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National and Global Petroleum Assessment

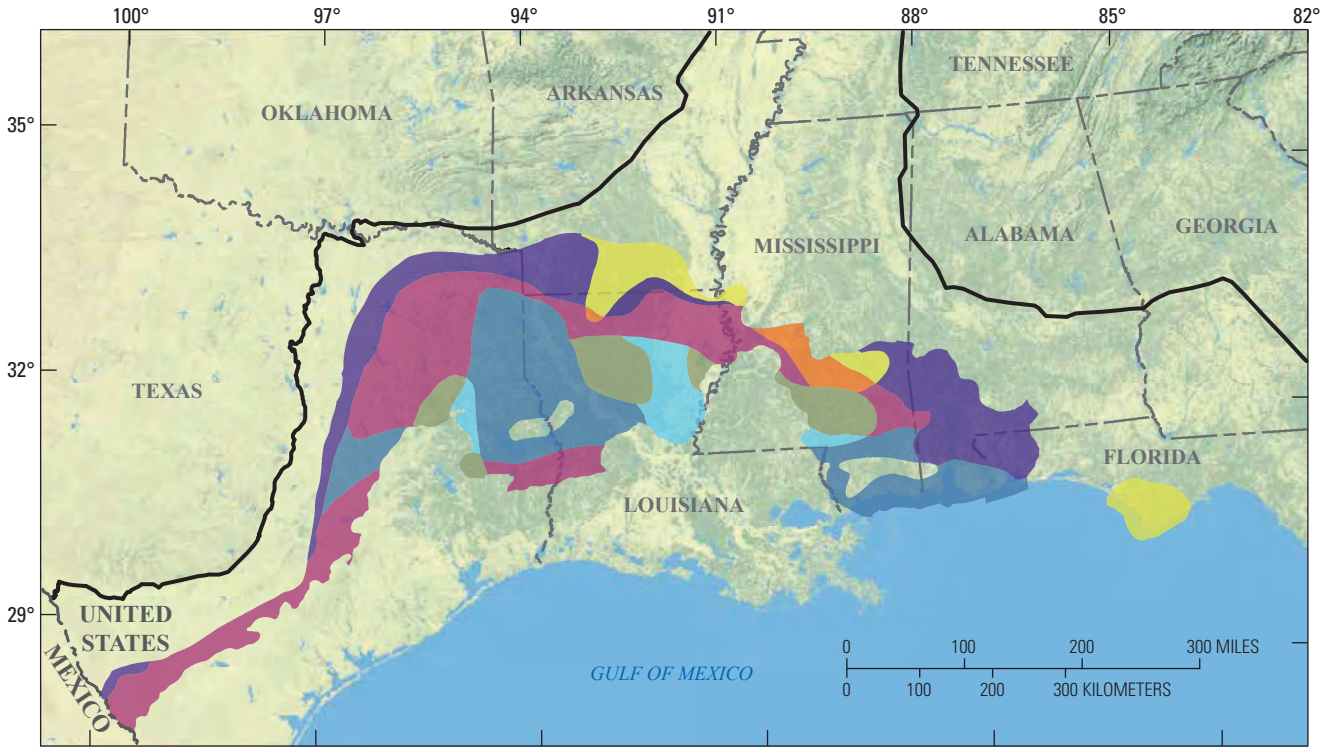
# Assessment of Continuous Oil and Gas Resources in the Upper Jurassic Smackover Formation of the Onshore U.S. Gulf Coast, 2022

*U*sing a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean continuous resources of 0.8 billion barrels of oil and 16 trillion cubic feet of gas in the Upper Jurassic Smackover Formation of the onshore U.S. Gulf Coast region.

## Introduction

The U.S. Geological Survey (USGS) assessed undiscovered, technically recoverable, continuous (unconventional) oil and gas resources in the Smackover Formation, which extends across the Gulf Coast region from the United States-Mexican border in Texas eastward to the Florida panhandle. Mudstones of the Smackover Formation are interpreted as a major petroleum source rock for the Upper Jurassic–Cretaceous–Tertiary Composite Total Petroleum System defined by the USGS in the Gulf Coast region (Warwick and others, 2007; Dubiel and others, 2010) (fig. 1).

The Smackover Formation is interpreted to have been deposited within a carbonate ramp setting, in which the ramp was a low-angle inclined carbonate surface extending from the Oxfordian shoreline to the deep basin (Mancini and others, 2019). In general, deposits of the outer ramp are mainly subtidal mudstones. Laminated mudstones within the condensed stratigraphic section of the outer ramp are commonly organic rich (Mancini and others, 2019), yet exploration of these mudstones as a self-sourced, continuous (unconventional) shale-oil or shale-gas reservoir has been limited (Yang and others, 2015). The inner-ramp facies range from similar subtidal mudstones to high-energy intertidal to supratidal carbonate facies. Most conventional oil and gas fields in the Smackover Formation are in carbonate facies of the inner-ramp environment.




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

**EXPLANATION**

- Smackover Inner Ramp Salt Basins and Peripheral Fault Zone Continuous Oil AU
- Smackover Inner Ramp Salt Basins and Peripheral Fault Zone Continuous Gas AU
- Smackover Outer Ramp Salt Basins Continuous Gas AU
- Smackover Inner Ramp Continuous Gas AU
- Smackover Outer Ramp Continuous Gas AU
- Smackover Inner Ramp Interbedded Sandstone Continuous Oil AU
- Smackover Inner Ramp Interbedded Sandstone Continuous Gas AU
- Upper Jurassic–Cretaceous–Tertiary Composite Total Petroleum System (part)


Upper Jurassic–Cretaceous–Tertiary Composite Total Petroleum System boundary is shown in plum

**Figure 1.** Map showing seven continuous assessment units (AUs) in the Smackover Formation within the Upper Jurassic–Cretaceous–Tertiary Total Petroleum System of the onshore Gulf Coast region.

The USGS defined seven continuous assessment units (AUs), five gas and two oil, within the Smackover Formation (fig. 1). Criteria used to define these AUs include the following: (1) spatial and temporal lithologic variability within the inner- and outer-ramp deposits, which affected thickness of the potential source interval; (2) presence of peripheral faults or salt basins, which may have affected petroleum migration compared to retention; (3) thermal maturity, which determined areas of oil compared to gas generation; (4) the distribution of Smackover Formation sandstones sourced from the ancestral Mississippi River (Shew and Garner, 1990), which may have provided the potential for conventional sandstone reservoirs or enhanced migration pathways through the sandstones, as well as affecting source-rock quality by dilution; and (5) maximum depth to the top of the Smackover Formation, which was 46,000 feet for this assessment. Potential gas resources at this depth are not technically recoverable using drilling and completion technologies because of high pressure and temperature conditions. Maximum temperature and pressure values used in this assessment were determined from current drilling and well-completion technologies (Wang and others, 2013; Chaplin and others, 2014; Song and Yang, 2016; Cameron, 2017), which limit the downdip extent of USGS conventional and continuous AU boundaries. This depth cutoff honors the requirement that the USGS assess only technically recoverable oil and gas resources as defined at the time of the assessment.

# Total Petroleum System and Assessment Units

The USGS defined seven continuous assessment units within the Smackover Formation (table 1). In addition to the criteria described in the "Introduction" section of this report, the five continuous gas AUs were partly defined by the modeled greater than 1.3 percent equivalent vitrinite reflectance ($R_{oe}$) thermal maturity contour and either the modeled 230 degrees Celsius temperature contour for technically recoverable resources or the 25,000 pound per square inch cutoff for technically recoverable resources (whichever is furthest inboard from the current coastline). More specifically, the Smackover Outer Ramp Continuous Gas AU was also defined by the extent of the outer-ramp depositional environment (Snedden and Galloway, 2019) and the areas outside of salt basins (Salvador, 1991). The Smackover Outer Ramp Salt Basins Continuous Gas AU was also defined by the extent of the outer-ramp depositional environment (Snedden and Galloway, 2019) and the extent of salt basins (Salvador, 1991). The Smackover Inner Ramp Continuous Gas AU was constrained by the extent of the inner-ramp depositional environment (Snedden and Galloway, 2019) and ramp areas outside of salt basins (Salvador, 1991). The Smackover Inner Ramp Salt Basins and Peripheral Fault Zone Continuous Gas AU was defined by the United States-Mexican border, the extent of the inner-ramp depositional environment (Snedden and Galloway, 2019), and the locations of salt basins (Salvador, 1991). The Smackover Inner Ramp Interbedded Sandstone Continuous Gas AU was constrained by the extent of the inner-ramp depositional environment (Snedden and Galloway, 2019) and the area of sandstone deposition in parts of northern Louisiana, central Mississippi, southern Alabama, and the westernmost part of the Florida panhandle.

The two continuous oil AUs were partly defined by the area between the 0.6 and 1.3 percent $R_{oe}$ thermal maturity boundaries for oil and gas, respectively. In addition, the Smackover Inner Ramp Salt Basins and Peripheral Fault Zone Continuous Oil AU was defined by the United States-Mexican border, the extent of the inner-ramp depositional environment (Snedden and Galloway, 2019), and the locations of salt basins and the peripheral fault zone (Salvador, 1991). The Smackover Inner Ramp Interbedded Sandstone Continuous Oil AU was constrained by the extent of the inner-ramp depositional environment (Snedden and Galloway, 2019) and the area of sandstone deposition within the Smackover Formation in parts of northern Louisiana, central Mississippi, southern Alabama, and the westernmost part of the Florida panhandle.

**Table 1.** Key input data for seven continuous oil and gas assessment units in the Smackover Formation.

[The average estimated ultimate recovery (EUR) input is the minimum, median, maximum, and calculated mean. Gray shading indicates not applicable. AU, assessment unit; %, percent; MMBO, million barrels of oil; BCFG, billion cubic feet of gas]

| Assessment input data—Continuous AUs | Smackover Inner Ramp Salt Basins and Peripheral Fault Zone Continuous Oil | | | | Smackover Inner Ramp Salt Basins and Peripheral Fault Zone Continuous Gas | | | |
|---|---|---|---|---|---|---|---|---|
| | Minimum | Mode | Maximum | Calculated mean | Minimum | Mode | Maximum | Calculated mean |
| Potential production area of AU (acres) | 1,000 | 5,887,500 | 11,775,000 | 5,887,833 | 1,000 | 8,297,000 | 16,594,000 | 8,297,333 |
| Average drainage area of wells (acres) | 80 | 140 | 180 | 133.3 | 80 | 120 | 160 | 120 |
| Success ratio (%) | 10 | 50 | 90 | 50 | 10 | 50 | 90 | 50 |
| Untested area (%) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Average EUR (MMBO, oil; BCFG, gas) | 0.01 | 0.03 | 0.08 | 0.032 | 0.05 | 0.2 | 2 | 0.298 |
| AU probability | 1.0 | | | | 1.0 | | | |
| **Assessment input data—Continuous AUs** | **Smackover Outer Ramp Salt Basins Continuous Gas** | | | | **Smackover Inner Ramp Continuous Gas** | | | |
| | Minimum | Mode | Maximum | Calculated mean | Minimum | Mode | Maximum | Calculated mean |
| Potential production area of AU (acres) | 1,000 | 1,487,000 | 2,974,000 | 1,487,333 | 1,000 | 6,722,500 | 13,445,000 | 6,722,833 |
| Average drainage area of wells (acres) | 80 | 120 | 160 | 120 | 80 | 120 | 160 | 120 |
| Success ratio (%) | 10 | 40 | 70 | 40 | 10 | 40 | 70 | 40 |
| Untested area (%) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Average EUR (MMBO, oil; BCFG, gas) | 0.05 | 0.1 | 1 | 0.146 | 0.05 | 0.1 | 1 | 0.146 |
| AU probability | 1.0 | | | | 1.0 | | | |

**Table 1.** Key input data for seven continuous oil and gas assessment units in the Smackover Formation.—Continued

[The average estimated ultimate recovery (EUR) input is the minimum, median, maximum, and calculated mean. Gray shading indicates not applicable. AU, assessment unit; %, percent; MMBO, million barrels of oil; BCFG, billion cubic feet of gas]

| Assessment input data—Continuous AUs | Smackover Outer Ramp Continuous Gas | | | | Smackover Inner Ramp Interbedded Sandstone Continuous Oil | | | |
|---|---|---|---|---|---|---|---|---|
| | Minimum | Mode | Maximum | Calculated mean | Minimum | Mode | Maximum | Calculated mean |
| Potential production area of AU (acres) | 1,000 | 2,374,000 | 4,748,000 | 2,374,333 | 1,000 | 2,273,000 | 4,546,000 | 2,273,333 |
| Average drainage area of wells (acres) | 80 | 120 | 160 | 120 | 80 | 140 | 180 | 133.3 |
| Success ratio (%) | 10 | 40 | 70 | 40 | 5 | 30 | 55 | 30 |
| Untested area (%) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100.0 |
| Average EUR (MMBO, oil; BCFG, gas) | 0.05 | 0.1 | 1 | 0.146 | 0.005 | 0.015 | 0.04 | 0.016 |
| AU probability | 1.0 | | | | 1.0 | | | |

| Assessment input data—Continuous AUs | Smackover Inner Ramp Interbedded Sandstone Continuous Gas | | | |
|---|---|---|---|---|
| | Minimum | Mode | Maximum | Calculated mean |
| Potential production area of AU (acres) | 1,000 | 702,000 | 1,404,000 | 702,333 |
| Average drainage area of wells (acres) | 80 | 120 | 160 | 120 |
| Success ratio (%) | 5 | 30 | 55 | 30 |
| Untested area (%) | 100 | 100 | 100 | 100 |
| Average EUR (MMBO, oil; BCFG, gas) | 0.025 | 0.05 | 0.5 | 0.073 |
| AU probability | 1.0 | | | |

Assessment input data are summarized in table 1 and in Schenk and Whidden (2023). Across the U.S. Gulf Coast, 41 wells have targeted the lower part of the Smackover Formation (S&P Global Commodity Insights, 2023), and of these, only 3 wells have sufficient production data to calculate estimated ultimate recoveries (EURs). For this reason, input data from USGS continuous oil and gas resource assessments of Upper Jurassic strata in northeast Mexico (Schenk and others, 2014) were used as guides for potential EUR distributions in the Smackover Formation.

**Table 2.** Results for seven continuous assessment units in the Smackover Formation.

[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]

| 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 | | | | | | | | | | | | | | |
| Smackover Inner Ramp Salt Basins and Peripheral Fault Zone Continuous Oil AU | 1.0 | Oil | 159 | 621 | 1,602 | 716 | 191 | 745 | 1,931 | 859 | 14 | 56 | 145 | 64 |
| Smackover Inner Ramp Salt Basins and Peripheral Fault Zone Continuous Gas AU | 1.0 | Gas | | | | | 1,355 | 6,315 | 30,726 | 9,867 | 94 | 442 | 2,158 | 691 |
| Smackover Outer Ramp Salt Basins Continuous Gas AU | 1.0 | Gas | | | | | 122 | 489 | 2,025 | 703 | 9 | 34 | 141 | 49 |
| Smackover Inner Ramp Continuous Gas AU | 1.0 | Gas | | | | | 551 | 2,215 | 9,314 | 3,182 | 38 | 155 | 649 | 223 |
| Smackover Outer Ramp Continuous Gas AU | 1.0 | Gas | | | | | 196 | 785 | 3,221 | 1,122 | 14 | 55 | 225 | 79 |
| Smackover Inner Ramp Interbedded Sandstone Continuous Oil AU | 1.0 | Oil | 18 | 72 | 187 | 83 | 21 | 86 | 225 | 100 | 2 | 6 | 16 | 7 |
| Smackover Inner Ramp Interbedded Sandstone Continuous Gas AU | 1.0 | Gas | | | | | 20 | 87 | 367 | 125 | 1 | 6 | 26 | 9 |
| **Total Smackover undiscovered continuous resources** | | | 177 | 693 | 1,789 | 799 | 2,456 | 10,722 | 47,809 | 15,958 | 172 | 754 | 3,360 | 1,122 |

## Undiscovered Resources Summary

The USGS quantitatively assessed oil and gas resources in seven continuous AUs in the Smackover Formation (table 2). For undiscovered, technically recoverable continuous oil and gas resources, the mean totals are 799 million barrels of oil (MMBO), or 0.8 billion barrels of oil, with an F95 to F5 fractile range from 177 to 1,789 MMBO; 15,958 billion cubic feet of gas (BCFG), or 16 trillion cubic feet of gas, with an F95 to F5 fractile range from 2,456 to 47,809 BCFG; and 1,122 million barrels of natural gas liquids (MMBNGL), or 1.1 billion barrels, with an F95 to F5 fractile range from 172 to 3,360 MMBNGL.

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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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