U.S. Gulf Coast Petroleum Systems Project

Assessment of Undiscovered Oil and Gas Resources in the Upper Cretaceous Austin Chalk and Tokio and Eutaw Formations, U.S. Gulf Coast, 2019

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resources of 6.9 billion barrels of oil and 41.5 trillion cubic feet of natural gas in conventional and continuous accumulations in the Upper Cretaceous Austin Chalk and Tokio and Eutaw Formations onshore and in State waters of the U.S. Gulf Coast region.

Introduction

The U.S. Geological Survey (USGS) assessed undiscovered, technically recoverable oil and gas in the Upper Cretaceous (Coniacian–Santonian) Austin Chalk and Tokio and Eutaw Formations in the subsurface of the Gulf Coast from southern Texas to the Florida Panhandle. The Austin Chalk and related stratigraphic units present onshore and in State waters of the U.S. Gulf Coast region are part of the Upper Jurassic–Cretaceous–Tertiary Composite Total Petroleum System (TPS) (Condon and Dyman, 2006).

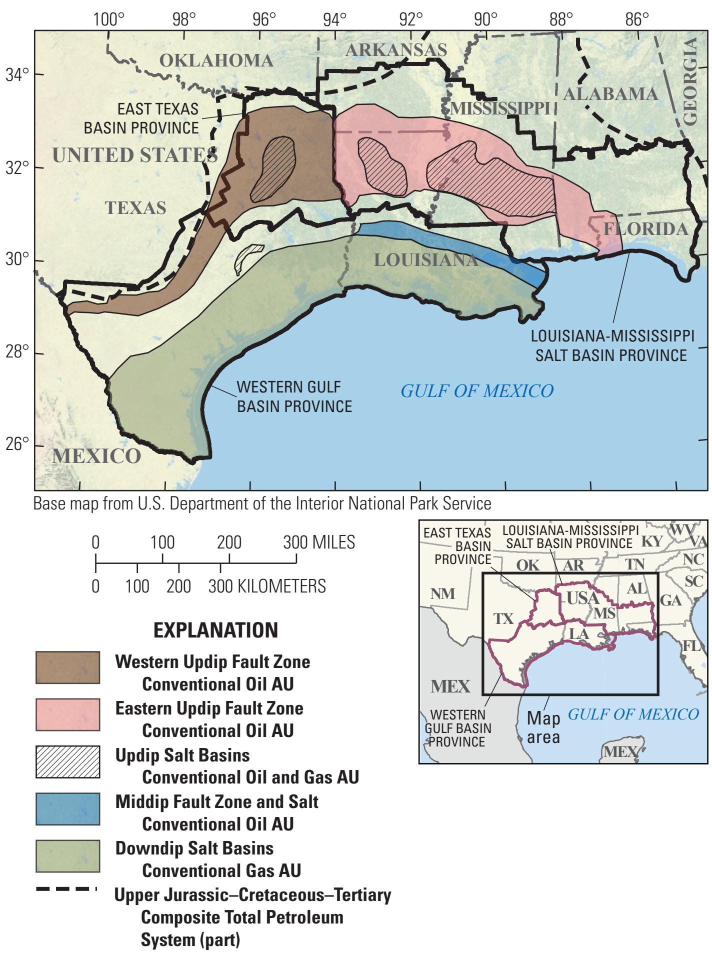


Figure 1. Map showing the Upper Jurassic–Cretaceous–Tertiary Composite Total Petroleum System and five conventional assessment units (AUs) in the Upper Cretaceous Austin Chalk and Tokio and Eutaw Formations of the U.S. Gulf Coast region.

Geologic Models for Assessment

The Austin Chalk, consisting of both chalk and marl, was deposited on a broad, low-relief marine shelf that deepened to the south and west during the Coniacian–Santonian marine transgression. Landward, to the northeast, the Austin Chalk transitions into sandstone and mudstone of the Tokio Formation in Arkansas and Louisiana and the Eutaw Formation in Mississippi and Alabama. The Tokio and Eutaw Formations were deposited in shallow to marginal marine depositional environments at the leading edge of the marine transgression. The source of hydrocarbons in Austin Chalk, Tokio, and Eutaw reservoirs varies spatially throughout the onshore Gulf Coast. Most of the hydrocarbons in the Austin Chalk are found in Texas and sourced from immediately underlying, thermally mature mudstone in the

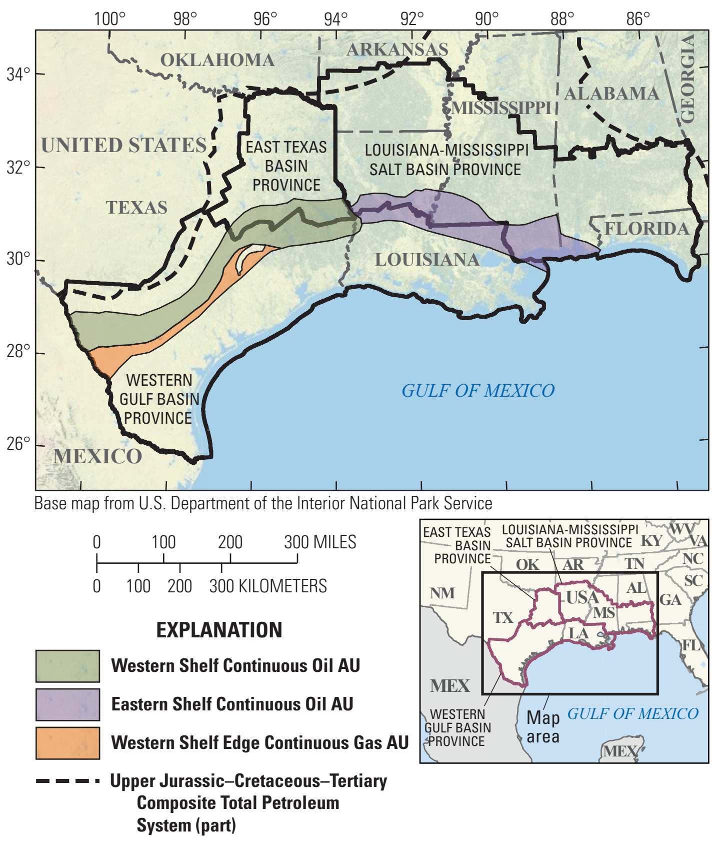


Figure 2. Map showing the Upper Jurassic–Cretaceous–Tertiary Composite Total Petroleum System and three continuous assessment units (AUs) in the Upper Cretaceous Austin Chalk of the U.S. Gulf Coast region.

Upper Cretaceous (Cenomanian–Turonian) Eagle Ford Group (a coupled Eagle Ford-Austin Chalk petroleum system). In northern areas of Texas, the Eagle Ford is thermally immature, and the deep Upper Jurassic (Oxfordian) Smackover Formation is a source of hydrocarbon. In eastern Texas and western Louisiana to the south where the Eagle Ford is thin to absent, hydrocarbons in the Austin Chalk are derived from sources in older Upper Cretaceous rocks (Hood and others, 2002). Hydrocarbons migrated into conventional reservoirs in the Austin Chalk and into sandstones in the Tokio and Eutaw Formations along regional-to-local faults and (or) salt diapirs. The Austin Chalk shows continuous reservoir characteristics where it overlies the thermally mature Eagle Ford or age-equivalent (Cenomanian–Turonian) source rocks. Hydrocarbons expelled from Cenomanian–Turonian source rocks under high temperatures and pressures migrated into continuous reservoirs in the fractured, basal part of the Austin Chalk.

Assessment Units

Based on the petroleum-system framework, the USGS defined and quantitatively assessed eight assessment units (AUs), five conventional and three continuous (figs. 1 and 2). Strata in the defined AUs within these areas share similar stratigraphic, structural, and petroleum-charge histories.

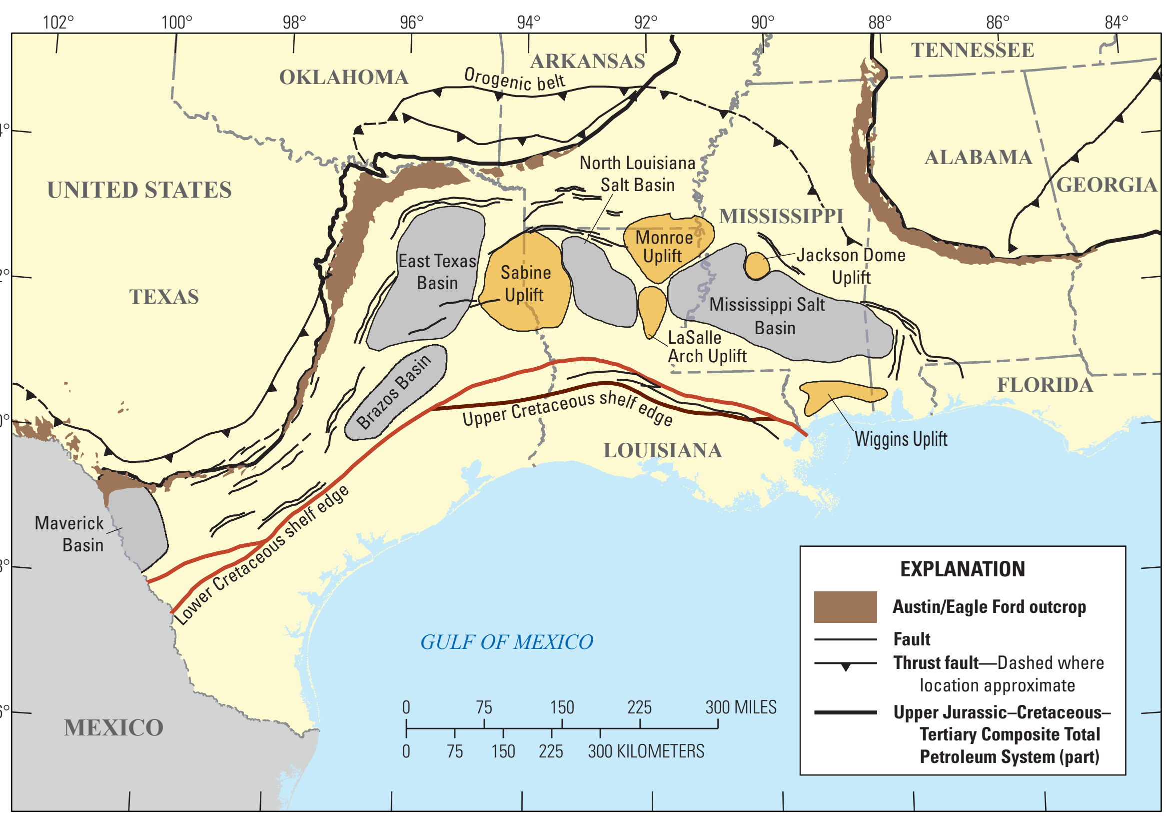
The Western Updip Fault Zone Conventional Oil AU (fig. 1) is defined by Austin Chalk reservoirs and is bounded on the northwest by the updip Austin Chalk/Eagle Ford outcrop belt and regional faults (fig. 3). The AU extends west to the Texas border with Mexico and includes parts of the Sabine Uplift and East Texas Basin. The AU extends downdip to the south across the shelf to a depth and temperature corresponding to the thermal maturity threshold for oil generation based on vitrinite reflectance (R_o=0.6 percent) in the Eagle Ford (Whidden and others, 2018).

The Eastern Updip Fault Zone Conventional Oil AU (fig. 1) is defined by Tokio and Eutaw sandstone lithofacies and is bounded on the northeast by outcrop and regional faults (fig. 3). The AU extends across the shelf toward the south and west and includes parts of the Sabine Uplift and North Louisiana and Mississippi Salt Basins (fig. 3). The southern boundary of the AU is the transition of the sandstone lithofacies with the northern updip limit of the Austin Chalk. This boundary generally corresponds to a depth and temperature range that defines the thermal maturity threshold for oil generation (R_o=0.6 percent) in Cenomanian and Turonian source rocks beneath the Tokio and Eutaw Formations (Montgomery, 1996; Hackley and others, 2018). The interface between the Western and Eastern Updip Fault Zone Conventional Oil AUs occurs near the Texas and Louisiana State line where the Austin Chalk in Texas transitions to the Tokio Formation in Louisiana.

The Updip Salt Basins Conventional Oil and Gas AU (fig. 1) is defined by areas in which movement of the Jurassic Louann Salt has influenced the migration, entrapment, and sealing of hydrocarbons in reservoirs of the Austin Chalk and Tokio and Eutaw Formations. These areas include the diapir trend in the Brazos Basin and parts of the East Texas Basin and North Louisiana and Mississippi Salt Basins (fig. 3).

The Middip Fault Zone and Salt Conventional Oil AU (fig. 1) is bounded on the north by the Lower Cretaceous shelf edge and on the south by the Upper Cretaceous shelf edge (fig. 3). Hydrocarbon accumulations within this AU are associated with salt diapirs and large-scale faults that are part of the deep Tuscaloosa fault zone in Louisiana. The western boundary of this AU is closely coincident with the Louisiana-Texas State line where shelf edges transition from a less structurally complex shelf margin in Texas to an active and more structurally complex shelf margin in Louisiana.

The Downdip Salt Basins Conventional Gas AU (fig. 1), without well penetrations, contains previously unassessed reservoirs in the Austin Chalk. The northern limit of the AU is defined by the Lower and Upper Cretaceous shelf edges (fig. 3) and producing gas wells in the Eagle Ford of Texas. The southern limit is the boundary with Federal waters in each of the respective States.



Base map from U.S. Department of the Interior National Park Service

Figure 3. Map showing major geologic features of the greater onshore Gulf Coast area where the Upper Cretaceous Austin Chalk and Tokio and Eutaw Formations were assessed (modified from Ewing and Lopez, 1991; Schruben and others, 1998; and Galloway, 2008).

The Western Shelf Continuous Oil AU (fig. 2) is defined on the north by the updip limit of oil generation (R_o=0.6 percent) in the Eagle Ford (Whidden and others, 2018). This threshold in thermal maturity is coincident with an observed transition from conventional reservoir field development of the Austin Chalk in the Western Updip Fault Zone Conventional Oil AU to continuous reservoir field development in the Western Shelf Continuous Oil AU. The transition is corroborated by comparing water-to-oil ratios of producing wells in the Austin Chalk in the two AUs over time. Water-to-oil ratios in the conventional AUs increase with time, whereas water-to-oil ratios in the continuous AUs overall remain constant with time. The southern boundary of this continuous oil AU corresponds to the thermal maturity threshold for gas generation (R_o=1.3 percent) in the Eagle Ford (Whidden and others, 2018). The AU extends west across the Maverick Basin to the Texas border with Mexico.

The Eastern Shelf Continuous Oil AU (fig. 2) is defined on the north by the updip limit of the Austin Chalk and the thermal maturity threshold for oil generation (R_o=0.6 percent) in the Upper Cretaceous (Turonian) Tuscaloosa marine shale (Hackley and others, 2018). The downdip limit is the thermal maturity threshold for gas generation (R_o=1.3 percent) in the Tuscaloosa marine shale (Hackley and others, 2018).

The Western Shelf Edge Continuous Gas AU (fig. 2) is defined on the north by the thermal maturity threshold for gas generation (R_o=1.3 percent) in the underlying Eagle Ford (Whidden and others, 2018). The southern boundary closely approximates the Lower Cretaceous shelf edge (fig. 3) and the downdip limit of productive gas wells in the Eagle Ford. This gas AU has no producing wells in the Austin Chalk.

Table 1 lists input data used to calculate undiscovered resources in the eight AUs—five conventional and three continuous.

Undiscovered Resources Summary

The USGS assessed undiscovered, technically recoverable resources for five conventional and three continuous AUs in the Austin Chalk and Tokio and Eutaw Formations of the U.S. Gulf Coast region. The estimated mean totals for conventional and continuous oil and gas resources (table 2) are 6,867 million barrels of oil (MMBO), or 6.9 billion barrels of oil, with an F95–F5 range from 2,067 to 12,582 MMBO; 41,475 billion cubic feet of gas (BCFG), or 41.5 trillion cubic feet of gas, with an F95–F5 range from 13,178 to 71,883 BCFG; and 1,345 million barrels of natural gas liquids (MMBNGL), or 1.3 billion barrels of natural gas liquids, with an F95–F5 range from 423 to 2,353 MMBNGL. Values of 0 at F95 reflect the chance that oil may not be present in the AU (geologic probability estimated to be less than 1).

Table 1. Key input data for five conventional and three continuous assessment units in the Austin Chalk and Tokio and Eutaw Formations of the U.S. Gulf Coast region.

[Well drainage area, success ratio, and estimated ultimate recovery are defined from analysis of the Austin, Tokio, and Eutaw wells. The average estimated ultimate recovery input is the minimum, median, maximum, and calculated mean. Gray shading indicates not applicable. AU, assessment unit; MMBO, million barrels of oil; BCFG, billion cubic feet of gas; %, percent; EUR, estimated ultimate recovery]

Assessment input data—Conventional AUs	Western Updip Fault Zone Conventional Oil AU				Eastern Updip Fault Zone Conventional Oil AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	3	6	3.1	1	6	12	6.2
Size of oil fields (MMBO)	0.5	1	10	1.3	0.5	1	10	1.3
AU probability	1.0				1.0			

Assessment input data—Conventional AUs	Updip Salt Basins Conventional Oil and Gas AU				Middip Fault Zone and Salt Conventional Oil AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	4	12	4.3	1	4	12	4.3
Number of gas fields	1	2	6	2.1				
Size of oil fields (MMBO)	0.5	2	10	2.3	0.5	1	10	1.3
Size of gas fields (BCFG)	3	6	70	7.9				
AU probability	1.0				1.0			

Assessment input data—Conventional AUs	Downdip Salt Basins Conventional Gas AU			
	Minimum	Median	Maximum	Calculated mean
Number of gas fields	1	50	150	53.2
Size of gas fields (MMBO)	5	10	1,000	24.9
AU probability	1.0			

Assessment input data—Continuous AUs	Western Shelf Continuous Oil AU				Eastern Shelf Continuous Oil AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	100,000	7,250,000	14,445,000	7,265,000	1,000	1,000,000	11,000,000	4,000,333
Average drainage area of wells (acres)	80	120	160	120	80	120	160	120
Area untested in AU (%)	80	90	94	88	98	99	100	99
Success ratio (%)	86	90	94	90	20	40	60	40
Average EUR (MMBO)	0.08	0.134	0.18	0.135	0.02	0.04	0.1	0.043
AU probability	1.0				0.5			

Assessment input data—Continuous AUs	Western Shelf Edge Continuous Gas AU			
	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	50,000	3,265,000	3,811,000	2,375,333
Average drainage area of wells (acres)	80	120	160	120
Area untested in AU (%)	87	97	98	94
Success ratio (%)	88	94	96	92.7
Average EUR (BCFG)	1.0	1.48	2	1.498
AU probability	1.0			

Table 2. Results for five conventional and three continuous assessment units in the Austin Chalk and Tokio and Eutaw Formations of the U.S. Gulf Coast region.

[Results shown are fully risked estimates. F95 represents a 95-percent chance of at least the amount tabulated; other fractiles are defined similarly. Gray shading indicates not applicable. MMBO, million barrels of oil; BCFG, billion cubic feet of gas; NGL, natural gas liquids; MMBNGL, million barrels of natural gas liquids]

Total petroleum system and assessment units (AUs)	AU probability	Accumulation type	Total undiscovered resources											
			Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Upper Jurassic–Cretaceous–Tertiary Composite Total Petroleum System														
Western Updip Fault Zone Conventional Oil AU	1.0	Oil	2	4	7	4	0	1	2	1	0	0	0	0
Eastern Updip Fault Zone Conventional Oil AU	1.0	Oil	4	7	13	8	0	1	1	1	0	0	0	0
Updip Salt Basins Conventional Oil and Gas AU	1.0	Oil	5	9	17	10	4	8	16	9	1	2	4	2
		Gas					6	15	37	17	0	0	0	0
Middip Fault Zone and Salt Conventional Oil AU	1.0	Oil	2	5	10	5	7	15	33	17	1	1	3	1
Downdip Salt Basins Conventional Gas AU	1.0	Gas					534	1,216	2,489	1,324	3	8	18	9
Total undiscovered conventional resources			**13**	**25**	**47**	**27**	**551**	**1,256**	**2,578**	**1,369**	**5**	**11**	**25**	**12**
Western Shelf Continuous Oil AU	1.0	Oil	2,054	6,434	11,399	6,554	3,801	12,451	24,631	13,107	71	242	525	263
Eastern Shelf Continuous Oil AU	0.5	Oil	0	31	1,136	286	0	91	3,448	857	0	3	105	26
Western Shelf Edge Continuous Gas AU	1.0	Gas					8,826	26,910	41,226	26,142	347	1,061	1,698	1,044
Total undiscovered continuous resources			**2,054**	**6,465**	**12,535**	**6,840**	**12,627**	**39,452**	**69,305**	**40,106**	**418**	**1,306**	**2,328**	**1,333**
Total undiscovered resources			**2,067**	**6,490**	**12,582**	**6,867**	**13,178**	**40,708**	**71,883**	**41,475**	**423**	**1,317**	**2,353**	**1,345**

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For More Information

Assessment results are also available at the USGS Energy Resources Program website at https://energy.usgs.gov.

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