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National and Global Petroleum Assessment

Assessment of Undiscovered, Technically Recoverable Conventional Oil and Gas Resources in the Upper Jurassic Smackover Formation, U.S. Gulf Coast, 2022

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resources of 143 million barrels of oil and 1,084 billion cubic feet of natural gas in conventional accumulations for the Upper Jurassic Smackover Formation in the onshore U.S. Gulf Coast region.

Introduction

The U.S. Geological Survey (USGS) has conducted a quantitative assessment of the undiscovered, technically recoverable conventional oil and gas resources in reservoirs within the Upper Jurassic (Oxfordian) Smackover Formation across the onshore Gulf Coast basin, including State waters, in Texas, Louisiana, Arkansas, Mississippi, Alabama, and Florida. The Smackover Formation is one of the most developed units within the Upper Jurassic–Cretaceous–Tertiary Composite Total Petroleum System (TPS; Condon and Dyman, 2006; fig. 1), with drilling and production activities dating back to the 1920s.

Geologic Background

The Smackover Formation comprises strata deposited during a widespread marine transgression in the Gulf of Mexico Basin and formed a regionally extensive carbonate shelf during the Late Jurassic (Oxfordian; Salvador, 1991). Two informal intervals of the Smackover Formation are generally recognized. The lower part of the Smackover Formation (also informally named the Brown Dense shale), composed of organic-rich calcareous shales overlying the Upper Jurassic Norphlet Formation, serves as the source for oil and gas found in numerous overlying reservoirs, including the grain-supported limestones and packstones of the

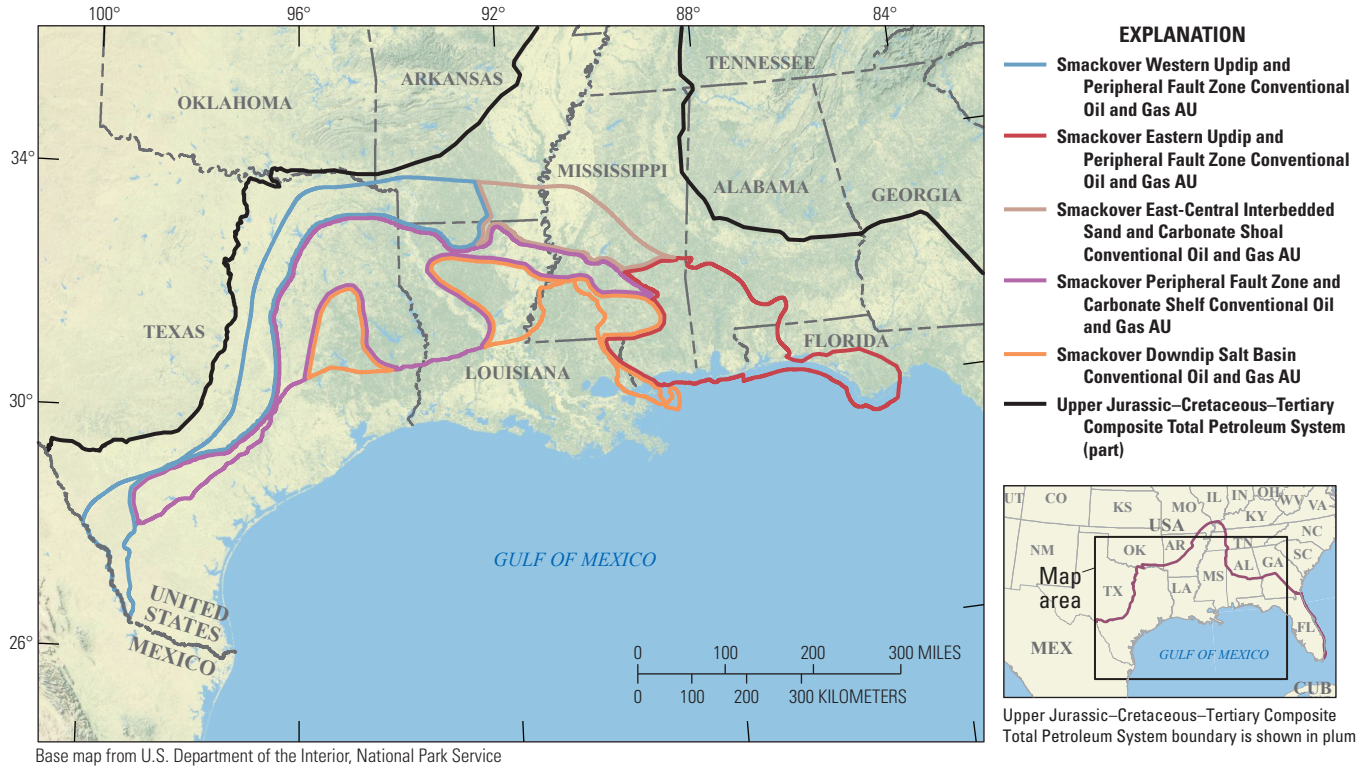

Figure 1. Map showing location of five Upper Jurassic Smackover Formation conventional oil and gas assessment units (AUs) in the U.S. Gulf Coast region.

upper part of the Smackover. Though the formation is primarily regarded as calcareous, there are sandstone deposits in some landward areas, including central Mississippi, southeastern Arkansas, and northeastern Louisiana due to fluvial input. Porosity of carbonates in the upper part of the Smackover Formation is highly variable due to differences in ooid content and degree of dolomitization. A variety of diagenetic alteration processes affect porosity, including the influence of meteoric water generating gypsum brines from anhydrites of the Upper Jurassic Buckner Formation (Heydari, 2003). Differences in the petroleum system across the formation from east to west are related to variability in (1) heat flux affecting thermal history, (2) organic matter type affecting the timing of oil generation and petroleum properties, and (3) thermochemical sulfate reduction affecting hydrocarbon preservation.

Factors related to the technical recoverability of hydrocarbons in conventional Smackover Formation accumulations were accounted for in the development of assessment unit (AU) boundaries. Pressure and temperature limits on drilling were evaluated and determined based on published reports and information obtained from operators regarding the limitations of drilling and completion equipment (Whidden and others, 2023). Three-dimensional basin modeling was conducted using stratigraphic, lithologic, and temperature data (IHS Markit, 2021). The model established basin-wide burial history trends and helped delineate depths to maximum temperatures and pressures. Specifically, the assessment excluded areas where reservoirs were estimated to be beyond technically recoverable limits based on the presence of excessively high temperatures or pressures.

Assessment Units

The petroleum-system framework is the basis for defining assessment units (AUs) in the USGS assessment process. Based on this approach, five conventional AUs were defined in the Smackover Formation (fig. 1; table 1; Birdwell and Schenk, 2024). These AUs were differentiated based on four principal criteria: (1) spatial and stratigraphic variability in lithologies within the Smackover (Snedden and Galloway, 2019); (2) the presence and extent of peripheral faults, salt basins, and other structural features compiled from a wide range of sources; (3) thermal maturity boundaries based on vitrinite reflectance equivalence (VR_{oe}, in percent) and gas-to-oil ratio data (IHS Markit, 2021), which determined the dominant form of petroleum present (oil or gas); and (4) degree of siliciclastic influence from the ancestral Mississippi River delta (Shew and Garner, 1990). The fourth factor has a complex impact on oil and gas prospects in the area of influence because it could account for additional conventional reservoirs, but it may also facilitate migration of oil and gas out of the Smackover Formation or dilute the source rock quality of the lower part of the Smackover. Additional field-scale petroleum system properties across the region were obtained from Nehring Associates Inc. (2018) and were also considered in defining AUs.

Both the Smackover Western and Eastern Updip and Peripheral Fault Zone Conventional Oil and Gas AUs are located within the extent of the inner platform ramp and carbonate shelf depositional environments defined and refined during the last 30 years (Snedden and Galloway, 2019 and references therein).

Table 1. Key input data for five conventional oil and gas assessment units in the Upper Jurassic Smackover Formation, U.S. Gulf Coast region.

[Shading indicates not applicable. AU, assessment unit; MMBO, million barrels of oil; BCFG, billion cubic feet of gas]

Assessment input data—Conventional AUs	Smackover Western Updip and Peripheral Fault Zone Conventional Oil and Gas AU				Smackover Eastern Updip and Peripheral Fault Zone Conventional Oil and Gas AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	30	60	30.7	1	40	70	40.6
Number of gas fields	1	10	20	10.3	1	10	40	11.0
Size of oil fields (MMBO)	0.5	1	30	1.6	0.5	1	45	1.9
Size of gas fields (BCFG)	3	6	400	12.8	3	6	500	13.9
AU probability	1.0				1.0			

Assessment input data—Conventional AUs	Smackover East-Central Interbedded Sand and Carbonate Shoal Conventional Oil and Gas AU				Smackover Peripheral Fault Zone and Carbonate Shelf Conventional Oil and Gas AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	5	15	5.3	1	5	10	5.1
Number of gas fields	1	5	10	5.1	1	10	50	11.4
Size of oil fields (MMBO)	0.5	1	5	1.1	0.5	1	5	1.1
Size of gas fields (BCFG)	3	5	300	9.9	3	6	500	13.9
AU probability	1.0				1.0			

Assessment input data—Conventional AUs	Smackover Downdip Salt Basins Conventional Oil and Gas AU			
	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	3	20	3.6
Number of gas fields	1	30	100	32.3
Size of oil fields (MMBO)	0.5	1	5	1.1
Size of gas fields (BCFG)	3	6	400	12.9
AU probability	1.0			

These AUs are bounded to the north by the extent of deposition of the Smackover Formation in the onshore Gulf Coast or the onset of oil generation based on thermal maturity (greater than 0.55 percent VR_{oe}) and gas-to-oil ratios calculated from cumulative production (greater than 20,000 cubic feet of natural gas per barrel of oil). They are bounded to the south by the downdip 1.78 percent VR_{oe} thermal maturity boundary for oil to gas cracking or by State waters. Differences in the stratigraphy within the upper part of the Smackover (Budd and Loucks, 1981; Mancini and others, 2004; Heydari and Baria, 2006) and in properties of the organic matter in the lower part of the Smackover (Sassen, 1989) are distinguishing factors between these AUs. For example, microbialites have only been identified as important features in the Eastern Updip and Peripheral Fault Zone AU, mainly in southeastern Alabama.

The Smackover East-Central Interbedded Sandstone and Carbonate Shoal Conventional Oil and Gas AU is distinguished from the updip and peripheral fault zone AUs by the presence of a thick fluvial sandstone package deposited between them by the ancestral Mississippi River. It is also bounded to the north by the known extent of Smackover deposition and to the south by the 1.78 percent VR_{oe} thermal maturity line.

The Smackover Peripheral Fault Zone and Carbonate Shelf Conventional Oil and Gas AU is located within the inner platform and carbonate shelf depositional environments but is defined to the north by the 1.78 percent VR_{oe} thermal maturity boundary for gas generation. Downdip limits vary across the AU and are either defined by the extent of the inner platform ramp and carbonate shelf depositional environments or the limits of the modeled 260 degrees Celsius temperature or 25,000 pounds per square-inch pressure cutoff lines for technically recoverable conventional resources (cutoff is determined by whichever boundary is farthest inland from the coastline).

The Smackover Downdip Salt Basin Conventional Oil and Gas AU is defined to the north by the extent of carbonate ramp and shelf deposition and to the south by the technically recoverable boundaries related to temperature and pressure described above. The depositional environment for this AU is represented by the open shelf-outer platform described by Snedden and Galloway (2019). The Smackover Formation is currently undrilled in this area, but because of the anticipated absence of the reservoir facies typical of the upper part of the Smackover, traps and reservoirs are expected to be related to salt structures and debris flows carrying sands sourced from fluvial inputs.

Undiscovered, Technically Recoverable Resources Summary

The USGS assessed undiscovered, technically recoverable resources for five conventional AUs in the Smackover Formation of the U.S. Gulf Coast region. The estimated mean totals for conventional oil and gas resources (table 2) are 143 million barrels of oil (MMBO), with an F95–F5 range from 83 to 227 MMBO; 1,084 billion cubic feet of gas (BCFG), with an F95–F5 range from 393 to 2,317 BCFG; and 72 million barrels of natural gas liquids (MMBNGL), with an F95–F5 range from 26 to 154 MMBNGL.

Table 2. Quantitative results for five conventional oil and gas assessment units in the Upper Jurassic Smackover Formation, 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. 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
Jurassic–Cretaceous–Tertiary Composite Total Petroleum System														
Smackover Western Updip and Peripheral Fault Zone Conventional Oil and Gas AU	1.0	Oil	29	49	81	51	34	58	97	61	3	5	8	5
		Gas					50	110	294	132	4	8	21	9
Smackover Eastern Updip and Peripheral Fault Zone Conventional Oil and Gas AU	1.0	Oil	45	73	117	76	54	87	141	91	5	8	13	8
		Gas					38	122	385	154	3	9	30	12
Smackover East-Central Interbedded Sand and Carbonate Shoal Conventional Oil and Gas AU	1.0	Oil	3	6	11	6	4	7	13	7	0	1	1	1
		Gas					18	39	126	51	1	3	9	4
Smackover Peripheral Fault Zone and Carbonate Shelf Conventional Oil and Gas AU	1.0	Oil	4	6	9	6	5	8	14	9	0	1	1	1
		Gas					34	122	412	159	2	9	29	11
Smackover Downdip Salt Basins Conventional Oil and Gas AU	1.0	Oil	2	3	9	4	2	5	14	6	0	0	1	0
		Gas					154	372	821	414	8	19	41	21
Total undiscovered conventional resources			**83**	**137**	**227**	**143**	**393**	**930**	**2,317**	**1,084**	**26**	**63**	**154**	**72**

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For More Information

Assessment results are also available at the USGS Energy Resources Program website, at https://www.usgs.gov/programs/energy-resources-program.

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