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Scientific Investigations Report 2020–5042

U.S. Department of the Interior
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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Volume	
barrel (bbl; petroleum, 1 barrel=42 gal)	0.1590	cubic meter (m^3)

Abbreviations

AU	assessment unit
EUR	estimated ultimate recovery
MBO	thousand barrels of oil
USGS	U.S. Geological Survey

Procedure for Calculating Estimated Ultimate Recoveries of Wells in the Wolfcamp Shale of the Midland Basin, Permian Basin Province, Texas

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Abstract

In 2016, the U.S. Geological Survey published an assessment of technically recoverable continuous oil and gas resources of the Wolfcamp shale in the Midland Basin, Permian Basin Province, Texas. Estimated ultimate recoveries (EURs) were calculated with production data from IHS Markit™ using DeclinePlus software in the Harmony interface. These EURs were a major component of the quantitative resource assessment. For five of the six assessment units in the study, an industry operator in the Midland Basin provided information that was used to differentiate the Wolfcamp horizontal well landing zones. The IHS Markit™ production database does not distinguish between the Wolfcamp A, B, C, and D well landing zones. These different units of the Wolfcamp have different production patterns that are important for calculation of EURs. The calculated mean EURs for each assessment unit ranged from 99,000 barrels of oil in the Wolfcamp C to 142,000 barrels of oil in the Wolfcamp A.

Introduction

In 2016, the U.S. Geological Survey (USGS) completed an assessment of technically recoverable, undiscovered continuous oil and gas resources of the Wolfcamp shale in the Midland Basin, Permian Basin Province, Texas (Gaswirth and others, 2016). Continuous resources for this assessment included shale oil, tight oil, and associated gas. The calculation of estimated ultimate recoveries (EURs) for oil wells is a major part of the USGS assessment methodology for continuous resources (Charpentier and Cook, 2012). This report outlines the procedure used to calculate EURs that were subsequently used in the quantitative assessment. EURs were calculated for wells in five of the six assessment units (AU) (fig. 1), listed below:

- Midland Basin Wolfcamp A Continuous Oil
- Midland Basin Wolfcamp B Upper Continuous Oil
- Midland Basin Wolfcamp B Lower Continuous Oil
- Midland Basin Wolfcamp C Continuous Oil
- Midland Basin Wolfcamp D Continuous Oil

Not enough wells or production data were available to calculate EURs for the sixth AU, the Midland Basin Northern Wolfcamp Continuous Oil AU.

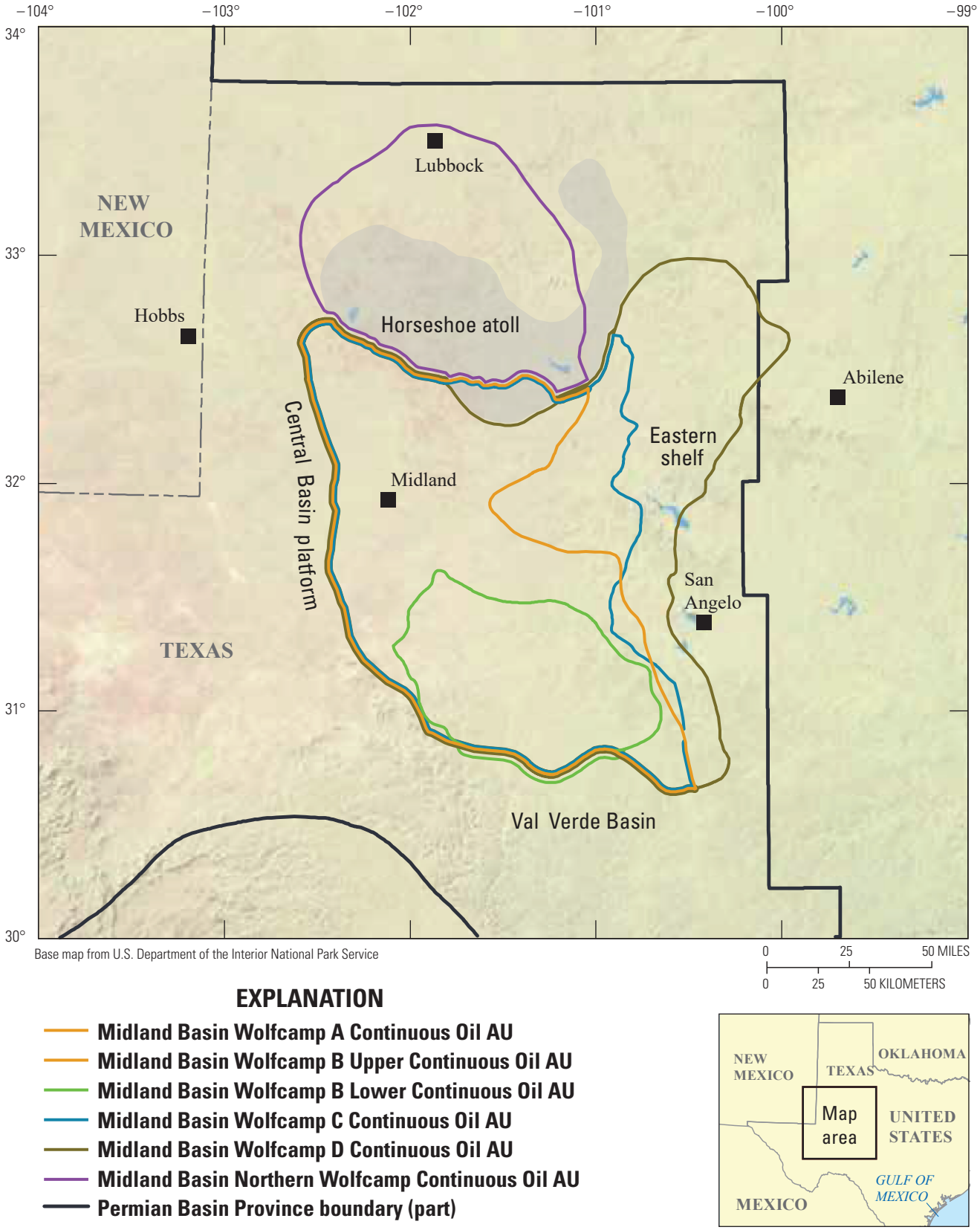

Figure 1. Map of western Texas with assessment unit (AU) boundaries for the Wolfcamp shale in the Midland Basin, Permian Basin Province. (Modified from Gaswirth and others, 2016).

Procedure

A resource assessment was performed on the Wolfcamp shale in the Midland Basin of the Permian Basin Province in Texas, as it was a previously identified formation of interest. The lead assessment geologist defined AU boundaries based on a variety of geologic criteria, including depth, lithology, and thermal maturity of source rocks. Wells within the basin were identified, and a map of the wells in each AU was created, yielding separate groups of wells for each AU.

Next, monthly production data were extracted from the IHS Markit database, current as of August 2016 (IHS Markit™, 2016). This is a proprietary database to which the USGS subscribes. Along with the production data, other ancillary data such as production start dates were concurrently extracted to aid in organization and application of the final EURs.

EURs were calculated using the IHS Markit DeclinePlus software, which is run on the Harmony interface (IHS Markit™, 2015). The DeclinePlus software is equipped to calculate decline curves using four different methods: (1) traditional decline (such as Arps), (2) multi-segment decline, (3) Duong, and (4) stretched exponential. For assessments of continuous oil and gas resources, the USGS uses the stretched exponential method because it is considered a mathematical construct for use on continuous resources (Valkó, 2009). The stretched exponential method is also used because traditional Arps decline methods are based on flow and other assumptions that are commonly invalid for wells in continuous accumulations (Anderson and others, 2010). In addition, the multi-segment method is a simple extension of traditional decline, and Duong tends to give erratic results likely owing to wells not meeting the method's slope requirements.

The EUR for each well was modeled on a 60-year timespan using 100 percent of the production data points available. Wells with less than 18 months of production were removed from the analysis because data from early production are commonly erratic, and an accurate trend cannot be modeled for these early stage wells. For this reason, about one-third of the available wells were removed from the analysis.

Any wells with EURs of less than 2,000 barrels of oil were also removed from the analysis. If a well is loaded into the DeclinePlus software with no production data, the software will calculate a fixed EUR value; this value is typically around 20,000 barrels of oil but varies based on the program settings. Wells with these fixed values were removed from the analysis. Finally, wells on the upper end of the range of EURs were investigated, and any with production profile shapes not suitable for production forecasting were removed. The wells that were removed from the analysis for any of these reasons were considered nonproducers but were subsequently used in the success ratio part of the overall assessment.

The procedure outlined above results in an EUR for each well and a distribution of EURs for each AU. The mean of each EUR distribution is critical and is used in the assessment process. The EUR distributions for five of the six AUs are shown in figure 2.

Data Granularity Improved for Five of the Six Wolfcamp AUs

The Wolfcamp shale is a highly productive, extensive formation that is drilled using stacked wells with long (thousands of feet), horizontal laterals. Differentiating the stratigraphic layers within the formation is necessary in order to calculate EURs that accurately reflect the performance of the Wolfcamp shale. Well landing zone data are not available in the IHS Markit database; however, the USGS received data from an industry operator in the Midland Basin that were used to determine where (Wolfcamp A, B, C, or D) each well was landed by the operator. EURs were only calculated for horizontal wells as this is the primary mode of new production for the Wolfcamp, now and into the foreseeable future.

EURs were also calculated for the historical, vertical wells in the Wolfcamp shale. These wells are drilled through multiple Wolfcamp layers and are likely perforated throughout. The EURs for vertical wells are similar to the sum of the EURs of the stacked laterals. This was expected because of the assumed perforation of multiple layers. The vertical EURs were not used for the resource assessment directly, but this observation was useful in confirming the calculated horizontal EURs.

Results

The largest mean EUR was in the Wolfcamp A at 142,000 barrels of oil. The smallest was in the Wolfcamp C at 99,000 barrels of oil. The Wolfcamp C is not typically pursued by operators compared to the other layers owing to its geologic characteristics. The Wolfcamp B had a mean of 113,000 barrels of oil, which was used as the basis for both the lower and upper AU. The Wolfcamp D had a mean EUR of 101,000 barrels of oil. The EUR means and ranges are helpful in calculating overall well productivity and were used to build EUR probability distributions for the assessment.

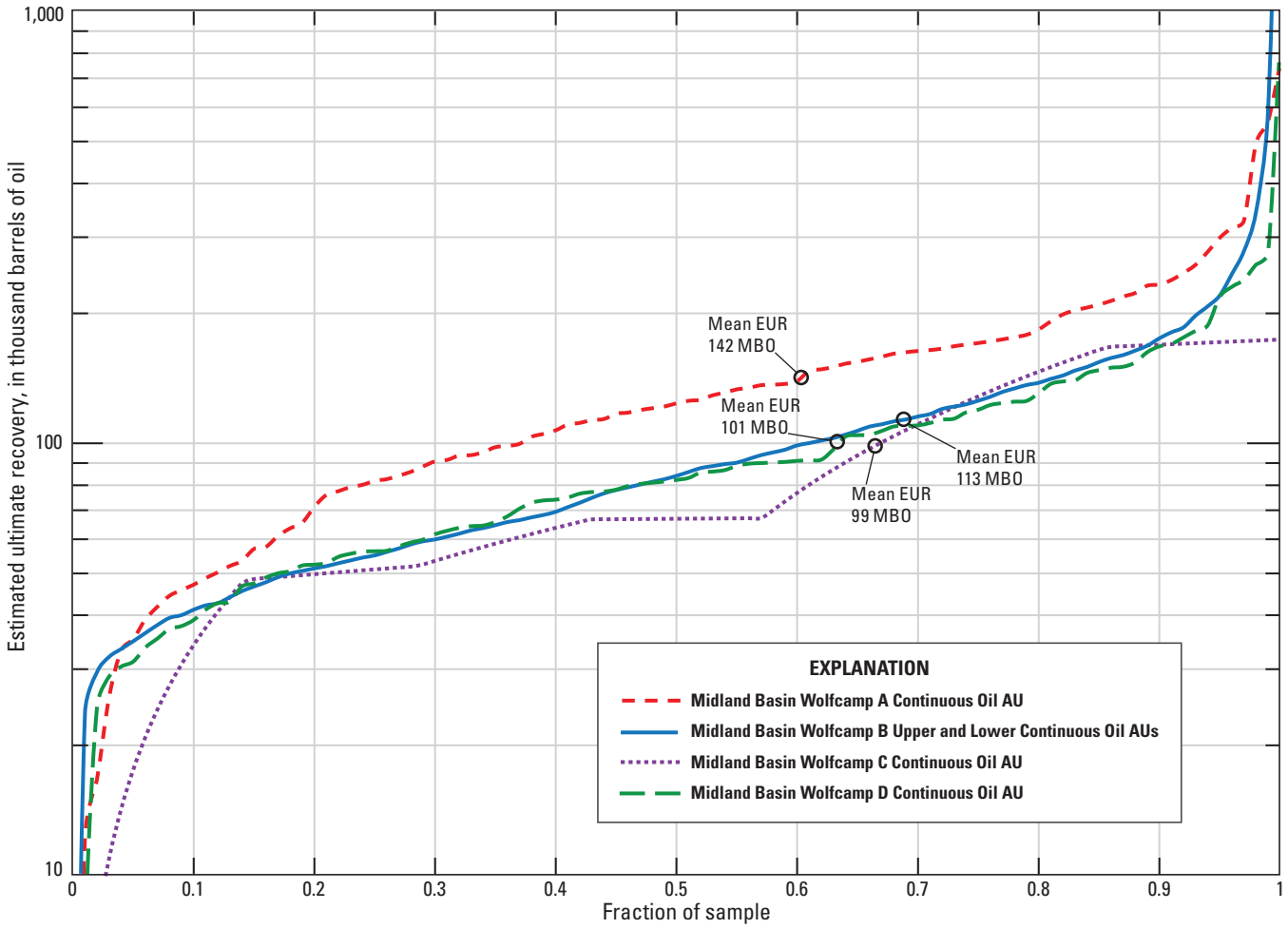

Figure 2. Estimated ultimate recovery (EUR) distributions for oil wells in five of the six assessment units (AUs) of the Wolfcamp shale in the Midland Basin, Permian Basin Province, Texas. (MBO, thousand barrels of oil).

Summary

This report outlines the steps taken to calculate estimated ultimate recoveries for continuous assessment units in the Wolfcamp shale in the Midland Basin, Permian Basin Province, Texas. The procedure included extra information for estimated ultimate recovery calculations from other U.S. Geological Survey assessments provided by an industry operator in the Midland Basin. The final calculated values of ranges and means of estimated ultimate recoveries in the assessment units were used as guides for a geology-based resource assessment in the Wolfcamp shale of the Midland Basin.

References Cited

Anderson, D.M., Nobakht, M., Moghadam, S., and Mattar, L., 2010, Analysis of production data from fractured shale gas wells, *in* Society of Petroleum Engineers Unconventional Gas Conference, Pittsburgh, Pa., February 23–25, 2010, Proceedings: Society of Petroleum Engineers, 15 p., accessed March 28, 2016, at https://doi.org/10.2118/131787-MS.

Charpentier, R.R., and Cook, T.A., 2012, Improved USGS methodology for assessing continuous petroleum resources (ver. 2, November 2012): U.S. Geological Survey Data Series 547, 30 p. and program. [Also available at https://pubs.usgs.gov/ds/547/.]

Gaswirth, S.B., Marra, K.R., Lillis, P.G., Mercier, T.J., Leathers-Miller, H.M., Schenk, C.J., Klett, T.R., Le, P.A., Tennyson, M.E., Hawkins, S.J., Brownfield, M.E., Pitman, J.K., and Finn, T.M., 2016, Assessment of undiscovered continuous oil resources in the Wolfcamp shale of the Midland basin, Permian Basin Province, Texas, 2016: U.S. Geological Survey Fact Sheet 2016–3092, 4 p. [Also available at https://doi.org/10.3133/fs20163092.]

IHS Markit™, 2015, DeclinePlus software, version 2: Englewood, Colo., IHS Markit™, accessed August 29, 2016, at http://www.fekete.com. [Also available from IHS Markit™, 15 Inverness Way East, Englewood, CO 80112.]

IHS Markit™, 2016, IHS Enerdeq® Browser: Englewood, Colo., IHS Markit™, accessed August 29, 2016, at https://www.ihsmarkit.com.

Valkó, P.P., 2009, Assigning value to stimulation in the Barnett Shale—A simultaneous analysis of 7000 plus production hystories and well completion records, *in* Society of Petroleum Engineers Hydraulic Fracturing Technology Conference, Woodlands, Tex., January 19–21, 2009, Proceedings: Society of Petroleum Engineers, 19 p., accessed March 2, 2015, at https://doi.org/10.2118/119369-MS.

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