

National and Global Petroleum Assessment

Assessment of Undiscovered Oil and Gas Resources in the Ventura Basin Province, California, 2016

Using a geology-based assessment methodology, the U.S. Geological Survey assessed mean undiscovered, technically recoverable resources of 250 million barrels of oil and 519 billion cubic feet of gas in the Ventura Basin Province of California.

Introduction

The U.S. Geological Survey (USGS) completed a geology-based assessment of undiscovered, technically recoverable conventional and continuous oil and gas resources in the part of the Ventura Basin Province that lies onshore or within State waters (within 3 miles of the shoreline) of California (fig. 1). Conventional oil and gas resources are those that have migrated upward into structural or stratigraphic traps from deep zones where the oil and gas is generated; water is present below the oil or gas. Continuous accumulations, in contrast, are those in which oil or gas is pervasively present in essentially all wells that penetrate them, that may not be structurally or stratigraphically trapped, and that typically lack oil-water or gas-water contacts. They are commonly produced with well-stimulation technology, such as hydraulic fracturing, referred to as “unconventional.” The same stimulation technology, however, is also used in many conventionally trapped accumulations. We estimated both the likely range of oil and gas volumes remaining to be discovered in accumulations similar to existing conventional oil and gas fields in the Ventura Basin Province (previously assessed by Keller [1995] as 1,060 million barrels of oil [MMBO], 1,900 billion cubic feet of gas [BCFG], and 60 million barrels of natural gas liquids [MMBNGL]), and the potential for oil and gas that might be present in a continuous accumulation at extreme depth in the floor of the basin.

Geologic Summary

The modern Ventura Basin is an east–west trending trough that extends from north of Los Angeles to the coastline near Ventura and continues offshore as the Santa Barbara Channel. Until about 16 million years ago, however, the crustal block that includes the Ventura Basin, the Santa Barbara Channel, the northern Channel Islands, and the western Transverse Ranges lay along the coast of southern California adjacent to present-day Los Angeles, where for tens of millions of years, a sequence of Upper Cretaceous and Paleogene nonmarine, nearshore, and deep marine sediments accumulated. An episode of extensional faulting accompanied by volcanism began at the end of early Miocene time about 16 million years ago as the San Andreas Fault system formed, tearing the Ventura Basin–Transverse Ranges block from the continent and rotating it clockwise toward its present position. For the next 10 million years, a blanket of marine, organic-rich mud, the Monterey Formation, was deposited across the region, ending about 5 million years ago when compression produced large folds and uplifted fault blocks including the western Transverse Ranges and the northern Channel Islands. The Ventura Basin is filled with more than 20,000 feet of upper Miocene, Pliocene, and Quaternary sandstone, shale, and conglomerate deposited in a rapidly subsiding zone between two flanking faulted uplifts that shed great volumes of clastic sediments into the deepening trough. These sediments buried the Monterey Formation and older potential source rocks to depths of more than 18,000 feet, where temperatures are high enough to generate oil and gas from the organic matter. Oil and gas have migrated upward along sandstone beds and

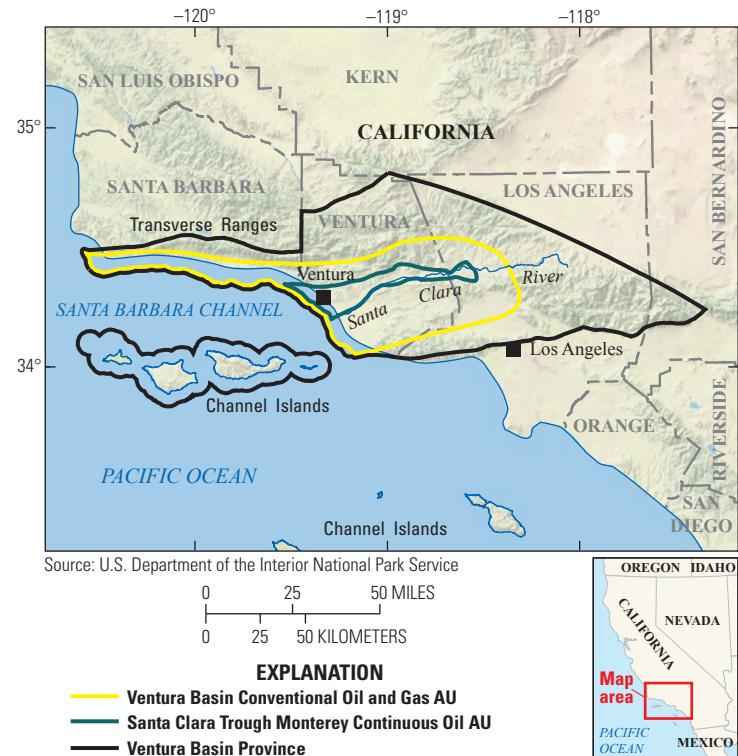


Figure 1. Map showing the location and boundaries of the Ventura Basin Province, California, and the two assessment units (AU) evaluated for this study.

faults to fill traps such as the numerous large oil fields near Ventura and in the Santa Barbara Channel. Petroleum continues to be generated, and where it has been unable to escape, some may remain in the Monterey Formation as a potential continuous resource. This assessment addresses the potential resources that may remain to be discovered in both conventional traps and in a deeply buried continuous accumulation.

Total Petroleum Systems and Assessment Units

Two assessment units (AUs) were defined in the Ventura Basin Province: (1) the Ventura Basin Conventional Oil and Gas AU and (2) the Santa Clara Trough Monterey Continuous Oil AU. Boundaries for the first AU outline the area where source rocks, either in the Monterey Formation or in older Cenozoic strata, have generated oil that has migrated to conventional traps (Cenozoic Composite Total Petroleum System). Boundaries of the continuous AU, where oil generated from the Monterey Formation (Monterey Total Petroleum System) might remain, follow faults that bound the deep structural trough parallel to the Santa Clara River on the north and south. Westward, both AUs are truncated at the boundary that separates California State waters from the Federal Outer Continental Shelf (OCS), as assessed by the Bureau of Ocean Energy Management.

Undiscovered Resources Summary

The Ventura Basin is well explored; no large conventional discoveries have been made for many decades except in the adjacent OCS. Potential for significant conventional oil and gas discoveries was judged to be highest in undrilled parts of the offshore State waters where major accumulations might exist. Onshore, most future conventional discoveries are predicted to be minor.

Conventional AU assessment input data are shown in table 1. The estimated mean total resources of oil and gas in undiscovered conventional fields in the Ventura Basin Conventional Oil and Gas AU are 246 MMBO and 512 BCFG with F95–F5 ranges of 25 to 792 MMBO and 48 to 1,666 BCFG, respectively. The estimated mean total resources for natural gas liquids are 15 MMBNGL with an F95–F5 range from 1 to 51 MMBNGL (table 2).

Table 1. Key assessment input data for two assessment units in the Ventura Basin Province, California.

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

Assessment input data—Conventional AU	Ventura Basin Conventional Oil and Gas AU			
	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	10	50	11.4
Number of gas fields	0	2	10	2.3
Sizes of oil fields (MMBO)	0.5	4	1,500	21.4
Sizes of gas fields (BCFG)	3	12	300	19.7
AU probability	1.0			
Assessment input data—Continuous AU	Santa Clara Trough Monterey Continuous Oil AU			
	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,000	40,000	170,000	70,333
Average drainage area of wells (acres)	5	10	40	18
Success ratio (%)	5	8	40	17.7
Average EUR (MMBO)	0.003	0.005	0.02	0.006
AU probability	1.0			

Table 2. Assessment results for two assessment units in the Ventura Basin Province, California.

[MMBO, million barrels of oil; BCFG, billion cubic feet of gas; NGL, natural gas liquids; MMBNGL, million barrels of natural gas liquids. Results shown are fully risked estimates. For gas accumulations, all liquids are included in the NGL category. F95 represents a 95-percent chance of at least the amount tabulated; other fractiles are defined similarly. Fractiles are additive under the assumption of perfect positive correlation. Shading indicates not applicable]

Total petroleum systems and assessment (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
Cenozoic Composite Total Petroleum System														
Ventura Basin Conventional Oil and Gas AU	1.0	Oil	25	155	792	246	42	277	1,534	467	1	8	47	14
		Gas					6	32	132	45	0	1	4	1
Total conventional resources			25	155	792	246	48	309	1,666	512	1	9	51	15
Monterey Total Petroleum System														
Santa Clara Trough Monterey Continuous Oil AU	1.0	Oil	1	3	12	4	1	5	18	7	0	0	1	0
Total continuous resources			1	3	12	4	1	5	18	7	0	0	1	0
Total undiscovered resources			26	158	804	250	49	314	1,684	519	1	9	52	15

References Cited

Keller, M.A., 1995, Ventura Basin Province (013), in Gautier, D.L., Dolton, G.L., Takahashi, K.I., and Varnes, K.L., eds., 1996, 1995 National assessment of United States oil and gas resources—Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series 30, release 2, 1 CD-ROM. [Also available at <https://certmapper.cr.usgs.gov/data/noga95/prov13/text/prov13.pdf>.]

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Continuous oil resources were estimated using success rates, estimated ultimate recoveries, and well drainage areas (table 1) similar to those used to assess the Monterey Formation in the San Joaquin and Los Angeles Basins (Tennyson and others, 2015, 2016). Volumes of undiscovered continuous oil in the deep basin are expected to be small because the large volume of oil that has rapidly migrated to shallow conventional traps indicates that oil is not likely to have been retained in the source rock. The estimated means of undiscovered recoverable continuous oil and gas in the Santa Clara Trough Monterey Continuous Oil AU are only 4 MMBO and 7 BCFG with F95–F5 ranges from 1 to 12 MMBO and 1 to 18 BCFG, respectively. The estimated volume of natural gas liquids in any continuous accumulation is very small with a mean of 0 MMBNGL and only a 5 percent chance of 1 MMBNGL (table 2).

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For More Information

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