C, Reed, R. M., and Hammes, U. for presentation titled: Spectrum of pore types in siliceous mudstones in shale-gas systems, 2011.

Top Ten Poster Presentation, AAPG Annual Convention, Long Beach, California, Loucks, R. G., et al., titled: Origin and Distribution of Microrhombic Calcite and Associated Micropores in the Lower Cretaceous Stuart City Tight-Gas-Carbonate Play in South Texas, 2012.

APPENDIX C

One of the major goals of Project STARR is to disseminate results and new concepts developed by the program. During the last reporting biennium (2010–2012), STARR researchers generated a wide variety of articles, abstracts, reports, and lectures, as well as one book.

Articles

William A. Ambrose

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Julia Gale

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Ursula Hammes

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Tucker F. Hentz

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Robert G. Loucks

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Osareni Ogiesoba

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Robert M. Reed

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Stephen C. Ruppel

Over, D. J., and Ruppel, S. C., 2011, Woodford conodonts and biostratigraphy (Upper Devonian–Carboniferous) in the subsurface of eastern New Mexico and Texas: Stratigraphy, v. 8, no. 4, p. 271–279.

Laura Zahm

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Abstracts

William A. Ambrose

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Robert W. Baumgardner, Jr.

McCreight, K., Rowe, H., Baumgardner, R. W., Jr., and Hamlin, H. S., 2012, Chemostratigraphy, mineralogy, and depositional environment of the Wolfcamp Formation, Midland Basin, Reagan County, Texas (abs.): American Association of Petroleum Geologists, Annual Convention, Abstract 1236324, 1 p.

Caroline L. Breton

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Bruce L. Cutright

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Edmond Locke Frost III

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Qilong Fu

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Ursula Hammes

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Sequence stratigraphy, depositional setting, and play attributes of the Pennsylvanian Marmaton sandstones, northwestern Anadarko Basin: presented to Devon Energy Corporation, Austin, Texas, February 1, 2011.

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Robert G. Loucks

Paragenesis of Lower Ordovician Ellenburger Group paleokarst breccias and fractures in Central and West Texas: invited talk presented at Permian Basin Section-SEPM Core Workshop: Central Texas Ellenburger, Midland, Texas, April 17, 2012.

Pore types and pore networks in mudstones in shale-gas systems: presented at Unconventional Gas Technical Forum, Ministry of Energy and Mines, Victoria, British Columbia, April 5, 2011.

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Seay Nance

Bone Spring Formation deep-water successions of the Delaware Basin, Texas and New Mexico: facies, rock-body geometries, depositional model, and developing investigations of mudrock: presented at BEG Symposium, Austin, Texas, October 2011.

(Wolfcampian/Leonardian) Bone Spring slope and basin-floor mudrock facies, Delaware Basin: presented at the West Texas Geological Society Fall Meeting, Midland, Texas, September 2011.

Lateral facies architecture and the role of antecedent topography on carbonate facies geometries in incipient icehouse climatic conditions Carboniferous/Lower Pennsylvanian (Baskirian/Morrowan): Hueco Mountains, Texas: poster presented at AAPG Annual Meeting, Houston, Texas, April 2011.

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Eric C. Potter

The basics of shale and tight-formation oil and gas plays, and how they are evolving over time: presented at the TCEQ Environmental Trade Fair & Conference, Austin, Texas, May 2, 2012.

Introduction: presented at STARR/PTTC Workshop: Sequence Stratigraphy, Depositional Systems, and Production Trends in the Atoka Series and Mid-Pennsylvanian Cleveland and Marmaton Formations, Western Anadarko Basin, Dallas, Texas, November 10, 2010.

Robert M. Reed

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Stephen C. Ruppel

Mudrocks: depositional processes, environments, and facies: presented at Unconventional Workshop sponsored by UT AAPG Student Chapter, Houston, Texas, April 10–13, 2011.

Fred P. Wang

Pressure, petrophysical properties and production of Haynesville-Bossier Shale in East Texas and North Louisiana Basin: presented at the PTTC Workshop on Haynesville Shale, Austin, Texas, June 16–17 2011.

Overview of development of organic-rich shales in North America: presented the Geochemical Research Institute of Chinese Academy of Science in Guangzho, Guangzho, China, August 12, 2011.

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William A. Ambrose

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APPENDIX D

Workshops and Guidebook Chapters

Ursula Hammes

Sedimentology, sequence stratigraphy, and geochemistry of Upper Permian (Zechstein) organic-rich mudrocks (Part II): core workshop presented at Landesanstalt für Bergbau, Geologie und Rohstoffe (LBGR) Brandenburg Bohrkern und Probenarchiv, Berlin, Germany, May 31, 2012.

Haynesville/Bossier core workshop: presented at Bureau of Economic Geology, Austin, Texas, June 22, 2011.

Sedimentology, sequence stratigraphy, geochemistry, and petrophysics of Upper Jurassic mudrocks in East Texas and North Louisiana (Part I): shale-gas workshop presented at University of Potsdam, December 16, 2011, Universität Potsdam, Potsdam, Germany, December 16, 2011.

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Robert G. Loucks

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Loucks, R. G., 2011, September Deep Shelf Gas Review, DSG Semiannual Meeting, Austin: The University of Texas at Austin, Bureau of Economic Geology.

Eric C. Potter

Woodruff, C. M., Jr., Collins, E. W., Potter, E. C., and Loucks, R. G., 2012, Canyon Dam Gorge and Natural Bridge Caverns: Guidebook for the Association of American State Geologists 104th Annual Meeting, Lakeway, Texas: The University of Texas at Austin, Bureau of Economic Society 29 p.

Robert M. Reed

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Stephen C. Ruppel

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