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Disclaimer

Abstract

The principal research effort for the first half of Year 3 of the project has been resource assessment. Emphasis has been on estimating the total volume of hydrocarbons generated and the potential amount of this resource that is classified as deep (>15,000 ft) gas in the North Louisiana Salt Basin, the Mississippi Interior Salt Basin, the Manila Subbasin and the Conecuh Subbasin. The amount of this resource that has been expelled, migrated and entrapped is also the focus of the first half of Year 3 of this study.

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Introduction

The University of Alabama and Louisiana State University have undertaken a cooperative 3-year, advanced subsurface methodology resource assessment project, involving petroleum system identification, characterization and modeling, to facilitate exploration for a potential major source of natural gas that is deeply buried (below 15,000 ft) in the onshore interior salt basins of the North Central and Northeastern Gulf of Mexico areas. The project is designed to assist in the formulation of advanced exploration strategies for finding and maximizing the recovery from deep natural gas domestic resources at reduced costs and risks and with minimum impact.

The results of the project should serve to enhance exploration efforts by domestic companies in their search for new petroleum resources; especially those deeply buried (below 15,000 ft) natural gas resources, and should support the domestic industry's endeavor to provide an increase in reliable and affordable supplies of fossil fuels.

Executive Summary

The principal research effort for the first half of Year 3 of the project has been resource assessment. Emphasis has been on estimating the total volume of hydrocarbons generated and the potential amount of this resource that is classified as deep (>15,000 ft) gas in the North Louisiana Salt Basin, the Mississippi Interior Salt Basin, the Manila Subbasin and the Conecuh Subbasin. The amount of this resource that has been expelled, migrated and entrapped is also the focus of the first half of Year 3 of this study.

The estimate of the total volume of hydrocarbons generated and expelled for the North Louisiana Salt Basin in this study (2870 billion barrels generated and 2170 billion barrels expelled) using a petroleum system approach is comparable to Zimmerman's (1999) estimate of the total volume of hydrocarbons generated/expelled (2472 billion barrels) for this basin. The estimate of the total volume of hydrocarbons generated and expelled for the Mississippi Interior Salt Basin in this study (910 billion barrels generated and 700 billion barrels expelled) is consistent with the findings of Mancini et al. (2003) for the petroleum system in this basin. In this study, the total volume of hydrocarbons generated for the Manila Subbasin is estimated to be 25 billion barrels, and the total volume of hydrocarbons generated for the Conecuh Subbasin is estimated to be 98 billion barrels.

Project Objectives

The objectives of the study are: to perform resource assessment of the in-place deep (>15,000 ft) natural gas resource of the onshore interior salt basins of the North Central and Northeastern Gulf of Mexico areas through petroleum system identification, characterization and modeling and to use the petroleum system based resource assessment to estimate the volume of the in-place deep gas resource that is potentially recoverable and to identify those areas in the interior salt basins with high potential to recover commercial quantities of the deep gas resource.

The project objectives will be achieved through a 3-year effort. First, emphasis is on petroleum system identification and characterization in the North Louisiana Salt Basin, the Mississippi Interior Salt Basin, the Manila Subbasin and the Conecuh Subbasin of Louisiana, Mississippi, Alabama and Florida panhandle. This task includes identification of the petroleum systems in these basins and the characterization of the overburden, source, reservoir and seal rocks of the petroleum systems and of the associated petroleum traps. Second, emphasis is on petroleum system modeling. This task includes the assessment of the timing of deep (>15,000 ft) gas generation, expulsion, migration, entrapment and alteration (thermal cracking of oil to gas). Third, emphasis is on resource assessment. This task includes the volumetric calculation of the total in-place hydrocarbon resource generated, the determination of the volume of the generated hydrocarbon resource that is classified as deep (>15,000 ft) gas, the estimation of the volume of deep gas that was expelled, migrated and entrapped, and the calculation of the potential volume of gas in deeply buried (>15,000 ft) reservoirs resulting from the process of thermal cracking of liquid hydrocarbons and their transformation to gas in the reservoir. Fourth, emphasis is on identifying those areas in the onshore interior salt basins with high potential to recover commercial quantities of the deep gas resource.

Experimental

Work Accomplished (Table 1)

In-Place Resource Assessment**—**Work has been completed on estimating the total volume of hydrocarbons generated in the North Louisiana Salt Basin, the Mississippi Interior Salt Basin, the Manila Subbasin and the Conecuh Subbasin. Work on the potential amount of this resource that is classified as deep (>15,000 ft) gas in these basins and subbasins continues. This assessment involves estimating the amount of the gas resource that is generated directly from the source rock (primary gas) and the amount that is the result of cracking oil to gas (secondary gas). Additional core rock samples were collected and analyzed to assist in this evaluation (Tables 2 and 3). The method of Schmoker (1994) and the use of petroleum system software applications (Platte River) were used in the estimation of the total volume of hydrocarbons generated and expelled in the interior salt basins. Listed below are the results of these determinations.

1. North Louisiana Salt Basin (by LSU, Roger Barnaby)

Total mass Smackover = (2.66×10^{13} m^3 volume Smackover) × (2.5 g/cm^3 average density) × (1×10^6 cm^3/m^3) = 6.65×10^{19} g

At 1% TOC, total mass of organic carbon = 0.01 × (6.65×10^{19} g) = 6.65×10^{17} g

Smackover original hydrocarbon index (HI_0) = 300 to 650 mg HC/g TOC
immature lower Smackover reported by Sassen and Moore (1998)

Smackover present-day hydrocarbon index (HI_p) = 6 to 58 mg HC/g TOC
average HI_p = 34 mg HC/g TOC; data from this study

Total mass of hydrocarbons generated per unit mass of organic carbon = ($HI_0 - HI_p$) = (650 – 34) = 616 mg HC/g TOC

Total mass of hydrocarbons generated = 616 mg HC/g TOC × (6.65×10^{17} g TOC) × (10^{-6} kg/mg) = 4.1×10^{14} kg

Converted to barrels of 25° API oil = (4.1×10^{14} kg × 7 bbls/1000 kg) = 2870×10^9 barrels

2. Mississipi Interior Salt Basin (by UA, Peng Li)

Area of the basin: 5.18×10^{10} m^2

Average thickness of lower Smackover: 115.65 m

Total mass of lower Smackover = (5.99×10^{12} m^3 volume Smackover) × (2.5 g/cm^3 average density) × (1×10^6 cm^3/m^3) = 1.50×10^{19} g

At 1.5% TOC, total mass of organic carbon = 0.015 × (1.50×10^{19} g) = 2.25×10^{17} g

Smackover original hydrocarbon index (HI_0) = 300-650 mg HC/g TOC
immature lower Smackover reported by Sassen and Moore (1998)

Smackover present-day hydrocarbon index (HI_p) = 4 to 137 mg HC/g TOC
average HI_p = 51 mg HC/g TOC reported by Mancini et al. (2003)

Total mass of hydrocarbons generated per unit mass of organic carbon = ($HI_0 – HI_p$) = (650 – 51) = 599 mg HC/g TOC

Total mass of hydrocarbons generated = 599 mg HC/g TOC × (2.25 × 10^{17} g TOC) × (10^{-6} kg/mg) = 1.3 × 10^{14} kg

Converted to barrels of 25° API oil = (1.3 × 10^{14} kg × 7 bbls/1000 kg) = 910 × 10^9 barrels

3. Manila Subbasin (by UA, Peng Li)

Area of the basin: 4.95 × 10^9 m^2.

Average thickness of lower Smackover: 66.72 m.

Total mass of lower Smackover = (3.30 × 10^{11} m^3 volume Smackover) × (2.5 g/cm^3 average density) × (1 × 10^6 cm^3/m^3) = 8.25 × 10^{17} g

At 2% TOC, total mass of organic carbon = 0.02 × (8.25 × 10^{17} g) = 1.65 × 10^{16} g

Smackover original hydrocarbon index (HI_0) = 300-650 mg HC/g TOC
immature lower Smackover reported by Sassen and Moore (1998)

Smackover present-day hydrocarbon index (HI_p) = 40 to 230 mg HC/g TOC
average HI_p = 87 mg HC/g TOC reported by Wade et al. (1987) and Claypool and Mancini (1989)

Smackover original hydrocarbon index (HI_0) = 300-650 mg HC/g TOC
immature lower Smackover reported by Sassen and Moore (1998)

Total mass of hydrocarbons generated per unit mass of organic carbon = ($HI_0 – HI_p$) = (300 – 87) = 213 mg HC/g TOC
minimum HI_0 value is used because terrestrially derived kerogen is present in the lower Smackover of the Manila Subbasin

Total mass of hydrocarbons generated = 213 mg HC/g TOC × (1.65 × 10^{16} g TOC) × (10^{-6} kg/mg) = 3.5 × 10^{12} kg

Converted to barrels of 25° API oil = (3.5 × 10^{12} kg × 7 bbls/1000 kg) = 25 × 10^{9} barrels

4. Conecuh Subbasin (by UA, Peng Li)

Area of the basin: 1.30 × 10^{10} m^2.

Average thickness of lower Smackover: 45.53 m.

Total mass of lower Smackover = (5.92× 10^{11} m^3 volume Smackover) × (2.5 g/cm^3 average density) × (1 × 10^{6} cm^3/m^3) = 1.48 × 10^{18} g

At 1.5% TOC, total mass of organic carbon = 0.015 × (1.48 × 10^{18} g) = 2.22 × 10^{16} g

Smackover original hydrocarbon index (HI_0) = 300-650 mg HC/g TOC
immature lower Smackover reported by Sassen and Moore (1998)

Smackover present-day hydrocarbon index (HI_p) = 3 to 114 mg HC/g TOC
average HI_p = 35 mg HC/g TOC reported by Claypool and Mancini (1989)

Total mass of hydrocarbons generated per unit mass of organic carbon = $(HI_0 – HI_p)$ = (650 – 35) = 615 mg HC/g TOC

Total mass of hydrocarbons generated:
= 615 mg HC/g TOC × (2.22 × 10^{16} g TOC) × (10^{-6} kg/mg) = 1.4 × 10^{13} kg

Converted to barrels of 25° API oil = (1.4 × 10^{13} kg × 7 bbls/1000 kg) = 98 × 10^9 barrels

Using petroleum system software the total mass of hydrocarbons expelled in the interior salt basins are as follows.

1. North Louisiana Salt Basin (by LSU, Roger Barnaby)
   3.1 × 10^{14} kg
   2170 billion barrels
2. Mississippi Interior Salt Basin (by UA, Peng Li)
   1.0 × 10^{14} kg
   700 billion barrels

Potentially Recoverable Deep Gas Volume— Work has been initiated on estimating the generated total resource and the deep gas resource in the North Louisiana Salt Basin, Mississippi Interior Salt Basin, Manila Subbasin and Conecuh Subbasin. A problem was identified with the software the UA was using in making these determinations. A new version of the software application has been acquired to complete this task. State oil and gas production data have been up dated and classified according to basin/subbasin and by reservoir (Tables 4-7). These data have been used to calculate gas to oil ratios (GOR). The GOR data is important in assessing the deep gas potential of these basins and subbasins.

Work Planned (Table 1)

***Potentially Recoverable Deep Gas Volume*—**The estimate of the volume of the generated total hydrocarbon resource and of the deep gas resource in the onshore interior salt basins and subbasins that was expelled, migrated and entrapped will continue.

***Oil Converted to Gas Assessment*—**The potential volume of gas in deeply buried reservoirs as a result of the thermal cracking of entrapped liquid hydrocarbons being converted in the reservoirs will be calculated.

***Identification of Deep Gas Resources*—**The areas in the onshore interior salt basins and subbasins with high potential for the recovery of commercial quantities of the deep gas resource will be identified.

Results and Discussion

The estimate of the total volume of hydrocarbons generated/expelled for the North Louisiana Salt Basin in this study using a petroleum system approach compares favorably with the total volume of hydrocarbons generated/expelled published by Zimmermann (1999). The estimate in this study is 2870 billion barrels generated using the method of Schmoker (1994) and is 2170 billion barrels expelled using the Platte River software application, and the estimate of Zimmermann (1999) is 2472 billion barrels generated/expelled.

The estimate of the total volume of hydrocarbons generated and expelled for the Mississippi Interior Salt Basin in this study is consistent with the findings published by Mancini et al. (2003) for the characteristics of the Smackover petroleum system inherent to this basin.

The apparent gas-prone nature of the North Louisiana Salt Basin and particularly the Monroe Uplift area has been of study by previous workers, including Zimmerman and Sassen (1993) and Lewan (2002). These researchers agree that the source of the gas produced from reservoirs in the Monroe Uplift area is the lower Smackover beds. These authors also concur that the gas is thermogenic in origin and that the timing of igneous activity, erosion, and migration play an important role in the presence of the large volume of gas in this area. These elements will be addressed in the assessment of the potential deep gas resource of the North Louisiana Salt Basin and Mississippi Interior Salt Basin in this study.

Conclusions

The project is on schedule to be completed on time although a software problem has resulted in the task involving the estimation of the volume of the potential deep gas resource to require additional time.

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Table 1

Milestone Chart—Year 3

	O	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**
In-Place Resource Assessment												
	xx	xx	xx									
Recoverable Deep Gas Volume												
				xx	xx	xx						
Oil Converted to Gas Assessment												
Identification of Deep Gas Resources												

Work Planned	
Work Completed	xx

Table 2. Organic geochemical analyses of potential source rocks, North Louisiana Salt Basin.

API	Parish	Depth (ft)	Unit	Kerogen Type Liptinite (%)	Kerogen Type Vitrinite (%)	Kerogen Type Inertinite (%)	TAI	Ro (%)
1711901362	Webster	10,290.00	Cotton Valley	65	30	5	2 to 2+	1.03
1707300756	Ouachita	9,915.00	Cotton Valley	75	20	5	2 to 2+	0.95
1706920233	Natchitoches	9,747.00	Mooringsport	80	15	5	2	0.81
1706120117	Lincoln	9,127.00	Cotton Valley	80	15	5	2	1.03
1701520655	Bossier	11,136.00	Bossier	20	70	10	2+	1.21
1701520878	Bossier	11,178.00	Smackover	25	65	10	2+	1.29
1701520655	Bossier	11,168.00	Bossier	65	25	10	2 to 2+	1.13
1706920072	Natchitoches	13,305.00	Smackover/Norphlet	75	20	5	3-	1.64

Table 3. Organic geochemical analyses of Hope Feet #1 (API 1706700061) in the Morehouse Parish, Monroe Uplift.

Depth (ft)	Unit	Kerogen Type Liptinite (%)	Kerogen Type Vitrinite (%)	Kerogen Type Inertinite (%)	TAI	Ro (%)
6,116.50	Smackover	80	15	5	2- to 2	0.63
6,210.50	Smackover	80	15	5	2- to 2	0.60
6,304.50	Smackover	80	15	5	2	0.66
6,530.50	Smackover	75	20	5	2	0.70
6,609.50	Smackover	70	25	5	2	0.69
6,649.50	Smackover	70	25	5	2- to 2	0.51
6,725.50	Smackover	85	10	5	- -	- -

Table 4. North Louisiana Salt Basin 2001 Oil & Gas Cumulative Production. *

Parish	Principal Reservoirs	Oil (Bbls)	Gas (Mcf)	GOR
Basin				
Webster	Ozan/Rodessa	204,138,070	3,696,121,592	18,106
Bienville	Sligo/Hosston	10,493,461	2,305,281,498	219,687
Claiborne	Nacatoch/Ozan/Sligo	469,423,557	2,543,033,078	5,417
	/Cotton Valley/Smackover			
Red River	Tuscaloosa/Paluxy/Rodessa	357,855	82,575,256	230,751
	/Hosston			
Natchitoches	Nacatoch/Sligo	81,200,000	834,000,000	10,270
Lincoln	Pine Island/Cotton Valley	31,224,187	2,272,668,985	72,786
Jackson	Hosston/Cotton Valley	2,336,084	375,328,103	160,665
Total		**799,173,214**	**12,109,008,512**	**15,152**
Sabine Uplift				
Caddo	Nacatoch	558,172,394	2,453,412,364	4,395
Bossier	Nacatoch/Lower Cretaceous	193,947,248	3,724,351,375	19,203
De Soto	Nacatoch/Paluxy	101,628,063	1,654,755,934	16,282
Total		**853,747,705**	**7,832,519,673**	**9,174**
Monroe Uplift				
Union	Nacatoch	19,687,968	193,987,271	9,853
Morehouse	Cotton Valley	201,005	3,798,739	18,899
Ouachita	Monroe Gas Rock	44,038	7,452,904,183	169,238,026
	Cotton Valley/Hosston/Sligo	40,698,299	766,122,977	18,824
Total		**60,631,310**	**8,416,813,170**	**138,820**
	Total of all parishes	**1,713,552,229**	**28,358,341,355**	**16,549**

*** by LSU, Goddard**

Table 5. Mississippi Interior Salt Basin 2005 Cumulative Oil & Gas Production.*

Reservior	Oil (Bbls)	Gas(Mcf)	GOR
Tertiary			
Wilcox	**273,753,647**	**198,084,956**	**724**
Upper Cretaceous			
Selma	39,205,424	224,393,889	5,724
Eutaw	301,449,711	1,754,506,272	5,820
Upper Tuscaloosa	26,338,415	19,226,238	730
Lower Tuscaloosa	610,702,463	1,805,166,543	2,956
Total	**977,696,013**	**3,803,292,942**	**3,890**
Lower Cretaceous			
Dantzler	783,201	72,450,931	92,506
Washita-Fredericksburg	56,943,318	255,821,157	4,493
Paluxy	56,544,588	568,991,732	10,063
Mooringsport	11,633,767	215,885,662	18,557
Ferry Lake	7,381	8,175	1,108
Rodessa	235,162,019	341,331,628	1,451
Pine Island	543,856	676,027	1,243
Sligo	30,927,220	157,859,597	5,104
James	902,320	80,356,905	89,056
Hosston	54,887,990	995,065,210	18,129
Cotton Valley	106,461,276	146,163,240	1,373
Total	**554,796,936**	**2,834,610,264**	**5,109**
Upper Jurassic			
Haynesville	6,421,491	349,786,844	54,471
Smackover	522,979,535	4,069,721,819	7,782
Norphlet	12,664,335	331,269,443	26,158
Total	**542,065,361**	**4,750,778,106**	**8,764**
Others (including Tuscaloosa production from Louisiana)	**872,883,419**	**1,277,775,162**	**1,464**
Total of all reservoirs	**3,221,195,376**	**12,864,541,430**	**3,994**

*** by UA**

Table 6. Manila Subbasin 2005 Cumulative Oil & Gas Production.*

County	Reservoirs	Oil (Bbls)	Gas (Mcf)	GOR
Clarke	Tuscaloosa	8,939,249	0	
	Smackover	19,492,266	8,775,544	450
Monroe	Haynesville/Smackover/Norphlet	37,237,789	49,818,511	1,338
	Total	**65,669,304**	**58,594,055**	**892**

***by UA**

Table 7. Conecuh Subbasin 2005 Cumulative Oil & Gas Production.*

County	Reservoirs	Oil (Bbls)	Gas (Mcf)	GOR
Baldwin	Paluxy/Washita-Fredericksburg/Dantzler	3,912,801	86,688	22
	Smackover	2,575,428	2,238,543	869
Conecuh	Haynesville/Smackover/Norphlet	5,256,519	6,617,103	1,259
Covington	Cotton Valley/Haynesville/Smackover	3,464,812	48,782	14
	Hosston	866,708	67,232	78
Escambia (AL)	Tuscaloosa	22,010,517	1,633,789	74
	Haynesville/Smackover/Norphlet	185,115,870	1,334,578,052	7,209
Escambia/Santa Rosa(FL)	Smackover/Norphlet	472,368,000	609,556,000	1,290
	Total	**695,570,655**	**1,954,826,189**	**2,810**

***by UA**